

DIAGNOSTIC/TROUBLESHOOTING MANUAL

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MaxxForce® 15 Engine Diagnostic Manual

Engine Family: MaxxForce® 15

EGES-515-1

2012

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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

1172042R1	MaxxForce® 15 <i>Engine Operation and Maintenance Manual</i>
EGES-510-2	MaxxForce® 15 <i>Engine Service Manual</i>
EGES-515-1	MaxxForce® 15 <i>Engine Diagnostic manual</i>
EGED-520-1	MaxxForce® 15 Hard Start and No Start Diagnostics Form
EGED-535-1	MaxxForce® 15 Performance Diagnostics Form
EGED-525-1	MaxxForce® 15 Engine Wiring Diagram Form

Technical Service Literature is revised periodically and mailed automatically to "Revision Service" subscribers. 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

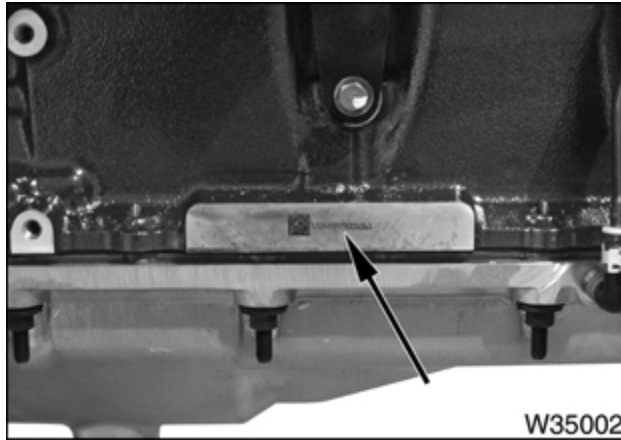


Figure 1 Engine serial number location

The engine serial number is located on the lower left side of the crankcase above the oil pan flange.

Engine Serial Number Example

152HM2YXXXXXXX

Engine Serial Number Codes

15.2 – Engine displacement

H – Diesel, turbocharged, Charge Air Cooler (CAC) and electronically controlled

M2 – Motor truck

Y – United States, Huntsville

7 digit suffix – Engine serial number sequence

Engine Emission Label

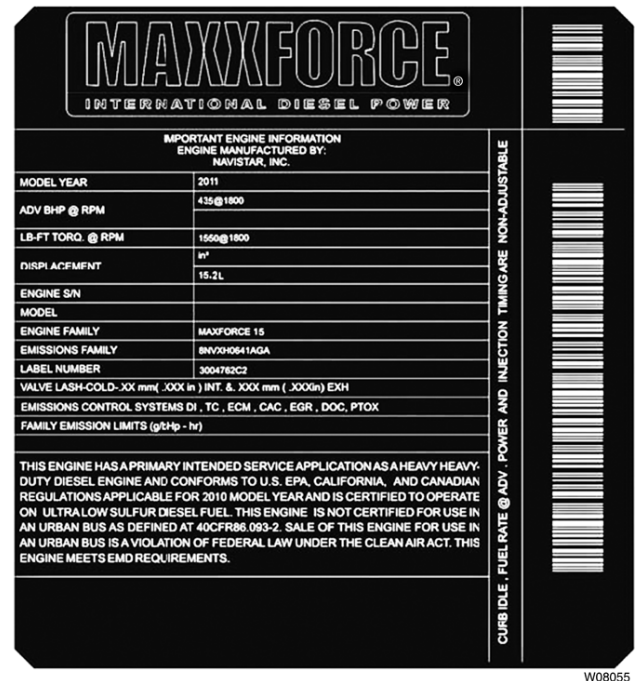


Figure 2 U.S. Environmental Protection Agency (EPA) exhaust emission label (example)

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
- Engine serial number
- EPA, EURO, OBD 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
- Engine Control Module (ECM)
- Cooling fan clutch
- High-pressure fuel pump
- Power steering pump
- Starter motor
- Turbochargers

Engine Specifications

MaxxForce® 15 Diesel Engine

Engine Configuration	4 stroke, inline six cylinder diesel
Advertised brake horsepower @ rpm	See EPA exhaust emission label
Peak torque @ rpm	See EPA exhaust emission label
Displacement	15.2 L (928 in ³)
Compression ratio	16.0:1
Stroke	171.5 mm (6.75 in)
Bore (sleeve diameter)	137.2 mm (5.40 in)
Engine weight (dry, without trim or accessories)	1 429 kg (3,150 lbs)
Firing order	1-5-3-6-2-4
Engine rotation (facing flywheel)	Counterclockwise
Aspiration	Dual turbocharged and Charge Air Cooled (CAC)
Combustion system	Direct injection turbocharged
Fuel system	High-pressure common rail
Lube system refill capacity (including filter)	
• Gravity drain from right rear and bottom front sump plugs	38 L (40 qts)
• Suction oil recovery option	34.5 L (36.5 qts)
Engine lubrication oil pressure at 99°C (210°F)	
• 600 rpm	Minimum 83 kPa (12 psi)
• 1,600 rpm	275 - 550 kPa (40 - 80 psi)
Idle speed (no load)	600 rpm, nominal
Thermostat transition range (start open — full open)	88°C - 103°C (190°F - 217°F)

Engine Description

The MaxxForce® 15 diesel engine has been designed for increased durability and reliability.

The cylinder head has four valves per cylinder with centrally located fuel injectors directing fuel over the pistons. This configuration provides improved performance and reduces emissions.

The overhead camshaft is supported by seven bearings in the cylinder head. The camshaft gear is driven from the front of the engine. The overhead valve train includes roller rocker arms and dual valves that open using a valve bridge.

The MaxxForce® 15 engine uses one piece forged steel pistons. Cooling jet cutouts and feed holes are placed on both sides of the pistons. Pistons may be installed in either direction however pistons are originally installed with casting bump on bottom of pin boss toward rear of engine.

The one piece crankcase can withstand high-pressure loads during operation. The crankcase uses replaceable wet cylinder sleeves that are sealed by a system of three O-rings.

Sound shields are strategically placed on the engine to reduce noise.

The crankshaft has seven main bearings with fore and aft thrust controlled at the forth bearing. One

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, and the front oil seal carrier is part of the front cover.

An oil pump is mounted within the oil pan to the bottom of the crankcase behind the front cover and is driven by the crankshaft. Pressurized oil is supplied to internal engine components, air compressor, power steering pump and turbochargers. All MaxxForce® 15 engines use an engine oil cooler and a spin-on can style engine oil filter element.

Fuel is drawn from the fuel tank through the frame-mounted fuel/water filter separator. A hand operated primer pump is located either on top of or next to the frame-mounted fuel/water separator. The fuel is then routed into the fuel pump and to the engine-mounted fuel filter. Conditioned fuel is then pumped to the fuel injectors.

The fuel injection system is direct common rail. The system includes a high-pressure fuel pump, fuel rail and fuel injectors. The injectors are installed in the cylinder head under the valve cover.

The MaxxForce® 15 engine uses dual turbochargers with an air-to-liquid Interstage Cooler (ISC) between turbochargers, and a chassis-mounted air-to-air Charge Air Cooler (CAC) to reduce air temperature before entering the intake.

The cold start assist system warms the incoming air supply before, during, and a short period after cranking to aid cold engine starting and reduce white smoke during warm-up.

The Exhaust Gas Recirculation (EGR) system circulates cooled exhaust into the intake air stream in the mixing duct. This cools the combustion process and reduces the formation of Nitrogen Oxides (NO_x) engine emissions. The EGR cooler assembly cools the exhaust gas in two stages.

An open crankcase breather system uses an oil separator to return oil to the crankcase and vent the crankcase gasses to the atmosphere. The oil separator is mounted on the cylinder head.

The engine brake is standard on the MaxxForce® 15. 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 Features

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

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 conditions.

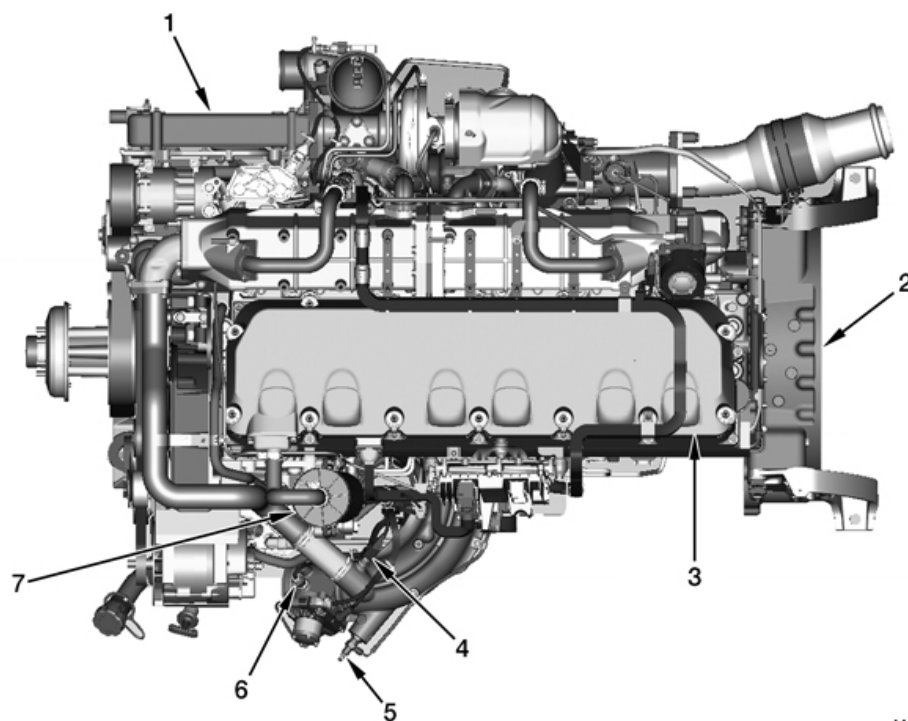
Chassis Mounted Features

The aftertreatment system, part of the larger exhaust system, processes engine exhaust so that it meets tailpipe emission requirements. Most of the aftertreatment system is mounted on the chassis.

- The Pre-Diesel Oxidation Catalyst (PDOC) and Diesel Oxidation Catalyst (DOC) which is mounted on the chassis, oxidizes hydrocarbons and carbon monoxide, provides heat for exhaust system warm-up, and aids in temperature management for the Diesel Particulate Filter (DPF) for passive DPF regeneration.
- The DPF temporarily stores carbon-based particulates then oxidizes the particulates and stores the noncombustible ash.

The High-Pressure Charge Air Cooler (HPCAC) mounted on the vehicle cooling module, is connected between the outlet of the high-pressure turbocharger and the inlet to the engine throttle valve assembly. The HPCAC is an air-to-air cooler that uses ambient air to cool pressurized air before it enters the engine.

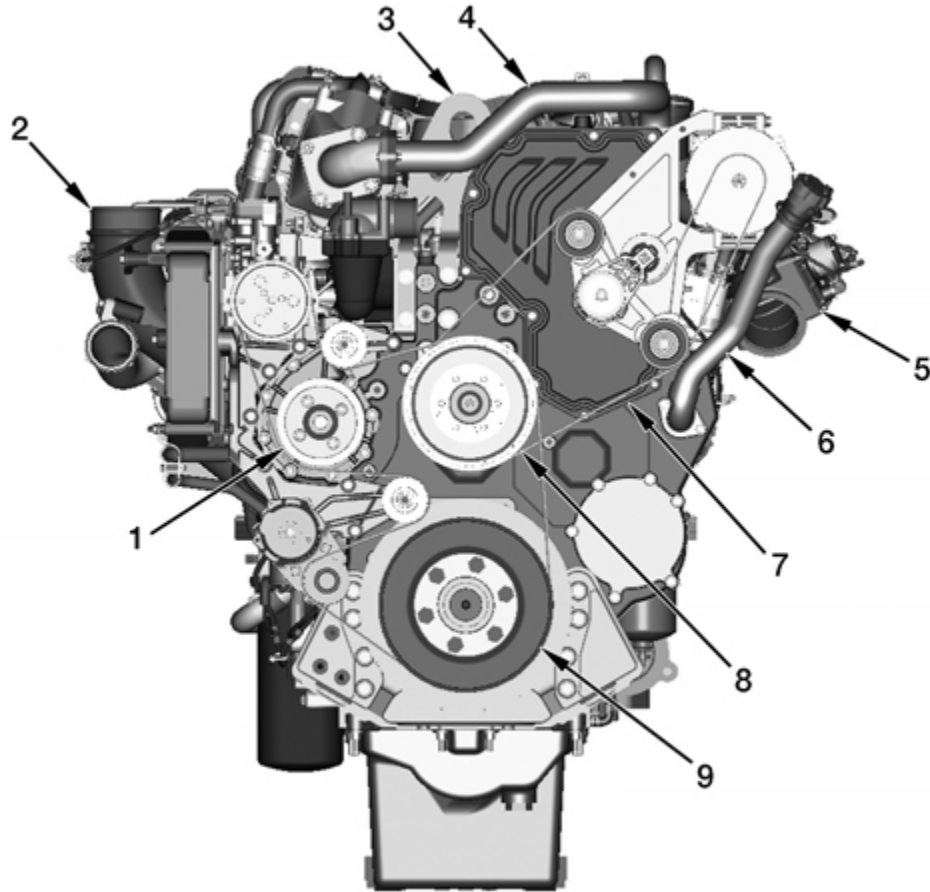
Engine Component Locations



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Figure 3 Component location – top

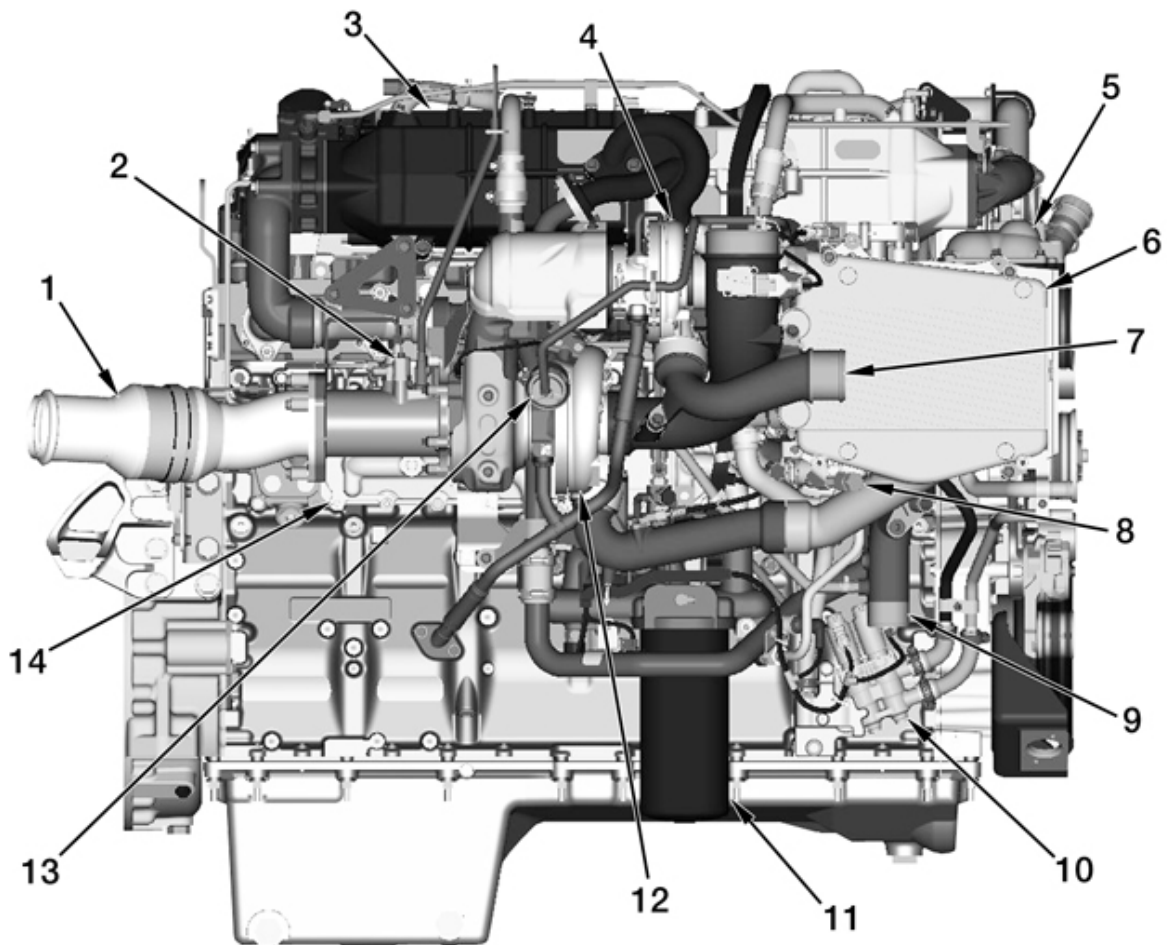
1. Turbocharger interstage cooler assembly	3. Valve cover assembly	6. Charge Air Cooler Outlet Temperature (CACOT) sensor
2. Flywheel housing assembly	4. Exhaust gas temperature sensor	7. Breather filter assembly
	5. Cold Start Fuel Igniter (CSFI)	



W35015

Figure 4 Component location – front

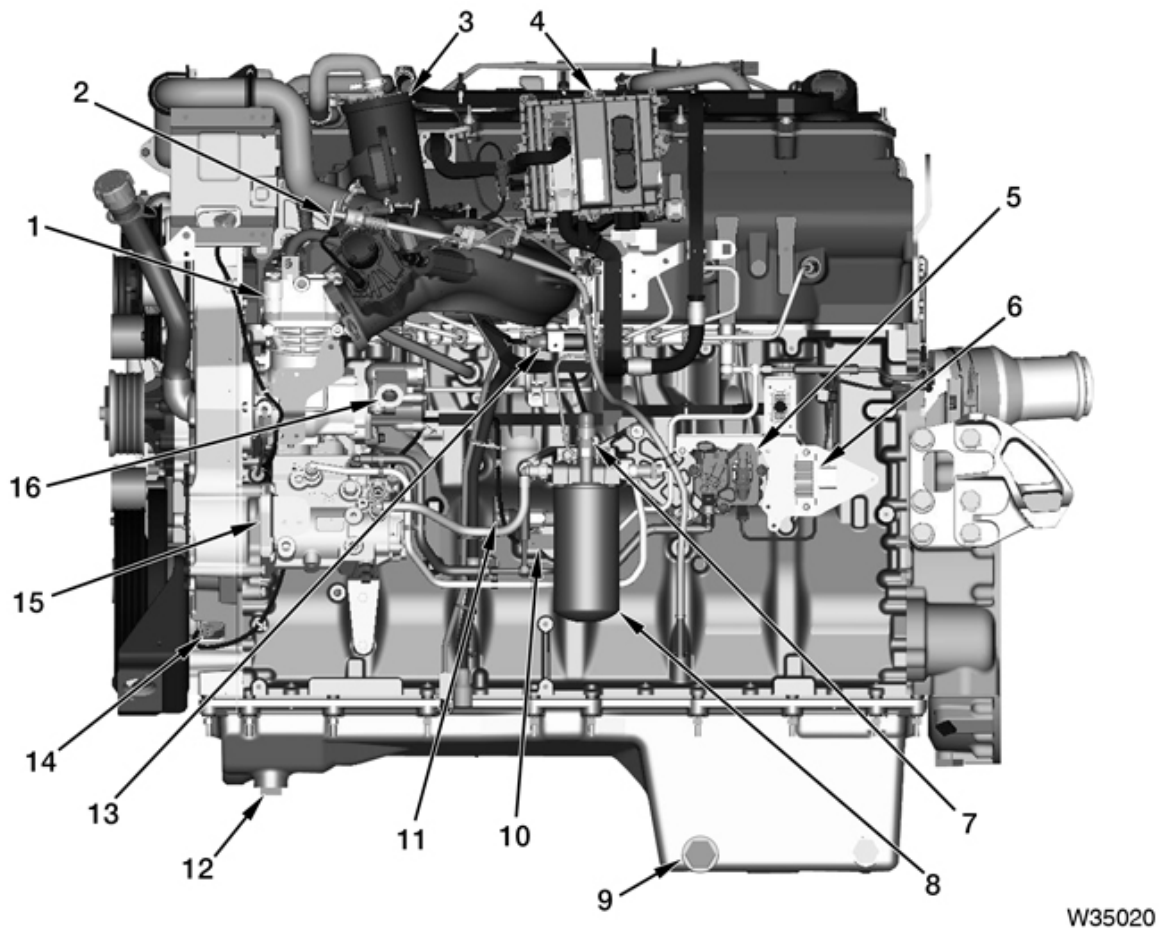
1. Water pump pulley	4. EGR crossover tube assembly	7. Camshaft gear cover
2. Air inlet duct (turbocharger)	5. Engine throttle valve assembly	8. Low mount fan drive
3. Front lifting eye	6. Oil filler pipe assembly	9. Damper (crankshaft)



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Figure 5 Component location – right

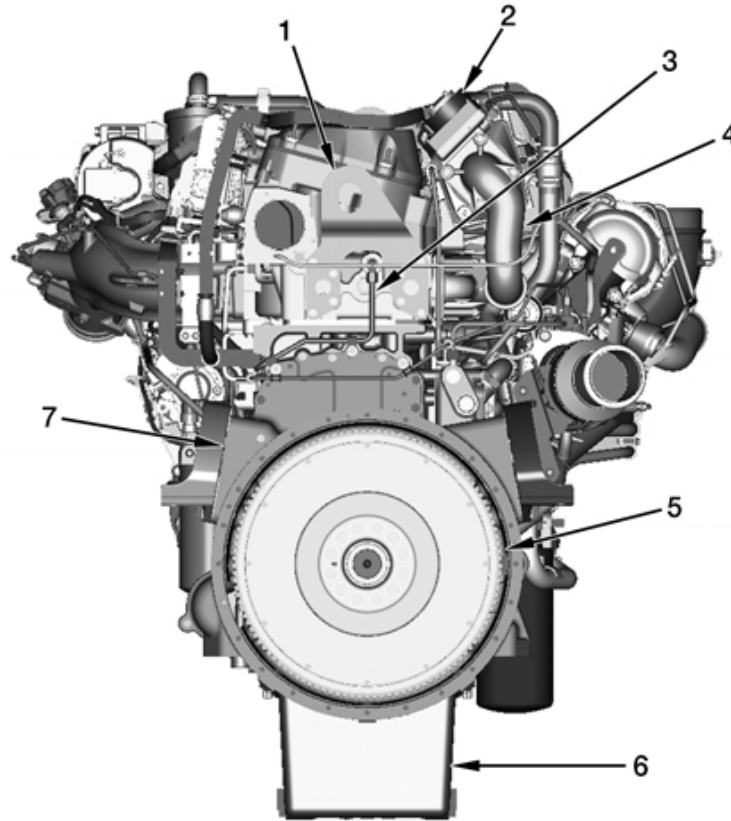
1. Pre-Diesel Oxidation Catalyst (PDOC) assembly	6. Interstage cooler assembly	11. Oil filter
2. Fuel doser	7. High-pressure turbocharger compressor outlet	12. Low-Pressure (LP) turbocharger assembly
3. Exhaust Gas Recirculation (EGR) cooler assembly	8. Oil supply tube for secondary filtration (to soot filter)	13. High-pressure turbocharger wastegate actuator
4. High-Pressure (HP) turbocharger assembly	9. Coolant inlet (from radiator)	14. Engine oil cooler assembly
5. Thermostat housing	10. Coolant Control Valve (CCV) assembly	



W35020

Figure 6 Component location – left

1. Air compressor	7. Fuel Delivery Pressure (FDP) sensor	12. Oil pan drain plug (front sump)
2. Oil level gauge assembly	8. Fuel filter	13. Cold Start Fuel Solenoid (CSFS)
3. Crankcase breather	9. Oil pan drain plug (rear sump)	14. 5 mm 60 degree speed sensor (crankshaft position sensor)
4. Engine Control Module (ECM)	10. Crankcase Pressure (CPS) sensor	15. High-pressure fuel pump
5. Down Stream Injection (DSI) assembly	11. Engine Oil Pressure (EOP) sensor	16. Power steering pump
6. 12V relay (for cold start assist solenoid)		



W35017

Figure 7 Component location – rear

1. Rear lifting eye	3. Fuel return tube assembly	6. Oil pan
2. Exhaust Gas Recirculation (EGR) valve assembly	4. EGR cooler supply tube	7. Flywheel housing
	5. Flywheel	

Air Management System (AMS)

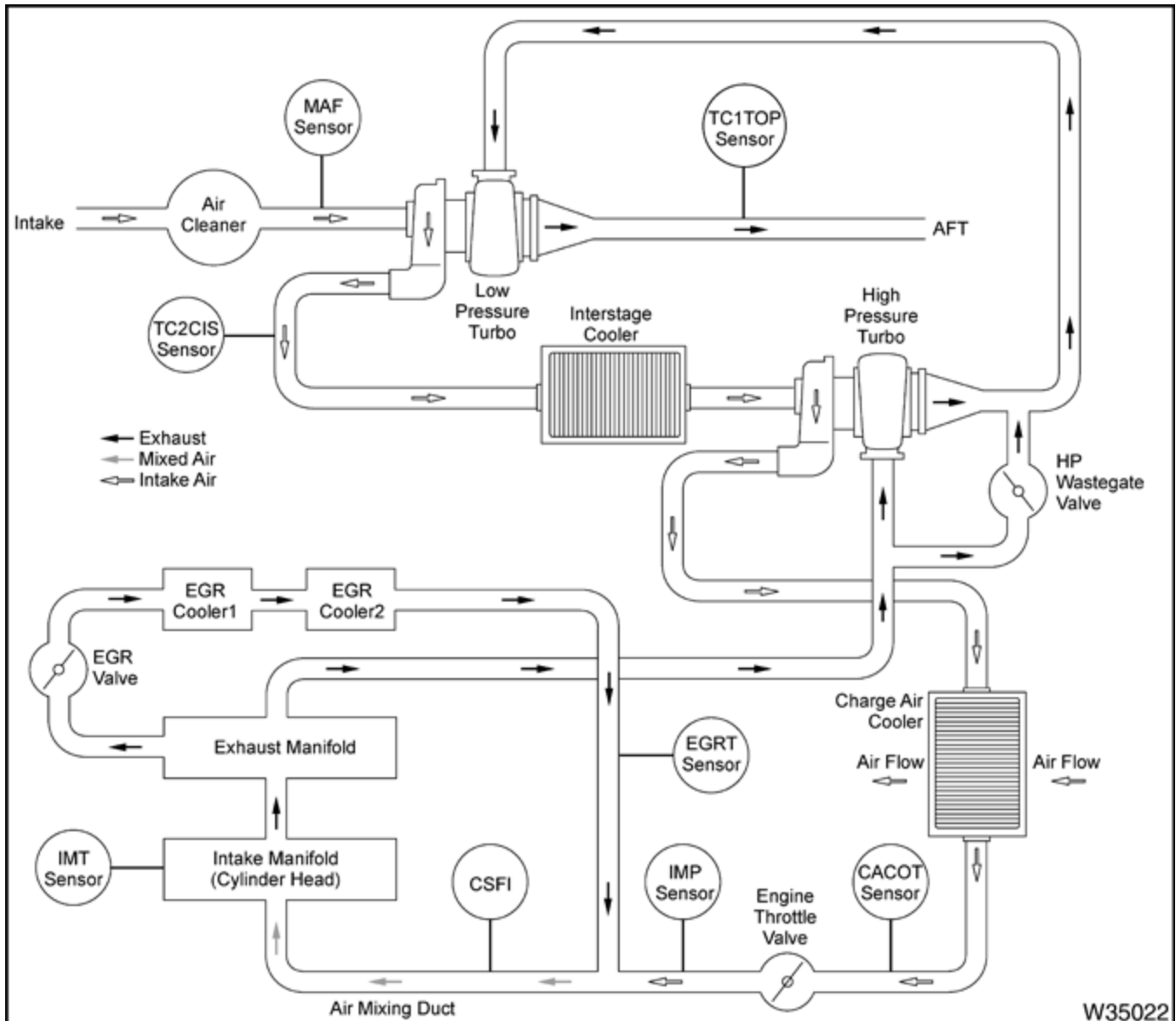


Figure 8 Air Management System (AMS)

Air Flow

Air flows through the air cleaner assembly and enters the low-pressure turbocharger. The low-pressure turbocharger increases the pressure, temperature, and density of the intake air before it enters the Interstage Cooler (ISC). Cooled compressed air flows from the ISC into the high-pressure turbocharger. The high-pressure turbocharger increases the intake air pressure up to 345 kPa (50 psi). The hot compressed

air flows into the Charge Air Cooler (CAC) where it is cooled, and then directed to the Engine Throttle Valve (ETV) and mixing duct area of the throttle valve assembly.

If the EGR control valve is open, exhaust gas passes through the EGR system into the mixing duct where it is mixed with the filtered intake air. This mixture flows through the mixing duct into the intake manifold and

cylinder head. The intake manifold is an integral part of the cylinder head casting.

If the EGR control valve is closed, only filtered intake air flows through the ETV, mixing duct, and into the intake manifold.

During cold weather, the Cold Start Fuel Igniter (CSFI) rapidly heats the intake air by injecting and igniting small quantities of fuel into the mixing duct.

After combustion, gases exit through the cylinder head exhaust valves and ports. The exhaust gas is forced through the exhaust manifold where, depending on the EGR valve assembly position, is split between the EGR system and the exit path through the high-pressure turbocharger and low-pressure turbocharger.

The exhaust gases flow from the low-pressure turbocharger through the vehicle aftertreatment system to the exhaust tail pipe.

Air Management Components

Turbochargers

The MaxxForce® 15 engine is equipped with an electronically controlled, pneumatically actuated two stage turbocharging system. This system provides high levels of charge air pressure to improve engine performance and help reduce emissions. Because of its ability to generate very high charge air pressure levels, the system is fitted with an air control valve to control over-boost and surging conditions. The air control valve is supplied compressed air from the vehicle air supply tank. The compressed air flow to the wastegate actuator is electronically controlled by the air control valve based on the Pulse Width Modulated (PWM) signal supplied by the Engine Control Module (ECM). The high and low-pressure turbochargers are installed as an assembly on the exhaust manifold, on the right side of the engine.

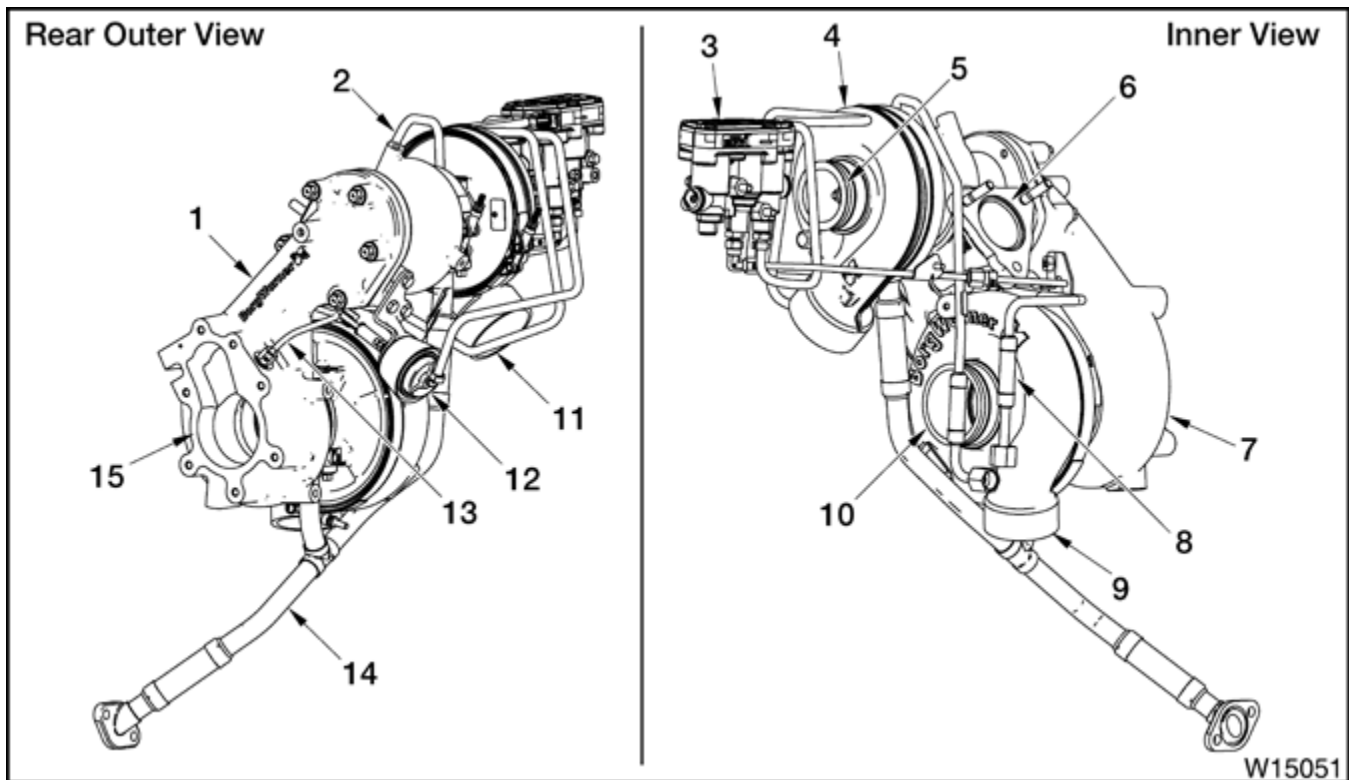


Figure 9 Low and high-pressure turbocharger components

1. Low-pressure turbocharger assembly	6. High-pressure turbocharger turbine inlet	11. High-pressure turbocharger compressor outlet
2. High-pressure turbocharger oil supply hose	7. Low-pressure turbocharger assembly	12. High-pressure turbocharger wastegate actuator
3. Air control valve	8. Low-pressure turbocharger oil supply hose	13. Turbine output pressure tube
4. High-pressure turbocharger assembly	9. Low-pressure turbocharger compressor outlet	14. Turbocharger oil drain tube assembly
5. High-pressure turbocharger compressor inlet	10. Low-pressure turbocharger compressor inlet	15. Low-pressure turbocharger turbine outlet

The low and high-pressure turbochargers are installed in series on the right side of the engine. The high-pressure turbocharger is connected directly to the exhaust manifold through the high-pressure turbine inlet. The turbine input of the low-pressure turbocharger is connected to the turbine outlet of the high-pressure turbocharger. The high-pressure turbocharger is equipped with a wastegate actuator which regulates turbocharger boost by controlling the amount of exhaust gases that pass through the turbine. When boost demand is low, the wastegate opens, allowing part of the exhaust gas flow to bypass the turbine.

Fresh air from the air filter enters the low-pressure compressor where it is compressed and directed into the Interstage Cooler (ISC). Cooled condensed air from the ISC enters the high-pressure compressor, where it is further compressed and directed to the High-Pressure Charge Air Cooler (HPCAC) mounted near the cooling module. Cooled and condensed air then flows directly into the engine throttle valve.

Interstage Cooler (ISC)

The ISC is installed between the low-pressure and the high-pressure turbochargers. The ISC air inlet

is connected to the low-pressure compressor outlet and uses engine coolant to regulate the charge air temperature. The ISC air outlet is connected to the compressor inlet on the high-pressure turbocharger.

High-Pressure Charge Air Cooler (HPCAC)

The HPCAC is installed between the high-pressure turbocharger compressor outlet and the Engine Throttle Valve (ETV). The HPCAC uses ambient air flow to regulate the charge air temperature. The HPCAC air outlet is connected to the ETV body.

Air Control Valve

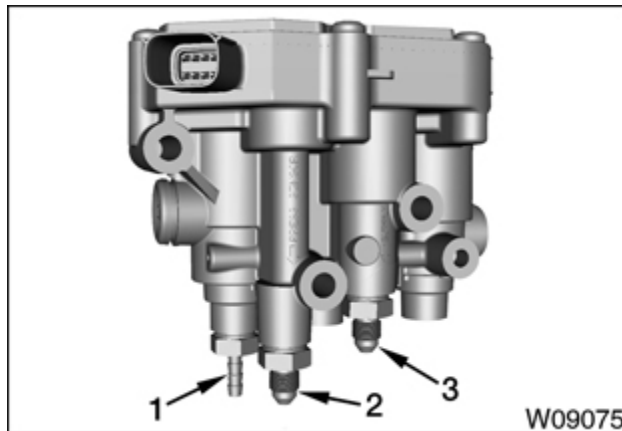


Figure 10 Air control valve

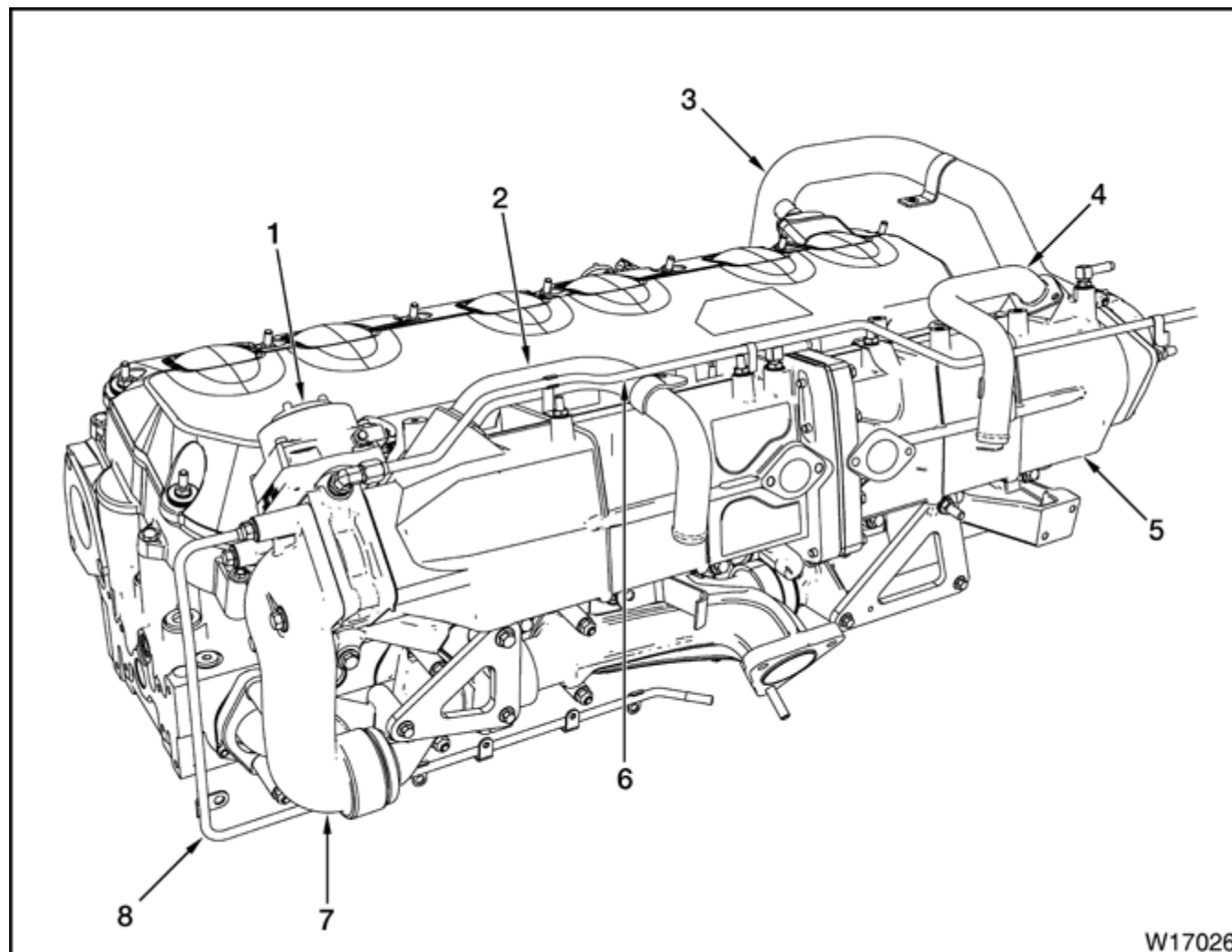
1. To high-pressure turbocharger wastegate actuator
2. Turbocharger 1 Turbine Output Pressure (TC1TOP) input to sensor
3. Compressed regulated air supply from chassis air tank

The air control valve controls air pressure to the high-pressure wastegate actuator based on turbine output pressure from a port on the output of the low-pressure turbocharger. The turbine output pressure sensor is integral to the air control valve. Air pressure to the air control valve is supplied from an air tank mounted on the chassis. The air control valve is controlled by the Engine Control Module (ECM).

The air control valve is normally closed. Thus, with no Pulse Width Modulated (PWM) signal, the air control valve remains closed and no air pressure is supplied to the wastegate actuator on the high-pressure turbocharger. When a decrease in charge air pressure is required, the ECM supplies a PWM ground voltage to the negative side of the wastegate control solenoid. The other side of the wastegate control solenoid is connected to 12V supply voltage. This causes the air control valve to open which supplies air pressure to the wastegate actuator.

The limit values of the PWM signal are between approximately 95%, corresponding to an open air control valve, and 5%, corresponding to a closed air control valve. When the air control valve closes, it interrupts the air supply to the wastegate actuator and at the same time relieves air pressure from the wastegate by allowing it to vent to atmosphere. The wastegate actuator then closes, resulting in increased charge air pressure.

Exhaust Gas Recirculation (EGR) System



W17026

Figure 11 EGR system

1. EGR valve assembly	5. EGR cooler assembly	8. EGRV coolant supply tube assembly
2. EGR coolant tube assembly	6. EGRV coolant return tube assembly	
3. EGR crossover tube assembly	7. EGR cooler supply tube	
4. EGR coolant tube assembly		

EGR System Overview

The EGR system reduces Nitrogen Oxides (NO_x) engine emissions by introducing cooled exhaust gas into the mixing duct. NO_x forms during a reaction between nitrogen and oxygen at high temperatures during combustion. An Oxygen Sensor (O₂S) located in the turbo exhaust duct, monitors the oxygen content in the exhaust gas and provides input to the Engine

Control Module (ECM) to control the EGR valve assembly.

The EGR system consists of an EGR valve, EGR cooler assembly and an O₂S. The EGR valve assembly is mounted on the rear of the EGR cooler assembly.

The EGR cooler assembly is located on the right side of the valve cover above the exhaust manifold.

EGR Flow

Exhaust gas from the exhaust manifold flows through the EGR cooler supply tube to the EGR valve assembly. When the EGR is activated, the EGR valve assembly opens and allows exhaust gas to enter the EGR cooler assembly for cooling. Cooled exhaust gas flows from the EGR cooler assembly into the mixing duct where it is mixed with filtered intake air.

EGR Control

The ECM monitors signals from the Intake Manifold Temperature (IMT) sensor and Engine Coolant Temperature (ECT) sensor to control the EGR system. The EGR is switched off (EGR valve assembly closed) if any of the following conditions are present:

- Charge air temperature is low
- Intake manifold temperature is low
- Engine coolant temperature is low
- During engine brake operation
- When Cold Ambient Protection (CAP) mode is active

The Oxygen Sensor (O2S) is installed in the turbocharger exhaust duct, in front of the

aftertreatment fuel injector. The O2S has a heater element that heats the sensor to its normal operating temperature of 780°C (1,436°F). During initial engine warm-up, the O2S heater element is activated only after the engine coolant reaches 40°C (104°F) and the exhaust gas temperature exceeds 100°C (212°F) for more than 30 seconds.

EGR Open Loop System

During the engine warm-up period and before the Oxygen Sensor (O2S) 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. The EGR actuator provides feedback to the ECM on current valve position through the EGRP sensor.

EGR Closed Loop System

After the Oxygen Sensor (O2S) 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 the O2S readings.

Aftertreatment (AFT) System

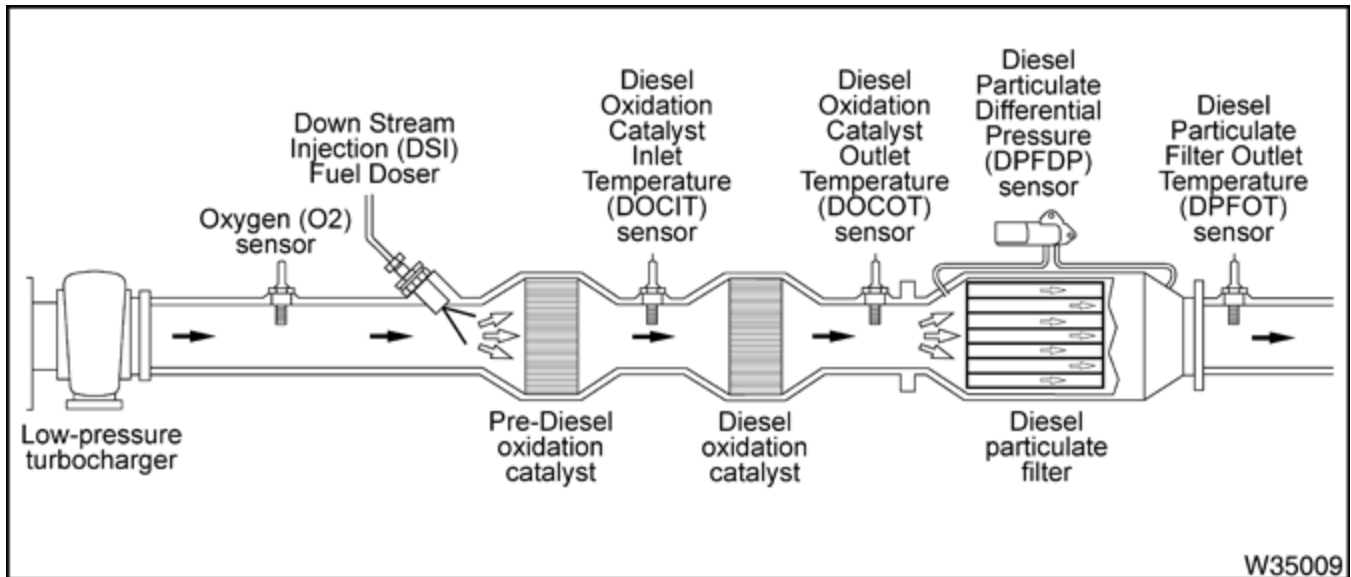


Figure 12 AFT system overview

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

The AFT system performs the following functions:

- Monitors exhaust gases and controls engine operating parameters for emission processing and failure recognition
- Cancels regeneration in the event of catalyst or sensor failure
- Monitors the level of soot accumulation in the Diesel Particulate Filter (DPF) and adapts engine operating characteristics to compensate for increased back pressure
- Controls engine operating parameters to make regeneration automatic
- Maintains vehicle and engine performance during regeneration

Sensors

Sensors output an electronic signal based on oxygen (O₂), temperature and pressure. The signals are used by the control system to regulate the aftertreatment function.

The sensors measure O₂, temperature and pressure at the center of the exhaust flow.

Down Stream Injection (DSI)

The aftertreatment system injects fuel through the fuel doser into the exhaust gas to increase the temperature necessary for DPF regeneration. The fuel doser is located in the turbo exhaust duct, directly after the low-pressure turbocharger, on the engine. Control of the down stream injection is done by the Engine Control Module (ECM). The ECM receives data from the aftertreatment sensors directly and determines when regeneration is required.

Pre-Diesel Oxidation Catalyst (PDOC)

The PDOC is located on the engine after the DSI.

The PDOC does the following:

- Aids in creating an exothermic reaction to improve exhaust emissions
- Allows for more efficient operation of the aftertreatment system

Diesel Oxidation Catalyst (DOC)

The DOC is located in the vehicle exhaust system.

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

Diesel Particulate Filter (DPF)

The DPF is located in the vehicle exhaust system.

The DPF does the following:

- Captures and temporarily stores carbon-based particulates in a filter

- Allows for oxidation (regeneration) of stored particulates once back pressure increases to a predetermined level
- Stores noncombustible ash

AFT Conditions and Responses

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

Aftertreatment Fuel Injection Components

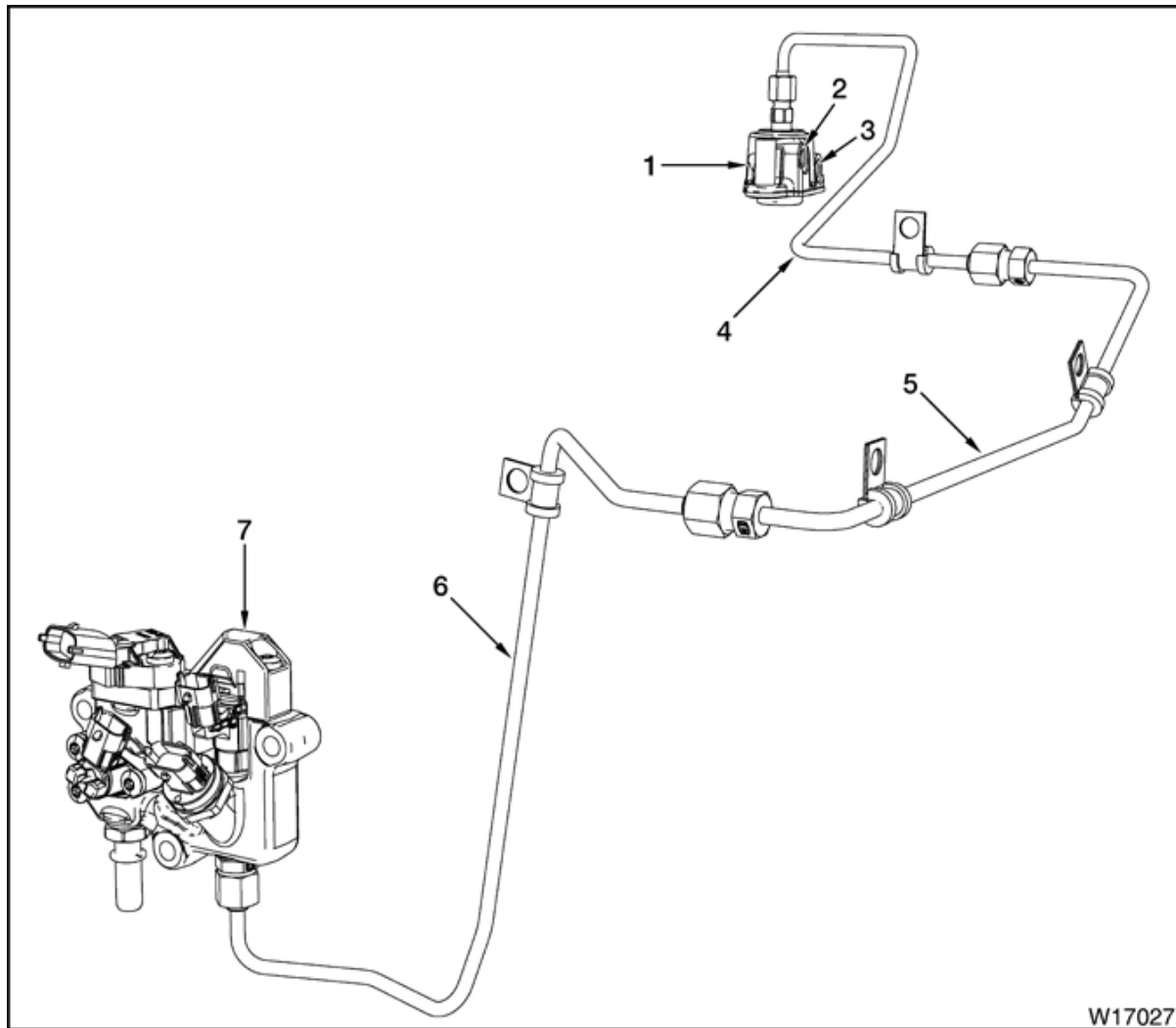


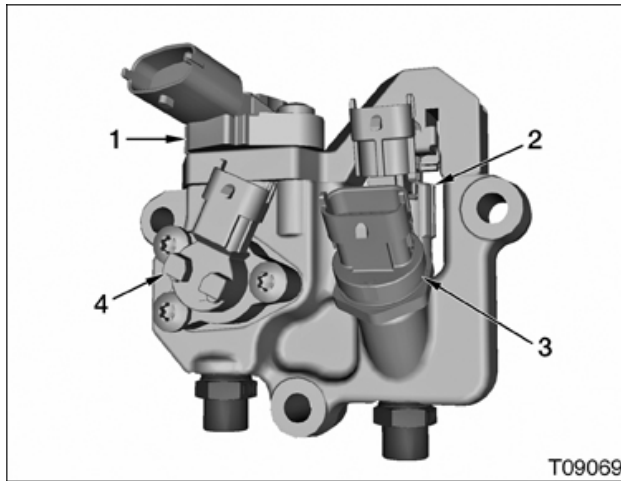
Figure 13 Aftertreatment fuel injection components

1. Fuel doser	4. Doser fuel from valve tube assembly	6. Doser fuel to injector tube assembly
2. Coolant supply port	5. Feed Injector unit tube assembly	7. Down Stream Injection (DSI) assembly
3. Coolant return port		

The down stream injection system includes the following:

- Engine Control Module (ECM)
- Fuel doser
- Down Stream Injection (DSI) assembly
- Fuel lines

The Engine Control Module (ECM) is mounted on the left side of the engine. The Down Stream Injection (DSI) assembly is installed on the left rear of the engine below the cylinder head.



When the ECM signals the AFTFSV to open, fuel pressure increases in the upstream cavity of the DSI assembly housing. The upstream AFTFIS immediately signals the ECM that pressure is increased by available fuel. The ECM then signals the AFTFD valve to open, allowing a specific amount of fuel to be pumped through the three fuel tubes to the fuel doser.

Fuel is injected into the exhaust stream from the fuel doser which increases the temperature inside the Diesel Particulate Filter (DPF) in order to convert soot to ash more efficiently.

The fuel doser is cooled with engine coolant.

Figure 14 Down Stream Injection (DSI) assembly

1. AFT fuel inlet sensor (AFTFIS) (press and temp)
2. AFT fuel doser (AFTFD) (valve)
3. AFT fuel pressure 2 (AFTFP2)
4. AFT fuel shut-off valve (AFTFSV)

Fuel Management System

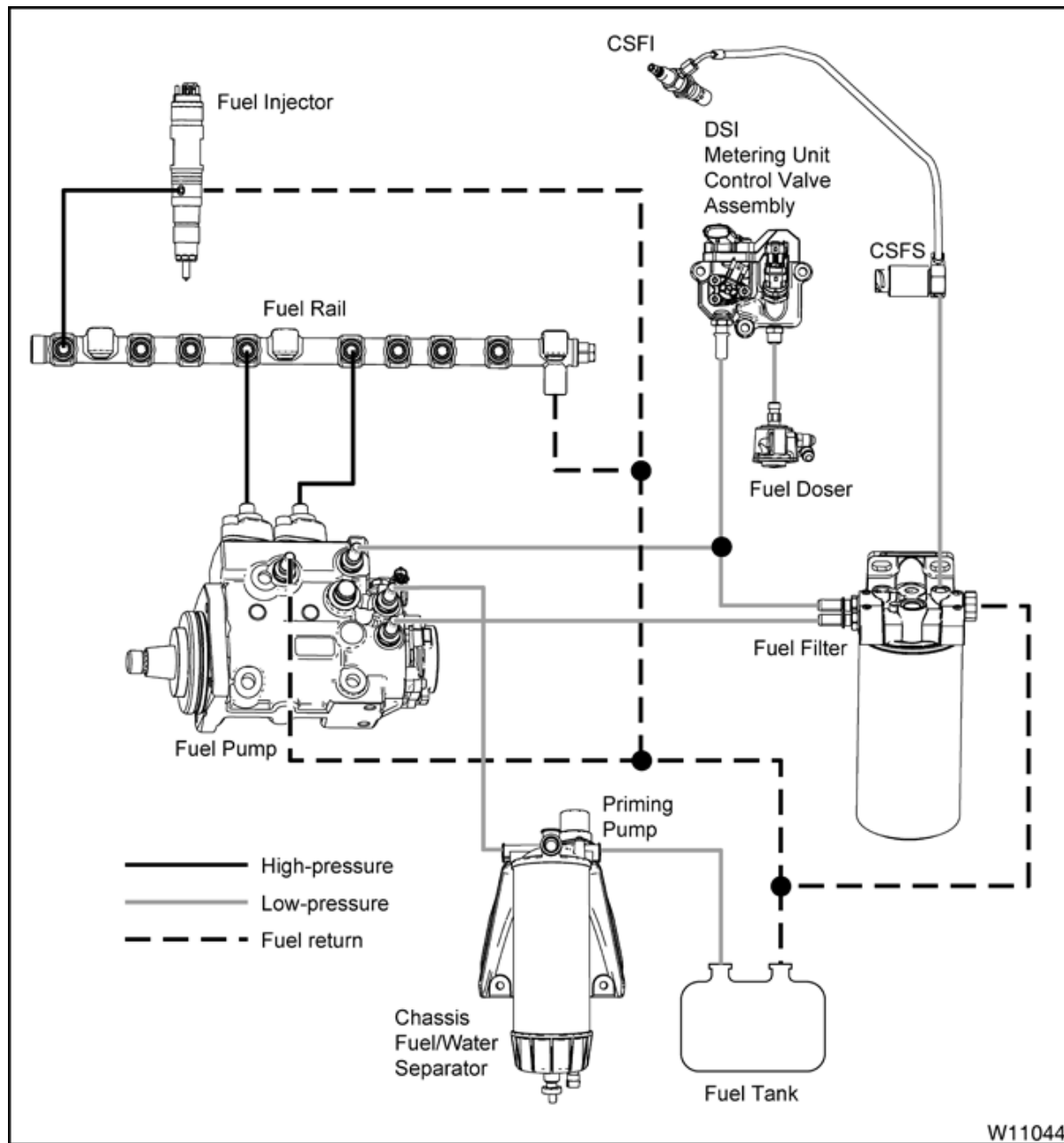


Figure 15 Fuel supply system flow

The MaxxForce® 15 engine is equipped with a high-pressure common rail injection system. The common rail fuel injection system provides fuel under constant high-pressure to the fuel injectors for optimal fuel atomization in the combustion chamber.

Fuel is drawn from the tank and through the frame mounted fuel filter/water separator by a low-pressure fuel pump mounted on the engine. Fuel flows from the low-pressure fuel pump through an engine mounted fuel filter before being supplied to a high-pressure pump. The high-pressure pump

supplies high-pressure fuel to a pressure pipe rail, which feeds the injectors through individual tubes. Unused fuel from injectors is returned to the tank through a passage around the quill tubes in the cylinder head. The low-pressure fuel pump and high-pressure pump are assembled as one gear driven unit on the engine.

The fuel system is controlled by the ECM, various sensors, and the Fuel Pressure Control Valve (FPCV) located in the high-pressure pump.

In addition to providing high-pressure fuel to the injectors, the fuel system also provides low-pressure filtered fuel to the aftertreatment and cold start assist systems.

DSI and Fuel Doser

In the aftertreatment system, filtered fuel from the fuel filter at supply pressure is delivered to the DSI assembly. The DSI assembly supplies precise amounts of fuel to the fuel doser.

Cold Start System

During cold weather, fuel is delivered to the Cold Start Fuel Igniter (CSFI) through the Cold Start Fuel Solenoid (CSFS). The CSFI then heats the intake air by injecting and igniting small quantities of fuel into the mixing duct.

Fuel Filter and Housing

An orifice and an additional regulator located within the fuel filter housing work together to reduce fuel pressure to 10 psi for the cold start system solenoid. Supply system pressure is regulated by a pressure regulator valve located in the supply pump. Excess fuel relieved to achieve the pressure reduction is returned back to the fuel pump. The maximum system pressure is regulated to 1 300 kPa (189 psi).

Chassis Mounted Components

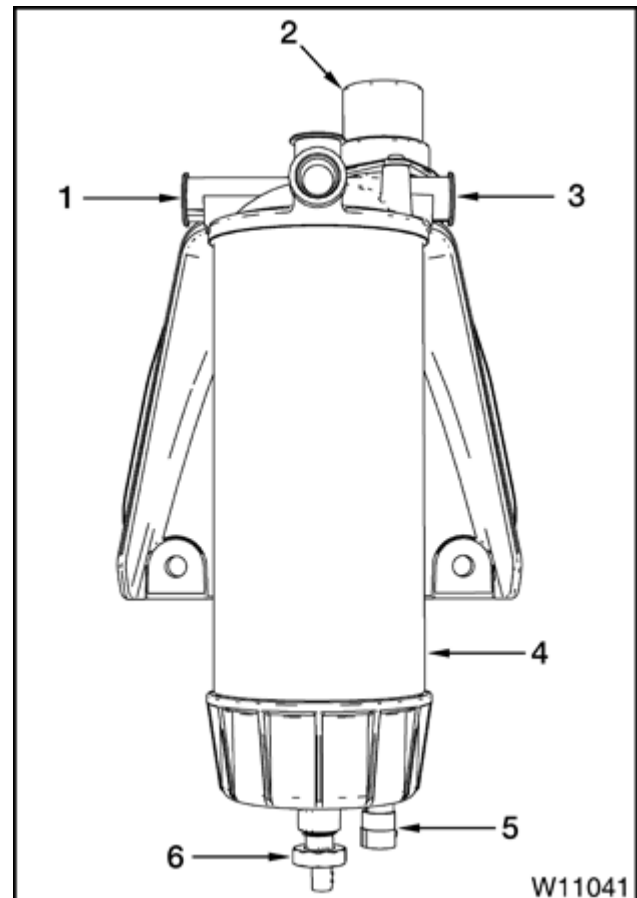


Figure 16 Racor® fuel filter assembly

1. Fuel outlet
2. Fuel primer pump assembly
3. Fuel inlet from tank
4. Fuel filter water separator assembly
5. Water In Fuel (WIF) sensor
6. Drain valve

Fuel Filter and Water Separator Assembly

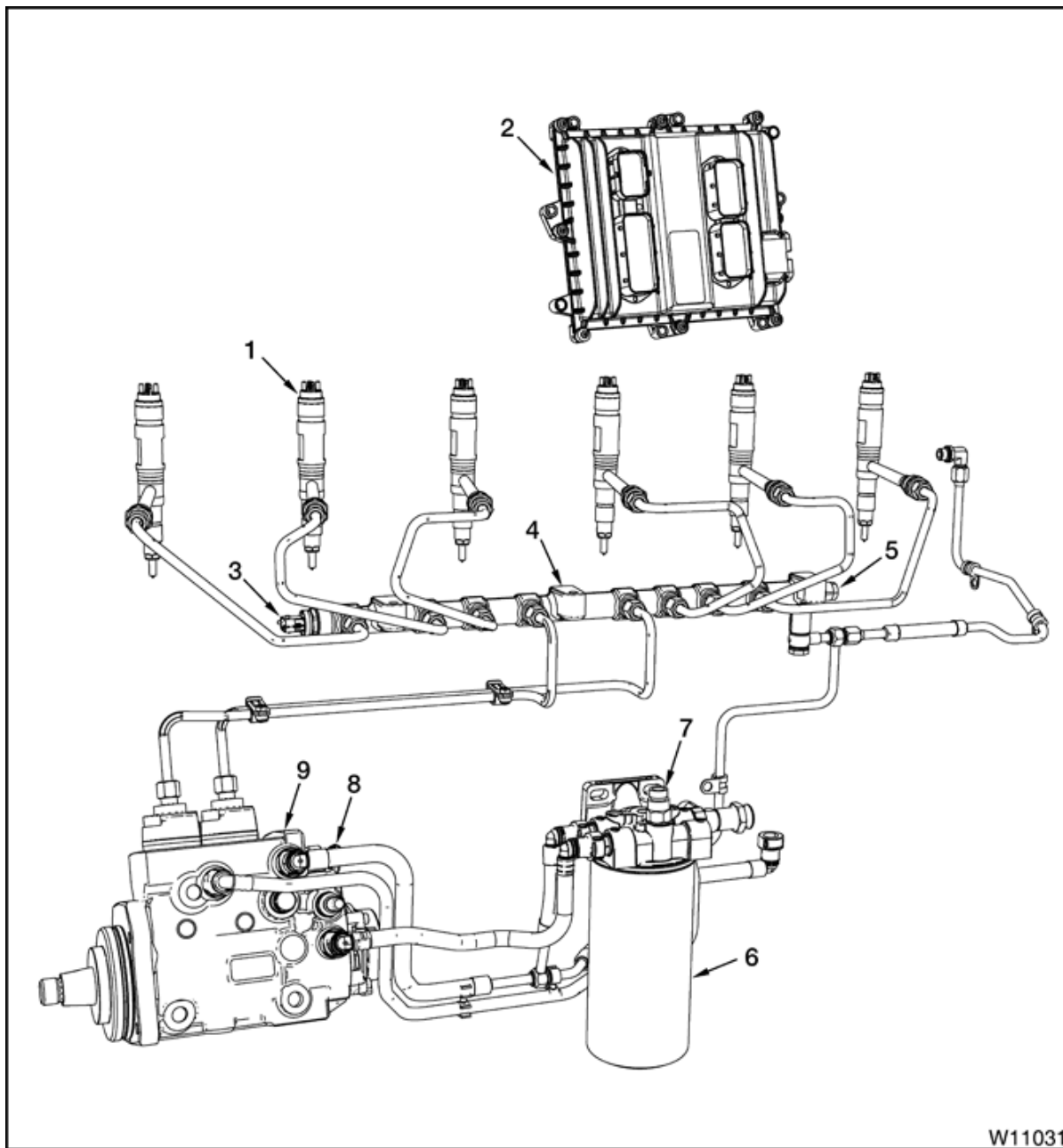
The Racor® fuel filter/water separator assembly is standard equipment. There is also an optional Davco® fuel filter water separator available depending on customer needs.

Fuel Primer Pump Assembly

The fuel is drawn from the tank through the chassis fuel filter and water separator assembly, through the chassis mounted fuel primer pump assembly and into

the low-pressure fuel pump. The fuel primer pump assembly is manually operated and is used to prime the low-pressure fuel system when the system is emptied.

Engine Mounted Components



W11031

Figure 17 Engine mounted fuel system components

1. Injector (6)	5. Pressure relief valve	8. Fuel Pressure Control Valve (FPCV)
2. Engine Control Module (ECM)	6. Fuel filter (low pressure)	9. Fuel pump (low and high-pressure)
3. Fuel Rail Pressure (FRP) Sensor	7. Fuel Delivery Pressure (FDP) sensor	
4. Rail assembly		

ECM

The ECM controls the fuel pressure with a PWM signal to the Fuel Pressure Control Valve (FPCV). Low pulse width PWM signals equal high-pressure and high pulse width signals equal low pressure. To protect the system, a PLV (Pressure Limiting Valve) is installed in the end of the fuel rail. When pressure exceeds 2,650 +/- 100 bar (38,435 +/- 1,450 psi), the PLV opens and reduces pressure to 1,000-1,200 bar (14,503-17,404 psi) to facilitate limp-home operation.

The fuel system is controlled by the ECM. Various engine sensors are input into fueling calculations. The ECM then controls the FPCV and the injectors for proper engine operation. The injection timing and quantity are calculated in the Engine Control Module (ECM) and implemented by solenoid valve controlled injectors.

Fuel Filter

The fuel filter housing assembly is located on the left side of the engine and has a disposable spin-on type filter element. An Engine Fuel Delivery Pressure (FDP) sensor is installed on the front side of the fuel filter housing assembly and it measures fuel pressure between the low-pressure fuel pump and the filter element. An additional function of the fuel filter housing 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 housing assembly is equipped with two additional ports to provide filtered fuel to the aftertreatment system and to the cold start assist system. An orifice regulator is integrated into the fuel filter housing assembly and regulates the fuel pressure for the cold start assist system to 70 kPa (10 psi).

Fuel Pump

Fuel injection pressure is generated by the high-pressure side of the fuel pump. High-pressure fuel quantity from the fuel pump is controlled by a FPCV. The fuel pump supplies both low and high-pressure fuel from one unit. The fuel pump is gear driven and is fuel lubricated. Fuel from the low-pressure side is forced through the fuel filter housing assembly and into the high-pressure side of the fuel pump. The flow of fuel to the suction chamber of the high-pressure pump is controlled by the FPCV in order to control the high-pressure fuel output.

Rail Assembly (Fuel Common Rail)

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

Fuel Rail Pressure (FRP) Sensor

The FRP sensor is a variable resistance sensor that monitors the fuel pressure in the high-pressure fuel rail.

The FRP sensor is mounted in the front of the high-pressure pipe rail on the left side of the engine.

Pressure Relief Valve

The pressure relief valve maintains fuel pressure in the rail assembly below 265 000 kPa (38,500 psi). If the rail assembly pressure exceeds this value, the relief valve opens and allows fuel to flow to the return line, and back to the tank. When the relief valve opens, the system goes into a limp-home mode and a steady rail pressure of 120 000 kPa (17,400 psi) is maintained until the engine is switched off. This will reset to normal operation upon the next key-in event.

Injector

The MaxxForce® 15 engine is equipped with electronically controlled solenoid valve 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 injector clamps. The seal between the injectors and the combustion chamber consists of a copper washer on the tip of each injector.

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. This first injection occurs only during idling and in partial load mode. 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.

Engine Lubrication System

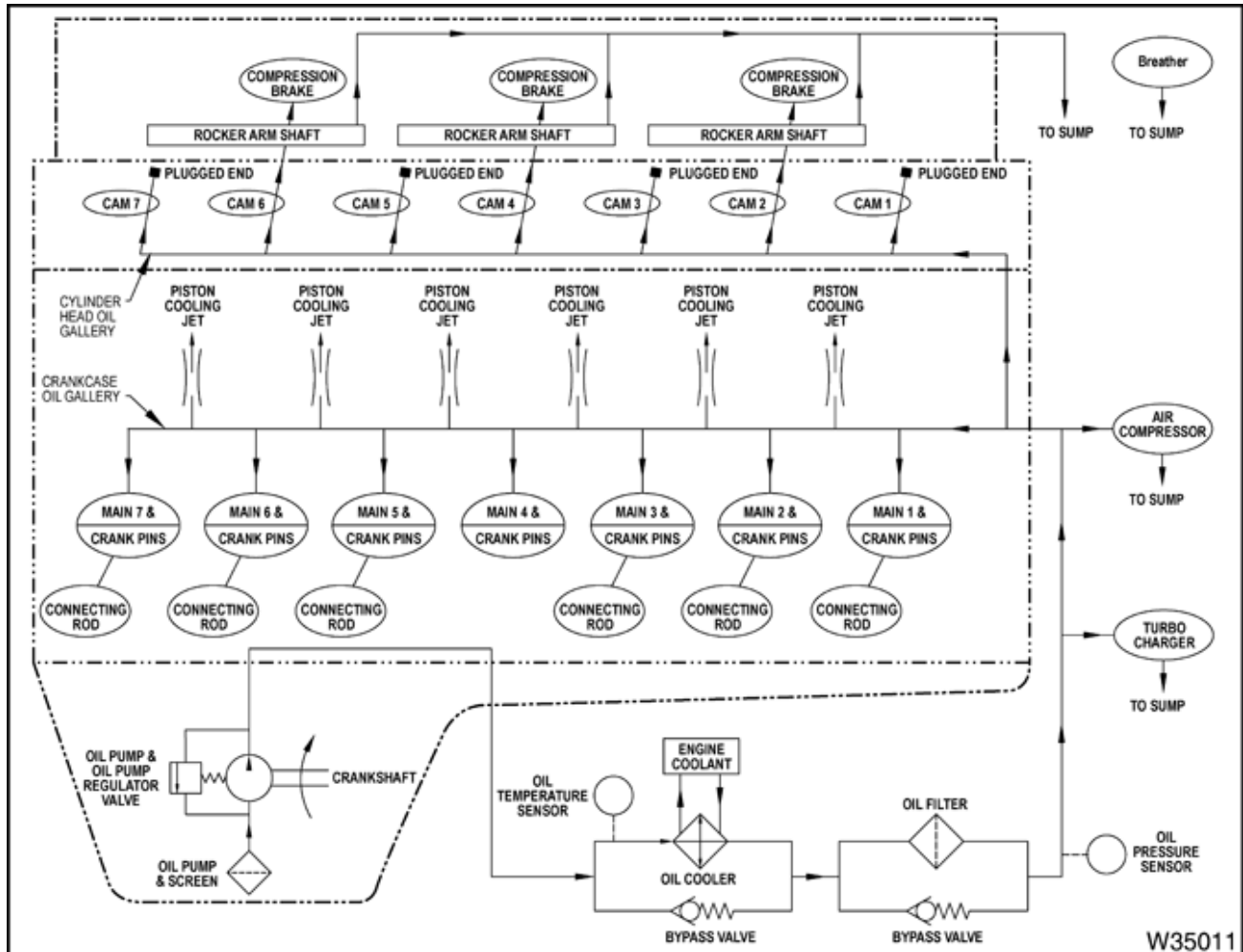


Figure 18 Oil system overview (typical)

Engine oil pressure is generated by an oil pump located under the oil pan which is driven off the crankshaft gear. The oil cooler and filter housing are located on the right side of the engine. The oil pump contains the oil pressure regulator. Oil flows to the cylinder head by means of an internal passage.

The front of the crankcase contains oil passages that supply oil to the gear train and air compressor. These passages ultimately supply oil to the cylinder head through the front hollow dowel that locates the cylinder head to the engine block. Oil drains back to the crankcase through passages in the cylinder head.

Oil Flow and Components

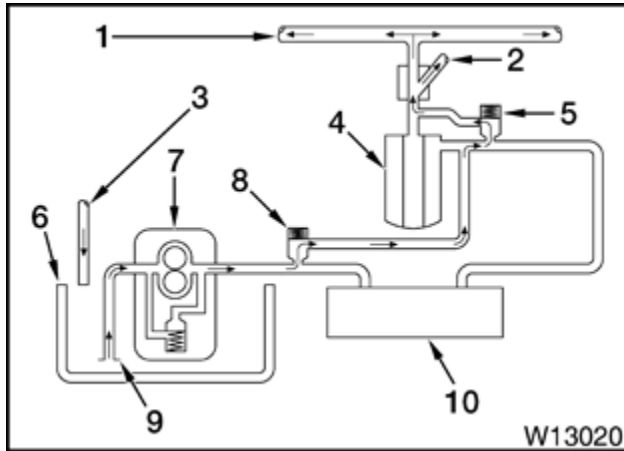


Figure 19 Oil flow through filter when oil is cold

1. Main oil gallery
2. Turbocharger oil supply line
3. Turbocharger oil drain tube
4. Oil filter element
5. Bypass valve (oil filter)
6. Oil pan
7. Oil pump
8. Bypass valve (oil cooler)
9. Oil pick-up tube
10. Engine oil cooler

When the engine oil is cold, oil is drawn from the oil pan through the pick-up tube to the oil pump. Due to the high viscosity of the cold oil, both bypass valves open. These bypass valves provide immediate lubrication to engine components when cold oil with high viscosity may not pass through the oil filter easily. The bypass valves allow oil to bypass the engine oil cooler and oil filter.

The bypass valve will also allow oil to bypass the oil filter in case the oil filter becomes restricted. This prevents a restricted oil filter from blocking oil flow to engine components.

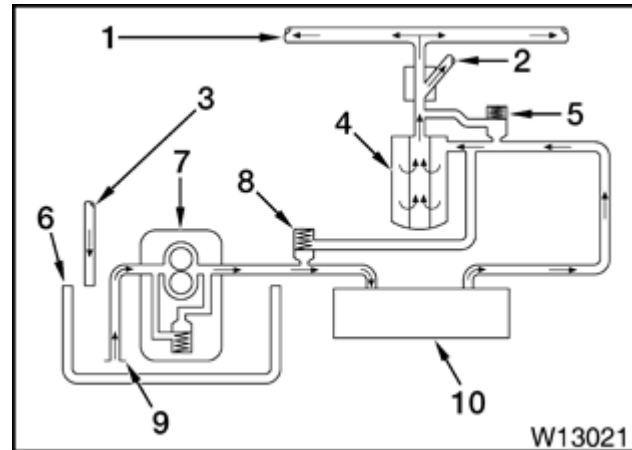


Figure 20 Oil flow through filter when oil is warm

1. Main oil gallery
2. Turbocharger oil supply line
3. Turbocharger oil drain tube
4. Oil filter element
5. Bypass valve (oil filter)
6. Oil pan
7. Oil pump
8. Bypass valve (oil cooler)
9. Oil pick-up tube
10. Engine oil cooler

When the oil is warm, unfiltered oil is drawn from the oil pan through the pick-up tube to the oil pump. The oil pump pushes the warm oil through the oil cooler towards the oil filter. The bypass valves will be closed due to the lower viscosity of the oil and its ability to flow through the oil cooler and oil filter. Filtered oil is directed to the turbocharger oil supply line and main oil gallery where it is distributed to engine components.

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 excess oil to flow to the oil gallery.

Clean oil enters the crankcase directly from the oil filter housing to lubricate the crankshaft, air compressor, intermediate gears, and turbochargers.

The crankshaft has cross-drillings that direct oil to the connecting rods.

Piston cooling jets 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 oil filter

housing to the center housing of each turbocharger. Oil drains back to the oil pan through the low and high-pressure turbocharger oil return tubes connected to the crankcase.

Engine Cooling System

Cooling System Components

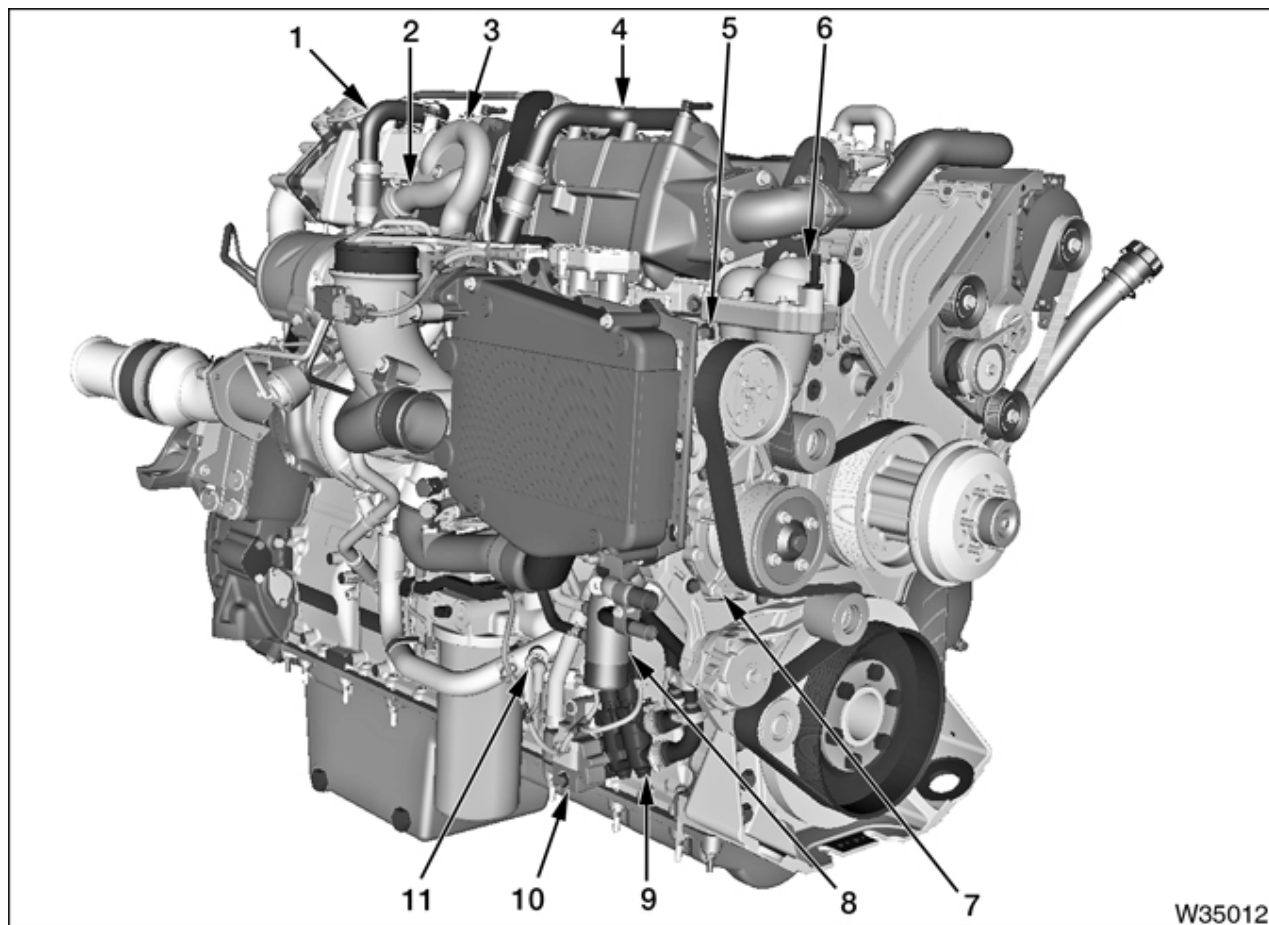


Figure 21 Cooling system components

1. EGR coolant tube assembly (primary EGR cooler)	4. EGR coolant tube assembly (secondary EGR cooler)	8. Water pump inlet
2. EGR coolant return (secondary EGR cooler)	5. Engine Coolant Temperature 1 (ECT1) sensor (behind ISC)	9. Coolant Control Valve (CCV) assembly
3. EGR coolant return (primary EGR cooler)	6. Thermostat housing cover	10. Coolant adapter
	7. Water pump	11. Engine Coolant Pressure 1 (ECP1) sensor

Cooling System Flow

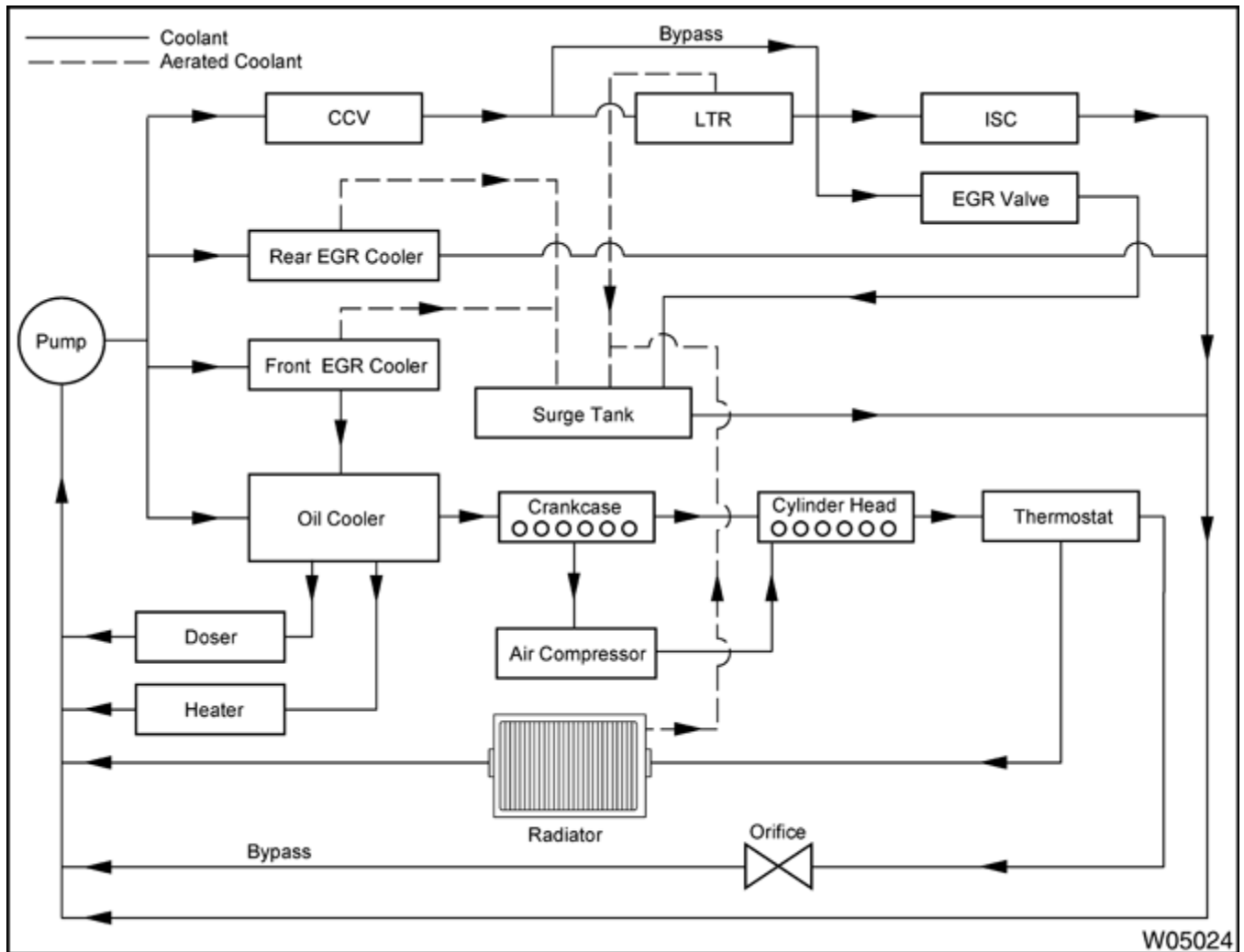


Figure 22 Cooling system flow

The water pump is located on the front cover and draws coolant from the radiator through the coolant inlet at the lower right side of the engine. The water pump pushes coolant to the oil cooler through a passage in the front cover.

Coolant flows to the crankcase and through the water jacket from rear to front. This coolant flows around the cylinder liners to absorb heat from combustion. The coolant may also pass through an optional engine coolant heater.

Coolant flows through the cylinder head water jackets towards the thermostat cavity at the front of the cylinder head. Depending on coolant temperature,

the thermostat can direct into two directions to exit the cylinder head.

When the thermostat is closed, coolant is directed through the bypass port, crankcase and front cover, and into the water pump.

When the thermostat is 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 moving air from the radiator fan. The coolant returns to the engine first through the transmission cooler, then through the engine water inlet pipe.

The air compressor is cooled with engine coolant supplied by a hose from the left side of the crankcase. Coolant passes through the air compressor cylinder head and returns through a hose back into the crankcase through the engine water inlet pipe.

The fuel doser is also cooled with engine coolant supplied by the oil cooler module. Coolant passes through the fuel doser and is returned to the engine water inlet pipe.

The oil cooler assembly receives coolant from the front cover water outlet pipe. Coolant passes between the oil cooler plates and returns to the crankcase.

Coolant from the water pump also flows through an external pipe to the rear EGR cooler and to the front EGR cooler. Coolant passes between the EGR cooler plates. Rear EGR cooler section coolant travels parallel to the exhaust flow. The front EGR cooler section coolant flows opposite to the exhaust flow. The coolant from the rear EGR cooler is then returned to the water inlet pipe. The coolant from the front EGR cooler is returned to an external pipe to the back of the oil cooler module. Deaeration ports are located on the top of both the rear and front EGR coolers which directs coolant and trapped air to the coolant surge tank.

Coolant from the water pump also flows through the Interstage cooler to regulate the charge air temperature. Flow through the Interstage cooler is controlled by the Coolant Controlled Valve (CCV). Depending on the coolant flow, CCV sends coolant through the Low Temperature Radiator (LTR) or bypass directly to the Interstage Cooler (ISC). When the charge air temperature is too low, CCV bypasses the LTR and directs all the coolant through the ISC. When the charge air temperature increases, CCV directs a percentage of coolant to the LTR before it enters the ISC to cool the charge air. If the engine coolant temperature is too high, CCV sends all of the coolant flow through the LTR and through the ISC to help cool the engine faster.

Coolant from the CCV also flows to the EGR valve. Flow through the EGR valve is supplied by an external pipe that also supplies to the Interstage cooler. The EGR valve coolant flow is then returned to the top port of the surge tank.

The surge tank provides expansion space for coolant and deaerated the cooling system. The following four vents provide coolant to the tank:

- Rear and Front EGR Cooler
- Main radiator vent
- Low temperature radiator vent

The surge tank returns coolant through the surge line, back to the water pump inlet. Cab heat is provided by the heater core, which receives warmed coolant from the coolant supply housing.

Thermostat Operation

The MaxxForce® 15 engine is fitted with two thermostats in a common housing to ensure sufficient coolant flow in all operating conditions. The thermostats are located at the front of the engine on the right side of the cylinder head.

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 88°C (190°F) and are fully open at 103°C (217°F).

When engine coolant is below 88°C (190°F), the thermostats are closed and block 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 88°C (190°F), the thermostats open and allow some coolant to flow to the radiator. When coolant temperature exceeds 103°C (217°F), the lower seat blocks the bypass port and directs full coolant flow to the radiator.

Coolant Control Valve (CCV) Assembly Operation

The CCV assembly is installed on the lower right side of the engine and controls coolant flow to the ISC, EGR valve, and LTR.

The CCV assembly has two separate solenoid actuated valves: Coolant Mixer Valve (CMV) and Coolant Flow Valve (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 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.

CFV

The flow valve varies the rate of coolant flow to the mixing valve. At 0% duty cycle the flow valve is fully open and coolant to the mixing valve is not restricted. When the flow valve receives 100% duty cycle, it partially closes restricting coolant to the mixing valve.

CMV

The mixing valve varies the amount of coolant that passes through the low temperature radiator, or LTR. With a 0% signal to the mixing valve, all coolant flows to the LTR before entering the ISC and the EGR valve. When 100% duty cycle is applied to the mixing valve, full coolant flow bypasses the LTR and is directed to the ISC and EGR valve.

MaxxForce® Engine Brake System

The MaxxForce® engine brake is standard equipment on the MaxxForce® 15L engine. The engine brake uses engine oil pressure to improve the engine braking power by holding the exhaust valves slightly open during the cylinder compression and power strokes.

During engine brake operation, both the compression and expansion strokes of the power cylinders are used to absorb road speed energy through the powertrain.

The operator can enable or disable the engine brake by pressing a dash mounted ON/OFF switch.

brake housing assemblies. This provides progressive braking capabilities with the retarding effect of two cylinders, four cylinders, or all six cylinders.

Engine Brake System Components

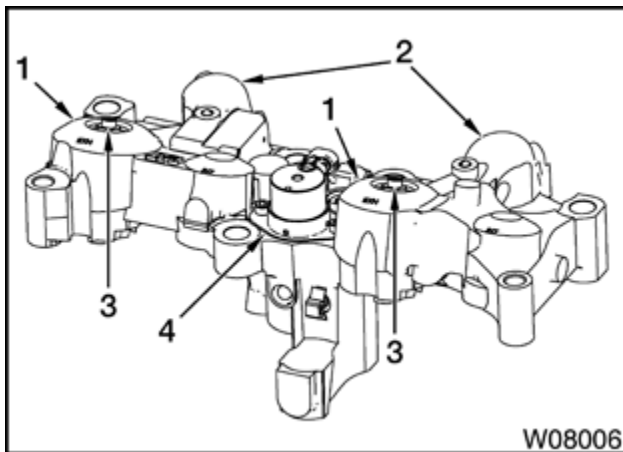


Figure 23 Engine brake housing

1. Slave piston
2. Master piston
3. Slave piston adjustment screw
4. Engine brake solenoid and spool valve

The engine brake consists of three identical housing assemblies; each housing is positioned over two cylinders. The housing assembly is mounted to the supports for the rocker shaft assembly with studs and nuts. The rocker arm and exhaust bridge assembly is used to transfer force from the slave piston to the exhaust valves.

The engine brake is controlled by the ECM. The control circuit for the engine brake permits the operation of either one, two, or all three engine



force at the flywheel. As the lost motion rocker arm moves down, the master piston will also move down and reduce the oil pressure on the slave piston. As a result, the slave piston will move upward and return exhaust valve operation to the engine valve train.

De-energizing the solenoid allows oil to drain back into the engine oil pan through the drain passages in the spool valve.

Open Crankcase Breather System

Open Crankcase Breather System Components

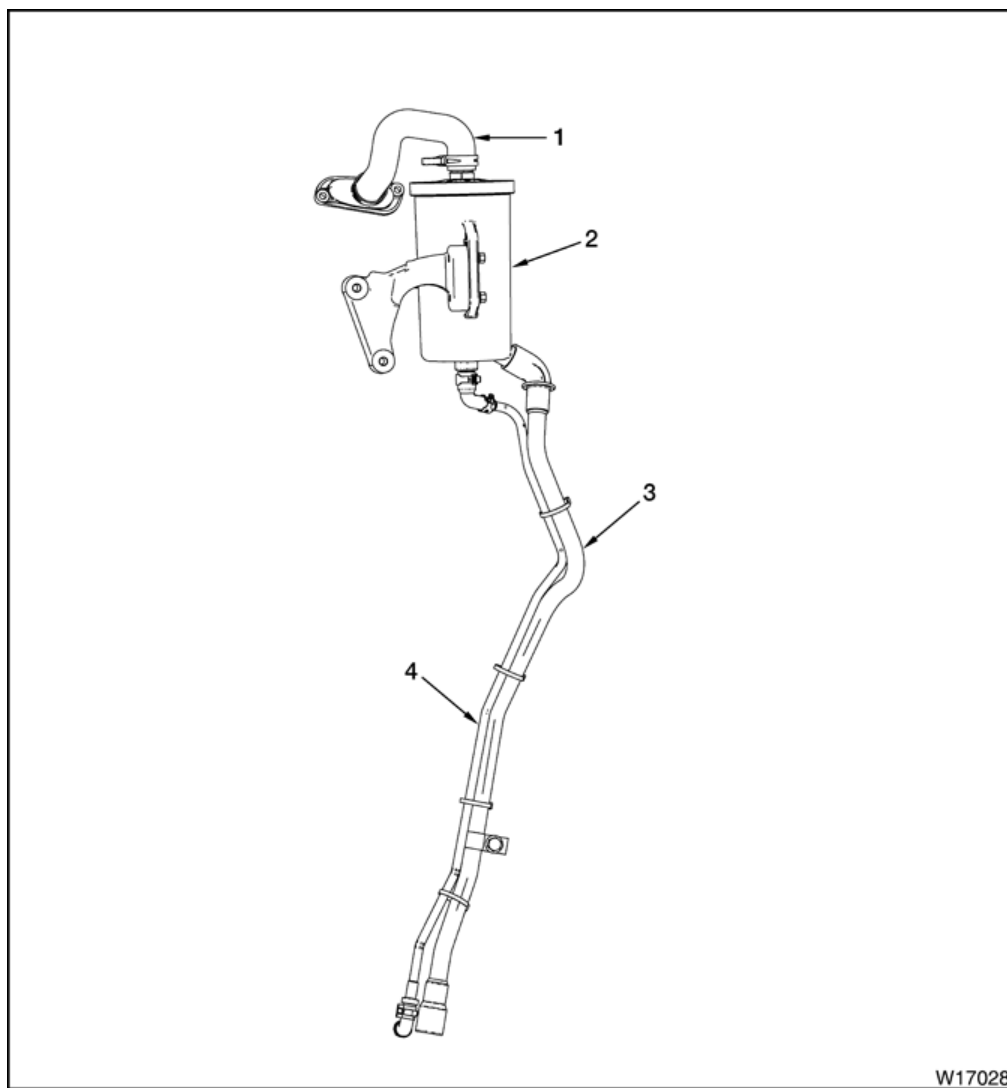


Figure 25 Open crankcase breather system

1. Breather inlet tube	3. Breather outlet tube
2. Breather filter assembly	4. Breather drain tube

Open Crankcase Breather System Operation

The open crankcase breather system uses an engine mounted oil separator to return oil to the crankcase and vent blow-by gases to the atmosphere. The primary component of the system is the breather filter in the breather filter assembly. The breather filter separates oil mist from blow-by gases.

The blow-by gases exit the crankcase from the valve cover and enter the breather system through the

breather inlet tube. From the breather inlet tube, blow-by gases enter the breather filter assembly where heavy oil particles are separated and drain into the oil pan through check valves in oil drain tube.

The cleaned blow-by gases exit to the atmosphere through the breather outlet tube.

Cold Start Assist System

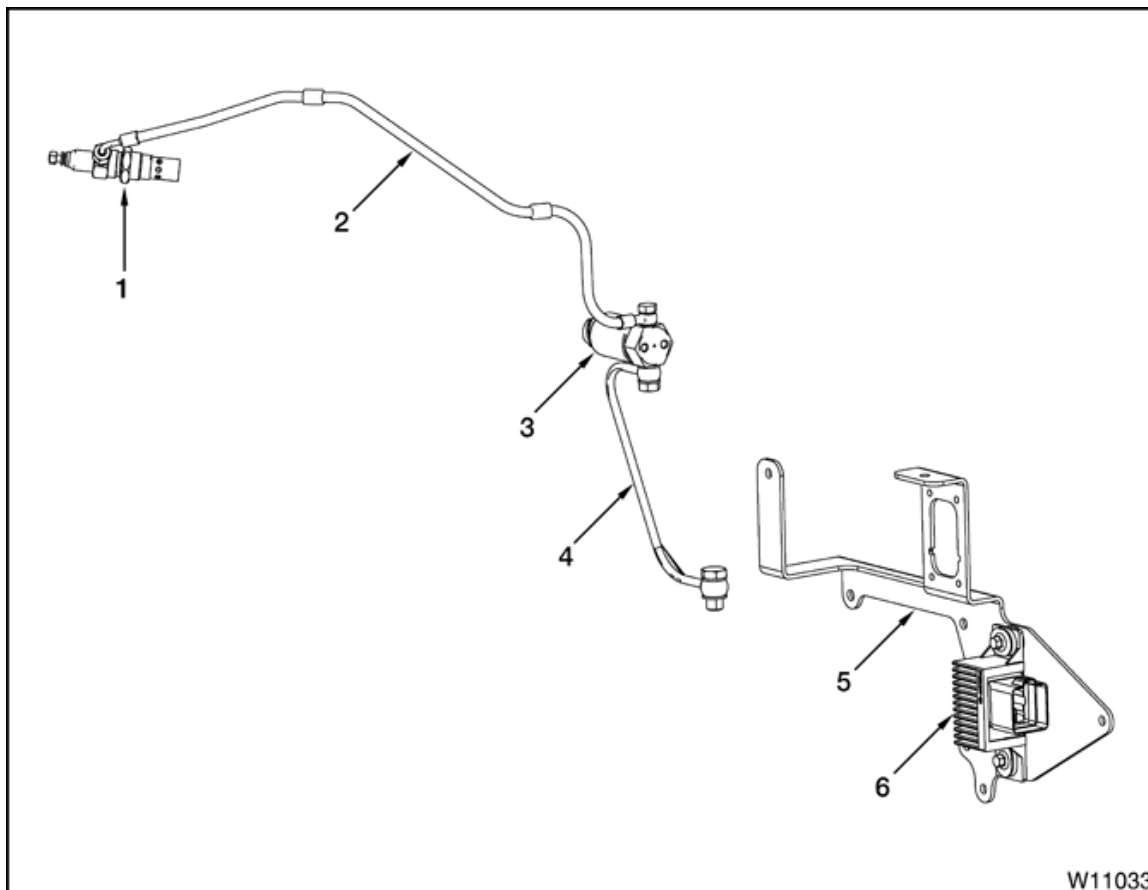
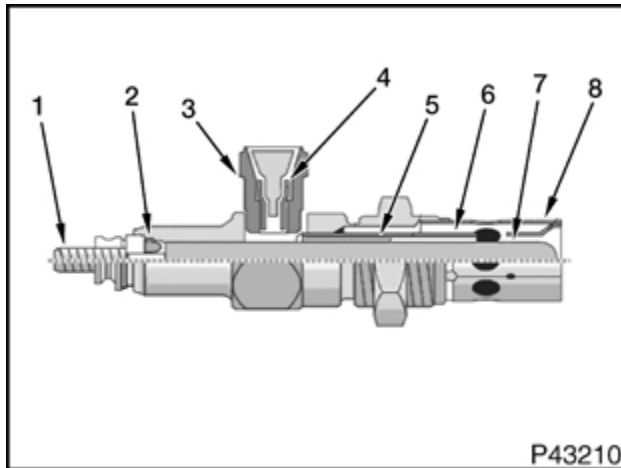


Figure 26 Cold start assist system components

1. Cold Start Fuel Igniter (CSFI)	3. Cold Star Fuel Solenoid (CSFS)	6. Cold Start Relay (CSR)
2. Solenoid to injector tube assembly	4. Filter to solenoid tube assembly	
	5. Relay support assembly	

Cold Start Fuel Igniter (CSFI)**Figure 27 Cold Start Fuel Igniter (CSFI)**

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

The function of the CSFI is to spray ignited fuel into the mixing duct. The ignited fuel warms incoming air to assist starting a cold engine. The CSFI is essentially a fuel injector and glow plug in one unit.

The CSFI 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 CSFI to enable the fuel vaporization and combustion.

The CSFI is installed on the left front side of the engine in the mixing duct.

Cold Start Relay (CSR)

The CSR is located on the rear left side of the engine. The CSR provides voltage to the CSFI and is controlled by the Engine Control Module (ECM).

Cold Start Fuel Solenoid (CSFS)

The CSFS valve is located on the left side of the engine and is controlled by the ECM. The CSFS valve is supplied regulated low pressure fuel from the fuel filter housing assembly through the solenoid to injector tube.

When the ECM provides 12 volts to the solenoid valve, the CSFS valve opens and allows fuel to flow to the CSFI through the solenoid to injector tube. Ground control is provided by the ECM.

Cold Start Assist System Operation

The cold start assist system operates only in temperatures lower than 11°C (52°F).

When the vehicle operator turns the ignition switch to ON, the wait-to-start lamp in the instrument cluster illuminates. The ECM activates the Cold Start Relay (CSR) based on the temperature readings from the Engine Coolant Temperature (ECT), Engine Oil Temperature (EOT), and the Intake Air Temperature (IAT) sensors. The CSR then energizes the CSFI for approximately 45 seconds.

Once the CSFI is heated to approximately 1 000°C (1,832°F), the wait-to-start lamp starts to flash and the operator needs to crank the engine. When the engine starts rotating, the solenoid valve opens and allows fuel to enter the CSFI through the solenoid to injector tube. The fuel passes through the vaporizer tube inside the CSFI. The vaporized fuel then mixes with the intake air and ignites in contact with the heater element.

Once the engine starts, the CSFI remains energized and fuel continues to be injected to the CSFI, and the wait-to-start lamp continues to flash for a maximum of 4 minutes. When the wait-to-start lamp stops flashing, the CSFI and the solenoid valve are deactivated. If the operator accelerates while the wait-to-start lamp flashes, the cold start assist system will shut down.

Electronic Control System

Electronic Control System Components

The MaxxForce® 15 engine is equipped with an Engine Control Module (ECM) that monitors and controls all functions of the engine and aftertreatment system.

Operation and Function

The Engine Control Module (ECM) monitors and controls engine performance 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 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

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 control module's microprocessors can process.

Microprocessor

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

Continuous calculations in the ECM occur in the foreground and background.

- Foreground calculations are faster than background calculations and are normally more critical for engine operation. Engine speed control is an example.
- Background calculations are normally variables that change at slower rates. Engine temperature is an example.

Diagnostic Trouble Codes (DTCs) are set by the microprocessor if inputs or conditions do not comply with expected values.

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:

- Pulse Width Modulated (PWM)
- Switched on or off
- CAN messages

Actuators

The ECM controls engine operation with the following:

- Coolant Flow Valve (CFV)
- Coolant Mixer Valve (CMV)
- Exhaust Gas Recirculation (EGR) valve
- Air control valves (TC1WC and TC2WC)
- Cold Start Fuel Solenoid (CSFS)
- Cold Start Relay (CSR)
- Engine Throttle Valve (ETV)
- Fuel Pressure Control Valve (FPCV)

Coolant Flow Valve and Coolant Mixer Valve

The Coolant Flow Valve (CFV) controls the maximum pressure in the LTR and the Coolant Mixer Valve (CMV) regulates the temperature of the coolant by directing the coolant either through the Low Temperature Radiator (LTR) or through an internal bypass. Both valves are controlled by the ECM.

The CFV and CMV are part of the Coolant Control Valve (CCV) assembly which is mounted on the lower right side of the engine.

Exhaust Gas Recirculation (EGR) Valve Assembly

The EGR valve assembly controls the flow of exhaust gases entering the EGR cooler assembly.

The EGR valve operates on a Pulse Width Modulated (PWM) voltage signal from the ECM. The ECM will then regulate the duty cycle of the PWM voltage signal to the EGR valve assembly actuator to open or close the valve as required.

A sensor within the EGR valve provides feedback to the ECM on the valve position. A fault code will be set if the ECM detects an error.

The EGR valve assembly is mounted on the rear of the EGR cooler assembly, on the right side of the engine.

Air Control Valve

The air control valve controls the wastegate actuator on the high-pressure turbocharger.

The air control valve either applies air pressure to the wastegate actuator, or vents system pressure to the atmosphere in response to commands from the ECM.

The air control valve is mounted on a bracket on the right side of the engine, below the secondary EGR cooler.

Cold Start Relay (CSR)

The cold start assist system aids cold engine starting by warming the incoming air supply during cranking and initial idling.

The CSR is a solid state relay that is pulse width modulated by the ECM to energize the CSFI. The CSFI is case grounded to the ETV assembly. The total time that the CSR energizes the CSFI is dependent on engine coolant temperature.

Cold Start Fuel Solenoid (CSFS)

The CSFS valve controls the fuel flow to the CSFI during cold start assist operation.

When the cold start assist is required, the ECM provides voltage to open the CSFS valve during cranking and initial idling.

The CSFS valve is mounted on the left side of the engine, above the fuel filter.

Engine Throttle Valve (ETV)

The ETV is a variable position actuator that restricts intake air flow by way of an internal butterfly valve to help heat the exhaust aftertreatment during regeneration, and to assist when heavy EGR is requested.

The ETV changes butterfly valve position in response to ECM signals. The ETV contains an internal position sensor that monitors butterfly valve position and transmits a position signal to the ECM.

The ETV is mounted on the left side of the engine.

Fuel Pressure Control Valve (FPCV)

The FPCV is a variable position actuator that regulates fuel pressure in the pressure pipe rail.

The FPCV changes valve position through pulse width modulated signals from the ECM. It controls the flow of fuel to the suction side of the high-pressure pump.

The FPCV is mounted on the high-pressure pump. They are serviced as an assembly.

Engine and Vehicle Sensors

Thermistor Sensor

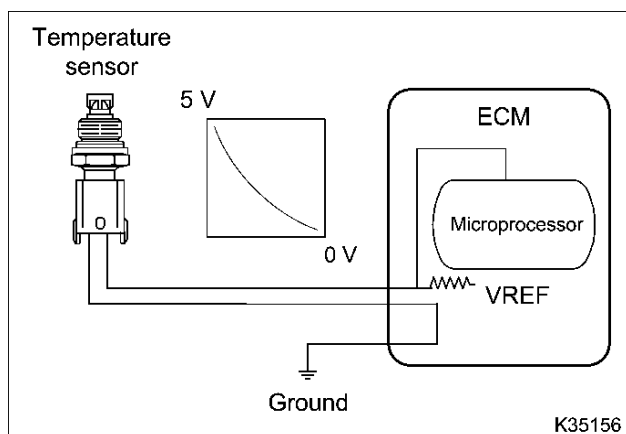


Figure 28 Thermistor sensor

A 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 in the control module to a voltage signal matched with a temperature value.

The top half of the voltage divider is the current limiting resistor inside the control module. 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
- Charge Air Cooler Outlet Temperature (CACOT)
- Engine Coolant Temperature (ECT) sensors
- Engine Oil Temperature (EOT) sensor
- Intake Manifold Temperature (IMT) sensor

Aftertreatment Temperature Sensors

Three sensors used in the Aftertreatment System include the following:

- Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor
- Diesel Oxidation Catalyst Outlet Temperature (DOCOT) sensor
- Diesel Particulate Filter Outlet Temperature (DPFOT) sensor

The DOCIT sensor provides a feedback signal to the Engine Control Module (ECM) indicating Diesel Oxidation Catalyst (DOC) inlet temperature. The DOCIT sensor is the first temperature sensor installed past the pre-diesel oxidation catalyst and just before the DOC.

The DOCOT sensor provides a feedback signal to the Engine Control Module (ECM) indicating Diesel Oxidation Catalyst (DOC) outlet temperature. The DOCOT sensor is installed just after the DOC.

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

During a DPF regeneration, the ECM monitors these sensors along with the EGR system and ETV.

Charge Air Cooler Outlet Temperature (CACOT) Sensor

Early production engines come equipped with a CACOT sensor; however, even though it is electronically connected to the system, it is disabled in the ECM software and not currently utilized. The CACOT sensor is installed in the engine throttle valve assembly.

Engine Coolant Temperature 1 (ECT1) Sensor

The ECT sensor is a thermistor sensor that detects engine coolant temperature.

This engine has two ECT sensors. The ECT1 sensor is installed on the right side of the engine behind the thermostat assembly. The ECT2 sensor is installed in the coolant manifold behind the interstage cooler.

The ECT1 and ECT2 signals are monitored by the ECM for operation of the instrument panel temperature gauge, coolant temperature compensation, charge air temperature control, optional Engine Warning Protection System (EWPS), and the wait-to-start lamp.

Engine Oil Temperature (EOT) Sensor

The EOT sensor is a thermistor sensor that detects engine oil temperature.

The EOT signal is monitored by the ECM for the Engine Warning Protection System (EWPS). The EOT sensor is also used by the oil temperature gauge in the instrument cluster.

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

Intake Manifold Temperature (IMT) Sensor

The IMT sensor is a thermistor sensor that monitors the temperature of the intake air.

EGR operation is shut down under certain temperature conditions to prevent sulphurous acids from condensing under cold charge-air temperatures and to protect the engine from excessively hot intake air in the event of an EGR fault.

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

Variable Resistance Sensor

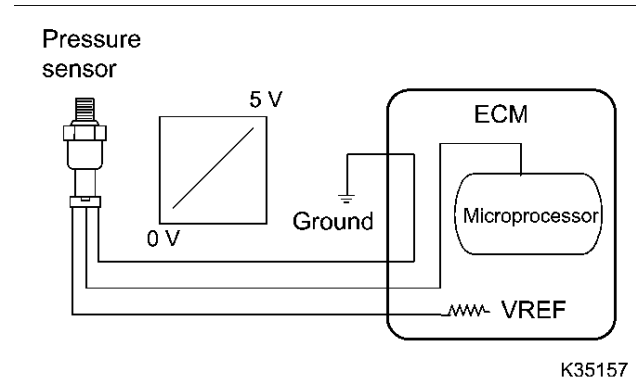


Figure 29 Variable resistance sensor

Variable resistance 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 resistance 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 control module. The control module compares the voltage with pre-programmed values to determine pressure.

Variable resistance sensors include the following:

- Exhaust Gas Differential Pressure (EGDP) sensor
- Fuel Delivery Pressure (FDP) sensor
- Engine Oil Pressure (EOP) sensor
- Fuel Rail Pressure (FRP) sensor
- Intake Manifold Pressure (IMP) sensor

Exhaust Gas Differential Pressure (EGDP) Sensor

The EGDP sensor provides a feedback signal to the Engine Control Module (ECM) indicating the pressure difference between the inlet and outlet of the particulate filter. The ECM monitors this sensor to determine DPF soot levels.

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

Engine Fuel Delivery Pressure (FDP) Sensor

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

The FDP sensor provides feedback to the ECM for the low-pressure fuel system.

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

Engine Oil Pressure (EOP) Sensor

The EOP sensor is a variable resistance 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 pressure sensor support, on the left side of the engine.

Fuel Rail Pressure (FRP) Sensor

The FRP sensor is a variable resistance sensor that monitors the fuel pressure in the pressure pipe rail.

The FRP sensor measures the fuel pressure just prior to injection.

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

Intake Manifold Pressure (IMP) Sensor

The IMP sensor is used to measure the absolute charge-air pressure.

The IMP sensor is installed in the ETV on top of the engine.

Magnetic Pickup Sensor

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 that is created by a moving metal trigger. The movement of the trigger then creates an AC voltage in the sensor coil.

Magnetic pickup sensors used include the following:

- Crankshaft Position (CKP) sensor
- Camshaft Position (CMP) sensor
- Vehicle Speed Sensor (VSS)

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 a 58 tooth timing disk on the front of the crankshaft. By comparing the CKP signal with the CMP signal, the ECM calculates engine rpm and timing requirements.

The CKP sensor is installed at the bottom left of the engine, in the front cover.

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 the camshaft timing ring mounted on the rear of the camshaft gear rotates past the CMP sensor. The ECM calculates camshaft speed and position from CMP signal frequency.

The CMP sensor is installed at the top left of the engine, in the front cover.

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 signal is transmitted over the CAN in vehicles with automatic transmission. 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.

Potentiometer

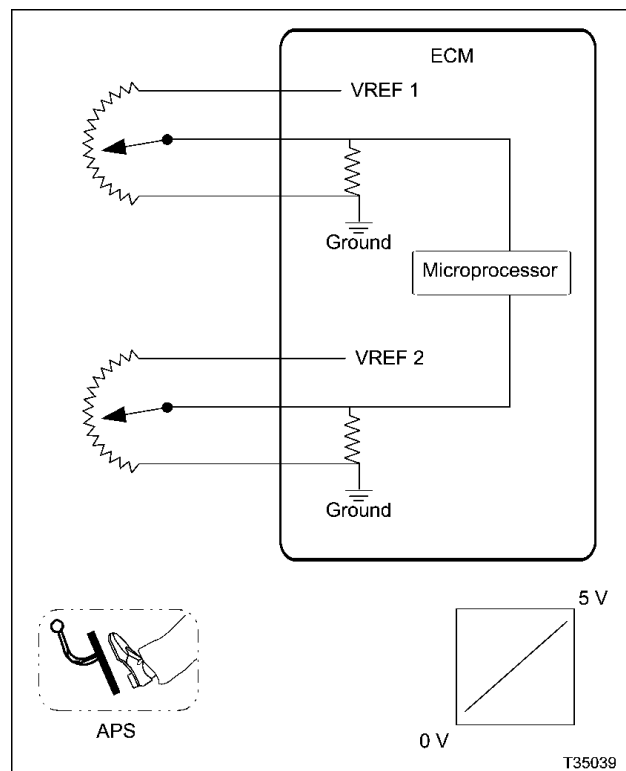


Figure 30 Potentiometer

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) Sensors

The dual track APP sensor provides the ECM with a feedback signal (linear analog voltage) that indicates the operator's demand for power. The dual track APP sensor is installed in the cab on the accelerator pedal.

Switches

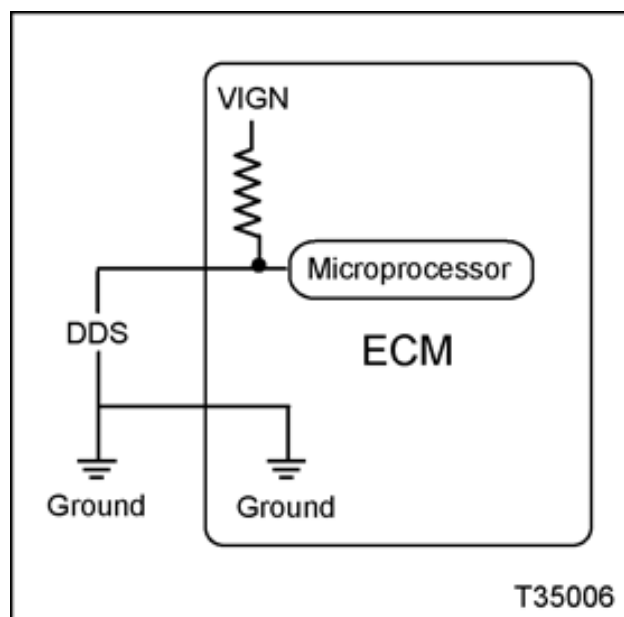


Figure 31 Switch

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)

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 or datalink communication functions as the DDS.

Engine Coolant Level (ECL) Switch

The ECL switch is part of the Engine Warning Protection System (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.

Oxygen Sensor (O2S)

The O2S monitors oxygen levels in exhaust gases.

The O2S is used to tune the engine operation to a specified air-to-fuel ratio.

The O2S compares oxygen levels in the exhaust stream with oxygen levels in the outside air. It then generates a voltage that is transmitted to the ECM. The level of voltage generated by the O2S

corresponds to the oxygen levels in the exhaust stream.

The O2S is installed in the turbocharger exhaust duct.

Turbocharger 2 Compressor Inlet Sensor (TC2CIS)

Early production engines will be equipped with a TC2CIS, however this sensor is not used by the engine control system at this time.

The TC2CIS is installed in the low-pressure turbocharger compressor outlet duct.

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Standard Electronic Control Features

NOTE: For the latest complete feature operation, and parameter information, use the MaxxForce® 15 Engine Feature Documentation found under the Body Builder Website Link within International Service Information Solutions (ISIS). 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).

Cold Start Assist

The cold start assist feature improves engine startup in cold weather. The Engine Control Module (ECM) controls the Cold Start Relay (CSR) and monitors the Engine Oil Temperature (EOT), Air Intake Temperature (AIT) and Engine Coolant Temperature

2 (ECT2) sensors. When the key is turned to the ON position, the ECM monitors the ECT2 and AIT sensors. If either sensor is below 11°C (52°F), the ECM enables the CSR. The CSR energizes the Cold Start Fuel Igniter (CSFI). When the CSFI reaches the proper operating temperature, the wait to start lamp flashes. As the engine is cranked, the ECM energizes the Cold Start Fuel Solenoid (CSFS) valve, introducing fuel into the CSFI, 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 Cold Start Assist 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

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 Society of Automotive Engineers (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® 15 Engine Feature Documentation found under the Body Builder Website Link within ISIS®. 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

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 upshift 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 in 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® 15 *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.

Upshift Indicator

The upshift 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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Connecting EST With ServiceMaxx™ Software to MaxxForce® Engine

To connect an Electronic Service Tool (EST) with ServiceMaxx™ software to a MaxxForce® engine, a RP1210A or RP1210B compliant cable must be connected between the EST and vehicle Diagnostic Connector. The Diagnostic Connector is located inside the cab, above the clutch pedal.

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 also has the following added sessions:

- Hard Start No Start
- Performance
- Programming

These added sessions do not load automatically but can be selected from the Sessions drop-down menu. They are available to help diagnose common systems and program special features.

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 *ServiceMaxx™ Users Guide* for further details.

Diagnostic Trouble Codes (DTCs)

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

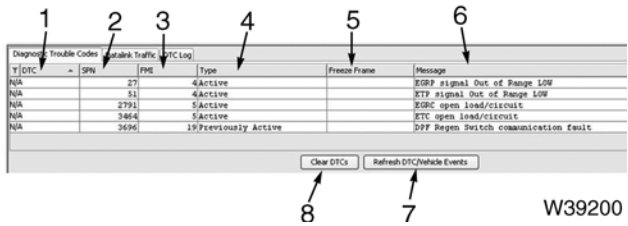


Figure 32 DTC window

- 1. DTC column (pre-2010)
- 2. SPN column
- 3. FMI column
- 4. Type column
- 5. Freeze Frame column
- 6. Message column
- 7. Refresh DTC/Vehicle Events button
- 8. Clear DTCs button

Suspect Parameter Number (SPN)

SPN identifies the individual component causing the DTC.

Failure Mode Indicator (FMI)

FMI identifies the fault or condition affecting the individual component.

Pending (Type)

Pending DTCs are possible emission codes detected on the first drive cycle.

Active (Type)

Active DTCs are codes that are currently active.

Previously Active (Type)

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

Healing (Type)

Healing DTCs can deactivate the Malfunction Indicator Lamp (MIL) if the monitoring system does not detect any malfunctions that would activate the MIL for three consecutive drive cycles.

Freeze Frame Data

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.

Message

The Message column displays a description of the condition causing the DTC.

Refresh DTC/Vehicle Events

The Refresh DTC/Vehicle Events button is used to ensure active and previously active DTCs do not return after they are cleared.

Clear DTCs

The Clear DTCs button is used to remove active, previously active, and pending DTCs from the display window.

Service Bay Tests

Engine Off Tests

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

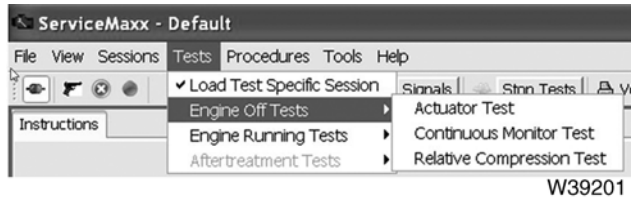


Figure 33 ServiceMaxx™ Software Tests Menu – Engine Off Tests

Actuator Test

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

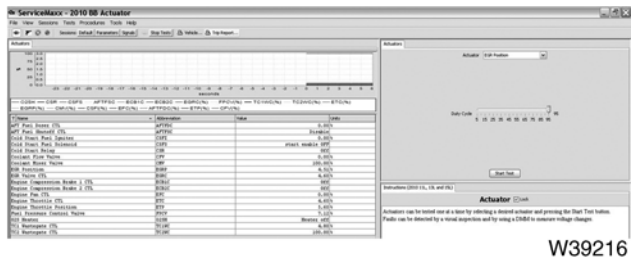


Figure 34 Actuator Test

Continuous Monitor Test

The Continuous Monitor Test helps detect intermittent circuit faults. During this test, signals are continuously monitored and faults are immediately logged. A graphical view of all signals is provided, allowing for easy detection of intermittent signal spiking or momentary loss of signal. Perform this test while manipulating connectors, wiring, and harnesses of the suspected faulty component.

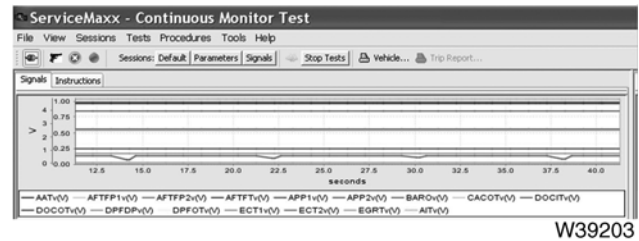


Figure 35 Continuous Monitor Test

Relative Compression Test

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

This test determines 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 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.

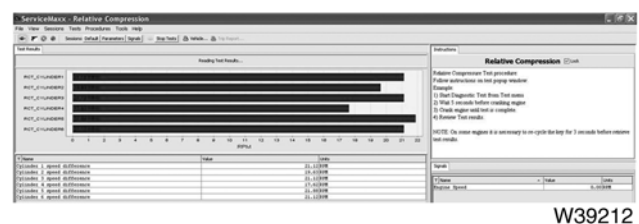


Figure 36 Relative Compression Test

Engine Running Tests

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

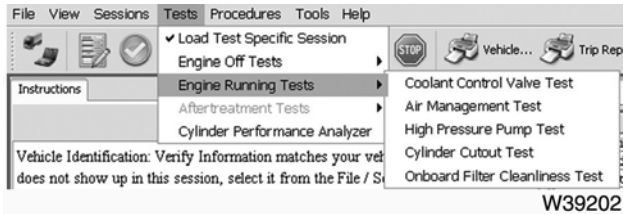


Figure 37 ServiceMaxx™ Software Tests Menu – Engine Running Tests

Coolant Valve Test

The Coolant Valve Test actuates the Coolant Flow Valve (CFV) and Coolant Mixer Valve (CMV) for 5 seconds at a time during the test. This test is used to verify the CFV and CMV are operating correctly, as well as to validate the performance of the interstage cooler.

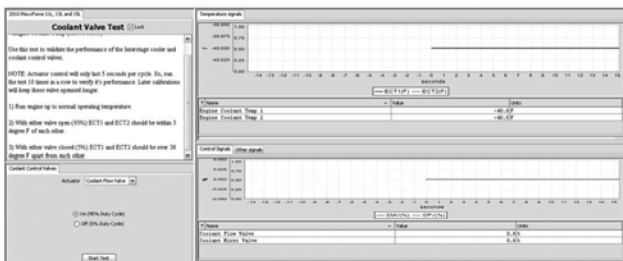


Figure 38 Coolant Valve Test

Air Management Test

The Air Management Test validates performance of the Air Management System (AMS) by monitoring the effects each actuator has on the Intake Manifold Pressure (IMP) sensor.

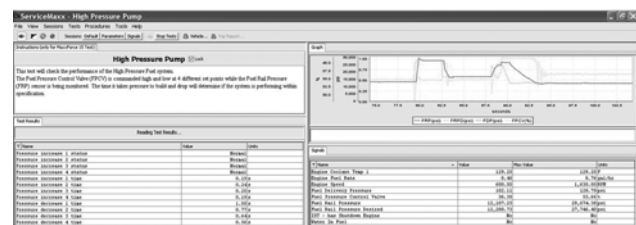


W39218

Figure 39 Air Management Test

High-pressure Pump Test

The High-pressure Pump Test validates performance of the Fuel Rail Pressure (FRP) system. This test commands the Fuel Pressure Control Valve (FPCV) high and low at four different set points while monitoring the FRP sensor. The time it takes for pressure to build and drop determines if system is performing within specification.



W39204

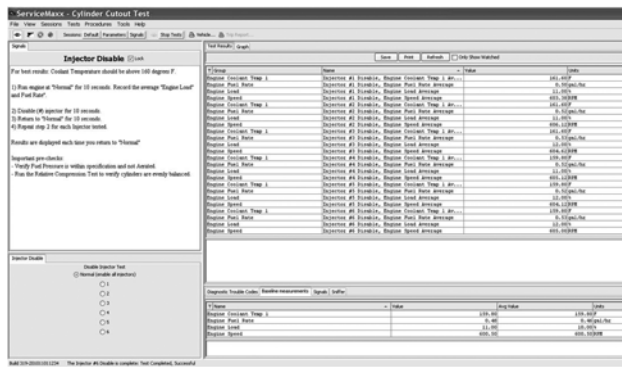
Figure 40 High-pressure Pump Test

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.
 - If Relative Compression Test results indicate low balanced cylinder(s), there is no need to run the Cylinder Cutout Test. Repair mechanical fault.
2. Verify fuel system pressure is not below specification and fuel is not aerated.

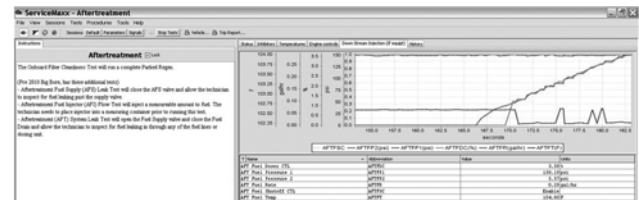


W39215

Figure 41 Cylinder Cutout Test

Onboard Filter Cleanliness Test

The Onboard Filter Cleanliness Test performs a parked regeneration (regen) and increases engine speed to measure pressure differential across the Diesel Particulate Filter (DPF). This test can be run at any time.



W39217

Figure 42 Onboard Filter Cleanliness Test

Service Tool Procedures

Service tool procedures are special ECM controls that allow the user to perform specific procedures. MaxxForce® 15 engines have four special procedures: O2 Sensor Calibration, Injector Quantity Adjustment (IQA), DPF Servicing, and Engine Fan. Follow on-screen instructions when running service tool procedures.

Engine Off Procedures

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



Figure 43 ServiceMaxx™ Software Procedures Menu – Engine Off Procedures

O2 Sensor Calibration

The Oxygen Sensor Calibration procedure calibrates the Oxygen Sensor (O2S). Anytime the O2S is replaced, this procedure needs to be performed.

Injection Quantity Adjustment

The Injection Quantity Adjustment (IQA) procedure is used to calibrate new injectors. Each injector is encrypted with an IQA code that must be programmed into the ECM anytime an injector has been replaced.

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.

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.

Engine Running Procedures

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



Figure 44 ServiceMaxx™ Software Procedures Menu – Engine Running Procedures

Engine Fan

The Engine Fan procedure turns the engine fan OFF and ON while the engine is running to help diagnose fan failures.

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Coolant System

Coolant System Components

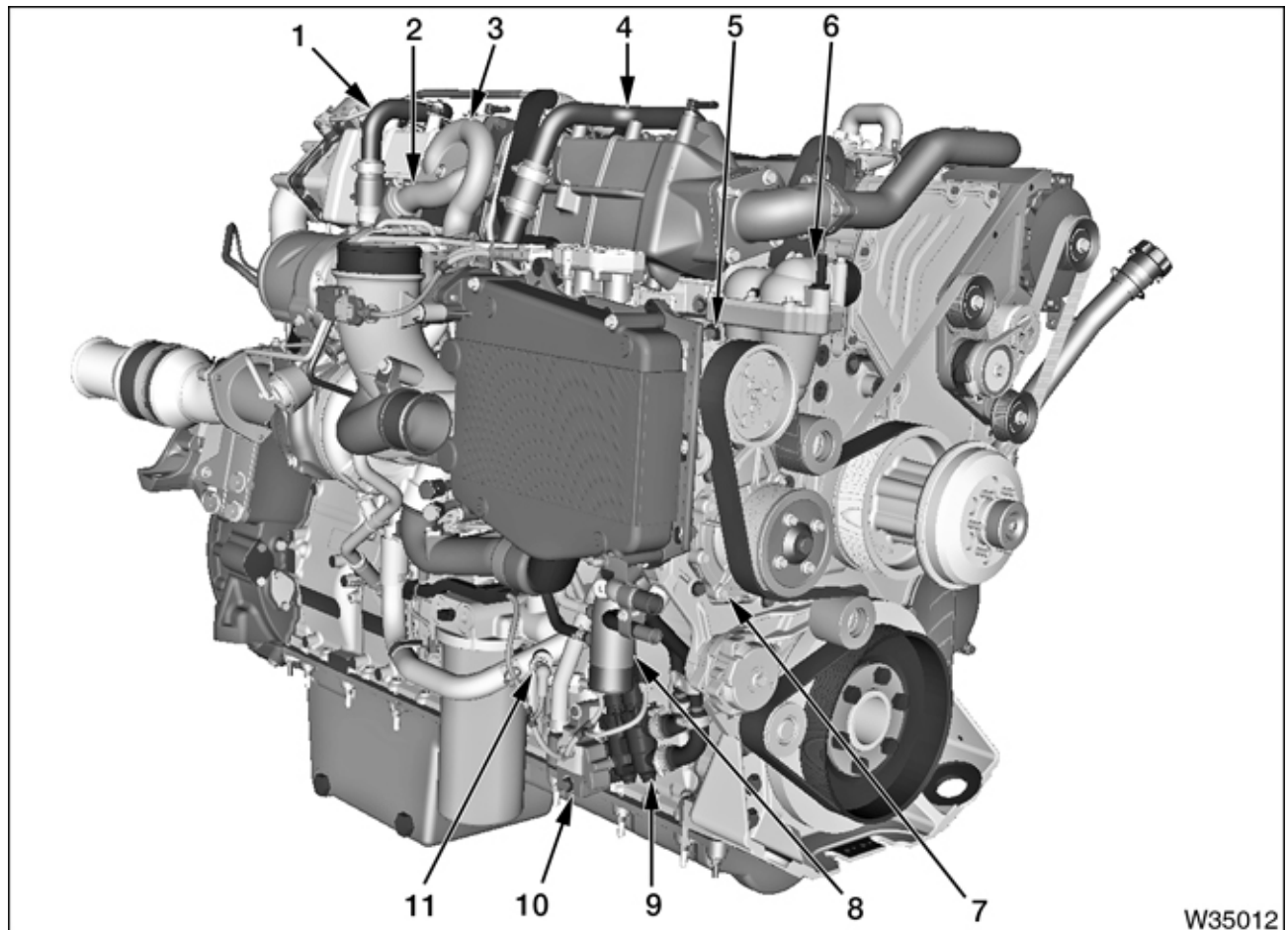


Figure 45 Coolant System Components

1. Exhaust Gas Recirculation (EGR) coolant tube assembly (primary EGR cooler)	4. EGR coolant tube assembly (secondary EGR cooler)	9. Coolant Control Valve (CCV) assembly (Coolant Mixer Valve [CMV] and Coolant Flow Valve [CFV])
2. EGR coolant return (secondary EGR cooler)	5. Engine Coolant Temperature 1 (ECT1) sensor (behind Interstage Cooler)	10. Coolant adapter
3. EGR coolant return (primary EGR cooler)	6. Thermostat housing cover	11. Engine Coolant Pressure (ECP) sensor
	7. Water pump	
	8. Water pump inlet	

Coolant Loss



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, 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 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.

Symptom

Consistent need to refill deaeration tank and active or previously active Diagnostic Trouble Codes (DTCs) related to the coolant 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 Aftertreatment Fuel Injector (AFI)
- Failed Coolant Control Valve (CCV)
- Failed Low Temperature Radiator (LTR)
- Failed air compressor
- Failed Interstage Cooler (ISC)
- Failed EGR cooler
- Damaged or failed distributor housing
- Failed oil cooler
- Cracked cylinder head
- Porous or cracked cylinder liner
- Cylinder liner O-ring leak

Tools

- ZTSE2384 – Radiator Pressure Testing Kit
- ZTSE6090 – EGR Cooler Pressure Test Kit

Procedure

1. Check engine service records to determine the frequency and quantity of coolant added.
 - If the vehicle's coolant system is being overfilled, there will be a small coolant loss everyday. Educate driver on correct coolant level.
 - If coolant system maintenance is correct, continue to next step.
- NOTE:** Ensure engine oil and coolant are within normal operating ranges and there is no coolant on the oil level gauge (dipstick), before running the engine.
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 72).
 - If coolant overflow is not detected, continue to next step.

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

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

- Allow the engine to cool for 15 minutes or more.
 - Wrap a thick cloth around the radiator cap or deaeration cap.
 - Loosen cap slowly a quarter to half turn to vent pressure.
 - Pause for a moment until all pressure has escaped to avoid being scalded by steam.
 - Continue to turn 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 coolant system.
 - If sealing surfaces are not damaged, continue to next step.
4. Connect Radiator Pressure Testing Kit to deaeration cap. Pressurize deaeration cap to its rated pressure.
- If deaeration cap does not hold the rated pressure, install a new deaeration cap. Retest coolant system.
 - If deaeration cap holds the rated pressure, continue to next step.
5. Connect Radiator Pressure Testing Kit to deaeration tank. Pressurize coolant system to 103 kPa (15 psi) for 15 minutes.

6. Visually inspect all components and hoses for external coolant leaks.

- If an external coolant leak is found, repair as necessary. Retest coolant system.
- If no external coolant leak is found, continue to next step.

 **WARNING:** To prevent personal injury or death, do not smoke or park vehicle near open flames or sparks when taking a fuel sample.

7. Obtain a fuel sample from fuel tank. Test fuel sample for coolant contamination.

- If fuel sample is contaminated with coolant, go to Coolant Leak to Fuel (page 75).
- If fuel sample is not contaminated with coolant, continue to next step.

8. Inspect intake manifold, Interstage Cooler (ISC) outlet, and EGR cooler for coolant.

- If there is coolant in the intake manifold, ISC outlet, or EGR cooler, go to Coolant Leak to Intake (page 77).

NOTE: The EGR cooler can be inspected by removing the cold side tubes at the intake.

- If there is no coolant in the intake manifold, ISC outlet, or EGR cooler, continue to next step.

9. Obtain an oil sample from engine. Test oil sample for coolant contamination.

- If oil sample is contaminated with coolant, go to Coolant Leak to Lube Oil (page 78).
- If oil sample is not contaminated with coolant, go to Coolant Leak to Exhaust (page 73).

Coolant Overflow**Symptom**

Coolant flowing or bubbling from the deaeration tank.

Possible Causes

- Failed air compressor
- Failed ISC
- Failed EGR cooler
- Failed cylinder head gasket
- Cracked cylinder liner
- Cracked cylinder head
- Failed oil cooler

Tools

- Hose pinch-off pliers (2)
- ZTSE2384 – Radiator Pressure Testing Kit
- ZTSE6042 – Interstage Cooler Test Kit
- ZTSE6090 – EGR Cooler Pressure Testing Kit

Air Compressor Leak Test

1. Partially drain coolant system.
2. Using hose pinch-off pliers, clamp off both coolant lines between air compressor and engine block.
3. Refill coolant 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.

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

Coolant Overflow Test

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

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

- Allow the engine to cool for 15 minutes or more.
 - Wrap a thick cloth around the radiator cap or deaeration cap.
 - Loosen cap slowly a quarter to half turn to vent pressure.
 - Pause for a moment until all pressure has escaped to avoid being scalded by steam.
 - Continue to turn cap counterclockwise to remove.
1. Remove deaeration tank cap.
 2. Connect Radiator Pressure Testing Kit to deaeration tank.
 3. Pressurize coolant system to 103 kPa (15 psi) for 15 minutes.
 4. Inspect the intake manifold and ISC outlet for coolant.
 - If there is coolant in the intake manifold or ISC outlet, go to Coolant Leak to Intake (page 77).
 - If there is no coolant in the intake manifold, but coolant is found in the ISC outlet, continue to next test.
 - If there is no coolant in the intake manifold or ISC outlet, go to EGR Cooler Leak Inspection (page 73).

Interstage Cooler (ISC) Leak Test

1. Completely drain engine coolant.

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

2. Pressure test the ISC following procedures in the *Engine Service Manual*.
3. Monitor air pressure in ISC for five minutes.
 - If ISC does not hold pressure, replace the ISC following procedures in the *Engine Service Manual*.
 - If ISC holds pressure, continue to next test.

Exhaust Gas Recirculation (EGR) Cooler Leak Inspection

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

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

2. Pressure test EGR cooler, in vehicle, following procedures in the *Engine Service Manual*.
 - If no leaks are found, go to Coolant Leak to Lube Oil (page 78).
 - If a leak is found, replace EGR cooler following procedures in the *Engine Service Manual*.
 - If EGR cooler is leaking coolant internally, replace Oxygen Sensor (O2S) following procedures in the *Engine Service Manual*. Perform O2S Calibration Procedure (page 348) anytime O2S 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 exhaust:

- Coolant residue at exhaust manifold flanges
- Observation of coolant loss without engine overheating
- Coolant smell in exhaust
- Coolant leaking from exhaust
- Engine hydraulic lock (severe cases only)
- Plugged 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 (O2S) must be replaced. See the *Engine Service Manual* for O2S replacement procedures. Perform O2S Calibration Procedure (page 348) anytime O2S is replaced.

Tools

- ZTSE2384 – Radiator Pressure Testing Kit
- ZTSE6090 – EGR Cooler Pressure Testing Kit

Aftertreatment Fuel Injector (AFI) Coolant 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, wear safety glasses with side shields.

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

- Allow the engine to cool for 15 minutes or more.
 - Wrap a thick cloth around the radiator cap or deaeration cap.
 - Loosen cap slowly a quarter to half turn to vent pressure.
 - Pause for a moment until all pressure has escaped to avoid being scalded by steam.
 - Continue to turn cap counterclockwise to remove.
1. Remove deaeration tank cap.
 2. Connect Radiator Pressure Testing Kit to deaeration tank.
 3. Disconnect exhaust pipe at Pre-Diesel Oxidation Catalyst (PDOC) assembly.
 4. Pressurize coolant system to 103 kPa (15 psi) for 15 minutes.

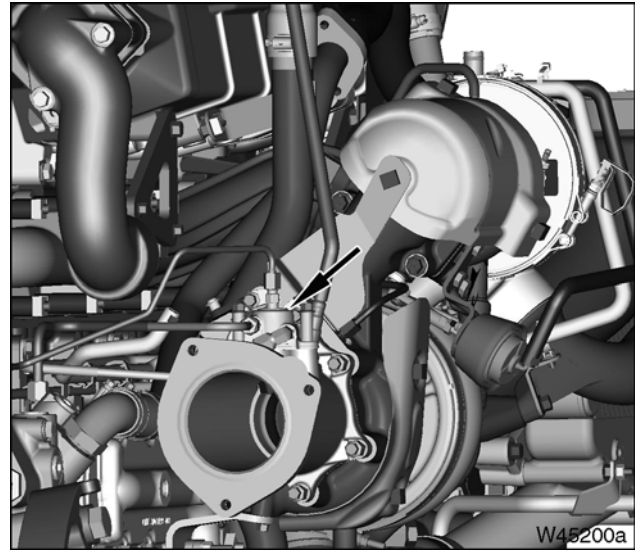


Figure 46 AFI nozzle

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

EGR Cooler Leak Inspection

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

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

2. Pressure test EGR cooler, in vehicle, following procedures in the *Engine Service Manual*.
 - If a leak is found, replace EGR cooler following procedures in the *Engine Service Manual* and retest.
 - If no leaks are found, go to Cylinder Head Leak Test (page 79).
 - If EGR cooler is leaking coolant internally, replace Oxygen Sensor (O2S) following procedures in the *Engine Service Manual*. Perform O2S Calibration Procedure (page 348) anytime O2S is replaced.

Coolant Leak to Fuel**Symptom**

Noticeable coolant separation in fuel sample.

Possible Causes

- Coolant heater auxiliary fuel filter (if equipped)
- Cracked cylinder head
- Leaking injector sleeves

Tools

- Diesel fuel container
- Clean plastic hose
- Coolant dye
- Tube fitting cap - McMaster-Carr part # 5482K69
- ZTSE2384 – Radiator Pressure Testing Kit
- ZTSE4618 – UV Leak Detection Kit

- ZTSE4886 – Fuel Inlet Restriction / Aeration Tool
- ZTSE6094-1 – Fuel Pressure Return Connector

Procedure

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

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

- Allow the engine to cool for 15 minutes or more.
 - Wrap a thick cloth around the radiator cap or deaeration cap.
 - Loosen cap slowly a quarter to half turn to vent pressure.
 - Pause for a moment until all pressure has escaped to avoid being scalded by steam.
 - Continue to turn cap counterclockwise to remove.
1. Remove deaeration cap.
 2. Add dye to coolant per manufacturer's instructions.
 3. Reinstall deaeration cap. Start engine and run until it reaches normal operating temperature. Shut engine OFF.

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

- Allow the engine to cool for 15 minutes or more.
 - Wrap a thick cloth around the radiator cap or deaeration cap.
 - Loosen cap slowly a quarter to half turn to vent pressure.
 - Pause for a moment until all pressure has escaped to avoid being scalded by steam.
 - Continue to turn cap counterclockwise to remove.
4. Remove deaeration cap.
 5. Connect Radiator Pressure Testing Kit to deaeration tank.

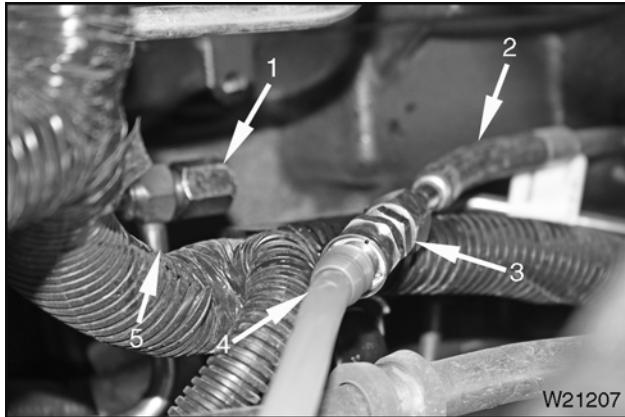


Figure 47 Tube fitting cap connected to fuel return tube assembly

1. Tube fitting cap
 2. Fuel return tube assembly
 3. Fuel Pressure Return Connector
 4. Clean plastic hose
 5. Fuel return line
6. Disconnect fuel return tube assembly at left, rear side of engine.
 7. Cap off fuel return line using tube fitting cap.
 8. Connect fuel return tube assembly to Fuel Pressure Return Connector.
 9. Connect clean plastic hose to Fuel Pressure Return Connector and route into diesel fuel container.
 10. Pressurize coolant system to 103 kPa (15 psi) for a minimum of 30 minutes.
 11. Monitor clean plastic hose and diesel fuel container for presence of dyed coolant.

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

 - If presence of coolant is found, continue to next step.
 - If no presence of coolant is found, fuel in the fuel tank may be contaminated. Drain fuel from supply tanks, replace with clean fuel, and replace fuel filters following procedures in the *Engine Service Manual*.
 12. Remove pressure from coolant system.
 13. Remove all high-pressure rail to injector tubes and high-pressure connector bodies following procedures in the *Engine Service Manual*.
 14. Pressurize coolant system to 103 kPa (15 psi).
 15. Inspect injector cavities using UV Leak Detection Kit black light.
 - If presence of coolant is found, replace injector sleeve on leaking cylinder following procedures in the *Engine Service Manual* and retest.
 - If presence of coolant is found after injector sleeve replacement, perform Cylinder Head Leak Test (page 79).
 - If no presence of coolant is found, there is no coolant in the fuel.

Coolant Leak to Intake

Symptom

Coolant overflowing from deaeration tank or air bubbles in coolant.

Possible Causes

- Failed ISC
- Failed EGR cooler
- Cracked cylinder head

Tools

- ZTSE6042 – Interstage Cooler Test Kit
- ZTSE6090 – EGR Cooler Pressure Testing Kit

Interstage Cooler (ISC) Leak Test

1. Determine location of coolant leakage.
 - If coolant is leaking out of the ISC outlet, continue to next step.
 - If coolant is leaking out of the intake manifold, go to EGR Cooler Leak Inspection.
2. Completely drain coolant system.

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

3. Pressure test the ISC following procedures in the *Engine Service Manual*.
4. Monitor air pressure in the ISC for a period of five minutes.
 - If ISC does not hold pressure, replace the ISC following procedures in the *Engine Service Manual*.

- If ISC holds pressure, continue to next test.

EGR Cooler Leak Inspection

1. Visually inspect EGR cooler for external cracks or leaks.
 - If an external leak or crack is found, replace EGR cooler following procedures in the *Engine Service Manual* and retest.
 - If no external leaks or cracks are found, continue to next step.
2. Remove front tubes from EGR cooler.

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

3. Pressure test EGR cooler, in vehicle, following procedures in the *Engine Service Manual*.
 - If a leak is found, replace EGR cooler following procedures in the *Engine Service Manual* and retest.
 - If no leaks are found, go to Cylinder Head Leak Test (page 79).
 - If EGR cooler is leaking coolant internally, replace Oxygen Sensor (O2S) following procedures in the *Engine Service Manual*. Perform O2S Calibration Procedure (page 348) anytime O2S is replaced.

Coolant Leak to Lube Oil

Symptom

Engine oil has 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 cavitating 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
- ZTSE6042 – Interstage Cooler Test Kit
- ZTSE6090 – EGR Cooler Pressure Testing Kit

Lube Oil Contamination Inspection

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



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



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

- Allow the engine to cool for 15 minutes or more.
 - Wrap a thick cloth around the radiator cap or deaeration cap.
 - Loosen cap slowly a quarter to half turn to vent pressure.
 - Pause for a moment until all pressure has escaped to avoid being scalded by steam.
 - Continue to turn cap counterclockwise to remove.
3. Remove deaeration tank cap.
 4. Connect Radiator Pressure Testing Kit to deaeration tank.
 5. Pressurize coolant system to 103 kPa (15 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 coolant leakage.
 - If coolant is leaking at air compressor drain, replace air compressor following procedures in the *Engine Service Manual*.
 - If coolant is leaking from front cover area, continue to next step.
 - If coolant is leaking at inside bottom edge of cylinder liner(s), go to Cylinder Head Leak Test (page 79).
 - If coolant is leaking at outside edge of cylinder liner, go to step 9.
 - If coolant is leaking from cracks in the crankcase, replace crankcase following procedures in the *Engine Service Manual*.
 - If coolant is leaking from oil cooler, pressure test oil cooler following procedures in the *Engine Service Manual*.
7. Remove water pump following procedures in the *Engine Service Manual*.

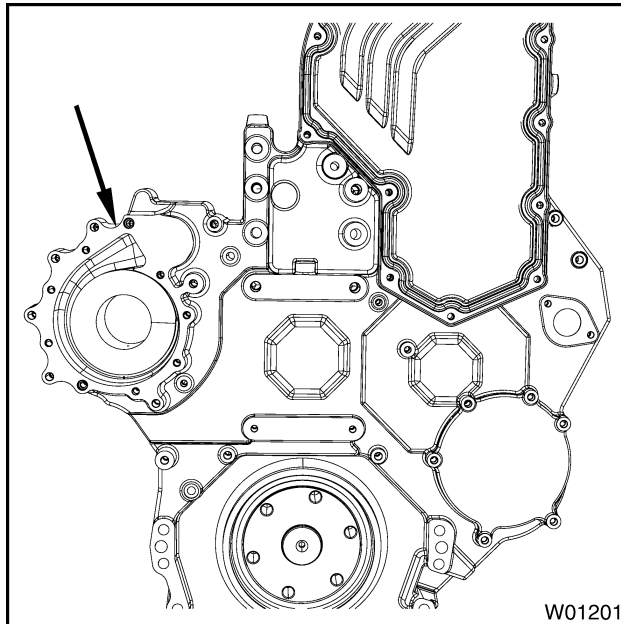


Figure 48 Water distribution housing

8. Inspect gear train area of water distribution housing for coolant leaks.
 - If coolant is leaking into gear train area, inspect water distribution housing and gasket for leak sources. Repair as necessary.
 - If coolant is not leaking from water distribution 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 outside of 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 test.

EGR Cooler Leak Inspection

1. Visually inspect EGR cooler for external cracks or leaks.
 - If an external leak or crack is found, replace EGR cooler following procedures in the *Engine Service Manual* and retest.
 - If no external leaks or cracks are found, continue to next step.
2. Remove front tubes from EGR cooler.

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

3. Pressure test EGR cooler, in vehicle, following procedures in the *Engine Service Manual*.
 - If a leak is found, replace EGR cooler following procedures in the *Engine Service Manual* and retest.
 - If no leaks are found, continue to next test.
 - If EGR cooler is leaking coolant internally, replace Oxygen Sensor (O2S) following procedures in the *Engine Service Manual*. Perform O2S Calibration Procedure (page 348) anytime O2S is replaced.

Cylinder Head Leak Test

1. Pressure test cylinder head following procedures in the *Engine Service Manual*.
 - If a leak(s) is found, install a new cylinder head following procedures in the *Engine Service Manual*.

Coolant Over-Temperature**Symptoms**

Red engine lamp illuminated and flashing while an audible alarm sounds. Active DTCs related to coolant over-temperature.

Possible Causes

- Incorrect part(s) 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
- ISC failure
- Chassis effects, transmission, or aftermarket equipment

Tools

- ZTSE2384 – Radiator Pressure Testing Kit
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit
- Digital Multimeter (DMM)

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" for DTC identification and diagnosis.
4. Check deaeration tank for correct fill level.
 - If coolant level is low and a coolant leak is suspected, fill coolant system and repair leak. See Coolant Loss (page 70).
 - If coolant level is low and other over-temperature conditions are still suspected, refill coolant system and continue to next step.
5. Inspect cooling fan blade, shroud, accessory drive belt(s), accessory drive belt tensioner(s), cooling fan drive clutch, and radiator for damage.
 - Repair or replace any damaged components, as necessary, following procedures in the *Engine Service Manual*. Test again to validate repair.
 - 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 coolant system.
 - Verify cooling fan blade, cooling fan drive clutch, and radiator are clean of debris and dirt buildup. Clean areas as required.
6. 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.

7. 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 the ignition Key ON, Engine OFF (KOEO). All the sensors should read within 5°C (10°F) of each other.

8. 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.

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

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

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

10. Connect Radiator Pressure Testing Kit to deaeration cap. Pressurize deaeration cap to its rated pressure.

- If deaeration cap does not hold the rated pressure, install a new deaeration cap.
- If deaeration cap holds the rated pressure, continue to next step.

11. Connect Radiator Pressure Testing Kit to deaeration tank. Run engine at elevated idle.

Monitor pressure in system using Radiator Pressure Testing Kit gauge.

- If pressure is higher than the pressure rating of cap, go to Coolant Overflow (page 72).
- If pressure is below rating of cap, continue to next step.

12. Using EST with ServiceMaxx™ software, monitor ECT1 and ECT2 sensor temperature readings.

- If temperature value for ECT2 sensor is below ECT1 sensor value, continue to next test.
- If temperature value for ECT2 sensor is above ECT1 sensor value, go to Coolant Control Valve (CCV) Test (page 82).

Coolant Over-Temperature – Engine Cooling

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

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

- Allow the engine to cool for 15 minutes or more.
- Wrap a thick cloth around the radiator cap or deaeration cap.
- Loosen cap slowly a quarter to half turn to vent pressure.
- Pause for a moment until all pressure has escaped 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.
6. Remove and inspect thermostats following procedures in the *Engine Service Manual*. Ensure the opening temperature on each thermostat matches its rating.
 - Replace thermostats as needed. Retest to validate repair.
 - If both thermostats pass test, continue to next step.
7. 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.

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.
4. Open Coolant Control Valve Test from Engine Running Tests drop-down menu.
5. Start engine and allow it to reach operating temperature.
6. Press record button.

NOTE: The Coolant Flow Valve (CFV) and Coolant Mixer Valve (CMV) will actuate for 5 seconds at a time during the test. The tests are repeated 10 times to ensure accuracy of test results.

7. Select Coolant Mixer Valve and cycle test 10 times.
8. Use recorded data to determine if CMV is operating correctly.
 - With CMV closed (95%), Engine Coolant Temperature 1 (ECT1) should be within 3°C (5°F) of Engine Coolant Temperature 2 (ECT2). If ECT1 is not within 3°C (5°F) of ECT2, the CMV is stuck open. Replace CCV assembly following procedures in the *Engine Service Manual*.
 - With CMV open (5%), there should be a difference of at least 17°C (30°F) between ECT1 and ECT2. If ECT1 is within 17°C (30°F) of ECT2, the CMV is stuck closed. Replace CCV assembly following procedures in the *Engine Service Manual*.
9. 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.



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, 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 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.

Incorrect Oil Level

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 oil level is below specification, inspect for leaks, oil consumption, or improper servicing. Repair as necessary. Fill to specification.
 - If oil level is above specification, inspect for improper servicing and contamination. Check service maintenance records and talk with customer to determine if the lube oil has been overfilled unintentionally.
 - If oil is not contaminated and service record is unknown, change oil and filter and retest to see if complaint reoccurs.
 - If oil is contaminated, drain to proper level and diagnose contamination.

Dilution From Coolant

Lube oil diluted with coolant can be described in different ways, depending on the quantity of coolant in the oil.

- A "milky" substance left under the valve cover and in the oil fill tube is the result of ethylene glycol-based coolant in which the moisture has not evaporated from the coolant/oil mixture.
- When the moisture has evaporated from coolant-contaminated oil, a light gray color and thick, sludgy consistency are present. If lube oil exhibits signs of coolant dilution, go to Coolant Leak to Lube Oil (page 78).

Dilution From Fuel

Lube oil contaminated with fuel will have a strong diesel fuel odor, and crankcase will likely be overfilled. If lube oil exhibits signs of fuel dilution, go to Fuel in Lube Oil (page 91).

Power Steering Fluid Leak to Lube Oil

Symptom

Engine oil level increases while power steering fluid level decreases.

Possible Causes

- Power steering pump leak

Procedure

1. Adjust engine 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 engine oil and power steering fluid levels.
 - If power steering fluid level has decreased and engine oil level has increased, install a new power steering pump following procedures in the *Engine Service Manual*.
 - If power steering fluid level has not decreased and engine oil level has not increased, power steering fluid is not leaking into engine oil.

Lube Oil to Coolant**Symptom**

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

Possible Causes

- Failed oil cooler
- Missing/damaged oil cooler gaskets
- Missing or damaged head gasket or spacer gasket

Procedure

1. Verify coolant is contaminated with lube oil by inspecting deaeration tank for presence of oil residue.
 - If coolant is contaminated, continue to next step.
2. Remove oil cooler from engine following procedures in the *Engine Service Manual*.
3. Pressure test oil cooler following procedures in the *Engine Service Manual*.
 - If oil cooler fails pressure test, replace oil cooler following procedures in the *Engine Service Manual*.
 - If oil cooler passes pressure test, replace both oil cooler gaskets following procedures in the *Engine Service Manual*.

Lube Oil to Intake**Symptom**

High lube oil consumption.

Possible Causes

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

Procedure

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

4. Monitor crankcase pressure signal and compare to performance specifications listed in Appendix A: Performance Specifications.

- If crankcase pressure is higher than specification, see Crankcase Oil Breather Test in "Performance Diagnostics."
- If crankcase pressure is within specification, continue to next step.

NOTE: Ensure oil level is not above specification before continuing. See Incorrect Oil Level (page 83).

5. Inspect air intake for lube oil.

- If lube oil is present at air intake, continue to next step.
- If there is no lube oil at air intake, lube oil is not leaking into intake.

6. Remove Interstage Cooler (ISC) assembly following procedures in the *Engine Service Manual*.

7. Inspect for lube oil at ISC inlet and Charge Air Cooler (CAC).

- If lube oil is present at the ISC inlet, inspect and repair low-pressure turbocharger assembly following procedures in the *Engine Service Manual*.
- If lube oil is present at the CAC and not the ISC, inspect and repair high-pressure turbocharger assembly following procedures in the *Engine Service Manual*.

Lube Oil to Exhaust**Symptom**

Lube oil is being consumed or Diesel Particulate Filter (DPF) or Diesel Oxidation Catalyst (DOC) is plugged. 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 in exhaust is determined from one of the listed possible causes, the Oxygen Sensor (O2S) must be replaced. See the *Engine Service Manual* for O2S replacement procedures. Perform O2S Calibration Procedure (page 348) anytime O2S is replaced.

Procedure

1. Remove DOC inlet pipe following procedures in the *Engine Service Manual*. Inspect for presence of lube oil.
 - If no oil is present, the substance leaking into the exhaust is most likely fuel. Verify AFI and Down Stream Injection (DSI) system is functioning properly. Go to Fuel to Exhaust (page 93).
 - If oil is present, 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. Repair power cylinder following procedures in the *Engine Service Manual*.
4. 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.

Low Oil Pressure

Symptom

Red engine lamp illuminated and flashing while an audible alarm sounds. Active DTCs related to low oil pressure.

Possible Causes

- Low oil level
- High oil level/oil contamination
- Incorrect oil viscosity
- Inaccurate Engine Oil Pressure (EOP) sensor/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 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
- NAVCoM or NAVLink Interface Kit
- ZTSE4409 – Pressure Test Kit
- ZTSE6091 – Manual Oil Pressure Test Tool

Oil Level and Pressure Check

Oil Level Check

! 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.

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 oil level is below specification, inspect for leaks, oil consumption, or improper servicing. Repair as necessary. Fill to specification.
 - If oil level is above specification, inspect for improper servicing and contamination. Check service maintenance records and talk with customer to determine if the lube oil has been overfilled unintentionally.
 - If oil is not contaminated and service record is unknown, change engine oil and filter and retest to see if complaint reoccurs.
 - If lube oil is contaminated with coolant, go to Coolant Leak to Lube Oil (page 78).
 - If lube oil is contaminated with fuel, go to Fuel in Lube Oil (page 91).
 - If engine was properly serviced, 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 with instrument panel oil pressure gauge.
 - If oil pressure is within specification, no repair is necessary.
 - If oil pressure is below specification, continue to next test.

Oil Pressure Test

1. Turn ignition switch to ON, engine OFF.
2. Connect EST to vehicle's Diagnostic Connector.
3. Start ServiceMaxx™ software.
4. Using EST, verify Engine Oil Pressure (EOP), Engine Oil Temperature (EOT), and engine speed differences.
 - If EOP is within specification, investigate for failed or malfunctioning instrument panel oil pressure gauge. See the appropriate chassis service manual for diagnosing oil pressure gauge.
 - If EST with ServiceMaxx™ software indicates low EOP, continue to next step.
5. Remove EOP sensor and install Manual Oil Pressure Test Tool.

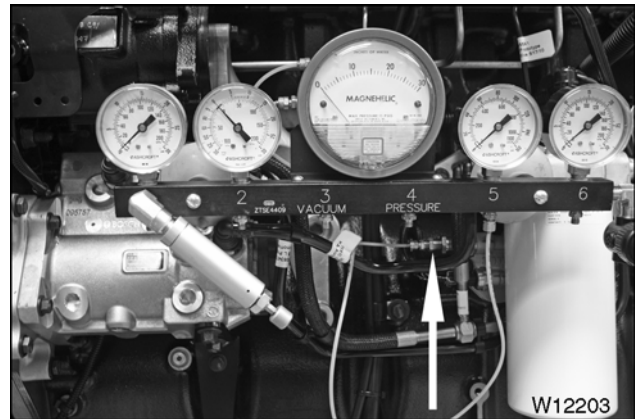


Figure 49 Manual Oil Pressure Test Tool

6. Connect test line between Manual Oil Pressure Test Tool and Pressure Test Kit.

7. Start engine and run to operating temperature. Using Pressure Test Kit gauge, measure oil pressure at both low and high idle and under no load conditions.
 - If oil pressure is within specification listed in Appendix A: Performance Specifications, perform EOP Sensor diagnostics in "Electronic Control Systems Diagnostics."
 - If oil pressure is not within specification, continue to next step.
8. 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 oil filter and retest system.
 - If engine fails test, continue to next step.
9. 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 metals and contaminants in oil.
10. Remove oil sending tube following procedures in the *Engine Service Manual*.
11. 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, continue to next step.
12. Inspect oil pickup tube for damage and for loose, damaged, or worn O-rings.
 - If O-rings are missing or damaged, replace as necessary.
 - If oil pickup tube is damaged, install a new oil pickup tube following procedures in the *Engine Service Manual* and retest.
 - If oil pickup tube is not damaged, continue to next step.

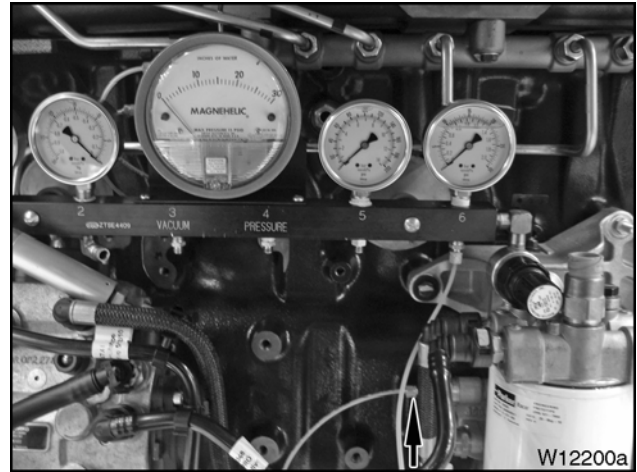


Figure 50 Test line connected to Manual Oil Pressure Test Tool

13. Connect test line between Manual Oil Pressure Test Tool and Pressure Test Kit regulated gauge.
14. Slowly apply air pressure in 34 kPa (5 psi) increments up to 207 kPa (30 psi).

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

15. 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 air or oil is coming out of oil pump pressure relief valve, remove pressure relief valve and inspect for sticking. Repair as necessary.
 - Rear of engine – oil galley plugs
 - Main and rod bearings
 - Upper engine – camshaft bearings (removal of the valve cover is required)

If no leak is found, 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.



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, 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 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.

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 tire 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 in Truck Computer Analysis of Performance and Economy (TCAPE) report.

3. Do all tests on Performance Diagnostics Form or in "Performance Diagnostics" section of this manual.

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
- Aftertreatment Fuel Injector (AFI)
- Injector sleeve leaking past O-ring

Tools

- Regulated air
- Fluid Line Pressurizing Tool
- ZTSE4409 – Pressure Test Kit

Procedure

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

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

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

- Allow the engine to cool for 15 minutes or more.
 - Wrap a thick cloth around the radiator cap or deaeration cap.
 - Loosen cap slowly a quarter to half turn to vent pressure.
 - Pause for a moment until all pressure has escaped to avoid being scalded by steam.
 - Continue to turn 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 fuel supply line from AFI.
5. 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 procedures in the *Engine Service Manual*.
 - If no air bubbles are present at deaeration tank, restore AFI to proper operating condition and continue to next step.
6. Reconnect AFI fuel supply line.
7. Disconnect fuel return tube assembly at left, rear side of engine.

8. Install Fluid Line Pressurizing Tool to fuel return tube assembly.

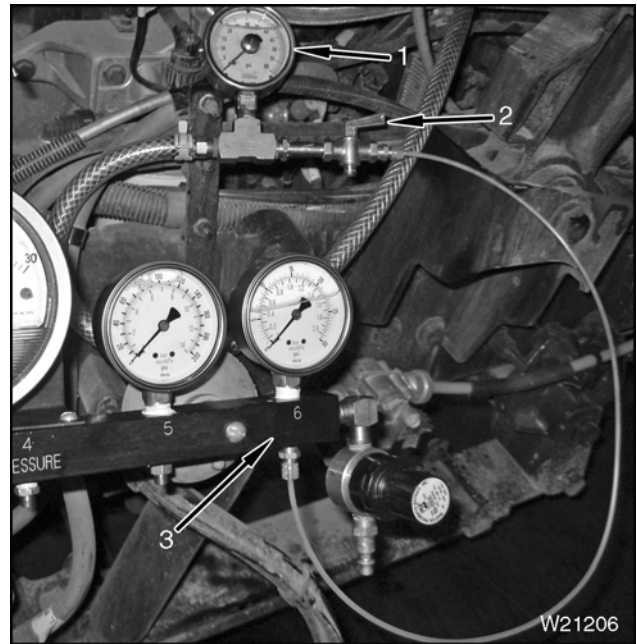


Figure 51 Fluid Line Pressurizing Tool connected to Pressure Test Kit

1. Fluid Line Pressurizing Tool
2. Gate valve
3. Pressure Test Kit

9. Connect Pressure Test Kit to Fluid Line Pressurizing Tool. Open gate valve.

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

10. Use Pressure Test Kit regulator to pressurize system to 207 kPa (30 psi) for up to 20 minutes.
11. Observe deaeration tank for air bubbles.
 - If air bubbles are observed at the deaeration tank, inspect injector sleeves for possible O-ring failure following procedures in the *Engine Service Manual*
 - If no air bubbles are observed at the deaeration tank, take a coolant sample to verify fuel contamination.

Fuel in Lube Oil**Symptom**

Oil contaminated with diesel fuel will have diesel fuel odor, and engine oil level will consistently increase.

Possible Causes

- Fuel injector(s)
- High-pressure fuel pump
- Cylinder misfire (wash down)
- Top injector sleeve O-ring
- Top injector O-ring
- An injector tip could cause contaminated engine oil, but this would most likely be identified as a performance problem.

Porous cylinder head

- Most likely on low-mileage vehicles

Tools

- One gallon of clean diesel fuel
- Fluid Line Pressurizing Tool
- ZTSE4409 – Pressure Test Kit

Procedure

NOTE: If engine has a misfire, check for related DTCs and repair as necessary. Continue to Special Tests in "Performance Diagnostics."

1. Place one drop of suspect oil on a clean sheet of printer or copier paper.
 - If oil wicks away rapidly into the paper, there is fuel contamination. Continue to next step.
 - If oil maintains a uniform and slow expanding stain, there is no fuel contamination, and no repair is required.
2. Remove valve cover following procedures in the *Engine Service Manual*.

3. Disconnect fuel return tube assembly at left, rear side of engine.
4. Install Fluid Line Pressurizing Tool to fuel return tube assembly.
5. Connect Pressure Test Kit to Fluid Line Pressurizing Tool. Open gate valve.

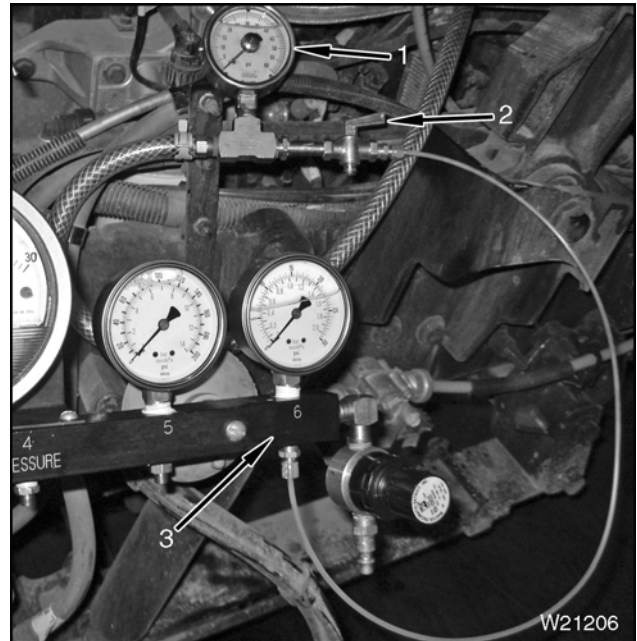


Figure 52 Fluid Line Pressurizing Tool connected to Pressure Test Kit

1. Fluid Line Pressurizing Tool
2. Gate valve
3. Pressure Test Kit



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

6. Pressurize fuel return system. Do not exceed 103.4 kPa (15 psi) of pressure.

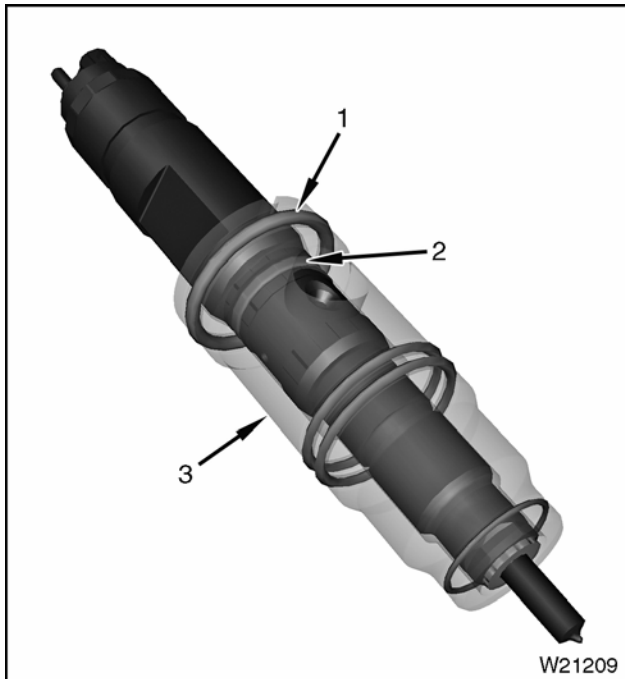


Figure 53 Possible injector leak points

1. Injector sleeve O-ring
 2. Injector O-ring
 3. Injector sleeve
7. Inspect all injector bodies and injector sleeves for escaping air.
 - If air is escaping from the outer part of the injector sleeve, replace injector sleeve O-ring following procedures in the *Engine Service Manual*.
 - If leaking from injector O-ring, continue to next step.
 - If inner part of injector sleeve is leaking air without performance problems, remove injector and replace injector O-ring following procedures in the *Engine Service Manual*.
 - If no leaks are found under both valve covers, check for related iKnow letters and service bulletins using the ISIS® system.

Fuel to Intake

Symptom

Black smoke from exhaust and eventual Diesel Particulate Filter (DPF) DTCs.

Possible Causes

- Cold Start Fuel Solenoid (CSFS) valve
- CSFS valve control

Procedure

1. If engine has a misfire, see Special Tests in "Performance Diagnostics."
2. Disconnect electrical connector from CSFS valve.
3. Disconnect fuel supply line from Cold Start Fuel Igniter (CSFI).
4. Pump fuel primer assembly while checking CSFS valve for fuel leakage.
5. Start engine and run at low idle. Check for fuel leakage from CSFS valve.
 - If a leak is found, install a new CSFS valve following procedures in the *Engine Service Manual*.
 - If no leak is found, check the CSFS valve control circuit. See CSFS in "Electronic Control Systems Diagnostics."

Fuel to Exhaust**Symptom**

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

Possible Causes

- Down Stream Injection (DSI) unit
- Internal engine damage

Procedure

1. Turn ignition switch to ON, engine OFF.
2. Connect EST to vehicle's Diagnostic Connector.
3. Start ServiceMaxx™ software.
4. Monitor ServiceMaxx™ software for active or previously active DTCs.
 - Repair any active or previously active DTCs. See "Electronic Control Systems Diagnostics."
5. If engine has a misfire, see Special Tests in "Performance Diagnostics."
6. Remove exhaust manifold from cylinder head following procedures in the *Engine Service Manual* and pinpoint the power cylinder of concern.

Compression to Fuel**Symptoms**

- Engine misfire
- One fuel tank overfilling
- Exhaust smell in fuel tanks
- Bubbles in fuel tanks

Possible Causes

- Incorrectly installed fuel injector
- Failed fuel injector
- Incorrectly installed fuel injector sleeve

Tools

- Clear diesel fuel container

- Fluid Line Pressurizing Tool
- Tube fitting cap - McMaster-Carr part # 5482K69

Procedure

1. Disconnect fuel return tube assembly at left, rear side of engine.
2. Cap off fuel return line using tube fitting cap.
3. Connect Fluid Line Pressurizing Tool to fuel return tube assembly.

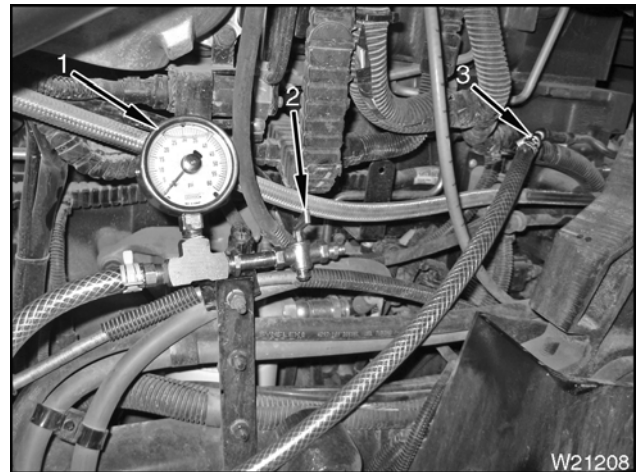


Figure 54 Fluid Line Pressurizing Tool connected to fuel return tube assembly

1. Fluid Line Pressurizing Tool
 2. Gate valve
 3. Barbed hose fitting
4. Close gate valve on Fluid Line Pressurizing Tool and monitor pressure.
 5. Start engine. Monitor for any pressure coming from fuel return line.
 - If pressure is not visible on the gauge, there is no compression leak to fuel, and no repair is required.
 - If pressure is visible on the gauge, perform Cylinder Cutout Test (page 169). The change in pressure could be an indication of a disabled injector.

NOTE: A failed cylinder could result in black discolorations on the injector end and/or injector sleeve.

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 engine cranking or when engine is running at idle
- Difficulty priming fuel system

Possible Cause

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

Procedure

If aeration is suspected, go to Fuel System in "Hard Start and No Start Diagnostics."

Water in Fuel

Symptoms

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

- Low engine power
- Engine stall during operation
- Rough running engine
- No start if water is frozen
- Illuminated Water In Fuel (WIF) lamp on instrument panel

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 mix gasoline, gasohol, or alcohol with diesel fuel. A heat source, spark, or electronic device can ignite fuel mixtures.

1. Put drain pan under filter housing.
2. Drain water separator following procedures in the *Engine Service Manual*.
3. Check fuel in drain pan for engine coolant or other contamination. Dispose of contents in 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 in 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 it is not a suitable grade for cold temperatures.
 - Fuel should not be dyed red or blue. These colors indicate off-highway fuel.
 - Fuel should not indicate 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 from water separator indicates water in fuel, obtain a fuel sample from fuel tanks.
 - If fuel sample from fuel tanks indicates water in fuel, replace fuel filters, drain fuel tanks, and refuel tanks with clean fuel.

Fuel System Priming

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

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

NOTE: If fuel system will not prime during diagnosis, the engine will exhibit pulsating fuel pressure. See Low-pressure Fuel System in "Hard Start and No Start Diagnostics."

Symptoms

Prime fuel system when the following conditions occur:

- Fuel tank is drained or runs dry.
- Chassis-mounted fuel filter is removed or replaced.
- Any fuel connection between fuel tank and engine-mounted fuel filter is broken.
- Engine-mounted fuel filter is removed or replaced.
- High-pressure fuel system is serviced.

Procedure

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 chassis-mounted fuel filter components that were removed (canister filter element, seals, or bowl) to specified torque values.
 - b. Pump fuel primer assembly until fuel pressure builds up on delivery side of primer pump. Pressure build-up is indicated by higher pumping force.

CAUTION: To prevent damage to 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 chassis-mounted filter cap and separate filter element from filter cap.
 - b. Ensure filter element is fully seated on standpipe.
 - c. Reassemble chassis-mounted fuel filter assembly.
- If engine does not start and there is no increase in pressure, allow starter to cool for two minutes and repeat steps 6 and 7.

Engine Brake System

Engine Brake Inspection

Symptom

Engine exhibits no deceleration when engine brake is engaged.

! 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, 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.

Possible Causes

Engine brake performance issues exhibit one or more of the following characteristics:

- Malfunctioning ON/OFF switch
- Engine brake lash adjustment (one or more cylinders out of adjustment)
- Low EOP (insufficient supply of oil pressure to operate engine brake)
- Low engine boost pressure while braking (below 138 kPa [20 psi] @ 2100 rpm with engine brake on high)
- Lube oil too cold or thick
- Improper slave piston adjustment or slave piston binding in bore
- Master piston not moving in bore
- Defective control valves or binding in housing bore
- Leaking engine brake housing plugs
- Broken outer control valve springs

- EOP extremely high or low
- Aeration in lube oil
- Lube oil diluted by fuel
- Low engine oil level
- Worn engine rocker lever bushings
- Restrictions in the engine oil passages leading to engine brake

Tools

- Digital Multimeter (DMM)
- ZTSE6076-7 – Lash Gauge

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:
 - Engine oil level on dipstick. Over- or underfilled condition in crankcase will cause aeration in engine brake hydraulic system.
 - Condition of engine lubricating oil and for presence of fuel, water, or both. This indicates engine problems and must be corrected.
 - Turbocharger, Charge Air Cooler (CAC), piping, and intake manifold leakage. Any loss of pressure will cause a reduction in engine brake power output.
 - Engine Control Module (ECM) is programmed correctly.
 - Accelerator Pedal Position (APP) sensor at 0 percent (accelerator pedal not depressed).
 - Clutch switch in CLOSED position.
 - Power Takeoff (PTO) switched to OFF (if equipped).

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 *Engine Service Manual*.
 - a. Remove upper valve cover, following procedures in the *Engine Service Manual*.
 - b. Check for cracks in engine brake housing.
 - c. Check for loose, damaged, brittle, or cracked wiring or connections at engine brake solenoid.
 - d. Check for loose or damaged hold down bolts.
 - e. Check exhaust bridges.
 - f. Check if engine brake slave piston setting is 0.8 mm.

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 a separate oil passage 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.

 **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 Engine Compression Brake 1 (ECB1), Engine Compression Brake 2 (ECB2), and Engine Compression Brake 3 (ECB3) to ECB harness connector.
5. Check resistance from each terminal to engine brake solenoid. This should be an open circuit. If a resistance is measured, replace engine brake solenoid assembly.
6. Check continuity from each engine brake solenoid to engine ground. Must be open circuit (no connection). Repair harness if required.
7. Check engine brake solenoid valve, screen, and engine brake solenoid seal rings. Replace if necessary.

Engine Brake Does Not Turn Off/Slow to Turn Off

8. Check ECM input sensors and repair if necessary.
9. 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.
10. Check for low 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

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

Engine Brake Weak in Effect or Low Braking Power

12. 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.

13. Check turbocharger for proper output. Inspect 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.

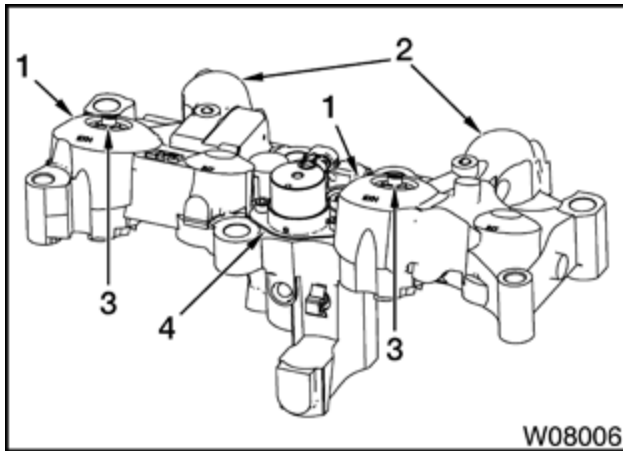


Figure 55 Engine Brake Assembly

1. Slave cylinder
 2. Master cylinder
 3. Slave cylinder adjustment screw
 4. Engine brake solenoid and spool valve
14. 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.

15. Check control valve(s) for binding in housing bore.
- Remove control valve(s). If body is scored, replace control valve. Check for contaminants in lube oil. Clean housing and control valve. If binding continues, replace housing.
16. Check control valve(s) for defects.
- Remove control valve(s). 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.
17. Check outer control valve springs for damage.

Oil Pressure Dropping Below Minimum Required for Engine Brake Operation**Engine Brake Oil Pressure Requirements**

Full Flow PSI	Over Pressure PSI
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.

18. 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 over- or underfilled with lube oil or by a problem with the engine oil pump or pickup tube.
19. 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.
20. Check engine oil level. See *Incorrect Oil Level* (page 83).

21. Check for worn engine rocker lever bushings. Replace if necessary.
22. 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

23. Check control valve inner spring for damage. Replace if necessary.
24. 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

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

Engine Brake Switch Not Working in Position 1 (cylinders 3 and 4)

NOTE: See ECB2 in "Electronic Control Systems Diagnostics" for circuit diagrams and diagnostics.

29. Check wiring between ECM 96-Pin E1 connector and ECB solenoid.

30. Check voltage at Pin E1-05.

- If voltage is 12 V, continue to next step.
- If voltage is not 12 V, check for open or short circuit.

31. Check for open or short ECB control circuit, Pin E1-47.

Engine Brake Switch Not Working in Position 2 (Cylinders 1, 2, 5, and 6)

NOTE: See ECB1 and ECB3 in "Electronic Control Systems Diagnostics" for circuit diagrams and diagnostics.

32. Check wiring between ECM 96-Pin E1 connector and ECB solenoid.

33. Check voltage at Pin E1-50 .

- If voltage is 12 V, continue to next step.
- If voltage is not 12 V, check for open or short circuit.

34. Check for open or short ECB control circuit, Pin E1-49.

Brake Piston Lash Adjustment Procedure

See *Engine Service Manual* for lash adjustment procedures.

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Diagnostics Form EGED-520

	Hard Start and No Start Diagnostics MaxxForce® 15 Beginning with 2011 Model Year	Technician _____ VIN _____ Complaint _____	Date _____ Unit No. _____ _____	ECM Calibration _____ HP Rating _____ _____	Torque _____ Engine SN _____ Transmission: Manual _____ Auto _____	Hours _____ Miles _____ _____
	Note: This form must be completed before calling for technical assistance.					

WARNING

To prevent personal injury or death, read all safety instructions in the Safety Information section of Engine Diagnostics Manual EGES-515-1 before doing form procedures.

Notes: Look up the VIN on the ISIS® network for build date, engine hp, engine serial number, ECM calibration, and transmission.

See Hard Start and No Start Diagnostics in EGES-515-1 for additional information to do each test or procedure. Record results on this form.

Do all checks in sequence unless otherwise stated. Doing a check or test out of sequence could cause incorrect results.

See EGES-515-1 Appendix A for Performance Specifications and Electronic Control Systems Diagnostics for DTCs.

1. Initial Key On Check

☐ Check Integral Digital Display for WATER IN FUEL indicator.

Comments _____

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

2. Visual Inspection

☐ Check all fluid levels.

☐ Inspect electrical connections.

☐ Inspect air filter minder.

☐ Inspect air filter.

☐ Inspect fuel filter.

☐ Inspect primary fuel filter.

Comments _____

Fuel Level Check

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

• If fuel gauge reads above empty, but tank is empty, diagnose gauge.

• If fuel tank is empty, add fuel and prime system. See Fuel System Priming in Hard Start and No Start Diagnostics.

Fuel Quality Check

☐ Route clear hose from fuel drain valve on filter housing to approved container. Open valve and fill.

☐ Check for water, waxing, silt, sediment, gasoline, or kerosene.

Comments _____

• If fuel quality is questionable, correct problem. Take a sample to verify fuel quality is satisfactory.

3. EST Connection and Data Recording

☐ Use ServiceMax™ software to record KEOED pressure and temperature values.

Note: Ideally, allow the engine to cold soak for at least 2 hours before recording results.

Sensor	Spec.	Actual
Air Inlet Temp	-	-
Engine Coolant Temp1	-	-
Engine Coolant Temp2	-	-
Engine Oil Temp	-	-
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 is out of specification, go to suspect sensor in Electronic Control Systems Diagnostics.

☐ Use ServiceMax™ software to run Actuator Test and record position values at 5% and 95%.

Signal	5%	95%
ECR Valve Position	-	-
Engine Throttle Position	-	-

• If signal is out of specification, go to suspect actuator in Electronic Control Systems Diagnostics.

☐ Monitor DPF status signal value.

DPF Status _____

• If DPF status is "Rigen needed-critical level", disconnect exhaust system upstream of Pre-DOC and attempt to start engine.

4. Check for DTCs

☐ Use ServiceMax™ software to record DTCs.

Active and Pending	Previously Active and Healing	SPN/FMI	SPN/FMI

• Correct any active and pending DTCs. See Electronic Control Systems Diagnostics.

• Investigate previously active DTCs with high counts.

5. Engine Cranking

Note: If, under normal operation, engine is subjected to temperatures below 10°C (50°F), go to Cold Start Assist System. If engine is subjected to temperatures greater than 10°C (50°F), proceed with Engine Cranking test.

☐ Use ServiceMax™ software to open Hard Start No Start System.

☐ Press record and start cranking engine for a maximum of 10 seconds.

Sensor	Spec.	Actual
Switched Battery (min)	10.5 V	-
Engine Speed	130 rpm	-
Fuel Delivery Pressure	30 psi	-
Fuel Rail Pressure	3771 psi	-
TC1 Turbine Outlet Pressure	<5 psi	-
DPF Differential Pressure	0 psi	-

• If SWBAT drops below specification, check cranking voltage at batteries using DMM. If not okay, check batteries and charging system, correct battery charger, and reset.

• If no rpm signal is present, see CMP Sensor and CMP Sensor 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.

• If FRP is within specification but FRP is below specification, go to High-Pressure Fuel System.

• If TC1 Turbine Outlet Pressure is above specification, open exhaust just before Pre-DOC and try to start engine. If engine starts, see AFT System in Electronic Control Systems Diagnostics.

• If a problem is not found after completing all of the above test steps, open a case file, attach Diagnostic results, and ServiceMax™ recorded file. Call tech support.

Special Test Procedures

Low Pressure Fuel System

Fuel System Priming

Note: Verify fuel level before priming.

☐ Pump fuel primer pump until fuel fills the system.

• If fuel does not pull from fuel tank, check for restricted or open supply line.

• If supply line is not restricted or open, replace primer pump.

Fuel Delivery Pressure (FDP) Test

☐ Remove FDP sensor and install Manual Oil Pressure Test Tool.

☐ Connect Pressure Test Kit to Manual Oil Pressure Test Tool.

☐ Crank engine while monitoring FDP.

Signal	Spec.	Actual
Fuel Delivery Pressure	30 psi	-

☐ Compare current FDP readings to FDP readings from Engine Cranking Test.

• If current FDP reading does not closely resemble previous FDP reading, go to FDP Sensor in "Electronic Control Systems Diagnostics."

• If FDP stays consistent, continue to next step.

☐ With engine OFF, disconnect fuel supply line at LP fuel pump inlet and cap off supply line.

☐ Connect Clean Fuel Source Tool to LP fuel pump inlet.

☐ Use Clean Fuel Source Tool to prime fuel system.

☐ Crank engine while monitoring FDP.

Signal	Spec.	Actual
Fuel Delivery Pressure	30 psi	-

• If FDP drops below specification, go to Fuel Dead Head Test.

• If FDP stays within specification, go to Fuel Aeration and Restriction Test.

Fuel Dead Head Test

☐ Retain Clean Fuel Source Tool connection to LP fuel pump inlet.

☐ Disconnect fuel line from LP fuel pump outlet and connect Fuel Inlet Restriction/Aeration Tool.

☐ Use compy check fitting to connect Pressure Test Kit to Fuel Inlet Restriction/Aeration Tool.

☐ Connect Fuel Block Off Tool to Fuel Inlet Restriction/Aeration Tool.

☐ Use Clean Fuel Source Tool to prime fuel system.

☐ Crank engine until fuel pressure stabilizes or up to a maximum of 20 seconds.

Gauge	Specification	Actual
LP Fuel Pump Pressure	130-189 psi	-

• If pressure is within specification, inspect engine mounted fuel filter and housing for defects or damage. If no defect or damage is found, go to High-Pressure Fuel System.

• If pressure is below specification, replace fuel pump. Refer to Engine Service Manual for replacement procedure and perform HP Pump Fuel Pressure Test in Hard Start and No Start Diagnostics.

HP Pump Fuel Return Pressure Test

☐ Restore fuel system to normal operating condition and disconnect HP fuel pump return line.

☐ Use Fuel Line Coupler to connect HP fuel pump return line to Fuel Inlet Restriction/Aeration Tool.

☐ Connect Pressure Test Kit to compy check fitting on Fuel Aeration/Restriction Tool.

☐ Start engine and run at high idle while monitoring Pressure Test Kit.

Gauge	Specification	Actual
Fuel Pressure	13 psi	-

• If above specification, inspect fuel return line between HP Pump and fuel tank for restriction.

• If pressure is less than specification, no further action is required.

Fuel Aeration and Restriction

Aeration Test

Note: See Figure 1 for Aeration Test Diagram.

☐ Remove Clean Fuel Source Tool from LP fuel pump inlet.

☐ Connect Fuel Inlet Restriction/Aeration Tool between LP pump outlet and fuel supply line to secondary filter using Fuel Line Coupler.

☐ Prime fuel system to remove air from lines.

☐ Crank engine while visually monitoring for fuel aeration.

• If fuel is not aerated, go to Restriction Test.

• If fuel is aerated, connect Clean Fuel Source Tool to primary filter inlet (Test Point 2).

☐ Prime fuel system to remove air from lines.

☐ Crank engine while visually monitoring for fuel aeration.

• If fuel is not aerated, repair open in supply line from primary filter to fuel tank.

• If fuel is aerated, repair open in LP fuel pump supply line or primary filter.

• If restriction is above specification and engine is equipped with Davco primary filter, go to Restriction Test Point 3.

Restriction Test

Note: See Figure 2 for Restriction Test Diagram.

Gauge Reading	Specification	Actual
Fuel restriction	19 in. Hg (max.)	-

☐ Connect Fuel Inlet Restriction/Aeration Tool to LP pump fuel supply line using Fuel Line Coupler.

☐ Connect Fuel Inlet Restriction/Aeration Tool to LP pump inlet using Fuel Outlet Fitting.

☐ Connect Pressure Test Kit vacuum gauge to Fuel Inlet Restriction/Aeration Tool.

☐ Prime fuel system to remove air from lines.

☐ Crank engine while monitoring vacuum gauge.

• If restriction is within specification, High-Pressure Fuel System Tests.

• If restriction is above specification and engine is equipped with Davco primary filter, go to Restriction Test Point 3.

Restriction Test Point 2

Gauge Reading	Specification	Actual
Fuel restriction	19 in. Hg (max.)	-

☐ Connect Clean Fuel Source Tool to primary filter inlet.

☐ Prime fuel system to remove air from lines.

☐ Crank engine while monitoring vacuum gauge.

• If restriction is within specification, repair restriction in supply line between primary filter and fuel tank.

• If restriction is above specification, repair or replace primary filter and check fuel lines.

Restriction Test Point 3

Gauge Reading	Specification	Actual
Fuel restriction	19 in. Hg (max.)	-

☐ Connect Clean Fuel Source Tool to primer pump inlet.

☐ Prime fuel system to remove air from lines.

☐ Crank engine while monitoring vacuum gauge.

• If restriction is within specification, go to test point 2.

• If restriction is above specification, repair or replace primer pump and check fuel lines. Reset with original fuel lines installed to verify condition is corrected.

High Pressure Fuel System

Fuel Rail Pressure (FRP) Circuit Test

☐ Disconnect FRP sensor electrical connector and attempt to start engine.

• If engine starts, diagnose FRP sensor circuits. Go to FRP Sensor in Electronic Control Systems Diagnostics.

• If engine does not start, reconnect FRP sensor and go to High-Pressure Pump Inlet Pressure Test.

High-Pressure Pump Inlet Pressure Test

☐ Disconnect fuel supply to DSI valve assembly.

☐ Use Fuel Line Coupler to connect Fuel Inlet Restriction/Aeration Tool to DSI fuel supply line.

☐ Connect Fuel Block Off Tool to Fuel Inlet Restriction/Aeration Tool.

☐ Connect Pressure Test Kit to Fuel Inlet Restriction/Aeration Tool.

☐ Crank engine while monitoring Pressure Test Kit.

Gauge Reading	Spec.	Actual
Inlet Pressure	30 psi	-

• If gauge pressure is within specification, go to High-Pressure Fuel Return Flow Test.

• If gauge pressure is lower than specification, replace secondary fuel filter and reset. Go to High-Pressure Fuel Return Flow Test.

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Figure 56 Diagnostics Form EGED-520 (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 for 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 (DTCs) and engine specifications.

Diagnostics Form EGED-520 is available in 50-sheet pads. To order technical service literature, contact your International dealer.

Diagnostics Form Header Information

Technician _____	Date _____	ECM Calibration _____	Torque _____	Hours _____
VIN _____	Unit No. _____	HP Rating _____	Engine SN _____	Miles _____
Complaint _____	Transmission: Manual _____ Auto _____			
Note: This form must be completed before calling for technical assistance.				

W00265

1. Fill in the following diagnostics form header information:

- Technician
- Date
- Unit No. (dealer's quick reference number)

- Vehicle Identification Number (VIN)
- Complaint (driver interview)

NOTE: Remaining header 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 a cold start problem, verify that the Cold Start Assist is working before continuing. See Cold Start Assist System Test (page 130).



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

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 illuminated, go to Fuel Quality Check (page 108).

2. Visual Inspection

Purpose

Check all fluid levels and inspect engine systems for problems (leaks, open connections, harness chafing, etc.).

Tools

None

Engine Oil

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

NOTE: American Petroleum Institute (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.

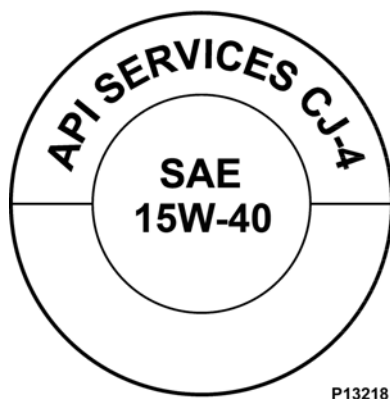


Figure 58 Lube oil requirements label

2. Use oil level gauge (dipstick) to verify engine oil level.

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

3. Record results on Diagnostics Form.
 - If oil level is below specification, inspect for leaks, oil consumption, or improper servicing. Repair as necessary and fill to specification.

- If oil level is above specification, inspect for fuel dilution, coolant contamination, or improper servicing. Repair as necessary and drain to proper level.

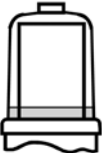
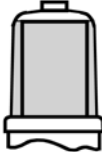
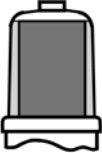
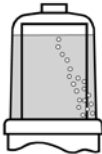
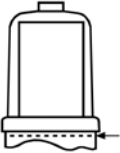
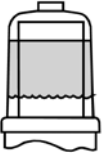
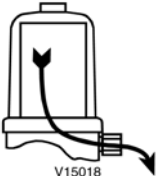
Fuel Level

! 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.
 - If fuel gauge reads above empty, but tank is empty, diagnose instrument panel fuel gauge. Verify fuel level is within specification before diagnosing a pressure problem.
 - If fuel tank is empty, add fuel and prime fuel system. See Fuel System Priming (page 117).

Davco® Fuel Filter Inspection

Visually inspect Davco® chassis-mounted fuel filter following the inspection table on the next page. If not equipped with a Davco® chassis-mounted fuel filter, continue to next test.

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.	Change fuel filter element.
 V15014	Fuel level is to top of fuel filter and looks to be full of wax.	1. Change 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 fuel filter assembly. 2. Check upper and lower connector O-rings.
 V15016	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 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 fuel filter assembly. NOTE: Do not drain with engine running. 3. Restart engine. Shut off engine and drain 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 following procedures in <i>Engine Service Manual</i>. 2. Repair (clean) or replace as necessary and retest.

Fuel Quality Check

Purpose

Check for poor fuel quality or for contaminants.

Tools

Clear diesel fuel container

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, shift transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.

NOTE: Ultra-Low Sulfur Diesel (ULSD) fuel is required for MaxxForce® 15L Diesel Engines with advanced aftertreatment systems.



Figure 59 Fuel requirements label

NOTE: WATER IN FUEL indicator on Integral Digital Display should cycle ON, and then OFF, if there is no water in fuel system. WATER IN FUEL indicator will stay ON if water is detected.

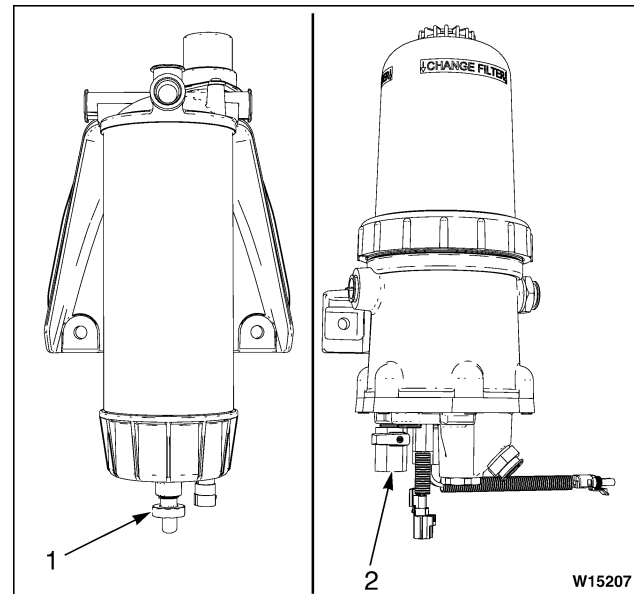


Figure 60 Fuel drain valves

1. Drain valve (Racor®)
2. Drain valve (Davco®)

1. Place clear diesel fuel container under fuel drain valve.
2. Open fuel drain valve to fill clear diesel fuel container.

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

NOTE: If fuel does not flow, crank engine.

3. Check for water, waxing, icing, sediment, gasoline, or kerosene by shaking fuel sample container and letting contents settle.
 - 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 next test.

Engine Coolant Level

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

1. Park vehicle on level ground.
2. Check coolant level as indicated on deaeration tank level window.

NOTE: Coolant that has leaked into exhaust system (wet exhaust) could damage the Diesel Particulate Filter (DPF). Inspect DPF for damage. See Coolant Leak to Exhaust (page 73) in "Engine Symptoms Diagnostics."

3. Record results on Diagnostics Form.
 - If level is below deaeration tank fill level, inspect for external leaks, internal leaks to other engine systems, or improper servicing. See "Engine Symptoms Diagnostics" if internal leak is suspected.
 - If level is above deaeration tank fill level, inspect for oil in coolant, fuel in coolant, or improper servicing.
 - If coolant is contaminated, determine contaminant, diagnose cause, repair as necessary, and replace coolant. See "Engine Symptoms Diagnostics."

Charge Air Cooler (CAC) System

1. Inspect the CAC, Interstage Cooler (ISC), and all piping for leaks.
2. Inspect all CAC connections and clamps.
 - If CAC system problem is found, make necessary repairs. See ISC Leak Test in "Engine Symptoms Diagnostics."

Electrical System

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

Intake Air

NOTE: Intake air restriction should be less than 3.3 kPa (13.4 inH₂O) at full engine load and rated speed.

1. Inspect air filter gauge located on air filter housing or dashboard.
 - If gauge indicates air filter needs replaced, verify there are no other restrictions in the air inlet or filter housing before replacing air filter.

Exhaust System

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

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

Purpose

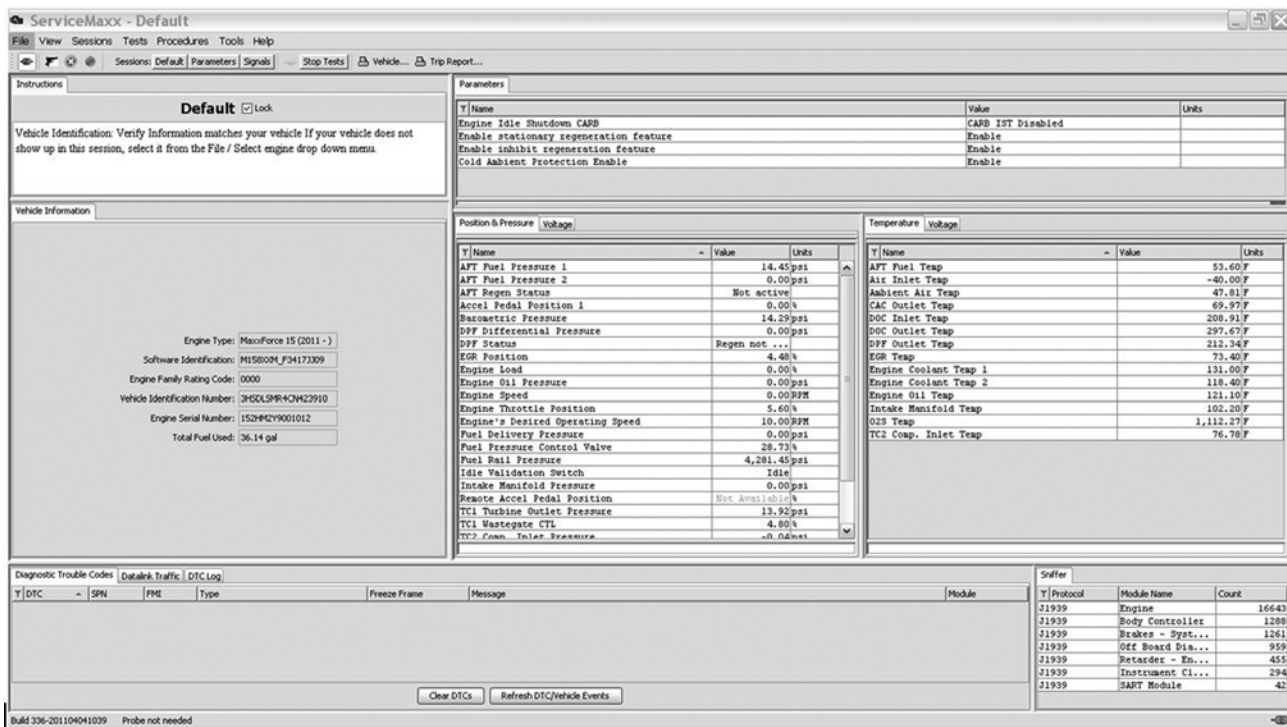
Check ECM software, sensor signals, and Diagnostic Trouble Codes (DTCs) and record additional vehicle information on Diagnostics Form.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

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 and no problems are found using the *ServiceMaxx™ Users Guide*, go to J1939 Data Link Communications in "Electronic Control Systems Diagnostics."



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Figure 61 ServiceMaxx™ software startup screen – vehicle connected

- Verify the following vehicle information matches the displayed information in ServiceMaxx™ software and record on Diagnostics Form:

- Engine Type
- Software Identification
- Engine Family Rating Code (EFRC)
- Vehicle Identification Number (VIN)
- Engine Serial Number (ESN)
- Total Fuel Used

NOTE: The engine serial number is located on the lower left side of the crankcase above the oil pan flange.

- Record the following Key ON, Engine OFF (KOE) temperature sensor values on the Diagnostics Form:

- Air Inlet Temperature (AIT)

- Engine Coolant Temperature (ECT1)
- Engine Oil Temperature (EOT)

- Record the following KOEO pressure and flow sensor values on the 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. Run Actuator Test and record the following position values at 5% and 95% duty cycles on the Diagnostics Form:
 - Exhaust Gas Recirculation Valve Position (EGRVP)
 - Engine Throttle Position (ETP)
9. Look for sensor values that are out of specification. A sensor out of specification could cause air management problems.
 - If sensor is out of specification, go to the suspect sensor in "Electronic Control Systems Diagnostics."
10. Record DPF status signal value on the Diagnostics Form.
 - If DPF status is "Regen needed – critical level," disconnect exhaust system upstream of Pre-DOC and attempt to start engine.

4. Check for Diagnostic Trouble Codes (DTCs)

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

- SPN – Identifies the individual component causing the DTC.
- FMI – Identifies the fault or condition affecting the individual component.
- Pending DTCs are possible emission faults that were detected on the first drive cycle.
- Active DTCs are codes that are currently active.
- Previously Active DTCs are historical codes that may be caused by intermittent signals or an operating condition that is not currently present.

Purpose

Identify DTCs.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

Procedure

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

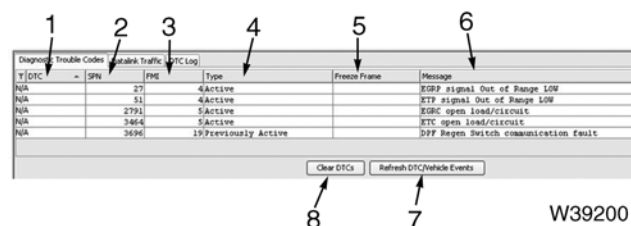


Figure 62 DTC window

1. DTC column (pre-2010)
 2. SPN column
 3. FMI column
 4. Type column
 5. Freeze Frame column
 6. Message column
 7. Refresh DTC/Vehicle Events button
 8. Clear DTCs button
4. Record DTCs and Freeze Frame Data on Diagnostics Form.
 5. Correct any active DTCs. See “Electronic Control Systems Diagnostics.”
 - Investigate previously active DTCs with high counts.

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
- NAVCoM or NAVLink Interface Kit
- Digital Multimeter (DMM)

Procedure

NOTE: If, under normal operation, engine is subjected to temperatures below 10°C (50°F), go to Cold Start Assist System Test (page 130). If engine is subjected to temperatures greater than 10°C (50°F), proceed with Engine Cranking test.

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 from the Sessions drop-down menu.

Signals: Volts			
T	Name	Value	Units
	Engine Speed	138.00	RPM
	Fuel Delivery Pressure	37.71	psi
	Fuel Rail Pressure	12,915.16	psi
	Fuel Rail Pressure Desired	12,127.08	psi
	TC1 Turbine Outlet Pressure	14.21	psi

W39211

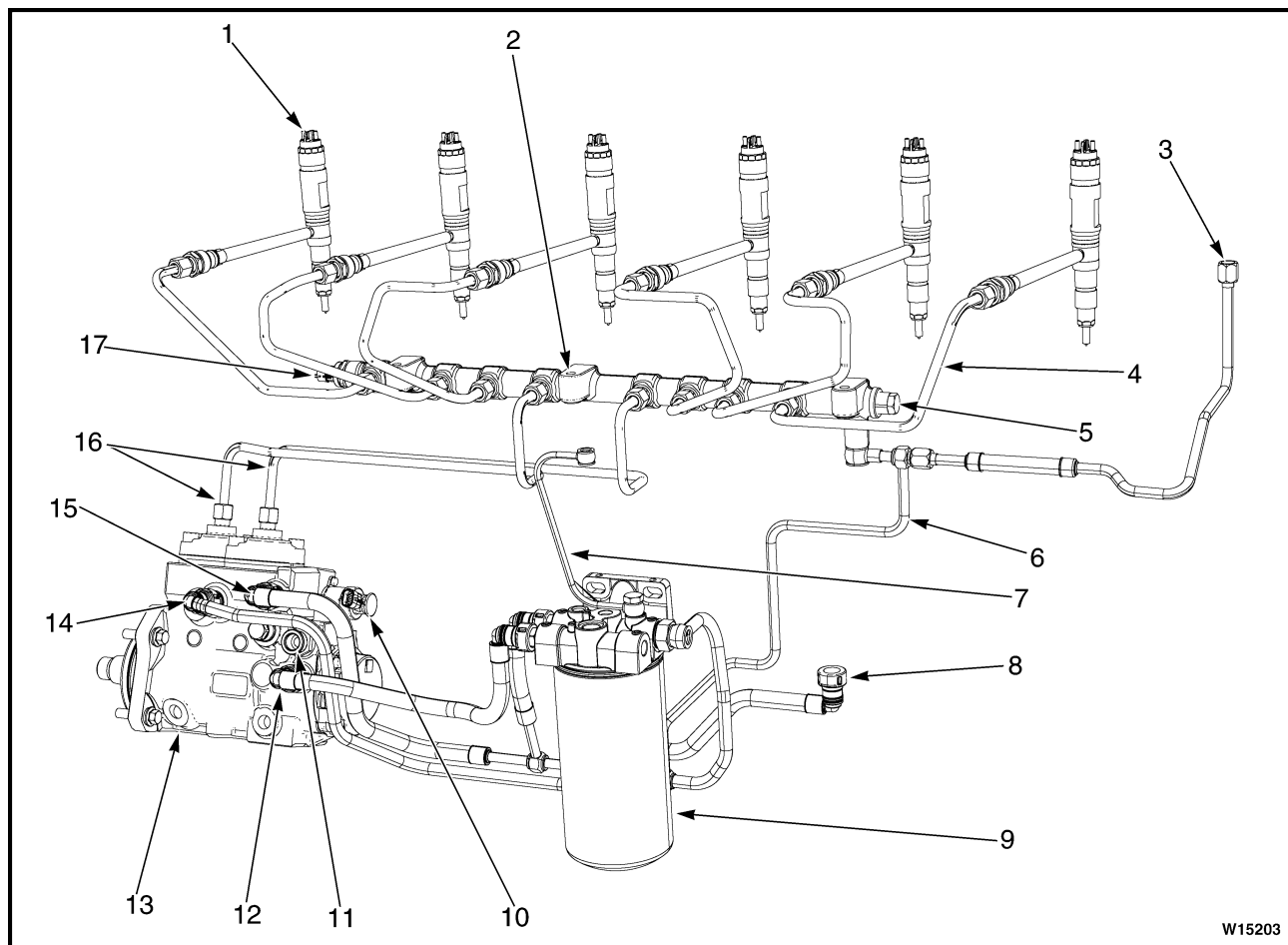
Figure 63 Hard Start – No Start session signals

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.

5. Crank engine for a maximum of 10 seconds while monitoring the following signals:
 - Switched Battery (SWBAT)
 - Engine Speed (RPM)
 - Fuel Delivery Pressure (FDP)
 - Fuel Rail Pressure (FRP)
 - TC1 Turbine Outlet Pressure (TC1TOP)
 - DPF Differential Pressure (DPFDP)
6. Record cranking results on the Diagnostics Form.
 - If SWBAT voltage drops below specification, continue to step 8.
 - If Engine Speed remains at 0.00 rpm with engine rotating, see CKP Sensor and CMP Sensor 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 117).
 - If FDP is within specification but FRP is below specification, go to High-pressure Fuel System (page 125).
 - If TC1TOP is above specification, continue to next step.
 - If DPFDP is not within specification, go to AFT System in “Electronic Control Systems Diagnostics.”
7. Disconnect exhaust just before Pre-Diesel Oxidation Catalyst (PDOC) following procedures in the *Engine Service Manual*. Try to start engine.
 - If engine starts, see AFT System in “Electronic Control Systems Diagnostics” for restricted PDOC or Diesel Particulate Filter (DPF).
8. Connect DMM to battery and monitor voltage during engine cranking.
 - If voltage drops below specification, check batteries and starting system. Connect battery charger and repeat test.
 - If voltage stays within specification, go to ECM Power in “Electronic Control Systems Diagnostics.”

Special Test Procedures

Fuel System



W15203

Figure 64 Fuel system

1. Injector (6)	7. Fuel supply to cold start assist system	12. Low-pressure fuel pump outlet
2. Fuel rail	8. Fuel supply to Down Stream Injection (DSI) assembly	13. Fuel pump
3. Fuel return tube assembly (from injectors)	9. Fuel filter (engine-mounted)	14. High-pressure fuel pump return
4. High-pressure rail to injector tube (6)	10. Fuel Pressure Control Valve (FPCV)	15. High-pressure fuel pump inlet
5. Fuel rail pressure relief valve	11. Low-pressure fuel pump inlet	16. High-pressure fuel rail supply lines
6. Fuel injector return line		17. Fuel Rail Pressure (FRP) sensor

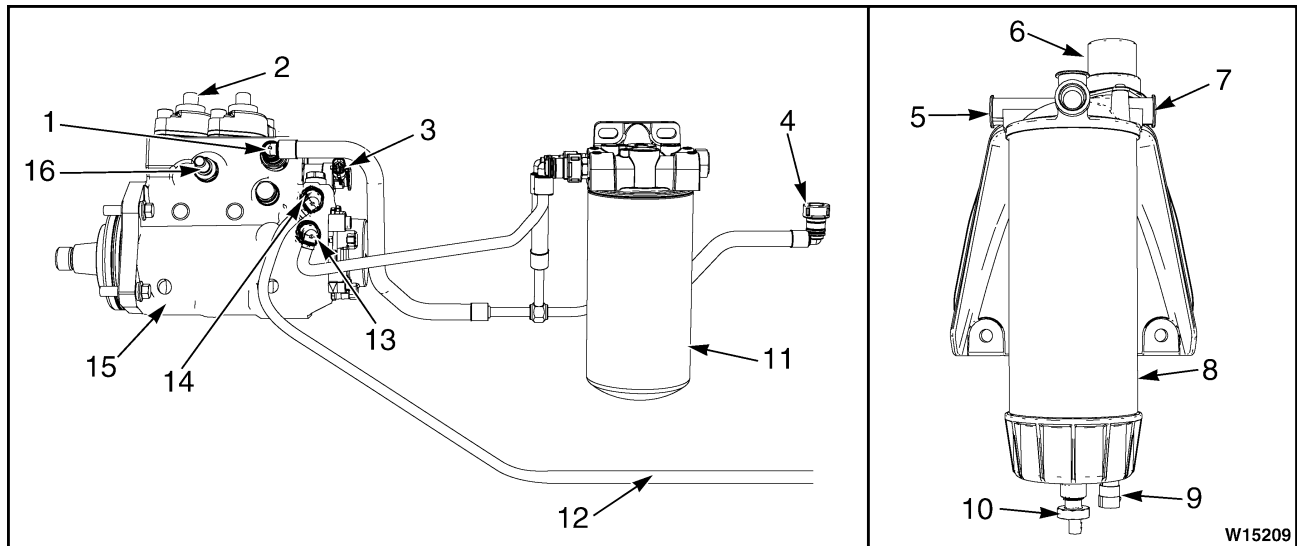
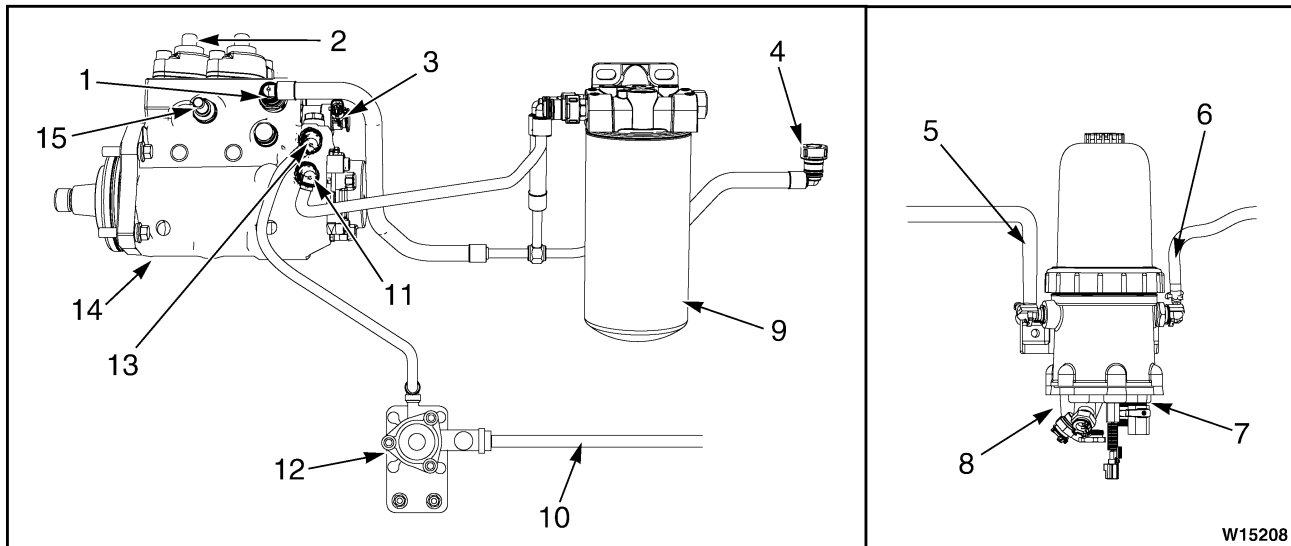


Figure 65 Fuel system with Racor® fuel filter assembly (chassis-mounted)

1. High-pressure fuel pump inlet
2. High-pressure fuel rail supply
3. Fuel Pressure Control Valve (FPCV)
4. Fuel supply to Down Stream Injection (DSI) assembly
5. Fuel outlet
6. Fuel primer pump assembly
7. Fuel supply from tank
8. Fuel filter water separator assembly
9. Water In Fuel (WIF) sensor
10. Drain valve
11. Fuel filter (engine-mounted)
12. Fuel supply from chassis-mounted filter
13. Low-pressure fuel pump outlet
14. Low-pressure fuel pump inlet
15. Fuel pump
16. High-pressure fuel pump return



W15208

Figure 66 Fuel system with Davco® fuel filter assembly (chassis-mounted)

1. High-pressure fuel pump inlet
2. High-pressure fuel rail supply
3. Fuel Pressure Control Valve (FPCV)
4. Fuel supply to Down Stream Injection (DSI) assembly
5. Fuel outlet
6. Fuel supply from tank
7. Fuel return to tank
8. Drain valve
9. Fuel filter (engine-mounted)
10. Fuel supply from chassis-mounted fuel filter
11. Low-pressure fuel pump outlet
12. Fuel primer pump assembly
13. Low-pressure fuel pump inlet
14. Fuel pump
15. High-pressure fuel pump return

Low-pressure 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.

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

Fuel System Priming

Purpose

Prime the fuel system.

Tools

None

Procedure

1. Verify there is fuel in fuel tank(s). See Fuel Level Check.
2. Pump fuel primer pump assembly until fuel fills the system.
 - If fuel does not pull from fuel tank, go to Fuel Aeration and Restriction Tests (page 121).

NOTE: The Davco® chassis-mounted fuel filter has a separate chassis-mounted primer pump assembly. The Racor® chassis-mounted fuel filter has a primer pump on top of the filter housing.

Fuel Delivery Pressure (FDP) Test

Purpose

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

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit
- 15-637-01 – Clean Fuel Source Tool
- ZTSE4409 – Pressure Test Kit
- ZTSE4891 – Air Cap, Fuel Cap, and Plug Kit
- ZTSE6091 – Manual Oil Pressure Test Tool

Procedure

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

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

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

NOTE: Ensure fuel lines are clear of debris before disconnecting fuel lines.

1. With engine OFF, remove FDP sensor and install Manual Oil Pressure Test Tool.
2. Connect Pressure Test Kit to Manual Oil Pressure Test Tool.
3. Crank engine while using Pressure Test Kit to monitor FDP.

4. Compare current FDP readings to FDP readings from the Engine Cranking test.
 - If current FDP reading does not closely resemble previous FDP reading, go to FDP Sensor in "Electronic Control Systems Diagnostics."
 - If FDP stays consistent, continue to next step.
5. With engine OFF, disconnect fuel supply line at low-pressure fuel pump inlet and cap it off using Air Cap, Fuel Cap, and Plug Kit.

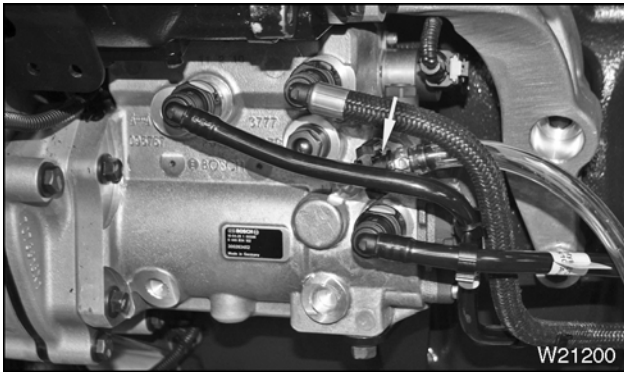


Figure 67 Clean Fuel Source Tool connected to low-pressure fuel pump inlet

6. Connect Clean Fuel Source Tool to low-pressure fuel pump inlet.
7. Use Clean Fuel Source Tool to prime fuel system.
 - a. Close the ball valve on the Clean Fuel Source Tool fuel supply line.
 - b. Fully squeeze the primer bulb on the Clean Fuel Source Tool. 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 fuel supply line.
8. Crank engine while using ServiceMaxx™ software to monitor FDP.
 - If FDP is below specification, go to Fuel Dead Head Test (page 118).
 - If FDP is within specification, go to Fuel Aeration and Restriction Tests (page 121).

Fuel Dead Head Test

Purpose

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

Tools

- Compucheck fitting – Star Products part # TU-32-25
- 15-637-01 – Clean Fuel Source Tool
- ZTSE4409 – Pressure Test Kit
- ZTSE4886 – Fuel Inlet Restriction / Aeration Tool
- ZTSE4905 – Fuel Block Off Tool

Procedure

1. Retain connection between Clean Fuel Source Tool and low-pressure fuel pump inlet from previous test.

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

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

2. Disconnect fuel line from low-pressure fuel pump outlet.

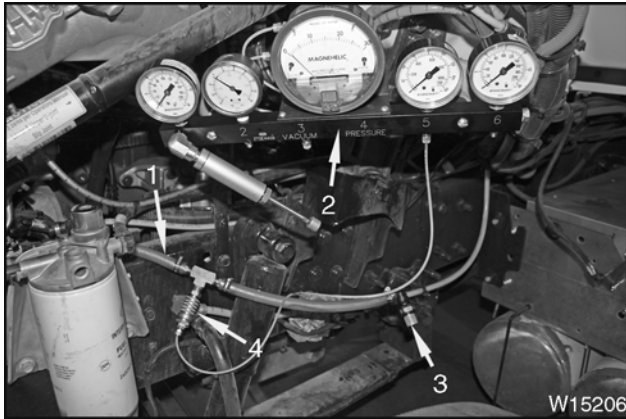


Figure 68 Fuel Inlet Restriction / Aeration Tool connected to low-pressure fuel pump outlet

1. Fuel Inlet Restriction / Aeration Tool
 2. Pressure Test Kit
 3. Fuel Block Off Tool
 4. CompucHECK fitting
3. Connect Fuel Inlet Restriction / Aeration Tool to low-pressure fuel pump outlet.
 4. Use compucHECK fitting to connect Pressure Test Kit to Fuel Inlet Restriction / Aeration Tool.
 5. Connect Fuel Block Off Tool to Fuel Inlet Restriction / Aeration Tool.

6. Use Clean Fuel Source Tool to prime fuel system.
 - a. Close the ball valve on the Clean Fuel Source Tool fuel supply line.
 - b. Fully squeeze the primer bulb on the Clean Fuel Source Tool. 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 fuel supply line.
7. Crank engine while monitoring Pressure Test Kit. Continue monitoring until fuel pressure stabilizes or for a maximum of 20 seconds.
 - If pressure is within or above specification, inspect engine-mounted fuel filter and housing for defects or damage. If no defect or damage is found, go to High-pressure Fuel System (page 125).
 - If pressure is below specification, replace fuel pump following procedures in the *Engine Service Manual*. To prevent damage to a newly installed fuel pump, perform HP Pump Fuel Return Pressure Test (page 120) any time fuel pump is replaced.

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

HP Pump Fuel Return Pressure Test

Purpose

Prevent damage to newly installed fuel pump.

Tools

- Compuccheck fitting – Star Products part # TU-32-25
- 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.

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

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

2. Disconnect high-pressure fuel pump return line.

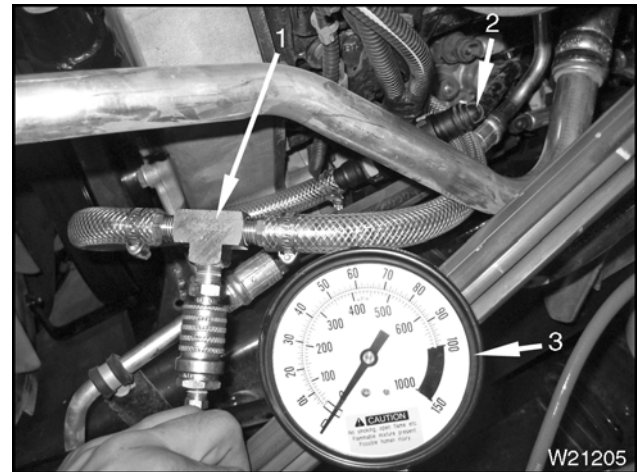


Figure 69 High-pressure fuel pump return line connected to Fuel Pressure Gauge

1. Fuel Inlet Restriction / Aeration Tool
 2. High-pressure fuel pump return line
 3. Fuel Pressure Gauge
3. Use Fuel Line Coupler to connect high-pressure fuel pump return line to Fuel Inlet Restriction / Aeration Tool.
 4. Use compuccheck fitting to connect Fuel Inlet Restriction / Aeration Tool to Fuel Pressure Gauge.
 5. Start engine and run at high idle while monitoring Fuel Pressure Gauge.
 - If pressure is above 89.6 kPa (13 psi), inspect fuel return line between high-pressure fuel pump and fuel tank for restriction.
 - If pressure is less than 89.6 kPa (13 psi), no further action is required.

Fuel Aeration and Restriction Tests

Aeration Test

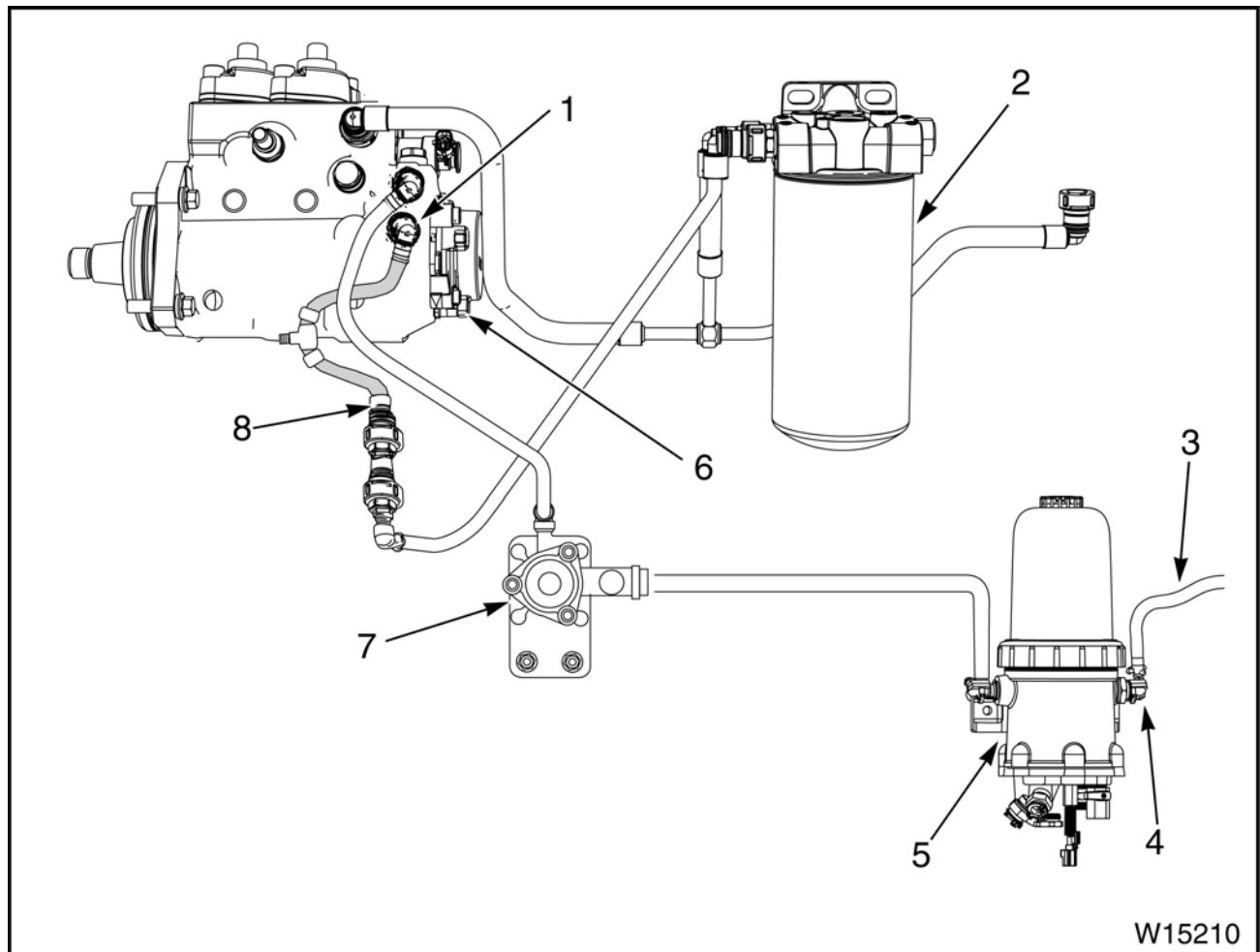


Figure 70 Aeration test diagram

1. Test point 1	4. Test point 2	7. Low-pressure fuel pump
2. Engine-mounted fuel filter	5. Chassis-mounted fuel filter	8. Fuel Inlet Restriction / Aeration Tool
3. Fuel supply from tank	6. Primer pump	

Purpose

Check for fuel aeration.

Tools

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

Procedure

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

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

1. Remove Clean Fuel Source Tool from low-pressure fuel pump inlet.
2. Use Fuel Line Coupler to connect Fuel Inlet Restriction / Aeration Tool between fuel supply line to engine-mounted fuel filter and low-pressure fuel pump outlet.
3. Prime fuel system to remove air from lines.
4. Crank engine while visually monitoring for fuel aeration (air bubbles passing through clean line).
 - If fuel is not aerated, go to Restriction Test.
 - If fuel is aerated, continue to next step.
5. Connect Clean Fuel Source Tool to chassis-mounted fuel filter inlet (test point 2).
6. Prime fuel system to remove air from lines.
7. Crank engine while visually monitoring for fuel aeration (air bubbles passing through clean line).
 - If fuel is not aerated, repair open in fuel supply line from chassis-mounted fuel filter to fuel tank.
 - If fuel is aerated, repair open in low-pressure fuel pump supply line or chassis-mounted fuel filter.

Restriction Test

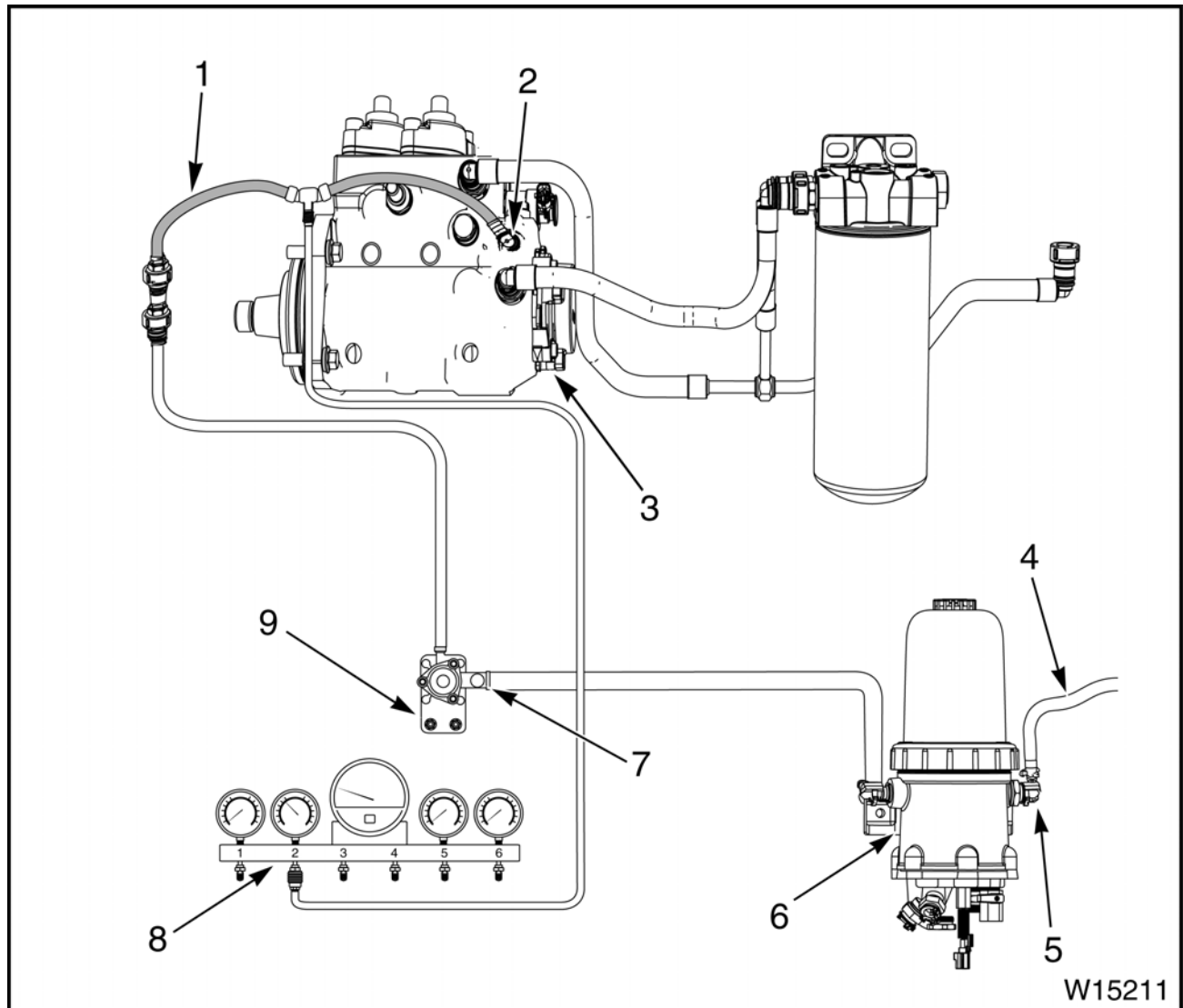


Figure 71 Restriction test diagram

1. Fuel Inlet Restriction / Aeration Tool	4. Fuel supply from tank	8. Pressure Test Kit
2. Test point 1	5. Test point 2	9. Primer pump
3. Low-pressure fuel pump	6. Chassis-mounted fuel filter	
	7. Test point 3	

Purpose

Check for fuel supply restriction.

Tools

- Compucheck fitting – Star Products part # TU-32-25
- 15-637-01 – Clean Fuel Source Tool
- ZTSE4409 – Pressure Test Kit
- ZTSE4886 – Fuel Inlet Restriction / Aeration Tool
- ZTSE4906 – Fuel Line Coupler
- ZTSE6124 – Fuel Outlet Fitting

Procedure

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



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

1. Use Fuel Line Coupler to connect Fuel Inlet Restriction / Aeration Tool to low-pressure fuel pump supply line.
2. Use Fuel Outlet Fitting to connect Fuel Inlet Restriction / Aeration Tool to low-pressure fuel pump inlet.
3. Use compucheck fitting to connect Pressure Test Kit vacuum gauge to Fuel Inlet Restriction / Aeration Tool.
4. Prime fuel system to remove air from lines.
5. Crank engine while monitoring Pressure Test Kit vacuum gauge.
 - If restriction is within specification, go to High-pressure Fuel System.
 - If restriction is above specification and engine is equipped with a Racor® chassis-mounted fuel filter, go to Restriction Test Point 2.

- If restriction is above specification and engine is equipped with a Davco® chassis-mounted fuel filter, go to Restriction Test Point 3.

NOTE: The Davco® chassis-mounted fuel filter has a separate chassis-mounted primer pump assembly. The Racor® chassis-mounted fuel filter has a primer pump on top of the filter housing.

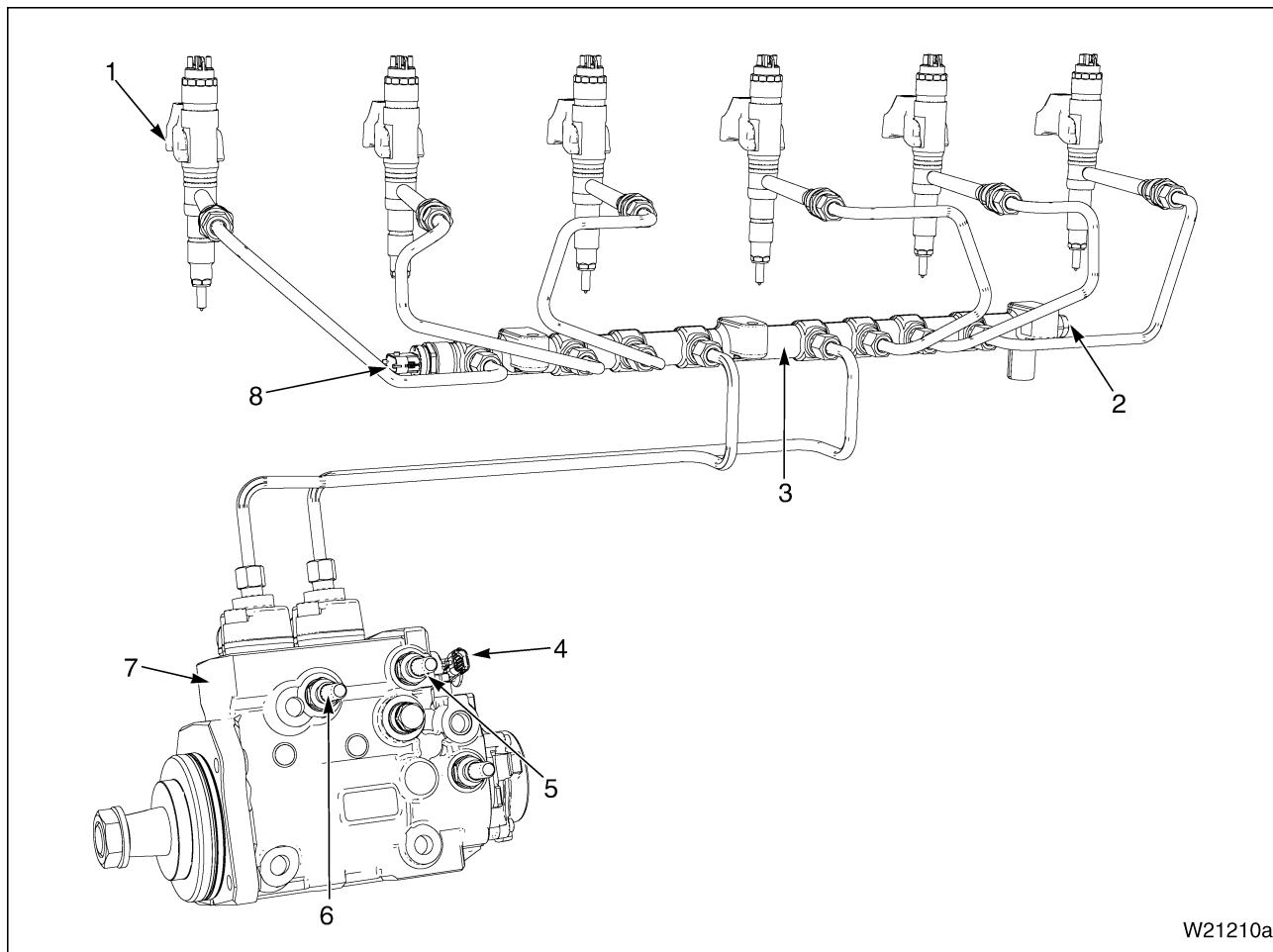
Restriction Test Point 2

1. Connect Clean Fuel Source Tool to chassis-mounted fuel filter inlet.
2. Prime fuel system to remove air from lines.
3. Crank engine while monitoring Pressure Test Kit vacuum gauge.
 - If restriction is within specification, repair restriction in fuel supply line between chassis-mounted fuel filter and fuel tank.
 - If restriction is above specification, repair or replace chassis-mounted fuel filter and check fuel lines.

Restriction Test Point 3

1. Connect Clean Fuel Source Tool to primer pump inlet.
2. Prime fuel system to remove air from lines.
3. Crank engine while monitoring vacuum gauge.
 - If restriction is within specification, go to Restriction Test Point 2.
 - If restriction is above specification, repair or replace primer pump and check fuel lines. Retest with original fuel lines installed to verify condition is corrected.

High-pressure Fuel System



W21210a

Figure 72 High-pressure fuel system

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

Fuel Rail Pressure (FRP) Circuit Test**Purpose**

Verify whether FRP sensor is biased.

Tools

None

Procedure

1. Disconnect FRP sensor electrical connector and attempt to start engine.
 - If engine starts, diagnose FRP sensor circuits. See FRP Sensor 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 supplied with sufficient pressure.

Tools

- CompucHECK fitting – Star Products part # TU-32-25
- ZTSE4681 – Fuel Pressure Gauge
- ZTSE4886 – Fuel Inlet Restriction / Aeration Tool
- ZTSE4905 – Fuel Block Off Tool

- ZTSE4906 – Fuel Line Coupler

Procedure

 **WARNING:** To prevent personal injury or death, engine must be OFF for at least 5 minutes before doing any work on high-pressure fuel system to allow for system depressurization.

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

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

1. Disconnect fuel supply line to Down Stream Injection (DSI) valve assembly.
2. Use Fuel Line Coupler to connect Fuel Inlet Restriction / Aeration Tool to DSI fuel supply line.
3. Connect Fuel Block Off Tool to Fuel Inlet Restriction / Aeration Tool.
4. Use compucHECK fitting to connect Fuel Pressure Gauge to Fuel Inlet Restriction / Aeration Tool.
5. Crank engine while monitoring Fuel Pressure Gauge.
 - If gauge pressure is within specification, go to High-pressure Fuel Return Flow Test.
 - If gauge pressure is below specification, replace engine-mounted fuel filter and retest. Go to High-pressure Fuel Return Flow Test.

High-pressure Fuel Return Flow Test

Purpose

Verify fuel return flow is within specifications.

Tools

- 90 degree elbow with swivel - Dixon part # 166FSV-6-6
- Clean plastic hose
- Diesel fuel container
- Tube fitting cap - McMaster-Carr part # 5482K69
- ZTSE4887-2 – High-pressure Return Line Tester
- ZTSE6094-1 – Fuel Pressure Return Connector

Procedure

NOTE: Before running this test, ensure low-pressure fuel system is operating correctly.

! WARNING: To prevent personal injury or death, engine must be OFF for at least 5 minutes before doing any work on high-pressure fuel system to allow for system depressurization.

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

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

1. Disconnect fuel return tube assembly (from injectors) at left, rear side of engine.

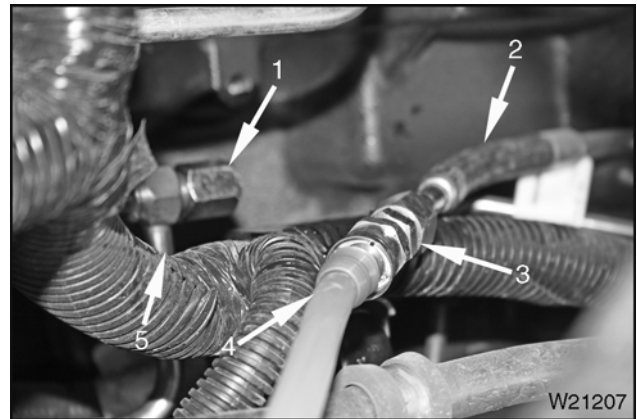


Figure 73 Tube fitting cap connected to fuel return tube assembly

1. Tube fitting cap
2. Fuel return tube assembly
3. Fuel Pressure Return Connector
4. Clean plastic hose
5. Fuel return line

2. Cap off fuel return line using tube fitting cap.
3. Connect fuel return tube assembly to Fuel Pressure Return Connector.
4. Connect clean plastic hose to Fuel Pressure Return Connector and route into diesel fuel container.
5. Crank engine and monitor fuel return from clean plastic hose.
 - If fuel flows from clean plastic hose, go to Fuel Rail Pressure (FRP) Leak Isolation.
 - If fuel does not flow from clean plastic hose, continue to next step.

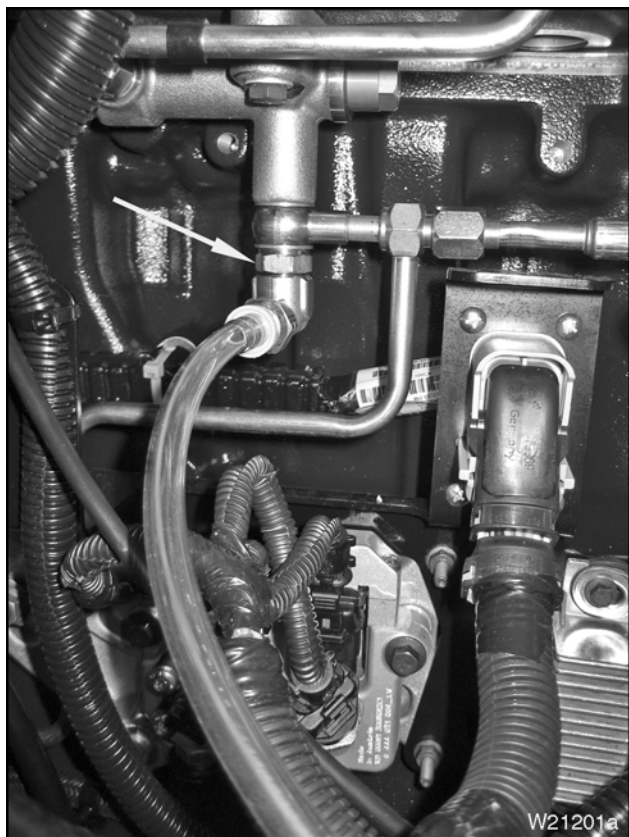


Figure 74 High-pressure Return Line Tester connected to fuel rail

6. Reinstall fuel return tube assembly disconnected in step 1.
7. Remove banjo bolt that connects fuel injector return line and fuel rail.
8. Use 90 degree elbow with swivel to connect High-pressure Return Line Tester to fuel rail (where banjo bolt was installed).
9. Route other end of High-pressure Return Line Tester to diesel fuel container.
10. Crank engine and monitor fuel return from High-pressure Return Line Tester.
 - If fuel flows from High-pressure Return Line Tester, replace FRP relief valve following procedures in the *Engine Service Manual*.
 - If fuel does not flow from High-pressure Return Line Tester, replace fuel pump following procedures in the *Engine Service Manual*. To prevent damage to a newly installed fuel pump, perform HP Pump Fuel Return Pressure Test (page 120) any time fuel pump is replaced.

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

Fuel Rail Pressure (FRP) Leak Isolation

Purpose

Isolate pressure loss in high-pressure fuel system.

Tools

- Diesel fuel container
- ZTSE4887-2 – High-pressure Return Line Tester
- ZTSE6098 – High-pressure Rail Plugs

Procedure

! WARNING: To prevent personal injury or death, engine must be OFF for at least 5 minutes before doing any work on high-pressure fuel system to allow for system depressurization.

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

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

1. Retain connection between High-pressure Return Line Tester and fuel injector return line from previous test.

2. Disconnect number six injector fuel line and cap off injector supply port with High-pressure Rail Plug.
3. Crank engine while monitoring fuel flow in High-pressure Return Line Tester.
 - If fuel flows out of High-pressure Return Line Tester, leave High-pressure Rail Plug connected and continue to next step.
 - If fuel does not flow out of High-pressure Return Line Tester and FRP builds starting pressure, replace number six high-pressure rail to injector tube and high-pressure connector body following procedures in the *Engine Service Manual*.
4. Disconnect number five injector fuel line and cap off fuel rail with High-pressure Rail Plug.
5. Crank engine while monitoring fuel flow in High-pressure Return Line Tester.
 - If fuel flows out of High-pressure Return Line Tester, leave High-pressure Rail Plug connected and continue capping off one injector supply port at a time until excessive leak is isolated. Replace high-pressure rail to injector tube and high-pressure connector body on any injector that is leaking bad enough to prevent engine from building FRP.

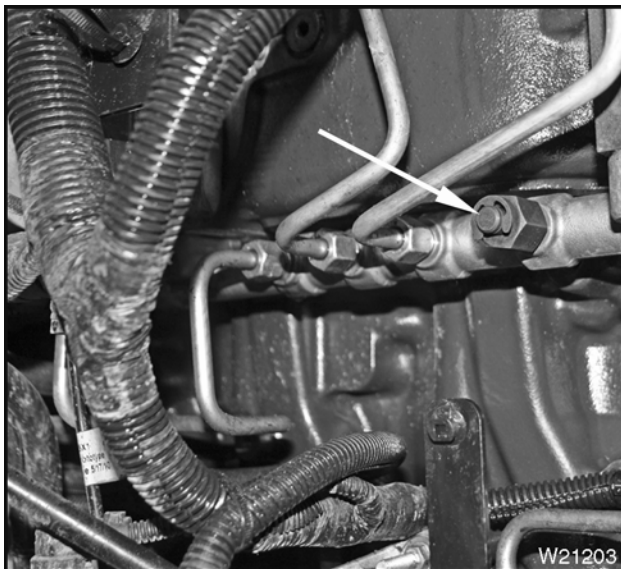


Figure 75 High-pressure Rail Plug installed on number six injector supply port

Cold Start Assist System

The Cold Start Assist system is only enabled during cold weather start ups.



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

Cold Start Assist System Test**Purpose**

Verify cold start assist system is working correctly at any temperature.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

Procedure

1. Turn ignition switch to ON, engine OFF.
2. Connect EST to vehicle's Diagnostic Connector.
3. Start ServiceMaxx™ software.
4. Open the Hard Start – No Start session. Monitor Engine Coolant Temperature 1 (ECT1).
 - If ECT1 is above 10°C (50°F), use ServiceMaxx™ software to run Cold Start Assist Procedure. Go to step 5.
 - If ECT1 is below 10°C (50°F), go to step 6.

CAUTION: To prevent damage to the starter, if engine fails to start within 20 seconds, release ignition switch and wait 2 to 3 minutes to allow starter motor to cool.

5. Start engine exactly 45 seconds after CSFI was commanded ON in Cold Start Assist Procedure. Monitor Intake Manifold Temperature (IMT).

NOTE: If engine start is not timed exactly, the test will abort and need to be restarted.

- If test fails or IMT does not rise approximately 5.5°C (10°F) during engine crank, go to Cold Start Fuel Igniter (CSFI) Test (page 131).
 - If test passes and IMT rises approximately 5.5°C (10°F) during engine crank, the cold start assist system is working correctly.
6. Cycle ignition switch and monitor WAIT TO START lamp in vehicle's dashboard.

NOTE: The ECM may take 15 seconds or longer to reset between ignition switch cycles.

7. When WAIT TO START lamp begins flashing, crank engine while using ServiceMaxx™ software to monitor IMT.
 - If IMT does not rise approximately 5.5°C (10°F) during engine crank, go to Cold Start Fuel Igniter (CSFI) Test (page 131).
 - If IMT rises approximately 5.5°C (10°F) during engine crank, the cold start assist system is working correctly.

Cold Start Fuel Igniter (CSFI) Test**Purpose**

Verify CSFI 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 76 Current clamp on CSFI power circuit

5. Connect EXP-1000 HD by Midtronics current clamp around CSFI power circuit
6. Select Cold Start Fuel Igniter from actuator drop-down menu.
7. Press the Start Test button while monitoring current draw.
 - If current draw is less than specification, go to CSFI in "Electronic Control Systems Diagnostics."
 - If current draw is at or above specification, CSFI is working correctly. Go to Fuel Supply at Cold Start Fuel Solenoid (CSFS) Test.

Fuel Supply at Cold Start Fuel Solenoid (CSFS) Test**Purpose**

Verify sufficient fuel pressure is being supplied to the CSFS.

Tools

- ZTSE4409 – Pressure Test Kit
- ZTSE6059-1 – Cold Start Solenoid Test Adapter Kit

Procedure

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

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

1. Disconnect fuel supply line to CSFS.

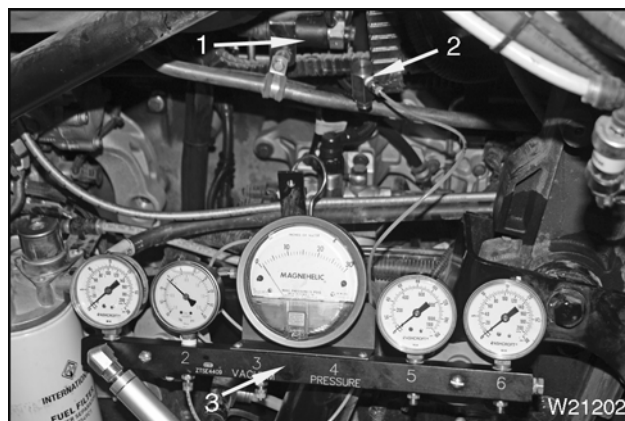


Figure 77 Pressure Test Kit connected to CSFS

1. CSFS
 2. Cold Start Solenoid Test Adapter Kit
 3. Pressure Test Kit
2. Use Cold Start Solenoid Test Adapter Kit to connect Pressure Test Kit to CSFS fuel supply line.
 3. Crank engine while monitoring Pressure Test Kit.
 - If pressure is below specification, verify line is not restricted. If fuel line is not restricted, pressure regulator is faulty. Replace engine-mounted fuel filter housing following procedures in the *Engine Service Manual*.
 - If pressure is within specification, go to Fuel Supply at Cold Start Igniter (CSFI) Test.

Fuel Supply at Cold Start Fuel Igniter (CSFI) Test**Purpose**

Verify sufficient fuel pressure is being supplied to the CSFI.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit
- ZTSE4409 – Pressure Test Kit
- ZTSE4657-4 – Fuel Pressure Test Kit
- ZTSE6059-2 – Cold Start 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 Cold Start Assist 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.
5. Reinstall fuel supply line to CSFS disconnected in previous test.

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

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

6. Disconnect fuel supply line to CSFI.

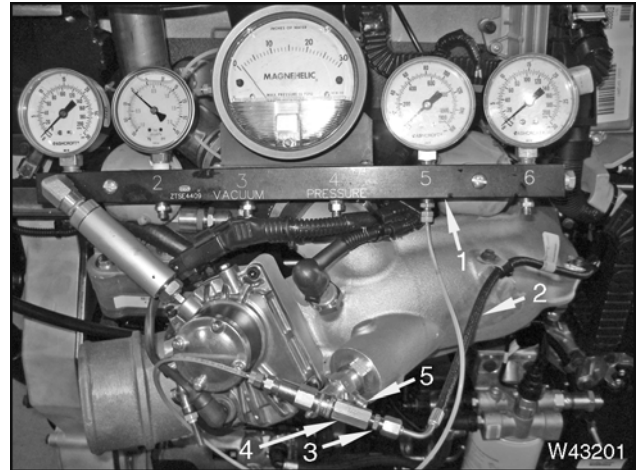


Figure 78 Pressure Test Kit connected to CSFI

1. Pressure Test Kit
 2. CSFI fuel supply line
 3. Cold Start Solenoid Test Adapter Kit
 4. Fuel Pressure Test Kit
 5. CSFI
7. Use Cold Start Solenoid Test Adaptor Kit and Fuel Pressure Test Kit to connect Pressure Test Kit to CSFI fuel supply line.
 8. Monitor WAIT TO START lamp in vehicle's dashboard. When WAIT TO START lamp begins flashing, crank engine while monitoring Fuel Pressure Gauge.
 - If pressure is below specification, verify fuel line is not restricted. If fuel line is not restricted, replace CSFS following procedures in the *Engine Service Manual*.
 - If pressure is within specification, replace CSFI following procedures in the *Engine Service Manual*.

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Diagnostics Form EGED-535

	Performance Diagnostics MaxxForce® 15 Beginning with 2011 Model Year	Technician _____ Date _____ ECM Calibration _____ VIN _____ Unit No. _____ HP Rating _____ Complaint _____	Torque _____ Hours _____ Engine SN _____ Miles _____ Transmission: Manual _____ Auto _____	Note: This form must be completed before calling for technical assistance.																																																				
	WARNING To prevent personal injury or death, read all safety instructions in the Safety Information section of Engine Diagnostics Manual EGED-515-1 before doing form procedures. Notes: Look up the VIN on the iSDS® network for build date, engine hp, engine serial number, ECM calibration, and transmission. See Performance Diagnostics in EGED-515-1 for additional information to do each test or procedure. Record results on this form. Do all checks in sequence unless otherwise stated. Doing a check or test out of sequence could cause incorrect results. See EGED-515-1 Appendix A for Performance Specifications and Electronic Control Systems Diagnostics for DTCs. ● If sensor is out of specification, go to suspect sensor in Electronic Control Systems Diagnostics. □ Use ServiceMax™ software to run Actuator Test and record position values at 5% and 95%. <table border="1" style="width: 100%; border-collapse: collapse; font-size: x-small;"> <tr> <th>Signal</th> <th>Spec</th> <th>5%</th> <th>Spec</th> <th>95%</th> </tr> <tr> <td>EGR Valve Position</td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Engine Throttle Position</td> <td></td> <td></td> <td></td> <td></td> </tr> </table> ● If signal is out of specification, go to suspect actuator in Electronic Control Systems Diagnostics. □ Monitor DPF status signal value. DPF Status _____ ● If DPF status is "Regen needed/critical level", run an onboard filter cleanliness test.				Signal	Spec	5%	Spec	95%	EGR Valve Position					Engine Throttle Position																																									
	Signal	Spec	5%	Spec	95%																																																			
	EGR Valve Position																																																							
Engine Throttle Position																																																								
1. Initial Key On Check □ Check Integral Digital Display for WATER IN FUEL indicator. Comments _____ ● 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. □ Inspect primary fuel filter. Comments _____ Fuel Level Check □ Check instrument panel gauge and look into tank to verify fuel level. ● If fuel gauge reads above empty, but tank is empty, diagnose gauge. ● If fuel tank is empty, add fuel and prime system. See Fuel System Priming in Hard Start and No Start Diagnostics. Fuel Quality Check □ Route clear hose from fuel drain valve on filter housing to approved container. Open valve and fill. □ Check for water, waxing, sludge, sediment, gasoline, or kerosene. Comments _____ ● If fuel quality is questionable, correct problem. Take a sample to verify fuel quality is satisfactory.																																																								
3. ECT Connection and Data Recording □ Use ServiceMax™ software to record KOED pressure and temperature values. Note: Ideally, allow the engine to cold soak for at least 2 hours before recording results. <table border="1" style="width: 100%; border-collapse: collapse; font-size: x-small;"> <tr> <th>Sensor</th> <th>Spec</th> <th>Actual</th> </tr> <tr> <td>Air Inlet Temp</td> <td>-</td> <td></td> </tr> <tr> <td>Engine Coolant Temp1</td> <td>-</td> <td></td> </tr> <tr> <td>Engine Coolant Temp2</td> <td>-</td> <td></td> </tr> <tr> <td>Engine Oil Temp</td> <td>-</td> <td></td> </tr> <tr> <td>Fuel Rail Pressure</td> <td>0 psi</td> <td></td> </tr> <tr> <td>TC1 Turbine Outlet Pressure</td> <td>0 psi</td> <td></td> </tr> <tr> <td>Fuel Delivery Pressure</td> <td>0 psi</td> <td></td> </tr> <tr> <td>Intake Manifold Pressure</td> <td>0 psi</td> <td></td> </tr> <tr> <td>Barometric Pressure</td> <td>-</td> <td></td> </tr> <tr> <td>DPF Differential Pressure</td> <td>0 psi</td> <td></td> </tr> </table>				Sensor	Spec	Actual	Air Inlet Temp	-		Engine Coolant Temp1	-		Engine Coolant Temp2	-		Engine Oil Temp	-		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																					
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4. Check for DTCs □ Use ServiceMax™ software to record DTCs. <table border="1" style="width: 100%; border-collapse: collapse; font-size: x-small;"> <tr> <th>Active and Pending</th> <th>Previously Active and Healing</th> </tr> <tr> <th>SPN/FMI</th> <th>SPN/FMI</th> </tr> <tr> <td> </td> <td> </td> </tr> <tr> <td> </td> <td> </td> </tr> </table> Note: If SPN 101 FMI 16 is present, go to Blow-By Test in Special Test Procedures. ● Correct any active and pending DTCs. See Electronic Control Systems Diagnostics. ● Investigate previously active DTCs with high counts.				Active and Pending	Previously Active and Healing	SPN/FMI	SPN/FMI																																																	
Active and Pending	Previously Active and Healing																																																							
SPN/FMI	SPN/FMI																																																							
5. Engine Low Idle to High Idle □ Use ServiceMax™ software to open Performance session. □ Monitor APP signal and press accelerator to floor. <table border="1" style="width: 100%; border-collapse: collapse; font-size: x-small;"> <tr> <th>Signal</th> <th>Low Idle</th> <th>Actual</th> <th>High Idle</th> <th>Actual</th> </tr> <tr> <td>APP</td> <td>0%</td> <td></td> <td>99.6%</td> <td></td> </tr> </table> ● If APP signal does not go from 0% to 99.6%, see APP Sensor in Electronic Control System Diagnostics. ● If APP signal does go from 0% to 99.6%, go to next step. □ Press record button and start engine. □ Allow engine to idle for 4 seconds. Push accelerator pedal to floor and hold for 10 seconds, return to low idle. □ Review results with accelerator pedal at 99.6%. <table border="1" style="width: 100%; border-collapse: collapse; font-size: x-small;"> <tr> <th>Signal</th> <th>Low Idle</th> <th>Act</th> <th>High Idle</th> <th>Act</th> </tr> <tr> <td>FDP</td> <td>70 - 130 psi</td> <td></td> <td>70 - 130 psi</td> <td></td> </tr> <tr> <td>Engine Speed</td> <td>600-650 rpm</td> <td></td> <td>1550-2200 rpm</td> <td></td> </tr> <tr> <td>IMP</td> <td>< 3 psi</td> <td></td> <td>13-16 psi</td> <td></td> </tr> <tr> <td>TC1TOP</td> <td>< 5 psi</td> <td></td> <td>< 5 psi</td> <td></td> </tr> </table> Note: Engine speed is determined by ECM Calibration. ● If engine does not accelerate smoothly, feels unbalanced (not running on all cylinders), perform Fuel Aeration and Restriction Test, Relative Compression Test, and Cylinder Cutout Test to isolate unbalanced cylinder. ● If FDP is below specification, go to Low-Pressure Fuel System in Special Test Procedures. ● If TC1TOP is above specification, inspect Pre-DOC and DOC for face plugging. □ If IMP is below specifications, check for the following conditions: <table border="1" style="width: 100%; border-collapse: collapse; font-size: x-small;"> <tr> <th>Condition</th> <th>Yes</th> <th>No</th> </tr> <tr> <td>CAC and tubing leaks</td> <td>Yes</td> <td>No</td> </tr> <tr> <td>Intake restriction</td> <td>Yes</td> <td>No</td> </tr> <tr> <td>Wastegate malfunction</td> <td>Yes</td> <td>No</td> </tr> <tr> <td>Low compression</td> <td>Yes</td> <td>No</td> </tr> <tr> <td>Turbocharger damage</td> <td>Yes</td> <td>No</td> </tr> </table> ● If IMP is within specifications, perform Blow-By Test.				Signal	Low Idle	Actual	High Idle	Actual	APP	0%		99.6%		Signal	Low Idle	Act	High Idle	Act	FDP	70 - 130 psi		70 - 130 psi		Engine Speed	600-650 rpm		1550-2200 rpm		IMP	< 3 psi		13-16 psi		TC1TOP	< 5 psi		< 5 psi		Condition	Yes	No	CAC and tubing leaks	Yes	No	Intake restriction	Yes	No	Wastegate malfunction	Yes	No	Low compression	Yes	No	Turbocharger damage	Yes	No
Signal	Low Idle	Actual	High Idle	Actual																																																				
APP	0%		99.6%																																																					
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Engine Speed	600-650 rpm		1550-2200 rpm																																																					
IMP	< 3 psi		13-16 psi																																																					
TC1TOP	< 5 psi		< 5 psi																																																					
Condition	Yes	No																																																						
CAC and tubing leaks	Yes	No																																																						
Intake restriction	Yes	No																																																						
Wastegate malfunction	Yes	No																																																						
Low compression	Yes	No																																																						
Turbocharger damage	Yes	No																																																						
6. High Pressure Pump Test □ Use ServiceMax™ software to run High Pressure Pump Test. <table border="1" style="width: 100%; border-collapse: collapse; font-size: x-small;"> <tr> <th>Test Points</th> <th>Results Value</th> </tr> <tr> <td>Pressure Increase 1</td> <td></td> </tr> <tr> <td>Pressure Increase 2</td> <td></td> </tr> <tr> <td>Pressure Increase 3</td> <td></td> </tr> <tr> <td>Pressure Increase 4</td> <td></td> </tr> </table> Note: High Pressure Pump Test will not run during an active regen. ● If test results display "Slow Response Time", go to High Pressure Fuel System in Special Test Procedures.				Test Points	Results Value	Pressure Increase 1		Pressure Increase 2		Pressure Increase 3		Pressure Increase 4																																												
Test Points	Results Value																																																							
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Pressure Increase 3																																																								
Pressure Increase 4																																																								
7. KOER Air Management Test Note: Truck air tank(s) must be full before running this test. □ Start engine and run KOER Air Management Test. Begin recording snapshot and follow instructions in ServiceMax™. Note: Record whether intake manifold pressure increases or decreases with actuator change. Note: TC1WC does not affect engine performance and is removed from post production engines. <table border="1" style="width: 100%; border-collapse: collapse; font-size: x-small;"> <tr> <th>Actuator</th> <th>IMP with Actuator OFF</th> <th>IMP with Actuator ON</th> </tr> <tr> <td>EGR Valve</td> <td></td> <td></td> </tr> <tr> <td>TC2 Wastegate Control</td> <td></td> <td></td> </tr> </table> ● If pressure does not decrease with actuator ON, go to ACV Tests in Special Test Procedures.				Actuator	IMP with Actuator OFF	IMP with Actuator ON	EGR Valve			TC2 Wastegate Control																																														
Actuator	IMP with Actuator OFF	IMP with Actuator ON																																																						
EGR Valve																																																								
TC2 Wastegate Control																																																								
8. Road Test (Full load, rated speed) Note: If truck has progressive shift or gear down protection enabled, disable these features prior to performing road test. □ Use ServiceMax™ software to open Performance session. □ Start engine. □ Find an open stretch of road. Start recording. When driving conditions are safe, select a suitable gear, press accelerator pedal fully to floor, and accelerate to rated speed at 100% load. □ When road test is complete, stop recording. □ Review recorded results with engine at rated speed and 100% load. Note: Performing the same test while bottling, will yield results slightly below specification. <table border="1" style="width: 100%; border-collapse: collapse; font-size: x-small;"> <tr> <th>Signal</th> <th>Engine @ rated speed and 100% load</th> <th>Actual</th> </tr> <tr> <td>FDP</td> <td>3190 psi</td> <td></td> </tr> <tr> <td>IMP</td> <td>70-130 psi</td> <td></td> </tr> <tr> <td>Engine Speed</td> <td>1550-2200 rpm</td> <td></td> </tr> <tr> <td>IMP</td> <td>40 psi</td> <td></td> </tr> <tr> <td>TC1TOP</td> <td>< 5 psi</td> <td></td> </tr> </table> Note: Engine speed is determined by ECM Calibration. ● If FDP is below specification, go to Low Pressure Fuel System in Special Test Procedures. ● If engine does not accelerate smoothly or feels unbalanced, perform Fuel Aeration and Restriction Test, Relative Compression Test, and Cylinder Cutout Test. ● If FRP is below specification, go to High Pressure Fuel System in Special Test Procedures. ● If TC1TOP is above specification, inspect Pre-DOC and DOC for face plugging. ● If IMP is below specifications, check for CAC and tubing leaks. If okay, perform Blow-By Test.				Signal	Engine @ rated speed and 100% load	Actual	FDP	3190 psi		IMP	70-130 psi		Engine Speed	1550-2200 rpm		IMP	40 psi		TC1TOP	< 5 psi																																				
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TC1TOP	< 5 psi																																																							
Special Test Procedures Air Control Valve (ACV) Tests Note: Truck air tank(s) must be full before running these tests. Turbocharger 2 Wastegate Control (TC2WC) □ Use ServiceMax™ software to open 2010 BB Actuator session. □ Select TC2WC from Actuator drop-down menu and set to 95%. Note: On a cold engine, TC2 Wastegate Control defaults to open (100%) to prevent turbocharger damage. □ Select TC2 Wastegate Control from Actuator drop-down menu and set to On (95% Duty cycle) for actuator rod to move. Note: If TC2 Wastegate Control displays a value of 100% before test is started, duty cycle must be set to Off (5% duty cycle) for actuator rod to move. □ Press Start button and measure travel of valve. <table border="1" style="width: 100%; border-collapse: collapse; font-size: x-small;"> <tr> <th>Signal</th> <th>Specification</th> <th>Actual</th> </tr> <tr> <td>TC2WC</td> <td>13 mm (full travel)</td> <td></td> </tr> </table> ● If actuator rod moves full travel, no action is required. ● If actuator rod does not move full travel, go to next step. □ Remove air supply line from actuator and repeat actuator test. ● If air cannot be heard leaving open air supply line, inspect supply line for blockage or damage. See TC2WC in Electronic Control Systems Diagnostics. ● If air can be heard leaving open air supply line, remove actuator rod from wastegate arm. Check if wastegate arm moves freely. ● If wastegate arm does not move freely, replace wastegate actuator. ● If wastegate arm does not move freely, replace turbocharger. Low Pressure Fuel System Fuel Delivery Pressure (FDP) Test □ With engine OFF, remove FDP sensor and install Manual Oil Pressure Test Tool. □ Connect Pressure Test Kit to Manual Oil Pressure Test Tool. □ Start engine while monitoring FDP. □ Press accelerator pedal to floor for 5 seconds, then return to low idle. <table border="1" style="width: 100%; border-collapse: collapse; font-size: x-small;"> <tr> <th>Signal</th> <th>Spec</th> <th>Actual</th> </tr> <tr> <td>Fuel Delivery Pressure</td> <td>30 psi</td> <td></td> </tr> </table> □ Compare current FDP readings to FDP readings from Engine Low Idle to High Idle test. ● If current FDP reading does not closely resemble previous FDP reading, go to FDP Sensor in Electronic Control Systems Diagnostics. ● If FDP stays consistent, continue to next step. □ With engine OFF, disconnect fuel supply line at LP fuel pump inlet and cap off supply line. □ Connect Clean Fuel Source Tool to LP fuel pump inlet. □ Use Clean Fuel Source Tool to prime fuel system. □ Crank engine while monitoring FDP. <table border="1" style="width: 100%; border-collapse: collapse; font-size: x-small;"> <tr> <th>Signal</th> <th>Spec</th> <th>Actual</th> </tr> <tr> <td>Fuel Delivery Pressure</td> <td>30 psi</td> <td></td> </tr> </table> ● If FDP drops below specification, go to Fuel Dead Head Test. ● If FDP stays within specification, go to Fuel Aeration and Restriction Test.				Signal	Specification	Actual	TC2WC	13 mm (full travel)		Signal	Spec	Actual	Fuel Delivery Pressure	30 psi		Signal	Spec	Actual	Fuel Delivery Pressure	30 psi																																				
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Fuel Dead Head Test □ Retain Clean Fuel Source Tool connection to LP fuel pump inlet. □ Disconnect fuel line from LP fuel pump outlet and connect Fuel Inlet Restriction/Aeration tool. □ Use coupler check fitting to connect Pressure Test Kit to Fuel Inlet Restriction/Aeration Tool. □ Connect Fuel Block Off Tool to Fuel Inlet Restriction/Aeration Tool. □ Use Clean Fuel Source Tool to prime fuel system. □ Crank engine until fuel pressure stabilizes or up to a maximum of 20 seconds. <table border="1" style="width: 100%; border-collapse: collapse; font-size: x-small;"> <tr> <th>Gauge</th> <th>Spec</th> <th>Actual</th> </tr> <tr> <td>LP Fuel Pump Pressure</td> <td>130-189 psi</td> <td></td> </tr> </table> ● If pressure is within specification, inspect engine mounted fuel filter and housing for defects or damage. If no defect or damage is found, go to High Pressure Fuel System. ● If pressure is below specification, replace fuel pump. Refer to Engine Service Manual for replacement procedure and perform HP Pump Fuel Return Pressure Test, in Hard Start and No Start diagnostics. Fuel Aeration and Restriction Aeration Test Note: See Figure 1 for Aeration Test Diagram. □ Remove Clean Fuel Source Tool from LP fuel pump inlet. □ Connect Fuel Inlet Restriction/Aeration Tool between LP pump outlet and fuel supply line to secondary filter using Fuel Line Coupler. □ Prime fuel system to remove air from lines. □ Start engine while visually monitoring for fuel aeration. ● If fuel is aerated, turn engine OFF and connect Clean Fuel Source Tool to primary filter inlet. □ Prime fuel system to remove air from lines. □ Start engine while visually monitoring for fuel aeration. ● If fuel is not aerated, repair open in supply line from primary filter to fuel tank. ● If fuel is aerated, repair open in LP fuel pump supply line or primary filter.				Gauge	Spec	Actual	LP Fuel Pump Pressure	130-189 psi																																																
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W00264a

Figure 79 Diagnostics Form EGED-535 (Performance)

The Performance Diagnostics Form directs technicians to systematically troubleshoot a performance condition and avoid unnecessary repairs.

This Diagnostic Manual section shows detailed instructions for 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 of this manual for Diagnostic Trouble Codes (DTCs) and engine specifications.

Diagnostics Form EGED-535 is available in 50-sheet pads. To order technical service literature, contact your International dealer.

Diagnostics Form Header Information

Technician _____	Date _____	ECM Calibration _____	Torque _____	Hours _____
VIN _____	Unit No. _____	HP Rating _____	Engine SN _____	Miles _____
Complaint _____	Transmission: Manual _____ Auto _____			
Note: This form must be completed before calling for technical assistance.				

W00265

1. Fill in the following diagnostics form header information:

- Technician
- Date
- Unit No. (dealer's quick reference number)

- Vehicle Identification Number (VIN)
- Complaint (driver interview)

NOTE: Remaining header 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.

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 for 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 illuminated, go to Fuel Quality Check (page 142).

2. Visual Inspection

Purpose

Check all fluid levels and inspect engine systems for problems (leaks, open connections, harness chafing, etc.).

Tools

None

Engine Oil

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

NOTE: American Petroleum Institute (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.

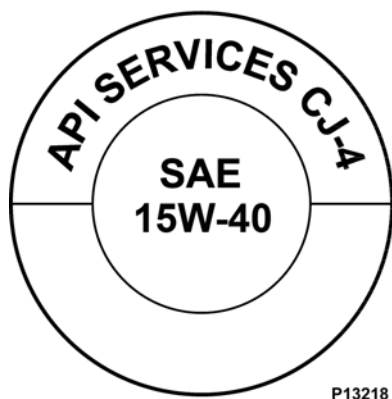


Figure 81 Lube oil requirements label

2. Use oil level gauge (dipstick) to verify engine oil level.

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

3. Record results on Diagnostics Form.
 - If oil level is below specification, inspect for leaks, oil consumption, or improper servicing. Repair as necessary and fill to specification.

- If oil level is above specification, inspect for fuel dilution, coolant contamination, or improper servicing. Repair as necessary and drain to proper level.

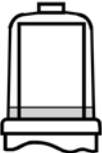
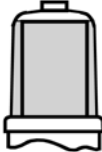
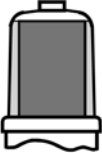
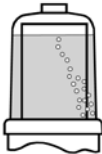
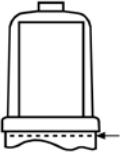
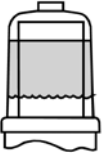
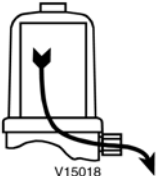
Fuel Level

! 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.
 - If fuel gauge reads above empty, but tank is empty, diagnose instrument panel fuel gauge. Verify fuel level is within specification before diagnosing a pressure problem.
 - If fuel tank is empty, add fuel and prime fuel system.

Davco® Fuel Filter Inspection

Visually inspect Davco® chassis-mounted fuel filter following the inspection table on the next page. If not equipped with a Davco® chassis-mounted fuel filter, continue to next test.

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.	Change fuel filter element.
 V15014	Fuel level is to top of fuel filter and looks to be full of wax.	1. Change 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 between fuel tank and chassis fuel filter assembly. 2. Check upper and lower connector O-rings.
 V15016	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 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 fuel filter assembly. NOTE: Do not drain with engine running. 3. Restart engine. Shut off engine and drain 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 following procedures in <i>Engine Service Manual</i>. 2. Repair (clean) or replace as necessary and retest.

Fuel Quality Check

Purpose

Check for poor fuel quality or for contaminants.

Tools

Clear diesel fuel container

Procedure

NOTE: Ultra-Low Sulfur Diesel (ULSD) fuel is required for MaxxForce® 15L Diesel Engines with advanced aftertreatment systems.



Figure 82 Fuel requirements label

NOTE: Instrument panel WATER IN FUEL lamp should cycle ON, then OFF, if there is no water in fuel system. Lamp will stay ON if water is detected.

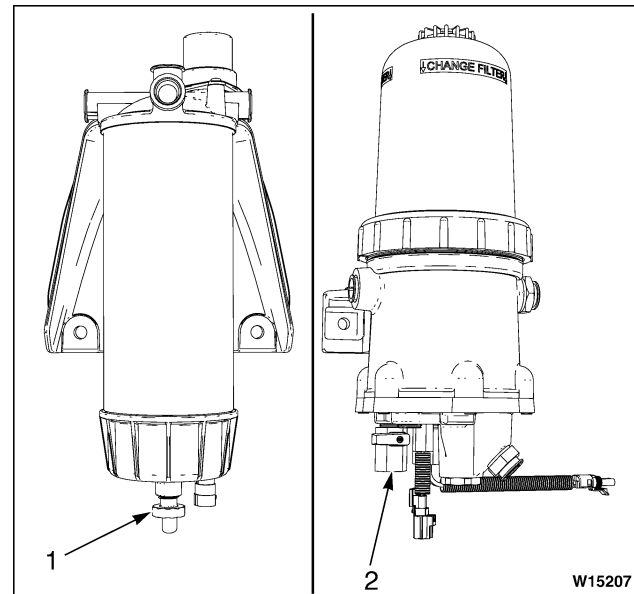


Figure 83 Fuel drain valves

1. Drain valve (Racor®)
2. Drain valve (Davco®)

1. Place clear diesel fuel container under fuel drain valve.

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

NOTE: If fuel does not flow, crank engine.

2. Open fuel drain valve to fill clear diesel fuel container.
3. Check for water, waxing, icing, sediment, gasoline, or kerosene by shaking fuel sample container and letting contents settle.
 - 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 next test.

Engine Coolant Level

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

1. Park vehicle on level ground.
2. Check coolant level as indicated on deaeration tank level window.

NOTE: Coolant that has leaked into exhaust system (wet exhaust) could damage the Diesel Particulate Filter (DPF). Inspect DPF for damage. See Coolant Leak to Exhaust (page 73) in "Engine Symptoms Diagnostics."

3. Record results on Diagnostics Form.
 - If level is below deaeration tank fill level, inspect for external leaks, internal leaks to other engine systems, or improper servicing. See "Engine Symptoms Diagnostics" if internal leak is suspected.
 - If level is above deaeration tank fill level, inspect for oil in coolant, fuel in coolant, or improper servicing.
 - If coolant is contaminated, determine contaminant, diagnose cause, repair as necessary, and replace coolant. See "Engine Symptoms Diagnostics."

Charge Air Cooler (CAC) System

1. Inspect the CAC, Interstage Cooler (ISC), and all piping for leaks.
2. Inspect all CAC connections and clamps.
 - If CAC system problem is found, make necessary repairs. See ISC Leak Test in "Engine Symptoms Diagnostics."

Electrical System

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

Intake Air

NOTE: Intake air restriction should be less than 3.3 kPa (13.4 inH₂O) at full engine load and rated speed.

1. Inspect air filter gauge located on air filter housing or dashboard.
 - If gauge indicates air filter needs replaced, verify there are no other restrictions in the air inlet or filter housing before replacing air filter.

Exhaust System

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

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

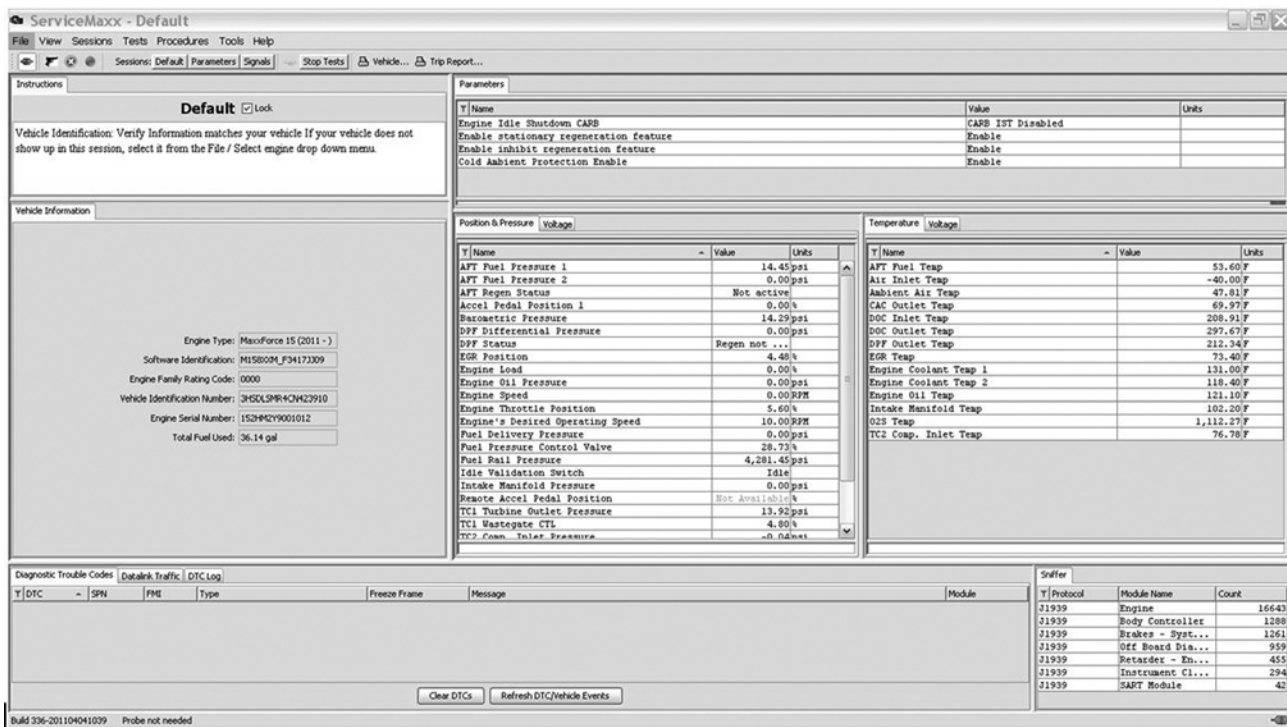
Check ECM software, sensor signals, and Diagnostic Trouble Codes (DTCs) and record additional vehicle information on Diagnostics Form.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

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 and no problems are found using the *ServiceMaxx™ Users Guide*, go to J1939 Data Link Communications in "Electronic Control Systems Diagnostics."



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Figure 84 ServiceMaxx™ software startup screen – vehicle connected

- Verify the following vehicle information matches the displayed information in ServiceMaxx™ software and record on Diagnostics Form:

- Engine Type
- Software Identification
- Engine Family Rating Code (EFRC)
- Vehicle Identification Number (VIN)
- Engine Serial Number (ESN)
- Total Fuel Used

NOTE: The engine serial number is located on a 6-inch pad on the left side of the engine block, below the high-pressure fuel pump and just above the oil pan.

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

- Air Inlet Temperature (AIT)

- Engine Coolant Temperature (ECT1)
- Engine Oil Temperature (EOT)

- Record the following KOEO pressure and flow sensor values on the 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 sensor is within specification, continue to next step.
8. Run Actuator Test and record the following position values at 5% and 95% duty cycles on the Diagnostics Form:
 - Exhaust Gas Recirculation Valve Position (EGRVP)
 - Engine Throttle Position (ETP)
9. Look for sensor values that are out of specification. A sensor out of specification could cause air management problems.
 - If sensor is out of specification, go to the suspect sensor in "Electronic Control Systems Diagnostics."
10. Record DPF status signal value on the Diagnostics Form.
 - If DPF status is "Regen needed-critical level," use ServiceMaxx™ software to run the 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 Suspect Parameter Number (SPN) and Failure Mode Indicator (FMI) identifiers only. These two identifiers are displayed in the DTC window.

- SPN – Identifies the individual component causing the DTC.
- FMI – Identifies the fault or condition affecting the individual component.
- Pending DTCs are possible emission faults that were detected on the first drive cycle.
- Active DTCs are codes that are currently active.
- Previously active DTCs are historical codes that may be caused by intermittent signals or an operating condition that is not currently present.

Purpose

Identify DTCs.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

Procedure

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

NOTE: If SPN 101 FMI 16 is present, go to Blow-by Test (page 166) in Special Test Procedures.

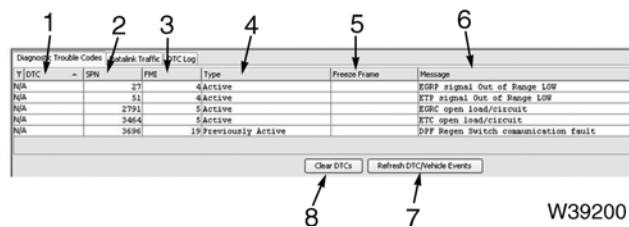


Figure 85 DTC window

1. DTC column (pre-2010)
 2. SPN column
 3. FMI column
 4. Type column
 5. Freeze Frame column
 6. Message column
 7. Refresh DTC/Vehicle Events button
 8. Clear DTCs button
4. Record DTCs and Freeze Frame Data on Diagnostics Form.
 5. Correct any active DTCs. See "Electronic Control Systems Diagnostics."
 - Investigate previously active DTCs with high counts.

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

- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

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 from the Sessions drop-down menu.
5. Monitor Accelerator Pedal Position (APP) signal while pressing accelerator pedal to the floor.
 - If APP signal does not go from 0% to 99.6%, see APP Sensor in "Electronic Control Systems Diagnostics."
 - If APP signal does go from 0% to 99.6%, continue to next step.

Signals			
Volts			
T Name	~	Value	Units
Engine Load		0.00%	
Engine Speed		0.00RPM	
Fuel Delivery Pressure		0.00psi	
Fuel Rail Pressure		22,442.89psi	
Fuel Rail Pressure Desired		12,127.08psi	
Intake Manifold Pressure		0.00psi	
Intake Manifold Pressure Desired		6.96psi	
TC1 Turbine Outlet Pressure		14.79psi	

W39213

Figure 86 Performance session signals

6. Monitor the following signals:

- Fuel Delivery Pressure (FDP)
- Engine Speed (RPM)
- Intake Manifold Pressure (IMP)
- Turbocharger 1 Turbine Outlet Pressure (TC1TOP)

7. Press the record button and start engine.

8. Allow engine to idle for 5 seconds. Push accelerator pedal to floor and hold for 10 seconds, then return to low idle.

9. Review recording results with accelerator pedal at 99.6% and record on Diagnostics Form.

NOTE: Engine speed is determined by Engine Control Module (ECM) calibration.

- If FDP is below specification, go to Low-pressure Fuel System (page 154).

- If engine does not accelerate smoothly or feels unbalanced (not running on all cylinders), perform Fuel Aeration and Restriction Test (page 157), Relative Compression Test (page 168), and Cylinder Cutout Test (page 169) to isolate unbalanced cylinder.
- If TC1TOP is above specification, inspect Diesel Oxidation Catalyst (DOC) and Pre-Diesel Oxidation Catalyst (PDOC) for face plugging.
- If IMP is below specification, check for:
 - Charge Air Cooler (CAC) and tubing leaks
 - Intake restriction
 - Wastegate malfunction
 - Low compression
 - Turbocharger damage

If IMP is within specification, perform Blow-by Test (page 166).

6. High Pressure Pump Test

Purpose

Validate performance of high-pressure fuel system.

Tools

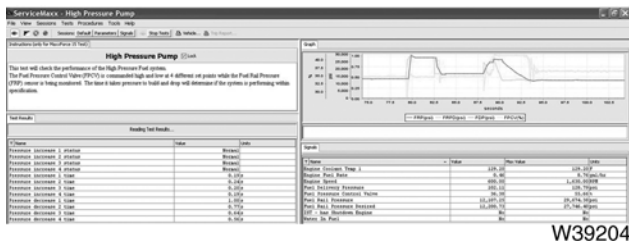
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

Procedure

NOTE: Verify there is not a problem with the low-pressure fuel system before running this test.

NOTE: Ensure Engine Coolant Temperature 1 (ECT1) is at least 38°C (100°F) before performing this test.

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 High Pressure Pump from the Sessions drop-down menu.



W39204

Figure 87 High Pressure Pump test

6. Record results on Diagnostics Form.
 - If high-pressure fuel pump fails this test, go to High-pressure Fuel System Test (page 161).

7. KOER Air Management Test

NOTE: Truck air tank(s) must be full before running this test.

Purpose

Verify air management valves are working correctly.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

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 from the Sessions drop-down menu.
5. Start engine.
6. Select 2010 BB Air Management from the Sessions drop-down menu. Begin recording snapshot and follow instructions in ServiceMaxx™ software.
7. Record results on Diagnostics Form.

NOTE: Record whether intake manifold pressure increases or decreases with actuator change.

- If any DTCs were set, see "Electronic Control Systems Diagnostics."
- If pressure does not decrease with actuator ON, go to ACV Tests in Special Test Procedures.

NOTE: Turbocharger 1 Wastegate Control (TC1WC) does not affect engine performance and is removed from postproduction engines.

8. Road Test (Full Load, Rated Speed)

Purpose

Check for unacceptable engine performance at full load and rated speed by means of maximum boost, minimum fuel pressure, and minimum Fuel Rail Pressure (FRP).

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

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.

1. Turn ignition switch to ON, engine OFF.
2. Connect EST to vehicle's Diagnostic Connector.
3. Start ServiceMaxx™ software.
4. Select Performance session from the Sessions drop-down menu.
5. Start engine.

Signals Volts			
T	Name	Value	Units
	Engine Load	0.00%	
	Engine Speed	0.00RPM	
	Fuel Delivery Pressure	0.00psi	
	Fuel Rail Pressure	22,442.69psi	
	Fuel Rail Pressure Desired	12,127.68psi	
	Intake Manifold Pressure	0.00psi	
	Intake Manifold Pressure Desired	6.96psi	
	TC1 Turbine Outlet Pressure	14.79psi	

W39213

Figure 88 Performance session signals

6. Monitor the following signals:
 - Fuel Rail Pressure (FRP) Desired

- Fuel Delivery Pressure (FDP)
- Engine Speed (RPM)
- Intake Manifold Pressure (IMP)
- TC1 Turbine Outlet Pressure (TC1TOP)

7. Find an open stretch of road. Start 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."

- If FDP is below specification, go to Low-pressure Fuel System (page 154).
- If engine does not accelerate smoothly or feels unbalanced (not running on all cylinders), perform Fuel Aeration and Restriction Tests (page 157), Relative Compression Test (page 168), and Cylinder Cutout Test (page 169) to isolate unbalanced cylinder.
- If FRP is below specification, go to High-pressure Fuel System Test (page 161).
- If TC1TOP is above specification, inspect Pre-Diesel Oxidation Catalyst (PDOX) for face plugging.
- If IMP is below specification, check for:
 - Charge Air Cooler (CAC) and tubing leaks
 - Intake restriction
 - Wastegate malfunction
 - Back pressure performance loss
 - Low compression
 - Turbocharger damage

If IMP is within specification, perform Blow-by Test (page 166).

Special Test Procedures

Air Control Valve (ACV) Tests



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.

Turbocharger 2 Wastegate Control (TC2WC) Test

Purpose

Verify TC2WC is working correctly.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

Procedure

NOTE: Truck air tank(s) must be full before running this test.

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 from Sessions drop-down menu.

NOTE: On a cold engine, TC2 Wastegate Control defaults to open (100%), to prevent turbocharger damage.

5. Check for DTCs.
 - If actuator DTC is present, see "Electronic Control Systems Diagnostics."
 - If there are no actuator DTCs, continue to next step.



Figure 89 Actuator TC2 Wastegate Control session

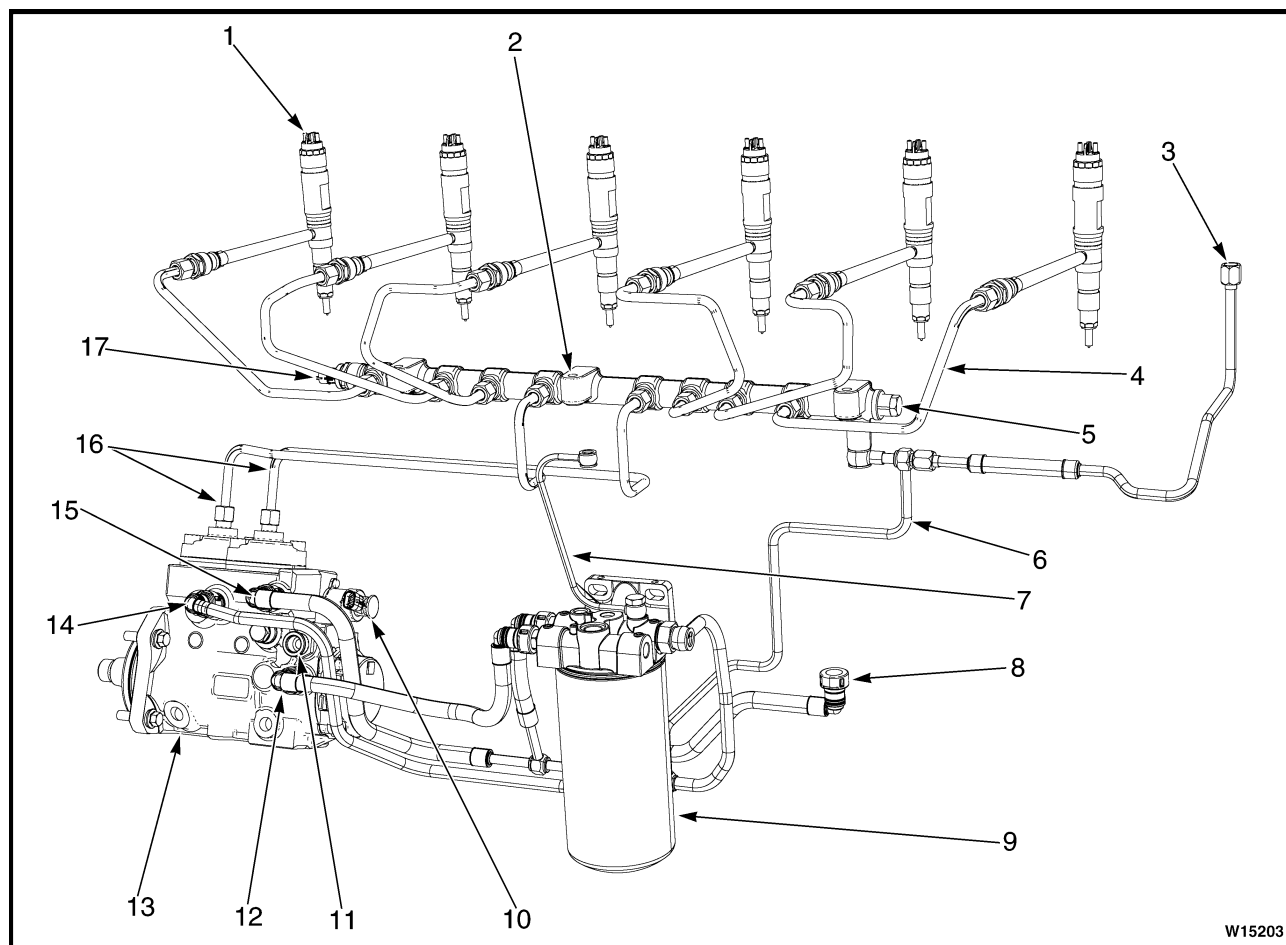
6. Select TC2 Wastegate Control from Actuator drop-down menu and set to On (95% Duty Cycle).

NOTE: If TC2 Wastegate Control displays a value of 100% before test is started, duty cycle must be set to Off (5% Duty Cycle) for actuator rod to move.

7. Press the Start Test button and visually monitor actuator rod movement.
 - If actuator rod moves full travel, no action is required.
 - If actuator rod does not move, continue to next step.
8. Remove air supply line from wastegate actuator and repeat test.
 - If air cannot be heard leaving the open air supply line while test is running, see TC2WC in "Electronic Control Systems Diagnostics."
 - If air can be heard leaving the open air supply line, reinstall air supply line and continue to next step.
9. Remove actuator rod from wastegate arm following procedures in the *Engine Service Manual*. Check wastegate arm.
 - If wastegate arm moves freely, replace wastegate actuator following procedures in the *Engine Service Manual*.

- If wastegate arm does not move freely, replace turbocharger following procedures in the *Engine Service Manual*.

Fuel System



W15203

Figure 90 Fuel system

1. Injector (6)	7. Fuel supply to cold start assist system	12. Low-pressure fuel pump outlet
2. Fuel rail	8. Fuel supply to Down Stream Injection (DSI) assembly	13. Fuel pump
3. Fuel return tube assembly (from injectors)	9. Fuel filter (engine-mounted)	14. High-pressure fuel pump return
4. High-pressure rail to injector tube (6)	10. Fuel Pressure Control Valve (FPCV)	15. High-pressure fuel pump inlet
5. Fuel rail pressure relief valve	11. Low-pressure fuel pump inlet	16. High-pressure fuel rail supply lines
6. Fuel injector return line		17. Fuel Rail Pressure (FRP) sensor

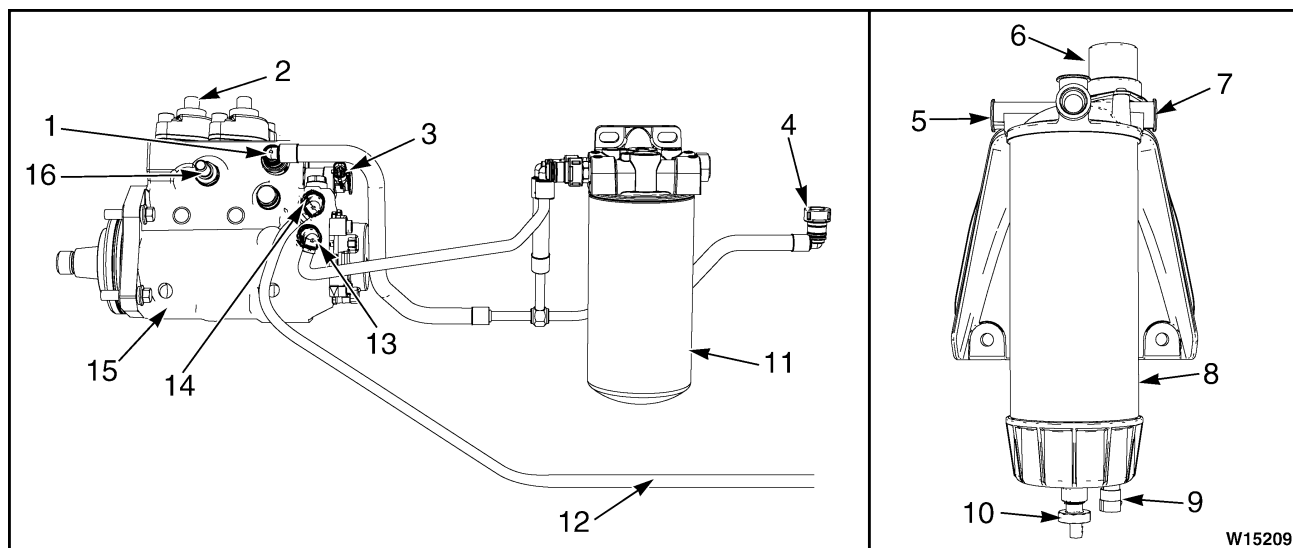


Figure 91 Fuel system with Racor® fuel filter assembly (chassis-mounted)

1. High-pressure fuel pump inlet
2. High-pressure fuel rail supply
3. Fuel Pressure Control Valve (FPCV)
4. Fuel supply to Down Stream Injection (DSI) assembly
5. Fuel outlet
6. Fuel primer pump assembly
7. Fuel supply from tank
8. Fuel filter water separator assembly
9. Water In Fuel (WIF) sensor
10. Drain valve
11. Fuel filter (engine-mounted)
12. Fuel supply from chassis-mounted filter
13. Low-pressure fuel pump outlet
14. Low-pressure fuel pump inlet
15. Fuel pump
16. High-pressure fuel pump return

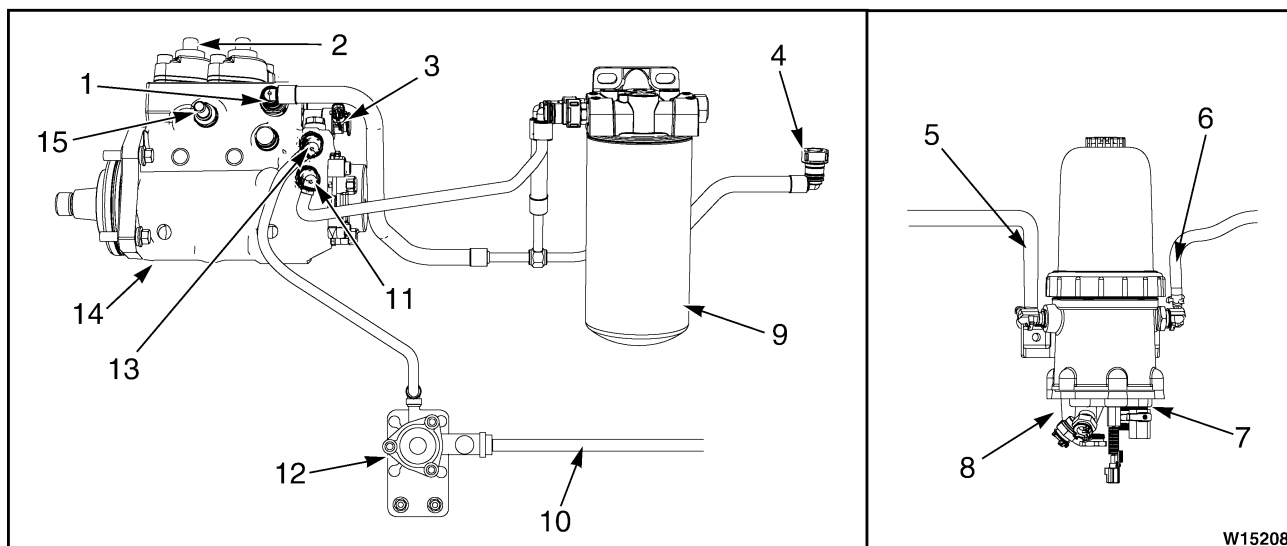


Figure 92 Fuel system with Davco® fuel filter assembly (chassis-mounted)

1. High-pressure fuel pump inlet
2. High-pressure fuel rail supply
3. Fuel Pressure Control Valve (FPCV)
4. Fuel supply to Down Stream Injection (DSI) assembly
5. Fuel outlet
6. Fuel supply from tank
7. Fuel return to tank
8. Drain valve
9. Fuel filter (engine-mounted)
10. Fuel supply from chassis-mounted fuel filter
11. Low-pressure fuel pump outlet
12. Fuel primer pump assembly
13. Low-pressure fuel pump inlet
14. Fuel pump
15. High-pressure fuel pump return

Low-pressure Fuel System

Fuel Delivery Pressure (FDP) Test

Purpose

Verify there is sufficient fuel pressure in low-pressure fuel system.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit
- 15-637-01 – Clean Fuel Source Tool
- ZTSE4409 – Pressure Test Kit
- ZTSE4891 – Air Cap, Fuel Cap, and Plug Kit
- ZTSE6091 – Manual Oil Pressure Test Tool

Procedure

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

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

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

NOTE: Ensure fuel lines are clear of debris before disconnecting fuel lines.

1. With engine OFF, remove FDP sensor and install Manual Oil Pressure Test Tool.
2. Connect Pressure Test Kit to Manual Oil Pressure Test Tool.

3. Start engine while using Pressure Test Kit to monitor FDP.
4. Press accelerator pedal to floor for 5 seconds, then return to low idle.
5. Compare current FDP readings to FDP readings from the Engine Low Idle to High Idle test.
 - If current FDP readings do not closely resemble previous FDP readings, go to FDP Sensor in “Electronic Control Systems Diagnostics.”
 - If FDP stays consistent, continue to next step.
6. Turn engine OFF.
7. Disconnect fuel supply line at low-pressure fuel pump inlet and cap it off using Air Cap, Fuel Cap, and Plug Kit.

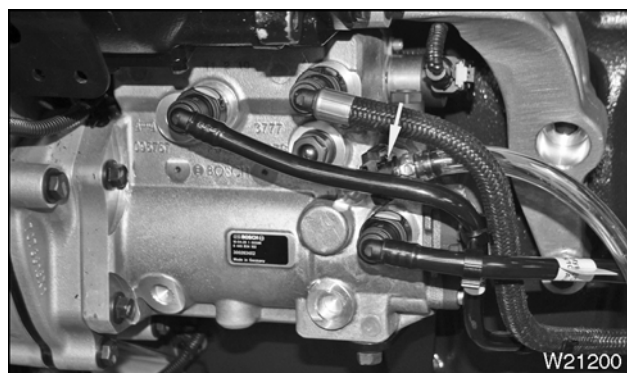


Figure 93 Clean Fuel Source Tool connected to low-pressure fuel pump inlet

8. Connect Clean Fuel Source Tool to low-pressure fuel pump inlet.

9. Use Clean Fuel Source Tool to prime fuel system.
 - a. Close the ball valve on the Clean Fuel Source Tool fuel supply line.
 - b. Fully squeeze the primer bulb on the Clean Fuel Source Tool. 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 fuel supply line.
10. Start engine while using ServiceMaxx™ software to monitor FDP.
11. Press accelerator pedal to floor for 5 seconds, then return to low idle.
 - If FDP is below specification, go to Fuel Dead Head Test (page 155).
 - If FDP is within specification, go to Fuel Aeration and Restriction Tests (page 157).

Fuel Dead Head Test

Purpose

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

Tools

- Compucheck fitting – Star Products part # TU-32-25
- 15-637-01 – Clean Fuel Source Tool
- ZTSE4409 – Pressure Test Kit
- ZTSE4886 – Fuel Inlet Restriction / Aeration Tool
- ZTSE4905 – Fuel Block Off Tool

Procedure

1. Retain connection between Clean Fuel Source Tool and low-pressure fuel pump inlet from previous test.

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

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

2. Disconnect fuel line from low-pressure fuel pump inlet.

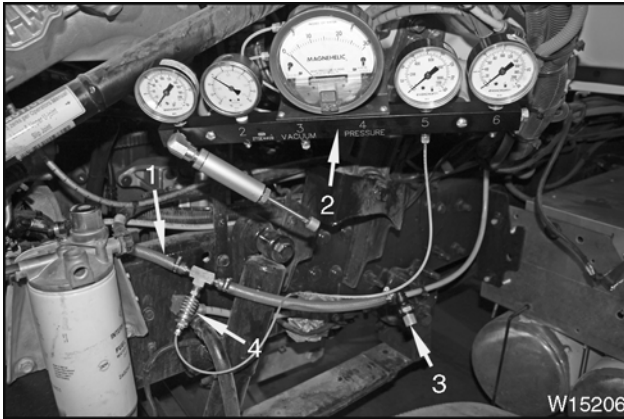


Figure 94 Fuel Inlet Restriction / Aeration Tool connected to low-pressure fuel pump outlet

1. Fuel Inlet Restriction / Aeration Tool
 2. Pressure Test Kit
 3. Fuel Block Off Tool
 4. Compucheck fitting
3. Connect Fuel Inlet Restriction / Aeration Tool to low-pressure fuel pump outlet.

4. Use compucheck fitting to connect Pressure Test Kit to Fuel Inlet Restriction / Aeration Tool.
5. Connect Fuel Block Off Tool to Fuel Inlet Restriction / Aeration Tool.
6. Use Clean Fuel Source Tool to prime fuel system.
 - a. Close the ball valve on the Clean Fuel Source Tool fuel supply line.
 - b. Fully squeeze the primer bulb on the Clean Fuel Source Tool. 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 fuel supply line.
7. Crank engine while monitoring Pressure Test Kit. Continue monitoring until fuel pressure stabilizes or for a maximum of 20 seconds.
 - If pressure is within or above specification, inspect engine-mounted fuel filter and housing for defects or damage. If no defect or damage is found, go to High-pressure Fuel System (page 161).
 - If pressure is below specification, replace fuel pump following procedures in the *Engine Service Manual*. To prevent damage to a newly installed fuel pump, perform HP Pump Fuel Return Pressure Test (page 120) in "Hard Start and No Start Diagnostics" 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

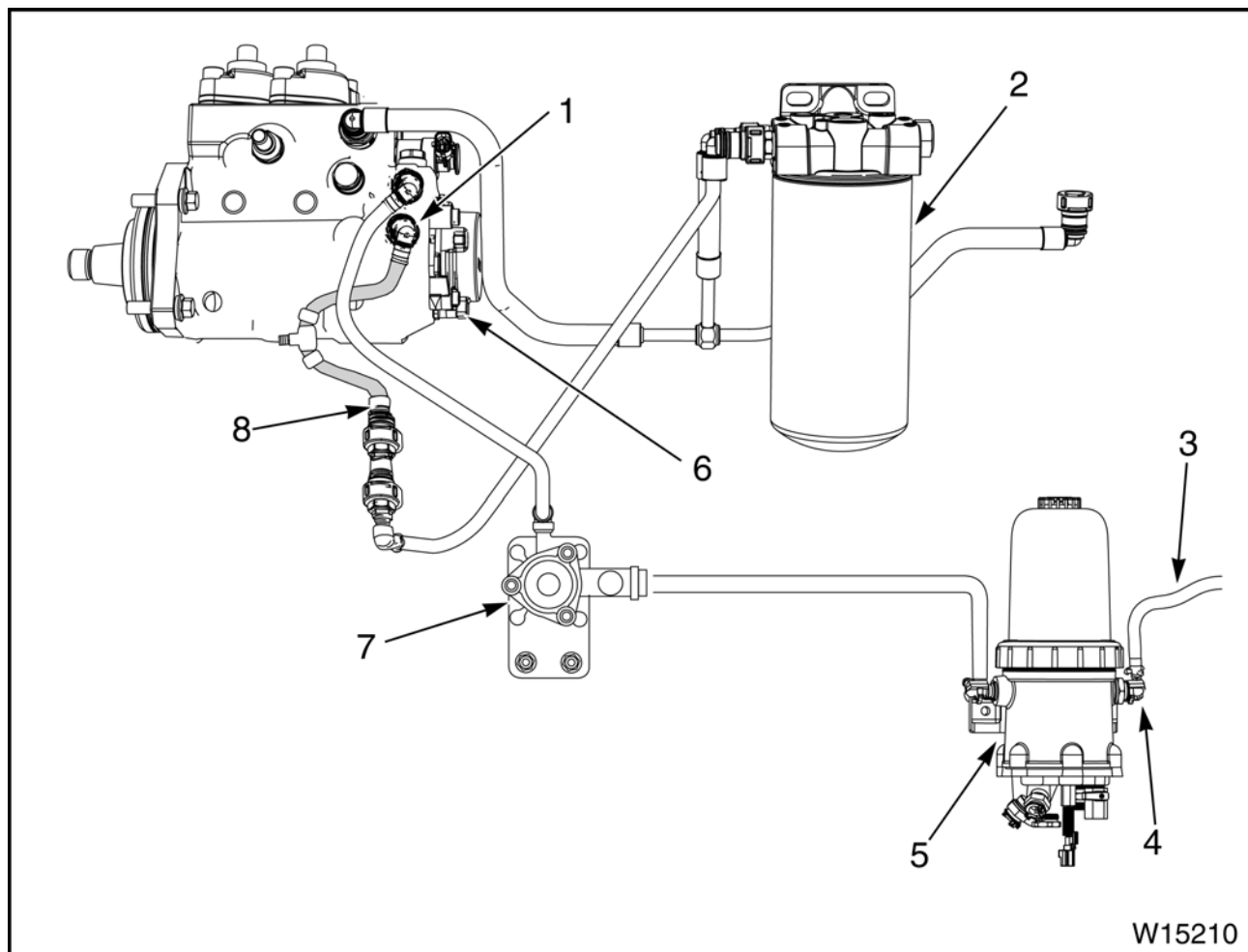


Figure 95 Aeration test diagram

1. Test point 1	4. Test point 2	7. Low-pressure fuel pump
2. Engine-mounted fuel filter	5. Chassis-mounted fuel filter	8. Fuel Inlet Restriction / Aeration Tool
3. Fuel supply from tank	6. Primer pump	

Purpose

Check for fuel aeration.

Tools

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

Procedure

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



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

1. With engine OFF, remove Clean Fuel Source Tool from low-pressure fuel pump inlet.
2. Use Fuel Line Coupler to connect Fuel Inlet Restriction / Aeration Tool between fuel supply line to engine-mounted fuel filter and low-pressure fuel pump outlet.
3. Prime fuel system to remove air from lines.
4. Start engine while visually monitoring for fuel aeration (air bubbles passing through clean line).
 - If fuel is not aerated, go to Restriction Test.
 - If fuel is aerated, continue to next step.
5. Turn engine OFF.
6. Connect Clean Fuel Source Tool to chassis-mounted fuel filter inlet (test point 2).
7. Prime fuel system to remove air from lines.
8. Start engine while visually monitoring for fuel aeration (air bubbles passing through clean line).
 - If fuel is not aerated, repair open in fuel supply line from chassis-mounted fuel filter to fuel tank.
 - If fuel is aerated, repair open in low-pressure fuel pump supply line or chassis-mounted fuel filter.

Restriction Test

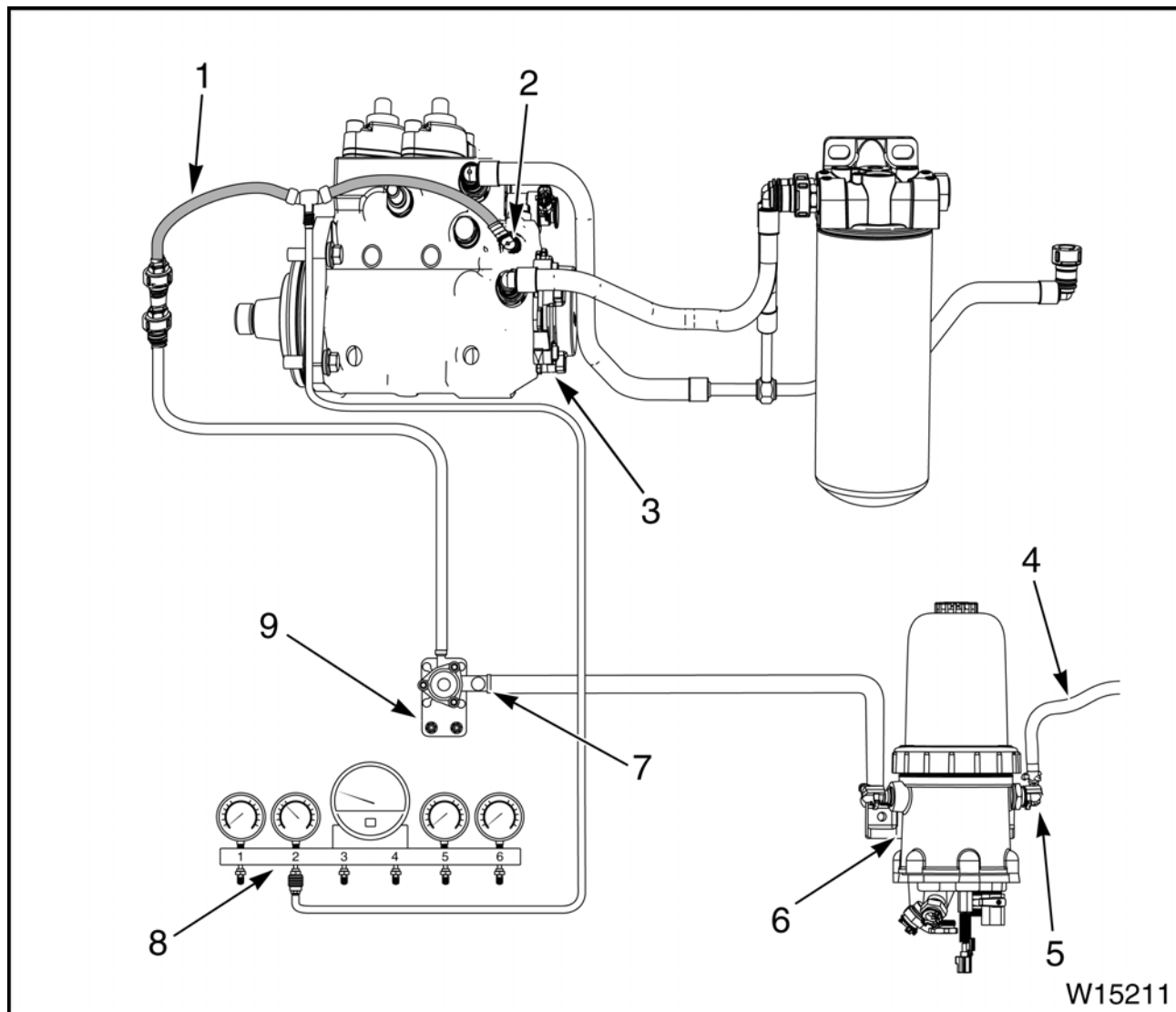


Figure 96 Restriction test diagram

1. Fuel Inlet Restriction / Aeration Tool	4. Fuel supply from tank	8. Pressure Test Kit
2. Test point 1	5. Test point 2	9. Primer pump
3. Low-pressure fuel pump	6. Chassis-mounted fuel filter	
	7. Test point 3	

Purpose

Check for fuel supply restriction.

Tools

- Compucheck fitting – Star Products part # TU-32-25
- 15-637-01 – Clean Fuel Source Tool
- ZTSE4409 – Pressure Test Kit
- ZTSE4886 – Fuel Inlet Restriction / Aeration Tool
- ZTSE4906 – Fuel Line Coupler
- ZTSE6124 – Fuel Outlet Fitting

Procedure

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



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

1. With engine OFF, use Fuel Line Coupler to connect Fuel Inlet Restriction / Aeration Tool to low-pressure fuel pump supply line.
2. Use Fuel Outlet Fitting to connect Fuel Inlet Restriction / Aeration Tool to low-pressure fuel pump inlet.
3. Use compucheck fitting to connect Pressure Test Kit vacuum gauge to Fuel Inlet Restriction / Aeration Tool.
4. Prime fuel system to remove air from lines.
5. Start engine while monitoring Pressure Test Kit vacuum gauge.
 - If restriction is within specification, go to High-pressure Fuel System.

- If restriction is above specification and engine is equipped with a Racor® chassis-mounted fuel filter, go to Restriction Test Point 2.
- If restriction is above specification and engine is equipped with a Davco® chassis-mounted fuel filter, go to Restriction Test Point 3.

NOTE: The Davco® chassis-mounted fuel filter has a separate chassis-mounted primer pump assembly. The Racor® chassis-mounted fuel filter has a primer pump on top of the filter housing.

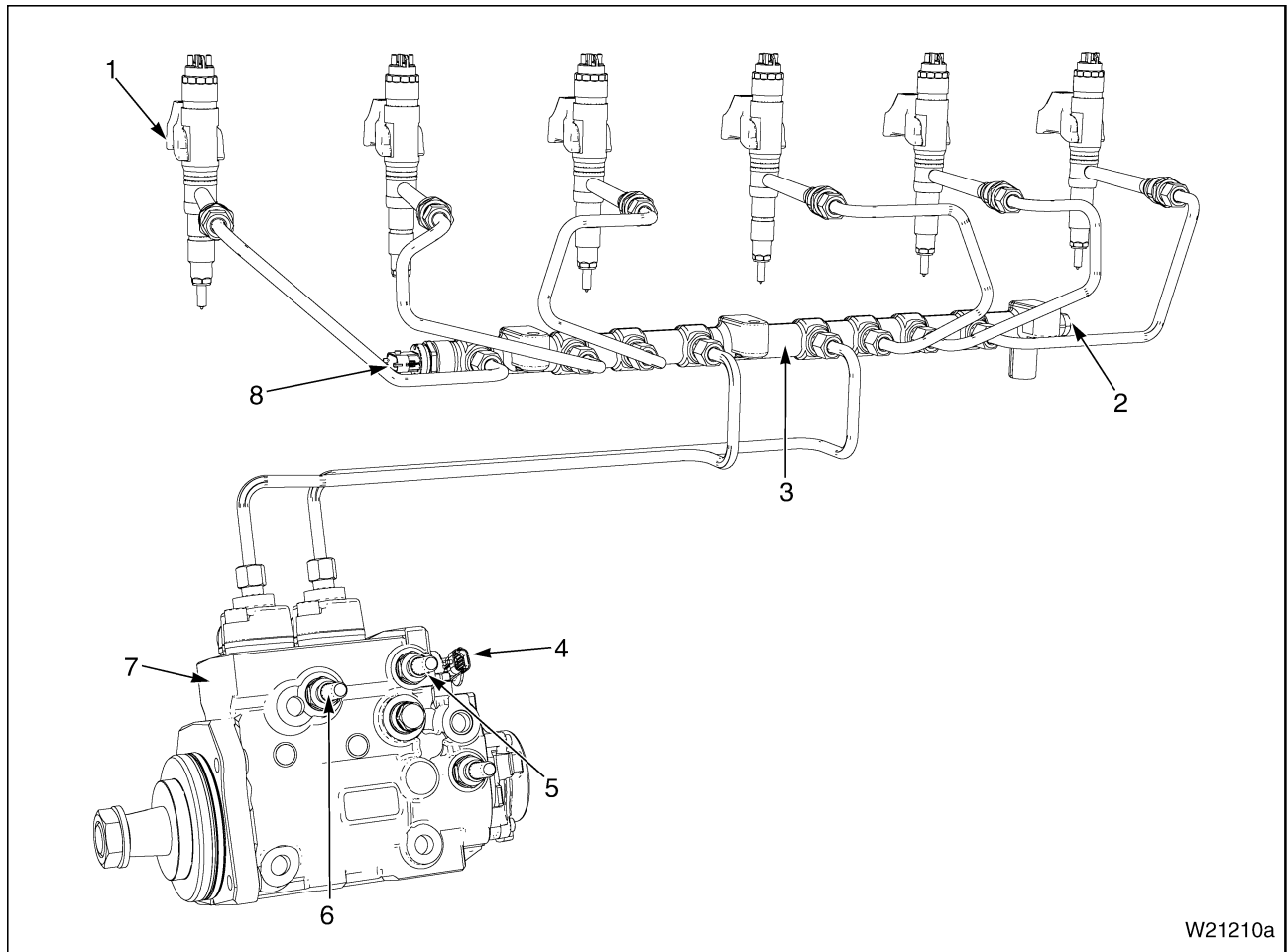
Restriction Test Point 2

1. With engine OFF, connect Clean Fuel Source Tool to chassis-mounted fuel filter inlet.
2. Prime fuel system to remove air from lines.
3. Crank engine while monitoring Pressure Test Kit vacuum gauge.
 - If restriction is within specification, repair restriction in fuel supply line between chassis-mounted fuel filter and fuel tank.
 - If restriction is above specification, repair or replace chassis-mounted fuel filter and check fuel lines.

Restriction Test Point 3

1. With engine OFF, connect Clean Fuel Source Tool to primer pump inlet.
2. Prime fuel system to remove air from lines.
3. Start engine while monitoring vacuum gauge.
 - If restriction is within specification, go to Restriction Test Point 2.
 - If restriction is above specification, repair or replace primer pump and check fuel lines. Retest with original fuel lines installed to verify condition is corrected.

High-pressure Fuel System



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Figure 97 High-pressure fuel system

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

High-pressure Pump Inlet Pressure Test**Purpose**

Verify high-pressure fuel system is working within specification.

Tools

- Compucheck fitting – Star Products part # TU-32-25
- Diesel fuel container with measuring marks
- ZTSE4887-2 – High Pressure Return Line Tester
- Tube fitting cap - McMaster-Carr part # 5482K69

Procedure

 **WARNING:** To prevent personal injury or death, engine must be OFF for at least 5 minutes before doing any work on high-pressure fuel system to allow for system depressurization.

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

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

1. Disconnect fuel supply line to Down Stream Injection (DSI) valve assembly.
2. Use Fuel Line Coupler to connect Fuel Inlet Restriction / Aeration Tool to DSI fuel supply line.
3. Connect Fuel Block Off Tool to Fuel Inlet Restriction / Aeration Tool.
4. Use compucheck fitting to connect Fuel Pressure Gauge to Fuel Inlet Restriction / Aeration Tool.
5. Start engine while monitoring Fuel Pressure Gauge.
 - If gauge pressure is within specification, go to High-pressure Fuel Return Flow Test.
 - If gauge pressure is below specification, replace engine-mounted fuel filter and run engine at high idle while monitoring Fuel Rail Pressure (FRP). If gauge pressure is still below specification, go to High-pressure Fuel Return Flow Test.

High-pressure Fuel Return Flow Test

Purpose

Verify fuel return flow is within specifications.

Tools

- 90 degree elbow with swivel - Dixon part # 166FSV-6-6
- Clean plastic hose
- Diesel fuel container
- Tube fitting cap - McMaster-Carr part # 5482K69
- ZTSE4887-2 – High-pressure Return Line Tester
- ZTSE6094-1 – Fuel Pressure Return Connector

Procedure

⚠ WARNING: To prevent personal injury or death, engine must be OFF for at least 5 minutes before doing any work on high-pressure fuel system to allow for system depressurization.

⚠ 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.

1. Disconnect fuel return tube assembly (from injectors) at left, rear side of engine.

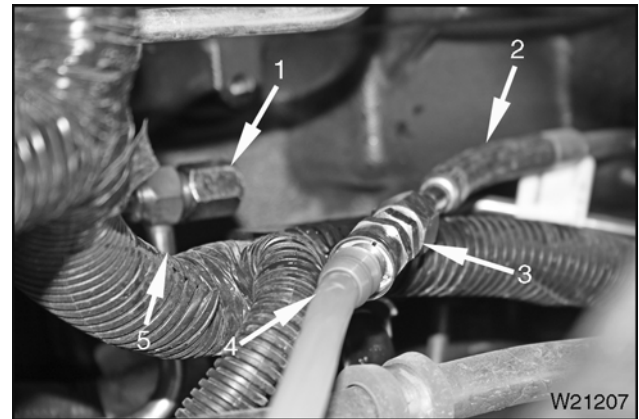


Figure 98 Tube fitting cap connected to fuel return tube assembly

1. Tube fitting cap
 2. Fuel return tube assembly
 3. Fuel Pressure Return Connector
 4. Clean plastic hose
 5. Fuel return line
2. Cap off fuel return line using tube fitting cap.
 3. Connect fuel return tube assembly to Fuel Pressure Return Connector.
 4. Connect clean plastic hose to Fuel Pressure Return Connector and route into diesel fuel container.
 5. Start engine and run for 1 minute while monitoring fuel return from clean plastic hose.
 - If fuel volume is above specification, go to Fuel Rail Pressure (FRP) Leak Isolation.
 - If fuel volume is within specification, continue to next step.

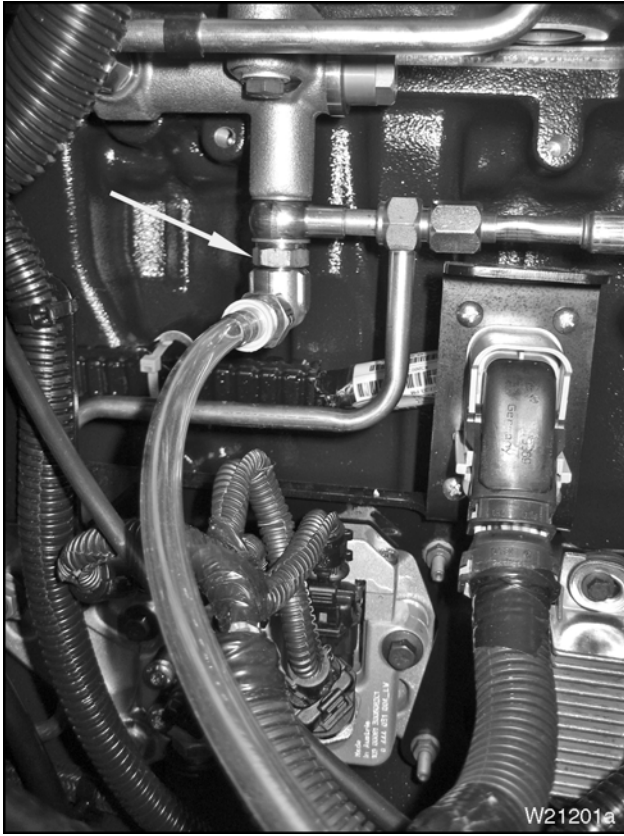


Figure 99 High-pressure Return Line Tester connected to fuel rail

6. Turn engine OFF.
7. Reinstall fuel return tube assembly disconnected in step 1.
8. Remove banjo bolt that connects fuel injector return line and fuel rail.
9. Use 90 degree elbow with swivel to connect High-pressure Return Line Tester to fuel rail (where banjo bolt was installed).
10. Route other end of High-pressure Return Line Tester to diesel fuel container.
11. Start engine and monitor fuel return from test line.
 - If fuel flows from High-pressure Return Line Tester, replace FRP relief valve following procedures in the *Engine Service Manual*.
 - If fuel does not flow from High-pressure Return Line Tester, replace fuel pump following procedures in the *Engine Service Manual*. To prevent damage to a newly installed fuel pump, perform HP Pump Fuel Return Pressure Test (page 120) in "Hard Start and No Start Diagnostics" any time fuel pump is replaced.

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

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
52 ml	47 ml	42 ml	37 ml	32 ml

Purpose

Isolate pressure loss in high-pressure fuel system.

Tools

- Diesel fuel container with measuring marks
- ZTSE4887-2 – High-pressure Return Line Tester
- ZTSE6098 – High-pressure Rail Plugs

Procedure

! WARNING: To prevent personal injury or death, engine must be OFF for at least 5 minutes before doing any work on high-pressure fuel system to allow for system depressurization.

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

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

1. Retain connection between High-pressure Return Line Tester and fuel injector return line from previous test.

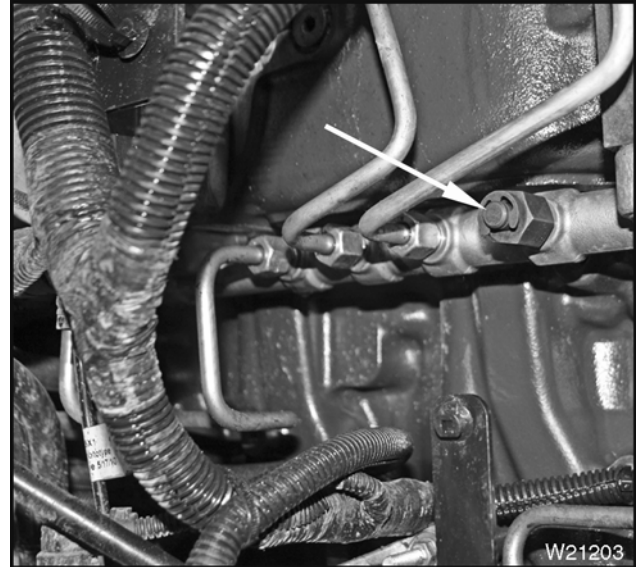


Figure 100 High Pressure Rail Plug installed on number six injector supply port

2. Disconnect number six injector fuel line and cap off rail with High-pressure Rail Plug.
3. Start engine and run at low idle for 1 minute.
4. Start timer and begin measurement when fuel begins to drip into diesel fuel container. Shut engine OFF after 1 minute. Continue measurement until fuel stops dripping.
 - If fuel volume is within specification, replace number six 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.
 - If fuel volume is above specification, continue to next step.

5. Disconnect number five injector fuel line and cap off fuel rail with High-pressure Rail Plug.
6. Start engine and run at low idle for 1 minute.
7. Start timer and begin measurement when fuel begins to drip into diesel fuel container. Shut engine OFF after 1 minute. Continue measurement until fuel stops dripping.
 - If fuel volume is above specification, leave High-pressure Rail Plugs connected and continue capping off one injector supply port at a time until excessive leak is isolated. Replace high-pressure rail to injector tube and high-pressure connector body on any injector that is leaking bad enough to prevent engine from building cranking FRP.
 - If fuel amount is within specification, replace high-pressure rail to injector tube and high-pressure connector body following procedures in the *Engine Service Manual*.

Blow-by Test**Purpose**

Check if engine is in need of a possible overhaul or repair due to cylinder or valve wear or damage. Verify proper operation of turbochargers.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit
- ZTSE4039 – Crankcase Pressure Test Tool
- ZTSE4409 – Pressure Test Kit
- ZTSE4891 – Air Cap, Fuel Cap, and Plug Kit
- ZTSE6114 – Crankcase Pressure Test Adapter

Procedure

NOTE: Ensure engine is at normal operating temperature of 70°C (158°F) and oil level is within specification before performing this test.

1. Turn ignition switch to ON, engine OFF.
2. Connect EST to vehicle's Diagnostic Connector.
3. Start ServiceMaxx™ software.
4. Select Performance session from the Sessions drop-down menu.
5. Start engine and monitor for SPN 101 FMI 16.
 - If code is previously active or active, continue to next step.
6. With engine OFF, disconnect breather inlet tube from the top of the breather filter assembly.

 **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.

7. Start engine and run at high idle. Allow crankcase pressure reading to stabilize before recording.
8. Record crankcase pressure on Diagnostics Form.
 - If pressure is within specification, replace breather filter. Test crankcase pressure using ServiceMaxx™ software and monitor crankcase pressure in Performance session. If code goes inactive and pressure is within specification, no further repair is needed.

- If pressure is above specification, continue to next step.
9. Turn engine OFF.
 10. If vehicle is equipped with centrifugal soot filter, remove air line from remote-mounted centrifugal soot filter assembly. If vehicle is not equipped with centrifugal soot filter, go to step 11.
 11. Cap air line using Air Cap, Fuel Cap, and Plug Kit.
 12. Start engine and run at high idle. Allow crankcase pressure reading to stabilize before recording.
 - If pressure is within or below specification, repair remote-mounted soot filter.
 - If pressure is above specification, continue to next step.
 13. Drain vehicle air tanks until pressure is removed from system and inspect air drain vent for oil contamination. Disconnect discharge line from air compressor and test again.
 - If pressure is within or below specification, repair or replace leaking air compressor following procedures in the *Engine Service Manual*.
 - If pressure is still above specification, go to Relative Compression Test to pinpoint suspect cylinder.

Relative Compression Test

Purpose

Verify all cylinders have good compression.

NOTE: This test will validate cylinder balance. If this test finds an unbalanced cylinder, it is due to a mechanical problem and is not an injector fault.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

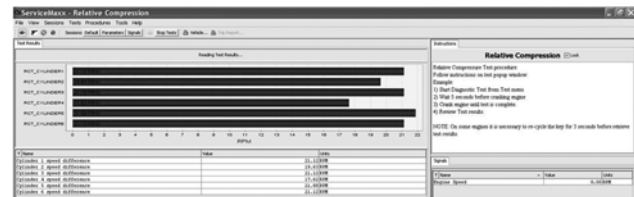
Procedure



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.

- Turn ignition switch to ON, engine OFF.
- Connect EST to vehicle's Diagnostic Connector.
- Start ServiceMaxx™ software.
- Select Relative Compression test.
- Follow on-screen instructions.
- Record results on Diagnostics Form.
 - If RPM for one cylinder is significantly lower than the other cylinders, that cylinder is suspect for compression loss.



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Figure 101 Relative Compression Test

Relative Compression Test Interpretation

The Relative Compression test determines cylinder integrity. The Engine Control Module (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 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.

Possible Causes

- Valve train damage
- Valves out of adjustment
- Worn or broken piston rings
- Excessive cylinder wall wear
- Damaged piston

Cylinder Cutout Test

Purpose

Determine cause of rough engine idle.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

Possible Causes

- Open or shorted injector wiring
- Scuffed or failed injector
- Power cylinder problem

Procedure

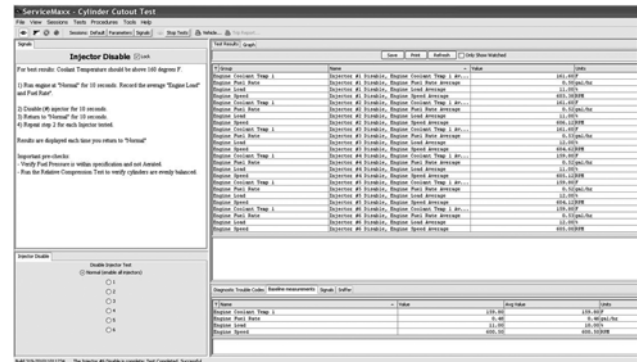
NOTE: Do the following before running this test:

- Run Relative Compression Test. If Relative Compression Test results display low balanced cylinder(s), there is no need to run Cylinder Cutout Test. Repair mechanical fault.
 - Verify fuel system pressure is not below specification and fuel is not aerated.
- Turn ignition switch to ON, engine OFF.
 - Connect EST to vehicle's Diagnostic Connector.
 - Start ServiceMaxx™ software.
 - Start engine.

- Select Cylinder Cutout Test.
- Follow on-screen instructions.
- Listen to tone changes from cylinder to cylinder.

NOTE: This test is only meant to isolate a low contributing cylinder due to an injector or injector circuit failure.

- Select Performance session.



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Figure 102 Cylinder Cutout Test

- 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 – New Injector Calibration

Purpose

Calibrate 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
- NAVCoM or NAVLink Interface Kit

Injection Quantity Adjustment (IQA) Overview

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.

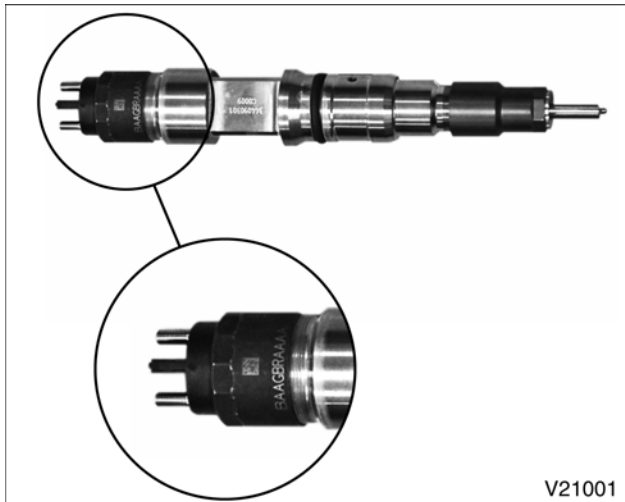


Figure 103 Picture of IQA code location

Procedure

1. Record IQA code stamped on new injector.
2. Replace failed injector following procedures in the *Engine Service Manual*.
3. Turn ignition switch to ON, engine OFF.
4. Connect EST to vehicle's Diagnostic Connector.

5. Start ServiceMaxx™ software.



Figure 104 Injection Quantity Adjustment procedure

6. Select Injection Quantity Adjustment from Procedures drop-down menu.
7. Type in the new IQA code (stamped on the top portion of the injector) into the proper cylinder location.

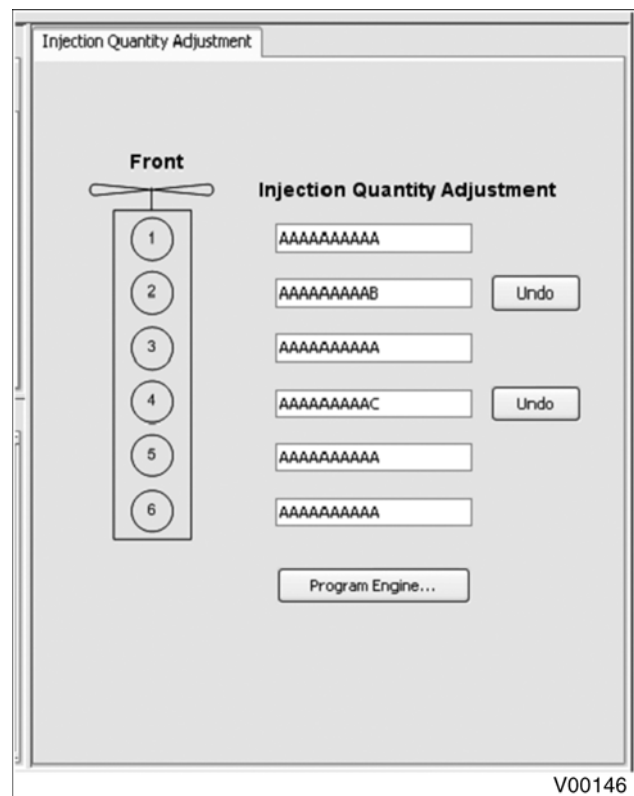


Figure 105 Injection Quantity Adjustment

NOTE: When the Undo button appears, the Program Engine button becomes active.

8. Press the Program Engine button.

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How To Use This Section

- New philosophy: Don't go directly to circuit section.

The Diagnostic Trouble Code (DTC) must direct you to the appropriate circuits.

- DTC list directs you to the appropriate circuit diagnostics and page numbers.

Diagnostic Trouble Codes (DTCs) and Subsection Diagnostics Page Locations

SPN	FMI	Sub-section	Condition Description
27	0	EGR (page 300)	EGRP fault: over temperature
27	3	EGR (page 300)	EGRP signal Out of Range HIGH
27	4	EGR (page 300)	EGRP signal Out of Range LOW
27	7	EGR (page 300)	EGRP does not agree with commanded position
51	0	ETV (page 311)	ETP fault: over temperature
51	3	ETV (page 311)	ETP signal Out of Range HIGH
51	4	ETV (page 311)	ETP signal Out of Range LOW
51	7	ETV (page 311)	ETP does not agree with commanded position
84	2	VS	Vehicle speed anti-tampering fault Refer to the <i>Chassis Electrical Circuit Diagram Manual</i>
91	2	APP (page 235)	APP1 and APP2 signal conflict
91	3	APP (page 235)	APP1 signal Out of Range HIGH
91	4	APP (page 235)	APP1 signal Out of Range LOW
94	0	FDP (page 318)	Fuel Delivery Pressure above maximum
94	3	FDP (page 318)	FDP signal Out of Range HIGH
94	4	FDP (page 318)	FDP signal Out of Range LOW
97	3	WIFL	WIFL short to PWR Refer to the <i>Chassis Electrical Circuit Diagram Manual</i>
97	4	WIFL	WIFL short to GND Refer to the <i>Chassis Electrical Circuit Diagram Manual</i>
97	5	WIFL	WIFL open load/circuit Refer to the <i>Chassis Electrical Circuit Diagram Manual</i>
98	3	EOL (page 304)	EOL signal Out of Range HIGH
98	4	EOL (page 304)	EOL signal Out of Range LOW
100	1	EWPS (page 314)	Engine Oil System below Critical Pressure

SPN	FMI	Sub-section	Condition Description
100	3	EOP (page 307)	EOP signal Out of Range HIGH
100	4	EOP (page 307)	EOP signal Out of Range LOW
100	11	EWPS (page 314)	Engine oil pressure below dealer programmed engine RPM value
100	17	EWPS (page 314)	Low engine oil pressure, event log
100	18	EWPS (page 314)	Engine Oil System below Warning Pressure
101	3	CCPS (page 241)	CCP signal Out of Range HIGH
101	4	CCPS (page 241)	CCP signal Out of Range LOW
101	16	CCPS (page 241)	Excessive Crankcase Pressure
102	2	IMP (page 328)	IMP signal does not agree with BARO
102	3	IMP (page 328)	IMP signal Out of Range HIGH
102	4	IMP (page 328)	IMP signal Out of Range LOW
105	3	IMT (page 331)	IMT signal Out of Range HIGH
105	4	IMT (page 331)	IMT signal Out of Range LOW
108	3	ECM Self (page 287)	BARO signal Out of Range HIGH
108	4	ECM Self (page 287)	BARO signal Out of Range LOW
109	3	ECP (page 289)	ECP signal Out of Range HIGH
109	4	ECP (page 289)	ECP signal Out of Range LOW
109	18	ECP (page 289)	Engine coolant pressure too low
110	0	EWPS (page 314)	Engine Coolant System above Critical Temperature
110	3	ECT1 (page 292)	ECT1 signal Out of Range HIGH
110	4	ECT1 (page 292)	ECT1 signal Out of Range LOW
110	11	EWPS (page 314)	Event logger, coolant temperature hot, extreme
110	15	EWPS (page 314)	Engine Coolant System above Warning temperature
111	1	EWPS (page 314)	Low Engine Coolant Level
		ECL (page 280)	
157	0	FRPS (page 325)	FRP relief valve opening fault
157	3	FRP (page 323)	FRP signal Out of Range HIGH
157	4	FRP (page 323)	FRP signal Out of Range LOW
157	14	FRPS (page 325)	FRP Relief Valve failure, Replace Valve & Re-set counter
158	15	ECM PWR (page 282)	ECM Switched voltage too HIGH
158	17	ECM PWR (page 282)	ECM Switched voltage too LOW
171	2	AAT (page 192)	AAT signal does not agree with other sensors
171	3	AAT (page 192)	AAT signal Out of Range HIGH (Body mounted sensor)

SPN	FMI	Sub-section	Condition Description
171	4	AAT (page 192)	AAT signal Out of Range LOW (Body mounted sensor)
175	0	EWPS (page 314)	Engine Oil System above Critical Temperature
175	3	EOT (page 309)	EOT signal Out of Range HIGH
175	4	EOT (page 309)	EOT signal Out of Range LOW
175	11	EWPS (page 314)	Oil Temperature exceeds limit by large amount
175	15	EWPS (page 314)	Engine Oil System above warning temperature
190	0	EWPS (page 314)	Engine Overspeed - Most Severe Level
190	11	EWPS (page 314)	Engine Overspeed, event log
190	15	EWPS (page 314)	Engine Overspeed detected
191	2	TOSS	TOSS signal erratic, intermittent or incorrect Refer to the <i>Chassis Electrical Circuit Diagram Manual</i>
191	3	TOSS	TOSS signal Out of Range HIGH Refer to the <i>Chassis Electrical Circuit Diagram Manual</i>
191	4	TOSS	TOSS signal Out of Range LOW Refer to the <i>Chassis Electrical Circuit Diagram Manual</i>
191	16	TOSS	Hard wired vehicle speed reading higher than limit Refer to the <i>Chassis Electrical Circuit Diagram Manual</i>
251	19	SART (page 350)	ECM not detecting SART module J1939
412	3	EGRT (page 298)	EGRT signal Out of Range HIGH
412	4	EGRT (page 298)	EGRT signal Out of Range LOW
560	19	Transmission	Transmission Driveline Engaged not detected on J1939 Refer to appropriate transmission manual
626	3	CSFS (page 259)	CSFS short to PWR
626	4	CSFS (page 259)	CSFS short to GND
626	5	CSFS (page 259)	CSFS open load/circuit
626	11	CSFS (page 259)	Cold Start Assist fault: Lack of heat in the Intake Manifold
628	12	ECM Self (page 287)	ECM Memory Error
629	8	ECM Self (page 287)	Engine Off timer fault
629	12	ECM Self (page 287)	ECM Internal chip Error
629	14	ECM Self (page 287)	ECM Internal component overtemperature
633	3	FPCV (page 321)	FPCV short to PWR
633	4	FPCV (page 321)	FPCV short to GND
633	5	FPCV (page 321)	FPCV open load/circuit
636	2	CMP (page 251)	CMP and CKP Synchronization Error

SPN	FMI	Sub-section	Condition Description
636	8	CMP (page 251)	CMP signal noise
636	10	CMP (page 251)	CMP signal missing
637	8	CKP (page 249)	CKP signal noise
637	10	CKP (page 249)	CKP signal inactive
639	14	J1939 (page 341)	J1939 Data Link Error (ECM unable to transmit)
639	19	J1939 (page 341)	J1939 Data Link Error (ECM unable to transmit or receive)
647	3	EFC (page 296)	EFC short to PWR
647	4	EFC (page 296)	EFC short to GND
647	5	EFC (page 296)	EFC open load/circuit
651	4	INJ (page 333)	INJ 1 short circuit
651	5	INJ (page 333)	INJ 1 open circuit
651	13	INJ (page 333)	Injector 1 programmable parameter error
652	4	INJ (page 333)	Injector 2 short circuit
652	5	INJ (page 333)	Injector 2 open circuit
652	13	INJ (page 333)	Injector 2 programmable parameter error
653	4	INJ (page 333)	Injector 3 short circuit
653	5	INJ (page 333)	Injector 3 open circuit
653	13	INJ (page 333)	Injector 3 programmable parameter error
654	4	INJ (page 333)	Injector 4 short circuit
654	5	INJ (page 333)	Injector 4 open circuit
654	13	INJ (page 333)	Injector 4 programmable parameter error
655	4	INJ (page 333)	Injector 5 short circuit
655	5	INJ (page 333)	Injector 5 open circuit
655	13	INJ (page 333)	Injector 5 programmable parameter error
656	4	INJ (page 333)	Injector 6 short circuit
656	5	INJ (page 333)	Injector 6 open circuit
656	13	INJ (page 333)	Injector 6 programmable parameter error
724	2	O2S (page 344)	O2S Slow response detected fueling to non-fueling
724	3	O2S (page 344)	O2S Circuit Fault: Open or short to PWR
724	4	O2S (page 344)	O2S Circuit Fault: Short to GND
724	5	O2S (page 344)	O2S Circuit Fault: Open circuit
724	20	O2S (page 344)	O2S adaptation above maximum limit
724	21	O2S (page 344)	O2S adaptation below minimum limit

SPN	FMI	Sub-section	Condition Description
837	14	SPEEDO	Speedometer Drive Output Error Refer to the <i>Chassis Electrical Circuit Diagram Manual</i>
974	3	RAPP	Remote APP signal Out of Range HIGH Refer to the <i>Chassis Electrical Circuit Diagram Manual</i>
974	4	RAPP	Remote APP signal Out of Range LOW Refer to the <i>Chassis Electrical Circuit Diagram Manual</i>
1072	3	ECB1 (page 274)	ECB1 Control short to PWR
1072	4	ECB1 (page 274)	ECB1 Control short to GND
1072	5	ECB1 (page 274)	ECB1 Control open load/circuit
1073	3	ECB2 (page 276)	ECB2 Control short to PWR
1073	4	ECB2 (page 276)	ECB2 Control short to GND
1073	5	ECB2 (page 276)	ECB2 Control open load/circuit
1081	3	WTSL	WTSL short to PWR Refer to the <i>Chassis Electrical Circuit Diagram Manual</i>
1081	4	WTSL	WTSL short to GND Refer to the <i>Chassis Electrical Circuit Diagram Manual</i>
1081	5	WTSL	WTSL open load/circuit Refer to the <i>Chassis Electrical Circuit Diagram Manual</i>
1110	31	EWPS (page 314)	ECM detects fueling without driver demand
1135	3	EOL (page 304)	EOT2 signal Out of Range HIGH
1135	4	EOL (page 304)	EOT2 signal Out of Range LOW
1177	3	TC2CIS (page 358)	TC2CIP signal Out of Range HIGH
1177	4	TC2CIS (page 358)	TC2CIP signal Out of Range LOW
1188	3	TC1WC (page 354)	TC1WC short to PWR
1188	4	TC1WC (page 354)	TC1WC short to GND
1189	3	TC2WC (page 356)	TC2WC short to PWR
1189	4	TC2WC (page 356)	TC2WC short to GND
1189	5	TC2WC (page 356)	TC2WC open load/circuit
1213	3	MIL	MIL circuit short to PWR Refer to the <i>Chassis Electrical Circuit Diagram Manual</i>
1213	4	MIL	MIL circuit short to GND Refer to the <i>Chassis Electrical Circuit Diagram Manual</i>
1213	5	MIL	MIL open load/circuit Refer to the <i>Chassis Electrical Circuit Diagram Manual</i>

SPN	FMI	Sub-section	Condition Description
1378	31	Service (page 349)	Change Engine Oil Service Interval
1590	19	ACC	Adaptive Cruise Control not detected on J1939 Refer to the <i>Chassis Electrical Circuit Diagram Manual</i>
2588	0	EWPS (page 314)	Vehicle overspeed 1, event log, extreme
2588	15	EWPS (page 314)	Vehicle overspeed 1, event log, non-extreme
2589	0	EWPS (page 314)	Vehicle overspeed 2, event log, extreme
2589	15	EWPS (page 314)	Vehicle overspeed 2, event log, non-extreme
2623	3	APP (page 235)	APP2 signal Out of Range HIGH
2623	4	APP (page 235)	APP2 signal Out of Range LOW
2630	3	CACOT (page 239)	CACOT signal Out of Range HIGH
2630	4	CACOT (page 239)	CACOT signal Out of Range LOW
2659	20	AMS (page 233)	EGR High Flow Rate detected
2659	21	AMS (page 233)	EGR Low Flow Rate detected
2791	3	EGR (page 300)	EGRC short to PWR
2791	5	EGR (page 300)	EGRC open load/circuit
2791	8	EGR (page 300)	EGR valve not receiving ECM PWM signal
2797	11	INJ (page 333)	Injector Control Group 1 short circuit (INJ 1, 3, 5)
2798	11	INJ (page 333)	Injector Control Group 2 short circuit (INJ 2, 4, 6)
3055	0	FRPS (page 325)	FRP exceeded maximum
3055	15	FRPS (page 325)	FRP below minimum with maximum command
3055	17	FRPS (page 325)	FRP above maximum with minimum command
3223	0	O2S (page 344)	O2S heater temperature above maximum
3223	1	O2S (page 344)	O2S heater temperature below minimum
3223	3	O2S (page 344)	O2S heater short to PWR
3223	4	O2S (page 344)	O2S heater short to GND
3223	5	O2S (page 344)	O2S heater open load/circuit
3223	17	O2S (page 344)	O2S heater temperature below minimum at low battery PWR
3246	2	DPFOT (page 271)	DPFOT signal does not agree with other exhaust sensors
3246	3	DPFOT (page 271)	DPFOT signal Out of Range HIGH
3246	4	DPFOT (page 271)	DPFOT signal Out of Range LOW
3251	0	AFT System (page 195)	DPFDP excessively HIGH (Plugged filter)
3251	2	DPFDP (page 268)	DPFDP above or below desired level
3251	3	DPFDP (page 268)	DPFDP signal Out of Range HIGH

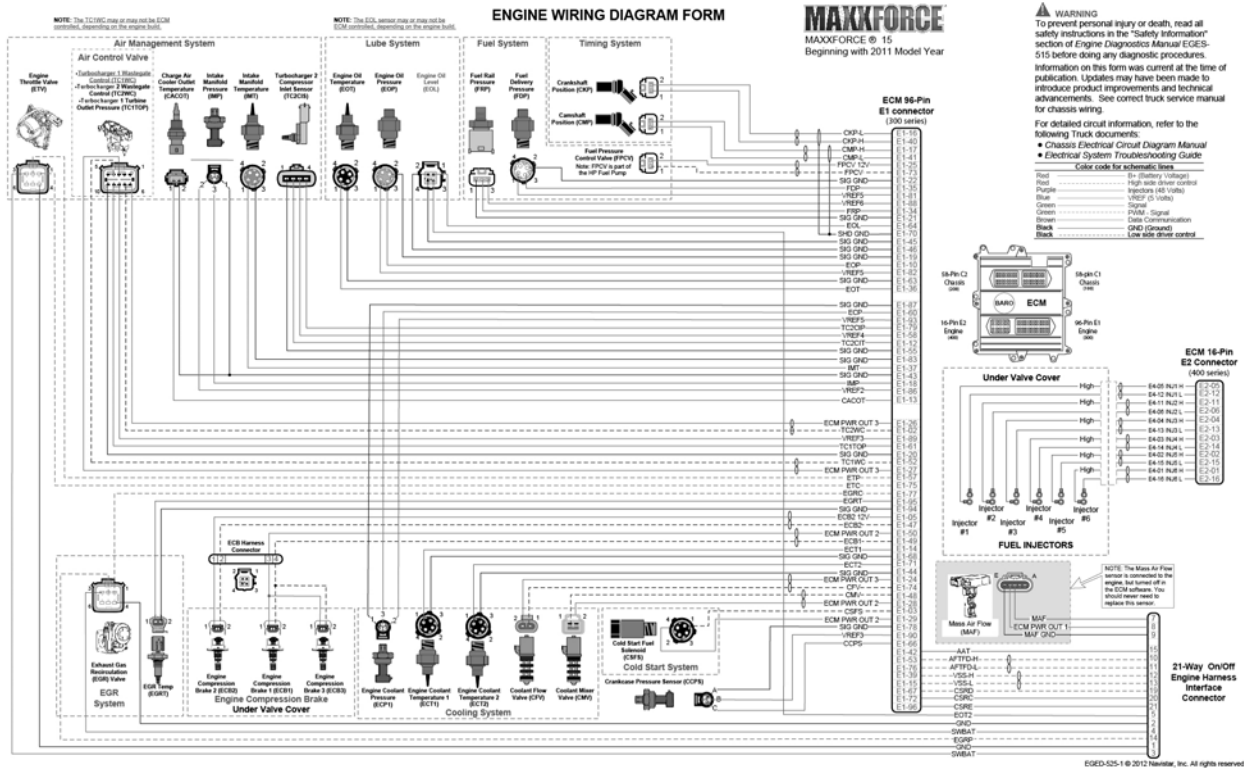
SPN	FMI	Sub-section	Condition Description
3251	4	DPFDP (page 268)	DPFDP signal Out of Range LOW
3251	14	AFT System (page 195)	DPFDP sensor pressure hoses reversed
3251	21	AFT System (page 195)	DPFDP excessively LOW (Sensor/circuit fault or missing DPF)
3464	3	ETV (page 311)	ETC short to PWR
3464	5	ETV (page 311)	ETC open load/circuit
3464	8	ETV (page 311)	ETC not receiving command from ECM
3471	1	AFT System (page 195)	Fuel Pressure 1 below desired (Low System Pressure)
3471	7	AFT System (page 195)	Fuel doser valve not responding as expected
3479	3	AFTFD (page 220)	AFT Fuel Doser Valve short to PWR
3479	5	AFTFD (page 220)	AFT Fuel Doser Valve open/load circuit
3479	6	AFTFD (page 220)	AFT Fuel Doser Valve High Side Short circuit
3480	0	AFT System (page 195)	AFTFP1 too high while dosing
3480	1	AFT System (page 195)	AFTFP1 too low while dosing
3480	2	AFTFIS (page 223)	AFTFP1 pressure sensor plausibility error
3480	3	AFTFIS (page 223)	AFTFP1 signal Out of Range HIGH
3480	4	AFTFIS (page 223)	AFTFP1 signal Out of Range LOW
3481	7	AFT System (page 195)	Incorrect dosing pressure, multiple events
3482	3	AFTFSV (page 230)	AFT Fuel Shutoff Valve short to PWR
3482	4	AFTFSV (page 230)	AFT Fuel Shutoff Valve short to GND
3509	14	VREF (page 361)	VREF1 voltage deviation ECM pins: C1-36 and E1-65
3510	14	VREF (page 361)	VREF2 voltage deviation ECM pins: E1-85 and E1-86
3511	14	VREF (page 361)	VREF3 voltage deviation ECM pins: E1-89 and E1-90
3512	14	VREF (page 361)	VREF4 voltage deviation ECM pins: C1-37, C1-43, C1-49, C2-08, E1-58 and E1-91
3513	14	VREF (page 361)	VREF5 voltage deviation ECM pins: C1-50, E1-80, E1-81, E1-82, E1-84 and E1-93
3514	14	VREF (page 361)	VREF6 voltage deviation ECM pin: E1-88
3556	0	AFT System (page 195)	AFT fuel pressure 2 excessively high (Restricted injection)
3556	1	AFT System (page 195)	AFT fuel pressure 2 below desired (Possible system leak)
3556	7	AFT System (page 195)	AFT fuel injector not responding as expected
3597	4	ECM PWR Output (page 284)	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 284)	ECM Power Output 2 below normal ECM Pins: C1-42, C2-06, E1-05, E1-28, E1-29 and E1-54

SPN	FMI	Sub-section	Condition Description
3599	4	ECM PWR Output (page 284)	ECM Power Output 3 below normal ECM Pins: C1-30, C2-03, E1-24, E1-26 and E1-27
3719	0	AFT System (page 195)	DPF Soot Load - Highest (level 3/3)
3719	15	AFT System (page 195)	DPF Soot Load - Lowest (level 1/3)
3719	16	AFT System (page 195)	DPF Soot Load - Moderate (level 2/3)
3720	0	AFT System (page 195)	DPF Ash load at maximum limit (Remove DPF for cleaning)
4076	0	EWPS (page 314)	ECT2 above Critical (EWPS programmable limit)
4076	3	ECT2 (page 294)	ECT2 signal Out of Range HIGH
4076	4	ECT2 (page 294)	ECT2 signal Out of Range LOW
4076	15	EWPS (page 314)	ECT2 above Warning (EWPS programmable limit)
4077	0	AFT System (page 195)	AFTFP2 too high while dosing
4077	1	AFT System (page 195)	AFTFP2 too low while dosing
4077	3	AFTFP2 (page 227)	AFTFP2 signal out of Range HIGH
4077	4	AFTFP2 (page 227)	AFTFP2 signal out of Range LOW
4077	14	AFTFP2 (page 227)	A/T downstream pressure sensor plausibility error
4765	2	DOCIT (page 262)	DOCIT signal does not agree with other exhaust sensors
4765	3	DOCIT (page 262)	DOCIT signal Out of Range HIGH
4765	4	DOCIT (page 262)	DOCIT signal Out of Range LOW
4766	2	DOCOT (page 265)	DOCOT signal does not agree with other exhaust sensors
4766	3	DOCOT (page 265)	DOCOT signal Out of Range HIGH
4766	4	DOCOT (page 265)	DOCOT signal Out of Range LOW
5456	3	AFTFIS (page 223)	AFTFT signal Out of Range HIGH
5456	4	AFTFIS (page 223)	AFTFT signal Out of Range LOW
5541	2	TC1TOP (page 351)	TC1TOP does not agree with other sensors
5541	3	TC1TOP (page 351)	TC1TOP signal Out of Range HIGH
5541	4	TC1TOP (page 351)	TC1TOP signal Out of Range LOW
5546	3	CMV (page 253)	CMV short to PWR
5546	4	CMV (page 253)	CMV short to GND
5546	5	CMV (page 253)	CMV open load/circuit
5547	3	CFV (page 246)	CFV short to PWR
5547	4	CFV (page 246)	CFV short to GND
5548	3	CSFI (page 255)	CSFI short to PWR
5548	4	CSFI (page 255)	CSFI short to GND

SPN	FMI	Sub-section	Condition Description
5548	5	CSFI (page 255)	Cold Start Relay or control circuit fault
5548	7	CSFI (page 255)	Cold Start Igniter or high power side circuit fault

Engine Wiring Diagram Form EGED-525 Usage

Engine Wiring Diagram Form



W00200a

Figure 106 Engine Wiring Diagram Form (front side)

Engine Wiring Diagram Form EGED-525 assists technicians in troubleshooting MaxxForce® diesel engines. Diagnostic schematics and signal values help technicians find problems to avoid unnecessary repairs.

The Engine Wiring Diagram 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*. Signal values can be found in Appendix B: Signal Values.

Engine Wiring Diagram Form EGED-525 is available in 50 sheet pads. To order technical service literature, contact your International dealer.

HD-OBD (Heavy Duty - Onboard Diagnostic) System Description

HD-OBD System

The 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)

DTC	SPN	FMI	Type	Freeze Frame	Message
N/A	27	4	Active		EGPF signal Out of Range LOW
N/A	31	4	Active		ETP signal Out of Range LOW
N/A	2791	5	Active		EGPC open lead/circuit
N/A	3464	5	Active		ETC open lead/circuit
N/A	3696	19	Previously Active		DPF Regen Switch communication fault

Clear DTCs Refresh DTC/Vehicle Events

W39200

Figure 107 DTC window in ServiceMaxx™ Software

1. DTC column (pre-2010)
2. SPN column
3. FMI column
4. Type column
5. Freeze Frame column
6. Message column
7. Refresh DTC/Vehicle Events button
8. Clear DTCs 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) – SPN identifies the individual component causing the DTC.

Failure Mode Indicator (FMI) – FMI identifies the fault or condition affecting the individual component.

Pending Faults – 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 HD-OBD fault can be set as pending.

Active Faults – Active faults are HD-OBD faults that were detected in the second drive cycle and are currently active.

Previously Active Faults – Previously active faults are historical faults that were detected in a previous drive cycle, but are not currently present.

Healing Faults – Healing faults are faults that can deactivate the MIL if the monitoring system does not detect any malfunctions, related or independent, that would activate the MIL for three consecutive drive cycles.

Permanent Faults – Permanent faults are historic faults and should not be treated as a current problem with the control system. When an active HD-OBD fault is set, a permanent fault is also set. (Up to four permanent fault codes can be stored at one time.) A permanent fault cannot be cleared with the Electronic Service Tool (EST) alone. There are only three ways to clear permanent faults:

- The monitor that set the DTC must execute and pass on three consecutive drive cycles.
- The active DTCs are cleared with an Electronic Service Tool (EST). The monitor that set the DTC must execute the minimum number of times that are needed to set the fault and pass each time.
- Engine Control Module (ECM) calibration update.

Freeze Frame

Freeze Frame data provides a snapshot or record of the conditions of the engine control system at the time the fault code was set. This can be helpful information when trying to duplicate the conditions that the code was set at. Freeze Frame Data is cleared as soon as the DTC is cleared.

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 lamp will turn off, the code will go previously 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. To pass inspection, all monitors must have a "Run Status" and no codes can be 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.

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 previously active DTCs.
- The HD-OBD compliance 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 ECM. 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 the 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

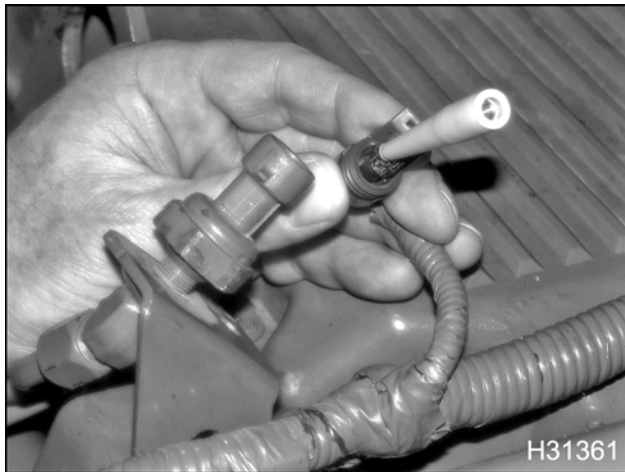


Figure 108 Pin grip check

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.

Diagnostics with EST

Sensors can be diagnosed quickly using an Electronic Service Tool (EST) with ServiceMaxx™ software. The tool monitors sensor signals back to the ECM while testing the sensor's harness connection. Start this procedure with Sensor End Diagnostics.

Actuators can be diagnosed using ServiceMaxx™ software to command Output State test (high or low) while measuring voltage at the actuator's harness connection.

Diagnostics without EST

Sensors can also be diagnosed using only a Digital Multimeter (DMM). Start this test procedure with Pinpoint Diagnostics.

“Example” Sensor Circuit Diagnostics – Using ServiceMaxx™ software

Circuit faults can quickly be diagnosed using the Electronic Service Tool (EST) while monitoring voltage the ECM is receiving from a sensor.

Continuous Monitor Test

Sensor circuit faults, such as OPEN and shorts, will display as ERROR on the EST. By running the Continuous Monitor Test, signals will display actual voltage the ECM is receiving.

NOTE: Sensors go out of range HIGH (5 V) when disconnected.

1. Run the Continuous Monitor Test.
2. Disconnect sensor. The IMP signal shown on the EST should display 5 V, unless shorted to ground.
3. Measure VREF with Digital Multimeter (DMM). Reading should be 5 V, unless OPEN or shorted to power or ground.
4. Measure voltage between VREF and SIG GND with DMM. Reading should be 5 V, unless SIG GND circuit is open.
5. Jump SIG GND circuit to IMP signal circuit (pin 1 to 3). The IMP signal shown on the EST should display 0 V, unless IMP signal circuit is OPEN.
6. If all circuits are within specification, the sensor is at fault.

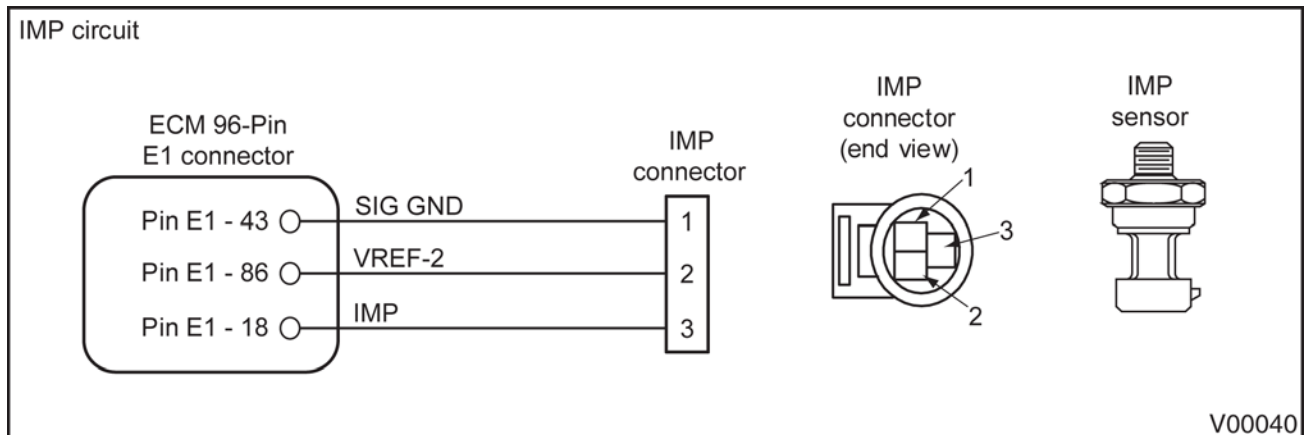


Figure 109 "Example" IMP sensor circuit diagram

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.		
Sensor Circuit Check With ServiceMaxx™ Software		
Connect breakout harness and leave sensor disconnected. Turn 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	0 V	If > 0.5 V, check IMP signal circuit for OPEN or short to PWR. Do Harness Resistance Check (page 185).
Short across breakout harness pins 1 and 3		
If checks 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.		

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Pinpoint 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 $\pm$ 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.
• 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 Pinpoint 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, and 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 $\pm$ 0.5 V	0%
A to GND or C-48 to GND	Pedal to floor	3.85 V $\pm$ 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
171	2	AAT signal does not agree with other sensors	Biased AAT sensor or circuit
171	3	AAT signal Out of Range HIGH (Body mounted sensor)	- AAT signal circuit OPEN or short to PWR - SIG GND circuit OPEN - Failed AAT sensor
171	4	AAT signal Out of Range LOW (Body mounted sensor)	- AAT signal circuit short to GND - Failed AAT sensor

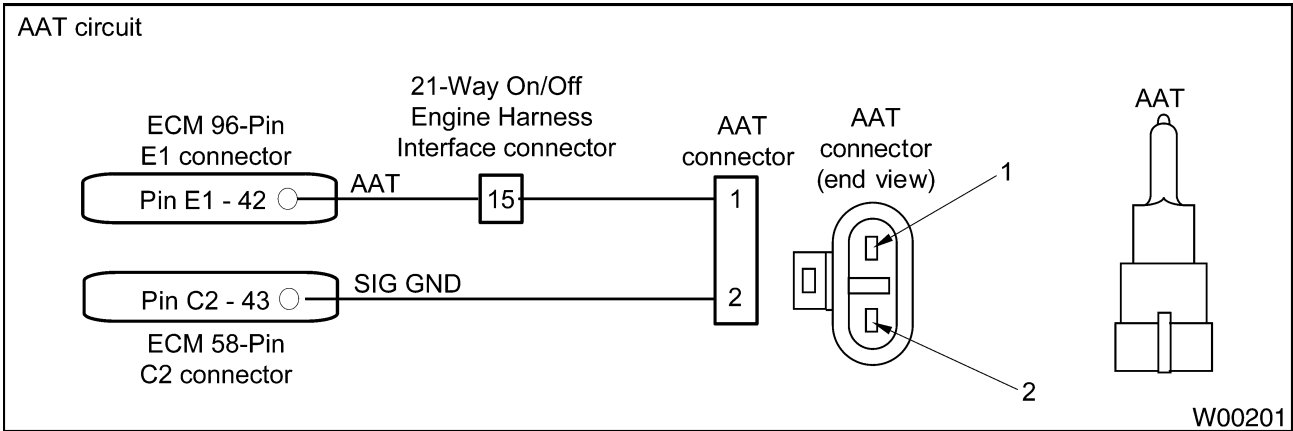


Figure 111 AAT circuit diagram

Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4484 (AAT)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

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 be active.
 - 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 171 FMI 2 – AAT signal does not agree with other sensors

Cold Soak Sensor Compare Check With ServiceMaxx™ Software

NOTE: Temperature values need to be measured after 4 hours of cold soak.

1. Turn ignition switch ON, engine OFF.
 2. Using ServiceMaxx™ software, open the Default session.
 3. Compare AAT and Air Intake Temperature (AIT). Sensor temperatures should be within 5°C (10°F) of each other.
 - If AAT is 5°C (10°F) above or below AIT, check for poor circuitry going to the AAT sensor.
 - If circuits are within specification, replace AAT sensor.
-

Sensor Circuit Check With ServiceMaxx™ Software

Connect Breakout Harness 4484 and leave sensor disconnected. Turn ignition switch to ON.

Test Point	Specifications	Comment– < Less than, > Greater than
EST – Monitor AATv	5 V	If <4.5 V, check AAT signal circuit for short to GND.
EST – Monitor AATv Short pin 1 to GND	0 V	If > 0.25 V, check AAT signal circuit for OPEN. Do Harness Resistance Check (page 194).
EST – Monitor AATv Short pin 1 to 2	0 V	If > 0.25 V, check SIG GND circuit for OPEN. Do Harness Resistance Check (page 194).
EST – Monitor AATv Short 500 Ω resistor across pins 1 and 2	0 V to 1 V	If > 1.0 V, check AAT signal circuit for short to PWR.
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace AAT sensor.		

Connector Voltage Check Without ServiceMaxx™ Software

Disconnect sensor. Turn ignition switch to 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 194).
2 to B+	B+	If < B+, check for short to PWR.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness 4484. 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 E1-42	< 5 Ω	If > 5 Ω , check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω , check for short circuit.
2 to C2-43	< 5 Ω	If > 5 Ω , check for OPEN circuit.

AFT System (Aftertreatment)

SPN	FMI	Condition	Possible Causes
3251	0	DPFDP excessively HIGH (Plugged filter)	- Biased DPFDP sensor or circuit - Plugged DPF - DPFDP sensor hose (before filter) restricted
3251	14	DPFDP sensor pressure hoses reversed	- DPFDP sensor pressure hoses reversed - DPFDP sensor hose (before filter) restricted
3251	21	DPFDP excessively LOW (Sensor/circuit fault or missing DPF)	- Biased DPFDP sensor or circuit - DPFDP sensor pressure hoses reversed - DPFDP sensor hose (before filter) leaking or disconnected
3471	1	Fuel Pressure 1 below desired (Low system pressure)	- AFTFD failure. Blocked, stuck open or closed - Leak in AFTFD fuel supply line - Failed AFT Fuel Pressure 1 sensor - AFTFSV stuck closed or blocked
3471	7	Fuel Doser Valve not responding as expected	- AFTFD failure. Blocked, stuck open or closed. - Stuck Hydrocarbon Injector or AFTFSV - Biased AFT Fuel Pressure 2 signal
3480	0	AFTFP1 too high while dosing	- Fuel Delivery Pressure (FDP) above maximum - Restricted fuel return line between filter housing and fuel tank
3480	1	AFTFP1 too low while dosing	- Fuel Delivery Pressure (DPF) below minimum - Dirty fuel filter - Stuck closed AFT Shutoff valve - Fuel Leak in DSI System
3481	7	Incorrect dosing pressure, multiple events	- Fuel Delivery Pressure (DPF) above maximum - Restricted fuel return line between filter housing and fuel tank
3556	0	AFT Fuel Pressure 2 excessively high (Restricted injection)	Failed AFTFSV
3556	1	AFT Fuel Pressure 2 below desired (Possible system leak)	- AFTFD stuck open - Failed AFTFSV

3556	7	AFT Fuel Injector not responding as expected	• DSI failed system validation cycle • Biased AFTFP1 sensor or circuit • Biased AFTFP2 sensor or circuit • Failed AFTFD or circuit • Failed AFTFSV or circuit • Hydrocarbon injector assembly failure (plugged)
3719	0	DPF Soot Load - Highest (level 3/3)	• Level 3 DPF plugged • Remove DPF for servicing
3719	15	DPF Soot Load - Lowest (level 1/3)	• Level 1 DPF Regen required
3719	16	DPF Soot Load - Moderate (level 2/3)	• Level 2 DPF Regen required
3720	0	DPF Ash load at maximum limit (Remove DPF for cleaning)	• Replace DPF and reset DPF replacement counter
4077	0	AFTFP2 too high while dosing	• AFT Fuel Doser (stuck closed) • Hydrocarbon Injector (plugged)
4077	1	AFTFP2 too low while dosing	• Fuel leak between Fuel Doser and Hydrocarbon Injector • AFT Fuel Shutoff valve stuck closed

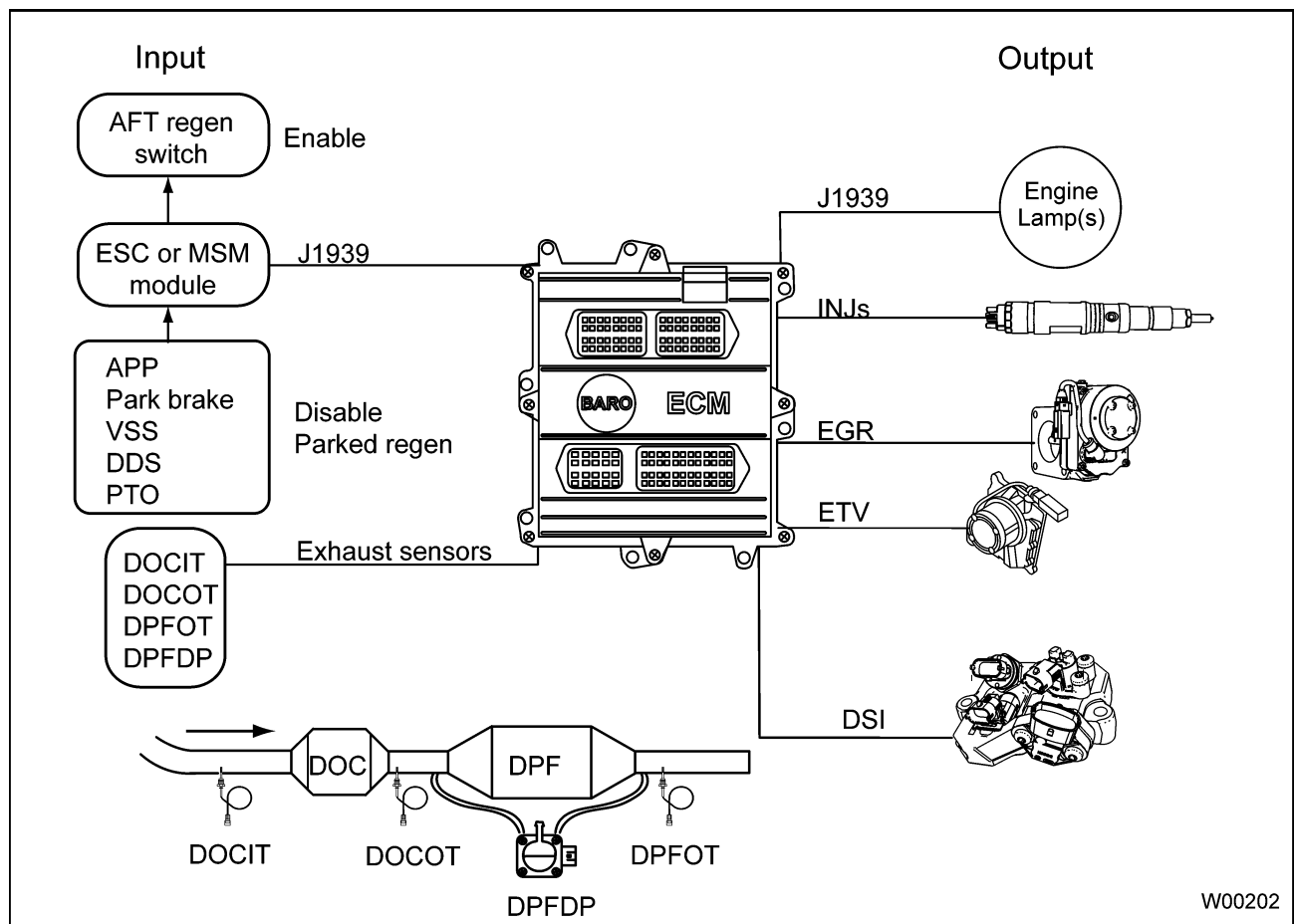


Figure 112 Function diagram for AFT System

The function diagram for the AFT System includes the following:

Engine Control Module (ECM)
with Barometric Pressure (BARO) internal sensor

Multiplex System Module (MSM) body module

Accelerator Pedal Position (APP) sensor

Park Brake

Vehicle Speed Sensor (VSS)

Driveline Disconnect Switch (DDS)

Power Take Off Switch (PTO)

Diesel Oxidation Catalyst (DOC)

Diesel Particulate Filter (DPF)

DOC Inlet Temperature (DOCIT) sensor

DOC Outlet Temperature (DOCOT) sensor

DPF Differential Pressure (DPFDP) sensor

DPF Outlet Temperature (DPFOT) sensor

Fuel Injectors (INJs)

Exhaust Gas Recirculation (EGR)

Engine Throttle Valve (ETV)

Warning Indicators

Down Stream Injection (DSI) unit

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 the ash from the DPF.

The soot is converted to carbon dioxide by a process of regeneration (Regen). The temperature at the face of the DPF is raised to approximately 538°C (1000°F), 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 Air Inlet Temperature (AIT), 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.

SPN 3251 FMI 0 – DPFDP excessively HIGH (Plugged filter)**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 270).
 2. Check DPFDP sensor hoses for correct routing or for restriction.
 - If sensor hoses are reversed or plugged, repair condition.
 3. Check for restriction. Remove and inspect filter for face plugging.
-

SPN 3251 FMI 14 – 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 270).
 2. Check DPFDP sensor hoses for correct routing and possible restriction.
 - If sensor hoses are reversed or plugged, 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)**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 270).
 2. Check DPFDP sensor hoses for correct routing or for restriction.
 - If sensor hoses are reversed or plugged, repair condition.
 3. Check for restriction. Remove and inspect DPF filter for cracks and leaks.
-

SPN 3471 FMI 1 – AFT Fuel Pressure 1 below desired (Low system pressure)

SPN 3471 FMI 1 sets when AFTFP1 sensor detects pressure below desired.

Pinpoint AFT System Fault

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, select DSI System Test from the Tests drop-down menu.
 2. Select the DSI System Test and follow the steps.
 3. If AFTFP1 has failed in any test, continue to next step.
 4. Check for fuel leaks before DSI unit.
 - If fuel leaks are found, repair leaks and go to step 1.
 - If no fuel leaks are found, continue to next step.
 5. Replace DSI unit according to *Engine Service Manual*
-

SPN 3471 FMI 7 – Fuel Doser Valve not responding as expected

SPN 3471 FMI 7 sets when the AFTFD does not respond as expected by the ECM.

Pinpoint AFT System Fault

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, load the Actuator session.
 2. Command AFT Fuel Doser ON and then OFF.
 3. Monitor DOCOT sensor for increase in temperature while AFT Fuel Doser valve is open.
 - If there is no change in temperature, replace AFT Fuel Doser valve following procedures in the *Engine Service Manual*.
 - If a temperature increase occurs, continue to next step.
 4. Check AFTFP2 sensor and sensor wiring.
 - If sensor is not within specification, see AFTFP2 Sensor (page 227).
-

SPN 3480 FMI 0– AFTFP1 too high while dosing

SPN 3480 FMI 0 sets when AFTFP1 sensor detects pressure above desired.

Pinpoint AFT System Fault

1. Check low-pressure fuel system. It should be operating within specification. See Fuel System in "Performance Diagnostics."
 - If fuel system pressure is above normal, diagnose fuel system failure in "Performance Diagnostics."
 - If fuel system is within specification, continue to next step.
-

SPN 3480 FMI 1 – AFTFP1 too low while dosing

Fault is set when AFT Fuel Pressure 1 sensor detects pressure below desired.

Pinpoint AFT System Fault

1. Check low-pressure fuel system. It should be operating within specification. See Fuel System in "Performance Diagnostics."
 - If fuel system pressure is below normal, diagnose fuel system failure in "Performance Diagnostics."
 - If fuel system is within specification, continue to next step.
 2. Check for fuel leaks in DSI System.
 - Repair or replace any leaking DSI components.
 3. Check AFT Fuel Shutoff valve operation.
 - Run KOEO Actuator Test and monitor AFT Fuel Pressure 1 and AFT Fuel Pressure 2.
 - If AFT Fuel Shutoff is not operating correctly, repair or replace AFT Fuel Shutoff valve.
-

SPN 3481 FMI 7 – Incorrect dosing pressure, multiple events

Fault is set when AFT Fuel Pressure 1 sensor detects pressure above desired multiple times.

Pinpoint AFT System Fault

1. Check low-pressure fuel system. It should be operating within specification. See Fuel System in "Performance Diagnostics."
 - If fuel system pressure is above normal, diagnose fuel system failure in "Performance Diagnostics."
-

SPN 3556 FMI 7 – AFT Fuel Injector not responding as expected

The DSI system automatically goes through a system validation before running a DPF Regen. If the system fails this validation, SPN 3556 FMI 7 will set and DPF Regen is disabled.

Pinpoint AFT System Fault

1. Key On, Engine Off, check for biased AFTFIS and AFTFP2 sensors. See KOEO in "Appendix A: Performance Specifications."
 - If either sensor is not within specification, go to sensor diagnostics in this section of the manual.
 2. Check low-pressure fuel system. It should be operating within specification. See Fuel System in "Performance Diagnostics."
 - If fuel system pressure is below normal, diagnose fuel system.
 - If fuel system is within specification, continue to next step.
 3. Inspect DSI system for external leaks.
 4. Remove and inspect Hydrocarbon Injector for plugging.
-

SPN 3719 FMI 0 – DPF Soot Load - Highest (level 3/3)

SPN 3719 FMI 0 sets when Level 3 DPF soot loading is 100% full and engine de-rate has been enabled. DPF regeneration is required.

Pinpoint AFT System Fault

1. Check for active DTC that could prevent AFT System from regenerating.
 - If active DTC is found, repair DTC that inhibits AFT System regeneration.
 - If no DTC is found, proceed to the next step.
 2. Perform a manual parked regeneration procedure. See Entry Conditions for a Parked Regen (page 208). If parked regeneration procedure fails, proceed to next step.
 3. Inspect DPF for damage or missing parts. If no damaged or missing parts are found, do the following:
 - Remove DPF and clean out the ash in a cleaning station.
 - Load DPF Servicing session and log in DPF serial number, cleaning, and installation date.
 - Click the "DPF has been serviced button."
-

SPN 3719 FMI 15 – DPF Soot Load - Lowest (level 1/3)

SPN 3719 FMI 15 sets when Level 1 DPF soot loading is above 80% full and a DPF regeneration is required.

Pinpoint AFT System Fault

1. Check for active DTC that could prevent AFT system regeneration.
 2. Drive vehicle at highway speeds for 20 to 30 minutes or perform a manual parked regeneration procedure. See Entry Conditions for a Parked Regen (page 208).
-

SPN 3719 FMI 16 – DPF Soot Load - Moderate (level 2/3)

SPN 3719 FMI 16 sets when Level 2 DPF soot loading is 100% full and a DPF regeneration is required.

Pinpoint AFT System Fault

1. Check for active DTC that could prevent AFT system regeneration.
 2. Perform a manual parked regeneration procedure. See Entry Conditions for a Parked Regen (page 208).
-

SPN 3720 FMI 0 – DPF Ash load at maximum limit (Remove DPF for cleaning)

SPN 3720 FMI 0 sets when the DPF is full of ash and must be removed and cleaned.

Pinpoint AFT System Fault

1. Remove DPF and clean out the ash in a cleaning station.
 2. Load DPF Servicing session and login DPF serial number, cleaning, and installation date.
 3. Click the "DPF has been serviced button."
-

SPN 4077 FMI 0 – AFTFP2 too high while dosing

Fault is set when AFT Fuel Pressure 2 sensor detects pressure above desired.

Pinpoint AFT System Fault

1. Disconnect exhaust just after the Exhaust Back Pressure Valve.
 2. Inspect the Hydrocarbon Injector.
 - If Hydrocarbon Injector is plugged, clean or replace component.
 - If Hydrocarbon Injector is not plugged, replace the AFT Fuel Doser.
-

SPN 4077 FMI 1 – AFTFP2 too low while dosing

Fault is set when AFT Fuel Pressure 2 sensor detects pressure below desired.

Pinpoint AFT System Fault

1. Check for fuel leaks at the DSI assembly.
 - If DSI is leaking, repair leak or replace DSI assembly.
 - If no leaks are found, replace AFT Fuel Doser.
-

AFT System Event Map

Engine	AFT System	Communication	Driver Response
Engine out of Regen mode DPFD monitors soot level	DPF collects soot produced by engine.	FMI: None Lamp: HEST lamp if DPFO is above 400 °C (752 °F) and under five mph	No response needed
Engine in Regen mode Changes in Air Management and fueling, fuel will be injected into the exhaust system. Exhaust sensors are monitored.	Soot level threshold is reached, System triggers DPF regeneration		
	DOC converts fuel to increase DPF temp		
	Soot burns as elevated temp is reached		
Engine in Regen mode.	Soot may continue to increase in the DPF due to inability to properly regenerate the filter	SPN 3719 FMI 15 DPF Soot Lowest (level 1/3)	Drive at highway speed or start a parked Regen
Engine in Regen Mode 15% Engine De-rate		SPN 3719 FMI 16 DPF Soot Moderate (level 2/3)	Perform Parked Regen
Engine in Regen mode. 85% Engine De-rate		SPN 3719 FMI 0 DPF Soot Highest (level 3/3)	Remove DPF for servicing

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 113 HET Lamp**

Hot Exhaust System Temperature lamp indicates exhaust temperature is above 400°C (752°F) and vehicle speed is below five mph.

Operator Action: Beware of surroundings, the exhaust is very hot.

Technician Action: None

Diesel Particulate Filter (DPF) Lamp**Figure 114 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 115 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 procedure below.

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 116 DPF Lamp Flashing, Amber Warning Lamp On Solid**

Operator Action: Perform a Parked Regen.

Technician Action: Verify the system is working without fault. See procedure below.

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 is now de-rated by 15% of normal engine power.

SPN 3719 FMI 0 DPF Soot Load - Highest (level 3/3)



Figure 117 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 de-rated by 85% of normal power.

Regen Inhibitors

A DPF Regen can be inhibited by disabling switches, or meeting entry conditions 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) 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 a 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°C (170°F)
 - Inhibiting DTCs must not be active (See Fault Code Regen Inhibitors (page 206))
 - 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, go to Check Rolling Regen Inhibitors (page 209).

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 at or above 75 °C (170 °F)
 - Vehicle speed not rolling
 - Inhibiting DTCs must not be active (See Fault Code Regen Inhibitors (page 206))
 - 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 Rolling Regen, go to Check Rolling Regen Inhibitors (page 209).

Sensor Compare Checks

1. Turn ignition switch ON, engine OFF.
2. Using ServiceMaxx™ software, open the Continuous Monitor session.

NOTE: Voltage values need to be measured after cold soak at about 21 °C (70 °F).

Test Point	Specification	Comment – < Less than, > Greater than
S_DOCIT Volts	0.88 V $\pm$ 0.10 V	If voltage is much higher or lower than the other AFT exhaust sensors, see DOCIT Sensor Circuit Check (page 264).
S_DOCOT Volts	0.88 V $\pm$ 0.10 V	If voltage is much higher or lower than the other AFT exhaust sensors, see DOCOT Sensor Circuit Check (page 267).
S_DPFOT Volts	0.88 V $\pm$ 0.10 V	If voltage is much higher or lower than the other AFT exhaust sensors, see DPFOT Sensor Circuit Check (page 272).
S_DPFDV Volts	0.70 V $\pm$ 0.10 V	If not within specifications, see DPFDV Sensor Circuit Check (page 270).
S_TC1TOP Volts	0.70 V $\pm$ 0.10 V	If not within specifications, see TC1TOP Sensor Circuit Check (page 352).
If Sensors are within specifications, continue to Exhaust Restriction Test.		

Regen Inhibitors**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 five 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. DPF must be replaced before continuing.
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 211).		

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. DPF must be replaced before continuing.
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)

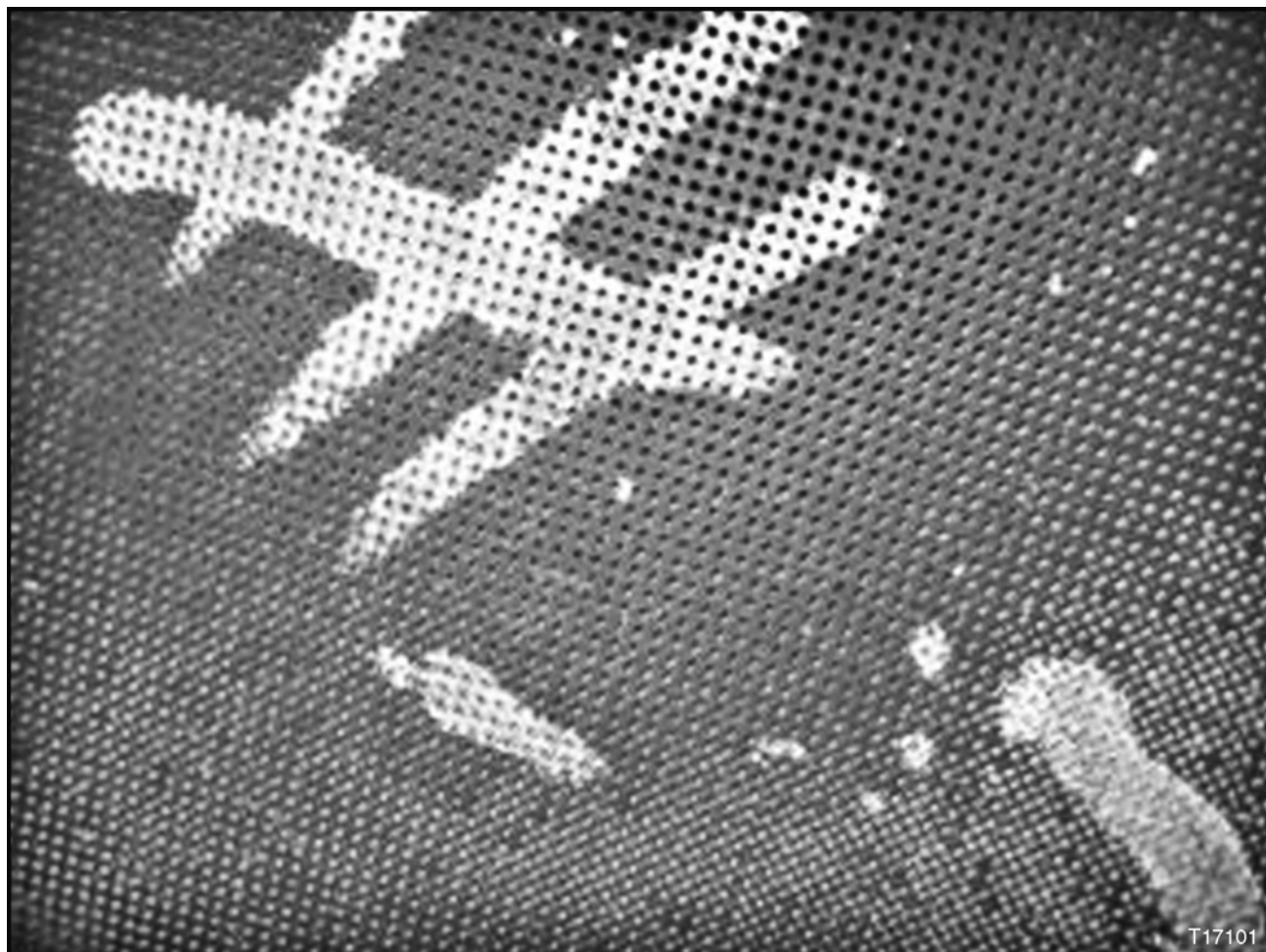
- **DOCOT:** 550-600°C (1022-1112°F) (after 5-10 minutes)
- **DPFOT:** 600-650°C (1112-1202°F) (after 10-15 minutes)
- **DPFDp:** Decreasing steadily once DPFIT and DPFOT are steady and above 550°C (1022°F).

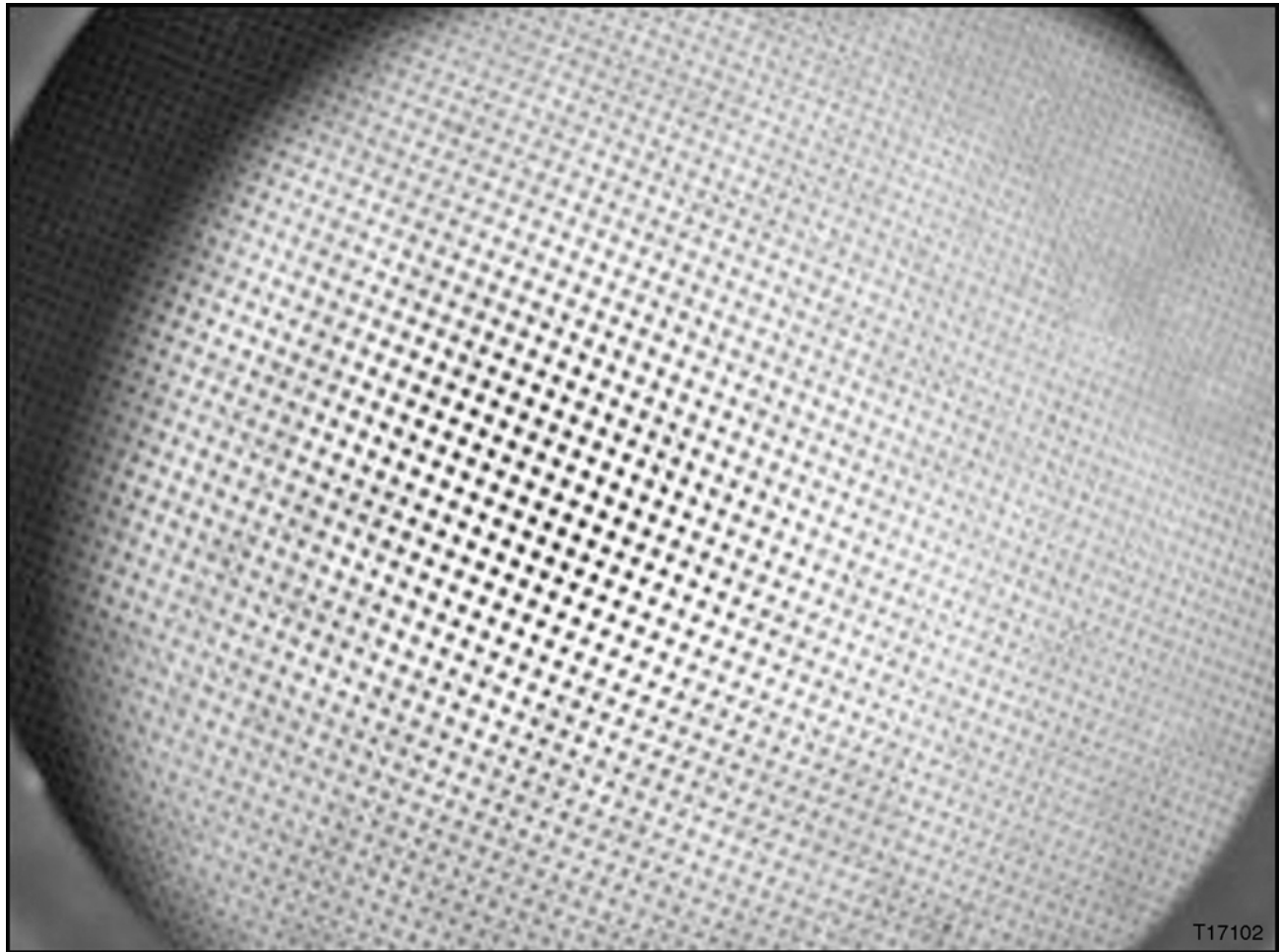
Connect the EST and open the Aftertreatment session. Start a Parked Regen and monitor signals.

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", then a Regen cannot be commanded to run.
Engine Coolant Temp	Above 66 °C (150 °F)	If below 66 °C (150 °F), 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 300).
ETV Position	80% ±5%	If not within specifications, see ETV (page 311).
DOCIT	250 °C (482 °F) to 300°C (572 °F)	If below 250 °C (482 °F), use the Electronic Service Tool (EST) with ServiceMaxx™ software and run the KOER Air Management Test. If above 300 °C (572 °F), check for proper ETV operation, and if engine is over fueling.
DOCOT	After 5-10 minutes above 530 °C (986 °F)	If below 530 °C (986 °F), replace DOC, and inspect DPF for soot leaking through the filter.
DPFOT	Below 700 °C (1292 °F)	If above 700 °C (1292 °F), replace DPF.
DPFDP	Below 3.4 kPa (0.5 psi)	If above 3.4 kPa (0.5 psi), after the system completes a full Parked Regen, replace the DPF.
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.		

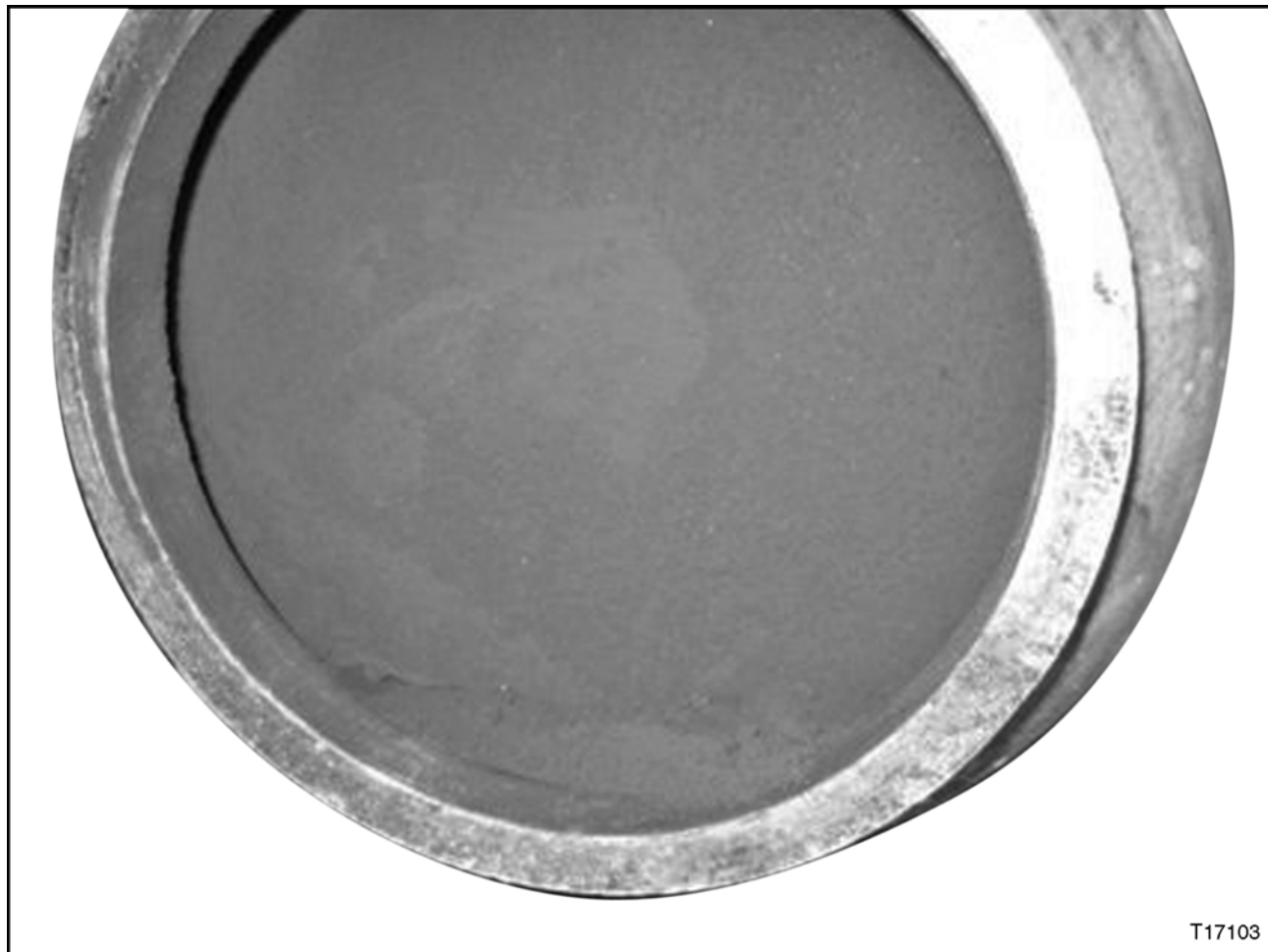
DPF Inspection**Normal DPF Inlet****Figure 118 DPF Inlet (Normal)**

Normal DPF Outlet**Figure 119 DPF Outlet (Normal)**

Inspect the inlet and outlet of the DPF.

Ensure 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."

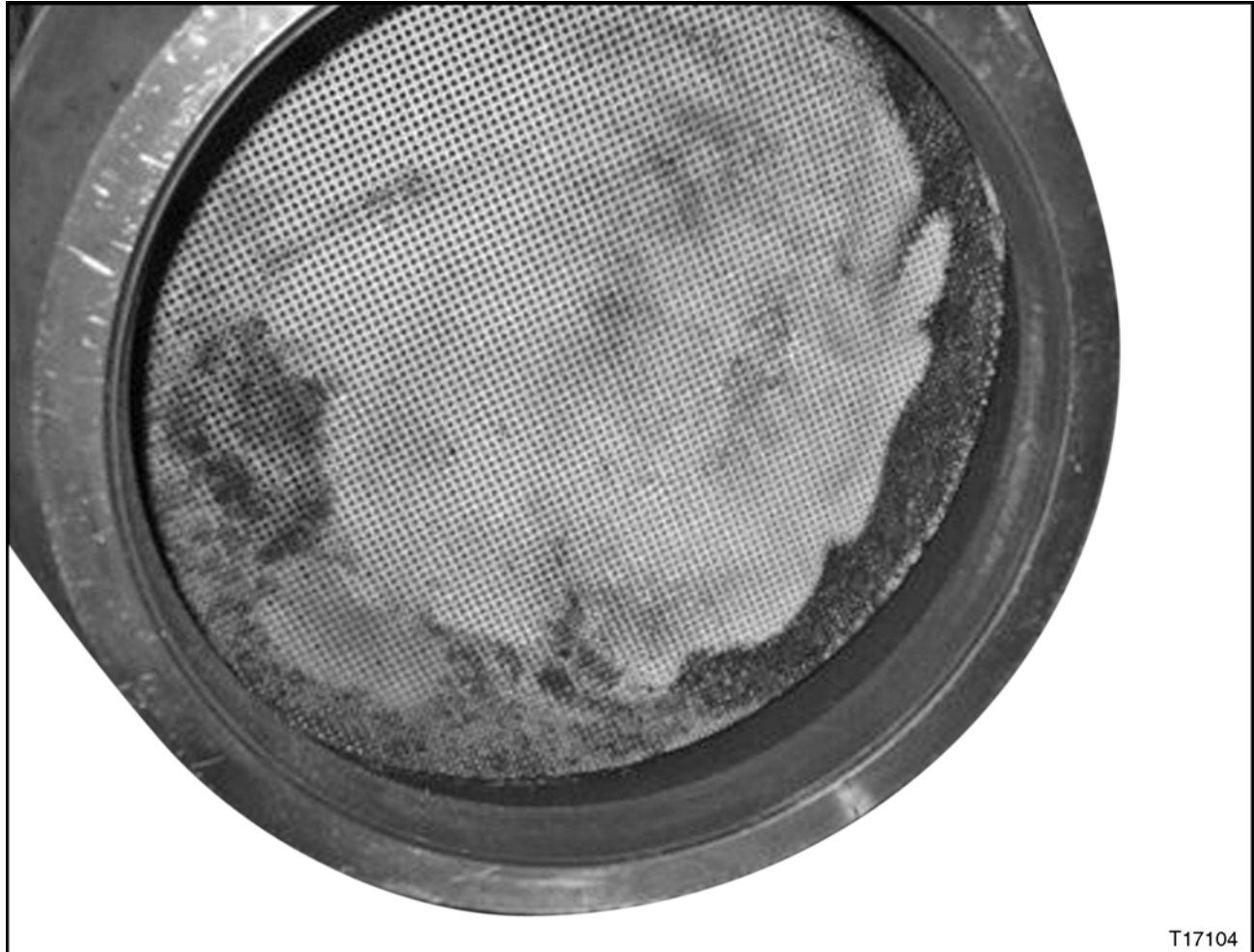
Possible Causes	Action
System is working correctly	None.

Plugged DPF Inlet**Figure 120 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.

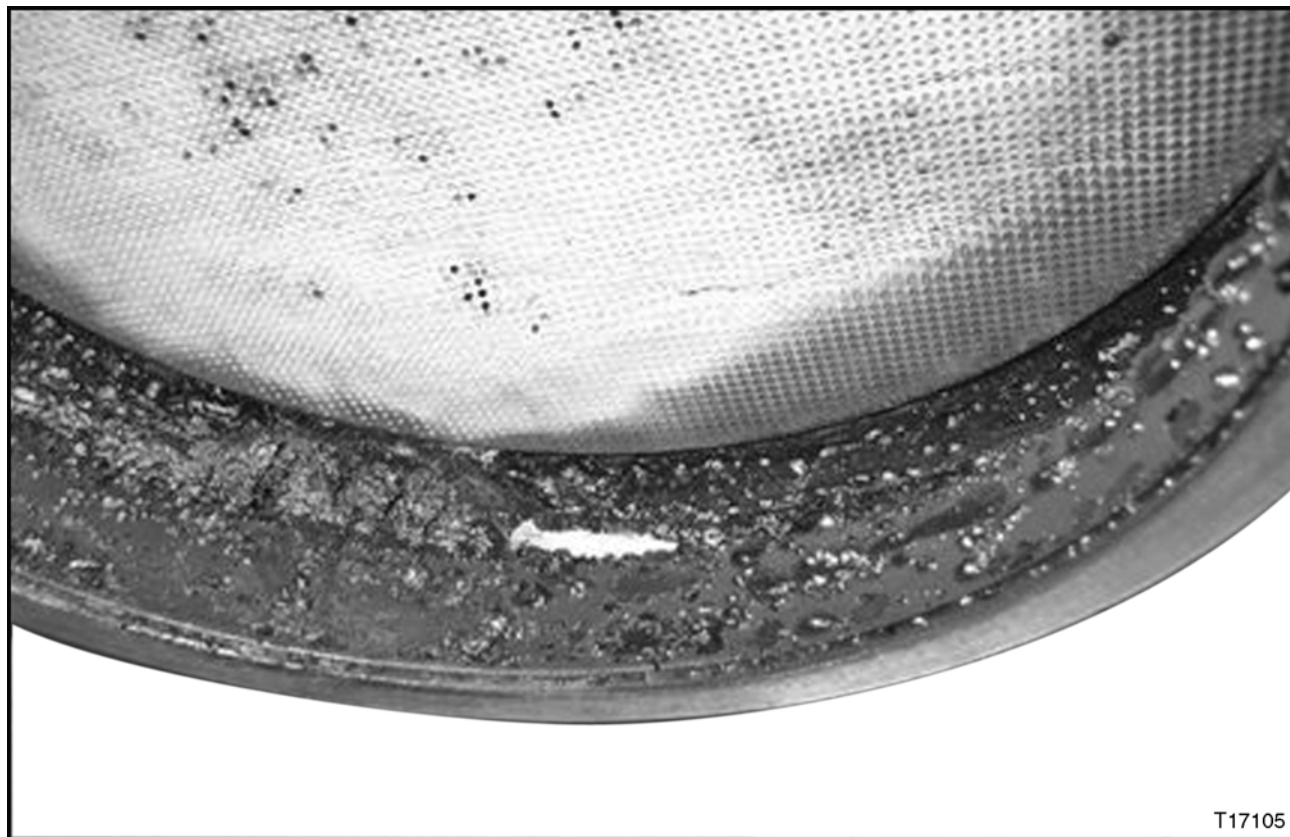
Possible Causes	Action
• Drive cycle (Unable to complete Regen) • Engine over-fueling • Boost problem • Intake throttle problem	1. Interview the operator about his drive cycle. 2. Verify there are no inhibitors (DTCs or switches). 3. Remove DPF for external cleaning.

DPF Contaminated with Coolant**Figure 121 Coolant Contamination**

Inspect the inlet and outlet of the DPF.

DPF shows signs coolant has flown through the exhaust system, contaminating the DPF.

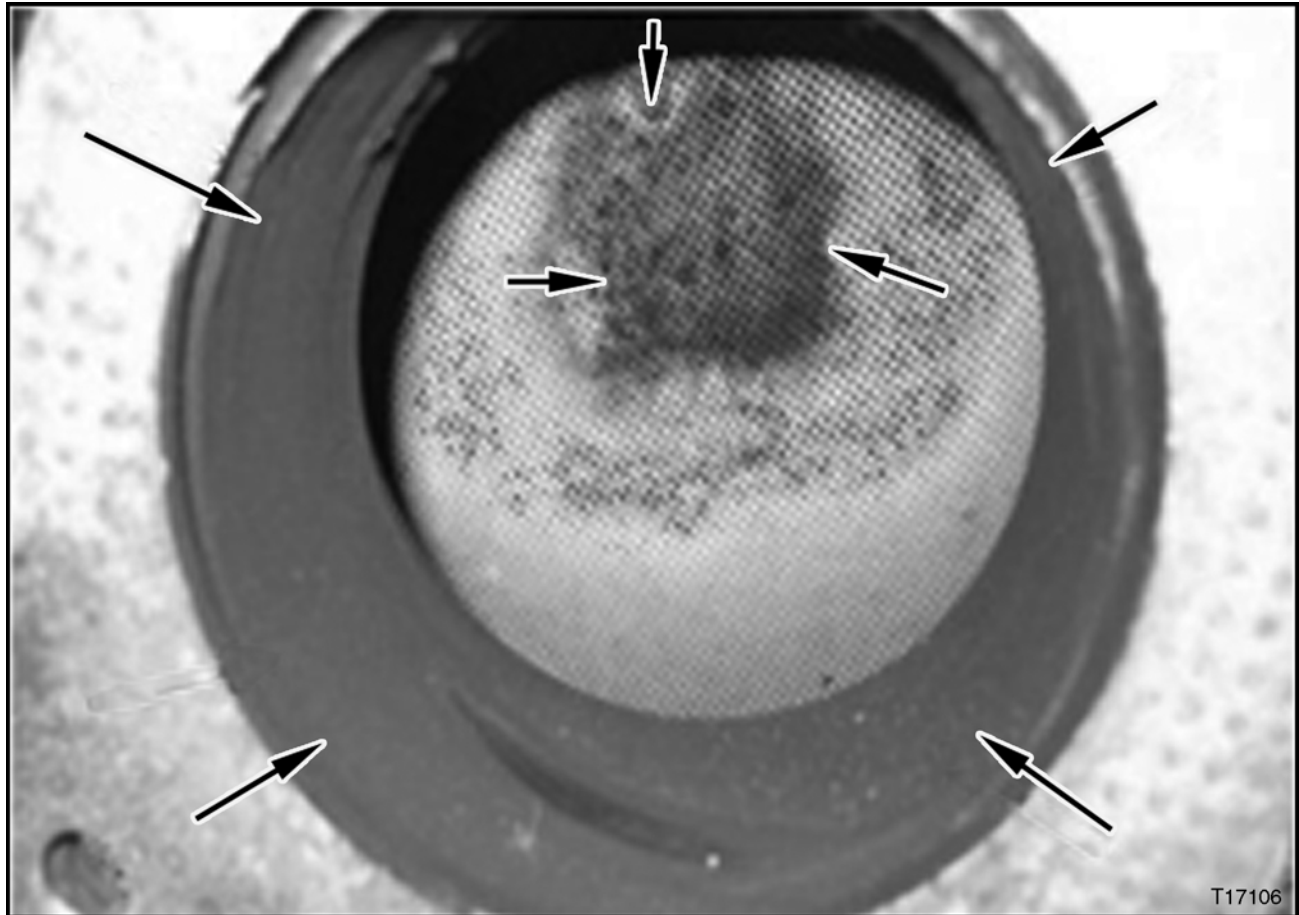
Possible Causes	Action
• Coolant is flowing through exhaust • Failed Interstage cooler • Failed EGR cooler • Failed injector sleeve • Leaking cylinder head cup plugs • Cylinder head porosity	1. Repair coolant problem. 2. The DPF cannot be cleaned; it must be replaced.

DPF Contaminated with Oil**Figure 122 Engine Oil Contamination, Soot Leakage**

Inspect the inlet and outlet of the DPF.

DPF will show signs of soot leakage and oil.

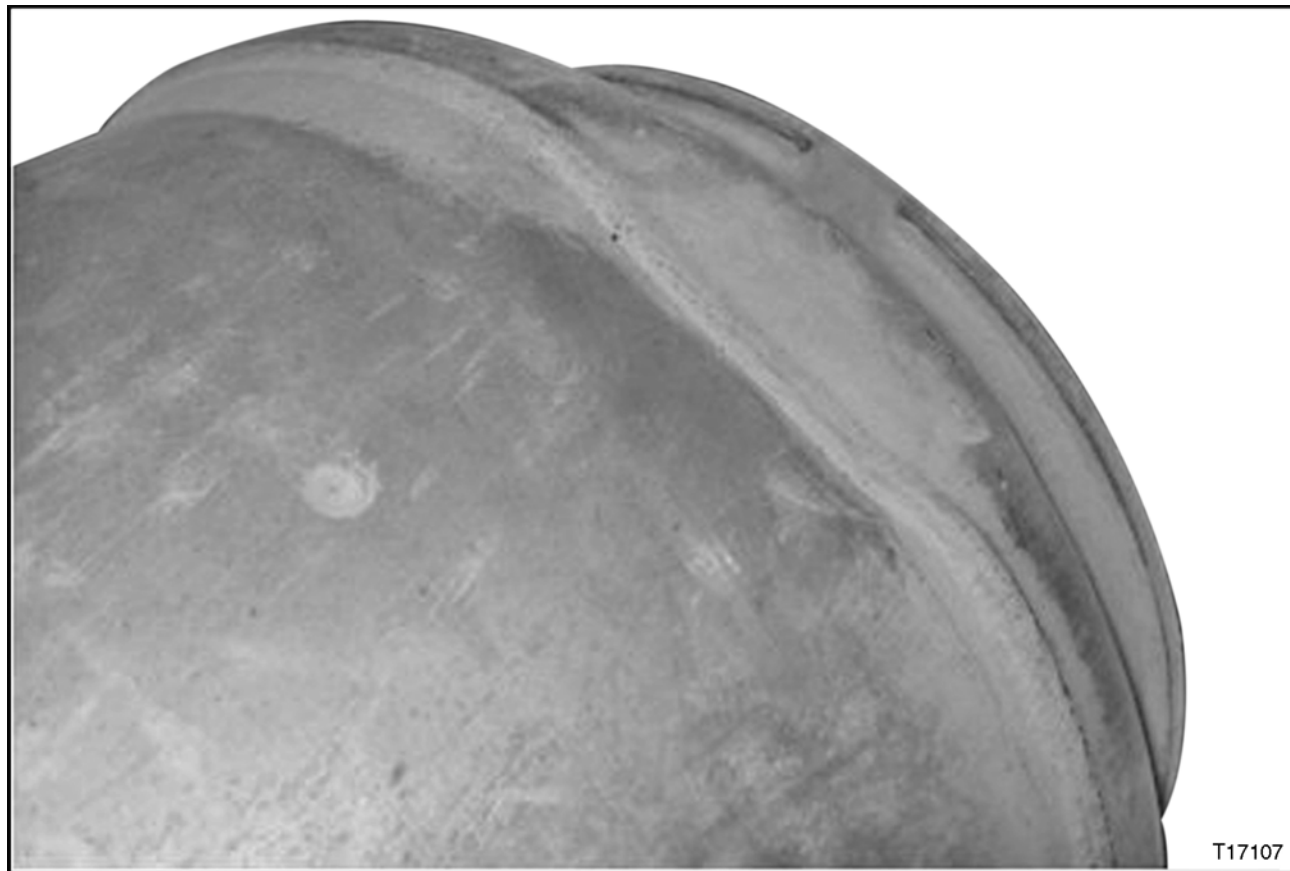
Possible Causes	Action
- Failed turbocharger - Failed piston rings - Failed cylinder sleeves - Failed valve guides	1. Repair engine oil to exhaust problem. 2. The DPF cannot be cleaned; it must be replaced. 3. Inspect the DOC for damage and replace if necessary.

DPF Outlet Leaking Soot**Figure 123 DPF 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	- The DPF cannot be cleaned; it must be replaced. - Inspect the DOC for damage and replace if necessary.

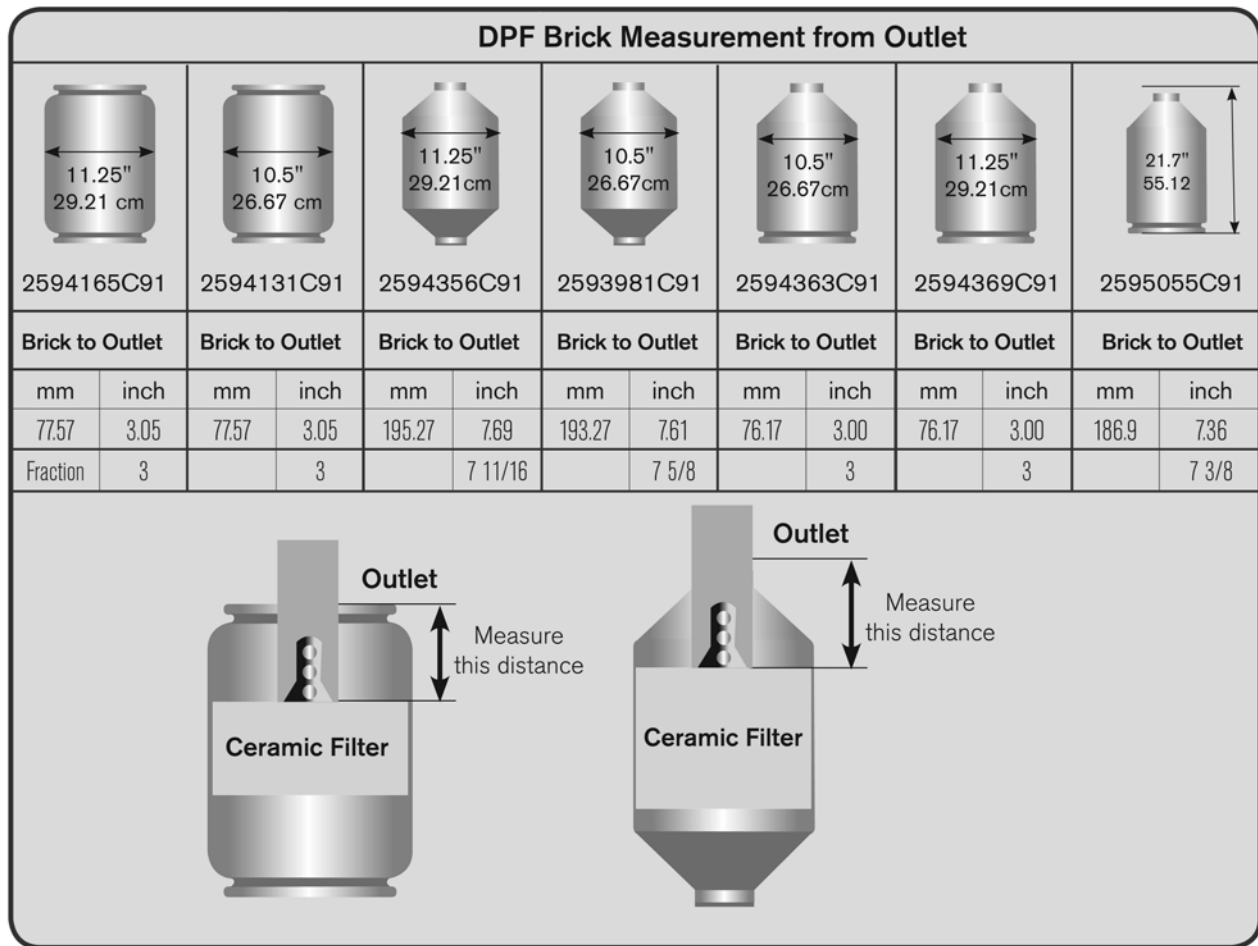
External Damage to DPF**Figure 124 DPF Can Damage**

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

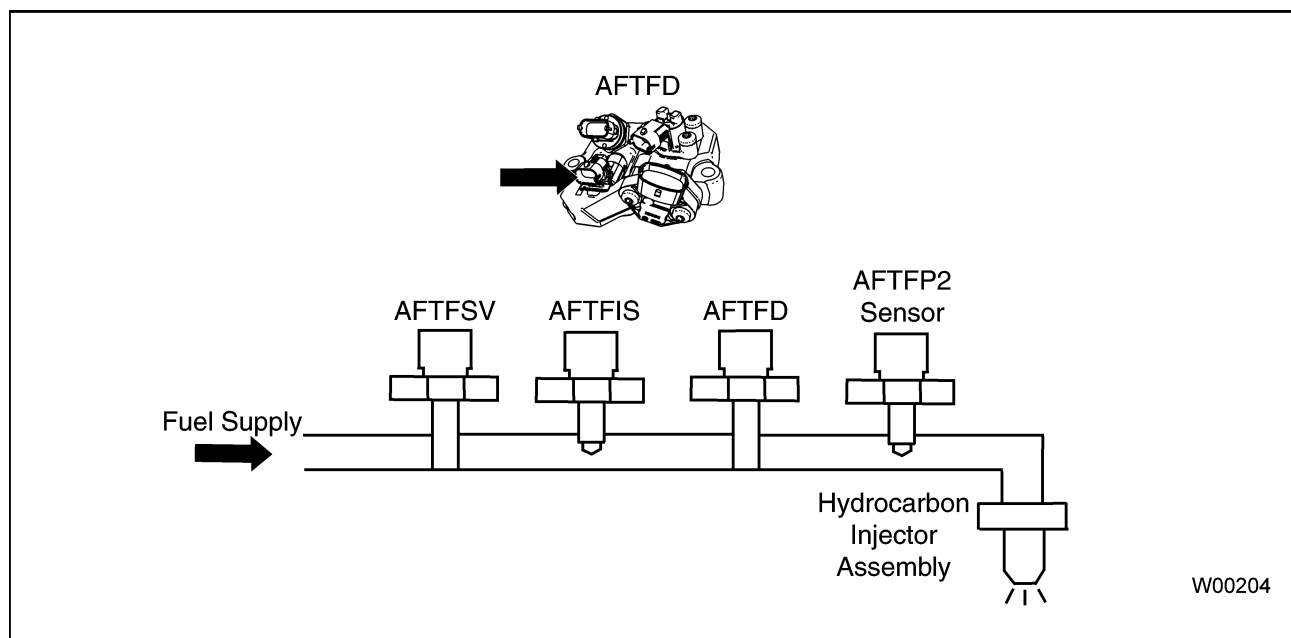
Figure 125 DPF Ceramic Filter Brick Measurement

Measure the distance between the ceramic filter brick and the outlet. If the distance is greater than the specification, the ceramic filter brick has moved out of its correct location. Replace the DPF.

Possible Causes	Action
Face plugged	If the distance is greater than 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	• AFTFD circuit OPEN • Failed AFTFD
3479	6	AFT Fuel Doser Valve High Side Short circuit	• AFTFD circuit short to GND • Failed AFTFD

**Figure 126 Functional diagram for AFTFD**

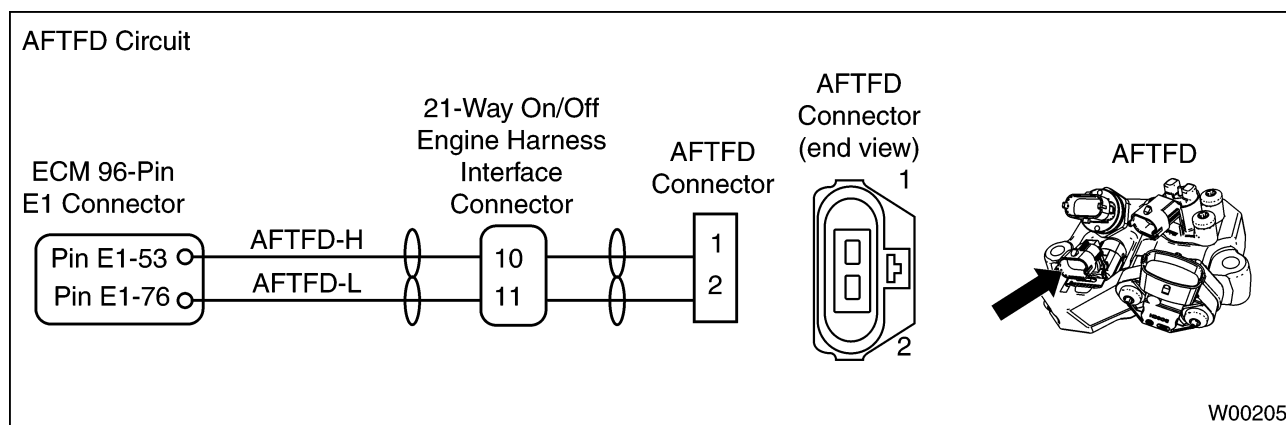


Figure 127 AFTFD circuit diagram

Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4828 (AFTFD)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

Connector Voltage Check – AFTFD Disconnected

Connect Breakout Harness 4828 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 $\pm$ 2.0 V	If < 10.0 V, check for OPEN circuit. Do Harness Resistance Check (page 222).
2 to GND	0 V - 1.0 V	If > 1.0 V, check for short to PWR. Do Harness Resistance Check (page 222).
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 4828 between AFTFD and engine harness.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, load the Actuator session.
3. Command AFT Fuel Doser On, and then Off.
4. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
2 to GND	On = 12.0 V $\pm$ 2.0 V	If < 10.0 V, check for OPEN circuit.
2 to GND	Off = 1.0 V $\pm$ 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 4828 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.		

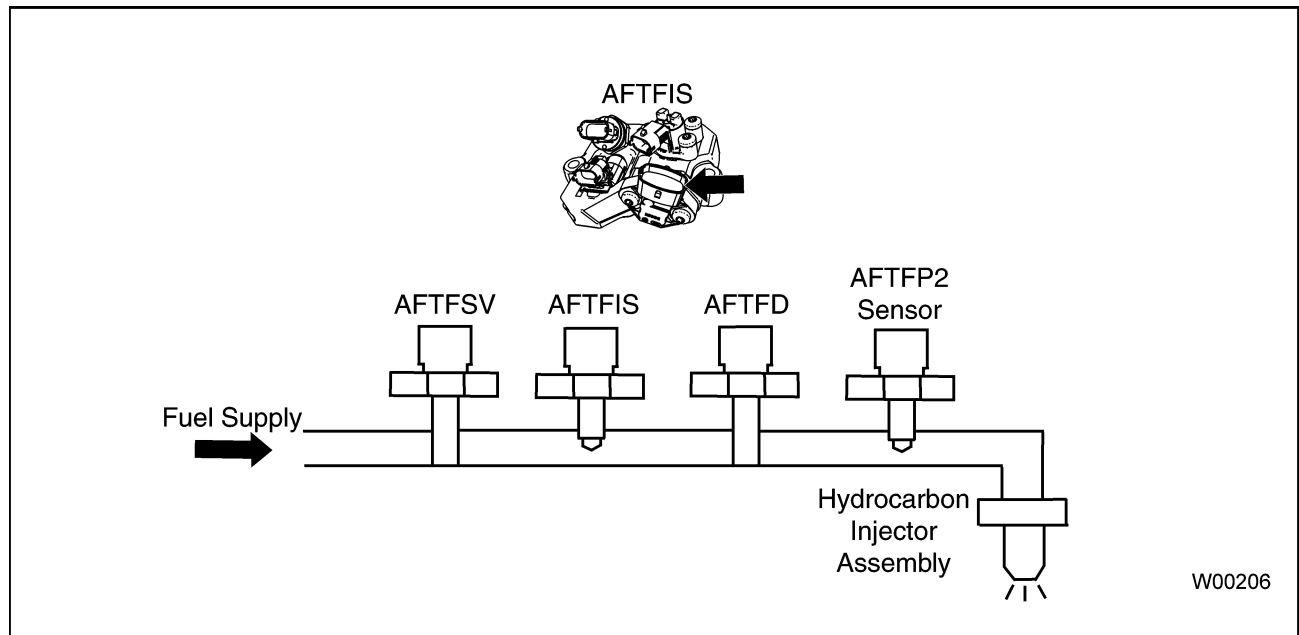
Harness Resistance Check

Turn ignition switch to OFF. Connect 180-pin Breakout Box and Breakout Harness 4828. 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
3480	2	AFTFP1 pressure sensor plausibility error	Biased AFTFP1 signal
3480	3	AFTFP1 signal Out of Range HIGH	- AFTFP1 signal circuit OPEN or short to PWR - SIG GND circuit OPEN - Failed AFTFIS
3480	4	AFTFP1 signal Out of Range LOW	- AFTFP1 signal circuit short to GND - Failed AFTFIS
5456	2	AFTFT does not agree with AAT after cold soak	Biased AFTFIS
5456	3	AFTFT signal Out of Range HIGH	- AFTFT signal circuit OPEN or short to PWR - Failed AFTFIS
5456	4	AFTFT signal Out of Range LOW	- AFTFT signal circuit short to GND - Failed AFTFIS

**Figure 128 Functional diagram for AFTFIS**

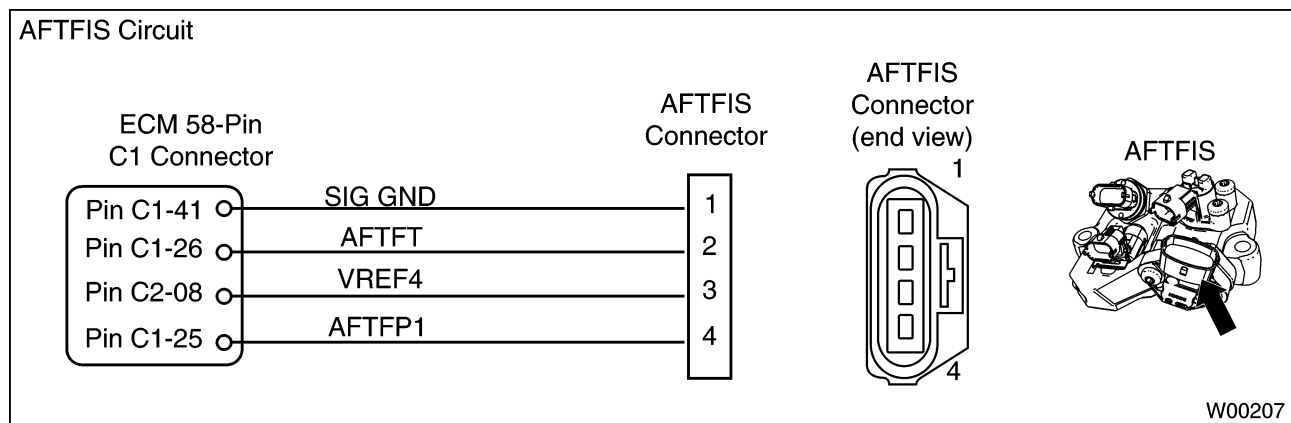


Figure 129 AFTFIS circuit diagram

Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4830 (AFTFIS)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

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.
 - If DTC is active, continue to Cold Soak Sensor Compare Check.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

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 5456 FMI 2 – AFTFT does not agree with AAT after cold soak**Cold Soak Sensor Compare Check With ServiceMaxx™ Software**

NOTE: Temperature values need to be measured after 4 hours of cold soak.

1. Turn ignition switch ON, engine OFF.
2. Using ServiceMaxx™ software, open the Default session.
3. Compare Aftertreatment Fuel Temperature (AFTFT) and Ambient Air Temperature (AAT). Sensor temperatures should be within 5°C (10°F) of each other.
 - If AFTFT is 5°C (10°F) above or below AAT, check for poor circuitry going to the AFTFIS.
 - If circuits are within specification, replace AFTFIS.

Sensor Circuit Check

Connect Breakout Harness 4830 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 (page 225).
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 4830. Leave sensor disconnected. Turn ignition switch to 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.

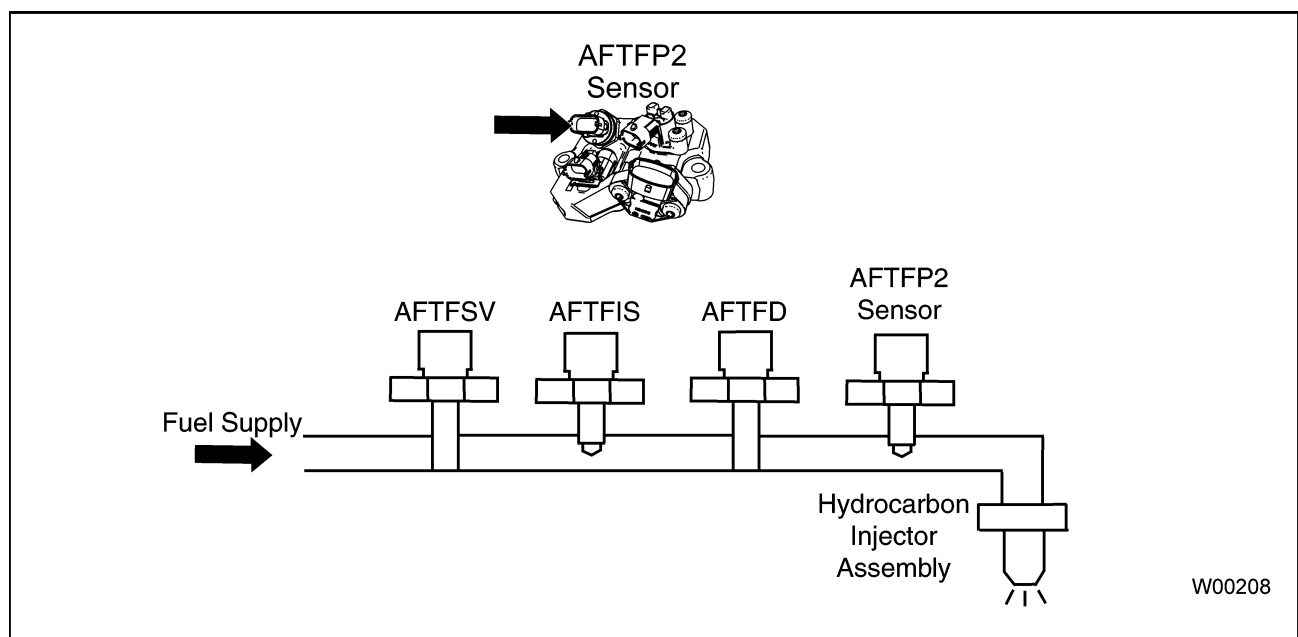
Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness 4830. 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 Sensor (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	A/T downstream pressure sensor plausibility error	Biased AFTFP2 signal

**Figure 130 Functional diagram AFTFP2 sensor**

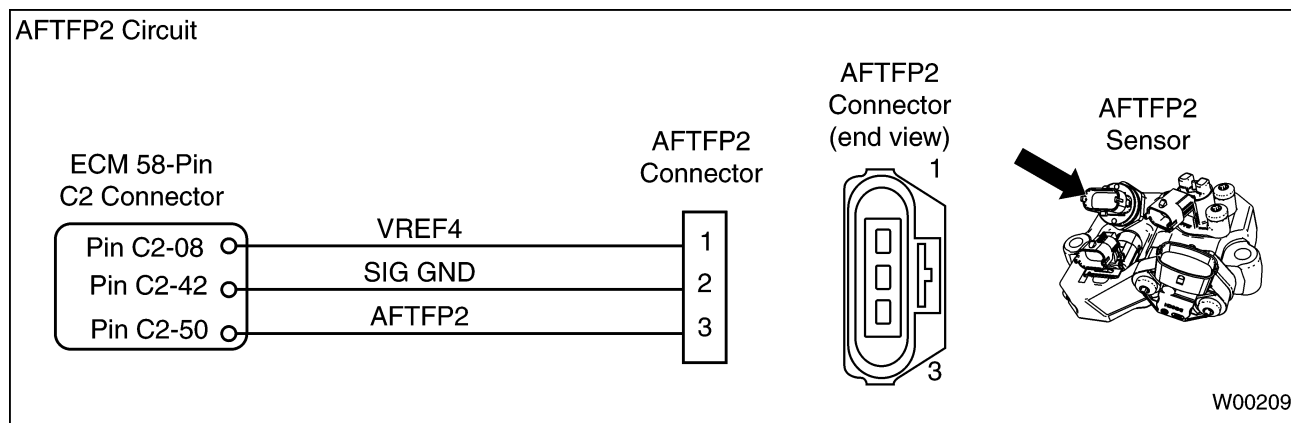


Figure 131 AFTFP2 sensor circuit diagram

Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 6027 (AFTFP2)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

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.
 - 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	4.5 V - 5.0 V	If > 5 V, check AFTFP2 signal circuit for short to GND.
DMM — Measure volts 3 to GND	5.0 V $\pm$ 0.5 V	If > 5.5 V, check VREF4 for short to PWR. If < 4.5 V, check VREF 4 for OPEN or short to GND. Do Harness Resistance Check (page 229).
DMM — Measure voltage 1 to 3	5 V $\pm$ 0.5 V	If < 4.5 V, check SIG GND for OPEN. Do Harness Resistance Check (page 229).
EST – Monitor AFTFP2v	0 V	If > 0.5 V, check AFTFP2 signal circuit for OPEN. Do Harness Resistance Check (page 229).
Short across breakout harness 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 6027. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	0 V	If > 0.25 V, check SIG GND circuit for short to PWR.
2 to GND	0 V	If > 0.25 V, check AFTFP2 circuit for short to PWR.
3 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 (page 229).

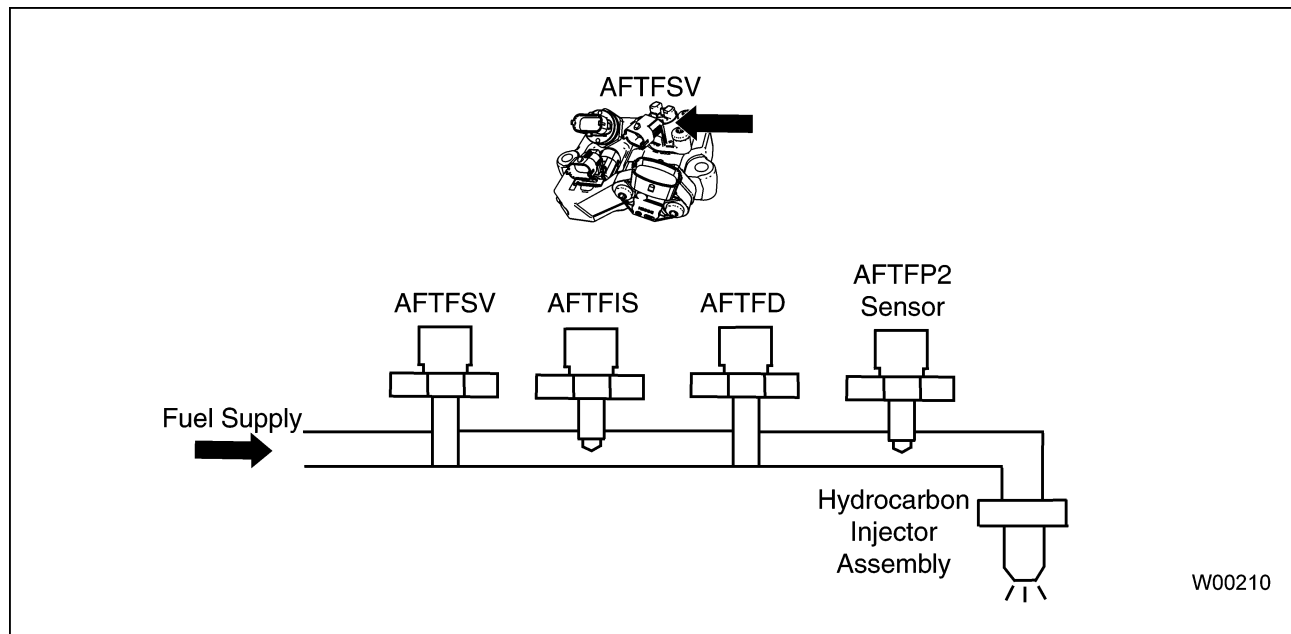
Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness 4829. 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	- AFTFS circuit short to PWR - Failed AFTFSV
3482	4	AFT Fuel Shutoff Valve short to GND	- AFTFS circuit short to GND - Failed AFTFSV



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Figure 132 Functional diagram AFTFSV

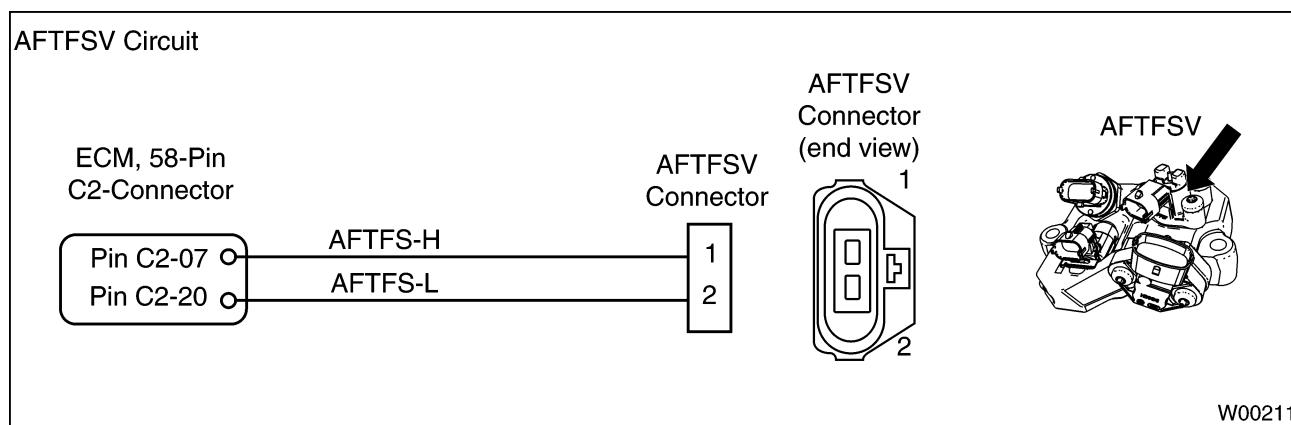


Figure 133 AFTFSV circuit diagram

Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4602 (AFTFSV)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

Connector Voltage Check – AFTFSV Disconnected

Connect Breakout Harness 4602 to engine harness. Leave AFTFSV disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specifications	Comment – < Less than, > Greater than
1 to GND	1 V ± 0.5 V	If < 5.0 V, check for OPEN circuit or short to GND. Do Harness Resistance Check (page 232). If > 2.5 V, check for short to PWR. Do Harness Resistance Check (page 232).
2 to GND	1 V ± 0.5 V	If < 5.0 V, check for OPEN circuit or short to GND. Do Harness Resistance Check (page 232). If > 2.5 V, check for short to PWR. Do Harness Resistance Check (page 232).
If measurements are within specifications, go to Operational Voltage Checks.		

Operational Voltage Check

NOTE: Ensure battery voltage is at or above 12 V before running this procedure.

1. Connect Breakout Harness 4602 between AFTFSV and engine harness.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, load the Actuator session.
3. Command AFT Fuel Shutoff Valve On, and then Off.
4. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
2 to GND	On = 12.0 V $\pm$ 2.0 V	If < 10.0 V, check for OPEN circuit.
2 to GND	Off = 1.0 V $\pm$ 0.5 V	If > 1.5 V, check for OPEN circuit or failed AFTFSV.

Actuator Resistance Check

Turn ignition switch to OFF. Connect Breakout Harness 4602 to AFTFSV. Leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Specifications	Comment – < Less than, > Greater than
1 to 2	1 Ω to 8 Ω	If not within specification, replace AFTFSV.
If measurements are within specifications, do Harness Resistance Check.		

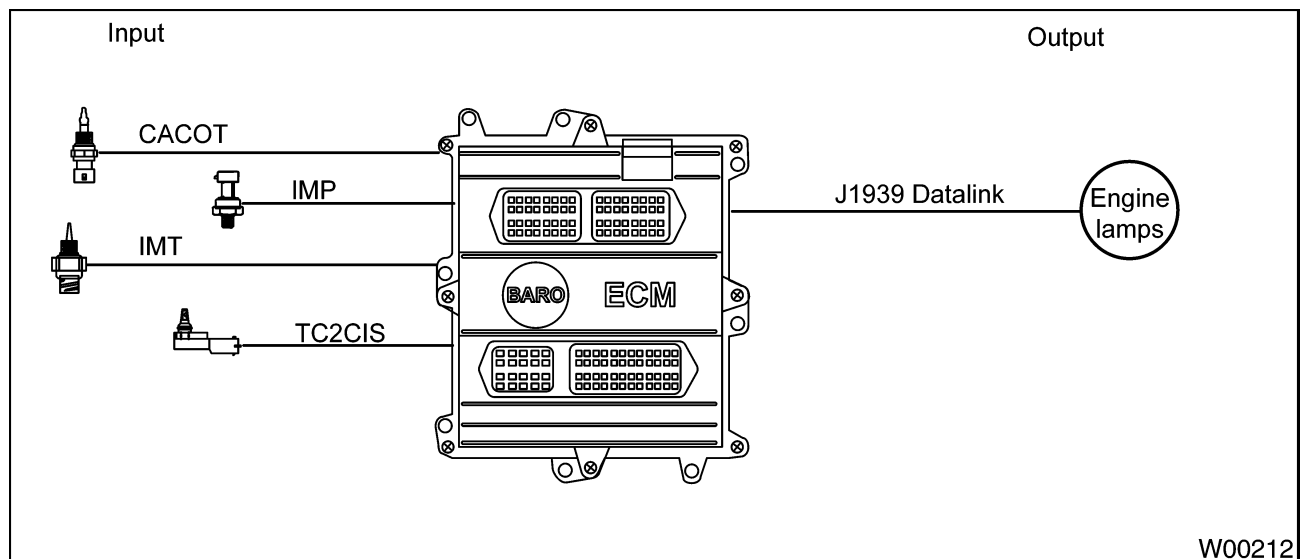
Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness 4602. Leave ECM and AFTFSV 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 C2-07	< 5 Ω	If > 5 Ω , check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω , check for short to GND.
2 to C2-20	< 5 Ω	If > 5 Ω , check for OPEN circuit.

AMS (Air Management System)

SPN	FMI	Condition	Possible Causes
2659	20	EGR High Flow Rate detected	- Biased O2S or circuit - Biased TC1TOP sensor or circuit - EGR Valve stuck open
2659	21	EGR Low Flow Rate detected	- Biased O2S or circuit - Biased TC1TOP sensor or circuit - EGR Valve stuck closed - Plugged EGR cooler - Restricted DOC or DPF

**Figure 134 Functional diagram for the AMS****SPN 2659/FMI 20 – EGR High Flow Rate detected****Pinpoint AMS System Fault**

1. Check for other active or inactive DTCs. Repair any electrical fault before continuing with this procedure.
2. Check for biased TC1TOP sensor.
3. Run Air Management test. During EGR portion of test, monitor IMP.
 - If IMP does not change state during EGR portion of Air Management test, go to EGR Valve (page 300).

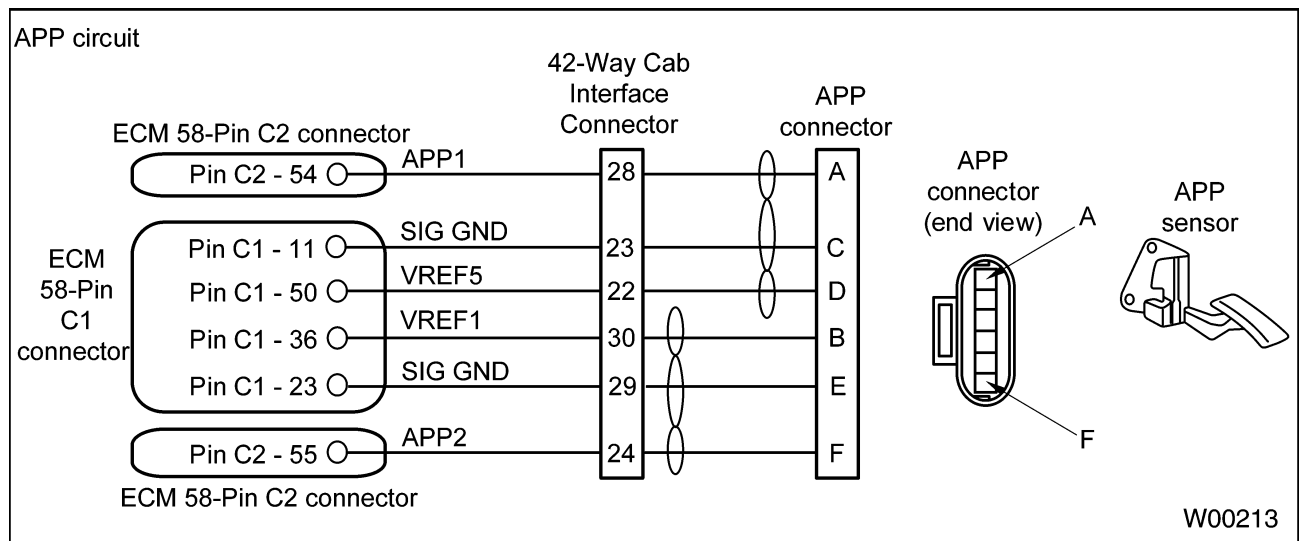
SPN 2659/FMI 21 – EGR Low Flow Rate detected

Pinpoint AMS System Fault

1. Check for other active or inactive DTCs. Repair any electrical fault before continuing with this procedure.
 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, go to EGR Valve (page 300) diagnostics.
 4. See EGR Cooler Leak Inspection in "Engine Symptoms Diagnostics."
-

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 135 APP circuit diagram**

Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4485A (APP)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

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.
 - 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 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 $\pm$ 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 (page 238).
DMM – Measure volts D to GND	5 V $\pm$ 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 (page 238).
EST - Monitor APP1v Short Pin A to C	5 V	If < 4.5 V, check APP1 circuit for OPEN, go to Harness Resistance Check (page 238).
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 (page 238).
DMM – Measure Volts B to Battery positive	B+	If < B+, check SIG GND for OPEN, go to Harness Resistance Check (page 238).
DMM – Measure Volts E to Battery positive	B+	If < B+, check SIG GND for OPEN, go to Harness Resistance Check (page 238).
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 4485A. Leave sensor disconnected. Turn ignition switch to 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 and Breakout Harness 4485A. Leave ECM and 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	> 1k Ω	If < 1k Ω , check for short circuit.
B to C1-11	< 5 Ω	If > 5 Ω , check for OPEN circuit.
C to GND	> 1k Ω	If < 1k Ω , check for short circuit.
C to C1-50	< 5 Ω	If > 5 Ω , check for OPEN circuit.
D to GND	> 1k Ω	If < 1k Ω , check for short circuit.
D to C1-36	< 5 Ω	If > 5 Ω , check for OPEN circuit.
E to GND	> 1k Ω	If < 1k Ω , check for short circuit.
E to C1-23	< 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

Connect 180-Pin Breakout Box and Breakout Harness 4485A between ECM and sensor. Turn ignition switch to ON. Use DMM to measure voltage or EST to read signal.

Test Point	Condition	DMM	EST Value
APP1	Foot off pedal	1.14V $\pm$ 0.25V	0%
A to GND or C2-54 to GND	Pedal to floor	4.32V $\pm$ 0.25V	99.6%
APP2	Foot off pedal	0.56V $\pm$ 0.25V	0%
F to GND or C2-55 to GND	Pedal to floor	2.16V $\pm$ 0.25V	99.6%

CACOT Sensor (Charge Air Cooler Outlet Temperature)

SPN	FMI	Condition	Possible Causes
2630	3	CACOT signal Out of Range HIGH	• CACOT signal circuit OPEN or short to PWR • SIG GND circuit OPEN • Failed CACOT sensor
2630	4	CACOT signal Out of Range LOW	• CACOT signal circuit short to GND • Failed CACOT sensor

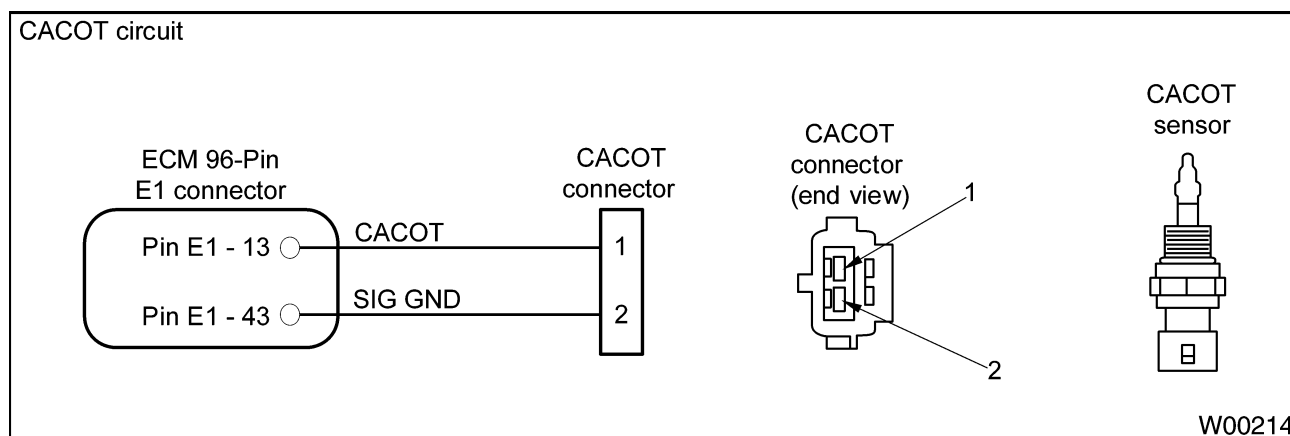


Figure 136 CACOT sensor circuit diagram

Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4993 (CACOT)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

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.
 - 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 With ServiceMaxx™ Software

Connect Breakout Harness 4993 and leave sensor disconnected. Turn ignition switch to 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 GND	0 V	If > 0.25 V, check CACOT signal circuit for OPEN. Do Harness Resistance Check (page 240).
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 240).
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.		

Without ServiceMaxx™ Software

Connect Breakout Harness 4993. Leave sensor disconnected. Turn ignition switch to 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 240).
2 to B+	B+	If < B+, check for short to PWR.

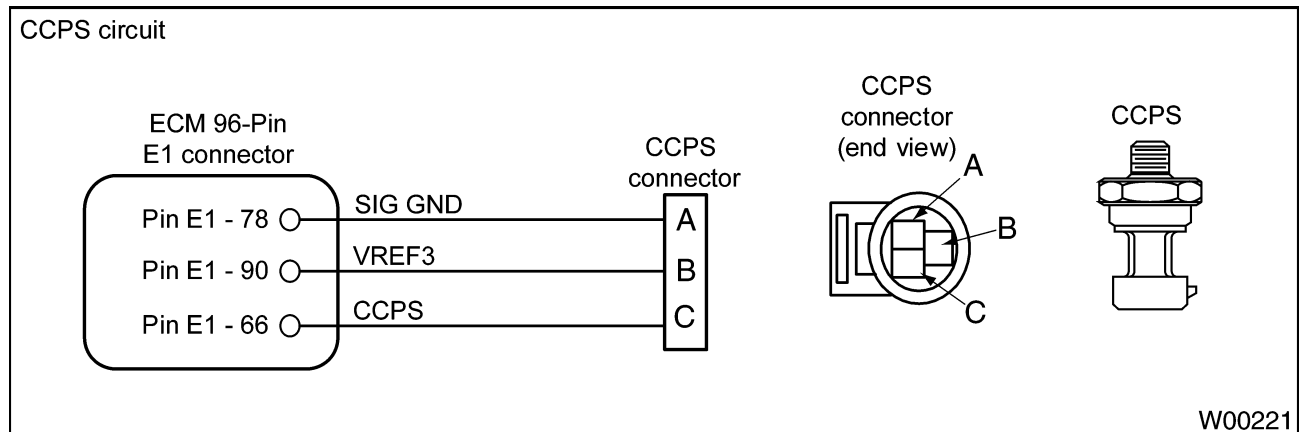
Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness 4993. 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 E1-13	< 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.

CCPS (Crankcase Pressure Sensor)

SPN	FMI	Condition	Possible Causes
101	3	CCP signal Out of Range HIGH	- CCPS signal circuit OPEN or short to PWR - SIG GND circuit OPEN - Failed CCPS
101	4	CCP signal Out of Range LOW	- CCPS signal circuit short to GND - VREF2 circuit OPEN - Failed CCPS
101	16	Excessive Crankcase Pressure	- Clogged breather filter - Malfunctioning centrifugal breather - Power cylinder problem

**Figure 137 CCPS circuit diagram****Tools**

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4850 (CCPS)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

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.
 - 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 4850 and leave sensor disconnected. Turn ignition switch to ON.

Test Point	Specification	Comment – < Less than, > Greater than
EST – Monitor CCPv	5.0 V $\pm$ 0.5 V	If < 4.5 V, check CCPS signal circuit for short to GND
DMM – Measure volts B to GND	5.0 V $\pm$ 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 308).
DMM – Measure voltage B to A	5 V $\pm$ 0.5 V	If < 4.5 V, check SIG GND circuit for OPEN. Do Harness Resistance Check (page 308).
EST – Monitor CCPv Short across breakout harness pins A and C	0 V	If > 0.5 V, check CCPS signal circuit for OPEN. Do Harness Resistance Check (page 308).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace EOP sensor.		

Connector Voltage Check

Connect Breakout Harness 4850. Leave CCPS disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
A to GND	0 V	If > 0.25 V, check SIG GND circuit for short to PWR.
B to GND	5 V $\pm$ 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 243).
C to GND	5 V $\pm$ 0.5 V	If < 4.5 V, check CCPS signal circuit for short to GND.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness 4850. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
A to GND	> 1k Ω	If < 1k Ω , check for short to GND.
A to E1-78	< 5 Ω	If > 5 Ω , check for OPEN circuit.
B to GND	> 1k Ω	If < 1k Ω , check for short to GND.
B to E1-90	< 5 Ω	If > 5 Ω , check for OPEN circuit.
C to GND	> 1k Ω	If < 1k Ω , check for short to GND.
C to E1-66	< 5 Ω	If > 5 Ω , check for OPEN circuit.

CCS (Cruise Control System)

SPN	FMI	Condition	Possible Causes
None			

Function

The CCS is a function of the 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 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 to 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
Cruise 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 Depressed = Applied	See Note
Park brake	Normal state = OFF Depressed = ON	See Note
Cruise On/Off	Unlatched = OFF Latched = ON	See Note
Cruise Set	Normal state = OFF Depressed = ON	See Note
Cruise Resume/Accel	Normal state = OFF Depressed = ON	See Note
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

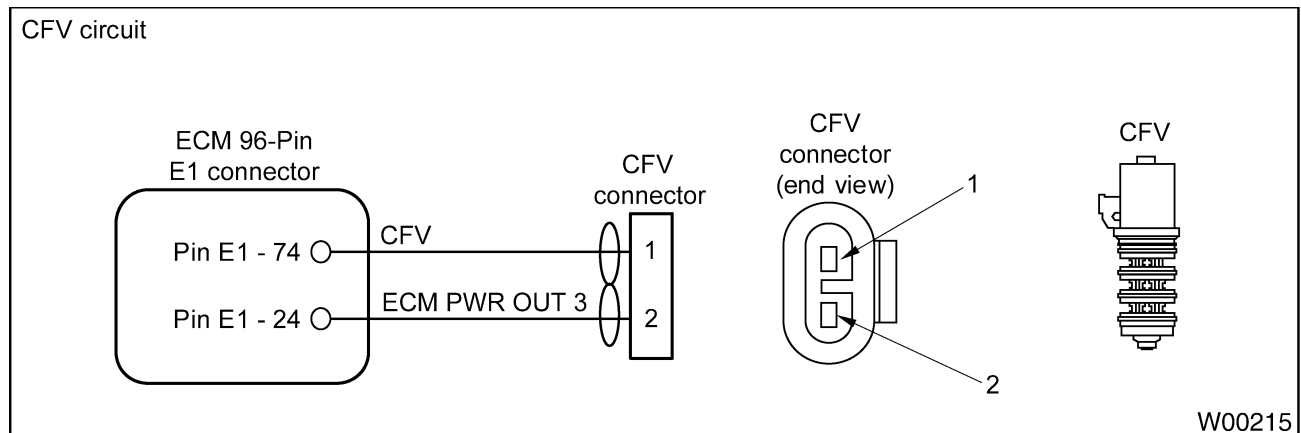


Figure 138 CFV circuit diagram

Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4871 (CFV)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

Connector Voltage Check

Connect Breakout Harness 4871 to engine harness and leave CFV disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specifications	Comment – < Less than, > Greater than
Pin 1 to GND	4 V $\pm$ 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 (page 248).		

Operational Voltage Check

NOTE: Ensure battery voltage is at or above 12, V before running this procedure.

1. Connect Breakout Harness 4871 between CFV and engine harness.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, load the Actuator session.
3. Command Coolant Flow Valve to 5%, and then 95%.
4. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	5% = 12.0 V $\pm$ 2.0 V	If < 10.0 V, check for OPEN circuit.
1 to GND	95% = 1.5 V $\pm$ 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 4871 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

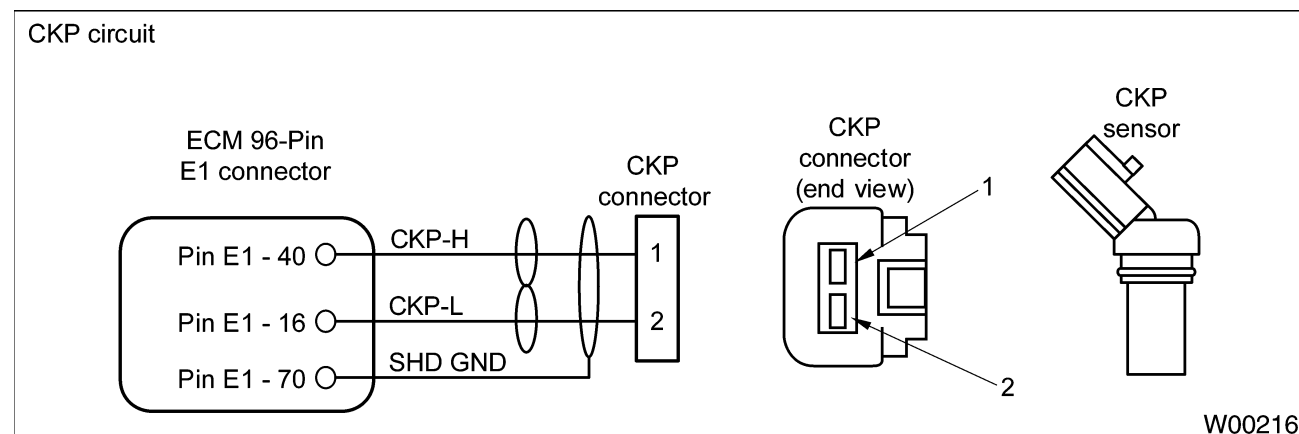
Turn ignition switch to OFF. Connect 180-Pin Breakout Box to ECM and Breakout Harness 4871 to engine harness and leave CFV and ECM disconnected. Use DMM to measure resistance.

Test Point	Specifications	Comment – < Less than, > Greater than
1 to E1-24	< 5 Ω	If > 5 Ω , check for OPEN circuit.
1 to GND	> 1k Ω	If < 1k Ω , check for short circuit.
2 to E1-74	< 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 69) in "Engine Symptoms Diagnostics" to diagnose a mechanical fault.

CKP Sensor (Crankshaft Position)

SPN	FMI	Condition	Possible Causes
637	8	CKP signal noise	• CKP sensor or circuit fault
637	10	CKP signal inactive	• CKP sensor or circuit fault

**Figure 139 CKP sensor circuit diagram****Tools**

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 6021 (CKP)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

Sensor Resistance Check

Test Point	Specifications	Comment
1 to 2	774 Ω to 946 Ω	If measurement is within specification, go to Harness Resistance Checks.
If measurement is not within specification, replace CKP sensor.		

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and leave ECM and CKP sensor disconnected. Use DMM to measure resistance.

Test Point	Specifications	Comment – < Less than, > Greater than
E1-40 to 1	< 5 Ω	If > 5 Ω , check for OPEN circuit.
E1-40 to GND	> 1k Ω	If < 1k Ω , check for short to GND.
E1-16 to 2	< 5 Ω	If > 5 Ω , check for OPEN circuit.
E1-16 to GND	> 1k Ω	If < 1k Ω , check for short to GND.
E1-40 to E1-16	>1k Ω	If < 1k Ω , check for CKP-H short to CKP-L.
If measurements are within specification, do Operational Checks.		

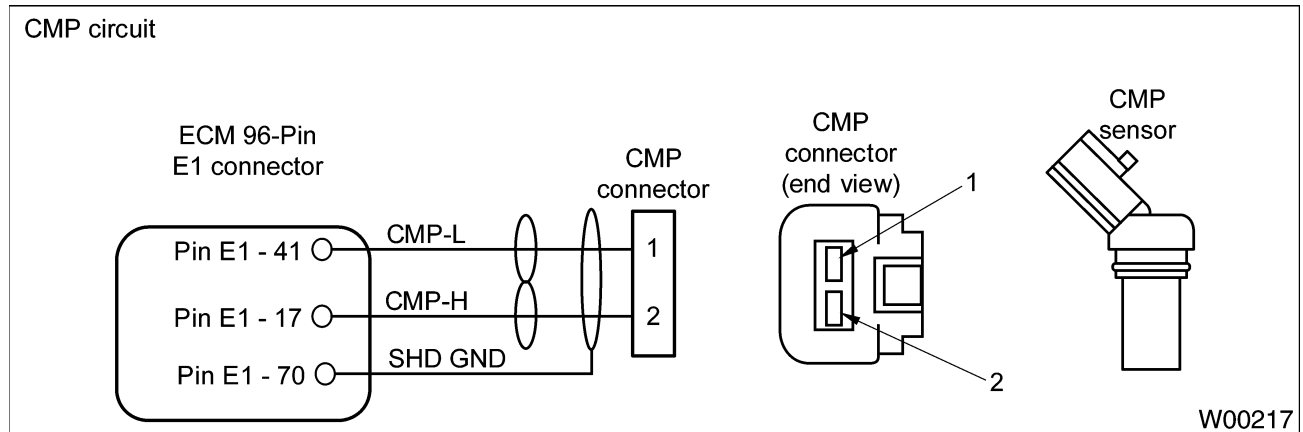
Operational Checks

Connect Breakout Harness 6021 between CKP sensor and engine harness. Use DMM set to AC Volts-Hz.

Test Point	Condition	DMM	Engine Speed
E1-40 to E1-16	Engine crank	100 Hz to 250 Hz	100 rpm to 250 rpm
	Low idle	630 Hz to 730 Hz	600 rpm to 700 rpm
	High idle	2230 Hz	2180 rpm

CMP Sensor (Camshaft Position)

SPN	FMI	Condition	Possible Causes
636	2	CMP and CKP Synchronization Error	- CMP sensor or circuit fault - Camshaft and crankshaft out of time
636	8	CMP signal noise	CMP sensor or circuit fault
636	10	CMP signal missing	CMP sensor or circuit fault

**Figure 140 CMP sensor circuit diagram****Tools**

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 6021 (CMP)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

Sensor Resistance Check

Test Point	Specifications	Comment
1 to 2	774 Ω to 946 Ω	If measurement is within specification, go to Harness Resistance Check.
If measurement is not within specification, replace CMP sensor.		

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and leave ECM and CMP sensor disconnected. Use DMM to measure resistance.

Test Point	Specifications	Comment – < Less than, > Greater than
E1-41 to 1	< 5 Ω	If > 5 Ω , check for OPEN circuit.
E1-41 to GND	> 1k Ω	If < 1k Ω , check for short to GND.
E1-17 to 2	< 5 Ω	If > 5 Ω , check for OPEN circuit.
E1-17 to GND	> 1k Ω	If < 1k Ω , check for short to GND.
E1-41 to E1-17	> 1k Ω	If < 1k Ω , check for CMP-H short to CMP-L.

If measurements are within specification, go to Operational Checks.

Operational Checks

Connect 180-Pin Breakout Box between ECM and CMP sensor. Use DMM set to AC volts – RPM2.

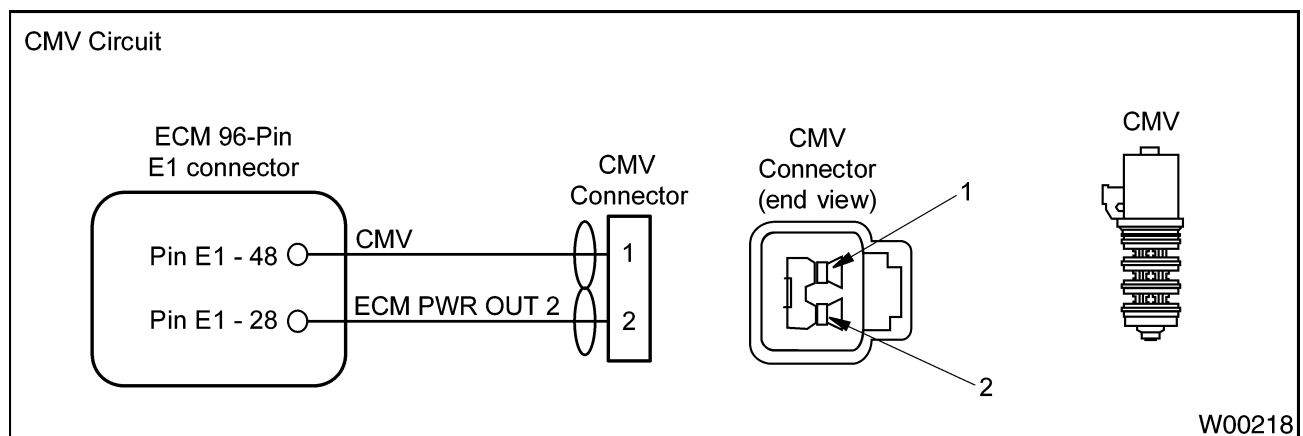
Test Point	Condition	Specifications
E1-41 to E1-17	Engine crank	100 rpm to 250 rpm
	Low idle	650 rpm to 700 rpm
	High idle	2180 rpm

SPN 636 FMI 2 – CMP and CKP Synchronization Error**Pin-Point Synchronization Fault**

- Do all circuit checks on the CMP sensor and CKP sensor.
 - If circuits are within specification, verify that the camshaft and crankshaft are synchronized. See the *Engine Service Manual*.

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 141 CMV sensor circuit diagram****Tools**

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4870 (CMV)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

Connector Voltage Check

Connect Breakout Harness 4870 to engine harness and leave CMV disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specifications	Comment – < Less than, > Greater than
Pin 1 to GND	4 V $\pm$ 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 4870 between CMV and engine harness.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, load the Actuator session.
3. Command Coolant Mixer Valve to 5%, and then 95%.
4. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	5% = 12.0 V $\pm$ 2.0 V	If < 10.0 V, check for OPEN circuit.
1 to GND	95% = 1.5 V $\pm$ 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 4870 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

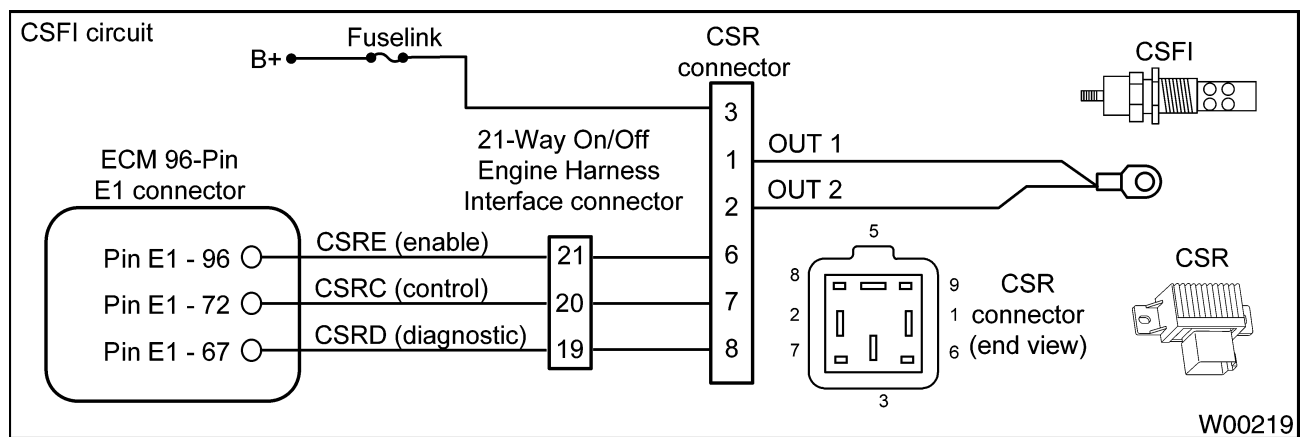
Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness 4870 to engine harness and leave CMV and ECM disconnected. Use DMM to measure resistance.

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.

CSFI (Cold Start Fuel Igniter)

SPN	FMI	Condition	Possible Causes
5548	3	CSFI short to PWR	- CSFI circuit short to PWR - Failed CSFI
5548	4	CSFI short to GND	- CSFI circuit short to GND - Failed CSFI
5548	5	Cold Start Relay or control circuit fault	- CSRE (enable) circuit fault - CSRC (control) circuit fault - CSRD (diagnostic) circuit fault - Cold Start Relay (CSR) failure
5548	7	Cold Start Relay return (relay, igniter, or circuit failure)	- CSFI failure - Fuse link failure - High current circuit fault (B+ to relay) - High current circuit fault (relay to igniter) - CSR failure

**Figure 142 CSFI circuit diagram****Tools**

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4885 (CSR)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

! WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

Voltage Check on CSFI - Actuator Test

Turn the ignition switch to ON. Run Actuator Test. Use DMM to measure voltage when CSR is cycled on. Batteries must be fully charged before performing this test.

Test Point	Specifications	Comment – < Less than, > Greater than
CSFI to GND	B+	If > 0 V to B+, do Amperage Draw Check - Actuator Test. If 0 V, do Voltage Checks on Relay Connector (page 256).

Amperage Draw Check - Actuator Test

Turn the ignition switch to ON. Run Actuator Test. Measure amperage draw to CSFI using DMM and Amp clamp. Set the DMM to DCmV and Zero the Amp clamp. Batteries must be fully charged before performing this test.

Test Point	Specifications	Comment
DMM - Measure amperage to CSFI		
CSFI	30 Amps (within 2 seconds)	If within specification, CSR and CSFI are working correctly. If not within specification, do Voltage Checks on Relay - Actuator Test (page 257).
If Amps are within specification, do Harness Resistance Check (page 258) for CSR circuit.		

Voltage Checks on Relay Connector

Connect Breakout Harness 4885 to CSR harness, leave CSR disconnected. Turn ignition switch to 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	9 V $\pm$ 1 V	If < 8 V, check for OPEN or short to GND.
7 to GND	4 V $\pm$ 1 V	If < 3 V, check for OPEN or short to GND. If > 5.5 V, check for short to PWR.
8 to GND	5 V $\pm$ 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 257).		

Voltage Checks on Relay - Actuator Test

Connect Breakout Harness 4885 between CSR 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	> 8 V	If < 8 V, check CSRE circuit for OPEN or short to GND. Do Harness Resistance Check (page 258).
Actuator state LOW	> 8 V	If < 8 V, check CSRE circuit for OPEN or short to GND. Do Harness Resistance Check (page 258).
Actuator state HIGH	< 0.5 V	If > 0.5 V, check CSRE circuit for short to PWR. Do Harness Resistance Check (page 258).
7 to GND, Run Actuator Test.		
Normal state	> 8 V	If < 8 V, check CSRC circuit for OPEN or short to GND. Do Harness Resistance Check (page 258).
Actuator state LOW	> 8 V	If < 8 V, check CSRC circuit for OPEN or short to GND. Do Harness Resistance Check (page 258).
Actuator state HIGH	< 0.5 V	If > 0.5 V, check CSRD circuit for short to PWR. Do Harness Resistance Check (page 258).
8 to GND, Run Actuator Test.		
Normal state	5 V $\pm$ 0.5 V	If < 4.5 V, check CSRD circuit for OPEN or short to GND. Do Harness Resistance Check (page 258).
Actuator state LOW	5 V $\pm$ 0.5 V	If < 4.5 V, check CSRD circuit for OPEN or short to GND. Do Harness Resistance Check (page 258).
Actuator state HIGH	5 V $\pm$ 0.5 V	If < 4.5 V, check CSRD circuit for OPEN or short to GND. Do Harness Resistance Check (page 258).
1 to GND, Run Actuator Test.		
Normal state	0 V	If > 0 V, replace CSR.
Actuator state LOW	0 V	If > 0 V, replace CSR.
Actuator state HIGH	B+	If < B+, replace CSR.
2 to GND, Run Actuator Test.		
Normal state	0 V	If > 0 V, replace CSR.
Actuator state LOW	0 V	If > 0 V, replace CSR.
Actuator state HIGH	B+	If < B+, replace CSR.
If measurements are not within specifications, do Harness Resistance Check (page 258).		

CSFI Resistance Check

Turn ignition switch to OFF. Use DMM to measure resistance between CSFI and engine GND.

Test Point	Specifications	Comment – < Less than, > Greater than
CSFI to GND	< 5 Ω	If > 5 Ω , replace failed CSFI.

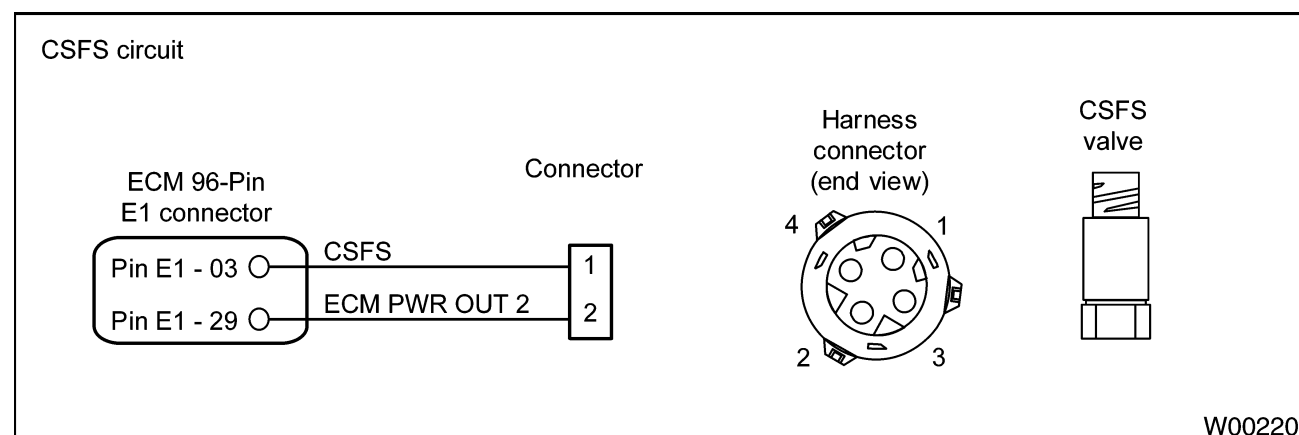
Harness Resistance Check

Connect Breakout Harness 4885 and 180-Pin Breakout Box and leave ECM and CSR disconnected. Use DMM to measure resistances.

Test Point	Specifications	Comment – < Less than, > Greater than
1 to CSFI	< 5 Ω	If > 5 Ω , check for OPEN circuit.
1 to GND	< 5 Ω	If > 5 Ω , check for OPEN CSFI.
2 to CSFI	< 5 Ω	If > 5 Ω , check for OPEN circuit.
2 to GND	< 5 Ω	If > 5 Ω , check for OPEN CSFI.
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 CSR.		

CSFS (Cold Start Fuel Solenoid)

SPN	FMI	Condition	Possible Causes
626	3	CSFS short to PWR	CSFS circuit short to PWR
626	4	CSFS short to GND	CSFS circuit short to GND
626	5	CSFS open load/circuit	- CSFS circuit OPEN - CSFS failure
626	11	Cold Start Assist fault: Lack of heat in the Intake Manifold	- Biased IMT sensor or circuit - Cold Start Assist System failure - Failed CSFS - Failed Cold Start Fuel Igniter (CSFI) - Failed Cold Start Relay (CSR) - Cold Start Assist circuit faults

**Figure 143 CSFS circuit diagram****Tools**

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4827 (CSFS)
- Digital Multimeter (DMM)

- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

! WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

Cold Soak Sensor Compare Check With ServiceMaxx™ Software**SPN 626 FMI 11 – Cold Start Assist fault: Lack of heat in the Intake Manifold**

During cold start DTC sets when IMT signal does not raise Intake Manifold Temperature (IMT) 10°C (50°F).

NOTE: Temperature values need to be measured after 4 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 (AIT). Sensor temperatures should be within 5°C (10°F) of each other.
 - If IMT is 5°C (10°F) above or below AAT, AIT, or IMT, check for poor circuitry going to the IMT sensor.
 - If IMT circuitry is in specification, see Cold Start Assist System Test in “Hard Start and No Start Diagnostics.”

Connector Voltage Check – CSFS Disconnected

Connect Breakout Harness 4827 to engine harness. Leave CSFS 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 261).
1 to GND	3.5 V ± 1.0 V	If < 2.5 V, check for OPEN circuit. Do Harness Resistance Check (page 261).

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 4827 between CSFS and engine harness.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, load the Actuator session.
3. Command Cold Start Fuel Solenoid to 5%, and then 95%.
4. 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 CSFS.

Actuator Resistance Check

Turn ignition switch to OFF. Connect Breakout Harness 4827 to CSFS 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 CSFS.
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 4827 to engine harness. Leave CSFS and ECM 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 CSFS valve.		

DOCIT Sensor (Diesel Oxidation Catalyst Inlet Temperature)

SPN	FMI	Condition	Possible Causes
4765	2	DOCIT signal does not agree with other exhaust sensors	Biased DOCIT sensor/circuit
4765	3	DOCIT signal Out of Range HIGH	- DOCIT signal circuit OPEN or short to PWR - SIG GND circuit OPEN - Failed DOCIT sensor
4765	4	DOCIT signal Out of Range LOW	- DOCIT signal circuit short to GND - Failed DOCIT sensor

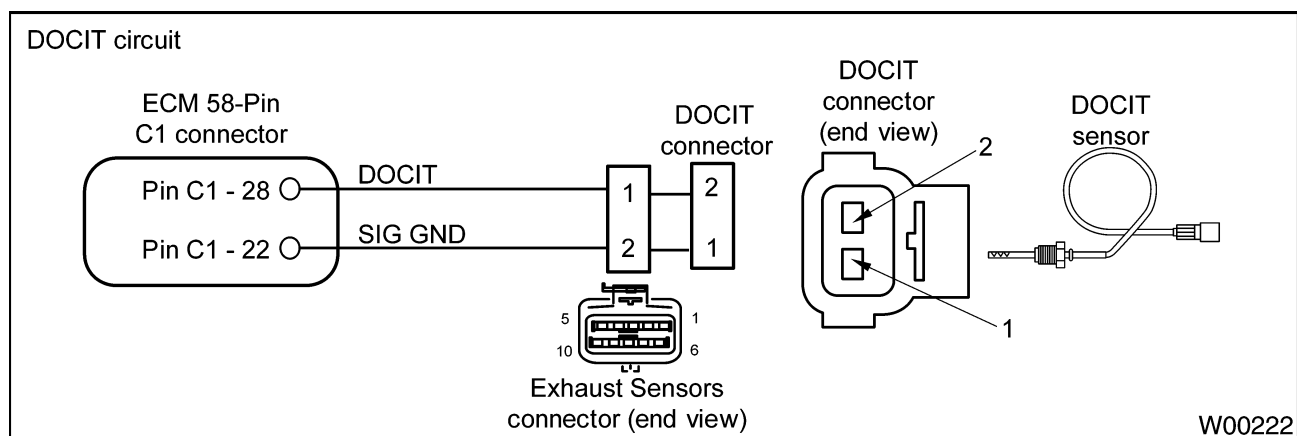


Figure 144 DOCIT circuit diagram

Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4760A (DOCIT)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

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.
 - 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 4765 FMI 2 – DOCIT signal does not agree with other exhaust sensors

Cold Soak Sensor Compare Check With ServiceMaxx™ Software

NOTE: Temperature values need to be measured after 4 hours of cold soak.

1. Turn ignition switch ON, engine OFF.
 2. Using ServiceMaxx™ software, open the Default session.
 3. Compare DOCIT, Diesel Oxidation Catalyst Outlet Temperature (DOCOT), and Diesel Particulate Filter Outlet Temperature (DPFOT). Sensor temperatures should be within 11°C (20°F) of each other.
 - If DOCIT is 11°C (20°F) above or below DOCOT or DPFOT, check for poor circuitry going to the DOCIT sensor.
 - If circuits are within specification, replace DOCIT sensor.
-

Sensor Circuit Check With ServiceMaxx™ Software

Connect Breakout Harness 4760A and leave sensor disconnected. Turn ignition switch to ON.

Test Point	Specifications	Comment– < Less than, > Greater than
EST – Monitor DOCITv	5 V	If <4.5 V, check DOCIT signal circuit for short to GND.
EST – Monitor DOCITv Short pin 1 to GND	0 V	If > 0.25 V, check DOCIT signal circuit for OPEN. Do Harness Resistance Check. (page 264).
EST – Monitor DOCITv Short pin 1 to 2	0 V	If > 0.25 V, check SIG GND circuit for OPEN. Do Harness Resistance Check. (page 264).
EST – Monitor DOCITv Short 500 Ω resistor across pins 1 and 2	< 1.0 V	If > 1.0 V, check DOCIT signal circuit for short to PWR.
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace DOCIT sensor.		

Connector Voltage Check Without ServiceMaxx™ Software

Connect Breakout Harness 4760A. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to B+	B+	If < B+, check for short to PWR.
2 to GND	4.5 V to 5 V	If < 4.5 V, check short to GND.

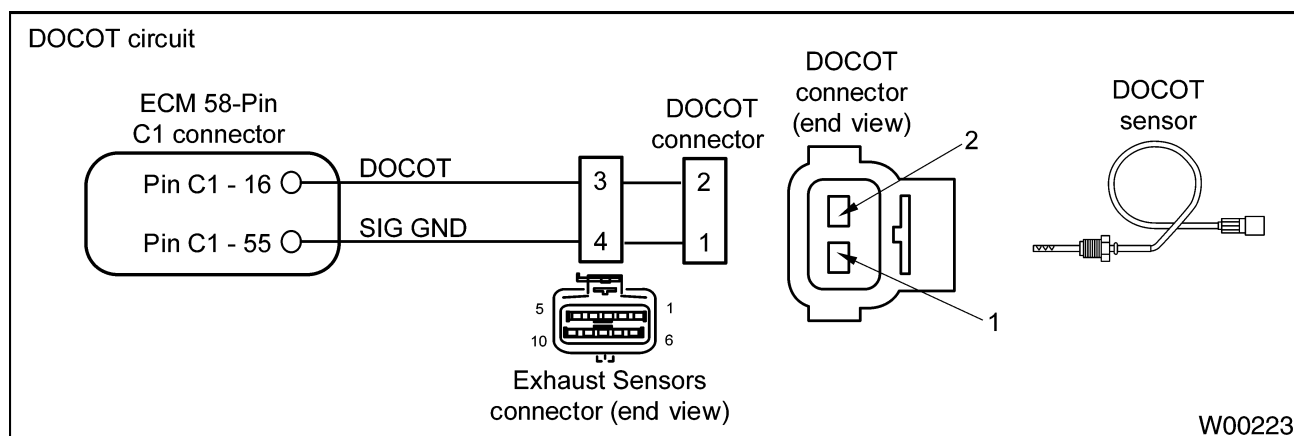
Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness 4760A. 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 C1-22	< 5 Ω	If > 5 Ω , check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω , check for short circuit.
2 to C1-28	< 5 Ω	If > 5 Ω , check for OPEN circuit.

DOCOT Sensor (Diesel Oxidation Catalyst Outlet Temperature)

SPN	FMI	Condition	Possible Causes
4766	2	DOCOT signal does not agree with other exhaust sensors	Biased DOCOT sensor or circuit
4766	3	DOCOT signal Out of Range HIGH	- DOCOT signal circuit OPEN or short to PWR - SIG GND circuit OPEN - Failed DOCOT sensor
4766	4	DOCOT signal Out of Range LOW	- DOCOT signal circuit short to GND - Failed DOCOT sensor

**Figure 145 DOCOT sensor circuit diagram****Tools**

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4760A (DOCOT)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

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.
 - 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 4766 FMI 2 – DOCOT signal does not agree with other exhaust sensors

Cold Soak Sensor Compare Check With ServiceMaxx™ Software

NOTE: Temperature values need to be measured after 4 hours of cold soak.

1. Turn ignition switch ON, engine OFF.
 2. Using ServiceMaxx™ software, open the Default session.
 3. Compare DOCOT, Diesel Oxidation Catalyst Inlet Temperature (DOCIT), and Diesel Particulate Filter Outlet Temperature (DPFOT). Sensor temperatures should be within 11°C (20°F) of each other.
 - If DOCOT is 11°C (20°F) above or below DOCIT or DPFOT, check for poor circuitry going to the DOCOT sensor.
 - If circuits are within specification, replace DOCOT sensor.
-

Sensor Circuit Check With ServiceMaxx™ Software

Connect Breakout Harness 4760A and leave sensor disconnected. Turn ignition switch to ON.

Test Point	Specifications	Comment– < Less than, > Greater than
EST – Monitor DOCOTv	5 V	If <4.5 V, check DOCOT signal circuit for short to GND.
EST – Monitor DOCOTv Short pin 1 to GND	0 V	If > 0.25 V, check DOCOT signal circuit for OPEN. Do Harness Resistance Check (page 267).
EST – Monitor DOCOTv Short pin 1 to 2	0 V	If > 0.25 V, check SIG GND circuit for OPEN. Do Harness Resistance Check (page 267).
EST – Monitor DOCOTv Short 500 Ω resistor across pins 1 and 2	< 1.0 V	If > 1.0 V, check DOCOT signal circuit for short to PWR.
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace DOCIT sensor.		

Connector Voltage Check Without ServiceMaxx™ Software

Connect Breakout Harness 4760A. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to B+	B+	If < B+, check for short to PWR.
2 to GND	4.5 V to 5 V	If < 4.5 V, check short to GND.

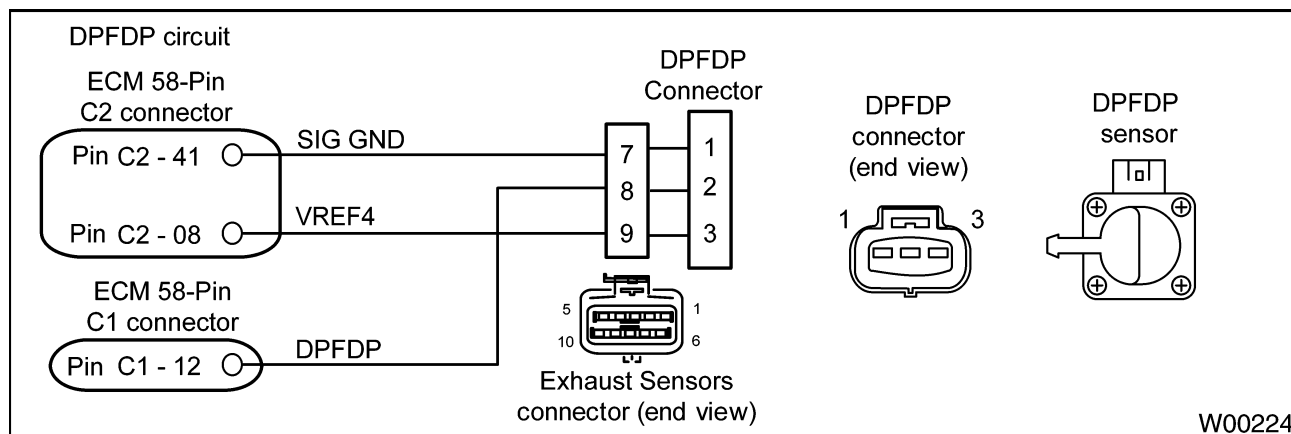
Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness 4760A. 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 C1-55	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
2 to C1-16	< 5 Ω	If > 5 Ω, check for OPEN circuit.

DPFDP Sensor (Diesel Particulate Filter Differential Pressure)

SPN	FMI	Condition	Possible Causes
3251	2	DPFDP above or below desired level	- Biased DPFDP sensor or circuit - Restricted or plugged DPF - Reversed DPFDP sensor hoses
3251	3	DPFDP signal Out of Range HIGH	- DPFDP signal circuit short to PWR - SIG GND circuit OPEN - Failed DPFDP sensor
3251	4	DPFDP signal Out of Range LOW	- DPFDP signal circuit OPEN or short to GND - Reversed DPFDP sensor hoses - Failed DPFDP sensor



W00224

Figure 146 DPFDP sensor circuit diagram
Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4761A (DPFDP)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

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.
 - 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 3251 FMI 2 – DPFD P above or below desired level

Biased Sensor or Circuit Check

1. Turn ignition switch to ON, engine OFF.
 2. Using ServiceMaxx™ software, open the Continuous Monitor session.
 3. Verify S_DPFD P volts are within specification. See "Appendix A: Performance Specifications."
 - If voltage is not within specification, check circuitry for poor continuity.
 - If voltage is within specification, verify sensor hoses are connected correctly.
-

Sensor Circuit Check With ServiceMaxx™ Software

Connect Breakout Harness 4761A and leave sensor disconnected. Turn ignition switch to ON.

Test Point	Specification	Comment – < Less than, > Greater than
EST – Monitor DPFDPv	0 V	If > 0.25 V, check DPFDP signal circuit for short to GND.
DMM — Measure volts 3 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 Check (page 270).
EST – Monitor DPFDPv Short across breakout harness pins 2 and 3	4.5 V ± 0.5 V	If < 4.5 V, check DPFDP signal circuit for OPEN. Do Harness Resistance Check (page 270).
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 270).

If checks are within specifications, connect sensor and clear DTCs. If active DTC remains, replace DPFDP sensor.

Connector Voltage Check Without ServiceMaxx™ Software

Connect Breakout Harness 4761A. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	0 V	If > 0.25 V, check SIG GND circuit for short to PWR.
2 to GND	0 V	If > 0.25 V, check DPFDP for short to PWR.
3 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 270).

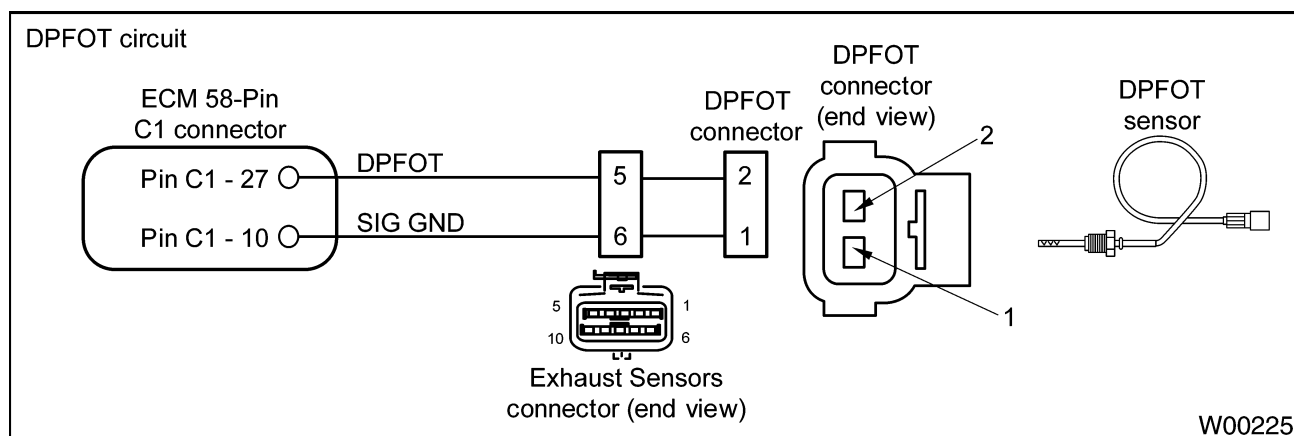
Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness 4761A. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment – < Less than, > Greater than
1 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
1 to C2-41	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
2 to C1-12	< 5 Ω	If > 5 Ω, check for OPEN circuit.
3 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
3 to C2-08	< 5 Ω	If > 5 Ω, check for OPEN circuit.

DPFOT Sensor (Diesel Particulate Filter Outlet Temperature)

SPN	FMI	Condition	Possible Causes
3246	2	DPFOT signal does not agree with other exhaust sensors	Biased DPFOT sensor or circuit
3246	3	DPFOT signal Out of Range HIGH	- DPFOT signal circuit OPEN or short to PWR - SIG GND circuit OPEN - Failed DPFOT sensor
3246	4	DPFOT signal Out of Range LOW	- DPFOT signal circuit short to GND - Failed DPFOT sensor

**Figure 147 DPFOT sensor circuit diagram****Tools**

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4760A (DPFOT)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

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.
 - 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 3246 FMI 2 – DPFOT signal does not agree with other exhaust sensors

Cold Soak Sensor Compare Check With ServiceMaxx™ Software

NOTE: Temperature values need to be measured after 4 hours of cold soak.

1. Turn ignition switch ON, engine OFF.
2. Using ServiceMaxx™ software, open the Default session.
3. Compare DPFOT, Diesel Oxidation Catalyst Inlet Temperature (DOCIT), and Diesel Oxidation Catalyst Outlet Temperature (DOCOT). Sensor temperatures should be within 11°C (20°F) of each other.
 - If DPFOT is 11°C (20°F) above or below DOCIT or DOCOT, check for poor circuitry going to the DPFOT sensor.
 - If circuits are within specification, replace DPFOT sensor.

Sensor Circuit Check With ServiceMaxx™ Software

Connect Breakout Harness 4760A. Leave sensor disconnected. Turn ignition switch to ON.

Test Point	Specification	Comment– < Less than, > Greater than
EST – Monitor DPFOTv	4.5 – 5 V	If < 4.5 V, check DPFOT signal circuit for short to GND.
EST – Monitor DPFOTv Short pin 1 to GND	0 V	If > 0.25 V, check DPFOT signal circuit for OPEN. Do Harness Resistance Check (page 273).
EST – Monitor DPFOTv Short pin 1 to 2	0 V	If > 0.25 V, check SIG GND circuit for OPEN. Do Harness Resistance Check (page 273).
EST – Monitor DPFOTv Short 500 Ω resistor across pins 1 and 2	< 1.0 V	If > 1.0 V, check DPFOT signal circuit for short to PWR.

If checks are within specification, connect sensor and clear DTCs. If active code remains, replace DPFOT sensor.

Connector Voltage Check Without ServiceMaxx™ Software

Connect Breakout Harness 4760A. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to B+	B+	If < B+, check for short to PWR.
2 to GND	4.5 V to 5 V	If < 4.5 V, check for short to GND.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness 4760A. 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 C1-10	< 5 Ω	If > 5 Ω , check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω , check for short circuit.
2 to C1-27	< 5 Ω	If > 5 Ω , check for OPEN circuit.

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

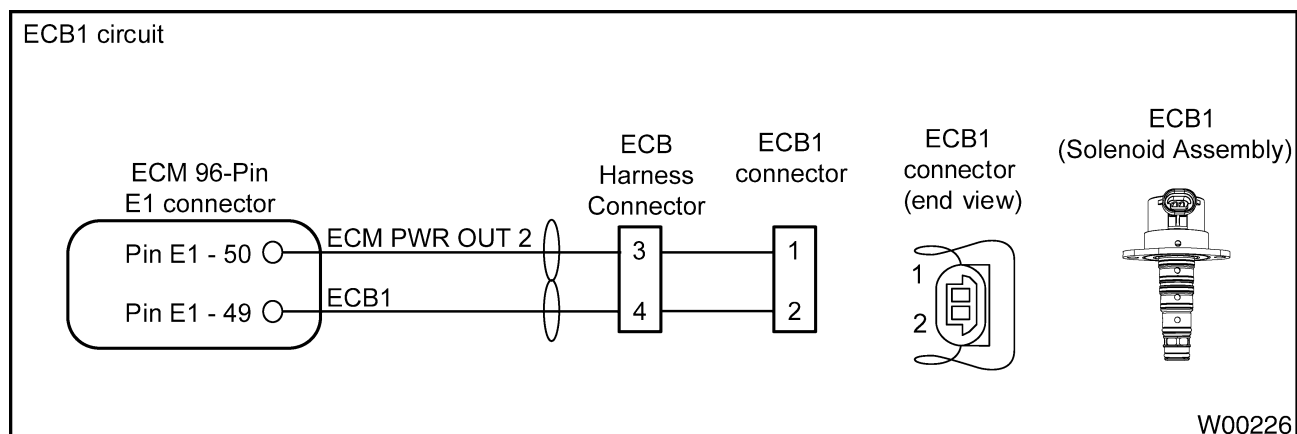


Figure 148 ECB1 circuit diagram

Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4484 (ECB)
- Digital Multimeter (DMM)

- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit



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 to engine harness 4484. Leave ECB1 disconnected. 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 275).
2 to GND	3.5 V $\pm$ 1.0 V	If < 2.5 V, check for OPEN circuit. Do Harness Resistance Check (page 275).
If measurements are within specifications, do Operational Voltage Check (page 275).		

Operational Voltage Check

NOTE: Ensure battery voltage is at or above 12 V before running this procedure.

1. Connect Breakout Harness 4484 between ECB1 and engine harness.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, load the Actuator session.
3. Command ECB1 to 5%, and then 95%.
4. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
2 to GND	5% = 12 V $\pm$ 2.0 V	If < 10 V, check for OPEN circuit.
2 to GND	95% = 0.5 V $\pm$ 0.5 V	If > 1 V, check for OPEN circuit or failed ECB1.

Actuator Resistance Check

Turn ignition switch to OFF. Connect Breakout Harness 4484 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 (page 275).		

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness 4484. Leave ECM and 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 E1-50	< 5 Ω	If > 5 Ω , check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω , check for short circuit.
2 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 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 OPEN circuit - Failed ECB2 solenoid

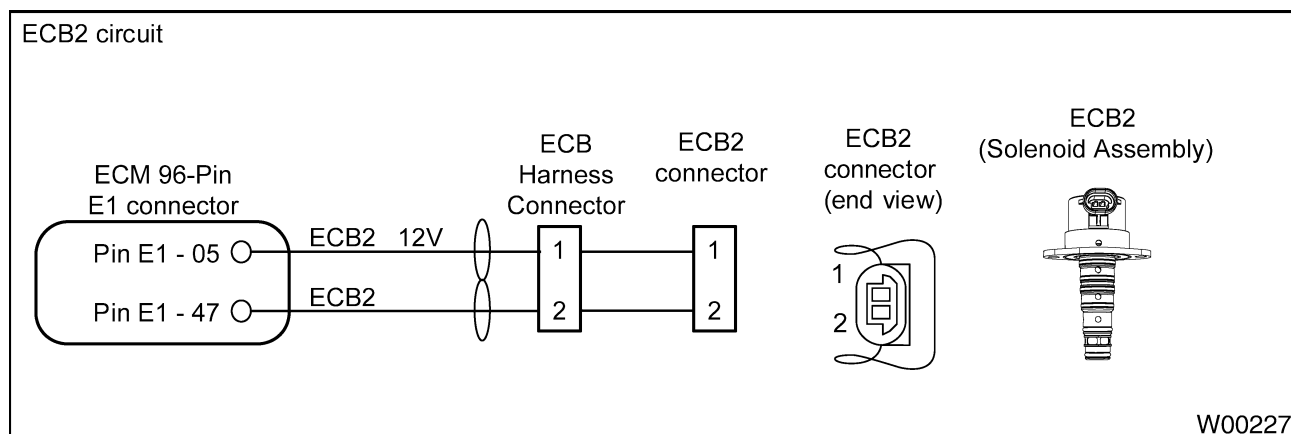


Figure 149 ECB2 circuit diagram

Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4484 (ECB)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

Connector Voltage Check – ECB2 Disconnected

Connect Breakout Harness 4484 to engine harness. Leave ECB2 disconnected. 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 277).
2 to GND	3.5 V $\pm$ 1.0 V	If < 2.5 V, check for OPEN circuit. Do Harness Resistance Check (page 277).
If measurements are within specifications, do Operational Voltage Check (page 277).		

Operational Voltage Check

NOTE: Ensure battery voltage is at or above 12 V before running this procedure.

1. Connect Breakout Harness 4484 between ECB2 and engine harness.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, load the Actuator session.
3. Command ECB2 to 5%, and then 95%.
4. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
2 to GND	5% = 12 V $\pm$ 2.0 V	If < 10 V, check for OPEN circuit.
2 to GND	95% = 0.5 V $\pm$ 0.5 V	If > 1 V, check for OPEN circuit or failed ECB2.

Actuator Resistance Check

Turn ignition switch to OFF. Connect Breakout Harness 4484 to ECB2 and leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to 2	9 Ω	If not within specification, replace ECB2.
If measurements are within specifications, go to Harness Resistance Check (page 277).		

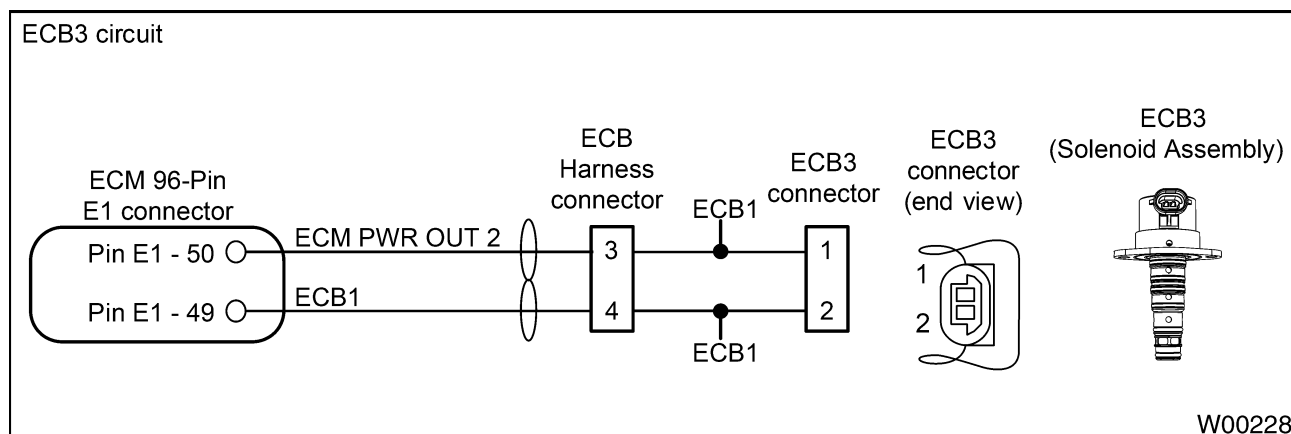
Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness 4484. Leave ECM and ECB2 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 ECB2.		

ECB3 (Engine Compression Brake 3)

SPN	FMI	Condition	Possible Causes
1073	3	ECB3 Control short to PWR	- ECB3 control circuit short to PWR - Failed ECB3 solenoid
1073	4	ECB3 Control short to GND	- ECB3 control circuit short to GND - Failed ECB3 solenoid
1073	5	ECB3 Control open load/circuit	- ECB3 control circuit OPEN - Failed ECB3 solenoid

**Figure 150 ECB3 circuit diagram****Tools**

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4484 (ECB)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

Connector Voltage Check – ECB3 Disconnected

Connect Breakout Harness 4484 to engine harness. Leave ECB3 disconnected. 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 279).
2 to GND	3.5 V $\pm$ 1.0 V	If < 2.5 V, check for OPEN circuit. Do Harness Resistance Check (page 279).
If measurements are within specifications, do Operational Voltage Check (page 279).		

Operational Voltage Check

NOTE: Ensure battery voltage is at or above 12 V before running this procedure.

1. Connect Breakout Harness 4484 between ECB3 and engine harness.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, load the Actuator session.
3. Command ECB3 to 5%, and then 95%.
4. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
2 to GND	5% = 12 V $\pm$ 2.0 V	If < 10 V, check for OPEN circuit.
2 to GND	95% = 0.5 V $\pm$ 0.5 V	If > 1 V, check for OPEN circuit or failed ECB3.

Actuator Resistance Check

Turn ignition switch to OFF. Connect Breakout Harness 4484 to ECB3 and leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to 2	9 Ω	If not within specification, replace ECB3.
If measurements are within specifications, go to Harness Resistance Check (page 279).		

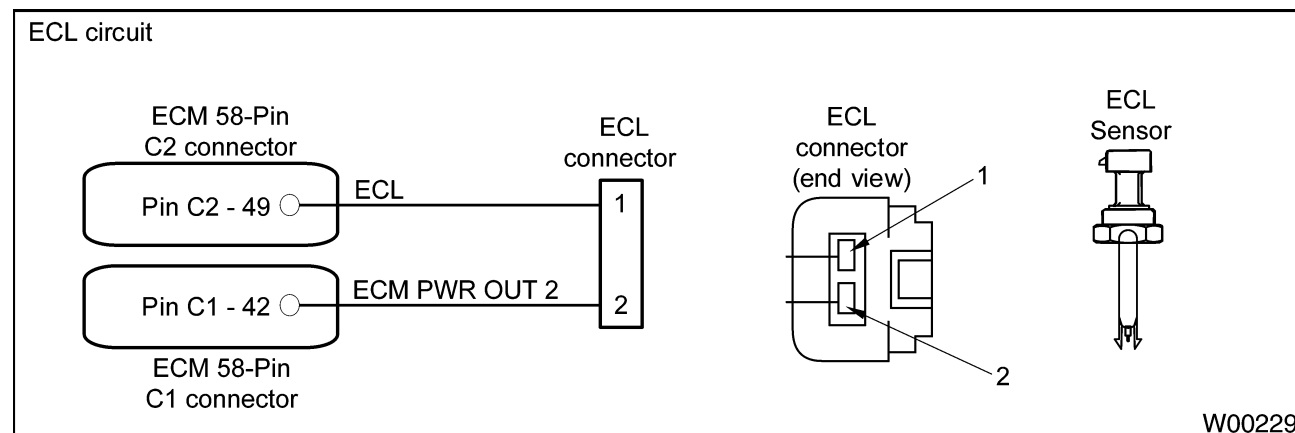
Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness 4484. Leave ECM and ECB3 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 E1-50	< 5 Ω	If > 5 Ω , check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω , check for short circuit.
2 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 ECB3.		

ECL Sensor (Engine Coolant Level)

SPN	FMI	Condition	Possible Causes
111	1	Low Engine Coolant level	- Low coolant level - Engine coolant system mechanical failure – check for leaks or boiling out

**Figure 151 ECL sensor circuit diagram****Tools**

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4484 (ECL)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

! WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

Pinpoint Diagnostics With ServiceMaxx™ Software

- 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. Turn ignition switch to 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 $\pm$ 2.0 V	If < 10.0 V, check for OPEN circuit.

Harness Resistance Check

Turn ignition switch to OFF. Leave 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 C1-49	< 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

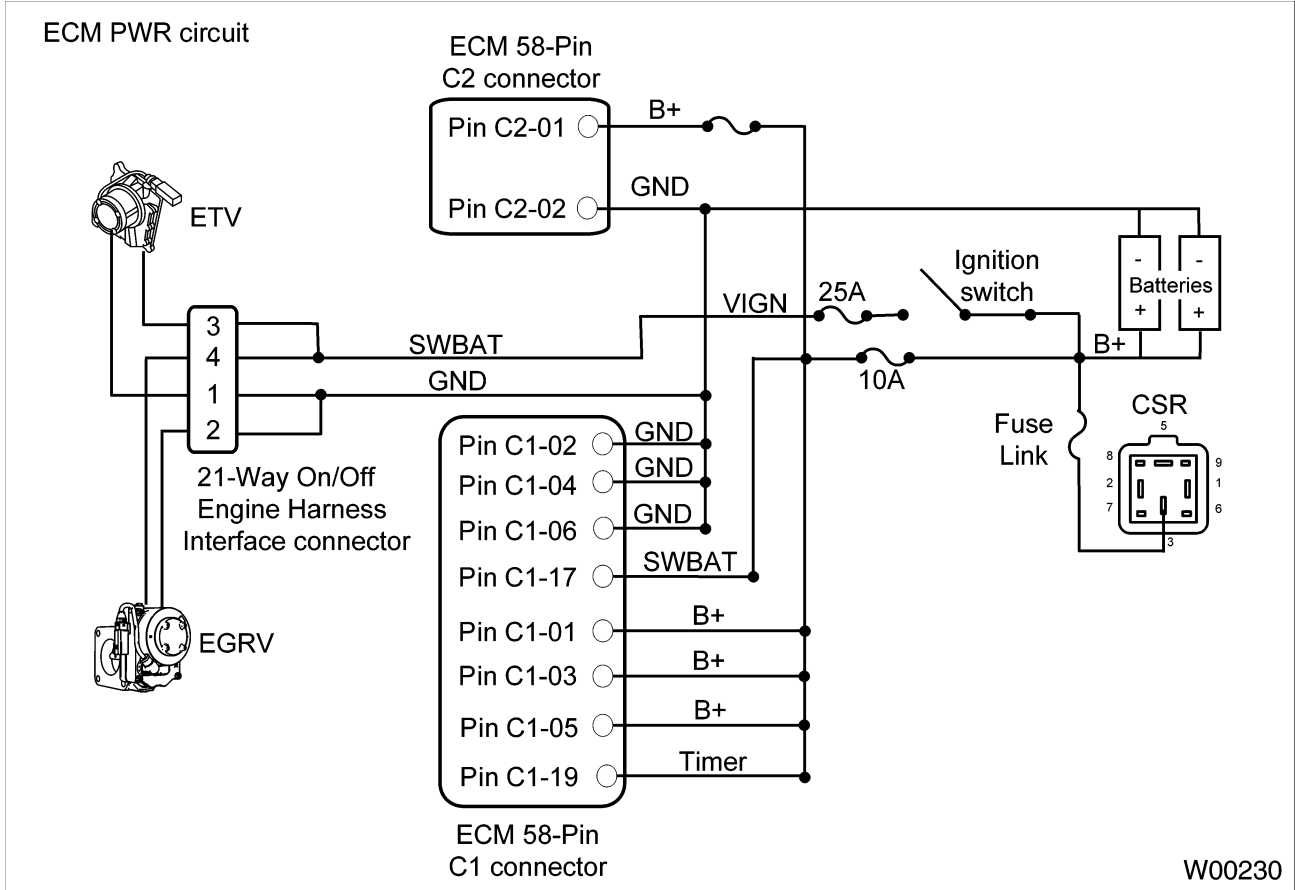


Figure 152 ECM PWR (Input Power) circuit diagram

SPN 158 FMI 15- ECM Switched voltage too HIGH

Pinpoint 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**Pinpoint 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.

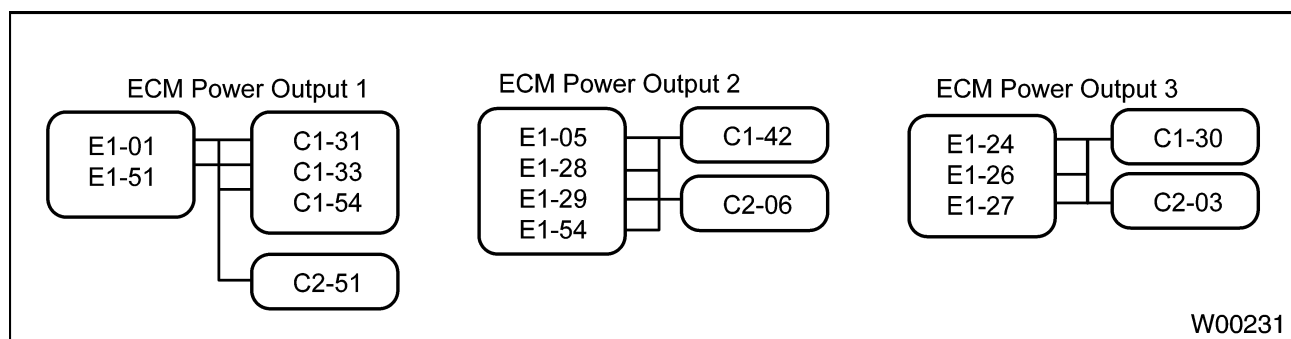
Voltage Checks at ECM

Connect breakout 180-pin box between ECM and vehicle harness. Turn the ignition switch to 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 153 ECM PWR (Output Power) circuit diagram****Voltage Checks for SPN 3597 FMI 4 – ECM Power Output 1**

Connect 180-Pin Breakout Box between ECM and engine harness. 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 (page 286).
C1-33 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check (page 286).
C1-54 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check (page 286).
C2-51 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check (page 286).
E1-01 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check (page 286).
E1-51 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check (page 286).

Voltage Checks for SPN 3598 FMI 4 – ECM Power Output 2

Connect 180-Pin Breakout Box between ECM and engine harness. 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 (page 286).
C2-06 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check (page 286).
E1-05 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check (page 286).
E1-28 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check (page 286).
E1-29 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check (page 286).
E1-54 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check (page 286).

Voltage Checks for SPN 3599 FMI 4 – ECM Power Output 3

Connect 180-Pin Breakout Box between ECM and engine harness. 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 (page 286).
C2-03 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check (page 286).
E1-24 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check (page 286).
E1-26 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check (page 286).
E1-27 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check (page 286).

Harness Resistance Check for SPN 3597 FMI 4 – ECM Power Output 1

NOTE: If circuit fault is intermittent, wiggle harness while measuring resistance.

Connect 180-Pin Breakout Box between ECM and engine harness. 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.
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.

Harness Resistance Check for SPN 3598 FMI 4 – ECM Power Output 2

NOTE: If circuit fault is intermittent, wiggle harness while measuring resistance.

Connect 180-Pin Breakout Box between ECM and engine harness. 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.

Harness Resistance Check for SPN 3599 FMI 4 – ECM Power Output 3

NOTE: If circuit fault is intermittent, wiggle harness while measuring resistance.

Connect 180-Pin Breakout Box between ECM and engine harness. 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.
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 Self-Diagnostics (Engine Control Module)

SPN	FMI	Condition	Possible Causes
108	3	BARO signal Out of Range HIGH	Internal ECM failure, replace ECM
108	4	BARO signal Out of Range LOW	Internal ECM failure, replace ECM
628	12	ECM Memory Error	Internal ECM failure, replace ECM
629	8	Engine Off timer fault	Internal ECM failure, replace ECM
629	12	ECM Internal chip Error	Internal ECM failure, replace ECM
629	14	ECM Internal component overtemperature	Internal ECM failure, replace ECM

SPN 108 FMI 3- BARO signal Out of Range HIGH

Checks whether the signal from the BARO sensor is above the maximum threshold.

Pinpoint ECM Self-Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

SPN 108 FMI 4 - BARO signal Out of Range LOW

Checks whether the signal from the BARO sensor is below the minimum threshold.

Pinpoint ECM Self-Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

SPN 628 FMI 12 - ECM Memory Error**Pinpoint ECM Self-Diagnostic Fault**

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

SPN 629 FMI 8 - Engine Off timer fault**Pinpoint ECM Self-Diagnostic Fault**

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

SPN 629 FMI 12 - ECM Internal chip Error**Pinpoint ECM Self-Diagnostic Fault**

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

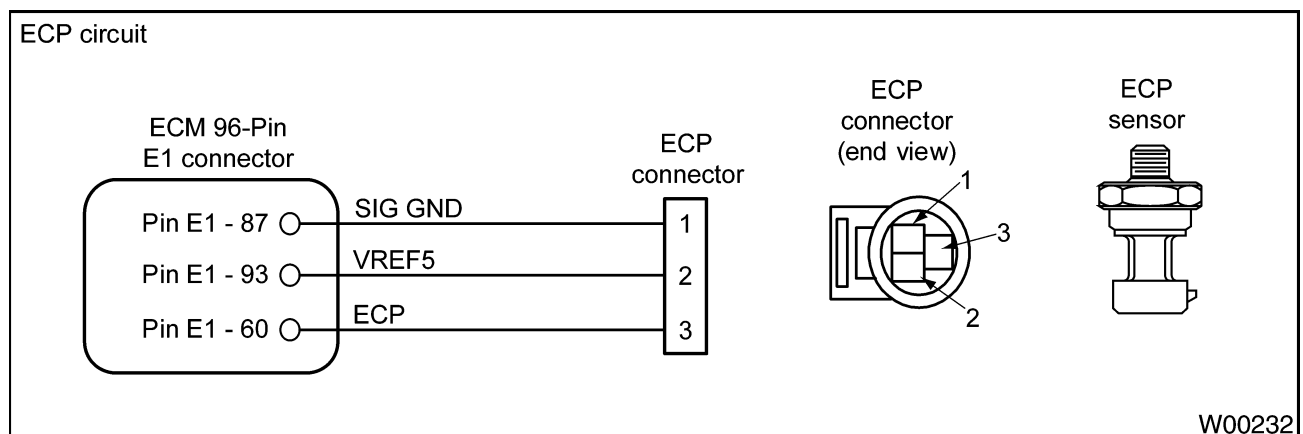
SPN 629 FMI 14 - ECM Internal component

Pinpoint ECM Self-Diagnostic Fault

1. Clear DTC, cycle ignition switch.
 2. If DTC is still active, replace ECM.
-

ECP Sensor (Engine Coolant Pressure)

SPN	FMI	Condition	Possible Causes
109	3	ECP signal Out of Range HIGH	- ECP signal circuit OPEN or short to PWR - SIG GND circuit OPEN - Failed ECP sensor - Missing or failed overflow cap
109	4	ECP signal Out of Range LOW	- ECP signal circuit short to GND - VREF circuit OPEN - Failed ECP sensor
109	18	Engine coolant pressure too low	- Radiator pressure cap missing or damaged - Coolant hose broken or leaking - Leaking Coolant System

**Figure 154 ECP sensor circuit diagram****Tools**

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4850 (ECP)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

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.
 - 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 4850 and leave sensor disconnected. Turn ignition switch to ON.

Test Point	Specification	Comment – < Less than, > Greater than
EST – Monitor ECPv	5.0 V $\pm$ 0.5 V	If < 4.5 V, check ECP signal circuit for short to GND
DMM – Measure volts 2 to GND	5.0 V $\pm$ 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 291).
DMM – Measure voltage 2 to 1	5 V $\pm$ 0.5 V	If < 4.5 V, check SIG GND circuit for OPEN. Do Harness Resistance Check (page 291).
EST – Monitor ECPv Short across Breakout Harness pins 1 and 3	0 V	If > 0.5 V, check ECP signal circuit for OPEN. Do Harness Resistance Check (page 291).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace ECP sensor.		

Connector Voltage Check

Connect Breakout Harness 4850. Leave ECP sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	0 V	If > 0.25 V, check SIG GND circuit for short to PWR.
2 to GND	5 V $\pm$ 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 291).
3 to GND	5 V $\pm$ 0.5 V	If < 4.5 V, check ECP signal circuit for short to GND.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness 4850. 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 to GND.
1 to E1-87	< 5 Ω	If > 5 Ω , check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω , check for short to GND.
2 to E1-93	< 5 Ω	If > 5 Ω , check for OPEN circuit.
3 to GND	> 1k Ω	If < 1k Ω , check for short to GND.
3 to E1-60	< 5 Ω	If > 5 Ω , check for OPEN circuit.

ECT1 Sensor (Engine Coolant Temperature 1)

SPN	FMI	Condition	Possible Causes
110	3	ECT1 signal Out of Range HIGH	- ECT1 signal circuit 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
110	11	Event Logger-Coolant Temperature hot, extreme	- Coolant temperature hot, exceeded dealer programmed warning/critical temperature - Biased ECT1 sensor or circuit - Engine coolant system failure, see Coolant System (page 69).

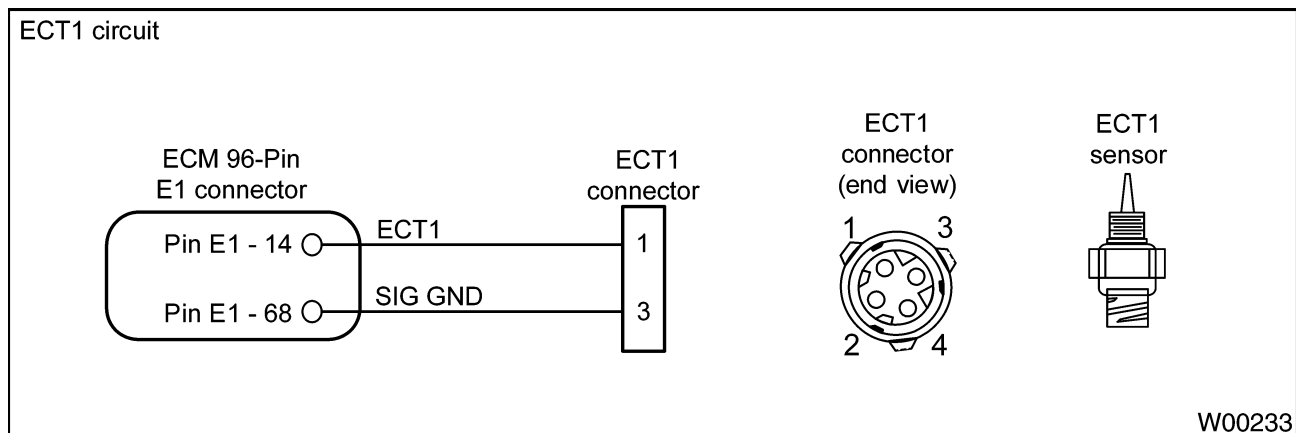


Figure 155 ECT1 sensor circuit diagram

Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4827 (ECT)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software

- NAVCoM or NAVLink Interface Kit

Pinpoint Diagnostics With ServiceMaxx™ Software

! WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

- 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.
 - 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 4827. Leave sensor disconnected. Turn ignition switch to ON.

Test Point	Specification	Comment– < Less than, > Greater than
EST – Monitor ECT1v	4.5 V to 5 V	If < 4.5 V, check ECT1 signal circuit for short to GND.
EST – Monitor ECT1v Short pin 1 to GND	0 V	If > 0.25 V, check ECT1 signal circuit for OPEN. Do Harness Resistance Check (page 293).
EST – Monitor ECT1v Short pin 1 to 3	0 V	If > 0.25 V, check SIG GND circuit for OPEN. Do Harness Resistance Check (page 293).
EST – Monitor ECT1v Short 500 Ω resistor across pins 1 and 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 4827. Leave sensor disconnected. Turn ignition switch to 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 Breakout Harness 4827. 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 E1-14	< 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
4076	3	ECT2 signal Out of Range HIGH	- ECT2 signal circuit OPEN or short to PWR - Failed ECT2 sensor
4076	4	ECT2 signal Out of Range LOW	- ECT2 signal circuit short to GND - Failed ECT2 sensor

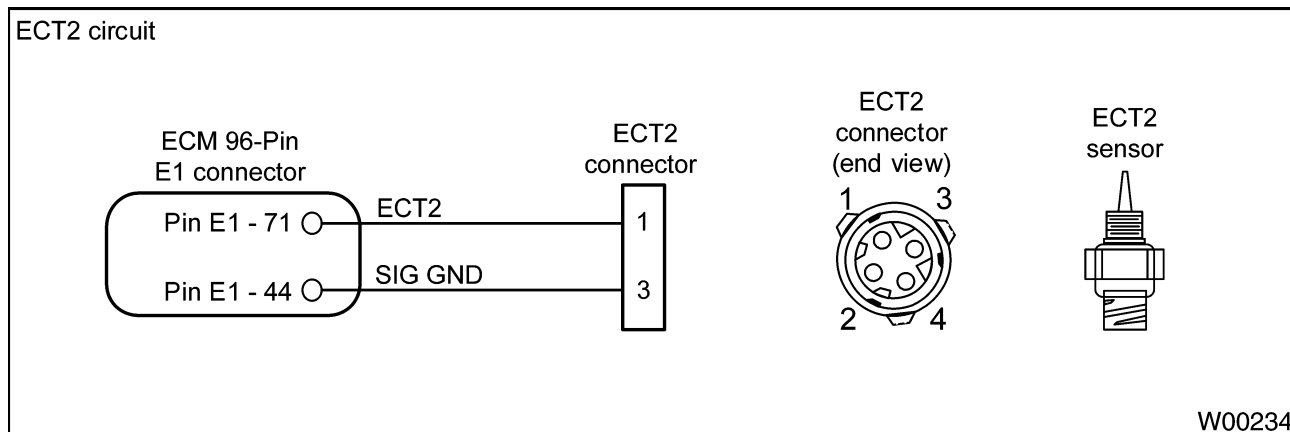


Figure 156 ECT2 sensor circuit diagram

Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4827 (ECT)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

Pinpoint Diagnostics With ServiceMaxx™ Software

! WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

- Using Electronic Service Tool (EST) with ServiceMaxx™ software, run the Continuous Monitor Test.
- 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.
 - 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 With ServiceMaxx™ Software

Connect Breakout Harness 4827. Leave sensor disconnected. Turn ignition switch to ON.

Test Point	Specification	Comment– < Less than, > Greater than
EST – Monitor ECT2v	4.5 V to 5 V	If <4.5 V, check ECT2 signal circuit for short to GND.
EST – Monitor ECT2v Short pin 1 to GND	0 V	If > 0.25 V, check ECT2 signal circuit for OPEN. Do Harness Resistance Check (page 295).
EST – Monitor ECT2v Short pin 1 to 3	0 V	If > 0.25 V, check SIG GND circuit for OPEN. Do Harness Resistance Check (page 295).
EST – Monitor ECT2v Short 500 Ω resistor across pins 1 and 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 4827. Leave sensor disconnected. Turn ignition switch to 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.

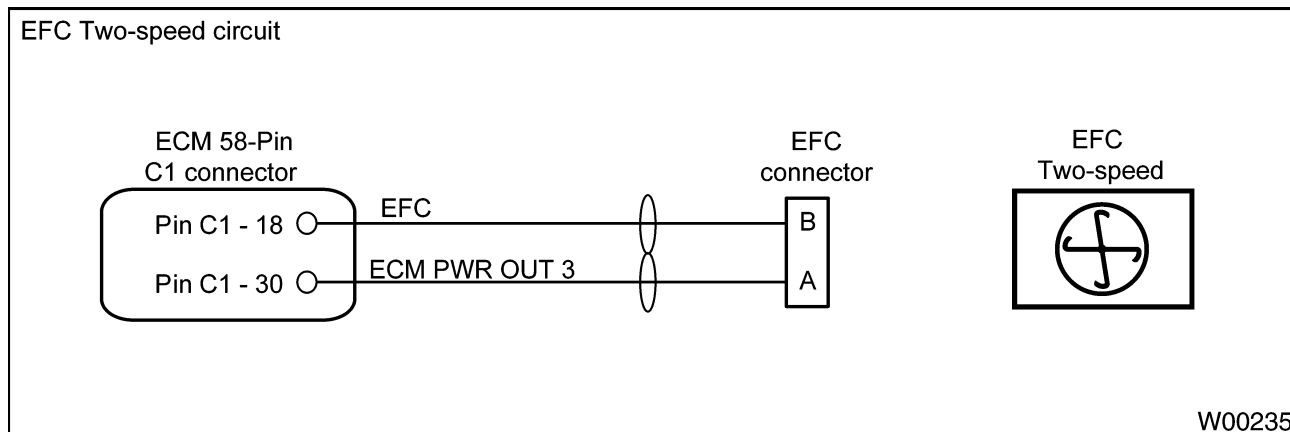
Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness 4827. 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 E1-71	< 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)

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 - Failed engine fan

**Figure 157 Two-Speed EFC circuit diagram****Tools**

- 1180-N4-0X0 – 180-Pin Breakout Box
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

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.

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.

Voltage Check at Single or Two-Speed EFC Connector - Actuator Test

Disconnect single or two-speed EFC 2-pin connector. Turn the ignition switch to ON. Run Actuator Test. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
A to GND	0 V to 0.25 V	If > 0.25V, check for short to PWR.
B to GND	0 V to 0.25 V	If > 0.25V, check for short to PWR.
Actuator Test - at HIGH state		
A to GND	0 V to 0.25 V	If > 0.25V, check for short to PWR.
Actuator Test - at LOW state		
A 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. Leave ECM disconnected.

Test Point	Specification	Comment – < Less than, > Greater than
A to GND	< 5 Ω	If > 5 Ω , check for OPEN circuit between EFC and GND.
C1-18 to B	< 5 Ω	If > 5 Ω , check for OPEN circuit between ECM and EFC.
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
412	1	EGRT signal stuck low, not warming up	Biased EGRT sensor or circuit
412	3	EGRT signal Out of Range HIGH	- EGRT signal circuit OPEN or shorted to PWR - SIG GND circuit OPEN - Failed EGRT sensor
412	4	EGRT signal Out of Range LOW	- EGRT signal circuit short to GND - Failed EGRT sensor or circuit

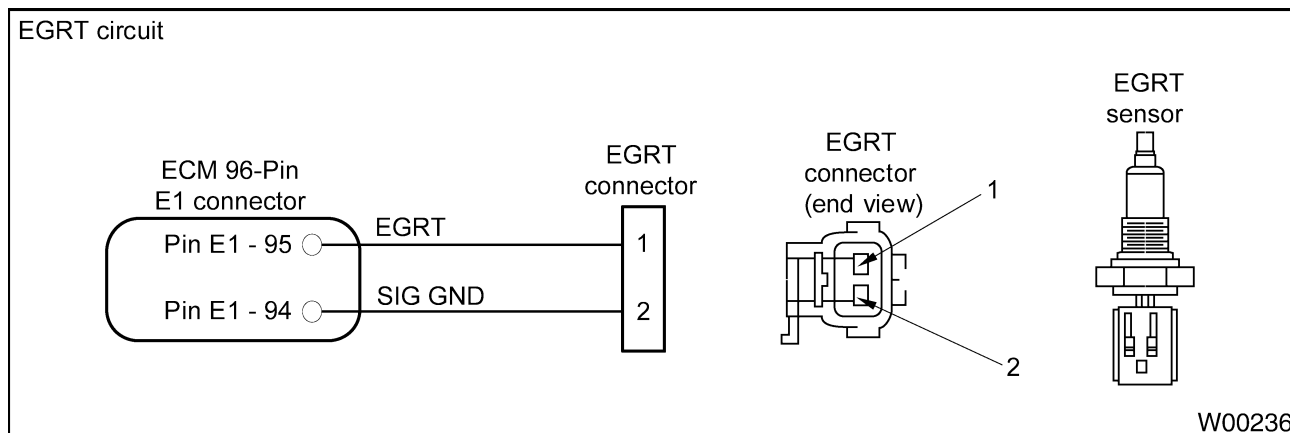


Figure 158 EGRT sensor circuit diagram

Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4760A (EGRT)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

Pinpoint Diagnostics With ServiceMaxx™ Software

! WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

- Using Electronic Service Tool (EST) with ServiceMaxx™ software, run the Continuous Monitor Test.
- 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.
 - 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 4760A and leave sensor disconnected. Turn ignition switch to 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 4760A to engine harness and leave EGRT 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 < 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 and Breakout Harness 4760A. 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 E1-94	< 5 Ω	If > 5 Ω , check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω , check for short circuit.
2 to E1- 95	< 5 Ω	If > 5 Ω , check for OPEN circuit.

EGR Valve (Exhaust Gas Recirculation)

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 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
2791	8	EGR valve not receiving ECM PWM signal	• Broken return spring in EGR valve

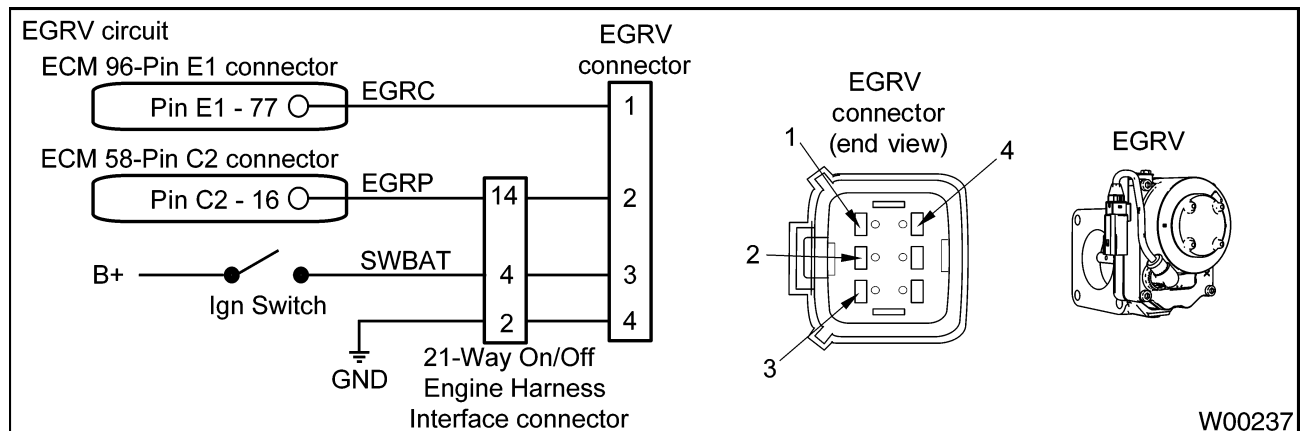


Figure 159 EGR Valve circuit diagram

Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 6016 (EGR)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

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 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 (page 302).

Connector Voltage Check — EGR Valve Disconnected

Connect Breakout Harness 6016 to engine harness. Leave EGR valve disconnected. 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 303).
3 to GND	B+	If < B+, check for OPEN in SWBAT circuit or blown fuse.
2 to GND	5.0 V $\pm$ 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 303).
1 to GND	0 V - 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 6016 between EGR valve and engine harness.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, load the Actuator session.
3. Command EGRP to 5%, and then 95%.
4. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
2 to GND	5% = 3.0 V $\pm$ 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 $\pm$ 0.5 V	If > 1.3 V, check for OPEN or short to PWR.
1 to GND	5% = 7.5 V $\pm$ 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 $\pm$ 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 and Breakout Harness 6016 to engine harness. Leave EGR valve and ECM 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.

EOL Sensor (Engine Oil Level)

NOTE: The EOL sensor may or may not be ECM controlled, depending on the engine build. If engine is not equipped with an EOL sensor and any of the below codes are active, disable programmable parameter 99841 (oil level sensor enable) and clear DTCs.

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	- EOT2 signal circuit short to GND - Failed EOL sensor

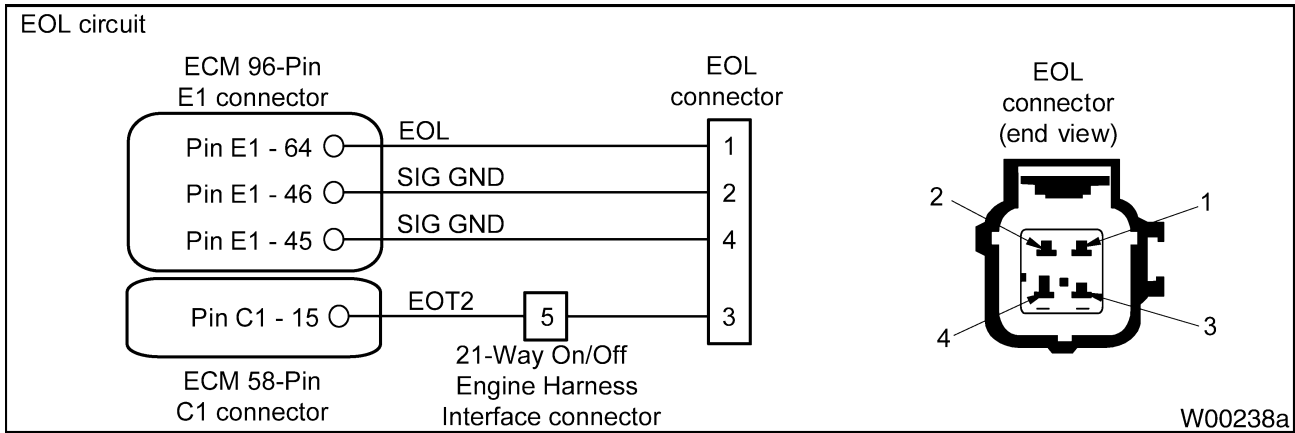


Figure 160 EOL sensor circuit diagram

Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 6004 (EOL)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

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

Disconnect engine harness from sensor.

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 (page 306).
EST – Monitor EOLv Short pin 1 to 4	0 V	If > 0.5 V, check SIG GND circuit for OPEN. Do Harness Resistance Check (page 306).
EST – Monitor EOT2v Short pin 3 to GND	0 V	If > 0.5 V, check EOT2 circuit for OPEN. Do Harness Resistance Check (page 306).
EST – Monitor EOT2v Short pin 2 to 3	0 V	If > 0.5 V, check SIG GND circuit for OPEN. Do Harness Resistance Check (page 306).

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 6004. Leave EOL 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 +/- 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 (page 306).
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 (page 306).
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 and breakout harness 6004. Leave EOL sensor and ECM 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 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
100	3	EOP signal Out of Range HIGH	- EOP signal circuit OPEN or short to PWR - SIG GND circuit OPEN - Failed EOP sensor
100	4	EOP signal Out of Range LOW	- EOP signal circuit short to GND - VREF5 circuit OPEN - Failed EOP sensor

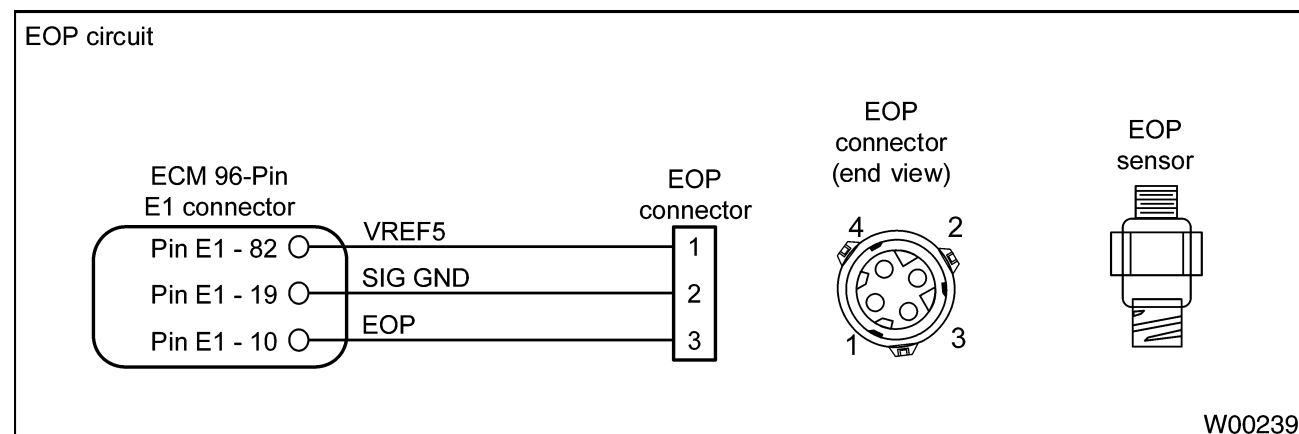


Figure 161 EOP sensor circuit diagram

Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4882 (EOP)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

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.
 - 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 4882 and leave sensor disconnected. Turn ignition switch to ON.

Test Point	Specification	Comment – < Less than, > Greater than
EST – Monitor EOPv	5.0 V $\pm$ 0.5 V	If < 4.5 V, check EOP signal circuit for short to GND.
DMM – Measure volts 1 to GND	5.0 V $\pm$ 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 308).
DMM – Measure voltage 1 to 2	5 V $\pm$ 0.5 V	If < 4.5 V, check SIG GND circuit for OPEN. Do Harness Resistance Check (page 308).
EST – Monitor EOPv Short across breakout harness pins 2 and 3	0 V	If > 0.5 V, check EOP signal circuit for OPEN. Do Harness Resistance Check (page 308).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace EOP sensor.		

Connector Voltage Check

Connect Breakout Harness 4882. Leave EOP 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 $\pm$ 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 308).
2 to GND	0 V	If > 0.25V, check SIG GND circuit for short to PWR.
3 to GND	5 V $\pm$ 0.5 V	If < 4.5 V, check EOP signal circuit for short to GND.

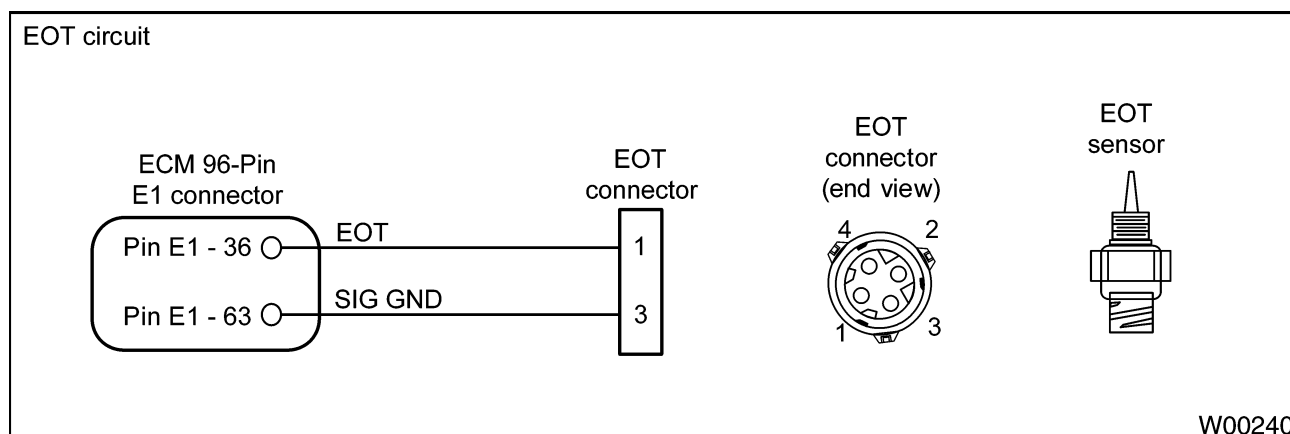
Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness 4882. 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 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
175	3	EOT signal Out of Range High	- EOT signal circuit OPEN or short to PWR - SIG GND circuit OPEN - Failed EOT sensor
175	4	EOT signal Out of Range LOW	- EOT signal circuit short to GND - Failed EOT sensor

**Figure 162 EOT sensor circuit diagram****Tools**

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4827 (EOT)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

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.
 - 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 4827. Leave sensor disconnected. Turn ignition switch to 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 310).
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 310).
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 4827. Leave sensor disconnected. Turn ignition switch to 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 Breakout Harness 4827. 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 E1-36	< 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
51	0	ETP fault: over temperature	ETV internal failure
51	3	ETP signal Out of Range HIGH	ETP circuit short to PWR
51	4	ETP signal Out of Range LOW	ETP circuit short to GND
51	7	ETP does not agree with commanded position	- Sticking or failed ETV - ETP circuit fault - ETC circuit fault
3464	3	ETC short to PWR	- ETC circuit short to PWR - Failed ETV
3464	5	ETC open load/circuit	- ETC circuit OPEN - Failed ETV
3464	8	ETC not receiving command from ECM	ETC circuit fault

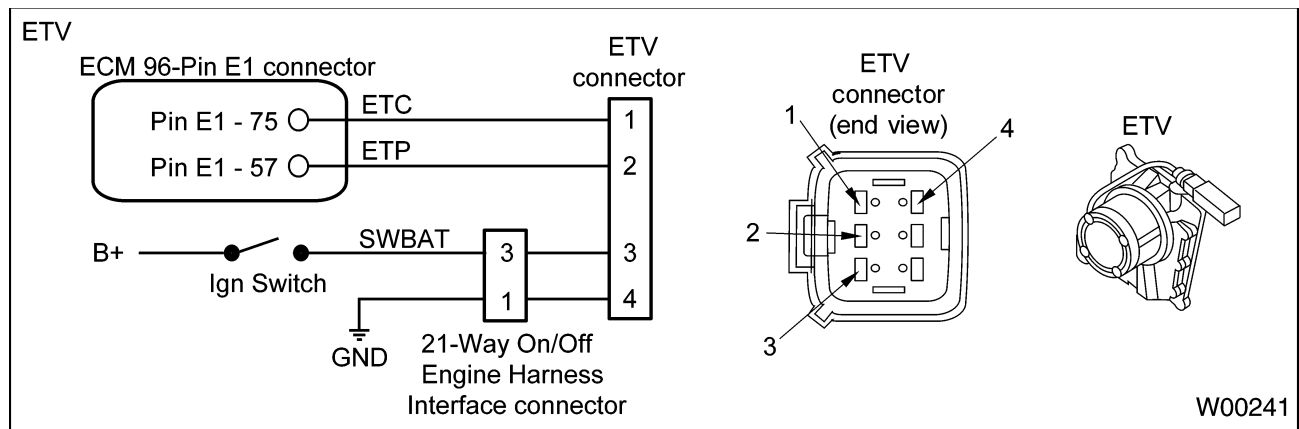


Figure 163 ETV valve circuit diagram

Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 6016 (ETV)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software

- NAVCoM or NAVLink Interface Kit

Pinpoint Diagnostics With ServiceMaxx™ Software

! WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

- Using Electronic Service Tool (EST) with ServiceMaxx™ software, load the Actuator session.
- 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 6016 to engine harness. Leave ETV disconnected. 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.
3 to GND	B+	If < B+, check for OPEN in SWBAT circuit or blown fuse.
2 to GND	12 V $\pm$ 2.0 V	If < 10 V, check for OPEN or short to GND. Do Harness Resistance Check (page 313).
1 to GND	0 V - 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 6016 between ETV and engine harness.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, load the Actuator session.
3. Command ETVP to 5%, and then 95%.
4. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
2 to GND	5% = 3.0 V $\pm$ 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 $\pm$ 0.5 V	If > 1.3 V, check for OPEN or short to PWR.
1 to GND	5% = 7.5 V $\pm$ 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 $\pm$ 0.5 V	If > 1.0 V, check for OPEN circuit or failed ETV.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness 6016 to engine harness. Leave ETV and ECM 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.

EWPS (Engine Warning Protection System)

SPN	FMI	Condition	Possible Causes
100	1	Engine Oil System below critical pressure	• Biased EOP sensor or circuit • Engine oil system mechanical failure
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
100	17	Low engine oil pressure, event log	• Oil pressure regulator stuck open • Biased EOP sensor or circuit • Engine oil system mechanical failure
100	18	Engine Oil System below Warning Pressure	• Biased EOP sensor or circuit • Engine oil system mechanical failure
110	0	Engine Coolant System above Critical Temperature	• Biased ECT1 sensor or circuit • Low coolant level • Engine coolant system mechanical failure
110	11	Event logger, coolant temperature hot, extreme	• Coolant temperature exceeded dealer programmed warning / critical limit • Biased ECT1 sensor or circuit • Engine coolant system mechanical failure
110	15	Engine Coolant System above Warning Temperature	• Biased ECT1 sensor or circuit • Low coolant level • Engine coolant system mechanical failure
111	1	Low Engine Coolant Level	• Low coolant level • Engine coolant system mechanical failure – check for leaks or boiling out
175	0	Engine Oil System above critical temperature	• Biased EOT sensor or circuit • Failed engine oil cooler
175	11	Oil Temperature exceeds limit by large amount	• Oil temperature exceeded dealer programmed limit • Plugged or failed engine oil cooler
175	15	Engine Oil System above warning temperature	• Biased EOT sensor or circuit

190	0	Engine Overspeed - Most Severe Level	• Transmission in too low of a gear at high vehicle speed • Shifting in too low of gear downhill • Injectors over-fueling
190	11	Engine Overspeed, event log	• Engine speed exceeded preset limits
190	15	Engine Overspeed detected	• Transmission in too low of a gear at high vehicle speed • Shifting in too low of gear downhill
1110	31	ECM detects fueling without driver demand	• Electrical failure
2588	0	Vehicle overspeed 1, event log, extreme	• Vehicle speed exceeded dealer programmed value overspeed level 1 and programmed extreme value
2588	15	Vehicle overspeed 1, event log, non-extreme	• Vehicle speed exceeded dealer programmed value overspeed level 1
2589	0	Vehicle overspeed 2, event log, extreme	• Vehicle speed exceeded dealer programmed value overspeed level 2 and programmed extreme value
2589	15	Vehicle overspeed 2, event log, non-extreme	• Vehicle speed exceeded dealer programmed value overspeed level 2
4076	0	ECT2 above Critical (EWPS programmable limit)	• Biased ECT2 sensor or circuit • Low coolant level • Engine coolant system mechanical failure
4076	15	ECT2 above Warning (EWPS programmable limit)	• Biased ECT2 sensor or circuit • Low coolant level • Engine coolant system mechanical failure

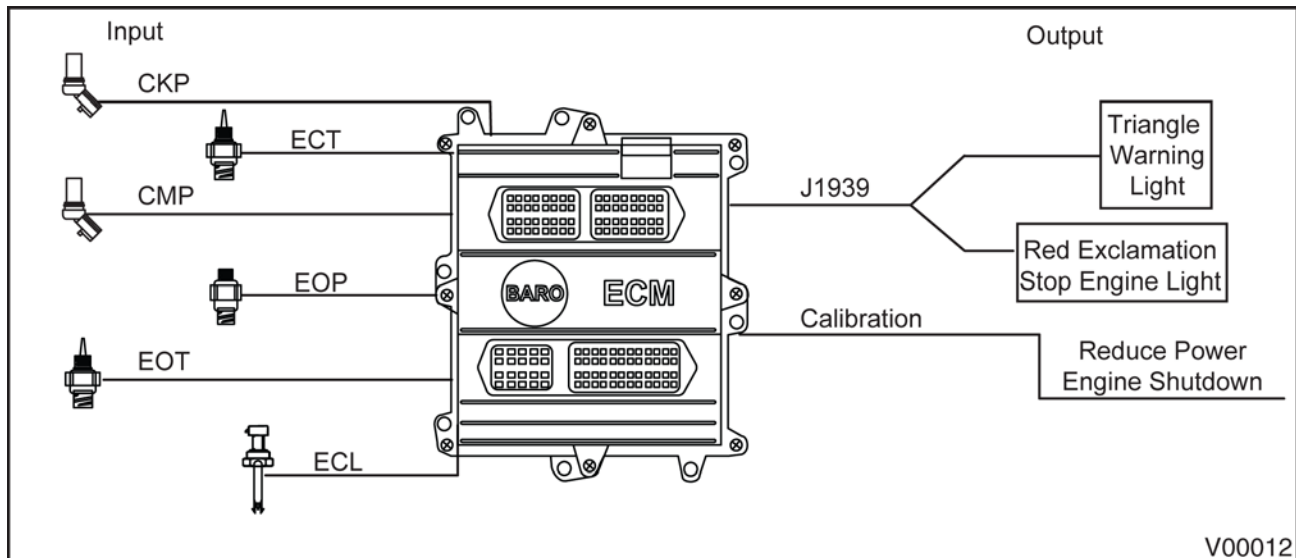


Figure 164 Functional diagram for the EWPS

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 – 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.

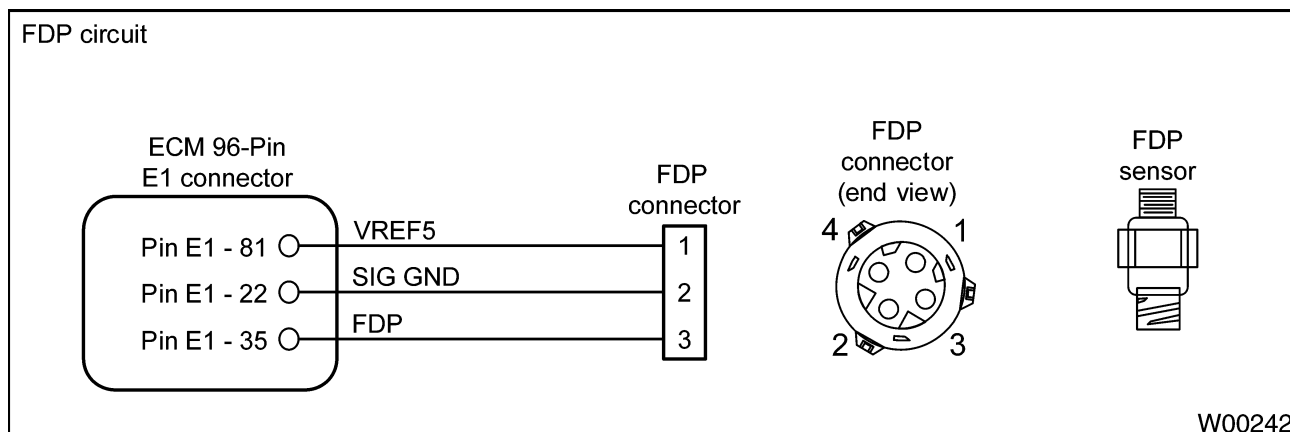
EOP Critical Pressure for Region 1 (7.5 psi/52 kPa) – Specifies the minimum oil pressure with engine speed greater than (EOP Engine Speed Region Boundary 1). Failure to meet set point commands an engine shut down.

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.

FDP Sensor (Fuel Delivery Pressure)

SPN	FMI	Condition	Possible Causes
94	0	Fuel Delivery Pressure above maximum	- Biased FDP sensor or circuit - Restricted fuel return line - Restricted fuel regulator valve
94	3	FDP signal Out of Range HIGH	- FDP signal circuit OPEN or short to PWR - SIG GND circuit OPEN - Failed FDP sensor
94	4	FDP signal Out of Range LOW	- FDP signal circuit short to GND - VREF5 circuit OPEN - Failed FDP sensor

**Figure 165 FDP sensor circuit diagram****Tools**

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4881 (FDP)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software

- NAVCoM or NAVLink Interface Kit

Pinpoint Diagnostics With ServiceMaxx™ Software

! WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

- 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.
 - 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 94 FMI 0 – Fuel pressure above maximum

Biased Sensor or Circuit Check

1. Turn ignition switch to ON, engine OFF
2. Using ServiceMaxx™ software, open the Continuous Monitor session.
3. Verify S_FDP volts are within specification. See “Appendix A: Performance Specifications.”
 - If voltage is not within specification, check circuitry for poor continuity. If circuits are within specification, replace FDP sensor.
4. Start engine and monitor FDP sensor.
 - If above performance specification, see Fuel System in “Performance Diagnostics.”

Sensor Circuit Check With ServiceMaxx™ Software

Connect Breakout Harness 4881 and leave sensor disconnected. Turn ignition switch to ON.

Test Point	Specification	Comment – < Less than, > Greater than
EST – Monitor FDPv	5.0 V $\pm$ 0.5 V	If > 4.5 V, check FDP signal circuit for short to GND
DMM — Measure voltage 1 to GND	5.0 V $\pm$ 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 320).
DMM — Measure voltage 1 and 2	5 V $\pm$ 0.5 V	If < 4.5 V, check SIG GND for OPEN. Do Harness Resistance Check (page 320).
EST – Monitor FDPv Short across breakout harness pins 2 to 3	5 V $\pm$ 0.5 V	If > 0.5 V, check FDP signal circuit for OPEN. Do Harness Resistance Check (page 320).
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 4881. 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 $\pm$ 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 320).
2 to GND	0 V	If > 0.25 V, check SIG GND circuit for short to PWR.
3 to GND	5.0 V	If <, 4.5 V, check FDP signal circuit for short to GND.

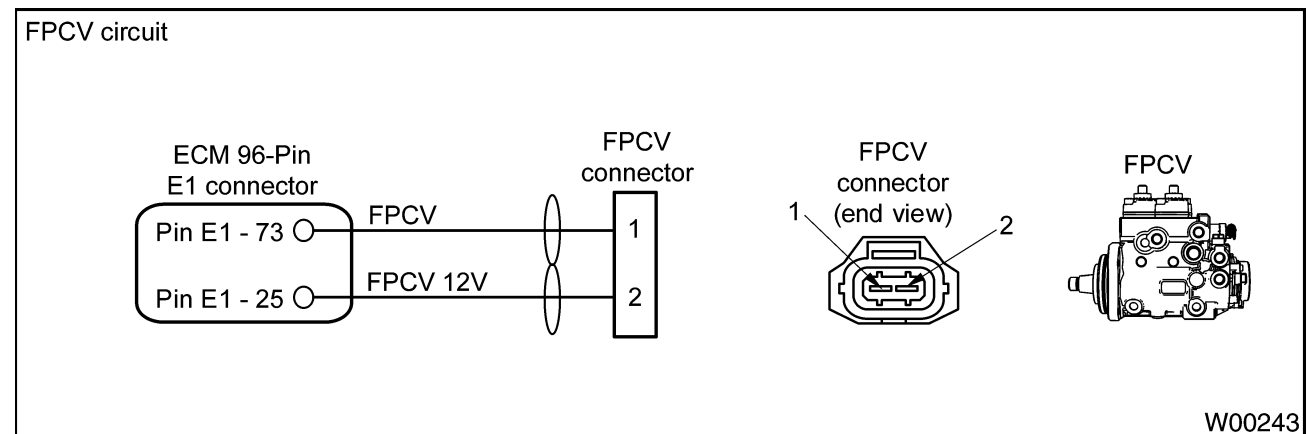
Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness 4881. 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 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
633	3	FPCV short to PWR	- FPCV circuit short to PWR - Failed FPCV
633	4	FPCV short to GND	- FPCV circuit short to GND - Failed FPCV
633	5	FPCV open load/circuit	- FPCV circuit OPEN - Failed FPCV

**Figure 166 FPCV circuit diagram****Tools**

- 1180-N4-0X0 – 180-Pin Breakout Box
- Breakout Harness 6021 (FPCV)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

- Select FPCV Position from the Actuator drop-down menu on the right side.
- Command actuator movement by clicking on the Start Test button. Monitor FPCV Position.
 - If FPCV does not closely match FPCV, check FPCV valve for mechanical problem.
 - If FPCV valve does not move, continue with pinpoint diagnostics.

Pinpoint Diagnostics With ServiceMaxx™ Software

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

- Using Electronic Service Tool (EST) with ServiceMaxx™ software, load the Actuator session.

Connector Voltage Check – FPCV Disconnected

Connect Breakout Harness 6021 to engine harness. Leave FPCV disconnected. 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 6021 between FPCV and engine harness.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, load the Actuator session.
3. Command FPCV to 5%, and then 95%.
4. 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 and Breakout Harness 6021 to engine harness. Leave FPCV and ECM 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 125) in "Hard Start and No Start Diagnostics."

FRP Sensor (Fuel Rail Pressure)

SPN	FMI	Condition	Possible Causes
157	3	FRP signal Out of Range HIGH	- FRP signal circuit OPEN or short to PWR - SIG GND circuit open - Failed FRP sensor
157	4	FRP signal Out of Range LOW	- FRP signal circuit short to GND - VREF6 circuit OPEN - Failed FRP sensor

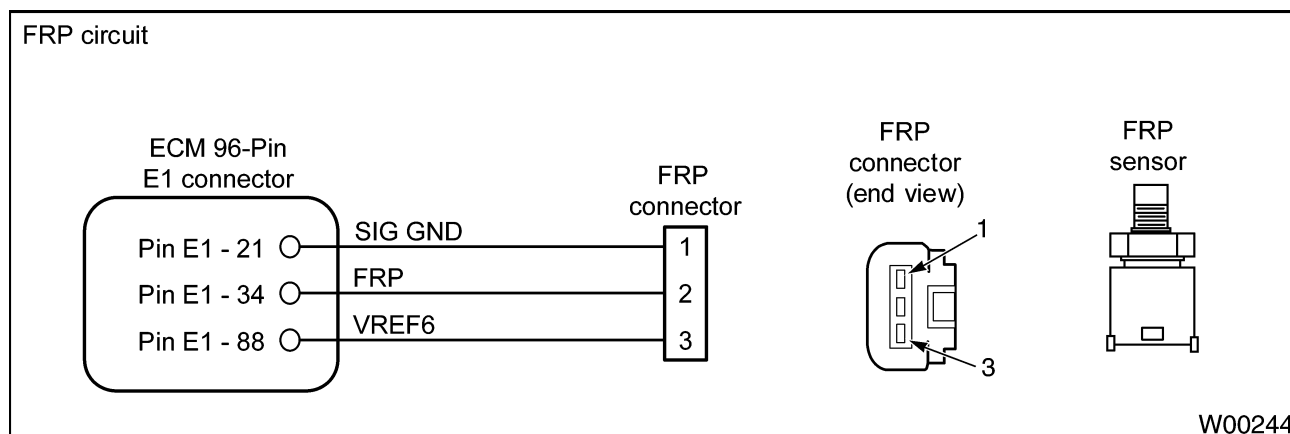


Figure 167 FRP sensor circuit diagram

Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4829 (FRP)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

Pinpoint Diagnostics With ServiceMaxx™ Software

! WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

- Using Electronic Service Tool (EST) with ServiceMaxx™ software, run the Continuous Monitor Test.
- 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.
 - 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 4829 and leave sensor disconnected. Turn ignition switch to ON.

Test Point	Specification	Comment – < Less than, > Greater than
EST – Monitor FDPv	5.0 V $\pm$ 0.5 V	If > 4.5 V, check FDP signal circuit for short to GND.
DMM — Measure volts 1 to GND	5.0 V $\pm$ 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 324).
DMM — Measure voltage 1 to 3	5 V $\pm$ 0.5 V	If < 4.5 V, check SIG GND for OPEN. Do Harness Resistance Check (page 324).
EST – Monitor FDPv Short across breakout harness pins 1 to 3	0 V	If > 0.5 V, check FDP signal circuit for OPEN. Do Harness Resistance Check (page 324).
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 4829. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
3 to GND	5.0 V $\pm$ 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 324).
1 to GND	0 V	If > 0.25 V, check SIG GND circuit for short to PWR.
2 to GND	5.0 V $\pm$ 0.5 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 and Breakout Harness 4829. 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 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.

FRP System (Fuel Rail Pressure)

SPN	FMI	Condition	Possible Causes
157	0	FRP relief valve opening fault	• Restricted fuel return line • Low fuel level • Fuel aeration • Low-pressure fuel system above maximum pressure • FPCV circuit fault
157	14	FRP Relief Valve failure - Replace valve & re-set Counter	• Replace FRP relief valve and reset PP counter
3055	0	FRP exceeded maximum	• Restricted fuel return line • Low fuel level • Fuel aeration • Low-pressure fuel system above maximum pressure • FPCV circuit fault
3055	15	FRP below minimum with maximum command	• Low Fuel Delivery Pressure (FDP) • Aerated fuel delivery • Restricted fuel supply line • Internal leak in high-pressure fuel system • Leaking FRP relief valve • Stuck or sticking FPCV • High-pressure fuel pump fault
3055	16	FRP not as expected - Run High-pressure Pump Test	• Low FDP • Aerated fuel delivery • Restricted fuel supply line • Internal leak in high-pressure fuel system • Leaking FRP relief valve
3055	17	FRP above maximum with minimum command	• FPCV stuck open • Biased high FRP sensor or circuit

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

At KOEO, verify FRP sensor is within specification. See "Appendix A: Performance Specifications."

Pinpoint FRP System Fault

1. Check for other active or previously active DTCs. Repair any electrical fault before continuing with this procedure.
 2. Verify fuel system is operating within specifications. See "Performance Diagnostics."
-

SPN 157 FMI 14 - FRP Relief Valve failure, Replace Valve and Re-set counter

Pinpoint FRP System Fault

1. Replace the fuel rail pressure relief valve and reset programmer parameters.
-

SPN 3055 FMI 0 - FRP exceeded maximum

Pinpoint FRP System Fault

1. Check for other active or inactive DTCs. Repair any electrical fault before continuing with this procedure.
 2. Verify fuel system is operating within specifications. See "Performance Diagnostics."
-

SPN 3055 FMI 15 - FRP below minimum with maximum command

Pinpoint FRP System Fault

1. Check for other active or inactive DTCs. Repair any electrical fault before continuing with this procedure.
 2. Verify fuel system and aeration is operating within specifications. See "Performance Diagnostics."
If low-pressure fuel system is acceptable, continue to step 3.
 3. Run High-pressure Fuel Pump Test
If Test fails, replace High-pressure Pump.
-

SPN 3055 FMI 16 - FRP not as expected – Run High-pressure Pump Test**Pinpoint FRP System Fault**

1. Check for other active or inactive DTCs. Repair any electrical fault before continuing with this procedure.
 2. Verify fuel system and aeration is operating within specifications. See "Performance Diagnostics."
If Low-pressure fuel system is acceptable, continue to step 3.
 3. Using ServiceMaxx™ software Run High-pressure Pump Test.
If Test fails, replace High-pressure Pump.
-

SPN 3055 FMI 17 - FRP above maximum with minimum command**Pinpoint FRP System Fault**

1. Check for other Active or Previous Active DTCs. Repair any electrical fault before continuing with this procedure.
 2. Check for Biased High FRP sensor at Key ON, Engine OFF (KOEO). See "Appendix A: Performance Specifications."
-

IMP Sensor (Intake Manifold Pressure)

SPN	FMI	Condition	Possible Causes
102	2	IMP signal does not agree with BARO	Biased IMP sensor or circuit
102	3	IMP signal Out of Range HIGH	- IMP signal circuit OPEN or short to PWR - SIG GND circuit OPEN - Failed IMP sensor
102	4	IMP signal Out of Range LOW	- IMP signal circuit short to GND - VREF2 circuit OPEN - Failed IMP sensor

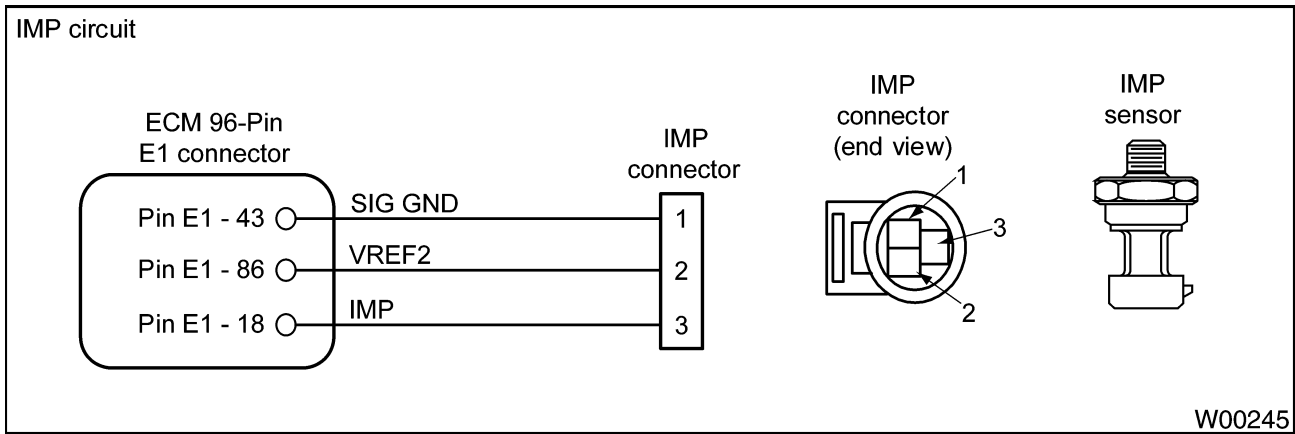


Figure 168 IMP sensor circuit diagram

Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4850 (IMP)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

Pinpoint Diagnostics With ServiceMaxx™ Software

- Using Electronic Service Tool (EST) with ServiceMaxx™ software, run the Continuous Monitor Test.
- 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.
 - 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 102 FMI 2 – IMP signal does not agree with BARO**Biased Sensor or Circuit Check**

1. Turn ignition key 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, check circuitry for poor continuity. If circuits are within specification, replace IMP sensor.

Sensor Circuit Check With ServiceMaxx™ Software

Connect Breakout Harness 4850 and leave sensor disconnected. Turn ignition switch to ON.

Test Point	Specification	Comment – < Less than, > Greater than
EST – Monitor IMPv	5.0 V $\pm$ 0.5 V	If < 4.5 V, check IMP signal circuit for short to GND. Do Harness Resistance Check (page 330).
DMM – Measure volts 2 to GND	5.0 V $\pm$ 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 330).
DMM – Measure voltage 1 to 2	5.0 V $\pm$ 0.5 V	If < 4.5 V, check SIG GND for OPEN. Do Harness Resistance Check (page 330).
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 330).
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 4850. Leave sensor disconnected. Turn ignition switch to 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 $\pm$ 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 330).
3 to GND	5.0 V $\pm$ 0.5 V	If < 4.5 V, check IMP signal circuit for short to GND. Do Harness Resistance Check (page 330).

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness 4850. 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 E1-43	< 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.

IMT Sensor (Intake Manifold Temperature)

SPN	FMI	Condition	Possible Causes
105	3	IMT signal Out of Range HIGH	- IMT signal circuit OPEN or short to PWR - SIG GND circuit OPEN - Failed IMT sensor
105	4	IMT signal Out of Range LOW	- IMT signal circuit short to GND - Failed IMT sensor

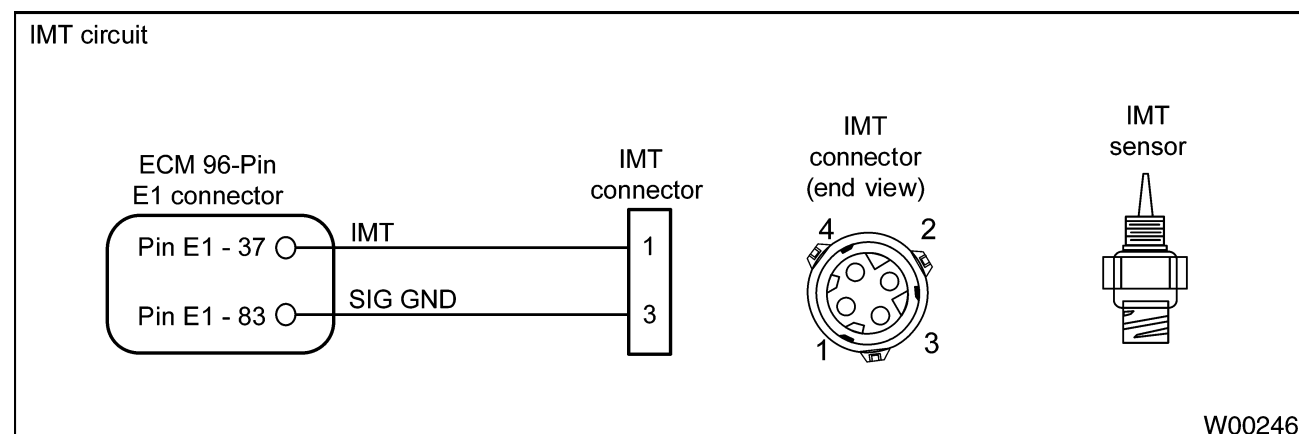


Figure 169 IMT sensor circuit diagram

Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4883 (IMT)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

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.
 - 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 With ServiceMaxx™ Software

Connect Breakout Harness 4883 and leave sensor disconnected. Turn ignition switch to ON.

Test Point	Specification	Comment– < Less than, > Greater than
EST – Monitor IMTv	5.0 V $\pm$ 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 4883. Leave sensor disconnected. Turn ignition switch to 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 Breakout Harness 4883. 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 Circuits (Injector)

SPN	FMI	Condition	Possible Causes
651 – 656	3	Injector # short to PWR	• Injector circuit short to PWR
651 – 656	4	Injector # short circuit	• Injector circuit short to GND
651 – 656	5	Injector # open circuit	• Injector circuit OPEN
651 – 656	13	Injector # programmable parameter error	• This code is set when the incorrect number was programmed into the ECM after an injector replacement. See Injector Replacement – New Injector Calibration (page 170) in “Performance Diagnostics.”
2797	11	Injector Control Group 1 short circuit (INJ 1, 3, 5)	• Short circuit on injectors 1, 3 or 5
2798	11	Injector Control Group 2 short circuit (INJ 2, 4, 6)	• Short circuit on injectors 2, 4 or 6

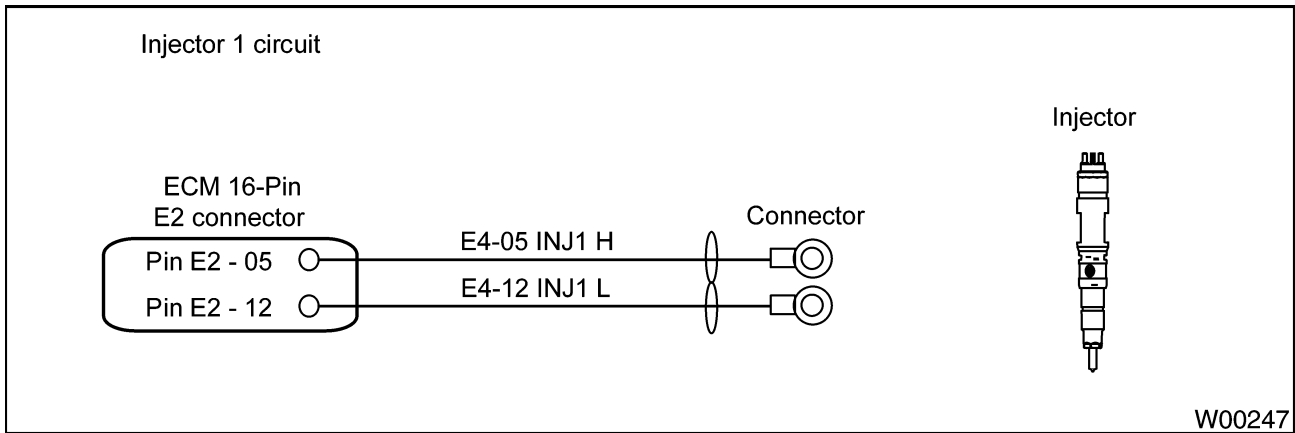


Figure 170 Injector 1 circuit diagram

Injector 1 – Resistance Checks Through Harness and 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 the ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch to OFF. Connect 180-Pin Breakout Box to the ECM harness connector. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
E2-05 to GND	> 1k Ω	If < 1k Ω , check circuit for short to GND or injector coil for internal short.
E2-12 to GND	> 1k Ω	
E2-05 to E2-12	0.4 Ω to 0.6 Ω	If > 0.6 Ω , check for OPEN circuit or OPEN injector coil. If < 0.4 Ω , check for cross-shortened circuits or injector coil for internal short.

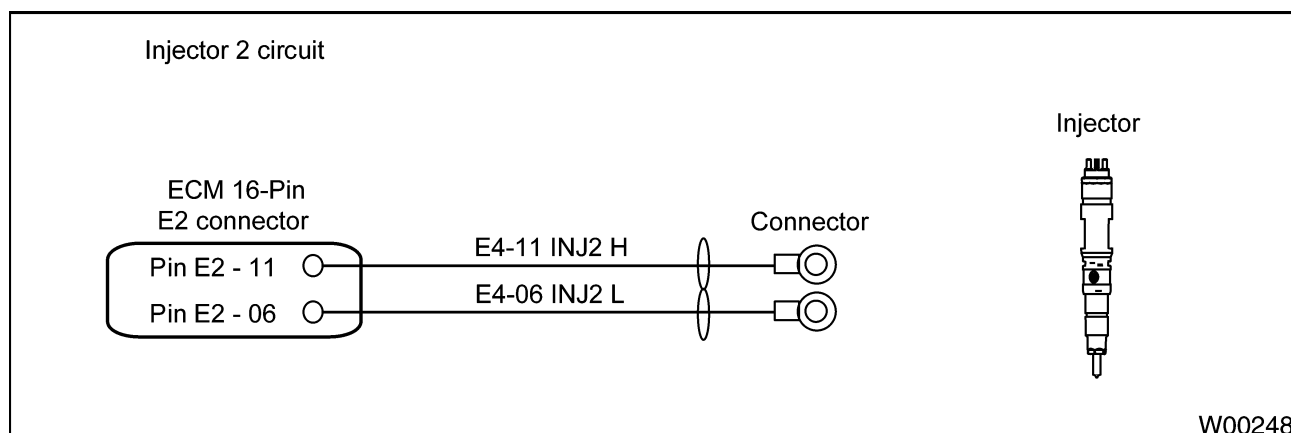


Figure 171 Injector 2 circuit diagram

Injector 2 – Resistance Checks Through Harness and 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 the ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch to OFF. Connect 180-Pin Breakout Box to the ECM harness connector. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
E2-11 to GND	> 1k Ω	If < 1k Ω , check circuit for short to GND or injector coil for internal short.
E2-06 to GND	> 1k Ω	
E2-11 to E2-06	0.4 Ω to 0.6 Ω	If > 0.6 Ω , check for OPEN circuit or OPEN injector coil. If < 0.4 Ω , check for cross-shortened circuits or injector coil for internal short.

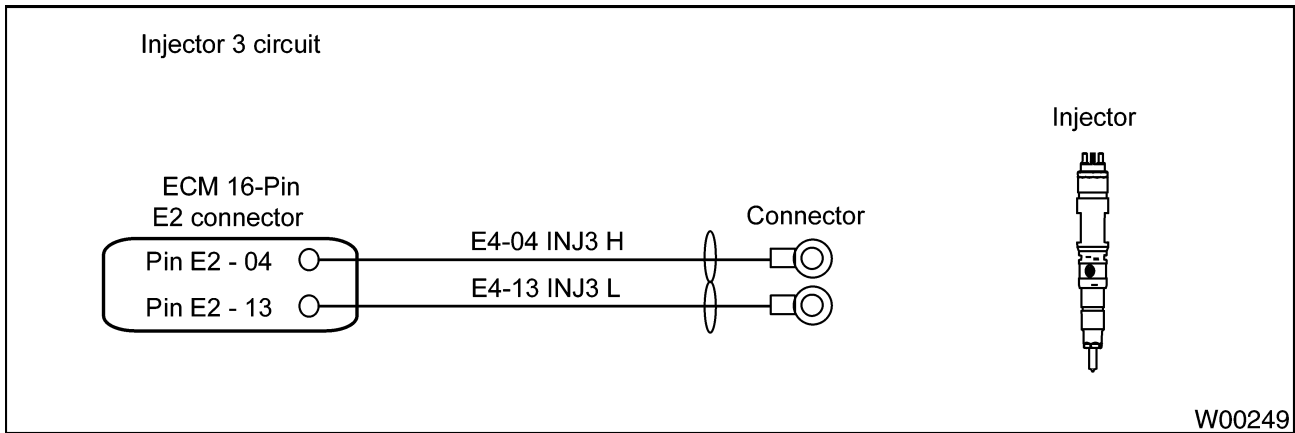


Figure 172 Injector 3 circuit diagram

Injector 3 – Resistance Checks Through Harness and 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 the ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch to OFF. Connect 180-Pin Breakout Box to the ECM harness connector. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
E2-04 to GND	> 1k Ω	If < 1k Ω , check circuit for short to GND or injector coil for internal short.
E2-13 to GND	> 1k Ω	
E2-04 to E2-13	0.4 Ω to 0.6 Ω	If > 0.6 Ω , check for OPEN circuit or OPEN injector coil. If < 0.4 Ω , check for cross-shortened circuits or injector coil for internal short.

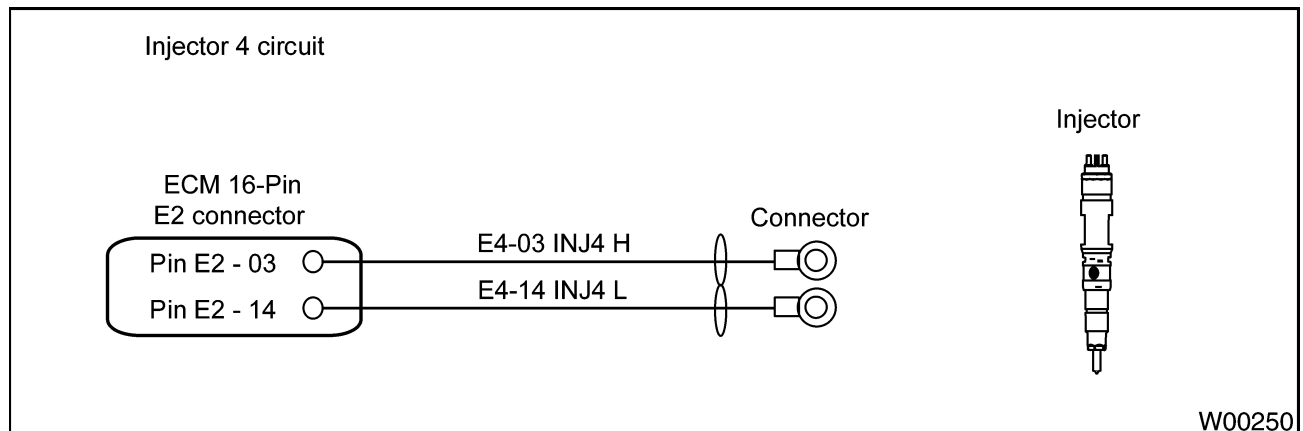


Figure 173 Injector 4 circuit diagram

Injector 4 – Resistance Checks Through Harness and 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 the ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch to OFF. Connect 180-Pin Breakout Box to the ECM harness connector. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
E2-03 to GND	> 1k Ω	If < 1k Ω , check circuit for short to GND or injector coil for internal short.
E2-14 to GND	> 1k Ω	
E2-03 to E2-14	0.4 Ω to 0.6 Ω	If > 0.6 Ω , check for OPEN circuit or OPEN injector coil. If < 0.4 Ω , check for cross-shortened circuits or injector coil for internal short.

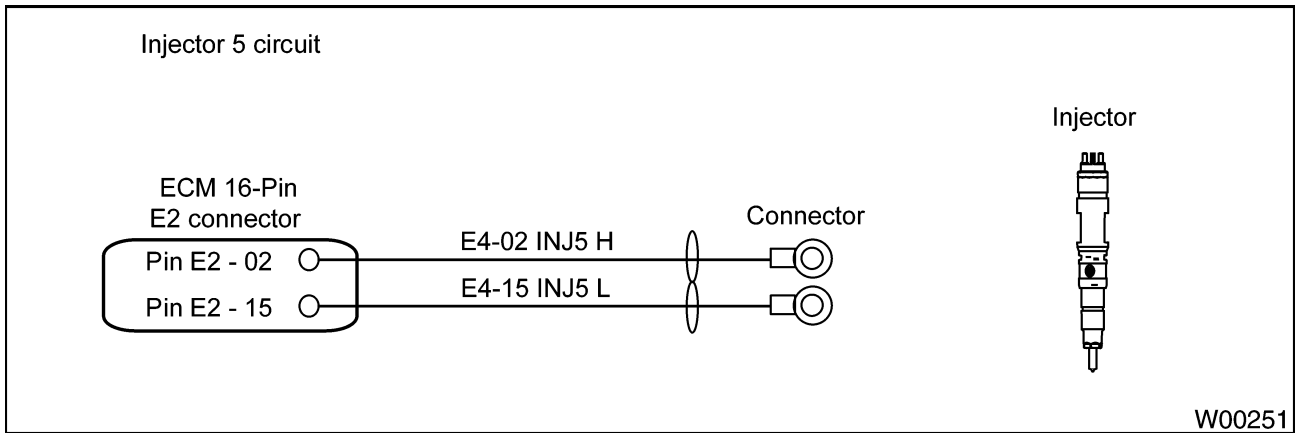


Figure 174 Injector 5 circuit diagram

Injector 5 – Resistance Checks Through Harness and 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 the ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch to OFF. Connect 180-Pin Breakout Box to the ECM harness connector. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
E2-02 to GND	> 1k Ω	If < 1k Ω , check circuit for short to GND or injector coil for internal short.
E2-15 to GND	> 1k Ω	
E2-02 to E2-15	0.4 Ω to 0.6 Ω	If > 0.6 Ω , check for OPEN circuit or OPEN injector coil. If < 0.4 Ω , check for cross-shortened circuits or injector coil for internal short.

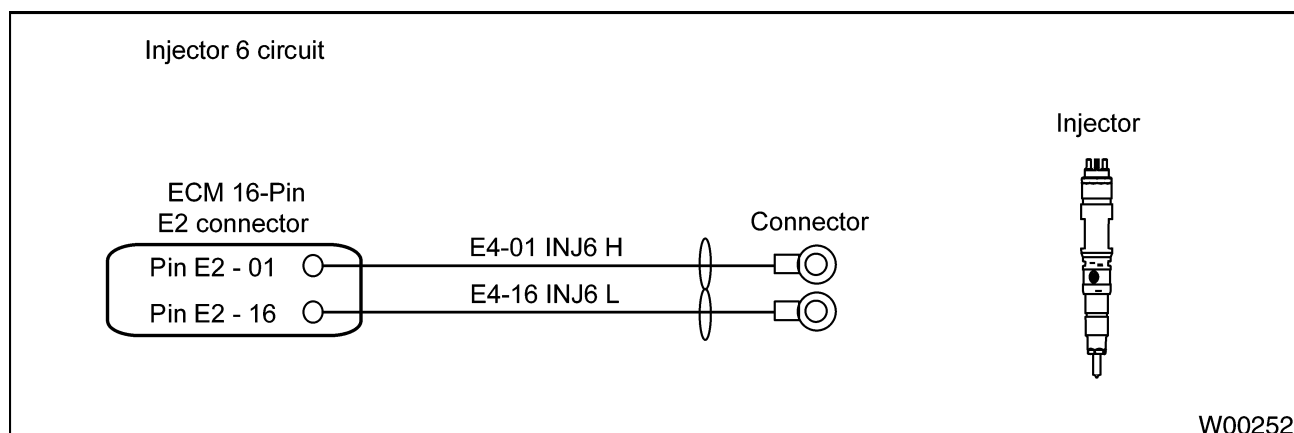


Figure 175 Injector 6 circuit diagram

Injector 6 – Resistance Checks Through Harness and 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 the ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch to OFF. Connect 180-Pin Breakout Box to the ECM harness connector. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
E2-01 to GND	> 1k Ω	If < 1k Ω , check circuit for short to GND or injector coil for internal short.
E2-16 to GND	> 1k Ω	
E2-01 to E2-16	0.4 Ω to 0.6 Ω	If > 0.6 Ω , check for OPEN circuit or OPEN injector coil. If < 0.4 Ω , check for cross-shortened circuits or injector coil for internal short.

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 five 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 five 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
639	14	J1939 Data Link Error (ECM unable to transmit)	- J1939 Data Link circuit fault - Failed ECM
639	19	J1939 Data Link Error (ECM unable to transmit or receive)	- J1939 Data Link circuit fault - Failed ECM

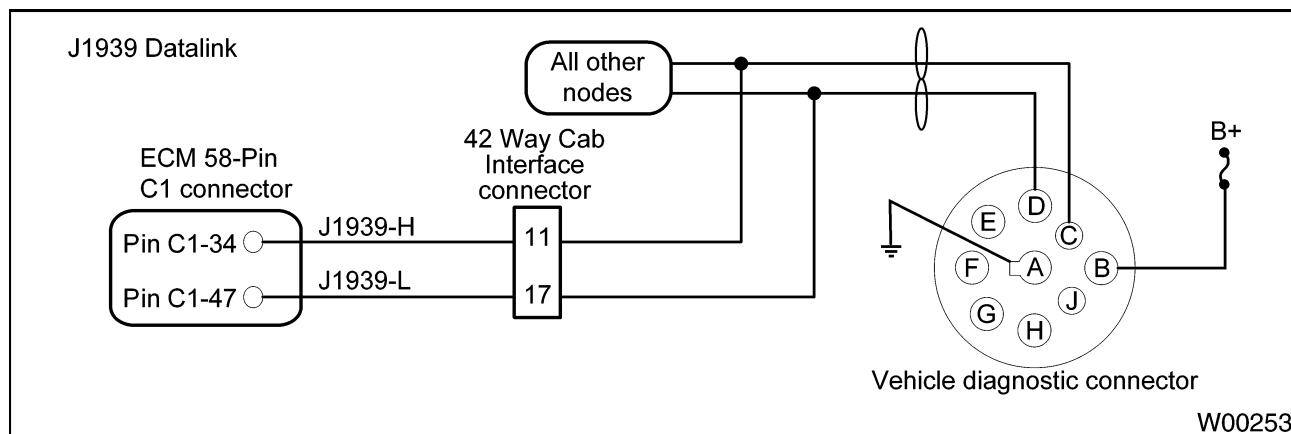


Figure 176 J1939 data link circuit diagram

Connector Voltage Check

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.

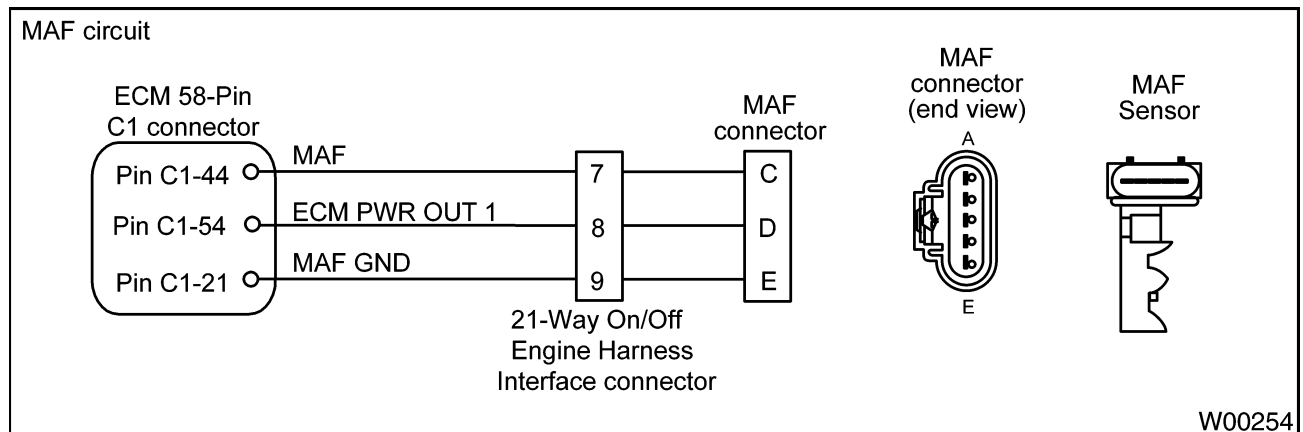
Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box. Leave ECM disconnected.

Test Point	Specification	Comment – < Less than, > Greater than
C to C1-47	< 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 C1-34	< 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.

MAF Sensor (Mass Air Flow)

SPN	FMI	Condition	Possible Causes
None			

**Figure 177 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.

O2S (Oxygen Sensor)

SPN	FMI	Condition	Possible Causes
724	2	O2S Slow response detected fueling to non-fueling	- Failed O2S - Replace sensor and run O2S calibration
724	3	O2S Circuit Fault: Open or short to PWR	- O2 circuit short to PWR - Failed O2S
724	4	O2S Circuit Fault: Short to GND	- O2 circuit short to GND - Failed O2S
724	5	O2S Circuit Fault: Open circuit	- O2S OPEN circuit - Failed O2S
724	20	O2S adaptation above maximum limit	- Biased TC1TOP sensor or circuit - Restricted exhaust - Failed O2S or circuit
724	21	O2S adaptation below minimum limit	- Biased TC1TOP sensor or circuit - Failed O2S or circuit
3223	0	O2S heater temperature above maximum	- Low resistance between VIRGND and NVOLT - Failed O2S
3223	1	O2S heater temperature below minimum	- Charging System fault (Low B+ when O2 Heater was commanded on) - O2S or circuit fault
3223	3	O2S heater short to PWR	- O2 heater circuit short to PWR - Failed O2S
3223	4	O2S heater short to GND	- O2 heater circuit short to GND - Failed O2S
3223	5	O2S heater open load/circuit	- O2 heater circuit OPEN - Failed O2S
3223	17	O2S heater temperature below minimum at low battery PWR	Charging system fault (low B+ when O2 heater was commanded ON)

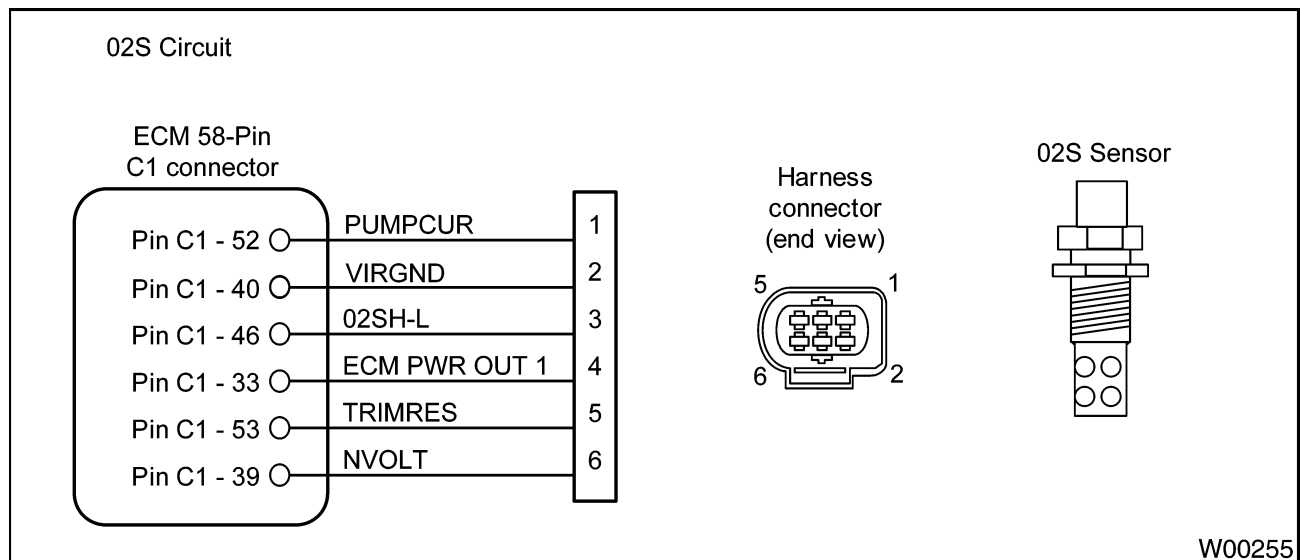


Figure 178 O2S circuit diagram

Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4735A (O2S)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

Function

The Exhaust O2S is an emission control feedback sensor. The O2S is used to monitor the amount of oxygen entering the exhaust system. The ECM uses this information to control engine fueling and EGRV operation.

O2S Sensor Circuit Operation

The O2S monitors exhaust emissions and operates in an open loop/closed loop system. The system remains in open loop until the following conditions are met:

- No active Engine Coolant Temperature (ECT) or O2S fault codes.
- Engine Speed above 500 rpm.
- Battery voltage above 10.8 V.
- Engine Coolant Temperature above 40°C (104°F).
- Exhaust Gas Temperature above 100°C (212°F) for 10 seconds.

Once the above conditions are met, the ECM enables the O2S internal heater and raises sensor temperature above 750°C (1,382°F) and goes into closed loop operation.

Biased Sensor or Circuit Check

SPN 724 FMI 20 – O2S adaptation above maximum limit**SPN 724 FMI 21 – O2S adaptation below minimum limit**Perform TC1TOP Sensor Circuit Check (page 352). Check for restricted exhaust.

1. Turn ignition switch ON, engine OFF.
 2. Using ServiceMaxx™ software, open the Continuous Monitor session.
 3. Verify S_TC1TOP volts are within specification. See “Appendix A: Performance Specifications.”
 - If 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 exhaust system restriction.
 - If TC1TOP voltage is within specification and exhaust is not restricted, verify O2S circuits are not open or shorted. Calibrate and install new O2S.
-

! 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 4735A, leave sensor disconnected. Turn ignition switch to ON. Used DMM to measure voltage

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	2.9 V $\pm$ 1 V	If < 1.9 V, check for OPEN or short to GND.
2 to GND	2.6 V $\pm$ 1 V	If < 1.6 V, check for OPEN or short to GND.
3 to GND	4.8 V $\pm$ 1 V	If < 3.8 V, check for OPEN or short to GND.
4 to GND	12 V $\pm$ 2 V	If < 10 V, check for OPEN circuit or short to GND.
5 to GND	2.9 V $\pm$ 1 V	If < 1.9 V, check for OPEN or short to GND.
6 to GND	3 V $\pm$ 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 the 180-Pin Breakout Box. Leave ECM and O2S disconnected.

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 O2S.

Pinpoint O2S System Fault

SPN 3223 FMI 1– O2S heater temperature below minimum

SPN 3223 FMI 17 – O2S heater temperature below minimum at low battery PWR

DTC will set if battery voltage is below 10 V when the O2S 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 charging system are working within specifications. See "Performance Diagnostics."
 - If charging system and battery voltage are working within specification, check for circuit faults to the O2S. If circuits are within specification, calibrate and install new O2S.

O2S Calibration Procedure – Using ServiceMaxx™ Software

Verify there are no O2S OPEN or short circuits before sensor replacement.

NOTE: Remove O2S from exhaust system before running O2 Sensor Calibration procedure.

1. Connect O2S to engine harness. Leave sensor outside the exhaust system.
2. Turn ignition switch to ON, engine OFF.
3. Start ServiceMaxx™ software.
4. Run O2 Sensor Calibration procedure.
5. After calibration is complete, install O2S in exhaust system.

Service Interval Messages

SPN	FMI	Condition	Possible Causes
1378	31	Change Engine Oil Service Interval	• Change engine oil and reset 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.

Stand Alone Real Time Clock (SART)

SPN	FMI	Condition	Possible Causes
251	19	ECM not detecting SART module on J1939	- SART module powering circuit fault - J1939 to SART module fault - Failed SART module

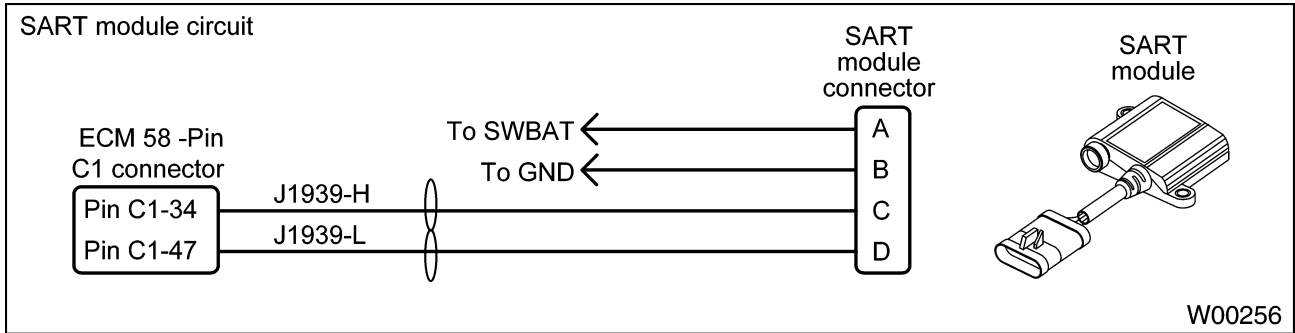


Figure 179 SART circuit diagram

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.

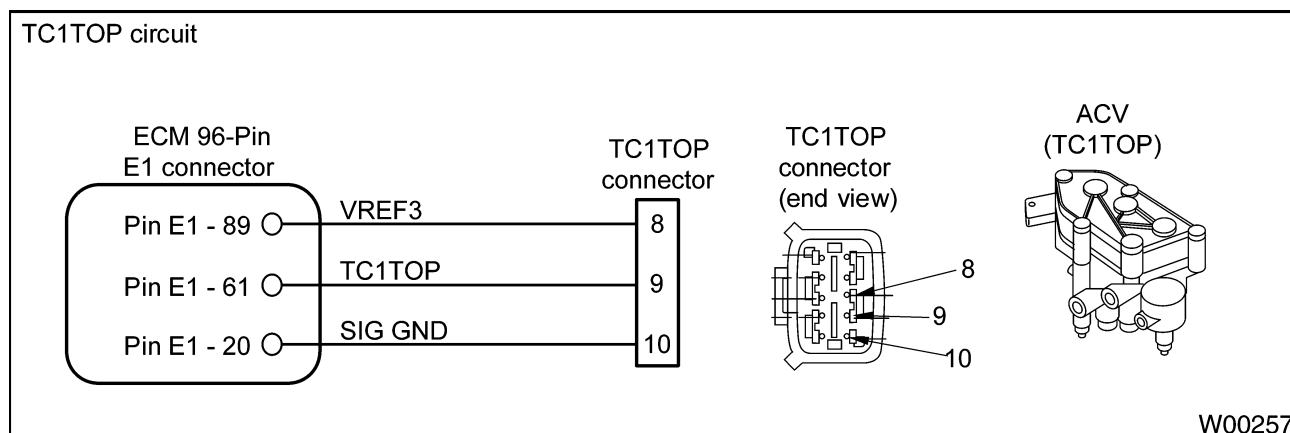
Harness Resistance Check

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
5541	2	TC1TOP Does not agree with other sensors	Biased TC1TOP sensor
5541	3	TC1TOP signal Out of Range HIGH	- TC1TOP signal circuit OPEN or short to PWR - SIG GND circuit OPEN - Failed TC1TOP sensor
5541	4	TC1TOP signal Out of Range LOW	- TC1TOP signal circuit short to GND - Failed TC1TOP sensor

**Figure 180 TC1TOP circuit diagram****Tools**

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 6003 (TC1TOP)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

Note: The TC1TOP, TC1WC, and TC2WC 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.

- Using Electronic Service Tool (EST) with ServiceMaxx™ software, run the Continuous Monitor Test.
- 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.
 - 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 6003 and leave sensor disconnected. Turn ignition switch to ON.

Test Point	Specification	Comment – < Less than, > Greater than
EST – Monitor TC1TOPv	4.5 to 5 V	If < 4.5 V, check TC1TOP signal circuit for short to GND. Do Harness Resistance Check (page 353).
DMM — Measure voltage 8 to GND	5.0 V $\pm$ 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 353).
DMM — Measure voltage 8 to 10	5 V $\pm$ 0.5 V	If < 4.5 V, check SIG GND for OPEN. Do Harness Resistance Check (page 353).
EST – Monitor TC1TOPv	0 V	If > 0.25 V, check TC1TOP signal for OPEN. Do Harness Resistance Check (page 353).
Short across breakout harness pins 9 and 10		

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 6003. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
8 to GND	5.0 V $\pm$ 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 353).
10 to GND	0 V	If > 0.25 V, check SIG GND circuit for short to PWR.
9 to GND	4.5 to 5 V	If < 4.5 V, check TC1TOP signal circuit for short to GND. Do Harness Resistance Check (page 353).

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness 6003. Leave ECM and sensor 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 E1-61	< 5 Ω	If > 5 Ω , check for OPEN circuit.
9 to GND	> 1k Ω	If < 1k Ω , check for short circuit.
9 to E1-20	< 5 Ω	If > 5 Ω , check for OPEN circuit.
10 to GND	> 1k Ω	If < 1k Ω , check for short circuit.
10 to E1-89	< 5 Ω	If > 5 Ω , check for OPEN circuit.

TC1WC (Turbocharger 1 Wastegate Control)

NOTE: TC1WC does not affect engine performance and is removed from postproduction engines.

SPN	FMI	Condition	Possible Causes
1188	3	TC1WC short to PWR	• TC1WC control circuit short to PWR • Failed TC1WC solenoid
1188	4	TC1WC short to GND	• TC1WC control circuit short to GND • Failed TC1WC solenoid
1188	5	TC1WC open load/circuit	• TC1WC control circuit OPEN • Failed TC1WC solenoid

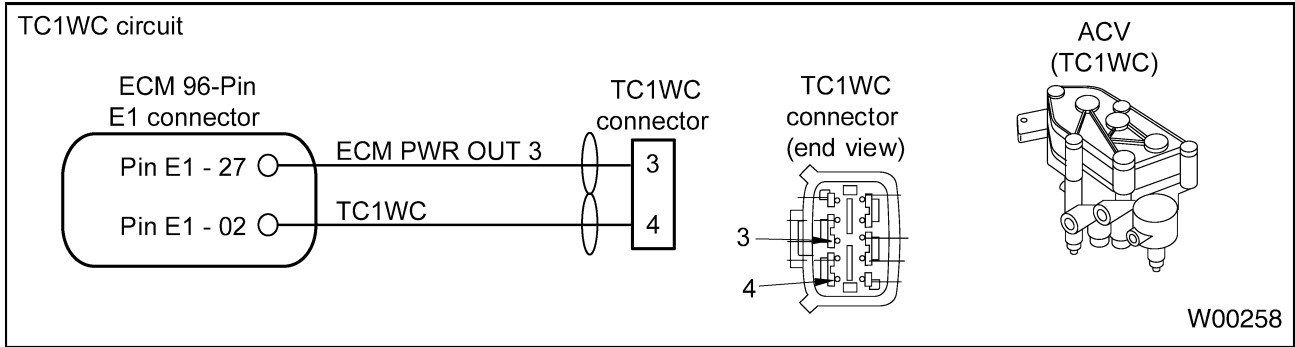


Figure 181 TC1WC circuit diagram

Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 6003 (TC1WC)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software

- NAVCoM or NAVLink Interface Kit

Note: The TC1WC, TC2WC, and TC1TOP circuits share the same connector to the Air Control Valve (ACV) assembly.

! WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

Connector Voltage Check – TC1WC Disconnected

Connect Breakout Harness 6003 to engine harness. Leave TC1WC disconnected. 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 (page 355).
4 to GND	3.5 V $\pm$ 1.0 V	If < 2.5 V, check for OPEN circuit. Do Harness Resistance Check (page 355).
If measurements are within specifications, do Operational Voltage Check (page 355).		

Operational Voltage Check

NOTE: Ensure air tanks have at least 621 kPa (90 psi) of pressure.

1. Connect Breakout Harness 6003 between TC1WC and engine harness.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, load the Actuator session.
3. Command TC1 Wastegate Control to 5%, and then 95%.
4. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
4 to GND	5% = 12 V $\pm$ 2.0 V	If < 10 V, check for OPEN circuit.
4 to GND	95% = 0.5 V $\pm$ 0.5 V	If > 1 V, check for OPEN circuit or failed ECB1.

Actuator Resistance Check

Turn ignition switch to OFF. Connect Breakout Harness 6003 to TC1WC and leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Specifications	Comment
3 to 4	4 Ω to 11 Ω	If not within specification, replace the TC1WC.
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 6003. Leave ECM and TC1WC 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 TC1WC.		

TC2WC (Turbocharger 2 Wastegate Control)

SPN	FMI	Condition	Possible Causes
1189	3	TC2WC short to PWR	- TC2WC control circuit short to PWR - Failed TC2WC solenoid
1189	4	TC2WC short to GND	- TC2WC control circuit short to GND - Failed TC2WC solenoid
1189	5	TC2WC open load/circuit	- TC2WC control OPEN circuit - Failed TC2WC solenoid

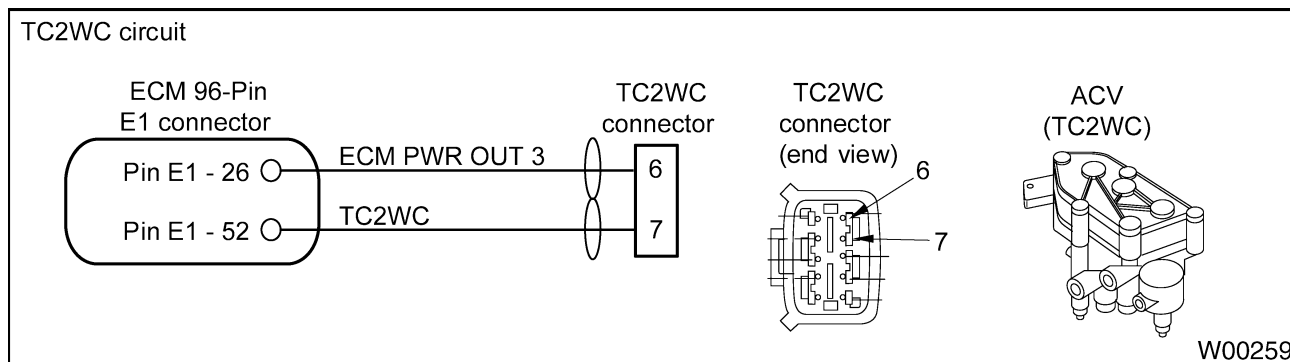


Figure 182 TC2WC valve circuit diagram

Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 6003 (TC2WC)
- Digital Multimeter (DMM)

- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

Note: The TC2WC, TC1WC, and TC1TOP circuits share the same connector to the Air Control Valve (ACV) assembly.

Connector Voltage Check – TC2WC Disconnected

Connect Breakout Harness 6003 to engine harness. Leave TC2WC disconnected. 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 (page 357).
7 to GND	3.5 V $\pm$ 1.0 V	If < 2.5 V, check for OPEN circuit. Do Harness Resistance Check (page 357).
If measurements are within specifications, do Operational Voltage Check (page 357).		

Operational Voltage Check

NOTE: Ensure air tanks have at least 621 kPa (90 psi) of pressure.

1. Connect Breakout Harness 6003 between TC2WC and engine harness.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, load the Actuator session.
3. Command TC2 Wastegate Control to 5%, and then 95%.
4. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
7 to GND	5% = 12 V $\pm$ 2.0 V	If < 10 V, check for OPEN circuit.
7 to GND	95% = 0.5 V $\pm$ 0.5 V	If > 1 V, check for OPEN circuit or failed ECB1.

Actuator Resistance Check

Turn ignition switch to OFF. Connect Breakout Harness 6003 to TC2WC 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 TC2WC.
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 6003. 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 TC2WC.		

TC2CIS (Turbocharger 2 Compressor Inlet Sensor)

SPN	FMI	Condition	Possible Causes
1177	3	TC2CIP signal Out of Range HIGH	• TC2CIP signal circuit OPEN or shorted to PWR • SIG GND circuit OPEN • Failed TC2CIP sensor
1177	4	TC2CIP signal Out of Range LOW	• TC2CIP signal circuit short to GND • Failed TC2CIS

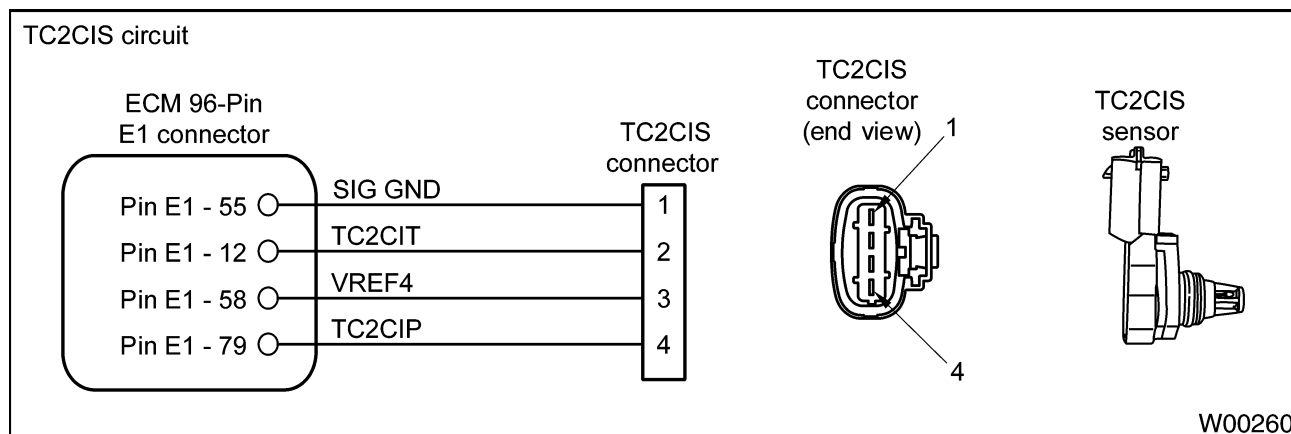


Figure 183 TC2CIS sensor circuit diagram

Tools

- 1180-N4-0X0 – 180-Pin Breakout Box
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness 4830 (TC2CIS)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- NAVCoM or NAVLink Interface Kit

! 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.
- 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

Test Point	Specification	Comment – < Less than, > Greater than
EST – Monitor TC2CITv	5 V	If < 5 V check TC2CIT circuit for short to GND.
EST – Monitor TC2CIPv	5 V	If < 5 V check TC2CIP 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 (page 360).
DMM — Measure voltage 1 to B+	B+	If < B+, check SIG GND for OPEN circuit.
EST - Monitor TC2CITv short 1 to 2	0 V	If > 0.5 V, check TC2CIT circuit for OPEN.
EST - Monitor TC2CIPv short 1 to 4	0 V	If > 0.5 V, check TC2CIP 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 4830. Disconnect TC2CIS. Turn ignition switch to 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	4.5 V – 5 V	If < 4.5 V, check for OPEN in TC2CIT circuit.
3 to GND	4.5 V – 5 V	If < 4.5 V, check for OPEN in VREF4 circuit.
4 to GND	4.5 V – 5 V	If < 4.5 V, check for OPEN in TC2CIP circuit.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness 4830 to engine harness. Leave TC2TIS sensor and ECM 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 E1–55	< 5 Ω	If > 5 Ω , check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω , check for short circuit.
2 to E1–12	< 5 Ω	If > 5 Ω , check for OPEN circuit.
3 to GND	> 1k Ω	If < 1k Ω , check for short circuit.
3 to E1–58	< 5 Ω	If > 5 Ω , check for OPEN circuit.
4 to GND	> 1k Ω	If < 1k Ω , check for short circuit.
4 to E1–79	< 5 Ω	If > 5 Ω , check for OPEN circuit.

VREF (Voltage Reference)

SPN	FMI	Condition	Possible Causes
3509	14	VREF1 voltage deviation ECM pins: C1-36 and E1-65	• VREF1 circuit short to GND • VREF1 circuit short to PWR • Failed sensor causing short to GND on VREF1 circuit
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
3511	14	VREF3 voltage deviation ECM pins: E1-89 and E1-90	• VREF3 circuit short to GND • VREF3 circuit short to PWR • Failed sensor causing short to GND on VREF3 circuit
3512	14	VREF4 voltage deviation ECM pins: C1-37, C1-43, C1-49, C2-08, E1-58 and E1-91	• VREF4 circuit short to GND • VREF4 circuit short to PWR • Failed sensor causing short to GND on VREF4 circuit
3513	14	VREF5 voltage deviation ECM pins: C1-50, E1-80, E1-81, E1-82, E1-84 and E1-93	• VREF5 circuit short to GND • VREF5 circuit short to PWR • Failed sensor causing short to GND on VREF5 circuit
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

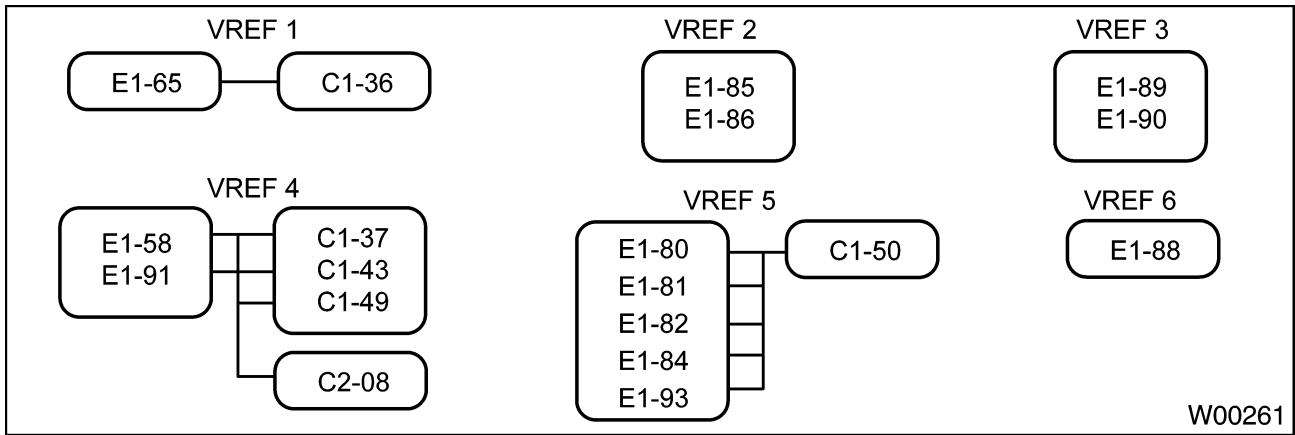


Figure 184 VREF circuit diagram

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 365) 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.
E1-65 to GND	5 V ± 0.7 V	See Result Comments.

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 365) and look for VREF2 circuit short to GND.

Test Point	Specification	Comment – < Less than, > Greater than
E1-85 to GND	5 V $\pm$ 0.7 V	See Result Comments.
E1-86 to GND	5 V $\pm$ 0.7 V	See Result Comments.

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 366) and look for VREF3 circuit short to GND.

Test Point	Specification	Comment – < Less than, > Greater than
E1-89 to GND	5 V $\pm$ 0.7 V	See Result Comments.
E1-90 to GND	5 V $\pm$ 0.7 V	See Result Comments.

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 366) and look for VREF4 circuit short to GND.

Test Point	Specification	Comment – < Less than, > Greater than
C1-37 to GND	5 V $\pm$ 0.7 V	See Result Comments.
C1-43 to GND	5 V $\pm$ 0.7 V	See Result Comments.
C1-49 to GND	5 V $\pm$ 0.7 V	See Result Comments.
C2-08 to GND	5 V $\pm$ 0.7 V	See Result Comments.
E1-58 to GND	5 V $\pm$ 0.7 V	See Result Comments.
E1-91 to GND	5 V $\pm$ 0.7 V	See Result Comments.

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 366) and look for VREF5 circuit short to GND.

Test Point	Specification	Comment – < Less than, > Greater than
C1-50 to GND	5 V $\pm$ 0.7 V	See Result Comments.
E1-80 to GND	5 V $\pm$ 0.7 V	See Result Comments.
E1-81 to GND	5 V $\pm$ 0.7 V	See Result Comments.

Voltage Checks for SPN 3513 FMI 14 – VREF5 (cont.)

E1-82 to GND 5 V $\pm$ 0.7 V See Result Comments.

E1-84 to GND 5 V $\pm$ 0.7 V See Result Comments.

E1-93 to GND 5 V $\pm$ 0.7 V See Result Comments.

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 366) and look for VREF6 circuit short to GND.

Test Point	Specification	Comment – < Less than, > Greater than
E1-88 to GND	5 V $\pm$ 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.

Connect 180-Pin Breakout Box between ECM and engine harness. Leave ECM and 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.
E1-65 to GND	> 1k Ω	If < 1k Ω , check for short circuit.

Harness Resistance Check for SPN 3510 FMI 14 – VREF2

NOTE: If circuit fault is intermittent, wiggle harness while measuring resistance.

Connect 180-Pin Breakout Box between ECM and engine harness. Leave ECM and 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.

Harness Resistance Check for SPN 3511 FMI 14 – VREF3

NOTE: If circuit fault is intermittent, wiggle harness while measuring resistance.

Connect 180-Pin Breakout Box between ECM and engine harness. Leave ECM and 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.
E1-90 to GND	> 1k Ω	If < 1k Ω , check for short circuit.

Harness Resistance Check for SPN 3512 FMI 14 – VREF4

NOTE: If circuit fault is intermittent, wiggle harness while measuring resistance.

Connect 180-Pin Breakout Box between ECM and engine harness. Leave ECM and 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.
C1-43 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.
E1-91 to GND	> 1k Ω	If < 1k Ω , check for short circuit.

Harness Resistance Check for SPN 3513 FMI 14 – VREF5

NOTE: If circuit fault is intermittent, wiggle harness while measuring resistance.

Connect 180-Pin Breakout Box between ECM and engine harness. Leave ECM and VREF5 sensors disconnected. Use DMM to measure resistance.

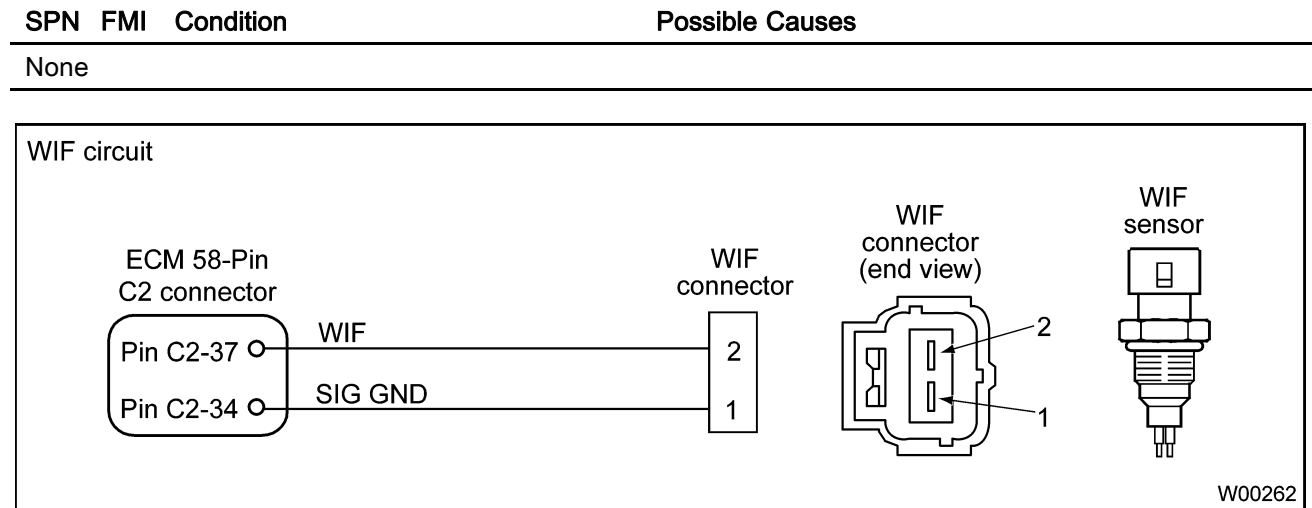
Test Point	Specification	Comment – < Less than, > Greater than
C1-50 to GND	> 1k Ω	If < 1k Ω , check for short circuit.
E1-80 to GND	> 1k Ω	If < 1k Ω , check for short circuit.
E1-81 to GND	> 1k Ω	If < 1k Ω , check for short circuit.
E1-82 to GND	> 1k Ω	If < 1k Ω , check for short circuit.
E1-84 to GND	> 1k Ω	If < 1k Ω , check for short circuit.
E1-93 to GND	> 1k Ω	If < 1k Ω , check for short circuit.

Harness Resistance Check for SPN 3514 FMI 14 – VREF6

NOTE: If circuit fault is intermittent, wiggle harness while measuring resistance.

Connect 180-Pin Breakout Box between ECM and engine harness. Leave ECM and 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)**Figure 185 WIF circuit diagram****Tools**

- 1180-N4-0X0 – 180-Pin Breakout Box
- Digital Multimeter (DMM)

Pinpoint Diagnostics With ServiceMaxx™ Software

⚠ WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

Voltage Check

Disconnect WIF sensor connector. Turn ignition switch to 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 to OFF. Disconnect harness from WIF sensor. 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.

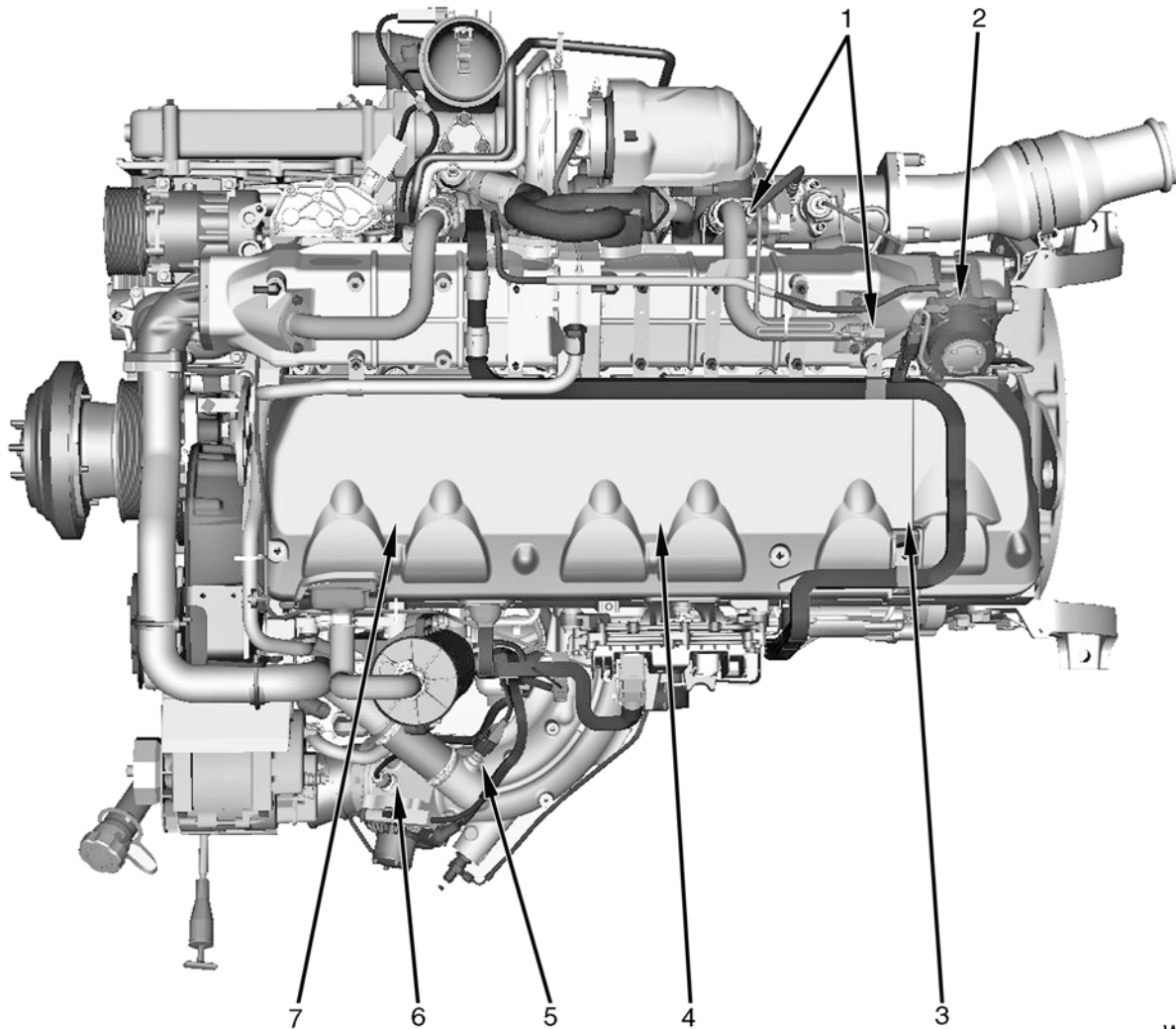
Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and leave ECM and 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.

Sensor and Actuator Locations

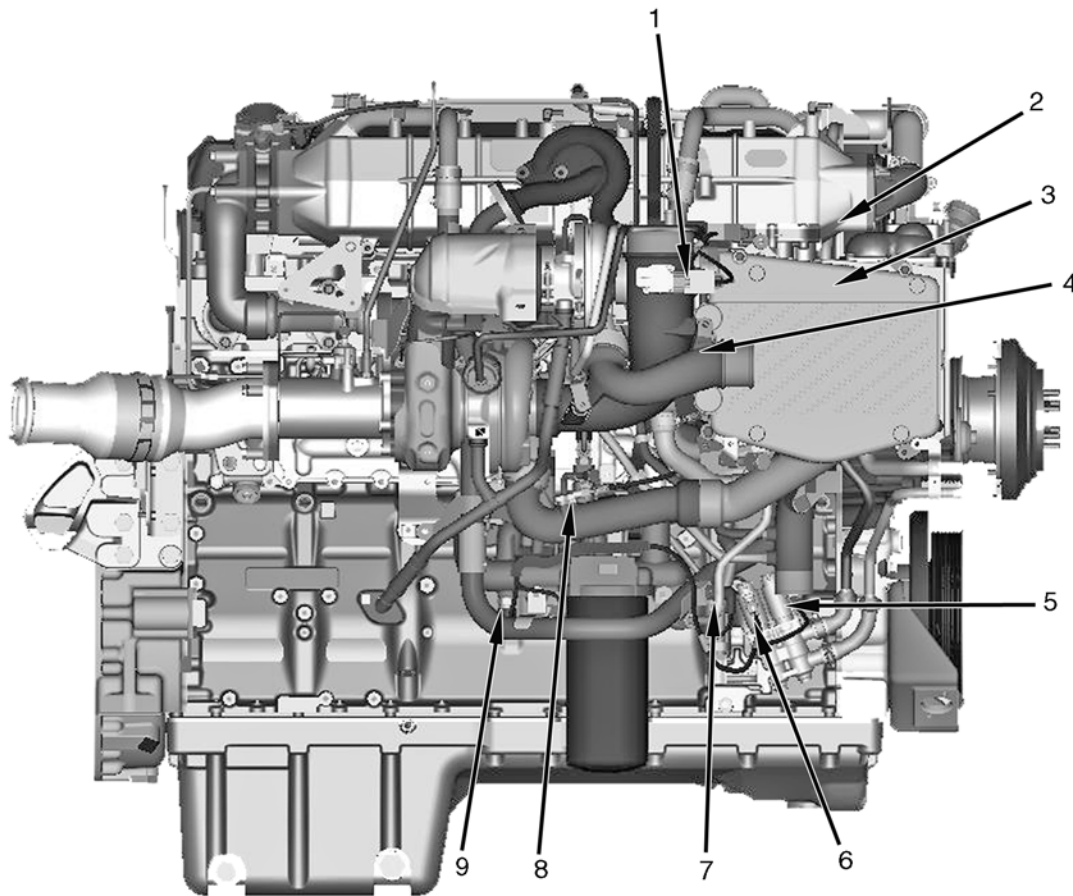
Engine Mounted Components



W60200

Figure 186 Component location – top

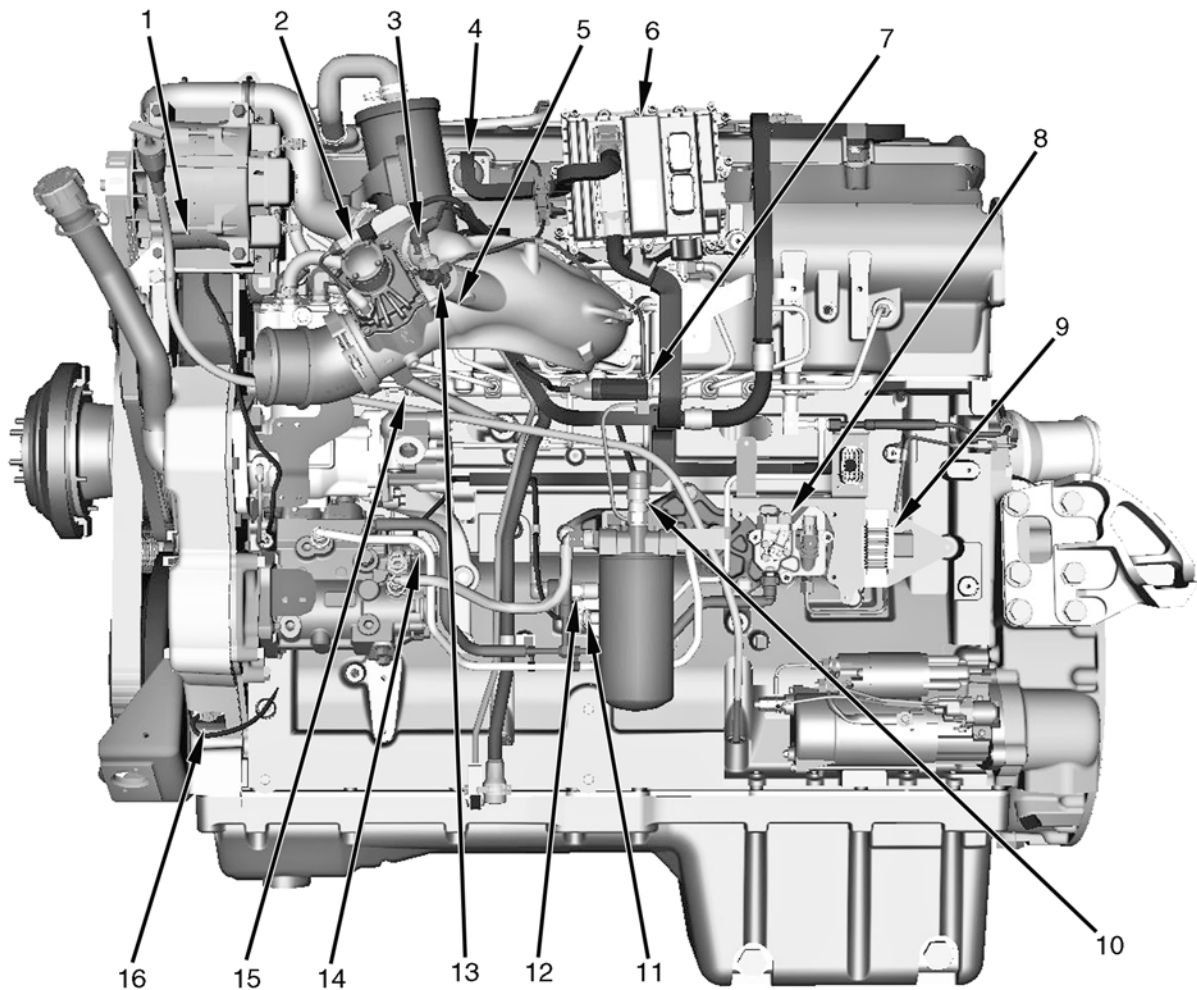
1. Oxygen Sensor (O2S) and connector	4. Engine Compression Brake 2 (ECB2) (under valve cover)	7. Engine Compression Brake 1 (ECB1) (under valve cover)
2. Exhaust Gas Recirculation (EGR) valve	5. Exhaust Gas Recirculation Temperature (EGRT) sensor	
3. Engine Compression Brake 3 (ECB3) (under valve cover)	6. Charge Air Cooler Outlet Temperature (CACOT) sensor	



W60201a

Figure 187 Component location – right

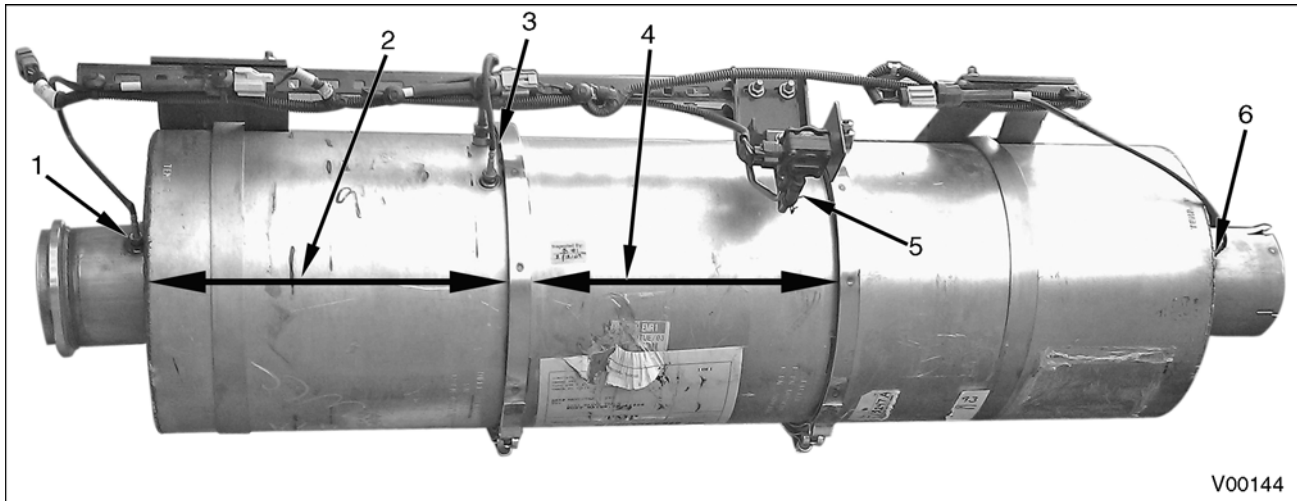
1. Mass Air Flow (MAF) sensor	4. Engine Coolant Temperature 1 (ECT1) sensor (behind interstage cooler)	8. Turbocharger 2 Compressor Inlet Sensor (TC2CIS)
2. Air Control Valve (ACV) (ACV contains TC2WC and TC1TOP sensor)	5. Coolant Mixer Valve (CMV)	9. Engine Oil Temperature (EOT) sensor
3. Engine Coolant Temperature 2 (ECT2) sensor (behind air inlet duct)	6. Coolant Flow Valve (CFV)	
	7. Engine Coolant Pressure (ECP) sensor	



W60202

Figure 188 Component location – left

1. Camshaft Position (CMP) sensor (behind alternator and bracket)	8. Down Stream Injection (DSI) unit (contains AFTFD, AFTFIS, AFTFP2 sensor, and AFTFSV)	14. Fuel Pressure Control Valve (FPCV)
2. Engine Throttle Valve (ETV)	9. Cold Start Relay (CSR)	15. Fuel Rail Pressure (FRP) sensor
3. Intake Manifold Pressure (IMP) sensor	10. Fuel Delivery Pressure (FDP) sensor	16. Crankshaft Position (CKP) sensor
4. Under Valve Cover (UVC) harness (to fuel injectors)	11. Crankcase Pressure Sensor (CCPS)	
5. Intake Manifold Temperature (IMT) sensor (behind ETV duct)	12. Engine Oil Pressure (EOP) sensor	
6. Engine Control Module (ECM)	13. Cold Start Fuel Igniter (CSFI)	
7. Cold Start Fuel Solenoid (CSFS)		

AFT System

V00144

Figure 189 AFT System Operation

1. Diesel Oxidation Catalyst Inlet Temperature (DOCIT)	3. Diesel Oxidation Catalyst Outlet Temperature (DOCOT)	5. Diesel Particulate Filter Differential Pressure (DPFDP)
2. Diesel Oxidation Catalyst (DOC)	4. Diesel Particulate Filter (DPF)	6. Diesel Particulate Filter Outlet Temperature (DPFOT)

Vehicle Mounted Components**Accelerator Pedal Position (APP) Sensor**

Figure 190 Accelerator Pedal Position (APP) sensor

The APP sensor is mounted on the accelerator pedal.

Ambient Air Temperature (AAT) Sensor

The AAT sensor is mounted in various cab locations, depending on vehicle configuration.

Engine Coolant Level (ECL) Sensor

The ECL sensor is installed in the surge tank.

Two Speed Engine Fan Control (EFC)

The EFC is mounted in various locations, depending on vehicle configuration.

Water in Fuel (WIF) Sensor

The WIF sensor is located on the chassis-mounted fuel filter.

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Electrical Tools

180-Pin Breakout Box

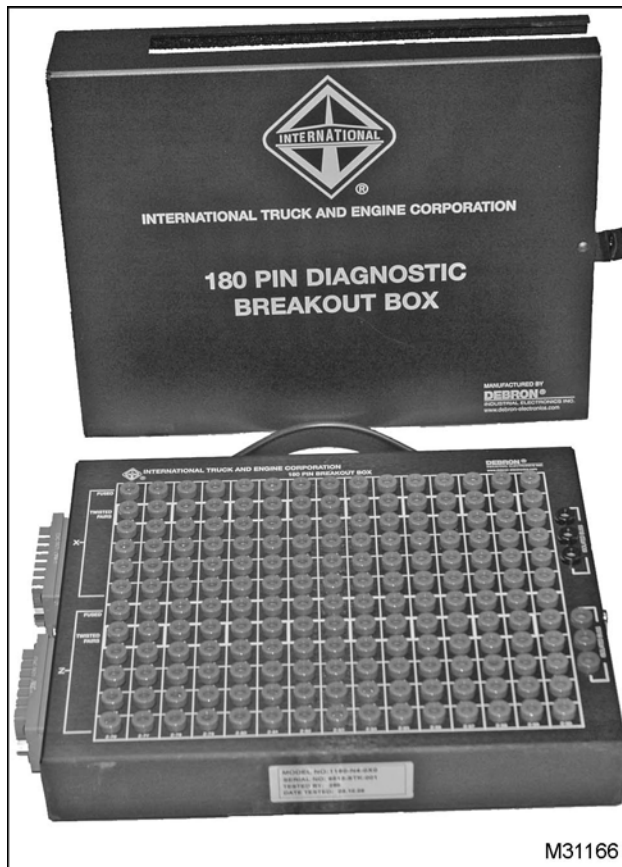


Figure 191 1180-N4-0X0

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 breakout box damage, do not pass high levels of electrical current through the breakout box internal circuitry. Breakout box should be used for measurement only, and not to activate or control circuits.

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 breakout box overlay (pin identifier) sheet.

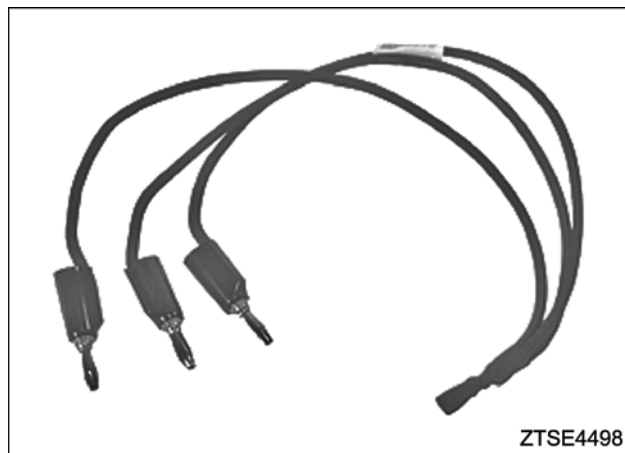
The standard box layout is as follows:

- 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.

2010 Emissions Breakout Harness Kit**Figure 192 ZTSE5025**

Breakout Harness Kit 5025 contains the following:

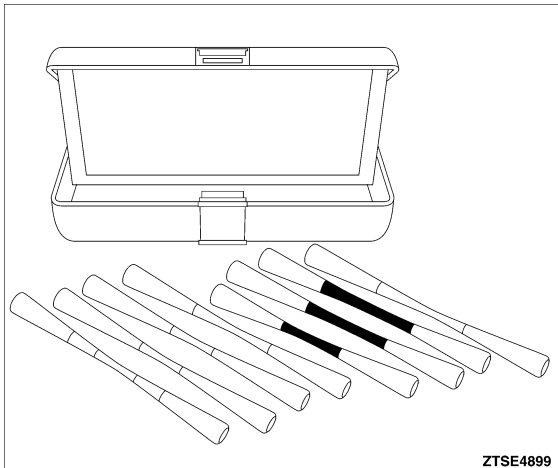
- Breakout Harness 4946
- Breakout Harness 4948
- Breakout Harness 4950
- Breakout Harness 4951
- Breakout Harness 4952
- Breakout Harness 4958
- Breakout Harness 4960
- Breakout Harness 4993
- Breakout Harness 6000
- Breakout Harness 6001
- Breakout Harness 6002
- Breakout Harness 6003
- Breakout Harness 6004
- Breakout Harness 6016
- Breakout Harness 6020
- Breakout Harness 6021
- Breakout Harness 6023
- Breakout Harness 6025
- Breakout Harness 6027
- Breakout Harness 6038
- Breakout Harness 6058

3-Banana Plug Harness**Figure 193 ZTSE4498**

The 3-Banana Plug Harness is used for sensor end diagnostics of sensor circuits.

500-Ohm Resistor Harness**Figure 194 ZTSE4497**

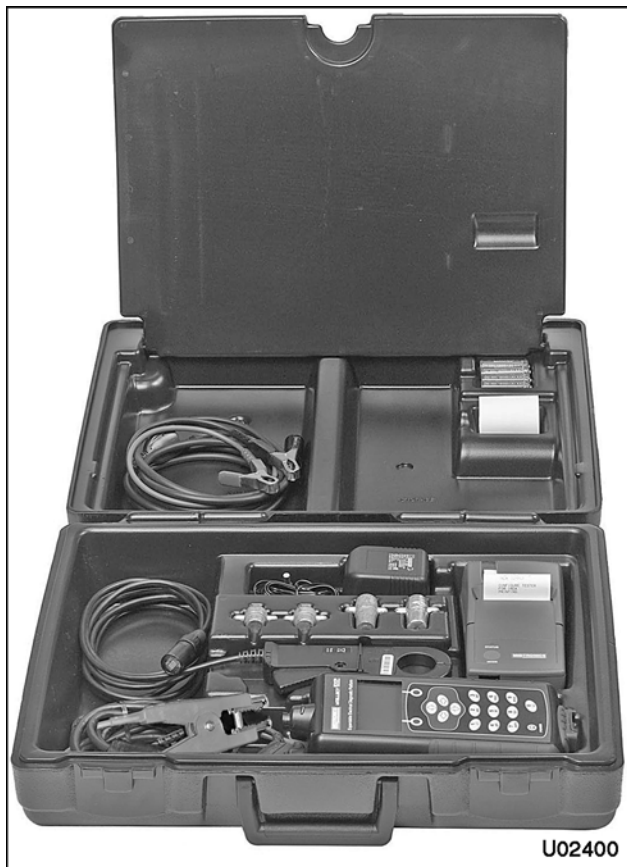
The 500-Ohm Resistor Harness is used for sensor end diagnostics of sensor circuits.

Big Bore Terminal Test Probe Kit**Figure 195 ZTSE4899**

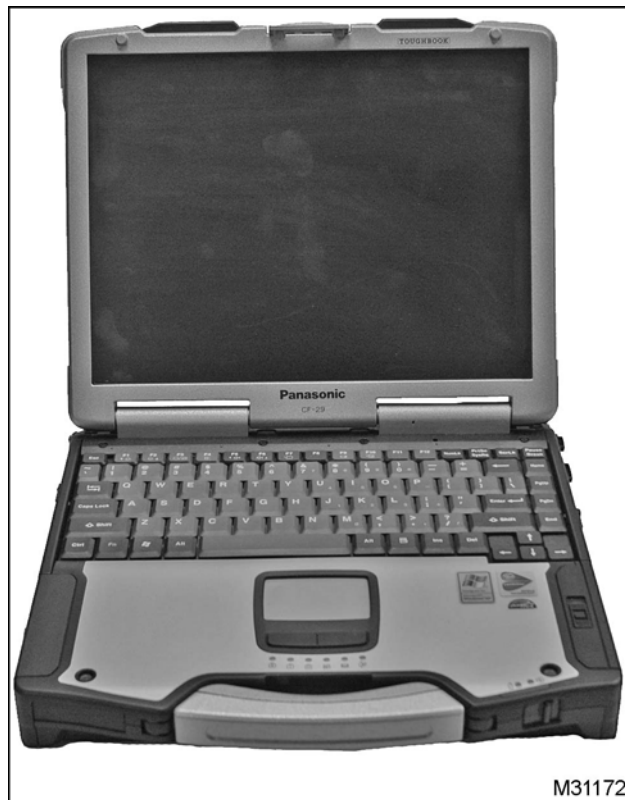
The terminal test probe kit is used to access circuits in connector and allows for use of a DMM without damaging harness connectors.

Digital Multimeter (DMM)**Figure 196 DMM (obtain locally)**

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 197 EXP-1000 HD INTL**

The EXP-1000 HD by Midtronics is used to measure current draw for cold start assist system.

EZ-Tech® Electronic Service Tool (EST)**Figure 198 J-45067**

The EST is used to run ServiceMaxx™ software for diagnosing and troubleshooting engine and vehicle problems.

EZ-Tech® Interface Kit cables are included with the EST.

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.

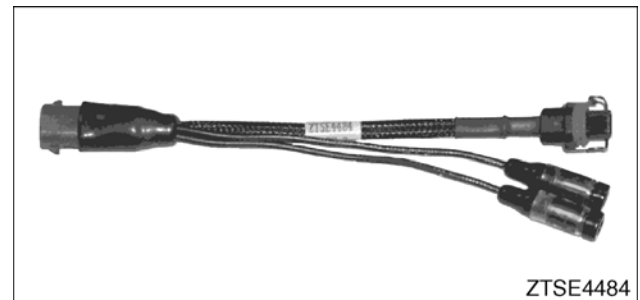
MaxxForce® 11 and 13 (15) Engine Tool Kit**Figure 199 ZTSE4904**

Breakout Harness Kit 4904 contains the following:

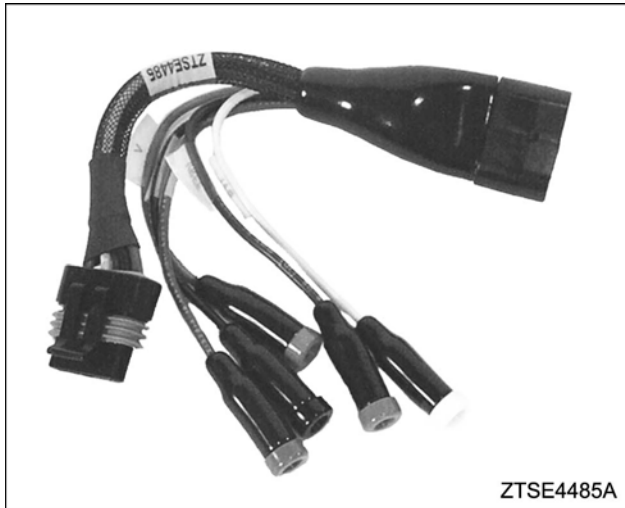
- Breakout Harness 4485A
- Breakout Harness 4735A
- Breakout Harness 4760A
- Breakout Harness 4761A
- Breakout Harness 4827
- Breakout Harness 4828
- Breakout Harness 4830
- Breakout Harness 4831
- Breakout Harness 4833
- Breakout Harness 4834
- Breakout Harness 4844
- Breakout Harness 4845
- Breakout Harness 4850
- Breakout Harness 4870
- Breakout Harness 4871
- Breakout Harness 4881
- Breakout Harness 4882
- Breakout Harness 4883
- Breakout Harness 4885
- Breakout Harness 4908

NAVCoM Interface Kit**Figure 200 NAVCoM Interface Kit**

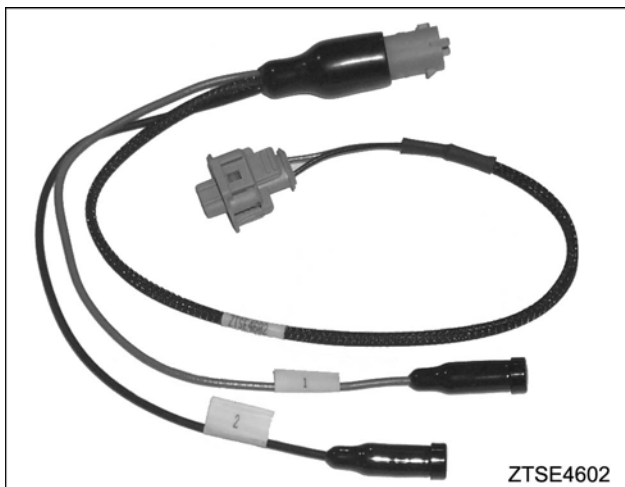
The NAVCoM Interface Kit is used to connect EST to ECM. The NAVLink Interface Kit is an alternative to the NAVCoM Interface Kit.

Breakout Harness 4484 (AAT, ECB1, ECB2, ECB3, and ECL)**Figure 201 ZTSE4484**

Breakout Harness 4484 is used to measure voltage and resistance on circuits connected to the Ambient Air Temperature (AAT) sensor, Engine Compression Brake (ECB) solenoids and the Engine Coolant Level (ECL) sensor.

Breakout Harness 4485A (APP)**Figure 202 ZTSE4485A**

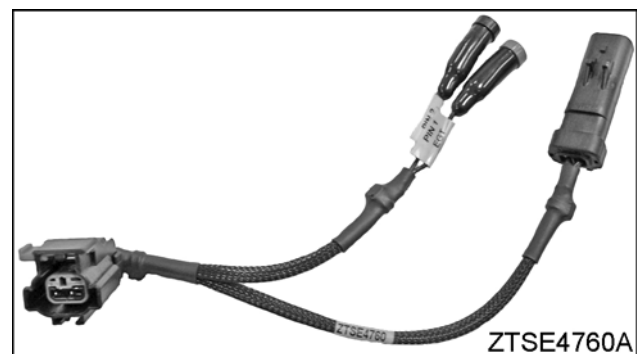
Breakout Harness 4485A is used to measure voltage and resistance on circuits connected to the Accelerator Pedal Position (APP) sensor.

Breakout Harness 4602 (AFTFSV)**Figure 203 ZTSE4602**

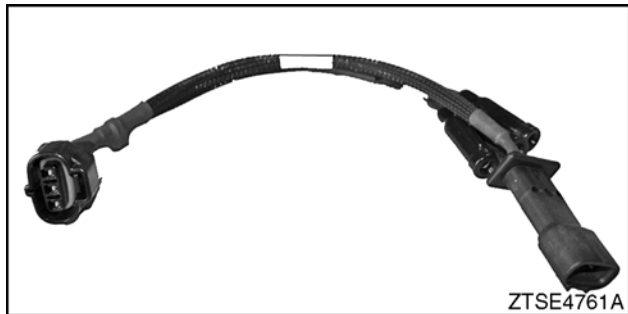
Breakout Harness 4602 is used to measure voltage and resistance on circuits connected to the Aftertreatment Fuel Shutoff Valve (AFTFSV).

Breakout Harness 4735A (O2S)**Figure 204 ZTSE4735A**

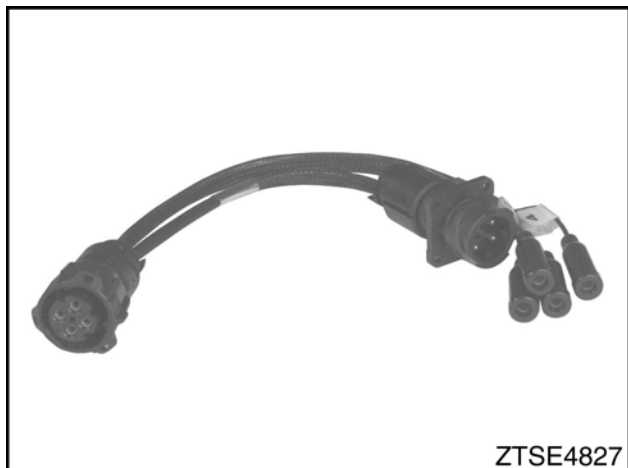
Breakout Harness 4735A is used to measure voltage and resistance on circuits connected to the Oxygen Sensor (O2S).

Breakout Harness 4760A (DOCIT, DOCOT, DPFOT, and EGRT)**Figure 205 ZTSE4760A**

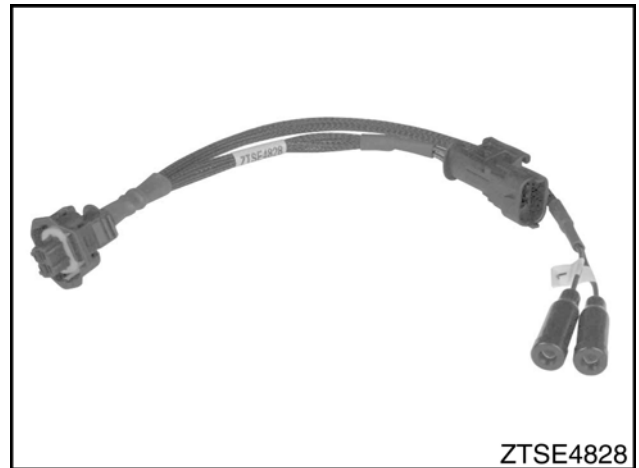
Breakout Harness 4760A is used to measure voltage and resistance on circuits connected to the Diesel Oxidation Catalyst Inlet Temperature (DOCIT), Diesel Oxidation Catalyst Outlet Temperature (DOCOT), Diesel Particulate Filter Outlet Temperature (DPFOT), and Exhaust Gas Recirculation Temperature (EGRT) sensors.

Breakout Harness 4761A (DPFDP)**Figure 206 ZTSE4761A**

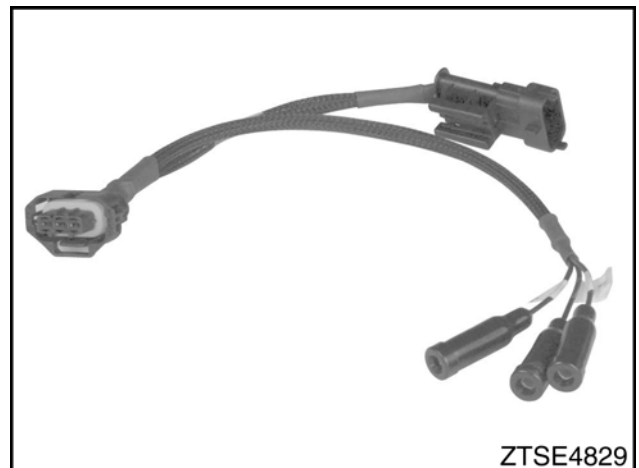
Breakout Harness 4761A is used to measure voltage and resistance on circuits connected to the Diesel Particulate Filter Differential Pressure (DPFDP) sensor.

Breakout Harness 4827 (CSFS, ECT1, ECT2, and EOT)**Figure 207 ZTSE4827**

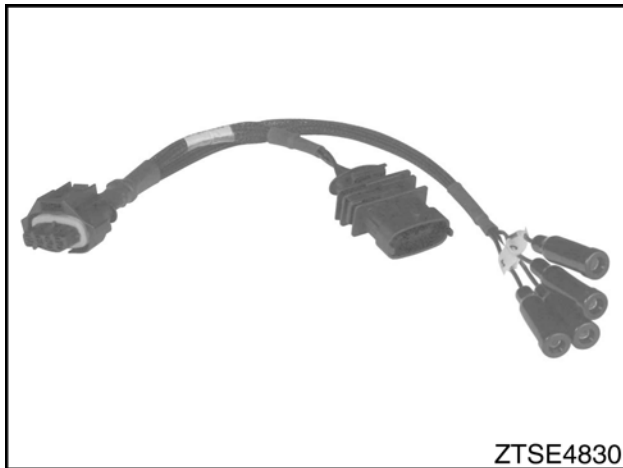
Breakout Harness 4827 is used to measure voltage and resistance on circuits connected to the Cold Start Fuel Solenoid (CSFS), Engine Coolant Temperature (ECT1), Engine Coolant Temperature 2 (ECT2), and Engine Oil Temperature (EOT) sensors.

Breakout Harness 4828 (AFTFD)**Figure 208 ZTSE4828**

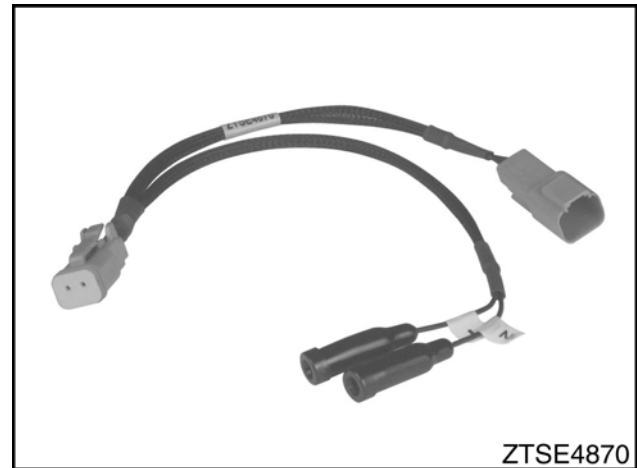
Breakout Harness 4828 is used to measure voltage and resistance on circuits connected to the Aftertreatment Fuel Doser (AFTFD).

Breakout Harness 4829 (FRP)**Figure 209 ZTSE4829**

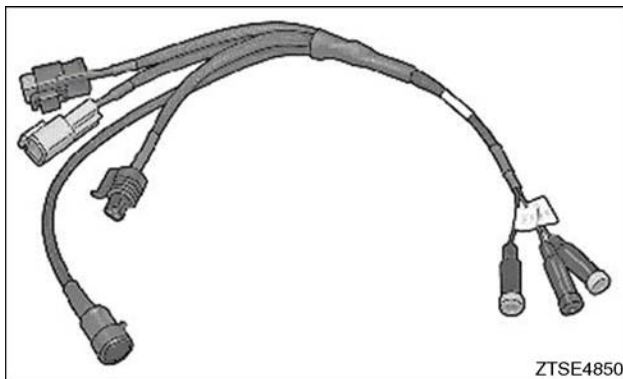
Breakout Harness 4829 is used to measure voltage and resistance on circuits connected to the Fuel Rail Pressure (FRP) sensor.

Breakout Harness 4830 (AFTFIS and TC2CIS)**Figure 210 ZTSE4830**

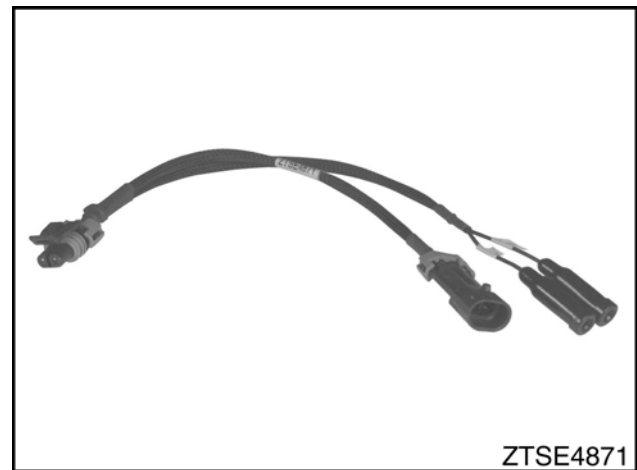
Breakout Harness 4830 is used to measure voltage and resistance on circuits connected to the Aftertreatment Fuel Inlet Sensor (AFTFIS) and Turbocharger 2 Compressor Inlet Sensor (TC2CIS).

Breakout Harness 4870 (CMV)**Figure 212 ZTSE4870**

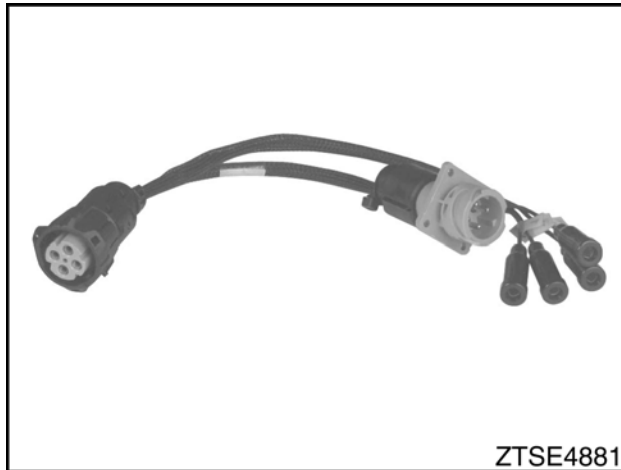
Breakout Harness 4870 is used to measure voltage and resistance on circuits connected to the Coolant Mixer Valve (CMV).

Breakout Harness 4850 (CCPS, ECP1, and IMP)**Figure 211 ZTSE4850**

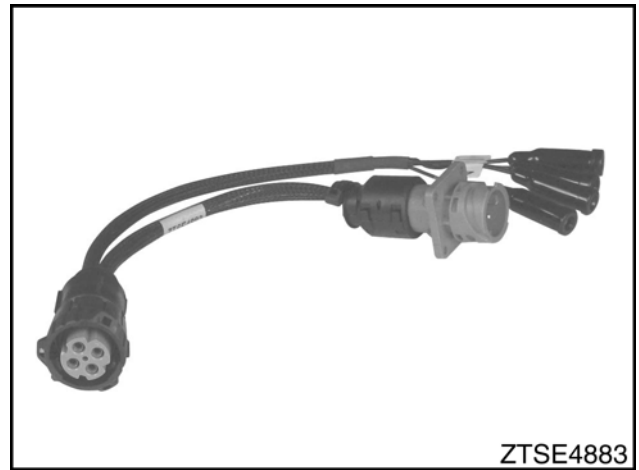
Breakout Harness 4850 is used to measure voltage and resistance on circuits connected to the Crankcase Pressure Sensor (CCPS), Engine Coolant Pressure 1 (ECP1), and Intake Manifold Pressure (IMP) sensors.

Breakout Harness 4871 (CFV and EFC)**Figure 213 ZTSE4871**

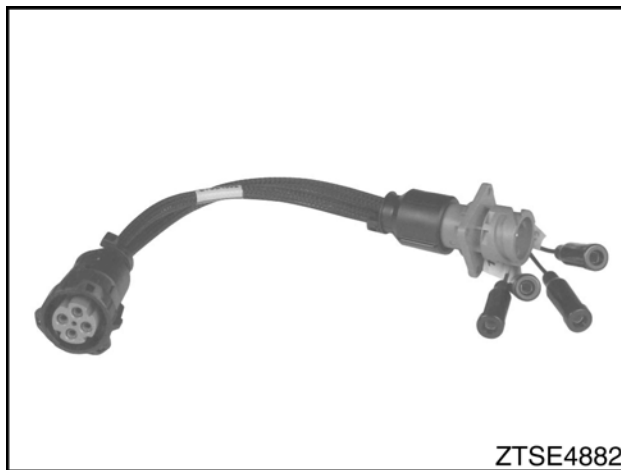
Breakout Harness 4871 is used to measure voltage and resistance on circuits connected to the Coolant Flow Valve (CFV) and Two-speed Engine Fan Control (EFC).

Breakout Harness 4881 (FDP)**Figure 214 ZTSE4881**

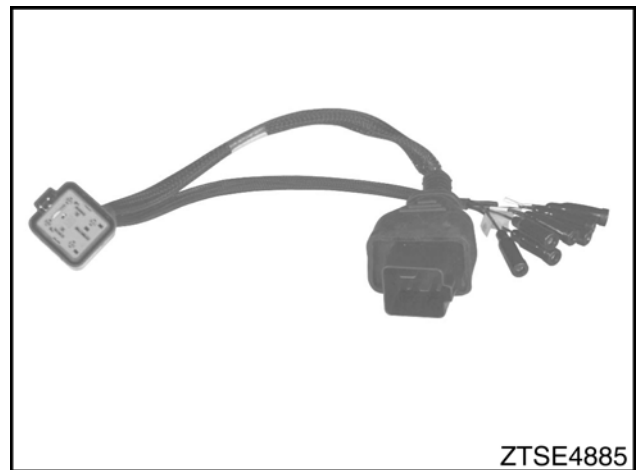
Breakout Harness 4881 is used to measure voltage and resistance on circuits connected to the Fuel Delivery Pressure (FDP) sensor.

Breakout Harness 4883 (IMT)**Figure 216 ZTSE4883**

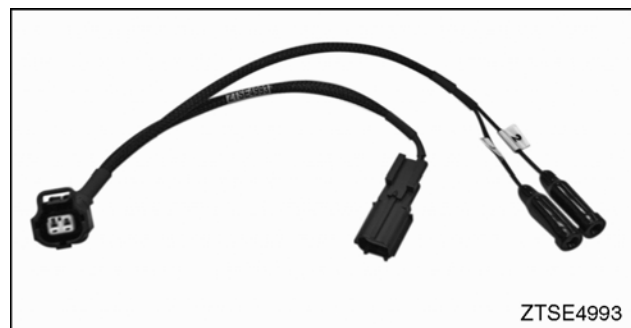
Breakout Harness 4883 is used to measure voltage and resistance on circuits connected to the Intake Manifold Temperature (IMT) sensor.

Breakout Harness 4882 (EOP)**Figure 215 ZTSE4882**

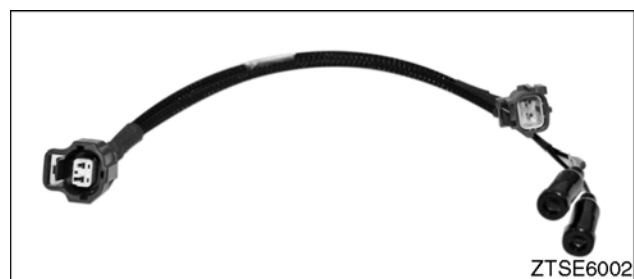
Breakout Harness 4882 is used to measure voltage and resistance on circuits connected to the Engine Oil Pressure (EOP) sensor.

Breakout Harness 4885 (CSR)**Figure 217 ZTSE4885**

Breakout Harness 4885 is used to measure voltage and resistance on circuits connected to the Cold Start Relay (CSR).

Breakout Harness 4993 (CACOT)**Figure 218 ZTSE4993**

Breakout Harness 4993 is used to measure voltage and resistance on circuits connected to the Charge Air Cooler Outlet Temperature (CACOT) sensor.

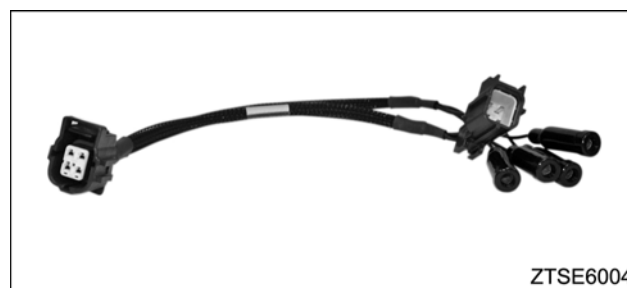
Breakout Harness 6002 (WIF)**Figure 219 ZTSE6002**

Breakout Harness 6002 is used to measure voltage and resistance on circuits connected to the Water In Fuel (WIF) sensor.

Breakout Harness 6003 (TC1WC, TC2WC, and TC1TOP)**Figure 220 ZTSE6003**

Breakout Harness 6003 is used to measure voltage and resistance on circuits connected to the Turbocharger 1 Wastegate Control (TC1WC), Turbocharger 2 Wastegate Control (TC2WC), and Turbocharger 1 Turbine Outlet Pressure (TC1TOP) sensor. All of which are housed inside of the Air Control Valve (ACV).

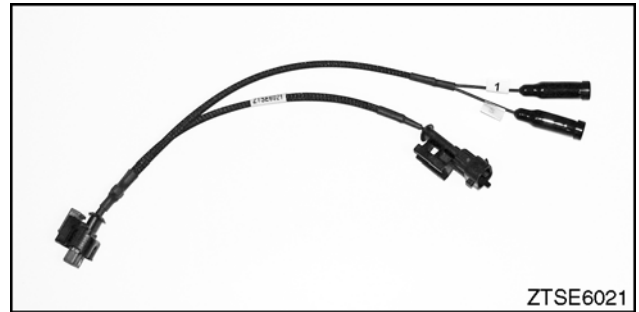
NOTE: TC1WC does not affect engine performance and is removed from post production engines.

Breakout Harness 6004 (ECB Harness Connector and EOL)**Figure 221 ZTSE6004**

Breakout Harness 6004 is used to measure voltage and resistance on circuits connected to the Engine Compression Brake (ECB) harness connector and Engine Oil Level (EOL) sensor.

Breakout Harness 6016 (ETV and EGR Valve)**Figure 222 ZTSE6016**

Breakout Harness 6016 is used to measure voltage and resistance on circuits connected to the Engine Throttle Valve (ETV) and Exhaust Gas Recirculation (EGR) valve.

Breakout Harness 6021 (CKP, CMP, and FPCV)**Figure 223 ZTSE6021**

Breakout Harness 6021 is used to measure voltage and resistance on circuits connected to the Crankshaft Position (CKP) sensor, Camshaft Position (CMP) sensor, and Fuel Pressure Control Valve (FPCV).

Breakout Harness 6027 (AFTFP2)**Figure 224 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

90 Degree Elbow with Swivel (Locally Obtained)

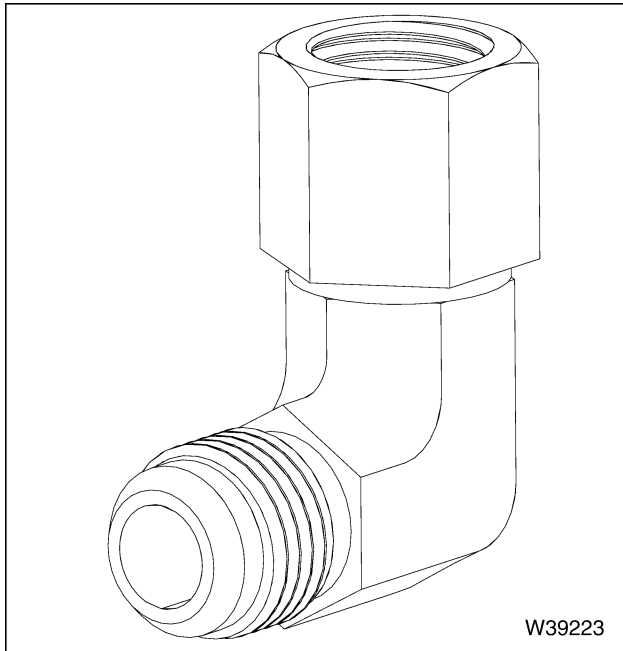


Figure 225 Dixon part # 166FSV-6-6

The 90 degree elbow with swivel is used to connect the High-pressure Return Line Tester to the fuel rail.

Air Cap, Fuel Cap, and Plug Kit

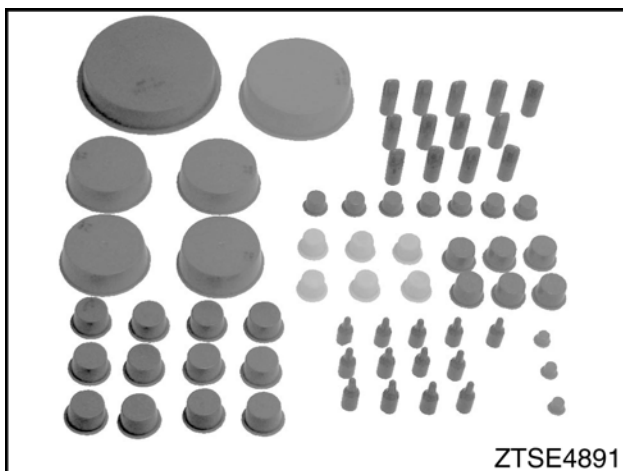


Figure 226 ZTSE4891

The Disposable Air and Fuel Caps are used to cap fuel system lines and fittings when 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

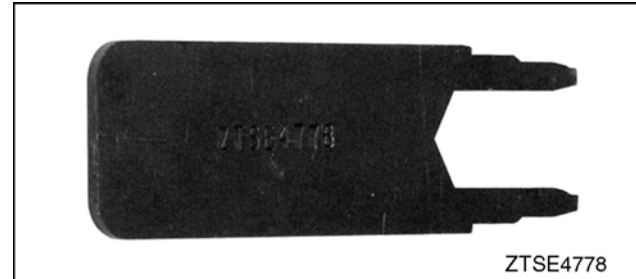


Figure 227 ZTSE4778

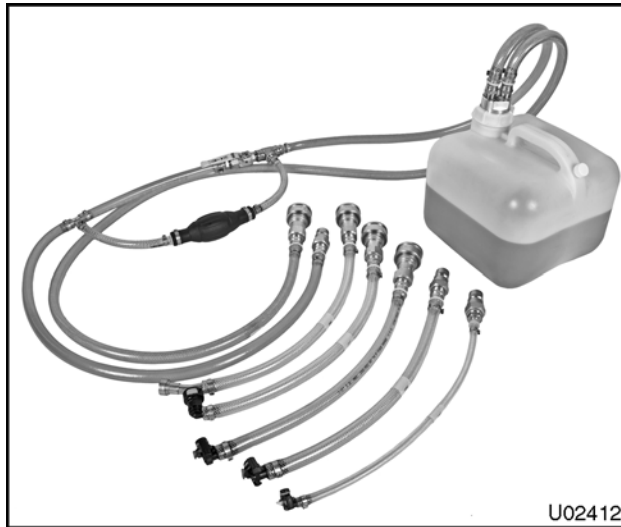
The Air Compressor Coolant Line Release Tool releases the locking mechanism to allow the removal of the coolant line on the air compressor.

Air Intake Guard

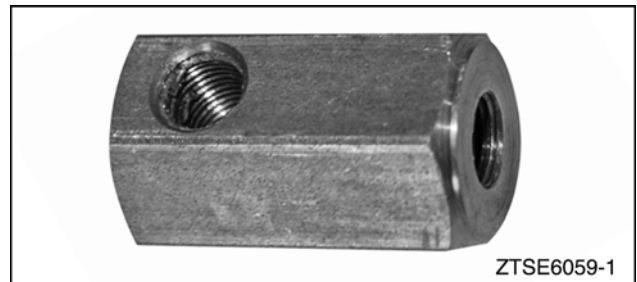


Figure 228 ZTSE6110

The Air Intake Guard is used to protect the turbochargers while performing diagnostics with the air cleaner disconnected.

Clean Fuel Source Tool**Figure 229 15-637-01**

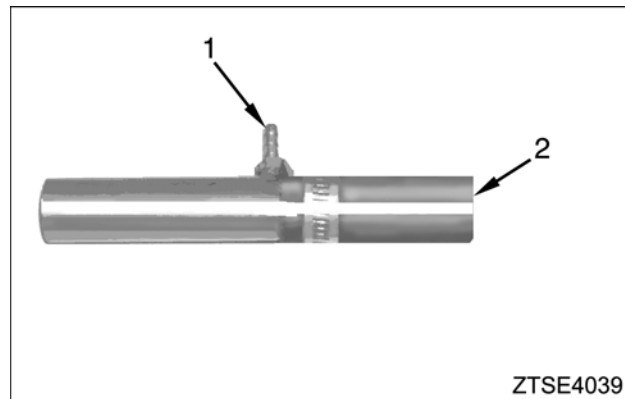
The Clean Fuel Source Tool is used to provide a clean, alternative fuel source to aid in the diagnosis of the fuel system.

Cold Start Solenoid Test Adapter Kit**Figure 230 ZTSE6059-1****Figure 231 ZTSE6059-2**

The Cold Start Solenoid Test Adapter Kit is used to connect the Pressure Test Kit to the Cold Start Fuel Igniter (CSFI) and Cold Start Fuel Solenoid (CSFS) fuel supply lines.

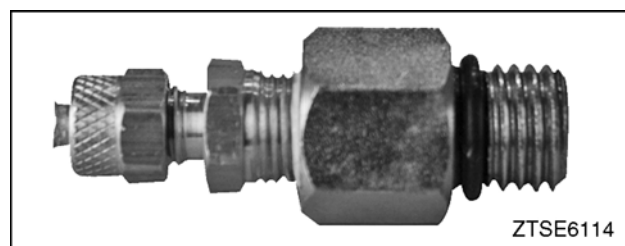
Compucheck Fitting (Locally Obtained)**Figure 232** Star Products part # TU-32-25

The compucheck fitting is used to connect testing equipment during fuel system diagnosis.

Crankcase Pressure Test Tool**Figure 233** ZTSE4039 (0.406 in. diameter)

1. To Pressure Test Kit
2. To sensor cavity

The Crankcase Pressure Test Tool is used to manually check crankcase pressure at the Crankcase Pressure Sensor (CCPS) cavity.

Crankcase Pressure Test Adapter**Figure 234** ZTSE6114

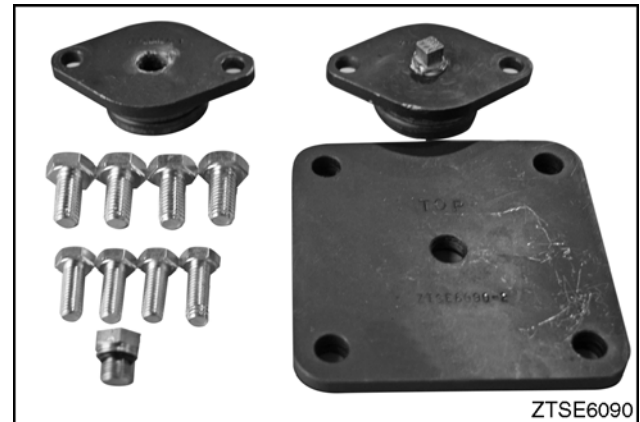
The Crankcase Pressure Test Adapter is used to manually check crankcase pressure at the Crankcase Pressure Sensor (CCPS) cavity.

Digital Manometer

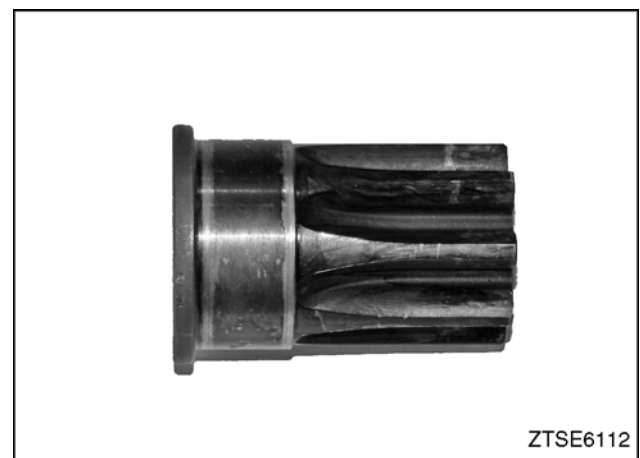
k35211

Figure 235 Obtain locally

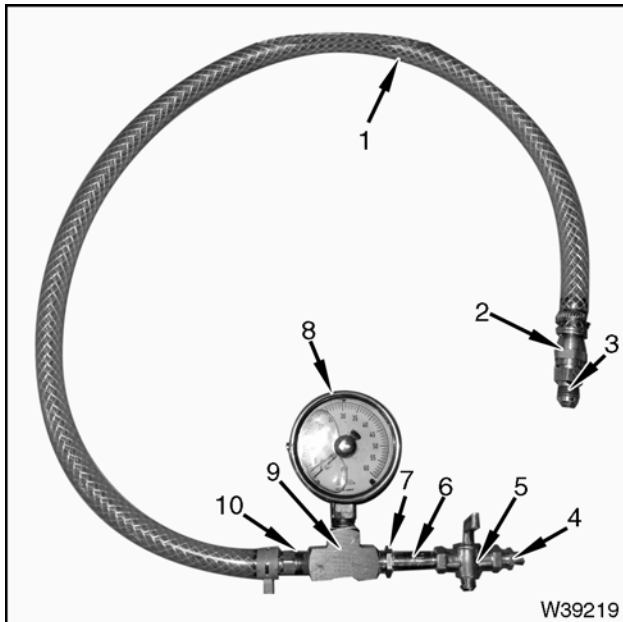
The Digital Manometer is used to measure low vacuum due to intake restriction or low crankcase pressure. A variety of digital manometers are available for purchase locally. The Slack Tube® Manometer (ZTSE2217A) is an alternative to the Digital Manometer.

EGR Cooler Test Tools**Figure 236** ZTSE6090

The EGR Cooler Test Tools are used to pressure test the Exhaust Gas Recirculation (EGR) cooler.

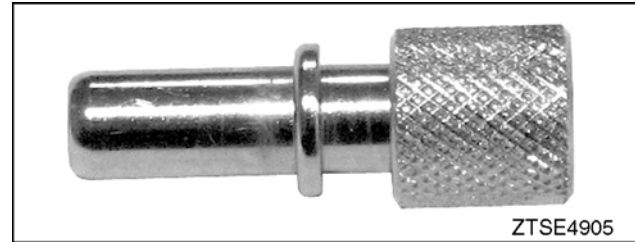
Engine Turning Tool**Figure 237** ZTSE6112

The Engine Turning Tool is used to manually turn the engine.

Fluid Line Pressurizing Tool (Locally Obtained)**Figure 238 Locally obtained**

1. 3/8 in plastic tubing, about 2 ft long – McMaster-Carr #5238K648
2. 1/4 in pipe, male, to 3/8 in barbed hose fitting – McMaster-Carr #5346K18
3. 3/8 in SAE flare to 1/4 in pipe female adapter (male to female) – McMaster-Carr #5346K35
4. 1/8" NPT to 1/8" tube adapter (male pipe to tube) – McMaster-Carr #5220K61
5. Panel-mount brass ball valve (female to female) – McMaster-Carr # 4114T21
6. 1/8 in NPT threaded pipe, 2 1/2 in long (male to male) – McMaster-Carr #4568K114
7. 1/4 in NPT male hex bushing to 1/8 in NPT female – McMaster-Carr #4429K411
8. Pressure gauge, 0 to 1,100 kPa (0 to 160 psi) – McMaster-Carr #4023K25
9. 1/4 in NPT female T fitting – McMaster-Carr #9171K27
10. 1/4 in pipe, male, to 3/8 in barbed hose fitting – McMaster-Carr #5346K18

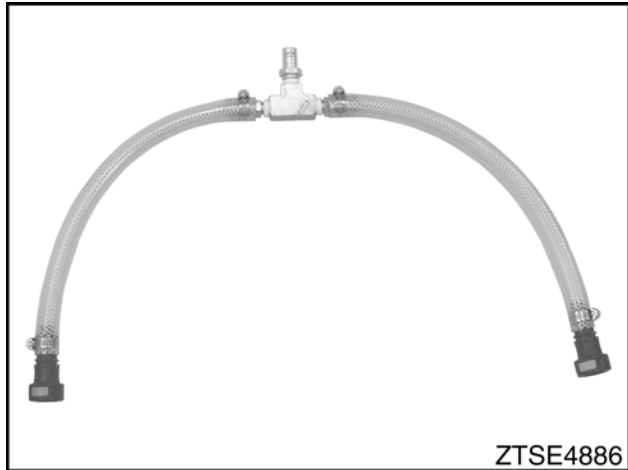
The Fluid Line Pressurizing tool is used to diagnose symptoms related to the fuel system.

Fuel Block Off Tool**Figure 239 ZTSE4905**

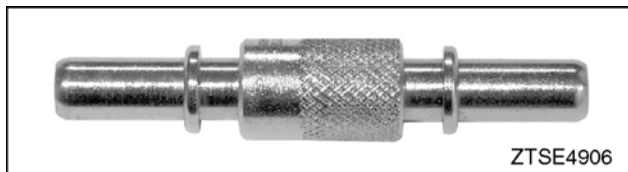
The Fuel Block Off Tool is used to block fuel lines.

Fuel Injector Cups**Figure 240 ZTSE4892**

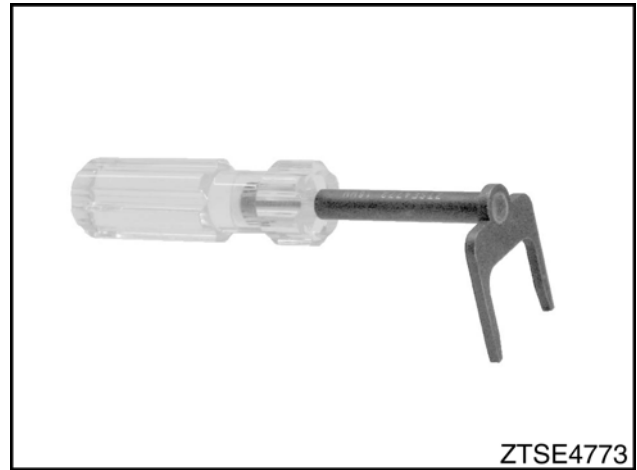
The Fuel Injector Cups are used to protect injectors, and prevent dirt and debris from damaging injectors while removed from engine.

Fuel Inlet Restriction / Aeration Tool**Figure 241 ZTSE4886**

The Fuel Inlet Restriction / Aeration Tool is used to check for pressure and aerated fuel in the low fuel pressure system.

Fuel Line Coupler**Figure 242 ZTSE4906**

The Fuel Line Coupler is used to connect fuel lines during fuel system diagnosis.

Fuel Line Disconnect Tool 11.8 mm**Figure 243 ZTSE4773**

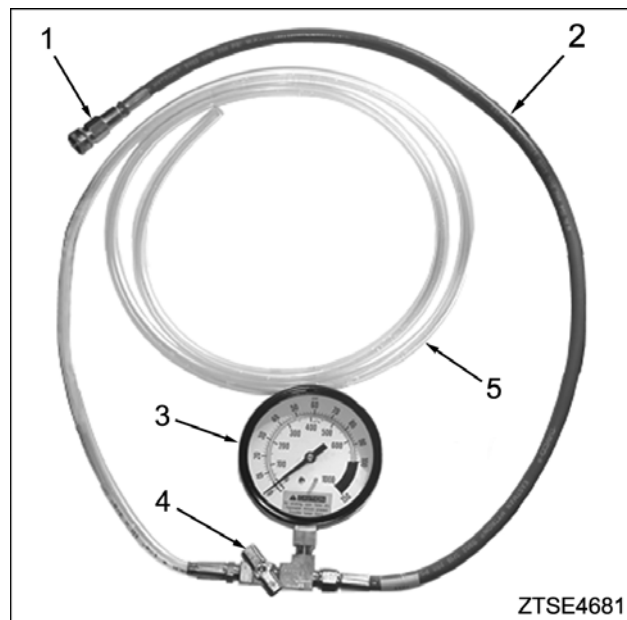
The Fuel Line Disconnect Tool 11.8 mm is used to release the locking mechanism on low-pressure fuel line connectors.

Fuel Line Fitting Removal Tool**Figure 244 FRX241**

The Fuel Line Fitting Removal Tool is used to remove fuel lines from cylinder head.

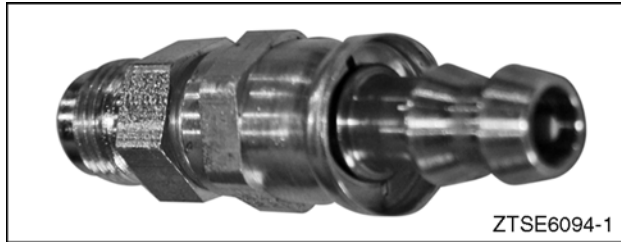
Fuel Outlet Fitting

The Fuel Outlet Fitting, ZTSE6124, is used to connect the Fuel Inlet Restriction / Aeration Tool during fuel system diagnosis.

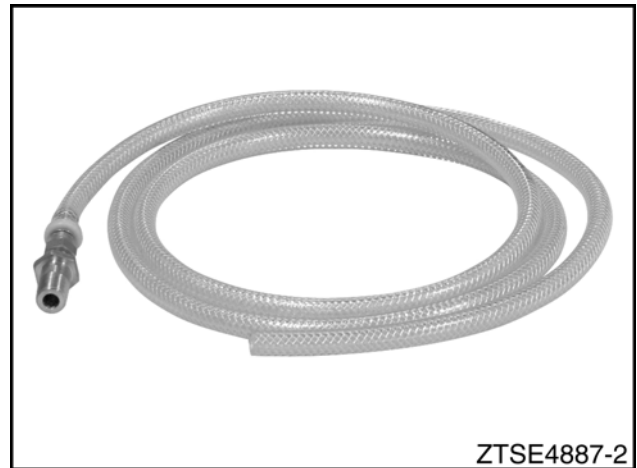
Fuel Pressure Gauge**Figure 245 ZTSE4681**

1. Quick disconnect check valve
2. Fuel test line
3. Fuel Pressure Gauge
4. Inline shut-off valve
5. Clear test line

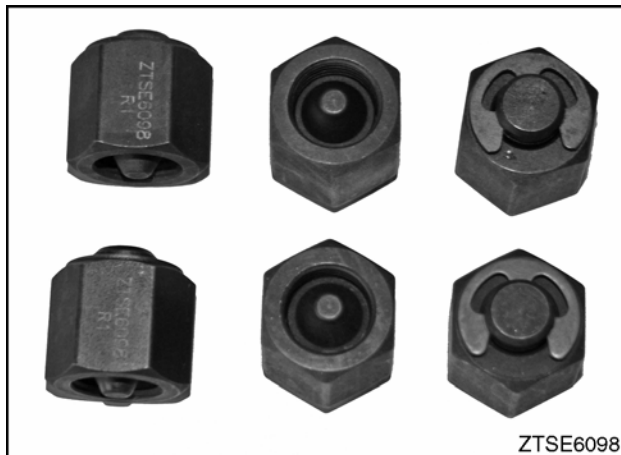
The Fuel Pressure Gauge is used to check for fuel pressure and aerated fuel in the low-pressure fuel system.

Fuel Pressure Return Connector**Figure 246** ZTSE6094-1

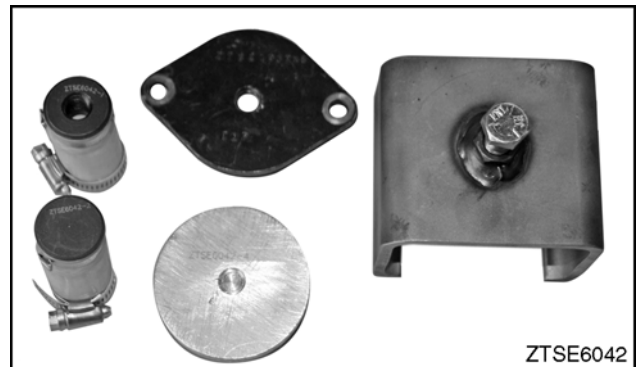
The Fuel Pressure Return Connector is used to connect fuel lines to High-pressure Return Line Tester.

High-pressure Return Line Tester – 19mm**Figure 248** ZTSE4887-2

The 19 mm High-pressure Return Line Tester is used to check for excessive fuel returning from fuel injectors at cylinder head fuel return port.

High-pressure Rail Plugs**Figure 247** ZTSE6098

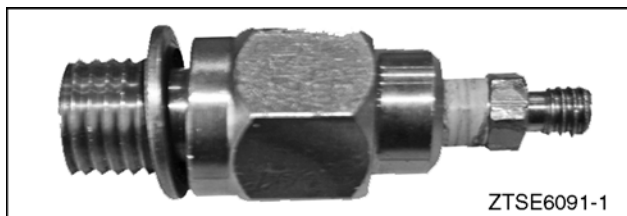
The High-pressure Rail Plugs are used to isolate individual injectors by blocking pressure pipe rail output.

Interstage Cooler Test Kit**Figure 249** ZTSE6042 1-4

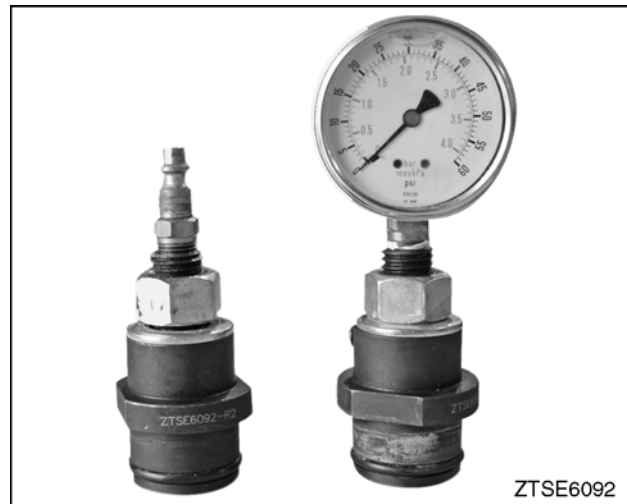
The Interstage Cooler Test Kit is used to pressure test the Interstage Cooler (ISC).

Lash Gauge**Figure 250 ZTSE6076-7**

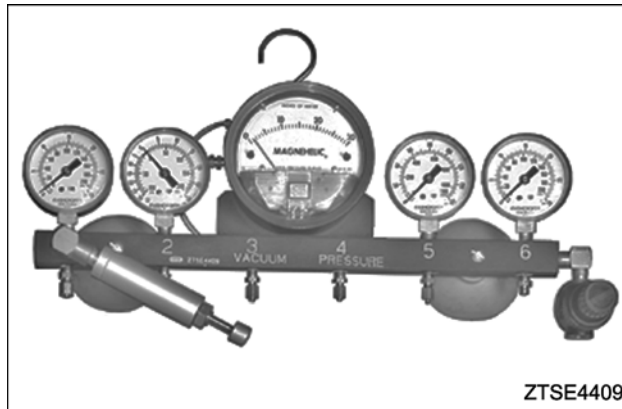
This Lash Gauge is used to adjust exhaust valve lash.

Manual Oil Pressure Test Tool**Figure 251 ZTSE6091-1**

The Manual Oil Pressure Test Tool is used to manually check oil pressure at the Engine Oil Pressure (EOP) sensor cavity.

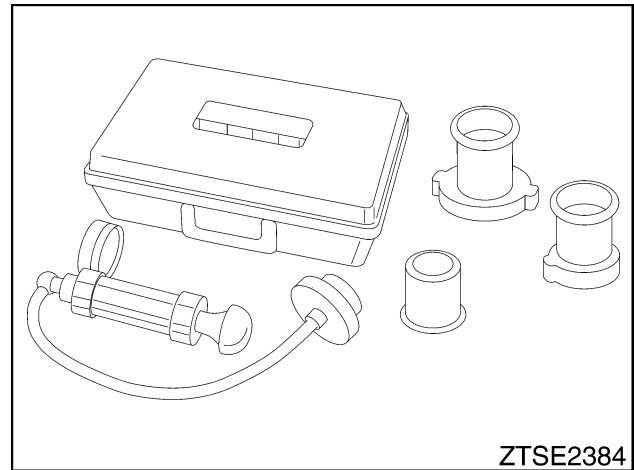
Oil Cooler Test Kit**Figure 252 ZTSE6092**

The Oil Cooler Test Kit is used to pressure test the oil cooler.

Pressure Test Kit**Figure 253 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 inHg vacuum / 0 to 200 kPa (0 to 30 psi) compound gauge measures fuel system inlet restriction and intake manifold pressure.
0-30 inH₂O 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 Testing Kit**Figure 254 ZTSE2384**

The Radiator Pressure Testing Kit is used to check pressure caps and cooling systems. The pressure gauge indicates if pressure cap holds rated pressure and whether coolant system has leaks or holds pressure.

Slack Tube® Manometer

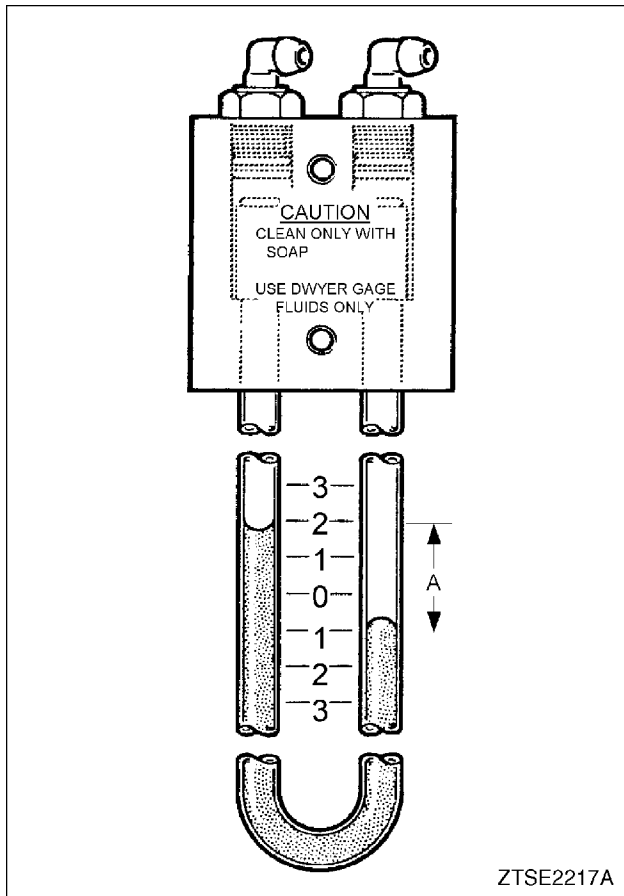


Figure 255 ZTSE2217A

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-H₂O).

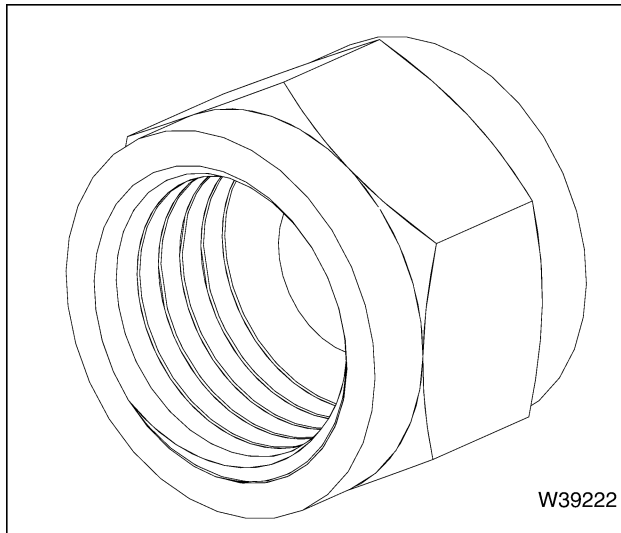
At times, both columns of the manometer will not travel the same distance. This is no concern if the leg not connected to the pressure or vacuum source is open to the atmosphere.
5. Compare the manometer reading with engine specifications.
6. When the test is done, clean the tube thoroughly using soap and water. Avoid liquid soaps and solvents.

Timing Pin



Figure 256 ZTSE6108

The timing pin is used to ensure engine is set at Top Dead Center (TDC).

Tube Fitting Cap (Locally Obtained)**Figure 257** McMaster-Carr part # 5482K69

The tube fitting cap is used to cap fuel lines.

UV Leak Detection Kit**Figure 258** 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.

Vacuum Analyzer and Fuel Pump Tester**Figure 259** ZTSE2499

The Vacuum Analyzer and Fuel Pump Tester is used to test the operation of the fuel pump.

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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

AIT – Air Inlet Temperature

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

CSFI – Cold Start Fuel Igniter

CSFS – Cold Start Fuel Solenoid

CSR – Cold Start Relay

CSS – Cold Start Solenoid

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
GPC – Glow Plug Control
GPD – Glow Plug Diagnostic
GPR – Glow Plug Relay
GVW – Gross Vehicle Weight

H₂O – 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
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
inH₂O – 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
lbf 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

O2S – Oxygen Sensor

O2SH – 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 – Transference Case

XMSN – Transmission

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Terminology

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 (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.

Air Inlet Temperature (AIT) sensor – A thermistor sensor that monitors intake air temperature.

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.

Cold Start Fuel Igniter (CSFI) – The CSFI heats the intake air by vaporizing and igniting fuel in the air inlet duct.

Cold Start Fuel Solenoid (CSFS) – As the engine is cranked, the ECM energizes the CSFS valve, introducing fuel into the CSFI, which ignites and warms the air being drawn into the engine.

Cold Start Relay (CSR) – The CSR provides voltage to the CSFI, and is controlled by the ECM.

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. 1hp = 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).

Hydrocarbon Injector – Injects fuel into the exhaust system to increase temperature of the exhaust gases.

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.

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 through 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 (NO_x) – Nitrogen oxides formed by a reaction between nitrogen and oxygen at high temperatures.

Oxygen Sensor (O2S) – 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 TakeOff (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 (KOEO)**

Barometric pressure (500 ft. above sea level)	99 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) / 0.5 V
Fuel delivery pressure	0 kPa (0 psi) / 0.5 V
Intake manifold pressure	0 kPa (0 psi) / 0.72 V
Diesel particulate filter differential pressure	0 kPa (0 psi) / 0.68 V
Engine oil pressure	0 kPa (0 psi) / 0.5 V
Accelerator pedal position sensor (at idle)	APP1 – 1.10 V / 0 %, APP2 – 0.54 V / 0 %
Accelerator pedal position sensor (depressed to floor)	APP1 – 4.22 V / 99 %, APP2 – 2.10 V / 99 %
Exhaust gas recirculation valve position	4.54 %
Engine throttle valve position	5.6 %

Engine Cranking

Battery voltage (min. based on ECM dropout)	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.)	207 kPa (30 psi) / 1.15 V
Fuel rail pressure (min. before DTC is set)	± 20 MPa (2900 psi) from set point
Fuel rail pressure (min. to start engine)	26 MPa (3771 psi) / 1 V
Turbocharger 1 turbine outlet pressure	< 34 kPa (< 5 psi) / 0.7 V
Diesel particulate filter differential pressure	0 kPa (0 psi) / 0.68 V
Fuel dead head test pressure	896 - 1303 kPa (130 - 189 psi)
High-pressure pump fuel return pressure	90 kPa (13 psi)
Fuel pump inlet restriction (max.)	483 mmHg (19 inHg)
High-pressure pump inlet pressure	207 kPa (30 psi)
Exhaust gas recirculation valve	4.42 %

Low Idle, no load, stabilized engine operating temperature

Fuel delivery pressure (min.)	482 kPa (70 psi) / 1.8 V
Fuel delivery pressure (max.)	896 kPa (130 psi) / 3.2 V
Engine speed	600 - 650 rpm
Intake manifold pressure	< 21 kPa (< 3 psi) / 0.7 V
Turbocharger 1 turbine outlet pressure	< 34 kPa (< 5 psi) / 0.7 V
Fuel pump inlet restriction (max.)	483 mmHg (19 inHg)
High-pressure pump inlet pressure	482 - 896 kPa (70 - 130 psi)
High-pressure fuel return flow	52 ml
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 temperature	96°C (205°F) / 0.44 V
Intake air temperature 2 (boost)	59°C (139°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	76°C (168°F) / 0.7 V
Intake manifold air temperature (max. before DTC is set)	135°C (275°F) / 0.47 V
Fuel rail pressure	85495 kPa (12400 psi) / 1.9 V
Engine oil pressure (min. with gauge)	150 kPa (21.765 psi) / 1.5 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 inH ₂ O)
Fuel delivery pressure (min.)	482 kPa (70 psi) / 1.8 V
Fuel delivery pressure (max.)	896 kPa (130 psi) / 3.2 V
Engine speed	1550 - 2200 rpm
Intake manifold pressure	90 - 110 kPa (13 - 16 psi) / 0.94 V
Turbocharger 1 turbine outlet pressure	< 34 kPa (< 5 psi) / 0.7 V
Fuel pump inlet restriction	483 mmHg (19 inHg)
Fuel rail pressure	211 MPa (21465 psi) / 2.94 V
Engine oil pressure (min. with gauge)	630 kPa (91.4 psi) / 4.7 V
Diesel particulate filter differential pressure (max. before DTC is set)	35 kPa (5 psi) / 1.9 V

Full load, rated speed on dynamometer, stabilized engine operating temperature

Air cleaner restriction (max.)	3.3 kPa (13.4 inH ₂ O)
Fuel rail pressure	220 MPa (31900 psi) / 4.1 V
Fuel delivery pressure (min.)	482 kPa (70 psi) / 1.3 V
Fuel delivery pressure (max.)	896 kPa (130 psi) / 3.2 V
Engine speed	1550 - 2200 rpm
Intake manifold pressure	276 kPa (40 psi)
Turbocharger 1 turbine outlet pressure	< 34 kPa (< 5 psi) / 0.7 V
Fuel pump inlet restriction (max. with gauge)	483 mmHg (19 inHg)
Water temperature differential across radiator (top and bottom)	9°C (16°F)
Engine oil pressure (min. with gauge)	500 kPa (72 psi) / 3.9 V
Engine oil temperature (max.)	98°C (208°F) / 0.41 V
Exhaust back pressure (max)	35 kPa (5 psi)
Diesel particulate filter differential pressure (max. before DTC is set)	35 kPa (5 psi) / 1.9 V

Component Specifications**Temperature Sensors (Engine Coolant Temperature 1 [ECT1], Engine Coolant Temperature 2 [ECT2], Engine Oil Temperature [EOT], Intake Manifold Temperature [IMT])**

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 / 19400 Ω
Temperature at 65°C (150°F)	3.9 V / 7100 Ω
Temperature at 93°C (200°F)	3.4 V / 4300 Ω
Temperature at 204°C (400°F)	1.6 V / 960 Ω
Temperature at 482°C (900°F)	0.34 V / 146 Ω

Other Components - Temperature at 20°C (68°F)

Camshaft Position (CMP) sensor	860 $\Omega \pm 10\%$
Crankshaft Position (CKP) sensor	860 $\Omega \pm 10\%$
Coolant Mixer Valve (CMV)	5.45 - 6.00 Ω
Coolant Flow Valve (CFV)	5.45 - 6.00 Ω
Cold Start Fuel Solenoid (CSFS)	8 $\Omega \pm 1\%$
Turbocharger Wastegate Control (TC2WC) solenoids	9.5 $\Omega \pm 10\%$

NOTE: All actuator tests were done with percentage set at 45 percent.

Actuator Output State

Exhaust Gas Recirculation (EGR) valve control	Before Test – 4.6 %
	After Test – 45.7 %
Exhaust Gas Recirculation Position (EGRP)	Before Test – 4.6 %
	After Test – 45.5 %
Engine Throttle Valve (ETV) control	Before Test – 4.6 %
	After Test – 44.9 %
Engine Throttle Valve (ETV) position	Before Test – 5.6 %
	After Test – 45.6 %
Turbocharger 2 Wastegate Control (TC2WC) solenoid	Before Test – 100 %
	After Test – 4.8 %

Cold Start Assist System

Cold start fuel igniter current draw	20 A
Cold start fuel solenoid fuel supply pressure	69 kPa (10 psi)
Cold start fuel igniter fuel supply pressure	69 kPa (10 psi)

Crankcase Pressure

High idle, no load – crankcase blow by flow	0.12 - 0.15 kPa (0.5 - 0.6 inH ₂ O)

TC2WC Rod Extension

Full travel	13 mm

MaxxForce® 15 (15.21L)**435 hp / Multi-torque @ 1700 rpm**

International® MaxxForce® 15 435 hp @ 1700 rpm

50 state 2010 Model Year (MY)

Engine model A435MT

Engine Family Rating Code (EFRC)

Injection timing Nonadjustable

High idle speed – manual transmission 2000 rpm

High idle speed – automatic transmission TBD

Low idle speed 600 - 750 rpm

Full load on chassis dynamometer or highway, stabilized engine operating temperature

Intake manifold pressure (gauge) Peak torque – TBD

Rated speed – TBD

450 hp / Multi-torque @ 1700 rpm

International® MaxxForce® 15 450 hp @ 1700 rpm

50 state 2010 Model Year (MY)

Engine model A450MT

Engine Family Rating Code (EFRC)

Injection timing Nonadjustable

High idle speed – manual transmission 2000 rpm

High idle speed – automatic transmission TBD

Low idle speed 600 - 750 rpm

Full load on chassis dynamometer or highway, stabilized engine operating temperature

Intake manifold pressure (gauge) Peak torque – 213 kPa (31 psi)

Rated speed – 303 kPa (44 psi)

450 hp / 1550 ft-lb @ 1700 rpm

International® MaxxForce® 15 450 hp @ 1700 rpm / 1550 ft-lb @ 1700 rpm

50 state 2010 Model Year (MY)

Engine model A450

Engine Family Rating Code (EFRC)

Injection timing Nonadjustable

High idle speed – manual transmission 2000 rpm and 2200 rpm

High idle speed – automatic transmission 2200 rpm

Low idle speed 600 - 750 rpm

Full load on chassis dynamometer or highway, stabilized engine operating temperature

Intake manifold pressure (gauge) Peak torque – TBD

Rated speed – TBD

450 hp / 1750 ft-lb @ 1700 rpm

International® MaxxForce® 15 450 hp @ 1700 rpm / 1750 ft-lb @ 1700 rpm

50 state 2010 Model Year (MY)

Engine model A450HT

Engine Family Rating Code (EFRC)

Injection timing Nonadjustable

High idle speed – manual transmission TBD

High idle speed – automatic transmission 2200 rpm

Low idle speed 600 - 750 rpm

Full load on chassis dynamometer or highway, stabilized engine operating temperature

Intake manifold pressure (gauge) Peak torque – TBD

Rated speed – TBD

500 hp / Multi-torque @ 1700 rpm

International® MaxxForce® 15 500 hp @ 1700 rpm

50 state 2010 Model Year (MY)

Engine model A500MT

Engine Family Rating Code (EFRC)

Injection timing Nonadjustable

High idle speed – manual transmission 2000 rpm

High idle speed – automatic transmission TBD

Low idle speed 600 - 750 rpm

Full load on chassis dynamometer or highway, stabilized engine operating temperature

Intake manifold pressure (gauge) Peak torque – 228 kPa (33 psi)

Rated speed – 303 kPa (44 psi)

500 hp / 1650 ft-lb @ 1700 rpm

International® MaxxForce® 15 500 hp @ 1700 rpm / 1650 ft-lb @ 1700 rpm

50 state 2010 Model Year (MY)

Engine model A500

Engine Family Rating Code (EFRC)

Injection timing Nonadjustable

High idle speed – manual transmission 2000 and 2200 rpm

High idle speed – automatic transmission 2200 rpm

Low idle speed 600 - 750 rpm

Full load on chassis dynamometer or highway, stabilized engine operating temperature

Intake manifold pressure (gauge) Peak torque – 228 kPa (33 psi)

Rated speed – 303 kPa (44 psi)

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Signal Values

NOTE: Voltage measurements were taken with the ignition Key ON, Engine OFF (KOEO) and the breakout connected between the Engine Control Module (ECM) and engine harness. See "Appendix A: Performance Specifications" (page 423) for actuator output voltages, sensor values, and component specifications in a wide 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	0.05 V
C2-13	AES	Auxiliary Engine Switch	N/A
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	1.11 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+
C2-33	BNO	Brake On/Off	N/A
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	4.66 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
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	1.18 V
C2-55	APP2	Accelerator Pedal Position 2	0 V

NOTE: Voltage measurements were taken with the ignition Key ON, Engine OFF (KOEO) and the breakout connected between the Engine Control Module (ECM) and engine harness. See "Appendix A: Performance Specifications" (page 423) for actuator output voltages, sensor values, and component specifications in a wide 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
C1-10	SIG GND	Signal Ground	0 V
C1-11	SIG GND	Signal Ground	0 V
C1-12	DPFDP	DPF Differential Pressure	0.74 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	0.07 - 11.79 V
C1-19	TIMER	Stand-Alone Real Timer	B+
C1-21	MAF GND	Mass Air Flow Ground	0.03 V
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	0.76 V
C1-26	AFTFT	AFT Fuel Temperature	3.24 V
C1-27	DPFOT	DPF Outlet Temperature	4.48 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
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	0
C1-42	ECM PWR OUT 2	ECM Power Output 2	B+
C1-44	MAF	Mass Air Flow	2.63 V
C1-46	O2SH-L	Oxygen Sensor High and Low	B+
C1-47	J1939-L	J1939 Datalink Low	2.40 V

ECM 58-pin C1 Connector			
ECM Pin	Abbreviation	Circuit Name	KOEO
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	0.03 V
C1-57	MIL	Malfunction Indicator Lamp	0.20 V

NOTE: Voltage measurements were taken with the ignition Key ON, Engine OFF (KOEO) and the breakout connected between the Engine Control Module (ECM) and engine harness. See "Appendix A: Performance Specifications" (page 423) for actuator output voltages, sensor values, and component specifications in a wide range of conditions.

ECM 96-pin E1 Connector			
ECM Pin	Abbreviation	Circuit Name	KOEO
E1-02	TC2WC	Turbocharger 2 Wastegate Control	B+
E1-03	CSFS	Cold Start Fuel Solenoid	B+
E1-05	ECB 2 12V	Engine Compression Brake 2 12V	B+
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	2.22 V
E1-14	ECT1	Engine Coolant Temperature 1	2.33 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
E1-24	ECM PWR OUT 3	ECM Power Output 3	B+
E1-25	FPCV 12V	Fuel Pressure Control Valve 12V	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+
E1-34	FRP	Fuel Rail Pressure	0.54 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
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

ECM 96-pin E1 Connector			
ECM Pin	Abbreviation	Circuit Name	KOEO
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	ECB2	Engine Compression Brake 2	TBD
E1-48	CMV	Coolant Mixer Valve	TBD
E1-49	ECB1	Engine Compression Brake 1	TBD
E1-50	ECM PWR OUT 2	ECM Power Output 2	TBD
E1-52	TC1WC	Turbocharger 1 Wastegate Control	TBD
E1-53	AFTFD-H	AFT Fuel Doser High	1.30 V
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
E1-60	ECP	Engine Coolant Pressure	0.90 V
E1-61	TC1TOP	Turbocharger 1 Turbine Outlet Pressure	0.94 V
E1-63	SIG GND	Signal Ground	0 V
E1-66	CCPS	Crankcase Pressure Sensor	2.55 V
E1-67	CSRD	Cold Start Relay Diagnostic	6.05 V
E1-68	SIG GND	Signal Ground	0 V
E1-70	SHD GND	Shield Ground	0 V
E1-71	ECT2	Engine Coolant Temperature 2	2.29 V
E1-72	CSRC	Cold Start Relay Control	0.59 V
E1-73	FPCV	Fuel Pressure Control Valve	8.90 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	EGRC	Exhaust Gas Recirculation Control	7.45 V
E1-78	SIG GND	Signal Ground	0 V
E1-79	TC2CIP	Turbocharger 2 Compression Inlet Pressure	1.09 V
E1-81	VREF5	Voltage Reference 5	5.00 V
E1-82	VREF5	Voltage Reference 5	5.00 V
E1-83	SIG GND	Signal Ground	0 V
E1-86	VREF2	Voltage Reference 2	5.0 V

ECM 96-pin E1 Connector			
ECM Pin	Abbreviation	Circuit Name	KOEO
E1-87	SIG GND	Signal Ground	0 V
E1-88	VREF6	Voltage Reference 6	5.00 V
E1-89	VREF3	Voltage Reference 3	5.0 V
E1-90	VREF3	Voltage Reference 3	5.0 V
E1-93	VREF5	Voltage Reference 5	5.0 V
E1-94	SIG GND	Signal Ground	0 V
E1-95	EGRT	EGR Temperature	4.66 V
E1-96	CSRE	Cold Start Relay Enable	1.17 V - B+

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Description

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.

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