DIAGNOSTIC MANUAL

2010 MaxxForce® DT, 9, and 10 Engines

Navistar, Inc.

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Foreword

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

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

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

Technical Service Literature	
1172040	MaxxForce® DT, 9, and 10 *Engine Operation and Maintenance Manual*
0000001835	MaxxForce® DT, 9, and 10 *Service Manual*
0000001624	MaxxForce® DT, 9, and 10 *Diagnostic Manual*
0000003221	MaxxForce® DT, 9, and 10 *Electronic Control Systems Form*

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

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

Service Diagnosis

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

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

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

Prerequisites for Effective Diagnosis

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

Technical Service Literature required for Effective Diagnosis

- *Engine Service Manual*
- *Engine Diagnostic Manual*
- 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 30 psi (207 kPa).
- Limit shop air pressure to 30 psi (207 kPa).
- 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

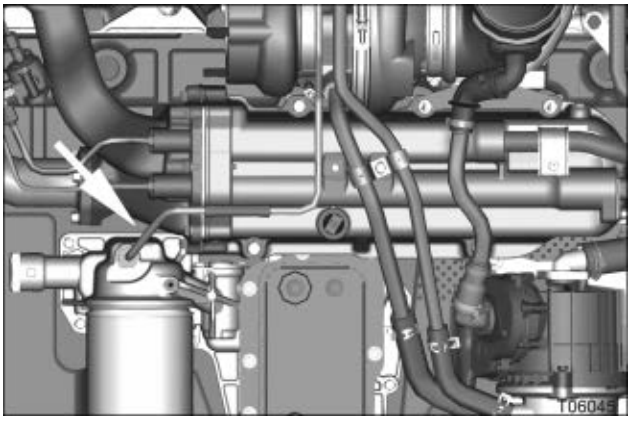


Figure 1 Engine serial number

The engine serial number is in two locations:

- Stamped on the right side of the crankcase, just above the oil filter header
- On the engine emission label on the valve cover

Engine Serial Number Examples

MaxxForce® DT: 466HM2UXXXXXXX

MaxxForce® 9 and 10: 570HM2UXXXXXXX

Engine Serial Number Codes

466 – Engine displacement
570 – Engine displacement
H – Diesel, turbocharged, Charge Air Cooler (CAC) and electronically controlled
M2 – Motor truck
U – United States
7 digit suffix – Engine serial number sequence beginning with 3300001

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 attached on top of the valve cover. 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, and reserved fields for specific applications

Engine Accessory Labels

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

- Air compressor
- Air conditioning compressor
- Alternator
- Cooling fan clutch
- Power steering pump
- Starter motor

Engine Description

MaxxForce® DT, 9, and 10 Diesel Engines	
Engine configuration	4 stroke, inline six cylinder diesel
MaxxForce® DT displacement	466 in^3 (7.6 L)
MaxxForce® 9 and 10 displacement	570 in^3 (9.3 L)
Bore (sleeve diameter)	4.59 in (116.6 mm)
Stroke	
• MaxxForce® DT	4.68 in (119 mm)
• MaxxForce® 9 and 10	5.75 in (146 mm)
Compression ratio	
• MaxxForce® DT	16.9 : 1
• MaxxForce® 9 and 10	16.5 : 1
Aspiration	Dual turbocharged and charge air cooled
Advertised brake horsepower @ rpm	See EPA exhaust emission label
Peak torque @ rpm	See EPA exhaust emission label
Engine rotation (facing flywheel)	Counterclockwise
Combustion system	Direct injection turbocharged
Fuel system	Electro-hydraulic injection
Total engine weight (oil and accessories)	
• MaxxForce® DT	1816 lbs (824 kg)
• MaxxForce® 9 and 10	1864 lbs (845 kg)
Cooling system capacity (engine only)	13.5 qts US (12.8 L)
Lube system capacity (including filter)	30 qts US (28 L)
Lube system capacity (overhaul only, with filter)	34 qts US (32 L)
Firing order	1-5-3-6-2-4

Standard Features

MaxxForce® DT, 9, and 10 diesel engines are designed for increased durability, reliability, and ease of maintenance.

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 camshaft is supported by four insert bushings pressed into the crankcase. The camshaft gear is driven from the front of the engine. A thrust flange is located between the camshaft and the drive gear. The overhead valve train includes mechanical roller lifters, push rods, rocker arms, and dual valves that open using a valve bridge.

MaxxForce® DT engines use one-piece aluminum alloy pistons. MaxxForce® 9 and 10 engines use one-piece steel pistons. All pistons have zero pin offset and centered combustion bowls; therefore, pistons can be installed safely without orientation: there is NO front-of-engine arrow or “CAMSIDE” marking on the piston crown to indicate a necessary piston direction.

The one piece crankcase uses replaceable wet cylinder sleeves that are sealed by a single crevice seal ring. Some applications include a crankcase ladder which is designed to support heavier loads and reduce engine noise.

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

A lube oil pump is mounted on the front cover and is driven by the crankshaft. Pressurized oil is supplied to engine components and the high-pressure injection system. All MaxxForce® DT, 9, and 10 engines use an engine oil cooler and spin-on engine oil filter.

The coolant supply housing serves as the mounting bracket for the refrigerant compressor. Mounting capabilities for a dual refrigerant compressor are available as an option. The pad mounting design of the alternator and refrigerant compressor brackets provide easy removal and improved durability.

The electric low-pressure fuel supply pump draws fuel from the fuel tank through the fuel filter assembly. The assembly includes a strainer, filter, drain valve, Water in Fuel (WIF) sensor, and Fuel Delivery Pressure (FDP) sensor. If equipped, an optional fuel heater element is installed in the fuel filter assembly. Conditioned fuel is pumped through the intake manifold and cylinder head to the fuel injectors.

The WIF sensor detects water in the fuel system. When water reaches the level of the sensor located in the fuel filter assembly, the instrument panel's amber FUEL FILTER lamp will illuminate. The collected water must be removed immediately. Water is drained by opening the drain valve on the fuel filter assembly.

The fuel injection system is electro-hydraulic. The system includes an under-valve-cover high-pressure oil manifold, fuel injectors, and a high-pressure oil pump. The injectors are installed in the cylinder head, under the high-pressure oil manifold.

MaxxForce® DT, 9, and 10 engines use dual turbochargers with an air-to-air High Pressure Charge Air Cooler (HPCAC) after the second stage. An interstage cooler is used after the first stage for applications with 245 hp and above.

The Intake Air Heater (IAH) system warms the incoming air to aid cold engine starting and to reduce white smoke and engine noise. The IAH system will initially illuminate the WAIT TO START lamp located on the instrument panel. When the lamp turns off, the engine can be started.

The Exhaust Gas Recirculation (EGR) system circulates cooled exhaust into the intake air stream in the intake manifold. This cools the combustion process and reduces the formation of NO_x engine emissions.

A closed crankcase breather system uses an engine mounted oil separator to return oil to the crankcase and vent crankcase pressure into the intake system.

The Down Stream Injection (DSI) system aides in controlling emissions by injecting fuel into the exhaust stream. The fuel causes an exothermic reaction which increases the temperature of the exhaust gas. This increase in temperature allows for more efficient conversion of soot into ash within the Diesel Particulate Filter (DPF). Along with DSI, the Diesel Oxidation Catalyst (DOC) aids in creating the required exothermic reaction. DSI consists of the Doser Control Unit (DCU), Downstream Injection (DSI) assembly, hydrocarbon injector assembly, fuel lines, and coolant lines. The Electronic Control Module (ECM) communicates with the DCU to control the timing and quantity of fuel sprayed from the hydrocarbon injector assembly. The ECM signals the exhaust brake valve assembly to control the position of the exhaust back pressure valve to increase or decrease the exhaust gas back pressure and temperature to allow the DOC and DPF to function efficiently.

The exhaust back pressure valve acts as an aftertreatment device to manage exhaust temperature. The resulting rise in back pressure, increases exhaust temperature.

Optional Features

Optional features include the following:

- Air compressor
- Hydraulic pump
- Engine brake
- Exhaust brake

An air compressor is available for applications that require air brakes or air suspension.

A hydraulic power steering pump can be used with or without the air compressor.

Engine brake and exhaust brake systems are available for applications that could benefit from added speed reduction capability.

Optional Cold Climate Features

Optional cold climate features include the following:

- Oil pan heater
- Coolant heater
- Fuel heater

All three heaters use an electric element to warm engine fluids in cold weather.

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

The coolant heater warms engine coolant surrounding the cylinders. Warmed engine coolant aids in cold engine start-up and performance.

The fuel heater is installed in the fuel filter assembly and warms the supply fuel. Warmed supply fuel prevents waxing, and improves performance and fuel economy during cold weather start-up.

Chassis Mounted Features

A Charge Air Cooler (CAC) is an air-to-air heat exchanger, which increases the density of the air charge.

The Aftertreatment System, part of the larger exhaust system, processes engine exhaust to meet tailpipe emission requirements.

- The Pre-Diesel Oxidation Catalyst (PDOC) aids in creating the required exothermic reaction before the exhaust gas enters the Diesel Oxidation Catalyst (DOC).
- The Diesel Oxidation Catalyst (DOC) oxidizes carbon monoxide, hydrocarbons, and small amounts of nitrogen oxide in the exhaust stream.
- The Diesel Particulate Filter (DPF) captures and oxidizes particulates in the exhaust stream and stores non-combustible ash.

Engine Component Locations (245 hp and above)

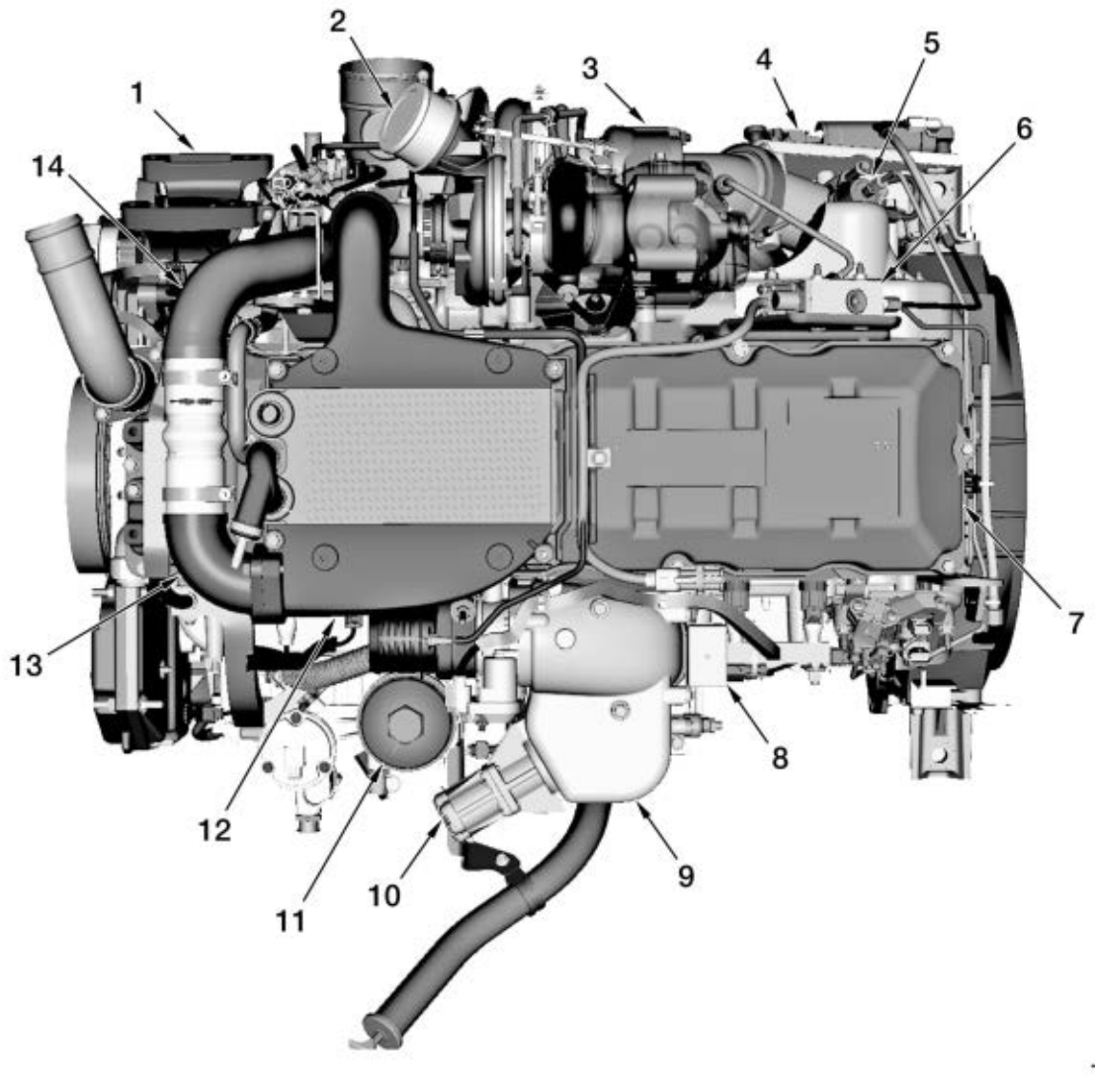


Figure 3 Component location – top

1. Alternator bracket
2. High-pressure turbocharger outlet
3. Low-pressure turbocharger
4. Exhaust back pressure valve
5. Hydrocarbon injector assembly
6. Exhaust brake valve assembly
7. Valve cover
8. Intake Air Heater (IAH) relay assembly
9. Air and EGR mixer duct
10. EGR valve
11. Fuel filter cap
12. Interstage cooler (245 hp and above)
13. Interstage cooler inlet elbow (245 hp and above)
14. Interstage cooler inlet duct (245 hp and above)

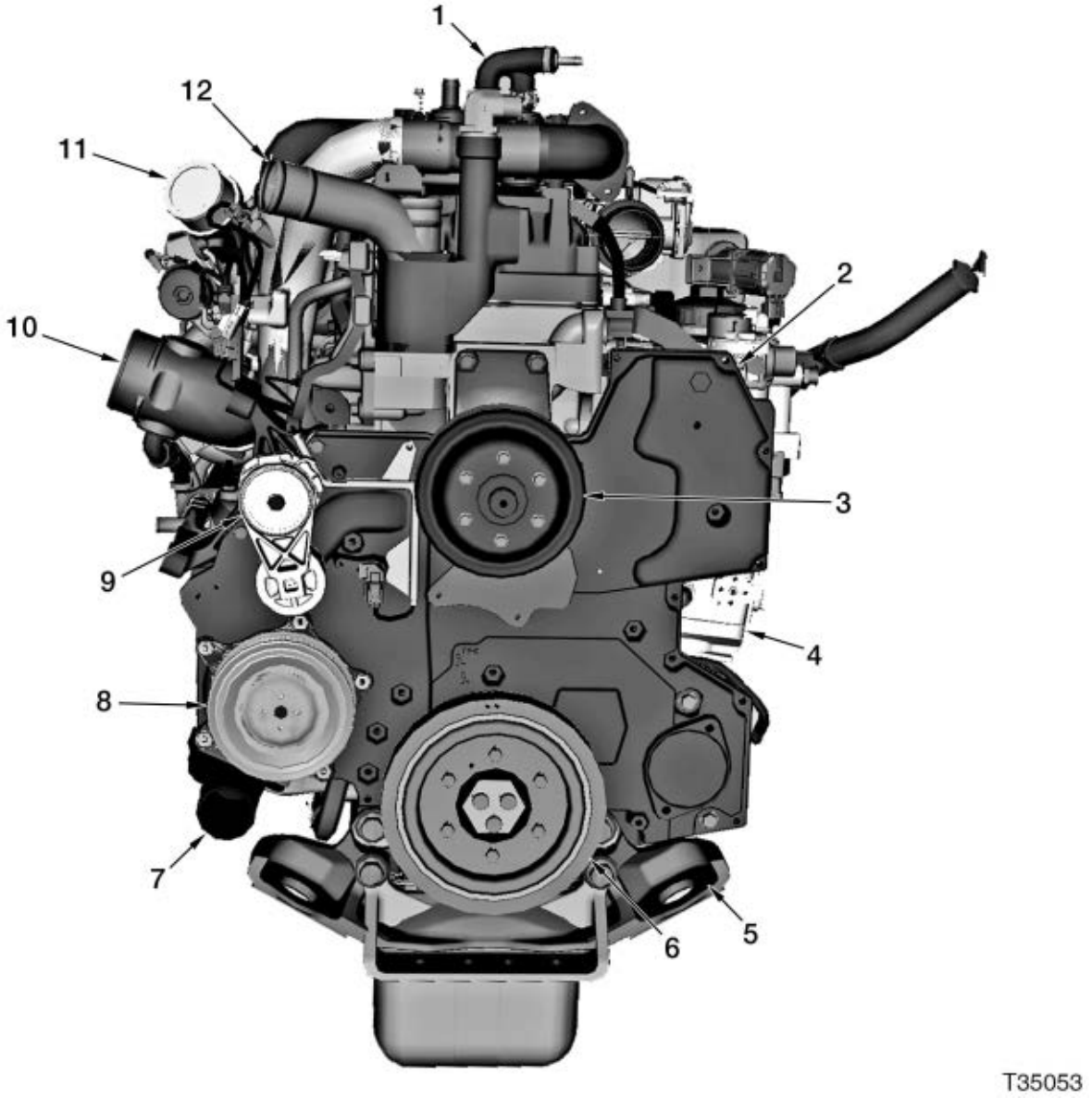


Figure 4 Component location – front

1. Deaeration hose elbow
2. Front cover
3. Fan drive pulley
4. Air compressor assembly
5. Front engine mounting bracket
6. Vibration damper assembly
7. Water inlet elbow
8. Water pump pulley
9. Automatic belt tensioner
10. Turbo air inlet duct
11. High-pressure turbocharger outlet
12. Water outlet tube assembly

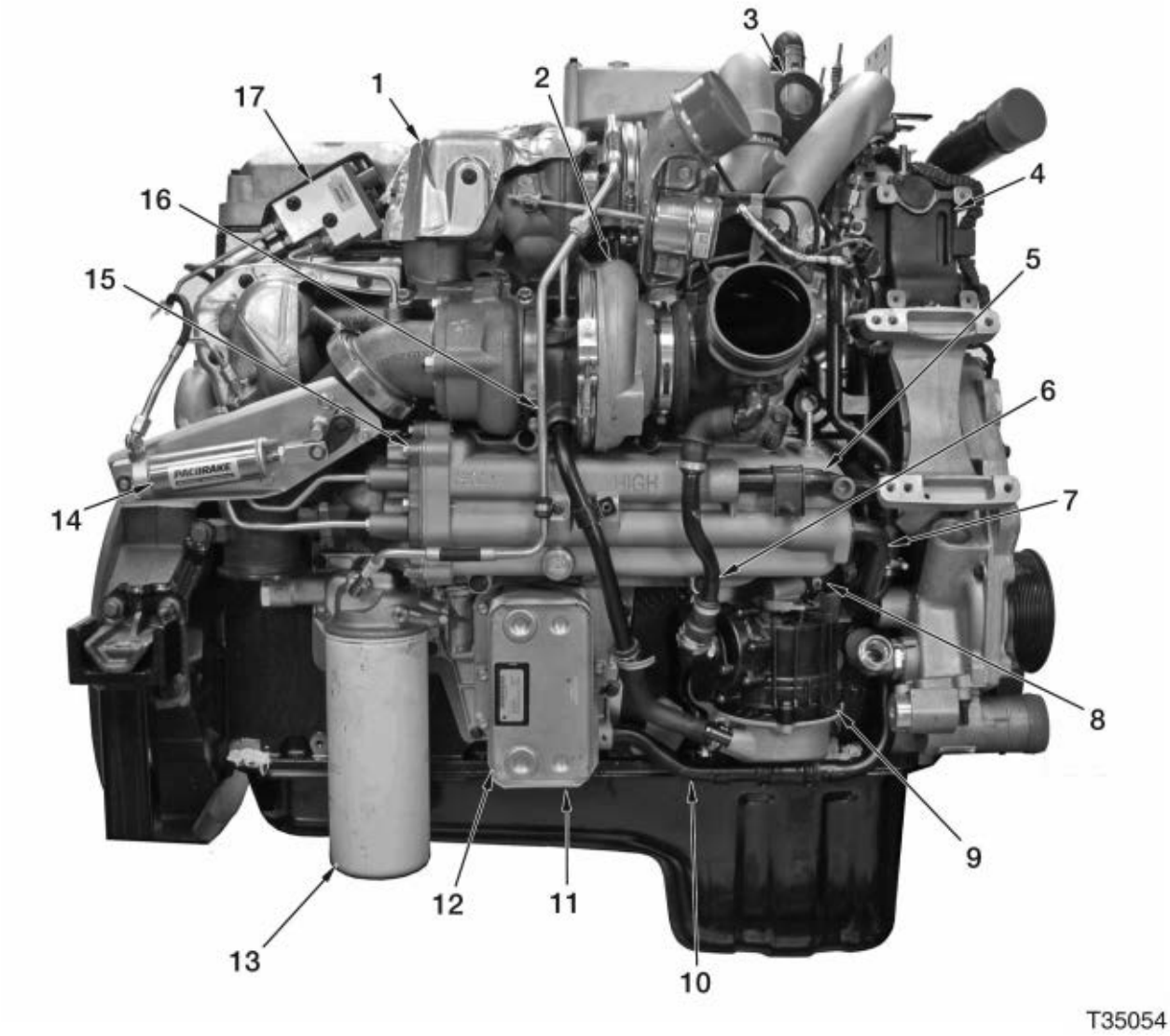


Figure 5 Component location – exhaust side

1. Turbocharger heat shield
2. Dual stage turbocharger assembly
3. Lifting eye
4. Coolant supply housing (refrigerant compressor mount)
5. Coolant supply tube assembly (high fin density EGR cooler)
6. Breather outlet tube
7. Coolant return tube assembly (high fin density EGR cooler)
8. Breather inlet tube
9. Crankcase breather assembly with turbine
10. Coolant return tube
11. M16 plug assembly (coolant drain under oil cooler module)
12. Oil cooler module
13. Oil filter assembly
14. Exhaust brake actuator
15. EGR cooler assembly
16. Turbo oil supply tube assembly
17. Exhaust brake valve

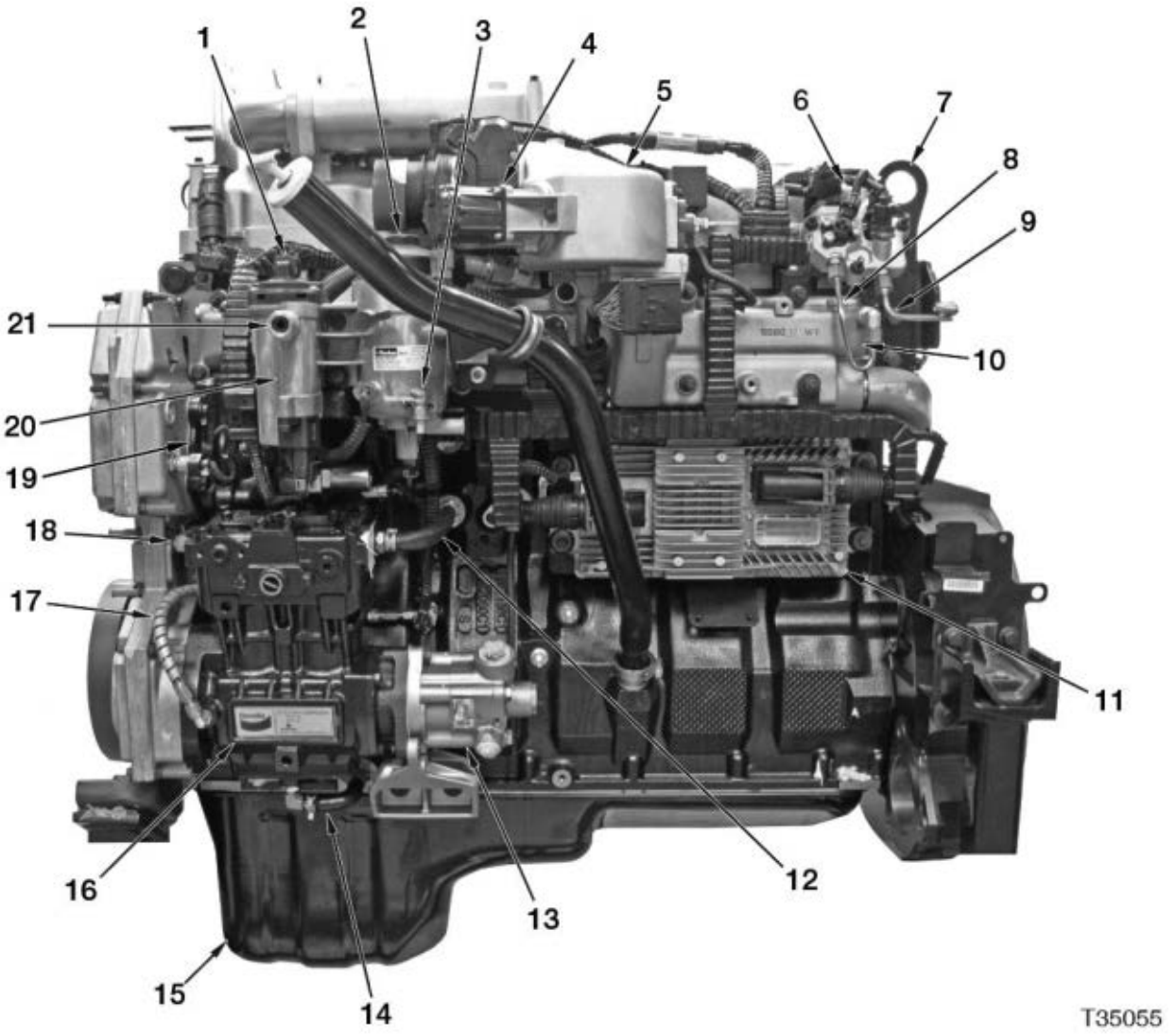


Figure 6 Component location – intake side

1. Electric fuel pump
2. Fuel filter cap
3. Water drain valve assembly
4. Exhaust Gas Recirculation (EGR) valve
5. Air and EGR mixer duct
6. Downstream Injection (DSI) assembly
7. Lifting eye
8. Downstream Injection (DSI) feed tube assembly
9. Injection unit inlet tube assembly
10. Intake manifold
11. Engine Control Module (ECM)
12. Coolant return hose (air compressor)
13. Power steering pump assembly
14. Oil drain hose (air compressor)
15. Oil pan
16. Air compressor assembly
17. Oil supply hose (air compressor)
18. Coolant supply hose (air compressor)
19. High pressure oil pump
20. Fuel filter assembly with heater
21. Electric fuel pump inlet

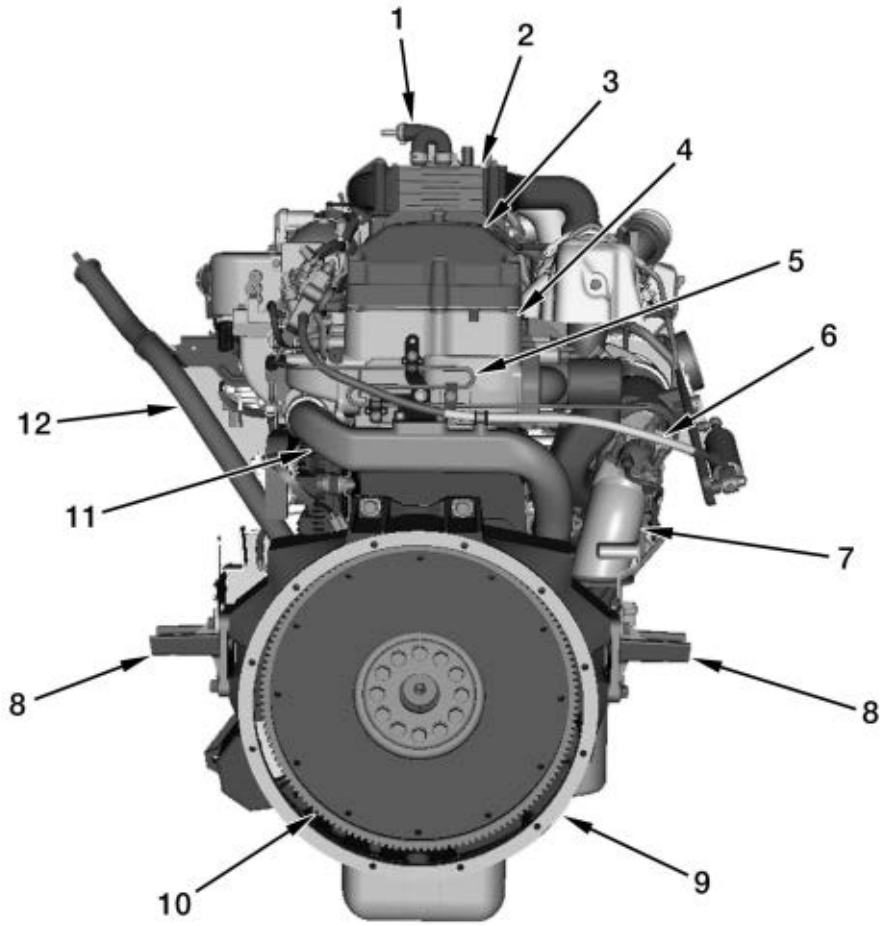


Figure 7 Component location – rear

1. Deaeration hose elbow
2. Interstage cooler (245 horsepower and above)
3. Valve cover
4. Cylinder head assembly
5. Injection unit inlet tube assembly
6. Exhaust brake valve to actuator hose
7. Exhaust pipe assembly
8. Rear engine mounting bracket (2)
9. Flywheel housing assembly
10. Flywheel
11. EGR crossover duct
12. Oil filler tube

Air Management System (AMS)

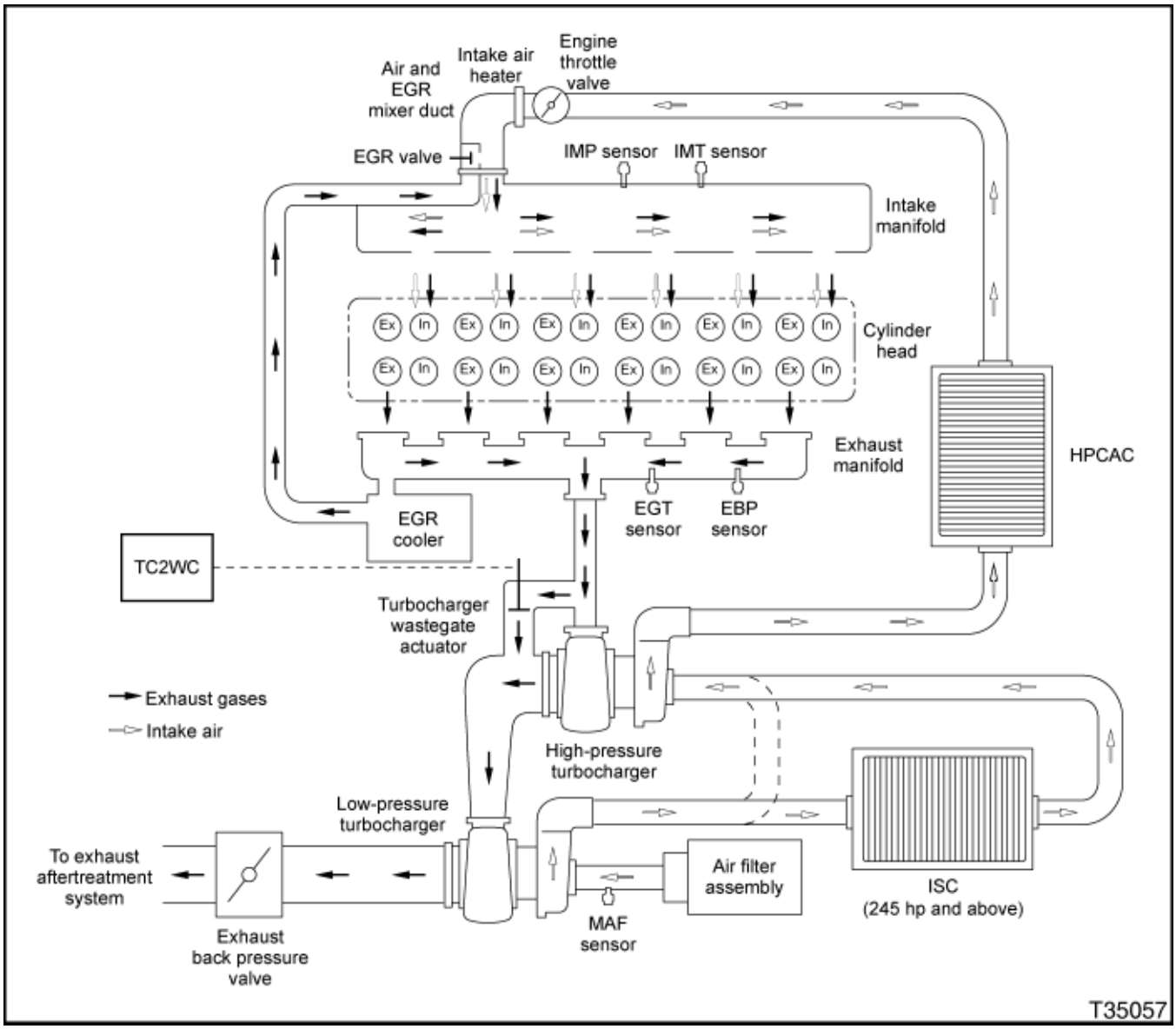


Figure 8 Air Management System (AMS)

The AMS includes the following:

- Air filter assembly
- Low-pressure turbocharger
- Interstage Cooler (ISC) (245 hp and above)
- High-pressure turbocharger
- High-pressure Charge Air Cooler (HPCAC)
- Engine Throttle Valve (ETV)

- Air and EGR mixer duct
- Exhaust and intake valves
- Exhaust Gas Recirculation (EGR) system
- Exhaust system
- Exhaust back pressure valve
- Exhaust – aftertreatment

Air Flow – Pre Combustion

Fresh air from the air filter enters the low-pressure compressor where it is compressed and directed into the ISC (245 hp and above ratings), if equipped. If not equipped with ISC, compressed air from the low-pressure compressor is piped directly to the high-pressure compressor inlet. The high-pressure turbocharger further increases the intake air pressure. The hot compressed air flows into the HPCAC where it is cooled, then through the Engine Throttle Valve (ETV) on the air and EGR mixer duct.

If the EGR valve is open, exhaust gas enters the high fin density EGR cooler from the rear of the exhaust manifold and is transferred to the intake manifold via the EGR crossover duct. The exhaust gas then passes through a port in the intake manifold to the air and EGR mixer duct where it is mixed with filtered intake air. This mixture then flows through the intake manifold and into the cylinder head.

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

Air Flow – Post Combustion

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

The exhaust back pressure valve acts as an aftertreatment device to regulate exhaust temperatures.

Exhaust gases flow from the engine through the vehicle aftertreatment system to the exhaust tail pipe.

Air Management Components

Turbochargers

MaxxForce® DT, 9, and 10 engines are equipped with an electronically controlled two stage turbocharging system. This system provides high levels of charge air pressure to improve engine performance and to help reduce emissions. Because of its ability to generate very high charge air pressure levels, and to avoid Charge Air Cooler (CAC) overloading conditions, the system is fitted with a spring loaded turbocharger wastegate.

The turbocharger wastegate is actuated by charge air pressure. The air pressure to the turbocharger wastegate actuator is controlled by the Turbocharger 2 Wastegate Control (TC2WC) valve. The TC2WC valve is controlled by Pulse Width Modulation (PWM) signals from the Electronic Control Module (ECM).

The high and low-pressure turbochargers are installed as an assembly on the exhaust manifold, on right side of engine.

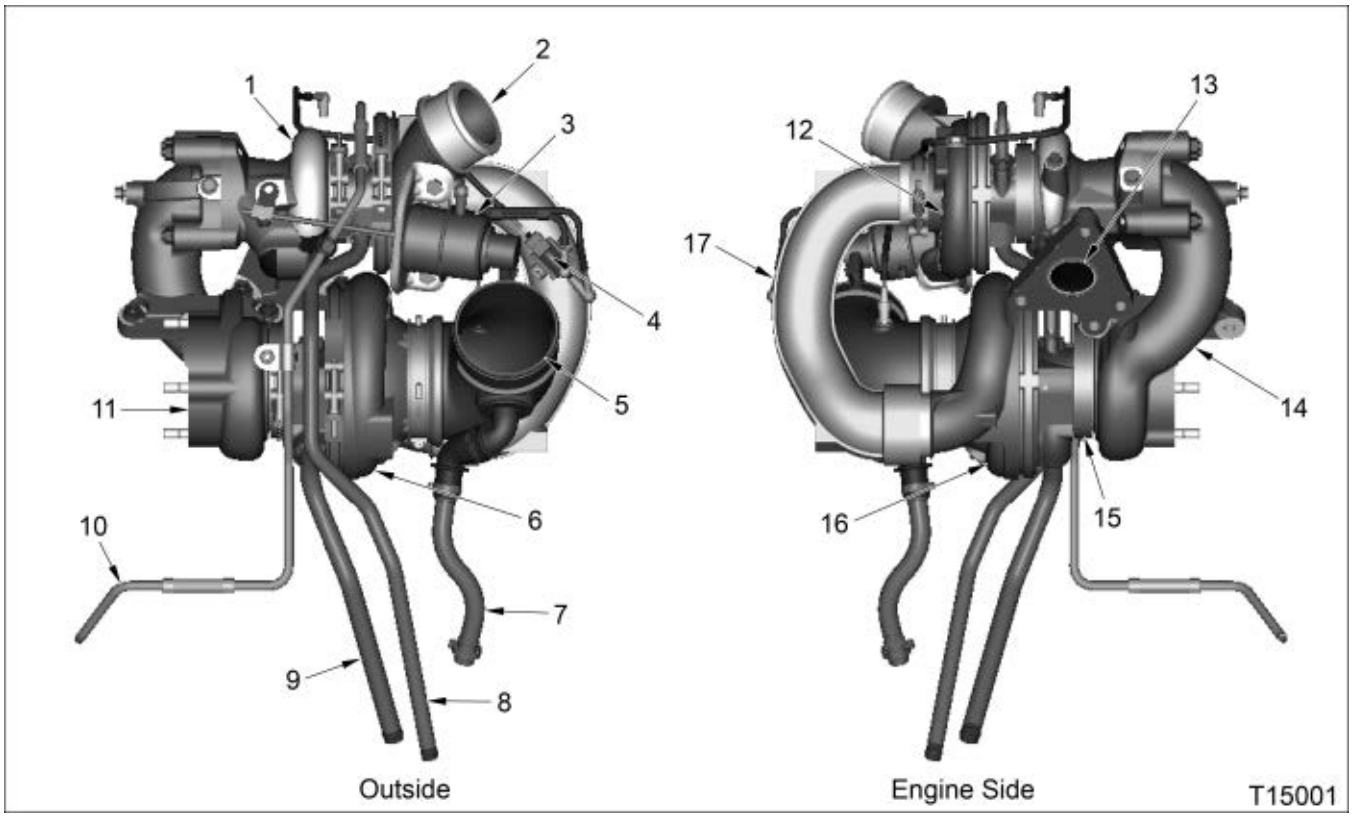


Figure 9 Low and high-pressure turbocharger components (below 245 hp shown)

1. High-pressure turbine housing
2. High-pressure turbocharger outlet
3. Turbo wastegate actuator
4. Turbocharger 2 Wastegate Control (TC2WC) valve
5. Turbo air inlet duct
6. Low-pressure compressor housing
7. Breather outlet tube
8. High-pressure turbo oil drain tube
9. Low-pressure turbo oil drain tube
10. Turbo oil supply tube assembly
11. Low-pressure turbine outlet
12. High-pressure compressor housing
13. High-pressure turbine inlet
14. Low-pressure turbine housing
15. Low-pressure bearing housing
16. Low-pressure compressor housing
17. Air crossover duct

The high-pressure turbocharger is connected directly to the exhaust manifold through the high-pressure turbine inlet. The high-pressure turbocharger is equipped with a wastegate that regulates the turbocharger boost by controlling the amount of exhaust gases that pass through the high-pressure turbine. When demand for power is low, such as during cruising speed, the turbocharger wastegate opens allowing part of the exhaust gas flow to bypass the high-pressure turbine.

The low-pressure turbine is attached directly to the output of the high-pressure turbine. The exhaust gas enters the low-pressure turbocharger through the low-pressure turbine housing and exits through the low-pressure turbine outlet.

Interstage Cooler (ISC)

The ISC is installed between the low-pressure and the high-pressure compressor housings for applications with 245 hp and above. 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 and the Engine Throttle Valve (ETV). The HPCAC air inlet is connected to the high-pressure compressor outlet and uses air-to-air to regulate the charge air temperature. The HPCAC air outlet is connected directly to the ETV body.

Turbocharger 2 Wastegate Control (TC2WC) Valve

The TC2WC valve controls the turbocharger wastegate actuator by regulating the amount of charge air pressure supplied to the wastegate actuator. The Pulse Width Modulated (PWM) signals sent to the TC2WC valve by the Electronic Control Module (ECM) are based on input signals from the Exhaust Back Pressure (EBP) sensor.

When demand for power is high, such as during acceleration, the TC2WC valve opens the wastegate which allows exhaust gas to enter the HP turbocharger in addition to the LP turbocharger. Once the vehicle reaches cruising speed, the TC2WC valve will close the wastegate and direct exhaust gas away from the HP turbocharger and only through the LP turbocharger.

Exhaust Gas Recirculation (EGR) System

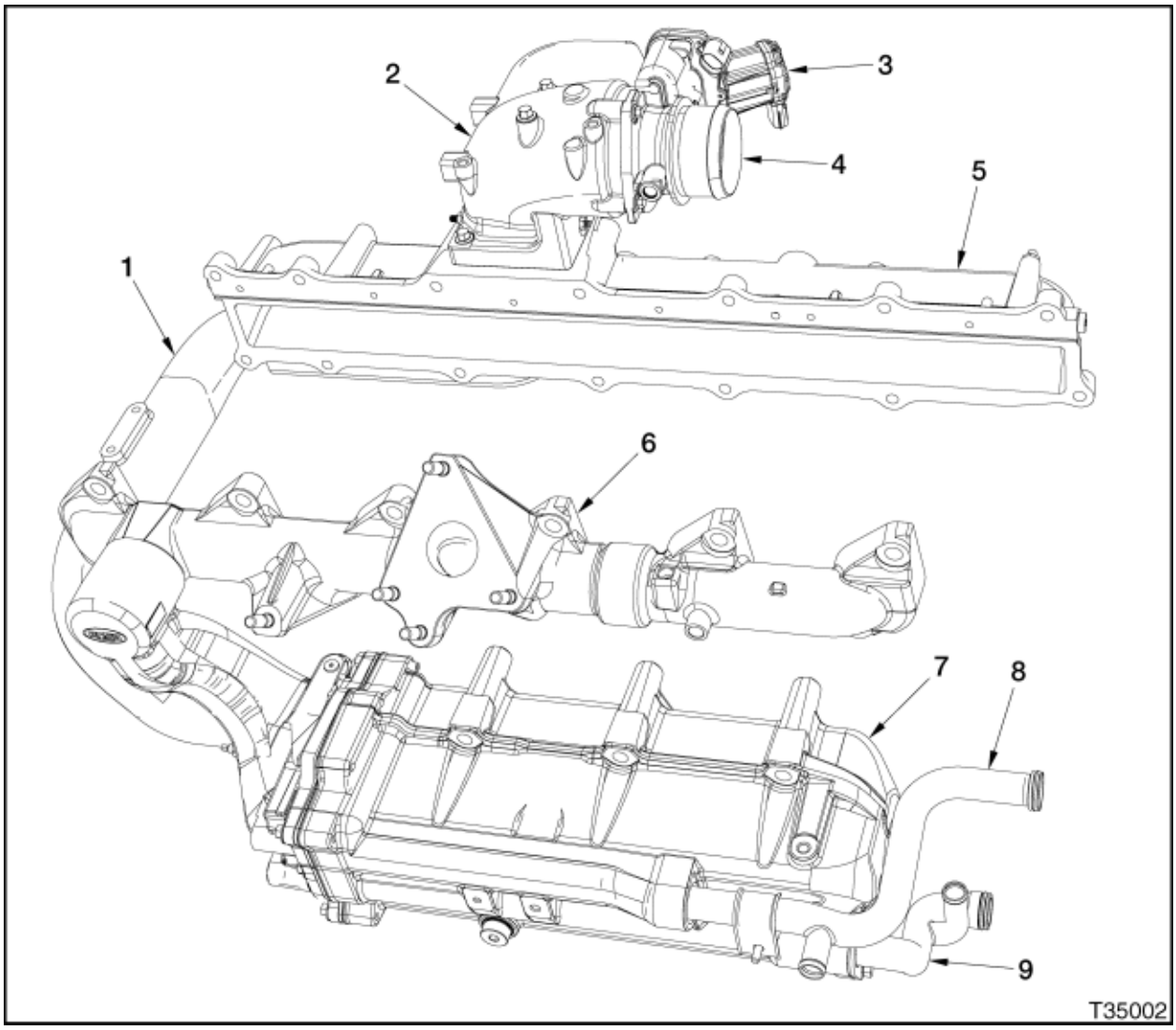


Figure 10 EGR system

1. EGR crossover duct
2. Air and EGR mixer duct assembly
3. EGR valve assembly
4. Engine throttle valve
5. Intake manifold assembly
6. Exhaust manifold assembly
7. High fin density EGR cooler assembly
8. Coolant supply tube
9. Coolant return tube

The EGR system includes the following:

- Air and EGR mixer duct assembly
- Engine throttle valve
- EGR valve assembly
- Coolant supply tube
- Coolant return tube
- EGR cooler assembly
- EGR crossover duct

The EGR system reduces Nitrogen Oxide (NO_x) engine emissions. NO_x forms during a reaction between nitrogen and oxygen at high temperatures during combustion. Combustion starts when fuel is injected into the compressed combustion chamber.

EGR Flow

When EGR is commanded, the EGR valve opens and allows exhaust gas from the exhaust manifold to flow into the EGR cooler for cooling. This cooled exhaust gas is directed through the EGR crossover duct into a port in the intake manifold and directed to the air and EGR mixer duct where it is mixed with filtered intake air.

EGR Valve

The EGR valve consists of three major components, a valve, an actuator motor, and an Integrated Circuit (IC).

The EGR valve is installed in the air and EGR mixer duct assembly on the intake side of the engine.

The EGR valve uses a DC motor to control position of the valve assembly. The motor pushes directly on the valve stem to open. The valve assembly has two poppets on a common shaft.

The IC has three hall effect position sensors to monitor valve movement.

EGR Closed Loop System

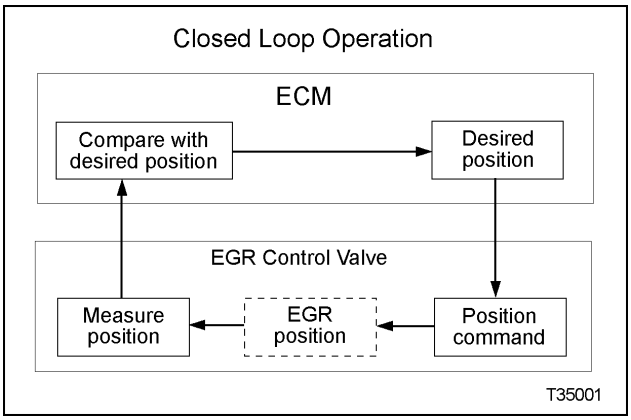


Figure 11 EGR closed loop system

The ECM commands EGR valve position based on engine speed and load conditions. The EGR control valve provides feedback to the ECM on current valve position.

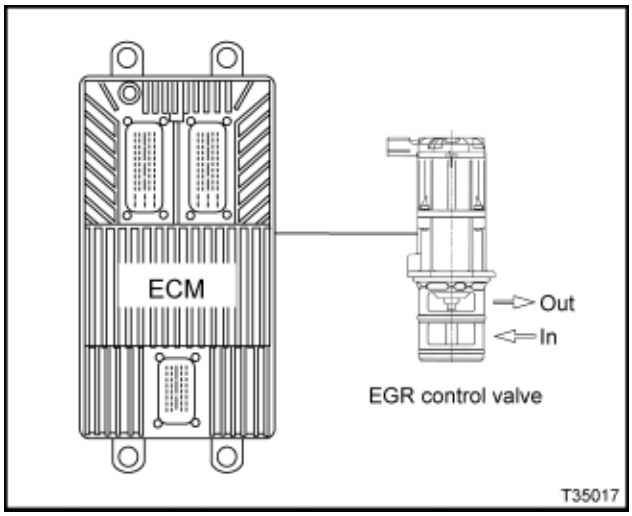


Figure 12 EGR control

Crankcase Ventilation System

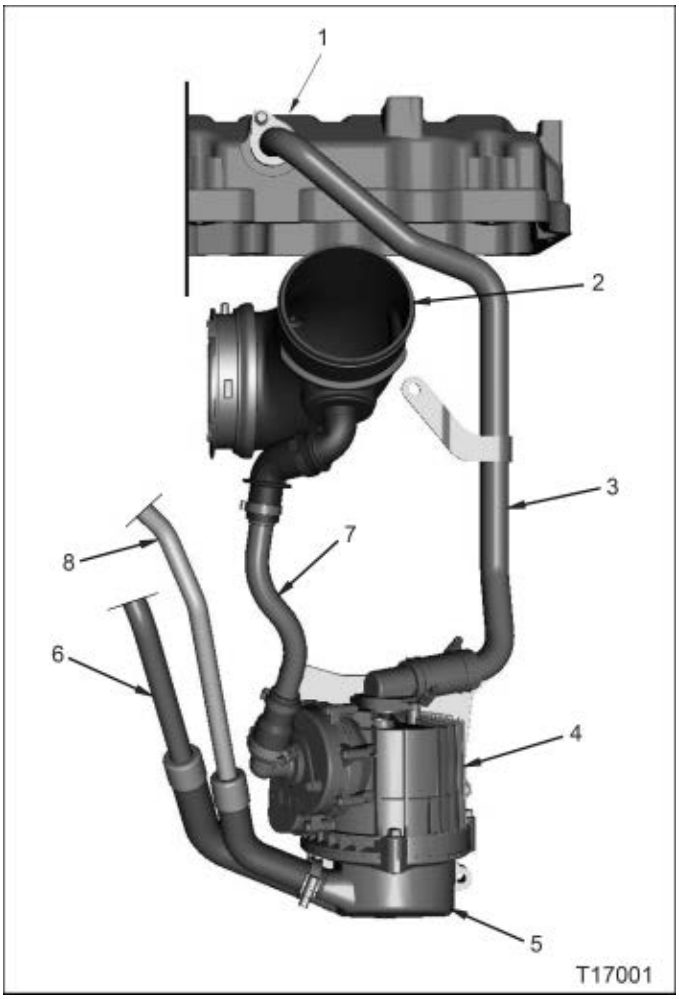


Figure 13 Crankcase ventilation system

1. Valve cover
2. Turbocharger air inlet duct
3. Crankcase breather inlet tube
4. Housing assembly (breather)
5. Housing assembly (turbine)
6. Low-pressure turbo drain tube
7. Breather outlet tube
8. High-pressure turbo drain tube

The crankcase ventilation system uses an engine mounted oil separator to return oil to the crankcase. The excess crankcase pressure is vented back into the intake system.

Oil extracted blow-by gases flow from the valve cover through the crankcase breather inlet tube into the breather housing assembly.

A high-speed centrifugal oil separator, driven by engine oil pressure, separates and directs oil to the side of housing assembly. The separated oil drains into the oil separator turbine housing, through the crankcase, and into the oil pan. The oil separator is located inside and towards the top of the housing assembly.

The turbine housing also provides oil drainage from the low-pressure and high-pressure turbochargers. The low-pressure and high-pressure turbo oil drain tubes direct turbocharger drain oil into the turbine housing. The oil drains out of the turbine housing, through the crankcase, and into the oil pan.

Blow-by gases are directed through the breather outlet tube and into the turbocharger air inlet duct.

Aftertreatment (AFT) System

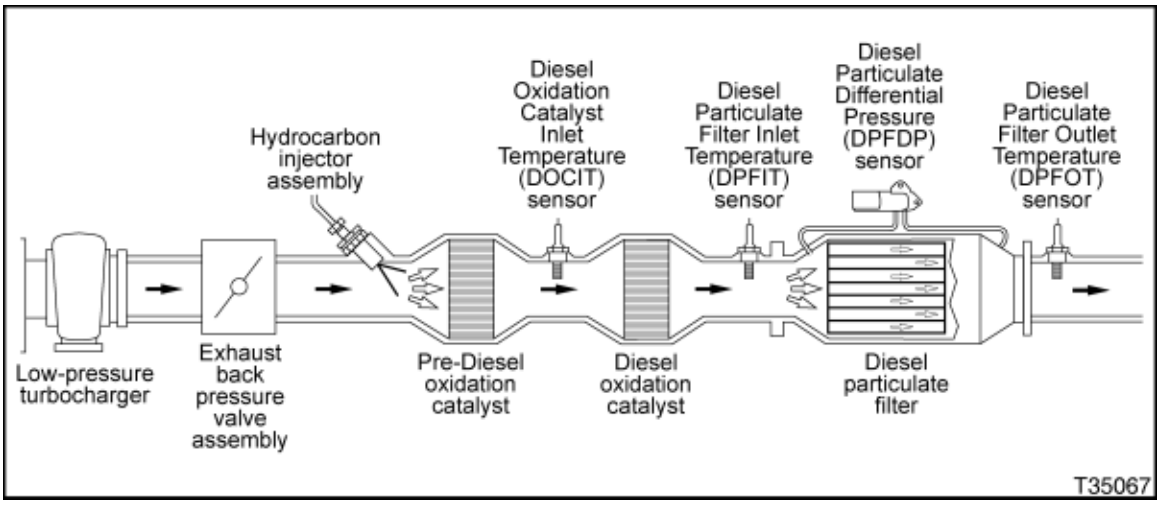


Figure 14 Aftertreatment (AFT) system

The 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.

AFT Control System

The control system performs the following functions:

- Monitors exhaust gases, the aftertreatment system, and controls engine operating parameters for emission processing and failure recognition
- Cancels regeneration in the event of catalyst or sensor failure
- Monitors exhaust pressure before and after 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 temperature or pressure. The signals are used by the control system to regulate the aftertreatment function.

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

Exhaust Back Pressure Valve

The exhaust back pressure valve also acts as an aftertreatment device to manage exhaust temperatures. The ECM will signal the exhaust back pressure valve to change the amount of air passing through the valve into the exhaust and through the DOC and DPF. The ECM interprets the increased back pressure as an increased load. In response to the increased pressure / load, the engine increases speed to meet the demand, resulting in increased exhaust temperature.

Pre-Diesel Oxidation Catalyst (PDOC)

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 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 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.

Downstream Injection System

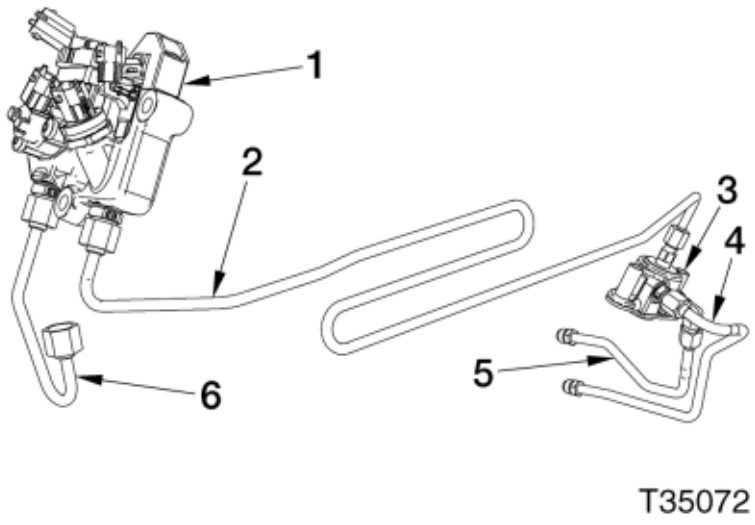


Figure 15 Aftertreatment (AFT) system

1. Downstream Injection (DSI) assembly
2. Injection unit inlet tube assembly
3. Hydrocarbon injector assembly
4. Injector coolant outlet tube
5. Injector coolant inlet tube
6. Downstream Injection (DSI) feed tube assembly

The downstream injection system includes the following:

- Doser Control Unit (DCU)
- Hydrocarbon injector assembly
- Downstream Injection (DSI) assembly
- Coolant lines
- Fuel lines

The Doser Control Unit (DCU) is mounted on the chassis of the vehicle. The DCU receives signals from the ECM and then signals the DSI assembly.

The DSI assembly is installed on the left rear of the engine above the intake manifold.

When the DCU signals the shutoff valve to open, fuel pressure increases in the upstream cavity of the DSI assembly housing. The upstream pressure sensor immediately signals the DCU that pressure is increased by available fuel. The DCU then signals the dosing valve to open, allowing a specific amount of fuel to be injected into the injector unit inlet tube assembly to the hydrocarbon injector assembly.

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

The hydrocarbon injector assembly is cooled with engine coolant from the EGR cooler assembly.

Fuel Management System

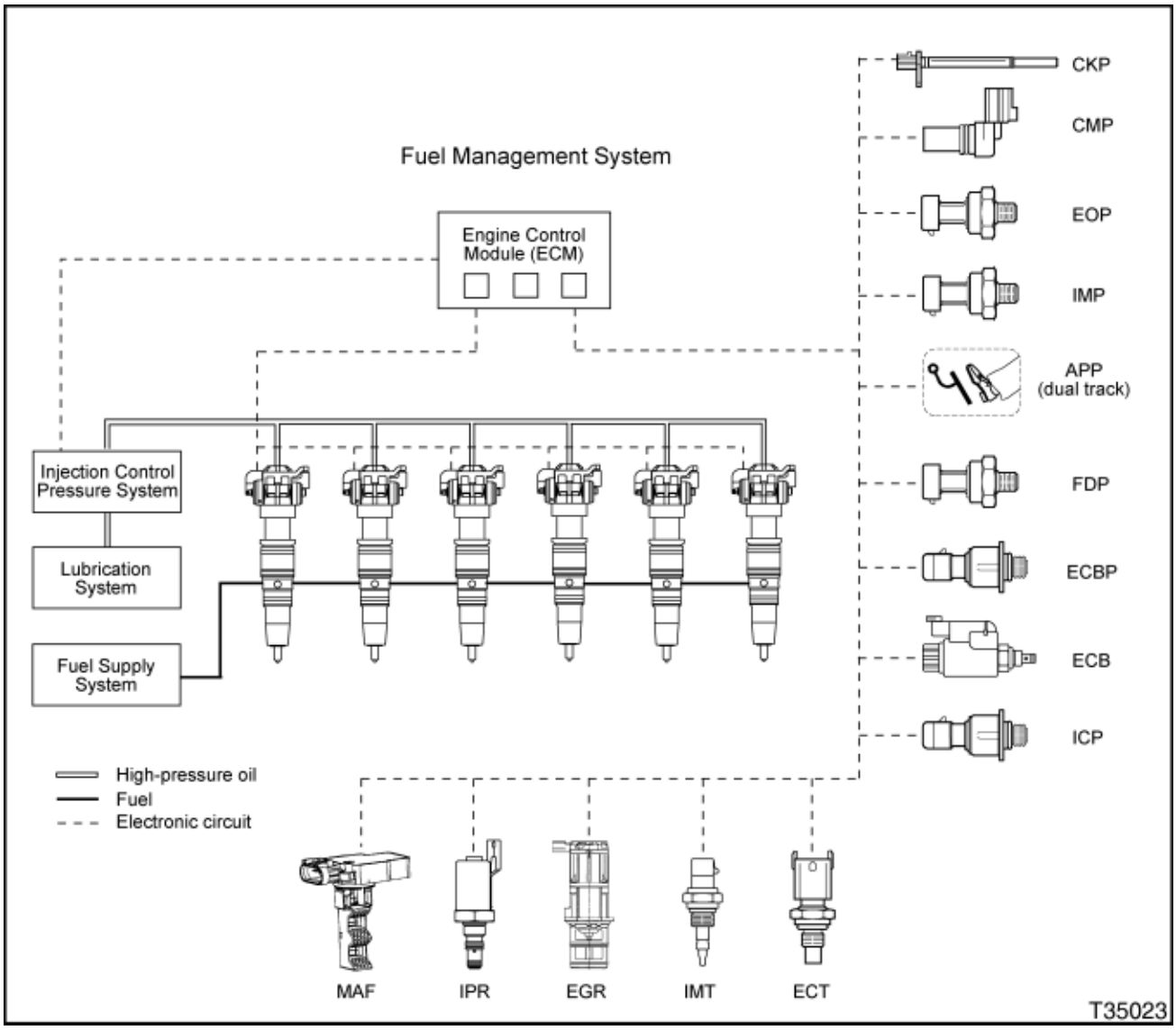


Figure 16 Fuel management system

The fuel management system includes the following:

- Lubrication system
- Injection Control Pressure (ICP) system
- Engine Compression Brake (ECB)
- Fuel supply system

- Fuel injectors
- Electronic control system

ICP System

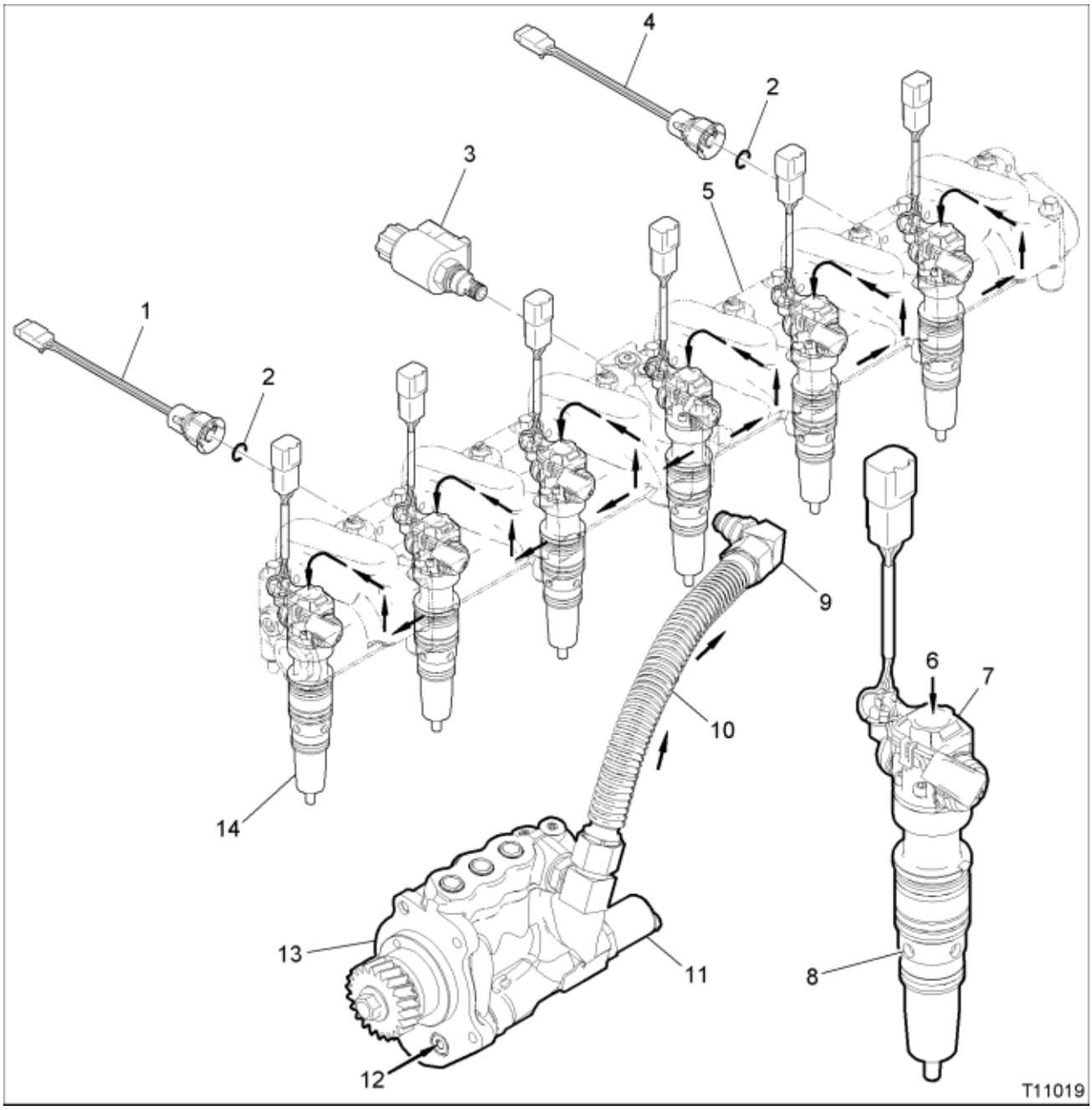


Figure 17 Injection Control Pressure (ICP) system

1. Engine Compression Brake Pressure (ECBP) sensor
2. O-ring (2)
3. Engine Compression Brake (ECB) valve
4. Injection Control Pressure (ICP) sensor
5. High-pressure oil manifold
6. Injector oil inlet from high-pressure oil manifold
7. Oil outlet (2)
8. Fuel inlet port (4)
9. 70 degree elbow
10. High-pressure oil hose
11. Injection Pressure Regulator (IPR) valve
12. Oil inlet from front cover reservoir
13. High-pressure oil pump assembly
14. Fuel injector assembly (6)

High-Pressure Oil Flow

The lubrication system supplies the oil reservoir located in the front cover. The reservoir provides oil for the high-pressure oil pump. The pump is mounted on the backside of the front cover and is gear driven by the upper idler gear.

High-pressure oil is directed to the high-pressure oil hose, cylinder head passage, and high-pressure oil manifold.

High-pressure oil is used by the fuel injectors to pressurize and inject fuel in the cylinders. This occurs when the OPEN coil for each fuel injector is energized.

Excess high-pressure oil is directed to the crankcase sump by the Injection Pressure Regulator (IPR) valve. The IPR valve is controlled by the Electronic Control Module (ECM) to maintain a desired injection control pressure.

If equipped with the optional engine brake, some high-pressure oil is directed internally to the engine brake pistons when the engine compression brake is activated. Since these two systems share a common gallery, a problem with the engine compression brake system can adversely affect injection control pressure and vise versa.

ICP Closed Loop System

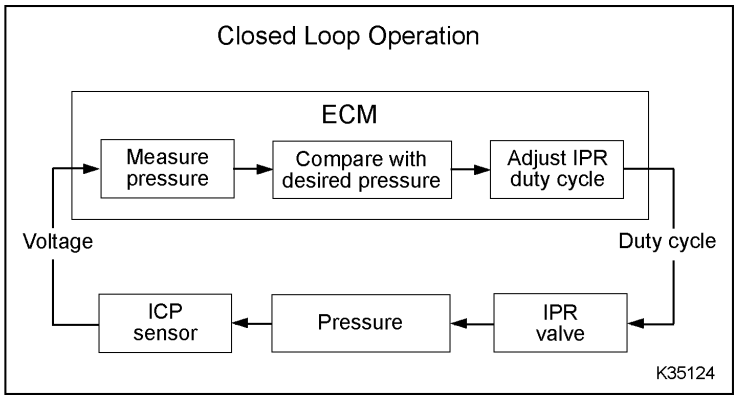


Figure 18 ICP closed loop system

The ICP (Injection Control Pressure) system is a closed loop system that uses the ICP sensor to continuously provide feedback to the ECM. The ECM commands the IPR duty cycle to adjust pressure to match engine requirements.

ICP Control System

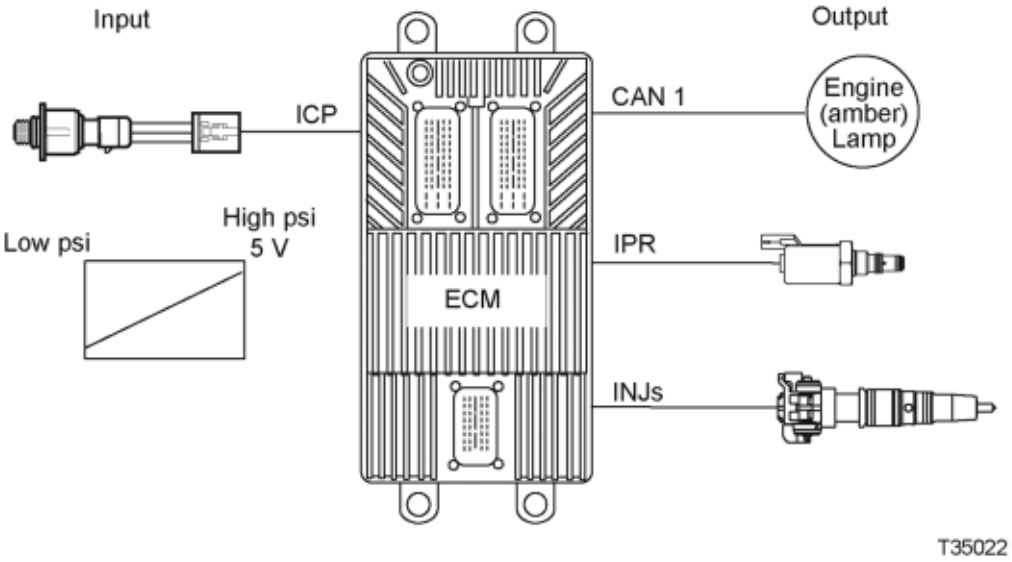


Figure 19 ICP control system

The IPR valve receives a Pulse Width Modulated (PWM) signal from the ECM. This controls the on and off time the IPR valve is energized. The on/off time is controlled by the ECM to meet calibrated desired values.

The IPR valve is mounted in the body of the high-pressure pump. The IPR valve maintains desired ICP by dumping excess oil back into the crankcase sump.

As demand for ICP increases, the ECM increases the current to the IPR valve solenoid. When demand for ICP decreases, the duty cycle to the IPR valve decreases and more oil is allowed to flow back to the crankcase sump.

When the ICP electrical signal is out-of-range, the ECM sets a fault code.

When ICP signals are out-of-range, the ECM ignores them and goes into open loop operation. The IPR valve will operate from programmed default values.

The ICP sensor is installed in the high-pressure oil manifold under the valve cover.

Fuel Injector



Figure 20 Fuel injector

1. Upper O-ring
2. Lower O-ring
3. Nozzle gasket
4. Injector nozzle
5. Fuel inlet port

Fuel Injector Features

Two 50 volt, 25 amp coils control a spool valve that directs oil flow in and out of the injector. Each injector has a single four pin connector that connects to the valve cover gasket assembly.

Injector Coils and Spool Valve

An OPEN coil and a CLOSE coil on the injector move the spool valve from side to side using magnetic force. The spool has two positions:

- When the spool valve is open, oil flows into the injector from the high-pressure oil manifold.
- When the spool valve is closed, oil exits from the top of the fuel injector and drains back to the crankcase.

Intensifier Piston and Plunger

When the spool valve is open, high-pressure oil enters the injector, pushing down the intensifier piston and plunger. Since the intensifier piston is 10 times greater in surface area than the plunger, the fuel injection pressure is also 10 times greater than injection control pressure on the plunger.

Plunger and Barrel

Fuel pressure builds at the base of the plunger in the barrel. When the intensifier piston pushes the plunger down, the plunger increases fuel pressure in the barrel 10 times greater than injection control pressure. The plunger has a hardened coating to resist scuffing.

Injector Needle

The injector needle opens inward when fuel pressure overcomes the Valve Opening Pressure (VOP). Fuel is atomized at high-pressure through the nozzle tip.

Fuel Injector Operation

The injector operation has three stages:

- Fill stage
- Injection
- End of injection

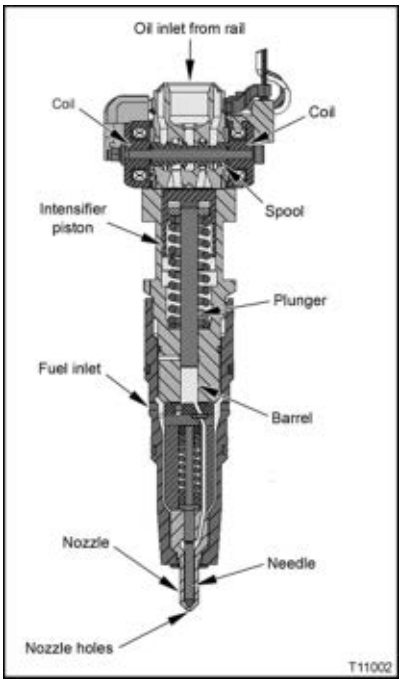


Figure 21 Fuel injector cross section

Fill Stage

During the fill stage, both coils are de-energized and the spool valve is closed. High-pressure oil from the high-pressure oil manifold is stopped at the spool valve.

Low-pressure fuel fills the four ports and enters through the edge filter on its way to the chamber beneath the plunger. The needle control spring holds the needle onto its seat to prevent fuel from entering the combustion chamber.

Injection

1. A pulse-width controlled current energizes the OPEN coil. Magnetic force moves the spool valve open. High-pressure oil flows past the spool valve and onto the top of the intensifier piston. Oil pressure overcomes the force of the intensifier piston spring and the intensifier starts to move down. An increase in fuel pressure under the plunger seats the fuel inlet check ball, and fuel pressure starts to build on the needle.
2. The pulse-width controlled current to the OPEN coil is shut off, but the spool valve remains open. High-pressure oil from the high-pressure oil manifold continues to flow past the spool valve. The intensifier piston and plunger continue to move and fuel pressure increases in the barrel. When fuel pressure rises above the VOP, the needle lifts off its seat and injection begins.

End of Injection

1. When the ECM determines that the correct injector on-time has been reached (the correct amount of fuel has been delivered), the ECM sends a pulse-width controlled current to the CLOSE coil of the injector. The current energizes the CLOSE coil and magnetic force closes the spool valve. High-pressure oil is stopped against the spool valve.
2. The pulse-width controlled current to close the coil is shut off, but the spool valve remains closed. Oil above the intensifier piston flows past the spool valve through the exhaust ports. The intensifier piston and plunger return to their initial positions. Fuel pressure decreases until the needle control spring forces the needle back on its seat.

Fuel Supply System

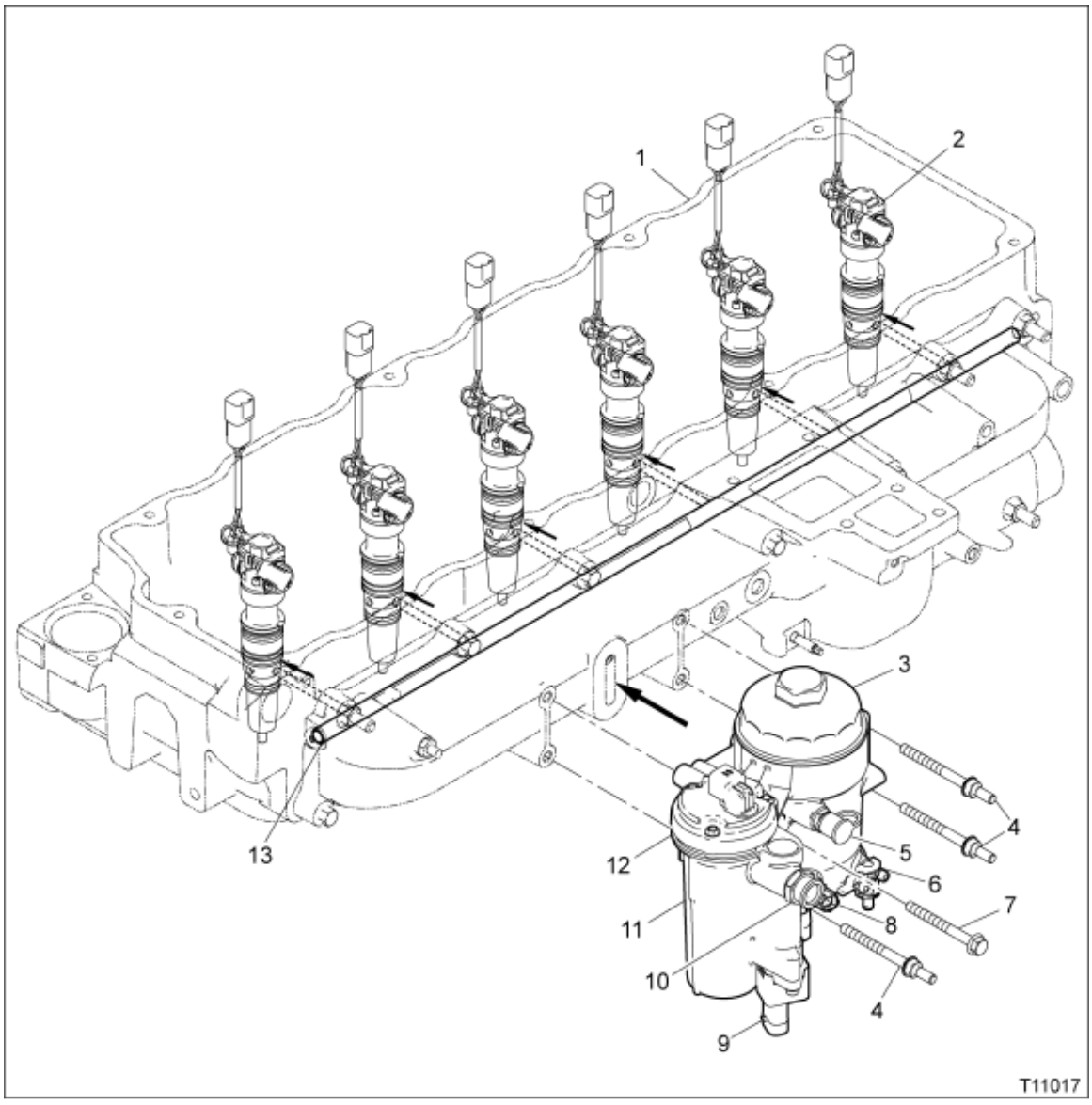


Figure 22 Low-pressure fuel system

1. Cylinder Head
2. Fuel injector assembly (6)
3. Fuel filter cap
4. M8 x 75 stud bolt (3)
5. Diagnostic coupling assembly and dust cap
6. Water drain valve assembly
7. M8 x 75 bolt
8. Water In Fuel (WIF) sensor
9. 250 watt heater assembly (optional)
10. Voss® Stop Flow adapter assembly (fuel inlet)
11. Fuel filter assembly (with optional heater)
12. Electric fuel pump assembly
13. Low pressure fuel rail (cast in intake manifold)

Fuel Supply System Flow

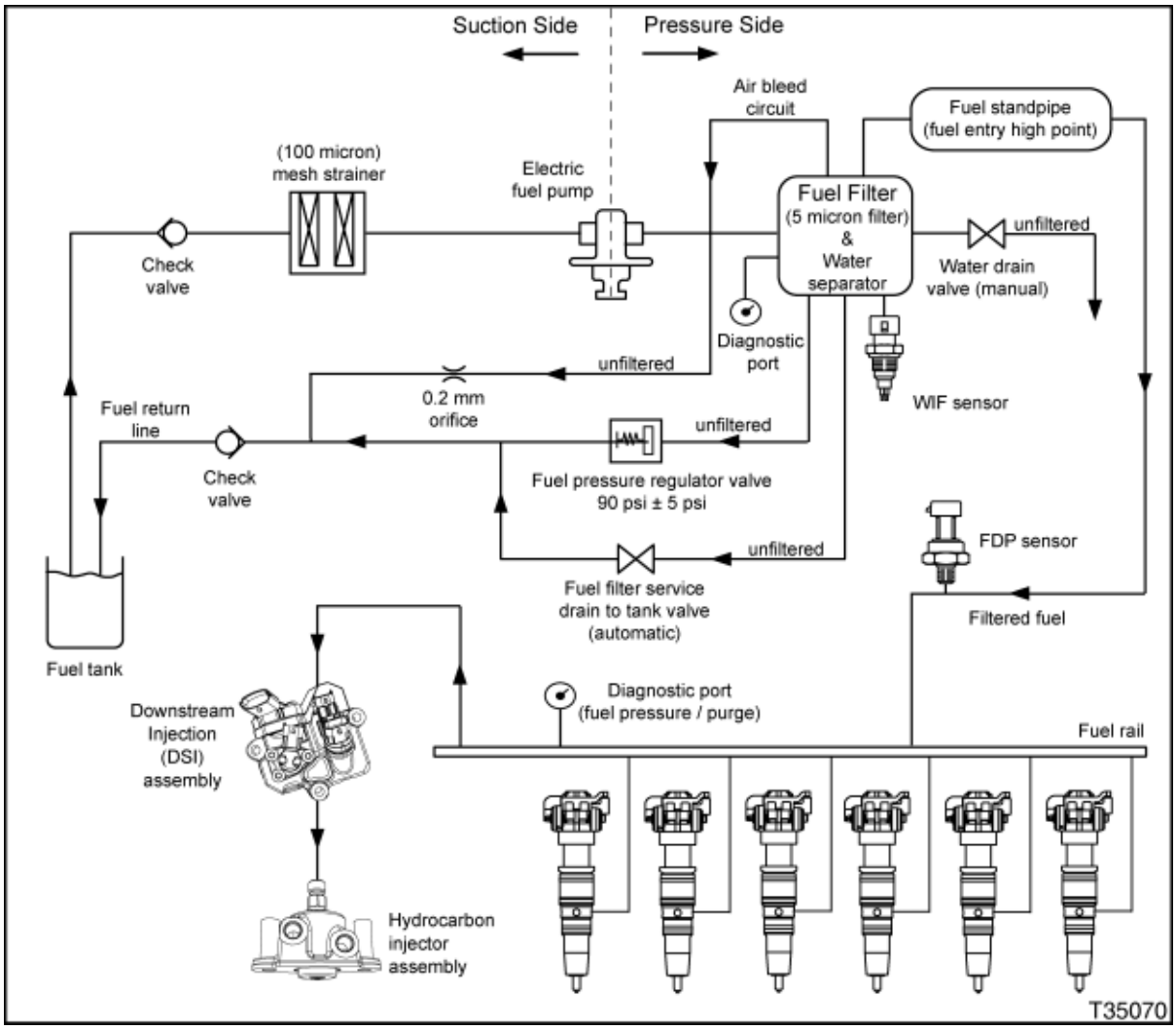


Figure 23 Fuel flow

The electric fuel pump draws fuel through the fuel lines from the fuel tank. Fuel enters the fuel filter assembly and passes through the 100 micron strainer.

An optional 250 watt electric heating element is available to warm incoming fuel to prevent waxing and optimize cold weather performance. The heater is installed in the fuel filter assembly, below the electric fuel pump.

Fuel flows from the strainer through the electric fuel pump to the fuel filter for further conditioning.

If water is in the fuel, the fuel filter element repels the water. The water is collected at the bottom of the main filter element cavity in the fuel filter assembly.

Fuel flows through the 5 micron filter element and the standpipe. The filter element removes debris from the fuel. The standpipe prevents fuel from draining from the fuel rail during service.

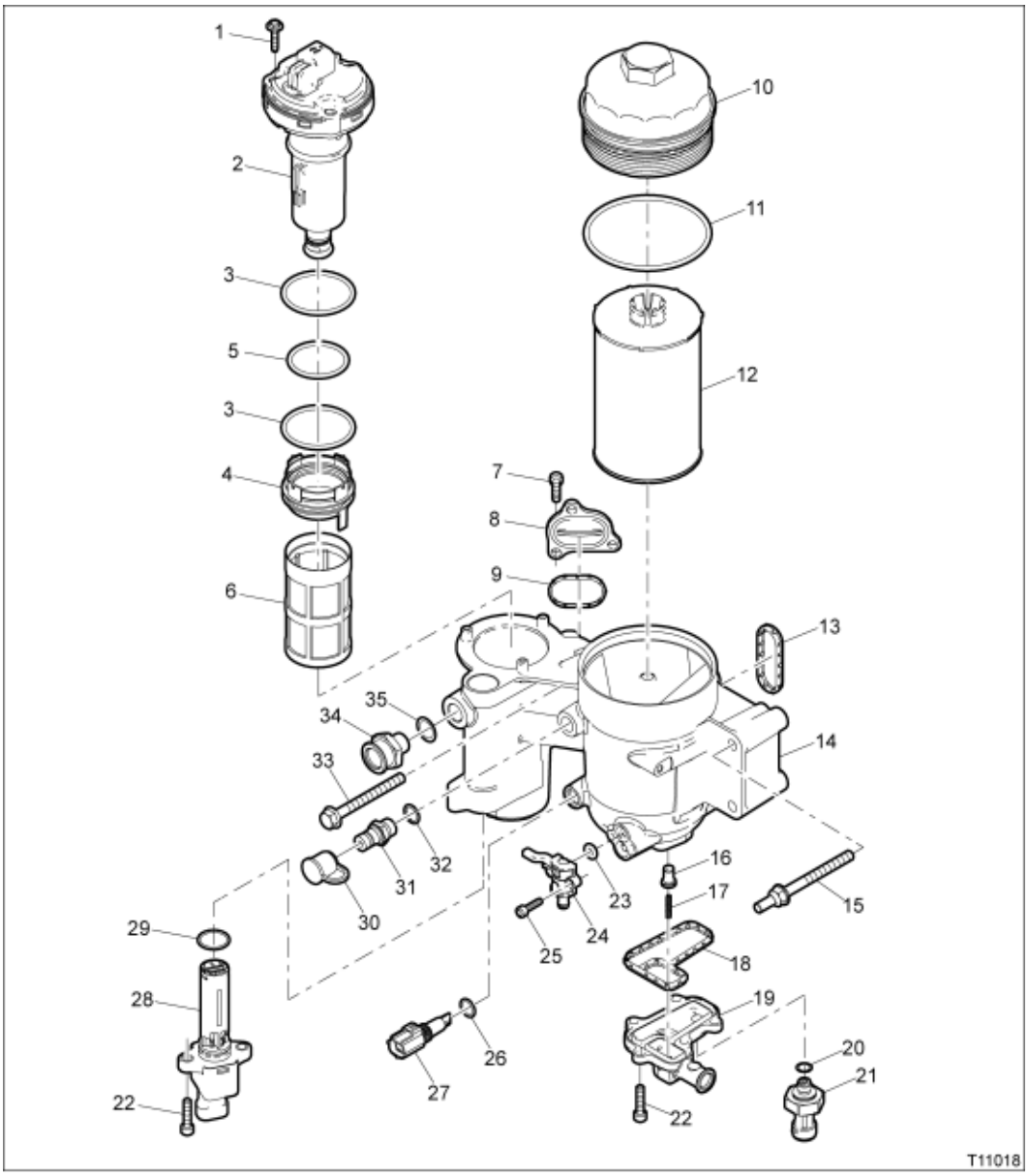


Figure 24 Fuel filter assembly components

1. M5 x 25 screw (3)
2. Electric fuel pump
3. Pump cover and housing O-ring (2)
4. Pump adapter
5. 3.53 x 40.87 ID O-ring
6. Pump strainer
7. M6 screw (3)
8. Port cover
9. Port cover seal
10. Fuel filter cap
11. O-ring gasket
12. Fuel filter element
13. Irregular molded gasket
14. Fuel filter assembly with heater
15. M8 x 75 stud bolt (3)
16. Fuel pressure regulator valve assembly
17. Fuel pressure regulator spring
18. Cover plate seal
19. Bottom cover plate
20. Sensor O-ring
21. Fuel Delivery Pressure (FDP) sensor
22. M6 screw (7)
23. O-ring
24. Water drain valve assembly
25. M5 x 18 Torx® screw (2)
26. O-ring seal
27. Water In Fuel (WIF) sensor
28. 250 watt heater assembly (optional)
29. Heater plug O-ring gasket
30. Dust cap
31. Diagnostic coupling
32. #906 O-ring
33. M8 x 75 bolt
34. Voss® Stop Flow adapter assembly (fuel inlet)
35. Gasket

When the maximum amount of water is collected in the element cavity, the WIF sensor sends a signal to the Electronic Control Module (ECM). The ECM turns on the amber Water In Fuel lamp located on the instrument panel.

A water drain valve is located on the fuel filter assembly and can be opened to drain contaminants (usually water) from the assembly.

A fuel pressure regulator valve is built into the fuel filter assembly. The regulator valve is calibrated to relieve excessive fuel pressure. Excess fuel is sent through a fuel return line back to the fuel tank. Return fuel is not filtered.

Fuel continuously flows from the top of the filter element cavity, through a 0.2 mm air bleed orifice (filter center tube feature), and into the return fuel line. This aids in removing trapped air from the element cavity as a result of servicing.

When the fuel filter is removed, a drain-to-tank port valve is opened. Fuel present in the filter assembly then drains out and back to the tank to provide improved cleanliness during servicing. When fuel lines are removed, a check valve eliminates spillage and ensures fuel line cleanliness.

The Fuel Delivery Pressure (FDP) sensor detects low fuel pressure caused by a fuel restriction or dirty fuel filter. The FDP sensor sends a signal to the ECM when pressure is below programmed values for various engine conditions. The ECM turns on an amber FUEL FILTER lamp located on the instrument panel.

Filtered fuel flows from the fuel filter assembly into the fuel rail. The fuel rail is an integral part of the intake manifold. Fuel flows into six cylinder head passages to each fuel injector.

When the fuel injectors are activated, fuel flows from the fuel passages through the injector inlet ports and into the fuel injectors.

Engine Lubrication System

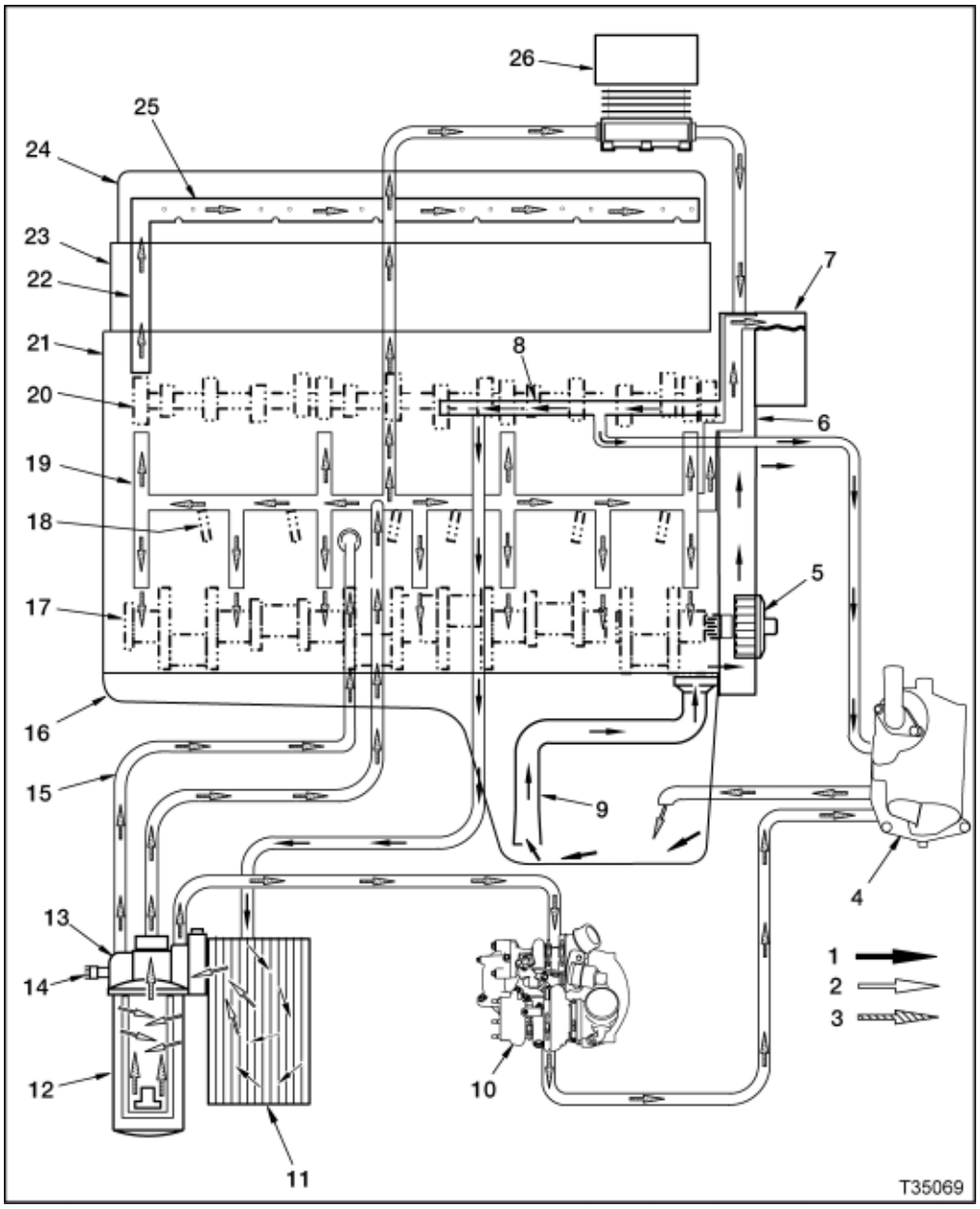


Figure 25 Lubrication system

1. Unfiltered oil
2. Cooled unfiltered oil
3. Filtered oil
4. Crankcase breather assembly
5. Oil pump
6. Front cover
7. Reservoir for high-pressure oil pump
8. Unfiltered oil gallery
9. Pick-up tube
10. Dual stage turbocharger
11. Oil cooler
12. Oil filter
13. Oil cooler module assembly
14. Oil pressure regulator relief valve
15. Regulator relief valve drain to sump
16. Oil pan assembly
17. Crankshaft
18. Piston cooling tube (6)
19. Main filtered oil gallery
20. Camshaft
21. Crankcase
22. Vertical gallery
23. Cylinder head
24. Valve cover
25. Rocker arm assembly oil gallery
26. Air compressor (optional)

Oil Flow

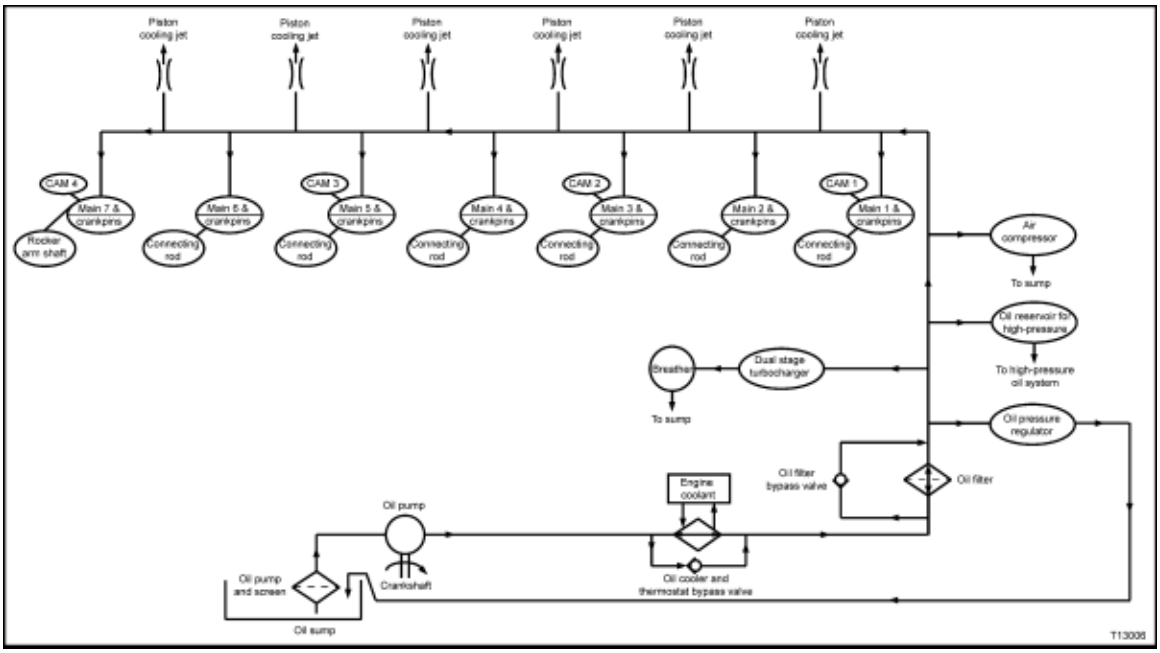


Figure 26 Lubrication system

Unfiltered oil is drawn from the oil pan through the pickup tube and front cover passage by the crankshaft driven oil pump. Pressurized oil is forced through a front cover passage, into the crankcase gallery, and to the oil system module assembly. Oil flow into the oil cooler is controlled by the thermal bypass valve.

The thermal bypass valve allows unfiltered oil to bypass the oil cooler when the oil temperature is cold, and flow directly to the oil filter. As the oil temperature begins to warm, the thermal bypass valve begins to open. This allows unfiltered oil to flow into the oil cooler and oil filter.

When the oil temperature is hot, the thermal bypass valve is fully open. This allows all unfiltered oil to flow through the oil cooler before entering the oil filter.

Unfiltered oil moves through plates in the oil cooler heat exchanger. Engine coolant flows around the plates to cool the surrounding oil.

Oil that exits or bypasses the oil cooler mixes and enters the spin-on oil filter. Oil flows from outside the filter element towards the inside to remove debris. When the filter is restricted, the oil filter bypass (located in the oil filter can) opens and allows oil to bypass the filter to maintain engine lubrication. The filter bypass valve opens when pressure reaches 60 psi (414 kPa).

After passing through the filter, the oil travels past the oil pressure regulator. The regulator directs excess oil back to the oil pan to maintain oil pressure at a maximum of 57 psi (393 kPa).

Clean regulated oil enters the main oil gallery of the engine to lubricate the crankshaft, camshaft, and tappets. The crankshaft has cross-drillings that direct oil to the connecting rods.

Oil is also provided to the high-pressure reservoir through a passage in the front cover.

Piston cooling jets continuously direct cooled oil to the bottom of the piston crowns.

Oil is provided to the cylinder head from the rear cam bearing through a passage at the rear of the crankcase. Oil flows through a passage in the cylinder head and rear rocker shaft support, then enters the hollow rocker shaft, which lubricates the rocker arms.

The crankcase breather assembly oil separator is driven by unfiltered oil pressure taken from the right side of the crankcase. Oil flows from the crankcase into the breather assembly oil separator. Passages direct the oil through a pressed brass nozzle that controls oil flow into the drive oil separator wheel. Oil drains into the base and mixes with oil from the breather system. The collected oil drains into the crankcase and then into the oil pan.

The turbocharger is lubricated with filtered oil from a supply tube assembly that connects the oil cooler module assembly to the center housing of each turbocharger. Oil drains back to the crankcase through drain tubes connected to the base of the breather housing assembly.

The optional air compressor is lubricated with filtered engine oil through a flexible hose. The hose is connected to a tee on the left side of the crankcase near the Engine Oil Pressure (EOP) sensor. Oil drains into the front cover and to the oil pan. Oil can also drain from the bottom of the air compressor through a tube into the crankcase.

The front gear train is splash lubricated with oil that drains from the high-pressure reservoir and the optional air compressor.

Engine Cooling System

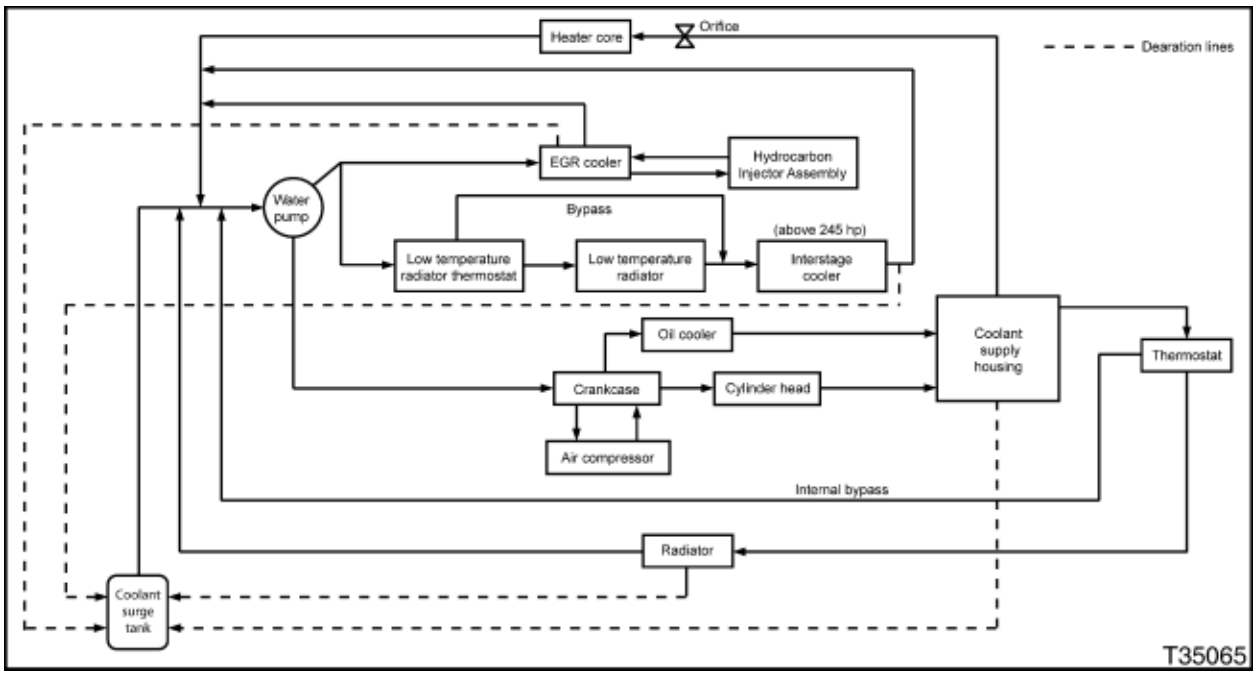


Figure 27 Cooling system components and flow

Cooling System Description

The engine cooling system includes the following:

- Chassis mounted radiator
- Low temperature radiator (if equipped)

- Low temperature radiator thermostat (if equipped)
- Interstage cooler (if equipped)
- Coolant fan
- Water inlet elbow
- Front engine cover
- Water pump
- Crankcase
- Cylinder sleeves
- Cylinder head
- Oil cooler module assembly
- Air compressor
- Thermostat
- Coolant supply housing / coolant port
- EGR cooler
- Coolant surge tank
- Coolant heater (if equipped)

The water pump pushes coolant into the crankcase, low temperature radiator, and EGR cooler.

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

Swirling coolant flow in the cylinder liner jackets directs coolant through passages in the cylinder head gasket and upwards into the cylinder head.

Coolant flows through the cylinder head water jackets towards the thermostat cavity at the front of the cylinder head. When the thermostat is closed, coolant is directed through the bypass port, crankcase, front cover, and into the water pump. When the thermostat is open, the bypass port is blocked, and coolant is directed through the radiator.

Coolant passes through the radiator and is cooled by moving air from the coolant fan. Coolant returns to the engine through the inlet elbow and front cover.

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 and returns to the cylinder head through a passage in the crankcase.

The oil cooler module assembly receives coolant from a passage in the crankcase. Coolant passes between the oil cooler plates and returns through a tube connected to the coolant supply housing.

The EGR cooler receives coolant from the water pump through a supply tube at the rear of the front cover. Coolant passing through the EGR cooler, flows through the cooler plates, cools the exhaust gas, and exits through a tube to the rear of the front cover that returns coolant to the pump inlet. The hydrocarbon injector assembly receives and returns coolant to the EGR cooler.

The EGR coolant supply tube also branches off to the low temperature radiator and to the interstage cooler (above 245 hp), if equipped. For engines with ratings above 245 hp, the coolant is routed through the low temperature thermostat, then through the low temperature radiator to the interstage cooler. Coolant is regulated by the low temperature radiator thermostat. Warm coolant is directed to the low temperature radiator and into

the interstage cooler. Cold coolant bypasses the low temperature radiator and moves directly into the interstage cooler.

The interstage cooler uses coolant to lower the charged air temperature that exits from the turbocharger low-pressure compressor and enters the turbocharger high-pressure compressor.

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

- Engine vent (top of coolant supply housing)
- EGR vent (top of EGR cooler)
- Main radiator vent (top of radiator)
- Interstage cooler vent (top of interstage cooler)

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.

Cooling System Components

Coolant Heater (optional)

An optional coolant heater is available to warm engine coolant in cold weather. The coolant heater warms the coolant surrounding the cylinders. Warmed engine coolant aids in cold engine start-up and performance. The coolant heater is installed on the left side of the crankcase, in front of the Electronic Control Module (ECM).

Thermostat Operation

Coolant travels through two ports after it passes through the thermostat. One port directs coolant to the radiator when the engine is at operating temperature. The other port directs coolant to the water pump until the engine reaches operating temperature. The thermostat begins to open at 190°F (88°C) and is fully open at 205°F (96°C).

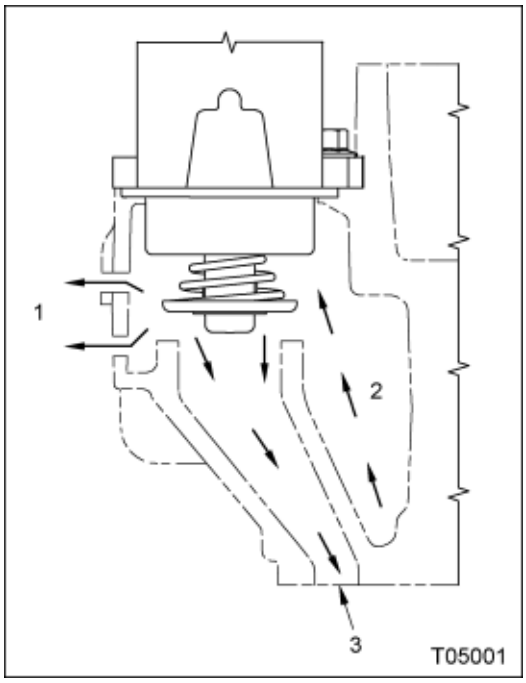


Figure 28 Thermostat closed

1. Coolant flow to heater port
2. Coolant in from engine
3. Bypass to water pump

When engine coolant is below 190°F (88°C), the thermostat is closed, blocking flow to the radiator. Coolant is forced to flow through a bypass port back to the water pump.

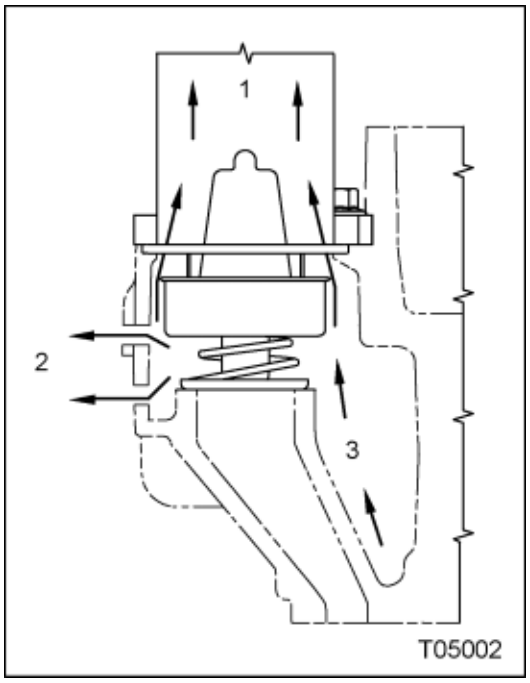


Figure 29 Thermostat open

1. Coolant out to radiator
2. Coolant flow to heater port
3. Coolant in from engine

When coolant temperature reaches the nominal opening temperature of 190°F (88°C), the thermostat opens allowing some coolant to flow to the radiator. When coolant temperature exceeds 205°F (96°C), the lower seat blocks the bypass port directing full coolant flow to the radiator.

Low Temperature Radiator (LTR) Thermostat Operation

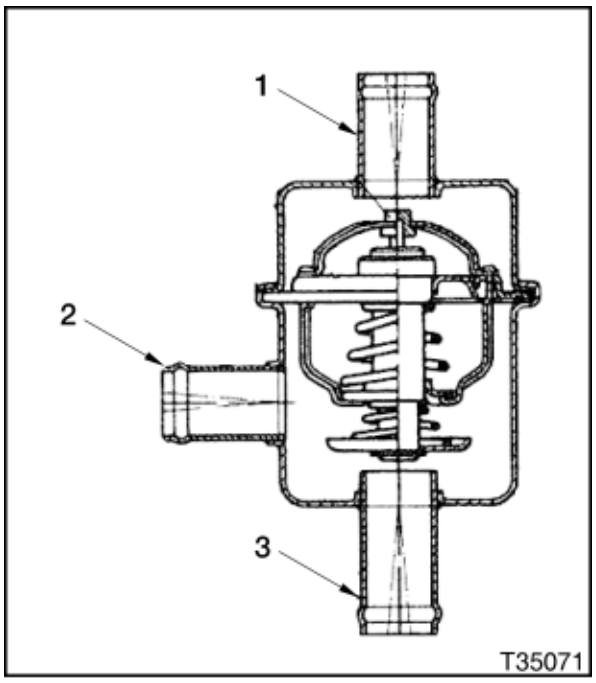


Figure 30 LTR thermostat

1. Thermostat outlet to low temperature radiator
2. Thermostat inlet
3. Thermostat bypass to ISC

Engines equipped with Interstage Cooler (ISC) will also have a Low Temperature Radiator (LTR) and LTR thermostat. The LTR thermostat is a wax element thermostat in a housing with one inlet port and two outlet ports. During cold engine operation (thermostat closed), coolant is directed to the ISC directly, through the bypass port. At normal operating temperature (thermostat open), coolant is directed to the LTR first and then to the ISC. The thermostat begins to open at 194°F (90°C) and is fully open at 209°F (98°C). The LTR thermostat is installed on the chassis near the LTR.

Electronic Control System

Electronic Control System Components

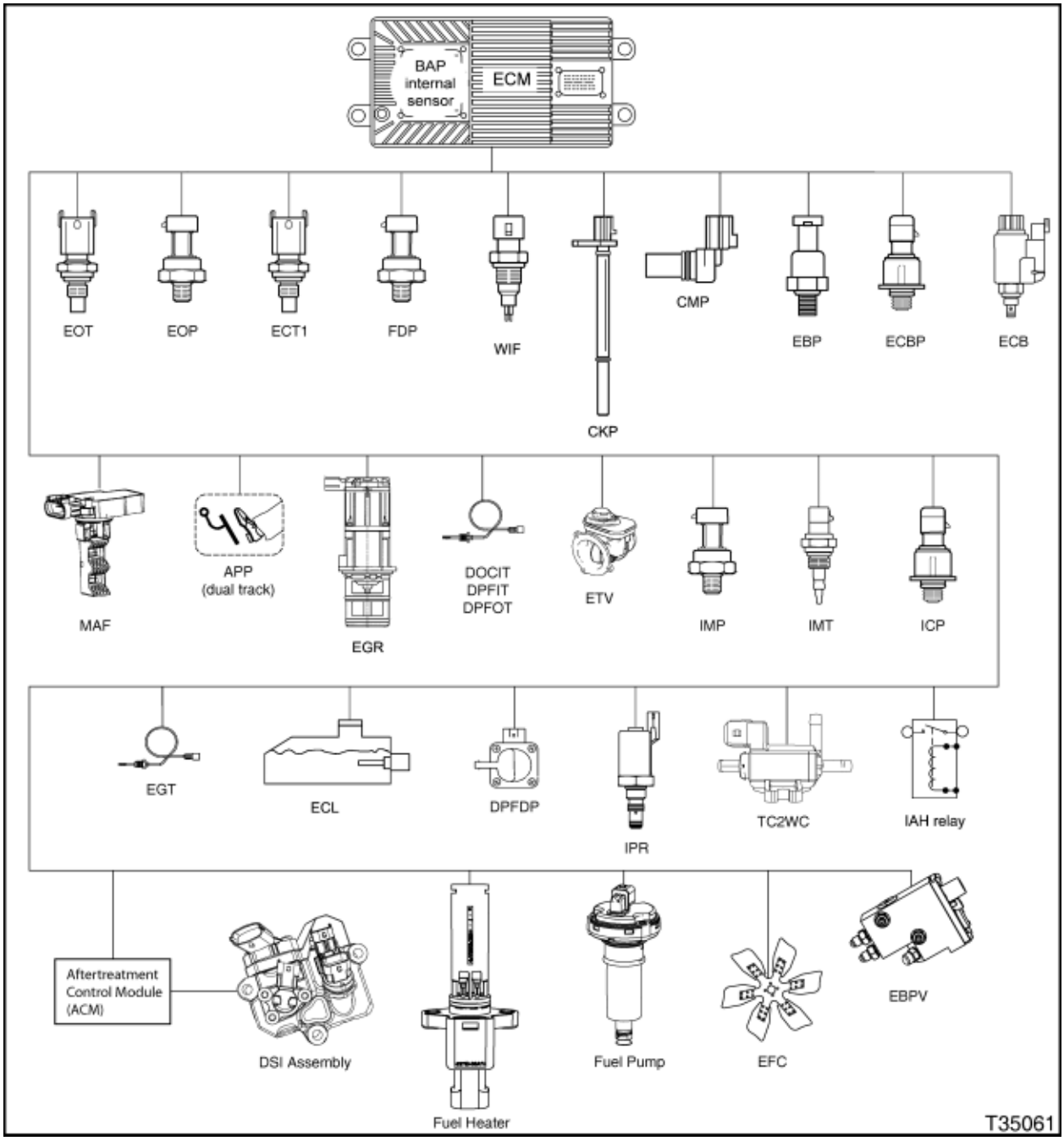


Figure 31 Electronic Control System

Operation and Function

The Electronic Control Module (ECM) monitors and controls engine performance to ensure maximum performance and adherence to emissions standards. The ECM performs the following functions:

- Provides Reference Voltage (VREF)
- Conditions input signals
- Processes and stores control strategies
- Controls actuators

Reference Voltage (VREF)

The ECM internal Power supply generates 5.0 V (Vcc) for the internal components, a reference voltage of 5.0 V for the A/D converters and also three independent short circuit protected 5.0 V tracking voltages (V_REF_1, V_REF_2, V_REF_3) for external devices.

- VREF 1 supplies 5 volts to engine sensors
- VREF 2 supplies 5 volts to vehicle aftertreatment and pedal
- VREF 3 supplies 5 volts to body builder and pedal

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.

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, the drivers complete a ground or power circuit to an actuator.

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

- Duty cycle (percent time on / off)
- Controlled pulse width
- Switched on or off

Actuators

The ECM controls engine operation with the following:

- Exhaust Gas Recirculation (EGR) valve
- Intake Air Heater (IAH) relay
- Engine Throttle Valve (ETV) and position sensor
- Turbocharger 2 Wastegate Control (TC2WC) valve (turbocharger wastegate actuator)
- Exhaust Back Pressure Valve (EBPV)
- Engine Compression Brake (ECB) valve
- Injection Pressure Regulator (IPR) valve

Exhaust Gas Recirculation (EGR) Valve

The EGR valve controls the flow of exhaust gases to the air and EGR mixer duct.

The EGR valve receives the desired valve position from the ECM for exhaust gas recirculation.

Sensors within the EGR valve provide feedback to the ECM on valve position and temperature. A fault code will be set if the ECM detects an error.

Intake Air Heater (IAH) Relay

The IAH system warms the incoming air supply prior to cranking to aid cold engine starting.

The ECM is programmed to energize the IAH element through the IAH relay while monitoring certain programmed conditions for engine coolant temperature, engine oil temperature, and atmospheric pressure.

The ECM activates the IAH relay. The relay supplies battery voltage to the heater elements for a set time, depending on engine coolant temperature and altitude.

Engine Throttle Valve (ETV) and Position Sensor

The engine throttle valve controls the flow of inlet air to regulate operating temperature for exhaust aftertreatment and base engine operation.

The integral throttle actuator controls the engine throttle valve.

The throttle actuator receives the desired engine throttle valve position from the ECM to activate the throttle valve. The throttle position sensor provides feedback to the ECM on the throttle valve position.

Turbocharger 2 Wastegate Control (TC2WC) valve (turbocharger wastegate actuator)

The turbocharger wastegate actuator regulates the charge air pressure by controlling the amount of exhaust gases that pass through the high-pressure turbine.

The TC2WC valve receives the command signal from the ECM. When the charge air pressure demand is low, the TC2WC valve opens, allowing control air to the turbocharger wastegate actuator. The actuator opens allowing part of the exhaust gas flow to bypass the high-pressure turbine.

Exhaust Back Pressure Valve (EBPV)

The Exhaust Back Pressure Valve (EBPV) controls the position of the exhaust valve increasing or decreasing exhaust gas back pressure and temperature to allow the DOC and DPF to function efficiently.

Engine Compression Brake (ECB) valve

The Engine Compression Brake (ECB) valve controls pressure entering the brake oil gallery from the injector oil gallery. This activates the brake actuator pistons and opens the exhaust valves. The ECB valve is installed in the center of the high-pressure oil manifold.

Injection Pressure Regulator (IPR) valve

The Injection Pressure Regulator (IPR) valve is used to maintain desired injection control pressure. Excess high-pressure oil is directed to the crankcase sump by the IPR valve.

Engine and Vehicle Sensors

Temperature Sensors

Thermistor Sensors

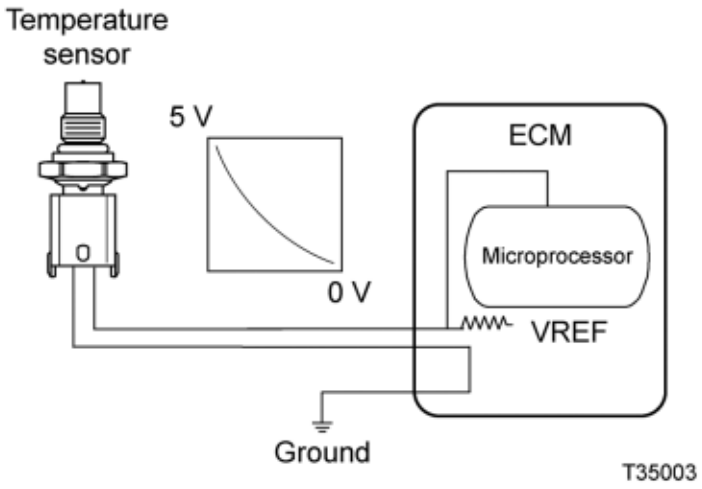


Figure 32 Thermistor sensor

A thermistor sensor varies electrical resistance with changes in temperature. Resistance in the thermistor decreases as temperature increases and increases as temperature decreases. Thermistors have a resistor that limits current in the ECM to a voltage signal matched with a temperature value.

The top half of the voltage divider is the current limiting resistor inside the ECM. A thermistor sensor has two electrical connectors, signal return and ground. The output of a thermistor sensor is a nonlinear analog signal.

Thermistor type sensors include the following:

- Engine Coolant Temperature (ECT) sensor
- Engine Oil Temperature (EOT) sensor
- Air Inlet Temperature (AIT) sensor
- Intake Manifold Temperature (IMT) sensor
- Charge Air Cooler Outlet Temperature (CACOT) sensor
- Turbocharger 2 Compressor Inlet Temperature (TC2CIT) sensor

ECT Sensor

The ECM monitors the ECT signal and uses this information for the instrument panel temperature gauge, coolant compensation, Engine Warning Protection System (EWPS), and IAH operation. The ECT is a backup, if the EOT is out-of-range. The ECT sensor is installed in the coolant supply housing (refrigerant compressor bracket).

EOT Sensor

The ECM monitors the EOT signal and uses this information to control fuel quantity and timing. The EOT signal allows the ECM to compensate for differences in oil viscosity for temperature changes. The EOT sensor is installed in the rear of the front cover, to the left of the high-pressure pump assembly.

AIT Sensor

The AIT sensor is integral to the Mass Air Flow (MAF) sensor. The ECM monitors the AIT signal to control injector timing and fuel rate during cold starts. The ECM also uses the AIT signal to control EGR position and engine throttle control.

IMT Sensor

The IMT sensor monitors the air temperature in the intake manifold. The ECM monitors the IMT signal for EGR operation. The IMT sensor is installed in the intake manifold, to the right of the IMP sensor.

CACOT Sensor

The CACOT sensor monitors the temperature of the air leaving the CAC. The ECM monitors the CACOT signal to evaluate the effectiveness and condition of the CAC.

TC2CIT Sensor

The TC2CIT sensor monitors the temperature of the air entering the Turbocharger 2 compressor. The ECM monitors the TC2CIT signal to evaluate the effectiveness and condition of the interstage cooler.

Exhaust Gas Temperature (EGT) sensors

The Aftertreatment System and exhaust manifold use the following sensors:

- Exhaust Gas Temperature (EGT) sensor
- Diesel Oxidation Catalyst Intake Temperature (DOCIT) sensor
- Diesel Particulate Filter Intake Temperature (DPFIT) sensor
- Diesel Particulate Filter Outlet Temperature (DPFOT) sensor

The Exhaust Gas Temperature (EGT) sensor used in the exhaust manifold provides a feedback signal to the ECM indicating exhaust gas temperature.

The DOCIT sensor provides a feedback signal to the ECM indicating Diesel Oxidation Catalyst (DOC) intake temperature. The DOCIT sensor is the first temperature sensor installed past the turbocharger and just before the DOC.

The DPFIT sensor provides a feedback signal to the ECM indicating Diesel Particulate Filter Intake (DPF) intake temperature. The DPFIT sensor is the second temperature sensor installed past the turbocharger and just after the DOC.

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

During a catalyst regeneration, the ECM monitors all three sensors along with the Exhaust Gas Recirculation (EGR) System and Engine Throttle Valve (ETV).

Variable Capacitance Sensors

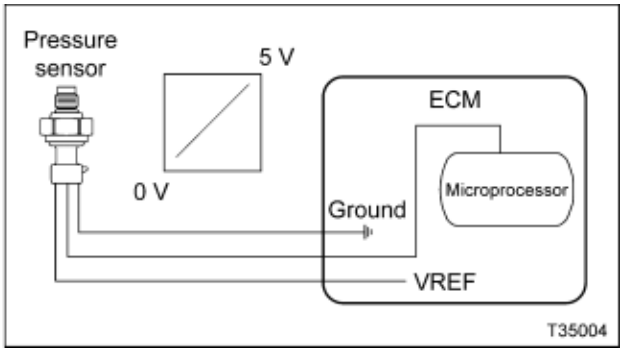


Figure 33 Variable capacitance sensor

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

This type of sensor has three wires: VREF, ground, and a signal wire.

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

The operational range of a variable capacitance sensor is linked to the thickness of the ceramic disk. The thicker the ceramic disk, the more pressure the sensor can measure.

Variable capacitance sensors include the following:

- Fuel Delivery Pressure (FDP) sensor
- Engine Oil Pressure (EOP) sensor
- Exhaust Back Pressure (EBP) sensor
- Mass Air Flow (MAF) sensor
- Intake Manifold Pressure (IMP) sensor

FDP Sensor

The ECM uses the FDP sensor signal to monitor engine fuel pressure and give an indication when the fuel filter needs to be changed. The FDP sensor is installed in the fuel filter assembly on the intake side of the crankcase.

EOP Sensor

The ECM monitors the EOP signal, and uses this information for the instrument panel pressure gauge and EWPS. The EOP sensor is installed in the intake side of the crankcase, below the fuel filter assembly.

EBP Sensor

The ECM monitors the exhaust pressure to control the EGR and intake throttle systems. The EBP sensor is installed in a tube mounted on the coolant supply housing (refrigerant compressor bracket).

MAF Sensor

The MAF sensor is used for closed loop control of the EGR valve and ETV. The ECM monitors the MAF signal to control the EGR and intake throttle systems. The MAF sensor also sends air temperature information to the ECM. The MAF sensor is installed in the intake air duct or air cleaner housing.

IMP Sensor

The ECM monitors the IMP signal to control the EGR and intake throttle systems. The IMP sensor is installed in the intake manifold, left of the IMT sensor.

Magnetic Pickup Sensors

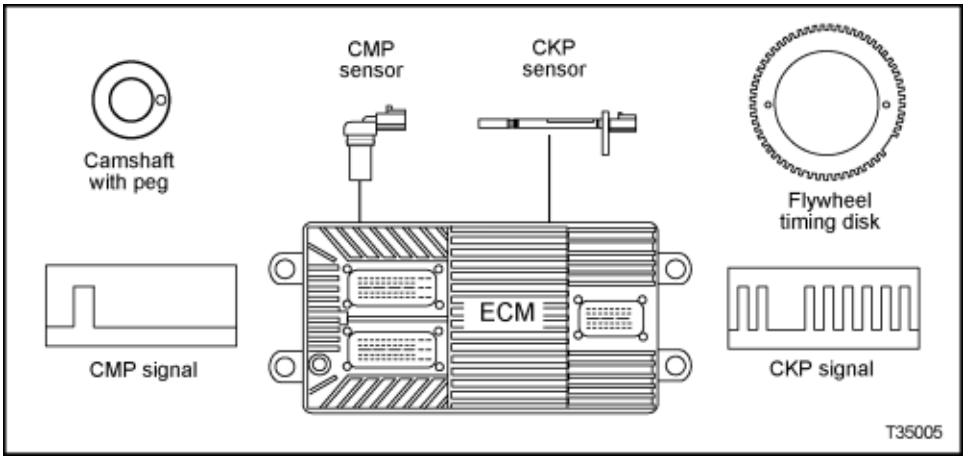


Figure 34 Magnetic pickup sensors

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)

CKP Sensor

The CKP sensor provides the ECM with a signal that indicates crankshaft speed and position. As the crankshaft turns, the CKP sensor detects a 60-tooth timing disk on the crankshaft. Teeth 59 and 60 are missing. By comparing the CKP signal with the CMP signal, the ECM calculates engine rpm and timing requirements. The CKP sensor is installed in the top left side of the flywheel housing.

CMP Sensor

The CMP sensor provides the ECM with a signal that indicates camshaft position. As the cam rotates, the sensor identifies the position of the cam by locating a peg on the cam. The CMP sensor is installed in the front cover, above and to the right of the water pump pulley.

VSS

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

High-pressure Sensors

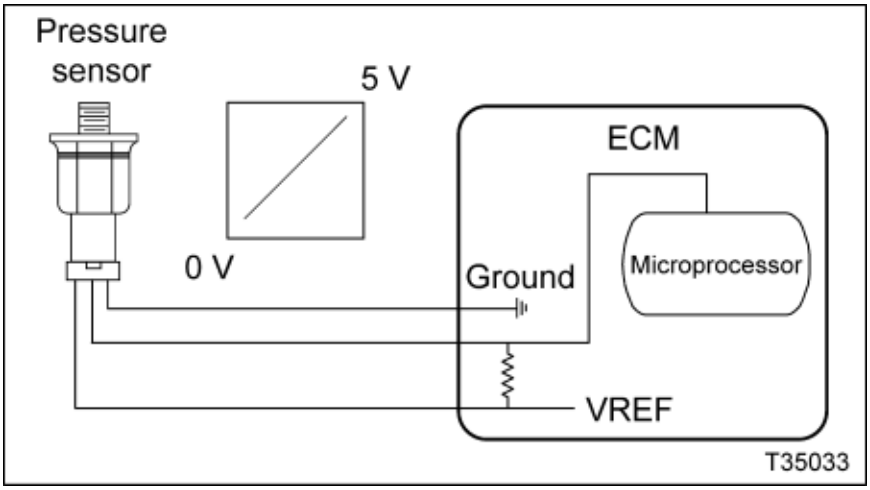


Figure 35 High-pressure sensor

High-pressure sensors convert pressure to a linear analog voltage output of 0 to 5 volts. Pressure to be measured exerts force on a diaphragm with a strain gauge bonded to it. This diaphragm stretches and compresses to change mechanical motion into an electrical signal.

This type of sensor has three wires: VREF, ground, and a signal wire.

The sensor is powered by VREF from the ECM and is grounded through the ECM to a common sensor ground. The ECM compares the voltage with pre-programmed values to determine pressure.

High-pressure sensors include the following:

- Diesel Particulate Filter Differential Pressure (DPFDP) sensor
- Engine Compression Brake Pressure (ECBP) sensor
- Injection Control Pressure (ICP) sensor

DPFDP Sensor

The DPFDP sensor provides a feedback signal to the ECM indicating the pressure difference between the inlet and outlet of the Diesel Particulate Filter (DPF). During a catalyst regeneration, the ECM monitors this sensor along with three Aftertreatment System thermistor sensors, the EGR System, and the Engine Throttle Valve (ETV).

ECBP

The ECM monitors the ECBP signal to determine oil pressure in the brake gallery of the high-pressure oil manifold. The ECBP sensor is under the valve cover, forward of the No. 2 fuel injector in the high-pressure oil manifold.

ICP

The ECM monitors the ICP sensor to determine injection control pressure for engine operation. The ICP sensor is used to control the IPR valve. It provides feedback to the ECM for Closed Loop IPR control. The ICP sensor is located under the valve cover, forward of the No. 6 fuel injector in the high-pressure oil manifold.

Potentiometer

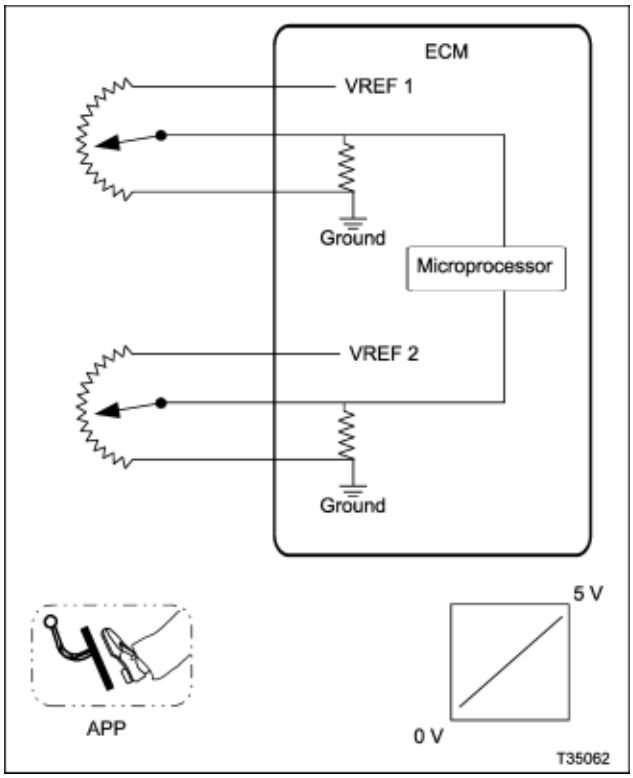


Figure 36 Potentiometer

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.

APP

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

Switches

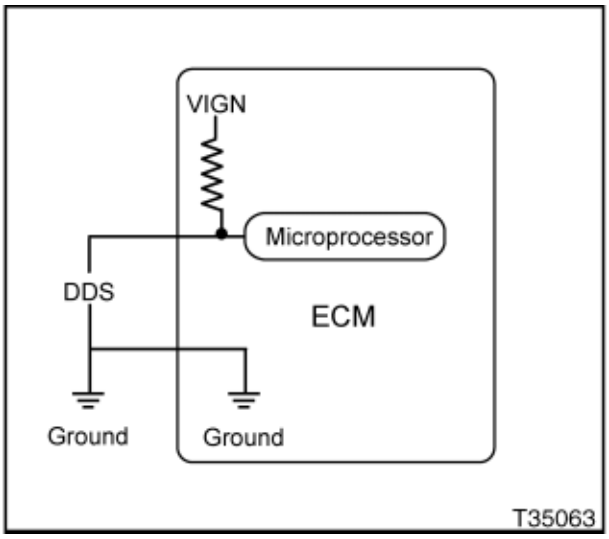


Figure 37 Switch

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 ECM 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)
- Water In Fuel (WIF)

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.

ECL

ECL is part of the Engine Warning Protection System (EWPS). The ECL switch is used in plastic deaeration tanks. When a magnetic switch is open, the tank is full.

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

WIF

A Water In Fuel (WIF) sensor in the fuel filter assembly is used to detect water in the fuel. The resistance of the WIF sensor circuit changes when the water level in the fuel filter assembly reaches the sensor. The ECM then sends a message to illuminate the amber water in fuel lamp, alerting the operator. The WIF is installed in the side of the fuel filter assembly.

Engine Throttle Valve Control System

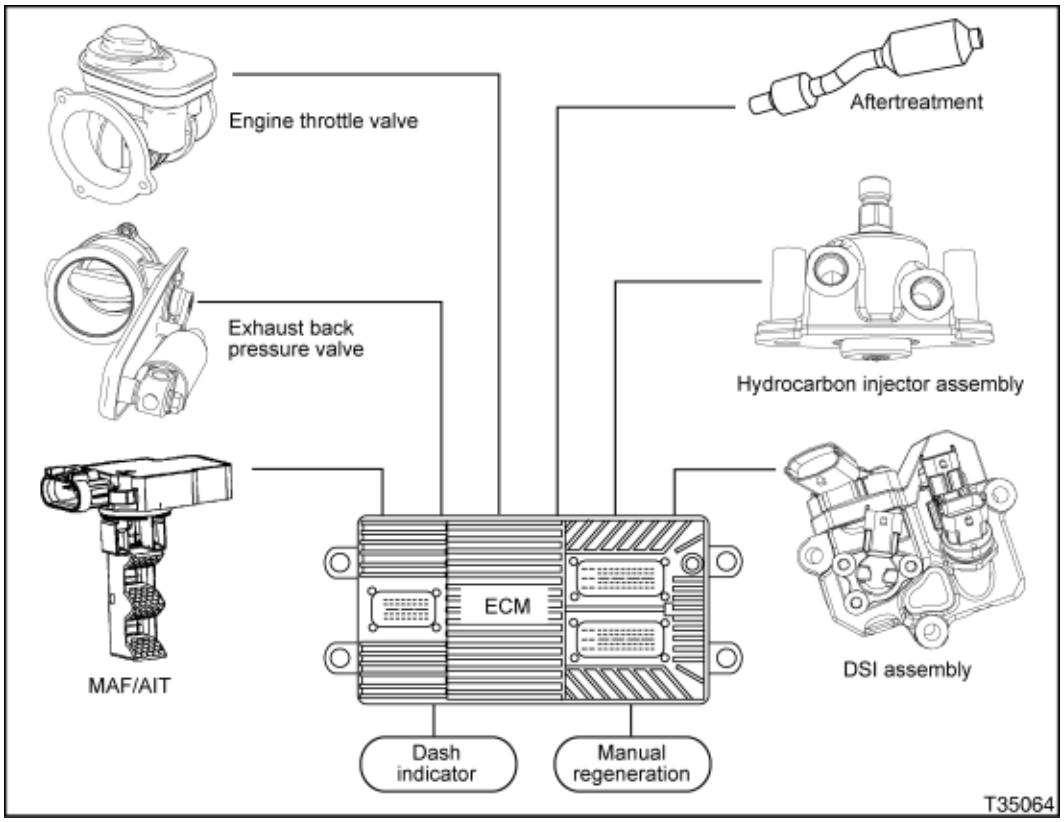


Figure 38 Engine throttle valve control system

The Engine Throttle Valve (ETV) is controlled to limit inlet air. As part of the air management system, the ETV is controlled by the ECM (closed loop) based on input from the Mass Air Flow (MAF) sensor for proper emissions control.

The ETV is also used to help control inlet air during a Diesel Particulate Filter (DPF) regeneration process of the aftertreatment system. It maintains vehicle and engine performance during regenerations.

Exhaust and Engine Brake System

Exhaust Brake

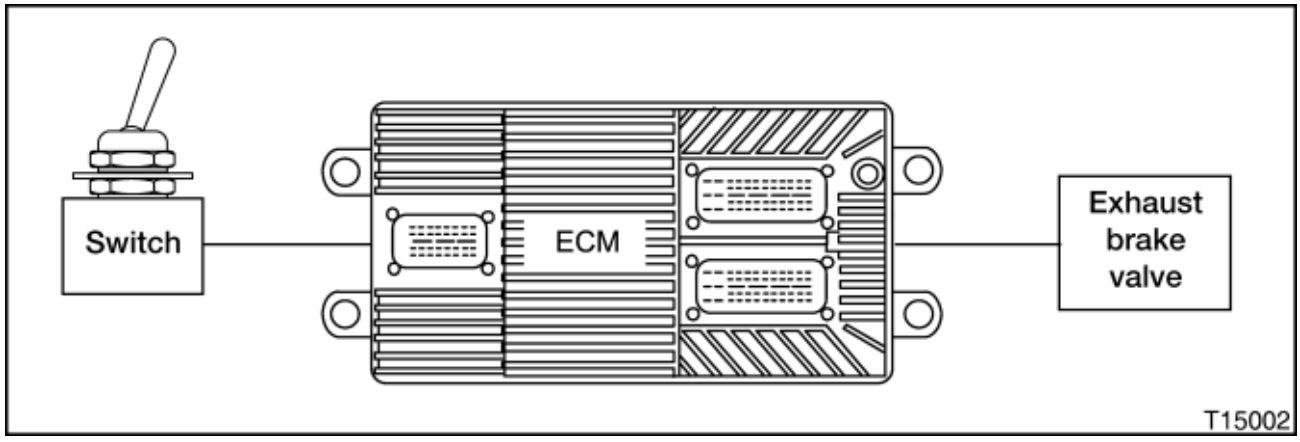


Figure 39 Exhaust brake system

The exhaust brake is available for all ratings and aids in the deceleration rate of vehicles.

The exhaust brake is an exhaust back pressure brake system that provides improved braking performance. The operator can enable the brake function by toggling an instrument panel mounted switch ON or OFF.

Engine Brake

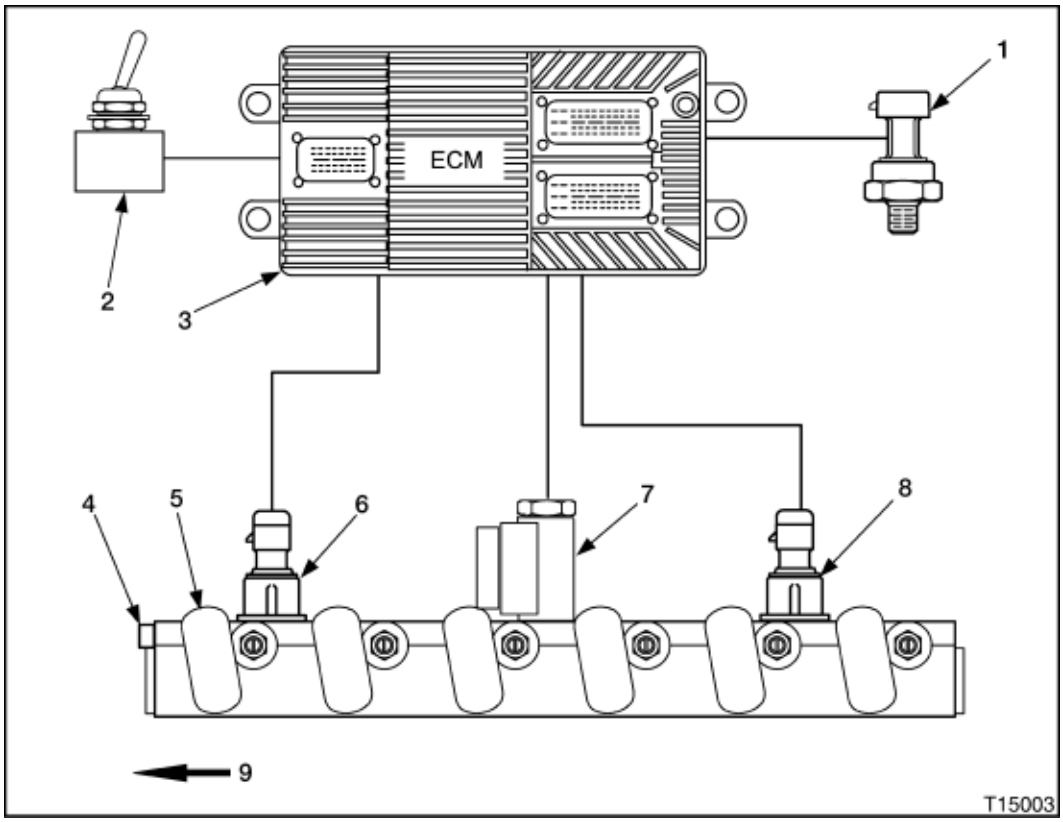


Figure 40 Engine brake system

1. Exhaust Back Pressure (EBP) sensor
2. Switch
3. Electronic Control Module (ECM)
4. Brake pressure relief valve
5. High-pressure oil manifold
6. Engine Compression Brake Pressure (ECBP) sensor
7. Engine Compression Brake (ECB) valve
8. Injection Control Pressure (ICP) sensor
9. Front of engine

ECBP

The ECM monitors the ECBP signal during engine normal and braking operation to determine if the engine brake system is working without fault. The ECBP sensor provides a feedback signal to the ECM indicating brake control pressure. The ECBP sensor is installed in the high-pressure oil manifold, under the valve cover.

ECB

The ECB valve controls pressure entering the brake oil gallery from the injector oil gallery. This activates the brake actuator pistons and opens the exhaust valves. The ECB valve is installed in the center of the high-pressure oil manifold.

Brake Pressure Relief Valve

The brake pressure relief valve vents excess pressure under the valve cover. Residual brake gallery pressure initially bleeds from the actuator bore. When brake gallery pressure reaches a set point, the brake pressure relief valve opens and oil drains back to the sump.

EBP

The EBP sensor is an input to the ECM for control of the Turbocharger 2 Wastegate Control (TC2WC) valve. The TC2WC valve controls the turbocharger wastegate actuator. The EBP sensor is mounted on a tube plumbed to the exhaust manifold on the exhaust side of the engine.

High-pressure Oil Manifold

The high-pressure oil manifold has two internal separated oil galleries. The manifold supplies high-pressure oil to each fuel injector during normal operation. High-pressure oil is directed to the brake pistons during engine brake operation.

Operation

During engine brake operation, The ECB valve opens to supply high-pressure oil to each brake actuator piston. These brake actuator pistons hold the exhaust valves partially open.

During normal engine operation, oil in the high-pressure manifold goes to the fuel injectors only. The engine compression brake valve, mounted in the high-pressure oil manifold, is closed to prevent oil from entering the brake gallery.

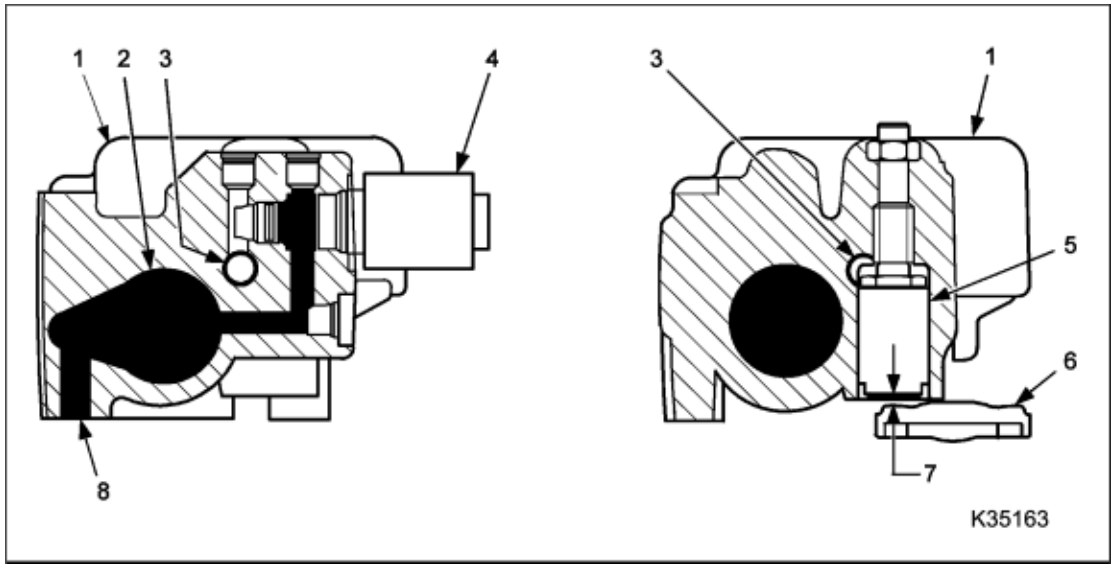


Figure 41 Engine compression brake valve and brake actuator – OFF

1. High-pressure oil manifold
2. High-pressure oil gallery
3. Brake oil gallery
4. Engine compression brake valve
5. Brake actuator piston assembly
6. Exhaust valve bridge
7. Valve lash (actuator retracted)
8. Oil inlet

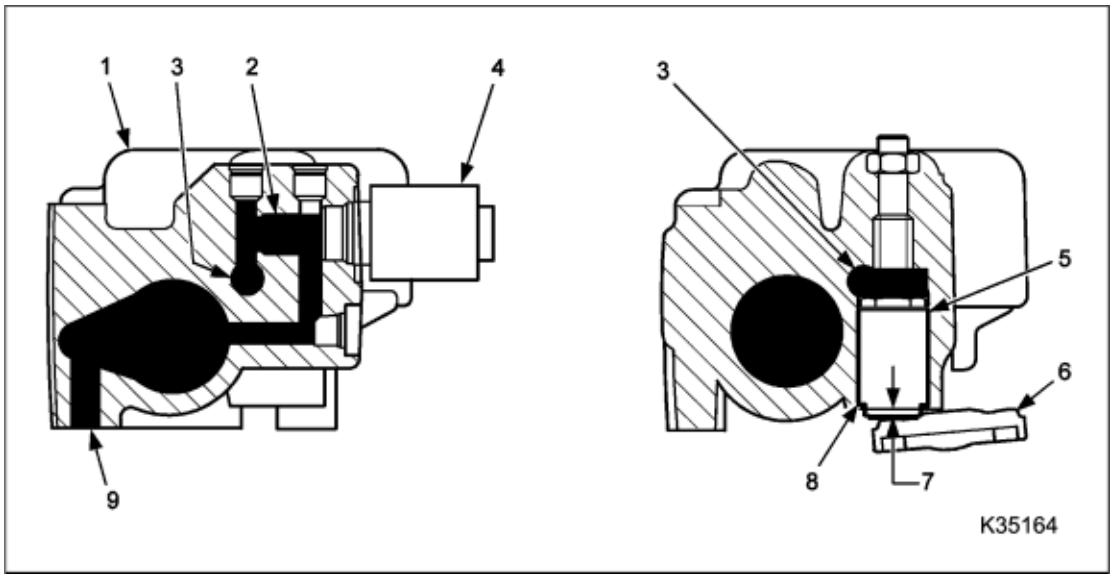


Figure 42 Engine compression brake valve and brake actuator – ON

1. High-pressure oil manifold
2. High-pressure oil flow to brake oil gallery
3. Brake oil gallery
4. Engine compression brake valve
5. Brake actuator piston assembly
6. Exhaust valve bridge
7. Valve lash (actuator deployed)
8. Normal oil seepage
9. Oil inlet

The ECM monitors the following criteria to make sure certain conditions are met:

- Anti-lock Brake System (ABS) (inactive)
- RPM (greater than 1200)
- APP (less than 5%)
- EOT (greater than or equal to 140°F [60°C])
- Operator input switches (On / Off)

If On is selected, and the preceding criteria are met, the engine brake will activate.

When the engine brake is activated, the ECM provides the power to activate the Engine Compression Brake (ECB) valve to allow oil from the injector oil gallery to flow to the brake oil gallery. High oil pressure activates the brake actuator pistons to open the exhaust valves.

Vehicle momentum is absorbed by the resulting compression release of the engine power cylinders when pistons are near the top of their stroke.

During an ABS event, the engine brake is deactivated. The engine brake is reactivated once the ABS event is over.

The ECM removes the power source from the ECB valve to deactivate the engine brake. Residual brake gallery pressure initially bleeds from the actuator bore. When brake gallery pressure bleeds down the brake pressure relief valve opens, and oil drains back to sump.

Operation Modes

The engine brake system provides three programmable modes of operation based on terrain, driving conditions, or driver preference.

Coast Mode

When the coast mode is programmed, the brake system will activate only when the driver applies the vehicle service brake. The coast mode allows the vehicle to coast without automatic brake system activation.

Latched Mode

When the latch mode is programmed, the brake system will activate when the driver releases the accelerator pedal. The brake system will deactivate when the driver depresses the accelerator or clutch pedals. The brake system will also deactivate when the engine speed is below a pre-programmed rpm.

Cruise Mode

When the cruise mode is programmed, the brake system performs similar to latch mode under normal driving conditions. When cruise control is used the brake system will activate when the vehicle travels down a grade. The brake system helps the cruise control system maintain the set vehicle speed.

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Standard Features

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.

SAE J1939 Communication Datalink

Vehicles are equipped with the SAE J1939 connector for communication between the Engine Control Module (ECM) and the Electronic Service Tool (EST).

The SAE J1939 datalink supports:

- Transmission of engine parameter data.
- Transmission and clearing of Suspect Parameter Number / Failure Mode Indicator (SPN / FMI) codes.
- Diagnostics and troubleshooting.
- Programming performance parameter values.
- Programming engine and vehicle features.
- Programming calibrations and strategies in the ECM.

For additional information, see J1939 Data Link (page 1089).

American Trucking Association (ATA) Datalink

This link is supported for legacy diagnostic purposes only. It is no longer the programming link, nor does it support the aftertreatment.

Service Diagnostics

NOTE: Model year 2010 vehicles no longer utilize DTC identification by number. DTCs are now identified using the SPN and FMI identifiers only. These two identifiers, known as the Suspect Parameter Number (SPN) and the Failure Mode Indicator (FMI), are displayed in the Electronic Service Tool (EST) with ServiceMaxx™ software in the DTC Window for model year 2010 vehicles and DTC for pre-2010 vehicles.

The EST provides diagnostic information using the SAE J1939 datalink. The recommended EST is the EZ-Tech® with ServiceMaxx™ diagnostic software provided by Navistar.

Faults from sensors, actuators, electronic components, and engine systems are detected by the ECM and sent to the EST as codes. Effective engine diagnostics require and rely on codes.

Identification is accomplished using two fault code identifiers. These two identifiers, known as the Suspect Parameter Number (SPN) and the Failure Mode Indicator (FMI) are displayed in the DTC window on model year 2010 or newer. On pre-2010 vehicles DTC may still be displayed in the ETC window.

- **Suspect Parameter Number (SPN)** The Suspect Parameter Number (SPN) identifies the individual component causing the DTC.
- **Failure Mode Indicator (FMI)** The Failure Mode Indicator (FMI) identifies the fault or condition effecting the individual component.

Event Logging System

The event logging system records engine operation above maximum rpm (overspeed), low coolant level, high coolant temperature, 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.

Electronic Speedometer and Tachometer

The engine control system calibrates vehicle speed up to 157 pulses per mile. Any new speed calibration information must be programmed with an EST.

The tachometer signal is generated by the ECM, by computing signals for the Camshaft position (CMP) sensor and Crankshaft Position (CKP) sensor. Calculations for each sensor are sent to the instrument panel and to the EST.

Aftertreatment System

The engine and vehicle exhaust piping includes an Aftertreatment System to capture soot and other particulates before they exit the exhaust pipe. The soot is captured by the Diesel Particulate Filter (DPF) and is periodically converted to carbon dioxide (CO2) by a Regeneration (Regen) process.

For additional information, see AFT System (page 346).

Engine Fuel Pressure (EFP) Monitor

The EFP monitors fuel pressure and indicates when the fuel filter needs to be serviced by illuminating the fuel filter indicator lamp on the Instrument Panel. For additional information, see FDP Sensor (page 803) or WIF Sensor (page 1199).

Intake Air Heater (IAH)

The Intake Air Heater (IAH) system warms the incoming air supply to aid cold engine starting and reduce white smoke during warm-up. The ECM controls the intake air heater and monitors the engine temperature. When the engine is ready for cranking, the ECM sends a message to shut off the WAIT TO START lamp.

For additional information, see IAH System (page 822).

Fast Idle Advance

Fast idle advance increases engine idle speed up to 875 rpm for faster warm up to operating temperature. This occurs when the ECM monitors ECT sensor input and adjusts the fuel injector operation accordingly.

Low idle speed is increased proportionally when the engine coolant temperature is below 158°F (70°C) at 700 rpm to below 14°F (-10°C) at 875 rpm maximum.

Cold Ambient Protection (CAP)

CAP safeguards the engine from damage caused by prolonged idle at no load during cold weather. CAP also improves cab warm-up.

CAP maintains engine coolant temperature by increasing engine rpm to a programmed value when ambient air temperature is below 68°F (20°C), coolant temperature is below 158°F (70°C), and engine has been idling at no load for over five minutes.

Engine speed will ramp up to 1400 rpm and will maintain at 1400 rpm until coolant temperature has reached 167°F (75°C).

- Engine load is greater than 45%
- Brake pedal is applied or brake switch fault is detected
- Clutch pedal is depressed or clutch pedal switch fault is detected (manual transmissions, if equipped with a clutch switch)
- Shift selector is moved from neutral (automatic transmissions). Shift selector must be in neutral for CAP to work
- Power Takeoff (PTO) switch, also used for electric hand throttle, is turned on and actively controls engine speed
- Accelerator pedal is depressed or Accelerator Pedal Sensor (APS) fault is detected
- Idle Shutdown Timer (IST) is enabled
- Engine Coolant Temperature (ECT) sensor fault is detected
- Intake Air Temperature (IAT) ambient temperature sensor fault is detected

Coolant Temperature Compensation

Coolant temperature compensation 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 the engine coolant temperature reaches approximately 225°F (107°C). A rapid reduction of 20 percent is commanded when engine coolant temperature reaches approximately 230°F (110°C).

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

Engine Crank Inhibit (ECI)

ECI will not allow the starting motor to crank when the engine is running or the automatic transmission is in gear.

For additional information, see ECI System (page 570).

Optional Features

Road Speed Limiting (RSL)

Road Speed Limiting (RSL) is a feature designed to regulate the maximum vehicle speed as controlled by the accelerator pedal.

Customer programmable parameters within the ECM provide vehicle speed governor related options that can be adjusted to suit the customer's needs. A parameter is used to set the maximum accelerator controlled vehicle speed.

Additional programming flexibility is included to allow a trade-off to be made between performance and fuel economy.

Cruise Control

The ECM controls the cruise control feature. The cruise control system functions similarly for all electronic engines. Maximum and minimum allowable cruise control speeds will vary based on model. To operate cruise control, see appropriate truck model Operator's Manual.

Traction Control

Traction control is a system that identifies when a wheel is going 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 Braking System (ABS) that supports traction control.

Exhaust Brake

The exhaust brake increases exhaust back-pressure to aid in the deceleration rate of the vehicle. This option is placed in the exhaust piping after the turbochargers. This option cannot be combined with the engine brake.

Engine Brake

The engine brake is a compression release brake system to aid in the deceleration rate of the vehicle. This option is built into the high-pressure oil manifold under the engine valve cover. This option cannot be combined with the exhaust brake.

Engine Warning Protection System (EWPS)

The EWPS safeguards the engine from undesirable operating conditions to prevent engine damage and to prolong engine life. The ECM will illuminate the red ENGINE lamp and sound the warning buzzer when the ECM detects:

- High coolant temperature
- Low oil pressure
- Low coolant level (3-way system only)

When the protection feature is enabled and a critical engine condition occurs, the on-board electronics will shut the engine down (3-way protection). An event logging feature will record the event in engine hours and odometer readings. After the engine has shutdown, and the critical condition remains, the engine can be started for a 30-second run time.

For complete EWPS description and additional information, see EWPS (page 788).

Idle Shutdown Timer (IST)



GOVERNMENT REGULATION: State and local regulations may limit engine idle time. The vehicle owner or operator is responsible for compliance with those regulations.

The IST allows the Engine Control Module (ECM) to shut down the engine during extended engine idle times.

Thirty seconds before IST-defined engine shutdown, a vehicle instrument panel indicator activates. There are two types of indicators:

- Amber flashing idle shutdown indicator for multiplex electrical systems
- Red flashing indicator with audible alarm for non-multiplex electrical systems

This continues until the engine shuts down or the low idle shutdown timer is reset

IST for California ESS Compliant Engines

Beginning in 2008 MY, all International® MaxxForce® engines certified for sale in the state of California will conform to mandatory California Air Resources Board (CARB) Engine Shutdown System (ESS) regulations.

Engine idle duration is limited for California Engine Shutdown System (ESS) compliant engines as follows:

- When vehicle parking brake is set, the idle shutdown time is limited to the California Air Resources Board (CARB) requirement of five minutes
- When vehicle parking brake is released, the idle shutdown time is limited to the CARB requirement of 15 minutes

The duration of CARB mandated values can be reduced by programming the customer IST programmable parameter to a value lower than 15 minutes.

Engine Idle Shutdown Timer (IST for Federal – Optional)

Idle time can be programmed from 5 to 120 minutes. While the EST is installed, the IST function will be active with the programmed shutdown time in effect. Parking brake transitions reset the idle timer. If the IST is enabled, the Cold Ambient Protection (CAP) will not function.

For additional information, see IST System (page 1073).

Electronic Fan (EFAN)

Engine electronics allow for the operation of an electronic fan or an air fan solenoid. The electronic fan commands higher airflow through the radiator when the Air Conditioner (A/C) is on or when the coolant or inlet air temperature goes above a set temperature. For additional information, see EFC (page 660).

Radiator Shutter Enable (RSE)

The Radiator Shutter Enable (RSE) feature provides a signal to open or close the radiator shutters. Closing the shutters will keep the engine warm during cold weather operation. This provides faster warm up of the passenger cab and enables faster windshield defrosting.

In Cab Power Take Off (PTO) Control

The engine speed control feature, commonly referred to as Power Take-off (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.

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 an example.

Remote Accelerator Pedal Position (RAPP)

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

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 and 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 an example.

Change Engine Oil Interval Message

The service interval feature is designed to provide a visual reminder to the operator that the 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.

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.

The change engine oil interval message can be programmed with the EST for mileage, hours, or amount of fuel used. The change oil message timer can be reset using the CRUISE ON and RESUME/ACCEL switches or the EST.

Fuel Heater

The fuel heater is installed in the fuel filter assembly. The heater warms the supply fuel to prevent waxing during cold conditions.

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Session Files

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

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

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

- Hard Start No Start
- Performance
- Programming

Diagnostic Trouble Codes (DTCs)

NOTE: Model year 2010 vehicles no longer utilize DTC identification by number. DTCs are now identified using the SPN and FMI identifiers only. These two identifiers, known as the Suspect Parameter Number (SPN) and the Failure Mode Indicator (FMI), are displayed in the Electronic Service Tool (EST) with ServiceMaxx™ software in the DTC Window for model year 2010 vehicles and DTC for pre-2010 vehicles.

Suspect Parameter Number (SPN)

The SPN identifies the individual component causing the fault or condition.

Failure Mode Indicator (FMI)

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

Active

Active faults or conditions are codes that are active now.

Previously Active

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

Intermittent or Inactive Fault Diagnostic Procedure

Overview

Use this test to diagnose inactive and/or intermittent faults. Inactive and/or intermittent faults are currently healing, previously active, or inactive.

NOTE: For component faults that are pending or active, follow specific step based diagnostics for fault.

NOTE: Permanent faults are historic faults and are used for reporting purposes only. They should never be treated as a current issue or used for diagnostics.

Tools Required

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939–compliant interface cable

Equipment Condition

None

Test Setup

1. Key-On, Engine-Off (KOEO).
2. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81).
3. Log in to ServiceMaxx™ software.

Test Procedure

1. Verify health report was saved. Clear fault codes.
2. Perform Continuous Monitor Test (page 87)and view voltage signal for suspect sensor.
   - The continuous monitor test will have you watch voltage signals for voltage spikes while wiggling affected harness and connections.
   - A voltage spike while performing continuous monitor wiggle test indicates a damaged harness and/or connector pin.

NOTE: During continuous monitor wiggle test, if a fault code sets (high or low), voltage will latch high or low. To continue performing continuous monitor wiggle test, faults will need to be cleared.

3. If a voltage spike or fault occurs during continuous monitor wiggle test start from the point the voltage spike occurred and inspect harness for rubbing, and inspect nearby connectors for pin damage, corrosion, fretting, etc.

Expected Outcome

The source of the intermittent / inactive fault will be isolated.

Follow-On Procedure

None

ECM Programmable Parameters

Many features can be programmed into the Engine Control Module (ECM) to fit many different applications. To make programming changes using ServiceMaxx™ software, load the Programming session. See the Body Builder website for further details: https://evalue.internationaldelivers.com/service/bodybuilder/general/default.aspx.

Connecting EST with ServiceMaxx™ Software to Engine

To connect the Electronic Service Tool (EST) with ServiceMaxx™ software to the engine, the Interface cable (RP1210B compliant supporting J1939 and J1708) must be connected between the EST and Diagnostic Connector.

The Diagnostic Connector is located inside the vehicle cab, above the clutch pedal.

Obtain Vehicle Health Report

Overview

Connect Electronic Service Tool (EST) to vehicle and generate a Health Report of current vehicle information:

- Vehicle Identification Number (VIN) validation
- Vehicle mileage
- Engine hours
- Diagnostic Trouble Codes (DTC)
- Engine Control Module (ECM) calibration
- Fuel economy data

Tools Required

- PocketMaxx™, EST with International Graphical User Interface, or Navistar® EZ-Tech Launcher

Equipment Condition

None

Test Setup

None

Test Procedure

1. Key-On Engine-Off (KOEO).
2. Connect interface cable between PocketMaxx™, EST, or EZ-tech Launcher and to vehicle Diagnostic Connector (page 81).
3. Use PocketMaxx™, EST, or EZ-tech Launcher to retrieve a vehicle Health Report.
4. Connect to internet and upload Health Report to Navistar® Service Portal.
5. Verify Health Report is visible on Navistar® Service Portal. Select Write Up > Vehicle Information.

Expected Outcome

Current vehicle Health Report is viewable on Navistar® Service Portal.

Follow-On Procedure

None

Record Snapshot of KOEO Data

Overview

Record Key-On Engine-Off (KOEO) data to be referenced now, and in the future.

Tools Required

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

Equipment Condition

Do not crank or run engine for 3 minutes or more. This will allow Injection Control Pressure (ICP) to bleed off.

Test Setup

1. Key-ON.
2. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81).
3. Log in to ServiceMaxx™.

Test Procedure

4. Select Sessions > Hard Start – No Start.
5. Cycle key OFF, then cycle key ON.

NOTE: Fuel pump will run for 10 seconds after the ignition key is cycled.

6. Select Tools > Start Recording Snapshot.
7. Wiggle harness connections on the Under Valve Cover (UVC) harness for ICP connector, ICP harness, and 36-pin Engine Control Module (ECM) connector.
8. Select Tools > Stop Recording Snapshot.

Expected Outcome

KOEO values will be within specification.

Follow-On Procedure

None

Record Snapshot of Engine Running Data

Overview

Record engine running data to be referenced now and in the future. Recreate engine running problem during the test if possible.

Tools Required

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

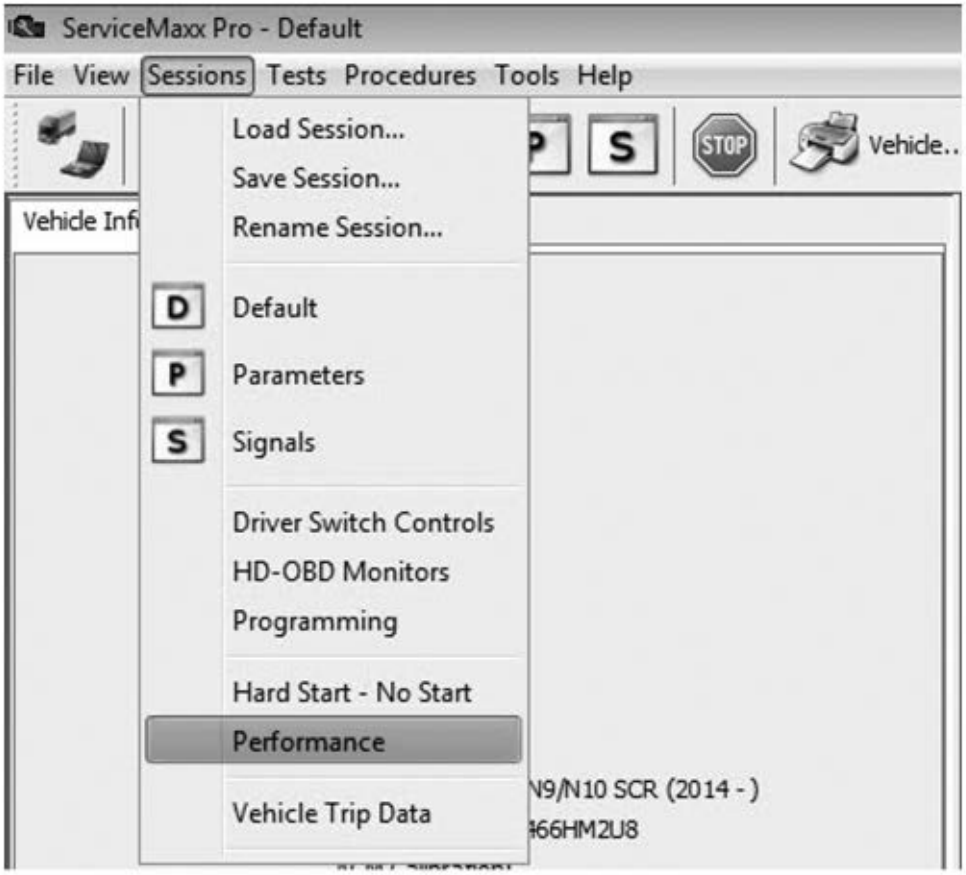
Equipment Condition

None

Test Setup

1. Key-On Engine-Running (KOER).
2. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81).
3. Log into ServiceMaxx™ software.

Test Procedure



0000312490

Figure 43 Sessions Menu

4. Select Sessions > Performance (Figure 43).

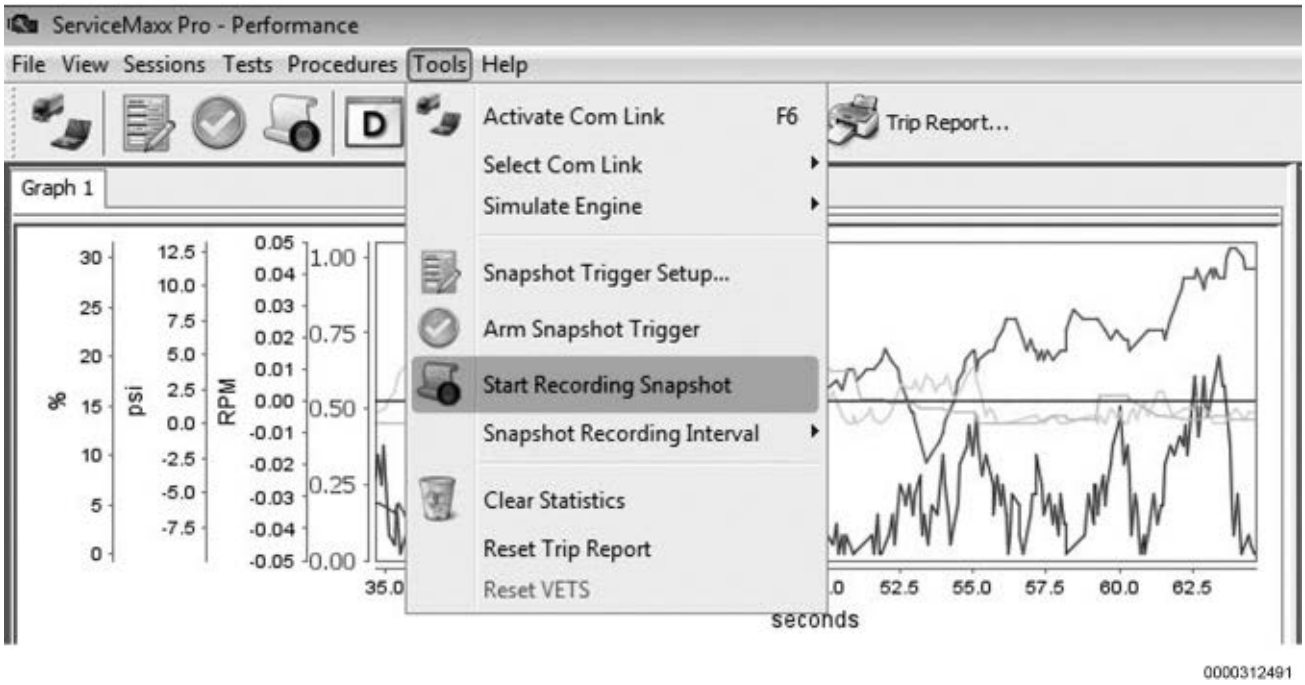


Figure 44 Start Recording

5. Select Tools > Start Recording Snapshot (Figure 44).
6. Recreate engine running problem.

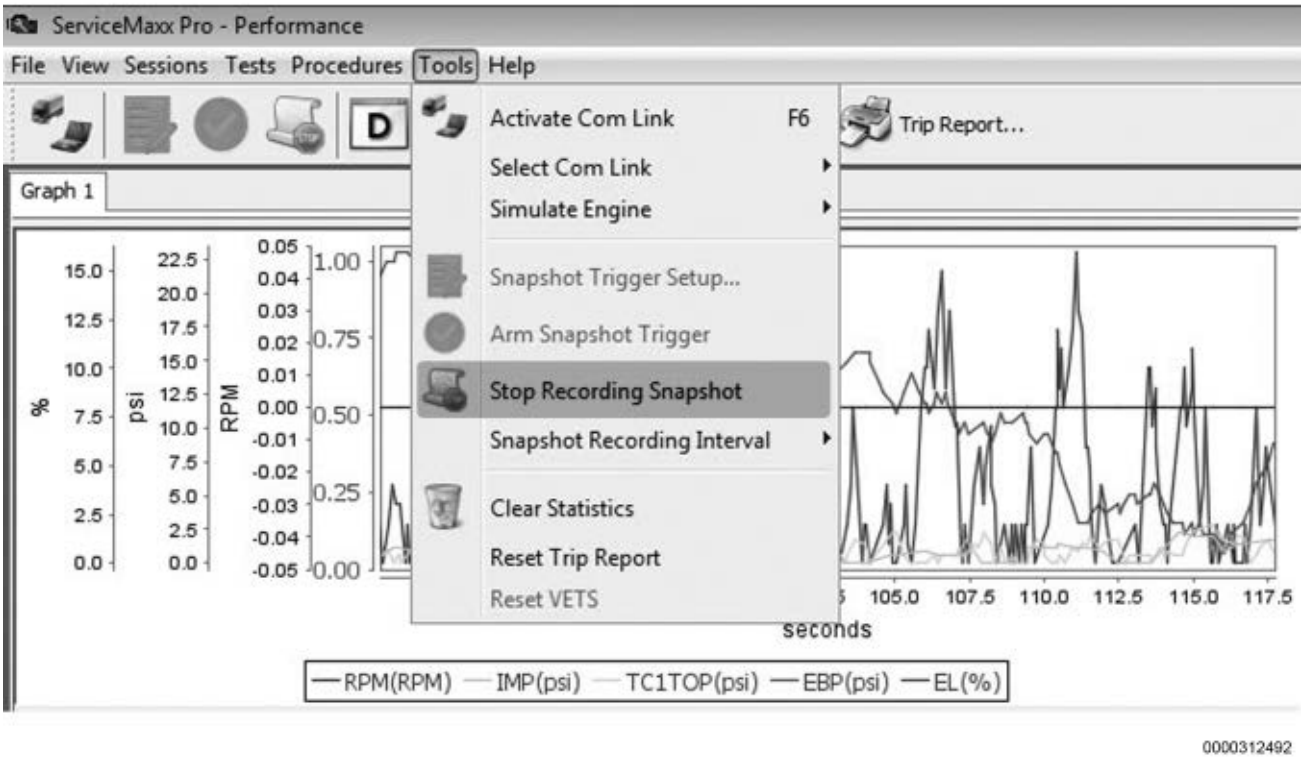


Figure 45 Stop Recording

7. Select Tools > Stop Recording Snapshot (Figure 45).

Expected Outcome

Engine running values will be within specification. Save Snapshot for reference later in diagnostic procedures.

Follow-On Procedure

None

Service Bay Tests

Key On, Engine Off (KOEO) Tests

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

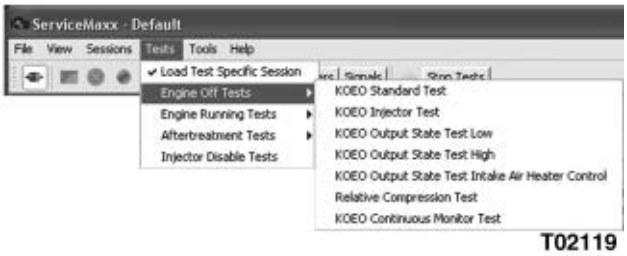


Figure 46 ServiceMaxx™ Test Menu – Engine Off Tests

KOEO Standard Test

The KOEO Standard Test cycles all actuators open and closed. Faults can be detected by visual inspection and by using a Digital Multimeter (DMM) to measure changes in voltage or duty cycles.

KOEO Injector Test

NOTE: KOEO Standard Test must be run before running this test.

The KOEO Injector Test electrically cycles each injector in sequence. This is an audible test only, and is not designed to provide additional codes. This test should only be used to help technicians identify if a suspected injector is functioning electrically.

The test will buzz all six injectors for two seconds, then pause for one second. The test will then buzz each individual injector, in sequence, for 2 seconds (with a 1 second pause in between). The individual buzz starts with cylinder location 1, and proceeds to cylinders 2, 3, 4, 5, and 6. A non-functioning injector can be easily identified by running this test.

KOEO Output State Low Test

NOTE: KOEO Standard Test must be run before running this test.

The KOEO Output State Low test commands all actuators to their low state. Some control systems have actuators that default to their high state. However, this engine control system only has actuators that default to their low state.

KOEO Output State High Test

NOTE: KOEO Standard Test must be run before running this test.

The KOEO Output State High test commands all actuators to their high state. This test is run so the functionality of related circuits and components can be verified. ServiceMaxx™ will monitor and display changes in voltage or duty cycle while actuator is commanded high or low.

KOEO Output State Intake Air Heater Test

NOTE: KOEO Standard Test must be run before running this test.

The KOEO Output State Intake Air Heater Test energizes the Intake Air Heater (IAH) relay for 30 seconds to test component functionality.

KOEO Continuous Monitor Test

NOTE: KOEO Standard Test must be run before running this test.

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

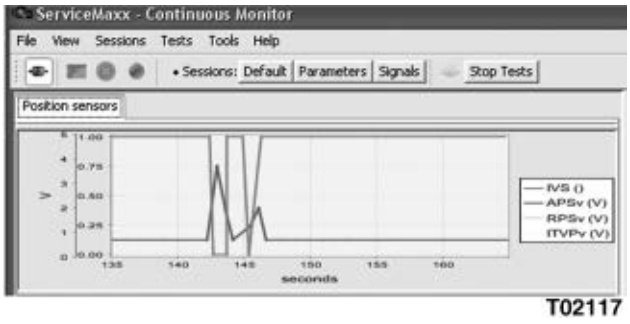


Figure 47 Continuous Monitor Test – Faulty Signal

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

KOEO Aftertreatment Tests – Doser Actuator Test

NOTE: KOEO Standard Test must be run before running this test.

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

NOTE: Run the KOEO Doser Actuator Test while monitoring sensor voltages. Wiggle the wiring harness and connections while looking for signal spikes.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- International® Electronic Engine Terminal Test Kit (page 1227)
- Breakout Harness 4602 (EOT, ECT, and AFTFSV) (page 1230)
- Breakout Harness 6021 (AFTFD) (page 1239)

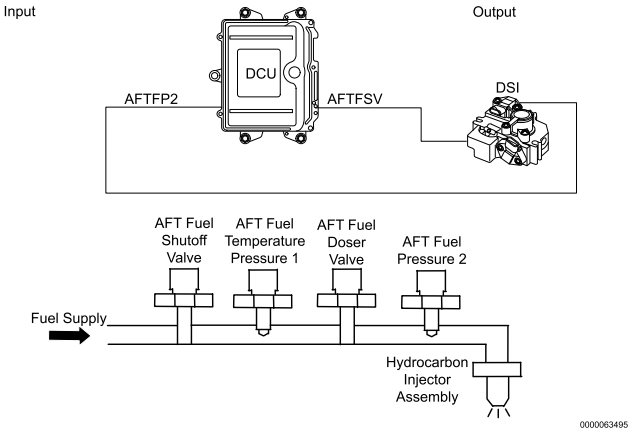


Figure 48 Functional diagram for AFTFSV and AFTFD

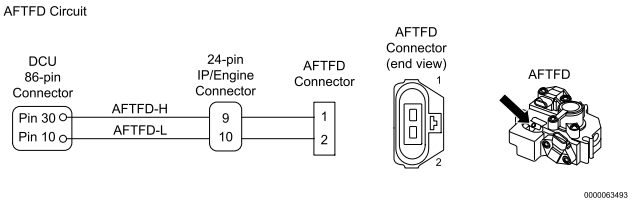


Figure 49 AFTFD Circuit Diagram

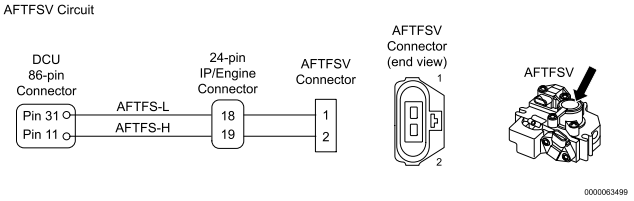


Figure 50 AFTFSV circuit diagram

KOEO Aftertreatment Test Pin-point Diagnostics

1. Using EST with ServiceMaxx™ software, open KOEO Aftertreatement Test – Doser Actuator Test.
2. From the Actuator drop down menu, select AFT Fuel Shutoff Valve and select On.
3. Set up pre-conditions for AFTFSV connector voltage check (page 345).
4. Depress Start Test, do AFTFSV connector voltage check (page 345).
5. Select Off, do AFTFSV connector voltage check (page 345).
6. From the Actuator drop down menu, select AFT Fuel Doser and select On.
7. Set up pre-conditions for AFTFD connector voltage check (page 324).
8. Depress Start Test, do AFTFD connector voltage check (page 324).
9. Select Off, do AFTFD connector voltage check (page 324).
10. Remove test equipment and reconnect disconnected connectors.

KOEO Engine Cranking Test

Overview

Monitors engine systems as the engine is cranked to determine if systems are able to meet minimum starting requirements.

Tools Required

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

Equipment Condition

None

Test Setup

GRAPHIC PLACE HOLDER

0000300422

1. Key-On Engine-Off (KOEO).

2. Connect Electronic Service Tool (EST) with ServiceMaxx sotware to vehicle diagnostic connector.
3. Log in to ServiceMaxx™.

Procedure

GRAPHIC PLACE HOLDER

0000300422

1. Select Sessions > Hard Start – No Start.
2. Select Tools > Start Recording Snapshot.
3. Crank engine for 10 seconds.
4. Select Tools > Stop Recording Snapshot.
5. Verify the following signals meet specification:

   Signals:

   - Switch Battery (SWBAT)
   - Engine Speed (RPM)
   - Injection Control Pressure (ICP)

- Fuel Delivery Pressure (FDP)
- Exhaust Back pressure (EBP)

Expected Outcome

All signal values meet specification (page 1292).

Follow-on Procedure

None

Relative Compression Test

The Relative Compression test measures cylinder balance based off of 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.

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

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

Fuel Pressure Adaptation Reset

Overview

Engine Control Module (ECM) maintains reliability of Fuel Rail Pressure (FRP) system as parts age by storing Fuel Pressure Adaptation (FPA) values.

When any fuel system part is replaced: [Engine Injection Pressure Regulator (IPR) valve, Injection Control Pressure (ICP) sensor, high-pressure pump, high-pressure rail, or ECM], this parameter must be reset.

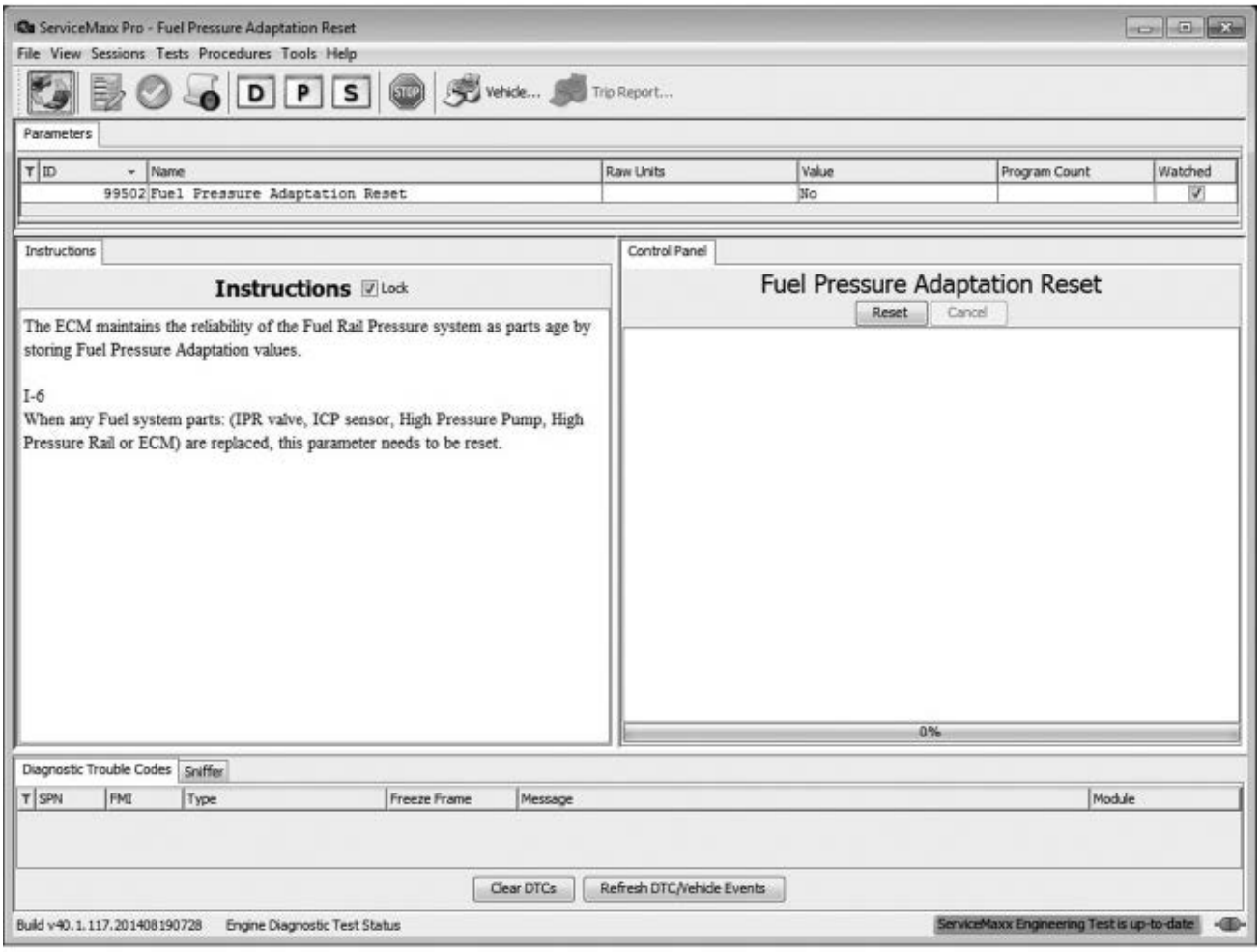
Tools Required

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (J1939 - compliant)

Equipment Condition

One of the following components was replaced:

- Engine Injection Control Pressure Regulator (IPR)
- Injection Control Pressure (ICP) sensor
- High-pressure pump
- High-pressure rail
- Engine Control Module (ECM)



0000314222

Figure 53 Fuel Pressure Adaptation Reset Screen

Test Setup

1. Key-On Engine-Off (KOEO).
2. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81).
3. Start ServiceMaxx™ software.

Test Procedure

1. Replace failed part.

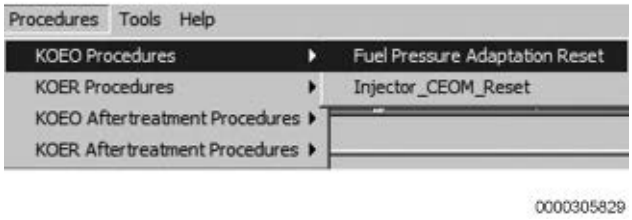


Figure 54 Fuel Pressure Adaptation Rest Drop-Down Menu

2. Select Fuel Pressure Adaptation Reset from KOEO Procedure (Figure 54) drop down menu.



Figure 55 Reset Button

3. Press Diesel Oxidation Catalyst (DOC) or DPF Replacement Reset button (Figure 55).

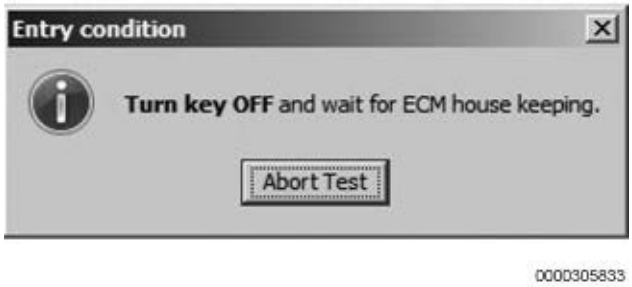


Figure 56 Example of on-screen Instructions

4. Follow on-screen instructions (Figure 56).

Follow-On Procedure

None

Key On, Engine Running (KOER) Tests

Overview

Key On, Engine Running (KOER) Standard Test verifies performance of the Injection Control Pressure (ICP) System. During this test, engine speed increases to 1500 RPM and the Engine Control Module (ECM)

commands the Injection Pressure Regulator (IPR) valve to control ICP. The ICP Desired signal is the pressure the ECM is commanding. The ECM will command 4000 psi, then 1000 psi. The ECM monitors the ICP sensor (Actual pressure) to validates the system's ability to meet ICP desired.

Tools Required

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939-Compliant Interface Cable

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



Figure 57 ServiceMaxx™ Tests Menu – Engine Running Tests

KOER Standard Test

Test Setup

1. Key-on, Engine-Off (KOEO).
2. Connect interface cable between Electronic Service Tool (EST) and 9-pin Vehicle Data Connector (VDC) (see Connecting EST with ServiceMaxx™ software to engine (page 81).
3. Log in to ServiceMaxx™.
4. Start engine and warm Engine Coolant Temperature (ECT) above 158°F (70°C)

Test Procedure

1. Select Key-on, Engine-Running (KOER) Standard test (2) from the Test drop down menu.
2. This test does not display pass or fail results and will display test complete (3) when finished.

Air Management Test

Overview

Tests performance of the Exhaust Gas Recirculation (EGR) valve by measuring changes in Mass Air Flow (MAF) through the MAF sensor and sets fault codes as necessary.

NOTE: Units operating at an altitude greater than 4,000' may fail this test with a normally operating system.

NOTE: If any faults are active the EGR valve will not open during the AMS test causing the data to be unusable.

NOTE: MAF Mean Value must be at least 1,100 mg during the first half of the test for the data to be usable, if below inspect for intake restriction do not proceed until corrected.

NOTE: Do not remove the EGR valve unless a SPN 27 and or SPN 2791 fault is set or valve fails to move.

Tools Required

- Electronic Service Tool (EST) with ServiceMaxx™ software

- Interface cable (RP1210B-compliant supporting J1939 and J1708)

Equipment Conditions

None

Test Setup

1. Connect EST with interface cable to vehicle diagnostic connector.
2. Log in to ServiceMaxx™ software.
3. Key-On Engine Running.
4. Run engine until Engine Coolant Temperature 1 (ECT 1) is above 158°F (70°C).

Test Procedure

1. Perform Key-On Engine-Running (KOER) Standard Test.
2. Go to Sessions > Performance and select the record snapshot icon from the toolbar.
3. Go to Tests > KOER Tests > Air Management Test.
4. When Air Management Test is complete, stop recording. Use the playback feature in ServiceMaxx™, and graph the following signal values:

   Signal Values:

   - Mass Air Flow (MAF) Mean Value (MMV)
   - Intake Manifold Pressure (IMP)
   - Exhaust Gas Recirculation (EGR) valve position
5. Compare Air Management Test graph to Air Management Graph 1 and Graph 2.

Follow-On Procedure

None

Graph 1: Air Management System Test (Good)

NOTE:

Colors in the graphs are used for clarity only and will not necessarily match the colors you will see in your ServiceMaxx™ snapshots

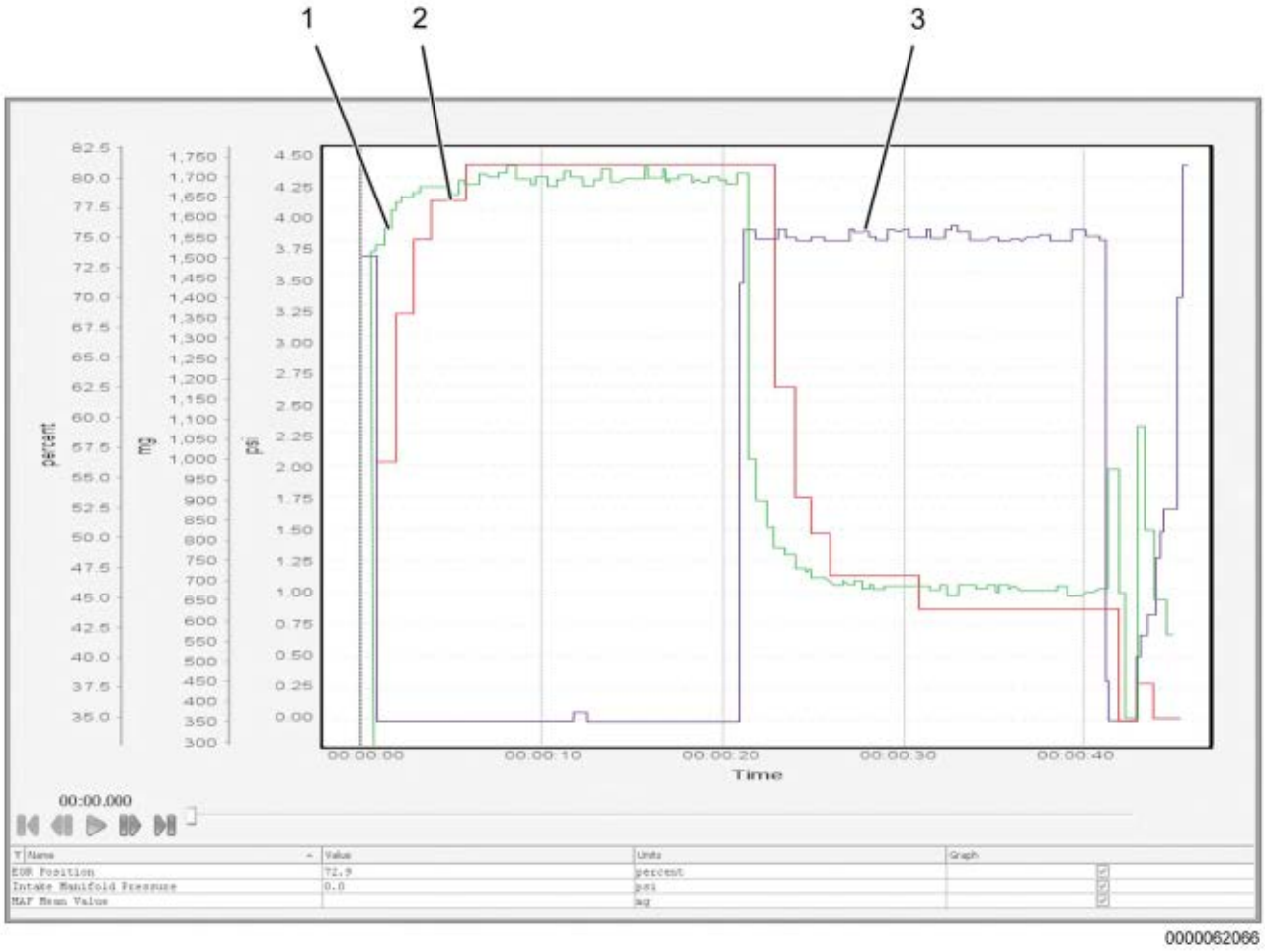


Figure 58 Graph 1: Air Management System Test (Good)

1. Mass Air Flow (MAF) Mean Value (MMV)(mg) [Green]
2. Intake Manifold Pressure (IMP) (psi) [Red]
3. Exhaust Gas Recirculation (EGR) valve position (percent) [Purple]

Graph Analysis:

This graph shows normal operation of the Air Management System (AMS) during the Air Management Test (AMT). The AMT gives pass or fail results based on the difference of flow in MAF Mean Value (MMV). It allows the user to validate the AMS by monitoring the effects each actuator has on Intake Manifold Pressure (IMP). IMP is normally between 2 psi (14 kPa) to 6 psi (41 kPa)

Actions:

1. When EGR valve is commanded ON, verify Intake Manifold Pressure (IMP) signal value drops.
2. When EGR valve is commanded ON, verify Mass Air Flow (MAF) Mean Value (MMV) drops. Calculate the difference between MMV at a stabilized high point and a stabilized low point, then compare to the table below.

Engine	MAF Mean Value (MMV) Difference	Tolerance
MaxxForce® DT 215 - 230 HP	690 – 1000	Less than 690 Fails AMS Test
MaxxForce® DT 245 - 300 HP	740 – 1000	Less than 740 Fails AMS Test
MaxxForce® 9 and 10 300 - 350 HP	850 – 1130	Less than 850 Fails AMS Test

NOTE: EGR valve position will never read less than 35% and is considered closed.

Graph 2: Air Management System Test (BAD)

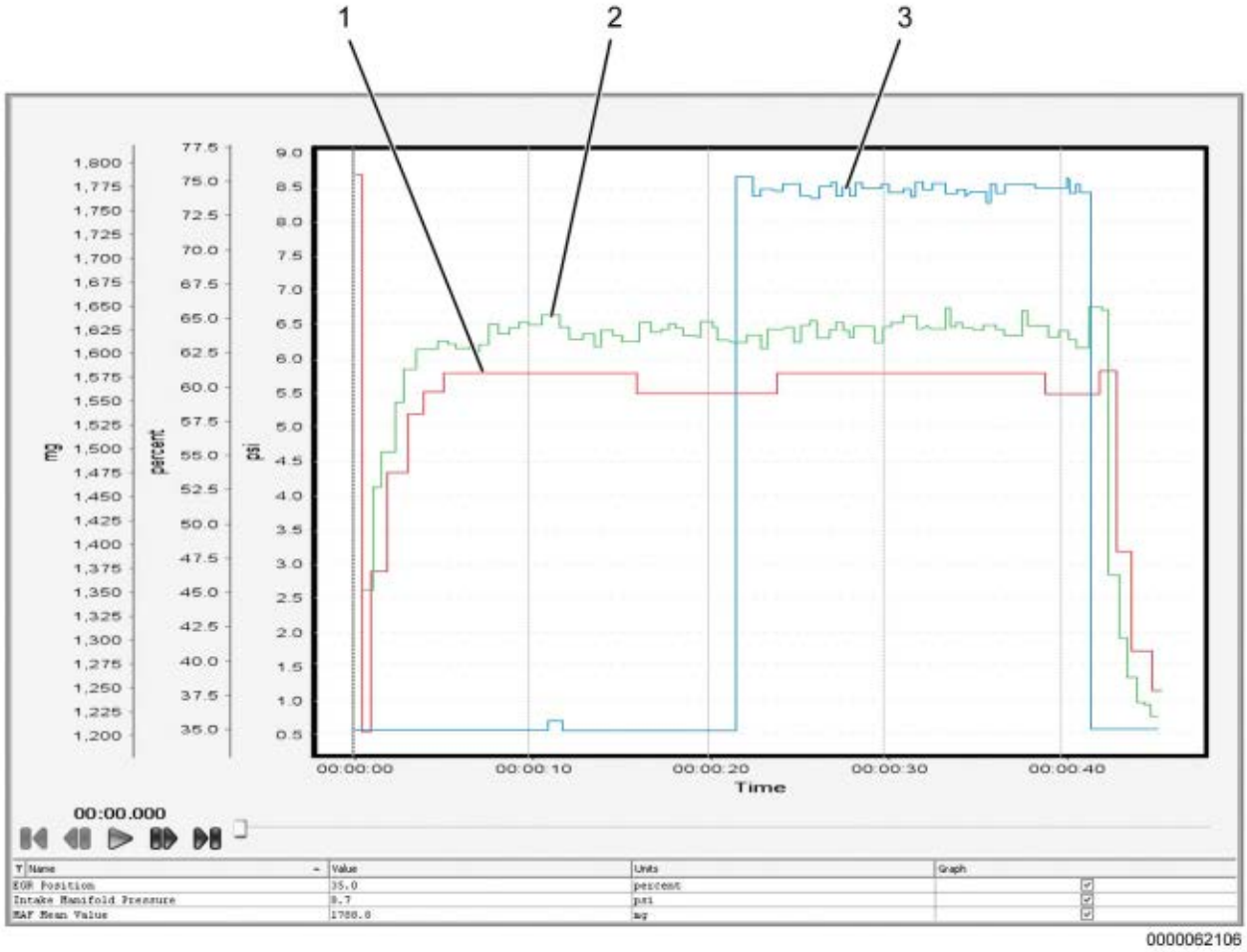


Figure 59 Graph 2: Air Management System Test (Bad)

1. Intake Manifold Pressure (IMP) (psi) [Red]
2. Mass Air Flow (MAF) Mean Value (MMV)(mg) [Green]
3. Exhaust Gas Recirculation (EGR) valve position (percent) [Blue]

Graph Analysis:

This graph shows an Air Management System (AMS) not operating as designed during the Air Management Test (AMT). The AMT gives pass or fail results. It allows the user to validate the AMS by monitoring the effects each actuator has on Intake Manifold Pressure (IMP). IMP is normally between 2 psi (14 kPa) to 6 psi (41 kPa) on engine ramp up during AMT. If the Exhaust Gas Recirculation (EGR) valve is not operating as designed, IMP will not respond to changes in EGR valve position. Excess soot will then be generated by the engine causing frequent regeneration of the aftertreatment system.

Actions:

1. When EGR valve is commanded ON, verify Intake Manifold Pressure (IMP) signal value drops. In this graph, IMP does not drop when EGR valve is commanded ON.

NOTE: EGR valve position will never read less than 35% and is considered closed.

Cylinder Cutout Test

The Cylinder Cutout Test will isolate 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.
3. Run Cylinder Cutout Test.

Onboard Filter Cleanliness Test

NOTE: KOER Standard Test must be run before running this test.

The Onboard Filter Cleanliness Test increases engine speed to measure pressure differential across the Diesel Particulate Filter (DPF).

Service Tool Procedures

These procedures are not Service Bay Tests, but special ECM controls that will allow the technician to perform specific procedures. The MaxxForce® DT, 9, and 10 engines have one special procedure, MAF Sensor Calibrate.

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

MAF Sensor Calibrate

NOTE: KOER Standard Test must be run before running this test.

The MAF Sensor Calibrate procedure calibrates the Mass Air Flow (MAF) sensor. Anytime the air filter or MAF sensor is replaced, this procedure needs to be performed.

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Description

Engine Symptoms Diagnostics Description

Diagnostic test procedures help technicians find problems systematically and quickly to avoid unnecessary repairs. Procedures in this section help identify causes for listed problems and conditions.

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, 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.

Coolant System

Coolant Over Flow

Overview

Tool installation instructions and testing procedure to diagnose combustion gasses in the cooling system. A failed cylinder head gasket or cracked cylinder sleeve are possible causes of combustion leaks. However, this should not be considered unless there is evidence of engine overheating and all other possible paths to a solution have been examined and eliminated.

Foam in deaeration tank could be caused by failed deaeration cap / gasket. If evidence of foam is present in deaeration tank, inspect cap / gasket prior to investigation of any possible causes.

Possible Causes

- Coolant loss from de-aeration tank
- Coolant aeration
- Engine overheat
- Misfire
- Shutdown when cold

Tools

- ZTSE2384 – Radiator Pressure Testing Kit
- 09–889–01 – Combustion in Cooling System Tester
- Test Beaker

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 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 to avoid being scalded by steam.
- Continue to turn cap counterclockwise to remove.

Test Procedure

Step 1	Check coolant level, contamination and quality.	Decision
Perform Coolant Quality Inspection (page 248) procedure. Does cooling system pass inspection?		Yes: Go to Step 2. No: Repair as needed and then go to Step 2.

Step 2	Determine if deaeration tank and cap will hold pressure.	Decision
Perform Deaeration Tank and Cap Test (page 251). Does deaeration cap and tank seal properly?		Yes: Go to Step 3. No: Repair or replace tank or cap as needed, then go to Step 3.

Step 3	Determine if cooling system over-flow or over-temperature occurs.	Decision
Perform Coolant Over-Flow/Over-Temperature Test (page 253). Does coolant overflow occur?		Yes, Overflow: Go to Step 4 (page 106). No: Over-Temperature: Go to Coolant Over Temperature (page 119) .

Step 4	Determine if air compressor is causing cooling system overflow.	Decision
Perform Air Compressor Overflow Test (page 254). Is the air compressor pressurizing the cooling system?		Yes: Repair or replace air compressor. Go to Step 11 (page 107). No: Go to Step 5.

Step 5	Determine if fuel injector sleeves or cylinder head are leaking.	Decision
A. Remove cylinder head. B. Perform Cylinder Head Pressure Test in the *Engine Service Manual*. Are any fuel injector sleeves, or the cylinder head leaking?		Yes: Replace leaking fuel injector sleeves, or leaking cylinder head then go to Step 11 (page 107). No: Go to Step 6.

Step 6	Determine if cylinder sleeves have cavitation or cracks.	Decision
Perform Cylinder Sleeve Cavitation and Crack Inspection (page 249) procedure. Are any cylinder sleeves cracked or damaged by cavitation?		Yes: Replace damaged cylinder sleeves as needed. Go to Step 11 (page 107). No: Go to Step 7.

Step 7	Determine if engine cylinder head is cracked.	Decision
Perform Inspecting Cylinder Head for Cracks in the *Engine Service Manual*. Is cylinder head cracked?		Yes: Replace cylinder head. Go to Step 11 (page 107). No: Go to Step 8.

Step 8	Determine if cylinder head gasket surface is warped.	Decision
Perform Measuring Cylinder Head Warpage procedure in *Engine Service Manual* and compare measurements to cylinder head gasket surface flatness specifications. Is cylinder head gasket surface flatness within specifications?		Yes: Go to Step 11. No: Go to Step 10.

Step 9	Measure cylinder head thickness to determine if cylinder head can be resurfaced.	Decision
Perform Measuring Cylinder Head Thickness procedure in *Engine Service Manual* and compare measurements to Cylinder head thickness specifications. Will cylinder head exceed minimum cylinder head thickness after resurfacing?		Yes: Resurface the cylinder head. Go to Step 11. No: Replace the cylinder head. Go to Step 11.

Step 10	Measure cylinder sleeve protrusion.	Decision
Perform Measuring Cylinder Sleeve Protrusion procedure in *Engine Service Manual*. Are Cylinder sleeve protrusion and Cylinder sleeve protrusion difference between all six sleeves within specification?		Yes: Go to Step 11. No: Correct liner protrusion and assemble engine. Go to Step 11.

Step 11	Reassemble and use Coolant Management Tool to fill cooling system.

End Diagnostic Steps
After performing all diagnostic steps, if fault remains, verify if each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Coolant Leak to Exhaust/Intake

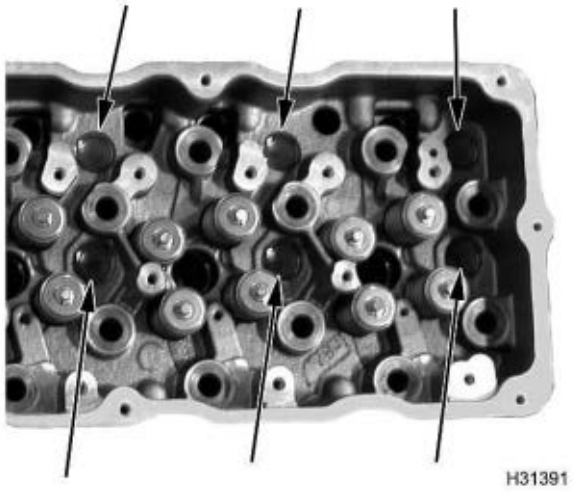


Figure 60 Cylinder head (top) cup plugs

Symptoms

- Loss of coolant without visible leaks
- White smoke
- Coolant odor in the exhaust
- Coolant dripping from the exhaust system
- Overheating
- Hydraulic cylinder lock

Tools

- Regulated compressed air
- ZTSE4648 – Water Supply Housing Pressure Adapter
- ZTSE2384 – Radiator Pressure Testing Kit
- KL 20030 NAV – EGR Cooler Leak Detection Kit
- ZTSE4409 – Pressure Test Kit
- ZTSE4937 – Interstage Block Off Kit (if equipped with interstage cooler)
- Coolant supply to Doser injector pressure test plugs. 5/16-18 (obtain locally)

Possible Causes

- Failed interstage cooler (if equipped)
- Failed Exhaust Gas Recirculation (EGR) cooler
- Failed injector sleeve
- Cylinder head porosity

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

Interstage Cooler Inspection

NOTE: The interstage cooler is only available on MaxxForce® DT, 9, and 10 engines with at least 245 hp.

Procedure

1. Visually inspect for coolant leaks; repair as necessary.
2. Start and run engine until normal operating temperature is reached.

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

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

3. Install the Radiator Pressure Test kit (page 1219) with the appropriate adapter.
4. Pressurize cooling system to 15 psi (103 kPa)

NOTE: If pressure drops rapidly without visible coolant leaks, coolant may be leaking down the intake piping into the low side turbocharger.

5. Remove interstage cooler inlet tube and inspect for coolant in the inlet port of the interstage cooler.
   - If no coolant is present, continue to next step.
   - If coolant is present, see the *Engine Service Manual* for interstage cooler replacement.
6. Drain coolant from the system. Remove the interstage cooler following the procedure in the *Engine Service Manual*.
7. Install interstage cooler block-off plates. Use Pressure Test Kit or regulated shop air to pressurize the cooler to 30 psi (207 kPa).

NOTE: Do not exceed 30 psi (207 kPa) test pressure.

8. Close the air supply shut-off valve and monitor for pressure loss. If necessary, submerge cooler into a tank of hot water and watch for air bubbles.
   - If interstage cooler does not hold pressure, see the *Engine Service Manual* for replacement.
   - If interstage cooler holds pressure, continue to EGR Cooler Inspection.

EGR Cooler Inspection

Cooling System Pressure Test

1. Visually inspect EGR cooler for external coolant leaks.
2. Install Radiator Pressure Test kit (page 1219) with the appropriate adapter.

3. Pressurize cooling system to 15 psi (103 kPa).
4. Check for external leaks in the cooling system.
   - If external leaks are found, repair as necessary.
   - If no leaks are found, continue to the next step.

NOTE: If pressure drops rapidly without visible coolant leaks, the EGR cooler may be leaking coolant internally.

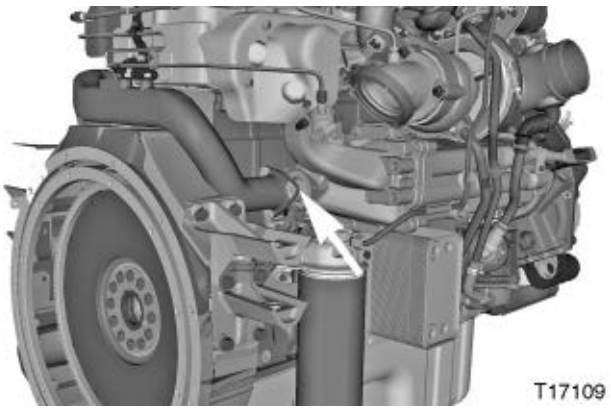


Figure 61 EGR outlet and cross-over tube

5. Remove the EGR cross-over tube (cooler-to-intake), following procedure in the *Engine Service Manual*.

- If coolant is present, go to In Vehicle EGR Cooler Test (page 111).
- If no coolant is present, continue to Injector Sleeve Inspection (page 112).

In Vehicle EGR Cooler Test

Equipment Condition

- Chock wheels and disconnect battery.
- Drain cooling system using Coolant Management Tool.
- Remove passenger side inner fender.
- Remove alternator.
- Remove alternator mounting bracket.
- Remove coolant supply and return tubes from front of EGR cooler.
- Disconnect coolant dearation line from top of EGR cooler.

EGR Cooler Test Procedure

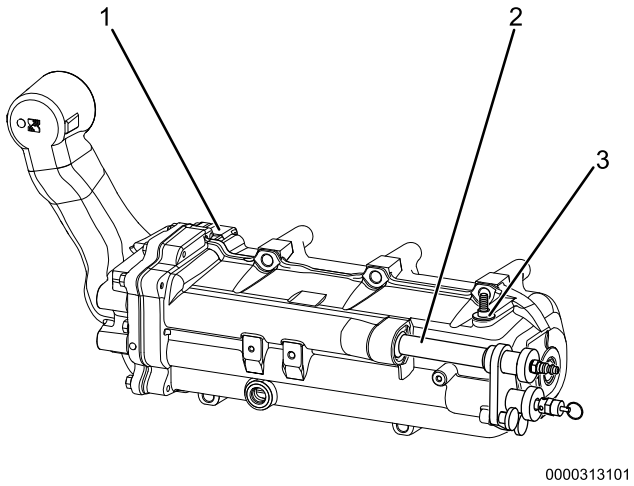


Figure 62 EGR Cooler Test Setup

1. EGR Cooler
2. Coolant Port Plug 20020–2
3. Plug 20020–1 or 3/8” Hose

1. Attach plug 20020-1 (Figure 62) (Item 3) to the dearation fitting, and tighten. Do not over tighten dearation fitting due to risk of damaging the O-ring.

NOTE: Some kits do not contain plug 20020-1. A capped off piece of 3/8" hose will work as a substitute for plug 20020-1. Ensure connection/plug are not leaking.

2. Install the coolant port plug assembly (20020-2) (Figure 62) (Item 2) into the coolant ports.
3. Attach pressure regulator with shut-off valve to air hose fitting on the coolant port plug (Figure 62) (Item 2). It may be necessary to use a short hose extension, depending on chassis or shut-off valve.
4. Pressurize EGR Cooler (Figure 62) (Item 1) to 55 psi (379 kPa), and close air supply valve.
5. Monitor air pressure gauge for 10 minutes and observe gauge for air pressure loss.

Decision

Did Air Pressure gauge drop 5 psi (34 kPa) or more after 10 minutes?

- Yes: Replace EGR Cooler.
- No: Go to Coolant Leak to Exhaust/Intake (page 109).

Injector Sleeve Inspection

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

Procedure

1. Remove injectors following the procedure in *Engine Service Manual*.
2. Inspect injector sleeves for signs of coolant leakage. Plug in the coolant heater to warm the coolant.

3. Install Radiator Pressure Test kit (page 1219) with the appropriate adapter.
4. Pressurize cooling system to 15 psi (103 kPa).
5. Inspect injector sleeves again for coolant leakage. Check for coolant entering each cylinder.
   - If a leak is occurring at an injector sleeve, replace the sleeve following the procedure in the *Engine Service Manual*.

     Test again to validate repair.
   - If no leaks are apparent, but coolant is entering a cylinder, replace the cylinder injector sleeve following the procedure in the *Engine Service Manual*.

     Test again to validate repair.

     If leak continues, go to Cylinder Head Leak Test (page 114).
   - If available, a bore scope inserted through injector sleeve may aid identification of coolant-washed cylinder prior to cylinder head removal.

Cylinder Head Leak Test

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

1. Remove the valve cover and other parts, as needed, following the procedure in the *Engine Service Manual*.
2. Plug in the coolant heater to warm the coolant.
3. Pressurize the cooling system to 15 psi (103 kPa).

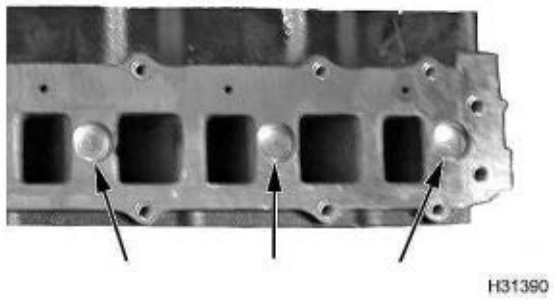


Figure 63 Cylinder head (intake side) cup plugs

4. Inspect the entire cylinder head including the cup plugs behind the intake manifold, if necessary.
   - If a leak is noticed, repair or replace if necessary.
   - If no leaks are noticed, go to the next step.
5. Drain coolant from system.
6. Remove cylinder head from engine following procedures in the *Engine Service Manual*.
7. Inspect and pressure test the cylinder head following procedures in the *Engine Service Manual*.
   - Inspect cylinder head gasket for damage at sealing points that show evidence of a leak. Verify crankcase and cylinder head surface flatness using a straightedge and feeler gauge following procedure in the *Engine Service Manual*. Replace the head gasket. Repair or replace the cylinder head if necessary.
   - Inspect the cylinder head for cracks following procedure in the *Engine Service Manual*. Repair or replace.
8. Magna-flux test the cylinder head for cracks.
9. Test the cooling system again after any repair to validate the repair.

Coolant in Lube Oil

Symptom

When the crankcase lube oil is contaminated with coolant, the oil will have a light-gray or black sludgy appearance. The crankcase may also be overfilled.

Tools

- ZTSE2384 – Radiator Pressure Testing Kit
- ZTSE4289A – Cylinder Head Pressure Test Kit
- ZTSE4648 – Water Supply Housing Pressure Adapter
- ZTSE4647 – Thermostat Opening Pressure Adapter (cylinder head)
- Straight edge
- Feeler gauge

Possible Causes

- Failed interstage cooler (if equipped)
- Cylinder head cup plug failure
- Crevice seal (liner O-ring) failure
- Cylinder head gasket leak
- Front cover gasket damage
- Failed oil cooler

NOTE: Oil cooler coolant leakage to oil will occur only when coolant pressure is higher than oil pressure. Diagnosis and repairs will not be authorized based solely on oil analysis.

Prior to pursuing diagnosis and repair of a coolant in oil complaint, the technician must complete the following:

- Visually examine an oil sample, taken through the drain plug, for coolant-in-oil contamination.
- If there is no visible evidence of coolant-in-oil, no further action is necessary.
- If there is visible presence of coolant in the engine oil sample, then the technician may proceed with diagnosis to identify the cause.

If the complaint is one of general coolant loss, then the following may be considered prior to releasing the vehicle to the customer:

- External leaks
- Coolant in air tank(s)
- Coolant in exhaust
- Skewed record due to periodic coolant overfilling; this could cause loss through the overflow tank (e.g., driver fills the coolant tank to the MAX line when engine is cold). The service department is advised to request records showing the quantity of coolant added over time and engine hours of operation. The complaint must always be independently confirmed by the service department.

Coolant System Inspection

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 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 to avoid being scalded by steam.
- Continue to turn cap counterclockwise to remove.

Procedure

1. Check oil level and quality to verify oil contamination complaint.
   - The presence of coolant in the oil will generally give the oil a light-gray or black sludgy appearance.
2. If oil contamination is verified, determine if the engine is equipped with an air compressor.
   - If yes, do steps 3 through 7.
   - If no, continue with step 8.
3. Install Radiator Pressure Test Kit (page 1219) with the appropriate adapter.
4. Plug in cylinder block heater to warm coolant

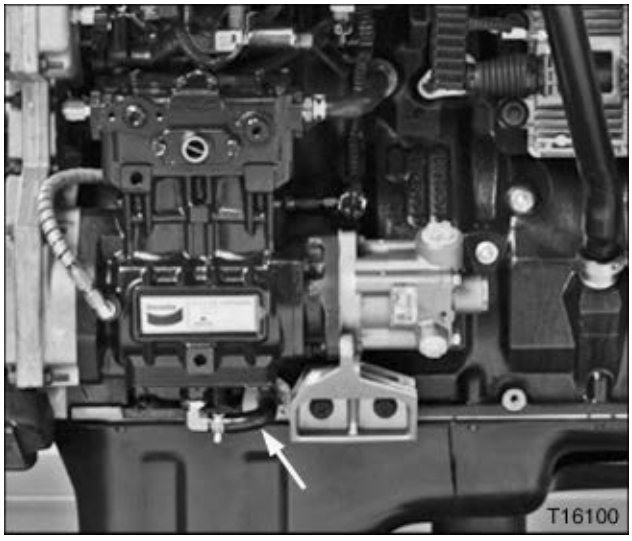


Figure 64 Air compressor oil drain-back hose

5. Remove air compressor oil drain-back hose from the bottom of compressor.
6. Pressurize the cooling system to 15 psi (103 kPa).

7. Look for coolant leaking from the air compressor oil drain-back port.
   - If coolant is leaking from air compressor, repair or replace air compressor.
   - If coolant is not leaking from the air compressor oil drain-back port, continue to step 8.
8. Drain engine oil and remove the oil filter.
9. Remove the oil pan following the procedure in the *Engine Service Manual*.
10. If not already done, install Radiator Pressure Test Kit (page 1219) with the appropriate adapter.
11. Pressurize cooling system to 15 psi (103 kPa). Inspect for coolant leaks.
    - If the engine does not have an air compressor and is leaking from the front cover area or the oil suction tube, do Front Cover Inspection (page 118).
    - If a leak is noticed between the cylinder sleeve and piston, replace the injector sleeve for that cylinder. Follow procedure in the *Engine Service Manual*.
    - If a leak is noticed between the cylinder sleeve and the engine block, replace the cylinder sleeve crevice seal for that cylinder. Follow procedure in the *Engine Service Manual*.
    - If a leak is noticed from the oil drain-back ports (camshaft side), do Cylinder Head Leak Test (page 114).
    - If no leak is noticed, leave pressure and heat on cooling system overnight and check the following day.
    - If coolant leak is noticed at the number seven main bearing, remove cylinder head to inspect for faults near crankcase-to-cylinder head oil supply gallery.
    - If no leak is noticed after inspection of oil supply hole and overnight pressure test, do the following sequential tests until problem is found:
      A. Re-examine symptoms and evidence that a coolant leak exists.
      B. Front Cover Inspection (page 118)
      C. Cylinder Head Leak Test (page 114)
12. After any repairs are completed, replace contaminated engine oil and coolant. Test the cooling system again to validate the repair.

Front Cover Inspection

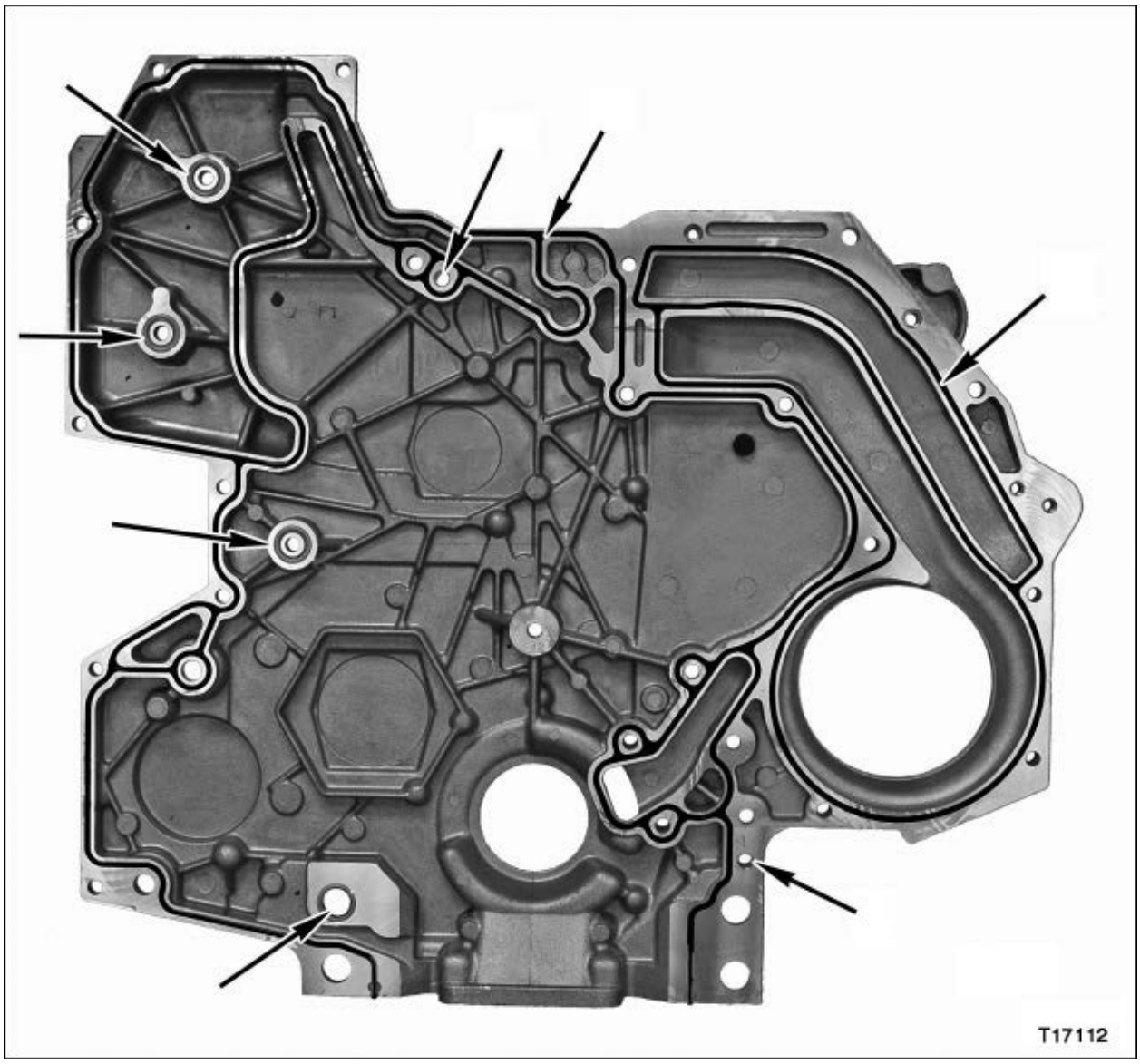


Figure 65 Possible front cover coolant leak locations

1. Remove front cover and inspect gaskets and sealing surfaces following procedure in the *Engine Service Manual*. Check front cover and crankcase with straight edge and feeler gauge. Repair or replace as required.
2. After repairs are completed, replace the engine oil and coolant. Test the cooling system again to validate the repair.

Coolant Over-Temperature

NOTE: Model year 2010 vehicles no longer utilize DTC identification by number. DTCs are now identified using the SPN and FMI identifiers only. These two identifiers, known as the Suspect Parameter Number (SPN) and the Failure Mode Indicator (FMI), are displayed in the Electronic Service Tool (EST) with ServiceMaxx™ software in the DTC Window for model year 2010 vehicles and DTC for pre-2010 vehicles.

Symptoms

When coolant temperature is above 224°F (107°C), codes will be set, the control system will command less fuel, and a power loss will occur.

When coolant temperature is above 228°F (109°C), the red ENGINE lamp will be illuminated and a code will be set.

When coolant temperature is above 234°F (112°C), the red ENGINE lamp will flash, an audible alarm will sound, and a code will be set. If the vehicle has the warning protection feature enabled, the engine will shutdown after 30 seconds.

Tools

- ZTSE2384 – Radiator Pressure Testing Kit
- Regulated compressed air
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Infared thermometer (locally obtained)

Possible Causes

- Defective radiator cap
- Low engine coolant level
- Internal or external coolant leaks
- Internal or external radiator blockage
- Broken/worn accessory drive belt
- Accessory belt tensioner failure
- Coolant thermostat stuck closed
- Slipping cooling fan drive clutch
- Water pump failure
- Cooling fan blade assembly wrong/damaged
- Instrument panel gauge error
- Engine Coolant Temperature (ECT) sensor biased
- Incorrect radiator
- Chassis effects, transmission, after-market equipment

Coolant System Inspection

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 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 to avoid being scalded by steam.
- Continue to turn cap counterclockwise to remove.
- Do not substitute water for coolant.

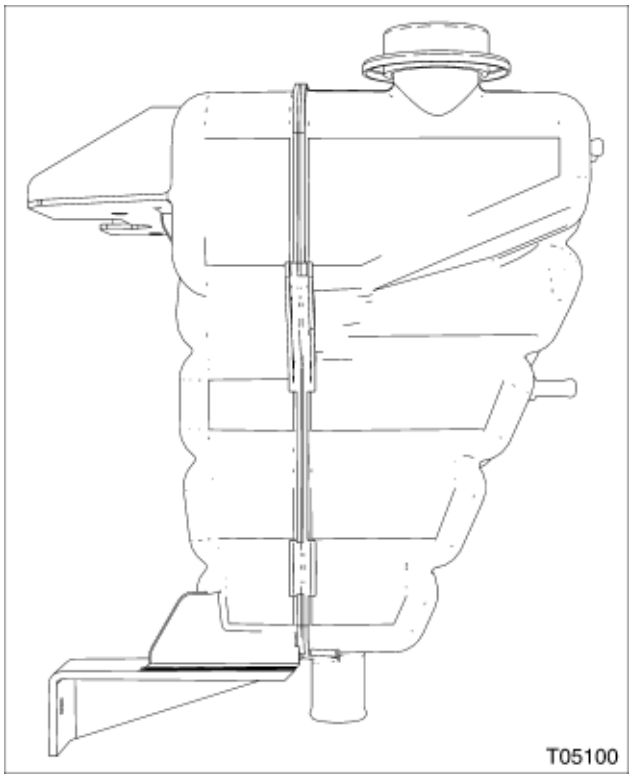


Figure 66 Deaeration tank (typical)

1. Check coolant deaeration tank for contamination and correct fill level.
   - If coolant level is low, do step 2.
   - If coolant level is correct, do step 6.
   - If coolant is contaminated with oil, go to Lube Oil in Coolant (page 130).
2. Pressure test deaeration tank cap.

3. Fill cooling system to the appropriate level.
4. Inspect for coolant leaks. Check for external leaks from coolant hoses, radiator, heater core, deaeration tank, deaeration tank, cap, engine, or cylinder head cup plugs. Check for coolant in oil.
   - If any external leaks are found, repair and fill cooling system. Test again for over-temperature condition.
   - If oil is contaminated with coolant, go to Coolant in Lube Oil (page 115).
   - If no leaks are found, continue with step 5.
5. Start engine.
6. Test again for over-temperature condition
   - If the engine is not running over-temperature, continue with step 7.
   - If the engine continues overheating, do step 8.

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

7. Install Radiator Pressure Test kit (page 1219) with the appropriate adapter.
8. Pressurize the cooling system to 15 psi (103 kPa).
   - If coolant is leaking externally, identify the leak and repair. Repeat the test to verify repair.
   - If coolant is not leaking externally, but the pressure is dropping, see Coolant Leak to Exhaust/Intake (page 109) and Coolant in Lube Oil (page 115).
9. Inspect the following items: cooling fan blade, shroud, accessory drive belt, accessory drive belt tensioner, cooling fan drive clutch, operation of electric or air fan, thermostat, and radiator.

   CAUTION: To prevent radiator damage, when using high-pressure washer, be careful not to get the wand too close to radiator fins.
   - If vehicle is new or recently repaired, verify the correct part number for any component related to the cooling system.
   - If the radiator cooling fins are blocked due to a build-up of dirt or debris, use a power washer to clean blockage from radiator fins or any debris on the cooling fan and fan drive clutch.

   NOTE: If heat exchangers are stacked, separation of each cooler is necessary for proper cleaning.
   - If no problems are identified, continue to Temperature Sensor Validation Test (page 122) in this section.

Temperature Sensor Validation Test

NOTE: Model year 2010 vehicles no longer utilize DTC identification by number. DTCs are now identified using the SPN and FMI identifiers only. These two identifiers, known as the Suspect Parameter Number (SPN) and the Failure Mode Indicator (FMI), are displayed in the Electronic Service Tool (EST) with ServiceMaxx™ software in the DTC Window for model year 2010 vehicles and DTC for pre-2010 vehicles.

1. Install Electronic Service Tool (EST) with ServiceMaxx™ software and check for active and inactive codes related to engine coolant over-temperature conditions.
   - If any codes remain relating to coolant over-temperature condition, correct codes before continuing.
   - If no codes exist, continue with step 2.

NOTE: The following test is only accurate if done after a cold soak of at least eight hours on the engine.

2. Using the Electronic Service Tool (EST) with ServiceMaxx™ software, compare Engine Coolant Temperature (ECT1), Engine Oil Temperature (EOT), Exhaust Manifold Temperature (EMT), and Intake Manifold Temperature (IMT) with Key-On Engine-Off.
3. Run engine up to operating temperature. Try to duplicate the operator's coolant over-temperature concern. Monitor the ECT1 using the Electronic Service Tool (EST) with ServiceMaxx™ software and the instrument panel coolant temperature gauge.
   - If instrument panel coolant temperature gauge reads a different temperature than the Electronic Service Tool (EST) with ServiceMaxx™ software and test gauge, repair instrument panel coolant temperature gauge fault.
   - If gauge is reading correctly, watch for gauge to drop down to make sure the thermostat is opening at desired temperature. If temperature rises steadily without dropping down, thermostat is possibly stuck closed. Replace thermostat, and recheck.

Cooling System Operating Pressure 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 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 to avoid being scalded by steam.
- Continue to turn cap counterclockwise to remove.

1. Install the Radiator Pressure Tester on the deaeration tank and run engine at elevated idle. Monitor the pressure in the system using the tester gauge to see if pressure rises above normal value of deaeration tank cap.
   - If the pressure is higher than specification and both upper and lower radiator hoses are at engine operating temperature, then continue to Coolant Over Flow (page 105).
   - If the pressure is lower than specification and upper and lower radiator hoses are at different engine operating temperatures, replace thermostat.

Lubrication System

Low Oil Pressure

Symptom

Low oil pressure can cause any or all of the following:

- Red ENGINE lamp
- Codes for Engine Oil Pressure (EOP) or Injection Control Pressure (ICP) fault
- Engine knock
- Engine hard start or no start condition
- Engine loss of power

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- ZTSE4409 – Pressure Test Kit
- Regulated compressed air

Possible Causes

- Low oil level: oil leak, oil consumption, or incorrect servicing
- High oil level: incorrect servicing, fuel in oil, or coolant in oil
- Incorrect oil viscosity
- Incorrect EOP sensor
- Oil pressure regulator stuck open
- Scored/damaged oil pump
- EOP sensor biased
- Broken, missing, or loose piston cooling jets
- Missing, damaged, or worn bearing inserts or camshaft bushings
- Aeration (cracked pickup tube or pickup tube gasket)
- Loose rocker arm bolt or worn rocker shaft

Lubrication System Inspection

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: Never check the oil level when the engine is running or immediately after the engine is shut down; the reading will be inaccurate. Allow 15 minute drain down time, before checking oil level.

1. Park vehicle on level ground.
2. Check oil level with oil level gauge. If oil level is low, fill to the correct level.

NOTE: When the crankcase lube oil is contaminated with coolant, the oil will have a light-gray or black sludgy appearance. The crankcase may also be overfilled.

3. Inspect oil for thickening and odor.
   - If oil is contaminated, go to Fuel in Lube (page 131) or Coolant in Lube Oil (page 115) test procedures.
   - If oil level is at the correct level and not contaminated, do step 5.
4. After repairs are completed, replace the contaminated oil, oil filter, and coolant as required.



Figure 67 Pressure Test Kit connected to EOP sensor fitting

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.

5. Connect the to the engine oil pressure test port located on the EOP sensor. If the engine is equipped with an air compressor, use an adapter inline to this port.
6. Measure pressure at low and high idle. The engine must be at operating temperature.
   - If oil pressure does not read within the specification listed in Appendix A (All Ratings, page 1291), go to Oil Pressure Regulator Inspection (page 125).
   - If oil pressure reads within specification listed in Appendix A (All Ratings, page 1291), compare mechanical gauge readings with instrument panel gauge and EOP value on the Electronic Service Tool (EST) with ServiceMaxx™ software.
   - If instrument panel engine oil pressure gauge reads a different value than the Electronic Service Tool (EST) with ServiceMaxx™ software and mechanical oil pressure gauge, repair instrument panel engine oil pressure gauge fault.

Oil Pressure Regulator Inspection

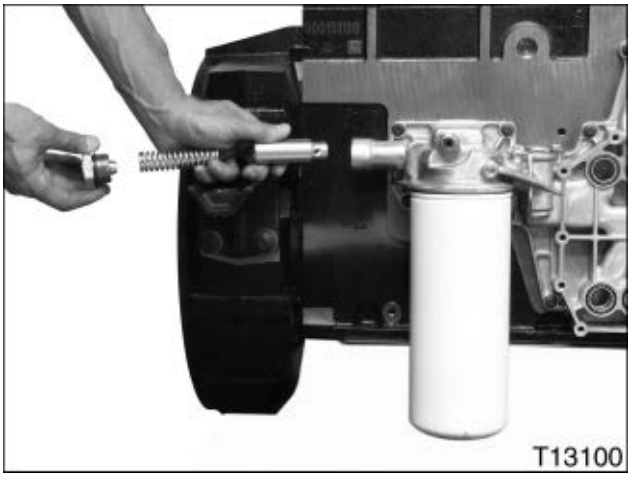


Figure 68 Oil pressure regulator

1. Remove and inspect oil pressure regulator as described in the *Engine Service Manual*.

   NOTE: The oil pressure regulator piston should move freely in its bore. Inspect valve cap and O-ring, spring, piston, and valve body for damage.

   - If oil pressure regulator fails inspection, install a new oil pressure regulator following the procedure in the *Engine Service Manual*.
   - If oil pressure regulator is functional and passes inspection, go to Oil and Crankcase Inspection (page 126).

Oil and Crankcase Inspection

1. Drain oil from engine. Inspect oil drain plug magnet, drained oil, and oil filter for debris.

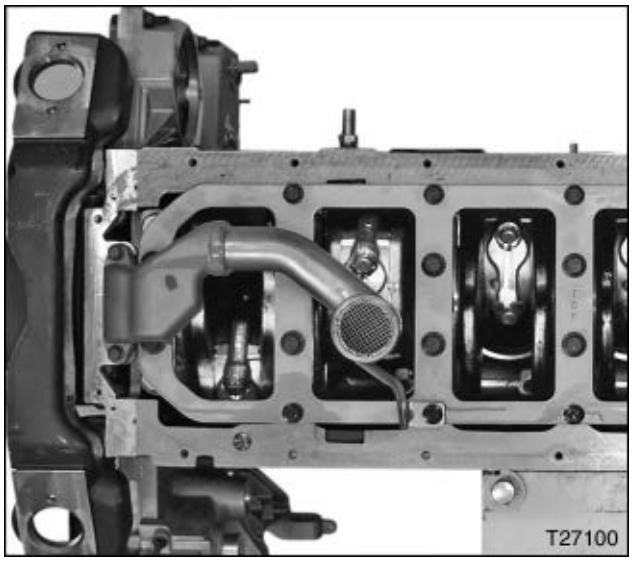


Figure 69 Bottom of engine

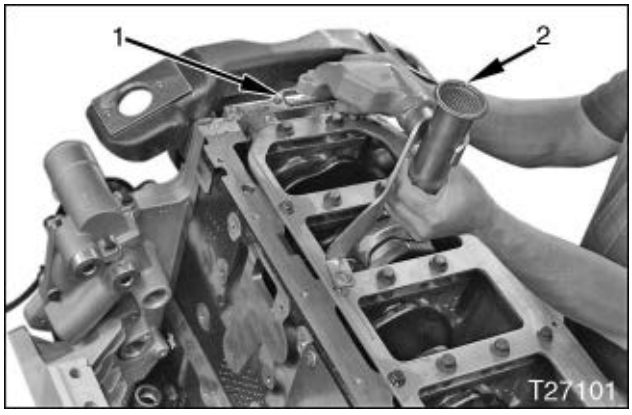


Figure 70 Oil suction tube assembly and gasket

1. Oil suction tube gasket
2. Oil suction tube assembly

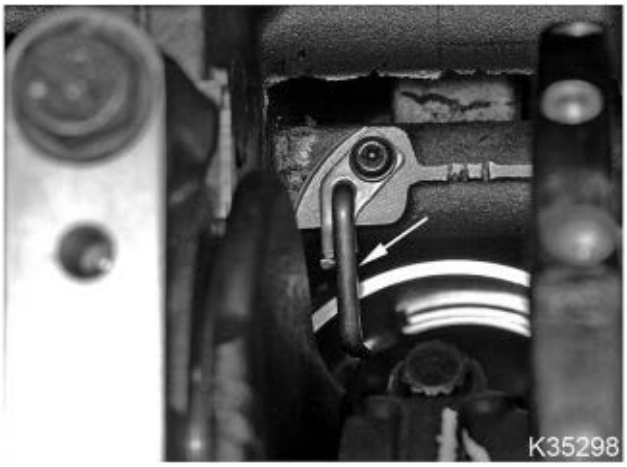


Figure 71 Piston cooling jet

2. Remove oil pan following the procedure in the *Engine Service Manual*.
3. Inspect the bottom of oil pan for debris.
4. Inspect for missing, loose, plugged, or damaged oil pickup tube, pickup tube gasket, piston cooling jets, bearing inserts, and cam bushings. Replace or repair as necessary.

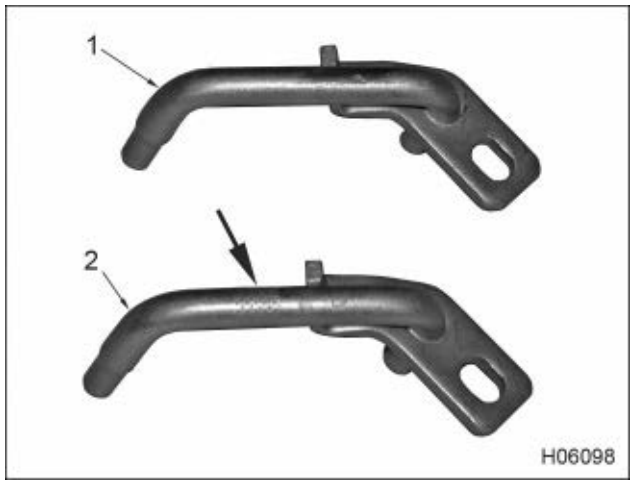


Figure 72 Piston cooling jets

1. Piston cooling jet (unknurled) – MaxxForce® DT engines
2. Piston cooling jet (knurled) – MaxxForce® 9 and 10 engines

5. Verify correct piston cooling jets are installed for the engine displacement.

Oil Pump Inspection

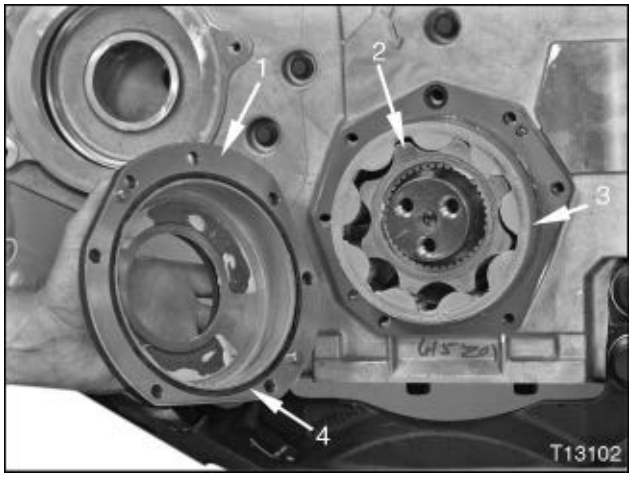


Figure 73 Lube oil pump housing cover

1. Lube oil pump housing
2. Inner gerotor
3. Outer gerotor
4. Oil pump seal

1. Remove and inspect the lube oil pump as described in the *Engine Service Manual*.
   - Inspect the lube oil pump housing and plate for gouging, scoring, or a discolored hot-scored appearance.
   - Inspect the gerotor gears for excessive wear or damage.
   - If no excessive damage is found, go to Front Cover Inspection (page 129).

Front Cover Inspection

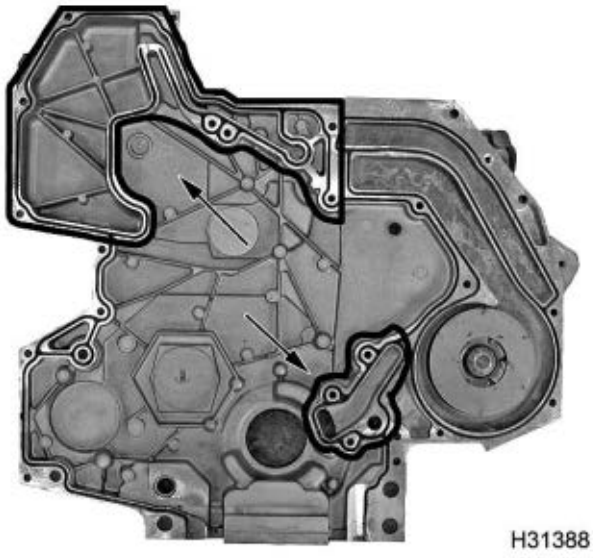


Figure 74 Possible front cover internal oil leak areas

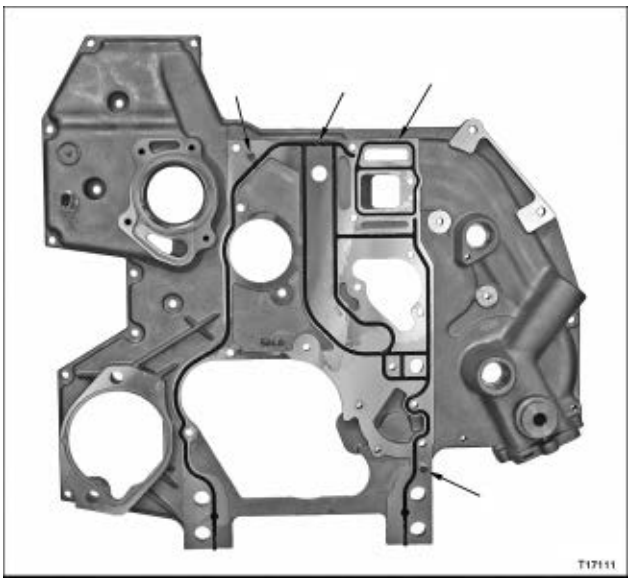


Figure 75 Possible front cover internal oil leak areas

1. Remove the front cover assembly (front half) from the engine following the procedure in the *Engine Service Manual*. Inspect the front cover and front cover gasket for damage. Repair or replace, if needed, and retest.

Lube Oil in Coolant

Symptom

Coolant contaminated with lube oil will have oil in the deaeration tank.

Tools

- ZTSE4939 – Oil Cooler Pressure Test Plate
- ZTSE4409 – Pressure Test Kit
- Regulated compressed air

Possible Causes

- Failed oil cooler

Procedure

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, 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 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 to avoid being scalded by steam.
- Continue to turn cap counterclockwise to remove.

1. Check for coolant contamination by inspecting deaeration tank for presence of oil.
2. Place a coolant drain pan under the oil cooler module.
3. Remove the coolant drain plug installed in the bottom of the oil cooler module. Drain coolant. This procedure will drain the entire cooling system.

NOTE: Install a new O-ring before installing the coolant drain plug.

4. Remove the oil cooler following the procedure in the *Engine Service Manual*.
5. Pressure test the oil cooler following the procedure in the *Engine Service Manual*. If a leak is noticed, replace the oil cooler. If there is no visible leak, no repair is necessary.
6. After repair is made, flush cooling system completely and monitor for contaminants. Repeat as necessary.

Fuel in Lube

Symptom

Oil contaminated with diesel fuel will cause the oil level in engine to increase.

Tools

None

Possible Causes

- Engine performance or start issues (misfire, rough idle, low power, poor start ability)
- Leaking fuel injector or injector O-ring (a leaking injector sleeve or injector tip could cause contaminated engine oil, but would most likely be identified as a performance problem.)

Procedure

1. Verify oil contamination.
2. Remove the oil level dipstick. Capture an oil drop on a clean paper towel.

   High fuel content will be indicated by an expanding ring of fuel moving outwards from the oil drop.

   - If excessive fuel is present, take an oil sample for analysis and monitor engine oil level.
   - If no excessive fuel is noted, no repair is required.

Engine Run / Start Symptoms

1.0 - Preliminary Vehicle Operational Checkout Procedure

Step 1	Inspect fuel level, quality, and fuel system.	Decision
	Perform Fuel Level Inspection, Fuel System Inspection, and Fuel Quality Check (page 191). Are fuel level and quality to specification, and did fuel system pass inspection?	Yes: Go to Step 2.
		No: Repair fuel system fault. After repairs are complete, retest for original problem.

Step 2	Inspect batteries, electrical system, and connections.	Decision
	Perform Batteries and Electrical System Inspection (page 193). Are batteries, electrical system, and connections in good condition, tight, not corroded, and is battery voltage in specification?	Yes: Go to Step 3.
		No: Repair broken, loose, or corroded electrical system connections or components. Charge batteries to 12.6 volts. After repairs are complete, retest for original problem.

Step 3	Inspect air intake system for damage or restrictions.	Decision
	Inspect Charge Air Cooler (CAC), Engine Throttle Valve (ETV), Mass Air Flow (MAF) sensor, air filter, intake piping, clamps, and connections for damage or restrictions. Are air intake system components damaged or restricted?	Yes: Repair air intake system damage or restrictions. After repairs are complete, retest for original problem.
		No: Go to Step 4.

Step 4	Inspect exhaust system for damage or restrictions.	Decision
	Inspect Diesel Oxidation Catalyst (DOC), Diesel Particulate Filter (DPF), Selective Catalyst Reduction (SCR) catalyst, exhaust brake, and exhaust piping for damage or restrictions. Are exhaust system components damaged or restricted?	Yes: Repair exhaust system damage or restrictions. After repairs are complete, retest for original problem.
		No: Go to Step 5.

Step 5	Inspect engine oil level.	Decision
	Perform Engine Oil and Quality Check (page 190). Is engine oil level to specification?	Yes: Go to Step 6.
		No: Correct engine oil level problem. After repairs are complete, retest for original problem.

Step 6	Inspect engine coolant level and quality.	Decision
	Perform Coolant Level Inspection (page 193) and Coolant Quality Inspection. (page 120) Are coolant level and quality to specification?	Yes: Go to Step 7.
		No: Fill engine coolant to specification. If coolant is contaminated, go to Coolant Contamination (page 105). After repairs are complete, retest for original problem.

Step 7	Obtain vehicle health report and check for current Engine Control Module (ECM) calibration.	Decision
	Perform Obtain Vehicle Health Report (page 81). Is ECM calibration current?	Yes: Go to Step 8.
		No: Ensure vehicle has latest ECM calibration. After repairs are complete, retest for original problem.

Step 8	Review Repair Order (RO) and operator complaint.	Decision
	Go to operational checkout procedure for specific symptom.	If engine will not start, go to: Engine Does Not Start Operational Checkout Procedure (page 135).
		If engine is hard to start, go to: Engine Hard to Start Operational Checkout Procedure (page 138).
		If engine has running problems while not under a load, go to: Engine Running, Engine Not Under Load Operational Checkout Procedure (page 142).
		If Engine has running problems while under a load, go to: Engine Running, Engine Under Load Operational Checkout Procedure (page 144).

End Diagnostic Steps
After performing all diagnostic steps, if fault remains, verify if each step was completed correctly and the proper decision was made. Notify supervisor for further action.

2.0 - Engine Does Not Start Operational Checkout Procedure

Overview

The following steps direct technicians to systematically troubleshoot engine no start conditions and to avoid unnecessary repairs.

Step 1	Check for no start related Diagnostic Trouble Codes (DTC).	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check DTC list for: • SPN 94 Fuel Delivery Pressure (FDP) • SPN 931 Engine Fuel Supply Pump Actuator (EFSPA) • SPN 164, 3055 Injection Control Pressure (ICP) • SPN 679 Injection Pressure Regulator (IPR) • SPN 636 Camshaft Position (CMP) • SPN 637 Crankshaft Position (CKP) • SPN 108, 158, 628, 629, 1136, 1387 Engine Control Module (ECM) • SPN 27, 2791 Exhaust Gas Recirculation (EGR) • SPN 110, 1659 Engine Coolant Temperature 1 (ECT1) • SPN 175 Engine Oil Temperature (EOT) • SPN 51, 3464, 3471 Engine Throttle Valve (ETV) Does EST DTC list have any of the fault codes listed above?	Yes: Go to Fault Code Diagnostics for no start related SPN / FMI. No: Go to Step 2. (page 136)

Step 2	Record snapshot of no start related Key-On Engine-Off (KOEO) data.	Decision
	Perform Record Snapshot of KOEO data (page 82). Are battery voltage, FDP, ICP, and engine temperature sensor values within KOEO specifications?	Yes: Go to Step 3. (page 137)
		No: Battery voltage out of specification: Repair battery, starting system, charging system, or ECM PWR circuit problem. After repairs are complete, retest for original problem.
		No: FDP out of specification: Go to Low Fuel Delivery Pressure (page 225).
		No: ICP out of specification: Go to SPN 164 FMI 0 Fault Code Diagnostics (page 833).
		No: One or more engine temperature sensors not within 20°F (7°C) of others after cold soak: Go to Fault Code Diagnostics (Circuit Diagnostics, page 316)for a sensor that is out of specification.

Step 3	Record snapshot of engine cranking data.	Decision
	Perform Engine Cranking Test (page 90). Are Switch Battery (SWBAT), Engine Speed (rpm), ICP, IPR, FDP, and EGR within engine cranking specification ?	Yes: Go to Step 4. (page 137)
		No: SWBAT or Engine Speed (rpm) out of specification: Go to 2.1 Engine Cranks Slow or Does Not Crank (page 146).
		No: ICP or IPR out of specification: Go to CPA High-Pressure Oil Pump (HPOP) Test (page 287).
		No: FDP out of specification: Go to Low Fuel Delivery Pressure (page 225).
		No: EGR out of specification: Go to SPN 2791 FMI 7 Fault Code Diagnostics (page 696).

Step 4	Engine no start, cold ambient temperature.	Decision
	Attempt to start engine. Does engine fail to start, specifically during cold ambient temperatures?	Yes: Go to 2.2 Engine No Start, Cold Ambient Temperature (page 150).
		No: Go to Step 5. (page 137)

Step 5	Engine at operating temperature, no re-start.	Decision
	A. Run engine to operating temperature. B. Attempt to start engine at operating temperature. Does engine fail to start, specifically after being run to operating temperature?	Yes: Go to 2.3 Engine at Operating Temperature, No Re-Start (page 152).
		No: Go to 2.4 Engine Never Starts (page 154).

3.0 - Engine Hard to Start Operational Checkout Procedure

Overview

The following steps direct technicians to systematically troubleshoot engine hard to start conditions and to avoid unnecessary repairs.

Step 1	Check for Hard to Start related Diagnostic Trouble Codes (DTC).	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check DTC list for: • SPN 94 Fuel Delivery Pressure (FDP) • SPN 931 Engine Fuel Supply Pump Actuator (EFSPA) • SPN 164 Injection Control Pressure (ICP) • SPN 679 Injection Pressure Regulator (IPR) • SPN 636 Camshaft Position (CMP) • SPN 637 Crankshaft Position (CKP) • SPN 108, 158, 628, 629, 1136, 1387 Engine Control Module (ECM) • SPN 27, 2791 Exhaust Gas Recirculation (EGR) • SPN 110, 1659 Engine Coolant Temperature 1 (ECT1) • SPN 175 Engine Oil Temperature (EOT) • SPN 1209 Exhaust Back Pressure (EBP) • SPN 1209 Air Management System (AMS) • SPN 3251 Diesel Particulate Filter Differential Pressure (DPFDP) • SPN 5541, 5543 Exhaust Back Pressure Valve (EBPV) • SPN 51, 3464, 3471 Engine Throttle Valve (ETV) • SPN 102 Intake Manifold Pressure (IMP) • SPN 132 Mass Air Flow (MAF) • SPN 651-656, 2797, 2798, 3055, 3659-3664, 4257 Injector (INJ) faults • SPN 4287 Engine Compression Brake Pressure (ECBP) Does EST DTC list have any of the fault codes listed above?	Yes: Go to Fault Code Diagnostics (page 299) for appropriate hard to start related SPN.
		No: Go to Step 2 (page 139).

Step 2	Record snapshot of Hard to Start related Key-On Engine-Off (KOEO) data.	Decision
	Perform Record Snapshot of KOEO Data . Are battery voltage, Fuel Delivery Pressure (FDP), Injection Control Pressure (ICP), and engine temperature sensor values within Key-On Engine-Off specifications?	Yes: Go to Step 3. (page 140)
		No: Battery voltage out of specification: repair battery, starting system, charging system, or ECM PWR circuit problem. After repairs are complete, retest for original problem.
		No: FDP out of specification: Go to Low Fuel Delivery Pressure (page 181).
		No: ICP out of specification: Go to SPN 164 FMI 0 Fault Code Diagnostics (page 833).
		No: One or more engine temperature sensors not within 20°F (7°C) of others after cold soak: Go to Fault Code Diagnostics (page 299) for sensor out of specification.

Step 3	Record snapshot of engine cranking data.	Decision
	Perform Engine Cranking Test (page 90). Are Switch Battery (SWBAT), Engine Speed (rpm), ICP, IPR, FDP, EGR, Turbocharger 1 Turbine Outlet Pressure (TC1TOP), and EBP within Engine cranking specification? *See Example TC1TOP (Actual) Calculations (page 1291).*	Yes: Go to Step 4. (page 141)
		No: SWBAT or Engine Speed (rpm) out of specification: Go to 2.1 Engine Cranks Slow or Does Not Crank (page 146).
		No: ICP or IPR out of specification: Go to Cylinder Performance Analyzer (CPA) – High-Pressure Oil Pump (HPOP) Test (page 287).
		No: FDP out of specification: Go to 8.1 - Low Fuel Delivery Pressure (page 181).
		No: EGR out of specification: Go to SPN 2791 FMI 7 Fault Code Diagnostics (page 696).
		No: TC1TOP or EBP out of specification: Look for exhaust restrictions. Go to 0000003081 *Aftertreatment Symptom-Based Diagnostic Manual* and 3.1 Engine Hard to Start, Cold Ambient Temperature(page 157).

Step 4	Determine if engine will not start specifically during cold ambient temperatures.	Decision
	Attempt to start engine. Is engine hard to start, specifically during cold ambient temperatures?	Yes: Go to 3.1 Engine Hard to Start, Cold Ambient Temperature (page 157).
		No: Go to Step 5. (page 141)

Step 5	Determine if engine is hard to re-start after being run to operating temperature	Decision
	A. Run engine to operating temperature. B. Attempt to re-start engine at operating temperature. Is engine hard to re-start specifically after being run to operating temperature?	Yes: Go to 3.2 Engine at Operating Temperature, Hard to Re-Start (page 159).
		No: Go to Step 6. (page 141)

Step 6	Determine if engine starts, and then stalls.	Decision
	Attempt to start engine. Does engine start and then stall?	Yes: Go to 3.3 Engine Starts, Then Stalls (page 161).
		No: Go to 2.4 Engine Never Starts (page 154).

4.0 - Engine Running, Engine Not Under Load Operational Checkout Procedure

Overview

The following steps direct technicians to systematically troubleshoot engine running problems while engine is not under a load.

Step 1	Check for related Diagnostic Trouble Codes (DTCs).	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check DTC list for: • SPN 91, 2623 Accelerator Pedal Position (APP) • SPN 94 Fuel Delivery Pressure (FDP) • SPN 931 Electronic Fuel Pump (EFP) • SPN 164, 3055 Injection Control Pressure (ICP) • SPN 679 Injection Pressure Regulator (IPR) • SPN 636 Camshaft Position (CMP) • SPN 637 Crankshaft Position (CKP) • SPN 27, 2791 Exhaust Gas Recirculation (EGR) • SPN 110, 1659 Engine Coolant Temperature 1 (ECT1) • SPN 175 Engine Oil Temperature (EOT) • SPN 1209 Exhaust Back Pressure (EBP) • SPN 5541, 5543 Exhaust Back Pressure Valve (EBPV) • SPN 3251 Diesel Particulate Filter Differential Pressure (DPFDP) • SPN 51, 3464 Engine Throttle Valve (ETV) • SPN 102 Intake Manifold Pressure (IMP) • SPN 132 Mass Air Flow (MAF) • SPN 651-656, 2797, 2798, 3055, 3659-3664, 4257 Injector (INJ) • SPN 105 Intake Manifold Temperature (IMT) Does EST DTC list have any of the above listed SPN?	Yes: Go to Fault Code Diagnostics for appropriate SPN. No: Go to Step 2.

Step 2	Record snapshot of engine running data and determine if engine idles properly.	Decision
	Perform Record Snapshot of Engine Running Data (page 82) while symptom is occurring. While recording engine running data, do the following: A. Run engine at idle. B. Full throttle for 15 seconds. C. Run engine at idle for 30 seconds. D. Full throttle for 15 seconds. E. Run engine at idle for 30 seconds. F. Stop recording. Does engine idle rough or surge at idle?	Yes: Go to 4.1 Rough Idle (page 162). No: Go to Step 3.

Step 3	Determine if engine is able to reach rated speed.	Decision
	A. Start engine. B. Increase engine rpm to rated speed, and return to idle. Is engine able to reach rated speed?	Yes: Go to Step 4. No: Go to 4.2 Engine Unable to Reach Rated Speed (No Load) (page 165).

Step 4	Determine if a popping noise is coming from engine air intake.	Decision
	A. Start engine. B. Listen for popping noise from engine air intake. C. Increase engine rpm to rated speed and return to idle. Is popping noise heard from engine air intake?	Yes: Go to 4.3 Popping Noise from Intake (page 167). No: Review operator complaint.

5.0 - Engine Running, Engine Under Load Operational Checkout Procedure

Overview

The following steps direct technicians to systematically troubleshoot engine running problems while under a load.

Step 1	Perform preliminary operational checkout procedure.	Decision
	Did you Perform 1.0 Preliminary Vehicle Operational Checkout Procedure (page 132)?	Yes: Go to Step 2.
		No: Go to 1.0 Preliminary Vehicle Operational Checkout Procedure (page 132).

Step 2	Check for Diagnostic Trouble Codes (DTCs).	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check DTC list for: • SPN 91, 2623 Accelerator Pedal Position (APP) • SPN 94 Fuel Delivery Pressure (FDP) • SPN 931 Electronic Fuel Pump (EFP) • SPN 164, 3055 Injection Control Pressure (ICP) • SPN 679 Injection Pressure Regulator (IPR) • SPN 636 Camshaft Position (CMP) • SPN 637 Crankshaft Position (CKP) • SPN 27, 2791 Exhaust Gas Recirculation (EGR) • SPN 110, 1659 Engine Coolant Temperature 1 (ECT1) • SPN 175 Engine Oil Temperature (EOT) • SPN 1209 Exhaust Back Pressure (EBP) • SPN 5541, 5543 Exhaust Back Pressure Valve (EBPV) • SPN 3251 Diesel Particulate Filter Differential Pressure (DPFDP) • SPN 51, 3464 Engine Throttle Valve (ETV) • SPN 102 Intake Manifold Pressure (IMP) • SPN 132 Mass Air Flow (MAF) • SPN 651-656, 2797, 2798, 3055, 3659-3664, 4257 Injector (INJ) • SPN 105 Intake Manifold Temperature (IMT) Does EST DTC list have any of the above listed SPN?	Yes: Go to Fault Code Diagnostics for appropriate SPN (page 1205).
		No: Go to Step 3.

Step 3	Record snapshot of engine running data and determine if engine has a misfire.	Decision
	Perform Record Snapshot of Engine Running Data (page 82) while symptom is occurring. Does engine speed vary by 50 rpm or more while symptom is occurring?	Yes: Go to 5.2 Misfire (Stumble/Surge/Run Rough) (page 175).
		No: Go to Step 4.

Step 4	Determine if engine has low power or slow acceleration.	Decision
	Review engine running snapshot. Does vehicle have low power or slow acceleration?	Yes: Go to 5.1 Low Power (Slow Acceleration) (page 169).
		No, if equipped with Power Takeoff (PTO): Go to Step 5.
		NOTE: No, if not equipped with PTO: review operator complaint.

Step 5	Determine if engine is able to reach desired speed during PTO operation.	Decision
	A. Start engine. B. Operate PTO. C. If vehicle is equipped with a manual PTO, increase engine rpm to desired operating speed. Does engine reach desired speed during PTO operation?	Yes: Review operator complaint.
		No: Go to 5.3 Engine Unable to Reach Desired Speed During PTO Operation (page 179).

6.0 - Fuel System Operational Checkout Procedure

Step 1	Perform preliminary operational checkout procedure.	Decision
Did you Perform 1.0 Preliminary Vehicle Operational Checkout Procedure (page 132)?		Yes: Go to Step 2. No: Go to 1.0 Preliminary Vehicle Operational Checkout Procedure (page 132).

Step 2	Determine if engine has a fuel delivery problem.	Decision
Perform Fuel Delivery Pressure (FDP) Test (page 225). Is fuel pressure between 60 and 100 psi?		Yes: Go to Step 3. No: Go to 6.1 Fuel Delivery Pressure (page 181).

Step 3	Determine if engine has fuel in the engine oil.	Decision
Look for engine oil over full ¾ “ or more and smells like fuel. Is fuel in the engine oil?		Yes: Go to Fuel in Engine Oil (page 131). No: Review operator complaint.

Engine Does Not Start Symptoms

2.1 - Engine Cranks Slow or Does Not Crank

Overview

Determine reason engine will not crank or will not crank fast enough to start the engine.

WARNING: To prevent personal injury or death when working with batteries, always wear face or eye protection, have water supply available, ensure good ventilation, and be sure no flames or sparks are present.

NOTE: Follow all instructions and safety procedures suggested by test equipment manufacturers.

NOTE: Cold batteries deliver less current.

NOTE: Before beginning the following diagnostics, perform Preliminary Vehicle and Engine Does Not Start Operational Checkout Procedures.

NOTE: See appropriate Truck Electrical System Troubleshooting Guide for additional starting and charging system information.

Possible Causes

- Failed batteries or low charge
- Corroded or loose battery cables

- Master battery switch turned Off, or Open battery cable circuit
- Starting system faults
- Crank inhibit fault
- Charging system faults
- Internal engine damage (hydro lock due to Exhaust Gas Recirculation (EGR) cooler or injector tip failure, etc.)
- Starter or flywheel gear binding or not engaging properly
- Power Take Off (PTO) or engine drive engaged

Test Procedure

Step 1	Determine if vehicle batteries are fully charged.	Decision
	Measure batteries voltage with a Digital Multimeter (DMM). Is voltage of each battery 12.5 volts or more?	Yes: Go to Step 2.
		No: Charge batteries. Test charging system. After repairs are complete, retest for original problem.

Step 2	Determine if master battery switch is Off or battery cable circuit has high resistance.	Decision
	Turn ignition key to the Run position and observe instrument panel lights and listen for injector pre-cycle. Do instrument panel lights come on and did injectors pre-cycle?	Yes: Go to Step 3.
		No: Turn master battery switch On or fix battery cable circuit. After repairs are complete, retest for original problem.

Step 3	Determine if batteries are able to deliver appropriate current to start engine.	Decision
	Using Midtronics – inTELLECT EXP HD – Battery and Electrical System tester (EXP1000HD), test fully charged batteries. Follow directions in tester instruction manual. Do batteries pass test?	Yes: Go to Step 4.
		No: Slow charge or replace each battery that fails test.

Step 4	Determine if PTO or engine drive is engaged.	Decision
	Are PTO or engine drive engaged?	Yes: Disengage PTO accessories and engine drives. After repairs are complete, retest for original problem.
		No: Go to Step 5

Step 5	Determine if engine has internal damage or starter / flywheel gears are binding.	Decision
	Using Engine Rotation Tool ZTSE6072, rotate crankshaft by hand to determine if starter/flywheel gears are binding or engine has internal damage. Does crankshaft rotate appropriately?	Yes: Go to step 5.
		No: Repair starter/flywheel binding or internal engine damage. See *Engine Service Manual*.

Step 6	Determine if starting system is operating properly.	Decision
	Using Midtronics – inTELLECT EXP HD – Battery and Electrical System Tester EXP1000HD, test starting system. Follow directions in tester instruction manual. Does starting system pass the test?	Yes: End Diagnostic Steps
		No: Low current draw: perform voltage drop test on main positive and negative battery cables. If voltage drop is 0.5 volts or more, clean or replace cable. After repairs are complete, retest for original problem.
		No: Zero current draw: check for crank inhibit faults, starter solenoid or circuit faults, failed starter, and ignition switch. After repairs are complete, retest for original problem.
		No: High current draw: check for faulty starter or internal engine damage. After repairs are complete, retest for original problem.

End Diagnostic Steps
After performing all diagnostic steps, if fault remains, verify if each step was completed correctly and the proper decision was made. Notify supervisor for further action.

2.2 - Engine No Start, Cold Ambient Temperature

Overview

Diagnosis engine no start in cold ambient conditions (40°F {4°C} or colder).

Before beginning the following diagnostics, perform Preliminary Vehicle Operational Checkout Procedure (page 132) and Engine Does Not Start Operational Checkout Procedure (page 135).

Possible Causes

- Engine Coolant Temperature 1 (ECT 1) sensor or circuit fault
- Engine Oil Temperature (EOT) sensor or circuit fault
- Intake Air Heater Control (IAHC) circuit fault (relay control)
- Low cylinder compression
- Failed Intake Air grid heater
- Failed Intake Air Heater Relay
- Open or shorted wiring to the Intake Air Heater (IAH) relay (high current)
- Open or shorted wiring to the IAH grid heater (high current)
- Failed engine coolant heater
- Failed oil pan heater (if equipped)

Test Procedure

Step 1	Check for Intake Air Heater Control (IAHC) Diagnostic Trouble Codes (DTC).	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check DTC list for SPN 729 Intake Air Heater Control (IAHC) (page 822)fault codes. Is SPN 729 active?	Yes: Go to Fault Code Diagnostics for SPN 729 (page 822).
		No: Go to step 2.

Step 2	Test Intake Air Heater (IAH) system.	Decision
	Perform Intake Air Heater Tests (page 242). Is IAH system operating properly and did all Intake Air Heater Tests pass?	Yes: Go to Step 3.
		No: Repair IAH faults. After repairs are complete, retest for original problem.

Step 3	Test coolant heater assembly.	Decision
	Perform Coolant Heater Assembly Test (page 249). Is engine coolant heater operating properly and passing all tests?	Yes: Go to Step 4.
		No: Repair engine coolant heater assembly faults. After repairs are complete, retest for original problem.

Step 4	If equipped, test oil pan heater assembly.	Decision
	Perform Oil Pan Heater Assembly Test (page 254). Is oil pan heater operating properly and did all tests pass?	Yes: Perform Relative Compression Test . If one or more cylinders have significant speed difference(s) than others, repair engine mechanical problem. After repairs are complete, retest for original problem.
		No: Repair oil pan heater assembly faults. After repairs are complete, retest for original problem.

End Diagnostic Steps
After performing all diagnostic steps, if fault remains, verify if each step was completed correctly and the proper decision was made. Notify supervisor for further action.

2.3 - Engine at Operating Temperature, No Re-Start

Overview

Engine will not re-start, after being run to operating temperature.

Before beginning the following diagnostics, perform Preliminary Vehicle Operational Checkout Procedure (page 132) and Engine Does Not Start Operational Checkout Procedure (page 135).

Possible Causes

- Injection Control Pressure (ICP) leak
- ICP circuit fault
- Combustion leak to low-pressure fuel system (injector)

Test Procedure

Step 1	Start and run engine to operating temperature.	Decision
	Is Engine Coolant Temperature 1 (ECT1) 158°F (70°C) or more?	Yes: Go to Step 2.
		No: Run engine to operating temperature.

Step 2	With engine at operating temperature, check Injection Control Pressure (ICP) at Key-On Engine-Off (KOEO).	Decision
	A. Do not crank or run engine for 3 minutes or more, to allow ICP to bleed off. B. Using Electronic Service Tool (EST) with ServiceMaxx™ software, check ICP pressure at KOEO. Is ICP above KOEO specification?	Yes: Go to SPN 164 FMI 0 Fault Code Diagnostics (page 833).
		No: Go to Step 3.

Step 3	With engine at operating temperature, record snapshot of engine cranking data.	Decision
	Perform Engine Cranking Test (page 90). Are ICP and Injection Pressure Regulator (IPR) within cranking specification?	Yes: Go to Step 4.
		No: Go to Cylinder Performance Analyzer (CPA) – High-Pressure Oil Pump (HPOP) Test (page 287).

Step 4	Determine if cylinder relative compression is within specification.	Decision
	Perform Relative Compression Test (page 215). Do one or more cylinders have significant speed difference(s) than others?	Yes: Repair engine mechanical or injector seal problem. After repairs are complete, retest for original problem.
		No: Go to Step 5.

Step 5	Measure fuel pressure to determine if combustion pressure is leaking into the fuel system.	Decision
	Perform Fuel Delivery Pressure (FDP) Test (page 225). Is FDP greater than specification and / or erratic?	Yes: Remove each injector and inspect injector seals and bottom of injector for burning.
		No: End Diagnostic Steps.

End Diagnostic Steps
After performing all diagnostic steps, if fault remains, verify if each step was completed correctly and the proper decision was made. Notify supervisor for further action.

2.4 - Engine Never Starts

Overview

Determine reason engine will not start.

Before beginning the following diagnostics, perform Preliminary Vehicle Operational Checkout Procedure (page 132) and Engine Does Not Start Operational Checkout Procedure (page 135).

Possible Causes

- Engine Control Module (ECM) fault
- No Start related Diagnostic Trouble Codes (DTC)
- Air Intake restriction
- Exhaust restriction
- Low Injection Control Pressure (ICP) or ICP leaks
- Injection Pressure Regulator (IPR) fault
- Low Fuel Delivery Pressure (FDP)
- Engine compression loss or mechanical problems
- Exhaust Gas Recirculation (EGR) system fault
- Combustion into fuel system

Test Procedure

Step 1	Determine if starting system is able to crank engine fast enough to start engine.	Decision
	Perform Engine Cranking Test (page 90). Is Engine Speed (rpm) at, or above, specification?	Yes: Go to Step 2.
		No: Go to 2.1 Engine Cranks Slow or Does Not Crank (page 146).

Step 2	Determine if ECM is able to communicate.	Decision
	Connect Electronic Service Tool (EST) with ServiceMaxx™ software to vehicle diagnostic connector and log in. Is EST able to log in and is ECM able to communicate?	Yes: Go to Step 3.
		No: Go to ECM Self Diagnostics (page 614) or ECM Power (Engine Control Module) (page 580) Fault Code Diagnostics.

Step 3	Check for related Diagnostic Trouble Codes (DTC).	Decision
	Using EST with ServiceMaxx™ software, check DTC list for: • SPN 94 Fuel Delivery Pressure (FDP) • SPN 931 Engine Fuel Supply Pump Actuator (EFSPA) • SPN 164 Injection Control Pressure (ICP) • SPN 679 Injection Pressure Regulator (IPR) • SPN 636 Camshaft Position (CMP) • SPN 637 Crankshaft Position (CKP) • SPN 108, 158, 628, 629, 1136, 1387 Engine Control Module (ECM) • SPN 27, 2791 Exhaust Gas Recirculation (EGR) • SPN 110, 1659 Engine Coolant Temperature 1 (ECT1) • SPN 175 Engine Oil Temperature (EOT) • SPN 1209 Exhaust Back Pressure (EBP) • SPN 1209 Air Management System (AMS) • SPN 3251 Diesel Particulate Filter Differential Pressure (DPFDP) • SPN 5541, 5543 Exhaust Back Pressure Valve (EBPV) • SPN 51, 3464, 3471 Engine Throttle Valve (ETV) • SPN 102 Intake Manifold Pressure (IMP) • SPN 132 Mass Air Flow (MAF) • SPN 729 Intake Air Heater Control (IAHC) Does EST DTC list have any of the above listed SPN?	Yes: Go to Fault Code Diagnostics (page 299) for specific SPN. No: Go to Step 4.

Step 4	Determine if engine air intake is restricted.	Decision
	A. Intake air restriction should be less than 25 in. H2O (6.2 kPa) at full rated engine speed. B. With engine at full rated speed, inspect air filter gauge on air filter housing or on dash panel. Is air filter gauge greater than 25 in. H2O (6.2 kPa) at full engine rated speed?	Yes: Repair intake restriction. After repairs are complete, retest for original problem. No: Go to Step 5.

Step 5	Determine if exhaust is restricted.	Decision
	Review KOEO and Engine Cranking Test data. Are Turbocharger 1 Turbine Outlet Pressure (TC1TOP) and EBP within cranking specification? *See Example TC1TOP (Actual) Calculations (page 1291).*	Yes: Go to Step 6.
		No: Repair exhaust restriction. After repairs are complete, retest for original problem.

Step 6	Determine if engine is able to build Injection Control Pressure (ICP).	Decision
	Review KOEO and Engine Cranking Test data. Are ICP and IPR both in specification?	Yes: Go to Step 7.
		No: Go to CPA HPOP Test (page 287).

Step 7	Determine if engine is able to build Fuel Delivery Pressure (FDP).	Decision
	Review KOEO and Engine Cranking Test data. Is FDP in specification during KOEO and cranking tests?	Yes: Go to Step 8.
		No: Go to Fuel Delivery Pressure (FDP) Tests (page 225).

Step 8	Determine if cylinder relative compression is within specification.	Decision
	Perform Relative Compression Test. (page 215) Do one or more cylinders have significant speed difference(s) than others?	Yes: Repair engine mechanical or injector seal problem. After repairs are complete, retest for original problem.
		No: Go to Step 9.

Step 9	Measure fuel pressure to determine if combustion pressure is leaking into the fuel system.	Decision
	Perform Fuel Delivery Pressure (FDP) Tests (page 225). Is fuel pressure greater then specification and/or erratic?	Yes: Inspect injector seals and bottom of each injector for burning. After repairs are complete, retest for original problem.
		No: End Diagnostic Steps.

End Diagnostic Steps
After performing all diagnostic steps, if fault remains, verify if each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Engine Hard to Start Symptoms

3.1 - Engine Hard to Start, Cold Ambient Temperature

Overview

Diagnosis engine hard to start in cold ambient conditions (40°F {4°C} or colder).

NOTE: Before beginning the following diagnostics, perform Preliminary Vehicle, and Engine Hard to Start Operational Checkout procedures.

Possible Causes

- Engine Coolant Temperature 1 (ECT 1) sensor or circuit fault
- Engine Oil Temperature (EOT) sensor or circuit fault
- Air Intake Heater Control (IAHC) circuit fault (relay control)
- Low cylinder compression
- Failed intake air grid heater
- Failed intake air heater relay
- Open or shorted Intake Air Heater (IAH) relay wiring (high current)
- Open or shorted IAH grid heater wiring (high current)
- Failed engine coolant heater
- Failed oil pan heater (if equipped)

Test Procedure

Step 1	Check for Intake Air Heater Control (IAHC) Diagnostic Trouble Codes (DTC).	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check DTC list for SPN 729 IAHC fault codes . Is SPN 729 active?	Yes: Go to Fault Code Diagnostics for SPN 729 .
		No: Go to Step 2.

Step 2	Test Intake Air Heater (IAH) system.	Decision
	Perform Intake Air Heater Tests (page 242). Is IAH system operating properly and did all Intake Air Heater Tests pass?	Yes: Go to Step 3.
		No: Repair IAH faults. After repairs are complete, retest for original problem.

Step 3	Test engine coolant heater assembly.	Decision
	Perform Coolant Heater Assembly Test (page 249). Is engine coolant heater operating properly and did all tests pass?	Yes: Go to Step 4.
		No: Repair engine coolant heater assembly faults. After repairs are complete, retest for original problem.

Step 4	If equipped, test oil pan heater assembly.	Decision
	Perform Oil Pan Heater Assembly Test (page 254). Is oil pan heater operating properly and did all tests pass?	Yes: Perform Relative Compression Test (page 215). If one or more cylinders have significant speed difference(s) than others, repair engine mechanical problem. After repairs are complete, retest for original problem.
		No: Repair oil pan heater assembly faults. After repairs are complete, retest for original problem.

End Diagnostic Steps
After performing all diagnostic steps, if fault remains, verify if each step was completed correctly and the proper decision was made. Notify supervisor for further action.

3.2 - Engine at Operating Temperature, Hard to Re-Start

Overview

Diagnosis hard to start after engine is at operating temperature and will not re-start.

NOTE: Before beginning the following diagnostics, perform Preliminary Vehicle and Engine Hard to Start Operational Checkout procedures.

Possible Causes

- Injection Control Pressure (ICP) leak
- ICP circuit fault
- Combustion leak to low-pressure fuel system (injector)

Test Procedure

Step 1	Start and run engine to operating temperature.	Decision
	Is Engine Coolant Temperature 1 (ECT1) 158°F (70°C) or more?	Yes: Go to Step 2.
		No: Run engine to operating temperature.

Step 2	With engine at operating temperature, check Key-On Engine-Off (KOEO) Injection Control Pressure (ICP).	Decision
	A. Do not crank or run engine for 3 minutes, or more, to allow Injection Control Pressure (ICP) to bleed off. B. Using Electronic Service Tool (EST) with ServiceMaxx™ software, check ICP pressure KOEO. Is ICP above KOEO specification?	Yes: Go to SPN 164 FMI 0 Fault Code Diagnostics (page 833).
		No: Go to Step 3.

Step 3	With engine at operating temperature, perform Engine Cranking test.	Decision
	Are ICP and Injection Pressure Regulator (IPR) within cranking specification?	Yes: Go to Step 4.
		No: Go to Cylinder Performance Analyzer (CPA) – High-Pressure Oil Pump (HPOP) Test (page 287).

Step 4	Perform Relative Compression test.	Decision
	Do one or more cylinders have significant speed difference(s) than others?	Yes: Repair engine mechanical or injector seal problem.
		No: Go to Step 5.

Step 5	Measure fuel pressure to determine if combustion pressure is leaking into the fuel system.	Decision
	Perform Fuel Delivery Pressure (FDP) test (page 225). Is fuel pressure greater than specification and / or erratic?	Yes: Remove each injector and inspect injector seals and bottom of injector for burning.
		No: End diagnostics.

End Diagnostic Steps
After performing all diagnostic steps, if fault remains, verify if each step was completed correctly and the proper decision was made. Notify supervisor for further action.

3.3 - Engine Starts, Then Stalls

Overview

Engine is able to start (possibly briefly), but is not able to continue to run.

Before beginning the following diagnostics, perform Preliminary Vehicle Operational Checkout Procedure (page 132) and Engine Hard to Start Operational Checkout Procedure (page 138).

Possible Causes

- Damaged or restricted intake: Change Air Cooler (CAC), Engine Throttle Valve (ETV), Mass Air Flow (MAF), air filter, intake piping, clamps, connections, etc.
- Damaged or restricted exhaust: Diesel Oxidation Catalyst (DOC), Diesel Particulate Filter (DPF), Selective Catalytic Reduction (SCR) catalyst, exhaust brake, exhaust piping, etc.
- Exhaust Gas Recirculation (EGR) valve (stuck or sticking open)
- Combustion gasses in fuel (injector)

Test Procedure

Step 1	Determine if engine air intake is restricted.	Decision
	A. Intake air restriction should be less than 25 in. H2O (6.2 kPa) at full rated engine speed. B. With engine at full rated speed, inspect air filter gauge on air filter housing or on dash panel. Is air filter gauge greater than 25 in. H2O (6.2 kPa) at full engine rated speed?	Yes: Repair intake restriction. After repairs are complete, retest for original problem.
		No: Go to Step 2.

Step 2	Determine if Exhaust Gas Recirculation (EGR) valve is stuck or sticking open.	Decision
	Perform EGRV Operational Test (page 240). Does EGR system pass EGRV Operational Test?	Yes: Go to Step 3.
		No: Repair EGR system problem. After repairs are complete, retest for original problem.

Step 3	Determine if cylinder relative compression is within specifications.	Decision
	Perform Relative Compression Test (page 215). Do one or more cylinders have significant speed difference(s) than others?	Yes: Repair engine mechanical or injector seal problem. After repairs are complete, retest for original problem.
		No: Go to Step 4.

Step 4	Measure fuel pressure to determine if combustion pressure is leaking into the fuel system.	Decision
	Perform Fuel Delivery Pressure (FDP) Test (page 225). Is fuel pressure greater then specification and / or erratic?	Yes: Inspect injector seals and bottom of each injector for burning. After repairs are complete, retest for original problem.
		No: End Diagnostics.

End Diagnostic Steps
After performing all diagnostic steps, if fault remains, verify if each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Engine Running, Engine Not Under Load Symptoms

4.1 - Rough Idle

Overview

Engine runs rough or surges at idle.

Before beginning the following diagnostics, perform Preliminary Vehicle Operational Checkout Procedure (page 132); and Engine Running, Engine Not Under Load Operational Checkout Procedure (page 142).

It is normal for engine to idle roughly until engine coolant temperature reaches 141°F (61°C) or more.

Possible Causes

- Injection Control Pressure (ICP)
- Injection Pressure Regulator (IPR)
- Fuel Delivery Pressure (FDP) (low pressure, aerated fuel, etc.)
- Injector circuit or mechanical failure
- Engine compression loss in one or more cylinders
- Engine air intake leaks (unmetered air entering engine air intake)
- Engine accessory dragging or locking up (A/C compressor, belt tensioner, fan drive, etc.)

Test Procedure

Step 1	Determine if Injection Pressure Regulator (IPR) system is operating properly.	Decision
	Review engine running snapshot. Verify IPR Ctrl is less than 35% at idle. Is IPR Ctrl 35% or greater at idle?	Yes: Go to Step 2.
		No: Go to Step 3.

Step 2	Determine if injectors and injector circuits are operating properly.	Decision
	Perform Cylinder Performance Analyzer (CPA) Cold Idle Test (page 261). Does Cylinder Performance Analyzer (CPA) Cold Idle Test determine a fault?	Yes, injector fault: Check resistance of suspect injector circuit. Repair circuit problem(s). If circuit checks are good, replace injector. After repairs are complete, retest for original problem.
		Yes, high-speed fluctuation: Check resistance in injector circuits through Under Valve Cover (UVC) connectors 2, 3, and 4. Repair circuit problem(s). If UVC circuit checks are good, go to Cylinder Performance Analyzer (CPA) – High-Pressure Oil Pump (HPOP) Test (page 287).
		No: Go to CPA Hot Idle Test (page 271).

Step 3	Determine if fuel delivery pressure is within specification.	Decision
	Perform Fuel Delivery Pressure (FDP) Test (page 225). Is fuel delivery pressure (gauge) within Low Idle, No Load, Stabilized Engine Operating Temperature specification?	Yes: Go to Step 4
		No: Go to Low Fuel Delivery Pressure (page 181).

CAUTION: To prevent engine damage, do not run engine more than 2 minutes with accessory drive belts disconnected.

Step 4	Determine if engine accessories are dragging or locking up.	Decision
	A. Remove accessory drive belt(s). B. Start engine and check for accessories dragging or locking up. Is rough engine idle still present?	Yes: Go to Step 5.
		No: Find and repair accessory dragging or locking up. After repairs are complete, retest for original problem.

Step 5	Determine if cylinder relative compression is within specification.	Decision
	Perform Relative Compression Test (page 215). Does one or more cylinders have significant speed difference(s) than others?	Yes: Repair engine mechanical or injector seal problem. After repairs are complete, retest for original problem.
		No: Go to Step 6.

Step 6	Determine if engine has air intake leaks.	Decision
	Inspect engine air intake piping, clamps, air filter and housing, screen under air filter, Charge Air Cooler (CAC), and Interstage Cooler (ISC) (if equipped) for leaks, damage, or restrictions. Is engine air intake leaking, damaged, or restricted?	Yes: Repair engine air intake as needed. After repairs are complete, retest for original problem.
		No: Connect Cylinder Performance Analyzer (CPA) Tool (page 257) and test injectors for leaks and misfires. Perform CPA Signal Check (page 266), CPA Hot Idle Test (page 271), and CPA Road Test (page 277).

End Diagnostic Steps
After performing all diagnostic steps, if fault remains, verify if each step was completed correctly and the proper decision was made. Notify supervisor for further action.

4.2 - Engine Unable To Reach Rated Speed (No Load)

Overview

Engine without a load is not able to increase rpm up to rated speed.

NOTE: Before beginning the following diagnostics perform 1.0 Preliminary Vehicle Operational Checkout Procedure (page 132); and 5.0 Engine Running, Engine Not Under Load Operational Checkout Procedures (page 144).

Possible Causes

- Accelerator Pedal Position (APP)
- Injection Control Pressure (ICP)
- Injection Pressure Regulator (IPR)
- Exhaust Gas Recirculation (EGR)
- Exhaust restriction
- Engine air restriction
- Fuel Delivery Pressure (FDP)

Test Procedure

Step 1	Determine if Accelerator Pedal Position (APP) meets full range.	Decision
	Review engine running snapshot. Verify APP percentage at idle and at full throttle. Is APP 0% at idle and 99% or greater at full throttle?	Yes: Go to Step 2.
		No: Repair APP sensor or circuit problem. After repairs are complete, retest for original problem.

Step 2	Determine if Injection Control Pressure (ICP) system is operating properly.	Decision
	Review engine running snapshot. Verify Injection Control Pressure is approximately the same as ICP Desired. Is Injection Control Pressure approximately the same as ICP Desired?	Yes: Go to Step 3.
		No: Go to Cylinder Performance Analyzer (CPA) – High-Pressure Oil Pump (HPOP) Test (page 287).

Step 3	Determine if Exhaust Gas Reticulation (EGR) system is operating properly.	Decision
	Review engine running snapshot. Verify EGR valve remains closed (35%). Is EGR Position 35%?	Yes: Go to Step 4.
		No: Go to SPN 2791 FMI 7 (page 696) Fault Code Diagnostics. After repairs are complete, retest for original problem.

Step 4	Determine if exhaust system is restricted.	Decision
	Review engine running snapshot. Verify Turbocharger 1 Turbine Outlet Pressure (TC1TOP) is less than 10 psi. *See Example TC1TOP (Actual) Calculations (page 1291).* Is TC1TOP 10 psi or greater?	Yes: Repair exhaust system restriction. After repairs are complete, retest for original problem.
		No: Go to Step 5.

Step 5	Determine if air intake is restricted.	Decision
	Review engine running snapshot. Verify Intake Manifold Absolute Pressure is within specification. Is Intake Manifold Absolute Pressure within specification?	Yes: Go to Step 6.
		No: Repair intake restriction. After repairs are complete, retest for original problem.

Step 6	Determine if fuel delivery pressure is within specification.	Decision
	Perform Fuel Delivery Pressure (FDP) Test (page 225). Is fuel delivery pressure (gauge) within Low Idle, No Load, Stabilized Engine Operating Temperature specification?	Yes: Connect CPA Tool (page 257)and perform CPA Signal Check (page 266), CPA Hot Idle Test (page 271), and CPA Road Test (page 277).
		No, Go to Low Fuel Delivery Pressure (page 181).

End Diagnostic Steps
After performing all diagnostic steps, if fault remains, verify if each step was completed correctly and the proper decision was made. Notify supervisor for further action.

4.3 - Popping Noise from Intake

Overview

Engine cylinder compression popping back through the intake.

Before beginning the following diagnostics, perform 1.0 Preliminary Vehicle Operational Checkout Procedure (page 132)and 4.0 Engine Running, Engine Not Under Load Operational Checkout Procedure (page 142).

Possible Causes

- Contaminated or incorrect fuel
- Sticking, damaged, or leaking intake or exhaust valve(s)
- Damaged push rod(s)
- Damaged rocker arm or shaft
- Failed roller tappet assembly
- Failed camshaft

Test Procedure

Step 1	Determine if cylinder relative compression is within specification.	Decision
	Perform Relative Compression Test (page 215). Does one or more cylinders have significant speed difference(s) than others?	Yes: Focus on cylinder(s) with low compression, and go to Step 2.
		No: Go to Step 2.

Step 2	Inspect valve train for loose or damaged rocker arm assembly, or valve lash out of adjustment.	Decision
	Refer to *Engine Service Manual* for steps A, B, and C. A. Remove valve cover. B. Inspect valve train for loose or damaged rocker arms, or valve lash out of adjustment (focusing on any cylinders with low compression from Step 1). C. Measure valve lash. Is valve train for any cylinders loose, damaged, or valve lash out of adjustment?	Yes, damaged rocker arm assembly: Replace damaged valve train components. After repairs are complete, retest for original problem.
		Yes, valve lash out of adjustment: Using *Engine Service Manual* perform Cleaning and Inspection of Push rods, and Measure Camshaft Lobe Lift. If camshaft lobe lift is out of specification, replace camshaft.
		No: End Diagnostic Steps.

End Diagnostic Steps
After performing all diagnostic steps, if fault remains, verify if each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Engine Running, Engine Under Load Symptoms

5.1 - Low Power (Slow Acceleration)

Overview

Vehicle or engine is not able to accelerate properly while under a load.

NOTE: Before beginning the following diagnostics, perform Preliminary Vehicle Operational Checkout Procedure (page 132), and Engine Running, Engine Under Load Operational Checkout Procedures.

Possible Causes

- Vehicle overloaded
- Road speed governor programmable parameter set too low
- Accelerator Pedal Position (APP) sensor or circuit
- Injection Control Pressure (ICP)
- Injection Pressure Regulator (IPR)
- Engine Control Module (ECM) barometric pressure error
- Exhaust restriction
- Boost control system fault
- Fuel Delivery Pressure (FDP)
- Exhaust Gas Recirculation (EGR) valve stuck or sticking open
- Intake restriction
- Turbocharger coking or damage
- Low compression

Test Procedure

Step 1	Determine if vehicle is overloaded.	Decision
	Review vehicle and engine load hauling capacity and compare to Tcape (available from International dealer). Is vehicle overloaded?	Yes: Reduce load. After repairs are complete, retest for original problem.
		No: Go to Step 2.

Step 2	Verify Road Speed Governor Programmable Features is set above desired vehicle speed.	Decision
	A. Go to Programmable Features (page 80). B. Review Max Vehicle Speed with Road Speed Limiting On and Road Speed Limiting Secondary Vehicle Speed Limit programmable parameters. Are Road Speed Limiting Programmable Features set above desired vehicle speed?	Yes: Go to Step 3. No: Set Road Speed Limiting Programmable Features to maximum desired vehicle speed. After repairs are complete, retest for original problem.

Step 3	Determine if Accelerator Pedal Position (APP) sensor is operating properly.	Decision
	A. Key-On Engine-Off (KOEO). B. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). C. Select Sessions > Performance D. Select Tools > Start Recording Snapshot E. Cycle accelerator pedal to full throttle and then release. F. Select Tools > Stop Recording Snapshot Is Accelerator Pedal Position 99% or greater at full throttle?	Yes: Perform 0 to 60 MPH Test (page 219), and then go to Step 4. No: Repair or replace APP sensor or circuit. After repairs are complete, retest for original problem.

Step 4	Determine if Injection Control Pressure (ICP) system is operating properly.	Decision
	Review 0 to 60 MPH snapshot, and verify ICP is approximately the same as ICP Desired, and is above 4000 psi at 100% APP and 100% engine load. Is ICP approximately the same as ICP Desired and above 4000 psi at 100% APP and 100% Engine Load?	Yes: Go to Step 5. No: Go to Cylinder Performance Analyzer (CPA) High-Pressure Oil

		Pump (HPOP) Test (page 287).

Step 5	Determine if Injection Pressure Regulator (IPR) system is operating properly.	Decision
	Review 0 to 60 MPH snapshot, and verify IPR Ctrl is less than 85%. Is IPR Ctrl 85% or greater?	Yes: Go to Cylinder Performance Analyzer (CPA) High-Pressure Oil Pump (HPOP) Test (page 287).
		No: Go to Step 6.

Step 6	Verify Engine Control Module (ECM) is reading proper Barometric Absolute Pressure (BAP) for local elevation and barometric pressure.	Decision
	A. Review Snapshot 0 to 60 MPH, and determine recorded BAP. B. Determine local elevation and barometric pressure. (Examples: 14.7 psia at sea level, 13.2 psia at 3000 ft., 11.8 psia at 6000 ft., 10.1 psia at 10,000 ft.) C. If BAP is not reasonable relative to local barometric pressure, verify local barometric pressure on a second vehicle. Is BAP reasonable relative to local barometric pressure?	Yes: Go to Step 7.
		No: Install a test ECM and fault should go away. Install original ECM. If fault returns, replace ECM. After repairs are complete, retest for original problem.

Step 7	Determine if exhaust is restricted.	Decision
	Review 0 to 60 MPH snapshot, and verify Turbocharger 1 Turbine Outlet Pressure (TC1TOP) is less than 8 psi. *See Example TC1TOP (Actual) Calculations (page 1291).* Is TC1TOP 8 psi or greater?	Yes: Repair exhaust system restriction. After repairs are complete, retest for original problem.
		No: Go to Step 8.

Step 8	Determine if boost control system is operating properly.	Decision
	Review 0 to 60 snapshot: verify Exhaust Back Pressure (EBP) is less than 60 psi. Is EBP less than 60 psi?	Yes: Go to Step 9.
		No: Perform Boost Control System Test . After repairs are complete, retest for original problem.

Step 9	Determine is Fuel Delivery Pressure (FDP) meets specification.	Decision
	Review 0 to 60 MPH snapshot, and verify FDP is within Full Load specification. Is FDP within Full Load specification?	Yes: Go to Step 10.
		No: Go to Low Fuel Delivery Pressure .

Step 10	Determine if Exhaust Gas Recirculation (EGR) valve is operating properly.	Decision
	Review 0 to 60 MPH snapshot, and verify EGR Position is approximately the same as EGR Valve CTL. Is EGR Position approximately the same as EGR Valve CTL?	Yes: Go to Step 11.
		No: Go to SPN 2791 FMI 7 (page 696) in Fault Code Diagnostics. After repairs are complete, retest for original problem.

Step 11	Validate performance of EGR system.	Decision
	Perform Air Management Test . Does Air Management Test pass and no fault codes are set?	Yes: Go to step 12.
		No: Go to Fault Code Diagnostics (page 299) for specific SPN/FMI. After repairs are complete, retest for original problem.

Step 12	Determine if Intake Manifold Pressure (IMP) during acceleration is reasonable.	Decision
	Review 0 to 60 MPH snapshot, and verify IMP is within 10 psi of Full Load specification for specific rating of engine. IMP can vary based on ECM calibration (engine rating) and vehicle weight. Is IMP within 10 psi of Full Load specification, for specific rating?	Yes: Go to Step 15.
		No: Go to Step 13.

Step 13	Inspect for intake (boost) leaks or restrictions.	Decision
	Inspect air intake system for leaks, damage, or restrictions. Inspect hoses and clamps, interstage cooler, and Charge Air Cooler (CAC). Are air intake components free from leaks, damage, or restrictions?	Yes: Go to Step 14.
		No: Repair air intake system leaks, damage, or restrictions. After repairs are complete, retest for original problem.

Step 14	Determine if turbocharger has damage or coking.	Decision
	Inspect Turbocharger for damage or coking. Remove turbocharger intake tube. Inspect for coking. Rotate impellor shaft. Determine if impellor fins are contacting housing. Does turbocharger have damage or coking	Yes, turbocharger coking without damage: Perform Cleaning Turbocharger Coking. After repairs are complete, retest for original problem.
		Yes, turbocharger damaged: replace turbocharger (iApproval may be required). After repairs are complete, retest for original problem.
		No: Repair air intake system leaks, damage, or restrictions. After repairs are complete, retest for original problem.

Step 15	Determine if cylinder relative compression is within specification.	Decision
	Perform Relative Compression Test (page 215). Does one or more cylinders have significant speed difference(s) than others?	Yes: Repair engine mechanical or injector seal problem. After repairs are complete, retest for original problem.
		No: End Diagnostic Steps

End Diagnostic Steps
After performing all diagnostic steps, if fault remains, verify if each step was completed correctly and the proper decision was made. Notify supervisor for further action.

5.2 - Misfire (Stumble / Surge / Runs Rough)

Overview

Engine power or speed (rpm) varies unexpectedly by more than 50 rpm under a load.

NOTE: Before beginning the following diagnostics, perform 1.0 Preliminary Vehicle Operational Checkout Procedure (page 132) and 5.0 Engine Running, Engine Under Load Operational Checkout Procedure (page 144).

Possible Causes

- Accelerator Pedal Position (APP) sensor or circuit
- Exhaust Back Pressure Valve (EBPV)
- Engine Throttle Valve (ETV)
- Exhaust Gas Recirculation (EGR) valve stuck or sticking
- Injection Control Pressure (ICP) system
- Injection Pressure Regulator (IPR)
- Fuel Delivery Pressure (FDP)
- Air intake (boost) leaks
- Engine compression loss of one or more cylinders
- Injector circuit or mechanical problem

Test Procedure

Step 1	Determine if Accelerator Pedal Position (APP) signal is correct and stable.	Decision
	Review snapshot of engine running data: Verify APP signal moves smoothly as the throttle is depressed and does not jump unexpectedly. Is APP signal stable and not jumping unexpectedly, 0% at idle, and 99% or greater at full throttle?	Yes: Go to Step 2.
		No: Repair APP sensor or circuit problem. After repairs are complete, retest for original problem.

Step 2	Determine if Exhaust Back Pressure Valve (EBPV) is operating properly.	Decision
	A. Start engine. B. Visually verify if EBPV is fully open and not moving (unless in regen mode). Look at valve and verify rod is fully retracted and not moving. C. Verify if EBPV cycles opened and closed three times after engine shutdown. Is EBPV fully open and not moving (unless in regen mode), and does EBPV cycle after shutdown?	Yes: Go to Step 3.
		No: Diagnose and repair EBPV system. After repairs are complete, retest for original problem.

Step 3	Determine if Engine Throttle Valve (ETV) is operating properly.	Decision
	Review snapshot of engine running data: Compare Engine Throttle Position (actual) to Engine Throttle CTL. Is Engine Throttle Position approximately the same as Engine Throttle CTL?	Yes: Go to Step 4.
		No: Repair ETV or circuit problem. After repairs are complete, retest for original problem.

Step 4	Determine if Exhaust Gas Recirculation (EGR) system is operating properly.	Decision
	Review snapshot of engine running data: Verify if EGR Position is approximately the same as EGR valve CTL. Is EGR Position approximately the same as EGR valve CTL?	Yes: Go to Step 5.
		No: Go to SPN 2791 FMI 7 (page 696)Fault Code Diagnostics. After repairs are complete, retest for original problem.

Step 5	Determine if Injection Control Pressure (ICP) system is operating properly.	Decision
	Review snapshot of engine running data: Verify injection control pressure is approximately the same as ICP Desired. Is injection control pressure approximately the same as ICP Desired?	Yes: Go to Step 6.
		No: Go to Cylinder Performance Analyzer (CPA) – High-Pressure Oil Pump (HPOP) Test (page 287).

Step 6	Determine if Injection Pressure Regulator (IPR) system is operating properly.	Decision
	Review snapshot of engine running data: Verify if IPR Ctrl is less than 80% while under load or less than 35% when stationary. Is IPR Ctrl 80% or greater under load, or greater than 35% when stationary?	Yes: Go to Cylinder Performance Analyzer (CPA) – High-Pressure Oil Pump (HPOP) Test (page 287).
		No: Go to Step 7.

Step 7	Determine if fuel delivery pressure is proper.	Decision
	Perform Fuel Delivery Pressure (FDP) Test (page 225). Is fuel delivery pressure (gauge) within specification (page 1291)?	Yes: Go to Step 8.
		No: Go to 8.1 – Low Fuel Delivery Pressure (page 181).

Step 8	Inspect for air intake (boost) leaks.	Decision
	Inspect air intake system for leaks or damage. Inspect hoses and clamps, Interstage Cooler (ISC), and Charge Air Cooler (CAC) for leaks or damage. Are air intake components free from leaks, damage, or restrictions?	Yes: Go to Step 9.
		No: Repair air intake system leaks, damage, or restrictions. After repairs are complete, retest for original problem.

Step 9	Determine if cylinder relative compression is within specification.	Decision
	Perform Relative Compression Test (page 215). Does one or more cylinders have significant speed difference(s) than others?	Yes: Using *Engine Service Manual*, repair engine mechanical or injector problem. After repairs are complete, retest for original problem.
		No: Connect Cylinder Performance Analyzer (CPA) Tool (page 257) and test injectors for leaks and misfires. Perform Cylinder Performance Analyzer (CPA) Signal Check (page 266), Cylinder Performance Analyzer (CPA) Hot Idle Test (page 271), and Cylinder Performance Analyzer (CPA) Road Test (page 277).

End Diagnostic Steps
After performing all diagnostic steps, if fault remains, verify if each step was completed correctly and the proper decision was made. Notify supervisor for further action.

5.3 - Engine Unable to Reach Desired Speed During PTO Operation

Overview

Engine is not able to increase rpm up to desired speed during Power Take Off (PTO) operation.

NOTE: Before beginning the following diagnostics perform 1.0 Preliminary Vehicle Operational Checkout Procedure (page 132) and 4.0 Engine Running, Engine Under Load Operational Checkout Procedure (page 142).

Possible Causes

- Power Take Off (PTO) circuit or system fault
- Auxiliary Engine Speed Control (AESC) set speed (not set high enough or not set correctly)
- Accelerator Pedal Position (APP)
- Injection Control Pressure (ICP)
- Injection Pressure Regulator (IPR)
- Exhaust Gas Recirculation (EGR)
- Exhaust restriction
- Intake restriction
- Fuel Delivery Pressure (FDP)

Test Procedure

NOTE: See *CT-471 Body Builder* books for additional Power Take Off (PTO) and Auxiliary Engine Speed Control (AESC) information.

Step 1	Determine if Power Take Off (PTO) engages.	Decision
	Engage PTO (See *CT-471 Body Builder Manual*). Did PTO engage properly?	Yes: Go to Step 2.
		No: Diagnose and repair PTO problem. After repairs are complete, retest for original problem.

Step 2	Verify if Auxiliary Engine Speed Control (AESC) / remote engine throttle programmable parameters are set above desired speed.	Decision
	A. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). B. Using ServiceMaxx™ software, select Sessions > Parameters. Are AESC parameters set above desired engine speed?	Yes: Go to Step 3.
		No: Set AESC programmable parameters to maximum desired

		engine speed. After repairs are complete, retest for original problem.

Step 3	Determine if Accelerator Pedal Position (APP) meets full range percent.	Decision
	Review engine running snapshot. Verify percent at idle and full throttle. Is APP 0% at idle and 99% or greater at full throttle?	Yes: Go to Step 4.
		No: Repair APP sensor or circuit problem. After repairs are complete, retest for original problem.

Step 4	Determine if Injection Control Pressure (ICP) system is operating properly.	Decision
	Review engine running snapshot. Verify if ICP is approximately the same as ICP Desired. Is ICP approximately the same as ICP Desired?	Yes: Go to Step 5.
		No: Go to CPA High-Pressure Oil Pump (HPOP) Test (page 287).

Step 5	Determine if Exhaust Gas Reticulation (EGR) system is operating properly.	Decision
	Review engine running snapshot. Verify if EGR Position is approximately the same as EGR Valve CTL. Is EGR position approximately the same as EGR Valve CTL?	Yes: Go to Step 5.
		No: Go to CPA High-Pressure Oil Pump (HPOP) Test (page 287).

Step 6	Determine if exhaust system is restricted.	Decision
	Review engine running snapshot. Verify if Turbocharger 1 Turbine Outlet Pressure (TC1TOP) is less than 8 psi. *See Example TC1TOP (Actual) Calculations (page 1291).* Is TC1TOP 8 psi or greater?	Yes: Repair exhaust system restriction. After repairs are complete, retest for original problem.
		No: Go to Step 7.

Step 7	Determine if engine air intake is restricted.	Decision
	A. Intake air restriction should be less than 25 in. H2O (6.2 kPa) at full rated engine speed. B. With engine at full rated speed, inspect air filter gauge on air filter housing or on dash pane. Is air filter gauge greater than 25 in. H2O (6.2 kPa) at full engine rated speed?	Yes: Go to Step 8.
		No: Repair intake restriction. After repairs are complete, retest for original problem.

Step 8	Determine is fuel delivery pressure meets specification.	Decision
	Perform Fuel Delivery Pressure (FDP) Test (page 225). Does FDP (gauge) meet low idle, no load, stabilized engine operating temperature specification?	Yes: Perform CPA Signal Check (page 266), CPA Hot Idle Test (page 271), and CPA Road Test (page 277).
		No: Go to Low Fuel Delivery Pressure (page 181).

End Diagnostic Steps
After performing all diagnostic steps, if fault remains, verify if each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Fuel System Symptoms

6.1 - Fuel Delivery Pressure

Overview

Diagnosis fuel delivery pressure low or high problem.

WARNING: To prevent personal injury or death, keep fuel away from flame and sparks.

Possible Causes

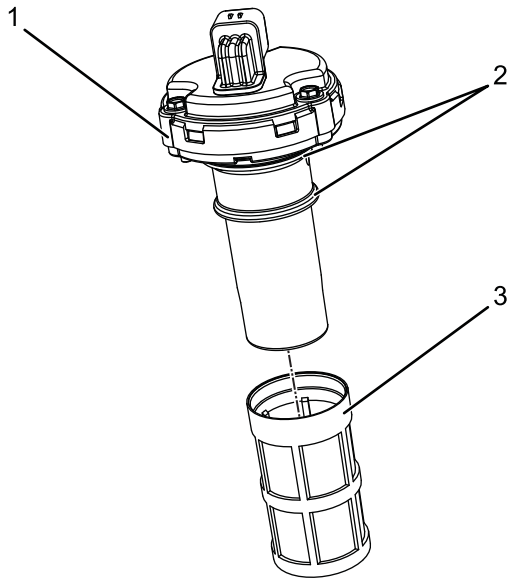
- Low / no fuel in fuel tanks
- Restricted fuel strainer
- Fuel filter restriction
- Fuel gelling in cold weather
- Fuel inlet restriction or leak (supply line, tank, pickup, optional primary fuel filter)

- Restricted fuel return line
- Electric fuel pump power, ground, or relay circuits
- Failed fuel pressure regulator
- Leaking or damaged fuel supply or return fittings
- Incorrect fuel pump O-rings
- Failed fuel pump

Test Procedure

Step 1	Perform operational checkout procedure.	Decision
	Did you perform 6.0 Fuel System Operational Checkout Procedure (page 146)?	Go to Step 2.
		Go to 6.0 Fuel System Operational Checkout Procedure (page 146).

Step 2	Measure fuel delivery pressure	Decision
Perform Fuel Delivery Pressure (FDP) Test (page 225). Did fuel delivery pressure meet specification?		No, Less than specification: Go to Step 3.
		No, Greater than specification: Go to Step 8.
		Yes: End Diagnostic Steps.



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Figure 76 Fuel Pump and O-rings

1. Electric Fuel Pump
2. Brown fuel pump O-rings
3. Fuel strainer

Step 3	Inspect fuel filter, fuel strainer, and fuel pump O-rings.	Decision
A. Disconnect fuel inlet from engine mounted fuel filter module. B. Inspect and clean fuel inlet fitting of debris. C. Turn Key On for 20 seconds (to reduce fuel in filter module). D. Turn Key Off. E. Remove and inspect engine mounted fuel filter. F. Remove and inspect fuel pump, strainer, and O-rings. **Low fuel delivery pressure, hard to start, or no start can be caused by non-Original Equipment Manufacturer (OEM) fuel filters and / or wrong O-rings installed on the fuel pump.** Is fuel filter made by a Navistar International approved manufacturer? Is fuel filter and strainer clean, and are fuel pump O-rings brown?		Yes: Go to Step 4. No: Install Navistar International approved fuel filter. Clean or replace fuel strainer. Install proper brown O-rings on fuel pump. After repairs are complete, retest for original problem.

Electronic Fuel Pump

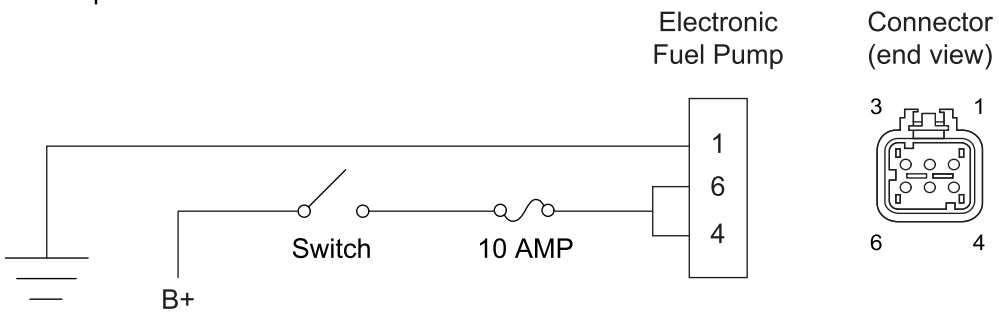


Figure 77 Electronic Fuel Pump PWR and GND

Step 4	Determine if fuel pump will run when provided power and ground.	Decision
CAUTION: Use a 10 amp fuse in the circuit, in case pump is shorted. With fuel pump removed from engine, provide power and ground to the pump: A. Install Fuel Pump Breakout Harness - ZTSE6023 on fuel pump connector, leave engine harness disconnected. B. Install power circuit with 10 amp fuse to pins-4 and 6. C. Ground pin-1. D. Listen for pump running. Let pump run for 30 seconds. Does pump run?		Yes: Reinstall fuel pump. Go to Step 5. No: Replace electric fuel pump. After repairs are complete, retest for original problem.

Step 5	Determine if electric fuel pump power and ground circuits are operating properly.	Decision
Perform Fuel Pump Voltage Test (page 238). Is voltage reading between Pin-6 and Pin-1, and between Pin-4 and Pin-1 within 0.5 volt of battery voltage when the fuel pump is energized?		Yes: Go to Step 7. No: Leave Breakout Harness connected. Go to Step 6.

Step 6	Determine if electric fuel pump power and ground circuits are operating properly.	Decision
Using a Digital Multimeter (DMM) measure voltage between pin-4 and ground, and between pin-6 and ground, when fuel pump is commanded on. Key must be Off for 10 seconds, or more, and then cycled On for Electronic Control Module (ECM) to command fuel pump On. Is voltage at pins 4 and 6 within 0.5 volts of battery voltage?		Yes: Repair electric fuel pump ground circuit. After repairs are complete, retest for original problem. No: Repair electric fuel pump power circuit. After repairs are complete, retest for original problem.

Step 7	Determine if fuel inlet problem is present.	Decision
Perform the Clean Fuel Source Test (page 230). Inspect for debris at fuel inlet, clean as needed. Is fuel pressure now greater than minimum Key-On Engine-Off (KOEO) specification?		Yes: Repair restriction in fuel supply line, pickup, fuel tank, or optional chassis mounted fuel filter. After repairs are complete, retest for original problem.
		No: Replace Fuel Pressure Regulator (see *Engine Service Manual*). After repairs are complete, retest for original problem.

Step 8	Determine if fuel return line is restricted.	Decision
A. Check vehicle fuel return line from the fuel filter module fitting to the fuel tank for restrictions. B. Connect Clean Fuel Source Tool Return Line 15-637-01-3 to the fuel filter module fuel return port. C. Start engine. Is fuel pressure now within specification?		Yes: Repair fuel return restriction. After repairs are complete, retest for original problem.
		No: Inspect that fuel filter module dry break fitting opens when return line fitting is attached. After repairs are complete, if fuel pressure is still high, replace fuel pressure regulator. After repairs are complete, retest for original problem.

End Diagnostic Steps
After performing all diagnostic steps, if fault remains, verify if each step was completed correctly and the proper decision was made. Notify supervisor for further action.

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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, do not let engine fluids stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.

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

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

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

Performance Specification Information See APPENDIX A (page 1291), or TSI to obtain the required specification information:

NOTE: Performance specifications are periodically published in a Technical Service Information (TSI) format to support new model year products. Check service bulletin repository on ISIS for appropriate model year application.

Initial Key On Check

Purpose

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

Tools

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

NOTE: Programming is only possible with the interface cable.

Procedure

1. Turn ignition switch to ON, engine OFF. Check or listen for the following:
   - WATER IN FUEL lamp (LCD display)
2. Record results on the Diagnostic Form.
   - If WATER IN FUEL lamp stays on, go to Fuel Quality Check (page 191).

Visual Inspection

Purpose

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

Tools

None

Engine Oil

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

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



Figure 78 Lube oil requirements label

   NOTE: Turn engine OFF. Wait 15 minutes for oil level to stabilize.

2. Use oil level gauge (dipstick) to verify engine oil level.
3. Record results on Diagnostic Form.
   - If level is below specification, inspect for leaks, oil consumption, or improper servicing. If engine oil level is low, fill to specification.
   - If level is above specification, inspect for improper servicing, coolant contamination, or fuel dilution. If engine oil level is above specification, drain to specification.
   - If oil is contaminated, determine source of contamination, repair as required. Replace oil and filter after repair.

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 gauge and visually look into fuel tank to verify fuel level.
   - If gauge reads above empty, but tank is empty, diagnose dash gauge. Verify sufficient fuel level before diagnosing a pressure problem.
   - If fuel tank is empty, add fuel and prime fuel system by cycling the ignition switch ON and OFF a few times.

   NOTE: The electric fuel pump will run for 10 seconds. Wait 10 seconds between switch cycles.

Fuel Quality Check

Purpose

Check fuel quality and for signs of contamination.

Tools

- Clear diesel fuel container

Procedure



Figure 79 Fuel requirements label

NOTE: Instrument panel Water In Fuel (WIF) lamp should cycle ON, then OFF, if there is no water in the system. Lamp will stay on if water is detected.



Figure 80 Fuel sample

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

   NOTE: If fuel does not drain, turn ignition switch ON to run the electric fuel pump. Electric fuel pump will run for 10 seconds with ignition switch ON.
3. Check for water, waxing, icing, sediment, gasoline, or kerosene by shaking fuel sample container and letting contents settle.
   - Sediments will fall to the bottom of the fuel sample container.
   - Gasoline and kerosene will separate from the diesel fuel.
   - Waxing or icing will prevent diesel fuel from flowing out of the fuel drain valve.
   - If the fuel quality is questionable, correct the problem. Take another sample to verify fuel quality is satisfactory.
   - If the 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.

CAUTION: Coolant in the Exhaust could damage the Diesel Particulate Filter (DPF). Inspect DPF for damage. See AFT System (Aftertreatment) (page 346) for inspection of the DPF. For coolant contamination, see Coolant Over Flow (page 105).

- If level is above or below deaeration tank fill level, inspect for leaks, coolant in the oil, or coolant in the intake or exhaust. See Coolant Over Flow (page 105) section and repair.
- If level is at deaeration tank fill level, and no tank contamination is evident, no action is required.
- If coolant is contaminated, determine the source, and repair as required. See *Engine Operation and Maintenance Manual*for coolant system requirements.

Charge Air Cooler (CAC) System

1. Inspect the CAC interstage cooler, and all piping for leaks.
2. Inspect all CAC connections and clamps.
    - If CAC system problem is found, make necessary repairs. See Coolant Over-Temperature (page 119).

Batteries and Electrical System Inspection

Overview

Inspect batteries, electrical system, and connections to help identify corroded connections, voltage drops, verify proper battery voltage, and identify damaged electrical connections and components.

WARNING: To prevent personal injury or death, disconnect the main battery negative terminal before disconnecting or connecting electrical components. Always connect ground cable last.

WARNING: To prevent personal injury or death when working with batteries, always wear face or eye protection, have water supply available, assure good ventilation, and be sure no flames or sparks are present.

Tools Required

- Digital Multi-Meter (DMM)
- Flash light (optional)
- Battery charger

Equipment Condition

None

Inspection Procedure

1. Inspect batteries and battery connections. If connections are corroded, loose, or damaged; clean and reinstall battery connections. If batteries are cracked or damaged replace as necessary.
2. If applicable, check batteries electrolyte level. If electrolyte is below the top of the plates in one or more cells, add distilled water.
3. Inspect electrical system for damaged electrical components or wiring, and loose connections (including engine grounds and starter connections). Repair damaged or loose components or connections.
4. Measure voltage of batteries. If voltage is less than 12.6 volts, charge batteries, and test charging system.

Expected Outcome

Batteries, wiring, electrical connections, and electrical components are clean, connections are tight, and not damaged. Batteries voltage 12.6-15 volts.

Intake Air

NOTE: Intake air restriction should be less than 25 in. H_2O (6.2 kPa) at full rated speed.

Inspect air filter gauge, located on air filter housing or on the dash panel.

- If gauge indicates air filter requires replacement, verify there are no other restrictions in the air inlet or filter housing before replacement of air filter.

Exhaust System

Inspect exhaust system (engine and vehicle) for damaged or plugged tailpipe.

- If exhaust system problem is found, make necessary repairs.

Electronic Service Tool (EST) with ServiceMaxx™ software Connection

Purpose

To check ECM software, sensor signals, Diagnostic Trouble Codes (DTCs) and to record additional vehicle information on the diagnostic form.

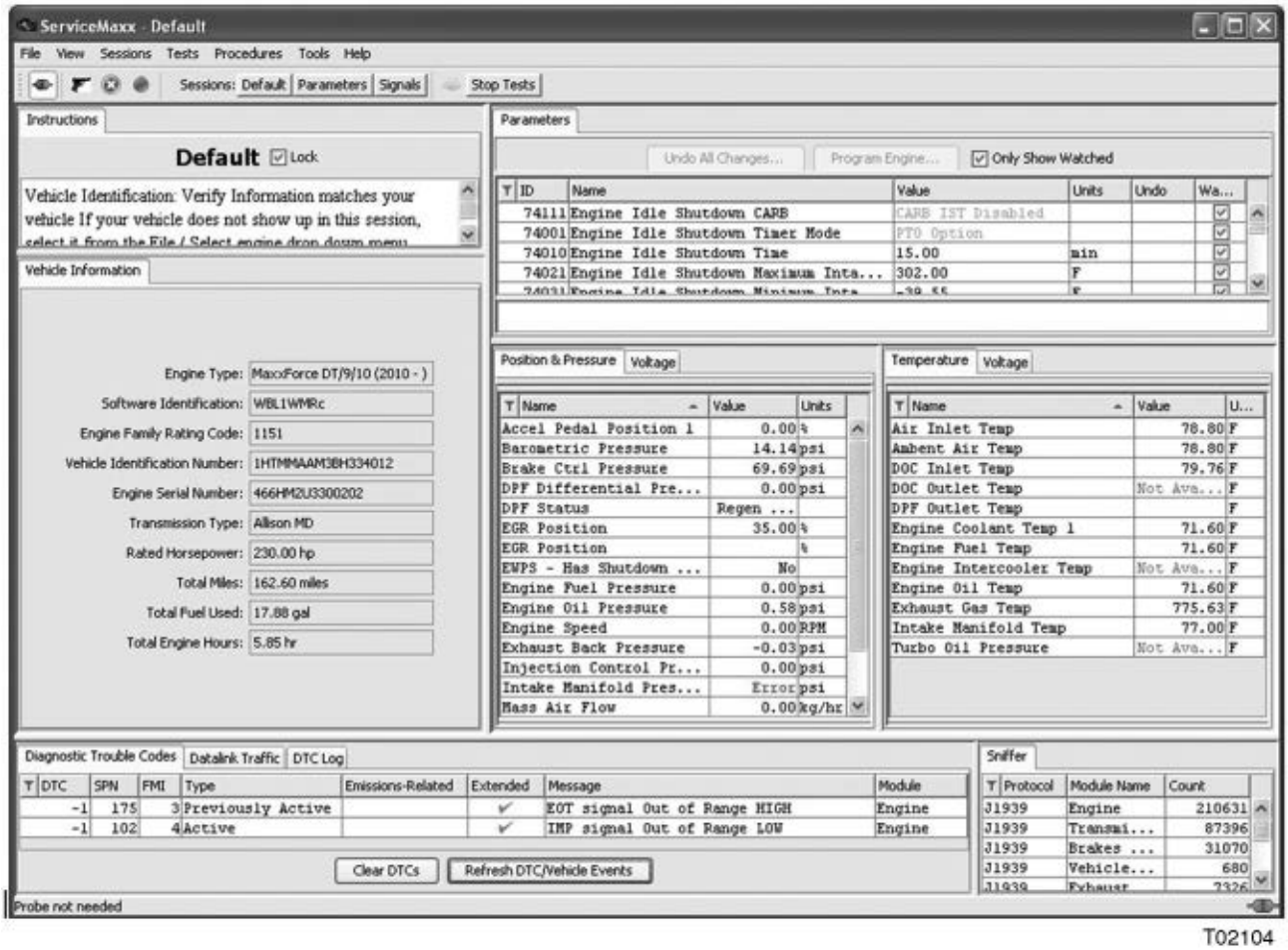
Tools

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

NOTE: Programming is only possible with the interface cable.

Procedure

1. Turn ignition switch to ON, engine OFF.



T02104

Figure 81 ServiceMaxx™ startup screen – vehicle connected

2. Connect the Electronic Service Tool (EST) with ServiceMaxx™ software to the vehicle's Diagnostic Connector.

3. Start the ServiceMaxx™ software.
   - If unable to communicate with the ECM, see the *ServiceMaxx™ Users Guide*.
   - If unable to communicate and no problems found with ServiceMaxx™ software, go to J1939 Data Link (page 1089).
   - If communication was established, continue to the next step.
4. Verify the following vehicle information matches the ServiceMaxx™ software displayed information and record on Diagnostic Form.
   - Vehicle Identification Number (VIN)
   - Software Identification
   - Rated Horsepower (HP)
   - Engine Family Rating Code (EFRC)
   - Transmission
   - Odometer (miles)
   - Engine Hours
   - Engine Serial Number (ESN)

   NOTE: The engine serial number is located on the right side of the crankcase, just above the oil filter header. It is also on the engine emission label on the valve cover.
5. Record the following Key ON, Engine OFF (KOEO) temperature sensor values on the Diagnostic Form.

   NOTE: If ECT1 is below 30°F (-1°C), verify Intake Air Heater is working before continuing. See Inlet Air Heater (page 1076).
   - Air Intake Temperature (AIT)
   - Engine Coolant Temperature 1 (ECT1)
   - Engine Oil Temperature (EOT)
6. Record the following KOEO pressure and flow sensor values on the Diagnostic Form:
   - Mass Air Flow (MAF)
   - Injection Control Pressure (ICP)
   - Exhaust Back Pressure (EBP)
   - Intake Manifold Pressure (IMP)
   - Barometric Absolute Pressure (BARO)
   - DPF Differential Pressure (DPFDP)

NOTE: The electric fuel pump will time out after 10 seconds unless engine speed is present. If electric fuel pump times out, wait 10 seconds between switch cycles to reset timer.

7. Record results on the Diagnostic Form.
8. Look for sensor values that are out of specification. A sensor out of specification could cause the ECM to command lower then normal starting pressure on certain systems.
   - If sensor is out of specification, go to the suspect sensor in ELECTRONIC CONTROL SYSTEM DIAGNOSTICS (page 1205).

9. Using ServiceMaxx™ software, run KOEO Output State High Test (page 87) and KOEO Output State Low Test (page 87) while monitoring the following signals:
   - EGR Control
   - Engine Throttle Position

   NOTE: The EGR Control signal displays duty cycle and not actual valve position. EGR valve closed is 35% and valve open is 80 to 90%.
10. Look for values that are out of specification. An actuator out of specification could cause air management problems.
    - If actuator is out of specification, go to the suspect actuator in ELECTRONIC CONTROL SYSTEM DIAGNOSTICS (page 1205).
11. Ensure air tanks are full.

NOTE: ServiceMaxx™ software does not have a Exhaust Back Pressure Valve (EBPV) feedback signal.

NOTE: Engine will cycle EBPV three times when engine is shut OFF.

12. Start engine and idle for five seconds.
13. Shut engine OFF and visually monitor EBPV for movement.
    - If EBPV does not cycle open and closed, go to next step.
    - If EBPV cycles open and closed, valve is working correctly.
14. Disconnect air supply to EBPV.
15. Start engine and idle for five seconds.
16. Shut engine OFF and visually monitor EBPV for movement.
    - If air flow cannot be heard, go to EBPV (Exhaust Back Pressure Valve) (page 535) section.
    - If air flow can be heard when cycled high, check valve or linkage for sticking.
17. Use ServiceMaxx™ software to monitor DPF status. Record results on Diagnostic Form.
    - If DPF status is “Regen needed - critical level”, run the Onboard Filter Cleanliness .

Check for DTCs

NOTE: Model year 2010 vehicles no longer utilize DTC identification by number. DTCs are now identified using the SPN and FMI identifiers only. These two identifiers, known as the Suspect Parameter Number (SPN) and the Failure Mode Indicator (FMI), are displayed in the Electronic Service Tool (EST) with ServiceMaxx™ software in the DTC Window for model year 2010 vehicles and DTC for pre-2010 vehicles.

- Suspect Parameter Number (SPN) – The SPN identifies the individual component causing the fault or condition.
- Failure Mode Indicator (FMI) – The FMI identifies the fault or condition affecting the individual component.
- Active faults or conditions are codes that are active now.
- Previously Active faults or conditions are historical faults that may be caused by intermittent signals, or an operating condition, which is not currently present.

Purpose

Identify SPN / FMIs.

Tools

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

NOTE: Programming is only possible with the interface cable.

Procedure

1. Turn ignition switch to ON, engine OFF.
2. Start the ServiceMaxx™ software.

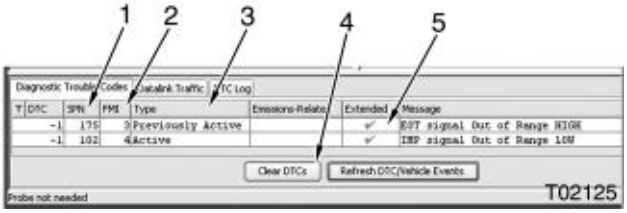


Figure 82 DTC window

1. Suspect Parameter Number (SPN) column
2. Failure Mode Indicator (FMI) column
3. Fault code column
4. Clear DTCs Type button
5. Extended (Freeze Frame)

NOTE: Click the extended button to receive a Freeze Frame data of when the code was set.

3. Record SPN / FMIs on the Diagnostics Form.
   - Correct any active codes. See the “DIAGNOSTIC TROUBLE CODE INDEX” (page 1205).
   - Investigate previously active codes with high counts for possible intermittent conditions.

KOER Standard Test

Purpose

To validate the performance of the ICP system (if equipped with an engine compression brake).

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- ZTSE4357 – Digital Multimeter

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.

Procedure

1. Turn ignition switch to ON, engine OFF.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, run KOER Standard Test.

NOTE: Engine Coolant Temperature must be above 158°F (70°C) to run this test.

3. Record results on diagnostic form.

- If SPN / FMI is set, see the DIAGNOSTIC TROUBLE CODE INDEX (page 1205).

Engine Low Idle to High Idle

Purpose

To validate engine performance throughout rpm range.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- ZTSE4681 – Fuel Pressure Gauge

Procedure

1. Turn ignition switch to ON, engine OFF.
2. Using ServiceMaxx™ software, load the Performance session.
3. Monitor Accelerator Pedal Position (APP) signal and press the accelerator pedal fully to the floor.
    - If APP signal does not go from 0% to 99.6%, see APP Sensor (page 411).
    - If APP signal does go from 0% to 99.6%, go to next step.

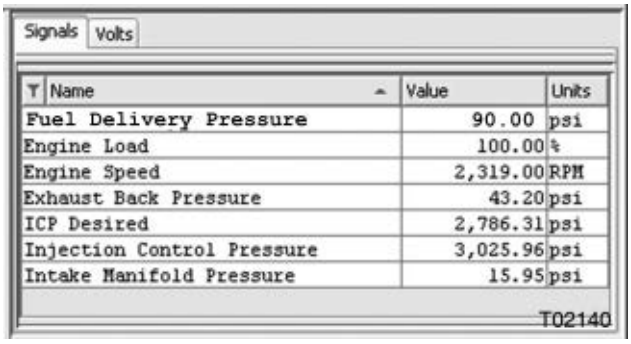


Figure 83 Signal monitoring example

4. Monitor the following signals:
   - Fuel Delivery Pressure (FDP)
   - Injection Control Pressure (ICP)
   - Exhaust Back Pressure (EBP)
   - Intake Manifold Pressure (IMP)
   - DPF Differential Pressure (DPFDP)

WARNING: Set parking brake and apply the service brake.

5. Connect Fuel Pressure Gauge to Intake Manifold Fuel Test Port.

NOTE: FDP sensor is only capable of measuring up to 75 psi (517 kPa) of pressure. Always use fuel gauge to measure fuel pressure.

6. Press the record button and start engine.
7. Allow engine to idle for 20 seconds. Press accelerator pedal to floor for 20 seconds. Return to low idle.
8. Record low idle and high idle results on the diagnostic form.
   - If FDP is above or below specification, see Fuel System (page 803).
   - If engine does not accelerate smoothly, feels unbalanced, (not running on all cylinders), perform Relative Compression Test (page 215) and Cylinder Performance Analyzer (CPA) Tests (page 257).
   - If DPFDP is above 2 psi (14 kPa), go to AFT System (page 346).
   - If ICP is below specification, go to Cylinder Performance Analyzer (CPA) High-pressure Oil Pump (HPOP) Test (page 257).
   - If EBP is above specification, remove turbocharger intake tube and inspect for turbocharger damage.
   - If IMP is below specification, check for Charge Air Cooler (CAC) and tubing leaks and perform the Crankcase Pressure Test (page 212).

Torque Converter Stall Test (Automatic Transmission Only)

Purpose

To validate engine performance under load conditions, see APPENDIX A (page 1291).

Tools

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

Procedure

1. Turn ignition switch to ON, engine OFF.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, load the Performance session.
3. Start engine.
4. Set parking brake and apply service brake.
5. Press the record button.
6. Push the accelerator firmly to the floor, and measure the time how long it takes to reach maximum RPM.

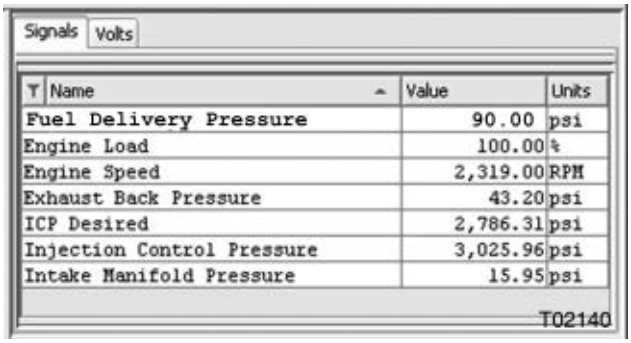


Figure 84 Signal monitoring example

7. Record stall RPM, FDP, and the amount of time on the diagnostic form.
8. Review recorded results at full engine load.
   - If FDP is below 75 psi (517 kPa), go to Fuel System (page 803).
   - If engine does not accelerate smoothly, feels unbalanced, (not running on all cylinders), perform Relative Compression Test (page 215) and Cylinder Performance Analyzer (CPA) Tests (page 257).
   - If stall RPM and amount of time is within specification, there is no power performance issue.

KOER Air Management Test

Overview

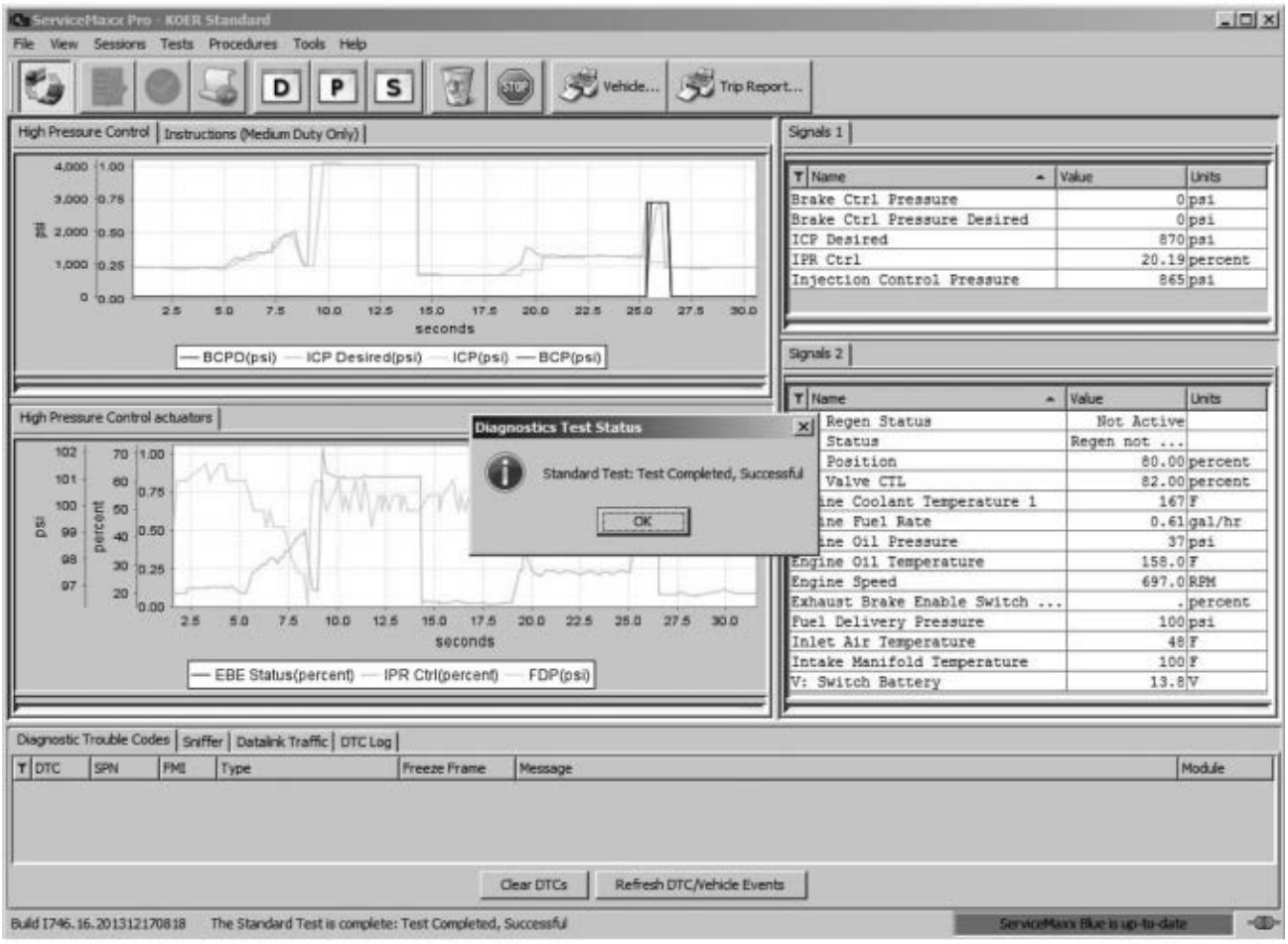
Tests performance of the Exhaust Gas Recirculation (EGR) valve by measuring changes in Mass Air Flow (MAF) through the MAF sensor and sets fault codes as necessary.

Tools Required

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

Equipment Conditions

None



0000310906

Figure 85 KOER Standard Test

Test Setup

1. Key-On Engine-Running (KOER).
2. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81).
3. Log in to ServiceMaxx™ software.
4. Run engine until Engine Coolant Temperature 1 (ECT1) is above 158°F (70°C).

Test Procedure

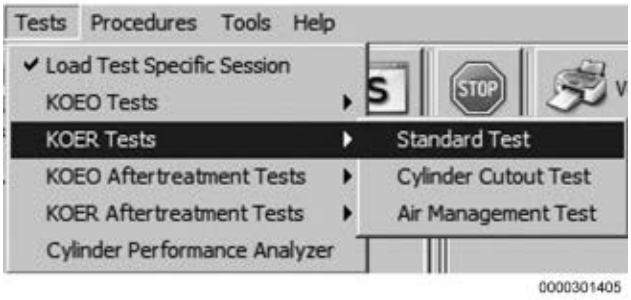


Figure 86 Select Test

5. Perform Key-On Engine-Running (KOER) Standard Test .
6. After test is complete, select Tests > KOER Tests > Air Management Test.
7. Follow on screen instructions.



Figure 87 Test Complete

Expected Outcome

Test runs successfully, and no fault codes are set.

Follow-On Procedure

None

Air Management System Graph (GOOD)

Overview

This graph shows normal operation of the Air Management System (AMS) during the Air Management Test (AMT). The AMT gives pass or fail results. It allows the user to validate the AMS by monitoring the effects each actuator has on Intake Manifold Pressure (IMP). IMP is normally between 2 psi (14 kPa) to 6 psi (41 kPa) on engine ramp up during AMT. If the Exhaust Gas Recirculation (EGR) valve is not operating as designed, IMP will not respond to changes in EGR valve position. When this occurs, excess soot will be generated by the engine causing frequent regeneration of the aftertreatment system.

When EGR valve is commanded ON, verify Intake Manifold Pressure (IMP) signal value drops. When EGR valve is commanded ON, verify Mass Air Flow (MAF) Mean Value (MMV) drops. Calculate the difference between MMV at a high point and a low point, then compare to the table below.

NOTE: EGR valve position will never read less than 35% and is considered closed.

Tools Required

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

Equipment Condition

None

Test Setup

Air Management Test Setup

Engine	MAF Mean Value	Tolerance
N9	1000	Less than 740 Fails AMS Test
N10	1130	Less than 850 Fails AMS Test

8. Key-On Engine-Off (KOEO).
9. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81).
10. Log in to ServiceMaxx™ software.
11. Perform air management test (if not already done and saved).

Test Procedure

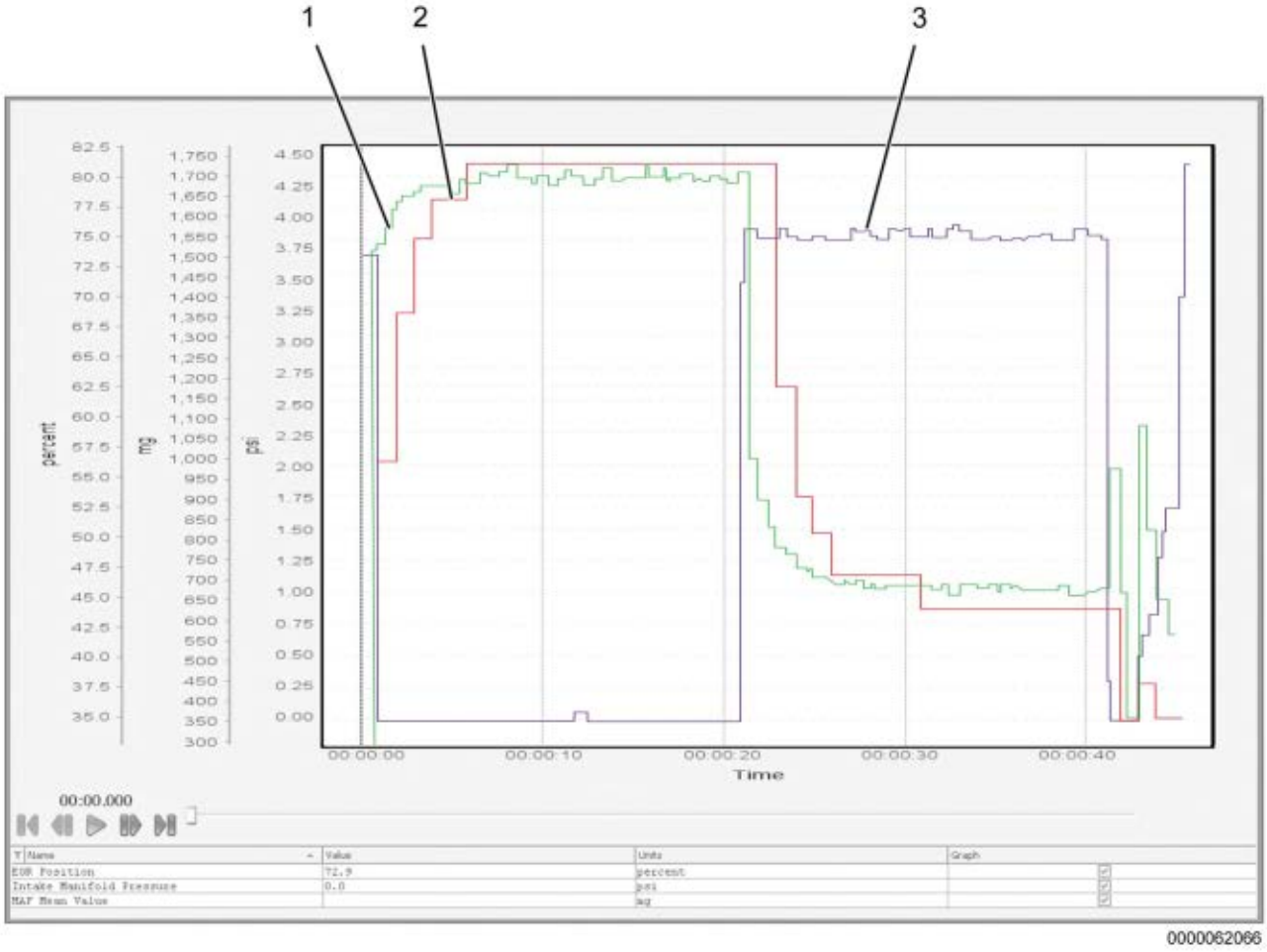


Figure 88 Air Management System Graph (Good)

1. Mass Air Flow Mean Value (MAF)
2. Intake Manifold Pressure (IMP)
3. Exhaust Gas Recirculation Valve Position (EGR)

12. Compare graph information with recorded data from test.
13. When EGR valve is commanded ON, verify IMP signal value drops.

Expected Outcome

A properly operating air management system graph will match this graph.

Follow-On Procedure

None

Air Management System Graph (BAD)

Overview

This graph shows an Air Management System (AMS) not operating as designed during the Air Management Test (AMT). The AMT gives pass or fail results. It allows the user to validate the AMS by monitoring the effects each actuator has on Intake Manifold Pressure (IMP). IMP is normally between 2 psi (14 kPa) to 6 psi (41 kPa) on engine ramp up during AMT. If the Exhaust Gas Recirculation (EGR) valve is not operating as designed, IMP will not respond to changes in EGR valve position. Excess soot will then be generated by the engine causing frequent regeneration of the aftertreatment system.

When EGR valve is commanded ON, verify Intake Manifold Pressure (IMP) signal value drops. In this graph, IMP does not drop when EGR valve is commanded ON.

NOTE: EGR valve position will never read less than 35 percent and is considered closed.

Tools Required

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

Equipment Condition

None

Test Setup

14. Key-On Engine-Off (KOEO).
15. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81).
16. Log in to ServiceMaxx™ software.
17. Perform Air Management Test (AMT) if not already done and saved.

Test Procedure

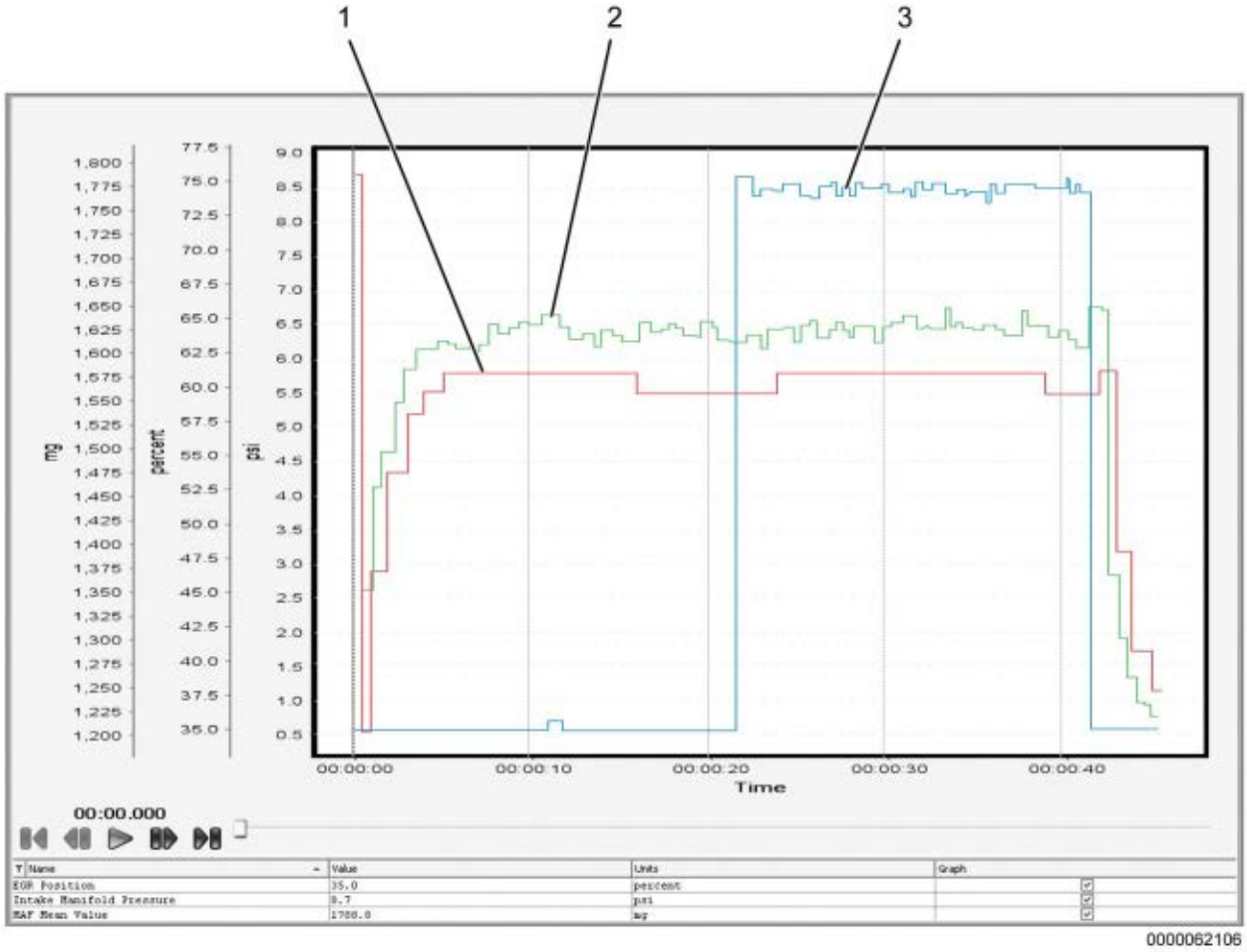


Figure 89 Air Management System Graph (Bad)

1. Intake Manifold Pressure (IMP)
2. Mass Air Flow (MAF)
3. Exhaust Gas Recirculation Valve (EGRV)

18. Compare graph information with recorded data from test.

Expected Outcome

An improperly-operating AMS graph will match this graph.

Follow-On Procedure

None

Turbocharger 2 Wastegate Control (TC2WC)

Purpose

Verify the turbocharger wastegate is operating properly.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- ZTSE4409 – Pressure Test Kit
- Measurement tool (ruler)

TC2WC Operational Test

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

Procedure

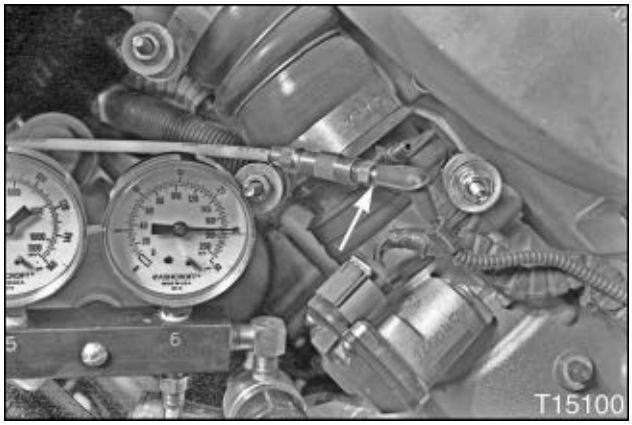


Figure 90 Air supply connected to the wastegate supply hose

1. Connect the Pressure Test Kit air regulator to shop air supply. Adjust regulator to 0 psi.
2. Connect the regulated air to the wastegate supply hose located next to the Engine Throttle Valve (ETV).

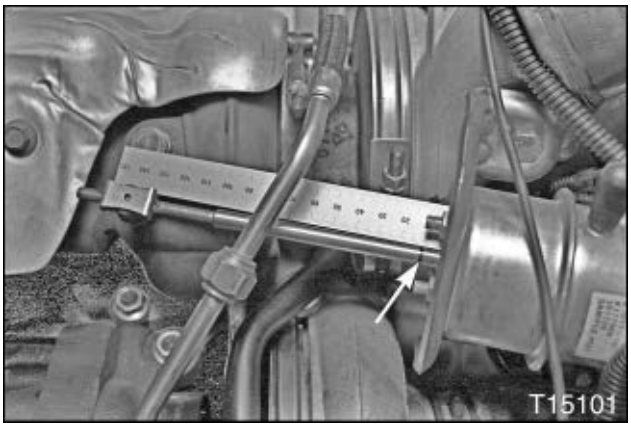


Figure 91 Turbocharger actuator rod mark during test

3. Mark the actuator rod at the base of the actuator.
4. Adjust the regulator to 21.5 psi (148.2 kPa).
5. Connect ServiceMaxx. Run the KOEO Output State High and Low tests. The turbocharger wastegate actuator rod should move “Full Travel” and stop at a seated position without sticking or shuttering. Measure the actuator rod movement. Compare measurement to specifications in APPENDIX A (page 1291).

   Does the actuator rod movement meet the specifications?

   Yes: System is operating correctly.

   No: Go to TC2WC System Leak Test (page 210).

TC2WC System Leak Test

1. Apply 21.5 psi (148.2 kPa) to the Wastegate supply hose. With the Key-Off, listen for air leaks at the hoses, solenoid valve, and actuator.

   Are any components leaking air?

   Yes: Repair air leaks and then continue to TC2WC Valve Mechanical Test (page 210).

   No: Go to TC2WC Valve Mechanical Test (page 210).

TC2WC Valve Mechanical Test

1. Reapply 21.5 psi (148.2 kPa) to the wastegate supply hose.
2. With the Key-Off, remove the hose from the wastegate actuator.

   Is air pressure exiting the hose?

   Yes: Go to TC2WC Linkage Inspection (page 210).

   No: Replace the Turbocharger 2 Wastegate Control (TC2WC) Valve and then go to TC2WC Operational Test (step 5) (page 209) and follow any additional steps required.

TC2WC Linkage Inspection



Figure 92 Actuator rod disconnected from turbocharger linkage

NOTE: When disconnecting the actuator rod from the wastegate lever, mark the inner nut position so the wastegate lever can be reinstalled in the same position.

1. Disconnect the actuator rod from the turbocharger wastegate arm, following the procedures in the *Engine Service Manual*.
2. Move the turbocharger wastegate arm by hand.

   Does the wastegate arm move freely?

   Yes: Install a new Wastegate Actuator. Assemble the Actuator Rod to the Wastegate arm and then go to Wastegate Actuator Rod Measurement Test (page 211).

No: Replace turbo and then go to Wastegate Actuator Rod Measurement Test (page 211).

Wastegate Actuator Rod Measurement Test

1. Connect ServiceMaxx. Turn Key-On Engine Off. Run KOEO Output State High and Low tests. Measure Wastegate Actuator Rod movement.

   Does the actuator rod movement meet the specifications in APPENDIX A (page 1291)?

   Yes: Solenoid and the Actuator are working correctly. Testing is completed.

   No: Go to step TC2WC Connector – Output State Test .

Oil Breather Separator Test

Purpose

Purpose of this test is to ensure that engine mounted crankcase breather is operating at correct speeds. A poorly operating breather system can lead to excessive oil carryover into air intake system which can eventually lead to coking of turbos.

Tools

- Hz Setting – Digital Multimeter (DMM)
- 1828345C91 (Dealer Sourced Item) – CMP Sensor
- ZTSE4951 – CMP Breakout Harness

Procedure

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

1. Locate provision on top of engine mounted crankcase breather.
2. Insert CMP in to provision.

   NOTE: CMP Sensor is to be installed in breather housing. Provision is 6mm deep. Do not modify housing for any reason.
3. Connect each multimeter lead to each pin on CMP.
4. Set multimeter to measure Hz (Hertz).
5. Warm engine to operating temperature 176˚F before collecting data. Take meter reading and then multiply it by 30 to get breather RPM.

NOTE: Oil: Viscosity, temperature, pressure and age (miles and hours) can affect breather operational speeds.

6. If breather speed exceeds (spins faster) than minimal RPM Specs, then do NOT replace the breather.
7. If breather speed fails (spins slower) to meet any of the minimum RPM Specs, then further diagnostics will be required before replacing breather assembly.
   - Verify Engine Oil: Level, Condition, Miles and Hours are within specification.
   - Verify Engine Oil Pressure is meeting performance specification (see diagnostic manual).
   - Inspect breather/centrifuge for excessive rotational resistance, sludge, or other abnormalities.

- Verify good oil flow from the breather oil jet in lower housing.

8. The breather is only to be replaced if it has failed one of breather speed tests and steps has been verified.

Crankcase Pressure Test

Purpose

Determine if engine repair is required due to wear. Verify the operation of the air compressor. Check for worn or damaged parts.

Tools

- ZTSE4039 – Crankcase Pressure Test Tool
- ZTSE2217A – Water Manometer
- ZTSE2217 – Digital Manometer – Alternative to Water Manometer
- Standard shop bolt to plug intake tube

Procedure

NOTE: Ensure engine is at normal operating temperature of 158°F (70°C) and oil level is in specification, before performing this test.

1. Verify the Crankcase breather is functioning properly before running this test by performing the Oil Breather Separator Test (page 211).
2. Disconnect breather outlet tube at crankcase breather.
3. Block off breather outlet tube using standard shop bolt, to prevent dirt ingestion.
4. Connect Crankcase Pressure Test Tool to the breather elbow.

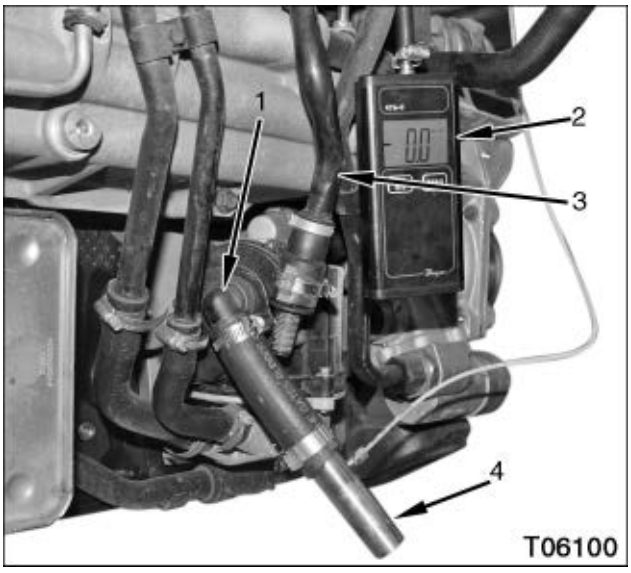


Figure 93 Crankcase Pressure Test Adapter installed

1. Breather elbow
2. Digital Manometer
3. Crankcase breather outlet tube
4. Crankcase Pressure Test Tool

5. Connect Manometer to Crankcase Pressure Test Adapter.

WARNING: To prevent personal injury or death, when routing test line, do not crimp line, run line too close to moving parts, or let line touch hot engine. Secure the gauge and test line to not obstruct vehicle operation.

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

6. Start engine, press the accelerator pedal fully to the floor. Allow the manometer reading to stabilize before taking the pressure reading.
7. Record crankcase pressure on diagnostic form.
   - If pressure is above specification, continue to next step.
   - If pressure is in specification, no repair is required.

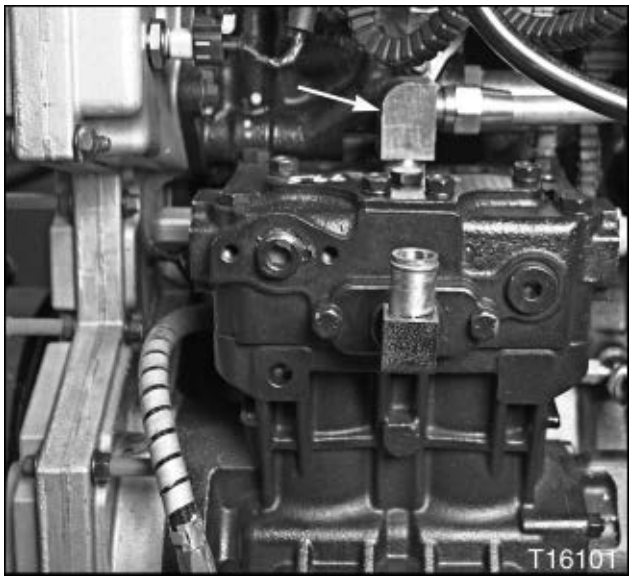


Figure 94 Air compressor discharge port

8. If engine has an air compressor, remove discharge line and test again.
   - If pressure is above specifications, go to the next step, Relative Compression Test (page 215), to pinpoint suspect cylinder.
   - If pressure is within specification, compressed air was leaking into the crankcase. Repair or replace air compressor. See *Engine Service Manual* in the Air Compressor and Power Steering sections.

Relative Compression Test

Purpose

To verify all cylinders have good compression.

NOTE: This test will validate cylinder balance. If cylinders are out of balance, this is mechanical problem and not an injector problem.

Tools

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

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's important that cranking rpm remains consistent throughout test.

1. Turn ignition switch to ON, engine OFF.
2. Using ServiceMaxx™ software, run Relative Compression Test.
3. Follow the on-screen instructions.
4. Record results on diagnostic form.

   If Speed Difference for one cylinder is significantly lower than others, that cylinder is suspect for compression loss.

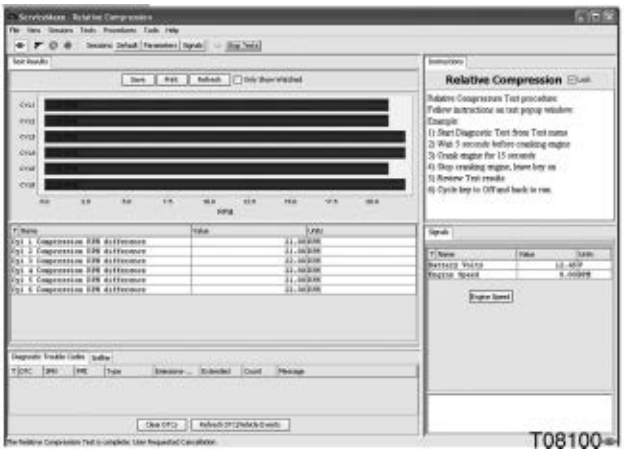


Figure 95 Electronic Service Tool (EST) with ServiceMaxx™ software Display

Relative Compression Test Interpretation

This 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.

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

Possible Causes

- Valves out of adjustment
- Valve train damage
- Worn or broken piston rings
- Excessive cylinder wall wear
- Damaged piston
- Bent rod

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 Injection Control Pressure (ICP)

Tools

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

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

1. Connect Fuel Pressure Gauge to intake manifold test port and secure gauge in a safe visible location.
2. Turn ignition switch to ON, engine OFF.
3. Using ServiceMaxx™ software, load the Performance session.
4. Start engine.
5. Find an open stretch of road. Start recording. When driving conditions are safe, select a suitable gear, press the accelerator pedal fully to the floor, and accelerate to rated speed at 100 percent load.

Signals | Volts

Name	Value	Units
Fuel Delivery Pressure	90.00	psi
Engine Load	100.00	%
Engine Speed	2,319.00	RPM
Exhaust Back Pressure	43.20	psi
ICP Desired	2,786.31	psi
Injection Control Pressure	3,025.96	psi
Intake Manifold Pressure	15.95	psi

T02140

Figure 96 Performance Diagnostics

6. When road test is complete, stop recording.
7. Review recorded results at 100 percent engine load at the rated speed specified in the Performance Specifications.
   - If FDP is below 586 kPa (85 psi), see Fuel System (page 803).
   - If engine does not accelerate smoothly, feels unbalanced, (not running on all cylinders), perform Fuel Aeration Test (page 190), Relative Compression Test (page 215), and Cylinder Performance Analyzer (CPA) Tests (page 257).
   - If ICP is below 4500 psi (31026 kPa), go to Cylinder Performance Analyzer (CPA)-High-Pressure Oil Pump (HPOP) Test (page 287).
   - If EBP is above specification, remove turbocharger intake tube and inspect for turbocharger damage.

0 to 60 MPH Test

Overview

This test checks for unacceptable performance under a load at rated speed, and requires operation of vehicle. Using record feature in ServiceMaxx™ while driving on an open stretch of road trying to reproduce complaint, signals are recorded so they can be analyzed to determine which system is causing faults.

WARNING: To prevent personal injury or death, do not exceed local speed limit laws or drive too fast for conditions when performing 0 to 60 mph test.

Tools Required

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

Equipment Condition

None

Test Setup

1. Key-On Engine-Running (KOER).
2. Connect Electronic Service Tool (EST) to Vehicle Diagnostic Connector (page 81).
3. Log in to ServiceMaxx™.
4. Run engine until Engine Coolant Temperature (ECT) is above 158°F (70°C).

Test Procedure

5. Drive vehicle to a suitable and safe location to perform test.
6. Pull over to side of road.

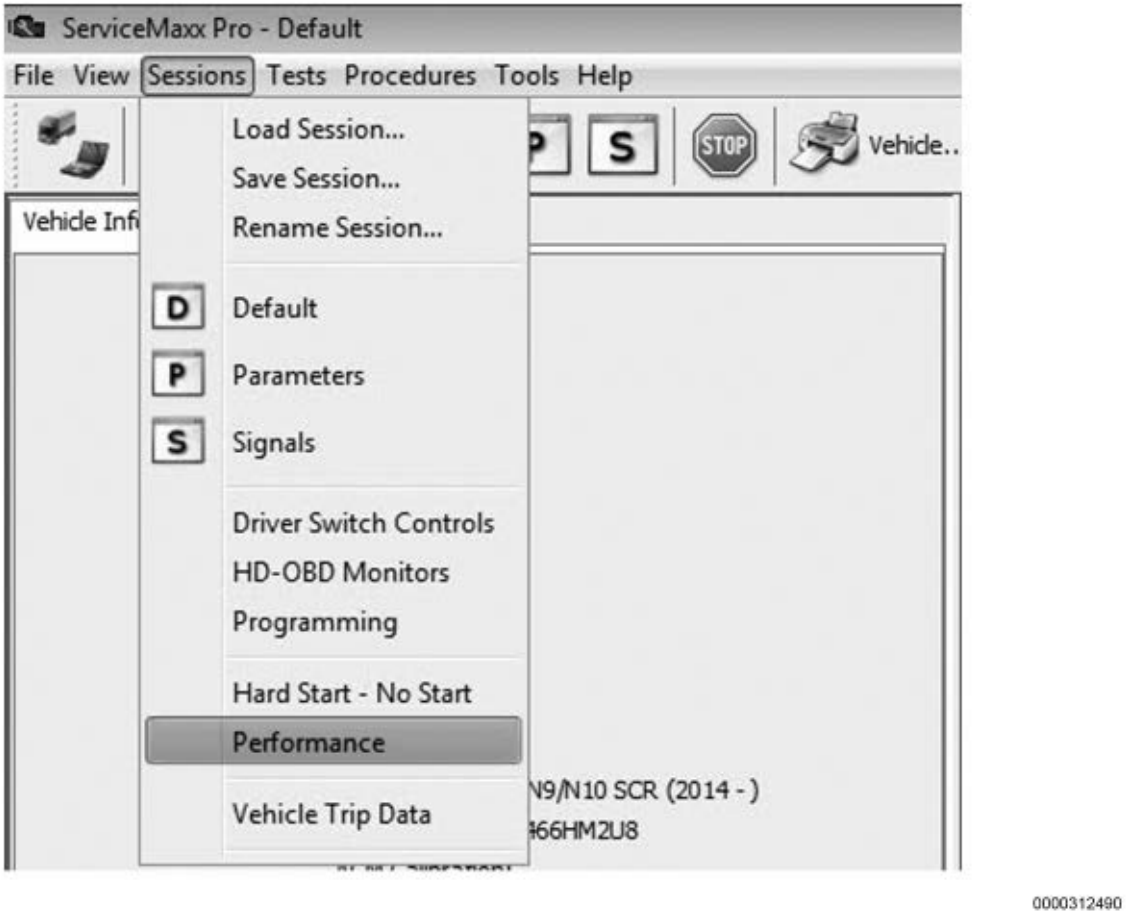


Figure 97 Menu – Select Performance

7. Select Sessions > Performance (Figure 97).

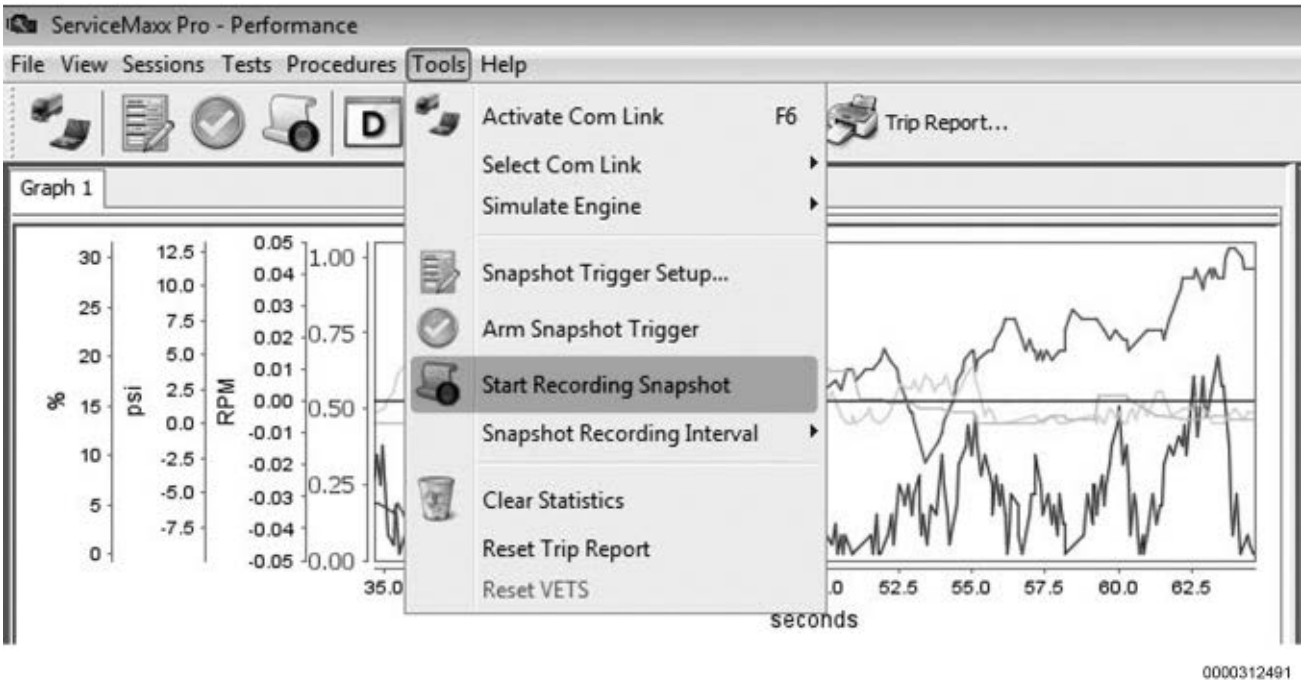


Figure 98 Menu – Select Start Recording Snapshot

8. Select Tools > Start Recording Snapshot (Figure 98).
9. When it is safe to do so, accelerate from 0 MPH to maximum allowed highway speed.
10. Repeat as necessary to reproduce complaint.

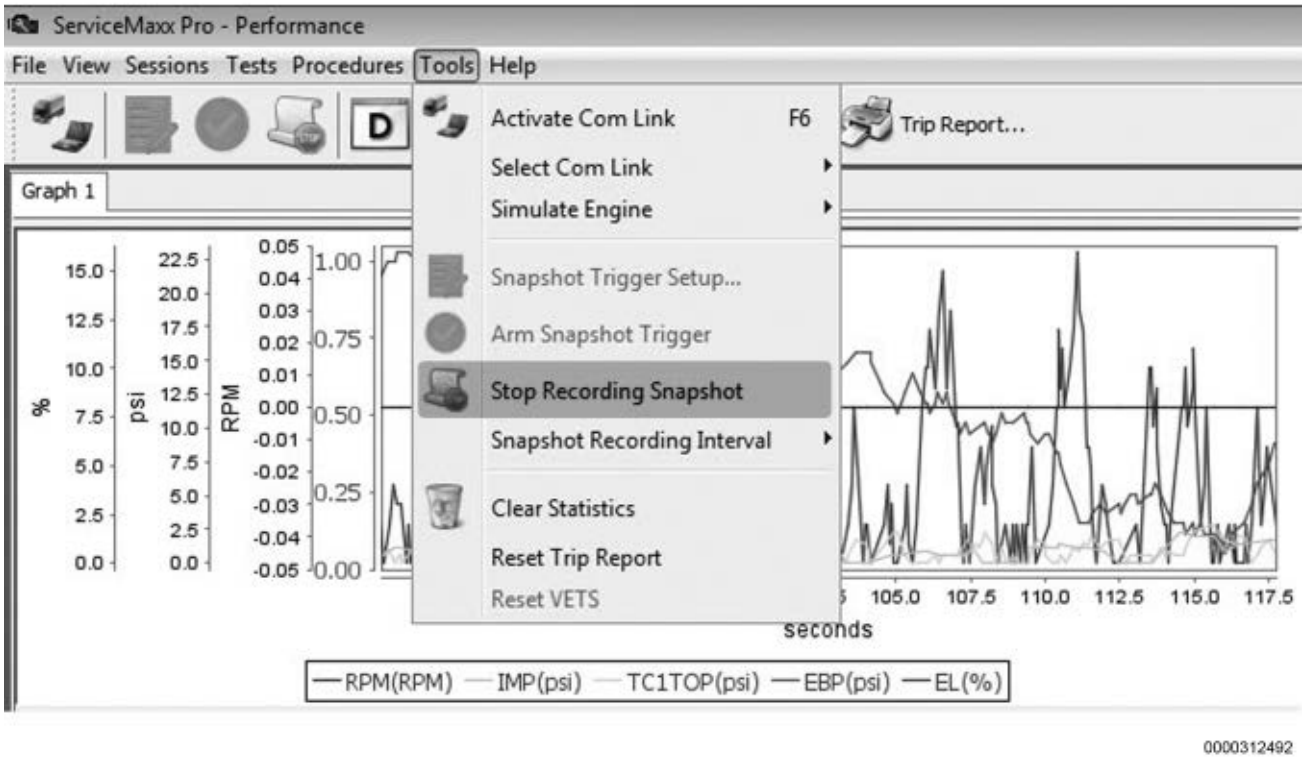


Figure 99 Menu – Select Stop Recording Snapshot

11. After test is complete, Select Tools > Stop Recording Snapshot (Figure 99) and save snapshot in EST.
12. Return to shop and review snapshot data.

Expected Outcome

Safely perform road test and record data for analysis.

Follow-on Procedure

None

Special 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.

Fuel System

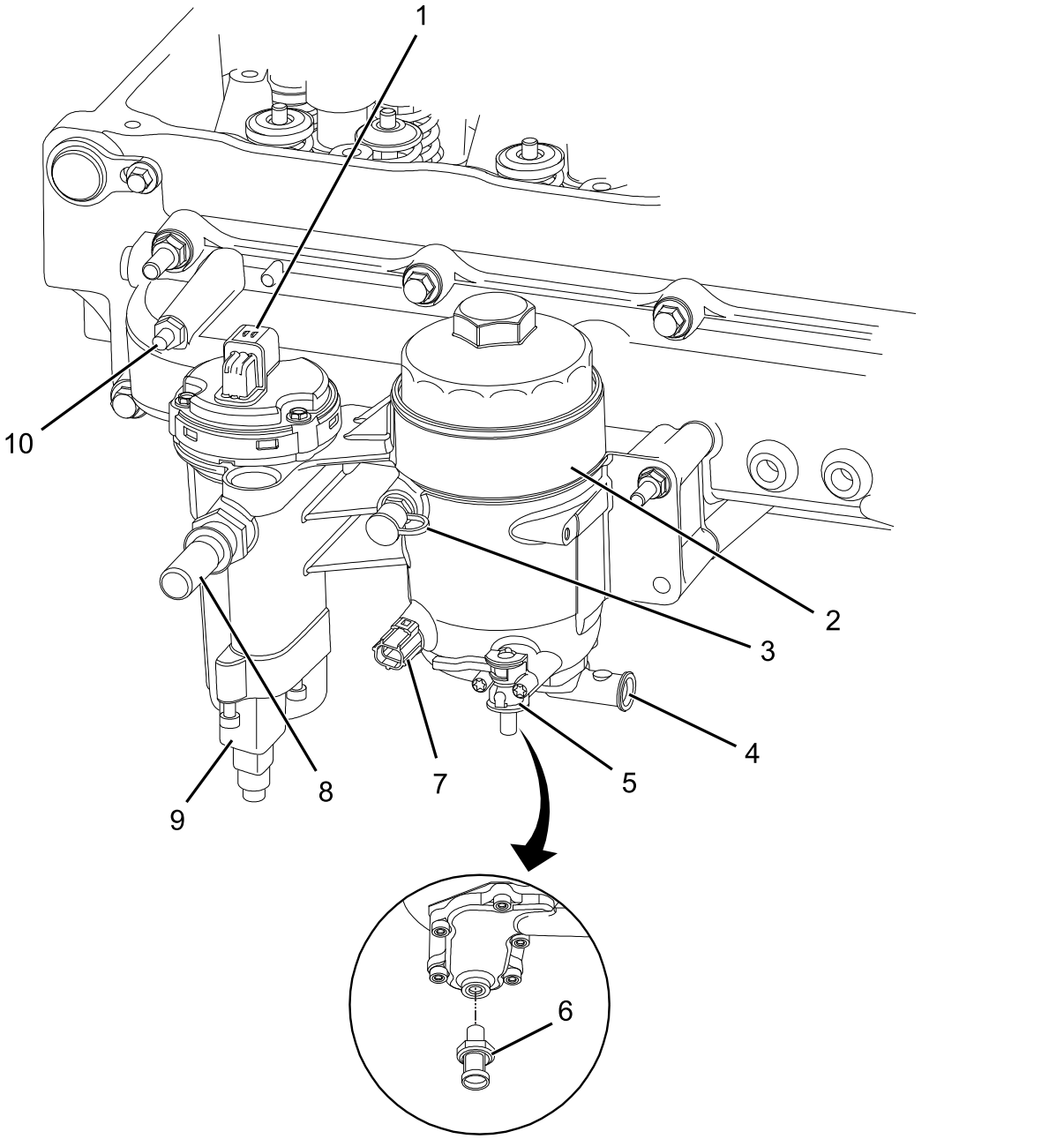


Figure 100 Low-pressure fuel system

1. Electric pressure fuel pump
2. Fuel filter module
3. Fuel filter test port (Compucheck)
4. Fuel return to tank and dry-break valve
5. Water drain valve
6. Fuel Delivery Pressure (FDP) sensor
7. Water in Fuel (WIF) sensor
8. Fuel supply line from tank
9. Fuel heater
10. Intake manifold fuel air bleed

Fuel System Inspection

Overview

Verify the fuel system is clean and free of damage.

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

Tools Required

None

Equipment Condition

None

Inspection Procedure

1. Visually inspect the condition and routing of fuel lines and connections.
   - If fuel lines or connections are damaged or routed incorrectly, repair or replace as necessary.
   - If fuel lines and connections are in good condition and routed correctly, go to step 2.
2. Remove fuel pump and fuel strainer. Inspect fuel strainer, fuel pump, and O-ring seals for cleanliness and damage.
   - If fuel pump, fuel strainer, or O-ring seals are dirty or damaged, replace as required.
   - If fuel pump, fuel strainer, or O-ring seals are clean and not damaged, go to step 3.
3. Remove fuel filter and inspect for: sediments, gasoline, kerosene, waxing, or icing.
   - If fuel filter is dirty or damaged, replace fuel filter.
   - If fuel filter is clean, go to next test.
4. Inspection is complete.

Expected Outcome

Fuel lines, fuel filter, fuel strainer, and fuel connections are clean and not damaged.

Fuel Delivery Pressure (FDP) Test

Purpose

To verify if the fuel system contributes to hard to start vehicles.

Tools

- ZTSE4681 – Fuel Pressure Gauge (page 1249)
- ZTSE4526 – Fuel / Oil Pressure Test Coupler (Compucheck) (page 1248)
- ZTSE6009 — Fuel Inlet Restriction and Aeration Tool (page 1248)
- Breakout Harness 6023 (EFP)
- ZTSE4357 – Digital Multimeter (page 1224)

- 15-637-01 – Clean Fuel Source Tool
- Clean diesel fuel container

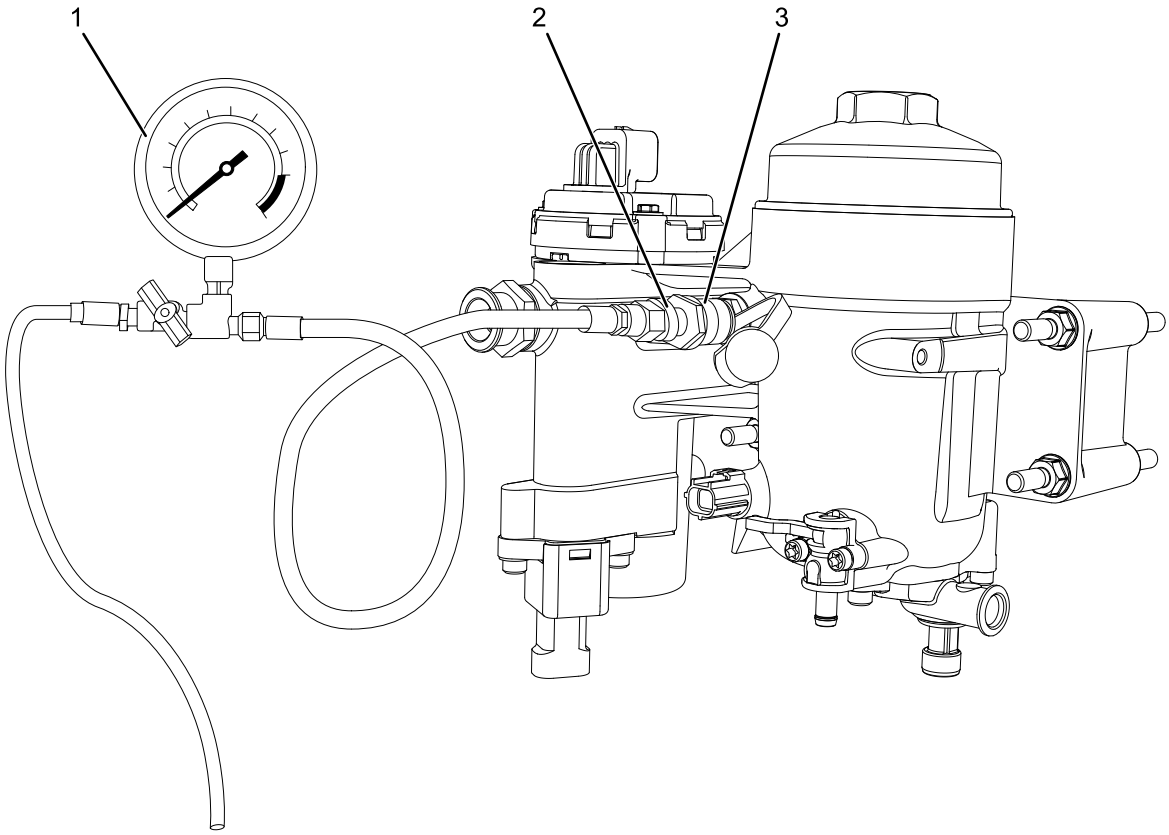
NOTE: Refer to the appropriate Engine Service Manual when the following procedures require engine component removal and installation.

NOTE: To energize fuel pump, turn Key-ON Engine-OFF (KOEO). Fuel pump will operate for 10 to 20 seconds. Allow fuel pump to complete the cycle then turn Key-OFF for 30 seconds to reset the Engine Control Module (ECM).

Equipment Condition

None

Test Setup



0000298401

Figure 101 Fuel Pressure Gauge to Fuel Filter Module Connection

1. Fuel Pressure Gauge ZTSE4681
2. Fuel Pressure Test Kit ZTSE4657
3. Fuel / Oil Pressure Test Coupler ZTSE4526

1. Key OFF.

2. Fuel Pressure Gauge ZTSE4681 (Figure 101) (Item 1) connected to Fuel Filter Module test port.
3. Valve closed on fuel gauge.
4. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81).
5. Log into ServiceMaxx™ software.

Test Procedure

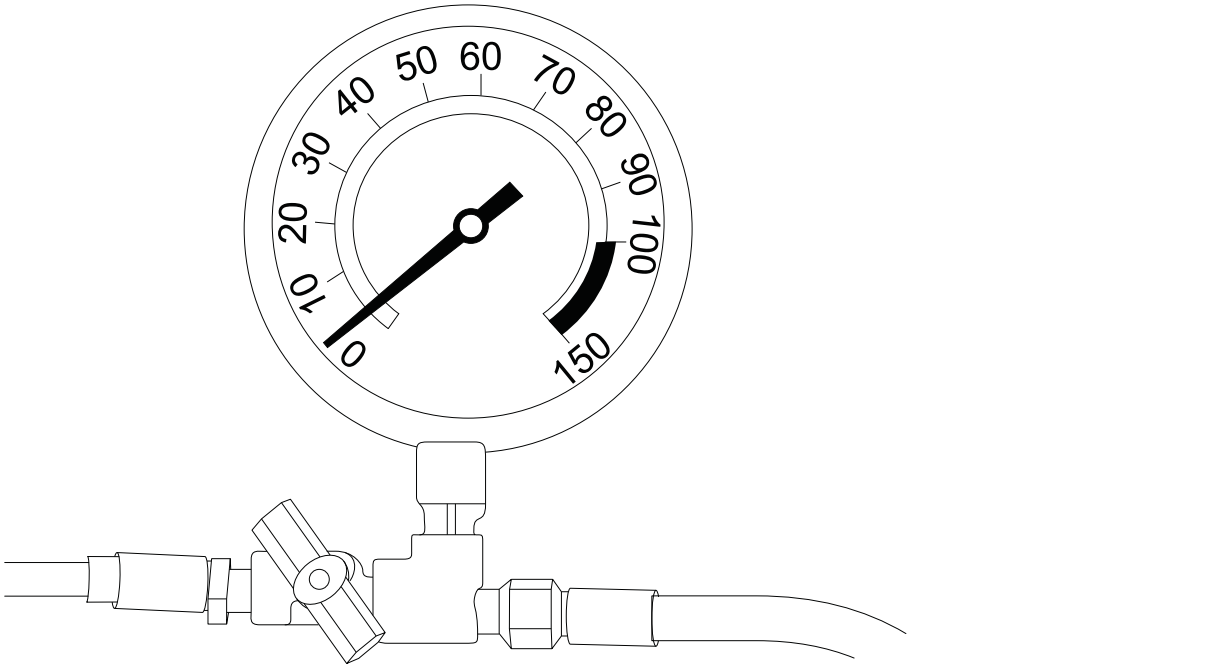


Figure 102 Fuel Pressure Gauge ZTSE4681

6. Turn Key-On Engine-Off (KOEO) to energize fuel pump (pump will run for 10 to 20 seconds).
7. Monitor and record fuel pressure displayed on gauge.
8. Turn key Off for a minimum of 30 seconds, allowing Engine Control Module (ECM) to reset.
9. Electric Fuel Pump can also be commanded on by using Output State High Test in ServiceMaxx™ software.
10. Perform Output State High Test (page 87) and monitor gauge and sensor signal in ServiceMaxx™ software.
11. Repeat as necessary to get an accurate and steady pressure reading.

Expected Outcome

Fuel Delivery Pressure (FDP) will be within specifications (page 1291).

Follow-On Procedure

None

Fuel Pressure Measurement

1. Attach the Fuel / Oil Pressure Test Coupler ZTSE4526 to the fuel pressure gauge ZTSE4681.
2. Connect the coupler to the fuel filter module test port.
3. Turn the valve on the fuel gauge fully clockwise to the closed position.
4. Measure the KOEO fuel pressure with the pump energized. Leave the pressure gauge installed.
   - If fuel pressure is < 70 psi (483 kPa), go to Pump Voltage Measurement .
   - If fuel pressure is > 100 psi (689 kPa), go to Return Line Restriction(page 238).
   - If fuel pressure is between 70 psi (483 kPa) and 100 psi (689 kPa), go to Clean Fuel Source Test .

Pump Voltage Measurement

Overview

This test is used to determine if the Engine Control Module (ECM) is commanding the Electric Fuel Pump (EFP) by measuring supply voltage to the EFP.

NOTE: Output state high test can be used to activate fuel pump.

Tools Required

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Digital Multimeter (DMM)
- Electric Fuel Pump (EFP) Breakout Harness ZTSE6023
- Interface cable (RP1210B-compliant supporting J1939 and J1708)

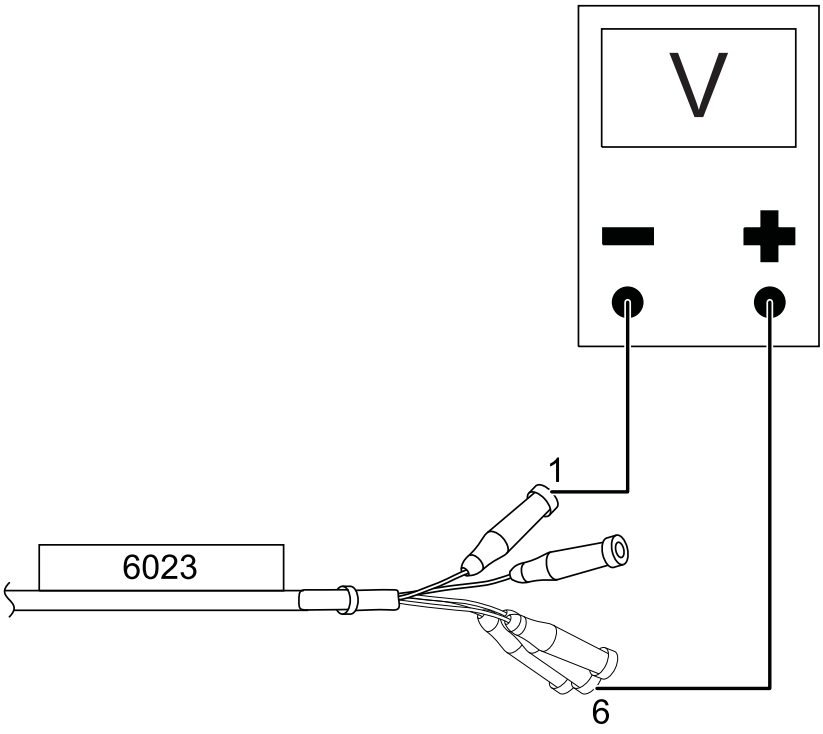
Equipment Condition

None

Test Setup

1. Key OFF.
2. Install Breakout Harness ZTSE6023 between Electric Fuel Pump (EFP) and EFP harness connector.
3. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81).
4. Log into ServiceMaxx™ software.

Test Procedure



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Figure 103 Pin-Point Test 1

5. Use ServiceMaxx™ and the Output State Test HIGH to command fuel pump On.
6. While Electric Fuel Pump (EFP) is energized, use Digital Multimeter (DMM) to measure voltage between Breakout Harness ZTSE6023, pin-6, and pin-1. Record measurement.

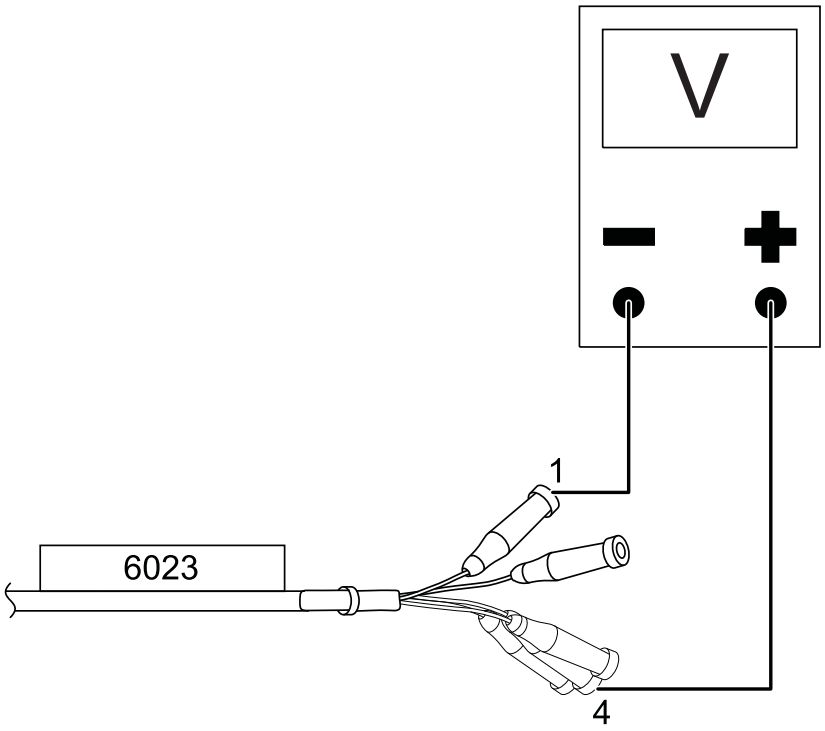


Figure 104 Pin-Point Test 2

7. While EFP is energized, use Digital DMM to measure voltage between Breakout Harness ZTSE6023, pin-4, and pin-1. Record measurement.
8. Repeat steps 1–3 as necessary.

Expected Outcome

Voltage reading between pin-6 and pin-1 and voltage reading between pin-4 and pin-1 are within specifications.

Follow-On Procedure

None

Clean Fuel Source Test

Overview

This test verifies that the fuel supply system is not restricted and is working as designed. By replacing vehicle tank, lines, and chassis-mounted filter (if equipped), this test isolates the Electric Fuel Pump (EFP) by providing a clean unrestricted fuel source.

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, wear safety glasses with side shields.

Tools Required

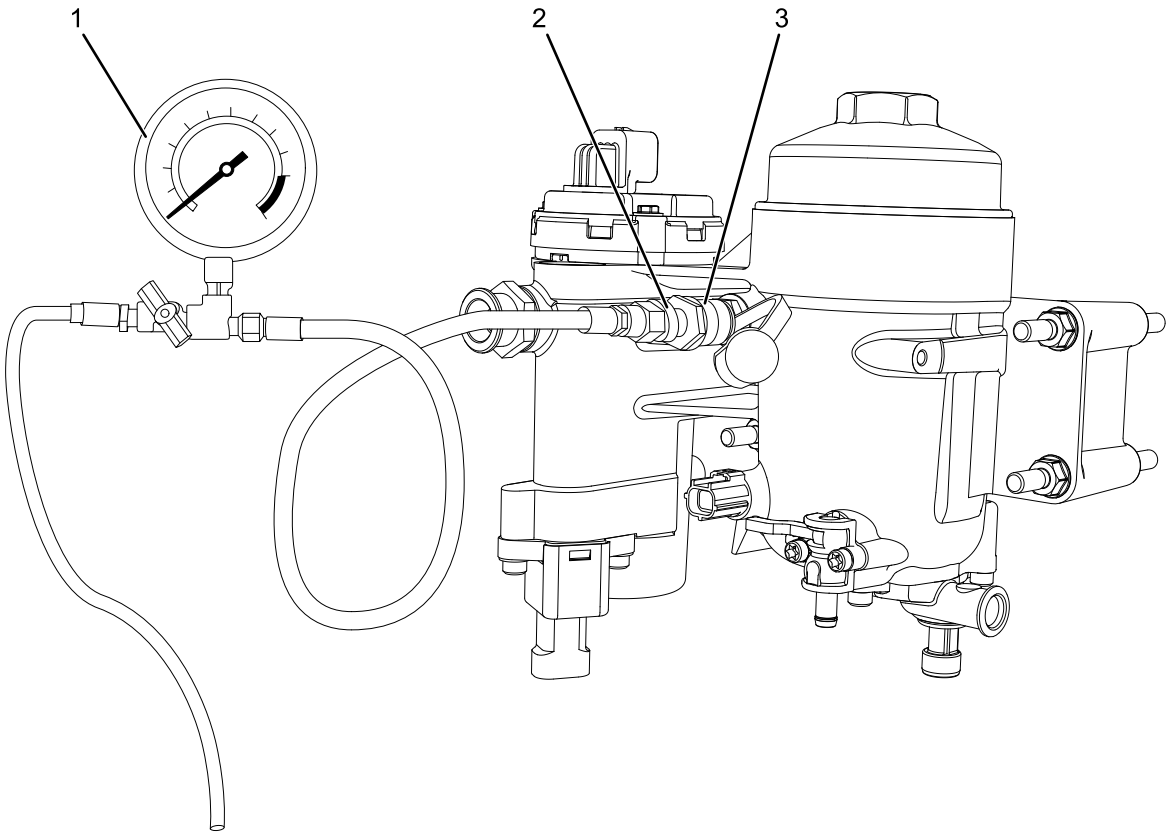
- Electronic Service Tool (EST) with ServiceMaxx™ Software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)
- Clean Fuel Source Tool – 15–637–01
- Fuel Pressure Gauge – ZTSE4681
- Fuel Pressure Test Kit – ZTSE4657
- Fuel / Oil Pressure Test Coupler (Compucheck) – ZTSE4526

Equipment Condition

None

Test Setup

1. Key-On Engine-Off (KOEO)
2. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81).
3. Log into ServiceMaxx™ software
4. Disconnect fuel inlet dry-break fitting from the fuel filter module.
5. Connect Clean Fuel Source Tool 15-637-01 to inlet side of fuel filter module and prime using primer bulb



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Figure 105 Fuel Pressure Gauge to Fuel Filter Module Connection

1. Fuel Pressure Gauge ZTSE4681
2. Fuel Pressure Test Kit ZTSE4657
3. Fuel/Oil Pressure Test Coupler ZTSE4526

6. Connect Fuel Pressure Gauge ZTSE4681 (Figure 105) (Item 1) to Fuel Filter Module test port using Fuel Pressure Test Kit ZTSE4657 (item 2) and Fuel/Oil Pressure Test Coupler ZTSE4526 (item 3).

Test Procedure

7. Perform Output State High Test (page 87) to energize Electric Fuel Pump (EFP)..
8. Observe fuel pressure reading while pump is energized.
9. Activate fuel pump as many times as needed to record a consistent and accurate pressure reading.

Expected Outcome

Fuel pressure reading will be within specification .

Follow-on Procedure

None

Restriction / Aeration Test

Overview

The purpose of this test is to measure restriction between vehicle mounted tank, fuel lines, chassis-mounted fuel filter (if equipped), and the fuel filter module. By measuring vacuum on the intake side of the fuel filter module and comparing it to specification, a restriction can be identified.

Equipment Condition

None

Test Setup

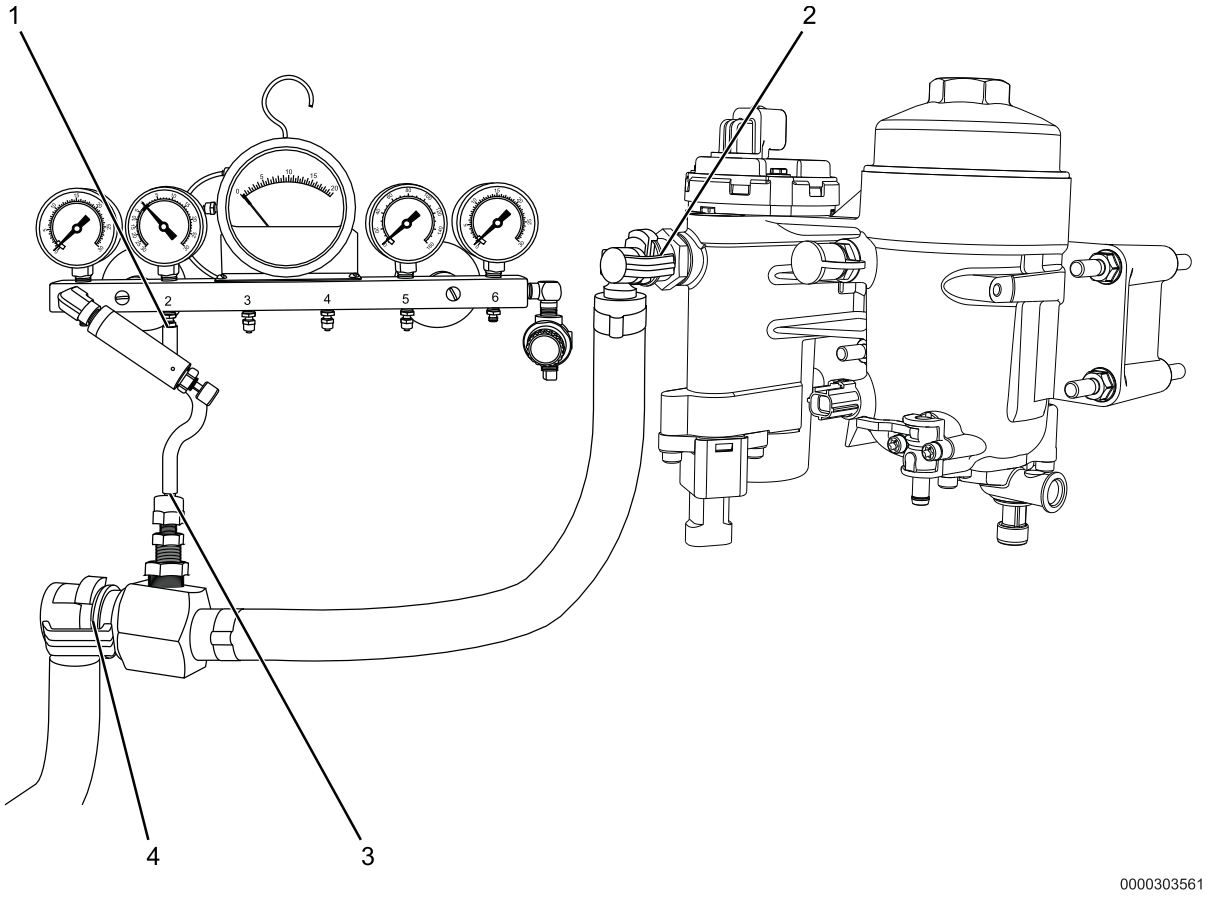


Figure 106 Fuel Restriction Test Tool Connection

1. ZTSE4409 In Hg Vacuum gauge fitting
2. Fuel Filter Module Intake
3. Vacuum Gauge to ZTSE6009 Fuel Restriction Tool line
4. Fuel supply line

1. Key OFF.

2. Install fuel Intake Restriction and Aeration Tool ZTSE6009 at fuel filter module intake (Figure 106). Attach fuel supply line to tool.
3. Attach Vacuum Gauge ZTSE4409 to Fuel Intake Restriction and Aeration Tool ZTSE6009.
4. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81).
5. Log in to ServiceMaxx™ software.

Test Procedure

6. Turn Key ON to energize Electric Fuel Pump (EFP) (pump will run for 10 to 20 seconds).
7. Electric Fuel Pump can be commanded on using the Output State High and Low Test (page 87) in ServiceMaxx™ software.
8. Run Output State High and Low Test (page 87) to command Electric Fuel Pump (test will run for 35 to 45 seconds).
9. Measure reading on the vacuum gauge.
10. If necessary, turn key OFF for a minimum of 30 seconds and repeat steps 1 or steps 2 and 3 and monitor vacuum gauge.

Expected Outcome

Vacuum gauge reading will be within specification.

Follow-on Procedure

None

Regulator Test

Overview

This test verifies that the fuel pressure regulator is working properly. With the fuel return line disconnected, there is no other path for the fuel to follow but through the pressure gauge assembly.

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 flame and sparks.

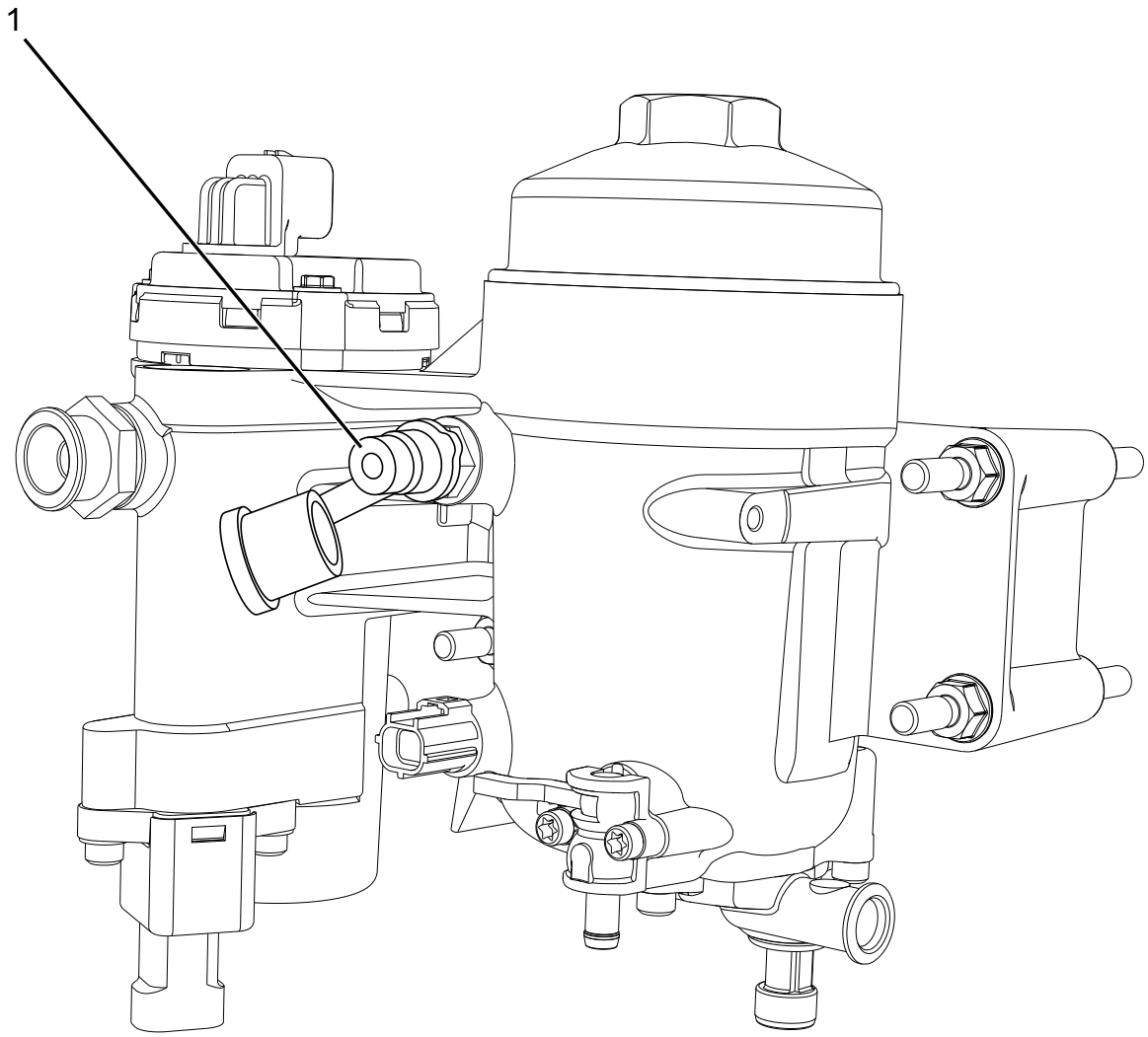
Tools Required

- Clean Fuel Source Tool 15-637-01
- Clear Fuel Container (graduated)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Fuel Pressure Gauge ZTSE4681
- Fuel / Oil Pressure Test Coupler ZTSE4526
- Fuel Pressure Test Kit ZTSE4657
- Interface cable (RP1210B-compliant supporting J1939 and J1708)

Equipment condition

None

Test Setup



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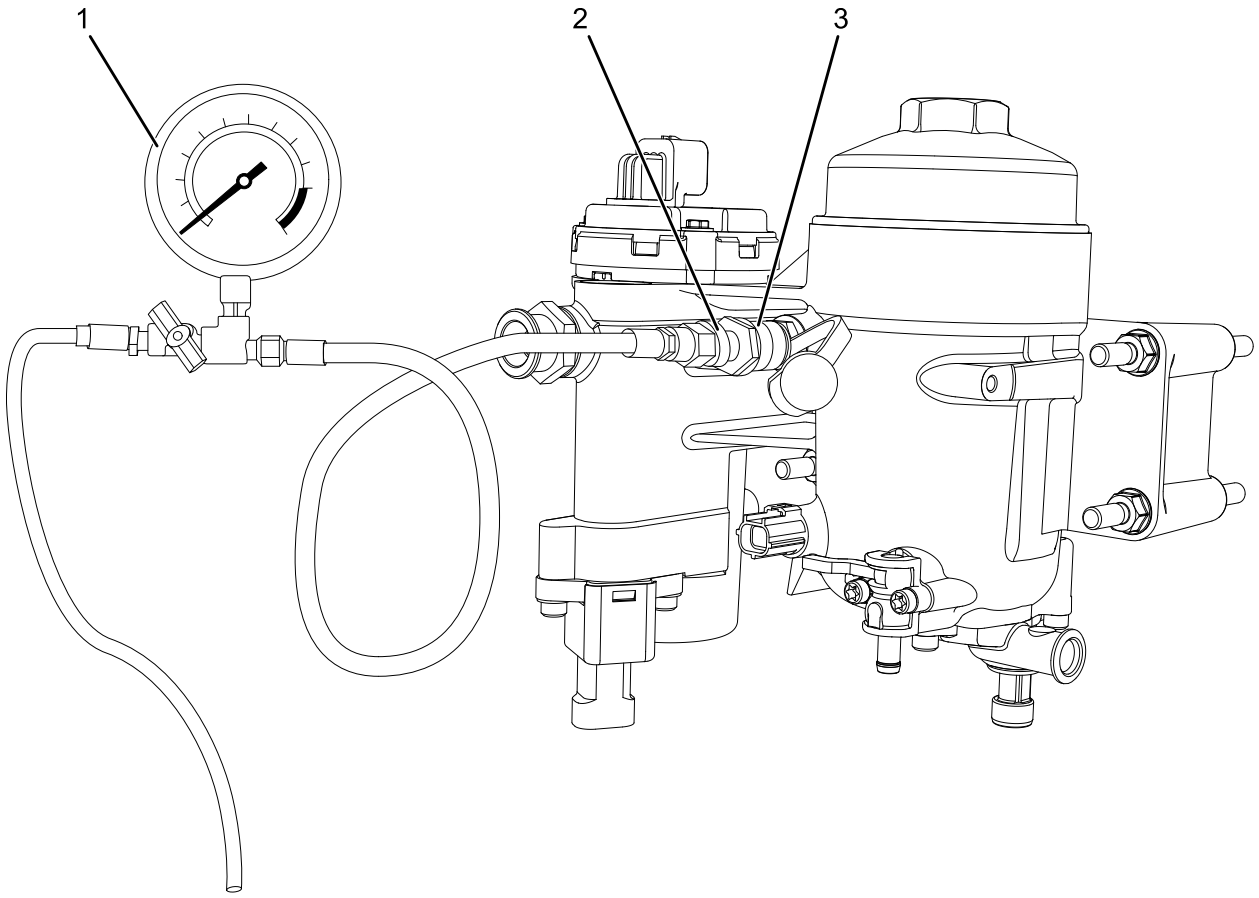
Figure 107 Fuel Regulator Test Setup

1. Fuel filter module test port

1. Key OFF.
2. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81).
3. Log in to ServiceMaxx™ software.

4. Connect Fuel Pressure Gauge ZTSE4681 (Figure 108) (Item 1) to fuel filter module test port (Figure 107) (Item 1).
5. Clear hose of Fuel Pressure Gauge ZTSE4681 inside Clear Fuel Container.
6. Close valve on Fuel Pressure Gauge ZTSE4681 by turning fully clockwise.
7. Attach Clean Fuel Source Tool 15-637-01 to filter module intake.
8. Disconnect return line from filter module.

Test Procedure



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Figure 108 Fuel Flow Test Procedure

1. Fuel Pressure Gauge ZTSE4681
2. Fuel Pressure Test Kit ZTSE4657
3. Fuel line coupler ZTSE4526

9. Open Fuel Pressure Gauge ZTSE4681 (Figure 108) (Item 1) valve by turning valve fully counterclockwise.

10. Output State High Test (page 87) using ServiceMaxx™ software to actuate Electric Fuel Pump (EFP) (pump will run for 35-45 seconds)
11. When EFP shuts off, turn key off for a minimum of 30 seconds, allowing Engine Control Module (ECM) to reset.
12. Repeat steps 2 and 3, three more times until you reach a total of four key cycles.
13. Close the valve on Fuel Pressure Gauge ZTSE4681 (Figure 108) (Item 1) by turning valve fully clockwise.
14. Measure the total amount of fuel in Clear Fuel Container.
15. Using the Electronic Service Tool (EST), determine Engine Coolant Temperature (ECT).
16. Compare the total amount of fuel collected to the ECT and EFP run time.

Minimum Fuel Pump Volume Specification

Key cycles	4			
ECT (°F)	–58 to 32	32 to 68	68 to 86	86 to 212
ECT (°C)	–50 to 0	0 to 20	20 to 30	30 to 100
Fuel Pump Run Time (seconds)	20	18	15	10
Min Fuel Pump Volume (gallons)	0.76	0.68	0.57	0.38
Min Fuel Pump Volume (liters)	2.88	2.57	2.16	1.44

Expected Outcome

Measured total fuel flow will be within specification.

Follow-On Procedure

Connect fuel return line at fuel filter module.

Strainer/Pump Inspection

1. Remove fuel pump and inspect strainer and pump O-rings.
2. Are pump O-rings or strainer damaged?
   - No: Reassemble fuel pump and connect engine harness. Go to Final Pressure Test .
   - Yes: Replace strainer and / or O-rings as required. Reassemble fuel pump and connect engine harness. Go to Final Pressure Test .

Final Pressure Test

1. Energize the pump and measure fuel pressure.
2. Is fuel pressure > 70 psi (483 kPa)?
   - Yes: Go to Fuel Pressure Measurement (page 228) and follow any additional steps required.

- No: Replace fuel pump.

  After repairs are complete, go to Fuel Pressure Measurement (page 228) and follow any additional steps required.

Return Line Restriction Test

1. Check vehicle fuel return line from module to fuel tank for restriction.
2. Is return fuel line to tank restricted?

- Yes: Repair as needed. After repairs are complete, go to Fuel Pressure Measurement (page 228) and follow any additional steps required.
- No: Inspect the fitting on the return line. If the fitting is not damaged, replace the pressure regulator. Measure fuel pressure. If the pressure is still high, replace the bottom plate on the filter module.

  After repairs are completed, go to Fuel Pressure Measurement (page 228) and follow any additional steps required.

Fuel Filter Inspection

1. Remove the engine mounted filter and inspect. Replace filter and service strainer as needed. Remove all tools. Diagnosis is complete.

Fuel Pump Voltage Test

Overview

This test is used to determine if the Engine Control Module (ECM) is commanding the Electric Fuel Pump (EFP) by measuring supply voltage to the EFP.

NOTE: Output state high test can be used to activate fuel pump.

Tools Required

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Digital Multimeter (DMM)
- Electric Fuel Pump (EFP) Breakout Harness ZTSE6023
- Interface cable (RP1210B-compliant supporting J1939 and J1708)

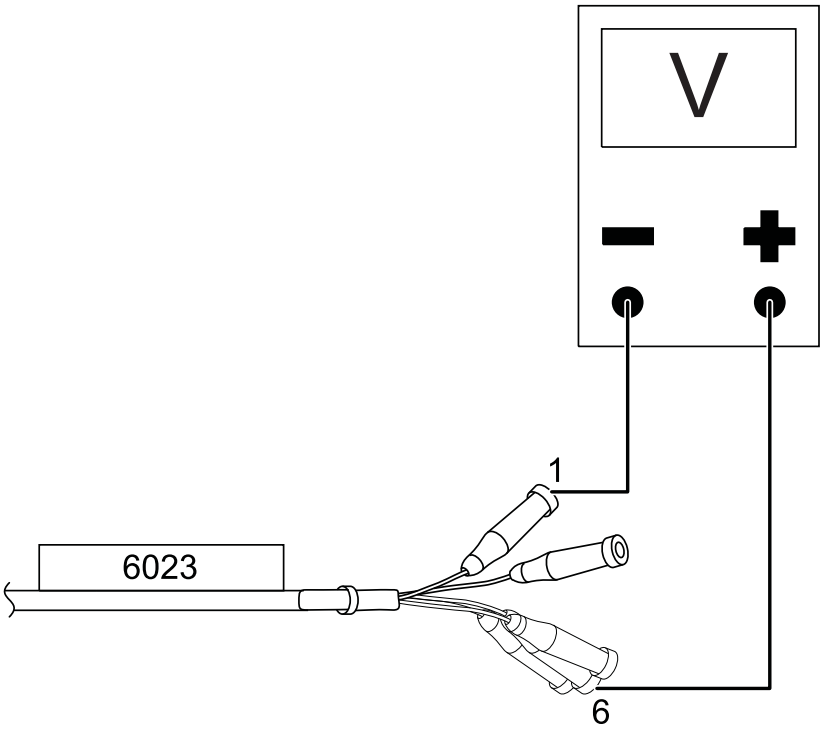
Equipment Condition

None

Test Setup

1. Key OFF.
2. Install Breakout Harness ZTSE6023 between Electric Fuel Pump (EFP) and EFP harness connector.
3. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81).
4. Log into ServiceMaxx™ software.

Test Procedure



0000301741

Figure 109 Pin-Point Test 1

5. Use ServiceMaxx™ and the Output State Test HIGH to command fuel pump On.
6. While Electric Fuel Pump (EFP) is energized, use Digital Multimeter (DMM) to measure voltage between Breakout Harness ZTSE6023, pin-6, and pin-1. Record measurement.

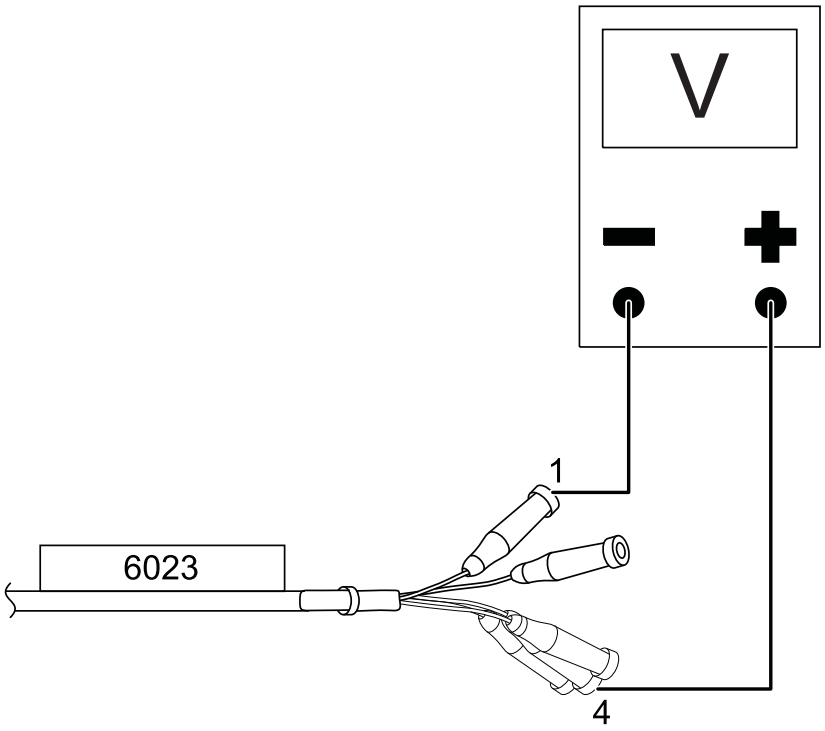


Figure 110 Pin-Point Test 2

7. While EFP is energized, use Digital DMM to measure voltage between Breakout Harness ZTSE6023, pin-4, and pin-1. Record measurement.
8. Repeat steps 1–3 as necessary.

Expected Outcome

Voltage reading between pin-6 and pin-1 and voltage reading between pin-4 and pin-1 are within specifications.

Follow-On Procedure

None

Exhaust Gas Recirculation (EGR) Valve Operational Test

Overview

This test commands the Exhaust Gas Recirculation (EGR) valve to perform a self-diagnostic routine and broadcast a fault code if there is a problem. The test commands the EGR valve completely open, waits for a significant dwell time, commands the EGR valve completely closed, waits for a significant dwell time, and repeats the test multiple times. The long dwell times and repeating tests are important. A stuck EGR valve will broadcast an SPN 2791 FMI 7 fault code. Allowing at least 30 seconds between Output State tests in

step 3 is critical. Output State tests will not finish without a minimum of 30 seconds between them. This is a manually-controlled test.

Tool Required

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

Equipment Condition

None

Test Setup

1. Key-On Engine-Off (KOEO)
2. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81).
3. Log in to ServiceMaxx™ software.
4. Perform KOEO Standard Test (page 199).

Test Procedure

1. Key OFF for minimum of 45 seconds before testing.

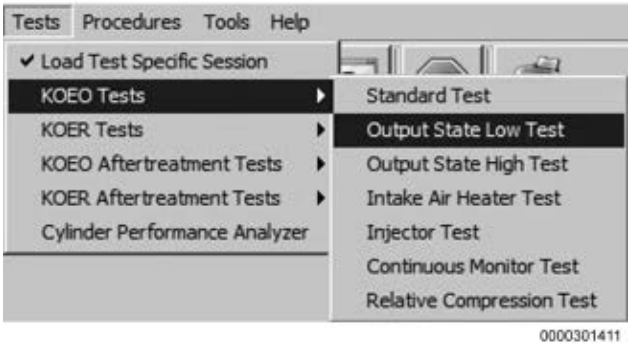


Figure 111 Tests – Output State Low

2. Select Tests > KOEO Tests > Output State Low Test (Figure 111) and wait 30 seconds for test to run.

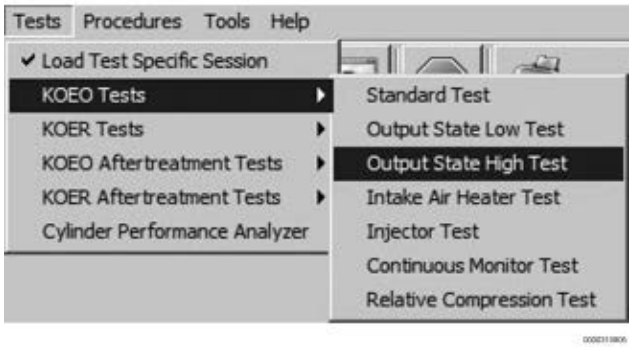


Figure 112 Tests – Output State High

3. Select Tests > KOEO Tests > Output State High Test (Figure 112) and wait 30 seconds for test to run.
4. Repeat step 2 and step 3 in sequence three more times, waiting 30 seconds for each test to run.

Expected Outcome

A free-moving Exhaust Gas Recirculation (EGR) valve will not broadcast an SPN 2971 FMI 7 fault code during the EGRV Operation Test. A stuck EGR valve will broadcast an SPN 2971 FMI 7 fault code.

Follow-On Maintenance

None

Intake Air Heater (IAH) System Test

Overview

Verify operation of the Intake Air Heater (IAH) system. The IAH is commanded on by the Engine Control Module (ECM) when Engine Coolant Temperature (ECT) is below 30°F (-1°C). This test uses diagnostic software to command and monitor operation of the IAH system. This test can be performed without diagnostic software if coolant temperature is below specification.

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

Tools Required

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

Equipment Condition

None

Test Setup

1. Key-On Engine-Off (KOEO).
2. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81).
3. Log in to ServiceMaxx™.

Test Procedure

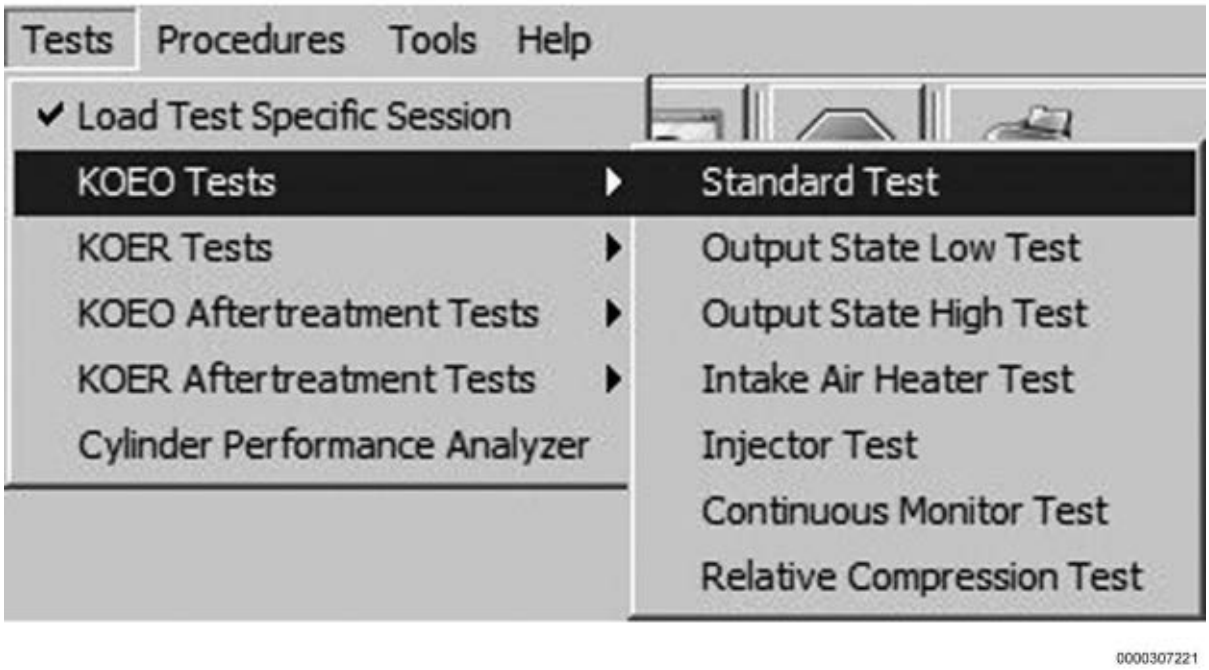


Figure 113 KOEO Standard Test Drop Down Menu

4. Perform KOEO Standard Test (Figure 113).
5. When test is complete, select Sessions > Hard Start – No Start.
6. Select Tests > KOEO Tests > Intake Air Heater Test.
7. Follow the on-screen instructions in ServiceMaxx™ software.
8. Crank engine over.
9. Monitor Air Intake Temperature (AIT).

Expected Outcome

Air Intake Temperature (AIT) will begin to rise when Intake Air Heater (IAH) system is on.

Follow-on Procedure

None

Intake Air Heater (IAH) Current Draw Test

Overview

Verify operation of Intake Air Heater (IAH) grid heating element. Using diagnostic software, digital multimeter (DMM) amp clamp, this test commands and monitors Intake Air Heater System operation. Intake Air Heater Test will command element on twice for 45 seconds.

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

CAUTION: Performing multiple IAH Tests in ServiceMaxx™ will cause the element to overheat and damage it.

Tools Required

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- Amp Clamp ZTSE4575

Equipment Condition

None

Test Setup

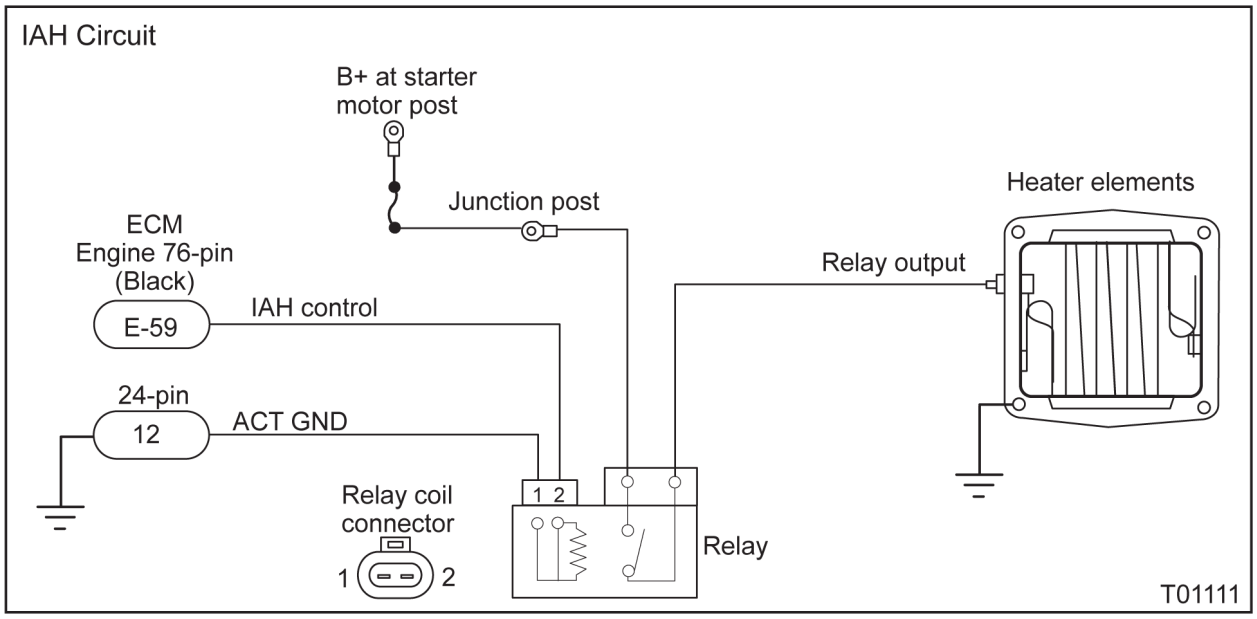


Figure 114 IAH Circut

1. Key-On Engine-Off (KOEO).
2. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81).
3. Log in to ServiceMaxx™ software.
4. Amp Clamp connected to Digital Multimeter (DMM) and clamped onto relay output wire from IAH relay to IAH grid heating element.

Test Procedure

5. Perform Key On-Engine-Off (KOEO) Standard Test (page 87).

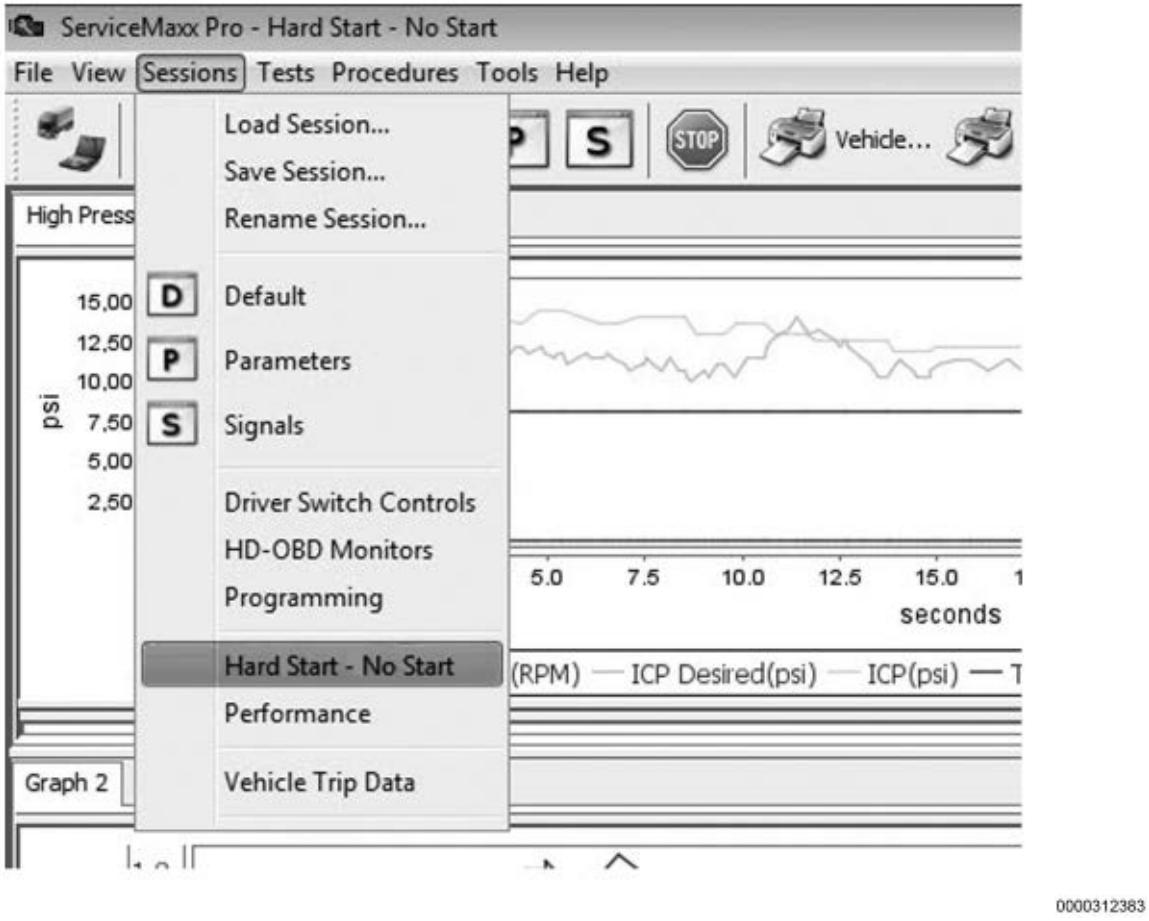


Figure 116 Sessions Menu

6. When test is complete, select Sessions > Hard Start – No Start (Figure 116).

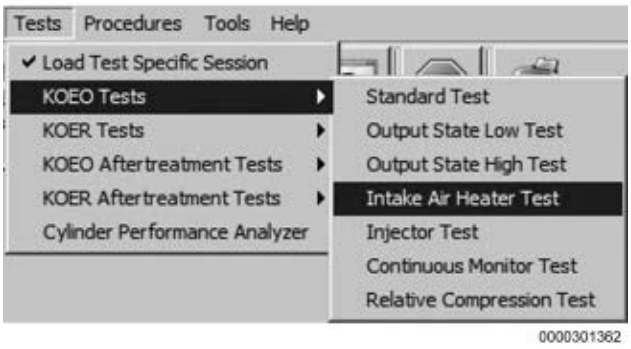


Figure 117 ServiceMaxx™ Tests Menu

7. Select Tests > KOEO Tests > Intake Air Heater Test (Figure 117).

8. Follow on-screen instructions in ServiceMaxx™ software.
9. Measure amperage draw with Digital Multimeter (DMM).

Expected Outcome

Current draw is within specification (125 Amps + / – 30 Amps within 2 seconds).

Intake Air Heater (IAH) Relay Test

Overview

The objective of this test is to determine if the Intake Air Heater (IAH) Relay is the source of an inoperative IAH system. A defective IAH Relay is found by measuring voltages on both sides of relay to validate its performance. All steps may not need to be performed. If any step condemns the relay, replace relay and retest.

CAUTION: Performing multiple IAH Tests with ServiceMaxx™ software will cause element to overheat. Overheating element will damage it.

Tools Required

- Electronic Service Tool with ServiceMaxx™ software
- Interface Cable (RP1210B-compliant supporting, J1939 and J1708)
- Digital Multimeter (DMM)
- Breakout Harness ZTSE6025

Equipment Condition

None

Test Setup

1. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81).
2. Log in to ServiceMaxx™ software.
3. Install Breakout Harness ZTSE6025 between Intake Air Heater (IAH) Relay and engine harness.

Test Procedure

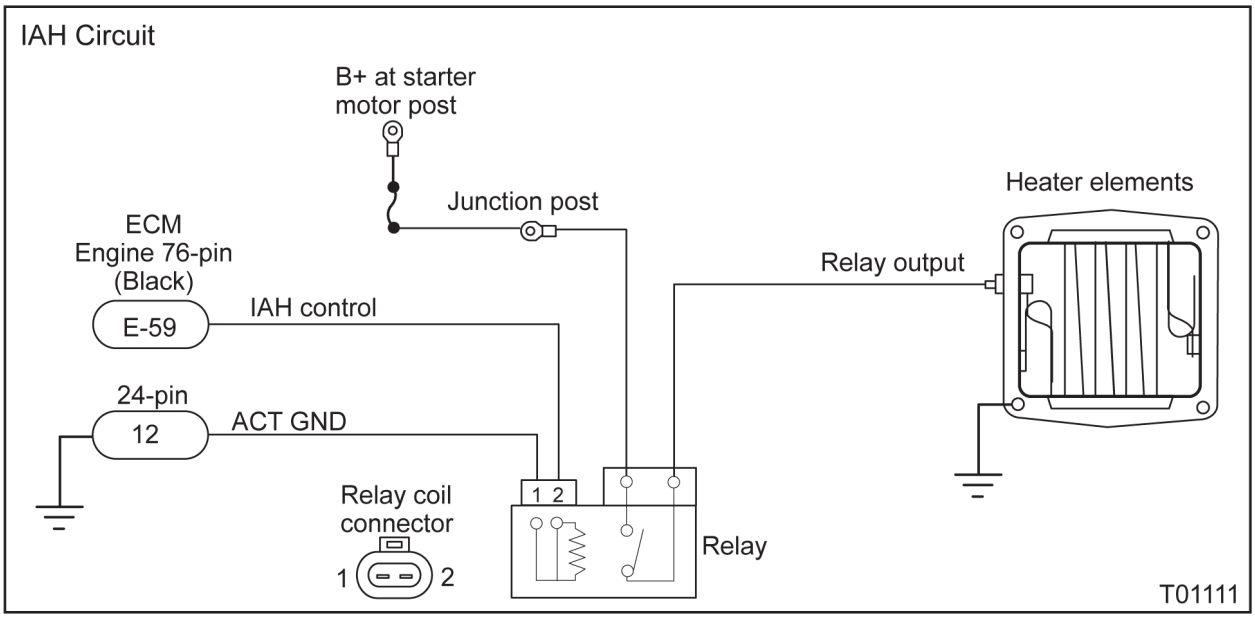


Figure 118 Intake Air Heater (IAH) Circuit Diagram

4. Measure voltage on relay input side B+ to a known good ground. Is measurement approximately equal to B+?
   - Yes: Go to Step 2.
   - No: Check B+ circuit for open, corrosion, or blown fuse.
5. Perform Intake Air Heater (IAH) system test (page 242). Measure voltage between relay output at heater element and a known good ground. Is voltage equal to B+ or equal to voltage reading taken in Step 1?
   - Yes: End diagnostic procedure.
   - No: Go to Step 3.
6. Perform Intake Air Heater (IAH) system test. Measure voltage between IAH Relay input terminal and IAH relay output terminal. Is voltage under 1 volt?
   - Yes: Go to Step 4.
   - No: Replace relay.
7. Perform Intake Air Heater (IAH) system test. Measure voltage between IAH Relay input terminal and a known good ground. Is voltage within 1 volt of B+?
   - Yes: Go to Step 5.
   - No: Check B+ circuit for poor connections.
8. Measure voltage between pin-1 and battery positive. Is voltage equal to B+?
   - Yes: Go to Step 4.
   - No: Check for an open between relay coil connector pin-1 and ground.

9. Perform Intake Air Heater (IAH) system test (page 242). Measure voltage between relay coil connector pin-1 and pin-2. Is voltage equal to B+?
   - Yes: End diagnostic procedure.
   - No: Go to diagnostics for SPN 729 FMI 5 .

Expected Outcome

There will be power and ground to coil side of relay when Intake Air Heater Test (IAH) is run. There will also be constant power to input side of relay. That power will transfer to output terminal for heating element when control circuit is commanded on.

Follow-On Procedure

None

Coolant Quality Inspection

Overview

Check coolant for proper freeze point, and for contamination.

Tools Required

- Coolant and Battery Refractometer ZTSE4796

Equipment Condition

- Park the vehicle on level ground.
- If engine was running, allow engine to cool for 15 minutes or more.

Inspection Procedure

1. Wrap a thick cloth around the deaeration cap.
2. Loosen cap slowly a quarter to half turn to vent pressure.
3. After pressure has been released, remove the cap.
4. Check coolant appearance for signs of contamination.
5. Take a sample from the deaeration tank.
6. Examine sample for lube oil and Diesel Exhaust Fluid (DEF).
   - Oil contamination will result in a dark sludge.
   - DEF contamination will give the coolant a dark yellow/brown color with a strong ammonia smell.
7. If coolant is not contaminated, check freeze point.

Expected Outcome

Coolant should be free of contamination, and at the correct freeze point.

Cylinder Sleeve Cavitation and Crack Inspection

Overview

Inspect cylinder sleeves for holes or cracks caused by cavitation (gas-filled bubbles formed in the coolant).

Tools Required

None

Equipment Condition

Remove cylinder head. See *Engine Service Manual*.

Inspection Procedure

1. Inspect piston crowns for signs of coolant leaks. Lack of carbon indicates possible coolant leak into the cylinder.
2. Bar engine over until pistons 1 and 6 are at Bottom Dead Center (BDC). Visually inspect cylinder sleeve for cracks or holes.
3. Inspect cylinder sleeves 1 and 6 for possible cavitation leaks and/or cracks.
4. Repeat for cylinders pairs 2-5 and 3-4.
5. Repair as needed.

Expected Outcome

Carbon deposits should be present on piston crowns, indicating cylinder sleeves are free of holes and cracks.

Coolant Heater Assembly Test

Overview

Verify operation of the Engine Coolant Heater.

WARNING: To prevent serious personal injury or death due to electric shock from 120 Volts Alternating Current (VAC), ensure conditions are appropriate and certified protective apparel is worn.

Tools Required

- Digital Multimeter (DMM)

Equipment Condition

None

Test Setup

1. Engine must be cold to perform this test.

Test Procedure

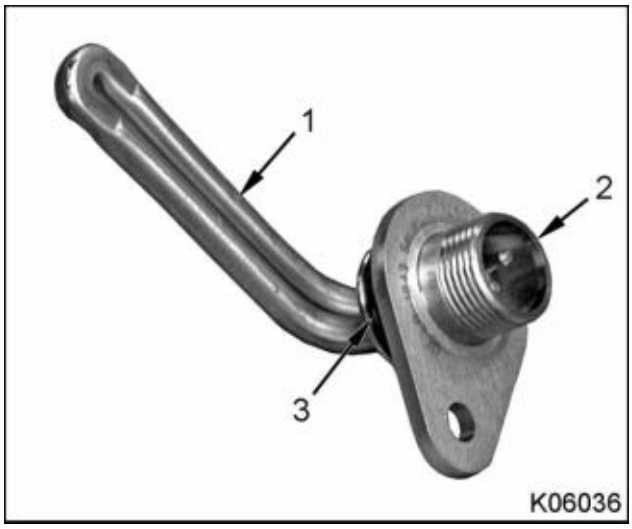
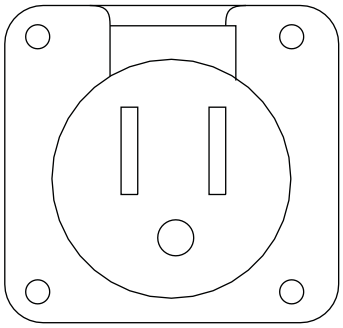


Figure 119 Engine Coolant Heater

1. Heater element
2. Cord adapter
3. O-ring



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Figure 120 External Plug Shown with Lid Removed for Clarity

2. Measure resistance at external plug for Oil Pan / Coolant Heater.
   - Reading should be approximately 12 ohms. If unit is equipped with both Coolant and Oil Pan Heater, they are wired on the same plug and the reading should be approximately 8.5 ohms. If reading is within specifications, go to step 3.
   - If reading is not within specifications, go to step 2.
3. Disconnect cord from coolant heater on the left side of the engine block and take resistance reading at the terminals on the heater itself. See information below for further direction.
   - If the reading is approximately 12 ohms, the cord needs to be replaced.
   - If the reading is not approximately 12 ohms, install cord and go to step 3.
4. Connect standard extension cord between wall outlet and truck-mounted plug (Figure 120).
5. Wait 2 to 3 minutes, and then check to see if coolant heater is heating up by feeling cord adapter.

Expected Outcome

Resistance checks will be within specification and coolant heater will heat when plugged in.

Follow-On Procedure

None

Deaeration Tank Cap Test

Overview

Verify proper operation of the deaeration tank cap.

WARNING: To avoid possible injury or death, use care when working around hot coolant.

Tools Required

- Radiator Pressure Testing Kit ZTSE2384
- Air Pressure Regulator

Equipment Condition

None

Test Setup

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

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

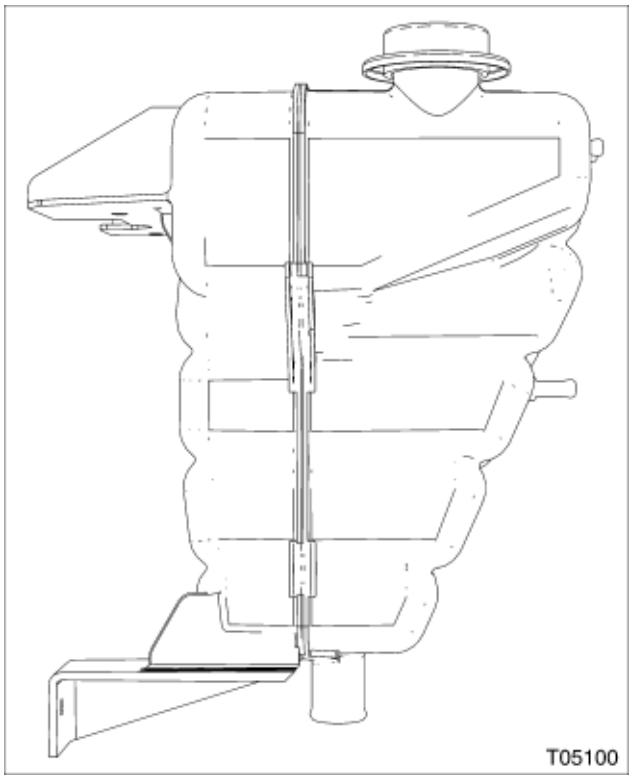


Figure 121 Deaeration Tank and Cap

- Remove cap from deaeration tank (Figure 121).
- Check deaeration tank neck (Figure 121) for cracks and warping.

Test Procedure

1. Determine rated pressure of deaeration tank cap.

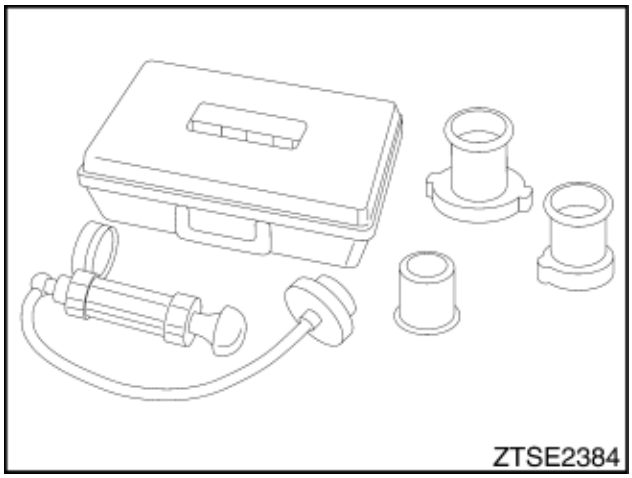


Figure 122 Radiator Pressure Testing Kit ZTSE2384

2. Install appropriate adapter from Radiator Pressure Testing Kit ZTSE2384 (Figure 122). Do not exceed rated pressure of the cap.
3. Apply pressure to the cap.
4. Replace cap if it cannot hold the specified air pressure.

Expected Outcome

Cap will hold rated pressure.

Follow-on Procedure

None

Coolant Over-Flow / Over-Temperature Test

Overview

This test is to determine if cooling system over heats or forces coolant out of overflow tube on deaeration tank.

WARNING: To prevent personal injury or death, be aware of hot coolant being expelled from the deaeration tank during this test.

Tools Required

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

Equipment Condition

None

Test Setup

- Key-On Engine-Off (KOEO).
- Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81).
- Log in to ServiceMaxx™ software .

Test Procedure

1. Use ServiceMaxx™ software to view Engine Coolant Temperature 1 (ECT1).
2. Start and run engine until it reaches normal operating temperature.
3. Raise engine speed to high idle. Check for coolant overflowing from deaeration tank.
4. Run engine temperature above 225°F (107°C) and radiator intake temperature above 200°F (93°C).
5. Monitor ECT1 and note if temperature exceeds normal operating temperature. Check for coolant overflowing out of deaeration tank overflow hose.

Expected Outcome

Coolant will not exceed normal operating temperature and coolant will not be expelled from overflow hose on deaeration tank.

Follow-On Procedure

None

Air Compressor Overflow Test

Overview

To determine if cooling system over heats or forces coolant out of overflow tube on deaeration tank due to a faulty air compressor.

Tools Required

None

Equipment Condition

None

Test Setup

- Disconnect discharge tube from air compressor housing.

Test Procedure

1. Start engine and run until reaching normal operating temperature.
2. Raise engine speed to high idle. Check for coolant overflow out of deaeration tank.
3. Run engine to above 225°F / radiator intake temperature above 200°F.
4. Check for coolant overflow out of deaeration tank overflow hose.

Expected Outcome

Air Compressor will not cause coolant to be expelled from overflow hose on deaeration tank.

Follow-on Procedure

None

Oil Pan Heater Test

Overview

Verify operation of the Engine Oil Pan Heater.

WARNING: To prevent serious personal injury or death due to electric shock from 120 Volts Alternating Current (VAC), ensure conditions are appropriate and certified protective apparel is worn.

Tools Required

- Digital Multimeter (DMM)

Equipment Condition

None

Test Setup

1. Ensure engine is cold prior to performing this test.

Test Procedure

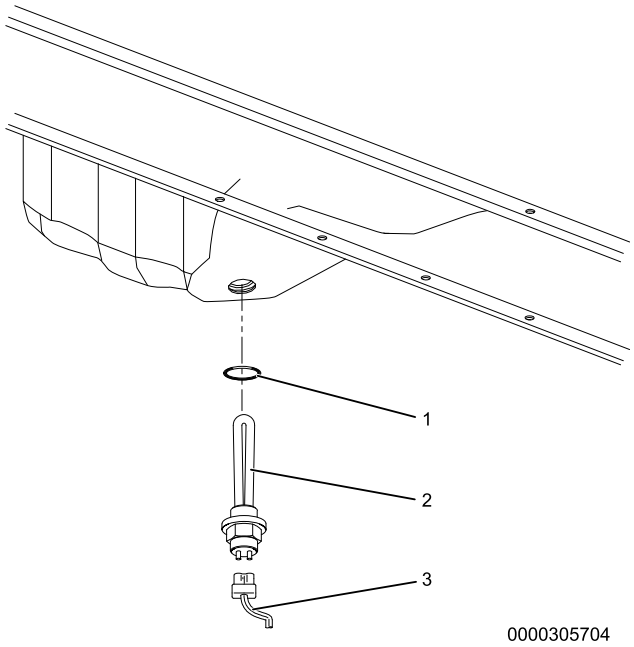
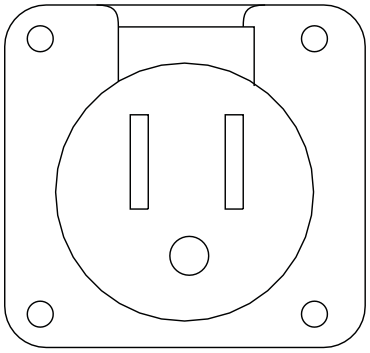


Figure 123 Oil Pan Heater

1. O-ring
2. Oil heater element
3. AC power cord



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Figure 124 Oil Pan Heater Plug (Shown with Cover Removed for Clarity)

1. Measure resistance at external plug for Oil Pan / Coolant Heater (Figure 124).
   - Reading should be approximately 12 ohms. If unit is equipped with both a Coolant and Oil Pan Heater, they are wired on the same plug and reading should be approximately 8.5 ohms. If reading is within specifications, go to step 3.
   - If reading is not within specifications, go to step 2.
2. Disconnect cord from Oil Pan Heater (Figure 123) on left side of engine oil pan. Measure resistance at terminals on heater itself.
   - If reading is approximately 12 ohms, cord needs to be replaced.
   - If reading is not approximately 12 ohms, install cord and go to step 3.
3. Connect standard extension cord between wall outlet and truck-mounted plug (Figure 124).
4. Wait 2 to 3 minutes, and check to see if Engine Oil Pan Heater (Figure 123) is heating up by feeling the area where cord attaches.

Expected Outcome

Resistance checks will be within specification and Oil Pan Heater will heat when plugged in.

Follow-On Procedure

None

Connect Cylinder Performance Analyzer (CPA) Tool

Overview

The Cylinder Performance Analyzer (CPA) Tool is a four-channel oscilloscope that is used to detect faults in various components. When used with the proper software, the CPA tool helps technicians diagnose engine systems by monitoring electrical signals from various engine-mounted sensors.

WARNING: To prevent personal injury or death, never allow the metal sensor tee harness connectors (BNC Connector) or the Cylinder Performance Analyzer (CPA) tool ports to contact metal, other sensor tee harness connectors, or ground.

CAUTION: To prevent damage, do not store the CPA tool in the engine compartment. Any exterior damage may adversely affect the functionality of the tool and cause flawed test results.

CAUTION: Secure the Cylinder Performance Analyzer (CPA) tool and test cables away from hot or moving parts and any source of radio frequency interference with cable ties while performing tests. Failure to comply could result in damage to equipment.

Tools Required

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)
- Cylinder Performance Analyzer (CPA) Tool Kit 12-999-01

Equipment Condition

Depending on truck model, it may be necessary to remove operator's side inner fender, quarter fenders and/or passenger side inner fender to properly connect and safely route test cables into cab.

Test Setup

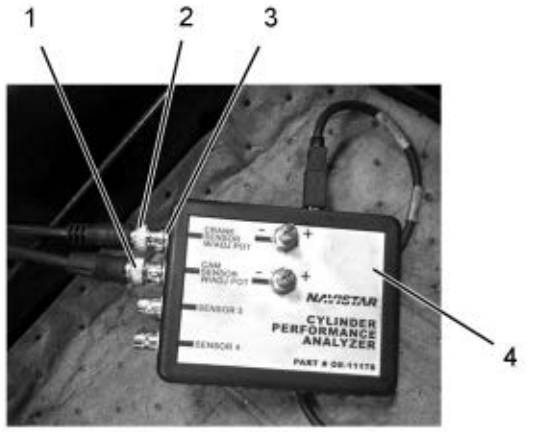


Figure 125 Cylinder Performance Analyzer (CPA) Tool

1. Camshaft Position (CMP) Sensor Tee Harness BNC connector
2. Crankshaft Position (CKP) Sensor Tee Harness BNC connector
3. CPA BNC connector
4. CPA tool (Most current version does not have adjusting knobs)

1. Connect Electronic Service Tool (EST) to vehicle diagnostic connector (page 81).
2. Key ON. Log in to ServiceMaxx™ software (page 82).

Test Procedure



Figure 126 Camshaft Position Sensor 1

1. Camshaft position (CMP) sensor tee harness
2. CMP sensor

1. Connect Yellow Tee Harness 12-999-01-02 between Camshaft Position (CMP) (Figure 126) (Item 1) and engine harness, making sure to tie it back from hot or moving parts.
2. Securely connect metal end to connector on Cylinder Performance Analyzer (CPA) tool labeled Cam Sensor.

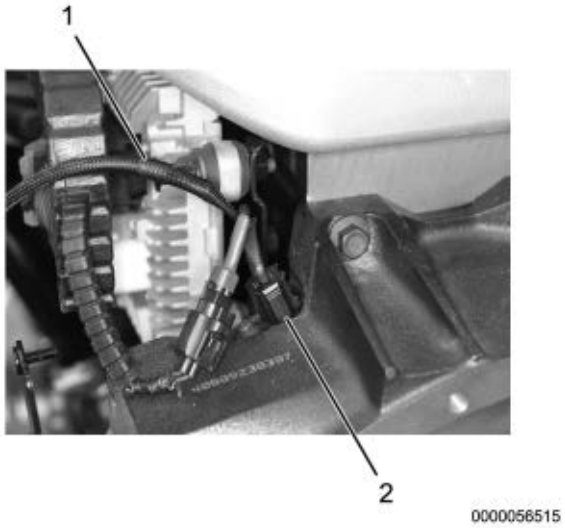


Figure 127 Crankshaft Position Sensor

1. Crankshaft position (CKP) sensor tee harness
2. CKP sensor

3. Connect Black Tee Harness 12-999-01-03 between Crankshaft Position (CKP) (Figure 127) (Item 1) and engine harness, making sure to tie it back from hot or moving parts.
4. Securely connect metal end to connector on CPA Tool labeled Crank Sensor.
5. Connect USB cable from CPA Tool to Electronic Service Tool (EST) with ServiceMaxx™ software.
   - Ensure light on CPA Tool (Figure 125) is flashing.
6. If doing CPA High Pressure Oil Pump (HPOP) Test, connect HPOP Test Harness 12–999–01–04 between engine harness and CPA Tool.
7. Recheck your test cable connections and routing to ensure they do not come in contact with hot or moving parts or unnecessary radio frequency interference.

Expected Outcome

Cylinder Performance Analyzer (CPA) tool test harnesses will be properly connected to perform standard tests.

Follow-on Procedure

Perform CPA Tool tests.

Cylinder Performance Analyzer (CPA) Cold Idle Test

Overview

Cylinder Performance Analyzer (CPA) Cold Idle Test detects faults with cylinder combustion during idle speed, and is usually performed if customer complaint includes a misfire during cold idle. When required, the Cold Idle Test should be performed prior to the Signal Check.

Tools Required

- Electronic Service Tool with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)
- Cylinder Performance Analyzer (CPA) Tool Kit 12-999-01

Equipment Condition

Depending on truck model, it may be necessary to remove operator's side inner fender, quarter fenders and/or passenger side inner fender to properly connect and safely route test cables into cab.

Test Setup

1. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81).
2. Key ON. Log in to ServiceMaxx™ software (page 82).
3. Connect Cylinder Performance Analyzer (CPA) (page 257) tool.

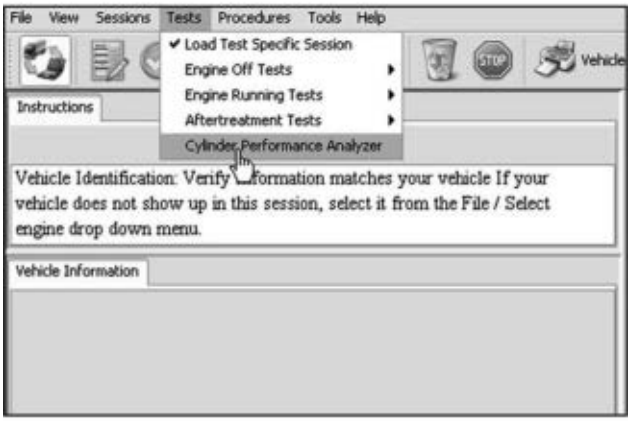


Figure 128 ServiceMaxx™ Menu

4. Start CPA software in ServiceMaxx™ by selecting Tests > Cylinder Performance Analyzer (Figure 128).



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Figure 129 Information Text Fields

5. Fill in Dealer location, operator / technician Information and Customer Complaint text fields (Figure 129).
6. Verify Vehicle Data matches the information in text fields (Figure 129).

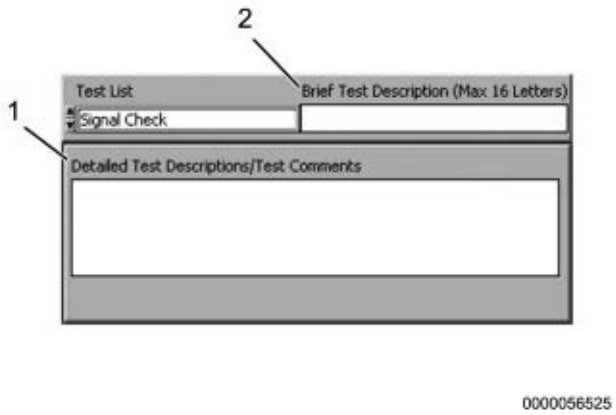


Figure 130 Test Description Text Fields

1. Detailed Test Description / Test Comments Field
2. Brief Test Description Text Field

7. Enter information into Brief Test Description (item 2) and Detailed Test Description / Test Comments (item 1) text fields (Figure 130).

Test Procedure

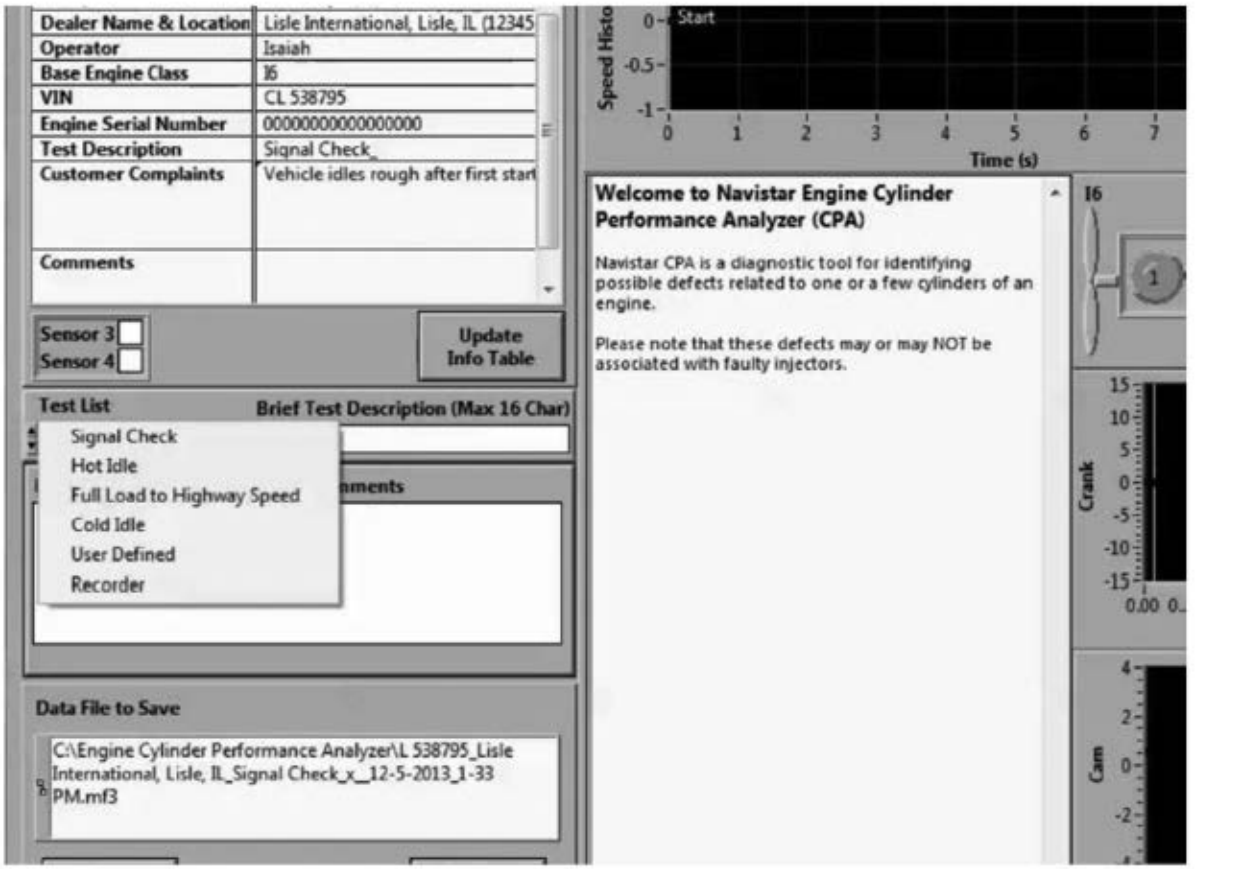
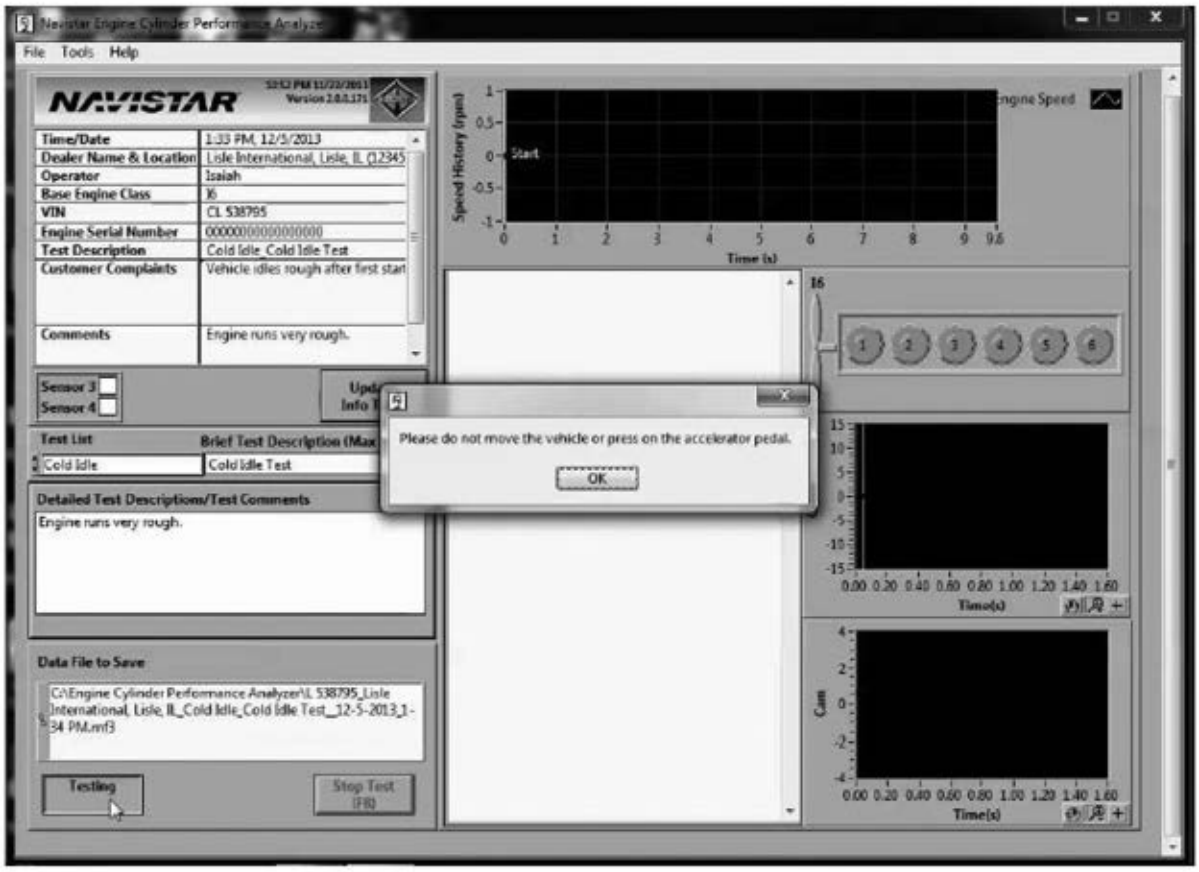


Figure 131 Test List

1. Select Cold Idle from Test List (Figure 131).
2. Start engine.



0000304884

Figure 132 Start Test Window

3. Click button on bottom left corner to Start Test (Figure 132).
4. Follow on screen instructions to complete test.
5. When End of Test text field appears, enter any final details about the test.
6. Click Return button to return to Home screen and view test results.

Expected Outcome

Test will run successfully, return to step based diagnostics with test information, or continue Cylinder Performance Analyzer (CPA) diagnostics as needed. Green cylinders indicate no defects were found; a red cylinder indicates a problem with that cylinder (may or may not be an injector); and light blue cylinders indicates high engine speed fluctuations, but no problem with a particular cylinder.

Follow-on Procedure

None

Cylinder Performance Analyzer (CPA) Signal Check

Overview

Signal check ensures information from Crankshaft Position (CKP) Sensor and Camshaft Position (CMP) sensor are being read properly by the Cylinder Performance Analyzer (CPA) program and are not distorted. Signal check must be performed before the full load to highway speed test, or any other test involving the vehicle being driven. CPA software will only recognize, for a limited time, that Signal Check has been completed before it resets and inhibits any test involving the vehicle being driven.

Tools Required

- Cylinder Performance Analyzer (CPA) Tool Kit 12-999-01
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)

Equipment Condition

Depending on truck model, it may be necessary to remove operator's side inner fender, quarter fenders and/or passenger side inner fender in order to properly connect and safely route test cables into cab.

Test Setup

1. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81).
2. Key ON. Log in to ServiceMaxx™ software (page 82).
3. Connect Cylinder Performance Analyzer (CPA) Tool Kit .

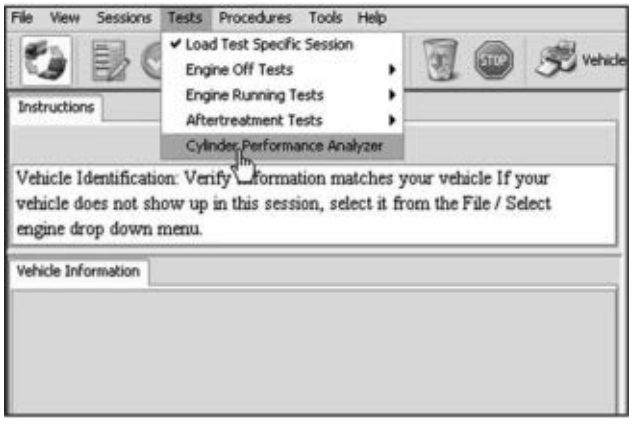


Figure 133 ServiceMaxx™ Software Menu for CPA

4. Start CPA software in ServiceMaxx™ by selecting Tests > Cylinder Performance Analyzer (Figure 133).



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Figure 134 Information Text Fields

5. Fill in dealer location, operator/technician information and customer complaint text fields (Figure 134).
6. Verify vehicle data matches information in text fields (Figure 134).

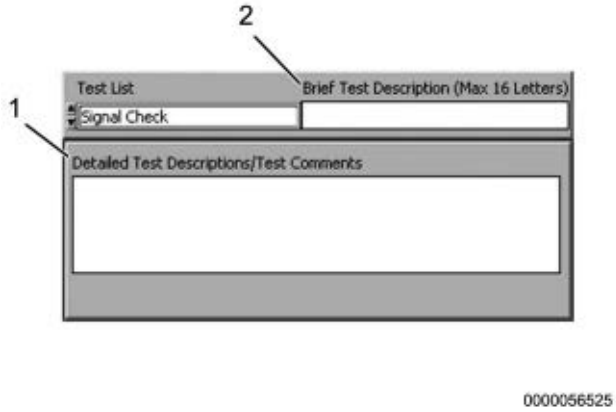


Figure 135 Test Description Text Fields

1. Detailed Test Description/Test Comments text Field
2. Brief Test Description text Field

7. Enter information into brief test description (item 2) and detailed test description/test comments (item 1) text fields (Figure 135).

Test Procedure

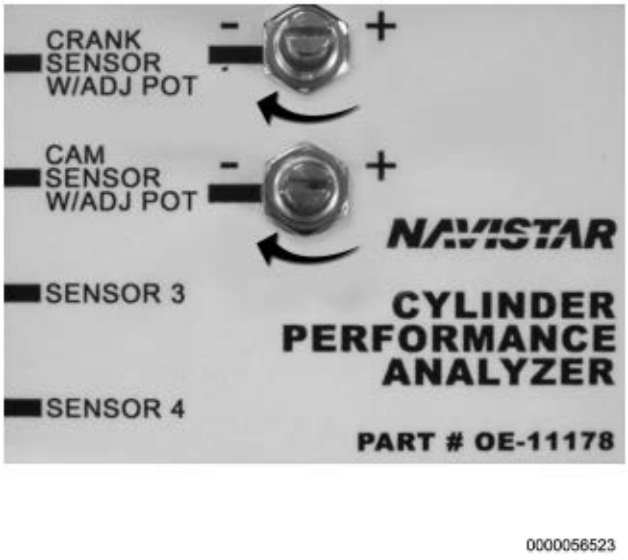


Figure 136 Cylinder Performance Analyzer

Later generations of the CPA tool do not have adjusting knobs. If using a tool with adjusting knobs, proper calibration is rotated fully to the right (clockwise) (Figure 136).

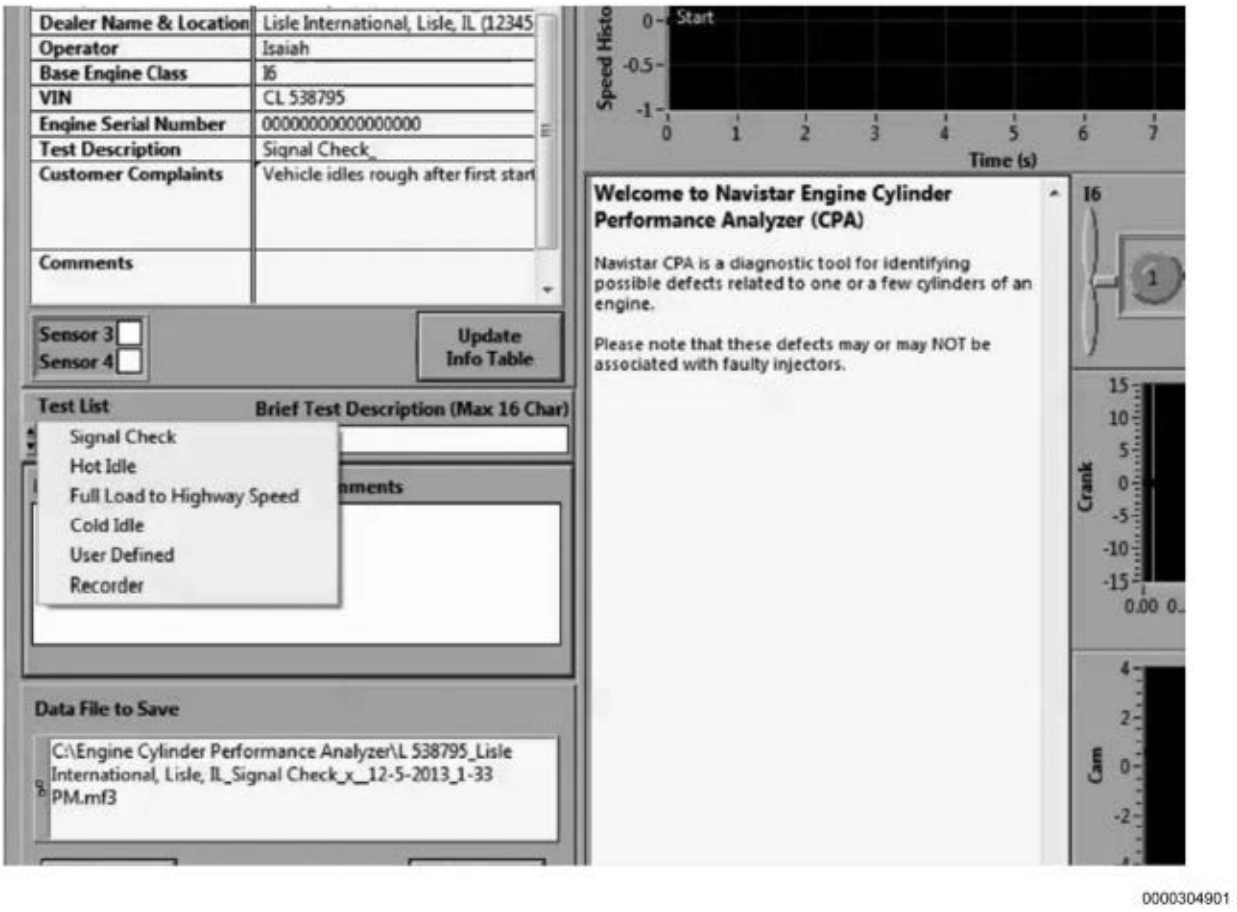
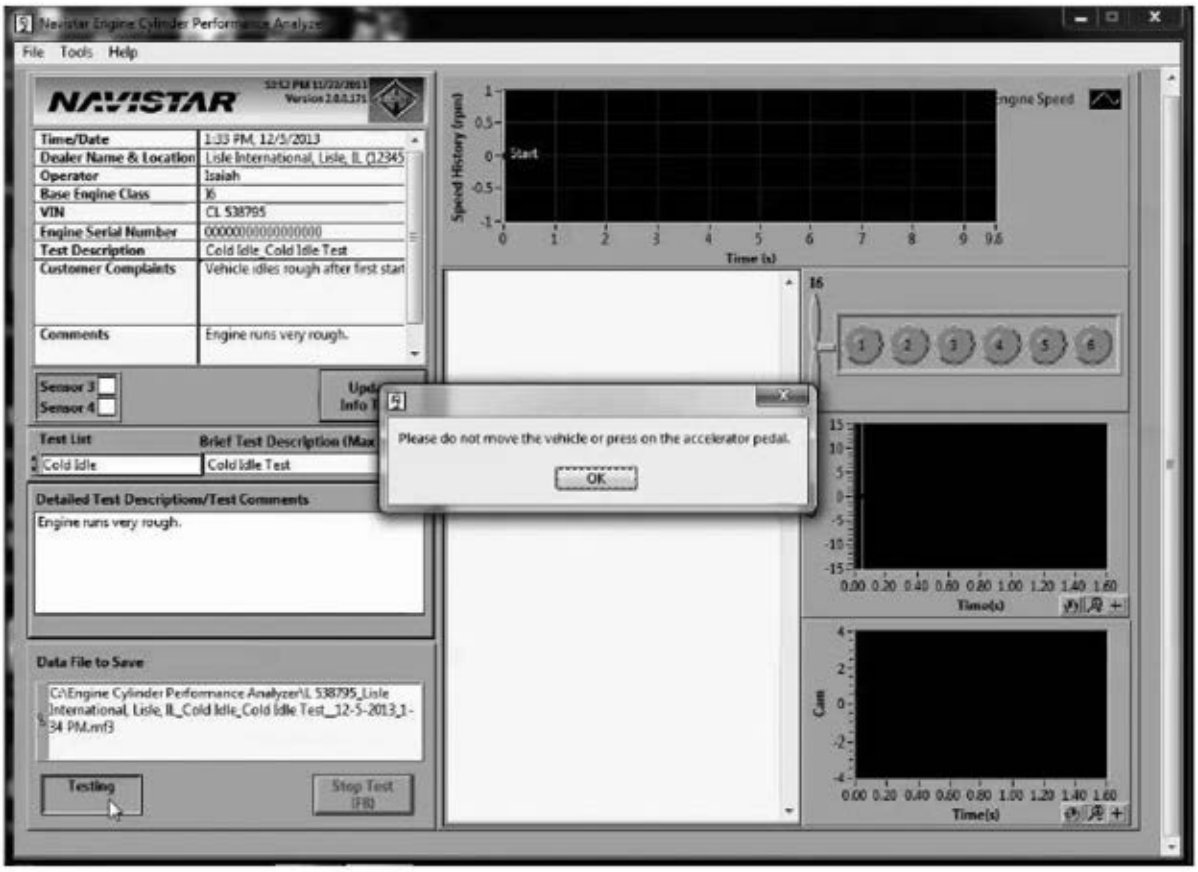


Figure 137 Test List

1. Select Signal Check from Test List (Figure 137).
2. Start engine.



0000304884

Figure 138 Start Test Window

3. Click button on bottom left corner to start test (Figure 138).



Figure 139 Signal Test Instructions

4. Follow on-screen instructions to complete test. (Figure 139)
5. When End of Test text field appears, enter any final details about the test.
6. Click Return button to return to home screen and view test results.

Expected Outcome

Test will run successfully, signal adjustment will be made, and any road test can be performed after test is run. Return to step based diagnostics or continue with Cylinder Performance Analyzer (CPA) diagnostics as needed.

Follow-On Procedure

None

Cylinder Performance Analyzer (CPA) Hot Idle Test

Overview

Hot-idle test detects faults with cylinder combustion during idle speed with engine at or above operating temperature, and is usually performed if customer complaint includes a misfire during hot idle. Signal check should be performed before hot-idle test.

Tools Required

- Cylinder Performance Analyzer (CPA) Tool Kit 12-999-01
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)

Equipment Condition

Depending on truck model, it may be necessary to remove operator’s side inner fender, quarter fender and / or passenger side inner fender in order to properly connect and safely route test cables into cab.

Test Setup

1. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81).
2. Key ON. Log in to ServiceMaxx™ software (page 82).
3. Connect Cylinder Performance Analyzer (CPA) Tool 12-999-01 (page 257).

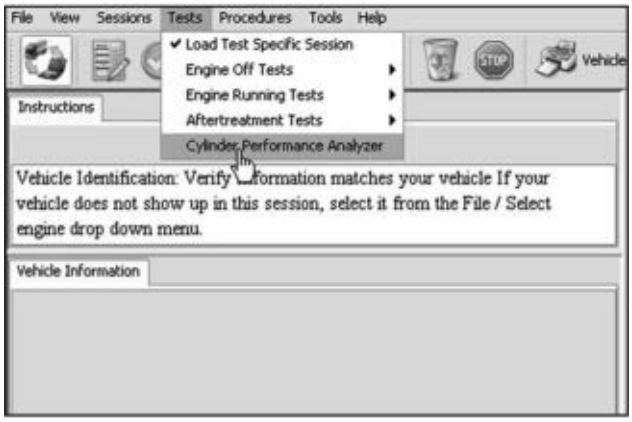


Figure 140 ServiceMaxx™ Menu

4. Start CPA software in ServiceMaxx™ by selecting Tests > Cylinder Performance Analyzer (Figure 140).



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Figure 141 Information Text Fields

5. Input dealer location, operator / technician and customer complaints in appropriate text fields (Figure 141).
6. Verify Vehicle Data (Figure 141) matches information in text fields.

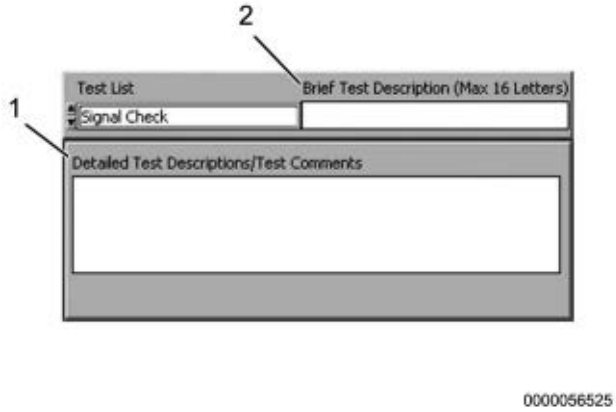
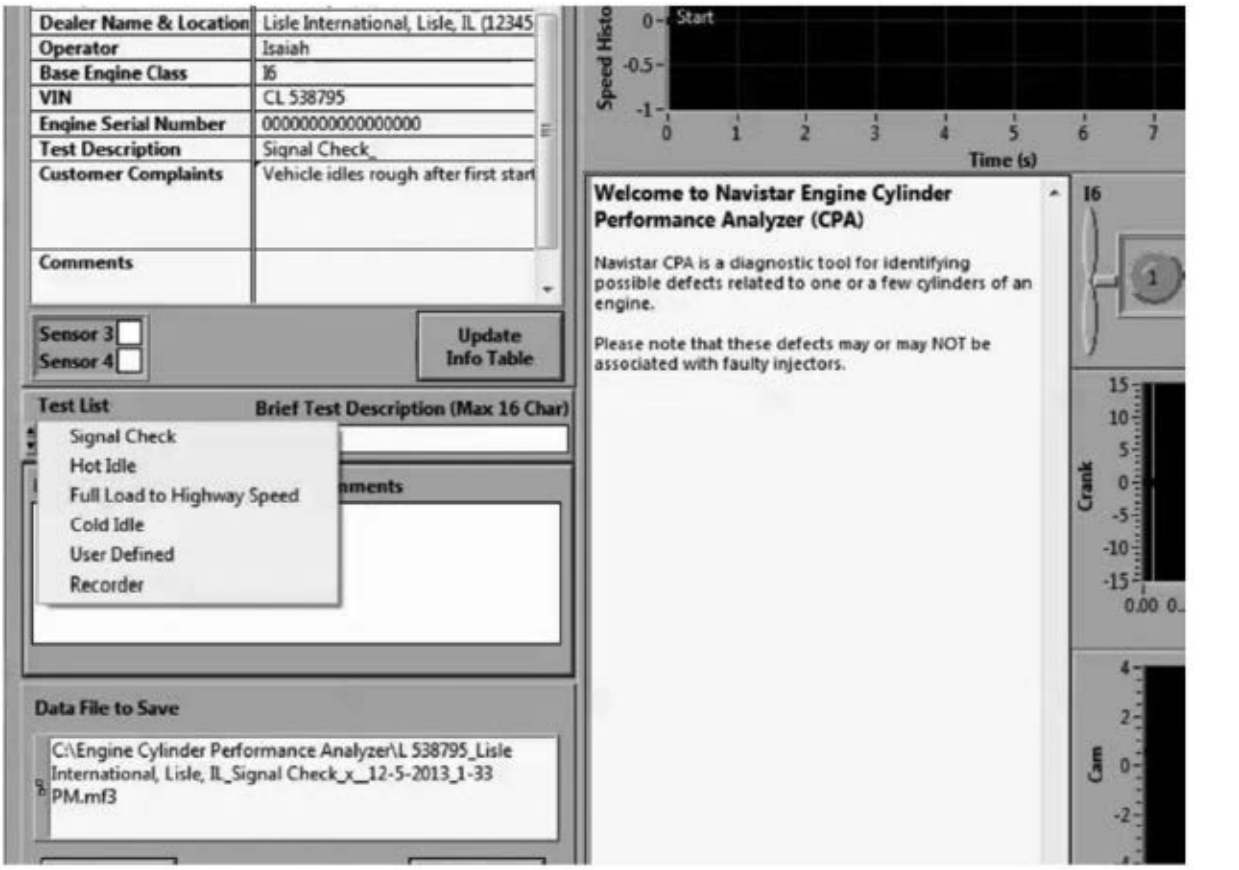


Figure 142 Test Description Text Fields

1. Detailed Test Description / Test Comments field
2. Brief Test Description field

7. Enter information into Brief Test Description (item 2) and Detailed Test Description / Test Comments (item 1) text fields that describe what and why you are testing (Figure 142).
8. Ensure engine coolant temperature is above 180°F (82°C), if not, run engine to reach operating temperature.
9. If necessary, perform CPA Signal Check (page 266).

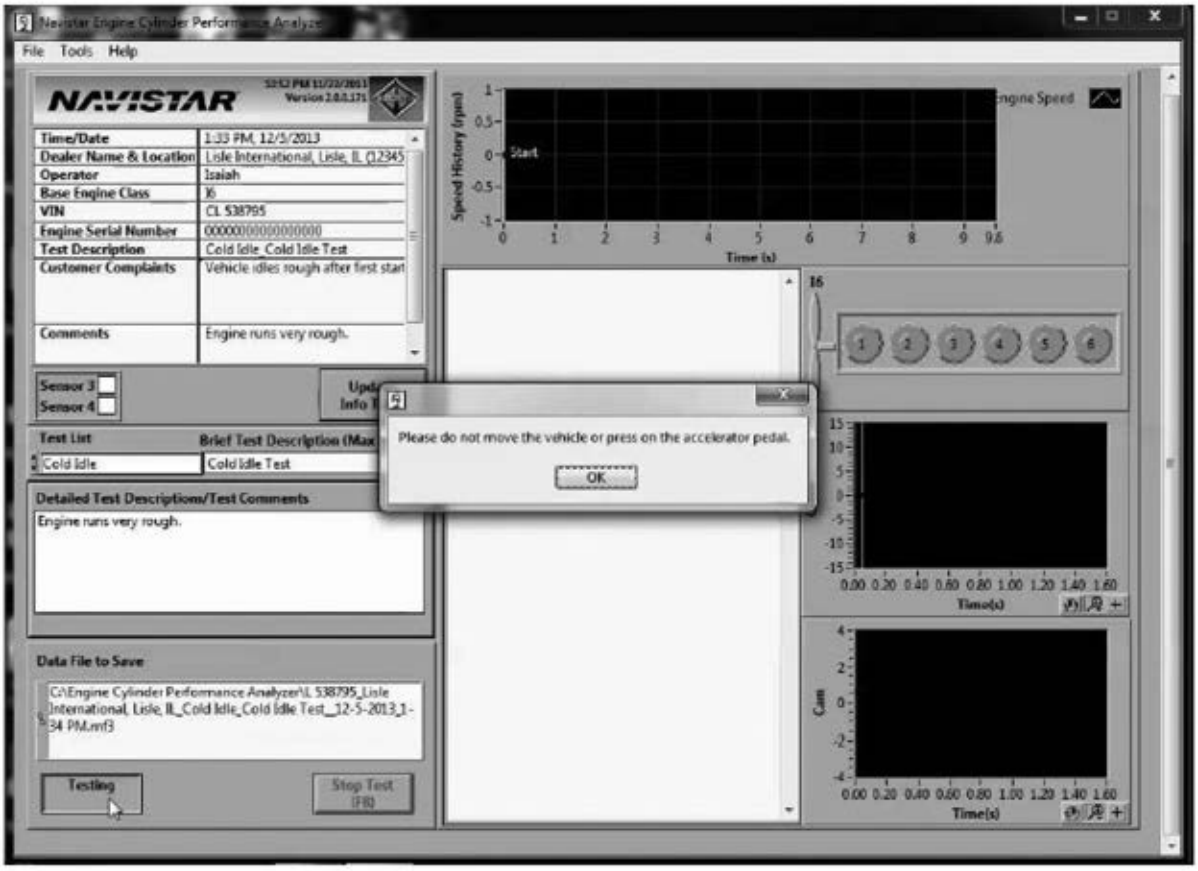
Test Procedure



0000304901

Figure 143 Test List

1. Select Hot Idle from Test List (Figure 143).
2. If engine is not running, Start engine.



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Figure 144 Start Test Window

3. Click button on bottom left corner to start test (Figure 144).
4. Follow on-screen instructions to complete this test.
5. When End of Test text field appears, enter any final details about test.
6. Click Return button to go back to home screen and view test results.

Expected Outcome

Test will run successfully. Return to step based diagnostics with test information or continue Cylinder Performance Analyzer (CPA) diagnostics as needed. Green cylinders indicate no defects were found; a red cylinder indicates a problem with that cylinder (may or may not be an injector); and light blue cylinders indicates high engine speed fluctuations, but no problem with a particular cylinder.

Follow-On Procedure

None

Cylinder Performance Analyzer (CPA) Road Test

Overview

The Full Load to Highway Speed Test is used to detect faults with cylinder combustion during acceleration, under a load and involves the vehicle being driven. The signal check must be performed prior to attempting this test. Testing will stop automatically once vehicle reaches highway speed and/or all necessary data has been collected. The Cylinder Performance Analyzer (CPA) software will only recognize for a limited time that signal check has been completed before it will reset and inhibit any test that involves vehicle being driven.

WARNING: To prevent personal injury or death, do not exceed local speed limits, disobey traffic laws or drive too fast for conditions while performing this test.

Tools Required

- Cylinder Performance Analyzer (CPA) Tool Kit 12-999-01
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)

Equipment Condition

Depending on the truck model, it may be necessary to remove operator's side inner fender, quarter fenders and/or passenger side inner fender in order to properly connect and safely route test cables into cab.

Test Setup

1. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81).
2. Key ON. Log in to ServiceMaxx™ software (page 82).
3. Connect Cylinder Performance Analyzer (CPA) Tool Kit (page 257) 12-999-01.

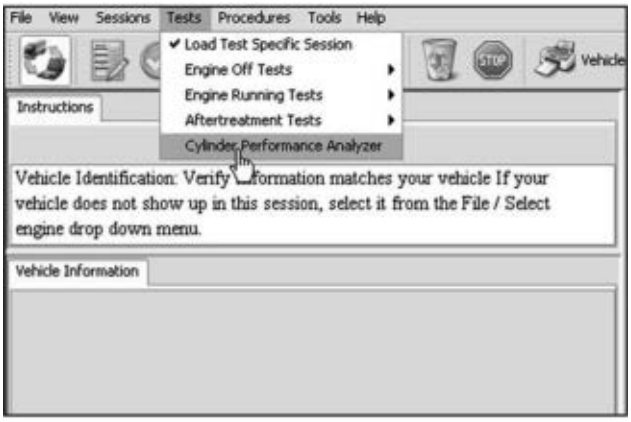


Figure 146 ServiceMaxx™ Menu

4. Start CPA software in ServiceMaxx™ by selecting Tests > Cylinder Performance Analyzer (Figure 146).



0000304881

Figure 147 Information Text Fields

5. Fill in dealer location, operator/technician information and customer complaint in text fields (Figure 147).
6. Verify vehicle data matches information in text fields (Figure 147).

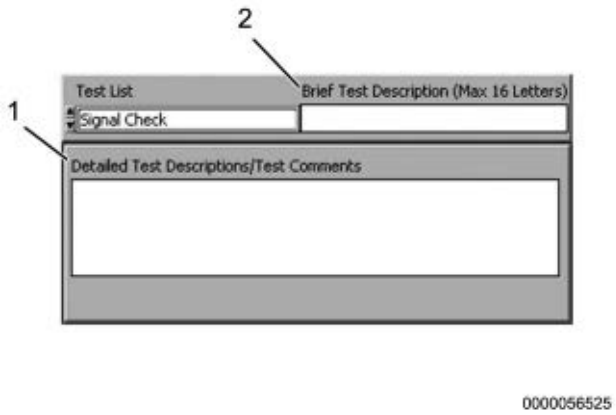


Figure 148 Test List

1. Detailed Test Description / Test Comments field
2. Brief Test Description field

7. Enter information into brief test description (item 2) and detailed test description/test comments (item 1) text fields (Figure 148).
8. If necessary, perform CPA Signal Check .

Test Procedure

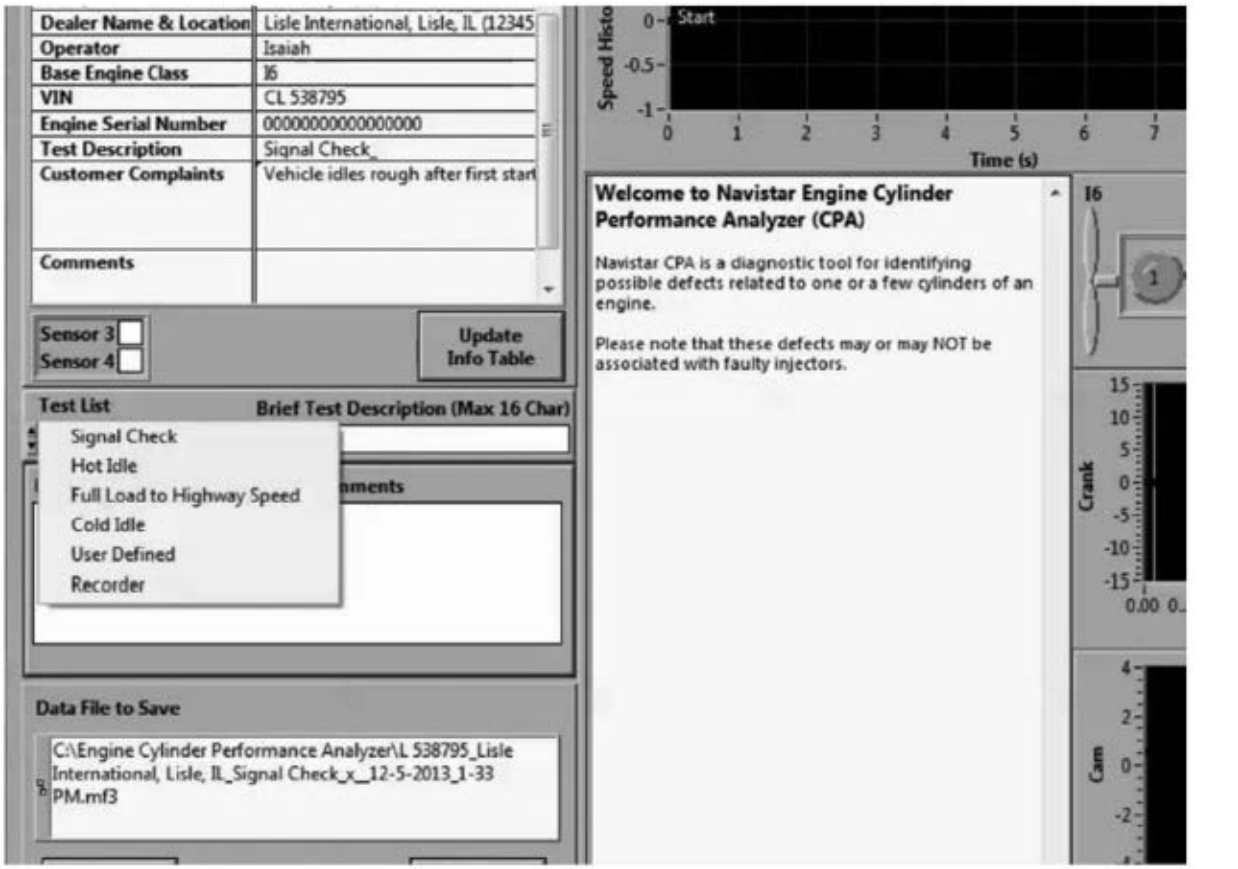
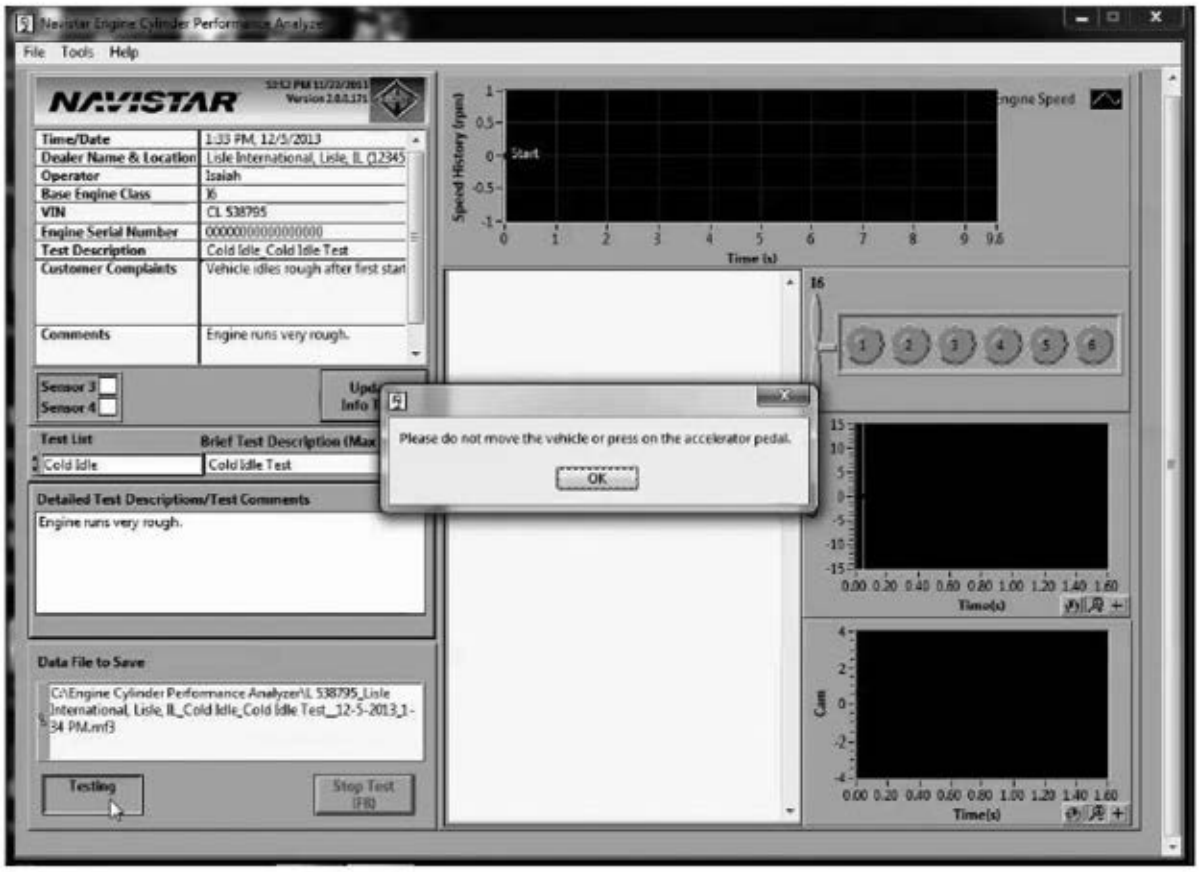


Figure 149 Test List

1. Select Full Load to Highway Speed test from Test List (Figure 149).
2. Start engine.



0000304884

Figure 150 Start Test Window

3. Click button on the bottom left corner to start test (Figure 150).
4. Follow on-screen instructions to complete test.
5. When End of Test text field appears, enter any final details about test.
6. Click Return button to return to home screen and view test results.

Expected Outcome

Test will complete successfully and will automatically stop when necessary data has been recorded. Review test results and return to step-based diagnostics or continue with Cylinder Performance Analyzer (CPA) testing as needed.

Follow-On Procedure

None

Cylinder Performance Analyzer (CPA) Advanced Testing

Overview

Cylinder Performance Analyzer (CPA) advanced testing can be used with or without the guidance of Navistar® Technical Services. This allows the user to test other sensor signals to perform a wider variety of diagnostics. Technician can not view data taken on sensor ports 3 and 4 without contacting tech central support.

Tools Required

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)
- Cylinder Performance Analyzer (CPA) Tool Kit 12-999-01

Equipment Condition

Depending on truck model, it may be necessary to remove operator's side inner fender, quarter fenders and/or passenger side inner fender to properly connect and safely route test cables into the cab.

Test Setup

1. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81).
2. Key ON. Log in to ServiceMaxx™ software (page 82).
3. Connect Cylinder Performance Analyzer (CPA) (page 257) tool.
4. Connect Extension Harness 12-999-01-05 and 2-Pin Banana Plug 12-999-01-06 to sensor(s) you wish to monitor and to CPA tool, ensuring to route them away from hot or moving parts.

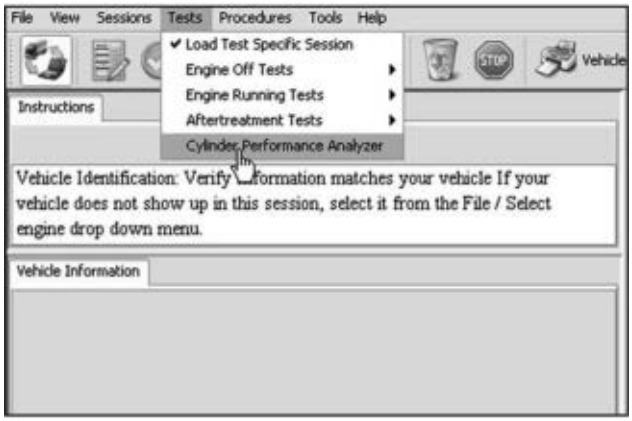


Figure 151 ServiceMaxx™ Menu

5. Start CPA software in ServiceMaxx™ by selecting Tests > Cylinder Performance Analyzer (Figure 151).



0000304881

Figure 152 Information Text Fields

6. Fill in dealer location, operator / technician information and customer complaint text fields (Figure 152).
7. Verify vehicle data matches information in text fields (Figure 152).

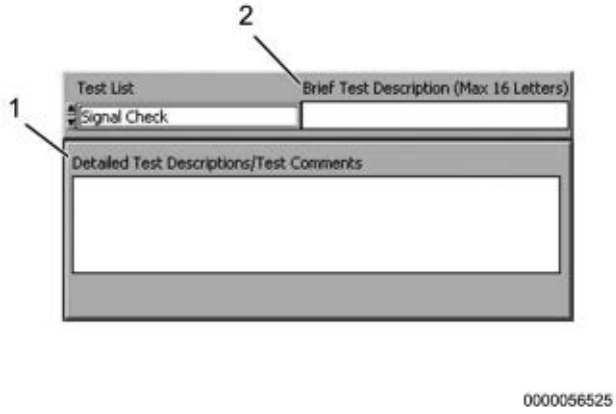


Figure 153 Test Description Text Fields

1. Detailed Test Description / Test Comments field
2. Brief Test Description field

8. Enter information into Brief Test Description (item 2) and Detailed Test Description / Test Comments (item 1) text fields (Figure 153).

Test Procedure

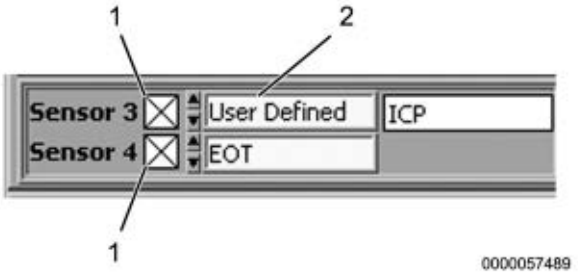


Figure 154 Sensor 3 and Sensor 4 data fields

1. Sensor 3 and 4 check box
2. Sensor connected

1. Add data for sensor(s) connected in the field for Sensor 3 and Sensor 4 (Figure 154), if needed.

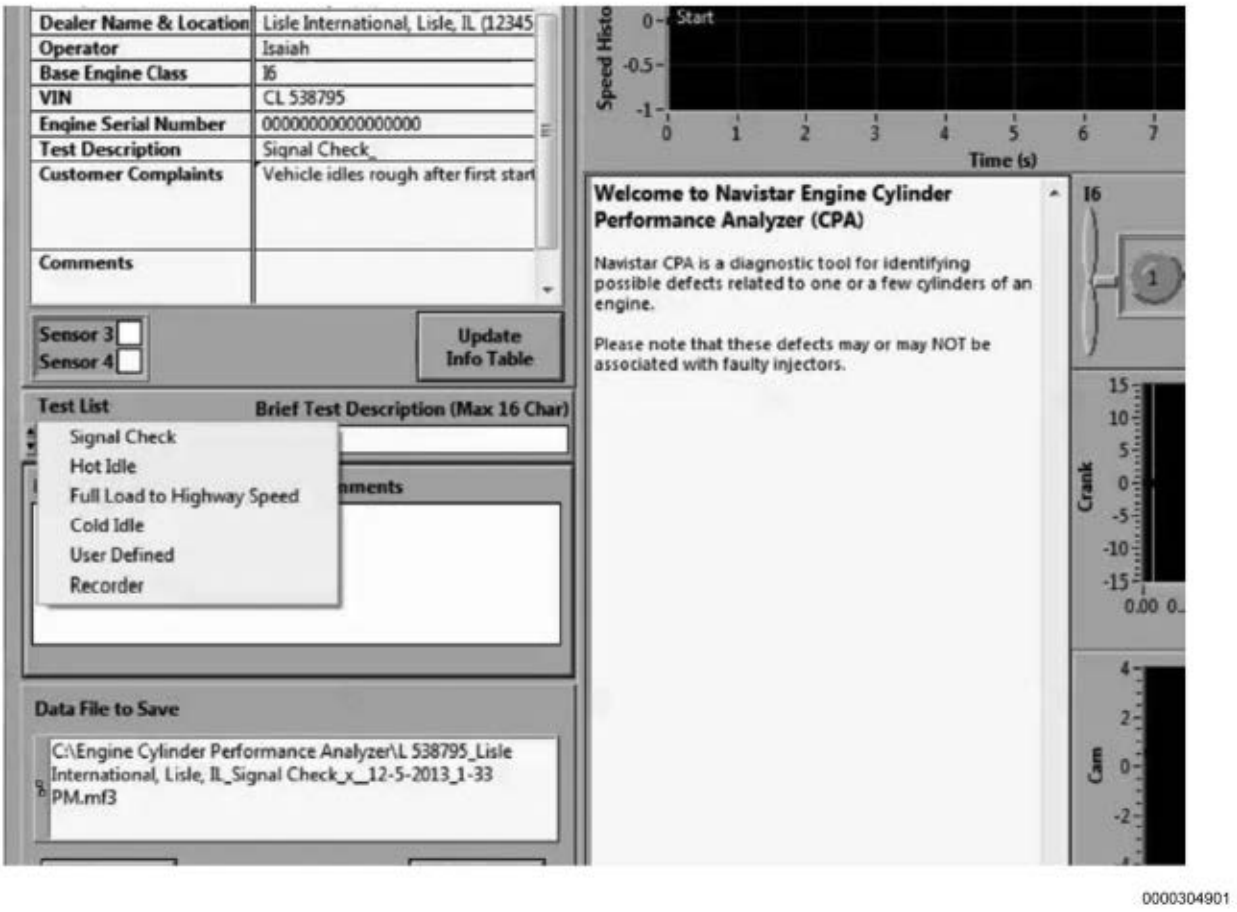
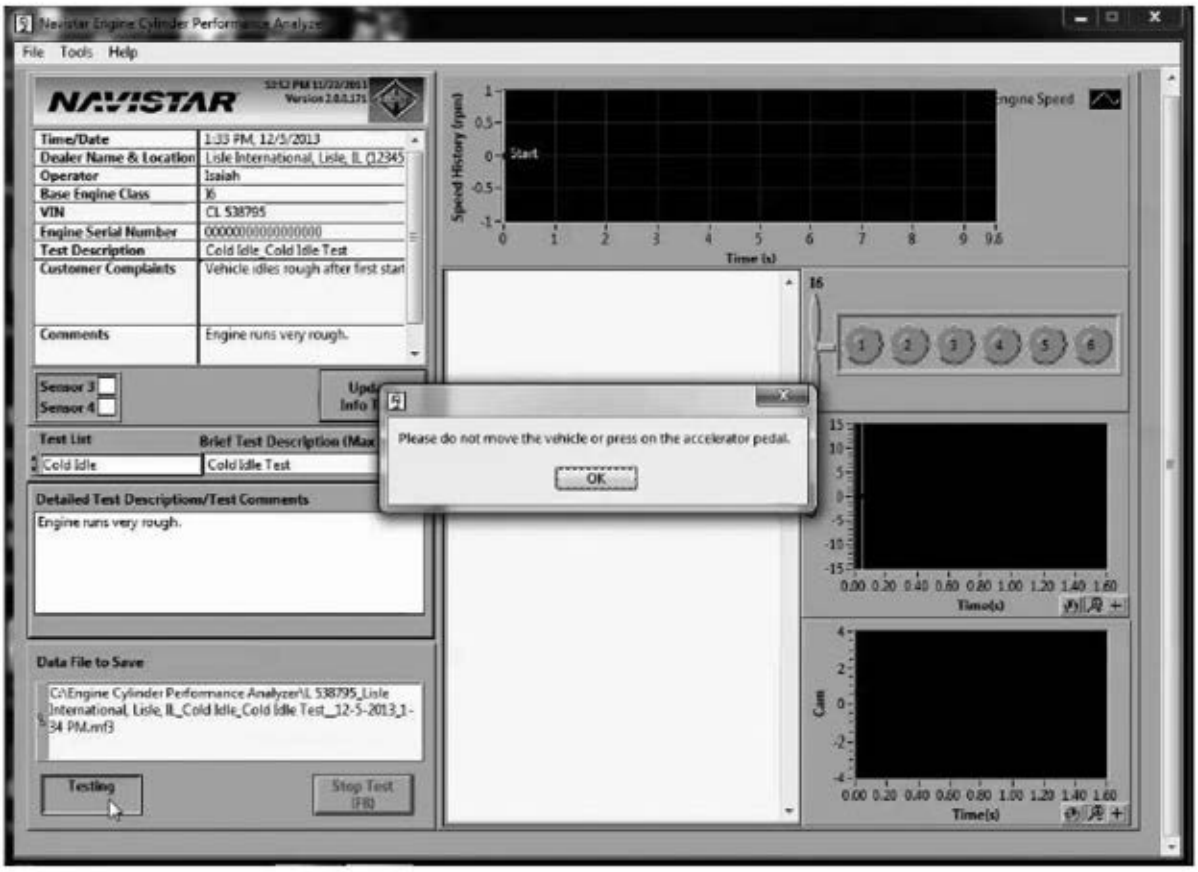


Figure 155 Test List

2. Select User Defined in the drop-down list of Tests (Figure 155).
3. Start Engine.



0000304884

Figure 156 Start Test Window

4. Click button on bottom left corner to start test (Figure 156).
5. Follow on-screen instructions to complete this test.
6. When End of Test text field appears, you can enter any final details about the test.
7. Click Return button to return to Home screen and view test results.

Expected Outcome

Test will run successfully, return to step based diagnostics with test information, or continue Cylinder Performance Analyzer (CPA) diagnostics as needed. Green cylinders indicate no defects were found; a red cylinder indicates a problem with that cylinder (may or may not be an injector); and light blue cylinders indicates high engine speed fluctuations, but no problem with a particular cylinder.

Follow-on Procedure

None

Cylinder Performance Analyzer (CPA) – High-Pressure Oil Pump (HPOP) Test

Overview

Cylinder Performance Analyzer (CPA) – High-Pressure Oil Pump (HPOP) Test is a group of tests used to diagnose defects in the High-Pressure Oil System consisting of the Injection Pressure Regulator (IPR) Engine Control Module (ECM) Powered Test, IPR (Full Fielded) Test, IPR Removed and Plug Tool Installed Test, and Pump Deadheaded Test. It may not be necessary to perform all tests in the CPA HPOP Test. If software detects a fault in the High Pressure Oil System during any test, a Warranty Authorization Code (WAC) will be generated. Any other faults will be displayed in the Summary Text Box. If no fault is found, the software will recommend performing the next test in the series.

Tools Required

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)
- Cylinder Performance Analyzer (CPA) Tool Kit – 12-999-01

Equipment Condition

Depending on truck model, it may be necessary to remove operator's side inner fender, quarter fenders and/or passenger side inner fender to properly connect and safely route test cables into cab.

Test Setup

1. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81).
2. Key ON. Log into ServiceMaxx™ software.
3. Connect Cylinder Performance Analyzer (CPA) Tool 12-999-01 (page 257).

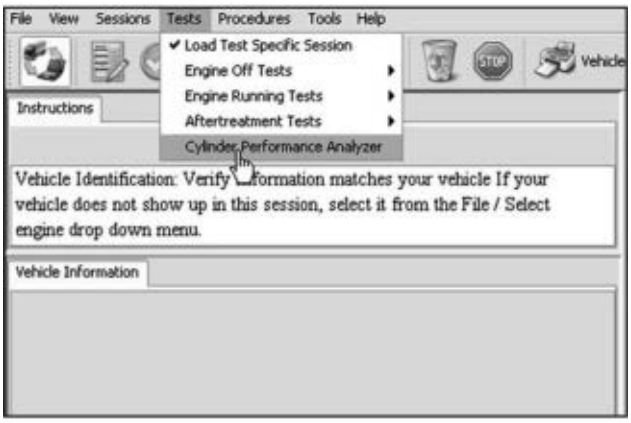


Figure 157 ServiceMaxx™ Menu

4. Start CPA software in ServiceMaxx™ software by selecting Tests > Cylinder Performance Analyzer (Figure 157).



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Figure 158 Information and Text Fields

5. Verify vehicle data matches information in text fields (Figure 158).
6. Fill in Dealer name and location, technician / operator information and customer complaints in the appropriate text fields (Figure 158).

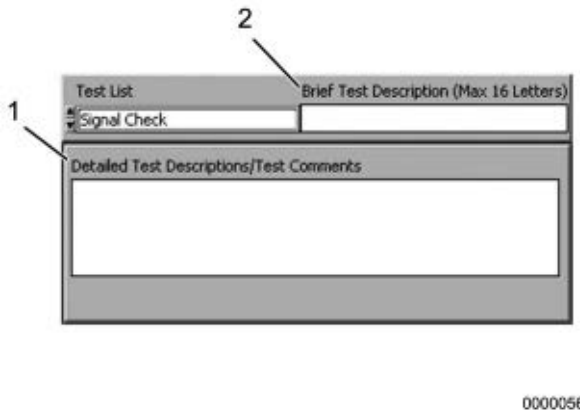


Figure 159 Brief and Detailed Test Description Fields

1. Detailed Test Description / Test Comment Field
2. Brief Test Description Text Field

7. Enter test details into the Brief Test Description (item 2) and Detailed Test Description / Test Comments (item 1) text fields (Figure 159).

Test Procedure

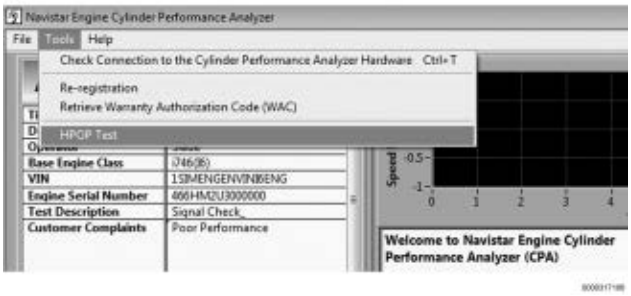
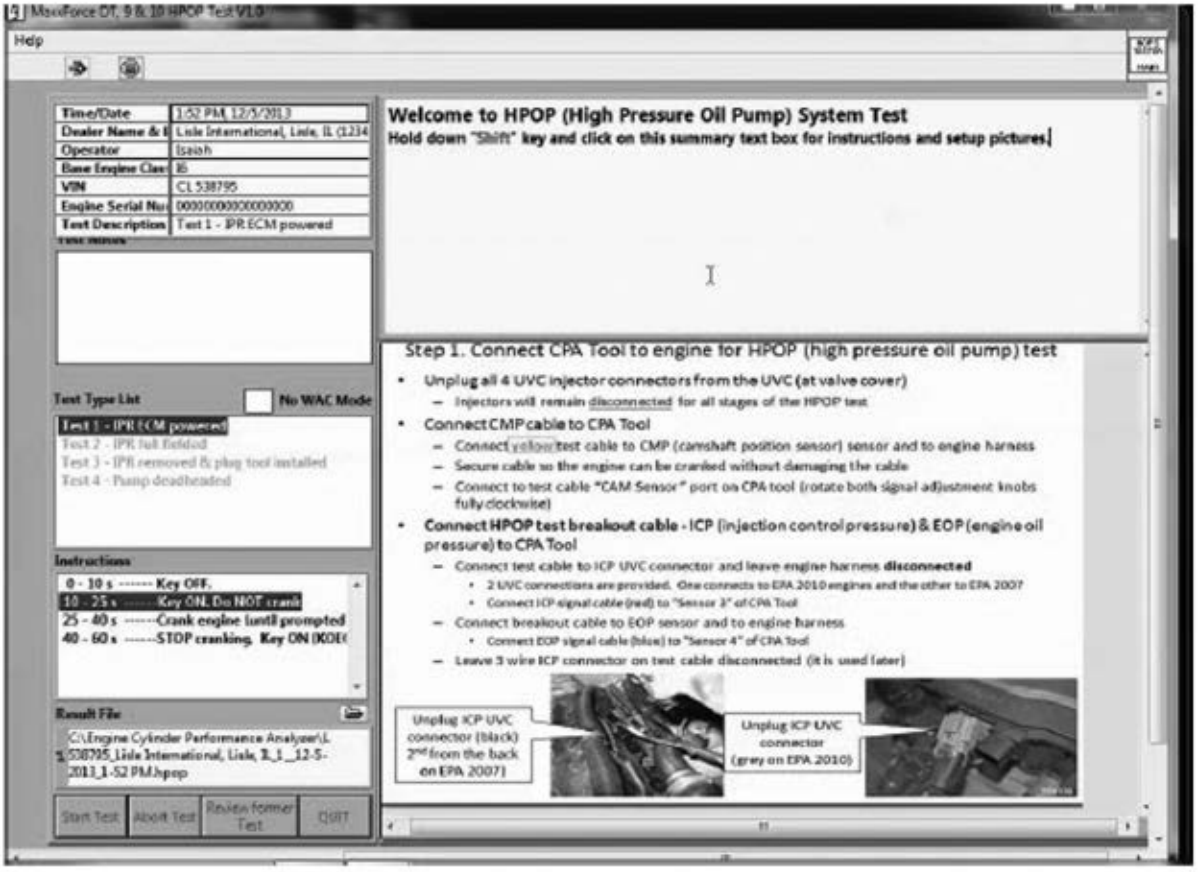


Figure 160 CPA Tools Menu

1. Select Tools > HPOP Tests (Figure 160).



0000305012

Figure 161 Instructions to Set-up and Perform Tests

2. Follow on-screen instructions (Figure 161) to prepare to run this group of tests.
3. Click the Start Test button on bottom left corner.
4. Follow on-screen instructions (Figure 161) to complete this test.
5. When End of Test text field appears, you can enter any final details about the test.
6. Click Return button to return to Home screen and view test results.
7. Perform next recommended test or make repairs as necessary

Expected Outcome

Tests will run successfully, identifying a failed component or sending the user to the next test in the sequence. When this series is complete, return to step-based diagnostics, or perform leak test according to Cylinder Performance Analyzer (CPA) findings.

Follow-on Procedure

None

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Description

Section Information

All electrical faults in the engine control system can be diagnosed in this section. All components are divided into separate test procedures and contain the following information:

- SPN / FMI with possible cause
- Circuit diagram
- Component function
- Circuit operation
- Component location
- Diagnostic tool list
- Sensor End Diagnostics (with ServiceMaxx™ software)
- Pin-point Diagnostics (without ServiceMaxx™ software)
- Step Based Diagnostics
- Harness resistance check
- Operational voltage check (most components)

Electronic Control System Diagnostics Form 0000003221

Diagnostic Form Example

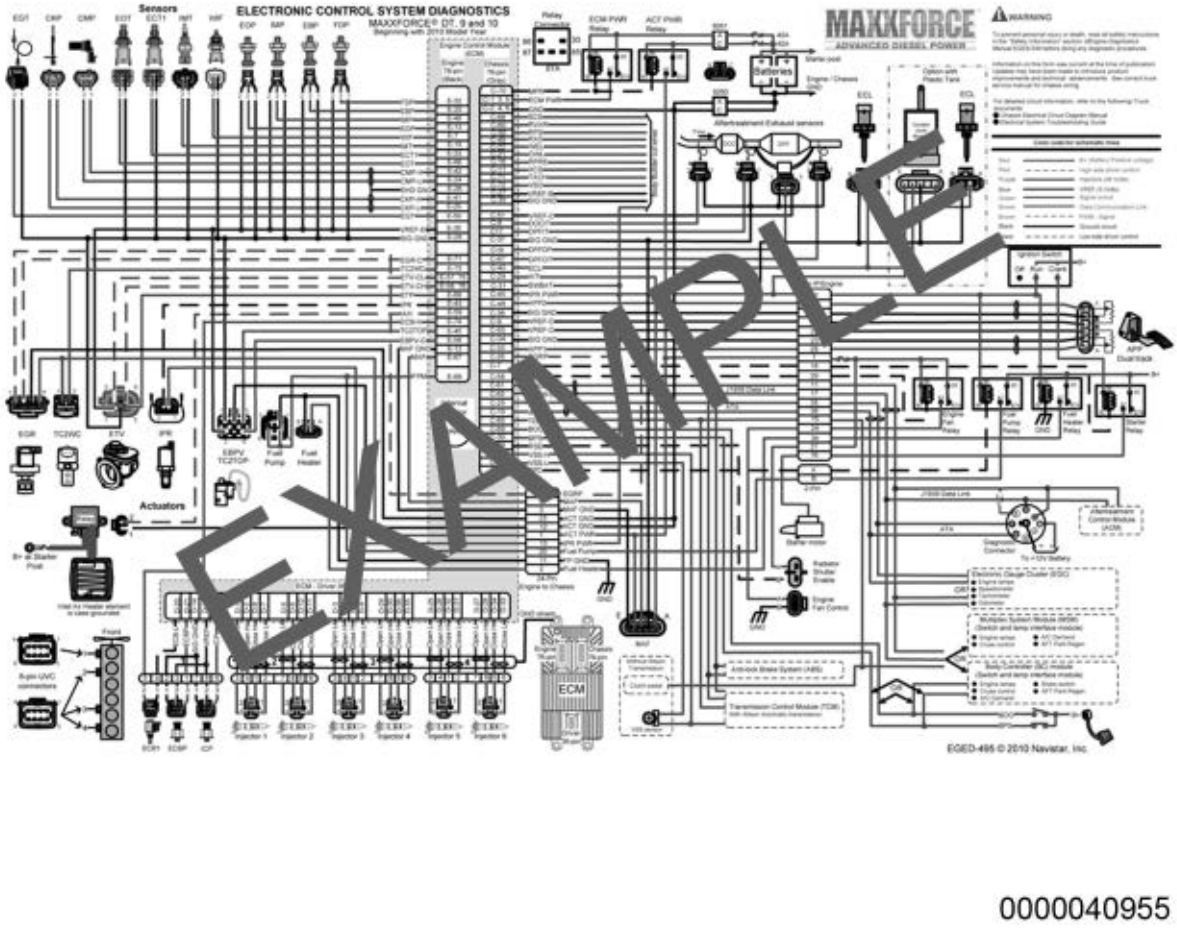


Figure 162 Diagnostic form (front side)

Engine diagnostic form 0000003221 assists technicians in troubleshooting MaxxForce® diesel engines. Diagnostic schematics and signal values help technicians find problems to avoid unnecessary repairs.

The front side of the Electronic Control Systems Diagnostics form consists of a circuit diagram for electrical components mounted on the engine side and vehicle side. The back side of the form consists of signal values. 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*.

Diagnostic Form 0000003221 is available in 50-sheet pads. To order technical service literature, contact your International dealer.

Sensor and Actuator Locations

Engine Mounted Components

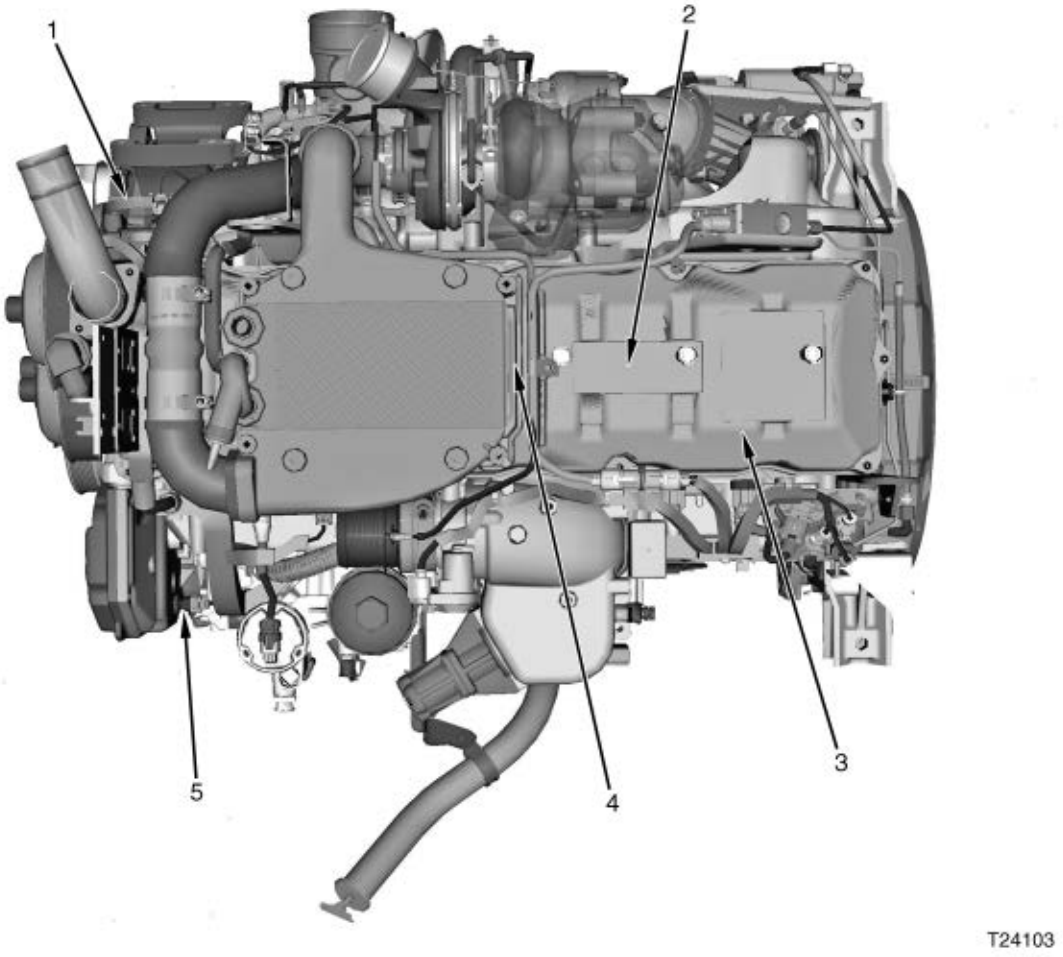


Figure 163 Component location – top

1. Engine Coolant Temperature 1 (ECT1) sensor
2. Engine Compression Brake (ECB) (under valve cover) valve
3. Injection Control Pressure (ICP) sensor (under valve cover)
4. Engine Compression Brake Pressure (ECBP) (under valve cover) sensor
5. Engine Oil Temperature (EOT) sensor

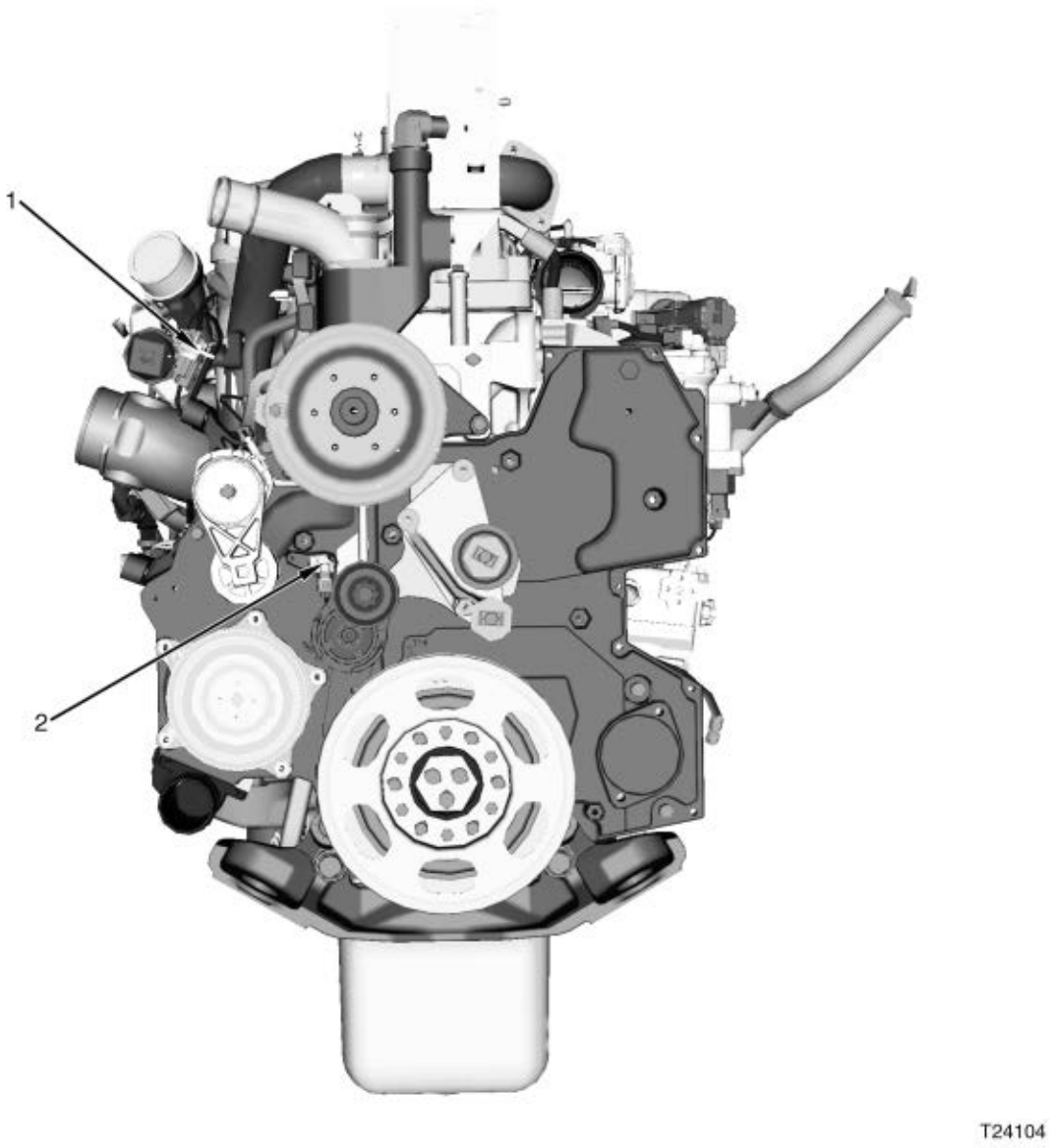


Figure 164 Component location – front

1. Turbocharger 2 Wastegate Control (TC2WC) solenoid
2. Crankshaft Position (CKP) sensor

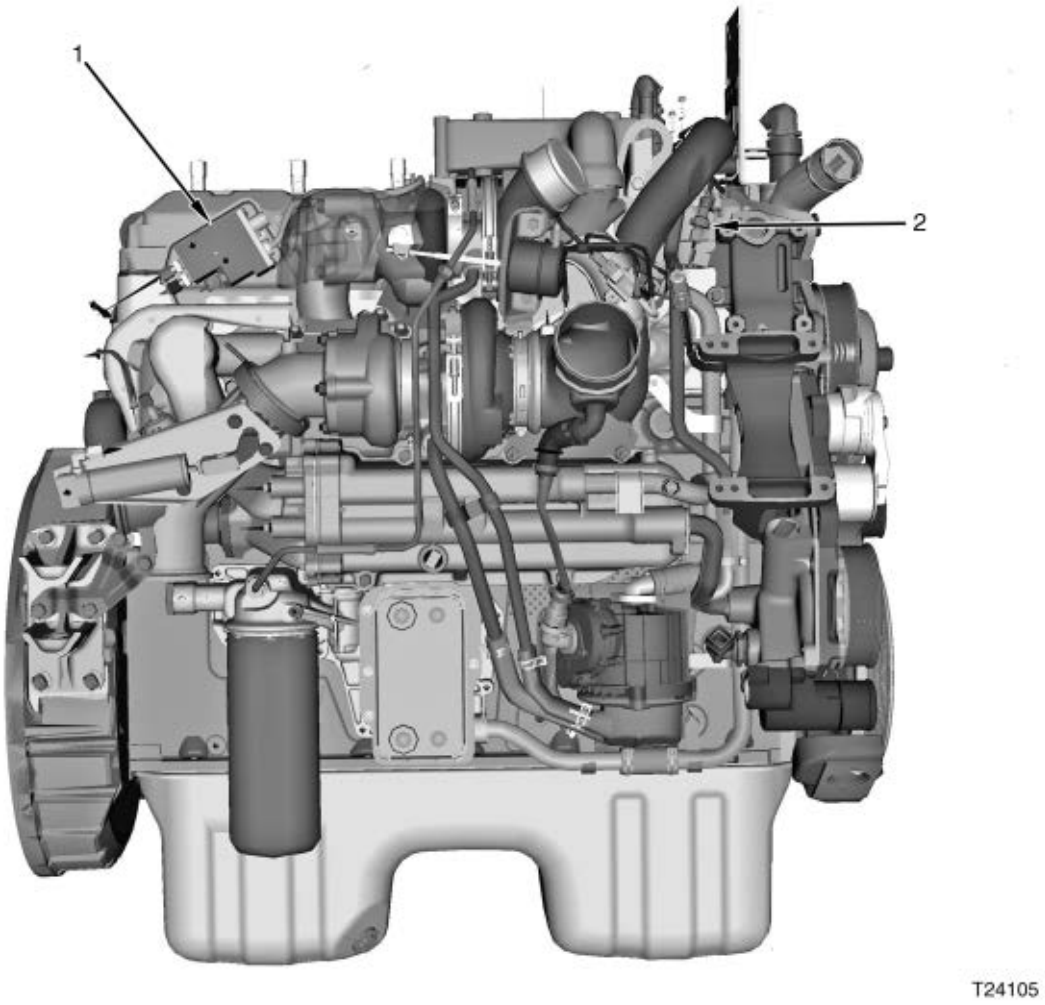


Figure 165 Component location – right

1. Exhaust Back Pressure Valve (EBPV)
2. Exhaust Back Pressure (EBP) sensor

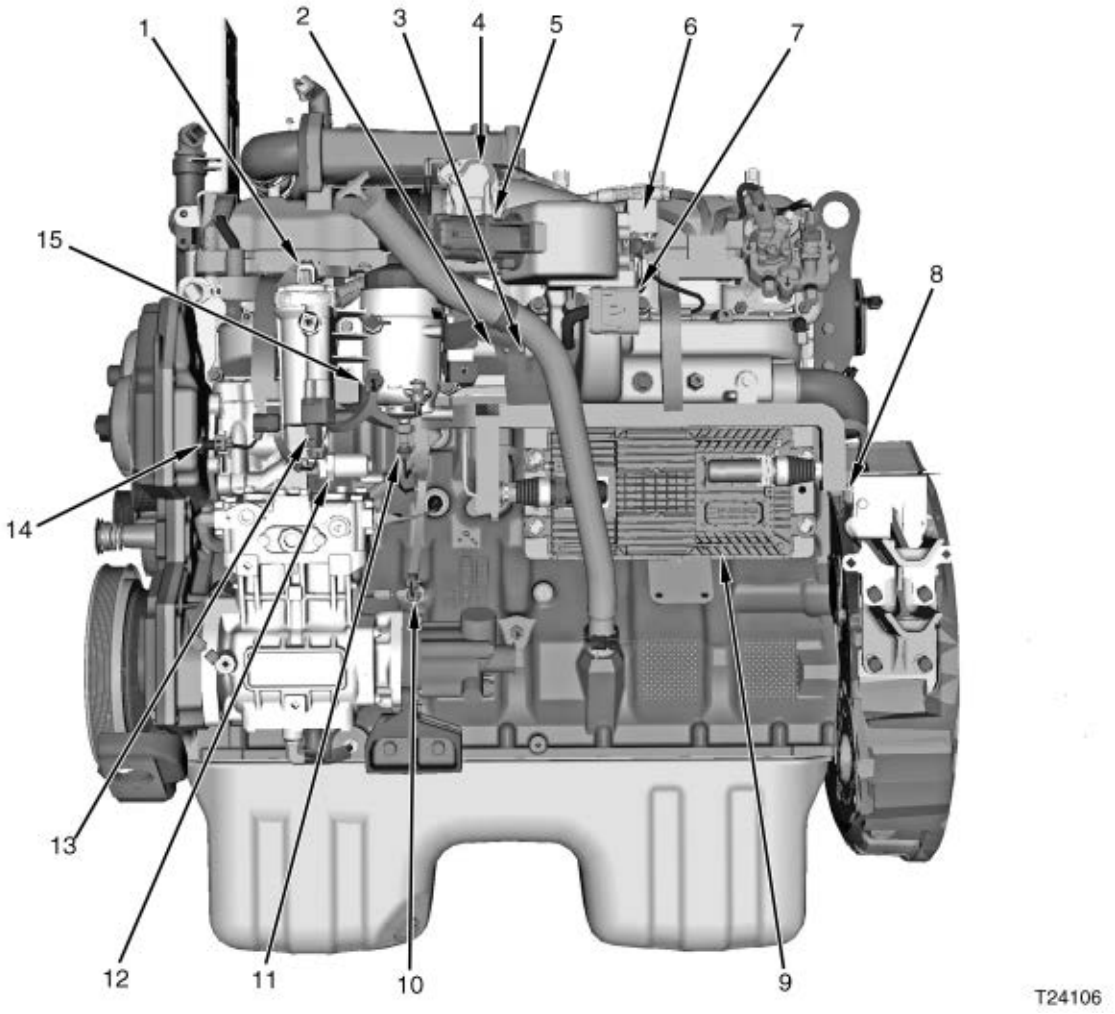


Figure 166 Component location – left

1. Fuel Pump
2. Intake Manifold Pressure (IMP) sensor
3. Intake Manifold Temperature (IMT) sensor
4. Engine Throttle Valve (ETV)
5. Exhaust Gas Recirculation Valve (EGRV)
6. Intake Air Heater (IAH) relay
7. 24-Pin Truck Interconnect
8. Camshaft Position (CMP) sensor
9. Engine Control Module (ECM)
10. Engine Oil Pressure (EOP) sensor
11. Fuel Delivery Pressure (FDP) sensor
12. Injection Pressure Regulator (IPR)
13. Fuel Heater
14. Engine Oil Temperature (EOT) sensor
15. Water In Fuel (WIF) sensor

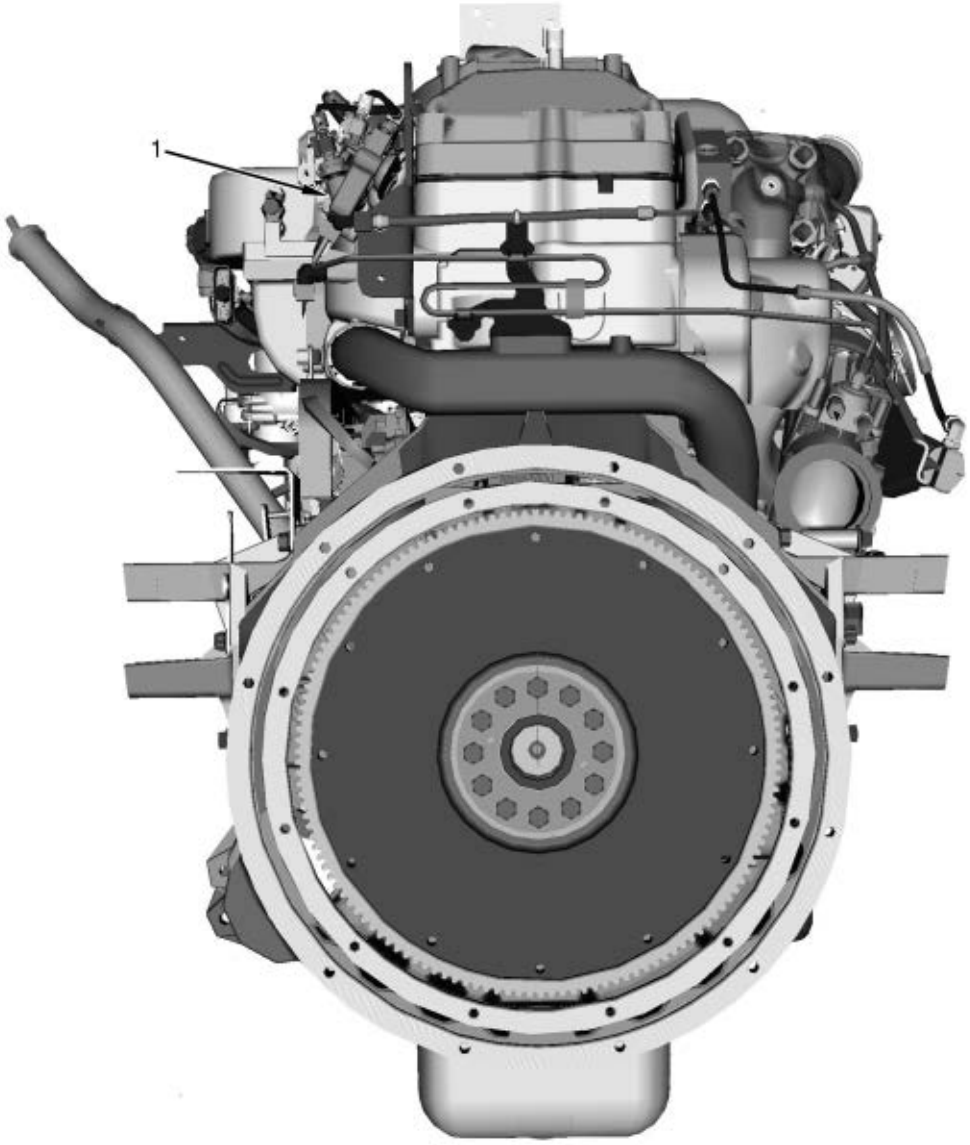


Figure 167 Component location – rear

1. Down Stream Injection (DSI)

Vehicle Mounted Components

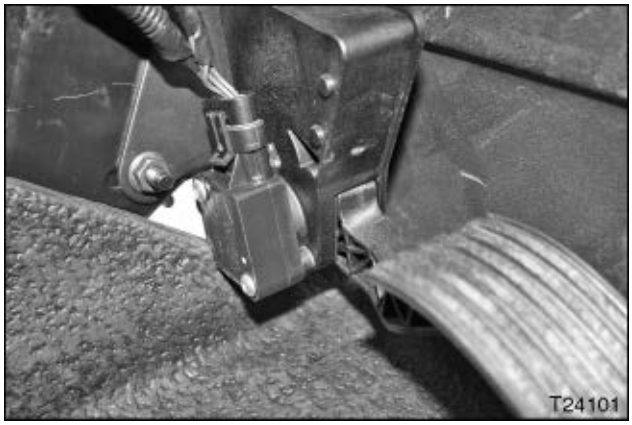


Figure 168 Accelerator Pedal Position (APP)

The APP is mounted on the accelerator pedal.

Diagnostic Procedure Process

Description

The test procedures in this section are based on the assumption there is an SPN / FMI code or problem with the component being 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 Pin-point the fault.

Pin-grip Inspection

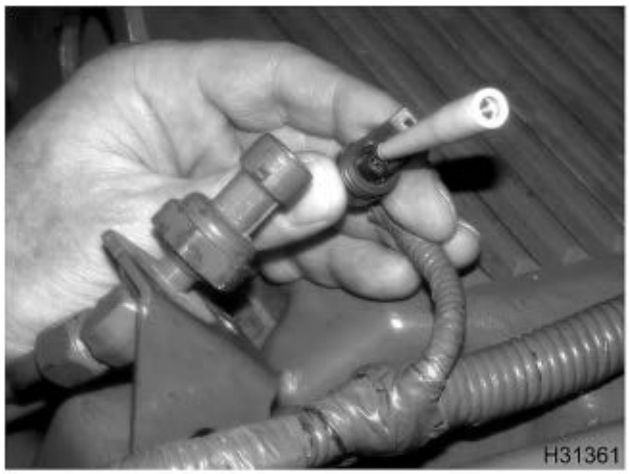


Figure 169 Pin grip check

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 Pin-point Diagnostics.

Diagnostics with Step Based Diagnostics

Sensors can also be diagnosed using Step Based Diagnostics. These procedures usually start by eliminating associated fault codes and then provide a step by step troubleshooting procedures for eliminating possible causes.

Sensor End Diagnostics (with ServiceMaxx™ software)

Sensor End Diagnostics (2-Wire)

1. Connect the EST to the Diagnostic Connector.
2. Turn ignition switch ON, engine OFF.
3. Start ServiceMaxx™ software.
4. Open the Continuous Monitor session. This session lists all engine sensors.

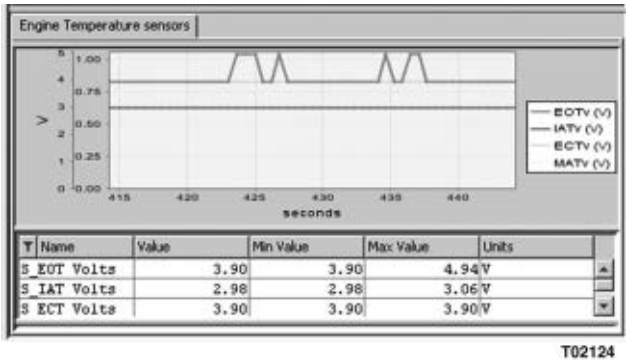


Figure 170 Sensor voltage

5. Monitor the sensor voltage and verify an active code is present.

   NOTE: If sensor signal circuit is shorted or open, the signal value will read NA or Error.

   - If the code is inactive, monitor the signal while wiggling the connector and all wires at suspected locations.

     If the circuit is interrupted, the signal will spike. Isolate the fault and repair.

   - If the code is active, continue to the next step.
6. Disconnect sensor. Inspect the connector for damaged pins. Repair as necessary.

Example

Connect breakout harness, leave sensor disconnected. Verify specified code goes active when fault is induced.

Test Point	Spec	Comment
EST – Check code	SPN 175 FMI 3	If SPN 175 FMI 4 is active, check EOT signal for short to GND. Do Harness Resistance Check.

- If specified code does not go active, repair short to Ground (GND) on the sensor signal circuit. Do Harness Resistance Check if additional assistance is needed in diagnosing fault.
- If specified code goes active, continue to next test point.

7. Short 3-Banana Plug Harness across the sensor signal circuit and engine GND.
8. The specified code should go active, unless the sensor signal circuit is open.

Example

Test Point	Spec	Comment
EST – Check code Short 3-Banana Plug Harness across 2 and GND	SPN 175 FMI 4	If SPN 175 FMI 3 is active, check EOT signal circuit for OPEN. Do Harness Resistance Check.

- If specified code does not go active, repair open in sensor signal circuit. Do Harness Resistance Check if additional assistance is needed in diagnosing fault.
- If specified code goes active, continue to next test point.

9. Short 3-Banana Plug Harness across the sensor signal circuit and Signal Ground (SIG GND) circuit.
10. The specified code should go active, unless the SIG GND circuit is open.

Example

Test Point	Spec	Comment
EST – Check code Short 3-Banana Plug Harness across 1 and 2	SPN 175 FMI 3	If code is not active, check SIG GND for OPEN. Do Harness Resistance Check.

- If corresponding code does not go active, repair open in SIG GND circuit. Do Harness Resistance Check if additional assistance is needed in diagnosing fault.
- If within specification, and both circuits tested acceptable, continue to the last step.

11. Connect the sensor and clear the codes, start the engine, and cycle the accelerator pedal a few times. If the active code remains, the sensor must be at fault. Replace the failed sensor.

Example

If checks are within specification, connect sensor and clear codes. If active code remains, replace sensor.

Sensor End Diagnostics (3-Wire)

1. Connect the EST to the Diagnostic Connector.
2. Turn ignition switch ON, engine OFF.
3. Start ServiceMaxx™ software.
4. Run Continuous Monitor session. (This session lists all engine sensors.)

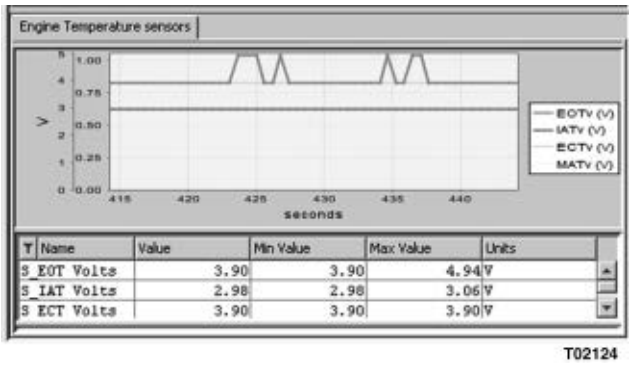


Figure 171 Sensor voltage

5. Monitor the sensor voltage and verify that an active code is present.

   NOTE: If sensor signal circuit is shorted or open, the signal value will read NA or Error.

   - If the code is inactive, monitor the signal while wiggling the connector and all wires at suspected locations.

     If the circuit is interrupted, the signal will spike. Isolate the fault and repair.

   - If the code is active, continue to the next step.

6. Disconnect the sensor. Inspect the connector for damaged pins. Repair as necessary.

Example

Test Point	Spec	Comment
EST – Check code	SPN 102 FMI 4	If SPN 102 FMI 3 is active, check IMP signal for short to Power (PWR)

- If specified code does not go active, repair short to voltage on sensor signal circuit.
- If specified code goes active, continue to next test point.

7. Use a DMM to measure voltage on the Reference Voltage (VREF) circuit. Voltage should read 5 volts, unless VREF is open or shorted to GND, or a voltage is greater than VREF.

Example

Test Point	Spec	Comment
DMM – Measure volts	5 V	If > 5.5 V, check VREF for short to PWR.
2 to GND		If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check.

- If not within specification, repair open or short in VREF circuit. Do Harness Resistance Check if additional assistance is needed in diagnosing fault.
- If within specification, continue to the next test point.

8. Short 3-Banana Plug Harness across VREF and the sensor signal circuit.
9. The specified code should go active, unless the sensor signal circuit is open.

Example

Test Point	Spec	Comment
EST – Check code Short breakout harness across 2 and 3	SPN 102 FMI 3	If SPN 102 FMI 4 is active, check IMP signal for OPEN or short to GND. Do Harness Resistance Check.

- If specified code does not go active, repair open in sensor signal circuit. Do Harness Resistance Check if additional assistance is needed in diagnosing fault.
- If specified code goes active, continue to the next test point.

10. Use a DMM to measure resistance on the SIG GND circuit to ground. Resistance should read less than 5 Ω, unless the SIG GND is open.

Example

Test Point	Spec	Comment
DMM – Measure resistance 1 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check.

- If not within specification, repair open in the SIG GND circuit. Do Harness Resistance Check if additional assistance is needed in diagnosing fault.
- If within specification, and all three circuits tested acceptable, continue to the last step.

11. Connect the sensor and clear the codes. If the active code remains, the sensor must be at fault. Replace the failed sensor.

Example

If checks are within specification, connect sensor and clear codes. If active code remains, replace sensor.

Pin-point Diagnostics (without ServiceMaxx™ software)

1. Connect breakout harness to the engine harness. Leave sensor disconnected.
2. Turn ignition switch ON, engine OFF.
3. Use a DMM to measure voltage on each circuit to engine ground.

Example

Test Point	Spec	Comment
C to GND	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 Intake Air Heater (IAH) test.
8. Use a DMM to measure voltage on each circuit to engine ground.

Example

Test Point	Test	Spec	Comment
A to GND	Key ON-Engine OFF (KOEO)	B+	If < B+, check for OPEN circuit.
B to GND	Key ON-Engine OFF (KOEO)	B+	If < B+, check actuator coil for OPEN.
B to GND	Output State HIGH	B+	If < B+, check actuator control circuit for short to GND.
B to GND	Output State LOW	7.5 V	If > 7.5 V, check actuator control circuit for OPEN or short to PWR or failed across coil.

- If any circuit is not within specification, the comment area will list possible cause or direct the technician to the next test point.

- If all circuits are within specification, the actuator may not be operating mechanically.

Harness Resistance Check

Complete Sensor End Diagnostics or Pin-point Diagnostics tests before using this procedure.

Resistance cannot be measured on a circuit if voltage is present. Isolate circuit from voltage before continuing.

1. Turn ignition switch to OFF or disconnect batteries.

   WARNING: To prevent personal injury or death, always disconnect main negative battery cable first. Always connect the main negative battery cable last.

2. Connect breakout box and breakout harness to vehicle or engine harness. Leave ECM and sensor or actuator disconnected.
3. Use a DMM to measure resistance on each circuit from point to point, then to engine ground.

Example

Test Point	Spec	Comment
E-66 to 2	< 5 Ω	If > 5 Ω, check EOT control circuit for OPEN.
E-66 to GND	> 1 kΩ	If < 1 kΩ, 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 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 ± 0.5 V	0%
A to GND or	Pedal to floor	3.85 ± 0.5 V	102%
C-48 to GND			
APP2	Foot off pedal	0 V	0 V
D to GND or	Pedal to floor	B+	B+
C-33 to GND			

Circuit Diagnostics

ACT PWR Relay (Actuator Power)

SPN	FMI	Condition
	None	No engine actuator power supplied from chassis harnes

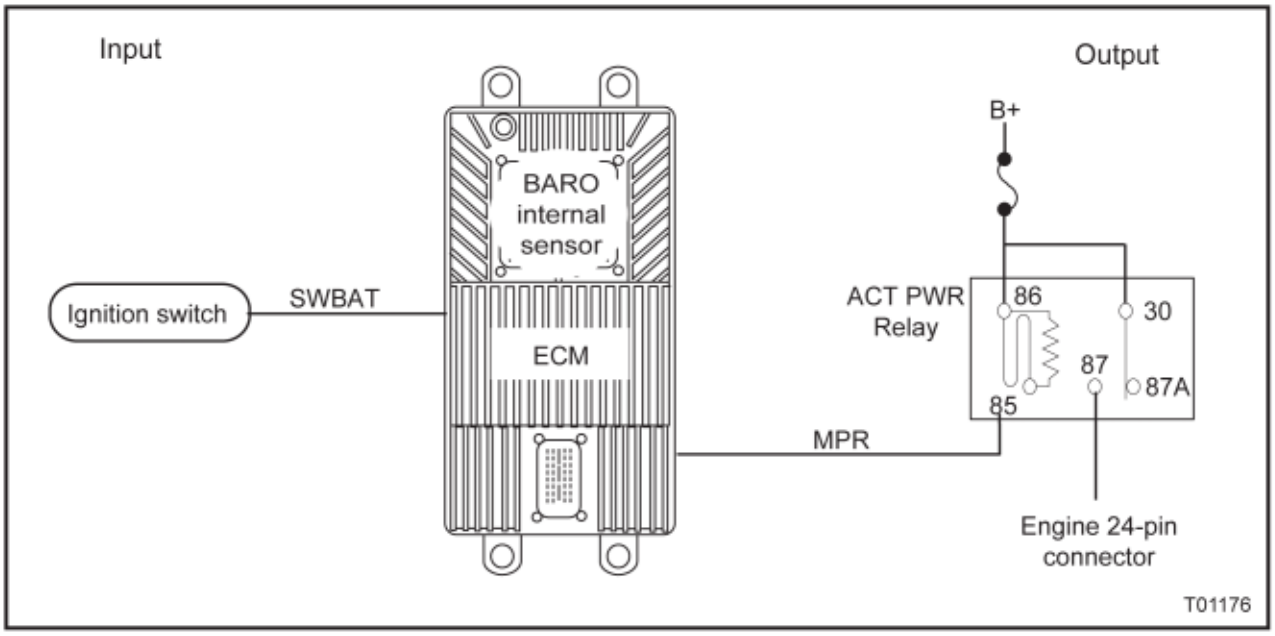


Figure 172 Function diagram for the ACT PWR

The function diagram for ACT PWR relay includes the following:

- Engine Control Module (ECM)
  with Barometric Absolute Pressure (BARO) Internal Sensor
- Actuator Power (ACT PWR) Relay
- Switched Battery (SWBAT)
- Battery (B+)
- Fuse
- Engine 24-pin Connector

Function

The ACT PWR circuit supplies the engine mounted actuators with switched battery voltage.

ACT PWR Relay Location

The ACT PWR relay is located in the engine harness, next to the ECM PWR relay.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)

- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- 00-00956-08 – 180-pin Breakout Box (page 1222)
- Breakout Harness 4674 (ACT PWR) (page 1231)
- Breakout Harness 6020 (24-pin) (page 1239)
- International® Electronic Engine Terminal Test Kit (page 1227)

ACT PWR Relay Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
None		No power supplied at engine 24-pin connector.	• Power loss to ECM • Blown fuse • Poor electrical connections (ECM PWR, ECM GND, or VIGN)

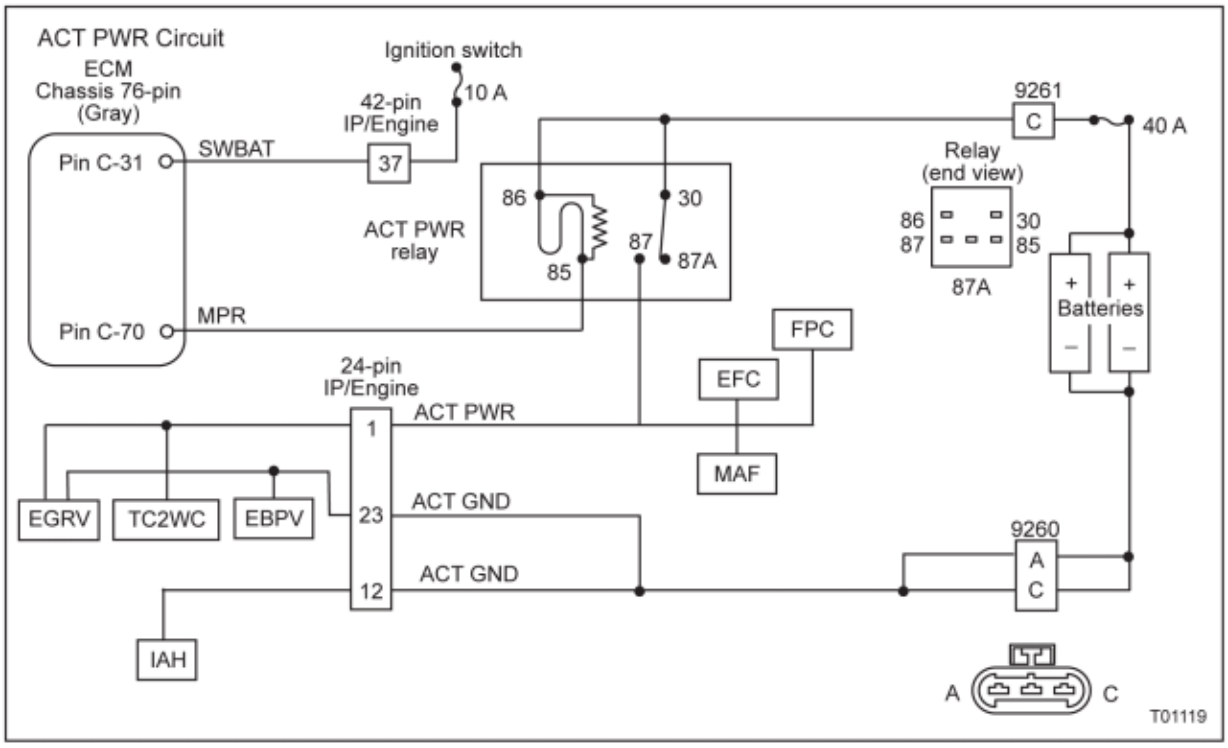


Figure 173 ACT PWR circuit diagram

1. Verify the ECM is powered by either cranking the engine, starting the engine, or communication is established with the EST.
   - If the ECM is not powering up, see ECM PWR (page 580).
   - If the ECM is powered, but there is no power going to the 24-pin connector, proceed to the next step.
2. Disconnect the engine to vehicle 24-pin connector.

NOTE: Inspect connector for damaged pins, corrosion, or loose pins. Repair if necessary.

3. Go to Voltage Checks at 24-pin Connector.

Voltage Checks at 24-pin Connector

CAUTION: To prevent engine damage, turn the ignition switch OFF before disconnecting 24-pin connector.

Connect Breakout Harness to 24-pin connector. Leave the engine harness disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment: < Less than, > Greater than
1 to GND	B+	If < B+, check for OPEN ACT PWR circuit, blown fuse, OPEN MPR control circuit, or failed relay. Do Voltage Checks at Relay.
1 to 12	B+	If < B+, check for OPEN ACT PWR GND circuit.
1 to 23	B+	If < B+, check for OPEN ACT GND circuit.

Voltage Checks at Relay

Connect Breakout Harness between relay and relay socket. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment: < Less than, > Greater than
86 to GND	B+	If < B+, check power circuit to relay coil for OPEN or short to GND, or blown fuse.
30 to GND	B+	If < B+, check power circuit to relay switch for OPEN or short to GND, or blown fuse.
85 to B+	B+	If < B+, check MPR control circuit for OPEN or short to PWR. Go to MPR Resistance Check.
87 to GND	B+	If < B+, replace relay. If B+, check for OPEN circuit between relay and the 24-pin connector.

Main Power Relay Control Circuit Resistance Check

Turn ignition switch to OFF. Connect 180-pin Breakout Box and Breakout Harness. Leave ECM, ECM PWR, and ACT PWR relay disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
C-70 to 85	< 5 Ω	If > 5 Ω, check MPR control circuit for OPEN.
C-70 to GND	> 1 kΩ	If < 1 kΩ, check MPR control circuit for short to GND.

ACT PWR circuit to 24-pin connector

Turn ignition switch to OFF. Connect 180-pin Breakout Box and Breakout Harness. Leave ACT PWR relay and Engine harness disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
Relay pin 87 to 24-pin 1	< 5 Ω	If > 5 Ω, check for OPEN circuit.
24-pin 1 to GND	> 1 kΩ	If < 1 kΩ, check for OPEN circuit.

ACT PWR Circuit Operation

The ACT PWR relay is controlled by the ECM, similar to the way the ECM controls its other relays. When the ECM receives the VIGN signal from the ignition switch, the ECM will enable the ECM relay and the ACT PWR relay.

The ECM receives SWBAT power at Pin C-45. This signals the ECM to provide a ground path from Pin C-70 to 85 to switch the ACT PWR relay. Switching the relay provides power from the battery positive terminal through a fuse and relay contacts 30 and 87 to Pin 1 and Pin 3 on the 24-pin connector.

Pin 23 and Pin 12 on the 24-pin connector are ACT GND circuits.

Fault Detection / Management

No codes are set for ACT PWR circuit failure. If ACT PWR is lost, the EGR will set KOEO Standard Test codes.

AFTFD (Aftertreatment Fuel Doser)

SPN	FMI	Condition	Possible Causes	Actions
3471	1	AFT Fuel Pressure 1 below desired (Low System Pressure)	• Low fuel delivery pressure • Restricted fuel filter • Aftertreatment (AFT) fuel shutoff valve failure • Biased AFT fuel pressure 1 sensor or circuit	Pin-point Diagnostics (page 323)
3471	7	AFT fuel doser valve not responding as expected	• Lower fuel delivery pressure • Restricted fuel filter • AFT Fuel shutoff valve failure • Biased AFT fuel pressure 1 sensor or circuit	Pin-point Diagnostics (page 323)
3471	10	AFT fuel doser valve abnormal rate of change	• AFTFD failure	Pin-point Diagnostics (page 323)
3479	3	AFT fuel doser valve short to PWR	• Aftertreatment Fuel Doser (AFTFD) circuit short to PWR • Failed AFTFD	Pin-point Diagnostics (page 323)
3479	4	AFT fuel doser valve short to GND	• AFTFD circuit open or short to GND • Failed AFTFD	Pin-point Diagnostics (page 323)
3479	5	AFT fuel doser valve open /load circuit	• Short to GND on low side • Internally shorted actuator	Step-based Diagnostics (page 324)
3479	6	AFT fuel doser valve high side short circuit	• Short to power on high side • Open wire to AFTFD • Open wire from AFTFD • Failed AFTFD • AFTFD-H circuit short to power	Step-based Diagnostics (page 327)

SPN	FMI	Condition	Possible Causes	Actions
			• AFTFD valve failed open	

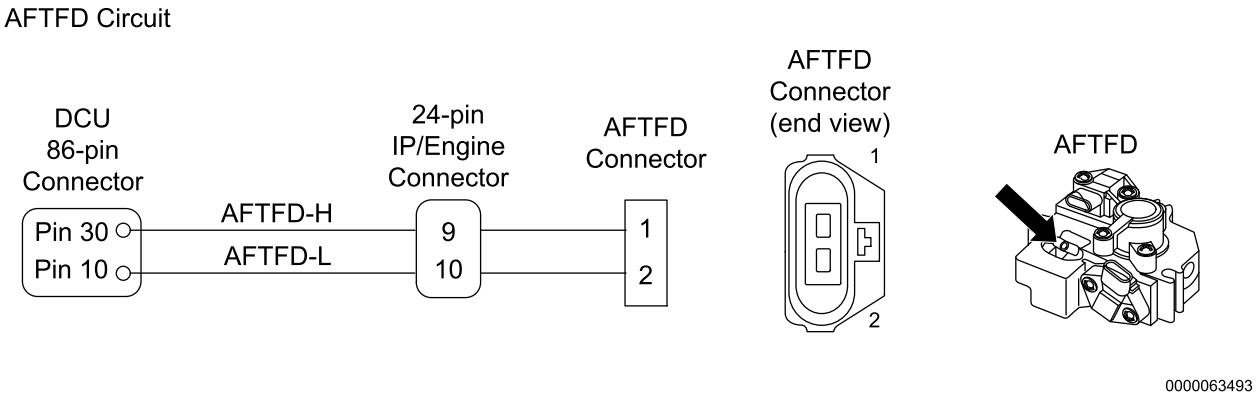


Figure 174 AFTFD Circuit Diagram

Overview

Pressurized fuel is supplied to the AFTFD through the fuel filter housing assembly. When the conditions required for regeneration are met, the Doser Control Unit (DCU) sends voltage to the AFTFD to open and inject fuel into the turbo exhaust pipe.

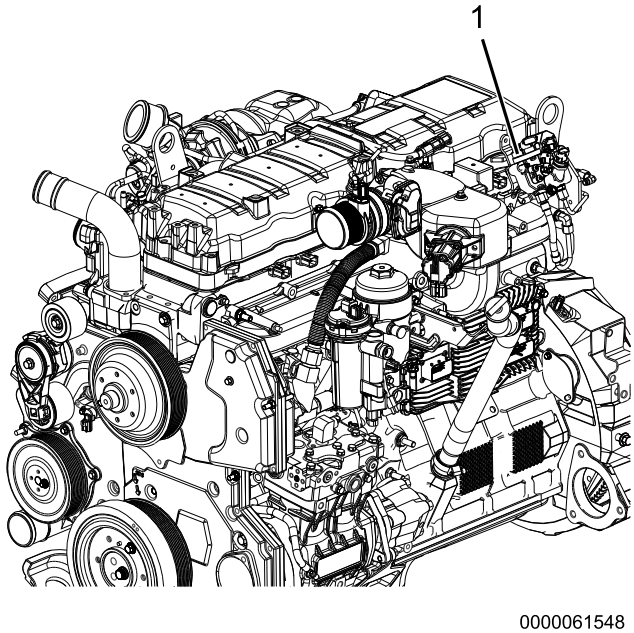


Figure 175 AFTFD Location

1. AFTFD

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- Breakout Harness 6021 (AFTFD) (page 1239)
- International® Electronic Engine Terminal Test Kit (page 1227)

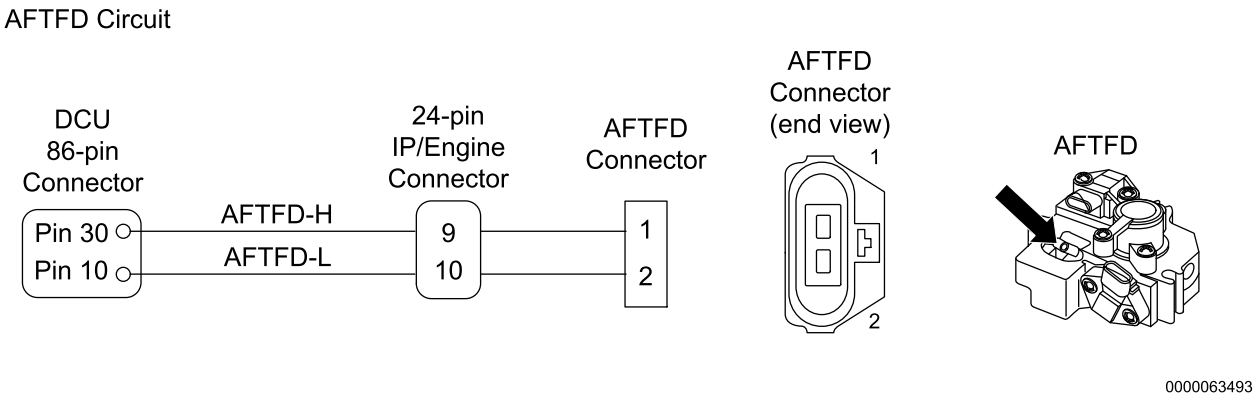


Figure 176 AFTFD Circuit Diagram

AFTFD Pin-point Diagnostics

NOTE: The KOEO Standard Test or KOEO Output State HIGH or LOW does not cycle this actuator.

NOTE: The sensors connected to the Doser Control Unit (DCU) cannot be monitored using ServiceMaxx™ software. If an SPN / FMI is set for this actuator, all you can do is verify that there is not a circuit fault. If circuits check out acceptable, then replace the actuator.

Connector Voltage Check

Test Point	Specification	Comment: < Less than, > Greater than
Connect Breakout Harness to engine harness and leave AFTFD disconnected. Turn ignition switch to ON. Use DMM to measure voltage.		
For ACM Part number 18990993C1		
1 to GND	6.0 ± 1.0 V	If < 5.0 volts, check for OPEN circuit or short to GND, go to Harness Resistance Check (page 324). If > 7.0 volts, check for short to PWR, go to Harness Resistance Check (page 324).
For ACM Part number 7085604C1 or 7094050C1		
1 to GND	12.0 ± 1.0 V	If < 11.0 volts, check for OPEN circuit or short to GND, go to Harness Resistance Check (page 324). If > 13.0 volts, check for short to PWR, go to Harness Resistance Check (page 324).
2 to B+	B+	If < B+, check for OPEN circuit. Do Harness Resistance Check (page 324).
If measurements are within specifications, then replace the AFT Fuel Doser.		

Harness Resistance Check

Test Point	Specification	Comment: < Less than, > Greater than
Turn ignition switch to OFF. Connect Breakout Harness to engine harness and leave AFTFD and DCU disconnected. Use DMM to measure resistance between AFTFD connector and DCU connector.		
1 to GND	> 1 kΩ	If < 1 kΩ check for short to GND.
1 to Pin 30	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
2 to Pin 10	< 5 Ω	If > 5 Ω, check for OPEN circuit.

SPN 3479

FMI 5 – AFT Fuel Doser Valve Open Load / Circuit

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Short to Ground Low Side	Circuit Current < 150 mA	Key ON	5 events
		Battery Voltage > 10.7 Volts AND < 15 Volts	

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

AFTFD Circuit

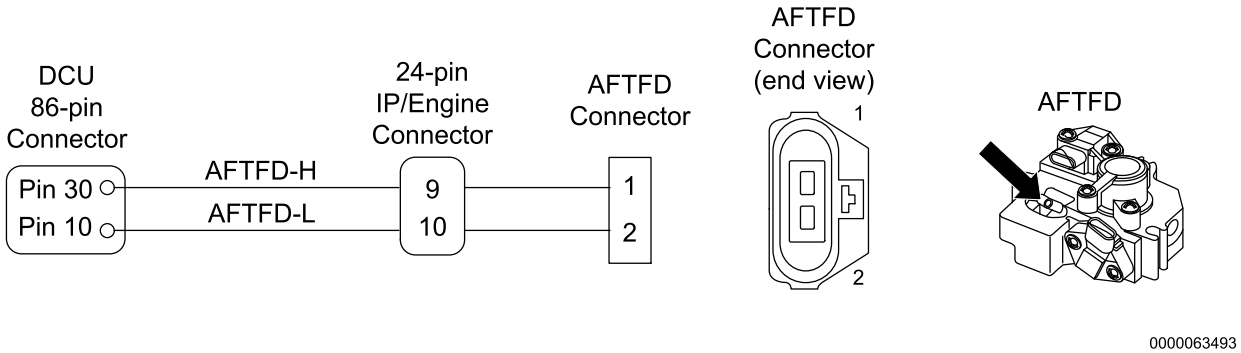


Figure 177 AFTFD Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3479 FMI 5 the only fault code active?	Yes: Go to Step 3.
		No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3479 FMI 5.
		No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit, inspect connections at the Aftertreatment Fuel Doser (AFTFD) valve. With key OFF, disconnect AFTFD connector. Check AFTFD and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the AFTFD connectors, harness, and terminals clean and undamaged?	Yes: Go to Step 4.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3479 FMI 5.

Step	Action	Decision
4	Test AFTFD circuits for short to ground on low side. Do connector voltage checks and resistance checks (page 323). Are AFTFD circuits within specifications?	Yes: Go to Step 5.
		No: Repair circuits as required. After repairs are complete, retest for SPN 3479 FMI 5.

Step	Action	Decision
5	AFTFD is operating within specification. Connect breakout harness 6021 between AFTFD and AFTFD connector. Using EST with ServiceMaxx™ software, do KOEO Aftertreatment Tests (page 87). Does Doser Actuator Test pass?	Yes: After doing all diagnostic steps, if SPN 3479 FMI 5 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace AFTFD. After repairs are complete, retest for SPN 3479 FMI 5.

NOTE: After doing all diagnostic steps, if SPN 3479 FMI 5 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3479 FMI 6 – AFT Fuel Doser Valve High Side Short Circuit

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
High Side Short to Power or Open Load	Circuit Voltage < 0.3 Volts OR > 2 Volts	Key ON	0.05 seconds
		Battery Voltage > 10.7 Volts AND < 15 Volts	

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

AFTFD Circuit

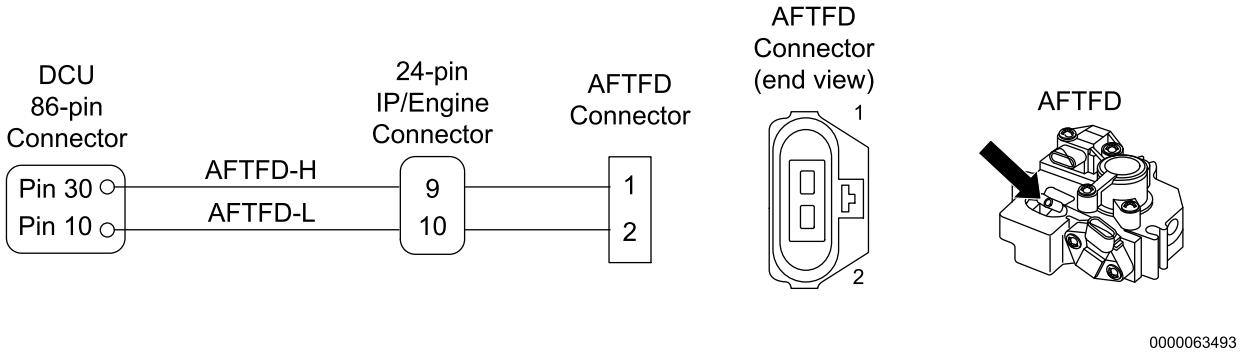


Figure 178 AFTFD Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3479 FMI 6 the only fault code active?	Yes: Go to Step 3.
		No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3479 FMI 6.
		No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit, inspect connections at the Aftertreatment Fuel Doser (AFTFD) valve. With key OFF, disconnect AFTFD connector. Check AFTFD and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the AFTFD connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3479 FMI 6.

Step	Action	Decision
4	Test AFTFD circuits for short to ground on low side. Do connector voltage checks and resistance checks (page 323). Are AFTFD circuits within specifications?	Yes: Go to Step 5.
		No: Repair circuits as required. After repairs are complete, retest for SPN 3479 FMI 6.

Step	Action	Decision
5	AFTFD is operating within specification. Connect breakout harness 6021 between AFTFD and AFTFD connector. Using EST with ServiceMaxx™ software, do Key On Engine Off KOEO Standard Test (page 87). Is voltage within specification (page 1291)?	Yes: After doing all diagnostic steps, if SPN 3479 FMI 6 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace AFTFD. After repairs are complete, retest for SPN 3479 FMI 6.

NOTE: After doing all diagnostic steps, if SPN 3479 FMI 6 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Aftertreatment Fuel Inlet Sensor (AFTIS)

SPN	FMI	Condition	Possible Causes	Actions
3480	3	Aftertreatment Fuel Pressure (AFTFP1) signal Out of Range HIGH	• AFTFP1 signal circuit OPEN or short to PWR • Failed Aftertreatment Fuel Inlet Sensor (AFTFIS)	Pin-point Diagnostics (page 331)
3480	4	AFTFP1 signal Out of Range LOW	• AFTFP1 signal circuit short to GND • Failed AFTFIS	Pin-point Diagnostics (page 331)
5456	2	Aftertreatment Fuel Inlet Temperature (AFTFIT) signal erratic, intermittent, or incorrect	• Biased AFTFIT sensor • High resistance connection at AFTFIT sensor • Low resistance connection at AFTFIT sensor • Wrong Doser Control Unit (DCU)	Step-based Diagnostics (page 546)
5456	3	AFTFIT signal Out of Range HIGH	• AFTFIT signal circuit OPEN or short to PWR • Failed AFTFIS	Pin-point Diagnostics (page 331)
5456	4	AFTFIT signal Out of Range LOW	• AFTFIT signal circuit short to GND • Failed AFTFIS	Pin-point Diagnostics (page 331)

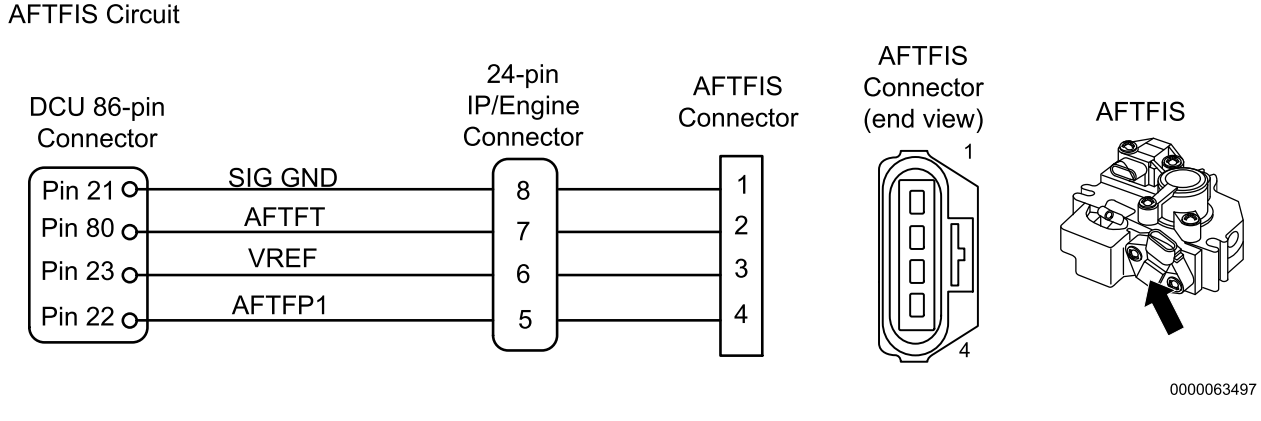


Figure 179 AFTFIS circuit diagram

Overview

The AFTFIS is comprised of a fuel temperature and fuel pressure sensor. The AFTFIS monitors fuel pressure and fuel temperature in the aftertreatment fuel system and provides a feedback signal to the DCU.

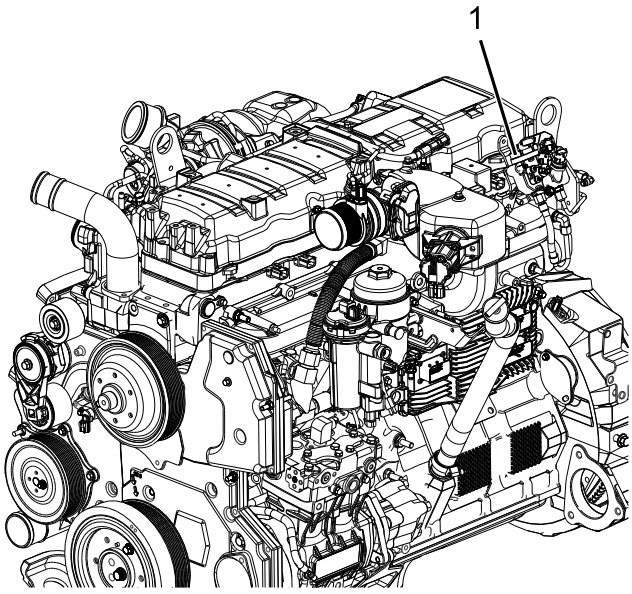


Figure 180 AFTFIS Location

1. AFTFIS

Tools

- EZ Tech® Electronic Service Tool (EST) – J-45067 (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- Breakout Harness 4830 (AFTFIS) (page 1233)
- International® Electronic Engine Terminal Test Kit (page 1227)

AFTFIS Pin-point Diagnostics

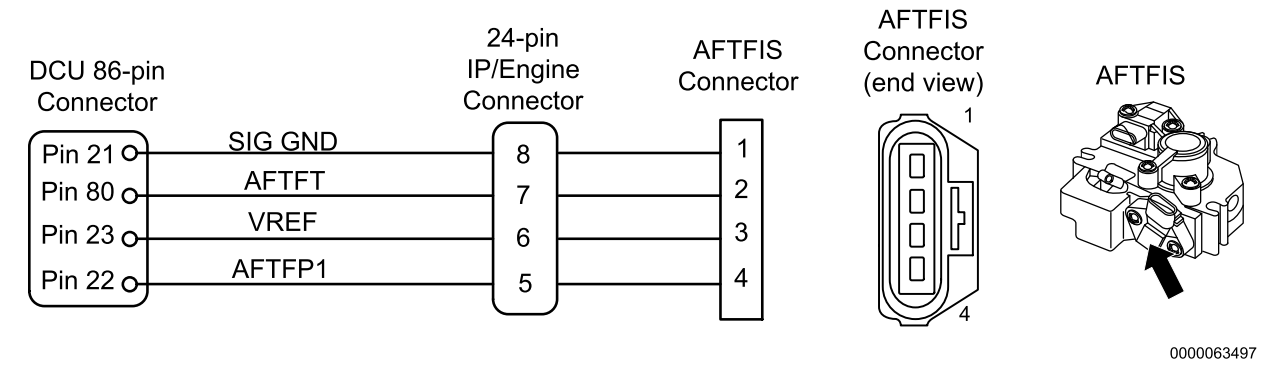


Figure 181 AFTFIS Circuit Diagram

Connector Voltage Check

Test Point	Specification	Comment: < Less than, > Greater than
Connect Breakout Harness. Leave sensor disconnected. Turn the ignition switch to ON. Use DMM to measure voltage.		
1 to B+	B+	If < B+, check SIG GND for OPEN circuit, go to Harness Resistance Check (page 331).
2 to GND	4.8 ± 1.0 V	If < 3.8 volts, check AFTFP1 for OPEN circuit, go to Harness Resistance Check (page 331).
3 to GND	5.0 ± 1.0 V	If < 4.0 volts, check VREF for OPEN circuit, go to Harness Resistance Check (page 331).
4 to GND	4.4 ± 1.0 V	If < 3.4 volts, check VREF for OPEN circuit, go to Harness Resistance Check (page 331).
If circuit measurements are all within specification, then replace the sensor.		

Harness Resistance Check

Test Point	Specification	Comment: < Less than, > Greater than
Turn ignition switch to OFF. Connect Breakout Harness. Leave DCU and AFTFIS disconnected. Use DMM to measure resistance between AFTFIS connector and DCU connector.		
1 to Pin 21	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
2 to Pin 80	< 5 Ω	If > 5 Ω, check AFTFP1 circuit for OPEN.
3 to Pin 23	< 5 Ω	If > 5 Ω, check VREF signal circuit for OPEN.
4 to Pin 22	< 5 Ω	If > 5 Ω, check AFTFT circuit for OPEN.

SPN 5456 FMI 2 – AFTFIT Signal Erratic, Intermittent, or Incorrect

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Comparison of Engine Fuel Temperature 1 sensor to the following sensors after a calibratible cold-soak period (time). Sensor 1 to 4 are in Air group and 5 to 7 are in Liquid group. 1. Engine Intake Manifold 1 Temperature 2. Engine Air Inlet Temperature 3. Engine Turbocharger 2 Compressor Inlet Temperature 4. Engine Charge Air Cooler Outlet Temperature 5. Engine Coolant Temperature 6. Engine Oil Temperature 1 7. Engine Fuel Temperature 1	Engine Intake Manifold 1 Temperature (Bias Hi) > Reference temperature value	Key ON	Immediate
	OR Engine Intake Manifold 1 Temperature (Bias low) ≤ Reference temperature value	Engine Off timer ≥ 28800 seconds	
	Error threshold value for comparison of sensors in same media (Air to Air media): Used for Equilibrium and Reference value calculation > 59°F (15°C)	Engine Coolant Temperature (ECT) ≥ -40°F (-40°C)	
	Error threshold value for comparison of sensors in different media (Air to Liquid media): Used for Equilibrium and Reference value calculation > 59°F (15°C)	Engine in Thermal Equilibrium Condition (Explained in operations summary document)	
	Error threshold value for comparison of sensors in same media (Liquid to Liquid): Used for Equilibrium and Reference value calculation > 59°F (15°C)	Similar sensors agree with other sensors with different group-index	

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
	Error threshold value for comparison of sensors in different media (Liquid to Air or vice versa): Used for Equilibrium and Reference value calculation > 59°F (15°C)	OR Faulty Sensor is alone in its group {No other sensor which measures the same media (in Liquid Path) is identified as a faulty sensor}	

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
	NOTE: Reference temperature value calculation is explained in Operations Summary Document		

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the difference between actual Aftertreatment Fuel Inlet Temperature (AFTFIT) and measured AFTFIT is incorrect or erratic.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

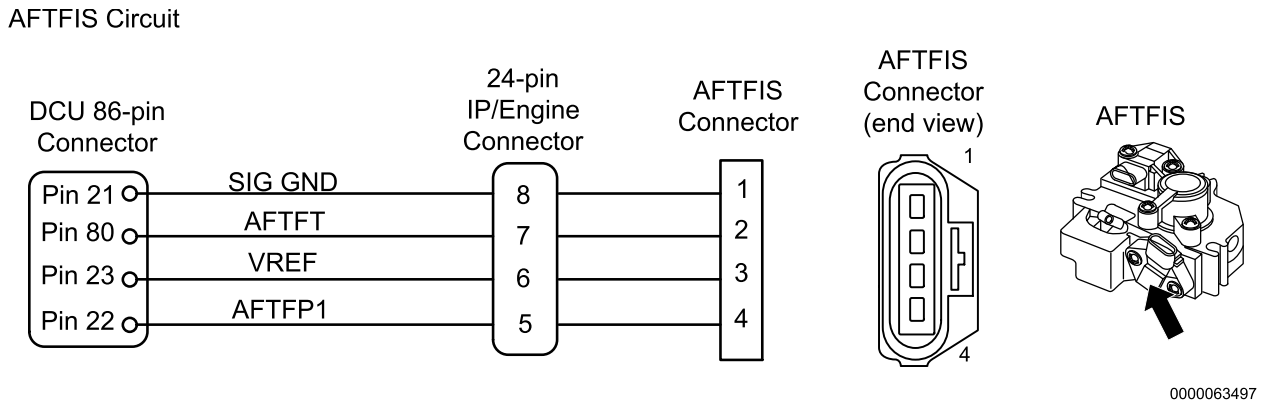


Figure 182 AFTFIS Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for 2013 Doser Control Unit (DCU) and 2013 calibration values. Is DCU the correct one and are calibration values valid for 2013?	Yes: Go to Step 2.
		No: If the CAN bus timing key is off, turn the timing key to ON. If the calibration values are not valid for 2013, load the 2013 values. After repairs are complete, retest for SPN 5456 FMI 2.

Step	Action	Decision
2	Using EST with ServiceMaxx™ software, check for other fault codes. Is SPN 5456 FMI 2 the only fault code active?	Yes: Go to Step 4.
		No: Go to Step 3.

Step	Action	Decision
3	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 5456 FMI 2.
		No: Go to Step 4.

Step	Action	Decision
4	Using terminal test kit, inspect connections at Aftertreatment Fuel Inlet Sensor (AFTFIT). With key OFF, disconnect AFTFIT sensor connector. Check AFTFIT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are AFTFIT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 5.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 5456 FMI 2.

Step	Action	Decision
5	Do Cold Soak Sensor Compare Check KOEO Continuous Monitor Test (page 87). Compare Engine Coolant Temperature (ECT) to Aftertreatment Fuel Inlet Temperature (AFTFIT), Intake Manifold Temperature (IMT), Air Inlet Temperature (AIT), Charge Air Cooler Outlet Temperature (CACOT), and Engine Oil Temperature (EOT) temperature sensors. All sensors should be within 59°F (15°C) of each other. Are all temperature sensors within 59°F (15°C) the other sensors?	Yes: Go to Step 6.
		No: Replace failed temperature sensor. After repairs are complete, retest for SPN 5456 FMI 2.

Step	Action	Decision
6	Test AFTFIT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 331). Are AFTFIT circuits within specifications?	Yes: Go to Step 7.
		No: Repair circuits as required. After repairs are complete, retest for SPN 5456 FMI 2.

Step	Action	Decision
7	Test AFTFIT sensor function. Connect breakout harness between AFTFIT and AFTFIT connector. Perform KOEO voltage check (page 331) of AFTFIT between AFTFIT signal and ground. Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 5456 FMI 2 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace AFTFIS. After repairs are complete, retest for SPN 5456 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 5456 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Aftertreatment Fuel Pressure 2 Sensor (AFTFP2)

SPN	FMI	Condition
4077	3	AFTFP2 signal Out of Range HIGH
4077	4	AFTFP2 signal Out of Range LOW
4077	10	AFTFP2 signal abnormal rate of change

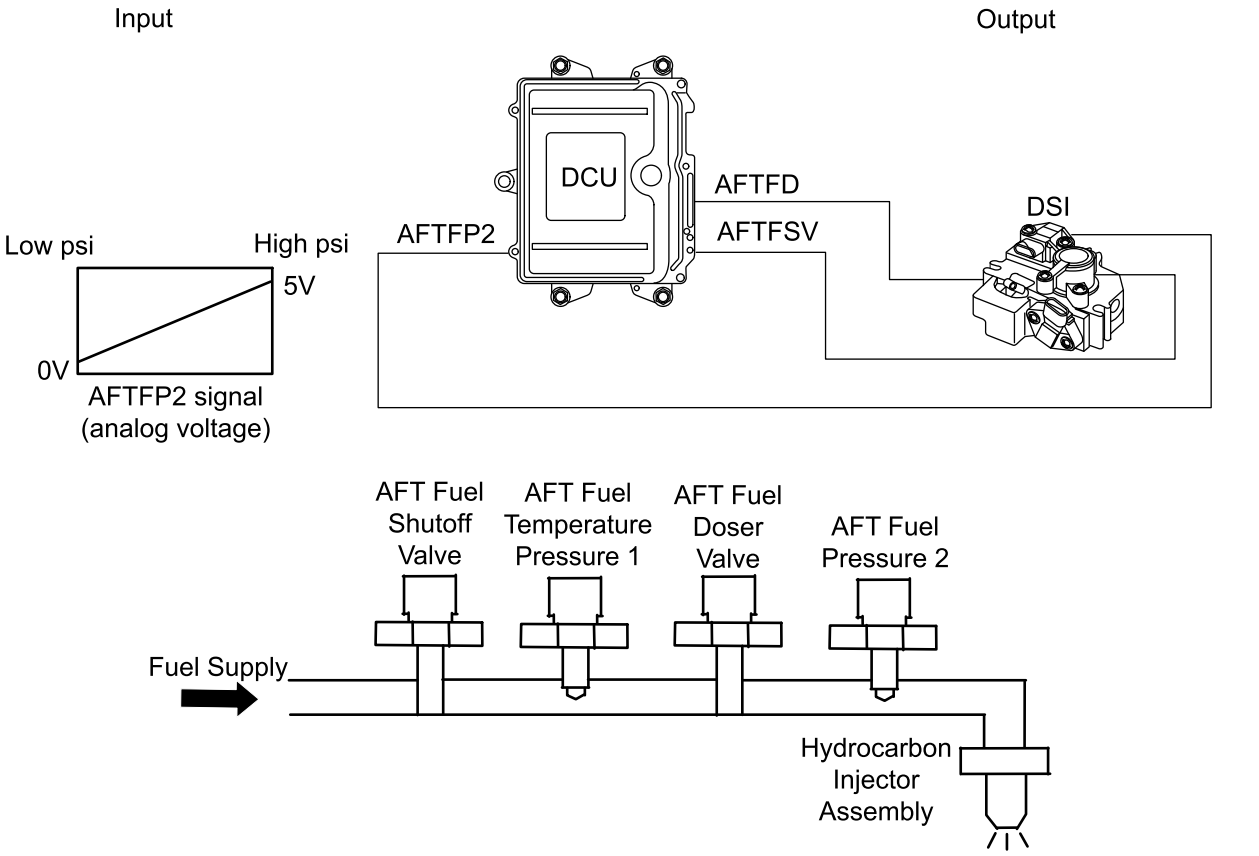


Figure 183 Functional diagram for the AFTFP2 sensor

The functional diagram for the AFTFP2 sensor includes the following:

- Doser Control Unit (DCU)
- Down Stream Injection (DSI) unit
- AFTFP2 sensor
- Aftertreatment Fuel Doser (AFTFD)
- Aftertreatment Fuel Shutoff Valve (AFTFSV)

Function

The AFTFP2 sensor monitors the fuel pressure in the aftertreatment fuel system and provides a feedback signal to the DCU.

Sensor Location

The AFTFP2 sensor is integrated into the Down Stream Injection (DSI) unit located on the left side of the engine, to the rear of fuel filter module.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- Breakout Harness ZTSE6027 (AFTFIS) (page 1233)
- International® Electronic Engine Terminal Test Kit (page 1227)

AFTFP2 Sensor End Diagnostics

SPN	FMI	Condition	Possible Causes
4077	3	AFTFP2 signal Out of Range HIGH	• AFTFP2 signal circuit OPEN or short to PWR • Failed AFTFIS
4077	4	AFTFP2 signal Out of Range LOW	• AFTFP2 signal circuit short to GND • Failed AFTFIS
4077	10	AFTFP2 signal abnormal rate of change	• Biased sensor or circuit

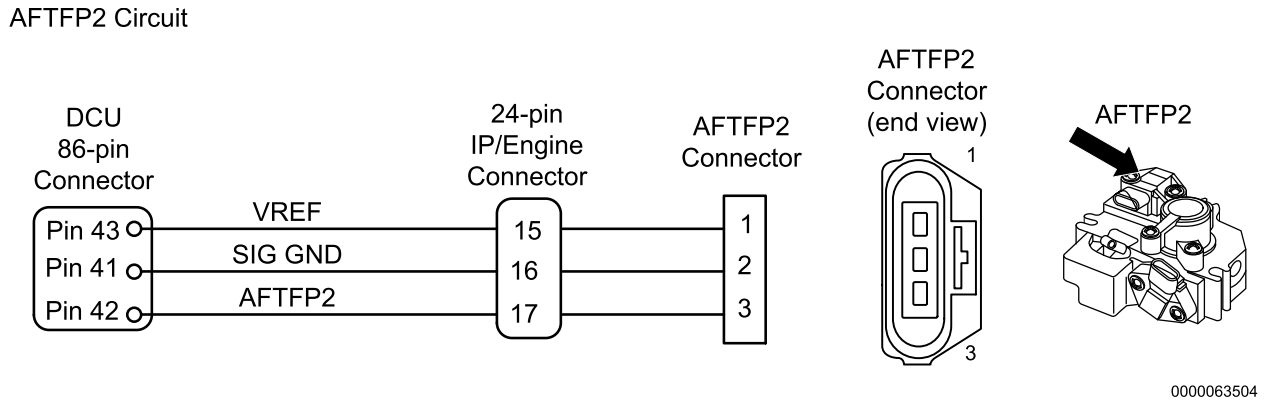


Figure 184 AFTFP2 circuit diagram

NOTE: The sensors connected to the Doser Control Unit (DCU) cannot be monitored using ServiceMaxx™ software. If an SPN / FMI is set for this sensor, all you can do is verify that there is not a circuit fault. If circuits check out acceptable, then replace the sensor.

Connector Voltage Check

Test Point	Specification	Comment: < Less than, > Greater than
Connect Breakout Harness. Leave sensor disconnected. Turn the ignition switch to ON. Use DMM to measure voltage.		
1 to GND	5.0 ± 1.0 V	If < 4 volts, check VREF for OPEN circuit, go to Harness Resistance Check (page 341).
2 to B+	B+	If < B+, check SIG GND for OPEN circuit, go to Harness Resistance Check (page 341).
3 to GND	5.4 ± 1.0 V	If < 4.4 volts, check AFTFP2 for OPEN circuit, go to Harness Resistance Check (page 341).
If circuit measurements are all within specification, then replace the sensor.		

AFTFP2 Pin-point Diagnostics

Harness Resistance Check

Test Point	Specification	Comment: < Less than, > Greater than
Turn ignition switch to OFF. Connect Breakout Harness. Leave DCU and AFTFP2 sensor disconnected. Use DMM to measure resistance between AFTFP2 connector and DCU connector.		
1 to Pin 43	< 5 Ω	If > 5 Ω, check VREF signal circuit for OPEN.
2 to Pin 41	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
3 to Pin 42	< 5 Ω	If > 5 Ω, check AFTFP2 circuit for OPEN.

AFTFP2 Circuit Operation

The AFTFP2 sensor is a pressure sensor that is supplied with 5 volts at Pin 1 from DCU Pin 43. The sensor is grounded at Pin 2 from DCU Pin 41 and returns a variable voltage signal from Pin 3 to DCU Pin 42.

Aftertreatment Fuel Shutoff Valve (AFTFSV)

SPN	FMI	Condition
3482	3	AFT Fuel Shutoff Valve short to PWR
3482	4	AFT Fuel Shutoff Valve short to GND
3482	7	AFT Fuel Shutoff Valve not responding as expected

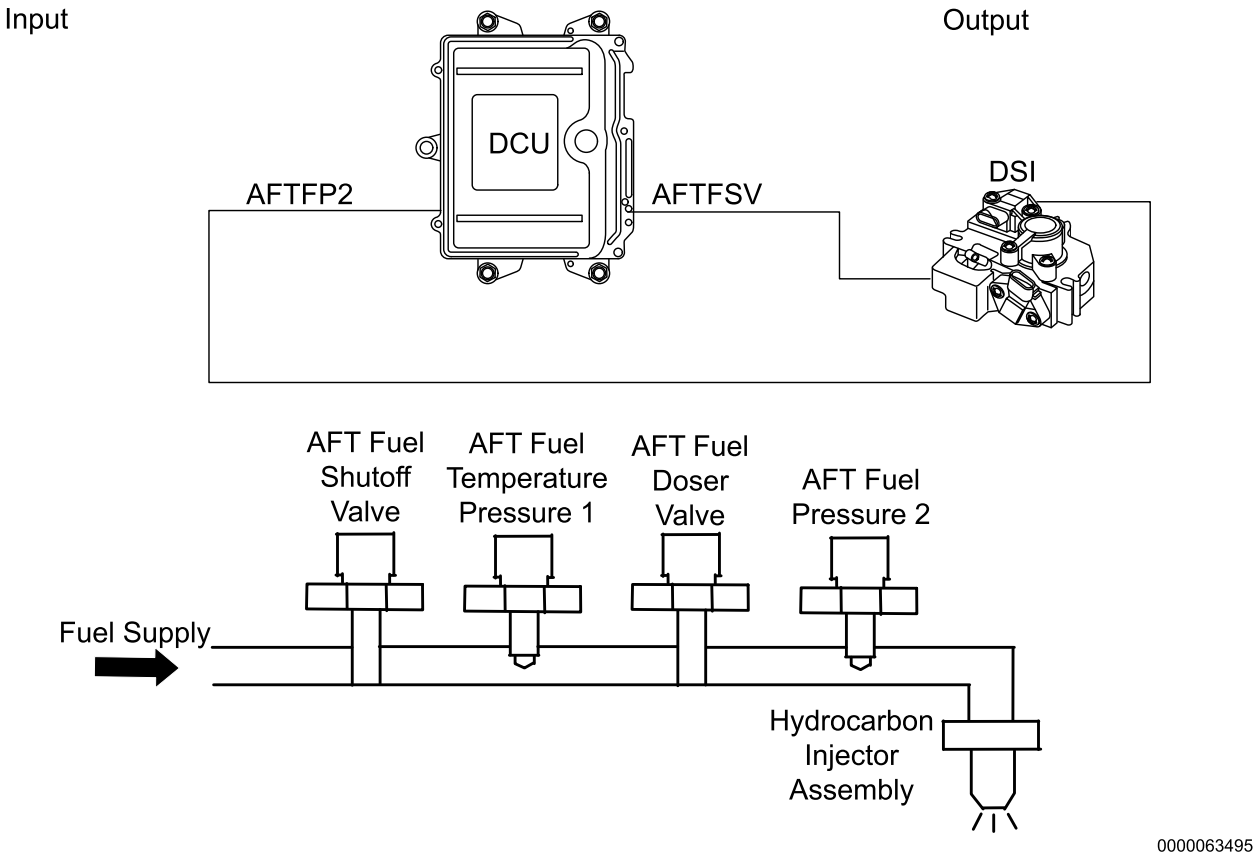


Figure 185 Functional diagram for AFTFSV

The functional diagram for the AFTFSV valve includes the following:

- Doser Control Unit (DCU)
- Down Stream Injection (DSI) unit
- Aftertreatment Fuel Pressure 2 (AFTFP2)
- Aftertreatment Fuel Shutoff Valve (AFTFSV)

Function

The AFTFSV controls the fuel supply to the AFTFD when regeneration is required. The AFTFSV is controlled by the DCU.

Component Location

The AFTFSV is integrated into the Down Stream Injection (DSI) unit located on the left side of the engine, to the rear of fuel filter module.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- Breakout Harness 4602 (AFTFSV) (page 1230)
- International® Electronic Engine Terminal Test Kit (page 1227)

AFTFSV Connector End Diagnostics

SPN	FMI	Condition	Possible Causes
3482	3	AFT Fuel Shutoff Valve short to PWR	• AFTFSV circuit OPEN or short to PWR • Failed AFTFSV
3482	4	AFT Fuel Shutoff Valve short to GND	• AFTFSV circuit short to GND • Failed AFTFSV
3482	7	AFT Fuel Shutoff Valve not responding as expected	• Biased AFT Fuel Pressure 1 sensor or circuit • AFT Fuel Shutoff Valve failure

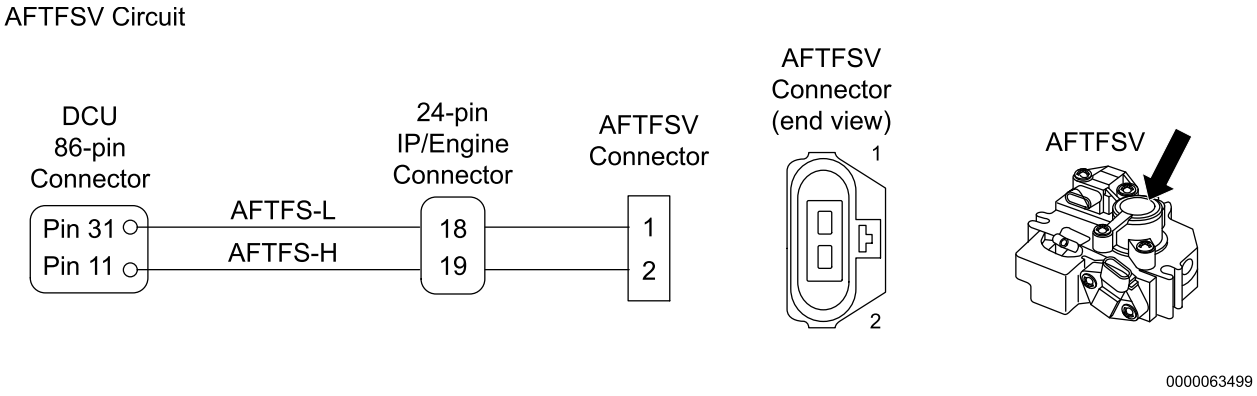


Figure 186 AFTFSV circuit diagram

NOTE: The KOEO Standard Test or KOEO Output State HIGH or LOW does not cycle this actuator.

NOTE: The sensors connected to the Doser Control Unit (DCU) cannot be monitored using ServiceMaxx™ software. If an SPN / FMI is set for this sensor, all you can do is verify that there is not a circuit fault. If circuits check out acceptable, then replace the sensor.

Connector Voltage Check

Test Point	Specification	Comment: < Less than, > Greater than
Connect Breakout Harness to engine harness and leave AFTFSV disconnected. Turn ignition switch to ON. Use DMM to measure voltage after 60 seconds.		
For ACM part number 1890993C1		
1 to GND	6.0 ± 1.0 V	If < 5.0 volts, check for OPEN circuit or short to GND, go to Harness Resistance Check (page 345). If > 7.0 volts, check for short to PWR, Do Harness Resistance Check (page 345).
For ACM part number 7085804C1 or 7094050C1		
1 to GND	12.0 ± 1.0 V	If < 11.0 volts, check for OPEN circuit or short to GND, go to Harness Resistance Check (page 345). If > 13.0 volts, check for short to PWR, Do Harness Resistance Check (page 345).
2 to B+	B+	If < B+, check for OPEN circuit. go to Harness Resistance Check (page 345).
If measurements are within specifications, replace AFT Fuel Shutoff Valve.		

Harness Resistance Check

Test Point	Specification	Comment: < Less than, > Greater than
Turn ignition switch to OFF. Connect Breakout Harness to engine harness and leave AFTFSV and DCU disconnected. Use DMM to measure resistance between AFTFSV connector and DCU connector.		
1 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
1 to 19	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
2 to 18	< 5 Ω	If > 5 Ω, check for OPEN circuit.

AFT System (Aftertreatment)

SPN	FMI	Condition	Possible Causes	Actions
3246	2	*Follow SPN 3246 FMI 20 Pin-point Diagnostics (page 353)*		
3246	20	DPFOT signal drifted HIGH	• Restricted Diesel Particulate Filter (DPF) • Diesel Oxidation Catalyst (DOC) failure • Engine over fueling • Downstream Injection over fueling • Biased Diesel Particulate Filter Outlet Temperature (DPFOT) sensor or circuit	Pin-point Diagnostics (page 353)
3246	21	DPFOT signal drifted low	• DPFOT sensor not connected to exhaust system • Exhaust system not attached to the engine • High resistance connections to DPFOT sensor	Step-based Diagnostics (page 359)
3251	0	DPFDP excessively high (plugged filter)	• Restricted or plugged filter • Biased Diesel Particulate Filter Differential Pressure (DPFDP) sensor or circuit • Reversed DPF sensor hoses	Step-based Diagnostics (SPN 3251 FMI 0 – DPFDP Excessively HIGH, page 359)
3251	2	DPFDP signal erratic, intermittent, or incorrect	• Biased DPFDP sensor or circuit • Restricted or plugged DPF • Reversed DPF sensor hoses	Step-based Diagnostics (page 363)
3251	14	DPFDP sensor pressure hoses reversed	• Reversed DPFDP hoses • Restriction in prefilter hose • Biased, damage, or faulty sensor or circuit • Missing DPF	Step-based Diagnostics (page 367)

SPN	FMI	Condition	Possible Causes	Actions
3251	21	DPFDP excessively low (sensor / circuit fault or missing DPF)	• DPFDP sensor tubes restricted or open • Biased DPFDP sensor or circuit	Pin-point Diagnostics (page 352)
3556	0	AFT Fuel Pressure 2 below Warning Pressure	• Hydrocarbon injector assembly failure (plugged) • Biased Aftertreatment (AFT) fuel pressure 2 sensor or circuit	Pin-point Diagnostics (page 352)
3556	1	AFT fuel pressure 2 below desired (possible system leak)	• Fuel leak from metering unit • Biased AFT fuel pressure 2 sensor or circuit	Pin-point Diagnostics (page 352)
3556	7	AFT fuel injector not responding as expected	• Hydrocarbon injector assembly failure (plugged) • Biased AFT fuel pressure 2 sensor or circuit	Pin-point Diagnostics (page 353)
3719	0	DPF soot load – highest (level 3/3)	• Level 3 DPF plugged • Remove DPF for servicing	Pin-point Diagnostics (page 353)
3719	15	DPF soot load – lowest (level 1/3)	• Level 1 DPF regeneration required	Pin-point Diagnostics (page 353)
3719	16	DPF soot load – moderate (level 2/3)	• Level 2 DPF regeneration required	Pin-point Diagnostics (page 353)
3936	0	DPF soot load – severe de-rate	• Level 3 DPF plugged • Remove DPF for servicing	Pin-point Diagnostics (page 354)
3936	2	DOC / DPF Inlet unable to achieve light off temperature	• Active regeneration SPN / FMI Code inhibitor • Biased DPFDP sensor or circuit • Engine unable to build enough heat to the DOC • DOC failure • Downstream Injection (DSI) failure to inject fuel to the exhaust • DPF failure	Pin-point Diagnostics (page 354)

SPN	FMI	Condition	Possible Causes	Actions
3936	8	DPF regenerations are occurring too frequently	• Low Turbocharger Boost Levels • Turbocharger boost leaks • Exhaust Gas Recirculation (EGR) high flow • Injector coking • Ash in DPF • Exhaust system leaks • Engine Compression Brake (ECB) is not relieving pressure • Valve Lash • Air / Fuel ratio is incorrect • DPFDP reading high	Step-based Diagnostics (page 370)
3936	14	DPF regeneration duration above limit	• Engine unable to build enough heat to the DOC • DOC failure • DSI failure to inject fuel into the exhaust • DPF failure	Pin-point Diagnostics (page 354)
3936	20	DOC inlet unable to achieve light off temperature	• Biased or Failed DPFIT sensor or circuit, • Biased or Failed Air Inlet Temperature (AIT) Sensor or circuit • Exhaust leaks • DSI Fault • DSI System Leak • Hydrocarbon Injection (HCI) or HCI housing Plugged • DOC failed or missing	Step-based Diagnostics (page 375)

SPN	FMI	Condition	Possible Causes	Actions
4766	10	DOCOT below minimum desired during regeneration	• Exhaust leaks • Biased sensor or circuit • Plugged air filter • Fuel Delivery Pressure (FDP) low • Aftertreatment DSI malfunction • Fuel leaks • HCI housing plugged • DOC failure (face plugged), material failure, or missing • Diesel Oxidation Catalyst Outlet Temperature (DOCOT) not heating up during exhaust injection	Step-based Diagnostics (page 380)
5319	31	DPF incomplete regeneration	• Biased DPFDP sensor or circuit • High DPFDP after DPF regeneration • DPFDP hoses damaged or restricted • Boost below spec • Exhaust leaks • High ash levels in DPF	Step-based Diagnostics (page 388)

Overview

The function diagram for the AFT System includes the following:

- Engine Control Module (ECM)
  with Barometric Absolute Pressure (BARO) Internal Sensor
- Body Controller (BC)
- Multiplex System Module (MSM) Body Module
- Accelerator Pedal Position (APP) Sensor
- Park Brake
- Vehicle Speed Sensor (VSS)
- Drive-line Disconnect Switch (DDS)
- Power Take Off Switch (PTO)
- Diesel Oxidation Catalyst (DOC)
- Diesel Particulate Filter (DPF)
- DPF Inlet Temperature (DPFIT) 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
- Intake Air Heater (IAH)
- Doser Control Unit (DCU)
- AFT Fuel Pressure Inlet Sensor (AFTFIS)
- AFT Fuel Pressure 2 (AFTFP2) sensor
- AFT Fuel Shutoff Valve (AFTFSV)
- AFT Fuel Doser (AFTFD)
- Downstream Injection (DSI) unit

The purpose of the Aftertreatment (AFT) System is to catalyze carbon monoxide (CO), Oxides of Nitrogen (NO_x), 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 1000°F (538°C), for a period of time, depending on the amount of soot that accumulated within the DPF. Regeneration time is calculated by the Engine Gas Differential Pressure (DPFDP) feedback.

Regeneration may take place as the vehicle is in operation under a steady state heavy engine loading condition, or by forcing a Stationary Regeneration process.

During a Stationary Regeneration the engine speed is increased, while the Engine Control Module (ECM) controls the engine systems. These system include post-injection, Exhaust Gas Recirculation (EGR), and Engine Throttle Valve (ETV). This increases the heat going into the exhaust system. The Intake Air Heater (IAH) will also cycle on and off, not just increase the Air Intake Temperature (AIT), but also add extra load on the engine. The Doser Control Unit (DCU) controls the Down Stream Injection (DSI) system to inject fuel into the exhaust just before the DOC.

The health of the system and the Regen processes are monitored by the DOC Inlet Temperature (DOCIT), DPF Inlet Temperature (DPFIT), DPF Outlet Temperature (DPFOT), and the Diesel Particulate Filter Differential Pressure (DPFDP) sensor. The DPFDP measures the pressure difference across the DPF filter. The temperature sensors measure the temperature differences across the DOC and DPF.

The DPF and 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.

Tools

- EZ Tech® Electronic Service Tool (EST) – J-45067 (page 1226)
- International® Electronic Engine Terminal Test Kit (page 1227)

Pin-point Diagnostics

AFT System Event Map

<table>
<tr><th>Engine</th><th>AFT System</th><th>Communication</th><th>Driver Response</th></tr>
<tr><td>Engine out of regeneration mode DPFDP monitors soot level.</td><td>DPF collects soot produced by engine.</td><td rowspan="4">SPN / FMI: None
Lamp: HEST lamp if DPFOT is above 752ºF (400ºC) and under 5 mph.</td><td rowspan="4">No response needed.</td></tr>
<tr><td rowspan="3">Engine in regeneration mode.
Changes in Air management and fueling, fuel is injected into the exhaust system.
Exhaust sensors are monitored.</td><td>Soot level threshold is reached, system triggers DPF regeneration.</td></tr>
<tr><td>DOC converts fuel to increase DPF temp.</td></tr>
<tr><td>Soot burns as elevated temp is reached.</td></tr>
<tr><td>Engine in regeneration mode.</td><td>Soot may continue to increase in the DPF due to inability to properly regenerate the filter.</td><td>SPN 3719 FMI 15 DPF, soot Lowest (level 1/3).</td><td>Drive at highway speed or start a parked Regen.</td></tr>
<tr><td>Engine in regeneration mode.
15 % Engine De-rate.</td><td rowspan="2"></td><td>SPN 3719 FMI 16 DPF, soot Moderate (level 2/3).</td><td>Perform Parked Regen.</td></tr>
<tr><td>Engine in regeneration mode.
85 % Engine De-rate.</td><td>SPN 3719 FMI 0 DPF, soot Highest (level 3/3).</td><td>Remove DPF for servicing.</td></tr>
</table>

SPN 3556 FMI 0 – AFT Fuel Pressure 2 Below Warning Pressure

See *0000003221* for circuit diagrams.

1. Check for loose, damaged or corroded pins or connectors at 86 pin ACM connector and 3 pin AFTFP2 connector

SPN 3556 FMI 1 – AFT Fuel Pressure 2 Below Desired (Possible System Leak)

See *0000003221* for circuit diagrams.

1. Check for loose, damaged or corroded pins or connectors at the 86 pin ACM connector & 3 pin AFTFP2 connector.

SPN 3556 FMI 7 – AFT Fuel Not Responding as Expected

Verify ECM Calibration is current.

Preform circuit checks from AFTFP2 @ the DSI module to ACM 86-Pin Connector

1. Pin 1 @ AFTFP2 to Pin 43 @ the ACM 86-Pin Connector
2. Pin 2 @ AFTFP2 to Pin 41 @ the ACM 86-Pin Connector
3. Pin 3 @AFTFP2 to Pin 42 @ the ACM 86-Pin Connector

SPN 3246 FMI 20 – DPFOT signal drifted HIGH

Pin-point AFT System Fault

SPN 3246 FMI 20 sets if DPF inlet or outlet temperature increases beyond maximum threshold. As a preventive measure, this fault disables regeneration until the next switch ON cycle.

1. Inspect DPFIT and DPFOT sensors for damage, loose connection, and sensor / harness rupture.
2. Check for biased exhaust temperature sensor. See Sensor Compare Checks.
3. Check for active / previously active faults indicating high soot load in DPF. Any of SPN 3719 FMI 0, 15, 16, or SPN 3936 FMI 0.
4. Perform DPF Filter Cleanliness Test from the service tool. If test result confirms reduced DOC efficiency, go to Parked Regeneration Checks .
5. Check for active / previously active fault codes referring to injector leakage.

SPN 3719 FMI 0 – DPF Soot Load – Highest (level 3/3)

Pin-point AFT System Fault

SPN 3719 FMI 0 sets when Level 3 DPF soot loading is over 100 % full and engine de-rate has been enabled. DPF regeneration is required.

See Symptom 3 (MEDIUM DUTY): SPN 3719 OR SPN 3936 Active Only or Frequent Regens (More than One Parked Regen Per Day) of *Aftertreatment Symptom-Based Diagnostic and Inspection Manual 0000003081.*

SPN 3719 FMI 15 – DPF Soot Load – Lowest (level 1/3)

Pin-point AFT System Fault

SPN 3719 FMI 15 sets when Level 1 DPF soot loading is above 80 % full and a DPF regeneration is required.

See Symptom 3 (MEDIUM DUTY): SPN 3719 OR SPN 3936 Active Only or Frequent Regens (More than One Parked Regen Per Day) of *Aftertreatment Symptom-Based Diagnostic and Inspection Manual 0000003081.*

SPN 3719 FMI 16 – DPF Soot Load – Moderate (level 2/3)

Pin-point AFT System Fault

SPN 3719 FMI 16 sets when Level 2 DPF soot loading is 100 % full and a DPF regeneration is required.

See Symptom 3 (MEDIUM DUTY): SPN 3719 OR SPN 3936 Active Only or Frequent Regens (More than One Parked Regen Per Day) of *Aftertreatment Symptom-Based Diagnostic and Inspection Manual 0000003081.*

SPN 3936 FMI 0 – DPF Soot Load – Severe De-Rate

Pin-point AFT System Fault
SPN 3936 FMI 0 sets when Level 4 DPF soot loading is overfull and engine shutdown is enabled. DPF regeneration functionality has been disabled.
See Symptom 3 (MEDIUM DUTY): SPN 3719 OR SPN 3936 Active Only or Frequent Regens (More than One Parked Regen Per Day) of *Aftertreatment Symptom-Based Diagnostic and Inspection Manual 0000003081.*

AFT System Cold Soak Sensor Compare Check

Cold Soak Sensor Compare Check
Temperature values need to be measured after four hours cold soak.

1. Turn switch ON, engine OFF
2. Using ServiceMaxx™ software, open the Continuous Monitor session.
3. Compare Diesel Particulate Filter Inlet Temperature (DPFIT), Diesel Oxidation Catalyst Inlet Temperature (DOCIT) and Diesel Particulate Filter Outlet Temperature (DPFOT). All temperature sensors should be within 68°F (20°C) of each other.
   - If any temperature sensor is above or below of the other sensors. Check for poor circuitry going to temperature sensor that is out of specification.
   - If the circuits are okay, replace failed temperature sensor.

SPN 3246 FMI 21 – DPFOT Signal Drifted LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Aftertreatment 1 Diesel Particulate Filter Outlet Temperature (DPFOT) stuck low	Aftertreatment 1 Diesel Particulate Filter Outlet Gas Temperature < 338°F (170°C)	Particulate Filter Regeneration NOT Active End Of Line Testing NOT Active [Engine Brake (Retarder) NOT active AND minimum wait time after retarder change of state has occurred] > 5 seconds Engine Torque limitation NOT Active Battery Voltage ≥ 10.787 Volts AND ≤ 15.787 Volts Engine Ignition Key is in "ON" position (Key ON) Time after engine start ≥ 30 seconds Engine Coolant Temperature (ECT) ≥ 19°F (-7°C) AND ≤ 230°F (110°C) 1. Engine Speed > 1500 RPM 2. Total Fueling quantity >100 mg/stk	15 seconds

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		3. Engine Intake Manifold #1 Pressure > 22 psi (150 kPa) Time spent in entry conditions 1 through 3 > 499 * 0.1 seconds Engine Inlet Air temperature < 140°F (60°C) SPN / FMIs 3246/3 and 3246/4 are NOT Active	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the DPFOT is less than 500°F (260°C).

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for fault codes. Is SPN 3246 FMI 21 the only fault code active?	Yes: Go to Step 3.
		No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3246 FMI 21.
		No: Go to Step 3.

Step	Action	Decision
3	Commence four hour cold soak for Step 5 below. Inspect exhaust system for reversed sensor hoses, restrictions, leaks, or physical damage. Is exhaust system free of restrictions, leaks, and physical damage?	Yes: Go to Step 4.
		No: Repair restrictions, leaks, or physical damage. After repairs are complete, retest for SPN 3246 FMI 21.

Step	Action	Decision
4	Using terminal test kit, inspect connections at DPFOT sensor. With Key OFF, disconnect DPFOT sensor. Check DPFOT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Is the DPFOT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 5.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3251 FMI 21.

Step	Action	Decision
5	Do Cold Soak Sensor Compare Check (page 1145). Compare Diesel Particulate Filter (DPF) Inlet Temperature (DPFIT), Diesel Oxidation Catalyst (DOC) Inlet Temperature (DOCIT), and DPF Outlet Temperature (DPFOT). All sensors should be within 68°F (20°C) of each other. Are all temperature sensors within 68°F (20°C) the other sensors?	Yes: Go to Step 6.
		Replace failed temperature sensor. After repairs are complete, retest for SPN 3246 FMI 21.

Step	Action	Decision
6	Test DPFOT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 518). Are DPFOT circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 7.
		No: Repair circuits as required. After repairs are complete, retest for SPN 3246 FMI 21.

Step	Action	Decision
7	Test DPFOT sensor. Connect breakout harness 4760A between DPFOT sensor and DPFOT sensor connector. Perform KOEO voltage check of DPFOT sensor between DPFOT signal and ground. Is voltage within specification (page 1317)?	Yes: After doing all diagnostic steps, if SPN 3246 FMI 21 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace DPFOT sensor. After repairs are complete, retest for SPN 3246 FMI 21.

NOTE: After doing all diagnostic steps, if SPN 3246 FMI 21 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3251 FMI 0 – DPFDP Excessively HIGH

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
N/A			

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN / FMI: 3246/20, 3251/2, 3251/21, 3556/0, 3556/1, 3556/7, 3719/0, 3719/15, 3719/16, 3936/0, 3936/2, and 3936/14

Drive Cycle to Determine Fault Status

N/A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for fault codes. Is SPN 3251 FMI 0 the only fault code active?	Yes: Go to Step 3.
		No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3251 FMI 0.
		No: Go to Step 3.

Step	Action	Decision
3	Commence four hour cold soak for Step 6 below. Inspect exhaust system for reversed sensor hoses, restrictions, leaks, or physical damage. Is exhaust system free of restrictions, leaks, and physical damage?	Yes: Go to Step 4.
		No: Repair restrictions, leaks, or physical damage. After repairs are complete, retest for SPN 3251 FMI 0.

Step	Action	Decision
4	Using terminal test kit, inspect connections at Diesel Particulate Filter Differential Pressure (DPFDP), Intake Air Heater (IAH), and Down Stream Injection (DSI) sensors. With key OFF, disconnect DPFDP, IAH, and DSI sensors. Check DPFDP, IAH, and DSI sensors and connectors for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are DPFDP, IAH, and DSI sensor connectors, harnesses, and terminals clean and undamaged?	Yes: Go to Step 5. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3251 FMI 0.

Step	Action	Decision
5	Test DPFDP, IAH, and DSI circuits for open, short, or high resistance conditions. Do DPFDP connector voltage checks and resistance checks (page 495), IAH connector voltage checks and resistance checks (page 824), and DSI connector voltage checks and resistance checks (page 323). Are DPFDP, IAH, and DSI circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 6. No: Repair circuits as required. After repairs are complete, retest for SPN 3251 FMI 0.

Step	Action	Decision
6	Check the health of the regeneration system. Do Cold Soak Sensor Compare Check (page 1145). Compare Diesel Particulate Filter Inlet Temperature (DPFIT), Diesel Oxidation Catalyst Inlet Temperature (DOCIT), and Diesel Particulate Filter Outlet Temperature (DPFOT). All sensors should be within 68°F (20°C) of each other. Is DPFIT within 68°F (20°C) the other sensors?	Yes: Go to Step 7. No: Replace out of specification sensor. After repairs are complete, retest for SPN 3251 FMI 0.

Step	Action	Decision
7	Test DPFDP, IAH, and DSI for intermittent circuit operation using EST with ServiceMaxx™ software. Do Key On Engine Off Continuous Monitor Test (page 87). Verify sensor voltages are within specifications. Is voltage within specification?	Yes: Go to step 8.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuits as required. After repairs are complete, retest for SPN 3251 FMI 0.

Step	Action	Decision
8	Remove DOC and DPF and inspect DPF internals for restrictions, damage, or evidence of defects. Look for:	Yes: Clean DPF using the appropriate DPF cleaning equipment using cleaning equipment instructions. Re-install DPF. Go to Step 9. After repairs are complete, retest for SPN 3251 FMI 0.
	• Black on both ends of filter • Black holes on clean side (not more than 20 allowed) • Discoloration rings • Chipped, cracked, dented, or bent rims • Packing failure • Oil soaked Does DPF meet all cleaning requirements?	No: Replace DPF. After replacement is complete, retest for SPN 3251 FMI 0.

WARNING: To prevent personal injury or death, do not perform an On Board Filter Cleanliness Test (OBFCT) or Parked Regeneration if liquid oil or fuel is present or suspected to be present in the DPF. Liquid oil or fuel will ignite during an OBFCT causing fires or damage to the vehicle or other equipment.

Step	Action	Decision
9	Using EST with ServiceMaxx™ software, start an On Board Filter Cleanliness Test (OBFCT). Is OBFCT running without an Abort Message in ServiceMaxx™?	Yes: Go to Step 10.
		No: Correct Parked Regen Inhibitors and redo step 8.

Step	Action	Decision
10	While running OBFCT, inspect for exhaust system for leaks or physical damage. Is exhaust system free of leaks and physical damage?	Yes: Go to Step 11.
		No: Repair leaks and / or physical damage. After repairs are complete, retest for SPN 3251 FMI 0.

Step	Action	Decision
11	After OBFCT is complete, does Diesel Particulate Filter Differential Pressure (DPFDP) signal measure below 0.5 psi (3 kPa) at high idle?	Yes: After doing all diagnostic steps, if SPN 3251 FMI 0 remains, verify each step was completed correctly and proper decisions were made. Notify supervisor for further action.
		No: Remove DPF and inspect for restrictions. If restricted, have the DPF cleaned using the appropriate DPF cleaning equipment. After repairs are complete, retest for SPN 3251 FMI 0.

NOTE: After doing all diagnostic steps, if SPN 3251 FMI 0 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3251 FMI 2 - DPFDP signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Particulate Filter Differential Pressure (DPFDP) sensor Key ON check indicates signal in-range but not rational or stuck in range.	Absolute value of DPFDP > 0.25 psi (1.5 kPa) Range of DPFDP since last monitor decision when Enable Conditions are met < 0.15 psi (1 kpa)	Key-On Engine-Running (KOER) > 30 seconds DPF Regeneration NOT Active Engine Brake Not Active > 5 seconds Battery voltage >=10.73 volts and <=15.13 volts Engine Speed >= 1000 RPM Engine coolant temperature >-58F (-50C) Intake Air Temperature >19.4F (-7C) Vehicle Speed >= 0 km/hr Exhaust gas flow > 600000 l/hr AND <= 2400000 l/hr Average DPFIT and DPFOT temperature > 392F (200C) and < 752F (400C) Inactive: SPN 108 FMI 3 and 4 (BARO); SPN 110 FMI 3 and 4 (ECT1); SPN 132 FMI 3 and 4 (MAF); SPN 172 FMI 3 and 4 (MAF); SPN 636 FMI 2, 7, 8 and 10 (CMP); SPN 3251 FMI 3, 4 (DPFDP).	Immediate

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects the aftertreatment Diesel Particulate Filter Differential Pressure (DPFDP) is greater than 0.25 psi (1.5 kpa), is not changing with engine conditions, or range since last monitor < 0.15 psi (1 kpa).

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 3251 FMI 3, 4 (DPFDP); SPN 3512 FMI 14 (VREF-4)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

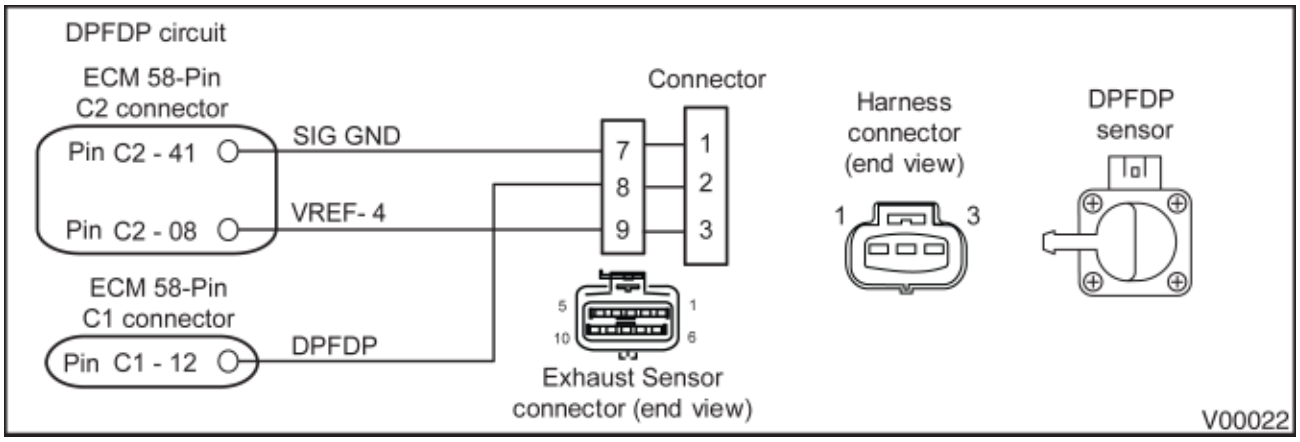


Figure 187 DPFDP sensor circuit diagram

Possible Causes

- DPFDP circuit high resistance
- Leaking or Restricted DPFDP sensor hoses
- Failed DPFDP sensor

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 3251 FMI 3 and 4 (DPFDP); SPN 3512 FMI 14 (VREF-4). Is EST DTC list free of SPN 3251 FMI 3 and 4; SPN 3512 FMI 14?	Yes: Go to step 2.
		No: Repair SPN 3251 FMI 3 and 4; SPN 3512 FMI 14. After repairs are complete, retest for SPN 3251 FMI 2.

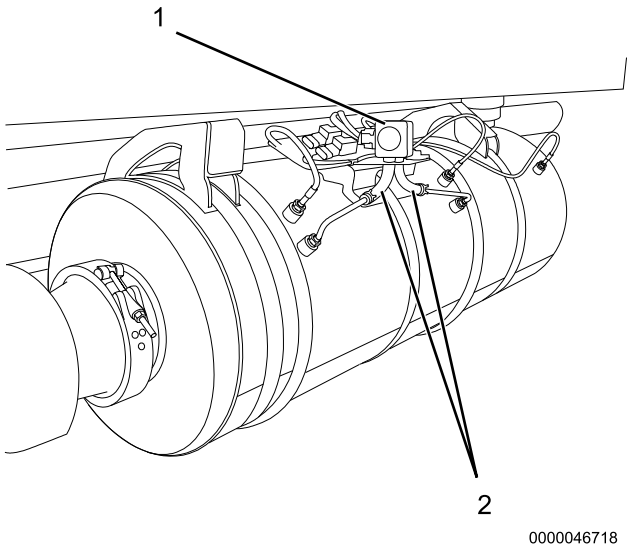


Figure 188 DPFDP Sensor Location (Typical)

1. DPFDP sensor
2. DPFDP sensor hoses

Step	Action	Decision
2	Inspect hoses and tube connections at the Diesel Particulate Filter Differential Pressure (DPFDP) sensor. Check sensor, tubes, and passages for leaks, restrictions, and damage. Are the DPFDP sensor module connections free of leaks, restrictions, and damage?	Yes: Go to step 3.
		No: Repair leaking, restricted or damaged hoses and connections. After repairs are complete, retest for SPN 3251 FMI 2.

Step	Action	Decision
3	Inspect connections at DPFDP sensor. Key OFF, disconnect DPFDP sensor. Check DPFDP sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the DPFDP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 4.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3251 FMI 2.

Step	Action	Decision
4	Inspect connections at Engine Control Module (ECM) sensor. Key OFF, disconnect ECM sensor. Check ECM sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 5.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3251 FMI 2.

Step	Action	Decision
5	Check DPFDP circuit for high resistance. Connect Breakout Harness ZTSE4761 to vehicle harness and leave DPFDP sensor disconnected. Connect 180-Pin Breakout Box and Breakout Harness 00-01467-00 to vehicle harness and leave ECM disconnected. Key OFF, use a DMM to measure resistance between Breakout Harness pin-2 and Breakout Box pin C1-12. Is resistance less than 5 ohms?	Yes: Replace the DPFDP sensor. After repairs are complete retest for SPN 3251 FMI 2.
		No: Repair high resistance between the DPFDP sensor module connector pin-2 and ECM connector pin C1-12. After repairs are complete retest for SPN 3251 FMI 2.

NOTE: After performing all diagnostic steps, if SPN 3251 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Also, see IK1201159 Suplemental Diagnostics for SPN 3251 FMI2 Above or Below Desired Level. Notify supervisor for further action.

SPN 3251 FMI 14 – DPFDP sensor pressure hoses reversed

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Excessive negative delta pressure	DPF Differential pressure < 0 psi (0 kPa)	Engine Speed > 1500 rpm Engine ON time > 300 seconds Total fuel injection > 70 mg/stk Ambient temperature > -58°F (-50°C) SPN / FMIs 3251/3 and 3251/4 are NOT Active	5 seconds

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the DPFDP is less than 0 psi (0 kPa).

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN / FMI: 3246/20, 3251/2, 3251/21, 3556/0, 3556/1, 3556/7, 3719/0, 3719/15, 3719/16, 3936/0, 3936/2, and 3936/14

Drive Cycle to Determine Fault Status

N/A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for fault codes. Is SPN 3251 FMI 14 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3251 FMI 14.
		No: Go to Step 3.

Step	Action	Decision
3	Inspect exhaust system for reversed sensor hoses, restrictions, leaks, or physical damage. Is exhaust system free of restrictions, leaks, and physical damage?	Yes: Go to Step 4.
		No: Repair restrictions, leaks, or physical damage. After repairs are complete, retest for SPN 3251 FMI 14.

Step	Action	Decision
4	Using terminal test kit, inspect connections at Diesel Particulate Filter Differential Pressure (DPFDP) sensor. With key OFF, disconnect DPFDP sensor. Check DPFDP sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Is the DPFDP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 5.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3251 FMI 14.

Step	Action	Decision
5	Test DPFDP circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 495). Are DPFDP circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 6.
		No: Repair circuits as required. After repairs are complete, retest for SPN 3251 FMI 14.

Step	Action	Decision
6	Test DPFDP for intermittent circuit operation using EST with ServiceMaxx™ software. Do Key On Engine Off Continuous Monitor Test (page 87). Verify sensor voltages are within specifications. Are the sensor voltages within specification?	Yes: After doing all diagnostic steps, if SPN 3251 FMI 14 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuits as required. After repairs are complete, retest for SPN 3251 FMI 14.

NOTE: After doing all diagnostic steps, if SPN 3251 FMI 14 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3936 FMI 8 – DPF Regenerations Are Occurring Too Frequently

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Aftertreatment 1 Diesel Particulate Filter (DPF) Very Frequent Regeneration	Ratio of Actual time and Model time (based on Speed / Torque (Table A086) * Engine Air Intake Temperature modifier (Table A087) * Ambient Pressure modifier (Table A088) * Modeled A / F Ratio modifier (Table A089) * Exhaust gas back pressure modifier (Table A090) * Estimated soot load modifier (Table A091) < 0.2 (ratio)	Particulate Filter Regeneration NOT Active Power Take Off (PTO) Mode NOT Active End Of Line Testing NOT Active [Engine Brake (Retarder) NOT active AND minimum wait time after retarder change of state has occurred] > 5 seconds Engine Torque limitation NOT Active Battery Voltage ≥ 10.787 Volts AND ≤ 15.787 Volts Engine Ignition Key is in "ON" position (Key ON) Time after engine start ≥ 30 seconds [Diesel Oxidation Catalyst Inlet Temperature (DOCIT) > 500°F (260°C) AND for time] > 720 seconds [Diesel Oxidation Catalyst Outlet Temperature (DOCOT) > 842°F (450°C) AND for time] > 720 seconds [Diesel Particulate Filter Outlet Temperature (DPFOT) > 932°F (500°C) AND for time] > 600 seconds	1 Regeneration Event

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		SPN / FMIs 27/14, 51/3, 51/4, 51/7, 102/3, 102/4, 102/7, 102/10, 102/18, 105/2, 105/3, 105/4, 108/3, 108/4, 132/0, 132/1, 132/3, 132/4, 172/2, 172/3, 172/4, 1173/16, 2659/20, 2791/2, 2791/3, 2791/4, 2791/7, 2791/8, 2791/14, 3242/3, 3242/4, 3246/2, 3246/3, 3246/4, 3251/3, 3251/4, 3251/21, 3464/11, 3471/1, 3471/7, 3479/3, 3479/5, 3479/6, 3479/5, 3480/3, 3480/4, 3482/3, 3482/4, 3356/0, 3556/1, 3556/7, 3936/2, 3936/20, 4077/3, 4257/16, 4765/3, 4765/4, 4766/10, 5319/31 5541/3, 5541/4, 5543/3, 5543/4, 5543/5 are NOT Active	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines DPF Regenerations Are Occurring Too Frequently.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN / FMIs: 105/2, 105/3, 105/4 132/11, 132/13, and 132/14

Drive Cycle to Determine Fault Status

N/A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for fault codes. Is SPN 3936 FMI 8 the only fault code active?	Yes: Go to Step 3.
		No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3936 FMI 8.
		No: Go to Step 3.

Step	Action	Decision
3	Review fault codes retrieved in Step 1. Are fault codes SPN / FMI 132/11, 132/13, or 132/14 present?	Yes: Go to Mass Air Flow (MAF) Calibration procedures (page 1101). After calibration complete, retest for SPN 3936 FMI 8.
		No: Go to Step 4.

Step	Action	Decision
4	Using terminal test kit, inspect connections at Diesel Particulate Filter Differential Pressure (DPFDP) sensor. With key OFF, disconnect DPFDP sensor. Check DPFDP sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Is the DPFDP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 5.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3936 FMI 8.

Step	Action	Decision
5	Inspect air intake system from air filter to engine intake manifold for restrictions, air leaks, or physical damage. Is air intake system free of restrictions, leaks, or physical damage?	Yes: Go to Step 6.
		No: Repair restrictions, air leaks or physical damage. After repairs are complete, retest for SPN 3936 FMI 8.

Step	Action	Decision
6	On systems with separate DOC and DPF; do DPF Filter Inspection . Is the condition of the DPF face within specification?	Yes: Go to Step 7.
		No: Clean or replace as required. After cleaning or replacement is complete, retest for SPN 3936 FMI 8.

Step	Action	Decision
7	Test for turbocharger low boost condition. Do Turbocharger 2 Wastegate Control (TC2WC) tests (page 208). Was wastegate performance within specifications?	Yes: Go to Step 8.
		No: Repair turbocharger as required. After repairs are complete, retest for SPN 3936 FMI 8.

Step	Action	Decision
8	Inspect exhaust system for restrictions, leaks, or physical damage. Is exhaust system free of restrictions, leaks, and physical damage?	Yes: Go to Step 9.
		No: Repair restrictions, leaks, or physical damage. After repairs are complete, retest for SPN 3936 FMI 8.

WARNING: To prevent personal injury or death, do not perform an On Board Filter Cleanliness Test (OBFCT) or Parked Regeneration if liquid oil or fuel is present or suspected to be present in the DPF. Liquid oil or fuel will ignite during an OBFCT causing fires or damage to the vehicle or other equipment.

Step	Action	Decision
9	Using EST with ServiceMaxx™ software, start an On Board Filter Cleanliness Test (OBFCT). Is OBFCT running without an Abort Message in ServiceMaxx™?	Yes: Go to Step 10.
		No: Correct parked regen inhibitors and redo Step 9.

Step	Action	Decision
10	While running OBFCT, inspect for exhaust system for leaks or physical damage. Is exhaust system free of leaks and physical damage?	Yes: Go to Step 11.
		No: Repair leaks and / or physical damage. After repairs are complete, retest for SPN 3251 FMI 0.

Step	Action	Decision
11	After OBFCT is complete, does DPFDP signal measure below 0.5 psi (3 kPa) at high idle?	Yes: Go to Step 12.
		No: Remove DPF and inspect for restrictions. If restricted, have the DPF cleaned using the appropriate DPF cleaning equipment. After repairs are complete, retest for SPN 3251 FMI 0.

Step	Action	Decision
12	Determine if intake and exhaust valves are operating correctly. Do Relative Compression Test(page 92). Are all engine cylinder performance readings similar?	Yes: Go to Step 13.
		No: Check valve lash and adjust as required or repair valve train damage. After adjustments or repairs are complete, retest for SPN 3936 FMI 8.

Step	Action	Decision
13	Determine if Engine Compression Brake (ECB), if equipped, is operating correctly. Do Key On Engine Off Output State Low test (page 87) and Output State High Test(page 87) and monitor ECBP. Is ECBP within specifications?	Yes: After doing all diagnostic steps, if SPN 3936 FMI 8 remains, verify each step was completed correctly and proper decisions were made. Notify supervisor for further action.
		No: Replace ECB valve. After replacement is complete, retest for SPN 3936 FMI 8.

NOTE: After doing all diagnostic steps, if SPN 3936 FMI 8 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3936 FMI 20 – DOC inlet unable to achieve light off temperature

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Aftertreatment Diesel Particulate Filter (DPF) System Feedback adaptive limits reached	[During Level 2 regeneration event, DPF Inlet temperature set point MINUS Actual DPF Inlet temperature > 212°F (100°C) AND for] > 0.5 * 100% monitor duration	Engine Air Inlet Temperature ≥ 19°F (-7°C) AND ≤ 140°F (60°C) End Of Line Testing NOT Active [Engine Brake (Retarder) NOT active AND minimum wait time after retarder change of state has occurred] > 5 seconds Engine Torque limitation NOT Active Battery Voltage ≥ 10.787 Volts AND ≤ 15.787 Volts Engine Ignition Key is in "ON" position (Key ON) Time after engine start ≥ 30 seconds Time in Level 2 regeneration > 9000 * 0.1 seconds Parameter Identifier (PID) controller has been saturated for at least > 0.8 * 100 % monitor duration SPN / FMIs 102/10, 102/18, 132/0, 132/1, 132/3, 132/4, 3242/3, 3242/4, 3246/2, 3246/3, 3246/4, 3251/3, 3251/4, 3356/0, 3556/1, 3471/1, 3471/7, 3479/3, 3479/5, 3479/6, 3480/3, 3480/4, 3482/3, 3482/4, 3556/7, 4077/3, 4765/3, 4765/4 are NOT Active	1 Regeneration Event

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the pressure in the DPF adaptive limits have been reached.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for fault codes. Is SPN 3936 FMI 20 the only fault code active?	Yes: Go to Step 3.
		No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3936 FMI 20.
		No: Go to Step 3.

Step	Action	Decision
3	Inspect exhaust system restrictions, leaks, or physical damage. Inspect the fuel system from fuel tank to Hydrocarbon Injector (HCI) port for leaks or physical damage. Is exhaust system and fuel system free of restrictions, leaks, and physical damage?	Yes: Go to Step 4.
		No: Repair restrictions, leaks, fuel leaks, or physical damage. For restricted HCI, go to Step 7. After repairs are complete, retest for SPN 3936 FMI 20.

Step	Action	Decision
4	Using terminal test kit, inspect connections at Diesel Particulate Filter Inlet Temperature (DPFIT) and Mass Air Flow / Air Inlet Temperature (MAF / AIT) sensor. With key OFF, disconnect DPFIT and MAF / AIT sensor. Check DPFIT and MAF / AIT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the DPFIT and MAF / AIT sensor connectors, harnesses, and terminals clean and undamaged?	Yes: Go to Step 5.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3936 FMI 20.

Step	Action	Decision
5	Test DPFIT and MAF / AIT circuits for open, short, or high resistance conditions. Do DPFIT connector voltage checks and resistance checks (page 505) and MAF / AIT connector voltage checks and resistance checks (page 1103). Are DPFIT and MAF / AIT circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 6.
		No: Repair circuits as required. After repairs are complete, retest for SPN 3936 FMI 20.

Step	Action	Decision
6	Test DPFIT and MAF / AIT for intermittent circuit operation using EST with ServiceMaxx™ software. Do Key On Engine Off Continuous Monitor Test (page 87). Verify sensor voltages are within specifications. Are the sensor voltages within specification?	Yes: Go to Step 7.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuits as required. After repairs are complete, retest for SPN 3936 FMI 20.

Step	Action	Decision
7	Remove the Hydrocarbon Injection (HCI) assembly (AFI Plugging) (see *Engine Service Manual and IK1200753 Hydrocarbon Injector Housing Cleaning Procedure*). Is HCI clean?	Yes: Go to Step 8.
		No: Replace the HCI assembly. After replacement is complete, retest for SPN 3936 FMI 20.

WARNING: To prevent personal injury or death, do not perform an On Board Filter Cleanliness Test (OBFCT) or Parked Regeneration if liquid oil or fuel is present or suspected to be present in the DPF. Liquid oil or fuel will ignite during an OBFCT causing fires or damage to the vehicle or other equipment.

Step	Action	Decision
8	Using EST with ServiceMaxx™ software, start an On Board Filter Cleanliness Test (OBFCT). Is OBFCT running without an Abort Message in ServiceMaxx™?	Yes: Go to Step 9.
		No: Correct parked regen inhibitors and redo Step 8.

Step	Action	Decision
9	While running OBFCT, inspect for exhaust system for leaks or physical damage. Is exhaust system free of leaks and physical damage?	Yes: Go to Step 10.
		No: Repair leaks and / or physical damage. After repairs are complete, retest for SPN 3936 FMI 20.

Step	Action	Decision
10	After OBFCT is complete, does Diesel Particulate Filter Differential Pressure (DPFDP) signal measure below 0.5 psi (3 kPa) at high idle?	Yes: After doing all diagnostic steps, if SPN 3936 FMI 20 remains, verify each step was completed correctly and proper decisions were made. Notify supervisor for further action.
		No: Remove DPF and inspect for restrictions. If restricted, have the DPF cleaned using the appropriate DPF cleaning equipment. After repairs are complete, retest for SPN 3936 FMI 20.

NOTE: After doing all diagnostic steps, if SPN 3936 FMI 20 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 4766 FMI 10 – DPF Catalyst System Efficiency Below Threshold

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Aftertreatment 1 Diesel Oxidation Catalyst (DOC) Hydrocarbon Conversion Efficiency	Aftertreatment 1 Actual Diesel Oxidation Catalyst (DOC) Hydrocarbon Conversion Efficiency ≤ Threshold defined by minimum expected DOC conversion efficiency defined as a function of modeled exhaust flow and average DOC temperature (Table A094)	End Of Line Testing NOT Active [Engine Brake (Retarder) NOT active AND minimum wait time after retarder change of state has occurred] > 5 seconds Engine Torque limitation NOT Active Battery Voltage ≥ 10.787 Volts AND ≤ 15.787 Volts Engine Ignition Key is in "ON" position (Key ON) Time after engine start ≥ 30 seconds Initialization time to begin DOC efficiency calculation (After active regeneration begins) ≥ 0.1 seconds Minimum time in regen to calculate DOC efficiency > 900 seconds Percentage Time spent in active regeneration (Level 2) ≥ 0.76 (* 100) % Average DOC Temperature > 500°F (260°C) And < 1022°F (550°C) Percent time spent in Average DOC temperature range ≥ 0.6 (* 100) % Exhaust Flow Rate > 50 g/second And < 300 g/second	1 Regeneration Event

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		Percent time spent in Exhaust flow rate range ≥ 0.5 (* 100) % Exhaust O_2 Concentration ≥ Output of ambient pressure based (Table A093) AND < 0.15 (* 100) % Percent time spent in Exhaust O_2 Concentration Range ≥ 0.6 (* 100) % Post 2 Injection Fuel Flow Rate > 0.5 g/second And < 3 g/second Percent time spent in Post 2 Injection Fuel Flow Range ≥ 0.4 (* 100) % Engine Speed > 1200 RPM AND < 2400 RPM Engine Speed In Range Time Ratio ≥ 0.4 (* 100) % Aftertreatment 1 Diesel Particulate Filter (DPF) outlet temperature MINUS Aftertreatment 1 DPF inlet temperature AND Aftertreatment 1 DPF outlet temperature MINUS Aftertreatment 1 Diesel Oxidation Catalyst (DOC) Inlet Temperature < 63°F (35°C) DPF in active Regeneration (Level 2) SPN / FMIs 27/14, 51/3, 51/4, 51/7, 102/10, 102/18, 132/0, 132/1, 132/3, 132/4, 2659/20, 2791/2, 2791/3, 2791/4, 2791/7, 2791/8, 2791/14, 3242/3, 3242/4, 3246/2, 3246/3, 3246/4, 3251/3, 3251/4, 3251/21, 3464/11,	

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		3471/1, 3471/7, 3479/3, 3479/6, 3479/5, 3480/3, 3480/4, 3482/3, 3482/4, 3936/8, 4077/3, 4765/3, 4765/4, 5319/31, 5541/3, 5541/4, 5543/3, 5543/4, 5543/5 are NOT Active.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the DOC is not working efficiently.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN / FMIs: 4765/2, 4765/7, and 4765/20

Drive Cycle to Determine Fault Status

N/A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for fault codes. Is SPN 4766 FMI 10 the only fault code active?	Yes: Go to Step 3.
		No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 4766 FMI 10.
		No: Go to Step 3.

Step	Action	Decision
3	Commence four hour cold soak for Step 7 below. Inspect air intake system, exhaust system, and air filter for restrictions, air leaks, or physical damage. Inspect the fuel system from fuel tank to Hydrocarbon Injection (HCI) valve for leaks or physical damage. **NOTE:** Cracks or dents in the main body of the Diesel Particulate Filter (DPF) indicate filter media is damaged, the DPF must be replaced. Damage to flanges do not warrant replacement as long as the DPF flanges can still be tightly sealed. Are air intake system, exhaust system, fuel system and air filter free of restrictions, leaks, and physical damage?	Yes: Go to Step 4.
		No: Repair restrictions, air leaks, fuel leaks, or physical damage. After repairs are complete, retest for SPN 4766 FMI 10.

Step	Action	Decision
4	Using terminal test kit, inspect connections at Diesel Oxidation Catalyst Inlet Temperature (DOCIT), Diesel Particular Filter Inlet Temperature (DPFIT), and DPF Outlet Temperature (DPFOT) sensors. With key OFF, disconnect DOCIT, DPFIT, and DPFOT sensor connectors. Check sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are DOCIT, DPFIT, and DPFOT sensor connectors, harnesses, and terminals clean and undamaged?	Yes: Go to Step 5.
		No: Repair damaged connector, harness, or terminal. After repairs are complete, retest for SPN 4766 FMI 10.

Step	Action	Decision
5	Test DPFIT, DOCIT, and DPFOT circuits for open, short, or high resistance conditions. Do DPFIT connector voltage checks and resistance checks (page 505), DOCIT connector voltage checks and resistance checks (page 484), and DPFOT connector voltage checks and resistance checks (page 518). Are DPFIT, DOCIT, and DPFOT circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 6. No: Repair circuits as required. After repairs are complete, retest for SPN 4766 FMI 10.

Step	Action	Decision
6	Connect breakout harness 4760A between DPFIT, DOCIT, and DPFOT sensors and DPFIT, DOCIT, and DPFOT sensor connectors. Do Key On Engine Off (KOEO) voltage check of DPFIT, DOCIT, and DPFOT sensors between sensor signal and ground. Is DPFIT, DOCIT, and DPFOT voltage within specification (page 1317)?	Yes: Go to Step 7. No: Repair circuits as required. After repairs are complete, retest for SPN 4766 FMI 10.

Step	Action	Decision
7	Do Cold Soak Sensor Compare Check (page 354). Compare DPFIT, DOCIT, and DPFOT. All sensors should be within 68°F (20°C) of each other. Is DPFIT within 68°F (20°C) the other sensors?	Yes: Go to Step 8. No: Repair DOCIT sensor or circuits. After repairs are complete, retest for SPN 4766 FMI 10.

Step	Action	Decision
8	Determine if Fuel Delivery Pressure (FDP) is within specification. Using EST with ServiceMaxx™ software, Key-On Engine-Running (KOER) monitor FDP sensor. FDP should be at a steady pressure of 90 ± 10 psi (621 ± 69 kPa). Is FDP between 90 ± 10 psi (621 ± 69 kPa)?	Yes: Go to Step 9.
		No: Do Fuel Pressure Check (page 803). After repairs are complete, retest for SPN 4766 FMI 10.

Step	Action	Decision
9	Check that Aftertreatment Fuel Shutoff Valve (AFTFSV) and Aftertreatment Fuel Doser (AFTFD) harness connectors are connected to the correct location. **NOTE:** AFTFSV and AFTFD harness connectors can be swapped. Are the Fuel Shutoff Valve (AFTFSV) and / or Aftertreatment Fuel Doser (AFTFD) sensor connected correctly?	Yes: Go to Step 10.
		No: Connect the Fuel Shutoff Valve (AFTFSV) and / or Aftertreatment Fuel Doser (AFTFD) sensor to the correct circuit. After repairs are complete, retest for SPN 4766 FMI 10.

WARNING: To prevent personal injury or death, do not perform an On Board Filter Cleanliness Test (OBFCT) or Parked Regeneration if liquid oil or fuel is present or suspected to be present in the DPF. Liquid oil or fuel will ignite during an OBFCT causing fires or damage to the vehicle or other equipment.

Step	Action	Decision
10	Using EST with ServiceMaxx™ software, start an On Board Filter Cleanliness Test (OBFCT). Is OBFCT running without an Abort Message in ServiceMaxx™?	Yes: Go to Step 11.
		No: Correct parked regen inhibitors and redo Step 10.

Step	Action	Decision
11	While running OBFCT, inspect for exhaust system for leaks or physical damage. Is exhaust system free of leaks and physical damage?	Yes: Go to Step 12.
		No: Repair leaks and / or physical damage. After repairs are complete, retest for SPN 4776 FMI 10.

Step	Action	Decision
12	After OBFCT is complete, does Diesel Particulate Filter Differential Pressure (DPFDP) signal measure below 0.5 psi (3 kPa) at high idle?	Yes: Go to Step 13.
		No: Remove DPF and inspect for restrictions. If restricted, have the DPF cleaned using the appropriate DPF cleaning equipment. After repairs are complete, retest for SPN 4766 FMI 10.

Step	Action	Decision
13	Check vehicle repair history for Exhaust Gas Recirculation (EGR) cooler repairs (internal coolant leak), since last Diesel Oxidation Catalyst (DOC) replacement. Is vehicle history free of EGR cooler repairs (internal coolant leak), since last DOC replacement?	Yes: Go to Step 14.
		No: Replace DOC. After repairs are complete, retest for SPN 4766 FMI 10.

Step	Action	Decision
14	Inspect for coolant leak to exhaust. Do Coolant Leak to Exhaust (page 109) test and check for coolant leaks. Is exhaust system free of coolant leaks?	Yes: Verify each step was completed correctly and proper decisions were made. Notify supervisor for further action.
		No: Repair coolant leak into exhaust system and replace DOC. After repairs are complete, retest for SPN 4766 FMI 10.

NOTE: After doing all diagnostic steps, if SPN 4766 FMI 10 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 5319 FMI 31 – DPF incomplete regeneration

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Particulate Filter (DPF) Incomplete regeneration	Soot load (Aftertreatment 1 DPF differential pressure sensor based) after a "Successful Regeneration Event" >95 hPa/m^3	Particulate Filter Regeneration NOT Active End Of Line Testing NOT Active [Engine Brake (Retarder) NOT active AND minimum wait time after retarder change of state has occurred] > 5 seconds Engine Torque limitation NOT Active Battery Voltage ≥ 10.787 Volts AND ≤ 15.787 Volts Engine Ignition Key is in "ON" position (Key ON) Time after engine start ≥ 30 seconds Volumetric flow > 88000 g/hr (400000 liters/hr) SUM [{Aftertreatment # 1 DPF Inlet temperature * 0.2 and Aftertreatment # 1 DPF outlet temperature * 0.8} < 752°F (400°C) Estimated soot load < 60 hPa/m^3 Number of failed regenerations < 10 regenerations SPN / FMIs 27/14, 102/10, 102/18, 108/3, 108/4, 132/0, 132/1, 132/3, 132/4, 2659/20, 2791/2, 2791/3, 2791/4, 2791/7, 2791/8, 2791/14, 3242/3, 3242/4, 3246/2, 3246/3, 3246/4, 3251/3, 3251/4, 3251/21, 3356/0, 3471/1, 3471/7, 3479/3,	1 Regeneration Event

(cont.)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		3479/5, 3479/6, 3480/3, 3480/4, 3482/3, 3482/4, 3556/1, 3556/7, 3936/2, 3936/8, 3936/20, 4077/3, 4257/16, 4765/3, 4765/4, 4766/10, 5541/3, 5541/4, 5543/3, 5543/4, 5543/5 are NOT Active.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the pressure is to low in the DPF.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN / FMIs 3251/2 and 3251/14

Drive Cycle to Determine Fault Status

N/A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for fault codes. Is SPN 5319 FMI 31 the only fault code active?	Yes: Go to Step 3.
		No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 5319 FMI 31.
		No: Go to Step 3.

Step	Action	Decision
3	Using Electronic Service Tool (EST) with ServiceMaxx™ software, monitor Diesel Particulate Filter Differential Pressure (DPFDP) signal with Key ON Engine OFF (KOEO). Is DPFDP within specifications?	Yes: Go to Step 6.
		No: Go to Step 4.

Step	Action	Decision
4	Using terminal test kit inspect connections at DPFDP sensor. With key OFF, disconnect DPFDP sensor. Check DPFDP sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the DPFDP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 5.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 5319 FMI 31.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Do Key On Engine Off Continuous Monitor Test (page 87). Are the sensor voltages within specifications?	Yes: Go to Step 6.
		No: Repair DPFDP sensor or circuits. After repairs are complete, retest for SPN 5319 FMI 31.

Step	Action	Decision
6	Check DPFDP sensor hoses for correct routing and restrictions. Inspect the DPFDP hoses for kinks, improper hose routing, reversed hoses, or damage. See DPFDP sensor locator for correct routing of hoses. Are the DPFDP hoses routed correctly and free of damage?	Yes: Go to Step 7.
		No: Repair DPFDP hoses. After repairs are complete, retest for SPN 5319 FMI 31.

WARNING: To prevent personal injury or death, do not perform an On Board Filter Cleanliness Test (OBFCT) or Parked Regeneration if liquid oil or fuel is present or suspected to be present in the DPF. Liquid oil or fuel will ignite during an OBFCT causing fires or damage to the vehicle or other equipment.

Step	Action	Decision
7	Using EST with ServiceMaxx™ software, start an On Board Filter Cleanliness Test (OBFCT). Is OBFCT running without an Abort Message in ServiceMaxx™?	Yes: Go to Step 8.
		No: Correct parked regen inhibitors and redo Step 7.

Step	Action	Decision
8	While running OBFCT, inspect for exhaust system for leaks or physical damage. Is exhaust system free of leaks and physical damage?	Yes: Go to Step 9.
		No: Repair leaks and/or physical damage. After repairs are complete, retest for SPN 5319 FMI 31.

Step	Action	Decision
9	After OBFCT is complete, does DPFDP signal measure below 0.5 psi (3 kPa) at high idle?	Yes: Go to Step 10.
		No: Remove DPF and inspect for restrictions. If restricted, have the DPF cleaned using the appropriate DPF cleaning equipment. After repairs are complete, retest for SPN 5319 FMI 31.

Step	Action	Decision
10	Determine if Intake Manifold Pressure (IMP) sensor or circuit is out of specifications. Using EST with ServiceMaxx™ software, do IMP Biased Sensor Check (page 885). Is IMP sensor within specifications?	Yes: Go to Step 11.
		No: Repair IMP sensor or circuit. After repairs are complete, retest for SPN 5319 FMI 31.

Step	Action	Decision
11	Verify IMP changes when Turbocharger 2 Wastegate Control (TC2WC), or Turbocharger 2 Wastegate (TC2WG) if installed, and Exhaust Gas Recirculation (EGR) valve are commanded on. Do Key-On Engine-Running (KOER) Air Management Test (page 201), while monitoring IMP sensor signal. Does IMP sensor signal change: • When TC2WC (TC2WG) is commanded On? • When EGR valve is commanded On?	Yes: Both change IMP signal when commanded ON: Go to Step 13.
		No: IMP signal changes only when TC2WC (TC2WG) is commanded ON: Do EGR

Step	Action	Decision
		Pin-point Diagnostics (page 679), and check for EGR issue. After repairs are complete, retest for SPN 5319 FMI 31.
		No: IMP signal changes only with EGR valve commanded ON: Do TC2WC voltage and circuit checks (page 1165) and TC2WG voltage and circuit checks (page 1132). After repairs are complete, retest for SPN 5319 FMI 31
		No: Neither change IMP signal when commanded ON: Go to Step 12.

Step	Action	Decision
12	Verify IMP sensor and bore are not restricted due to carbon buildup. Remove and inspect IMP sensor and bore for carbon buildup. Is IMP sensor and bore free of carbon buildup?	Yes: Go to Step 13.
		No: Clean IMP sensor bore of carbon deposits. After repairs are complete, retest for SPN 5319 FMI 31.

Step	Action	Decision
13	Do Road Test (Full load to highway speed) (page 218), 100% engine load (when safe to do so). Record a snapshot of the following signals: DPFDP 0.5 to 0.8 psi (3 to 6 kPa). Soot load less than 40% Is DPFDP signal within specifications?	Yes: After doing all diagnostic steps, if SPN 5319 FMI 31 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Remove DPF for inspection and clean or replace as necessary. After repairs are complete, retest for SPN 5319 FMI 31.

NOTE: After doing all diagnostic steps, if SPN 5319 FMI 31 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

AMS (Air Management System)

SPN	FMI	Condition	Possible Causes	Actions
1209	0	EBP above desired level	• Biased Exhaust Back Pressure (EBP) sensor or circuit • Restricted Exhaust • Plugged Diesel Oxidation Catalyst (DOC) • Plugged Diesel Particulate Filter (DPF) • Failed Turbocharger	Pin-point Diagnostics (page 395)
1209	7	EBP signal not responding as expected	• EBP signal not seeing a difference in pressure from low idle to high idle	Pin-point Diagnostics (page 395)
2659	10	EGR Slow Response Fault	• EGR valve sticking	Step-based Diagnostics (page 397)
2659	14	Service Tool Test – EBP was unable to detect EGR movement	• Biased EBP sensor or circuit • Plugged EBP sensor tube • Failed EGR valve	Pin-point Diagnostics (page 403)
2659	20	EGR High Flow Rate detected	• Charge Air Cooler (CAC) system leaks • Biased EBP sensor or circuit • Biased IMP sensor or circuit • EGR valve sticking closed	Pin-point Diagnostics
2659	21	EGR Low Flow Rate detected	• Restricted airflow (intake or exhaust) • Restricted EGR cooler • Biased EBP sensor or circuit • Plugged EBP sensor tube	Step-based Diagnostics (page 406)

SPN	FMI	Condition	Possible Causes	Actions
			• Biased IMP sensor or circuit • EGR valve sticking closed	

Overview

The AMS Test is performed on the EGR System. During AMS Test, engine speed is increased, injection timing and ICP pressure are fixed, and the EGR valve is temporarily closed. As the test progresses, the EGR valve is opened. This test operates by monitoring the MAF readings during the test. Airflow is first measured with the EGR closed, and then with the EGR opened. These two measurements are then compared by the ECM. If the measured difference is not within the minimum and maximum values expected, a code will be set.

Tools

- EZ Tech® Electronic Service Tool (EST) – J-45067 (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Breakout Harness 4948 (EGR) (page 1236)
- Digital Multimeter (DMM) (page 1224)
- 00-00956-08 – 180-pin Breakout Box (page 1222)
- International® Electronic Engine Terminal Test Kit (page 1227)

Pin-point Diagnostics

SPN 1209 FMI 0 – EBP above desired level

The code will set when EBP is 10 psi (69 kPa) above desired level.

Estimated EGR percent is less than the minimum limit for the operating conditions.

The code will set when EBP is 10 psi (69 kPa) above.

Pin-point AMS Fault

1. Check for other active or inactive EBP, MAF, IMP, or EGR faults. Repair any fault before continuing with this procedure.
2. Check for biased sensor. Verify BARO, MAF, IMP, and EBP are within KOEO specification. See KOEO (page 1291).
3. Check the back pressure valve operation. See EBPV (Exhaust Back Pressure Valve) (page 535).
4. Check for restricted EGR cooler. See Restricted EGR Cooler (page 393).
5. Check EGR operation. Monitor EGRP signal and run Output State Low Test (page 87). See EGR Actuator (Exhaust Gas Recirculation) (page 675).
6. Check for restricted exhaust. See performance specification at full load rated speed (page 1291).

SPN 1209 FMI 1 – EBP below desired level

This code will set when EBP is 10 psi (69 kPa) below desired level.

Estimated EGR percent is less than the minimum limit for the operating conditions.

Pin-point AMS Fault

1. Check for other active or inactive EBP, MAF, IMP, or EGR faults. Repair any fault before continuing with this procedure.
2. Check for biased sensor. Verify BARO, MAF, IMP, and EBP are within KOEO Specification. See KOEO (page 1291).
3. Check for plugged EBP or tubing.
4. Check the exhaust back-pressure valve operation. See EBPV (Exhaust Back Pressure Valve) (page 535).

SPN 2659 FMI 14 – Service Tool Test – EBP was unable to detect EGR movement

This code is set if EBP does not meet expected response during the Air Management Test.

Pin-point AMS Fault

1. Check for active or inactive EBP codes. See EBPV (Exhaust Back Pressure Valve) (page 535) Sensor in this section of manual and check EBP KOEO (page 1291) specification.
2. Check for plugged EBP sensor or tubing.
3. Check for active or inactive codes. See appropriate Pin-point test.
4. Check EGR operation. Monitor EGR position (EGRP) while running KOEO Output State test (page 87). See EGR Actuator (Exhaust Gas Recirculation) (page 675).
5. Check for restricted exhaust system.

SPN 2659 FMI 20 – EGR High Flow Rate detected

The code will set when EBP is 10 psi (69 kPa) below desired level.

Estimated EGR percent is greater than the maximum limit for the operating conditions.

Pin-point AMS Fault

1. Check for other active or inactive EBP, MAF, IMP, or EGR faults. Repair any fault before continuing with this procedure.
2. Check for biased sensor. Verify BARO, MAF, IMP, and EBP are within KOEO Specification. See KOEO (page 1291).
3. Check the plugged EBP sensor or tubing.
4. Check EGR operation. Monitor EGR position (EGRP) while running Output State Low Test (page 87). See EGR Actuator (Exhaust Gas Recirculation) (page 675).

SPN 2659 FMI 21 – EGR Low Flow Rate detected

This code is set if EBP does not meet expected response during the EGR portion of the AMS test.

Pin-point AMS Fault

1. Check for other active or inactive EBP, MAF, IMP, or EGR faults. Repair any faults before continuing with this procedure.
2. Check for biased sensor. Verify that BARO, MAF, IMP, and EBP are within KOEO specification. See KOEO (page 1291).
3. Inspect EGR cooler. See EGR Cooler Inspection (page 110).
4. Check EGR operation. Monitor EGR position (EGRP) while running Output State Low Test (page 87). See “EGR Actuator (Exhaust Gas Recirculation) (page 675).

Cold Soak Sensor Compare Check

Cold Soak Sensor Compare Check

Temperature values need to be measured after four hours cold soak.

1. Turn switch ON, engine OFF
2. Using ServiceMaxx™ software, open the Continuous Monitor session.
3. Compare Engine Coolant Temperature 1 (ECT1) to Engine Oil Temperature (EOT), Intake Manifold Temperature (IMT), Air Inlet Temperature (AIT), Charge Air Cooler Outlet Temperature (CACOT), and Aftertreatment Fuel Inlet Temperature (AFTFIT) temperature sensors. All temperature sensors should be within 59°F (15°C) of each other.
   - If any temperature sensor is 59°F (15°C) above or below other temperature sensors, check for biased temperature sensor circuit or a failed temperature sensor.
   - If the circuits are acceptable, replace the failed temperature sensor.

SPN 2659 FMI 10 - EGR Slow Response Fault

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Engine Exhaust Gas Recirculation (EGR) Mass Flow Rate Slow Response Monitor	N9 and N10 High Torque (> 330 HP): Integral of EGR Mass Flow Rate absolute deviation from set point > 6000 (mg/stroke) * seconds N9 and N10 Standard Torque (< 330 HP): Integral of EGR Mass Flow Rate absolute deviation from set point > 5000 (mg/stroke) * seconds	1. Engine Speed > 800 rpm 2. Torque Set point > 200 N·m 3. Engine Speed gradient > -20.02 rpm/s 4. Torque Set point gradient ≥ 5 N·m/s 5. Engine Inlet Air Mass flow rate sensor set point] ≤ Moving mean value of the total air mass flow Entry conditions 1 through 5 listed above have to be satisfied for EGR Slow Response (Under) OR [6. Engine Speed > 1100 rpm 7. Torque Set point > 1800 N·m 8. Engine Speed gradient > -10.01 rpm/s AND < 14.99 rpm/s 9. Torque Set point gradient > -5 N·m/s AND < 15 N·m/s 10. Engine Inlet Air Mass flow rate sensor set point] ≥ Moving mean value of the total air mass flow Entry conditions 6 through 10 listed above have to be satisfied for EGR Slow Response (Over) Engine Coolant Temperature dependent activation condition (Table A037) Barometric pressure dependent activation condition (Table A038) Engine Intake Air Temperature dependent activation condition (Table A039) Turbocharger #2 Compressor intake gas temperature dependent activation (Table A040) Particulate Filter Regeneration NOT active

		Power Take Off (PTO) is NOT active AND Time after PTO change of state to not active > 5 seconds End of Line tests not active Engine Exhaust Brake or Vehicle Retarder NOT active Time after Engine Exhaust Brake or Vehicle Retarder state of change to not active > 5 seconds Torque limiting in Limp Home Mode is NOT active Fuel cut off in engine deceleration NOT active Limp Home Mode NOT active Time after exiting Limp Home Mode > 0 SCR warm-up is NOT occurring SPN/FMI 132/3, 132/4, 172/3, 172/4, 172/2, 102/3, 102/4, 102/7, 105/3, 105/4, 105/2, 108/3, 108/4, 636/7, 636/2, 110/3, 110/4, 110/2, 2791/2, 2791/7, 2791/14, 2791/14, 2791/14, 27/14, 2791/8, 2791/8, 2791/3, 2791/4, 2659/21 are NOT active

Fault Overview

Fault sets when Engine Control Module (ECM) determines EGR mass flow rate is low. ECM continuously monitors control system. If sensor signal is higher or lower than expected, ECM disregards signal and uses a calibrated default value. ECM sets an SPN/FMI, turns on Warning Engine Lamp (WEL), and runs engine in a default range.

Lamp Reaction

Malfunction Indicator Lam (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

SPN / FMIs: 27/0, 27/3, 27/4, 27/7, 27/14, 2791/2, 2791/3, 2791/4, 2791/7, 2791/8, 2791/14, 132/0, 132/1, 132/3, 132/4, 132/11, 132/13, 132/14, 132/31, 102/2, 102/3, 102/4, 102/7, 102/10, 102/16, 102/18, 105/2, 105/3, 105/4, 108/2, 108/3, 108/4, 110/0, 110/2, 110/3, 110/4, 110/7, 110/15, 110/16, 110/17, 110/18, 3464/11, 51/0, 51/2, 51/3, 51/4, 51/5, 51/7, 51/11, 651-656/14, 4257/16, 4257/18, 164/16, 164/18

Fault Facts

Drive Cycle to Determine Fault Status

N/A

Possible Causes

- Restricted airflow (intake or exhaust)
- Restricted EGR cooler
- Biased EBP sensor or circuit
- Plugged EBP sensor tube
- Biased IMP sensor or circuit
- EGR valve sticking closed

Step 1	Check for active or pending fault code.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 2659 FMI 10. Is EST DTC list SPN 2659 FMI 10 active or pending?	Yes: Go to Step 2.
		No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Check for associated fault codes.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 2659 FMI 10. Is EST DTC list free of SPN 2659 FMI 10?	Yes: Go to Step 3.
		No: Repair SPN 2659 FMI 10. After repairs are complete, retest for SPN 2659 FMI 10.

Step 3	Do Mass Air Flow (MAF) Calibration Procedure.	Decision
	Using ServiceMaxx™ software. Ensure KOER MAF Sensor Calibration are met and MAF Calibration Pre-Checks are done, prior to doing this procedure. Did MAF sensor calibration run successfully?	Yes: Go to Step 4.
		No: Repair air intake system leaks. After repairs are complete, retest for SPN 2659 FMI 10.

Step 4	Inspect connections at Exhaust Gas Recirculation (EGR) valve.	Decision
	A. Key OFF. B. Disconnect EGR valve connector. C. Check EGR valve and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are EGR valve connector, harness, and terminals clean and undamaged?	Yes: Go to Step 5.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2659 FMI 10.

Step 5	Exhaust Gas Recirculation (EGR) Operational Test.	Decision
	Perform EGR Operational Test(page 240). Are there any active SPN 2791 or SPN 27 fault codes active?	Yes: Replace EGR valve. After repairs are complete, retest for SPN 2659 FMI 10.
		No: Go to Step 6.

Step 6	Visually inspect Exhaust Brake Actuator.	Decision
	Start engine and let run for 5 seconds before shutting off engine and visually inspect Exhaust Brake Actuator. Exhaust Brake Actuator should cycle open and closed 3 times after engine shut down. Does Exhaust Brake Actuator cycle open and closed 3 times?	Yes: Go to Step 9.
		No: Go to Step 7.

Step 7	Listen for air pressure to Exhaust Brake Actuator.	Decision
	Disconnect air supply to Exhaust Brake Actuator. Start engine and run for at least 5 seconds. Turn engine off and listen to Exhaust Brake Actuator supply line for air pressure leakage. Does Exhaust Brake Actuator air supply line leak air pressure?	Yes: Replace Exhaust Brake Housing. After repairs are complete, retest for SPN 2659 FMI 10.
		No: Go to Step 8.

Step 8	Verify air pressure leakage from Exhaust Brake Control Valve air supply line.	Decision
	With vehicle air pressure 60 psi or greater. Disconnect Exhaust Brake Control Valve air supply line. Exhaust Brake Control Valve air supply line should leak air pressure. Does Exhaust Brake Control Valve air supply leak air pressure?	Yes: Replace Exhaust Brake Control valve. After repairs are complete, retest for SPN 2659 FMI 10.
		No: Repair Exhaust Brake Control Valve air pressure supply line. After repairs are complete, retest for SPN 2659 FMI 10.

Step 9	Perform Air Management Test	Decision
	Perform KOER Air Management Test. Does KOER Air Management Test return “Satisfactory?	Yes: Go to Step 10.
		No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 10	Analyze KOER Air Management Test results.	Decision
	Analyze graphs produced by KOER Air Management Test against “Good” and “Bad” graphs Does test graph match “Good” graph?	Yes: Go to Step 11.
		No: Diagnose and repair failed actuator. After repairs are complete, repeat this step to verify repairs.

Step 11	Do Mass Air Flow (MAF) Calibration Procedure.	Decision
	Using ServiceMaxx™ software. Ensure KOER MAF Sensor Calibration are met and MAF Calibration Pre-Checks are done, prior to doing this procedure. Did MAF sensor calibration run successfully?	Yes: Replace MAF sensor. After repairs are complete, retest MAF sensor.
		No: Verify all MAF calibration requirements are met and MAF calibration pre-checks are done. Repeat MAF calibration. After repairs are complete,

		retest for SPN 2659 FMI 10.

End Diagnostic Tests
After performing all diagnostic steps, if SPN 2659 FMI 10 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

SPN 2659 FMI 14 - EGR System Flow Rate Error During Air Management

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
See SPN 2659 FMI 10(page 397)	See SPN 2659 FMI 10(page 397)	See SPN 2659 FMI 10(page 397)

Possible Causes

- EGR valve
- MAF sensor calibration
- Induction system air leaks

Step 1	Perform Air Management Test	Decision
	Perform KOER Air Management Test(page 95). Does KOER Air Management Test return “Satisfactory?	Yes: Go to Step 2.
		No: Perform Air Management Test Inspection.

Step 2	Do leak check of intake system.	Decision
	Perform a pressure check of the intake air system. Did the intake air system pass the pressure test?	Yes: Go to Step 3.
		No: Repair intake air system leaks. After repairs are complete, retest for SPN 2659 FMI 14.

Step 3	Do Mass Air Flow (MAF) Calibration Procedure.	Decision
	Using ServiceMaxx™ software. Ensure KOER MAF Sensor Calibration are met and MAF Calibration Pre-Checks are done, prior to doing this procedure. Did MAF sensor calibration run successfully?	Yes: System OK.
		No: Repair air intake system leaks. After repairs are complete, retest for SPN 2659 FMI 14.

End Diagnostic Tests
After performing all diagnostic steps, if SPN 2659 FMI 14 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

SPN 2659 FMI 20 - EGR High Flow Rate detected

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Engine Exhaust Gas Recirculation (EGR) Mass Flow Rate High Flow Monitor	Engine Air Inlet Mass Flow set point MINUS measured Mass Air Flow ≥ Threshold Value based on Speed/Torque Table (Table A041) * Engine Air Inlet Temperature modifier (Table A042) * Intake Manifold Temperature modifier (Table A043) * Coolant Temperature modifier (Table A044) * barometric pressure modifier (Table A045)	1. Monitor enable condition based on Speed/Torque based table (Table A046) 2. Monitor enable condition based on Engine Inlet Air Mass flow rate value and barometric pressure table (Table A047) Delay timer to run diagnostics after entry conditions 1 and 2 (mentioned above) are satisfied ≥ 4 seconds Particulate Filter Regeneration NOT active Power Take Off (PTO) is NOT active AND Time after PTO change of state to not active > 5 seconds End of Line tests not active Engine Exhaust Brake or Vehicle Retarder NOT active Time after Engine Exhaust Brake or Vehicle Retarder state of change to not active > 5 seconds Torque limiting in Limp Home Mode is NOT active Limp Home Mode NOT active Time after exiting Limp Home Mode > 0 SCR warm-up is NOT occurring SPN/FMI 132/3, 132/4, 172/3, 172/4, 172/2, 102/3, 102/4, 102/7, 105/3, 105/4, 105/2, 108/3, 108/4, 636/7, 636/2, 110/3, 110/4, 110/2, 651/4, 651/5, 655/4, 652/5, 653/4, 653/5, 656/4, 654/5, 652/4, 655/5, 654/4, 656/5, 3464/31, 51/7, 51/7, 51/3, 51/4, 2791/2, 2791/7, 2791/14, 2791/14, 2791/14, 27/14, 2791/8, 2791/8, 2791/3, 2791/4, 4752/4, 102/18 are NOT active

Fault Overview

Lamp Reaction

Malfunction Indicator Lam (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

SPN/FMI 132/3, 132/4, 172/3, 172/4, 172/2, 102/3, 102/4, 102/7, 105/3, 105/4, 105/2, 108/3, 108/4, 636/7, 636/2, 110/3, 110/4, 110/2, 651/4, 651/5, 655/4, 652/5, 653/4, 653/5, 656/4, 654/5, 652/4, 655/5, 654/4, 656/5, 3464/31, 51/7, 51/7, 51/3, 51/4, 2791/2, 2791/7, 2791/14, 2791/14, 2791/14, 27/14, 2791/8, 2791/8, 2791/3, 2791/4, 4752/4, 102/18, 1209/0, and 102/2.

Fault Facts

Ensure that correct PP is programmed for air induction system.

Drive Cycle to Determine Fault Status

Key ON

Possible Causes

- EGR valve stuck open or damaged O-rings
- Induction system leaks
- Excessive exhaust back pressure
- MAF sensor calibration

Step 1	Check for active or pending fault code.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 2659 FMI 20. Is EST DTC list SPN 2659 FMI 20 active or pending?	Yes: Go to Step 2.
		No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Check for associated fault codes.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 2659 FMI 20. Is EST DTC list free of SPN 2659 FMI 20?	Yes: Go to Step 3.
		No: Repair SPN 2659 FMI 20. After repairs are complete, retest for SPN 2659 FMI 20.

Step 3	Inspect Intake Air System for leaks.	Decision
	Visually inspect intake air system for leaks Are any system leaks found?	Yes: Repair leaks. After repairs are complete, retest for SPN 2659 FMI 20.
		No: Go to Step 4.

Step 4	Exhaust Gas Recirculation (EGR) Operational Test.	Decision
	Perform EGR Operational Test(page 240). Are there any active SPN 2791 or SPN 27 fault codes active?	Yes: Replace EGR valve. After repairs are complete, retest for SPN 2659 FMI 10.
		No: Go to Step 6.

Step 5	Do Mass Air Flow (MAF) Calibration Procedure.	Decision
	Using ServiceMaxx™ software. Ensure KOER MAF Sensor Calibration are met and MAF Calibration Pre-Checks are done, prior to doing this procedure. Did MAF sensor calibration run successfully?	Yes: Replace MAF sensor. After repairs are complete, retest MAF sensor.
		No: Verify all MAF calibration requirements are met and MAF calibration pre-checks are done. Repeat MAF calibration. After repairs are complete, retest for SPN 2659 FMI 10.

End Diagnostic Tests
After performing all diagnostic steps, if SPN 2659 FMI 20 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

SPN 2659 FMI 21 – EGR Low Flow Rate Detected

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine Exhaust Gas Recirculation (EGR) Mass Flow Rate Low Flow Monitor	Engine Air Inlet Mass Flow (MAF) set point MINUS measured MAF ≥ Threshold Value based on Speed / Torque (Table A048) * Engine Air Inlet	Particulate Filter Regeneration NOT Active Barometric Pressure ≥ 11 psi (73.5 kPa) AND ≤ 15 psi (103 kPa)	4 seconds

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
	Temperature modifier (Table A049) * Intake Manifold Temperature modifier (Table A050) * Coolant Temperature modifier (Table A051) * Ambient Pressure modifier (Table A052)	Engine Air Inlet Temperature (AIT) $\geqq$ 19°F (-7°C) AND $\leqq$ 140°F (60°C) Power Take Off (PTO) Mode NOT Active End Of Line Testing NOT Active [Engine Brake (Retarder) NOT active AND minimum wait time after retarder change of state has occurred] > 5 seconds Engine Torque limitation NOT Active Engine is NOT coasting (such as Throttle Cut OFF mode) Battery Voltage $\geqq$ 10.787 Volts AND $\leqq$ 15.787 Volts Engine Ignition Key is in "ON" position (Key ON) Time after engine start $\geqq$ 30 seconds Engine Coolant Temperature (ECT) $\geqq$ 68°F (20°C) AND $\leqq$ 230°F (110°C) 1. Monitor enablement condition based on Speed / Torque based (Table A053) 2. Monitor enablement condition based on Engine Inlet Air Mass flow rate value and Ambient pressure (Table A054) Delay timer to run diagnostics after entry conditions 1 and 2 (mentioned above) are satisfied $\geqq$ 3 seconds	

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		SPN / FMIs 27/14, 51/3, 51/4, 51/7, 102/3, 102/4, 102/7, 102/18, 105/3, 105/4, 105/2, 108/3, 108/4, 110/2, 110/3, 110/4, 132/0, 132/1, 132/3, 132/4, 172/2, 172/3, 172/4, 636/2, 636/7, 651/4, 651/5, 652/4, 652/5, 653/4, 653/5, 654/4, 654/5, 655/4, 655/5, 656/4, 656/5, 2791/2, 2791/3, 2791/4, 2791/7, 2791/8, 2791/14, 3464/11, 4752/4 are NOT Active.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the EGR mass flow rate is low.

Fault Detection / Management

The ECM continuously monitors the control system. If the sensor signal is higher or lower than expected, the ECM disregards the signal and uses a calibrated default value. The ECM sets an SPN / FMI, turns on the Warning Engine Lamp (WEL), and runs the engine in a default range.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN / FMIs: 27/0, 27/3, 27/4, 27/7, 27/14, 2791/2, 2791/3, 2791/4, 2791/7, 2791/8, 2791/14, 132/0, 132/1, 132/3, 132/4, 132/11, 132/13, 132/14, 132/31, 102/2, 102/3, 102/4, 102/7, 102/10, 102/16, 102/18, 105/2, 105/3, 105/4, 108/2, 108/3, 108/4, 110/0, 110/2, 110/3, 110/4, 110/7, 110/15, 110/16, 110/17, 110/18, 3464/11, 51/0, 51/2, 51/3, 51/4, 51/5, 51/7, 51/11, 651-656/14, 4257/16, 4257/18, 164/16, 164/18

Drive Cycle to Determine Fault Status

N/A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 2659 FMI 21 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 2659 FMI 21.
		No: Go to Step 3.

Step	Action	Decision
3	Do MAF Calibration Procedure — Using ServiceMaxx™ software (page 1101). Ensure MAF Calibration Requirements are met and MAF Calibration Pre-Checks are done, prior to doing this procedure. Did the MAF sensor calibration run successfully?	Yes: Go to Step 4.
		No: Repair air intake system leaks. After repairs are complete, retest for SPN 2659 FMI 21.

Step	Action	Decision
4	Inspect connections at the Exhaust Gas Recirculation (EGR) valve. With key OFF, disconnect EGR valve connector. Check EGR valve and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the EGR Valve connector, harness, and terminals clean and undamaged?	Yes: Go to Step 5.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2659 FMI 21.

Step	Action	Decision
5	Perform EGR Operational Test(page 679). Are there any active SPN 2791 or SPN 27 fault codes active?	Yes: Replace EGR valve
		No: Go to Step 6.

Step	Action	Decision
6	Start engine and let run for 5 sec before shutting off engine and visually inspect Exhaust Brake Actuator. The Exhaust Brake Actuator should cycle open and closed 3 times after engine shut down. Does Exhaust Brake Actuator cycle open and closed 3 times?	Yes: Go to Step 9.
		No: Go to Step 7.

Step	Action	Decision
7	Disconnect air supply to Exhaust Brake Actuator. Start engine and run for at least 5 seconds. Turn engine off and listen to Exhaust Brake Actuator supply line for air pressure. Does Exhaust Brake Actuator air supply line leak air pressure?	Yes: Replace Exhaust Brake Housing and retest for SPN 2659 FMI 21. No: Go to Step 8.

Step	Action	Decision
8	With truck air pressure 60 psi or greater. Disconnect Exhaust Brake Control Valve air supply line. Exhaust Brake Control Valve air supply line should leak air pressure. Does Exhaust Brake Control Valve air supply leak air pressure?	Yes: Replace Exhaust Brake Control valve and retest. After repairs are complete, retest for SPN 2659 FMI 21. No: Repair Exhaust Brake Control Valve air pressure supply line and retest. After repairs are complete, retest for SPN 2659 FMI 21.

Step	Action	Decision
9	Perform Air Management Test (page 201). Does Air Management test graph match Graph 1 (page 97) or Graph 2 (page 99)?	Graph 1: Go to step 10 Graph 2: Diagnose and repair failed actuator. After repairs are complete, repeat this step to verify repairs.

Step	Action	Decision
10	Do MAF Calibration Procedure – Using ServiceMaxx™ software (page 1101). Ensure MAF Calibration Requirements are met and MAF Calibration Pre-Checks are done, prior to doing this procedure. Did the MAF sensor calibration run successfully?	Yes: After doing all diagnostic steps, if SPN 2659 FMI 21 remains verify each step was completed correctly and proper decisions were made. Notify supervisor for further action. No: Verify all MAF calibration requirements are met and MAF calibration pre-checks are done. Repeat MAF calibration. After repairs are complete, retest for SPN 2659 FMI 21.

NOTE: After doing all diagnostic steps, if SPN 2659 FMI 21 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

APP Sensor (Accelerator Pedal Position)

SPN	FMI	Condition
91	2	APP1 and APP2 signal conflict
91	3	APP1 signal Out of Range HIGH (page 416)
91	4	APP1 signal Out of Range LOW (page 420)
521	2	Brake applied while APP applied
521	19	Brake switch circuit fault
2623	3	APP2 signal Out of Range HIGH (page 425)
2623	4	APP2 signal Out of Range LOW (page 428)

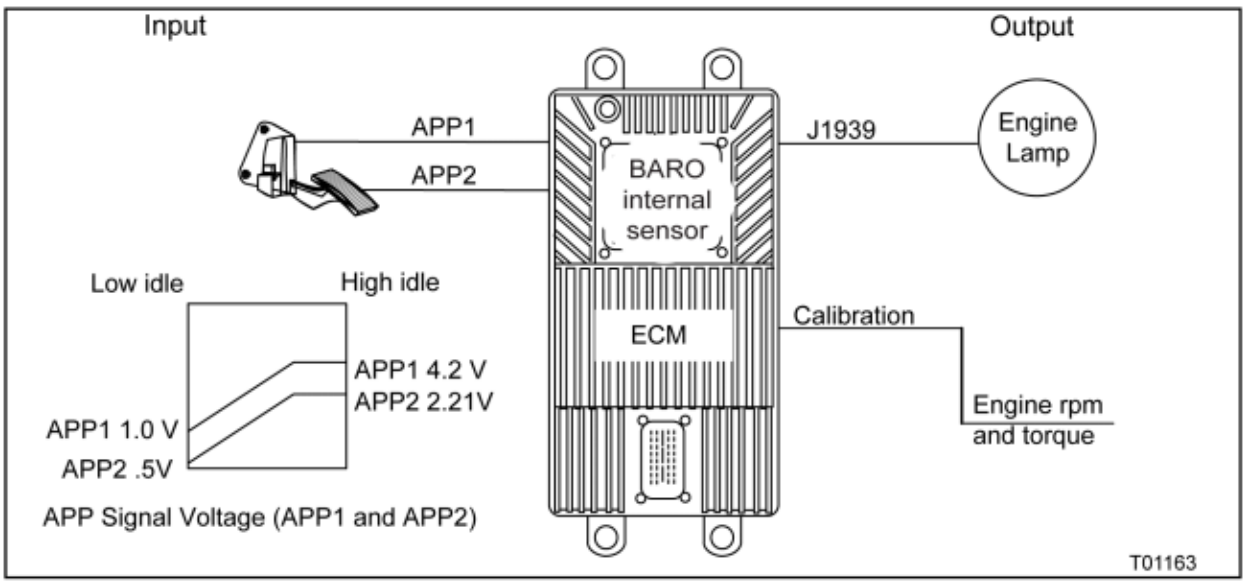


Figure 189 Function diagram for the APP

The function diagram for the APP includes the following:

- Accelerator Pedal Position (APP) Sensor
- Engine Control Module (ECM)
  with Barometric Absolute Pressure (BARO) Internal Sensor
- Engine Lamp

Function

The APP sensor is controlled by the operator. The ECM uses this sensor to control engine output based on the operator's demand for power.

Sensor Location

The APP sensor is installed in the cab on the accelerator pedal assembly.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- 00-00956-08 – 180-pin Breakout Box (page 1222)
- 3-Banana Plug Harness (page 1228)
- Breakout Harness 4485A (APP) (page 1230)
- International® Electronic Engine Terminal Test Kit (page 1227)

APP Sensor End Diagnostics

SPN	FMI	Condition	Possible Causes
91	2	APP1 and APP2 signal conflict	• APP1 and APP2 miss-matched • Biased 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 • VREF circuit OPEN • Failed APP sensor
521	2	Brake applied while APP applied	• The Operator was applying Accelerator Pedal and brake pedal at the same time • APP1 sensor or circuit fault • Brake Pedal switch or circuit fault
521	19	Brake switch circuit fault	• Brake Pedal switch or circuit fault
2623	3	APP2 signal Out of Range HIGH	• APP2 signal circuit short to PWR • SIG GND circuit OPEN • Failed sensor
2623	4	APP2 signal Out of Range LOW	• APP2 signal circuit OPEN or short to GND • VREF circuit OPEN • Failed sensor

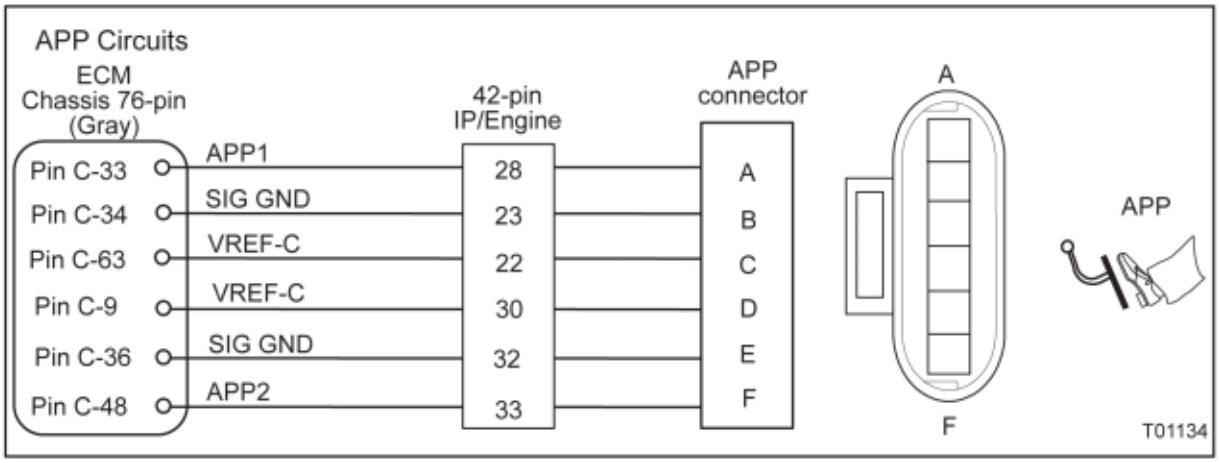


Figure 190 APP circuit diagram

1. Using EST and ServiceMaxx™ software, open the Continuous Monitor session.
2. Verify sensor voltage is within KOEO specification. See Key-On Engine-Off (page 1292).
3. Monitor sensor voltage. Verify an active code for the sensor.
   - If code 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 code will go active.
   - If code is active, proceed to the next step.
4. Disconnect engine harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

5. Connect Breakout Harness 4485A to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect Breakout Harness 4485A to engine harness. Leave sensor disconnected. Turn ignition switch to ON. Use EST to verify correct code goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Specification	Comment: < Less than, > Greater than
EST – Check code Sensor Disconnected	SPN 91 FMI 4	If SPN 91 FMI 3 is active, check APP1 signal for short to PWR.
	SPN 2623 FMI 4	If SPN 2623 FMI 3 is active, check APP1 for short to PWR.
DMM – Measure volts C to GND	5 ± 0.5 V	If > 5.5 volts, check VREF for short to PWR. If < 4.5 volts, check VREF for OPEN or short to GND. Go to Harness Resistance Check.
DMM – Measure volts D to GND	5 ± 0.5 V	If > 5.5 volts, check VREF for short to PWR. If < 4.5 volts, check VREF for OPEN or short to GND. Go to Harness Resistance Check.
EST – Check code Short Pin A to C	SPN 91 FMI 3	If SPN 91 FMI 4 is active, check APP1 circuit for OPEN. Go to Harness Resistance check.
	SPN 2623 FMI 4	
EST – Check code Short Pin D to F	SPN 91 FMI 4	If SPN 2623 FMI 4 is active, check APP2 circuit for OPEN. Go to Harness Resistance check.
	SPN 2623 FMI 3	
DMM – Measure volts B to B+	B+	If < B+, check SIG GND for OPEN. Go to Harness Resistance Check.
DMM – Measure volts E to B+	B+	If < B+, check SIG GND for OPEN. Go to Harness Resistance Check.
If checks are within specification, connect sensor, clear codes, and cycle the pedal a few times. If active code returns, replace sensor.		

APP Pin-point Diagnostics

Harness Resistance Check

Turn ignition switch to OFF. Disconnect both battery GND cables. Connect 180-pin Breakout Box and Breakout Harness 4485A. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
A to C-33	< 5 Ω	If > 5 Ω, check APP1 signal circuit for OPEN.
B to C-34	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
C to C-63	< 5 Ω	If > 5 Ω, check VREF-C circuit for OPEN.
D to C-9	< 5 Ω	If > 5 Ω, check VREF-C circuit for OPEN.
E to C-36	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
F to C-48	< 5 Ω	If > 5 Ω, check APP2 signal circuit for OPEN.

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 and EST to read signal.

Test Point	Condition	DMM	EST Value
APP1	Foot off pedal	1.14 ± 0.25 V	0 %
A to GND or			
C-33 to GND	Pedal to floor	4.32 ± 0.25 V	99.6 %
APP2	Foot off pedal	0.56 ± 0.25 V	0 %
F to GND or			
C-48 to GND	Pedal to floor	2.16 ± 0.25 V	99.6 %

APP Circuit Operation

The APP contains two position sensors. The two sensors (APP1 and APP2) are integrated into this single component and mounted on the accelerator pedal.

The ECM determines accelerator pedal position by processing input signals from APP1 and APP2.

APP

The APP is a dual potentiometer sensor supplied with two 5-volt VREF circuits. A 5-volt reference is supplied to Pin C from ECM Pin C-63, and to Pin D from ECM Pin C-9. The sensor is grounded using Pin B from ECM Pin C-34 and Pin E from ECM Pin C-36. The sensor returns a variable voltage signal from Pin A (APP1) to ECM Pin C-33, and from Pin F (APP2) to ECM Pin C-48.

APP Auto-calibration

The ECM auto-calibrates the APP signals every time the ignition switch is turned on. The ECM “learns” the lowest and highest pedal positions allowing for maximum pedal sensitivity. When the switch is turned off, this information is lost until the next switch cycle where the process is repeated. No accelerator pedal adjustment is needed with this feature.

Fault Detection / Management

When the ignition switch is on, the ECM continuously monitors the APP circuits for expected voltages. It also compares APP and APP2 signals for conflict. If a conflict occurs, the ECM will set a code.

Any malfunction of the APP circuits will illuminate the Warn Engine Lamp (WEL). If the ECM detects an Out-of-Range signal condition for either APP signal, the ECM will ignore the faulty APP signal. The ECM will continue to operate using only the properly functioning sensor.

If a disagreement in the state of APP1 and APP2 is detected, the ECM will allow only a maximum of 50 percent power to be commanded. If APP1 and APP2 signals are both detected as Out of Range, the engine will be allowed to operate at low idle only.

NOTE: If multiple APP codes are present, verify the APP part number is correct for the specific vehicle model.

NOTE: If elevated low idle rpm is experienced after replacing the pedal assembly or APP sensor, and there are no codes present, check pedal assembly or APP sensor part numbers for correctness.

SPN 91 FMI 3 - APP1 signal Out of Range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Accelerator Pedal Position 1 (APP1) signal greater than expected.	APP1 signal greater than 4.575 volts	Key ON

Fault Overview

Fault code sets when Engine Control Module (ECM) detects Accelerator Pedal Position 1 (APP1) signal is greater than 4.575 volts.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 3510 FMI 3 and 4 (VREF2)

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON

Possible Causes

- APP1 circuit short to power
- SIG GND circuit Open
- Failed APP sensor

Step 1	Check for active or pending fault code.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 91 FMI 3. Is EST DTC list SPN 91 FMI 3 active or pending?	Yes: Go to Step 2.
		No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Check for associated fault codes.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 3510 FMI 3 and 4 (VREF2). Does EST DTC list show SPN 3510 FMI 3 and 4 as active or pending?	Yes: Repair SPN 3510 FMI 3 and 4. After repairs are complete, retest for SPN 91 FMI 3.
		No: Go to Step 3.

Step 3	Inspect connections at Accelerator Pedal Position (APP) sensor.	Decision
	A. Key OFF. B. Disconnect APP sensor and connector. C. Check APP sensor and connector terminals for damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the APP sensor connector, harness, and terminal clean and undamaged?	Yes: Perform Pin-Point Tests (SPN 91 FMI 3) (page 418).
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 91 FMI 3.

End Diagnostic Tests
After performing diagnostic steps, if SPN 91 FMI 3 remains, verify if step was completed correctly and the proper decision was made. Notify supervisor for further action.

Pin-Point Tests (SPN 91 FMI 3)

APP Circuit

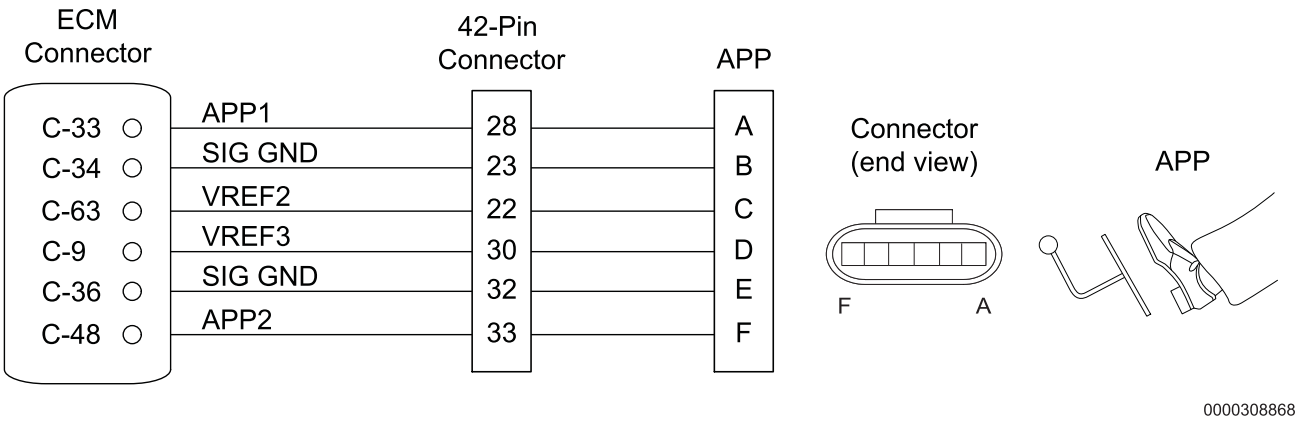


Figure 191 Pin-Point Test APP Circuit Diagram

See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4485A
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)

Test 1 Setup
A. Key OFF. B. Disconnect Accelerator Pedal Position (APP) sensor. C. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). D. Key ON. Log in to ServiceMaxx™ software.

Test 1	Specification
Using EST with ServiceMaxx™ software, clear Diagnostic Trouble Code (DTC) list.	SPN 91 FMI 3 sets
Decision	
Does SPN 91 FMI 3 set after DTC list is cleared?	Yes: Repair short to PWR between APP sensor connector pin-A and Engine Control Module (ECM) pin C-33.
	No: Go to Test 2.

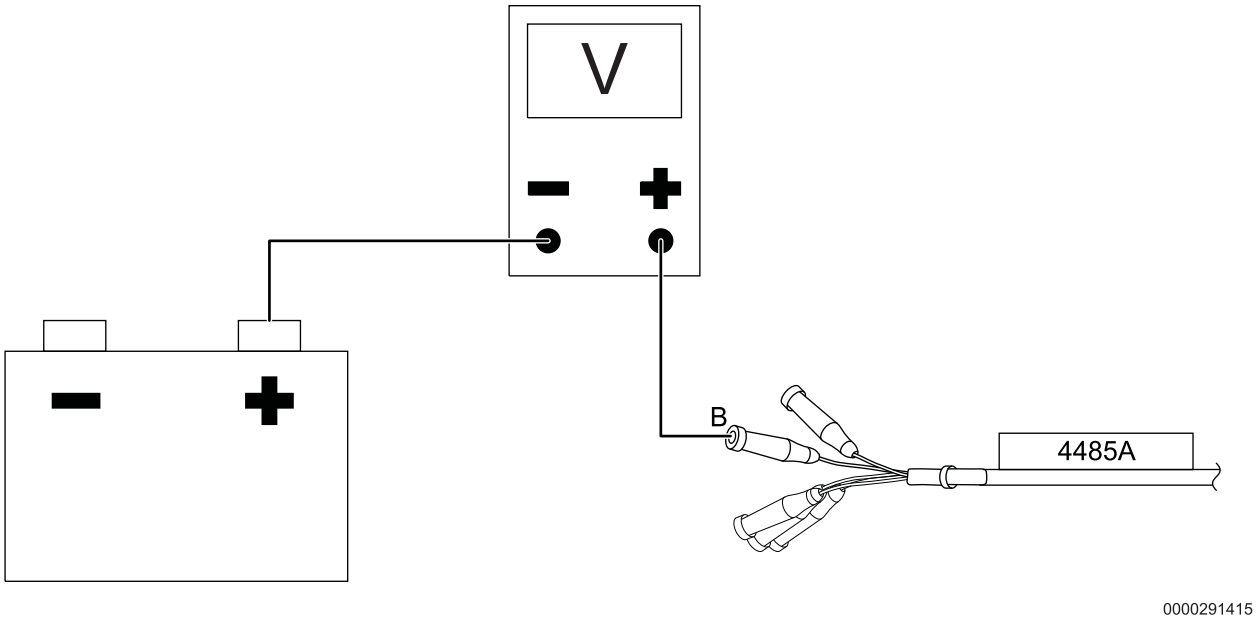


Figure 192 Pin-Point Test 2 APP1 Circuit Check

Test 2 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4435A to vehicle harness and leave APP sensor disconnected. C. Key ON.

Test 2	Specification
Use Digital Multimeter (DMM) to measure voltage between Breakout Harness ZTSE4485A pin-B and PWR.	Within 0.5 volt of B+
Decision	
Is voltage within 0.5 volt of B+?	Yes: Replace APP sensor. After repairs are complete, retest for SPN 91 FMI 3.
	No: Repair Open between APP pin-B and ECM pin C-34. After repairs are complete, retest for SPN 91 FMI 3.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and the proper decision was made. Return to SPN 91 FMI 3 fault code diagnostics.

SPN 91 FMI 4 - APP1 signal Out of Range LOW

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
APP1 signal less than expected.	APP1 signal less than 0.825 volts	Key ON

Fault Overview

Fault code sets when Engine Control Module (ECM) detects Accelerator Pedal Position 1 (APP1) signal is less than 0.825 volts.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 3510 FMI 3 and 4 (VREF2)

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON

Possible Causes

- APP1 signal circuit Open
- APP1 VREF circuit Open
- APP1 signal circuit short to GND
- Failed APP sensor

Step 1	Check for active fault code.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 FMI 4. Does EST DTC list show SPN 94 FMI 4 as Active or Pending?	Yes: Go to Step 2.
		No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Check for associated fault codes.	Decision
	Using EST with ServiceMaxx™ software, check DTC list for SPN 3510 FMI 3 and 4 (VREF2). Is EST DTC list free of SPN 3510 FMI 3 and 4?	Yes: Go to Step 3.
		No: Repair SPN 3510 FMI 3 and 4. After repairs are complete, retest for SPN 91 FMI 4.

Step 3	Inspect connections at Accelerator Pedal Position (APP) sensor.	Decision
	A. Key OFF. B. Disconnect APP sensor connector. C. Check APP1 sensor and connector terminals for damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the APP sensor connector, harness, and terminal clean and undamaged?	Yes: Perform Pin-Point Tests (SPN 91 FMI 4) (page 421).
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 91 FMI 4.

Pin-Point Tests (SPN 91 FMI 4)

APP Circuit

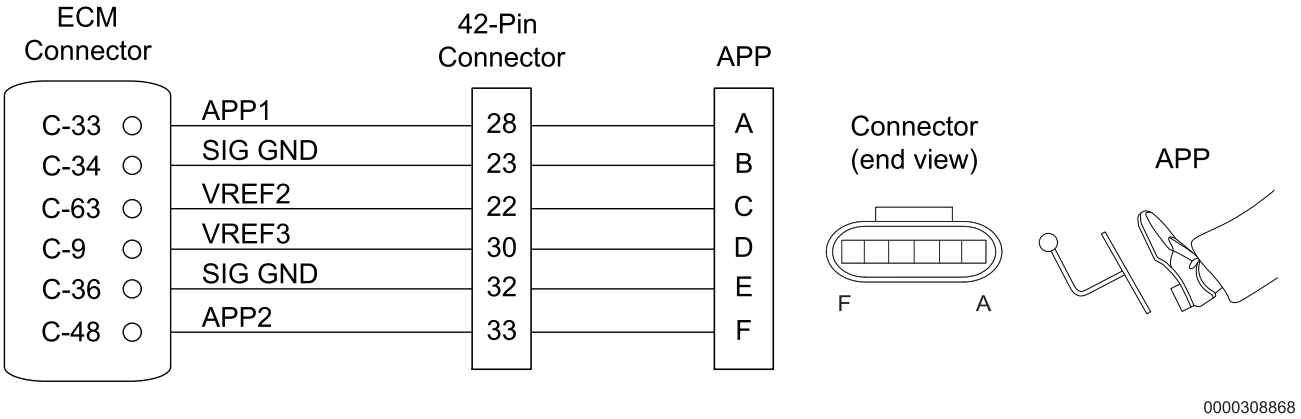


Figure 193 APP1 Sensor Circuit Diagram

See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4485A
- Breakout Harness ZTSE4498
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)

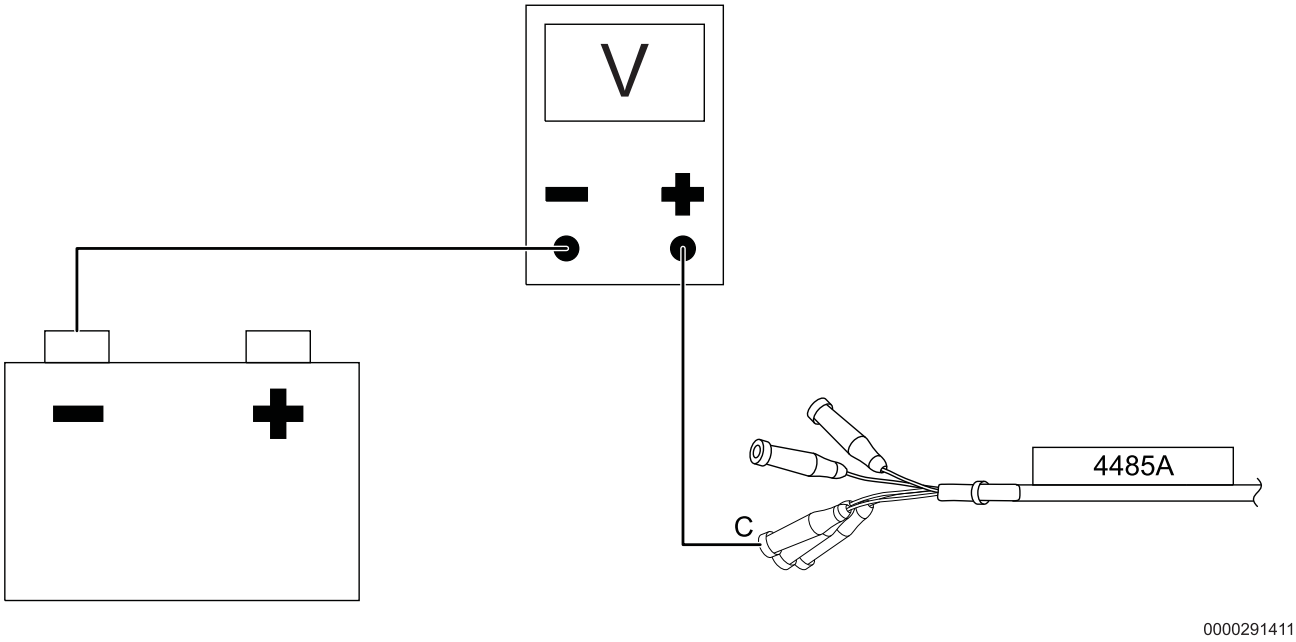
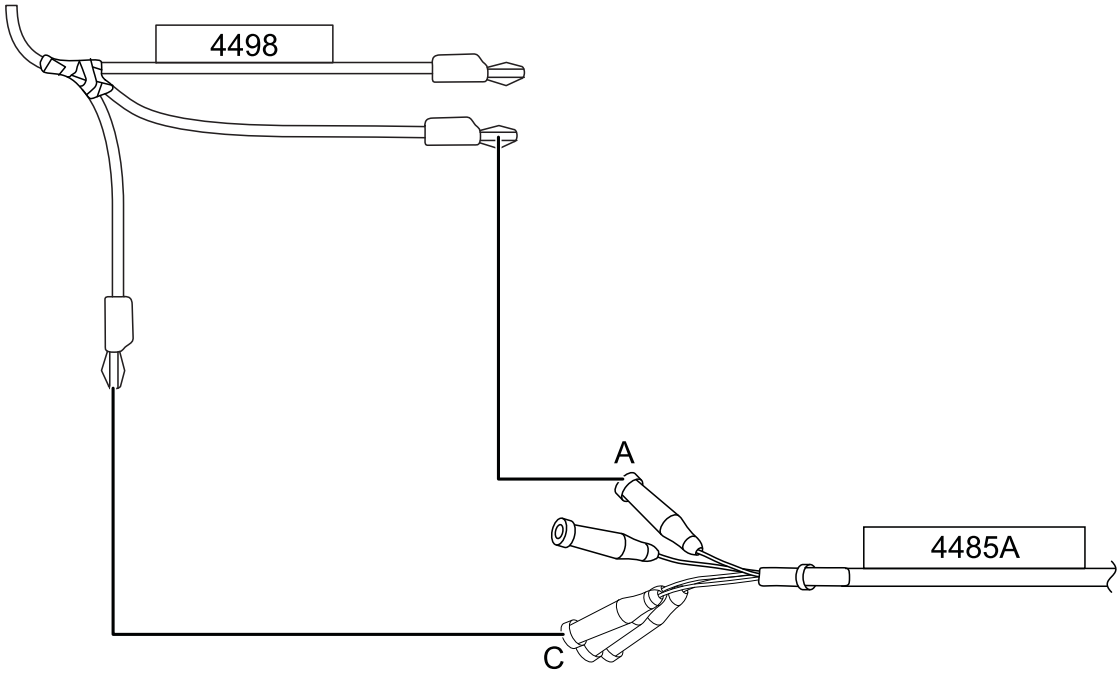


Figure 194 Pin-Point Test 1 APP1 Circuit Check

Test 1 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4485A to Accelerator Pedal Position (APP) and leave sensor disconnected. C. Key ON.

Test 1	Specification
Using a DMM, measure voltage between Breakout Harness ZTSE4485A pin C and a known good GND.	5 volts ± 1 volt
Decision	
Is voltage within 1 volt of 5 volts?	Yes: Go to Test 2.
	No: Repair Open between APP sensor connector pin-C and Engine Control Module (ECM) 76-pin chassis connector pin C-63. After repairs are complete, retest for SPN 91 FMI 4.



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Figure 195 Pin-Point Test 2 APP1 Circuit Check

Test 2 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4485A to Accelerator Pedal Position (APP) and leave sensor disconnected. C. Using Breakout Harness ZTSE4498, short pin-A and pin-C of Breakout Harness ZTSE4485A together. D. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). E. Key ON. Log in to ServiceMaxx™ software.

Test 2	Specification
Clear Diagnostic Trouble Code (DTC) list using EST with ServiceMaxx™ software.	DTC list SPN 91 FMI 3 sets
Decision	
Does SPN 91 FMI 3 set after DTC list is cleared?	Yes: Replace Accelerator Pedal Position (APP) sensor. After repairs are complete, retest for SPN 91 FMI 4.
	No: Go to Test 3.

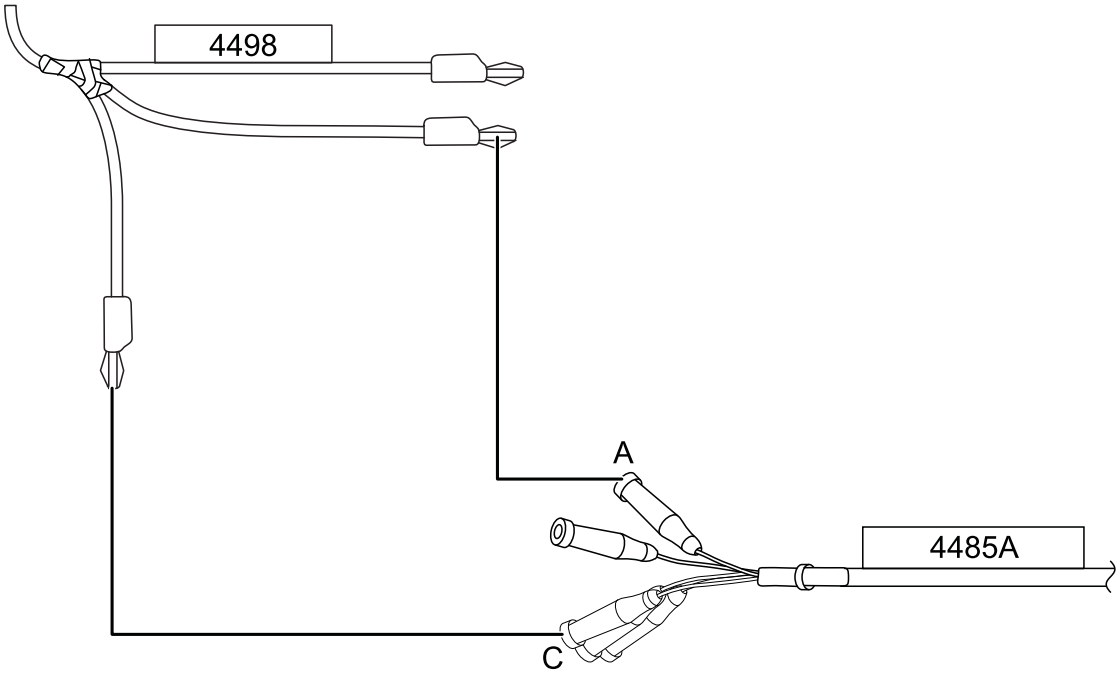


Figure 196 Pin-Point Test 3 APP1 Circuit Check

Test 3 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4485A to Accelerator Pedal Position (APP) and leave sensor disconnected. C. Using Breakout Harness ZTSE4498, short pin-A and pin-C of Breakout Harness ZTSE4485A together. D. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector. E. Key ON. Log in to ServiceMaxx™ software.

Test 3	Specification
Clear Diagnostic Trouble Code (DTC) list using EST with ServiceMaxx™ software.	DTC list SPN 3510 FMI 4 sets
Decision	
Does SPN 3511 FMI 4 set after DTC list is cleared?	Yes: Repair short to GND between APP sensor pin A and Engine Control Module (ECM) pin C-33. After repairs are complete, retest for SPN 91 FMI 4.
	No: Repair Open between APP sensor pin A and ECM pin C-33. After repairs are complete, retest for SPN 91 FMI 4.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and the proper decision was made. Return to SPN 91 FMI 4 fault code diagnostics.

SPN 2623 FMI 3 - APP2 Signal Out of Range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Values
Accelerator Pedal Position (APP) signal is greater than expected.	APP2 signal > 2.476 volts	Key ON

Fault Overview

Fault code sets when Electronic Control Module (ECM) detects that APP2 voltage is greater than 2.476 volts.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON.

Possible Causes

- APP2 circuit short to PWR
- SIG GND circuit Open
- Failed APP sensor

Step 1	Check for active or pending fault code.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 2623 FMI 3. Does EST DTC list show SPN 2623 FMI 3 as active or pending?	Yes: Go to Step 2.
		No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Inspect connections at Accelerator Pedal Position (APP) sensor connector	Decision
	A. Key OFF. B. Disconnect APP sensor connector. C. Check APP sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the APP sensor connector, harness, and terminals clean and undamaged?	Yes: Perform Pin-Point Tests (SPN 2623 FMI 3)(page 426). No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2623 FMI 3.

Pin-Point Tests (SPN 2623 FMI 3)

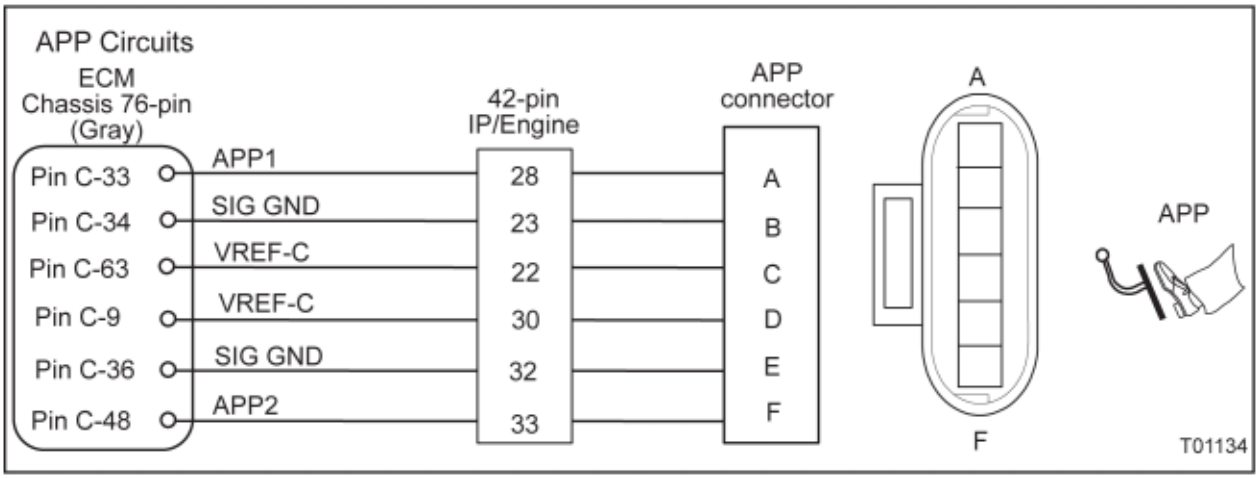


Figure 197 Accelerator Pedal Position (APP) Sensor Circuit Diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

NOTE: See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4485A
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)

Test 1 Setup
A. Key OFF. B. Disconnect Accelerator Pedal Position (APP) sensor C. Key ON.

Test 1	Specification
Using EST with ServiceMaxx™ software, clear Diagnostic Trouble Code (DTC) list.	SPN 2623 FMI 4 sets after DTC list is cleared
Decision	
Does fault code SPN 2623 FMI 4 set?	Yes: Go to Test 2.
	No: Repair short to PWR between APP connector pin-F and Engine Control Module (ECM) connector pin C-48.

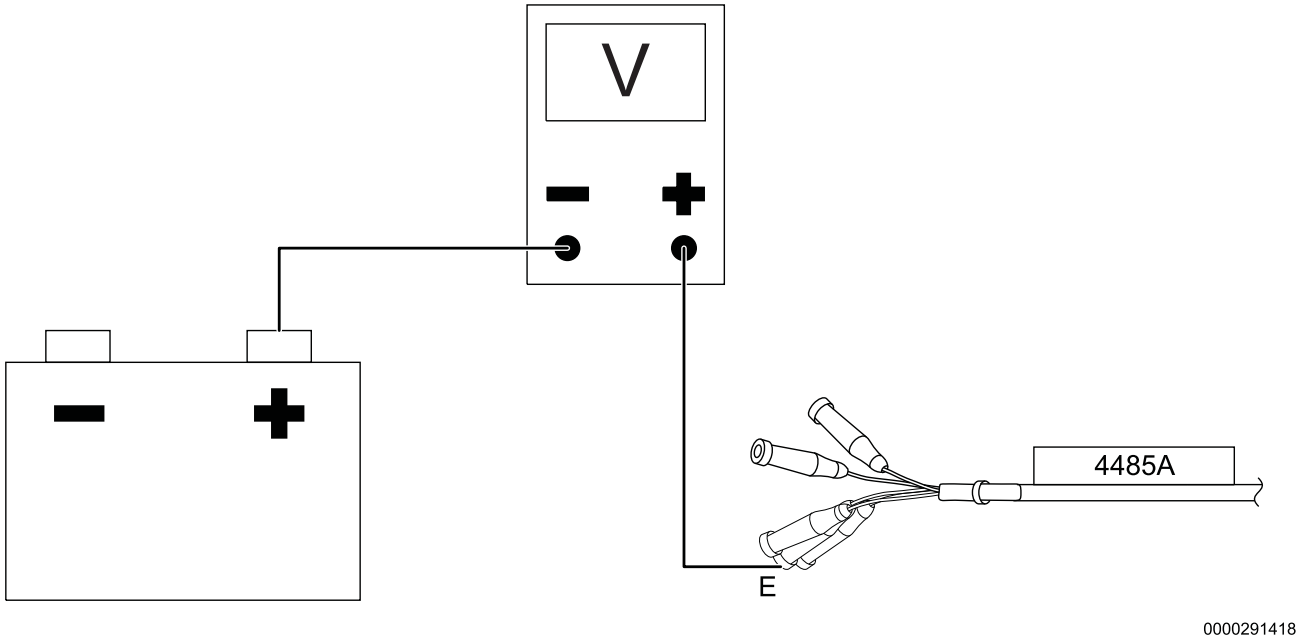


Figure 198 Pin-Point Test 2 Accelerator Pedal Position (APP2) Sensor Voltage Check

Test 2 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4485A to Accelerator Pedal Position (APP) sensor vehicle harness connector and leave sensor disconnected. C. Key ON.

Test 2	Specification
Use a Digital Multimeter (DMM) to measure voltage between Breakout Harness ZTSE4485A pin-E and B+.	12 volts ± 1 volt
Decision	
Is voltage within 1 volt of 12 volts?	Yes: Replace APP sensor. After repairs are complete, retest for SPN 2623 FMI 3.
	No: Repair Open between APP sensor connector pin-E and ECM connector pin C-36. After repairs are complete, retest for SPN 2623 FMI 3.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and the proper decision was made. Return to SPN 2623 FMI 3 fault code diagnostics.

SPN 2623 FMI 4 - APP2 Signal Out of Range LOW

Condition / Description	Setting Criteria	Enable Conditions / Values
Accelerator Pedal Position 2 (APP2) signal is lower than expected.	APP2 signal < 0.273 volt	Key ON

Fault Overview

Fault code sets when Electronic Control Module (ECM) detects that Accelerator Pedal Position (APP) sensor is reading lower than 0.273 volt on APP2 signal circuit.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 3511 FMI 3 and 4 (VREF3)

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON.

Possible Causes

- APP2 circuit Open
- APP2 circuit short to GND
- VREF3 circuit Open

- Failed APP sensor

Step 1	Check for associated fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 3511 FMI 3 and 4 (VREF3). Does EST DTC list free of SPN 3511 FMI 3 and 4?		Yes: Go to Step 2. No: Repair SPN 3511 FMI 3 and 4. After repairs are complete, retest for SPN 2623 FMI 4.

Step 2	Inspect connections at Accelerator Pedal Position (APP) sensor connector	Decision
	A. Key OFF. B. Disconnect APP sensor connector. C. Check APP sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the APP sensor connector, harness, and terminals clean and undamaged?	Yes: Perform Pin-Point Tests (SPN 2623 FMI 4)(page 429). No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2623 FMI 4.

Pin-Point Tests (SPN 2623 FMI 4)

APP Circuit

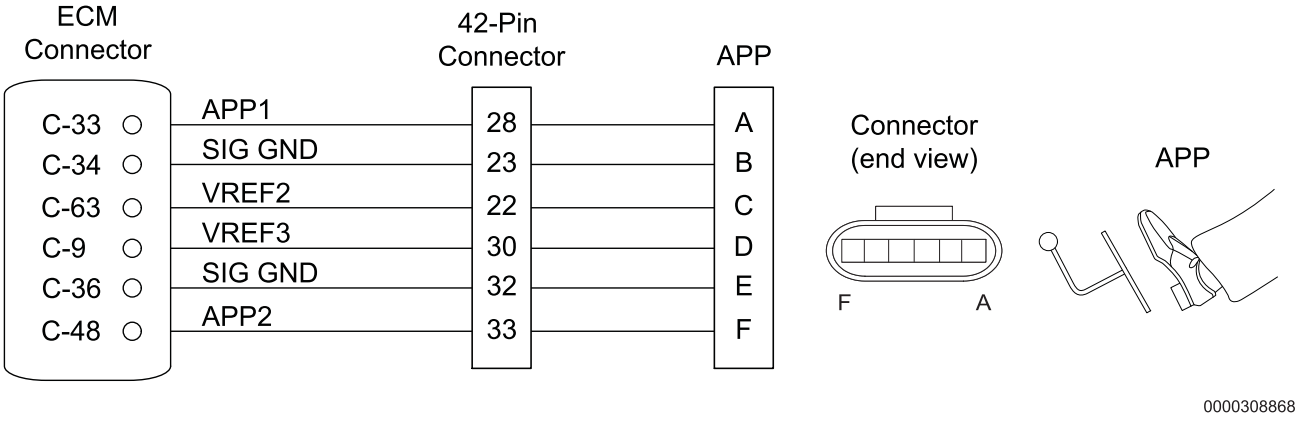


Figure 199 Accelerator Pedal Position (APP) Sensor Circuit Diagram

NOTE: See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- 180-Pin Breakout Box 00-00956-08
- Breakout Harness ZTSE4485A
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)

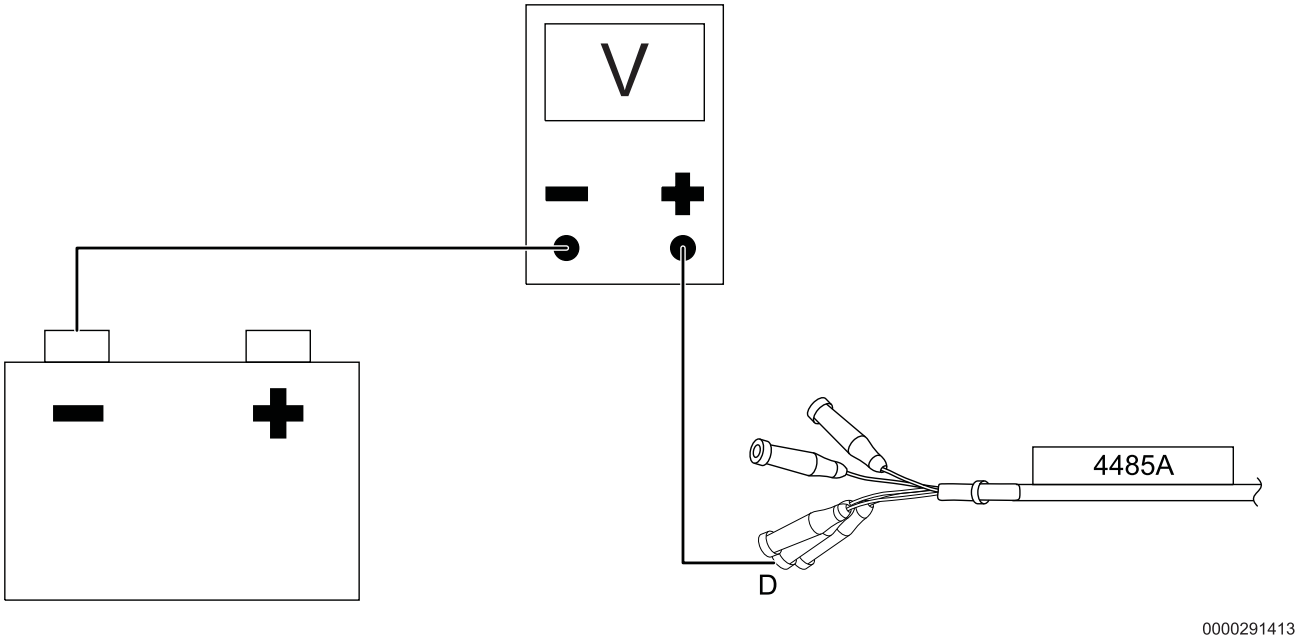
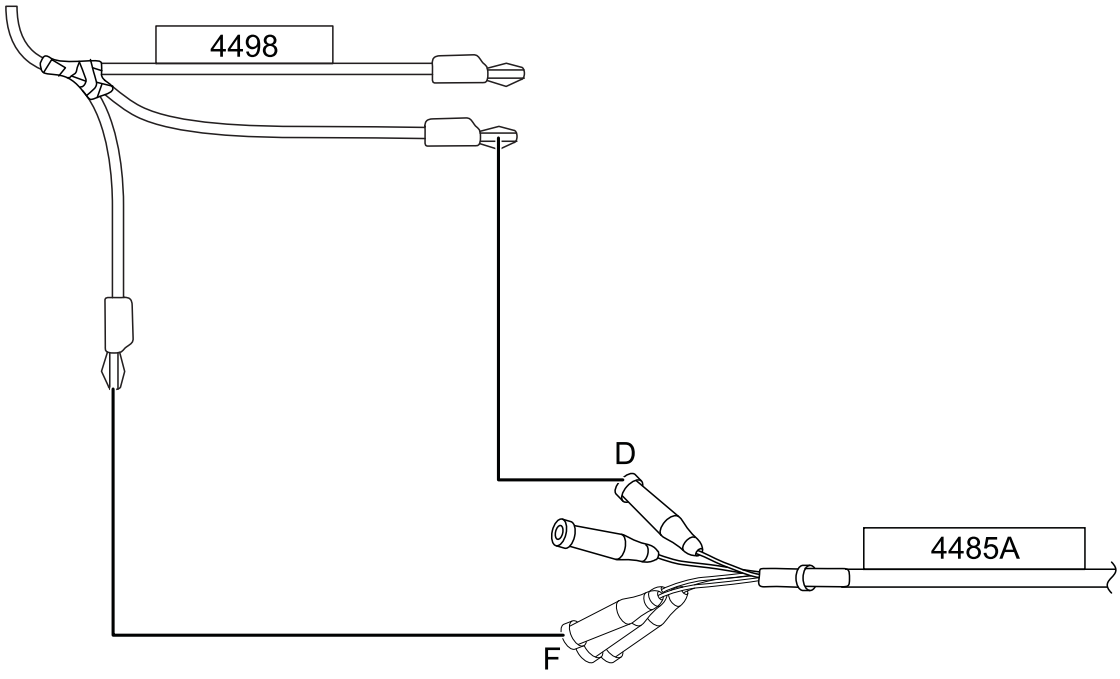


Figure 200 Pin-Point Test 1 APP Sensor Voltage Check

Test 1 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4485A to Accelerator Pedal Position (APP) sensor vehicle harness connector and leave sensor disconnected. C. Key ON.

Test 1	Specification
Use a Digital Multimeter (DMM) to measure voltage between Breakout Harness ZTSE4485A pin-D and a known good ground.	1 volt of 5 volts
Decision	
Is voltage within 1 volt of 5 volts?	Yes: Go to Test 2.
	No: Repair Open between APP sensor connector pin-D and Engine Control Module (ECM) connector pin C-9. After repairs are complete, retest for SPN 2623 FMI 4.

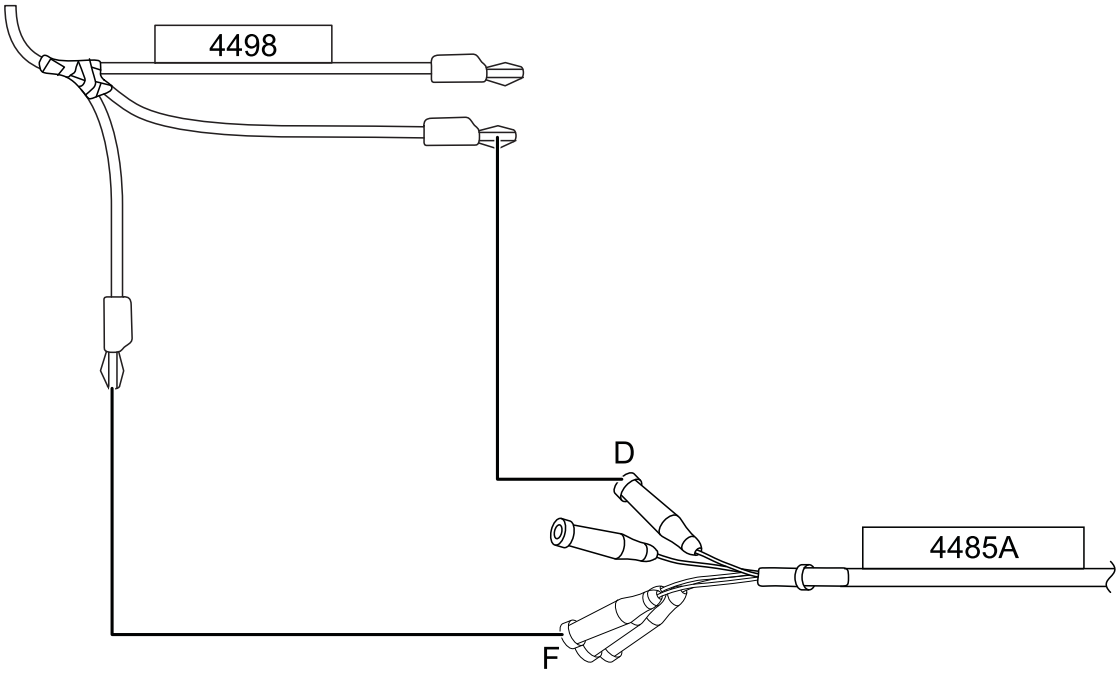


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Figure 201 Pin-Point Test 2 APP Sensor Circuit Check

Test 2 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4485A to APP sensor vehicle harness connector and leave sensor disconnected. C. Using ZTSE4498 short pin-D to pin-F. D. Connect Electronic Service Tool (EST) to vehicle Diagnostic (page 81). E. Key ON. Log on to ServiceMaxx™ software.

Test 2	Specification
Using EST with ServiceMaxx™ software, clear Diagnostic Trouble Code (DTC) list.	SPN 2623 FMI 3 sets in DTC list.
Decision	
Does SPN 2623 FMI 3 become active or pending in DTC list?	Yes: Replace APP sensor. After repairs are complete, retest for SPN 2623 FMI 3.
	No: Go to Test 3.



0000307556

Figure 202 Pin-Point Test 3 APP Sensor Circuit Check

Test 3 Setup
A. Key OFF.
B. Connect Breakout Harness ZTSE4485A to APP sensor vehicle harness connector and leave sensor disconnected.
C. Using ZTSE4498 short pin-D to pin-F.
D. Connect EST to vehicle Diagnostic.
E. Key ON. Log in to ServiceMaxx™ software.

Test 3	Specification
Using EST with ServiceMaxx™ software, clear DTC list.	SPN 3511 FMI 4 sets in DTC list.
Decision	
Does SPN 3511 FMI 4 become active or pending in DTC list?	Yes: Repair short to GND between APP pin-F and ECM pin C-48. After repairs are complete, retest for SPN 2623 FMI 4.
	No: Repair Open between APP pin-F and ECM pin C-48. After repairs are complete, retest for SPN 2623 FMI 4.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and the proper decision was made. Return to SPN 2623 FMI 4 fault code diagnostics.

ATA Datalink (American Trucking Association)

SPN	FMI	Condition
None	None	No communication to Electronic Gauge Cluster (EGC)

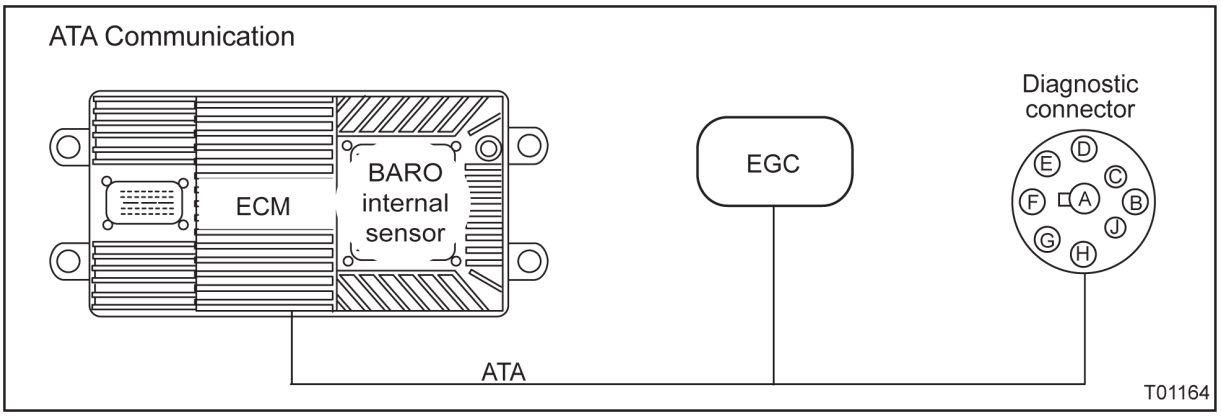


Figure 203 Function diagram for ATA

The function diagram for the American Trucking Association (ATA) includes the following:

- Engine Control Module (ECM)
  with Barometric Absolute Pressure (BARO) Internal Sensor
- Electronic Gauge Cluster (EGC)
- Diagnostic Connector

Function

The ATA datalink provides communication between the ECM and an ATA compatible EGC. The EST tool can access this datalink at the Diagnostic Connector.

Location

The ATA circuits are connected to the ECM, EGC, and Diagnostic Connector. The Diagnostic Connector is located under the dash on the driver's side.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- 00-00956-08 – 180-pin Breakout Box (page 1222)
- International® Electronic Engine Terminal Test Kit (page 1227)

ATA Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
None		No communication with EST	• B+ circuit OPEN or shorted to GND • GND circuit OPEN • ATA circuits OPEN or shorted to PWR or GND

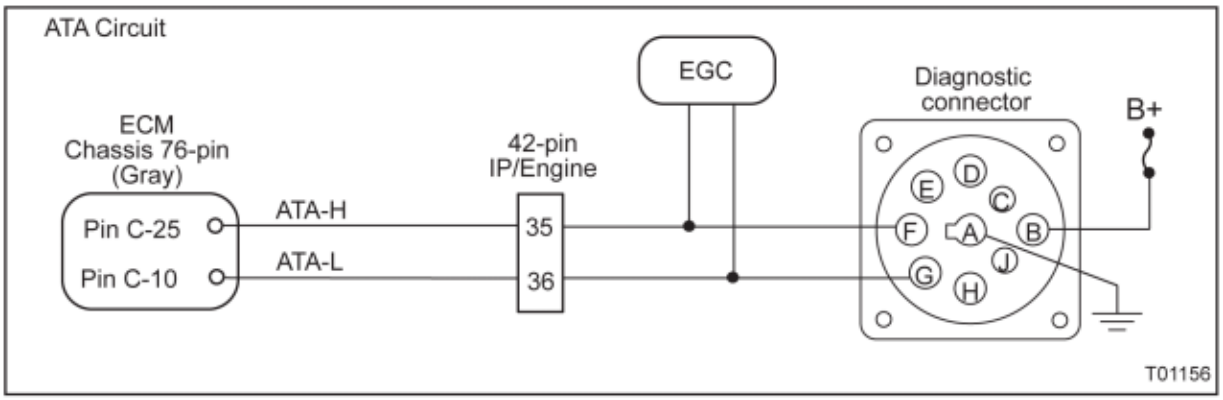


Figure 204 ATA circuit diagram

Connector Voltage Check – EST

Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment: < Less than, > Greater than
B to GND	B+	If < B+, check B+ circuit to Diagnostic Connector for OPEN or short to GND, or blown fuse.
B to A	B+	If < B+, check GND circuit to Diagnostic Connector for OPEN.
F to GND	1 to 4 V	The sum of F to GND and G to GND should equal 4 to 5 volts.
G to GND	1 to 4 V	The sum of G to GND and F to GND should equal 4 to 5 volts.

See truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for EGC diagnostic information.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-pin Breakout Box. Leave ECM disconnected.

Test Point	Specification	Comment: < Less than, > Greater than
F to C-25	< 5 Ω	If > 5 Ω, check ATA-H for OPEN in circuit
F to GND	> 1 kΩ	If < 1 kΩ, check ATA-H for short to GND
G to C-10	< 5 Ω	If > 5 Ω, check ATA-L for OPEN in circuit
G to GND	> 1 kΩ	If < 1 kΩ, check ATA-L for short to GND
A to GND	< 5 Ω	If > 5 Ω, check GND for OPEN in circuit

ATA Operation

Diagnostic Connector

The fuse protected B+ signal is supplied to the Diagnostic Connector through Pin B, and GND is through Pin A. American Trucking Association High (ATA-H) signal runs from ECM Pin C-25 and Diagnostic Connector Pin F. American Trucking Association Low (ATA-L) signal runs from ECM Pin C-10 and Diagnostic Connector Pin G.

EGC

There are two types of EGC modules, one uses J1939 Data Link communication and the other uses ATA communication. The following information is sent through data communication:

- Engine lamp (red)
- Engine lamp
- Coolant level lamp
- Wait to start lamp
- Water In Fuel (WIF) lamp
- Speedometer
- Tachometer (TACH)
- Odometer / Hour meter
- Change oil message
- Oil pressure gauge
- Engine Oil Temperature (EOT) gauge
- Engine Coolant Temperature (ECT) gauge

Fault Detection / Management

There are no engine codes for ATA communication faults. See truck *Truck Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide*.

Repair Information

The ATA circuits use a twisted wire pair. All repairs must maintain one complete twist per inch along the entire length of the circuit. This circuit is polarized, one positive and one negative. Reversing the polarity of this circuit will disrupt communication.

CACOT Sensor (Charge Air Cooler Outlet Temperature)

SPN	FMI	Condition	Possible Causes	Actions
2630	2	CACOT Signal Erratic, Intermittent, or Incorrect	• Biased CACOT sensor • High resistance connections to CACOT sensor • Shorted connections for CACOT sensor	Step-based Diagnostics (page 440)
2630	3	CACOT signal out of range HIGH	• Defective CACOT sensor • CACOT connector disconnected • CACOT signal or signal return open • CACOT short to battery	Step-based Diagnostics (page 443)
2630	4	CACOT signal out of range LOW	• CACOT signal circuit short to GND • Failed sensor	Step-based Diagnostics (page 449)
2630	16	CACOT Under cooling	• Low coolant level • Engine overheating • Excessive boost levels • Biased Barometric Absolute Pressure (BARO) sensor • Biased Intake Manifold Temperature (IMT) sensor • Biased Inlet Air Temperature (IAT) sensor • Biased CACOT sensor • Biased Intake Manifold Pressure (IMP) sensor	Step-based Diagnostics (page 452)

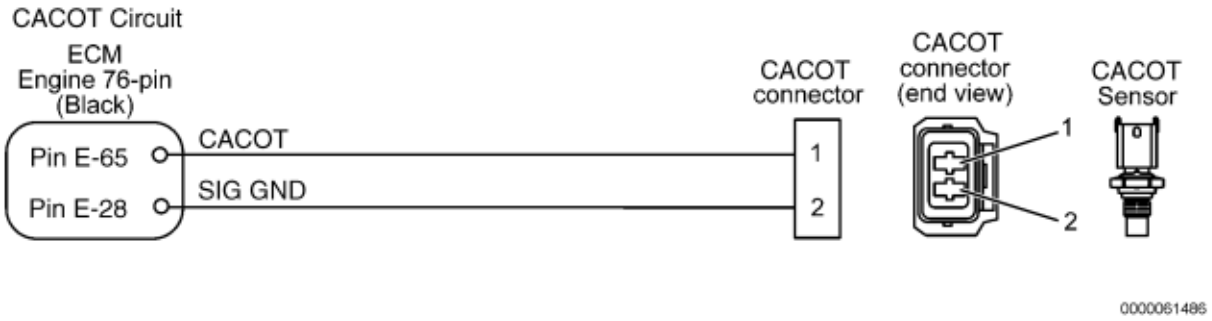


Figure 205 CACOT Circuit Diagram

Overview

The Charge Air Cooler Outlet Temperature (CACOT) sensor is a thermistor style sensor that measures charged-air temperature entering the Engine Throttle Valve (ETV). As temperature increases, resistance drops, causing the voltage signal interpreted by the Engine Control Module (ECM) to vary. The ECM monitors this signal for Exhaust Gas Recirculation (EGR) system control and CAC performance.

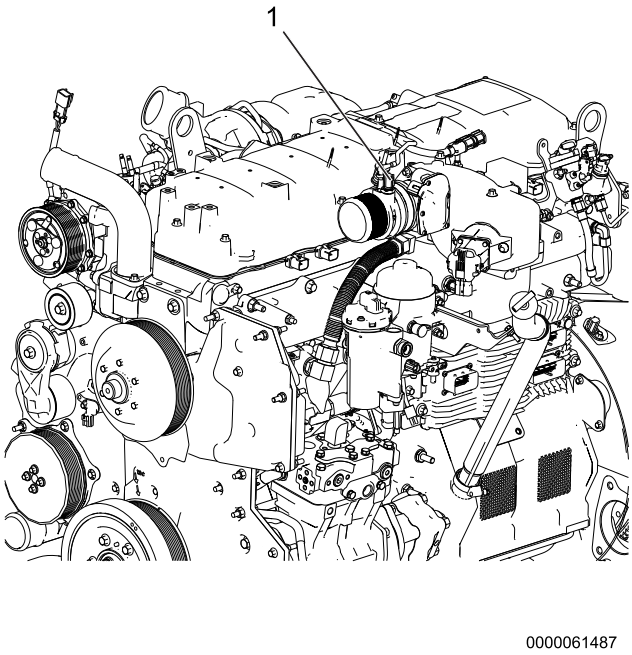


Figure 206 CACOT Sensor Location

1. CACOT Sensor

Tools

- EZ-Tech® Electronic Service Tool (EST) – J-45067
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM)

- 00-00956-08 – 180-pin Breakout Box
- Breakout Harness ZTSE4993 (CACOT)
- International® Electronic Engine Terminal Test Kit ZTSE4435C

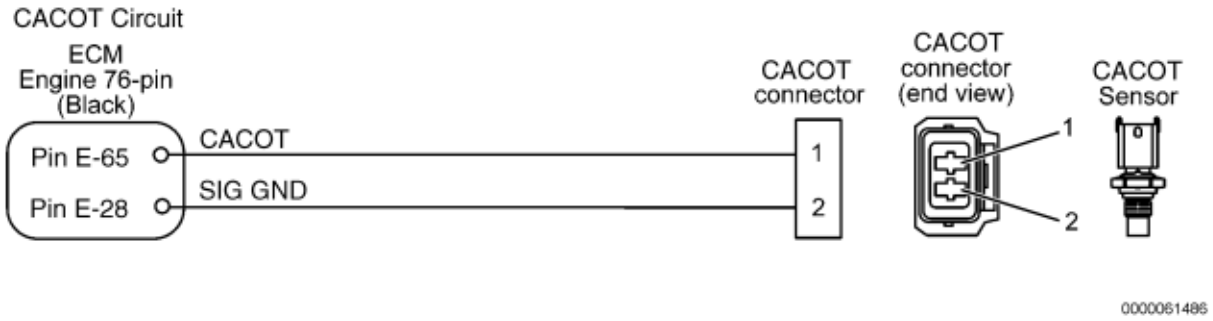


Figure 207 CACOT Circuit Diagram

Connector Voltage Check

Connect Breakout Harness ZTSE4993. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment
2 to B+	B+	If < B+, check for short to power, or OPEN circuit. Go to Harness Resistance Check (page 439).
1 to GND	4.6 V to 5 V	If < 4.5 volts, check for OPEN or short to GND. Do Harness Resistance Check (page 439). If > 5 volts and < 8 volts, check that DMM leads are connected correctly. If > 8 volts check for short to B+.

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect Breakout Harness ZTSE4993. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment
2 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit.
1 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-pin Breakout Box and Breakout Harness ZTSE4993. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment
2 to E-28	< 5 Ω	If > 5 Ω, check for OPEN circuit.
1 to E-65	< 5 Ω	If > 5 Ω, check for OPEN circuit.

SPN 2630 FMI 2 - CACOT signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Comparison of Engine Charge Air Cooler Outlet Temperature sensor to the following sensors after a calibrated adjustable cold-soak period (time). Sensor 1 to 4 are in Air group and 5 and 6 are in Liquid group. 1. Engine Intake Manifold 1 Temperature 2. Engine Air Inlet Temperature 3. Engine Turbocharger 2 Compressor Inlet Temperature 4. Engine Charge Air Cooler Outlet Temperature 5. Engine Coolant Temperature 6. Engine Oil Temperature 1	{Engine Intake Manifold 1 Temperature (Bias Hi) > Reference temperature value OR Engine Intake Manifold 1 Temperature (Bias low)} ≤ Reference temperature value Error threshold value for comparison of sensors in same media (Air to Air media): Used for Equilibrium and Reference value calculation > 59°F (15°C) Error threshold value for comparison of sensors in different media (Air to Liquid media): Used for Equilibrium and Reference value calculation > 59°F (15°C) Error threshold value for comparison of sensors in same media (Liquid to Liquid): Used for Equilibrium and Reference value calculation > 59°F (15°C) Error threshold value for comparison of sensors in different media (Liquid to Air or vice versa) : Used for Equilibrium and Reference value calculation > 59°F (15°C) {NOTE: Reference temperature value calculation is explained in Operations Summary Document}	Key ON Engine Off timer ≥ 28800 seconds Engine Coolant Temperature ≥ -40°F (-40°C) Engine in Thermal Equilibrium Condition (Explained in operations summary document) Similar sensors agree with other sensors with different group-index OR Faulty Sensor is alone in its group (i.e. No other sensor which measures the same media (in Air Path) is identified as a faulty sensor)

Fault Overview

ECM compares Charge Air Cooler Outlet Temperature (CACOT) sensor to Intake Manifold Temperature (IMT), Intake Air Temperature (IAT), Turbocharger 2 Compressor Intake Temperature (TC2CIT), Engine Coolant Temperature 1 (ECT1), and Engine Oil Temperature (EOT) sensors after calibrated adjustable cold-soak period (time).

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Initial Key ON

Possible Causes

- Failed CACOT sensor
- Failed wiring

Step 1	Check for active or pending fault codes.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 2630 FMI 2. Is EST DTC list SPN 2630 FMI 2 active or pending?	Yes: Go to Step 2.
		No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Inspect connections at Charge Air Cooler Outlet Temperature (CACOT) connector.	Decision
	A. Key OFF. B. Disconnect CACOT connector. C. Check CACOT and connector terminals for: damaged or pinched wires; moisture or corroded terminals; loose, bent, or broken pins; or broken connector housing. Are CACOT connector, harness, and terminals clean and undamaged?	Yes: Go to Step 3.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2630 FMI 2.

Step 3	Inspect connections at Charge Air Cooler Outlet Temperature (CACOT) connector.	Decision
	A. Key OFF. B. Connect Breakout Harness ZTSE4993 between pin-1 and pin-2 on CACOT connector. C. Key-On Engine-Off (KOEO). Using EST with ServiceMaxx™ software, measure voltage between pin-1 and pin-2.	Yes: Replace CACOT sensor. After repairs are complete, retest for SPN 2630 FMI 2.

	Is voltage less than 0.5 volts?	
		No: Go to step 4.

Step 4	Inspect connections at Charge Air Cooler Outlet Temperature (CACOT) connector.	Decision
	A. Key OFF. B. Connect Breakout Harness ZTSE4993 between pin-1 and known good GND. C. Key-On Engine-Off (KOEO). Using EST with ServiceMaxx™ software, measure resistance. Is resistance less than 5 ohms?	Yes: Repair CACOT signal wire. After repairs are complete, retest for SPN 2630 FMI 2.
		No: Repair CACOT SIG GND wire. After repairs are complete, retest for SPN 2630 FMI 2.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 2630 FMI 2 fault code diagnostics.

SPN 2630 FMI 3 - CACOT Signal Out of Range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Charge Air Cooler Outlet Temperature (CACOT) sensor voltage reading greater than expected.	CACOT sensor voltage < 4.70 volt {<-53°F (-47°C)}	Key ON

Fault Overview

Fault Code sets when Engine Control Module (ECM) detects Charge Air Cooler Temperature (CACOT) sensor voltage is greater than 4.70 volts.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected after two bad trips.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON

Possible Causes

- CACOT circuit short to PWR
- CACOT circuit Open
- CACOT SIG GND circuit Open
- Failed component

Step 1	Check for active or pending fault codes.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx software, check Diagnostic trouble Code (DTC) list for SPN 2630 FMI 3. Is EST DTC list SPN 2630 FMI 3 active or pending?	Yes: Go to Step 2.
		No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Inspect connections at CACOT	Decision
	A. Key OFF. B. Disconnect Charge Air Cooler Outlet Temperature (CACOT) sensor. C. Check CACOT sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the CACOT sensor connector, harness, and terminals clean and undamaged?	Yes: Perform Pin-Point Tests (SPN 2630 FMI 3).
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2630 FMI 3.

Pin-Point Tests (SPN 2630 FMI 3)

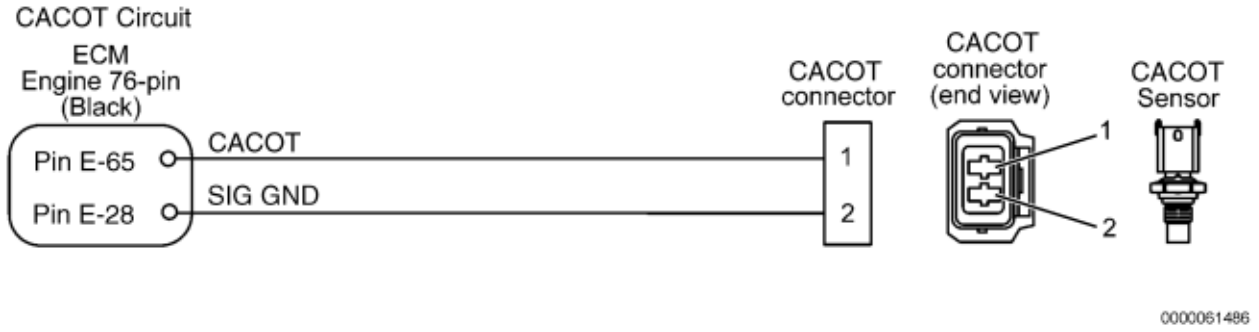


Figure 208 CACOT Sensor Circuit Diagram

NOTE: See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Box 00-00956-08
- Breakout Harness ZTSE4498
- Breakout Harness ZTSE4993
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)

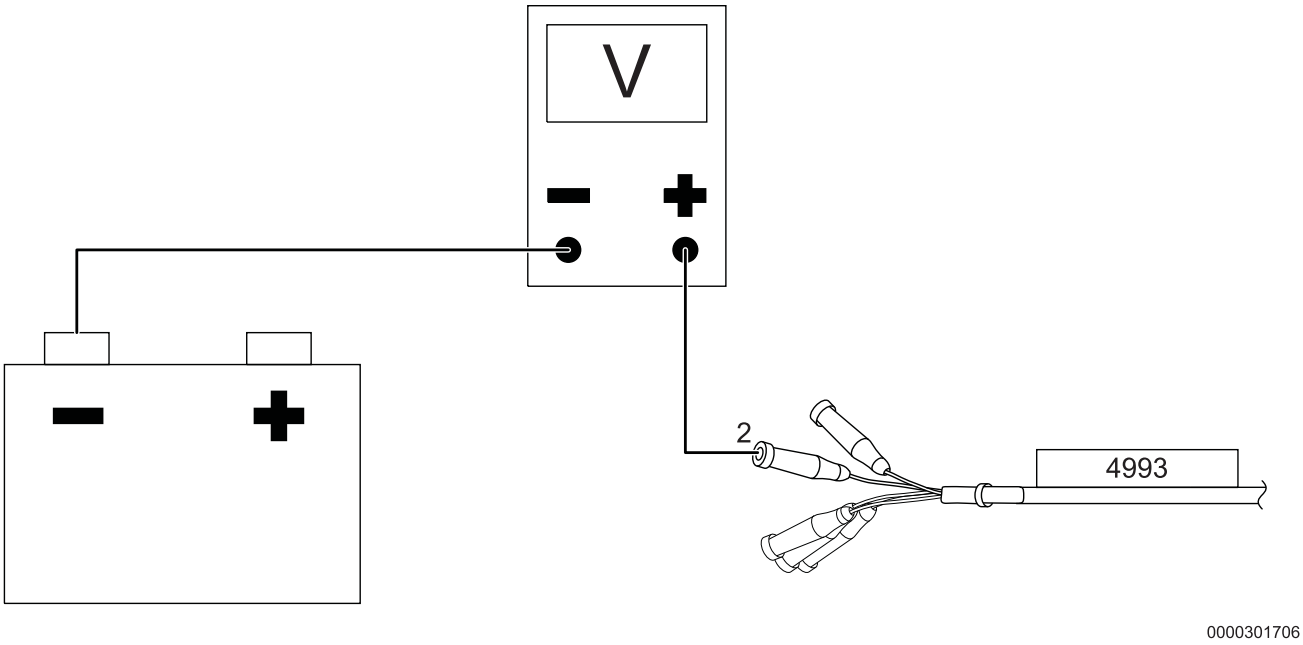
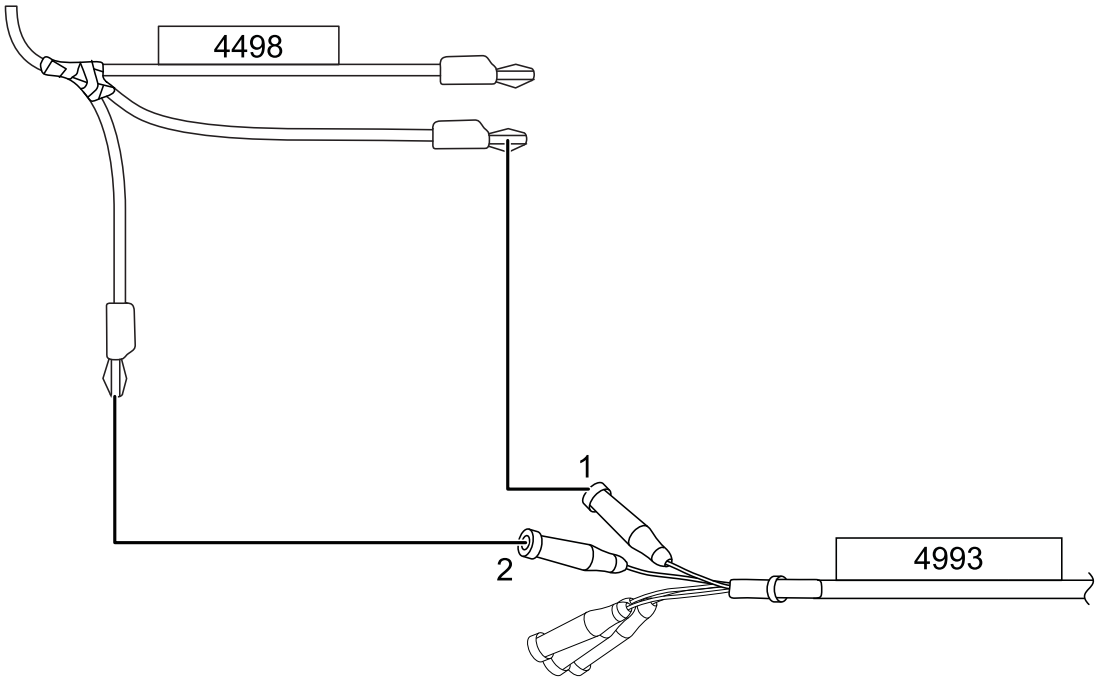


Figure 209 Pin-Point Test 1 CACOT Circuit Voltage Check

Test 1 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4993 to CACOT sensor vehicle harness connector and leave sensor disconnected. C. Key ON.

Test 1	Specification
Use a Digital Multimeter (DMM) to measure voltage between CACOT signal pin-28 and known good ground.	< 6 volts
Decision	
Is voltage greater than 6 volts?	Yes: Repair short to PWR between Engine Control Module (ECM) pin E-28 and CACOT pin-2. After repairs are complete, retest for SPN 2630 FMI 3.
	No: Go to Test 2.



0000301703

Figure 210 Pin-Point Test 2 SIG GND Circuit Check

Test 2 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4993 to CACOT sensor vehicle harness connector and leave sensor disconnected. C. Using Breakout Harness ZTSE4498 short pin-1 and pin-2 of Breakout Harness ZTSE4993 together. D. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). E. Key ON. Log in to ServiceMaxx™ software.

Test 2	Specification
Using EST with ServiceMaxx software, clear Diagnostic Trouble Code (DTC) list.	SPN 2630 FMI 4
Decision	
Does SPN 2630 FMI 4 set after DTC list is cleared?	Yes: Replace CACOT sensor. After repairs are complete, retest for SPN 2630 FMI 3.
	No: Go to Test 3.

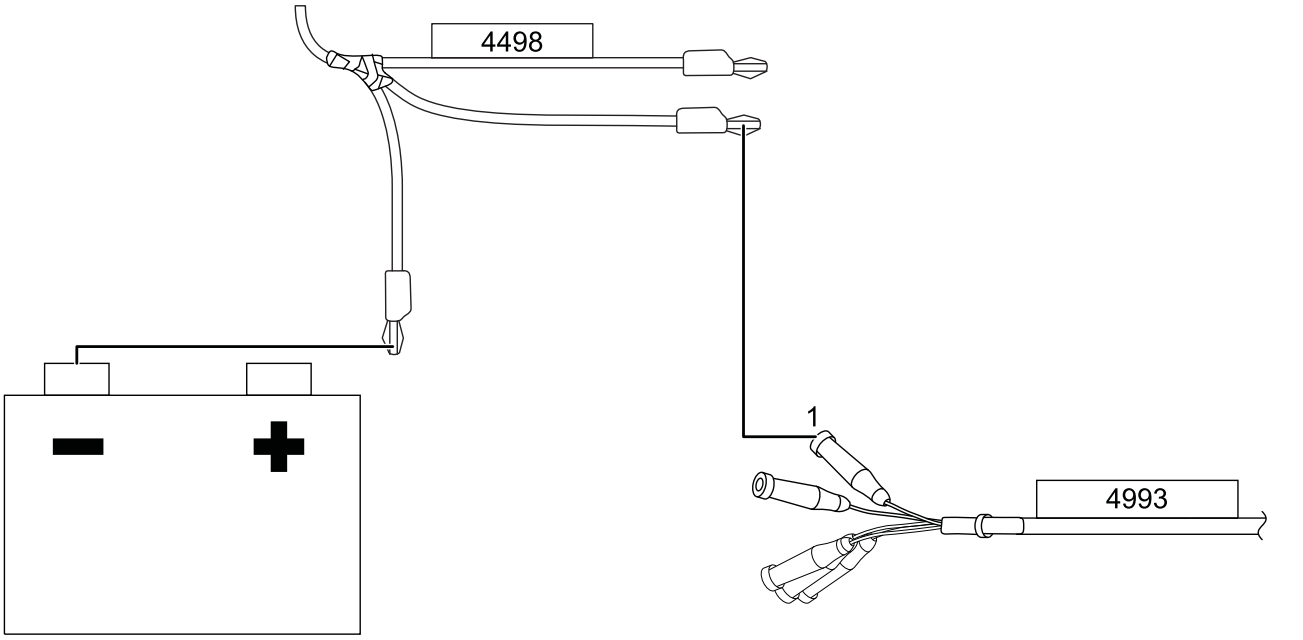


Figure 211 Pin-Point Test 3 CACOT Circuit Check

Test 3 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4993 to CACOT sensor vehicle harness and leave sensor disconnected. C. Using Breakout Harness ZTSE4498 short pin-1 of Breakout Harness ZTSE4993 to battery ground. D. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector. E. Key ON. Log in to ServiceMaxx™ software.

Test 3	Specification
Using EST with ServiceMaxx software, clear DTC list.	SPN 2630 FMI 3
Decision	
Does SPN 2630 FMI 3 set after DTC list is cleared?	Yes: Repair Open between CACOT pin-1 and ECM pin E-28. After repairs are complete, retest for SPN 2630 FMI 3.
	No: Repair Open between CACOT pin-2 and ECM pin E-65. After repairs are complete, retest for SPN 2630 FMI 3.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and the proper decision was made. Return to SPN 2630 FMI 3 fault code diagnostics.

SPN 2630 FMI 4 - CACOT Signal Out of Range LOW

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Charge Air Cooler Outlet Temperature (CACOT) sensor signal is lower than expected.	CACOT sensor signal < 0.11 volts (> 311°F {155°C})	Key ON

Fault Overview

Fault Code sets when Engine Control Module (ECM) detects Charge Air Cooler Outlet Temperature (CACOT) signal is less than 0.11 volts.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive trips.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON

Possible Causes

- CACOT circuit short to ground
- Failed CACOT sensor

Step 1	Check for active or pending fault codes.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 2630 FMI 4. Is EST DTC list SPN 2630 FMI 4 active or pending?	Yes: Go to Step 2.
		No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Inspect connections at Charge Air Cooler Outlet Temperature (CACOT) sensor.	Decision
	A. Key OFF. B. Disconnect CACOT electrical connector. C. Check CACOT sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent or broken pins; or broken connector housing. Are the CACOT sensor connector, harness, and terminals clean and undamaged?	Yes: Perform Pin-Point Tests (SPN 2630 FMI 4) (page 450).
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2630 FMI 4.

Pin-Point Tests (SPN 2630 FMI 4)

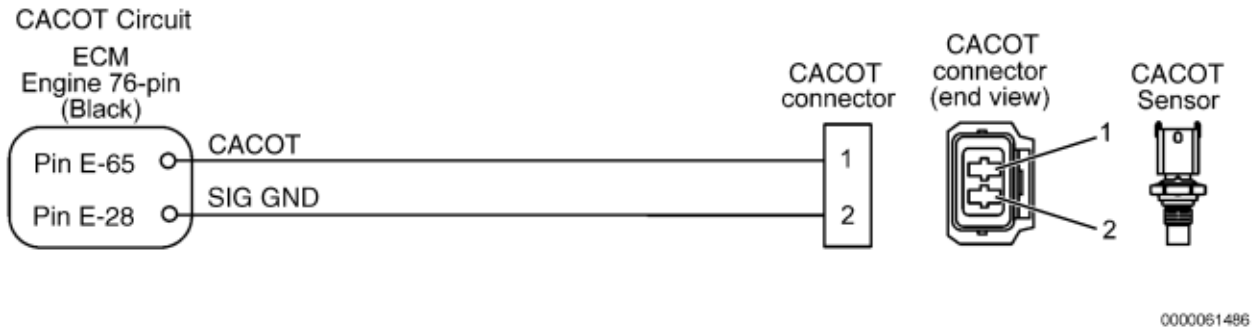


Figure 212 CACOT Sensor Circuit Diagram

NOTE: See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

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

Test 1 Setup
A. Key OFF. B. Disconnect Charge Air Cooler Outlet Temperature (CACOT) sensor. C. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). D. Key ON. Log in to ServiceMaxx™ software.

Test 1	Specification
Using EST with ServiceMaxx™ software, clear Diagnostic Trouble Code (DTC) list.	SPN 2630 FMI 3 sets after DTC list is cleared
Decision	
Does SPN 2630 FMI 3 set after DTC list is cleared?	Yes: Replace CACOT sensor. After repairs are complete, retest for SPN 2630 FMI 4.
	No: Repair short to ground between CACOT pin-1 and Engine Control Module (ECM) pin E-65. After repairs are complete, retest for SPN 2630 FMI 4.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and the proper decision was made. Return to SPN 2630 FMI 4 fault code diagnostics.

SPN 2630 FMI 16 – CACOT Under cooling

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Comparison of Charge Air Cooler Outlet Temperature (CACOT) Sensor reading to Modeled Value	Engine Charge Air cooler outlet temperature (CACOT) > Threshold defined by Speed / Torque (Table A031) * Mass Air Flow modifier (Table A032) * Vehicle speed modifier (Table A033) * Inlet Air Temperature modifier (Table A034) * Atmospheric Pressure modifier (Table A104) * Engine Coolant Temperature based modifier map (Table A117)	Particulate Filter Regeneration NOT Active Barometric Pressure ≥ 11 psi (73.5 kPa) and ≤ 15 psi (103 kPa) Power Take Off (PTO) Mode NOT Active End Of Line Testing NOT Active Engine Brake (Retarder) NOT active AND minimum wait time after retarder change of state has occurred > 5 seconds Engine Torque limitation NOT Active Engine is NOT coasting (such as Throttle Cut OFF mode) Vehicle Speed ≥ 20 miles/hour Battery Voltage ≥ 10.787 Volts AND ≤ 15.787 Volts Engine Ignition Key is in "ON" position (Key ON) Time after engine start ≤ 30 seconds	45.5 seconds

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		Engine Coolant Temperature (ECT) ≥ 68°F (20°C) and ≤ 230°F (110°C) Monitor enablement based on Speed / Torque (Table A035) Monitor enablement based on Engine Air Inlet Temperature (AIT) based enablement (Table A036) Monitor enablement based on Engine Coolant Temperature based enablement (Table A118) - Calibrated out	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the Charge Air Cooler (CAC) efficiency is below the programmed threshold.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN / FMIs: 111/1, 111/2, 110/15, 110/16, 1136/0, 108/2, 108/3, 105/2, 105/3, 105/4, 172/2, 172/3, 172/4, 102/2, 102/7, 102/10, 102/18, 1209/0, 1209/1, 1209/2, 1209/3, 1209/4, and 1209/7

Drive Cycle to Determine Fault Status

N/A

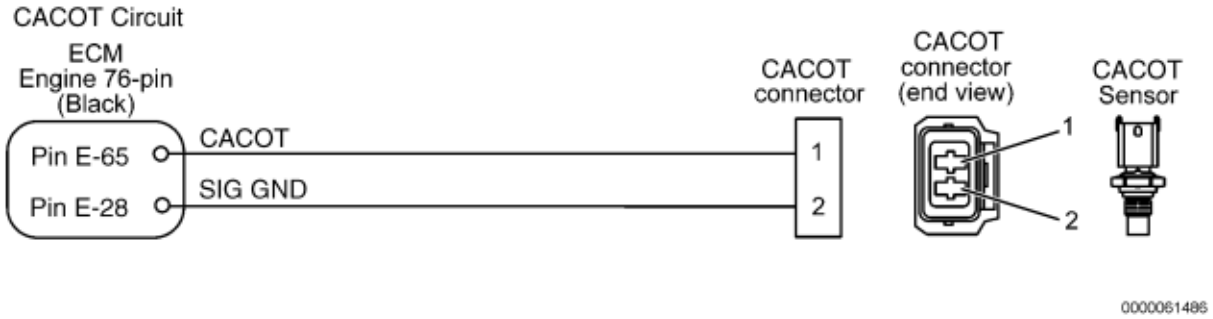


Figure 213 CACOT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 2630 FMI 16 the only fault code active?	Yes: Go to Step 3.
		No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 2630 FMI 16.
		No: Go to Step 3.

Step	Action	Decision
3	Park vehicle on level ground. Check coolant level as indicated on deaeration tank level window. See Engine Coolant Level in Hard Start and No Start Diagnostics . Is fluid level at deaeration tank fill level?	Yes: Go to Step 4.
		No: Fill the deaeration tank. See Coolant System Inspection in Engine Symptoms Diagnostics (page 116). After repairs are complete, retest for SPN 2630 FMI 16.

Step	Action	Decision
4	Inspect vehicle grille for obstructions that may reduce air flow to the Charge Air Cooler (CAC). Is vehicle grille free of obstructions?	Yes: Go to Step 5.
		No: Repair or remove obstruction from grille. After repairs are complete, retest for SPN 2630 FMI 16.

Step	Action	Decision
5	Check engine fan, fan shroud, and air dams for damage and proper operation. Are engine fan, fan shroud, and air dams intact and operating properly?	Yes: Go to Step 6.
		No: Repair or replace engine fan, fan shroud, and/or air dams. After repairs are complete, retest for SPN 2630 FMI 16.

Step	Action	Decision
6	Check turbocharger wastegate operation. Do KOEO Turbocharger 2 Wastegate Control (TC2WC) tests (page 1165). Did TC2WC tests pass?	Yes: Go to Step 7.
		No: Repair or replace turbocharger wastegate components or turbocharger, as required. After repairs are complete, retest for SPN 2630 FMI 16.

Step	Action	Decision
7	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Do Key On Engine Off Continuous Monitor Test (page 87). Verify Barometric Absolute Pressure (BARO), Intake Manifold Temperature (IMT), Air Inlet Temperature (AIT), Intake Manifold Pressure (IMP), and Charge Air Cooler Outlet Temperature (CACOT) sensor voltages are within specifications (page 1291). Are BARO, IMT, AIT, IMP, and CACOT sensor voltages within specifications?	Yes: After doing all diagnostic steps, if SPN 2630 FMI 16 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuits as required. After repairs are complete, retest for SPN 2630 FMI 16.

NOTE: After doing all diagnostic steps, if SPN 2630 FMI 16 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

CCOSS Sensor (Crankcase Oil Seperator Speed)

SPN	FMI	Condition
4227	7	CC Oil Separator Speed: Not spinning

1. If calibration is EER5 or newer, verify Crankcase Breather Configuration (Open or Closed).
2. Verify Parameter Configuration PID# 69250 (Open or Closed).
3. Set Parameter to reflect breather configuration.

CCS (Cruise Control System)

SPN	FMI	Condition
596	19	Cruise Control Enable Switch not detected on J1939

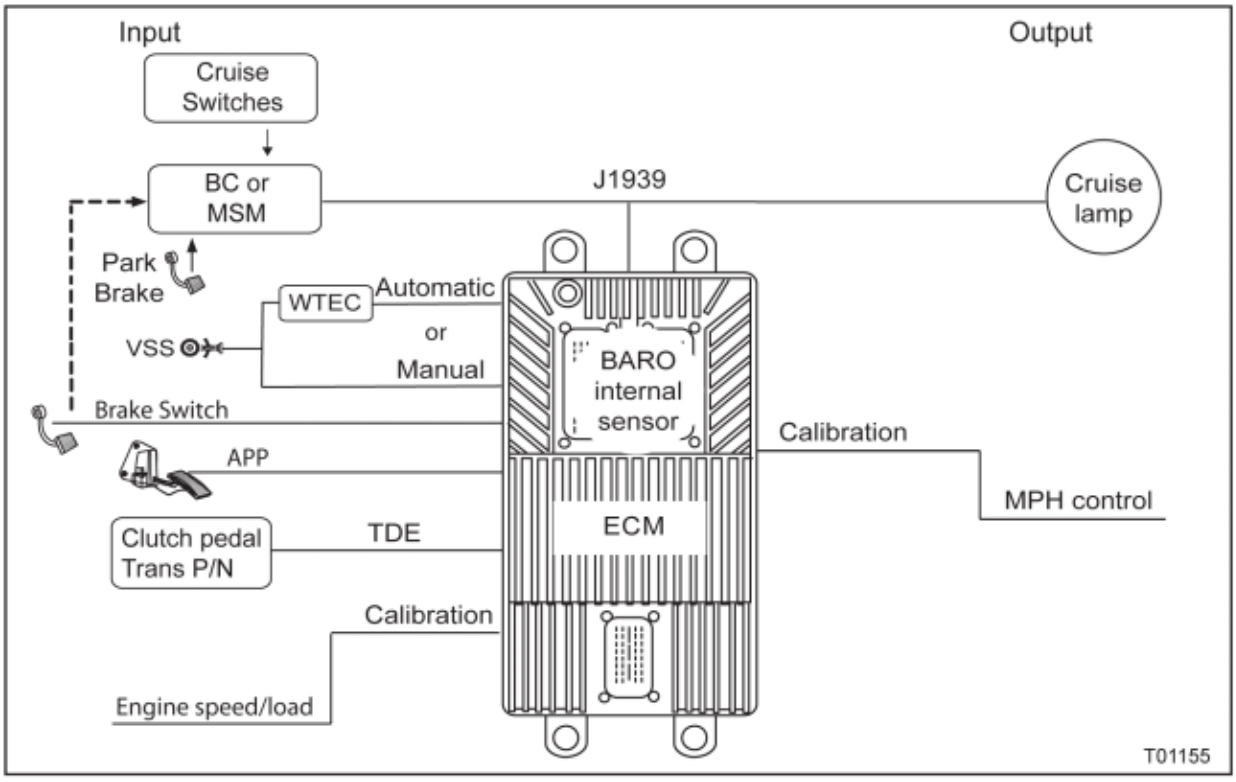


Figure 214 Function diagram for CCS

The function diagram for the CCS includes the following:

- Engine Control Module (ECM) with Barometric Absolute Pressure (BARO) Internal Sensor
- Body Controller (BC)
- Multiplex System Module (MSM)
- Cruise Control Switches
- Accelerator Pedal Position (APP)
- Brake Switch
- Transmission Drive line Engaged (TDE)
- Park Brake Switch
- Vehicle Speed Sensor (VSS)
- Cruise Lamp

Function

CCS is a function of the ECM. With the use of 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.

Location

The cruise control switches are wired to the BC. The switch state is communicated to the ECM through the J1939 Data Link Network.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)

CCS Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
596	19	Cruise Control Enable Switch not detected on J1939	• Cruise Control switch or circuit fault • See BCM for troubleshooting switch

Programmable Parameters

Verify Cruise Control Programming. Using ServiceMaxx™ software, open the Programming session file and verify that all Parameters are set correctly.

Test Point	Specification	Comment
Cruse Control Mode	Enabled	If Disabled, change control to Enabled

Switch Checks

Turn ignition switch to ON. Connect the EST to the Diagnostic Connector. Open the CCS session to monitor signals.

NOTE:

- If signals not within specification, diagnose switch interface with BC or MSN module. See *Chassis Electrical Circuit Diagnostic Manual* and *Electrical System Troubleshooting Guides*.
- If 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, go to road test.		

CKP Sensor (Crankshaft Position)

SPN	FMI	Condition
637	8	CKP signal noise
637	10	CKP signal inactive

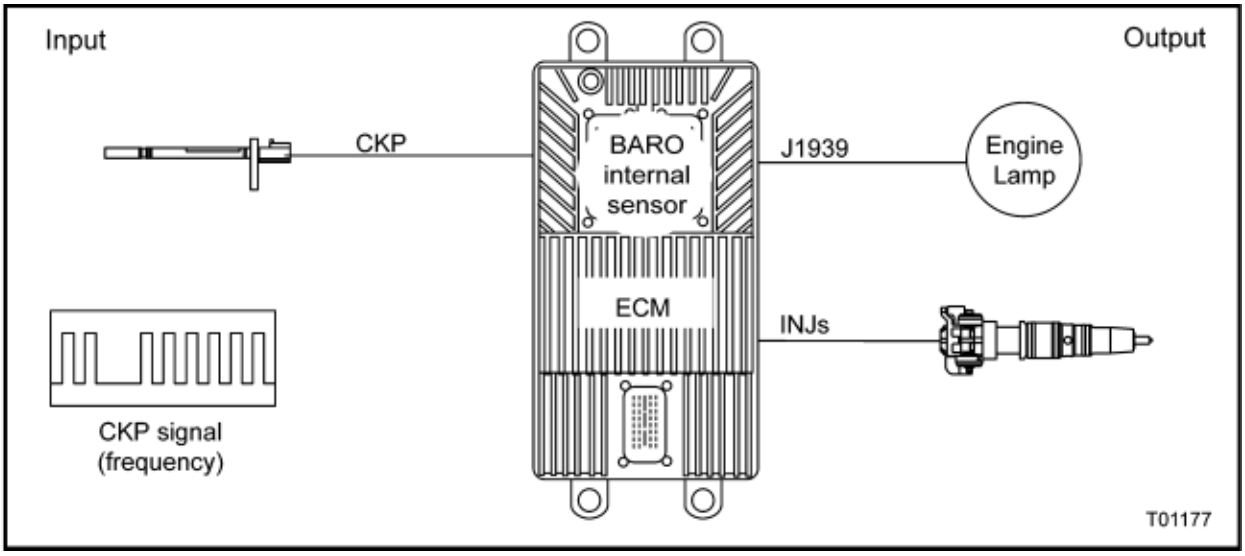


Figure 215 Function diagram for the CKP sensor

The function diagram for the CKP sensor includes the following:

- Engine Control Module (ECM)
  with Barometric Absolute Pressure (BARO) Internal Sensor
- Crankshaft Position (CKP) Sensor
- Fuel Injector (INJ)
- Engine Lamp

Function

The CKP sensor provides the ECM with a crankshaft speed and position signal. The ECM uses this signal with the CMP signal to calculate engine speed and crankshaft position.

Sensor Location

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

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- 00-00956-08 – 180-pin Breakout Box (page 1222)

- Breakout Harness 4950 (CKP) (page 1236)
- International® Electronic Engine Terminal Test Kit (page 1227)

CKP Pin-point Diagnostics

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

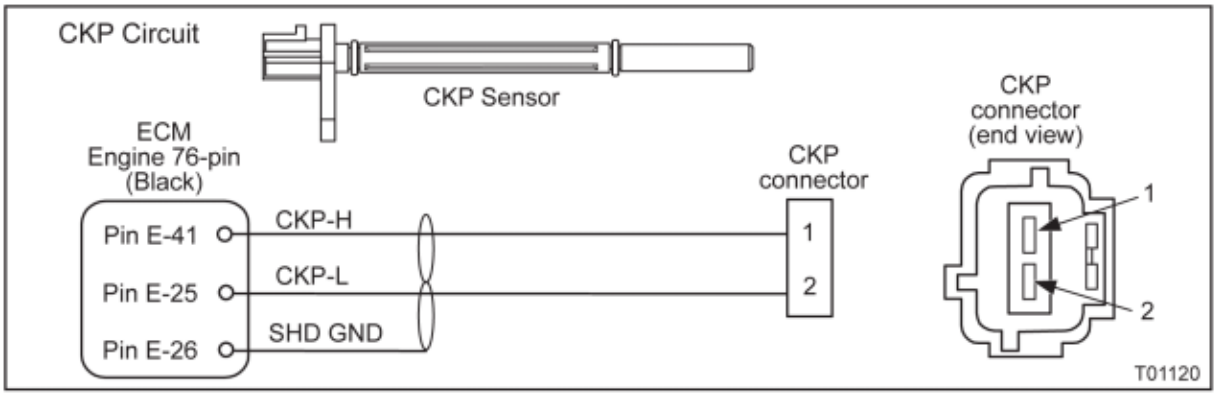


Figure 216 CKP circuit diagram

Sensor and Circuit Resistance Check

Turn ignition switch to OFF. Disconnect ECM. Connect 180-pin Breakout Box. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
E-25 to E-41	800 Ω to 1 kΩ	If < 800 Ω, check for failed sensor. Go to Harness Resistance Check. If > 1 kΩ, check for OPEN circuit or failed sensor. Go to Harness Resistance Check.

Harness Resistance Check

Turn ignition switch to OFF. Leave ECM disconnected. Disconnect engine harness from sensor. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than > Greater than
E-25 to 2	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-25 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
E-41 to 1	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-41 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
If circuit measurements are all within specification, then replace the sensor.		

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

Operational Checks

Connect 180-pin Breakout Box between ECM and sensor. Set DMM to AC Volts-Hz and measure frequency.

Test Point	Condition	Specification
E-41 to E-25	Engine crank	100 to 250 Hz @ 100 rpm to 250 rpm
	Low idle	5.50 to 6.50 Hz @ 650 rpm to 700 rpm
	High idle	2600 to 2750 Hz @ 2700 rpm

CKP Circuit Operation

The CKP sensor contains a permanent magnet that creates a magnetic field. The signal is created when the timing disk rotates and breaks the magnetic field created by the sensor. The ECM pins for the CKP sensor are CKPL E-25 and CKPH E-41.

As the crankshaft turns, the CKP sensor detects a 60-tooth timing disk on the crankshaft. Teeth 59 and 60 are missing.

The sensor produces pulses for each tooth edge that passes it. Crankshaft speed is derived from the frequency of the CKP sensor signal. The crankshaft position is determined by synchronizing the SYNC tooth with the SYNC gap signals from the target disk. From the CKP signal frequency, the ECM can calculate engine rpm.

By comparing the CKP signal with the CMP signal, the ECM calculates engine rpm and timing. Diagnostic information on the CKP input signal is obtained by performing accuracy checks on frequency and duty cycle with software strategies.

NOTE: The engine will not operate without a CKP signal.

Fault / Detection Management

During engine cranking, the ECM monitors the CMP signal and ICP to verify the engine is rotating. If the CKP signal is inactive during this time, a code will be set. Electrical noise can also be detected by the ECM. If the level is sufficient to effect engine operation, a corresponding code will be set. An inactive CKP signal will cause a no start condition.

CMP Sensor (Camshaft Position)

SPN	FMI	Condition
636	2	CMP and CKP Synchronization Error
636	7	CMP to CKP incorrect reference

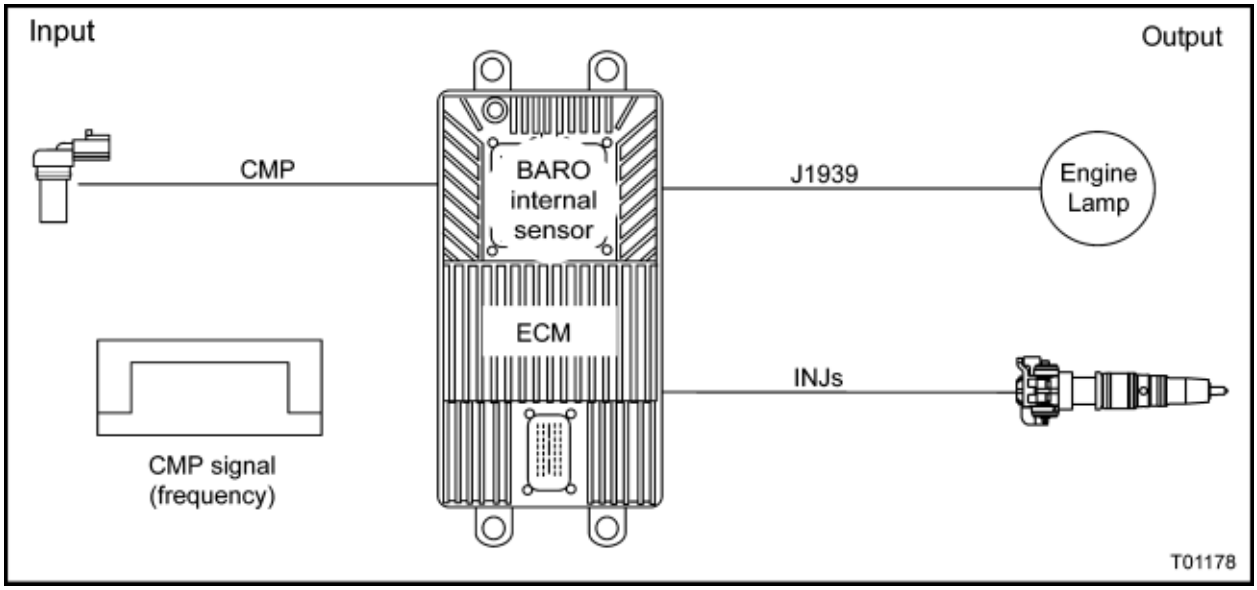


Figure 217 Function diagram for the CMP sensor

The function diagram for the CMP sensor includes the following:

- Engine Control Module (ECM)
  with Barometric Absolute Pressure (BARO) Internal Sensor
- Camshaft Position (CMP) Sensor
- Fuel Injector (INJ)
- Engine Lamp

Function

The CMP sensor provides the ECM with a camshaft speed and position signal. The ECM uses this signal with the CKP signal to monitor crankshaft and camshaft positions.

Sensor Location

The CMP sensor is installed in the front cover, above and to the right of the water pump pulley.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)

- 00-00956-08 – 180-pin Breakout Box (page 1222)
- Breakout Harness 4951 (CMP) (page 1237)
- International® Electronic Engine Terminal Test Kit (page 1227)

CMP Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
636	2	CMP and CKP Synchronization Error	• CMP sensor or circuit fault • Camshaft and Crankshaft out of time
636	7	CMP to CKP incorrect reference	• CMP sensor or circuit fault • Camshaft and Crankshaft out of time

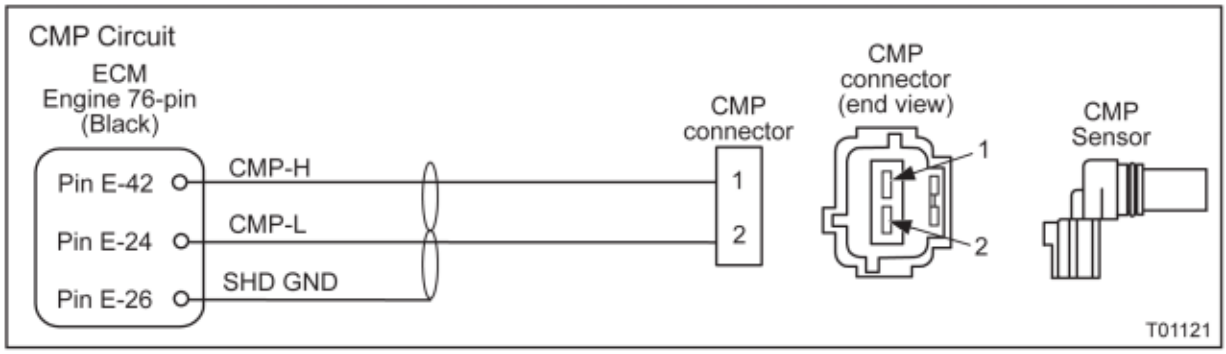


Figure 218 CMP circuit diagram

Sensor and Circuit Resistance Check

Turn ignition switch to OFF. Disconnect ECM. Connect 180-pin Breakout Box. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
E-24 to E-42	300 Ω to 400 Ω	If < 300 Ω, check for failed sensor. Go to Harness Resistance Check. If > 400 Ω, check for OPEN circuit or failed sensor. Go to Harness Resistance Check.

Harness Resistance Check

Turn ignition switch to OFF. Disconnect engine harness from sensor. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
E-24 to 2	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-24 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
E-42 to 1	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E-42 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

If circuit measurements are all within specification, then replace the sensor.

If SPN 636 FMI 2 was set, remove CKP and CMP sensors and inspect for metal debris. Verify camshaft and crankshaft are synchronized.

Operational Checks

Connect 180-pin Breakout Box between ECM and sensor. Use DMM set to AC volts – RPM2.

Test Point	Condition	Specification
E-42 to E-24	Engine crank	100 to 250 rpm
	Low idle	650 to 700 rpm
	High idle	2700 rpm

CMP Circuit Operation

The CMP sensor provides the ECM with a signal that indicates camshaft speed and position.

The CMP sensor contains a permanent magnet that creates a magnetic field. The signal is created when a peg on the camshaft disk rotates and breaks the magnetic field. As the cam rotates, the sensor identifies camshaft position. The ECM pins for the CMP sensor are CMPL E-24 and CMPH E-42.

By comparing the CMP signal with the CKP signal, the ECM calculates engine rpm and timing. Diagnostic information on the CMP input signal is obtained by performing accuracy checks on frequency and duty cycle with software strategies.

NOTE: The engine will not operate without a CMP signal.

Fault / Detection Management

During engine cranking, the ECM monitors the CKP signal to verify the camshaft is rotating. If the CMP signal is inactive during this time, a code will be set. Electrical noise can also be detected by the ECM. If the level is sufficient to effect engine operation, a corresponding code will be set. An inactive CMP signal will cause a no start condition.

Cylinder Balance

SPN	FMI	Condition
3387 – 3392	20	Cylinder (#) Balance maximum limit exceeded
3387 – 3392	21	Cylinder (#) Balance below minimum limit

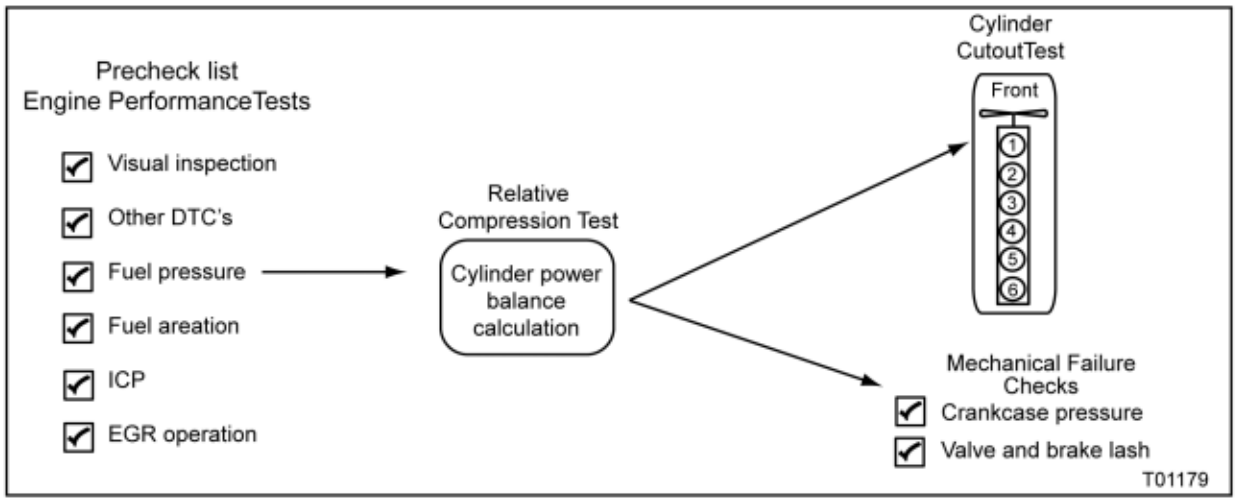


Figure 219 Function diagram for the Cylinder Balance

Cylinder Balance Operation

Many factors influence the combustion process in a power cylinder. This can affect the production of torque or horsepower from that cylinder. Some of the factors include piston and cylinder geometry, injector performance, and Injection Control Pressure. Variations in these factors can cause unevenness in torque and horsepower from one cylinder to the next. Power cylinder unevenness also causes increased engine noise and vibration, especially at low idle conditions. This is also referred to as rough idle.

The ECM uses a Cylinder Balance control strategy to even the power contribution of the cylinders, particularly at low idle conditions. This strategy incorporates information from the CKP system. The ECM uses the instantaneous engine speed near Top Dead Center (TDC) for each cylinder as an indication of that cylinder's power contribution. The ECM computes a nominal instantaneous engine speed value based on all cylinders. The nominal value would be the expected value from all cylinders if the engine is balanced. By knowing the error quantities, the ECM can add or subtract fuel from a particular cylinder. The control strategy attempts to correct the cylinder imbalance by using fuel quantity compensation through adjustments of the pulse width values for each fuel injector. This method of compensation is repeated until all error quantities are close to zero, causing all cylinders to contribute the same amount.

Cylinder Balance Diagnostics

SPN	FMI	Condition	Possible Causes
3387 – 3392	20	Cylinder (#) Balance maximum limit exceeded	• Low Fuel Pressure • Aerated fuel • Contaminated fuel • Base engine compression imbalance • Failed injector (Mechanical)
3387 – 3392	21	Cylinder (#) Balance below minimum limit	

SPN 3387 through 3392 FMI 20 – Cylinder (#) balance maximum limit exceeded

SPN 3387 through 3392 FMI 21 – Cylinder (#) balance below minimum limit

The ECM continuously calculates the balance of each cylinder during normal engine operation. If a cylinder is over, or under, performing, a cylinder balance code will set.

Pin-point Cylinder Balance Fault

1. Visually inspect engine for damaged or disconnected components.
   - Check all fluid levels.
   - Check engine and control system for electrical or mechanical damage.
2. Check for other active codes.
   - If injector circuit faults SPN 651 through 656 are set, go to injector circuit diagnostic.
3. Check fuel pressure, fuel aeration, and possible fuel contamination.

   Note: These checks can be verified quickly by using the Fuel Pressure Test Gauge with shutoff valve. See Fuel Pressure and Aeration test (page 803).
4. Check ICP voltage at switch ON, engine OFF.
   - Using ServiceMaxx™ software, open the Continuous Monitor session and verify S_ICP Volt is within KOEO specification.
   - If not within specification, see ICP Sensor (Injection Control Pressure) .
5. Inspect EGR valve. Verify valve is not stuck open.
   - Using ServiceMaxx™ software, run KOEO Output State Test (page 87) while monitoring the signal state. Verify EGR valve is working within Specification. See All Ratings (page 1291).
6. Run Relative Compression Test (page 215) to verify if cylinder imbalance is a mechanical problem and not an injector problem.
   - Check crankcase pressure.
   - Check valve lash and brake lash. See *Engine Service Manual*.

DCU Power (Doser Control Unit)

SPN	FMI	Condition
609	3	DCU Switched voltage too HIGH (page 471)
609	4	DCU Switched voltage too LOW (page 473)
609	12	DCU Internal chip Error
609	19	DCU not detected on J1939
1231	19	DCU Error – J1939 communication fault

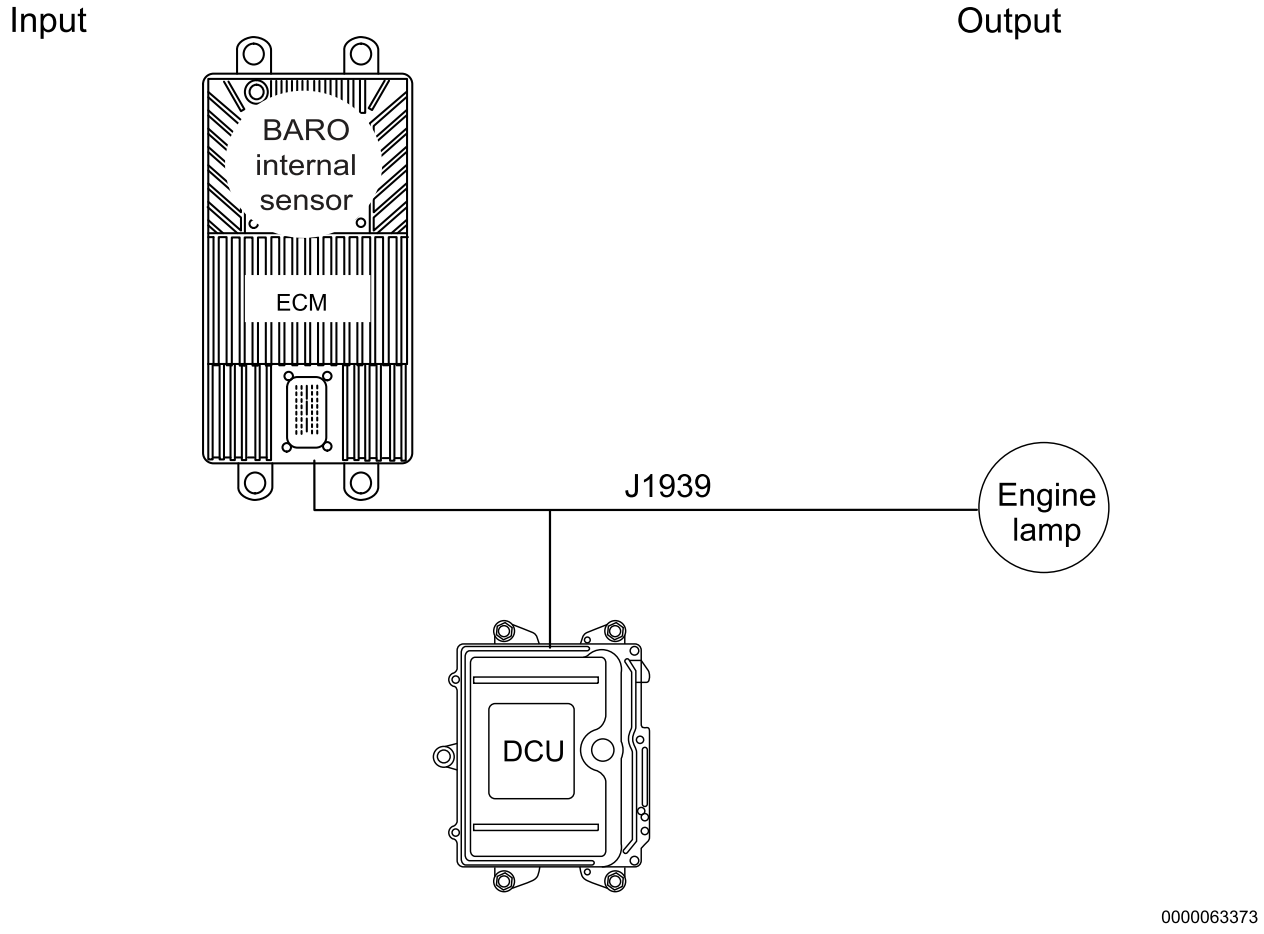


Figure 220 Functional Diagram for DCU

The functional diagram for the DCU includes the following:

- Engine Control Module (ECM)
  with Barometric Absolute Pressure (BARO) Internal Sensor
- Doser Control Unit (DCU)

- Engine Lamp

Function

The DCU controls the Downstream Injection (DSI) System during a DPF regeneration. The ECM controls the monitoring and regeneration process in the aftertreatment system.

Component Location

The DCU is installed underneath the cab just below the driver's floorboard.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- International® Electronic Engine Terminal Test Kit (page 1227)

DCU PWR Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
609	3	DCU Switched voltage too HIGH	• Jump start using more than system voltage • Batteries wired incorrectly
609	4	DCU Switched voltage too LOW	• Low discharge batteries • Charging system failure • High resistance in DCU powering circuits
609	12	DCU Internal chip Error	• Internal DCU fault, replace module
609	19	DCU not detected on J1939	• J1939 circuit fault between ECM and DCU • DCU power or ground circuit faults • Failed DCU
1231	19	DCU Error – J1939 communication fault	• DCU J1939 communication circuit fault

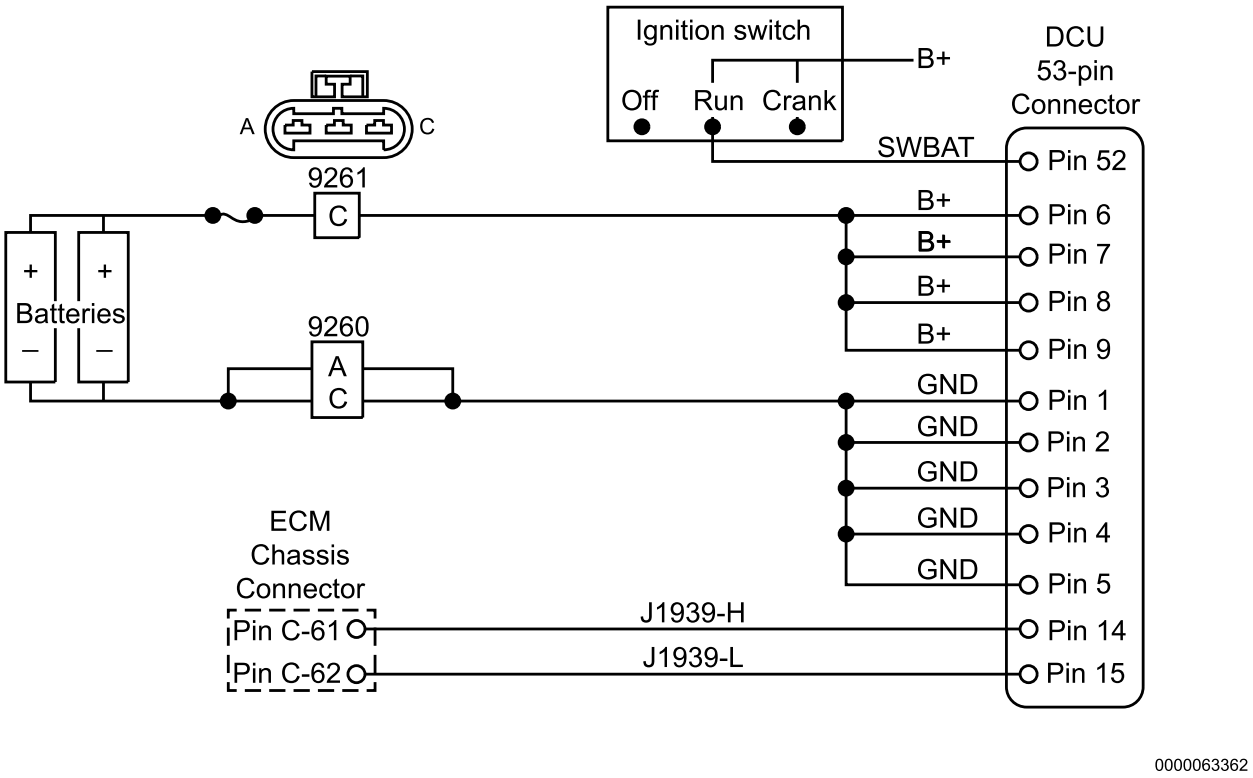


Figure 221 DCU PWR circuit diagram

DCU Power circuit checks

Test Point	Specification	Comment: < Less than, > Greater than
DCU disconnected. Turn ignition switch to ON. Use DMM to measure voltage.		
C-52 to GND	B+	If < B+, check for OPEN on SWBAT circuit or blown fuse.
C-1 to B+	B+	If < B+, check for OPEN in DCU ground circuit.
C-2 to B+	B+	
C-3 to B+	B+	
C-4 to B+	B+	
C-5 to B+	B+	
C-6 to GND	B+	If < B+, check for OPEN in power circuit.
C-7 to GND	B+	
C-8 to GND	B+	
C-9 to GND	B+	
If measurements are within specifications, continue to J1939 Voltage Checks.		

J1939 Voltage Checks

Test Point	Specification	Comment: < Less than, > Greater than
DCU disconnected. Turn ignition switch to ON. Use DMM to measure voltage.		
14 to GND	1 to 4 V	Sum of 14 to GND and 15 to GND should equal 4 to 5 volts.
15 to GND	1 to 4 V	Sum of 15 to GND and 14 to GND should equal 4 to 5 volts.
If measurements are within specifications, continue to J1939 Harness Resistance Check.		

J1939 Harness Resistance Check

Test Point	Specification	Comment: < Less than, > Greater than
Breakout box connected to the ECM, leave ECM and DCU disconnected. Turn ignition switch to OFF. Use DMM to measure resistance.		
C-61 to 14	< 5 Ω	If > 5 Ω, check for OPEN circuit.
C-62 to 15	< 5 Ω	If > 5 Ω, check for OPEN circuit.
If DCU voltage checks and J1939 checks are all within specifications, replace DCU module.		

SPN 609 FMI 3 - ACM (CES) Switched voltage too HIGH

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Voltage supply to Hydrocarbon Doser Control Unit higher than normal.	Battery voltage > 17 Volts	Key ON
Voltage at the output of Hydrocarbon Doser Control Unit voltage divider higher than normal.	Battery Raw voltage measured after Doser Control Unit voltage divider > 1 Volts	Key ON

Fault Overview

Fault is set when voltage supply to Doser Control Unit (DCU) is higher than normal or voltage at output of DCU voltage divider is higher than normal

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

None

Fault Facts

Jump-starting from a vehicle or booster pack using greater than 16 volts can also cause this fault to set.

Drive Cycle to Determine Fault Status

None

Possible Causes

- Batteries wired incorrectly
- Excessive charging voltage

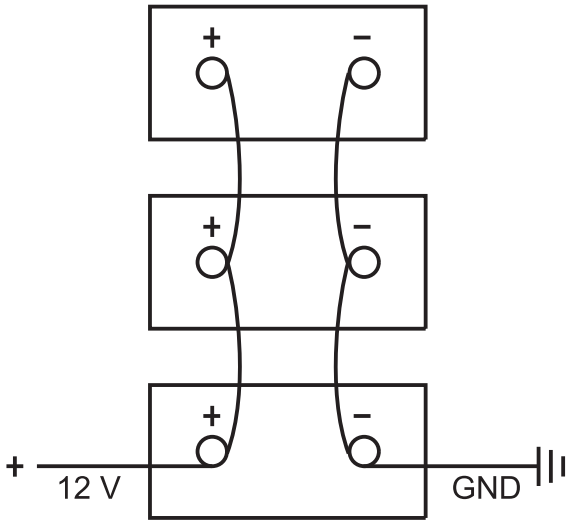


Figure 222 Approved Battery Cable Sequence

Step 1	Check for correct parallel battery pack wiring.	Decision
	Check for correct parallel battery pack wiring. Positive battery cable(s) should be connected from positive battery terminal to positive battery terminal. Negative battery cable(s) should be connected from negative battery terminal to negative battery terminal. Is battery pack correctly assembled (wired in parallel and Not in series)?	Yes: Replace alternator. After repairs are complete, retest for SPN 609 FMI 3.
		No: Reassemble battery pack. After repairs are complete, retest for SPN 609 FMI 3.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 609 FMI 3 fault code diagnostics.

SPN 609 FMI 4 - ACM (CES) Switched voltage too LOW

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Voltage supply to Hydrocarbon Doser Control Unit lower than normal.	Battery voltage < 10 Volts	Key ON
Voltage at the output of Hydrocarbon Doser Control Unit voltage divider lower than normal.	Battery Raw voltage measured after Doser Control Unit voltage divider < 0.583 Volts	Key ON

Fault Overview

Fault is set when voltage supply to Doser Control Unit (DCU) is lower than normal or voltage at output of DCU voltage divider is lower than normal.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

None

Possible Causes

- Low battery or charging system voltage
- SWBAT circuit high resistance
- GND circuit high resistance

Step 1	Inspect connections at Aftertreatment Control Module (ACM).	Decision
	A. Key OFF. B. Disconnect ACM J1 and J2 connectors. Check ACM and connector terminals for: damaged or pinched wires; moisture of corroded terminals; loose, bent, or broken pins; or broken connector housing. Are ACM harnesses and terminals clean and undamaged?	Yes: Go to Step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 609 FMI 4.

Step 2	Check Charging voltage.	Decision
	Perform charging system test, see *Medtronics Manual*. Is charging system performing to specifications?	Yes: Perform Pin-Point Tests. No: Repair charging system. After repairs are complete, perform KOEO SCR Faults Reset Request Procedure.

Pin-Point Tests (SPN 609 FMI 4)

NOTE: See latest version of Navistar® N9 and N10 SCR Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness 18-537-01
- 180-pin Breakout Box
- Digital Multimeter (DMM)

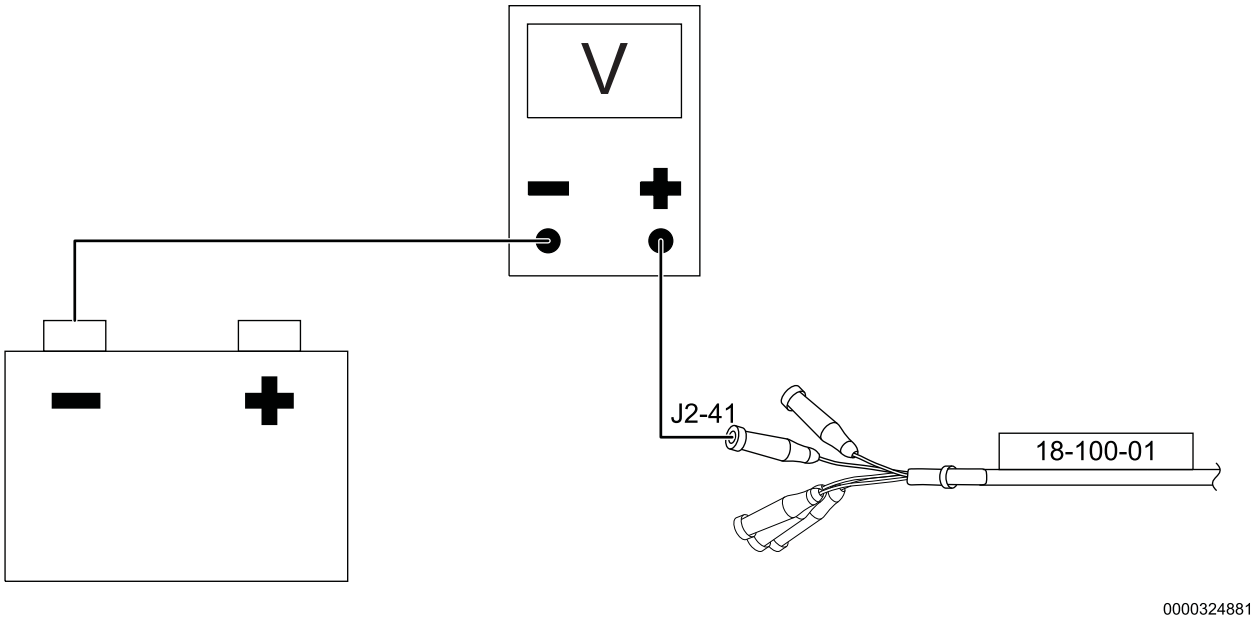


Figure 223 Test 1 Aftertreatment Control Module (ACM) Circuit Resistance Check

Test 1 Setup
A. Key OFF. B. Disconnect ACM J2 connector. C. Connect 180-Pin Breakout Box and ACM Breakout Harness 18-537-01 between ACM J2 harness and ACM, leave ACM J2 disconnected. D. Key ON.

Test 1	Specification
Use DMM to measure voltage between Breakout Harness 18-537-01 between pin J2-41 and a known good GND.	B+ ± 0.5 volts
Decision	
Is voltage B+ ± 0.5 volts?	Yes: Repair high resistance between ACM pin J2-04 or J2-06 and GND. After repairs are complete, perform KOEO SCR Faults Reset Request Procedure.
	No: Repair high resistance between ACM pin J2-41 and Switched Ignition Relay. After repairs are complete, perform KOEO SCR Faults Reset Request Procedure.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and the proper decision was made. Return to SPN 609 FMI 4 fault code diagnostics.

DCU VREF Circuits

SPN	FMI	Condition
3512	14	DCU VREF 1 or 2 voltage above or below normal

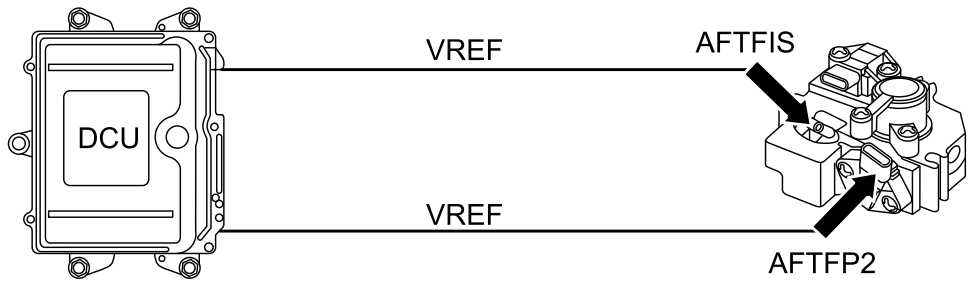


Figure 224 Functional Diagram for DCU

Functional diagram for the DCU includes the following:

- Doser Control Unit (DCU)

Function

The DCU supplies a 5-volt reference to the AFT Fuel Pressure 1 and AFT Fuel Pressure 2 sensors. If this circuit is shorted to power or ground, both sensors become inoperative.

Component Location

The DCU is installed underneath cab just below driver's floorboard.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- Breakout Harness 6020 (24-pin) (page 1239)
- International® Electronic Engine Terminal Test Kit (page 1227)

DCU VREF Circuit

SPN	FMI	Condition	Possible Causes
3512	14	DCU VREF 1 or 2 voltage above or below normal	• DCU VREF circuit short to PWR • DCU VREF circuit short to GND • Failed sensor causing short to GND on VREF circuit

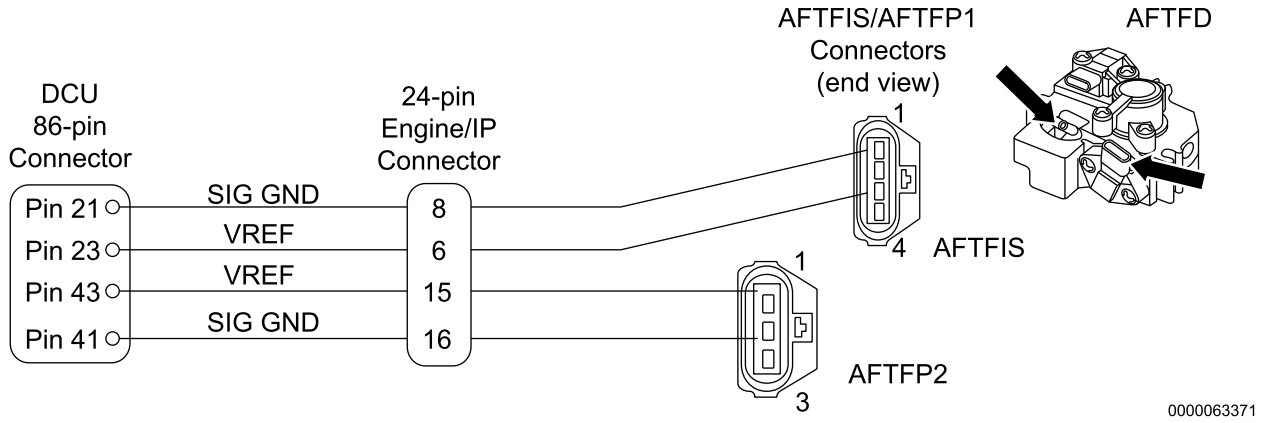


Figure 225 DCU PWR circuit diagram

Connector Voltage Check

Test Point	Specification	Comment: < Less than, > Greater than
Connect Breakout Harness, disconnect AFTFIS and AFTFP2 sensors. Turn ignition switch to the ON position. Use DMM to measure voltage.		
Pin 8 to B+	B+	If < B+, check SIG GND for OPEN circuit. Go to Harness Resistance Check.
Pin 6 to GND	5 ± 0.5 V	If < 4.5 volts, check SIG GND for OPEN circuit. Go to Harness Resistance Check.
Pin 15 to GND	5 ± 0.5 V	If < 4.5 volts, check for OPEN or short to GND. Go to Harness Resistance Check.
Pin 16 to B+	B+	If < B+, check SIG GND for OPEN circuit. Go to Harness Resistance Check.

Harness Resistance Check

Test Point	Specification	Comment: < Less than, > Greater than
Turn ignition switch to OFF, disconnect 86-pin connector and AFTFIS and AFTFP2 sensors. Use DMM to measure resistance between DCU connector and sensor connectors.		
AFTFIS		
21 to 1	< 5 Ω	If > 5 Ω, check for OPEN circuit.
23 to 3	< 5 Ω	If > 5 Ω, check for OPEN circuit.
AFTFP2		
43 to 1	< 5 Ω	If > 5 Ω, check for OPEN circuit.
41 to 2	< 5 Ω	If > 5 Ω, check for OPEN circuit.

DOCIT Sensor (Diesel Oxidation Catalyst Inlet Temperature)

SPN	FMI	Condition	Possible Causes	Actions
4765	2	DOCIT signal erratic, intermittent, or incorrect	• DOCIT biased sensor or circuit	Pin-point Diagnostics (page 483)
4765	3	DOCIT signal Out of Range HIGH	• DOCIT signal circuit OPEN or short to PWR • SIG GND circuit OPEN • Failed Diesel Particulate Filter Outlet Temperature (DPFOT) sensor	Pin-point Diagnostics (page 483)
4765	4	DOCIT signal Out of Range LOW	• DOCIT signal circuit short to GND • Failed DPFOT sensor	Pin-point Diagnostics (page 483)
4765	7	DOCIT not increasing with engine temp	• Biased DPFOT sensor or circuit	Pin-point Diagnostics (page 483)
4765	20	DOCIT signal drifted HIGH	• Alternate fuel source • Unburned hydrocarbons in exhaust system	Step-based Diagnostics (page 485)
4765	21	DOCIT signal drifted LOW	• DOCIT sensor not connected to exhaust system • Exhaust system not attached to the engine • High resistance connections to DOCIT sensor	Step-based Diagnostics (page 489)

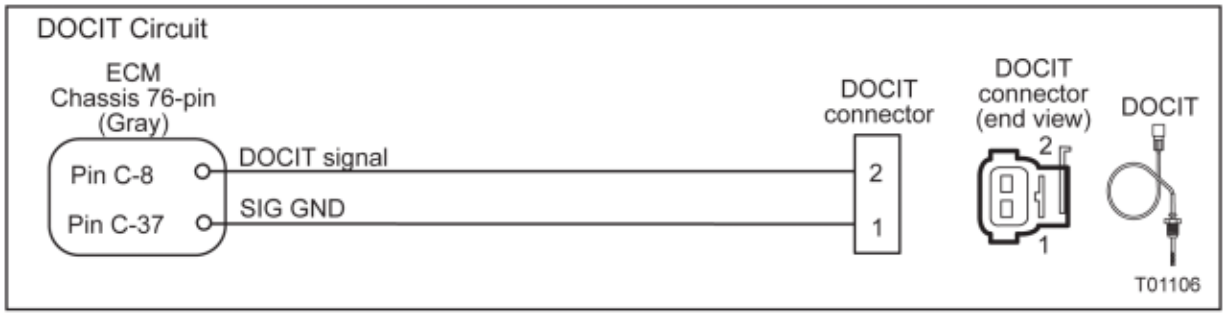


Figure 226 DOCIT Circuit Diagram

Overview

The Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor provides a feedback signal to the Engine Control Module (ECM) indicating DOCIT. Before and during a catalyst regeneration, the ECM will monitor this sensor along with the DPFIT, DPFOT, DPFDP, EGRP, and ETVP.

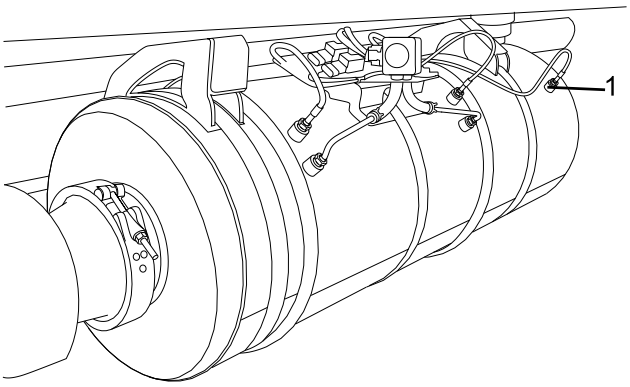


Figure 227 DOCIT Sensor Location

1. DOCIT Sensor

Tools

- EZ Tech® Electronic Service Tool (EST) – J-45067 (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- 00-00956-08 – 180-pin Breakout Box (page 1222)
- 3-Banana Plug Harness (page 1228)
- Breakout Harness 4760A (DOCIT) (page 1232)
- International® Electronic Engine Terminal Test Kit (page 1227)

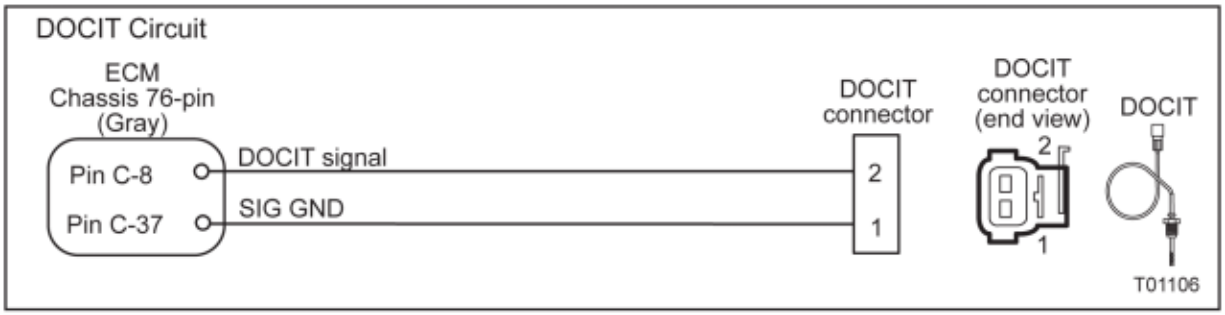


Figure 228 DOCIT Circuit Diagram

DOCIT Pin-point Diagnostics

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST with ServiceMaxx™ software, open Continuous Monitor Session.
2. Monitor sensor voltage. Verify an active code for sensor.
   - If code 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 code will go active.
   - If code is active, proceed to the next step.
3. Disconnect chassis harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

4. Connect Breakout Harness 4760A to chassis harness. Leave sensor disconnected.

SPN 4765 FMI 2 – DOCIT signal erratic, intermittent, or incorrect

Cold Soak High Temperature Sensor Compare Check
Temperature values need to be measured after four hours cold soak.

1. Turn switch ON, engine OFF.
2. Using ServiceMaxx™ software, open Continuous Monitor session.
3. Compare DOC Inlet Temp, DPF Inlet Temp and DPF Outlet Temp. All temperature sensors should be within 68°F (20°C) of each other.
   - If any temperature sensor is above or below of the other sensors, check for poor circuitry going to failed temperature sensor.
   - If the circuits are acceptable, replace the failed temperature sensor.

SPN 4765 FMI 7 – DOCIT not increasing with engine temperature

Cold Soak High Temperature Sensor Compare Check

Temperature values need to be measured after four hours of cold soak.

1. Turn switch ON, engine OFF.
2. Using ServiceMaxx™ software, open Continuous Monitor session.
3. Compare DOC Inlet Temp, DPF Inlet Temp, and DPF Outlet Temp. All temperature sensors should be within 68°F (20°C) of each other.
   - If any temperature sensor is above or below other sensors, check for poor circuitry going to failed temperature sensor.
   - If the circuits are okay, then replace the failed temperature sensor.

Sensor Circuit Check

Connect Breakout Harness 4760A. Leave sensor disconnected. Turn ignition switch to ON. Use EST to verify that correct code goes active when corresponding fault is induced.

Test Point	Specification	Comment
EST – Check code	SPN 4765 FMI 3	If SPN 4765 FMI 4 is active, check DOCIT signal for short to GND. Go to Harness Resistance Check (page 484).
EST – Check code Short 3-Banana Plug Harness across 2 and GND	SPN 4765 FMI 4	If SPN 4765 FMI 3 is active, check DOCIT signal for OPEN. Go to Harness Resistance Check (page 484).
EST – Check code Short 3-Banana Plug Harness across 1 and 2	SPN 4765 FMI 4	If SPN 4765 FMI 3 is active, check SIG GND for OPEN. Go to Harness Resistance Check (page 484).
If checks are within specification, connect sensor and clear codes. If active code remains, replace sensor.		

Connector Voltage Check

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 SIG GND for OPEN circuit.
2 to GND	± 5 V	If < 4.5 volts, check for OPEN or short to GND. Go to Harness Resistance Check (page 484).

Harness Resistance Check

Turn ignition switch to OFF. Disconnect ECM. Leave sensor disconnected. Connect 180-pin Breakout Box and Breakout Harness 4760A. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
1 to C-37	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to C-8	< 5 Ω	If > 5 Ω, check for OPEN circuit.

SPN 4765 FMI 20 – DOCIT Signal Drifted HIGH

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Aftertreatment 1 Diesel Oxidation Catalyst Intake Gas Temperature (DOCIT) Stuck high	Aftertreatment 1 Diesel Oxidation Catalyst Intake Gas Temperature Inlet temperature (DOCIT) > 932°F (500°C)	Particulate Filter Regeneration NOT Active End Of Line Testing NOT Active [Engine Brake (Retarder) NOT active AND minimum wait time after retarder change of state has occurred] > 5 seconds Engine Torque limitation NOT Active Battery Voltage ≥ 10.787 Volts AND ≤ 15.787 Volts Engine Ignition Key is in "ON" position (Key ON) Time after engine start ≥ 30 seconds Engine Coolant Temperature (ECT) ≥ 19°F (-7°C) AND ≤ 219°F (104°C) Minimum time after Completing a Regeneration Event ≥ Time value as defined by Speed / Torque based (Table A065) * Engine Air Inlet Temperature modifier	5 seconds

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		(Table A066) * Barometric Pressure modifier (Table A067) * 0.1 seconds Pre-debounce time ≥ 40 seconds Engine Air Inlet Temperature (AIT) < 140°F (60°C) SPN / FMI 4765/3 and 4765/4 are NOT Active.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the DOCIT sensor is measuring temperature greater than 842°F (450°C).

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN / FMI: 1322/31, 1323/31, 1324/31, 1325/31, 1326/31, 1327/31, and 1328/31.

Drive Cycle to Determine Fault Status

N/A

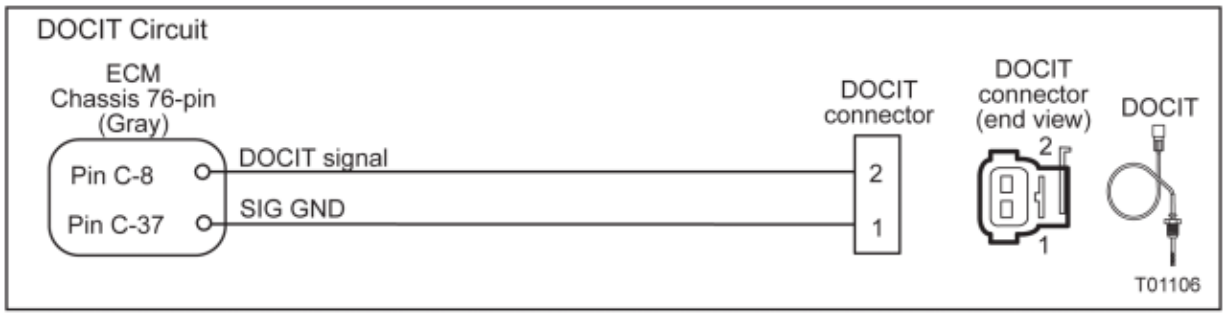


Figure 229 DOCIT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 4765 FMI 20 the only fault code active?	Yes: Go to Step 3.
		No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 4765 FMI 20.
		No: Go to Step 3.

Step	Action	Decision
3	Do Cold Soak Sensor Compare Check (page 483). Compare Diesel Particulate Filter (DPF) Inlet Temperature (DPFIT), Diesel Oxidation Catalyst (DOC) Inlet Temperature (DOCIT), and DPF Outlet Temperature (DPFOT). All sensors should be within 68°F (20°C) of each other. Are all temperature sensors within 68°F (20°C) the other sensors?	Yes: Go to Step 4.
		No: Replace failed temperature sensor. After repairs are complete, retest for SPN 4765 FMI 20.

Step	Action	Decision
4	Using terminal test kit inspect connections at DOCIT sensor. With Key OFF, disconnect DOCIT sensor connector. Check DOCIT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are DOCIT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 5.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4765 FMI 20.

Step	Action	Decision
5	Test DOCIT circuits for open, short, or high resistance conditions. Do Connector Voltage Checks (page 484) and Harness Resistance Checks (page 484). Are DOCIT circuits within specifications?	Yes: Go to Step 6.
		No: Repair any circuit faults. After repairs are complete, retest for SPN 4765 FMI 20.

Step	Action	Decision
6	Test DOCIT sensor. Connect breakout harness 4760A between DOCIT sensor and DOCIT sensor connector. Do KOEO voltage check of DOCIT sensor between DOCIT signal and ground. Is voltage within specification?	Yes: Go to Step 7.
		No: Replace DOCIT sensor. After repairs are complete, retest for SPN 4765 FMI 20.

Step	Action	Decision
7	Check engine for oil ingestion. Do Charge Air Cooler (CAC) System checks (page 193). Is the CAC system free of engine oil?	Yes: Go to Step 8.
		No: Repair oil ingestion condition. After repairs are complete, retest for SPN 4765 FMI 20.

Step	Action	Decision
8	Remove the Hydrocarbon Injection (HCI) assembly (AFI Plugging) (see *Engine Service Manual and IK1200753 Hydrocarbon Injector Housing Cleaning Procedure*). Is HCI clean?	Yes: After doing all diagnostic steps, if SPN 4765 FMI 20 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace the HCI assembly. After replacement is complete, retest for SPN 4765 FMI 20.

NOTE: After doing all diagnostic steps, if SPN 4765 FMI 20 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 4765 FMI 21 – DOCIT Signal Drifted LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Aftertreatment 1 Diesel Oxidation Catalyst Intake Gas Temperature (DOCIT) stuck low	Aftertreatment 1 Diesel Oxidation Catalyst Intake Gas Temperature (DOCIT) < 446°F (230°C)	Particulate Filter Regeneration NOT Active End Of Line Testing NOT Active [Engine Brake (Retarder) NOT active AND minimum wait time after retarder change of state has occurred] > 5 seconds Engine Torque limitation NOT Active Battery Voltage ≥ 10.787 Volts AND ≤ 15.787 Volts Engine Ignition Key is in "ON" position (Key ON) Time after engine start ≥ 30 seconds Engine Coolant Temperature (ECT) ≥ 19°F (-7°C) AND ≤ 219°F (104°C) 1. Engine Speed > 1500 rpm 2. Total Fueling quantity	15 Seconds

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		> 80 mg/stk 3. Engine Intake Manifold #1 Pressure (IMP) > 22 psi (150 kPa) Time in entry condition 1 through 3 > 849 * 0.1 seconds Engine Inlet Air temperature (AIT) < 140°F (60°C) SPN / FMI 4765/3 and 4765/4 are NOT Active	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the DOCIT sensor is measuring temperature less than 446°F (230°C).

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

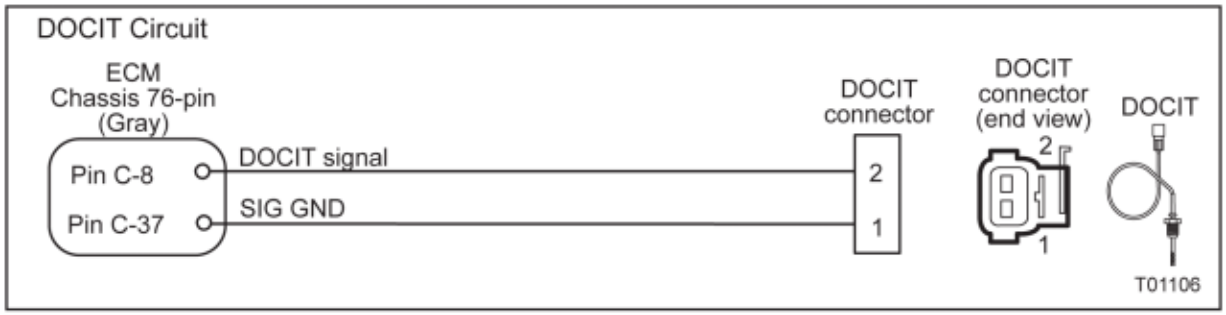


Figure 230 DOCIT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 4765 FMI 21 the only fault code active?	Yes: Go to Step 3.
		No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 4765 FMI 21.
		No: Go to Step 3.

Step	Action	Decision
3	Inspect exhaust system. Check exhaust system (engine and vehicle) for damage or leaks and to ensure the Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor is installed. Is exhaust system undamaged and sensor installed?	Yes: Go to Step 4.
		No: Repair exhaust. After repairs are complete, retest for SPN 4765 FMI 21.

Step	Action	Decision
4	Using terminal test kit inspect connections at DOCIT sensor. With Key OFF, disconnect DOCIT sensor connector. Check DOCIT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are DOCIT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 5.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4765 FMI 21.

Step	Action	Decision
5	Test DOCIT circuits for open, short, or high resistance conditions. Do Connector Voltage Checks (page 484) and Harness Resistance Checks (page 484). Are DOCIT circuits within specifications?	Yes: Go to Step 6.
		No: Repair any circuit faults. After repairs are complete, retest for SPN 4765 FMI 21.

Step	Action	Decision
6	Do Cold Soak Sensor Compare Check (page 483). Compare Diesel Particulate Filter (DPF) Inlet Temperature (DPFIT), Diesel Oxidation Catalyst (DOC) Inlet Temperature (DOCIT), and DPF Outlet Temperature (DPFOT). All sensors should be within 68°F (20°C) of each other. Are all temperature sensors within 68°F (20°C) the other sensors?	Yes: Go to Step 7.
		No: Replace failed temperature sensor. After repairs are complete, retest for SPN 4765 FMI 21.

Step	Action	Decision
7	Test DOCIT sensor. Connect breakout harness 4760A between DOCIT sensor and DOCIT sensor connector. Do KOEO voltage check of DOCIT sensor between DOCIT signal and ground. Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 4765 FMI 21 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace DOCIT sensor. After repairs are complete, retest for SPN 4765 FMI 21.

NOTE: After doing all diagnostic steps, if SPN 4765 FMI 21 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

DPFDP Sensor (Diesel Particulate Filter Differential Pressure)

SPN	FMI	Condition	Possible Causes	Actions
3251	3	DPFDP signal Out of Range HIGH	• DPFDP signal circuit short to battery • Failed DPFDP sensor	Step-based Diagnostics (page 496)
3251	4	DPFDP signal Out of Range LOW	• Reversed DPFDP sensor hoses • DPFDP sensor connector open • DPFDP VREF open • DPFDP signal open • Failed DPFDP sensor	Step-based Diagnostics (page 499)
3251	10	DPFDP in range stuck fault	• DPFDP sensor tubes restricted or open • Biased DPFDP circuit or sensor	Pin-point Diagnostics (page 494)

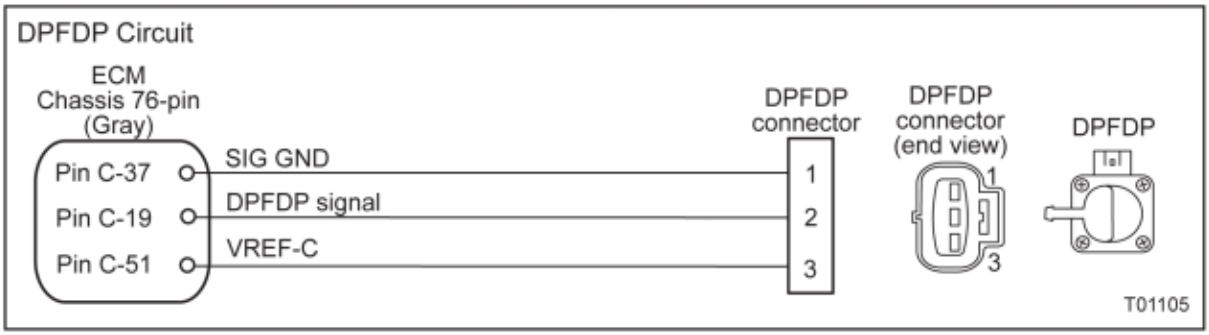


Figure 231 DPFDP circuit diagram

Function

The DPFDP sensor provides a feedback signal to the ECM, indicating the pressure difference between the inlet and outlet of the Diesel Particulate Filter. Before and during a catalyst regeneration, the ECM will monitor this sensor along with the DOCIT, DPFIT, DPFOT, EGRP, and ETVP.

Sensor Location

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

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)

- 00-00956-08 – 180-pin Breakout Box (page 1222)
- 3-Banana Plug Harness (page 1228)
- Breakout Harness 4761A (DPFDP) (page 1232)
- International® Electronic Engine Terminal Test Kit (page 1227)

SPN 3251 FMI 10 – DPFDP in range stuck fault

1. Verify DPFDP sensor hoses are not disconnected, leaking or plumb backwards.
2. Turn switch ON, engine OFF
3. Using ServiceMaxx™ software, open the Continuous Monitor session.
4. Verify S_DPFDP Volts are within specification. See APPENDIX A (page 1291).
   - If voltage is not within specification, check circuitry for poor continuity. If circuits are okay, replace DPFDP sensor.

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

NOTE: For FMI 10, verify sensor pressure hoses are not restricted, reversed, or disconnected.

1. Using EST with ServiceMaxx™ software, open the Continuous Monitor session.
2. Monitor sensor voltage. Verify an active code for the sensor.
   - If code is inactive, monitor the signal while wiggling the connector and all wires at suspected locations. If the circuit is interrupted, the signal will spike and the Code will go active.
   - If code is active, proceed to the next step.
3. Disconnect chassis harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

4. Connect Breakout Harness 4761A to chassis harness. Leave sensor disconnected.

Sensor Circuit Check

Connect Breakout Harness 4761A. Leave sensor disconnected. Turn ignition switch to ON. Use EST to verify correct code goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Specification	Comment: < Less than, > Greater than
EST – Check code	SPN 3251 FMI 4	If SPN 3251 FMI 3 is active, check DPFDP signal for short to PWR.
DMM – Measure volts 3 to GND	5 ± 0.5 V	If > 5.5 volts, check VREF for short to PWR. If < 4.5 volts, check VREF for OPEN or short to GND. Go to Harness Resistance Check.
EST – Check code Short breakout harness across 2 and 3	SPN 3251 FMI 3	If SPN 3251 FMI 4 is active, check DPFDP signal for OPEN. Go to Harness Resistance Check.
DMM – Measure Volts 1 to B+	B+	If < B+, check SIG GND for OPEN. Go to Harness Resistance Check.
If checks are within specification, connect sensor and clear codes. If active code remains, replace sensor.		

Connector Voltage Check

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 B+	B+	If < B+, check for short to PWR. Go to Harness Resistance Check.
3 to GND	5 ± 0.5 V	If > 5.5 volts, check VREF for short to PWR. If < 4.5 volts, check VREF for OPEN or short to GND. Go to Harness Resistance Check.
2 to B+	B+	If < B+, check for short to PWR. Go to Harness Resistance Check.

Harness Resistance Check

Turn ignition switch to OFF. Disconnect ECM. Leave sensor disconnected. Connect 180-pin Breakout Box and Breakout Harness 4761A. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
1 to C-37	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN
2 to C-19	< 5 Ω	If > 5 Ω, check DPFDP signal circuit for OPEN
3 to C-51	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN

DPFDP Circuit Operation

The DPFDP is a differential pressure sensor that is supplied with a 5-volt VREF at Pin 3 from ECM Pin C-51. The sensor is grounded at Pin 1 from ECM Pin C-37. The sensor returns a variable voltage signal from Pin 2 to ECM Pin C-19.

SPN 3251 FMI 3 – DPFDP Signal Out of Range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Aftertreatment 1 Diesel Particulate Filter (DPF) Differential Pressure signal Out of Range HIGH	DPF differential pressure sensor voltage > 4.722 Volts	Key ON SPN / FMI 3510/3 and 3510/4 are NOT active	5 Seconds

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the DOCIT sensor is measuring temperature less than 500°F (260°C).

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

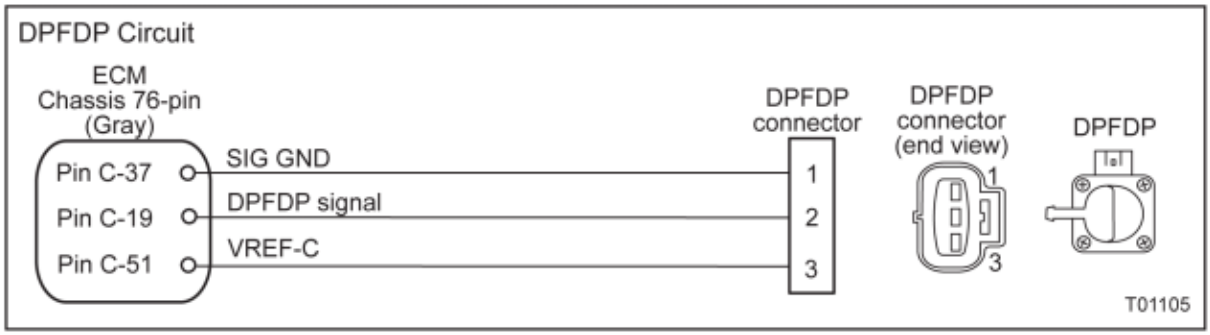


Figure 232 DPFDP circuit diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3251 FMI 3 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3251 FMI 3.
		No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit inspect connections at Diesel Particulate Filter Differential Pressure (DPFDP) sensor. With Key OFF, disconnect DPFDP sensor connector. Check DPFDP sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are DPFDP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3251 FMI 3.

Step	Action	Decision
4	Test DPFDP circuits for open, short, or high resistance conditions. Do Connector Voltage Checks (page 495) and Harness Resistance Checks (page 495). Are DPFDP circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 5.
		No: Repair any circuit faults. After repairs are complete, retest for SPN 3251 FMI 3.

Step	Action	Decision
5	Test DPFDP for intermittent circuit operation using EST with ServiceMaxx™ software. Do Key On Engine Off Continuous Monitor Test (page 87). Verify sensor voltages are within specifications (All Ratings, page 1291). Are the sensor voltages within specifications?	Yes: After doing all diagnostic steps, if SPN 3251 FMI 3 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in

Step	Action	Decision
		this section. Repair circuits as required. After repairs are complete, retest for SPN 3251 FMI 3.

NOTE: After doing all diagnostic steps, if SPN 3251 FMI 3 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3251 FMI 4 – DOCIT Signal Drifted LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Aftertreatment 1 Diesel Particulate Filter (DPF) Differential Pressure signal Out of Range LOW	DPF differential pressure sensor voltage < 0.425 Volts	Key ON SPN / FMI 3510/3 and 3510/4 are NOT active	5 Seconds

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the DOCIT sensor is measuring temperature less than 500°F (260°C).

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

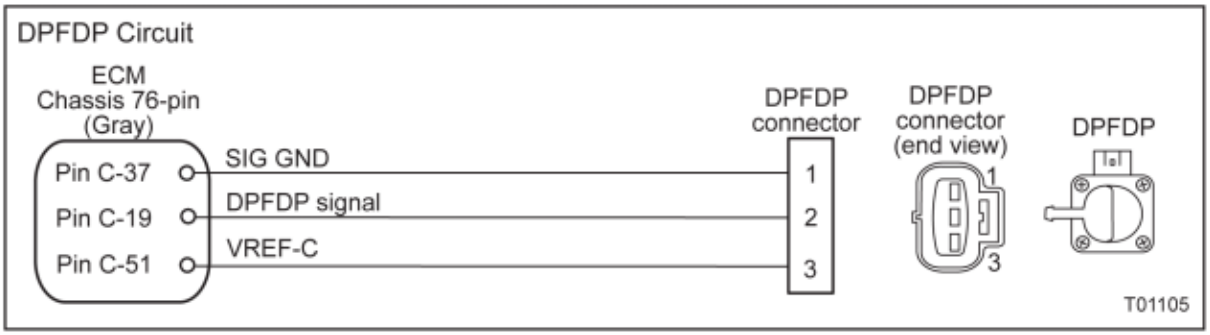


Figure 233 DPFDP circuit diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3251 FMI 4 the only fault code active?	Yes: Go to Step 3.
		No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3251 FMI 4.
		No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit inspect connections at Diesel Particulate Filter Differential Pressure (DPFDP) sensor. With Key OFF, disconnect DPFDP sensor connector. Check DPFDP sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are DPFDP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3251 FMI 4.

Step	Action	Decision
4	Test DPFDP circuits for open, short, or high resistance conditions. Do Connector Voltage Checks (page 495) and Harness Resistance Checks (page 495). Are DPFDP circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 5.
		No: Repair any circuit faults. After repairs are complete, retest for SPN 3251 FMI 4.

Step	Action	Decision
5	Inspect exhaust system for restrictions, leaks, or physical damage. Inspect DPFDP sensor lines for reversed lines. Including check exhaust tailpipe for evidence of soot. Is exhaust system free of restrictions, leaks, reversed hoses, and physical damage? **NOTE:** Soot in the exhaust tailpipe indicates a cracked DPF.	Yes: Go to Step 6.
		No: Repair restrictions, leaks, reversed hoses, or physical damage. After repairs are complete, retest for SPN 3251 FMI 4.

Step	Action	Decision
6	Test DPFDP for intermittent circuit operation using EST with ServiceMaxx™ software. Do Key On Engine Off Continuous Monitor Test (page 87). Verify sensor voltages are within specifications (All Ratings, page 1291). Are the sensor voltages within specifications?	Yes: After doing all diagnostic steps, if SPN 3251 FMI 4 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuits as required. After repairs are complete, retest for SPN 3251 FMI 4.

NOTE: After doing all diagnostic steps, if SPN 3251 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

DPFIT Sensor (Diesel Particulate Filter Inlet Temperature)

SPN	FMI	Condition	Possible Causes	Actions
3242	2	DPFIT signal erratic, intermittent, or incorrect	• Biased DPFIT circuit or sensor	Pin-point Diagnostics (page 504)
3242	3	DPFIT signal out of range high	• DPFIT signal OPEN or short to PWR • SIG GND circuit OPEN • Failed DPFIT sensor	Pin-point Diagnostics (page 504)
3242	4	DPFIT signal out of range low	• DPFIT signal circuit short to GND • Failed DPFIT sensor	Pin-point Diagnostics (page 504)
3242	7	DPFIT sensor or circuit fault	• Biased DPFIT sensor or circuit	Pin-point Diagnostics (page 504)
3242	20	DPFIT signal drifted high	• Biased DPFIT sensor • Partial short circuits in wiring • Alternative fuel in exhaust system • Doser leaking fuel into exhaust • Engine misfire • Restricted exhaust causing excessive Exhaust Gas Temperature (EGT) values	Step-based Diagnostics (page 505)
3242	21	DPFIT signal drifted low	• DPFIT sensor not connected in exhaust system • Exhaust system not connected to engine • High resistance connections to DPFIT sensor	Step-based Diagnostics (page 511)

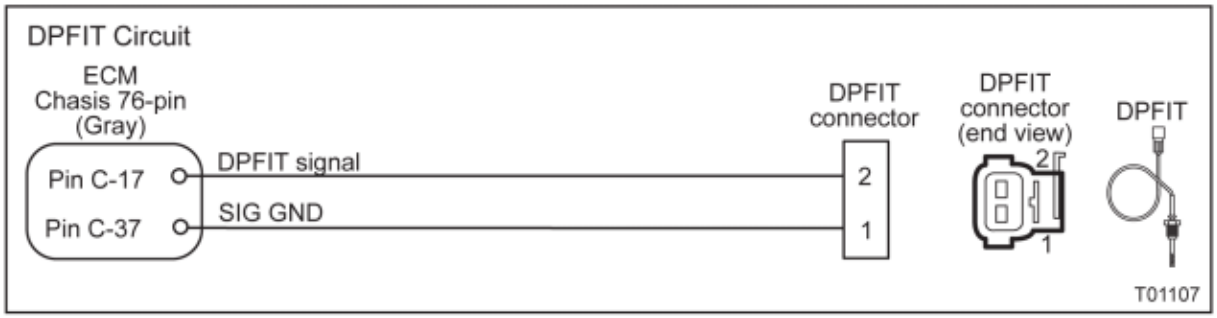


Figure 234 DPFIT circuit diagram

Overview

The Diesel Particulate Filter Inlet Temperature (DPFIT) sensor provides a feedback signal to the ECM, indicating Diesel Particulate Filter inlet temperature. Before and during a catalyst regeneration, the ECM will monitor this sensor along with the Diesel Oxidation Catalyst Inlet Temperature (DOCIT), Diesel Particulate Filter Outlet Temperature (DPFOT), Diesel Particulate Filter Differential Pressure (DPFDP), Exhaust Gas Recirculation Position (EGRP), and Engine Throttle Valve Position (ETVP).

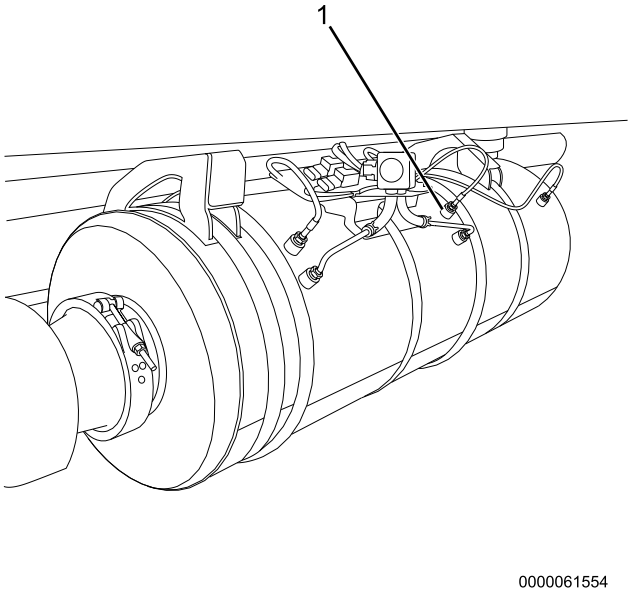


Figure 235 DPFIT Sensor Location

Tools

- EZ Tech® Electronic Service Tool (EST) – J-45067 (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- 00-00956-08 – 180-pin Breakout Box (page 1222)
- 3-Banana Plug Harness (page 1228)

- Breakout Harness 4760A (DPFIT) (page 1232)
- International® Electronic Engine Terminal Test Kit (page 1227)

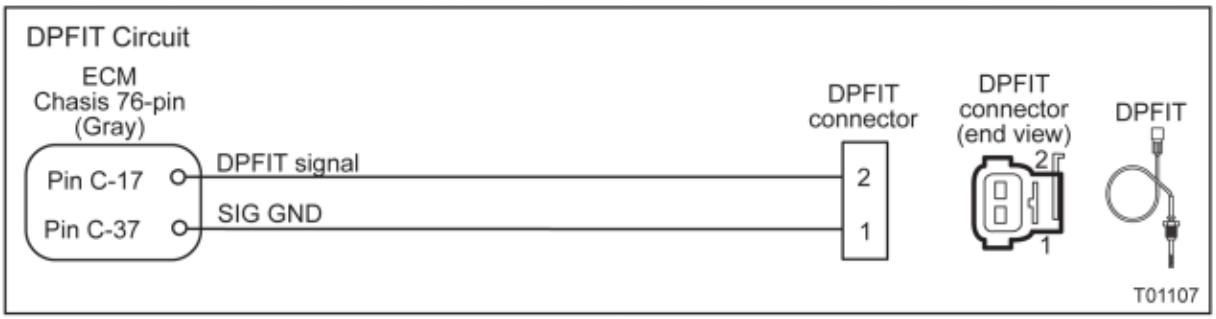


Figure 236 DPFIT circuit diagram

Pin-point Diagnostics

SPN 3242 FMI 2 – DPFIT signal erratic, intermittent, or incorrect

Cold Soak High Temperature Sensor Compare Check
Temperature values need to be measured after four hours cold soak.

1. Turn switch ON, engine OFF
2. Using ServiceMaxx™ software, open Continuous Monitor session.
3. Compare DPF Inlet Temp, DOC Inlet Temp and DPF Outlet Temp. All temperature sensors should be within 68°F (20°C) of each other.
   - If any temperature sensor is above or below of other sensors. Check for poor circuitry going to temperature sensor.
   - If circuits are okay, then replace failed temperature sensor.

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST with ServiceMaxx™ software, open Continuous Monitor Session.
2. Monitor sensor voltage. Verify an active code for sensor.
   - If code is inactive, monitor signal while wiggling connector and all wires at suspected locations. If circuit is interrupted, signal will spike and code will go active.
   - If code is active, proceed to next step.
3. Disconnect chassis harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

4. Connect Breakout Harness 4760A to chassis harness. Leave sensor disconnected.

Sensor Circuit Check

Connect Breakout Harness 4760A. Leave sensor disconnected. Turn ignition switch to ON. Use EST to verify correct code goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Specification	Comment
EST – Check code	SPN 3242 FMI 3	If SPN 3242 FMI 4 is active, check DPFIT signal for short to GND. Go to Harness Resistance Check.
EST – Check code Short 3-Banana plug harness across 2 and GND	SPN 3242 FMI 4	If SPN 3242 FMI 3 is active, check DPFIT signal for OPEN. Go to Harness Resistance Check.
EST – Check code Short 3-Banana plug harness across 1 and 2	SPN 3242 FMI 4	If SPN 3242 FMI 3 is active, check SIG GND for OPEN. Go to Harness Resistance Check.
If checks are within specification, connect sensor and clear codes. If active code remains, replace sensor.		

Connector Voltage Check

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	5 V	If < 5 volts, check for OPEN or short to GND. Go to Harness Resistance Check.

Harness Resistance Check

Turn ignition switch to OFF. Disconnect ECM. Leave sensor disconnected. Connect 180-pin Breakout Box and Breakout Harness 4760A. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
1 to C-37	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to C-17	< 5 Ω	If > 5 Ω, check for OPEN circuit.

SPN 3242 FMI 20 – DPFIT Signal Drifted High

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Aftertreatment 1 Diesel Particulate Filter Intake Gas Temperature (DPFIT) stuck high	Aftertreatment 1 Diesel Particulate Filter Intake Gas Temperature (DPFIT) > 932°F (500°C)	Particulate Filter Regeneration NOT Active End Of Line Testing NOT Active [Engine Brake (Retarder) NOT active	5 seconds

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		AND minimum wait time after retarder change of state has occurred] > 5 seconds Engine Torque limitation NOT Active Battery Voltage ≥ 10.787 Volts AND ≤ 15.787 Volts Engine Ignition Key is in "ON" position (Key ON) Time after engine start ≥ 30 seconds Engine Coolant Temperature (ECT) ≥ 19°F (-7°C) AND ≤ 230°F (110°C) Minimum time after Completing a Regeneration Event ≥ Time value as defined by Speed / Torque based (Table A068) * Engine Air Inlet Temperature (AIT) modifier (Table A069) * Barometric Pressure modifier (Table A070) * 0.1 seconds Pre-debounce time ≥ 40 seconds	

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		Engine Air Inlet Temperature (AIT) < 140°F (60°C) SPN / FMI 3242/3 and 3242/4 are NOT active	

Fault Overview

Fault sets when the ECM determines the difference between actual Aftertreatment Fuel Temperature (AFTFT) and measured AFTFT is incorrect and/or erratic.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN / FMI: 1322/31, 1323/31, 1324/31, 1325/31, 1326/31, 1327/31, 1328/31, 2659/20, 3471/1, 3471/7, 3471/10, 3480/3, 3480/4, and 3482/7.

Drive Cycle to Determine Fault Status

N/A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3242 FMI 20 the only fault code active?	Yes: Go to Step 3.
		No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3242 FMI 20.
		No: Go to Step 3.

Step	Action	Decision
3	Do Cold Soak Sensor Compare Check (page 1145). Compare Diesel Particulate Filter (DPF) Inlet Temperature (DPFIT), Diesel Oxidation Catalyst (DOC) Inlet Temperature (DOCIT), and DPF Outlet Temperature (DPFOT). All sensors should be within 68°F (20°C) of each other. Are all temperature sensors within 68°F (20°C) the other sensors?	Yes: Go to Step 4.
		No: Replace failed temperature sensor. After repairs are complete, retest for SPN 3242 FMI 20.

Step	Action	Decision
4	Using terminal test kit, inspect connections at DPFIT sensor. With key OFF, disconnect DPFIT sensor connector. Check DPFIT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are DPFIT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 5.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3242 FMI 20.

Step	Action	Decision
5	Test DPFIT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 505). Are DPFIT circuits within specifications?	Yes: Go to Step 6.
		No: Repair circuits as required. After repairs are complete, retest for SPN 3242 FMI 20.

Step	Action	Decision
6	Test DPFIT sensor. Connect breakout harness 4760A between DPFIT sensor and DPFIT sensor connector. Do KOEO voltage check of DPFIT sensor between DPFIT signal and ground. Is voltage within specification?	Yes: Go to Step 7.
		No: Replace DPFIT sensor. After repairs are complete, retest for SPN 3242 FMI 20.

Step	Action	Decision
7	Remove Diesel Oxidation Catalyst (DOC) and Diesel Particulate Filter (DPF), inspect DOC internal for restrictions, damage, or evidence of defects. Look for: chips, cracks, dents, or bent rims Dents on ends are acceptable if: • No damage to sealing surfaces on ends of DOC canister. • Clamps are not prevented from seating properly. • DOC is not oil-or fuel-soaked. **NOTE:** DOC cannot be cleaned using cleaning equipment. It must be cleaned using On Board Filter Cleaning. Oil-or fuel-soaked DOC must be replaced. Is DOC condition satisfactory?	Yes: Re-install DOC. Go to Step 9.
		No: Replace DOC. Go to step 8.

Step	Action	Decision
8	Inspect the DPF. Do DPF Filter Inspection section. Does DPF pass inspection?	Yes: Re-install DPF. Go to Step 9.
		No: Clean, repair, or replace following direction in DPF Inspection section. Locate root cause of any contamination, and repair. After repairs are complete, retest for SPN 3242 FMI 20.

Step	Action	Decision
9	Remove the Hydrocarbon Injection (HCI) assembly (AFI Plugging) (see *Engine Service Manual and IK1200753 Hydrocarbon Injector Housing Cleaning Procedure*). Is HCI clean?	Yes: Go to Step 10.
		No: Replace the HCI assembly. After replacement is complete, retest for SPN 3242 FMI 20.

WARNING: To prevent personal injury or death, do not perform an On Board Filter Cleanliness Test (OBFCT) or Parked Regeneration if liquid oil or fuel is present or suspected to be present in the DPF. Liquid oil or fuel will ignite during an OBFCT causing fires or damage to the vehicle or other equipment.

Step	Action	Decision
10	Using EST with ServiceMaxx™ software, start an On Board Filter Cleanliness Test (OBFCT). Is OBFCT running without an Abort message in ServiceMaxx™?	Yes: Go to Step 11.
		No: Replace DPF. Redo Step 10.

Step	Action	Decision
11	After OBFCT is complete, does Diesel Particulate Filter Differential Pressure (DPFDP) signal measure below 0.5 psi (3 kPa) at high idle? Is OBFCT running without an Abort message in ServiceMaxx™?	Yes: After doing all diagnostic steps, if SPN 3242 FMI 20 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Remove DPF for external cleaning. After repairs are complete, retest for SPN 3242 FMI 20.

NOTE: After doing all diagnostic steps, if SPN 3242 FMI 20 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3242 FMI 21 – DPFIT Signal Drifted Low

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Aftertreatment 1 Diesel Particulate Filter Intake Gas Temperature (DPFIT) stuck low	Aftertreatment 1 Diesel Particulate Filter Intake Gas Temperature (DPFIT) < 410°F (210°C)	Particulate Filter (DPF) Regeneration NOT Active End Of Line Testing NOT Active [Engine Brake (Retarder) NOT active AND minimum wait time after retarder change of state has occurred] > 5 seconds Engine Torque limitation NOT Active Battery Voltage ≥10.787 Volts AND ≤ 15.787 Volts Engine Ignition Key is in "ON" position (Key ON) Time after engine start ≥ 30 seconds Engine Coolant Temperature (ECT) ≥ 19°F (-7°C) and ≤ 230°F (110°C) 1. Engine Speed > 1500 rpm 2. Total Fueling quantity	15 seconds

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		> 80 mg/stk 3. Engine Intake Manifold #1 Pressure (IMP) > 22 psi (150 kPa) Time spent in entry conditions 1 through 3 > 849 * 0.1 seconds Engine Inlet Air Temperature (AIT) < 140°F (60°C) SPN / FMI 3242/3 and 3242/4 are NOT Active	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the DPFIT is reading under 410°F (210°C).

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3242 FMI 21 the only fault code active?	Yes: Go to Step 3.
		No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3242 FMI 21.
		No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit, inspect connections at DPFIT sensor. With key OFF, disconnect DPFIT sensor connector. Check DPFIT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are DPFIT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3242 FMI 21.

Step	Action	Decision
4	Inspect exhaust system. Check exhaust system (engine and vehicle) for damage or leaks. Is exhaust system undamaged?	Yes: Go to Step 5.
		No: Repair exhaust. After repairs are complete, retest for SPN 3242 FMI 21.

Step	Action	Decision
5	Do Cold Soak Sensor Compare Check (page 1145). Compare Diesel Particulate Filter (DPF) Inlet Temperature (DPFIT), Diesel Oxidation Catalyst (DOC) Inlet Temperature (DOCIT), and DPF Outlet Temperature (DPFOT). All sensors should be within 68°F (20°C) of each other. Are all temperature sensors within 68°F (20°C) the other sensors?	Yes: Go to Step 6.
		No: Replace failed temperature sensor. After repairs are complete, retest for SPN 3242 FMI 21.

Step	Action	Decision
6	Test DPFIT circuits for open, short, or high resistance conditions. Doconnector voltage checks and resistance checks (page 505). Are DPFIT circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 7.
		No: Repair circuits as required. After repairs are complete, retest for SPN 3242 FMI 21.

Step	Action	Decision
7	Test DPFIT sensor. Connect breakout harness 4760A between DPFIT sensor and DPFIT sensor connector. Do KOEO voltage check (page 505) of DPFIT sensor between DPFIT signal and ground. Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 3242 FMI 21 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace DPFIT sensor. After repairs are complete, retest for SPN 3242 FMI 21.

NOTE: After doing all diagnostic steps, if SPN 3242 FMI 21 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

DPFOT Sensor (Diesel Particulate Filter Outlet Temperature)

SPN	FMI	Condition
3246	2	DPFOT signal erratic, intermittent, or incorrect
3246	3	DPFOT signal Out of Range HIGH
3246	4	DPFOT signal Out of Range LOW
3246	7	DPFOT not warming along with engine

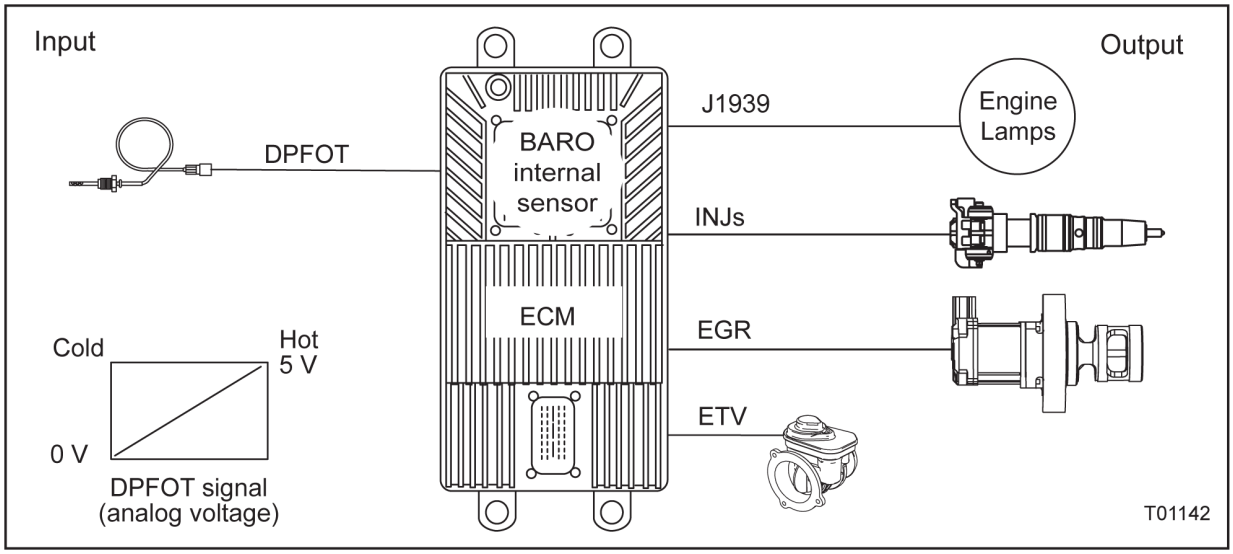


Figure 237 Function diagram for the DPFOT Sensor

The function diagram for the DPFOT sensor includes the following:

- Engine Control Module (ECM)
  with Barometric Absolute Pressure (BARO) Internal Sensor
- DPF Outlet Temperature (DPFOT) Sensor
- Exhaust Gas Recirculation (EGR)
- Engine Throttle Valve (ETV)
- Fuel Injector (INJ)
- Engine Lamps

Function

The DPFOT sensor provides a feedback signal to the ECM, indicating Diesel Particulate Filter outlet temperature. Before and during a catalyst regeneration, the ECM will monitor this sensor along with the DOCIT, DPFIT, DPFDP, EGRP, and ETV.

Sensor Location

The DPFOT sensor is the third exhaust temperature sensor installed down stream of the turbocharger. It is located just after the DPF.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- 00-00956-08 – 180-pin Breakout Box (page 1222)
- 3-Banana Plug Harness (page 1228)
- Breakout Harness 4760A (DPFOT) (page 1232)
- International® Electronic Engine Terminal Test Kit (page 1227)

DPFOT Sensor End Diagnostics

SPN	FMI	Condition	Possible Causes
3246	2	DPFOT signal erratic, intermittent, or incorrect	• 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
3246	7	DPFOT not warming along with engine	• Biased DPFOT circuit or sensor

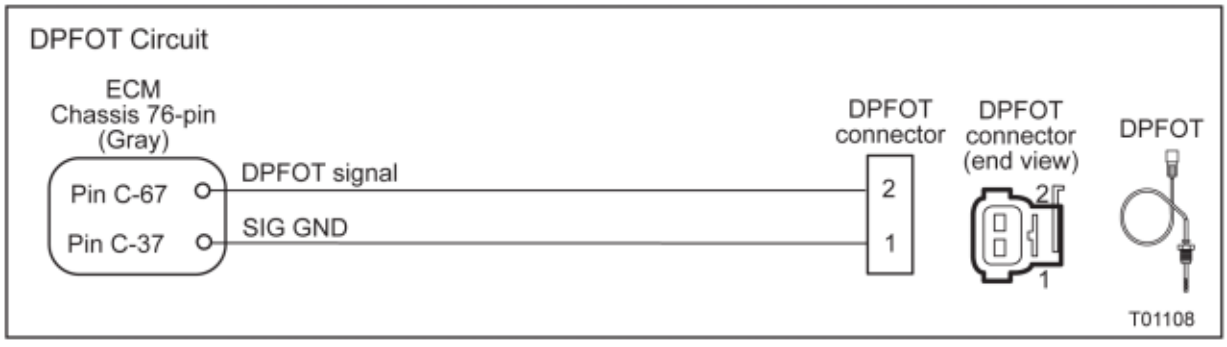


Figure 238 DPFOT circuit diagram

SPN 3246 FMI 2 – DPFOT signal erratic, intermittent, or incorrect

Cold Soak High Temperature Sensor Compare Check

Temperature values need to be measured after four hours cold soak.

1. Turn switch ON, engine OFF
2. Using ServiceMaxx™ software, open the Continuous Monitor session.
3. Compare DPF Outlet Temp, DOC Inlet Temp, and DPF Inlet Temp. All temperature sensors should be within 68°F (20°C) of each other.
   - If any temperature sensor is above or below of the other sensors. Check for poor circuitry going to failed temperature sensor.
   - If the circuits are okay, then replace failed temperature sensor.

SPN 3246 FMI 7 – DPFOT not warming along with engine

Cold Soak High Temperature Sensor Compare Check

Temperature values need to be measured after four hours cold soak.

1. Turn switch ON, engine OFF
2. Using ServiceMaxx™ software, open the Continuous Monitor session.
3. Compare DPF Outlet Temp, DOC Inlet Temp, and DPF Inlet Temp. All temperature sensors should be within 68°F (20°C) of each other.
   - If any temperature sensor is above or below of the other sensors. Check for poor circuitry going to failed temperature sensor.
   - If the circuits are okay, then replace failed temperature sensor.

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST with ServiceMaxx™ software, open the Continuous Monitor Session.
2. Monitor sensor voltage. Verify an active code for the sensor.
   - If code 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 code will go active.
   - If code is active, proceed to the next step.
3. Disconnect chassis harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

4. Connect Breakout Harness 4760A to chassis harness. Leave sensor disconnected.

Sensor Circuit Check

Connect Breakout Harness 4760A. Leave sensor disconnected. Turn ignition switch to ON. Use EST to verify correct code goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Specification	Comment
EST – Check code	SPN 3246 FMI 3	If SPN 3246 FMI 4 is active, check DPFOT signal for short to GND. Go to Harness Resistance Check.
EST – Check code Short 3-Banana plug harness across 2 and GND	SPN 3246 FMI 4	If SPN 3246 FMI 3 is active, check DPFOT signal for OPEN. Go to Harness Resistance Check.
EST – Check code Short 3-Banana plug harness across 1 and 2	SPN 3246 FMI 4	If SPN 3246 FMI 3 is active, check SIG GND for OPEN. Go to Harness Resistance Check.
If checks are within specification, connect sensor and clear codes. If active code remains, replace sensor.		

DPFOT Pin-point Diagnostics

Connector Voltage Check

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	± 5 V	If < 4.5 volts, check for OPEN or short to GND. Go to Harness Resistance Check.

Harness Resistance Check

Turn ignition switch to OFF. Disconnect ECM. Leave sensor disconnected. Connect 180-pin Breakout Box and Breakout Harness 4760A. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
1 to C-37	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to C-67	< 5 Ω	If > 5 Ω, check for OPEN circuit.

DPFOT Circuit Operation

The DPFOT is a thermistor sensor that is supplied with a 5-volt VREF at Pin 2 from ECM Pin C-67. The sensor is grounded at Pin 1 from ECM Pin C-37. As temperature increases, the resistance of the thermistor increases. This causes the signal voltage to increase.

EBP Sensor (Exhaust Back Pressure)

SPN	FMI	Condition
1209	1	EBP below desired level
1209	2	EBP signal erratic, intermittent, o
1209	3	EBP signal Out of Range HIGH
1209	4	EBP signal Out of Range LOW

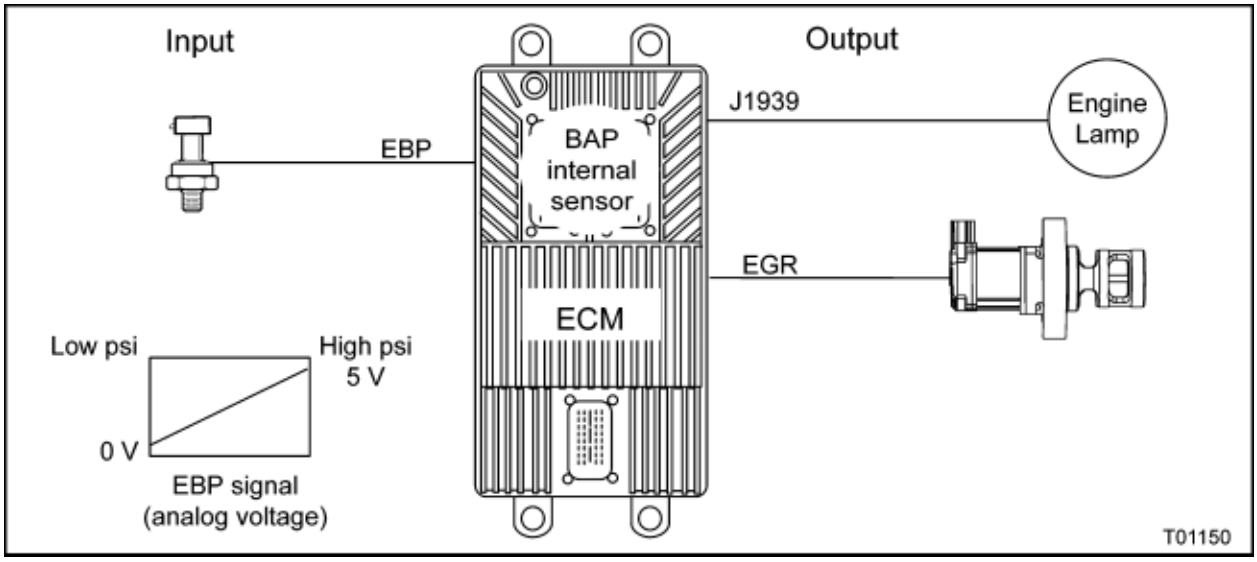


Figure 239 Function diagram for the EBP sensor

The function diagram for the EBP sensor includes the following:

- Exhaust Back Pressure (EBP) Sensor
- Engine Control Module (ECM)
  with Barometric Absolute Pressure (BARO) Internal Sensor
- Exhaust Gas Recirculation (EGR) Valve
- Engine Lamp

Function

The EBP sensor measures exhaust back pressure that allows the ECM to control the EGR system.

Sensor Location

The EBP sensor is installed in a tube connected to the exhaust manifold at the top right rear of the engine.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)

- 00-00956-08 – 180-pin Breakout Box (page 1222)
- 3-Banana Plug Harness (page 1228)
- Breakout Harness 4850 (EBP) (page 1234)
- International® Electronic Engine Terminal Test Kit (page 1227)

EBP Sensor End Diagnostics

SPN	FMI	Condition	Possible Causes
1209	1	EBP below desired level	• Biased EBP sensor or circuit • Plugged EBP sensor tube • Failed Turbocharger
1209	2	EBP signal erratic, intermittent, or incorrect	• Biased EBP sensor or circuit
1209	3	EBP signal Out of Range HIGH	• EBP signal circuit OPEN or short to PWR • SIG GND circuit OPEN • Failed EBP sensor
1209	4	EBP signal Out of Range LOW	• EBP signal circuit short to GND • VREF circuit OPEN • Failed EBP sensor

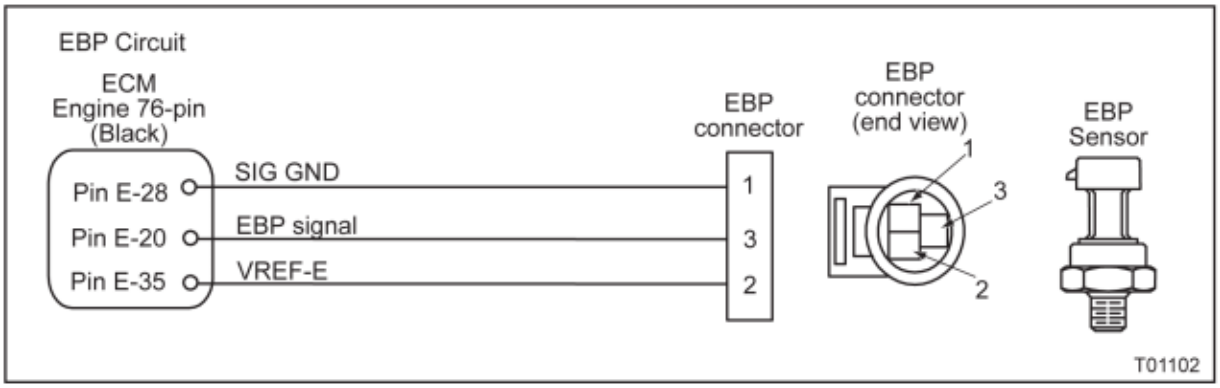


Figure 240 EBP circuit diagram

SPN 1209 FMI 2 – EBP signal erratic, intermittent, or incorrect

Check for Biased sensor or circuit

1. Turn switch ON, engine OFF
2. Using ServiceMaxx™ software, open the Continuous Monitor session.
3. Verify S_EBP Volts are within specification. See APPENDIX A (page 1291).
   - If voltage is not within specification, check circuitry for poor continuity. If circuits are okay, replace EBP sensor.

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST with ServiceMaxx™ software, open the Continuous Monitor session.
2. Monitor sensor voltage. Verify an active code for the sensor.
   - If code 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 code will go active.
   - If code is active, proceed to the next step.
3. Disconnect engine harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

4. Connect breakout harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect Breakout Harness 4850 to engine harness. Leave sensor disconnected. Turn ignition switch to ON. Use EST to verify correct code goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Specification	Comment: < Less than, > Greater than
EST – Check code	SPN 1209 FMI 4	If SPN 1209 FMI 3 is active, check EBP signal for short to PWR.
DMM – Measure volts 2 to GND	5 ± 0.5 V	If > 5.5 volts, check VREF for short to PWR. If < 4.5 volts, check VREF for OPEN or short to GND. Go to Harness Resistance Check.
EST – Check code Short breakout harness across 2 and 3	SPN 1209 FMI 3	If SPN 1209 FMI 4 is active, check EBP signal for OPEN or short to GND. Go to Harness Resistance Check.
DMM – Measure Volts 1 to B+	B+	If < B+, check SIG GND for OPEN. Go to Harness Resistance Check.
If checks are within specification, connect sensor and clear codes. If active code remains, replace sensor.		

EBP Pin-point Diagnostics

Connector Voltage Check

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 for short to PWR.
2 to GND	5 ± 0.5 V	If > 5.5 volts, check VREF for short to PWR. If < 4.5 volts, check VREF for OPEN or short to GND. Go to Harness Resistance Check.
3 to B+	B+	If < B+, check for short to PWR.

Harness Resistance Check

Turn ignition switch to OFF. Disconnect ECM. Leave sensor disconnected. Connect 180-pin Breakout Box and Breakout Harness 4850. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
1 to E-28	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
2 to E-35	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN.
3 to E-20	< 5 Ω	If > 5 Ω, check EBP signal circuit for OPEN.

EBP Circuit Operation

The EBP sensor is a variable capacitance sensor supplied with a 5-volt reference voltage at Pin 2 from ECM Pin E-35. The sensor is grounded at Pin 1 from ECM Pin E-28. The sensor returns a variable voltage signal from Pin 3 to ECM Pin E-20.

Fault Detection / Management

The ECM monitors the BARO sensor as a baseline for zeroing the MAP and EBP signals.

The ECM continuously monitors the control system. If the sensor signal is higher or lower than expected, the ECM disregards the sensor signal and uses a calibrated default value. The ECM will set a code, turn on the warning lamp, and run the engine in a default range.

SPN 1209 FMI 2 - EBP Signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Comparison of Engine Exhaust Gas Pressure with Engine Intake Manifold 1 Pressure and Barometric Pressure	[Absolute value of difference between Barometric Pressure and Engine Intake Manifold 1 Pressure < 4.4 psi (30 kPa) AND Absolute value of difference between Engine Exhaust Gas Pressure and Barometric Pressure > 4.4 psi (30 kPa) AND Absolute value of difference between Engine Exhaust Gas Pressure and Engine 1 Intake Manifold Pressure > 4.4 psi (30 kPa) AND Engine Wastegate Actuator Position Command] < 100%	Key ON Time after Key ON > 0 seconds Battery Voltage > 9 Volts AND < 16 Volts [1. Engine Speed < 50 RPM 2. Engine Fuel Mass Command < 10 mg/stk 3. Engine Wastegate Actuator Position Command < 100% 4. Engine Throttle position < 10% 5. Engine Exhaust Gas Recirculation Valve Position Command < 40% Minimum time entry conditions (1) through (5) - mentioned above are satisfied] > 20 * 0.1 seconds OR [Engine Speed < 100 RPM AND Engine Fuel Mass Command] < 100 mg/stk SPN / FMI 108/3,108/4, 1209/3, 1209/4, 102/3, and 102/4 are NOT active

Fault Overview

Fault sets when absolute pressure difference between Barometric Absolute Pressure (BARO) and Intake Manifold Pressure (IMP) and absolute pressure difference between Exhaust Gas Pressure (EGP) and BARO and absolute pressure difference between EGP and IMP are greater than 4.4 psi (30 kPa) for two seconds with Wastegate Actuator Position Command is less than 100%.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

Fault Facts

Exhaust Back Pressure (EBP) cannot be checked in SMX, because SMX does not display negative values for EBP. Type 2 errors are possible due to 4.4 psi (30 kPa) value.

Drive Cycle to Determine Fault Status

Initial Key ON

Possible Causes

- Defective sensor

Step 1	Check for active or pending fault code.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software. A. Key ON, clear codes. B. Key OFF, wait for EST screens to clear. C. Key ON, check Diagnostic Trouble Code (DTC) list for SPN 1209 FMI 2. Is EST DTC list SPN 1209 FMI 2 active or pending?	Yes: Go to Step 2.
		No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Check for associated fault codes.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 1209 FMI 2. Is EST DTC list free of SPN 1209 FMI 2?	Yes: Replace Exhaust Gas Pressure (EGP) sensor. After repairs are complete, retest for SPN 1209 FMI 2.
		No: Repair SPN 102 FMI 2. After repairs are complete, retest for SPN 1209 FMI 2.

End Diagnostic Tests
After performing all diagnostic steps, if SPN 1209 FMI 2 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

SPN 1209 FMI 3 - EBP Signal Out of Range HIGH

Condition/Description	Setting Criteria	Enable Conditions/Values
Exhaust Back-Pressure (EBP) Sensor signal Out of Range High.	Exhaust Back-Pressure (EBP) sensor signal voltage is greater than 4.8 volts	Key ON SPN 3509 FMIs 3 and 4 are not active

Fault Overview

Fault sets when Exhaust Back-Pressure (EBP) sensor signal voltage is greater than 4.8 volts for 2.5 seconds.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 3509 FMI 3 and 4 (VREF1)

Fault Facts

A restricted exhaust system can set this fault.

Drive Cycle to Determine Fault Status

Key ON

Possible Causes

- EBP signal short to battery
- Failed EBP sensor
- Open SIG GND

Step 1	Check for associated fault codes.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 3509 FMI 3 and 4. Is EST DTC list free of SPN 3509 FMI 3 and 4 (VREF1)?	Yes: Go to Step 2.
		No: Repair SPN 3509 FMI 3 and 4. After repairs are complete, retest for SPN 1209 FMI 3.

Step 2	Inspect connections at Exhaust Back Pressure (EBP) sensor.	Decision
	A. Key OFF. B. Disconnect EBP sensor connector. C. Check EBP sensor and connector terminals for damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the EBP sensor, connector harness, and terminals clean and undamaged?	Yes: Perform Pin-Point Tests (SPN 1209 FMI 3)(page 527).
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 1209 FMI 3.

Pin-Point Tests (SPN 1209 FMI 3)

EBP Circuit

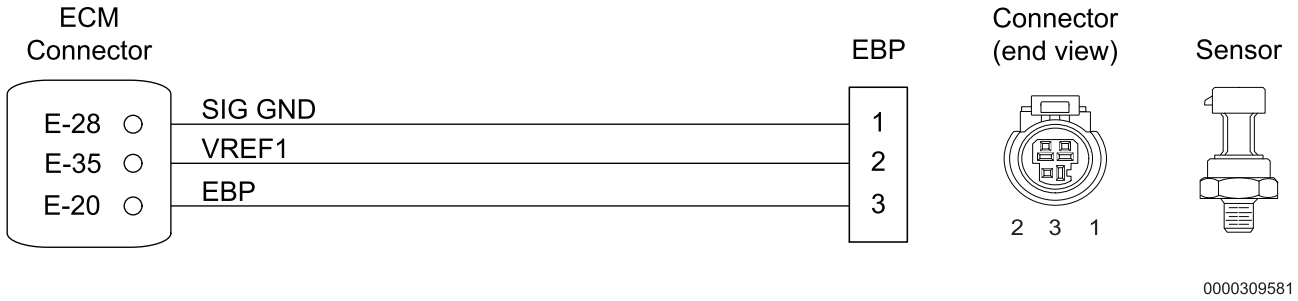


Figure 241 EBP Sensor Circuit Diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

NOTE: See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4850
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)

Test 1 Setup
A. Key OFF. B. Disconnect EBP sensor vehicle harness connector and leave EBP sensor disconnected. C. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). D. Key ON. Log in to ServiceMaxx™ software.

Test 1	Specification
Using EST with ServiceMaxx™ software, clear Diagnostic Trouble Code (DTC) list.	SPN 1209 FMI 3
Decision	
Does SPN 1209 FMI 3 set after DTC list is cleared?	Yes: Repair short to power between EBP pin-3 and Engine Control Module (ECM) Pin E-20. After repairs are complete, retest for SPN 1209 FMI 3.
	No: Go to Test 2.

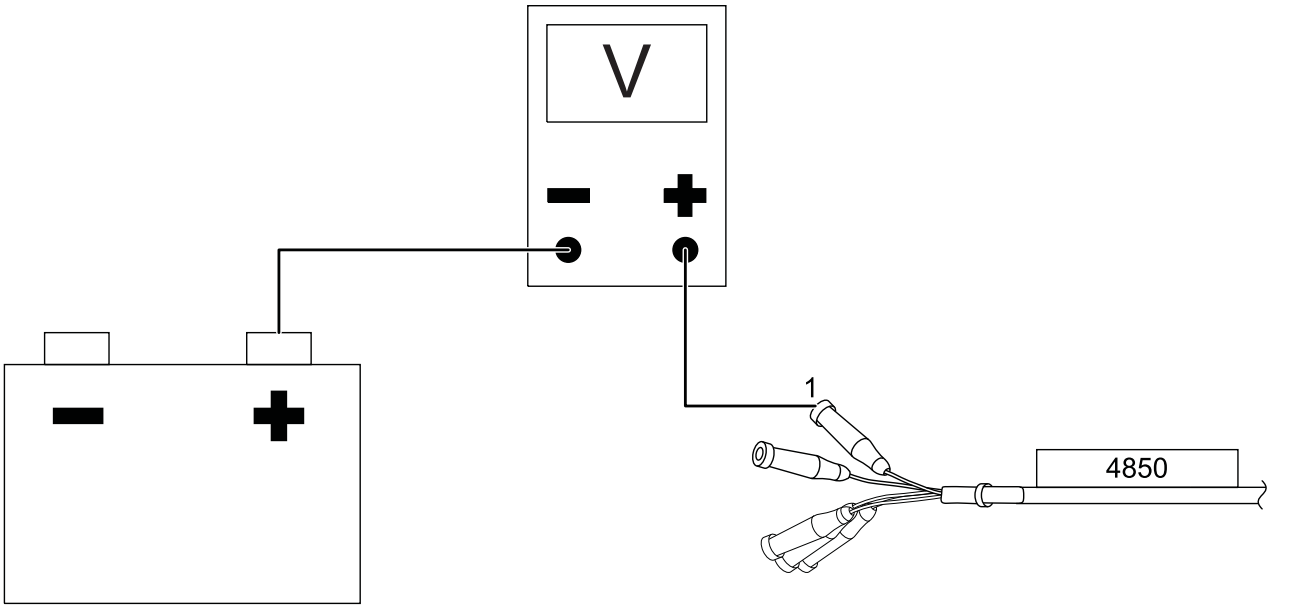


Figure 242 Pin-Point Test 2 EBP Sensor Circuit

Test 2 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4850 to EBP sensor vehicle harness connector and leave EBP sensor disconnected C. Key ON.

Test 2	Specification
Use a DMM to measure voltage between ZTSE4850 pin-1 and B+.	B+
Decision	
Is the measure voltage B+?	Yes: Replace EBP sensor. After repairs are complete, retest for SPN 1209 FMI 3.
	No: Repair Open between EBP pin-1 and Engine Control Module (ECM) pin E-28. After repairs are complete, retest for SPN 1209 FMI 3.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and the proper decision was made. Return to SPN 1209 FMI 3 fault code diagnostics.

SPN 1209 FMI 4 - EBP Signal Out of Range LOW

Condition / Description	Setting Criteria	Enable Conditions/Values
Engine Exhaust Gas Pressure Sensor signal Out of Range Low	Exhaust Back Pressure Sensor Voltage less than 0.2 volts	Key ON SPN 3509 FMI 3 and 4 are NOT active

Fault Overview

Fault sets when Exhaust Back Pressure (EBP) sensor voltage less than 0.2 volts.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive trips.

Associated Faults

SPN 3509 FMI 3 and 4 (VREF1)

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON

Possible Causes

- EBP signal circuit Open
- EBP signal circuit short to GND
- VREF Open
- Failed EBP sensor

Step 1	Check for associated fault codes.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 3509 3 and 4 (VREF1). Is EST DTC list free of SPN 3509 FMI 3 and 4?	Yes: Go to Step 2.
		No: Repair SPN 3509 FMI 3 and 4. After repairs are complete, retest for SPN 3509 FMI 3 and 4.

Step 2	Inspect connections at Exhaust Back-Pressure (EBP) sensor.	Decision
	A. Key OFF. B. Disconnect EBP sensor connector. C. Check EBP sensor and connector terminals for damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the EBP sensor, connector, harness, and terminals clean and undamaged?	Yes: Perform Pin-Point Tests (SPN 1209 FMI 4) (page 530).
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 1209 FMI 4.

Pin-Point Tests (SPN 1209 FMI 4)

EBP Circuit

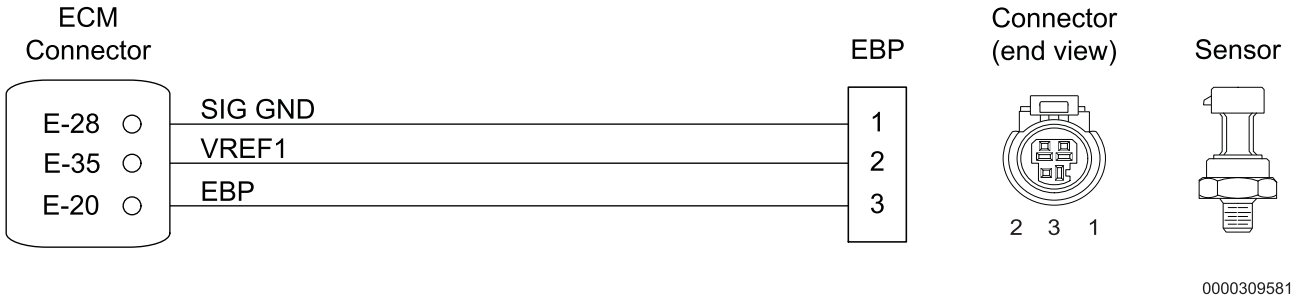


Figure 243 Exhaust Back Pressure (EBP) Sensor Circuit Diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

NOTE: See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4850
- Breakout Harness ZTSE4498
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)

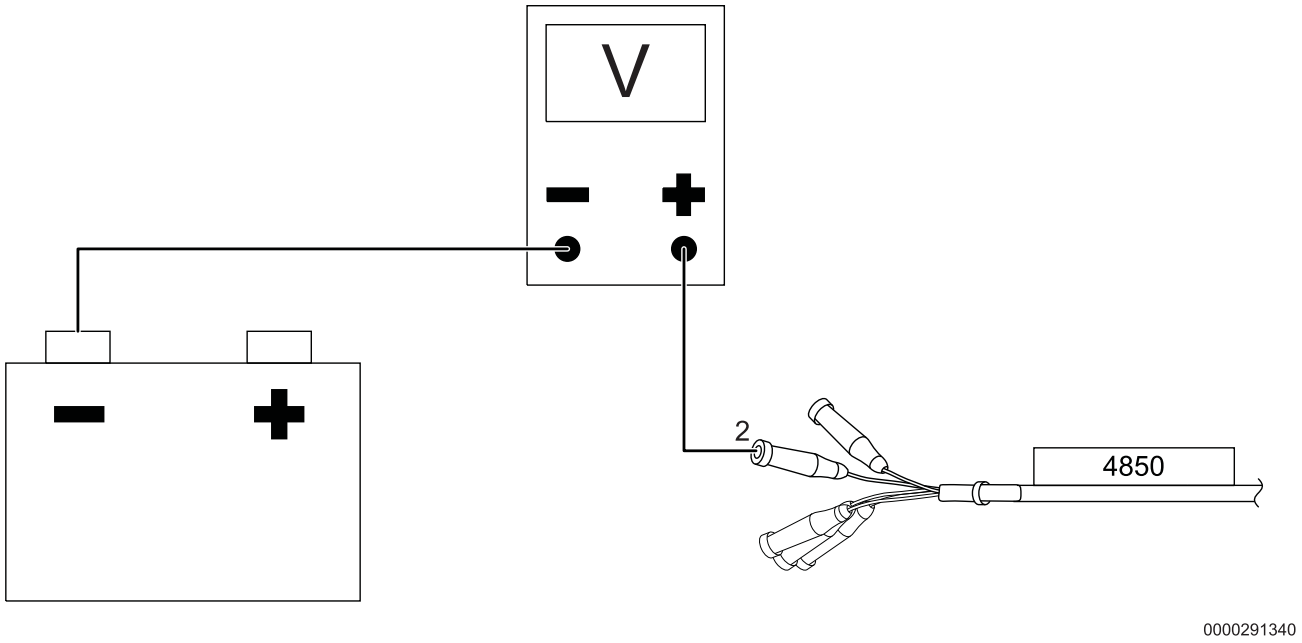


Figure 244 Pin-Point Test 1 EBP Circuit Voltage Check

Test 1 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4850 to EBP sensor vehicle harness connector and leave sensor disconnected. C. Key ON.

Test 1	Specification
Use a Digital Multimeter (DMM) to measure voltage between Breakout Harness ZTSE4850 pin-2 and known good ground.	Within 1 volt of 5 volts
Decision	
Is voltage within 1 volt of 5 volts?	Yes: Go to Test 2.
	No: Repair Open between EBP pin-2 and Engine Control Module pin E-35. After repairs are complete, retest for SPN 1209 FMI 4.

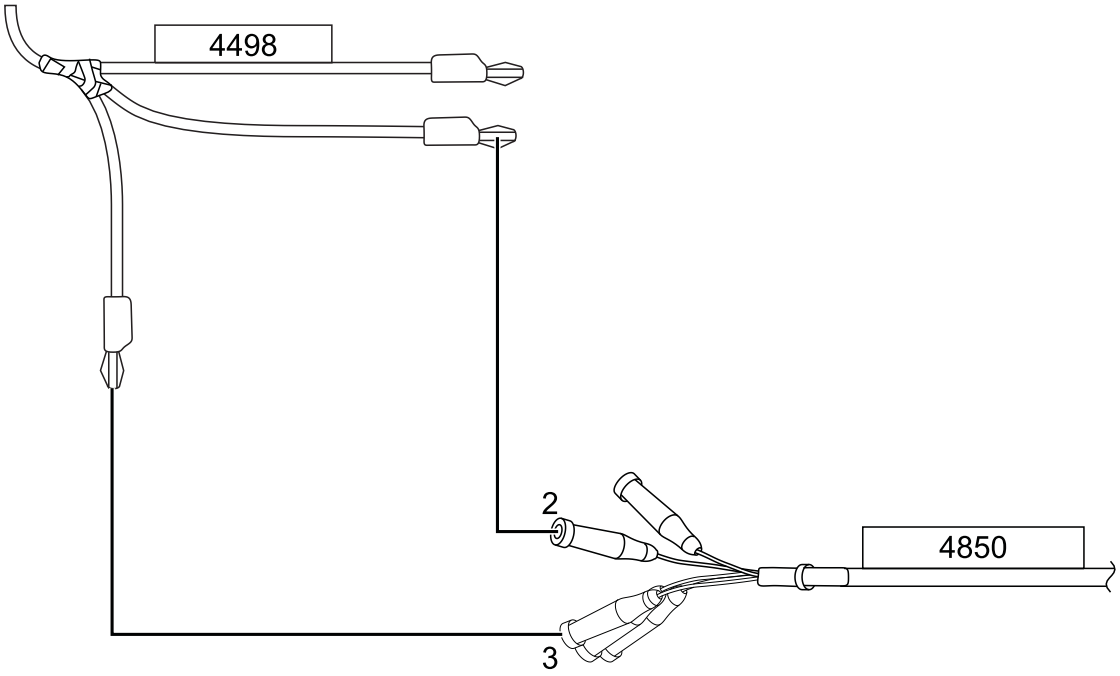
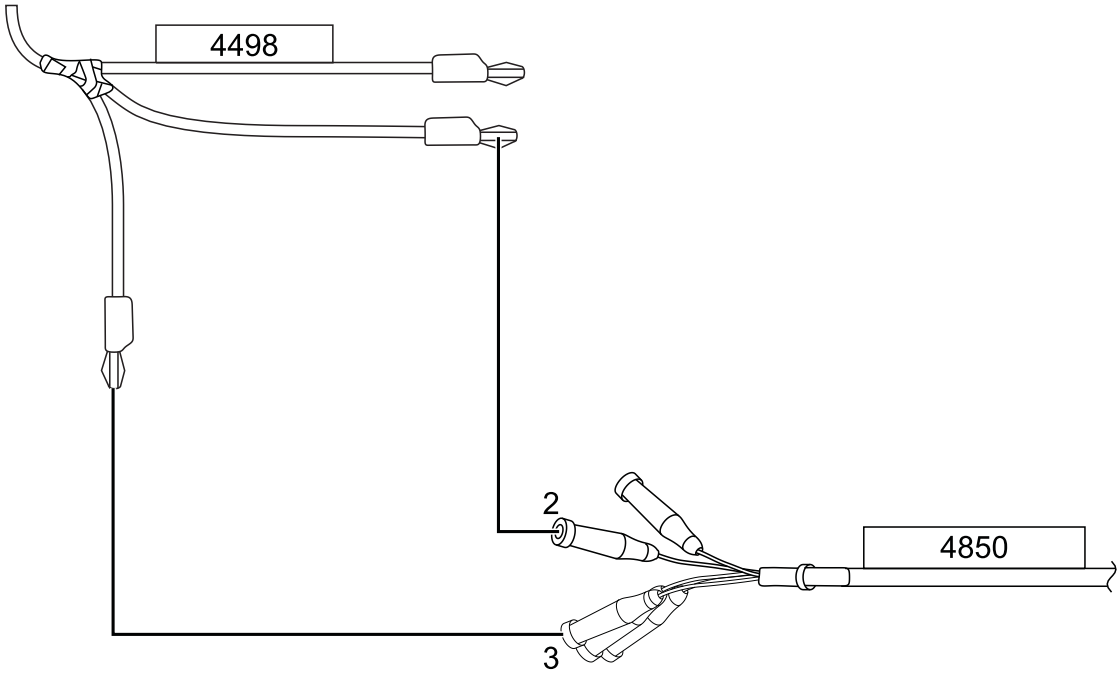


Figure 245 Pin-Point Test 2 EBP Sensor Circuit Check

Test 2 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4850 to EBP sensor vehicle harness connector and leave sensor disconnected. C. Using Breakout Harness ZTSE4498, short pin-2 and pin-3 of Breakout Harness ZTSE4850 together. D. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). E. Key ON. Log in to ServiceMaxx™ software.

Test 2	Specification
Use EST with ServiceMaxx™ software to clear Diagnostic Trouble Code (DTC) list.	SPN 1209 FMI 3
Decision	
Does SPN 1209 FMI 3 set after DTC list is cleared?	Yes: Replace EBP sensor. After repairs are complete, retest for SPN 1209 FMI 4.
	No: Go to Test 3.



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Figure 246 Pin-Point Test 3 EBP Sensor Circuit Check

Test 3 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4850 to EBP vehicle harness connector and leave sensor disconnected. C. Using Breakout Harness ZTSE4498, short pin-1 and pin-3 of Breakout Harness ZTSE4850 together. D. Connect EST to vehicle Diagnostic Connector. E. Key ON. Log in to ServiceMaxx™ software.

Test 3	Specification
Use EST with ServiceMaxx™ to clear DTC list.	SPN 3509 FMI 4
Decision	
Does SPN 3509 FMI 4 set?	Yes: Repair short to ground between EBP pin-3 and Engine Control Module (ECM) pin E-20. After repairs are complete, retest for SPN 1209 FMI 4.
	No: Repair Open between EBP pin-3 and ECM pin E-20. After repairs are complete, retest or SPN 1209 FMI 4.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and the proper decision was made. Return to SPN 1209 FMI 4 fault code diagnostics.

EBPV (Exhaust Back Pressure Valve)

SPN	FMI	Condition	Possible Causes	Actions
5541	1	TC1TOP pressure below minimum	• Failed Exhaust Back Pressure valve (Stuck open)	Pin-point Diagnostics (page 522)
5541	2	TC1TOP Signal Erratic, Intermittent, or incorrect	• Biased TC1TOP sensor	Step-based Diagnostics (page 538)
5541	3	TC1TOP signal Out of Range HIGH	• TC1TOP signal circuit OPEN or short to GND • TC1TOP Sensor Failure	Step-based Diagnostics (SPN 5541 FMI 3 – TC1TOP signal Out of Range HIGH, page 540)
5541	4	TC1TOP signal Out of Range LOW	• Open Connector • TC1TOP VREF Open • TC1TOP Signal Open • TC1TOP signal circuit OPEN or short to GND • TC1TOP Sensor Failure	Step-based Diagnostics (SPN 5541, page 542)
5543	3	EBPC short to PWR	• EBPC circuit short to PWR • Failed EBPC valve	Step-based Diagnostics (SPN 5543, page 544)
5543	4	EBPC short to GND	• EBPC circuit short to GND • Failed EBPC valve	Step-based Diagnostics (SPN 5543, page 546)
5543	5	EBPC open load/circuit	• EBPC circuit OPEN • EBPC GND circuit OPEN • Failed EBPC valve	Step-based Diagnostics

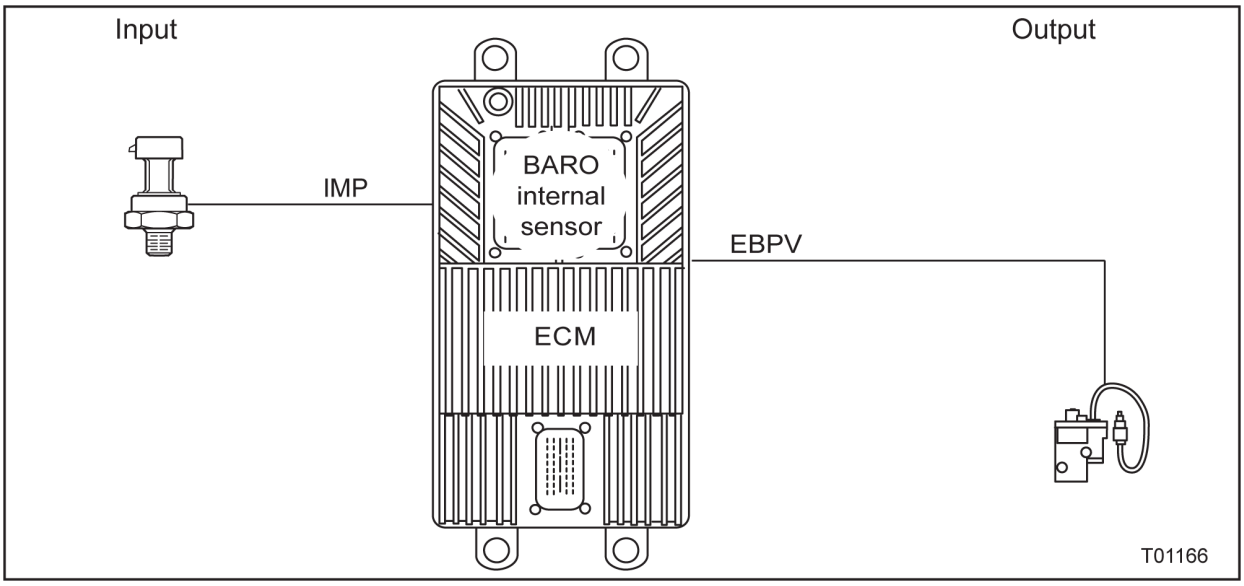


Figure 247 Function diagram for the EBPV

The function diagram for the EBPV includes the following:

- Engine Control Module (ECM)
  with Barometric Absolute Pressure (BARO) Internal Sensor
- Exhaust Back Pressure Valve (EBPV)
- Intake Manifold Pressure (IMP) Sensor

Function

The ECM commands the EBPV to control the Exhaust Brake.

Location

The EBPV is installed in the exhaust pipe.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- International® Electronic Engine Terminal Test Kit (page 1227)

EBPV Pin-point Diagnostics

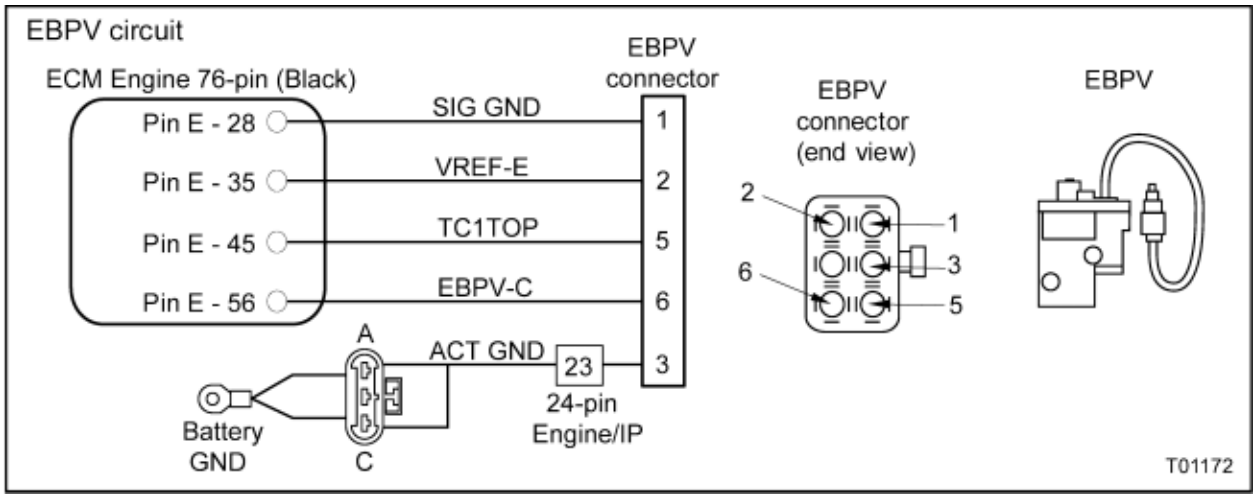


Figure 248 EBPV circuit diagram

Voltage Check at EBPV Connector – Output State Test

Disconnect EBPV 6-pin 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 for OPEN circuit, see Harness Resistance Check.
3 to B+	B+	If < B+, Check ACT GND for OPEN circuit, go to Harness Resistance Check.
2 to GND	5 ± .5 V	If > 5.5 volts, check VREF for short to PWR.
		If < 4.5 volts, check VREF for OPEN or short to GND, go to Harness Resistance Check.
5 to B+	B+	If < B+, Check TC2TOP for OPEN circuit, go to Harness Resistance Check.
6 to GND	2.4 ± 0.5 V	If < 1.9 volts, Check EBPV for OPEN circuit, go to Harness Resistance Check.

Operational Voltage Check

NOTE: The KOEO Output State Test does not cycle the EBPV. However, the EBPV is cycled 3 times every time the engine is shut down. Validate this control by running the engine and shutting it down.

Connect Breakout Harness 4834 between engine harness and EBPV connector. Start engine. Turn engine OFF while using DMM to measure voltage.

Test Point	Test	Specification	Comment: < Less than, > Greater than
6 to GND	Commanded ON	> 7.0 V	If < 7 volts, check EBPV circuit for OPEN or short to GND.

Operational Voltage Check (cont.)

Turn ignition switch to ON, engine OFF.			
6 to GND	Commanded OFF	< 0.5 V	If > 0.5 volts, check EBPV circuit for OPEN or failed EBPV.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-pin Breakout Box. Leave ECM and EBPV disconnected.

Test Point	Specification	Comment: < Less than, > Greater than
1 to E-28	< 5 Ω	If > 5 Ω, check SIG GND for OPEN circuit.
2 to E-35	< 5 Ω	If > 5 Ω, check VREF for OPEN circuit.
3 to GND	< 5 Ω	If > 5 Ω, check ACT GND for OPEN circuit.
5 to E-45	< 5 Ω	If > 5 Ω, check TC1TOP for OPEN circuit.
6 to E-56	< 5 Ω	If > 5 Ω, check EBPV for OPEN circuit.

EBPV Circuit Operation

The EBPV is controlled by the ECM. It is supplied with 5-volt reference voltage at Pin 2 from ECM Pin E-35. It is grounded at Pin 1 from ECM Pin E-28 and at Pin 3, through Pin 23 of the 24-pin Engine / IP connector to ECM Pins C-2, 4, and 6. It returns a variable voltage signal proportional to the measured pressure from Pin 5 to ECM Pin E-45, and Pin 6 to ECM Pin E-56.

Fault Detection / Management

The ECM monitors the internal BARO sensor as a base line for zeroing the IMP and EBPV signals. An OPEN or short to ground in the EBPV can be detected by the ECM during an on-demand engine standard test.

SPN 5541 FMI 2 - TC1TOP Signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Comparison of Engine Turbocharger 1 Turbine Outlet Pressure with any of the following pressure sensors: a. Engine Intake Manifold 1 Pressure Sensor OR b. Barometric Pressure Sensor OR c. Engine Exhaust Back Pressure Sensor.	Absolute Value of difference between Engine Turbocharger 1 Turbine Outlet Pressure and the following sensors: a. Engine Intake Manifold 1 Pressure > 3.6 psi (25 kPa) (OR) b. Engine Exhaust Gas Pressure > 3.6 psi (25 kPa) (OR) c. Barometric Pressure > 3.6 psi (25 kPa)	Key ON Engine Speed ≤ 50 RPM SPN / FMI 1209/3, 1209/4, 102/3, 102/4, 108/3, 108/4, and 1387/31 are NOT active

Function

Fault set when comparison of Turbocharger 1 Turbine Outlet Pressure (TC1TOP) to Intake Manifold Pressure (IMP), Barometric Absolute Pressure (BARO), or Exhaust Back Pressure (EBP) has an absolute pressure value difference of greater than 3.6 psi (25 kPa).

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during one trip.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Initial Key ON

Possible Causes

- Biased Turbocharger 1 Turbine Outlet Pressure (TC1TOP) sensor

Step 1	Check for active or pending fault code.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software. A. Key ON, clear codes. B. Key OFF, wait for EST screens to clear. C. Key ON, check Diagnostic Trouble Code (DTC) list for SPN 5541 FMI 2. Is EST DTC list SPN 5541 FMI 2 active or pending?	Yes: Go to Step 2.
		No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Check for associated fault codes.	Decision
	Using EST with ServiceMaxx™ software, check DTC list for SPN 5541 FMI 2. Is EST DTC list free of SPN 5541 FMI 2?	Yes: Replace IMP sensor. After repairs are complete, retest for SPN 102 FMI 2.
		No: Repair SPN 5541 FMI 2. After repairs are complete, retest for SPN 5541 FMI 2.

End Diagnostic Tests
After performing all diagnostic steps, if SPN 27 FMI 14 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

SPN 5541 FMI 3 – TC1TOP signal Out of Range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine Turbocharger 1 Turbine Outlet Pressure (TC1TOP) signal Out of Range HIGH	Engine Turbocharger 1 Turbine Outlet Pressure (TC1TOP) sensor pressure voltage > 4.8 Volts [> 78 psi (537.1 kPa)]	Key ON	2.5 seconds
		SPN / FMIs 3509/3 and 3509/4 are NOT active	

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

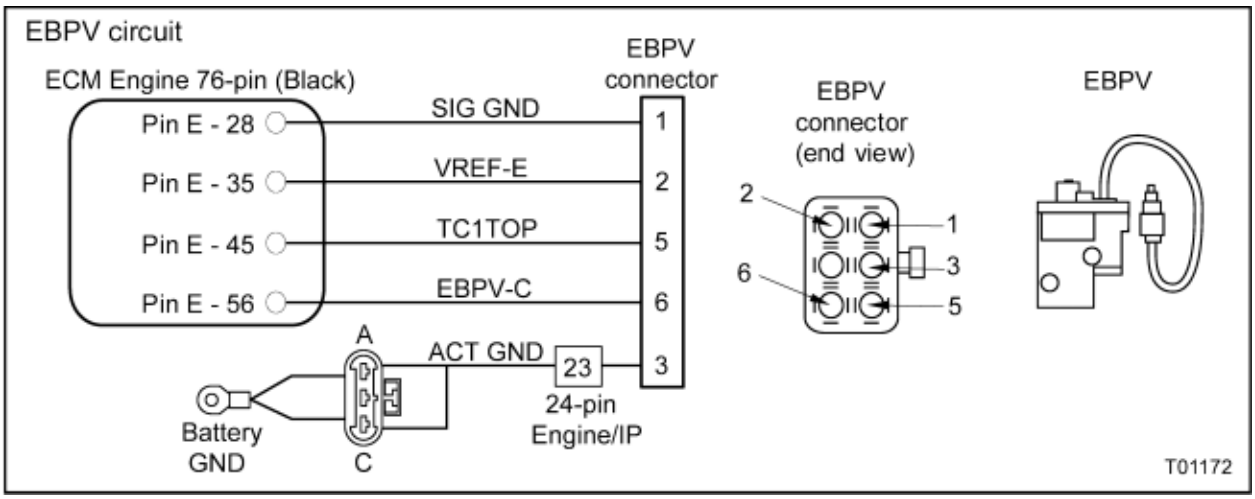


Figure 249 EBPV circuit diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 5541 FMI 3 the only fault code active?	Yes: Go to Step 3.
		No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 5541 FMI 3.
		No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit, inspect connections at Turbocharger 1 Turbine Outlet Pressure (TC1TOP). Key OFF, disconnect TC1TOP sensor connector. Check TC1TOP sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are TC1TOP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 5541 FMI 3.

Step	Action	Decision
4	Test TC1TOP circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 537). Are TC1TOP circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 5.
		No: Repair circuits as required. After repairs are complete, retest for SPN 5541 FMI 3.

Step	Action	Decision
5	Test TC1TOP sensor. Connect breakout harness between TC1TOP sensor and TC1TOP sensor connector. Do KOEO voltage check of TC1TOP sensor between TC1TOP signal and ground. Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 5541 FMI 3 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace TC1TOP sensor. After repairs are complete, retest for SPN 5541 FMI 3.

NOTE: After doing all diagnostic steps, if SPN 5541 FMI 3 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 5541

FMI 4 – TC1TOP signal Out of Range LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine Turbocharger 1 Turbine Outlet Pressure (TC1TOP) signal Out of Range LOW	Engine Turbocharger 1 Turbine Outlet Pressure (TC1TOP) sensor pressure voltage < 0.2 Volts [< 0 psi (0 kPa)]	Key ON	2.5 seconds
		SPN / FMIs 3509/3 and 3509/4 are NOT active	

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

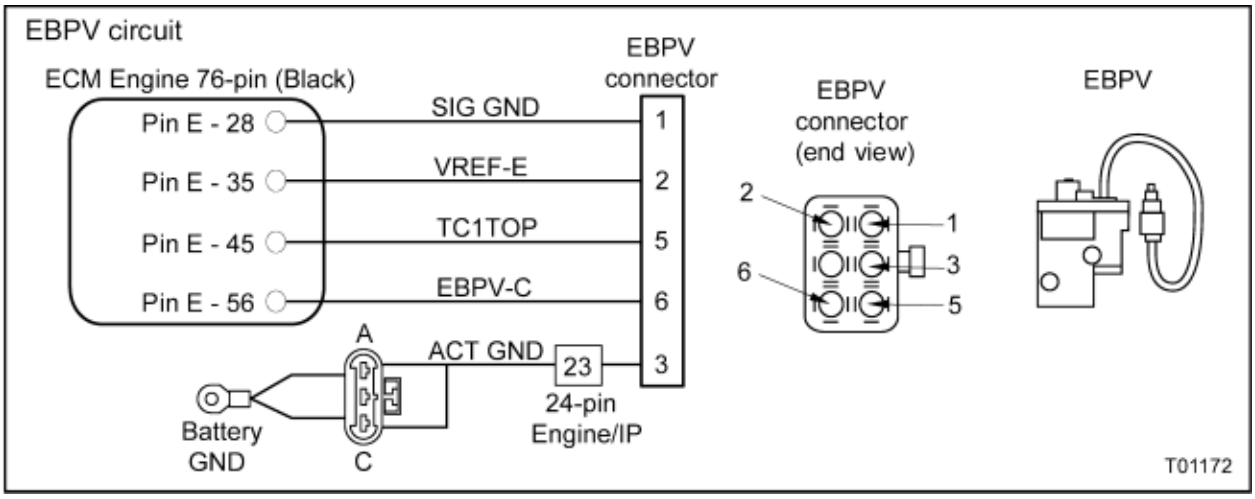


Figure 250 EBPV circuit diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 5541 FMI 4 the only fault code active?	Yes: Go to Step 3.
		No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 5541 FMI 4.
		No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit, inspect connections at Turbocharger 1 Turbine Outlet Pressure (TC1TOP). Key OFF, disconnect TC1TOP sensor connector. Check TC1TOP sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are TC1TOP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 5541 FMI 4

Step	Action	Decision
4	Test TC1TOP circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 537). Are TC1TOP circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 5.
		No: Repair circuits as required. After repairs are complete, retest for SPN 5541 FMI 4.

Step	Action	Decision
5	Test TC1TOP sensor. Connect breakout harness between TC1TOP sensor and TC1TOP sensor connector. Do KOEO voltage check of TC1TOP sensor between TC1TOP signal and ground. Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 5541 FMI 4 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace TC1TOP sensor. After repairs are complete, retest for SPN 5541 FMI 4.

NOTE: After doing all diagnostic steps, if SPN 5541 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 5543

FMI 3 – EBPC Short to PWR

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine Exhaust Brake (EBP) Actuator Circuit Short to Power	Current on the driver > 8 Amps for 100 microseconds	Key ON Battery Voltage > 5 Volts Engine Exhaust Brake Actuator driver enabled SPN / FMIs 158/15 and 158/17 are NOT active	5 seconds

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

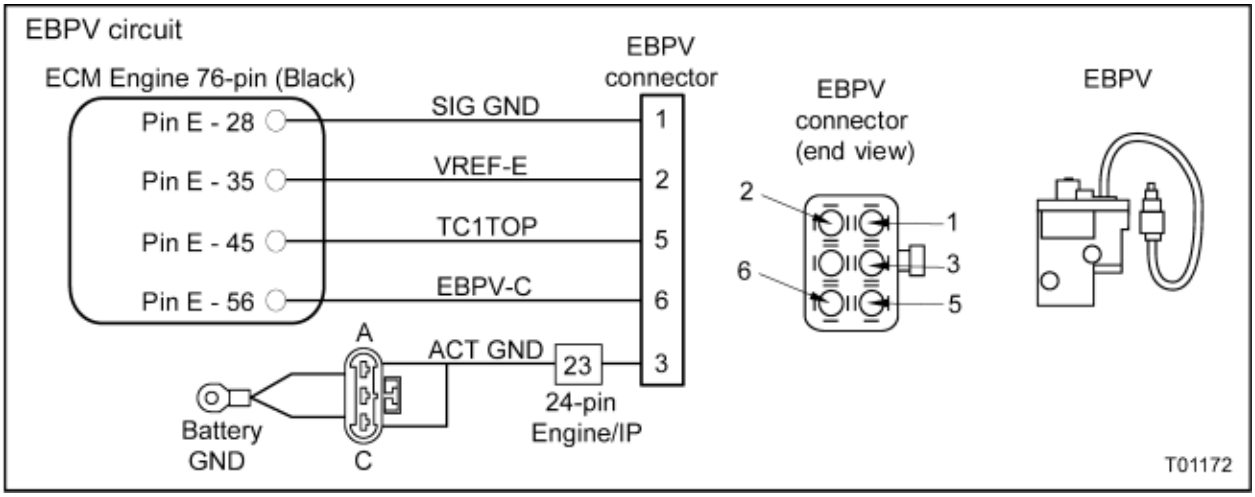


Figure 251 EBPV circuit diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 5543 FMI 3 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 5543 FMI 3.
		No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit, inspect connections at Engine Exhaust Brake (EBP). Key OFF, disconnect EBP sensor connector. Check EBP sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are EBP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 5543 FMI 3

Step	Action	Decision
4	Test EBP circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 537). Are EBP circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 5.
		No: Repair circuits as required. After repairs are complete, retest for SPN 5543 FMI 3.

Step	Action	Decision
5	Test EBP sensor. Connect breakout harness between EBP sensor and EBP sensor connector. Do KOEO voltage check of EBP sensor between EBP signal and ground. Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 5543 FMI 3 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace EBP sensor. After repairs are complete, retest for SPN 5543 FMI 3.

NOTE: After doing all diagnostic steps, if SPN 5543 FMI 3 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 5543

FMI 4 – EBPC Short to GND

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine Exhaust Brake Actuator (EBP) Circuit Short to Ground	Current on the driver > 8 Amps for 100 microseconds	Key ON Battery Voltage > 5 Volts Engine Exhaust Brake Actuator driver enabled SPN / FMIs 158/15 and 158/17 are NOT active	5 seconds

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

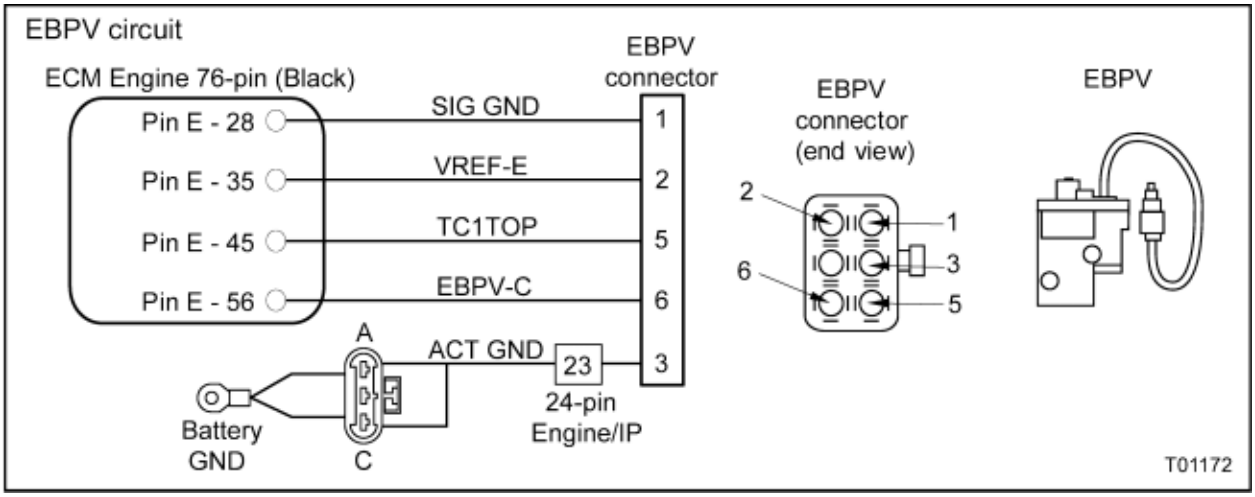


Figure 252 EBPV circuit diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 5543 FMI 4 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 5543 FMI 4.
		No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit, inspect connections at Engine Exhaust Brake (EBP). Key OFF, disconnect EBP sensor connector. Check EBP sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are EBP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 5543 FMI 4.

Step	Action	Decision
4	Test EBP circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 537). Are EBP circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 5.
		No: Repair circuits as required. After repairs are complete, retest for SPN 5543 FMI 4.

Step	Action	Decision
5	Test EBP sensor. Connect breakout harness between EBP sensor and EBP sensor connector. Do KOEO voltage check of EBP sensor between EBP signal and ground. Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 5543 FMI 4 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace EBP sensor. After repairs are complete, retest for SPN 5543 FMI 4.

NOTE: After doing all diagnostic steps, if SPN 5543 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 5543 FMI 5 - EBPC open load / circuit

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Engine Exhaust Brake Actuator Circuit Open Circuit	Current on driver < 25 mA for 100 microseconds	Key On Battery Voltage > 9 Volts Engine Exhaust Brake Actuator driver enabled SPN / FMI 158/15 and 158/17 are NOT active

Fault Overview

Fault sets when Exhaust Back Pressure Control (EBPC) is less than 25 mA for 100 microseconds when enabled.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

SPN 158 FMI 15 and 17

Fault Facts

None

Drive Cycle to Determine Fault Status

Continuous

Possible Causes

- Exhaust Back Pressure Control (EBPC) circuit Open
- ACT GND circuit Open
- Failed Exhaust Back Pressure Valve (EBPV)

Step 1	Check for associated fault codes.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 158 FMI 15 and 17. Is EST DTC list free of SPN 158 FMI 15 and 17?	Yes: Go to Step 2.
		No: Repair SPN 158 FMI 15 and 17. After repairs are complete, retest for SPN 5543 FMI 5.

Step 2	Inspect connections at Exhaust Back Pressure Control (EBPC) connector.	Decision
	A. Key OFF B. Disconnect EBPC C. Check EBPC and connector terminals for: damaged or pinched wires; moisture in terminals; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are EBPC connector, harness, and terminals clean and undamaged?	Yes: Perform pinpoint tests(page 549).
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 5543 FMI 5.

Pin-Point Tests (SPN 5543 FMI 5)

See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4834
- Digital Multimeter (DMM)

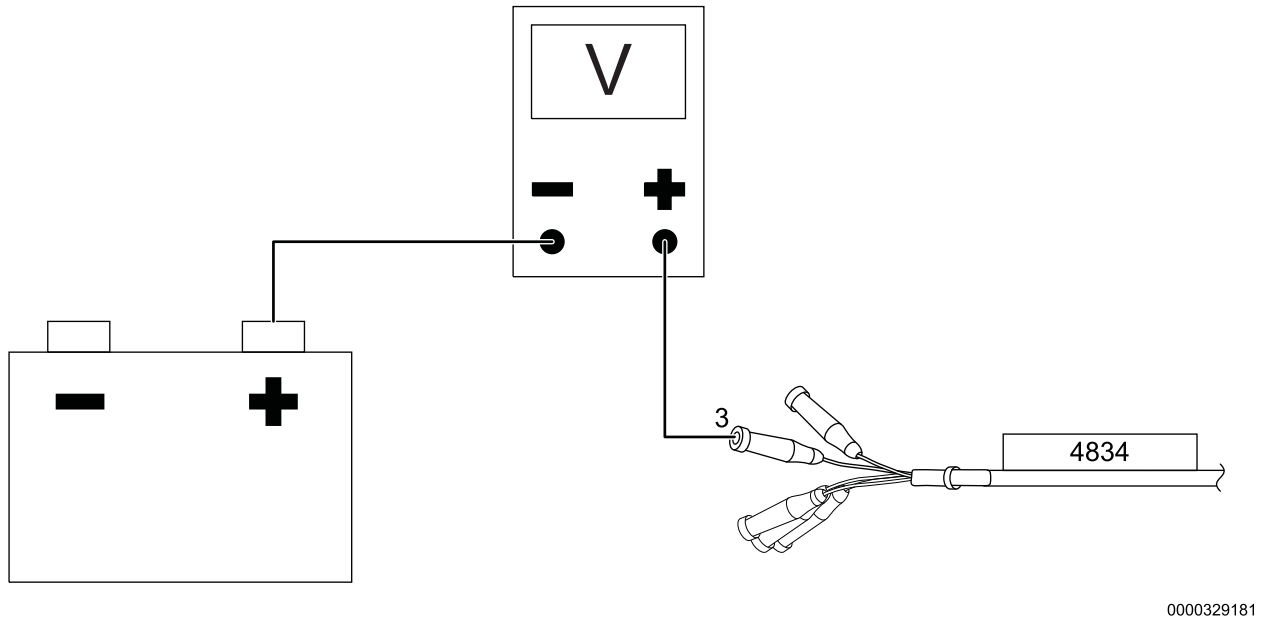


Figure 254 Test 1 Exhaust Back Pressure Valve (EBPV) connector Circuit Voltage Check

Test 1 Setup
A. Key OFF. B. Disconnect Exhaust Back Pressure Valve (EBPV) connector. C. Connect Breakout Harness ZTSE4834 to vehicle harness and leave EBPV connector disconnected. D. Key ON.

Test 1	Specification
Using DMM measure voltage between Breakout Harness ZTSE4834 pin-3 and PWR.	B+ ± 0.5 volts
Decision	
Is voltage B+ ± 0.5 volts?	Yes: Go to Test 2.
	No: Repair Open between EBPV pin-3 and ACT GND. After repairs are complete, retest for SPN 5543 FMI 5

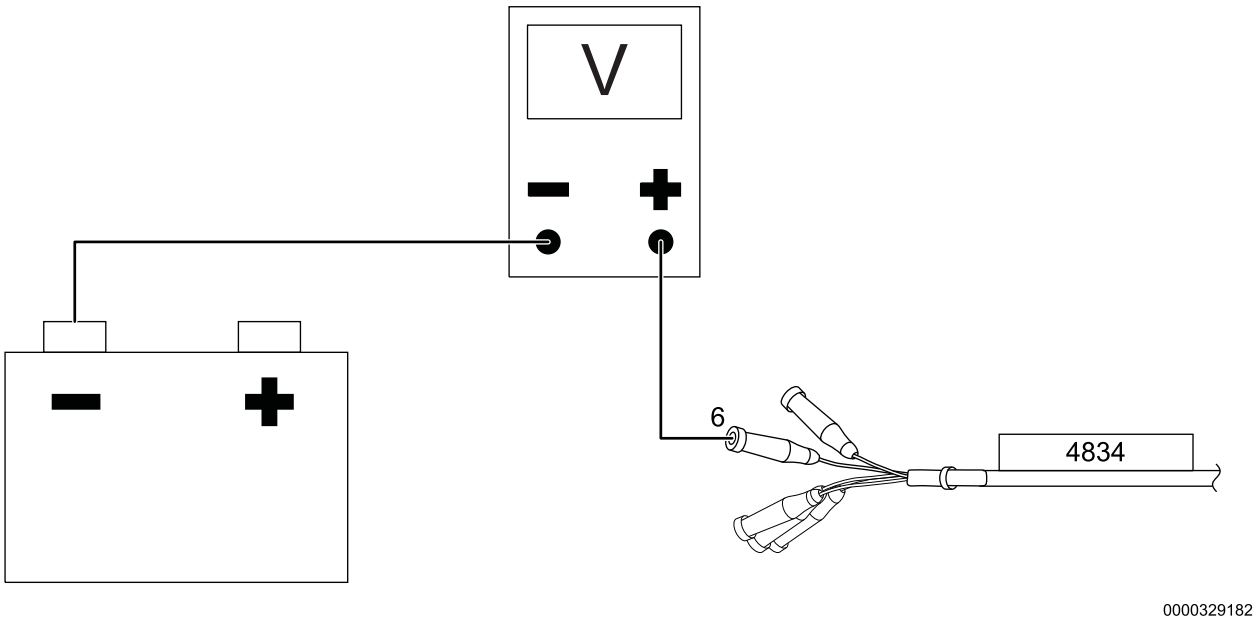


Figure 255 Test 2 Exhaust Back Pressure Valve (EBPV) connector Circuit Voltage Check

Test 2 Setup
A. Key OFF. B. Disconnect Exhaust Back Pressure Valve (EBPV) connector. C. Connect Breakout Harness ZTSE4834 to vehicle harness and leave EBPV connector disconnected. D. Key ON.

Test 2	Specification
Using DMM measure voltage between Breakout Harness ZTSE4834 pin-6 and known good GND.	2.5 ± 0.5 volts
Decision	
Is voltage 2.5 ± 0.5 volts?	Yes: Replace EBPV assembly. After repairs are complete, retest for SPN 5543 FMI 5.
	No: Repair Open between EBPV pin-6 and Engine Control Module (ECM) pin E-56. After repairs are complete, retest for SPN 5543 FMI 5.

End Diagnostic Steps
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 5543 FMI 5 fault code diagnostics.

ECB Valve (Engine Compression Brake)

SPN	FMI	Condition
4287	0	ECBP above desired level
4287	1	ECBP below desired level
4287	3	ECBP signal Out of Range HIGH
4287	4	ECBP signal Out of Range LOW

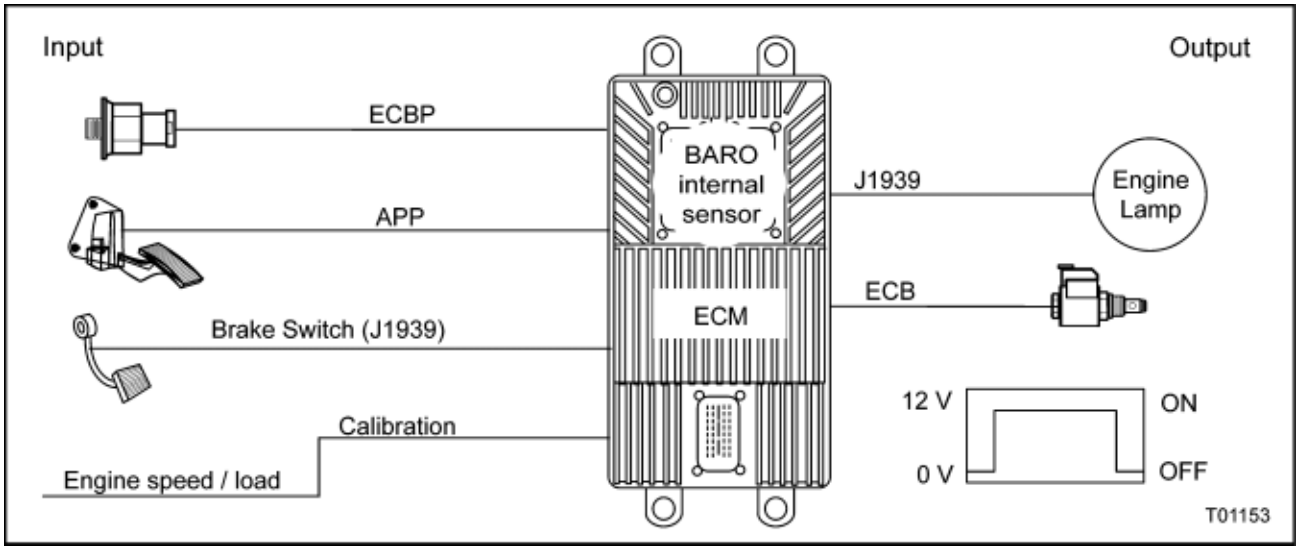


Figure 256 Function diagram for the ECB

The function diagram for the ECB includes the following:

- Engine Control Module (ECM)
  with Barometric Absolute Pressure (BARO) Internal Sensor
- Engine Compression Brake Pressure (ECBP) Sensor
- Accelerator Position (APP) Sensor
- Brake Switch
- Engine Compression Brake (ECB) Valve
- Engine Lamp

Function

The ECB valve works in conjunction with the ICP system to keep the exhaust valves partially open during engine braking.

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.

Valve Location

The ECB valve is installed in the center of the high-pressure oil rail.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- 00-00956-08 – 180-pin Breakout Box (page 1222)
- Breakout Harness 4952 (ECB) (page 1237)
- 500 Ohm Resistor Harness (page 1229)
- 3036 – 36-pin ECM Cables (page 1220)
- International® Electronic Engine Terminal Test Kit (page 1227)

ECB Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
4287	0	ECBP above desired level	• Biased ECBP sensor of circuit • ECB valve open when brake is commanded off
4287	1	ECBP below desired level	• Biased LOW ECBP sensor • ECBP sensor or ECB valve circuit fault • Failed ECB valve
4287	3	ECBP signal Out of Range HIGH	• ECBP circuit OPEN or short to PWR • Failed ECBP sensor
4287	4	ECBP signal Out of Range LOW	• ECBP circuit OPEN or short to PWR • Failed ECBP sensor

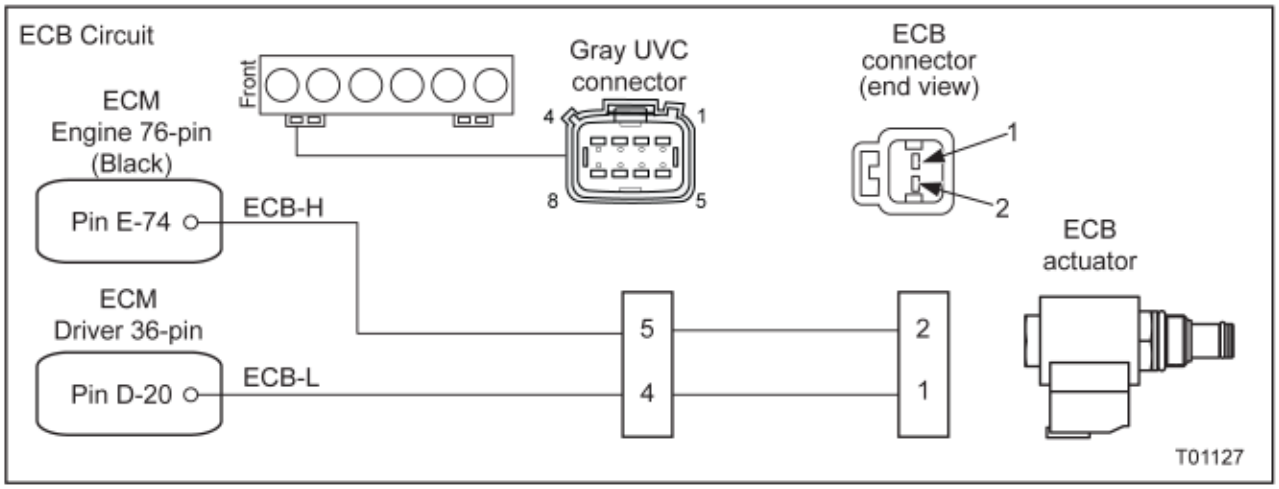


Figure 257 ECB circuit diagram

Connector Voltage Check

Connect Breakout Harness 4952 to engine harness. Leave valve cover disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment: < Less than, > Greater than
4 to GND	0 V	If > 0.25 volts, check ECB-L circuit for short to PWR.
5 to GND	3.5 ± 1 V	If < 2.5 volts, check ECB-H circuit for OPEN or short to GND.
5 to GND	3.5 ± 1 V	If > 4.5 volts, check ECB-H circuit for short to PWR.

Connector Resistance Checks to GND

Turn ignition switch to OFF. Connect Breakout Harness 4952 to engine harness. Leave valve cover disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
4 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit.
5 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Actuator Resistance Check

Turn ignition switch to OFF. Connect Breakout Harness 4952 to valve cover connector. Leave disconnected from engine harness. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
4 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
5 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
4 to 5	10 ± 2 Ω	If out of specification, check UVC harness for OPEN circuits or shorts to GND. If UVC circuits are acceptable, replace the ECB.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-pin Breakout Box and Breakout Harness 4952. Leave ECM and Gray UVC connector disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
4 to D-20	< 5 Ω	If > 5 Ω, check for OPEN circuit.
5 to E-74	< 5 Ω	If > 5 Ω, check for OPEN circuit.

ECB Circuit Operation

The ECB consists of a solenoid / valve assembly and is installed in the high-pressure rail between the ICP oil gallery and the brake oil gallery.

The ECB valve is supplied with ground at Pin 1, through Pin 4 of gray UVC connector, from ECM Pin D-20. The ECM controls the engine brake by supplying 12 volts at sensor connector Pin 2, through Pin 5 of gray UVC connector, from ECM Pin E-74.

When the engine brake is activated, the ECM provides power to activate the ECB and allows oil from the injector oil gallery to flow into the brake oil gallery. High-pressure oil activates the brake actuator pistons to open the exhaust valves.

The ECM deactivates the engine brake by shutting off power to the ECB. Residual brake gallery pressure initially bleeds from the actuator bore. When brake gallery pressure reaches 1000 psi (6.9 MPa), the brake pressure relief valve opens and oil drains back to the sump.

Fault Detection / Management

When the engine is running, the ECM compares engine brake control pressure to injection control pressure and ECBP desired. When the brake is activated, brake control pressure equals injection control pressure.

If the brake control pressure does not match injection control pressure, the ECM disables the engine brake, a code is set, and the engine lamp is illuminated.

When the engine brake is not active and the ECM detects an undesired value, the ECM will set a code and the engine lamp will be illuminated.

The Output Circuit Check (OCC) can detect open or shorted circuits to the ECB during KOEO Standard Test.

A bias ECBP sensor can also cause a fault. The brake shutoff valve and the ECBP sensor circuit should both be diagnosed.

ECBP Sensor (Engine Compression Brake Pressure)

SPN	FMI	Condition
4287	0	ECBP above desired level(page 561)
4287	1	ECBP below desired level (page 563)
4287	3	ECBP signal Out of Range HIGH
4287	4	ECBP signal Out of Range LOW (page 564)

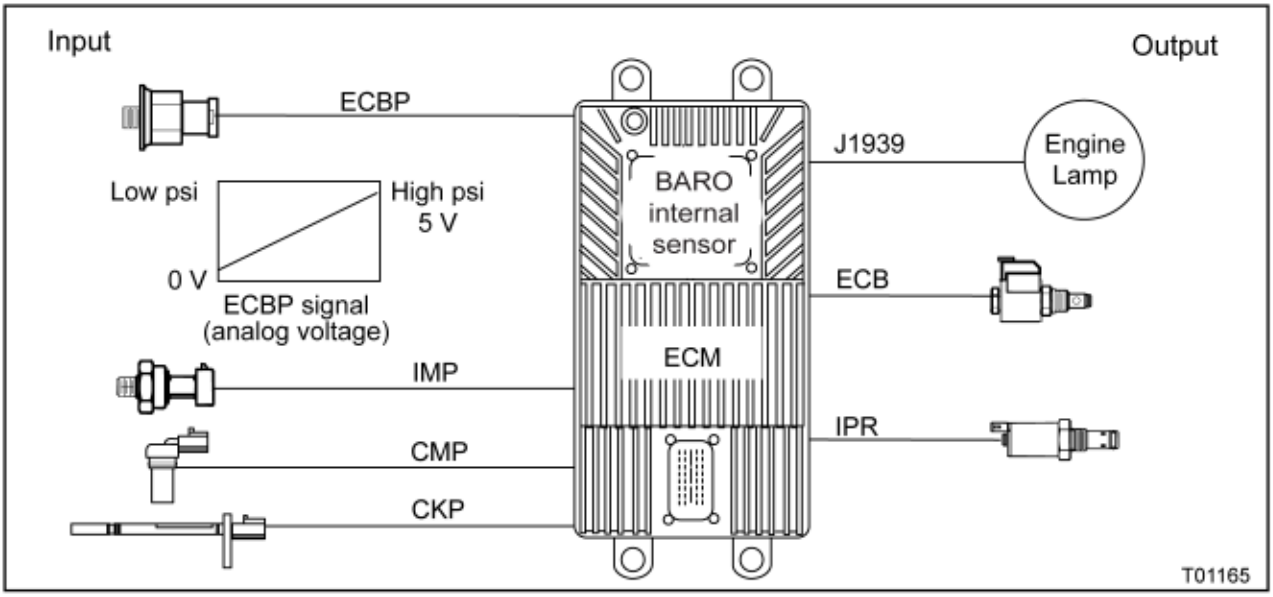


Figure 258 Function diagram for the ECBP sensor

The function diagram for the ECBP sensor includes the following:

- Engine Control Module (ECM)
  with Barometric Absolute Pressure (BARO) Internal Sensor
- Engine Compression Brake Pressure (ECBP) Sensor
- Intake Manifold Pressure (IMP) Sensor
- Camshaft Position (CMP) Sensor
- Crankshaft Position (CKP) Sensor
- Injection Pressure Regulator (IPR)
- Engine Compression Brake (ECB)
- Engine Lamp

Function

The ECB is a compression release brake that works in conjunction with the ICP system to keep the exhaust valves partially open during engine braking.

The ECBP sensor provides a feedback signal to the ECM indicating brake control pressure. The ECM monitors the ECBP signal during engine normal and braking operation to determine if the compression release brake system is working without fault.

Sensor Location

The ECBP sensor is installed in the high-pressure oil rail, under the valve cover.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- 3-Banana Plug Harness (page 1228)
- 00-00956-08 – 180-pin Breakout Box (page 1222)
- Breakout Harness 4952 (ECBP) (page 1237)
- International® Electronic Engine Terminal Test Kit (page 1227)

ECBP Sensor End Diagnostics

SPN	FMI	Condition	Possible Causes
4287	0	ECBP above desired level	• Biased ECBP sensor of circuit • ECB valve open when brake is commanded off
4287	1	ECBP below desired level	• ECBP signal circuit is short to GND • Failed ECBP sensor
4287	3	ECBP signal Out of Range HIGH	• ECBP circuit OPEN or short to PWR • Failed ECBP sensor
4287	4	ECBP signal Out of Range LOW	• ECBP signal circuit is short to GND • Failed ECBP sensor

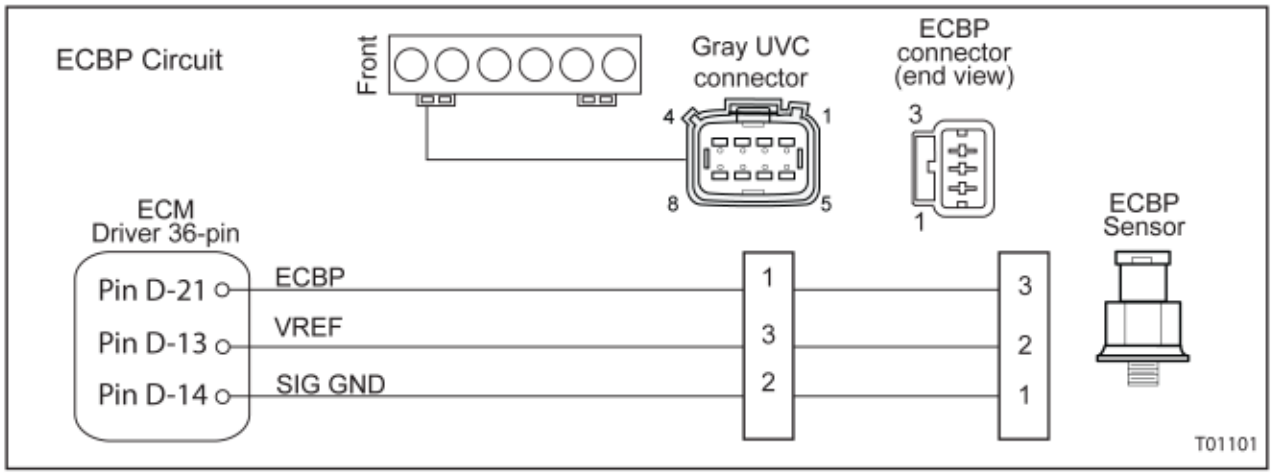


Figure 259 ECBP circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using the EST with ServiceMaxx™ software, open the Continuous Monitor session.
2. Verify sensor voltage is within KOEO specification. See APPENDIX A (page 1291).
3. Monitor sensor voltage. Verify an active codes for the sensor.
   - If code 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 codes will go active.
   - If code is active, proceed to the next step.
4. Disconnect engine harness from valve cover connector.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

5. Connect Breakout Harness 4952 to engine harness. Leave valve cover connector disconnected.

Sensor Circuit Check

Connect Breakout Harness 4952 to engine harness. Leave valve cover connector disconnected. Turn ignition switch to ON. Use EST to verify correct code goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Specification	Comment: < Less than, > Greater than
EST – Check codes	SPN 4287 FMI 3	If SPN 4287 FMI 4 is active, check ECBP signal for short to GND.
DMM – Measure resistance 2 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Go to Harness Resistance Check.
EST – Check codes Short breakout harness across 1 and 2	SPN 4287 FMI 4	If SPN 4287 FMI 3 is active, check ECBP signal for OPEN. Go to Harness Resistance Check.
DMM – Measure volts 3 to GND	5 ± 0.5 V	If > 5.5 volts, check VREF for short to PWR. If < 4.5 volts, check VREF for OPEN or short to GND. Go to Harness Resistance Check.
If checks are within specification, connect sensor and clear codes. If active code remains, check under valve cover harness for OPEN or shorts. If within specifications, replace sensor.		

ECBP Pin-point Diagnostics

Connector Voltage Check

Connect Breakout Harness 4952 to engine harness. Leave valve cover connector disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment: < Less than, > Greater than
1 to GND	5 V	If < 5 volts, check for short to GND.
2 to GND	0 to 0.25 V	If > 0.25 volts, check for short to PWR.
3 to GND	5 ± 0.5 V	If > 5.5 volts, check VREF for short to PWR. If < 4.5 volts, check VREF for OPEN or short to GND. Go to Harness Resistance Check.

Under Valve Cover (UVC) Resistance Check

Disconnect engine harness. Connect Breakout Harness 4952 to gray UVC connector. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
1 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
2 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
3 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Harness Resistance Check

Turn ignition switch to OFF. Disconnect gray UVC connector and the ECM 36-pin driver connector. Connect 180-pin Breakout Box. Leave ECM and valve cover connector disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
1 to D-21	< 5 Ω	If > 5 Ω, check ECBP signal circuit for OPEN.
2 to D-14	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
3 to D-13	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN.

ECBP Circuit Operation

The ECBP sensor is a micro-strain gauge sensor that is supplied with a 5-volt VREF at sensor connector Pin 2, through Pin 3 of gray UVC connector, from ECM Pin D-13. The sensor is grounded at sensor connector Pin 1, through Pin 2 of the gray UVC connector, from ECM Pin D-14. The sensor returns a variable voltage signal from sensor connector Pin 3, through Pin 1 of gray UVC connector, to ECM Pin D-21.

Fault Detection / Management

The ECM continuously monitors the ECBP sensor signal to determine if the signal is within an expected range.

When the engine is running, the ECM compares ECB pressure to injection control pressure and ECB pressure desired. When the brake is activated, ECB pressure equals injection control pressure.

If the ECB pressure does not match injection control pressure, the ECM disables the ECB. A code is set, and the engine lamp is illuminated.

When the ECB is not active and the ECM detects an undesired value, the ECM sets a code and the engine lamp is illuminated.

An ECB valve that is stuck open or closed can also cause a fault. The brake shut-off valve and the ECBP sensor circuit should both be diagnosed.

SPN 4287 FMI 0 - ECBP above desired level

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Exhaust valve actuation system oil pressure not plausible (pressure higher than expected).	[{Measured retarder pressure MINUS retarder pressure set point > 4.501 MPa OR measured retarder pressure when commanded OFF} > 1.041 MPa for time] > 20 seconds	Key ON [Engine Brake Latched feature selected OR Engine Brake Coast feature selected OR Engine Brake with Cruise Control feature selected]

Fault Overview

Fault code sets when Engine Control Module (ECM) detects that Brake Control Pressure (BCP) signal is greater than expected.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

SPN 164 FMI 0, 1, 3, 4, 15, 16, 17, 18 (ICP); SPN 679 FMI 3, 4 (IPR); SPN 4287 FMI 3, 4 (ECBP); and SPN 5543 FMI 3, 4, 5 (EBPV)

Fault Facts

None

Drive Cycle to Determine Fault Status

TBD

Possible Causes

- Biased Brake Control Pressure (BCP) sensor
- Failed Engine Compression Brake 1 (ECB1) valve
- Failed Relief valve
- Failed Injection Pressure Regulator (IPR) valve

Step 1	Check for associated fault codes.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 164 FMI 0, 1, 3, 4, 15, 16, 17, 18 (ICP); SPN 679 FMI 3, 4 (IPR); SPN 4287 FMI 3, 4 (ECBP); and SPN 5543 FMI 3, 4, 5 (EBPV). Is EST DTC list free of SPN 164 FMI 0, 1, 3, 4, 15, 16, 17, 18; SPN 679 FMI 3, 4; SPN 4287 FMI 3, 4; and SPN 5543 FMI 3, 4, 5?	Yes: Repair SPN 164 FMI 0, 1, 3, 4, 15, 16, 17, 18; SPN 679 FMI 3, 4; SPN 4287 FMI 3, 4; and SPN 5543 FMI 3, 4, 5. After repairs are complete, retest for SPN 4287 FMI 0.
		No: Go to Step 2.

Step 2	Check Brake Control Pressure (BCP) offset.	Decision
	With Key-On Engine-Off (KOEO), check BCP offset. Is BCP > 145 psi (1.0 MPa)?	Yes: Replace BCP sensor. After repairs are complete, retest for SPN 4287 FMI 0.
		No: Go to Step 3.

Step 3	Check for leaking Engine Compression Brake (ECB1) valve assembly	Decision
	A. Start Engine. B. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector. (page 81) C. Using EST with ServiceMaxx™ software, monitor Brake Control Pressure (BCP). Is BCP > 145 psi (1.0 MPa) with engine running (engine compression brake never commanded on)?	Yes: Replace ECB1 valve assembly. After repairs are complete, retest for SPN 4287 FMI 0.
		No: Go to Step 4.

Step 4	Operate engine and test engine brake.	Decision
	A. Activate engine brake. B. Using Electronic Service Tool (EST) with ServiceMaxx™ software, record a snapshot recording of engine brake operation (brake commanded ON and brake commanded OFF). Is Brake Control Pressure (BCP) > 145 psi (1.0 MPa) AFTER the brake has been commanded off?	Yes: Replace relief valve. After repairs are complete, retest for SPN 4287 FMI 0.
		No: Go to Step 5.

Step 5	Operate engine and test engine brake.	Decision
	A. Activate engine brake. B. Record a snapshot recording of engine brake operation (brake commanded ON and brake commanded OFF). Is Brake Control Pressure (BCP) error < 653 psi (-4.5 MPa)?	Yes: Replace Injection Pressure Regulator (IPR) valve. After repairs are complete, retest for SPN 4287 FMI 0.
		No: System OK.

End Diagnostic Steps
After performing all diagnostic steps, if SPN 4287 FMI 0 remains, verify if each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 4287 FMI 1 - ECPB below desired level

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Engine Exhaust Valve Actuation System Oil Pressure NOT plausible (Pressure lower than expected)	[Engine Injection Control pressure MINUS Measured Retarder pressure AND > 580.3 psi (4.001 MPa) for time] > 20 seconds	Key ON [Engine Brake Latched feature selected OR Engine Brake Coast feature selected OR Engine Brake with Cruise Control feature selected]

Fault Overview

Fault sets when engine Exhaust Valve Actuation System Oil Pressure is lower than expected. Injection control pressure minus measured retarder pressure is greater than 580.3 psi (4.001 MPa) for greater than 20 seconds.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

SPN 4287 FMI 3 and 4

Fault Facts

None

Drive Cycle to Determine Fault Status

Continuous

Possible Causes

- Failed ECBP

Step 1	Check for active or pending fault codes.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software. A. Key ON, clear codes. B. Key OFF, wait for EST screens to clear. C. Key ON, check Diagnostic Trouble Code (DTC) list for SPN 4287 FMI 1. Is EST DTC list SPN 4287 FMI 1 active or pending?	Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Check for associated fault codes.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 4287 FMI 3 and 4 (ECPB). Is EST DTC list free of SPN 4287 FMI 3 and 4?	Yes: Replace ECBP sensor. After repairs are complete, retest for SPN 4287 FMI 1. No: Repair SPN 4287 FMI 3 and 4. After repairs are complete, retest for SPN 4287 FMI 1.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 4287 FMI 1 fault code diagnostics.

SPN 4287 FMI 4 - ECBP signal Out of Range LOW

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Exhaust valve actuation system oil pressure sensor signal Out of Range Low.	Exhaust valve actuation system oil pressure sensor signal voltage < 0.103 Volts (< -1.106 MPa)	Key ON [Engine Brake Latched feature selected OR Engine Brake Coast feature selected OR Engine Brake with Cruise Control feature selected]

Fault Overview

None

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive trips.

Associated Faults

SPN 3509 FMI 3 and 4

Fault Facts

None

Drive Cycle to Determine Fault Status

TBD

Possible Causes

- Brake Control Pressure (BCP) circuit short to ground
- Flying short on BCP circuit
- Failed BCP Sensor

Step 1	Check for active or pending fault code.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 4287 FMI 4. Is EST DTC list SPN 4287 FMI 4 active or pending?	Yes: Go to Step 2.
		No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Check for associated fault codes.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 3509 FMI 3 and 4. Is EST DTC list free of SPN 3509 FMI 3 and 4?	Yes: Go to Step 3.
		No: Repair SPN 3509 FMI 3 and 4. After repairs are complete, retest for SPN 4287 FMI 4.

Step 3	Inspect Under Valve Cover (UVC) connector.	Decision
	A. Key OFF. B. Disconnect UVC connector. C. Check UVC connector terminals for damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are UVC connector, harness, and terminals clean and undamaged?	Yes: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4287 FMI 4. No: Go to Step 4.

Step 4	Isolate fault to engine harness or Under Valve Cover (UVC) harness.	Decision
	A. Key OFF. B. Disconnect UVC harness for Brake Control Pressure (BCP) sensor. Is SPN 4287 FMI 4 still active?	Yes: Correct short circuit to ground between UVC connector pin-1 and Engine Control Module (ECM) pin D-21. After repairs are complete, retest for SPN 4287 FMI 4. No: Perform Pin-Point Test (SPN 4287 FMI 4) (page 566).

End Diagnostic Steps
After performing all diagnostic steps, if SPN 4287 FMI 4 remains, verify if each step was completed correctly and the proper decision was made. Notify supervisor for further action.

GRAPHIC
PLACE
HOLDER

0000300422

Figure 260 Test 1 BCP Sensor Circuit Resistance Check

See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Digital Multimeter (DMM)
- Breakout Harness ZTSE4793

GRAPHIC
PLACE
HOLDER

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Figure 261 Test 1 BCP Sensor Circuit Resistance Check

Test 1 Setup
A. Key OFF. B. Connect Breakout harness ZTSE4793 between engine side and vehicle side of Under Valve Cover (UVC) harness connector.

Test 1	Specification
Use Digital Multimeter (DMM) to measure resistance between Breakout Harness ZTSE4602 pin-1 and known good ground.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Replace Brake Control Pressure (BCP) sensor. After repairs are complete, retest for SPN 4287 FMI 4.
	No: Repair short to short to ground between UVC pin-1 and BCP pin-3. After repairs are complete, retest for SPN 4287 FMI 4.

End Pin-Point Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 4287 FMI 4 fault code diagnostics.

ECI Circuit (Engine Crank Inhibit)

SPN	FMI	Condition
None		Engine starter motor will not engage

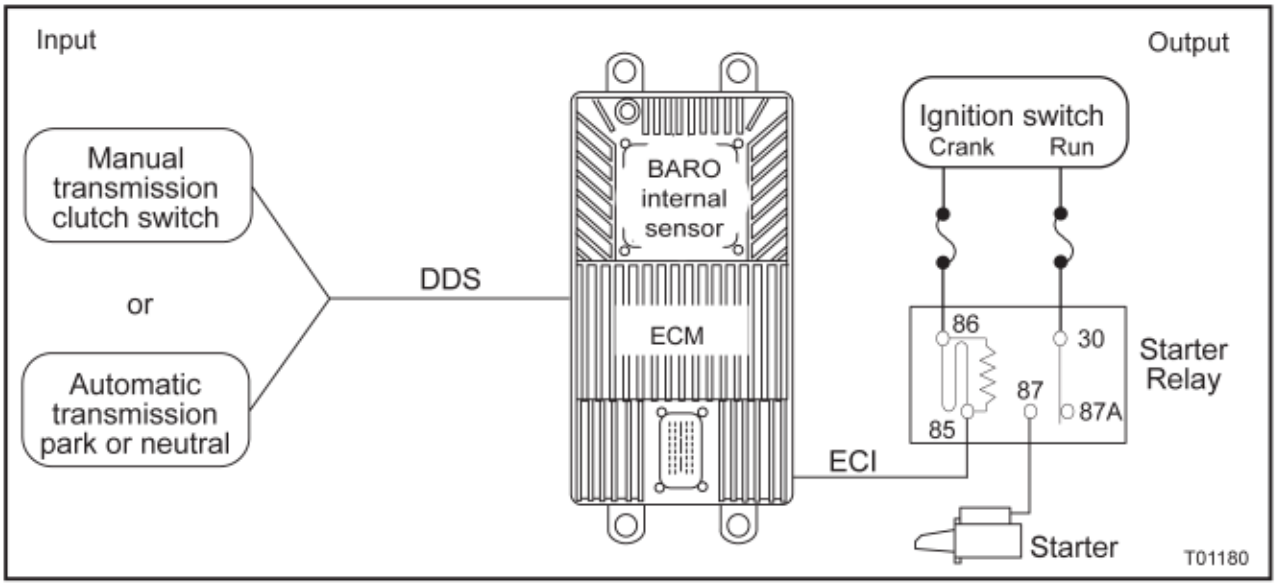


Figure 262 ECI function diagram

The function diagram for the ECI circuit consists of the following:

- Engine Control Module (ECM)
  with Barometric Absolute Pressure (BARO) Internal Sensor
- Starter
- Starter Relay
- Engine Crank Inhibit (ECI) Circuit
- Drive line Disengagement Switch (DDS)

Function

The ECI circuit is controlled by the ECM. It prevents starter engagement while the engine is running (above a set calibrated rpm). Starter engagement is also prevented when the automatic transmission is in gear or the manual transmission clutch pedal is not depressed. The starter relay can also be disabled by an optional over crank thermocouple.

Location

The relay and switches are vehicle-mounted parts. For additional supporting information, see truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide*.

Tools

- Digital Multimeter (DMM) (page 1224)

- 00-00956-08 – 180-pin Breakout Box (page 1222)
- Breakout Harness 4674 (ECM) (page 1231)

ECI Circuit Diagnostics

SPN	FMI	Condition	Possible Causes
None		Engine starter motor will not engage	• Transmission in gear • Clutch pedal not depressed • No PWR to automatic transmission module • No PWR to ECM • Blown fuse • Failed starter relay • OPEN DDS circuit • OPEN ECI circuit • Failed Ignition Switch (VIGN) • Failed starter motor

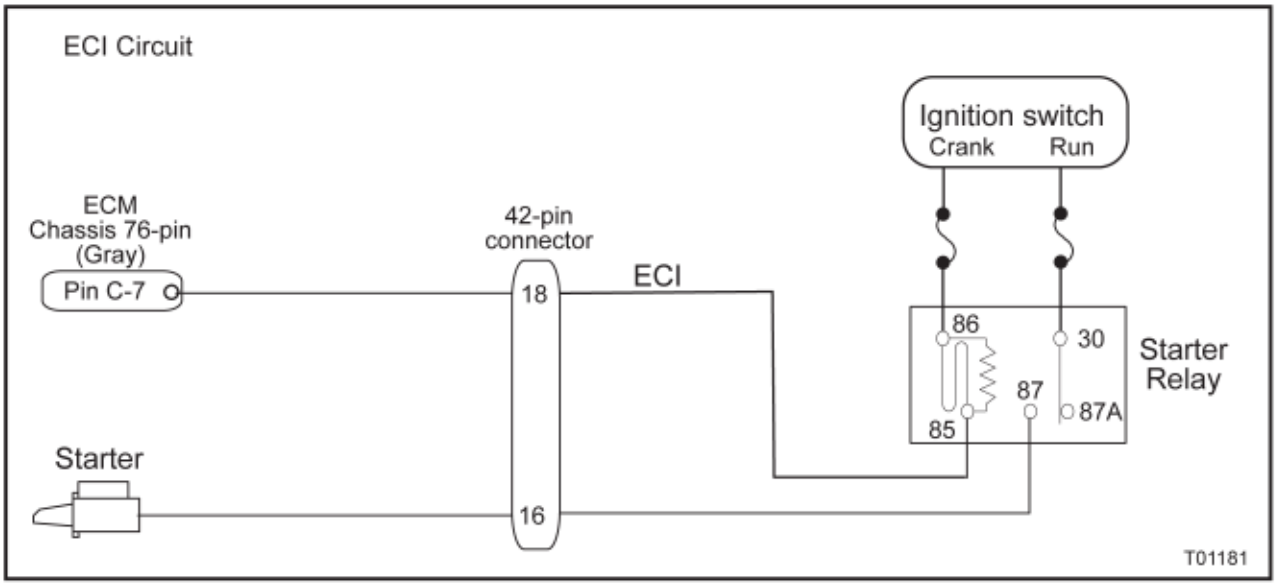


Figure 263 ECI circuit diagram

For additional circuit information see truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide*.

Voltage Check at Relay

Connect Breakout Harness 4674 between relay and relay socket. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment: < Less than, > Greater than
30 to GND	B+	If < B+, check power circuit to relay switch for OPEN or short to GND, or blown fuse.
Use DMM to measure voltage while cranking engine.		
86 to GND	B+	If < B+, check PWR circuit to relay coil for OPEN or short to GND, blown fuse, or possible failed ignition switch. For additional circuit information, see truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide*.
85 to GND	< 2 V	If B+, check ECI control circuit for OPEN or failed thermal over-crank protection switch. If 4 to 5 volts, check DDS circuit to ECM, and go to Voltage Check at ECM (page 573).
87 to GND	B+	If < B+, replace relay. If B+, check voltage at starter.

Voltage Check at ECM

Connect 180-pin Breakout Box between ECM and chassis harness. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment: < Less than, > Greater than
C-31 to GND	B+	If < B+, check VIGN circuit for OPEN or short to GND, blown fuse, or possible failed ignition switch.
C-2 to GND C-4 to GND C-6 to GND	0 V	If voltage is present, check for OPEN ECM GND circuit. Go to ECM PWR in this section of manual.
C-1 to GND C-3 to GND C-5 to GND	B+	If < B+, check for OPEN ECM PWR circuit. Go to ECM PWR in this section of manual.
Place automatic transmission in park or neutral (manual transmission, depress clutch). Use DMM to measure voltage.		
C-65 to GND	B+	If < B+, check DDS for OPEN circuit. • For automatic transmission, see transmission diagnostics. • For manual transmission, check PWR circuit to clutch pedal or blown fuse. A failed clutch pedal switch is possible.
C-7 to GND	< 2 V	If > 2 volts, check ECM programming.

Harness Resistance Check – ECM to Relay

Turn ignition switch to OFF. Disconnect ECM. Leave relay disconnected. Connect 180-pin Breakout Box and relay harness. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
85 to C-7	< 5 Ω	If > 5 Ω, check ECI control circuit for OPEN or possible failed thermal over-crank protection switch.
85 to GND	> 1 kΩ	If < 1 kΩ, check ECI control for short to GND.
87 to starter	< 5 Ω	If > 5 Ω, check ECI control for OPEN or possible failed thermal over-crank protection switch.
87 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND.

Operational Voltage Check

Connect 180-pin Breakout Box between ECM and chassis harness. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Condition
DDS C-65 to GND	B+	ECM Input – Clutch pedal not depressed or automatic transmission in gear. Cranking is disabled.
	0 V	ECM Input – Clutch pedal to the floor or automatic transmission in park or neutral. Cranking is enabled.
Use DMM to measure voltage while cranking engine.		
ECI C-7 to PWR	0 V	ECM Control – Engine Crank Inhibit enabled.
	B+	ECM Control – Engine Crank Inhibit disabled.

Harness Resistance Check – Relay to Battery

WARNING: To prevent personal injury or death, always disconnect main negative battery cable first. Always connect the main negative battery cable last.

Disconnect both battery GND cables. Disconnect ECI relay and VIGN. Use DMM to measure resistance.

86 to VIGN	< 5 Ω	If > 5 Ω, check circuit for OPEN.
86 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
30 to B+ battery post	< 5 Ω	If > 5 Ω, check circuit for OPEN or blown fuse.
30 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
C-65 DDS circuit	See vehicle electrical diagrams. Check for OPEN or short to GND. Possible failed clutch switch or automatic transmission module circuit faults.	

ECI Circuit Operation

The ECM controls the starting system. The clutch switch or transmission neutral switch provides input to the ECM. Both switches prevent the starter from being engaged unless the automatic transmission is in park or neutral, or the manual transmission clutch is depressed.

DDS Circuit

The ECM monitors the DDS on Pin C-65. B+ indicates the drivetrain is disengaged and the engine is ready to start. Zero volts indicates the drivetrain is engaged and the engine is not ready to start. The source of this signal depends on the vehicle's hardware configuration. See appropriate electrical diagrams when diagnosing this circuit.

Ignition Switch

VIGN is supplied to the starter relay coil (Pin 86) when engine is cranked.

ECI Circuit

The ECM controls starter disable with the ECI circuit, pin C-7 to starter relay coil Pin 85. Open or B+ will disable the relay. A 0-volt (GND) will enable the relay.

Engine Control Module (ECM)

When the ECM recognizes that the engine is not running and the drive line is not engaged, the ECM will ground Pin C-7. This provides a current path for the ECI relay to close when the Start switch is engaged or the starter button is depressed.

When the ECM recognizes that the engine is running or the drive line is engaged, the ECM will open Pin C-7. This prevents the ECI relay from closing and the starter motor from engaging.

Starter Relay

The engine starter relay controls voltage to the starter motor. Turning the ignition switch to the start position supplies current to energize the starter relay at Pin 86. If the engine is not running and the drive line is not engaged, ECM Pin C-7 will enable the relay by supplying a ground to Pin 85 of the relay. When the relay is closed, current passes through the relay to the starter solenoid.

Clutch Switch

Manual transmissions use the clutch switch to supply a signal to the ECM indicating the drive line is disengaged. A 12-volt signal on the DDS circuit indicates the clutch is disengaged. A 0-volt signal indicates the clutch is engaged.

Neutral Switch

Allison LCT transmissions use the neutral position switch to supply power to the starter relay and a signal to the ECM that the drive line is disengaged. Vehicles programmed for Allison AT / MT transmissions receive a 12-volt signal on the DDS circuit indicating the transmission is out of gear. A 0-volt signal indicates the transmission is in gear. When the transmission is in gear, no power is available to the starter relay.

WTEC MD with Auto Neutral

Allison MD World Transmission Electronically Controlled (WTEC) transmissions (with optional Auto Neutral) have a crank inhibit system with an additional relay. The relay inhibits cranking when the transmission is in auto

neutral. Pin 6 of the transmission module controls 12-volt to Pin 86 of the starter relay. Pin C-65 of the ECM receives 12-volt from the WTEC auto neutral relay when the transmission is shifted to neutral or auto neutral.

Fault Detection / Management

There are no codes associated with the ECI system.

ECL Switch (Engine Coolant Level)

SPN	FMI	Condition
111	2	ECL signal erratic, intermittent, or incorrect

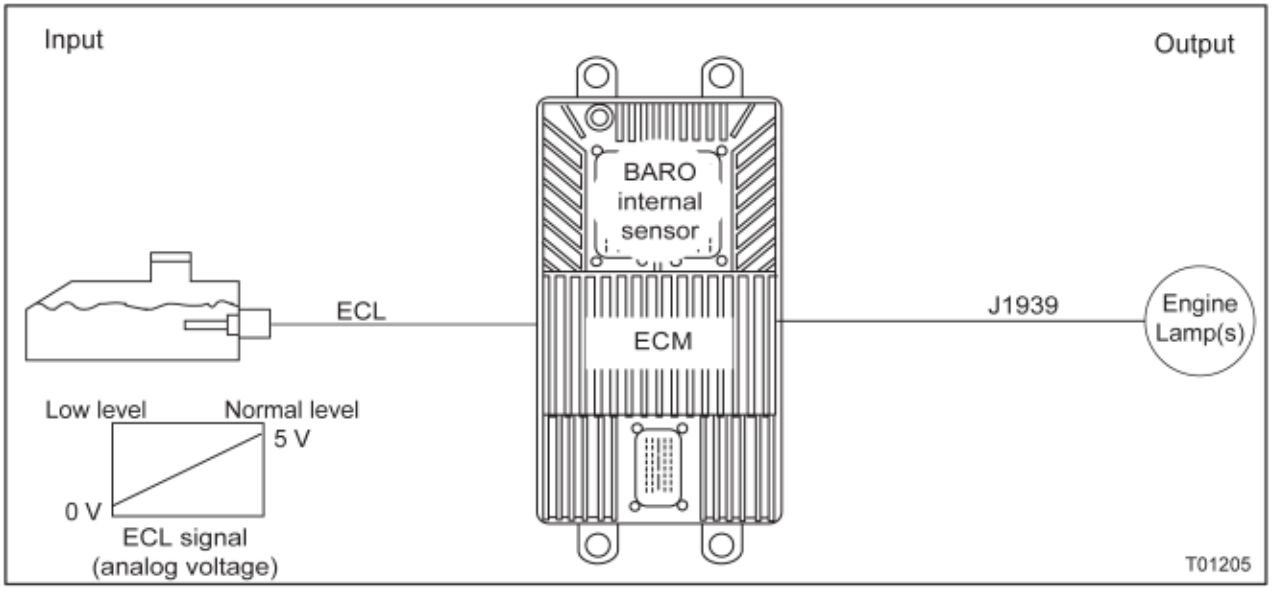


Figure 264 Functional diagram for the ECL switch

The functional diagram for the ECL switch includes the following:

- Engine Control Module (ECM)
  with Barometric Absolute Pressure (BARO) Internal Sensor
- Engine Coolant Level (ECL) Switch
- J1939 Datalink
- Engine Lamp(s)

Function

The ECM monitors engine coolant level and alerts the operator when coolant is low. The ECM can be programmed to shut the engine off when coolant is low.

Coolant level monitoring is a customer programmable feature that can be programmed by the EST. The coolant level feature is operational if programmed for 3-way warning or 3-way protection.

Location

The ECL switch is installed in the vehicle plastic deaeration tank.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)

- 96-pin Breakout Box – DLC II

ECL Switch Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
111	2	ECL signal erratic, intermittent, or incorrect	• ECL sensor or circuit fault

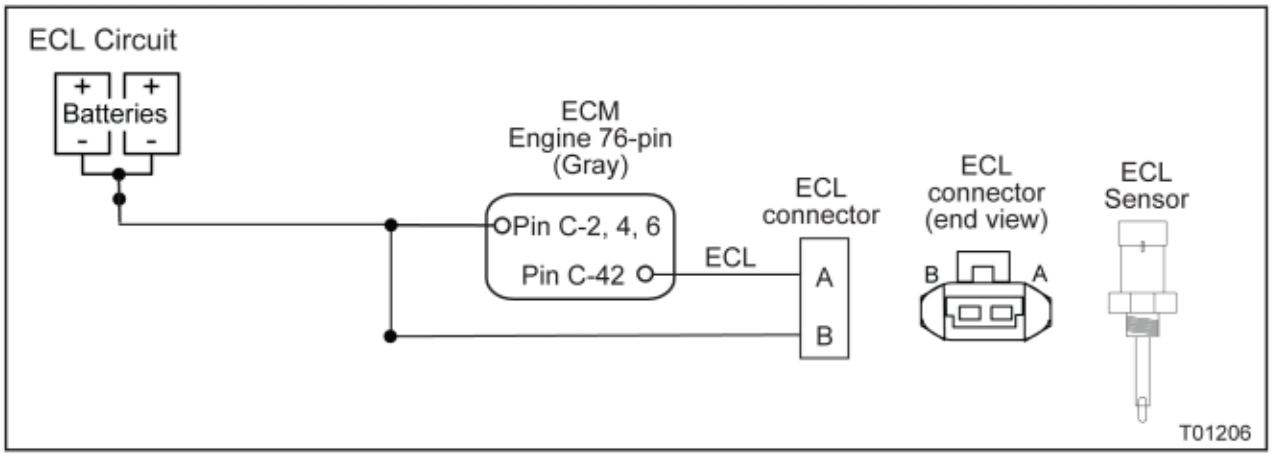


Figure 265 ECL switch circuit diagram

Connector Voltage Check

Test Point	Specification	Comment: < Less than, > Greater than
Disconnect ECL switch. Turn ignition switch to ON. Use DMM to measure voltage.		
A to GND	5 ± 0.5 V	If < B+, check for short to PWR.
B to B+	B+	If < B+, check for short to GND.

Connector Resistance Check to GND

Turn ignition switch to OFF. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
B to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
A to GND	> 5 Ω	If < 5 Ω, check for OPEN circuit. Do Harness Resistance Check.

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and sensor breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment
1 to C2-42	4.5 to 5 V	If < B+, check for short to GND.
2 to C1-42		If < B+, check for short to PWR.

ECL Circuit Operation

The ECL switch operates on a capacitance sensing principle. The probe of the ECL switch is installed in the plastic deaeration tank and it forms one plate of the capacitor, while the coolant forms the other plate. With the coolant present, the capacitance is greater than when the coolant is absent. This difference in capacitance is used by the electronic sensor to provide a solid-state ON-OFF signal at ECM Pin C-42.

Fault Detection / Management

The ECM continuously monitors the ECL circuit for in-range faults. The ECM does not detect open or short circuits in the ECL system. When the ECM detects an in-range fault, a code sets.

ECM PWR (Engine Control Module Power)

SPN	FMI	Condition
158	15	ECM Switched voltage too HIGH (page 585)
158	17	ECM Switched voltage too LOW

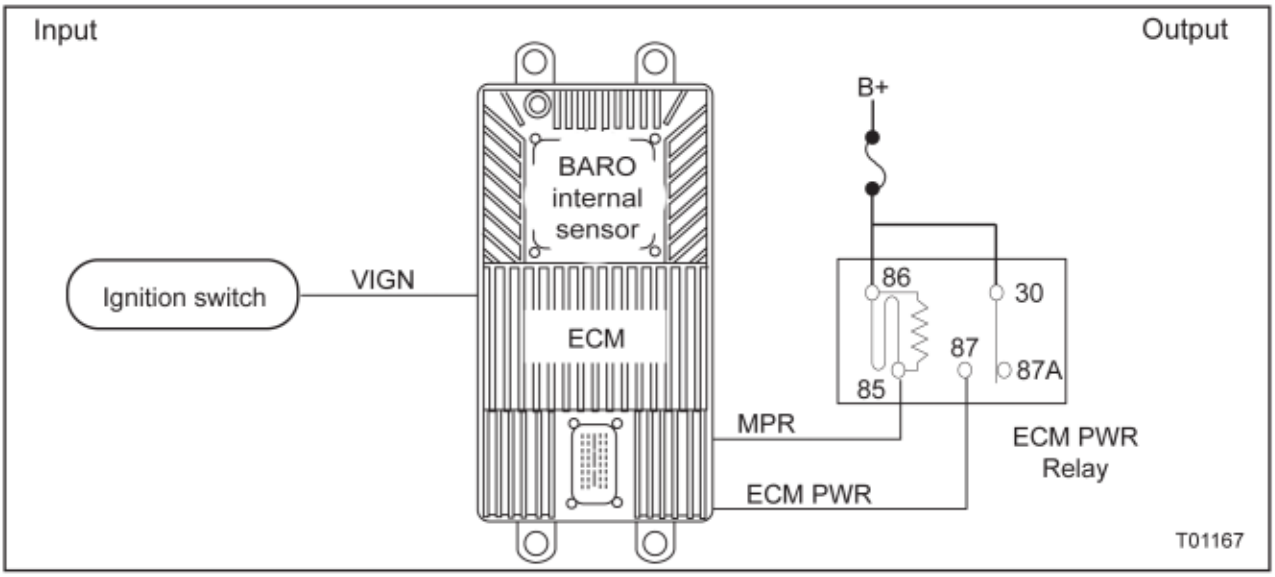


Figure 266 Function diagram for the ECM PWR

The function diagram for ECM PWR includes the following:

- Engine Control Module (ECM)
  with Barometric Absolute Pressure (BARO) Internal Sensor
- ECM PWR Relay
- Main Power Relay (MPR)
- Ignition Switch (VIGN) or Power Relay
- Battery (B+)
- Fuses

Function

The ECM requires battery power to operate the Body Controller (BC) and perform maintenance after the ignition switch is turned off. To do this, the ECM must control its own power supply. When the ECM receives the VIGN signal from the ignition switch, the ECM will enable the relay to power-up. When the ignition switch is turned off, the ECM performs internal maintenance, then disables the ECM relay.

ECM Location

The ECM is installed on the left side of the engine, just below the intake manifold.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- 00-00956-08 – 180-pin Breakout Box (page 1222)
- Breakout Harness 4674 (ECM) (page 1231)
- International® Electronic Engine Terminal Test Kit (page 1227)

ECM PWR Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
158	15	ECM Switched voltage too HIGH	• Battery voltage above 17.5 volts • Jump start using more than system voltage • Batteries wired incorrectly
158	17	ECM Switched voltage too LOW	• Battery voltage below 7 volts • Low discharged batteries • Charging system failure

- High resistance in ECM powering circuits

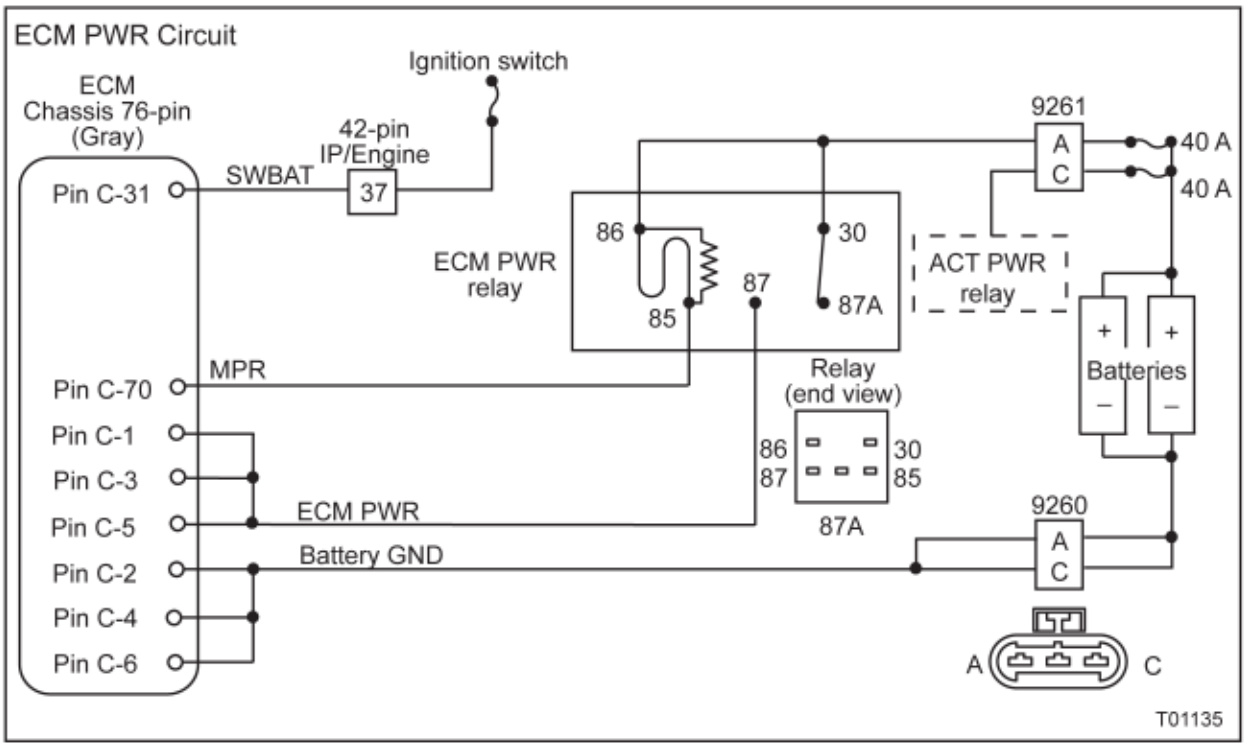


Figure 267 ECM PWR circuit diagram

NOTE: Reference the truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for vehicle side electrical system.

Voltage Checks at Relay

Connect Breakout Harness 4674 between relay and relay socket. Turn ignition switch to ON. Use DMM to measure voltage.

CAUTION: To prevent engine damage, turn the ignition switch OFF before removing ECM PWR relay or any ECM connector supplying power to the ECM. Failure to turn the ignition switch OFF will cause a voltage spike and damage to electrical components.

Test Point	Specification	Comment: < Less than, > Greater than
86 to GND	B+	If 0 V, check power circuit to relay coil for OPEN or short to GND, or blown fuse.
		If < B+, check for failed circuitry between batteries and relay. Go to Harness Resistance Check.
30 to GND	B+	If 0 volts, check power circuit to relay switch for OPEN or short to GND, or blown fuse.
		If < B+, check for failed circuitry between batteries and relay. Go to Harness Resistance Check.
85 to GND	0 to 2 V	If > 2 volts, check MPR control circuit for OPEN or short to PWR. Go to Harness Resistance Check.
87 to GND	B+	If < B+, replace relay.
		If B+, check ECM PWR and ECM GND circuits at the ECM. Go to Voltage Checks at ECM.

Voltage Checks at ECM

Connect 180-pin Breakout Box between ECM and chassis harness. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment: < Less than, > Greater than
C-31 to GND	B+	If < B+, check VIGN circuit for OPEN or short to GND, or blown fuse.
C-2 to GND	0 V	
C-4 to GND	0 V	If voltage is present, check for OPEN circuit. Go to Harness Resistance Check.
C-6 to GND	0 V	
C-70 to GND	0 to 2 V	If > 2 volts, check MPR control circuit for OPEN or short to PWR. Go to Harness Resistance Check.
C-1 to GND	B+	
C-3 to GND	B+	If < B+, check for OPEN circuit, failed relay, or blown fuse. Go to Harness Resistance Check.
C-5 to GND	B+	

Harness Resistance Check

Turn ignition switch to OFF. Disconnect ECM, ECM PWR relay, and ACT PWR relays. Connect 180-pin Breakout Box and Breakout Harness 4674. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
C-70 to 85	< 5 Ω	If > 5 Ω, check MPR control circuit for OPEN.
C-70 to GND	> 1 kΩ	If < 1 kΩ, check MPR control circuit for short to GND.
C-1 to 87	< 5 Ω	If > 5 Ω, check ECM PWR circuit for OPEN.
C-1 to GND	> 1 kΩ	If < 1 kΩ, check ECM PWR circuit for short to GND.
C-3 to 87	< 5 Ω	If > 5 Ω, check ECM PWR circuit for OPEN.
C-3 to GND	> 1 kΩ	If < 1 kΩ, check ECM PWR circuit for short to GND.
C-5 to 87	< 5 Ω	If > 5 Ω, check ECM PWR circuit for OPEN.
C-5 to GND	> 1 kΩ	If < 1 kΩ, check ECM PWR circuit for short to GND.
C-2 to GND	< 5 Ω	If > 5 Ω, check ECM GND circuit for OPEN.
C-4 to GND	< 5 Ω	If > 5 Ω, check ECM GND circuit for OPEN.
C-6 to GND	< 5 Ω	If > 5 Ω, check ECM GND circuit for OPEN.

Harness Resistance Check on Relay Power Circuits

Turn ignition switch to OFF. Disconnect both battery GND cables. Use DMM to measure resistance.

WARNING: To prevent personal injury or death, always disconnect main negative battery cable first. Always connect the main negative battery cable last.

Test Point	Specification	Comment: < Less than, > Greater than
Relay (30) to battery positive post	< 5 Ω	If > 5 Ω, check for OPEN circuit or blown fuse.
Relay (30) to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
Relay (86) to battery positive post	< 5 Ω	If > 5 Ω, check for OPEN circuit or blown fuse.
Relay (86) GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

ECM PWR Circuit Operation

The ECM receives VIGN power at Pin C-45. This signals the ECM to provide a ground path from Pin C-70 to 85 to switch the ECM PWR relay. Switching the relay provides power from the battery positive terminal through 1 fuse and relay contacts 30 and 87 to Pins C-1, C-3, and C-5.

The ECM is grounded to the battery negative terminal at ECM Pin C-2, C-4, and C-6.

Fault Detection / Management

The ECM internally monitors battery voltage. When the ECM continuously receives less than 7 volts or more than 17.5 volts, a code will be set.

SPN 158 FMI 15 - ECM Switched voltage too HIGH

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Engine Control Module Switched voltage too HIGH	Battery Voltage > 16 Volts	Key ON Time after Engine start > 10 seconds Intake Air heater has been turned "OFF" for > 10 seconds

Fault Overview

Fault sets when Engine Control Module (ECM) Switched voltage is too High.

Lamp Reaction

Malfunction Indicator Lam (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Continuous

Possible Causes

- Charging voltage excessive
- Incorrect battery pack wiring (series instead of parallel)

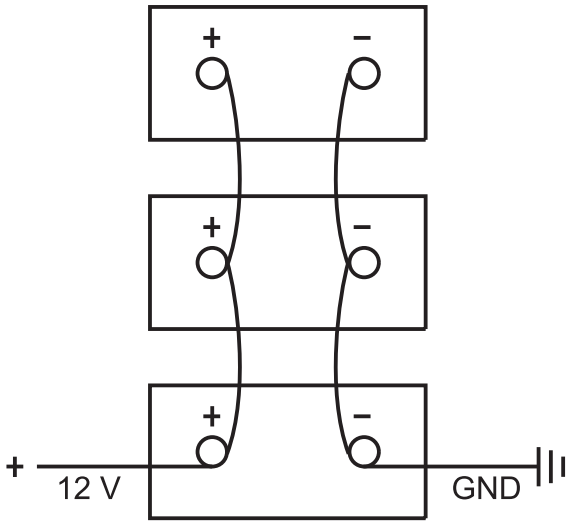


Figure 268 Approved Battery Cable Sequence

Step 1		Decision
	Check for correct parallel battery pack wiring. Positive battery cable(s) should be connected from positive battery terminal to positive battery terminal. Negative battery cable(s) should be connected from negative battery terminal to negative battery terminal. Is battery pack correctly assembled (wired in parallel and Not in series)?	Yes: Replace alternator. After repairs are complete, retest for SPN 158 FMI 15.
		No: Reassemble battery pack. After repairs are complete, retest for SPN 158 FMI 15.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 158 FMI 15 fault code diagnostics.

Engine Idle Speed

Overview of Engine Sensor

SPN	FMI	Description
188	0	Engine unable to achieve desired idle speed (too high) (page 587)
188	1	Engine unable to achieve desired idle speed (too low) (page 589)

SPN 188 FMI 0 - Engine unable to achieve desired idle speed (too high)

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Engine idle speed is too high.	Engine speed > 106.7% of desired idle speed	Key ON Engine Coolant Temperature 1 (ECT1) between 16°F (-9°C) and 248°F (120°C) Vehicle speed < 0.62 mph Power Take Off (PTO) not engaged Accelerator pedal position 0%

Fault Overview

Fault code sets when vehicle is stationary and engine speed is greater than what is requested by Engine Control Module (ECM).

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

SPN 110 FMI 2 (ECT1); SPN 5395 FMI 0 (EWPS)

Fault Facts

None

Drive Cycle to Determine Fault Status

None

Possible Causes

- External fuel source
- Engine oil leak to intake
- Fuel leak to intake
- Contaminated fuel

Step 1	Check for associated fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 110 FMI 2 (ECT1) and SPN 5395 FMI 0 (EWPS). Is EST DTC list free of SPN 110 FMI 2 and SPN 5395 FMI 0?		Yes: Go to Step 2. No: Repair SPN 110 FMI 2 and SPN 5395 FMI 0. After repairs are complete, retest for SPN 188 FMI 0.

Step 2	Inspect for airborne combustibles (such as propane saturated air or ether) near engine.	Decision
Inspect air filter and intake system for stains, concentrations of contaminants, odors / smells from external fuel sources, and modifications. Is engine intake system intact and free from any external fuel sources?		Yes: Go to Step 3. No: Repair source of airborne combustibles. After repairs are complete, retest for SPN 188 FMI 0.

Step 3	Inspect for a engine oil leak to intake.	Decision
Perform 7.3 - Engine Oil to Intake . Is engine oil leaking to intake?		Yes: Go to Step 4. No: Repair engine oil to intake. After repairs are complete, retest for SPN 188 FMI 0.

Step 4	Inspect for contaminated fuel (alternate fuels other than diesel fuel).	Decision
Perform Fuel Quality Inspection. Is diesel fuel in good condition and not contaminated?		Yes: Diagnostics complete. No: Drain fuel tank, and fill with clean and / or known good diesel fuel. After repairs are complete, retest for SPN 188 FMI 0.

End Diagnostic Steps
After performing diagnostic steps, if SPN 188 FMI 0 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

SPN 188 FMI 1 - Engine Unable to Achieve Desired Idle Speed (Too Low)

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Engine idle speed is too low.	Engine speed < 93.3% of desired idle speed	Key ON Engine Coolant Temperature 1 (ECT1) between 16°F (-9°C) and 248°F (120°C) Vehicle speed < 0.62 mph PTO not engaged Accelerator pedal position 0%

Fault Overview

Fault sets when vehicle is stationary and engine speed is less than what is requested by Engine Control Module (ECM).

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

SPN 651, 652, 653, 654, 655, 656 (INJ); SPN 1322, 1323, 1324, 1325, 1326, 1327, 1328 FMI 31 (ENG); and SPN 5395 FMI 1 (EWPS)

Fault Facts

None

Drive Cycle to Determine Fault Status

None

Possible Causes

- Low Fuel Delivery Pressure (FDP)
- Low cylinder compression
- Clutch or Power Take Off (PTO) engagement without command

Step 1	Check for associated fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 651, 652, 653, 654, 655, 656 (INJ); SPN 1322, 1323, 1324, 1325, 1326, 1327, 1328 FMI 31 (ENG); and SPN 5395 FMI 1 (EWPS). Is EST DTC list free of SPN 651, 652, 653, 654, 655, 656; SPN 1322, 1323, 1324, 1325, 1326, 1327, 1328 FMI 31; and SPN 5395 FMI 0?		Yes: Go to Step 2. No: Repair SPN 651, 652, 653, 654, 655, 656; SPN 1322, 1323, 1324, 1325, 1326, 1327, 1328 FMI 31; and SPN 5395 FMI 1. After repairs are complete, retest for SPN 188 FMI 1.

Step 2	Check air intake, exhaust, and fuel systems for restrictions, leaks or damage.	Decision
Inspect air intake system, exhaust system, and air filter for restrictions, air leaks, or physical damage. Inspect fuel system from fuel tank to Down Stream Injection (DSI) assembly for leaks, physical damage, or contamination. Are air intake system, exhaust system, fuel system, and air filter free of restrictions, leaks, physical damage, and contamination?		Yes: Go to Step 3. No: Repair restrictions, air leaks, fuel leaks, or physical damage. Replace contaminated fluids as required. After repairs are complete, retest for SPN 188 FMI 1

Step 3	Check that Fuel Delivery Pressure (FDP) is within specification.	Decision
Using EST with ServiceMaxx™ software, Key-On Engine-Running (KOER) and monitor FDP sensor. Is FDP within specification?		Yes: Go to Step 4. No: Perform Fuel Delivery Pressure (FDP) Test(page 224). After repairs are complete, retest for SPN 188 FMI 1.

Step 4	Determine if the engine has a mechanical cylinder balance problem (compression loss).	Decision
Perform Crankcase Pressure Test.(page 212) Does engine have excessive crankcase pressure?		Yes: Repair base engine compression imbalance. After repairs are complete, retest for SPN 188 FMI 1. No: Go to Step 5.

Step 5	Check for Power Take Off (PTO) engagement without command.	Decision
Key-On Engine-Running (KOER), monitor PTO output shaft rotation. Is PTO output shaft rotating without throttle?		Yes: Repair PTO unit. After repairs are complete, retest for SPN 188 FMI 1. No: Go to Step 6.

Step 6	Determine if engine has a fuel injector problem.	Decision
Perform KOER Cylinder Cutout Test. Did one or more cylinders have significant speed difference(s) than others?		Yes: Replace injector suspected by KOER Cylinder Cutout Test. After repairs are complete, retest for SPN 188 FMI 1. No: Go to Step 7.

Step 7	Inspect for failed valve train components.	Decision
A. Remove valve cover (see *Engine Service Manual*). B. Inspect for bent valves, fallen bridges, and valves out of adjustment. Is valve train free of failed valve train components?		Yes: Diagnostics complete. No: Repair failed valve train components. After repairs are complete retest for SPN 188 FMI 1.

End Diagnostic Steps
After performing diagnostic steps, if SPN 188 FMI 1 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

Transmission Output Shaft Speed (TOSS)

SPN	FMI	Condition	Possible Causes	Actions
191	3	TOSS / VSS Signal Out of Range High	• TOSS / VSS sensor circuit short PWR • TOSS / VSS sensor failure	Step-based Diagnostics (page 595)
191	4	TOSS / VSS Signal Out of Range Low	• TOSS / VSS sensor circuit OPEN • TOSS / VSS sensor circuit short PWR • TOSS / VSS sensor failure	Step-based Diagnostics (page 598)

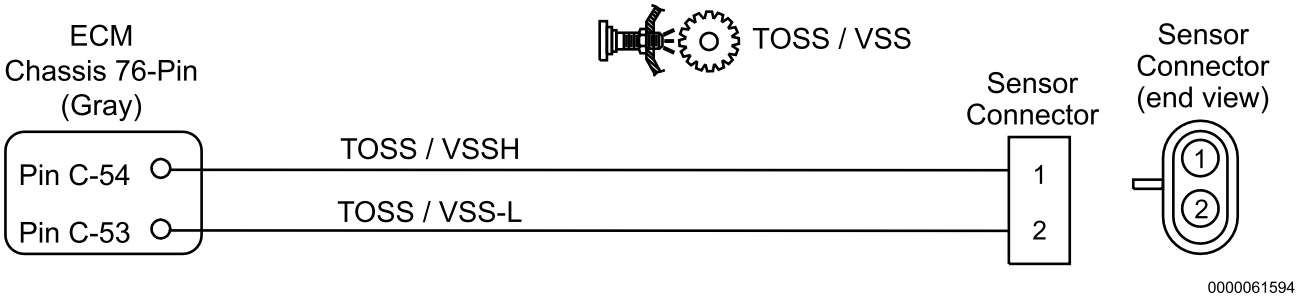


Figure 269 TOSS / VSS Circuit Diagram

Overview

The Transmission Output Shaft Speed (TOSS) sensor or Vehicle Speed Sensor (VSS) provides a feedback signal to the Engine Control Module (ECM) indicating the vehicle speed.

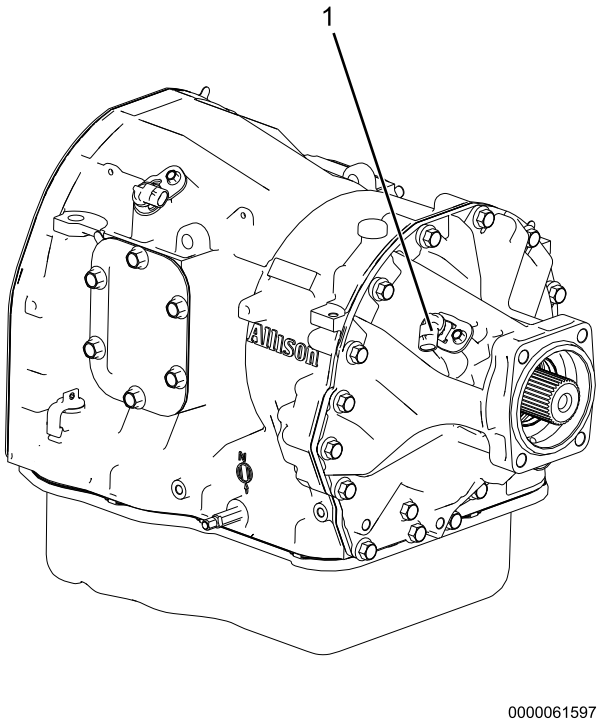


Figure 270 TOSS / VSS Sensor Location

1. TOSS / VSS Sensor

Tools

- EZ Tech® Electronic Service Tool (EST) – J-45067 (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- 00-00956-08 – 180-pin Breakout Box (page 1222)
- International® Electronic Engine Terminal Test Kit (page 1227)

Pin-point Diagnostics

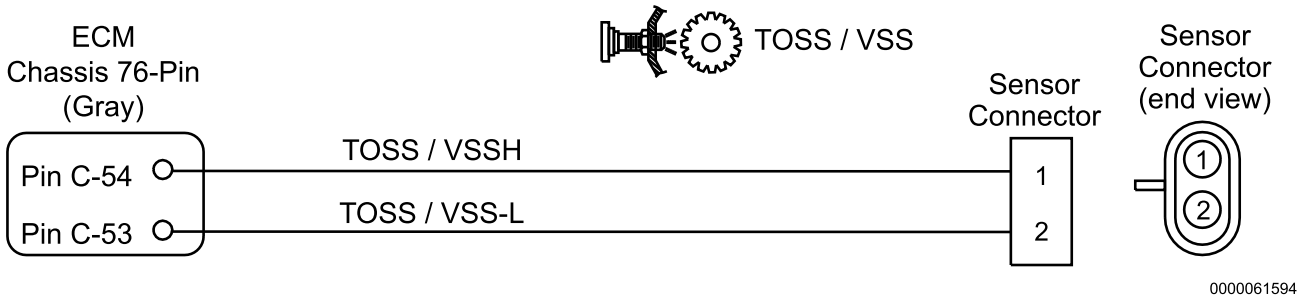


Figure 271 TOSS / VSS Circuit Diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

Connector Voltage Check

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 or short to PWR.
2 to GND	4.6 to 5 V	If < 4.5 volts, check for OPEN or short to GND. Go to Harness Resistance Check.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-pin Breakout Box and sensor Breakout Harness. Leave ECM and sensor disconnected.

Test Point	Specification	Comment: < Less than, > Greater than
1 to C-54	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to C-53	< 5 Ω	If > 5 Ω, check for OPEN circuit.

SPN 191

FMI 3 – TOSS / VSS Signal Out of Range High

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Transmission Output Shaft Speed (TOSS) signal Out of Range HIGH	Transmission sensor voltage (VSS +) > 4.492 Volts	Key ON	5.1 seconds
	OR Transmission sensor voltage (VSS -) > 4.492 Volts	[Vehicle Speed Sensor (VSS) signal frequency ≤ 0.2 Hz	
		for] ≥ 0.5 seconds	
		Manual Transmission Selected (Manual Isochronous and non-Isochronous: Allison AT / MT)	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the TOSS is receiving transmission sensor voltage (VSS +) or transmission sensor voltage (VSS -) is receiving more than 4.492 volts.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

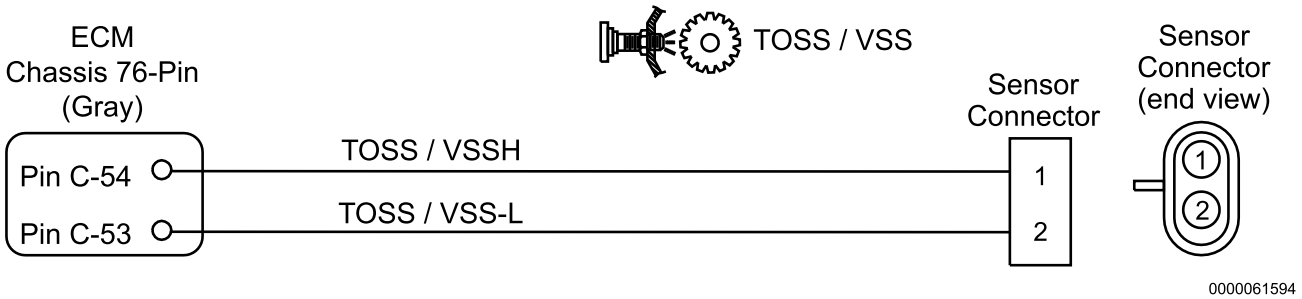


Figure 272 TOSS / VSS Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for fault codes. Is SPN 191 FMI 3 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 191 FMI 3. No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit, inspect connections at Transmission Output Shaft Sensor / Vehicle Speed Sensor (TOSS / VSS). With key OFF, disconnect TOSS / VSS sensor. Check TOSS / VSS sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are TOSS / VSS sensor connectors, harnesses, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 191 FMI 3.

Step	Action	Decision
4	Test TOSS / VSS circuit for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 594). Is TOSS / VSS circuit within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 191 FMI 3.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Do Key On Engine Off Continuous Monitor Test (page 87). Does circuit operate properly?	Yes: After doing all diagnostic steps, if SPN 191 FMI 3 remains active, verify steps were completed correctly and proper decisions were made. Notify supervisor for further action. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 191 FMI 3.

NOTE: After doing all diagnostic steps, if SPN 191 FMI 3 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 191

FMI 4 – TOSS / VSS Signal Out of Range Low

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Transmission Output Shaft Speed (TOSS) signal Out of Range LOW	Transmission sensor voltage (VSS +) < 0.488 Volts	Key ON	5.1 seconds
	OR Transmission sensor voltage (VSS -) < 0.488 Volts	[Vehicle Speed Sensor (VSS) signal frequency ≤ 0.2 Hz	
		for] ≥ 0.5 seconds	
		Manual Transmission Selected (Manual Isochronous and non-Isochronous: Allison AT / MT)	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the TOSS is receiving transmission sensor voltage (VSS +) or transmission sensor voltage (VSS -) is receiving less that 0.488 volts.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

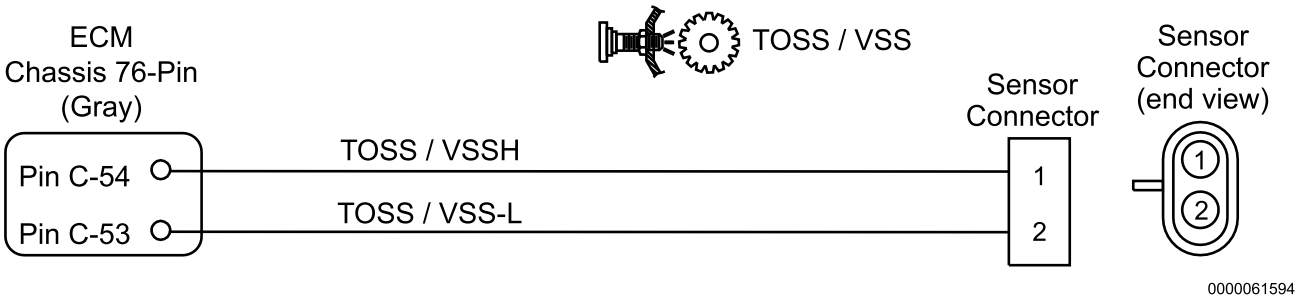


Figure 273 TOSS / VSS Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for fault codes. Is SPN 191 FMI 4 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 191 FMI 4. No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit, inspect connections at Transmission Output Shaft Sensor / Vehicle Speed Sensor (TOSS / VSS). With key OFF, disconnect TOSS / VSS sensor. Check TOSS / VSS sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are TOSS / VSS sensor connectors, harnesses, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 191 FMI 4.

Step	Action	Decision
4	Test TOSS / VSS circuit for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 594). Is TOSS / VSS circuit within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 191 FMI 4.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Do Key On Engine Off Continuous Monitor Test (page 87). Does circuit operate properly?	Yes: After doing all diagnostic steps, if SPN 191 FMI 4 remains active, verify steps were completed correctly and proper decisions were made. Notify supervisor for further action. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 191 FMI 4.

NOTE: After doing all diagnostic steps, if SPN 191 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Torque Limitation

SPN	FMI	Condition	Possible Causes	Actions
518	2	Torque Limitation – Too High ECT	• Engine Coolant Temperature (ECT) too hot	Step-based Diagnostics (SPN 518, page 602)

Tools

- EZ Tech® Electronic Service Tool (EST) – J-45067 (page 1226)
- Breakout Harness 4602 (EOT, ECT, and AFTFSV) (page 1230)
- International® Electronic Engine Terminal Test Kit (page 1227)

SPN 518

FMI 2 – Torque Limitation – Too High ECT

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
N/A			

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the engine cooling system is too hot.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for fault codes. Is SPN 518 FMI 2 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 518 FMI 2. No: Go to Step 3.

Step	Action	Decision
3	Start 4 hour cold soak for Step 7 below, while doing following steps. Test Engine Coolant Temperature (ECT1) circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 633). Are ECT circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 4. No: No: Repair circuits as required. After repairs are complete, retest for SPN 518 FMI 2.

Step	Action	Decision
4	Inspect vehicle grille for obstructions that may reduce air flow to the Charge Air Cooler (CAC). Is vehicle grille free of obstructions?	Yes: Go to Step 5. No: Repair or remove obstruction from grille. After repairs are complete, retest for SPN 518 FMI 2.

Step	Action	Decision
5	Check engine fan, fan shroud, and air dams for damage and proper operation. Are engine fan, fan shroud, and air dams intact and operating properly?	Yes: Go to Step 6. No: Repair or replace engine fan, fan shroud, and/or air dams. After repairs are complete, retest for SPN 518 FMI 2.

Step	Action	Decision
6	Check CAC for oil, dirt, or other debris. Do CAC checks . Is the CAC system free of dirt, debris, or oil?	Yes: Go to Step 7. No: Clean CAC. After repairs are complete, retest for SPN 518 FMI 2.

Step	Action	Decision
7	Do Cold Soak Sensor Compare Check (page 632). Compare ECT1 to Engine Oil Temperature (EOT), Intake Manifold Temperature (IMT), Air Inlet Temperature (AIT), Charge Air Cooler Outlet Temperature (CACOT), and Aftertreatment Fuel Inlet Temperature (AFTFIT) sensors. All temperature sensors should be within 59°F (15°C) of each other. Are all temperature sensors within 59°F (15°C) the other sensors?	Yes: Go to Step 8. No: Replace failed temperature sensor. After repairs are complete, retest for SPN 518 FMI 2.

Step	Action	Decision
8	Determine if thermostat is stuck closed. Run engine after Step 7 has been completed and evaluated. Feel upper radiator hose and determine if warm coolant begins to flow before the thermostat opening temperature is reached. Does the upper radiator hose temperature stay cool after reasonable engine warm up time?	Yes: After doing all diagnostic steps, if SPN 518 FMI 2 remains active, verify each step was completed correctly and proper decisions were made. Notify supervisor for further action. Remove and inspect thermostats following the procedure in the *Engine Service Manual*. After repairs are complete, retest for SPN 518 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 518 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Brake Switch

SPN	FMI	Condition	Possible Causes	Actions
597	2	Brake switch or circuit fault	• Brake and accelerator depressed at same time • Body controller false input • Brake On / Off (BOO) switch dislodged (always on) • BOO switch closed • Not able to use cruise control	Step-based Diagnostics (page 608)
597	19	Brake switch not detected on J1939	• Body Control Module (BCM) Controller Area Network (CAN) message not being reported • Brake switch or circuit fault • See BCM for troubleshooting switch	Step-based Diagnostics (SPN 597, page 611)



Figure 274 Brake Switch Circuit Diagram

Overview

The brake switch provides an ON/OFF signal to the Engine Control Module (ECM) indicating brake switch position.

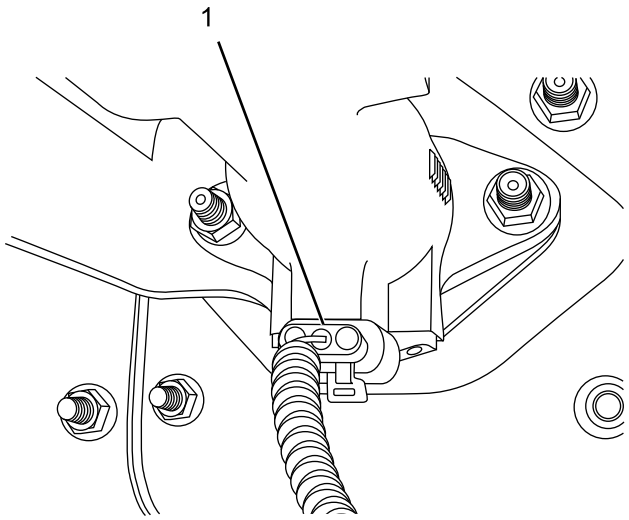


Figure 275 Brake Switch Location

1. Brake Switch

Tools

- EZ Tech® Electronic Service Tool (EST) – J-45067 (page 1226)
- International® Electronic Engine Terminal Test Kit (page 1227)
- 00-00956-08 – 180-pin Breakout Box (page 1222)

Pin-point Diagnostics

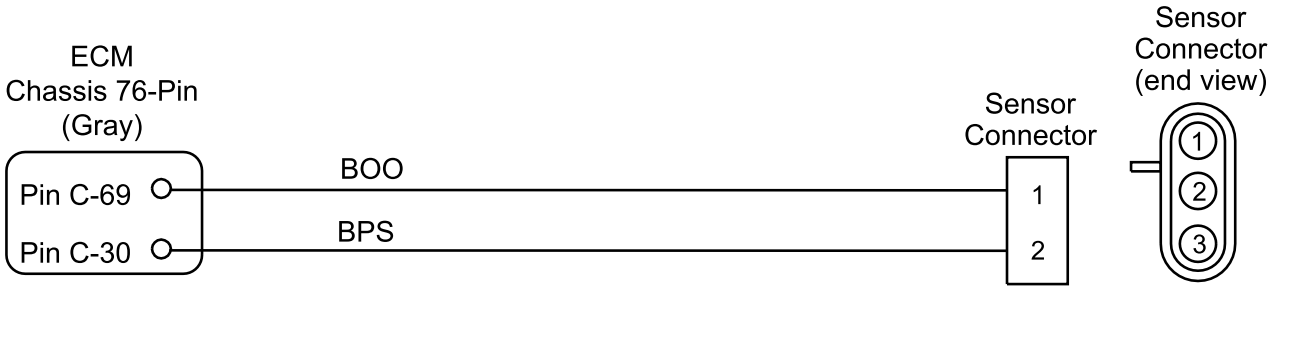


Figure 276 Brake Switch Circuit Diagram

Connector Voltage Check

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	4.6 to 5 V	If < 4.5 volts, check for OPEN or short to GND. Go to Harness Resistance Check.

Harness Resistance Check

Turn ignition switch to OFF. Disconnect ECM. Leave sensor disconnected. Connect 180-pin Breakout Box and Breakout Harness. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
1 to C-69	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to C-30	< 5 Ω	If > 5 Ω, check for OPEN circuit.

Switch Checks

Turn ignition switch to ON. Connect the EST to the Diagnostic Connector. Open the CCS session to monitor signals.

NOTE:

- If signals not within specification, diagnose switch interface with BC or MSN module. See *Chassis Electrical Circuit Diagnostic Manual* and *Electrical System Troubleshooting Guides*.
- If within specification, go to next test point.

Test Point	Specification	Comment
Brake Switch (BOO)	Normal state = Released	See Note
	Depressed = Applied	
Park Brake	Normal state = OFF	See Note
	Depressed = ON	
Cruise On / Off (COO)	Unlatched = OFF	See Note
	Latched = ON	
Cruise Set	Normal state = OFF	See Note
	Depressed = ON	
Cruise Resume / Accel	Normal state = OFF	See Note
	Depressed = ON	

If all switches are within specifications, go to road test.

SPN 597

FMI 2 – Brake Switch Circuit Fault

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
N/A			

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN / FMI: 596/19.

Drive Cycle to Determine Fault Status

N/A



Figure 277 Brake Switch Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for fault codes. Is SPN 597 FMI 2 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 597 FMI 2. No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit, inspect connections at Brake Pedal Switch (BPS) and Body Control Module (BCM). With key OFF, disconnect BPS and BCM. Check BPS and BC connectors for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housings. Are BPS and BC connectors, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 597 FMI 2.

Step	Action	Decision
4	Using EST with ServiceMaxx™ software, do BPS or BC checks (page 608). Do all switches operate within specifications?	Yes: Go to Step 5. No: Replace switches as required. After repairs are complete, retest for SPN 597 FMI 2.

Step	Action	Decision
5	Do Road Test (page 218) (full load to highway speed) 100 % engine load (when safe to do so). Record a snapshot of the following signals: Brake switch and Accelerator Pedal Position 1 (APP1). Are test point signals within specification?	Yes: After doing all diagnostic steps, if SPN 597 FMI 2 remains, verify each step was completed correctly and proper decisions were made. Notify supervisor for further action. No: Replace switches as required. After repairs are complete, retest for SPN 597 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 597 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 597

FMI 19 – Brake Switch Not Detected On J1939

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
N/A			

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN / FMI: 596/19.

Drive Cycle to Determine Fault Status

N/A



Figure 278 Brake Switch Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for fault codes. Is SPN 597 FMI 19 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 597 FMI 19. No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit, inspect connections at Brake Pedal Switch (BPS) and Body Control Module (BCM). With key OFF, disconnect BPS and BCM. Check BPS and BC connectors for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housings. Are BPS and BC connectors, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 597 FMI 19.

Step	Action	Decision
4	Test brake switch circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 607). Are brake switch circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 597 FMI 19.

Step	Action	Decision
5	Verify Brake Switch Programming. Using EST with ServiceMaxx™ software, open Programming session file and verify that all Parameters are set correctly. Brake switch Mode should be Enabled. Is Brake Switch Mode set to Enabled?	Yes: Go to Step 6. No: Change mode to Enabled. After repairs are complete, retest for SPN 597 FMI 19.

Step	Action	Decision
6	Using EST with ServiceMaxx™ software, do BPS or BC checks (page 608). Do all switches operate within specifications?	Yes: Go to Step 7. No: Replace switches as required. After repairs are complete, retest for SPN 597 FMI 19.

Step	Action	Decision
7	Do Road Test (page 218) (full load to highway speed) 100 % engine load (when safe to do so). Record a snapshot of the following signals: Brake Switch and Accelerator Pedal Position 1 (APP1). Are test point signals within specification?	Yes: After doing all diagnostic steps, if SPN 597 FMI 19 remains, verify each step was completed correctly and proper decisions were made. Notify supervisor for further action. No: Replace switches as required. After repairs are complete, retest for SPN 597 FMI 19.

NOTE: After doing all diagnostic steps, if SPN 597 FMI 19 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

ECM Self Diagnostics (Engine Control Module)

SPN	FMI	Condition	Possible Causes	Actions
108	2	BARO signal erratic, intermittent, or incorrect	• Internal ECM failure	Step-based Diagnostics (page 616)
108	3	BARO signal out of range high	• Internal ECM failure	Step-based Diagnostics (page 617)
108	4	BARO signal out of range low	• Internal ECM failure	Step-based Diagnostics (page 617)
628	12	ECM memory error	• Internal ECM failure	Step-based Diagnostics (page 618)
629	0	ECM Error – CPU Load Excessively HIGH	• CPU load > 98 %	Step-based Diagnostics (page 619)
629	8	ECM Error - Engine Off Timer fault	• Failed KAPWR fuse • KAPWR circuit Open	Step-based Diagnostics
1136	0	ECM error – over temperature	• ECM overheating	Step-based Diagnostics (page 615)
1387	31	Altitude reference adder fault	• Barometric Absolute Pressure (BARO), Exhaust Back Pressure (EBP), and Intake Manifold Pressure (IMP) do not agree • Biased, damaged, or failed BARO (ECM), EBP, or IMP sensor • Biased, failed, or damaged actuator PWR circuit	Step-based Diagnostics (page 625)

Overview

The ECM automatically performs diagnostic self-checks. The ECM self-test includes memory, programming, and internal power supply checks. The ECM will detect internal SPN / FMIs depending on the severity of the problem. Additionally, the ECM provides SPN / FMI management strategies to permit limited engine and vehicle operation.

Tools

- EZ Tech® Electronic Service Tool (EST) – J-45067 (page 1226)
- International® Electronic Engine Terminal Test Kit (page 1227)

Pin-point ECM Self Diagnostic Fault

SPN 108 FMI 2 – BARO signal erratic, intermittent, or incorrect

Pin-point ECM Self Diagnostic Fault

1. Clear code, cycle Ignition Switch (VIGN).
2. If code is still active, replace ECM.

SPN 108 FMI 3 – BARO signal out-of-range HIGH

Pin-point ECM Self Diagnostic Fault

Checks whether the signal from the BARO sensor is above the maximum threshold.

1. Clear code, cycle ignition switch.
2. If code is still active, replace ECM.

SPN 108 FMI 4 – BARO signal out-of-range LOW

Pin-point ECM Self Diagnostic Fault

Checks whether the signal from the BARO sensor is below the minimum threshold.

1. Clear code, cycle ignition switch.
2. If code is still active, replace ECM.

SPN 628 FMI 12 – ECM Error - Program memory error

Pin-point ECM Self Diagnostic Fault

Indicates an error occurred in the ECM.

1. Clear code, cycle ignition switch.
2. If code is still active, replace ECM.

SPN 629 FMI 12 – ECM Error - Internal hardware failure

Pin-point ECM Self Diagnostic Fault

Indicates an error occurred in the ECM.

1. Clear code, cycle ignition switch.
2. If code is still active, replace ECM.

SPN 1136 FMI 0 – ECM Error – over temperature

Pin-point ECM Self Diagnostic Fault

1. Correct any abnormal condition of ECM overheating.
2. If code is set in cool conditions, then replace ECM.

SPN 108 FMI 2 - BARO Signal Erratic, Intermittent or Incorrect

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Barometric Absolute Pressure (BARO) signal erratic, intermittent, or incorrect	BARO reading at Key-On is more than 4.35 psi (30 kPa) different than the EBP and IMP sensor readings.	Initial Key ON

Fault Overview

Fault code sets when Electronic Control Module (ECM) detects that Barometric Absolute Pressure (BARO) sensor signal is erratic intermittent or incorrect

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

None

Fault Facts

BARO sensor is located inside Engine Control Module (ECM). If there is a confirmed BARO failure, ECM must be replaced.

Drive Cycles

Initial Key ON

Possible Cause

- Failed ECM

Step 1	Check for active or pending fault code.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software. A. Key ON, clear codes. B. Key OFF, wait for EST screens to clear. C. Key ON, check Diagnostic Trouble Code (DTC) list for SPN 108 FMI 2. Is EST DTC list SPN 108 FMI 2 active or pending?		Yes: Replace ECM. After repairs are complete, retest for SPN 108 FMI 2. No: Diagnostics complete.

End Diagnostic Steps
After performing all diagnostic steps, if SPN 108 FMI 2 remains, verify if each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 108 FMI 3 - BARO signal Out of Range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Barometric Pressure (BARO) Sensor signal Out of Range High	BARO sensor voltage > 4.68 Volts - 16.6 psi (114.5 kPa)	Key ON

Fault Overview

Fault Code sets when Barometric Pressure (BARO) sensor is above maximum threshold.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

None

Fault Facts

The BARO sensor is installed inside Engine Control Module (ECM).

Drive Cycle to Determine Fault Status

Continuous Component Monitor.

Possible Causes

- Failed ECM

Step 1	Check for active fault code.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 108 FMI 3. Does EST DTC list show SPN 108 FMI 3 as active or pending?		Yes: End diagnostics. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79). After repairs are complete, retest for SPN 108 FMI 3.

End Diagnostic Steps
After performing all diagnostic steps, if SPN 108 FMI 3 remains, verify if each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 108 FMI 4 - BARO signal Out of Range LOW

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Barometric Pressure (BARO) Sensor signal Out of Range Low	BARO sensor voltage < 0.45 Volts - 2.9 psi (20.55 kPa)	Key ON

Fault Overview

Determines if Barometric Pressure (BARO) sensor is below minimum threshold.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

None

Fault Facts

The BARO sensor is installed inside Engine Control Module (ECM).

Drive Cycle to Determine Fault Status

TBD

Possible Causes

- Failed ECM

Step 1	Check for active fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 108 FMI 4. Does EST DTC list show SPN 108 FMI 4 as Active or Pending?		Yes: End diagnostic. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

End Diagnostic Steps
After performing all diagnostic steps, if SPN 108 FMI 4 remains, verify if each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 628 FMI 12 - ECM Memory Error

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Engine Control Module (ECM) Error - A/D conversion monitoring	Internal ECM Fault	Key ON

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects an internal memory error within the ECM.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON

Possible Causes

- Failed ECM

Step 1	Check for active or pending fault code.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 628 FMI 12. Is SPN 628 FMI 12 set after DTC list is cleared?		Yes: Replace Engine Control Module (ECM). After repairs are completed, retest for SPN 628 FMI 12.
		No: Diagnostics complete.

End Diagnostic Step
After performing diagnostic step, if SPN 628 FMI 12 remains, verify if step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 629 FMI 0 - ECM Error - CPU Load Excessively HIGH

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Engine Control Module (ECM) Central Processing Unit (CPU) load excessively high detected.	ECM CPU load is excessively high	Key ON

Fault Overview

Fault Code sets when the ECM detects CPU load is excessively high.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON

Possible Causes

- Failed Software

- Failed ECM

Step 1	Check for associated fault code.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™, clear fault code. Run drive cycle and check for fault code SPN 629 FMI 0 in DTC list.		Yes: Reprogram Electronic Control Module (ECM). Go to Step 2.
Did fault code set?		No: End of diagnostics.

Step 2	Reprogram ECM.	Decision
Using EST with ServiceMaxx™, clear fault code. Run drive cycle and check for fault code SPN 629 FMI 0 in DTC list.		After repairs are complete, retest for SPN 629 FMI 0.
Did fault code set?		No: End of diagnostics.

End Diagnostic Step
After performing diagnostic step, if SPN 629 FMI 0 remains, verify if step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 629 FMI 8 - ECM Error - Engine Off Timer fault

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Engine OFF timer is not reading as expected.	Engine Control Module (ECM) communicates any of following has occurred: A. PIC timer is stopped B. PIC time is invalid C. PIC chip error status detected D. PIC chip has no power Absolute difference of engine OFF timer count and ECM timer count > 5% Engine OFF timer value lower than ECM power down time at previous ECM power cycle	Key ON Key-On Engine-Running (KOER) Sum of engine run time and engine OFF timer < 86,340 seconds PIC (engine OFF timer) chip is running Time after Key ON > 30 seconds PIC timer not stopped No battery faults on PIC timer No PIC timer error Engine OFF timer value < 86,340 seconds

Fault Overview

Fault code sets when Engine Control Module (ECM) detects engine OFF timer is not reading as expected.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

None

Fault Facts

PIC timer is a smart sensor that measures engine OFF time.

Drive Cycle to Determine Fault Status

TBD

Possible Causes

- Failed KAPWR fuse
- KAPWR circuit Open

Step 1	Check for active fault code.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 629 FMI 8. Does EST DTC list show SPN 629 FMI 8 as Active or Pending?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Check for active fault code after Engine Control Module (ECM) reset.	Decision
A. Using EST with ServiceMaxx™ software, clear DTC list. B. Key OFF. Allow ECM to power down. C. Key ON. Does EST DTC list free show SPN 629 FMI 8 as Active or Pending?		Yes: Go to Step 3. No: Repair is complete. After repairs are complete, clear fault code and retest for SPN 629 FMI 8.

Step 3	Inspect connections at KAPWR Fuse holder.	Decision
A. Key OFF. B. Disconnect KAPWR Fuse holder harness connector. C. Check KAPWR Fuse holder connector terminals for damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are KAPWR Fuse holder connector, harness and terminals clean and undamaged?		Yes: Go to Step 4 No: Repair connector, connector, harness, or terminal damage. Repair is complete. After repairs are complete, retest for SPN 629 FMI 8

Step 4	Inspect KAPWR 5 amp fuse.	Decision
Inspect KAPWR 5 amp fuse. Is KAPWR 5 amp fuse burned out?		Yes: Replace KAPWR 5 amp fuse and repair short to GND between Engine Control Module (ECM) pin C-46 and KAPWR 5 amp fuse. After repairs are complete, clear fault code and retest for SPN 629 FMI 8. No: Go to Step 5.

Step 5	Check voltage at terminal block for Engine Control Module (ECM) timer fuse.	Decision
Measure voltage between fuse terminal block (9261 side) and known good ground. Is B+ voltage present at ECM timer fuse terminal block?		Yes: Repair Open circuit between terminal block and ECM terminal C-46. After repairs are complete, retest for SPN 629 FMI 8. No: Repair Open between terminal block and truck wiring harness. After repairs are complete, retest for SPN 629 FMI 8.

End Diagnostic Steps
After performing diagnostic steps, if SPN 629 FMI 8 remains, verify if each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 629 FMI 12 - ECM Internal chip Error

Condition / Description	Setting Criteria	Enable Conditions / Condition Values	Time Requirements
Comparison of Actual vs. Estimated engine speed	Absolute Value of {Actual Engine Speed MINUS Engine Speed calculated from a Software Timer (n_32_sub_mon)} / {Actual Engine Speed} > 0.101 (ratio)	Key ON	Immediate
Error of Engine Control Module's Non Volatile Memory (NVRAM write error)	Engine Control Unit indicates a Hardware error in Non Volatile Memory	Key ON	50 seconds
	Hardware Error in the ATIC_35 Chip detected	Key ON	Immediate
Engine Control Module Self Test for Hardware Error	Hardware Error in the ATIC_39 Chip detected	Key ON	Immediate
Processor Monitoring	This error is set in if one of the following is true: 1. Error in Engine Control Module Self Test 2. RAM Error in the Micro Controller 3. ROM Error in the Micro Controller 4. Pendrive check error	Key ON	1 Event
		Called by Processor Monitoring as a subroutine on demand	

Fault Overview

Fault code sets when the ECM detects an internal chip error within the ECM.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON.

Possible Causes

- Failed ECM

Step 1	Check for active fault code.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™, clear fault code. Run drive cycle and use EST with ServiceMaxx™ to check DTC list for fault code. Does code set?		Yes: Replace Engine Control Module (ECM). After repairs are completed, retest for SPN 629 FMI 12.
		No: Diagnostics complete.

End Diagnostic Step
After performing diagnostic step, if SPN 629 FMI 12 remains, verify if step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 1387

FMI 31 – Altitude Reference Adder Fault

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Altitude Reference Adder Strategy (ARA) General Fault {Comparison of Engine Exhaust Gas Pressure with Engine Intake Manifold #1 Pressure and Barometric Pressure}	[Absolute value of difference between Barometric Pressure and Engine Intake Manifold #1 Pressure > 4 psi (30 kPa)	Key ON	1 second
	AND Absolute value of difference between Engine Exhaust Gas Pressure and Barometric Pressure > 4 psi (30 kPa)	Time after Key ON > 0 seconds	
	AND Absolute value of difference between Engine Exhaust Gas Pressure and Engine #1 Intake Manifold Pressure.(IMP) > 4 psi (30 kPa)	Battery Voltage > 8.01 Volts AND < 16.99 Volts	
	AND Engine Wastegate Actuator Position Command] < 100 %	[1. Engine Speed < 50 RPM	
		2. Engine Fuel Mass Command < 10 mq/stk	
		3. Engine Wastegate Actuator Position Command < 100 %	
		4. Engine Throttle position < 10 %	
		5. Engine Exhaust Gas Recirculation Valve Position (EGR-P) Command < 40 %	
		Minimum time entry conditions (1) through (5) – mentioned above are satisfied] > 20 * 0.1 seconds	
		OR [Engine Speed	

FMI 31 – Altitude Reference Adder Fault (cont.)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		< 100 RPM	
		AND Engine Fuel Mass Command] < 100 mg/stk	
		SPN / FMI 102/3, 102/4, 108/3,108/4, 1209/3 and 1209/4 are NOT active	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines that it has exceeded 98 % CPU load.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN / FMI: 102/2, 102/7, 102/16, 102/18, 108/2, 628/12, 629/0, 629/12, 1209/0, 1209/1, 1209/7, and 1209/31.

Drive Cycle to Determine Fault Status

N/A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for fault codes. Is SPN 1387 FMI 31 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 1387 FMI 31. No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit, inspect connections at Exhaust Back Pressure (EBP) and Intake Manifold Pressure (IMP) sensors. With key OFF, disconnect EBP and IMP sensors. Check EBP and IMP sensors and connectors for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housings. Are the EBP and IMP sensor connectors, harnesses, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 1387 FMI 31.

Step	Action	Decision
4	Test EBP and IMP circuits for open, short, or high resistance conditions. Do EBP connector voltage checks and resistance checks (page 522) and IMP connector voltage checks and resistance checks (page 885). Are Barometric Absolute Pressure (BARO), EBP, and IMP circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 1387 FMI 31.

Step	Action	Decision
5	Test BARO, EBP, and IMP for intermittent circuit operation using EST with ServiceMaxx™ software. Do Key On Engine Off Continuous Monitor Test (page 87). Verify EBP and IMP sensor voltages are within specifications (page 1291). Are the sensor voltages within specifications (page 1291)?	Yes: After doing all diagnostic steps, if SPN 1387 FMI 31 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuits as required. After repairs are complete, retest for SPN 1387 FMI 31.

NOTE: After doing all diagnostic steps, if SPN 1387 FMI 31 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

ECT1 Sensor (Engine Coolant Temperature 1)

SPN	FMI	Condition	Possible Causes	Actions
110	2	ECT1 signal erratic, intermittent, or incorrect	• Biased ECT1 sensor or circuit	Pin-point Diagnostics (page 634)
110	3	ECT1 signal Out of Range HIGH	• ECT1 signal circuit OPEN or short to PWR • SIG GND circuit OPEN • Failed ECT1 sensor	Pin-point Diagnostics (page 636)
110	4	ECT1 signal Out of Range LOW	• ECT1 signal circuit short to GND • Failed ECT1 sensor	Pin-point Diagnostics (page 642)
110	7	ECT1 and EOT Temperature Conflict	• Radiator plugged • Coolant degraded • Coolant low • Thermostat stuck closed • Oil cooler under cooling	Step-based Diagnostics (SPN 110 FMI 7 - ECT1 and EOT Temperature Conflict, page 644)
110	17	Engine Coolant System Below OBD Monitoring Temperature	• Thermostat stuck open • Thermostat sticking • Engine fan stuck on • Large cabin heater	Step-based Diagnostics (page 648)
110	18	Engine Coolant System Below closed loop minimum temperature	• Thermostat stuck open • Thermostat sticking • Extended idle time • Engine fan stuck on • Large cabin heater	Step-based Diagnostics (page 652)
1659	20	ECT1 below expected: Check Thermostat	• Thermostat stuck open • Thermostat sticking • Auxiliary cab heaters • Cooling fan stuck on	Step-based Diagnostics (page 656)

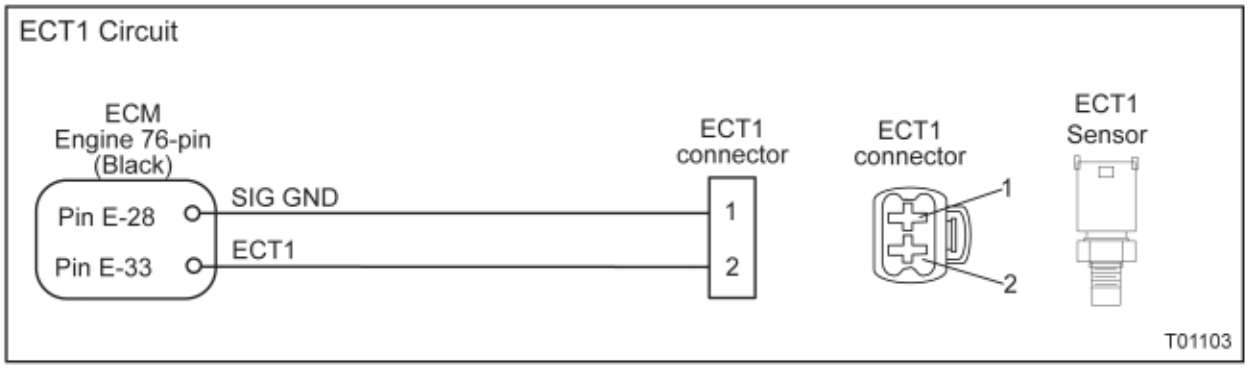


Figure 279 ECT1 Circuit Diagram

Overview

The ECT sensor provides a feedback signal to the ECM indicating engine coolant temperature. During engine operation, the ECM will monitor the ECT signal to control the following features:

- Engine Warning and Protection System (EWPS)
- Cold Ambient Protection (CAP)
- Idle Shutdown Timer (IST)
- Cold idle advance
- Coolant compensation

The EWPS is an optional feature that can be enabled or disabled. When the EWPS is enabled, the operator is warned of an overheat condition and, if programmed, will shutdown the engine.

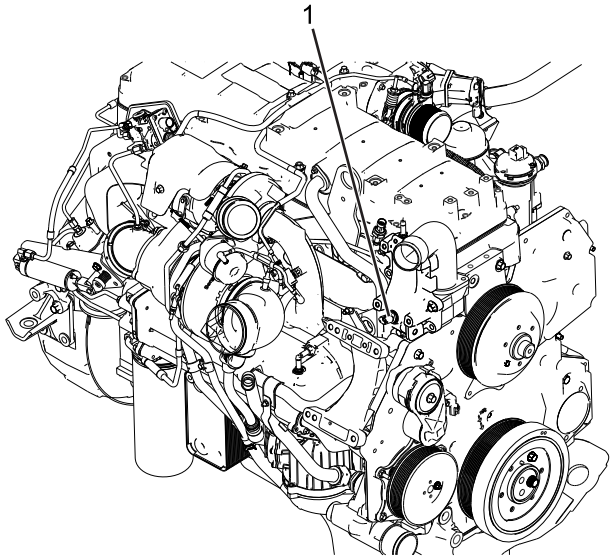


Figure 280 ECT1 Sensor Location

1. ECT1 sensor

Tools

- EZ Tech® Electronic Service Tool (EST) – J-45067 (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- 00-00956-08 – 180-pin Breakout Box (page 1222)
- 3-Banana Plug Harness (page 1228)
- Breakout Harness 4602 (ECT) (page 1230)
- International® Electronic Engine Terminal Test Kit (page 1227)

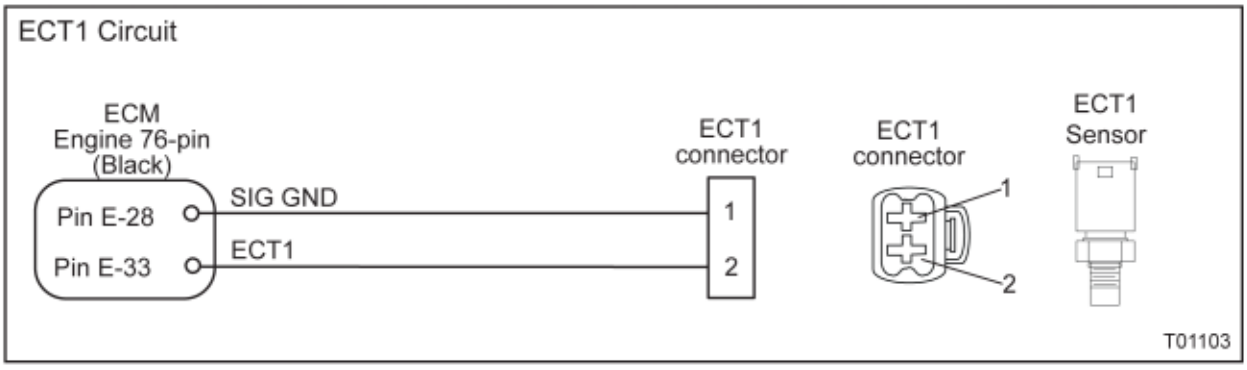


Figure 281 ECT1 Circuit Diagram

Pin-point Diagnostics

SPN 110 FMI 2 – ECT1 signal erratic, intermittent, or incorrect

Cold Soak Low Temperature Sensor Compare Check

Temperature values need to be measured after four hours cold soak.

1. Turn ignition switch ON, engine OFF
2. Using ServiceMaxx™ software, open the Continuous Monitor session.
3. Compare EOT with ECT1 and IMT. All temperature sensors should be within 59°F (15°C) of each other.
   - If any temperature sensor is above or below any other sensors. Check for biased temperature sensor circuit or failed temperature sensor.
   - If the circuits are acceptable, replace the failed temperature sensor.

SPN 110 FMI 7 – ECT1 and EOT Temperature Conflict

Cold Soak Sensor Compare Check

Temperature values need to be measured after four hours cold soak.

1. Turn ignition switch ON, engine OFF
2. Using ServiceMaxx™ software, open the Continuous Monitor session.
3. Compare Engine Coolant Temperature 1 (ECT1) to Engine Oil Temperature (EOT), Intake Manifold Temperature (IMT), Air Inlet Temperature (AIT), Charge Air Cooler Outlet Temperature (CACOT), and Aftertreatment Fuel Inlet Temperature (AFTFIT) sensors. All temperature sensors should be within 59°F (15°C) of each other.
   - If any temperature sensor is 59°F (15°C) above or below any other sensors. Check for biased temperature sensor circuit or failed temperature sensor.
   - If the circuits are acceptable, replace failed temperature sensor.

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST with ServiceMaxx™ software, open the Continuous Monitor session.
2. Monitor sensor voltage. Verify an active code for the sensor.
   - If code 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 code will go active.
   - If code is active, proceed to the next step.
3. Disconnect engine harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

4. Connect Breakout Harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect Breakout Harness 4602. Leave sensor disconnected. Turn ignition switch to ON. Use EST to verify correct code goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Specification	Comment
EST – Check code	SPN 110 FMI 3	If SPN 110 FMI 4 is active, check ECT signal for short to GND. Go to Harness Resistance Check.
EST – Check code Short 3-Banana Plug Harness across 2 and GND	SPN 110 FMI 4	If SPN 110 FMI 3 is active, check ECT signal for OPEN. Go to Harness Resistance Check.
EST – Check code Short 3-Banana Plug Harness across 1 and 2	SPN 110 FMI 4	If SPN 110 FMI 3 is active, check SIG GND for OPEN. Go to Harness Resistance Check.
If checks are within specification, connect sensor and clear codes. If active code remains, replace sensor.		

Connector Voltage Check

Connect Breakout Harness 4602. 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	4.6 to 5 V	If < 4.5 volts, check for OPEN or short to GND. Go to Harness Resistance Check.

Harness Resistance Check

Turn ignition switch to OFF. Disconnect ECM. Leave sensor disconnected. Connect 180-pin Breakout Box and Breakout Harness 4602. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
1 to E-28	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to E-33	< 5 Ω	If > 5 Ω, check for OPEN circuit.

SPN 110 FMI 2 - ECT1 signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Comparison of Engine Coolant Temperature 1 sensor to the following sensors after a calibrated adjustable cold-soak period (time). Sensor 1 to 4 are in Air group and 5 to 7 are in Liquid group. [1. Engine Intake Manifold 1 Temperature 2. Engine Air Intake Temperature 3. Engine Turbocharger 2 Compressor Intake Temperature 4. Engine Charge Air Cooler Outlet Temperature 5. Engine Coolant Temperature 6. Engine Oil Temperature 1 7. Engine Fuel Temperature 1]	{Engine Intake Manifold 1 Temperature (Bias Hi) > Reference temperature value. OR Engine Intake Manifold 1 Temperature (Bias low)} ≤ Reference temperature value. Error threshold value for comparison of sensors in same media (Air to Air media): Used for Equilibrium and Reference value calculation > 59°F (15°C) Error threshold value for comparison of sensors in different media (Air to Liquid media): Used for Equilibrium and Reference value calculation > 59°F (15°C) Error threshold value for comparison of sensors in same media (Liquid to Liquid): Used for Equilibrium and Reference value calculation > 59°F (15°C) Error threshold value for comparison of sensors in different media (Liquid to Air or vice versa): Used for Equilibrium and Reference value calculation > 59°F (15°C) {NOTE: Reference temperature value calculation is explained in Operations Summary Document}	Key ON Engine Off timer ≥ 28800 seconds Engine Coolant Temperature ≥ -40°F (-40°C) Engine in Thermal Equilibrium Condition {Explained in operations summary document} [Similar sensors agree with other sensors with different group-index OR Faulty Sensor is alone in its group {i.e. No other sensor which measures the same media (in Liquid Path) is identified as a faulty sensor}]

Fault Overview

ECM Compares Engine Coolant Temperature 1 (ECT1) sensor to Intake Air Temperature (IAT), Turbocharger 2 Compressor Intake Temperature (TC2CIT), Charge Air Cooler Outlet Temperature (CACOT), Intake Manifold Temperature (IMT), and Engine Oil Temperature (EOT) sensors after calibrated adjustable cold-soak period (time).

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Initial Key ON

Possible Causes

- Harness or circuit resistance
- Biased Engine Coolant Temperature 1 (ECT1) sensor at KOEO

Step 1	Check for active or pending fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 110 FMI 2. Is EST DTC list SPN 110 FMI 2 active or pending?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Inspect connections at Engine Coolant Temperature 1 (ECT1) connector.	Decision
A. Key OFF. B. Disconnect ECT1 connector. C. Check ECT1 and connector terminals for: damaged or pinched wires; moisture or corroded terminals; loose, bent, or broken pins; or broken connector housing. Are ECT1 connector, harness, and terminals clean and undamaged?		Yes: Go to Step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 110 FMI 2.

Step 3	Inspect connections at Engine Coolant Temperature 1 (ECT1) connector.	Decision
A. Key OFF. B. Connect Breakout Harness ZTSE4993 between pin-1 and pin-2 on ECT1 connector. C. Key-On Engine-Off (KOEO). Using EST with ServiceMaxx™ software, measure voltage between pin-1 and pin-2. Is voltage less than 0.5 volts?		Yes: Replace ECT1 sensor. After repairs are complete, retest for SPN 110 FMI 2. No: Go to step 4.

Step 3	Inspect connections at Engine Coolant Temperature 1 (ECT1) connector.	Decision
A. Key OFF. B. Connect Breakout Harness ZTSE4993 between pin-1 and known good GND. C. Key-On Engine-Off (KOEO). Using EST with ServiceMaxx™ software, measure resistance. Is resistance less than 5 ohms?		Yes: Repair ECT1 signal wire. After repairs are complete, retest for SPN 110 FMI 2. No: Repair ECT1 SIG GND wire. After repairs are complete, retest for SPN 110 FMI 2.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 110 FMI 2 fault code diagnostics.

SPN 110 FMI 3 - ECT1 Signal Out of Range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Engine Coolant Temperature 1 (ECT1) sensor signal reading is greater than expected.	ECT1 sensor voltage > 4.80 Volts	Key ON

Fault Overview

Fault code sets when Engine Control Module (ECM) detects ECT1 signal is greater than 4.80 volts.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive trips.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON

Possible Causes

- ECT1 signal circuit Open
- ECT1 signal circuit short to PWR
- SIG GND circuit Open

- Failed ECT1 sensor

Step 1	Check for active or pending fault code.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 110 FMI 3. Is EST DTC list SPN 110 FMI 3 active or pending?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Inspect connections at ECT1 sensor.	Decision
A. Key OFF. B. Disconnect ECT1 sensor connector. C. Check ECT1 sensor and connector terminals for damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECT1 sensor, connector, harness, and terminals clean and undamaged?		Yes: Perform Pin-Point Tests (SPN 110 FMI 3). (page 637) No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 110 FMI 3.

End Diagnostic Tests
After performing all diagnostic steps, if SPN 110 FMI 3 remains, verify if each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Pin-Point Tests (SPN 110 FMI 3)

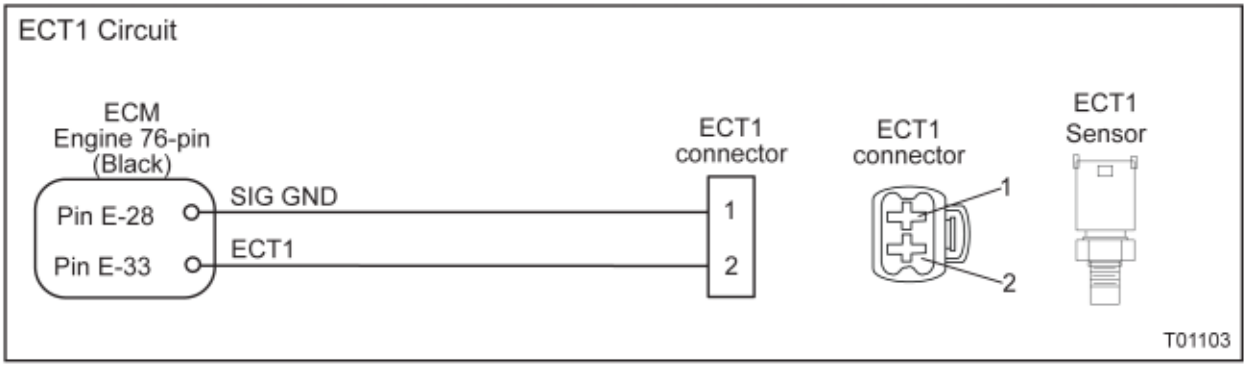


Figure 282 ECT1 Sensor Circuit Diagram

NOTE: See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4602
- Breakout Harness ZTSE4498
- Digital Multimeter (DMM) ZTSE4357

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

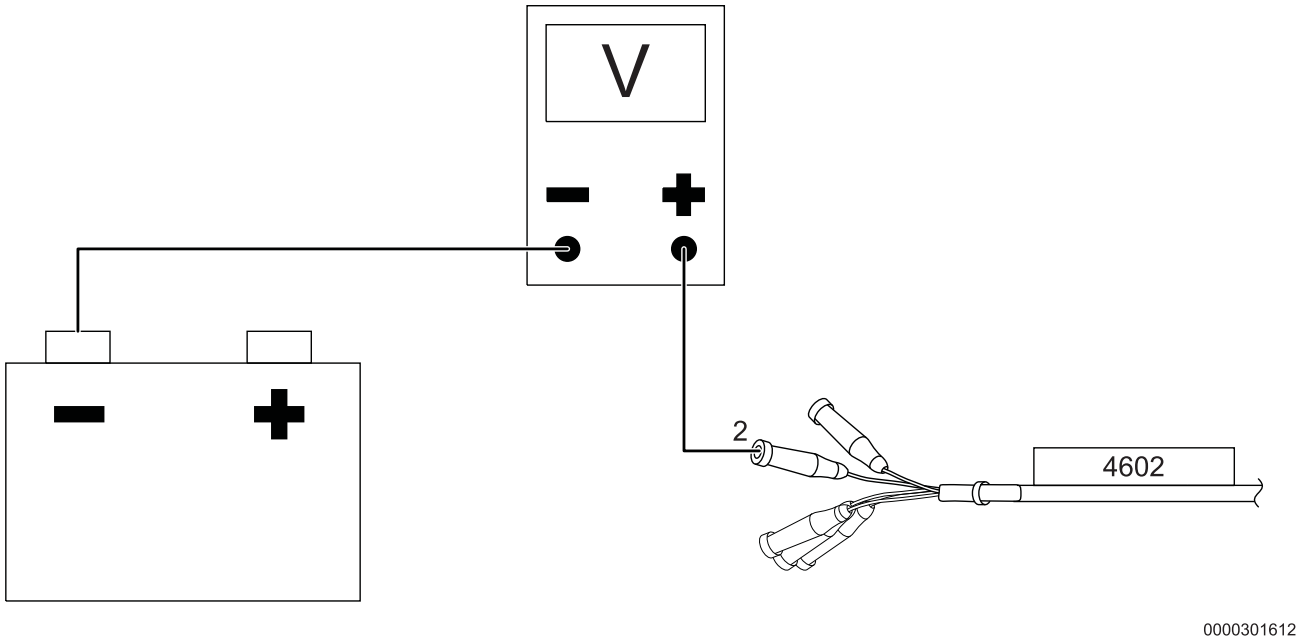
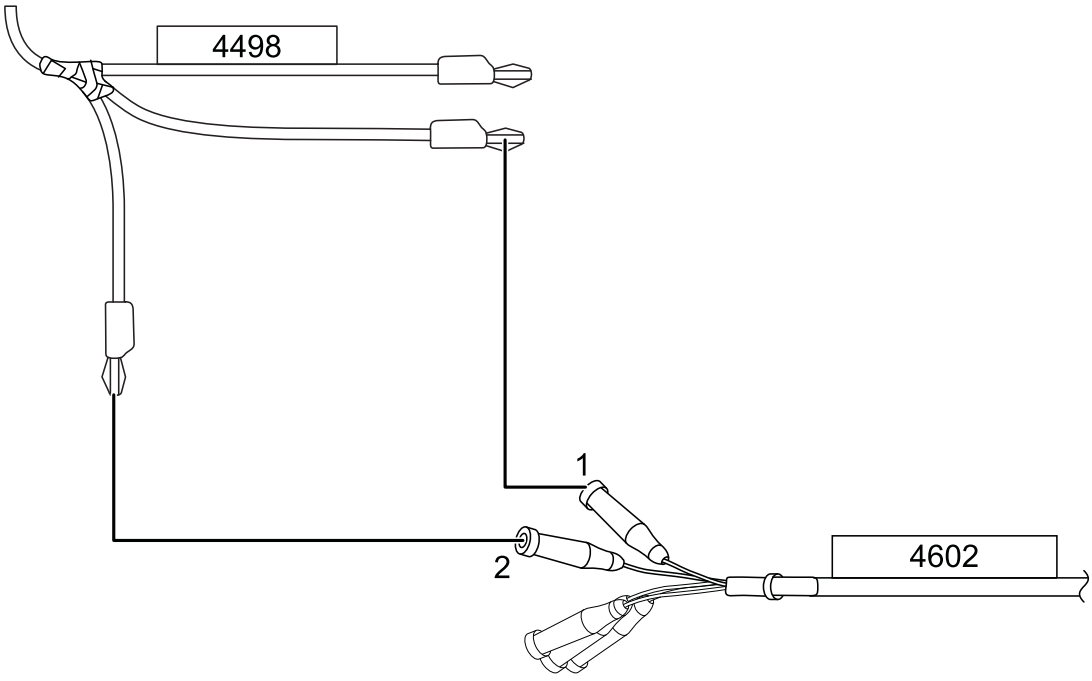


Figure 283 Test 1 ECT1 Sensor Circuit Check

Test 1 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4602 to vehicle harness and leave Engine Coolant Temperature 1 (ECT1) sensor disconnected. C. Key ON.

Test 1	Specification
Use a Digital Multimeter (DMM) to measure voltage between Breakout Harness ZTSE4602 pin-2 and known good ground.	< 6 volts
Decision	
Is voltage greater than 6 volts?	Yes: Repair short to power between ECT1 pin-2 and Engine Control Module (ECM) pin E-33. After repairs are complete, retest for SPN 110 FMI 3.
	No: Go to Test 2.



0000303783

Figure 284 Test 2 ECT1 Sensor Circuit Check

Test 2 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4602 to vehicle harness and leave ECT1 sensor disconnected. C. Using Breakout Harness ZTSE4498, short pin-1 and pin-2 of Breakout Harness ZTSE4602 together. D. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). E. Key ON. Log in to ServiceMaxx™

Test 2	Specification
Using EST with ServiceMaxx™, clear Diagnostic Trouble Code (DTC) list.	SPN 110 FMI 4 sets in DTC list.
Decision	
Does SPN 110 FMI 4 set after DTC list is cleared?	Yes: Replace ECT1 sensor. After repairs are complete, retest for SPN 110 FMI 3.
	No: Go to Step 3.

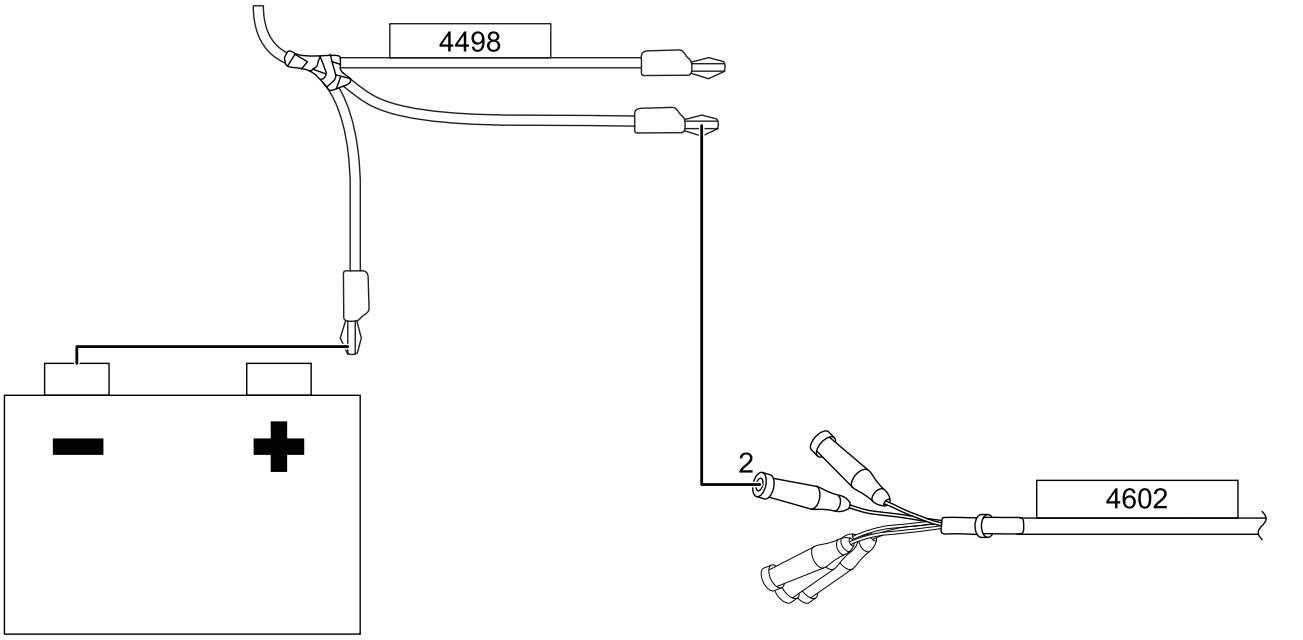


Figure 285 Test 3 ECT1 Sensor Circuit Check

Test 3 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4602 to vehicle harness and leave ECT1 sensor disconnected. C. Using Breakout Harness ZTSE4498, short pin-2 of Breakout Harness ZTSE4602 to ground. D. Connect EST to vehicle Diagnostic Connector. E. Key ON. Log in to ServiceMaxx™

Test 3	Specification
Using EST with ServiceMaxx™, clear DTC list.	SPN 110 FMI 4 sets in DTC list.
Decision	
Does SPN 110 FMI 4 set after DTC list is cleared?	Yes: Repair Open between ECT1 pin-1 and ECM pin E-28. After repairs are complete, retest for SPN 110 FMI 3.
	No: Repair Open between ECT1 pin-2 and ECM pin E-33. After repairs are complete, retest for SPN 110 FMI 3.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and the proper decision was made. Return to SPN 110 FMI 3 fault code diagnostics.

SPN 110 FMI 4 - ECT1 signal Out of Range LOW

Condition / Description	Setting Criteria	Enable Conditions / Values
Engine Coolant Temperature 1 Sensor Signal Out of Range Low	Engine Coolant Temperature 1 Sensor Voltage < 0.17 Volts (> 162.5 °C)	Key ON

Fault Overview

Fault code sets when Engine Control Module (ECM) detects that Engine Coolant Temperature 1 (ECT1) sensor signal voltage is less than .17 volts.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips. Time required: 2 seconds.

Associated Faults

SPN 3509 FMI 3 and 4 (VREF-1)

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON.

Possible Causes

- ECT1 circuit short to GND
- Failed ECT1 sensor

Step 1	Check for associated fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 3509 FMI 3 and 4 (VREF-1). Is EST DTC list free of SPN 3509 FMI 3 and 4?		Yes: Go to Step 2. No: Repair SPN 3509 FMI 3 and 4. After repairs are complete, retest for SPN 110 FMI 4.

Step 2	Inspect connections at Engine Coolant Temperature 1 (ECT1) sensor.	Decision
A. Key OFF. B. Disconnect ECT1 sensor connector. C. Check ECT1 sensor and connector terminals for damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECT1 sensor, connector, harness, and terminals clean and undamaged?		Yes: Perform pin-point tests SPN 110 FMI 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 110 FMI 4.

Pin-Point Tests (SPN 110 FMI 4)

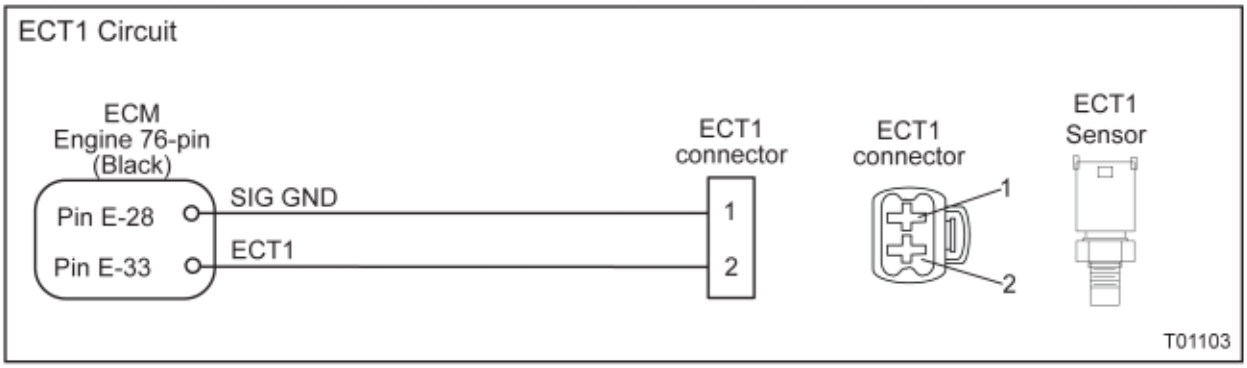


Figure 286 ECT1 Sensor Circuit Diagram

NOTE: See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

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

Test 1 Setup
A. Key OFF. B. Disconnect Engine Coolant Temperature 1 (ECT1) electrical connector. C. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). D. Key ON. Log into ServiceMaxx™ software.

Test 1	Specification
Using EST with ServiceMaxx™ software, clear Diagnostic Trouble Code (DTC) list.	DTC list SPN 110 FMI 3 sets
Decision	
Does SPN 110 FMI 3 set after DTC list is cleared?	Yes: Replace ECT1 sensor. After repairs are complete, retest for SPN 110 FMI 4.
	No: Repair short to GND between ECT1 connector pin-2 and ECM pin E-33. After repairs are complete, retest for SPN 110 FMI 4.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and the proper decision was made. Return to SPN 110 FMI 4 fault code diagnostics.

SPN 110 FMI 7 - ECT1 and EOT Temperature Conflict

FMI 7 – ECT1 and EOT Temperature Conflict

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
N/A			

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

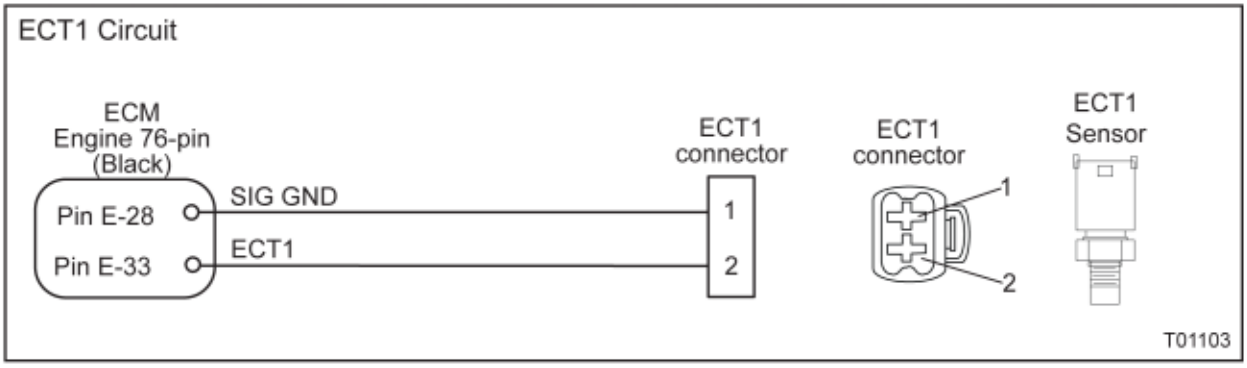


Figure 287 ECT1 Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for fault codes. Is SPN 110 FMI 7 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 110 FMI 7. No: Go to Step 3.

Step	Action	Decision
3	Park vehicle on level ground. Start 4 hour cold soak for step 9 below, while doing following steps. Check coolant level as indicated on deaeration tank level window. Is level below deaeration tank fill level?	Yes: Fill deaeration tank . After repairs are complete, retest for SPN 110 FMI 7. No: Go to Step 4.

Step	Action	Decision
4	Test Engine Coolant Temperature 1 (ECT1) and Engine Oil Temperature (EOT) circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 633). Are ECT1 and EOT circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 110 FMI 7.

Step	Action	Decision
5	Inspect vehicle grille for obstructions that may reduce air flow to the Charge Air Cooler (CAC). Is vehicle grille free of obstructions?	Yes: Go to Step 6. No: Repair or remove obstruction from grille. After repairs are complete, retest for SPN 110 FMI 7.

Step	Action	Decision
6	Check engine fan, fan shroud, and air dams for damage and proper operation. Are engine fan, fan shroud, and air dams intact and operating properly?	Yes: Go to Step 7. No: Repair or replace engine fan, fan shroud, and/or air dams. After repairs are complete, retest for SPN 110 FMI 7.

Step	Action	Decision
7	Check CAC for oil, dirt, or other debris. Do CAC checks . Is the CAC system free of dirt, debris, or oil?	Yes: Go to Step 8. No: Clean CAC. After repairs are complete, retest for SPN 110 FMI 7.

Step	Action	Decision
8	Remove and inspect oil cooler following the procedure in the *Engine Service Manual*. Is oil cooler clean and free of damage?	Yes: Go to Step 9. No: Replace oil cooler assembly. After repairs are complete, retest for SPN 110 FMI 7.

Step	Action	Decision
9	Do Cold Soak Sensor Compare Check (page 632). Compare ECT1 to EOT, Intake Manifold Temperature (IMT), Air Inlet Temperature (AIT), Charge Air Cooler Outlet Temperature (CACOT), and Aftertreatment Fuel Inlet Temperature (AFTFIT) sensors. All sensors should be within 59°F (15°C) of each other. Is ECT1 within 59°F (15°C) of the other sensors? Is EOT within 59°F (15°C) of the other sensors?	If both ECT1 and EOT are within 59°F (15°C), go to Step 10.
		If ECT1 is NOT within 59°F (15°C) of other sensors, replace ECT1 sensor. After repairs are complete, retest for SPN 110 FMI 7.
		If EOT is NOT within 59°F (15°C) of other sensors, replace EOT sensor. After repairs are complete, retest for SPN 110 FMI 7.
		If neither ECT1 or EOT are within 59°F (15°C) of any other sensors, replace ECT1 and EOT sensors. After repairs are complete, retest for SPN 110 FMI 7.

Step	Action	Decision
10	Determine if thermostat is stuck OPEN. Run engine after Step 9 has been completed and evaluated. Feel upper radiator hose and determine if warm coolant begins to flow before the thermostat opening temperature is reached. Does the upper radiator hose temperature stay cool after reasonable engine warm up time?	Yes: Go to Step 11.
		No: Remove and inspect thermostats following the procedure in the *Engine Service Manual*. After repairs are complete, retest for SPN 110 FMI 7.

Step	Action	Decision
11	Check for coolant overflowing deaeration tank or coolant degrading, Do Coolant Over Flow procedure (page 105). Did Coolant Over Flow procedure complete satisfactorily?	Yes: After doing all diagnostic steps, if SPN 110 FMI 7 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Do corrective actions described in the over flow procedure. After repairs are complete, retest for SPN 110 FMI 7.

NOTE: After doing all diagnostic steps, if SPN 110 FMI 7 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 110 FMI 17 - Engine Coolant System below OBD monitoring temperature

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Engine Coolant Temperature stuck in Range Low monitor	Engine coolant temperature < 104°F (40°C)	Key ON Modeled Engine Coolant Temp ≥ 104°F (40°C) Engine Coolant Temperature at Engine Startup ≥ 104°F (40°C) Engine Air Intake Temperature ≥ -40°F (-40°C) Engine Run Mode Active Timer > 120 seconds Exhaust Brake Position Control ≤ 99.97% NOT [{1. Mass of Fuel ≤ 28 mg/stk AND 2. Engine Speed} ≤ 740 RPM Condition 1 and 2 listed Above True for at least] ≥ 300 seconds Ambient Pressure {Calibrated Out} > 1.07 psi (7.363 kPa) Cold Ambient protection Mode Not active NOT in active regeneration PTO Mode NOT Active [{Percentage time spent below ≤ 740 RPM within a drive cycle} < 0.35 * 100% OR {Cumulative time spent below ≤ 740 RPM within a drive cycle] <300 seconds SPN / FMI 132/3, 132/4, 132/0, 132/1, 172/3, 172/4, 172/2, 1173/2, 2630/2, 108/3, 108/4, 4765/3, 4765/4, 110/3, 110/4, 110/2, 175/3, 1754, 175/2, 164/0, 164/3, 164/4, 651/4, 651/5, 652/4, 652/5, 653/4, 653/5, 654/4, 654/5, 655/4, 655/5, 656/4, 656/5, 5395/0, 5395/1, 1173/16, 651/14, 652/14, 653/14, 654/14, 655/14, 656/14, 1323/31, 1324/31, 1325/31, 1326/31, 1327/31, 1328/31, 1322/31, 110/18, 4257/0, 4257/1, 164/16, and 164/18 are NOT Active

Step	Action	Decision
6	Determine if thermostat is stuck OPEN. Run engine after Step 5 has been completed and evaluated. Feel upper radiator hose and determine if warm coolant begins to flow before the thermostat opening temperature is reached. Does the upper radiator hose temperature stay cool after reasonable engine warm up time?	Yes: After doing all diagnostic steps, if SPN 110 FMI 17 remains active, verify each step was completed correctly and proper decisions were made. Notify supervisor for further action.
		No: Remove and inspect thermostats following the procedure in the *Engine Service Manual*. After repairs are complete, retest for SPN 110 FMI 17.

Fault Overview

Fault sets when Engine Control Module (ECM) determines Engine Coolant Temperature 1 (ECT1) is stuck in Range Low monitor.

Lamp Reaction

Malfunction Indicator Lam (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

SPN 110 (ECT1)

Fault Facts

Drive Cycle to Determine Fault Status

Possible Causes

- Thermostat stuck open
- Engine fan stuck on
- Low coolant level
- EFC short to GND
- Failed ECT1

Step 1	Check for associated fault codes	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 110 (ECT1). Is EST DTC list free of SPN 110 ?		Yes: Go to Step 2.
		No: Repair SPN 110. After repairs are complete, retest for SPN 110 FMI 17.

Step 2	Check coolant level	Decision
Perform visual inspection of deaeration tank level. Is deaeration tank level between Cold level and Hot level?		Yes: Go to Step 3. No: Fill or drain deaeration tank to operating level. After repairs are complete, retest for SPN 110 FMI 17.

Step 3	Check for failed Engine Coolant Temperature 1 (ECT1)	Decision
Start and run engine. Using Digital IR Thermometer, ZTSE4799, measure ECT1 temperature sensor reading. Is thermometer reading within 10°F (-12.2°C) of ECT1 reading?		Yes: Go to Step 4. No: Replace ECT1 sensor. After repairs are complete, retest for SPN 110 FMI 17.

Step 4		Decision
With engine running, using Digital IR Thermometer, ZTSE4799, measure upper radiator hose temperature after thermostat has opened and compare to ECT1 sensor reading. Is thermometer reading on upper radiator hose within 5°F (-15°C) of ECT1 reading after thermostat opens?		Yes: Perform Pin-Point Tests(page 654). No: Replace thermostat. After repairs are complete, retest for SPN 110 FMI 17.

Pin-Point Tests (SPN 110 FMI 17)

Tools Required

- Breakout Harness ZTSE4908 (EFAN)
- Digital Multimeter (DMM)

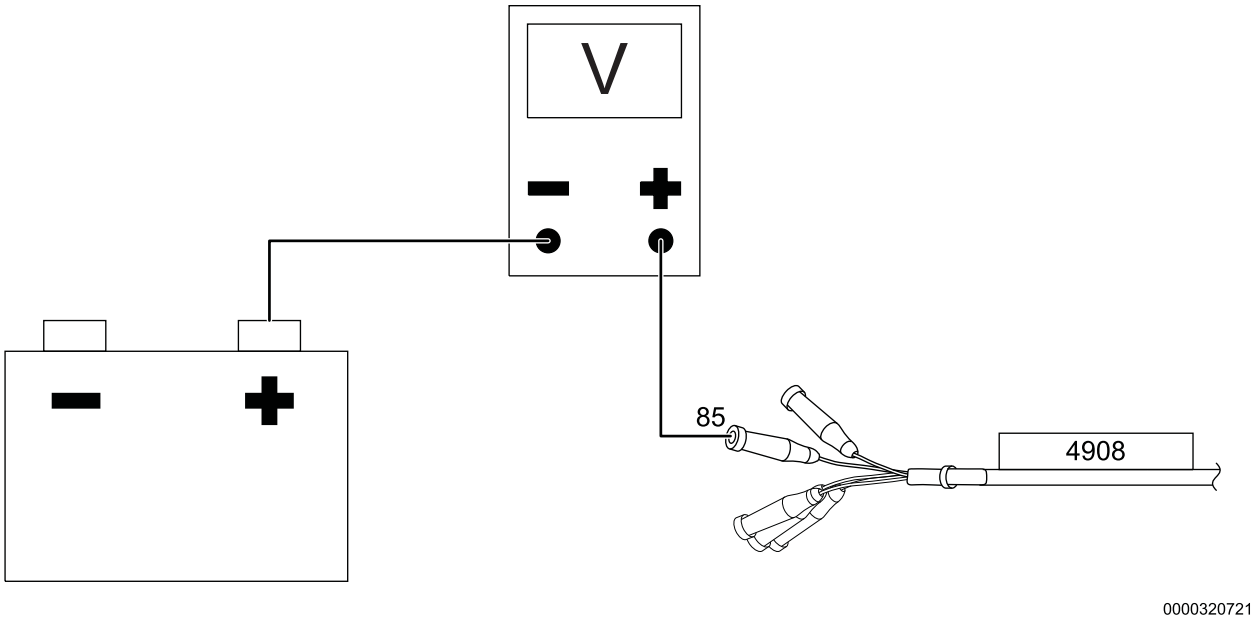


Figure 288 Test 1 Engine Fan Relay Circuit Voltage Check

Test 1 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4908 to relay vehicle harness connector and leave Engine Fan Relay disconnected. C. Key ON.

Test 1	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4908 pin-85 and PWR.	< 0.5 volts
Decision	
Is voltage less than 0.5 volts?	Yes: Diagnose fan clutch (See cooling system diagnostic manual. After repairs are complete, retest for SPN 110 FMI 17.
	No: Repair Short to GND between Engine Fan Relay pin-85 and Engine Control Module (ECM) pin C-58. After repairs are complete, retest for SPN 110 FMI 17.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and the proper decision was made. Return to SPN 110 FMI 17 fault code diagnostics.

SPN 110 FMI 18 - Engine Coolant System below closed loop minimum Temperature

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Minimum closed-loop coolant temperature not reached	Engine coolant temperature < 68°F (20°C)	Key ON Modeled Engine Coolant Temp> 68°F (20°C) Engine Coolant Temperature at Startup {Calibrated Out} ≤ 68°F (20°C) Engine Air Intake Temperature ≥ -40°F (-40°C) Engine Run Mode Active Timer > 120 seconds Exhaust Brake Position Control≤ 99.97% Ambient Pressure {Calibrated out} > 1.07 psi (7.363 kPa) Accumulated power {Calibrated Out} > -100 joules/second NOT [{1. Mass of Fuel ≤ 28 mg/stk AND 2. Engine Speed} ≤ 740 RPM Condition 1 and 2 listed Above True for at least] ≥ 300 seconds Cold Ambient protection Mode Not active NOT in active regeneration PTO Mode NOT Active [{Percentage time spent below ≤ 740 RPM within a drive cycle} < 0.35 *100% OR {Cumulative time spent below ≤ 740 RPM within a drive cycle] < 300 seconds SPN / FMI 132/3, 132/4, 132/0, 132/1, 172/3, 172/4, 172/2, 1173/2, 2630/2, 108/3, 108/4, 4765/3, 4765/4, 110/3, 110/4, 110/2, 175/3, 1754, 175/2, 164/0, 164/3, 164/4, 651/4, 651/5, 652/4, 652/5, 653/4, 653/5, 654/4, 654/5, 655/4, 655/5, 656/4, 656/5, 5395/0, 5395/1, 1173/16, 651/14, 652/14, 653/14, 654/14, 655/14,

		656/14, 1323/31, 1324/31, 1325/31, 1326/31, 1327/31, 1328/31, 1322/31, 4257/0, 4257/1, 164/16, 164/18, and 110/17 are NOT Active

Fault Overview

Fault sets when minimum closed-loop coolant temperature of < 68°F (20°C) is not reached.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is during two trips.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON

Possible Causes

- Thermostat stuck open
- Engine fan stuck on
- Low coolant level
- EFC Short to GND
- Failed ECT1

Step 1	Check for associated fault codes	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 110 FMI 17. Is EST DTC list free of SPN 110 FMI 17?		Yes: Go to Step 2. No: Repair SPN 110 FMI 17. After repairs are complete, retest for SPN 110 FMI 17.

Step 2	Check coolant level	Decision
Perform visual inspection of deaeration tank level. Is deaeration tank level between Cold level and Hot level?		Yes: Go to Step 3. No: Fill or drain deaeration tank to operating level. After repairs are complete, retest for SPN 110 FMI 17.

Step 3	Check for failed Engine Coolant Temperature 1 (ECT1)	Decision
Start and run engine. Using Digital IR Thermometer, ZTSE4799, measure ECT1 temperature sensor reading. Is thermometer reading within 10°F of ECT1 reading?		Yes: Go to Step 4. No: Replace ECT1 sensor. After repairs are complete, retest for SPN 110 FMI 17.

Step 4		Decision
With engine running, using Digital IR Thermometer, ZTSE4799, measure upper radiator hose temperature after thermostat has opened and compare to ECT1 sensor reading. Is thermometer reading on upper radiator hose within 5°F of ECT1 reading after thermostat opens?		Yes: Perform Pin-Point Tests(page 654). No: Replace thermostat. After repairs are complete, retest for SPN 110 FMI 17.

Pin-Point Tests (SPN 110 FMI 17)

Tools Required

- Breakout Harness ZTSE4908 (EFAN)
- Digital Multimeter (DMM)

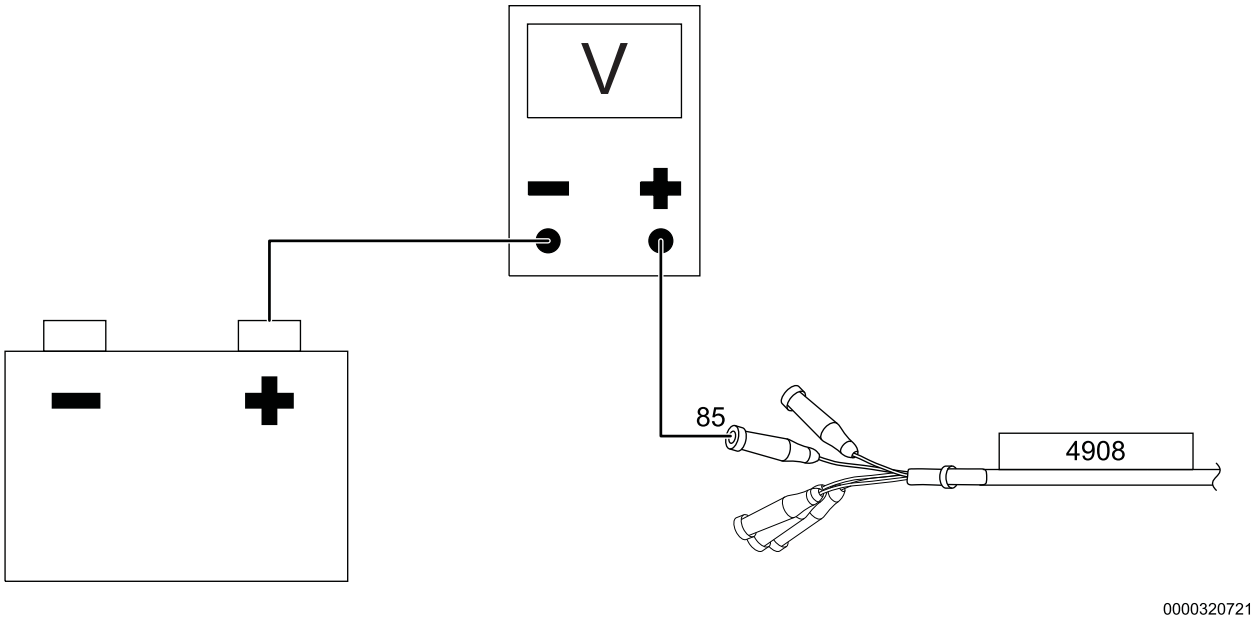


Figure 289 Test 1 Engine Fan Relay Circuit Voltage Check

Test 1 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4908 to relay vehicle harness connector and leave Engine Fan Relay disconnected. C. Key ON.

Test 1	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4908 pin-85 and PWR.	< 0.5 volts
Decision	
Is voltage less than 0.5 volts?	Yes: Diagnose fan clutch (See cooling system diagnostic manual. After repairs are complete, retest for SPN 110 FMI 18.
	No: Repair Short to GND between Engine Fan Relay pin-85 and Engine Control Module (ECM) pin C-58. After repairs are complete, retest for SPN 110 FMI 18.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and the proper decision was made. Return to SPN 110 FMI 18 fault code diagnostics.

SPN 1659 FMI 20 - ECT1 below expected: Check Thermostat

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Thermostat Monitor: Time to warm-up	Engine Coolant Temperature < 160°F (71°C)	Key ON Modeled Engine Coolant Temp > 180°F (82.11°C) Engine Air Intake Temperature ≥ 19.4°F (-7°C) Engine Speed ≥ 0 RPM Engine Coolant Temperature at Engine Startup ≥ 15.5°F (-9.16°C) AND ≤ 127.1°F (52.84°C) Ambient Pressure > 10.7 psi (73.63 kPa) Engine Run Mode Active Timer > 120 seconds Exhaust Brake Position Control ≤ 99.97% Accumulated power {Calibrated Out} > -100 joules/second NOT [{1. Mass of Fuel ≤ 28 mg/stk AND 2. Engine Speed} ≤ 740 RPM Condition 1 and 2 listed Above True for at least] ≥ 300 seconds [{Percentage time spent below ≤ 740 RPM within a drive cycle} < 0.35 * 100% OR {Cumulative time spent below ≤ 740 RPM within a drive cycle] < 300 seconds Cold Ambient protection Mode Not active NOT in active regeneration PTO Mode NOT Active Intake Air Heater OFF SPN / FMI 132/3, 132/4, 132/0, 132/1, 172/3,4, 172/2, 1173/2, 2630/2, 108/3,4, 4765/3,4, 110/3,4, 110/2, 175/3,4, 175/2, 164/0, 164/3,4, 651/4, 651/5, 652/4, 652/5, 653/4, 653/5, 654/4, 654/5, 655/4, 655/5,

		656/4, 656/5, 5395/0, 5395/1, 1173/16, 651/14, 652/14, 653/14, 654/14, 655/14, 656/14, 1323/31, 1324/31, 1325/31, 1326/31, 1327/31, 1328/31, 1322/31, 110/18, 4257/16, 4257/18, 164/16, 164/18, and 110/17 are NOT Active

Fault Overview

Lamp Reaction

Malfunction Indicator Lam (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

SPN 110 (ECT1)

Fault Facts

Drive Cycle to Determine Fault Status

Road Test

Possible Causes

- Thermostat stuck Open
- Engine fan stuck ON
- Low coolant level
- EF short to GND
- Failed ECT1

Step 1	Check for associated fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 110 (ECT1). Is EST DTC list free of SPN 110?		Yes: Go to Step 2. No: Repair SPN 110. After repairs are complete, retest for SPN 1659 FMI 20.

Step 2	Check coolant level	Decision
Perform visual inspection of deaeration tank level. Is deaeration tank level between Cold level and Hot level?		Yes: Go to Step 3. No: Fill or drain deaeration tank to operating level. After repairs are complete, retest for SPN 1659 FMI 20.

Step 3	Check for failed Engine Coolant Temperature 1 (ECT1)	Decision
Start and run engine. Using Digital IR Thermometer, ZTSE4799, measure ECT1 temperature sensor reading. Is thermometer reading within 10°F (-12.2°C) of ECT1 reading?		Yes: Go to Step 4. No: Replace ECT1 sensor. After repairs are complete, retest for SPN 1659 FMI 20.

Step 4		Decision
With engine running, using Digital IR Thermometer, ZTSE4799, measure upper radiator hose temperature after thermostat has opened and compare to ECT1 sensor reading. Is thermometer reading on upper radiator hose within 5°F (-15°C) of ECT1 reading after thermostat opens?		Yes: Perform Pin-Point Tests(page 658). No: Replace thermostat. After repairs are complete, retest for SPN 1659 FMI 20.

Pin-Point Tests (SPN 1659 FMI 20)

Tools Required

- Breakout Harness ZTSE4908 (EFAN)
- Digital Multimeter (DMM)

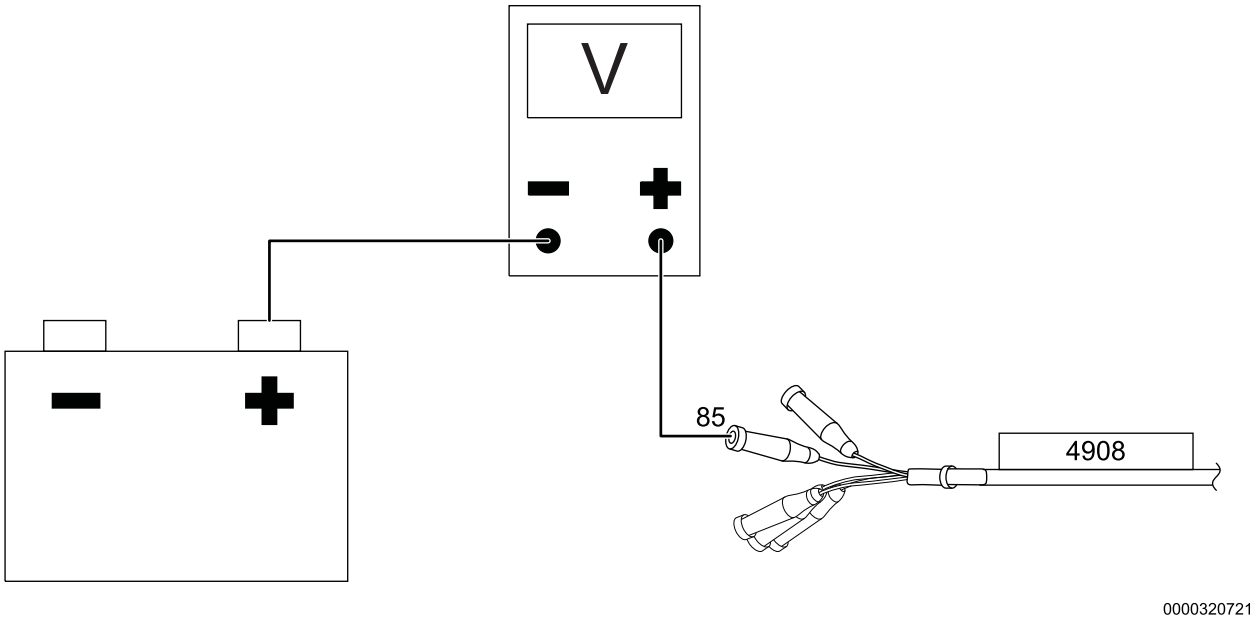


Figure 290 Test 1 Engine Fan Relay Circuit Voltage Check

Test 1 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4908 to relay vehicle harness connector and leave Engine Fan Relay disconnected. C. Key ON.

Test 1	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4908 pin-85 and PWR.	< 0.5 volts
Decision	
Is voltage less than 0.5 volts?	Yes: Diagnose fan clutch (See cooling system diagnostic manual. After repairs are complete, retest for SPN 1659 FMI 20.
	No: Repair Short to GND between Engine Fan Relay pin-85 and Engine Control Module (ECM) pin C-58. After repairs are complete, retest for SPN 1659 FMI 20.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and the proper decision was made. Return to SPN 1659 FMI 20 fault code diagnostics.

EFC (Engine Fan Control)

SPN	FMI	Condition
None		

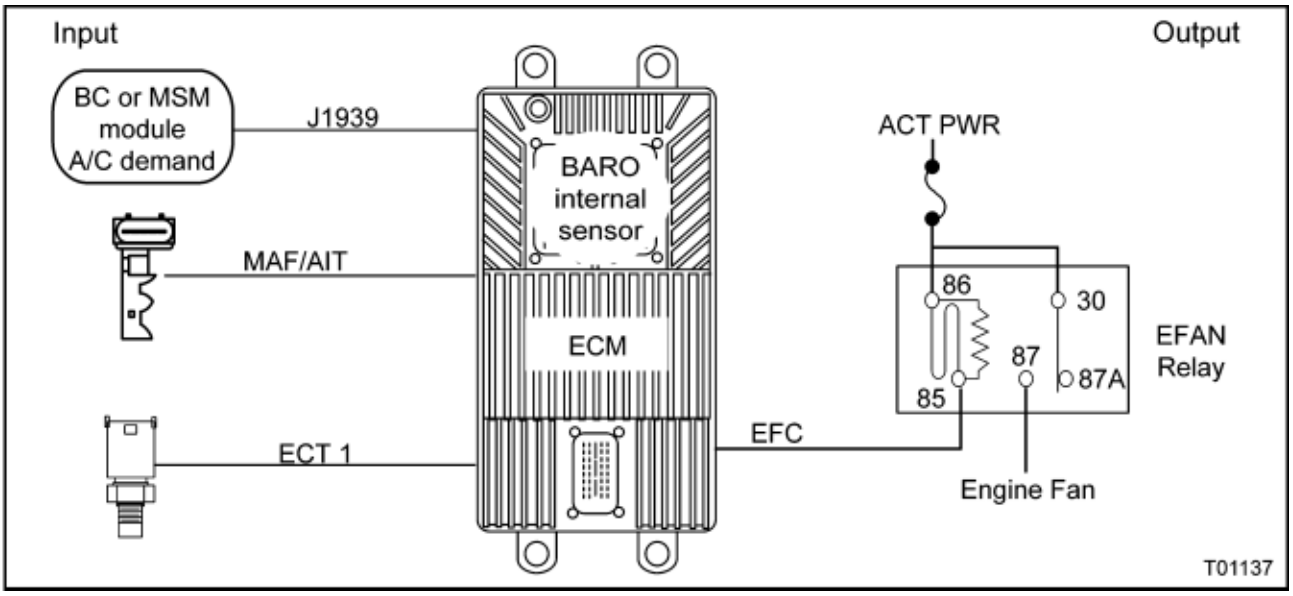


Figure 291 Function diagram for EFC

The function diagram for EFC includes the following:

- Engine Control Module (ECM)
  with Barometric Absolute Pressure (BARO) Internal Sensor
- Engine Fan Control (EFC)
- Body Controller (BC)
- Multiplex System Module (MSM)
- Engine Coolant Temperature (ECT) Sensor
- Air Inlet Temperature (AIT) signal from the Mass Air Flow (MAF) Sensor
- Engine Fan Control (EFC) relay

Function

The purpose of the engine fan is to allow a higher airflow through the radiator when the Air Condition (A/C) is on or when the ECT or AIT goes above a set temperature.

Location

The relay and switches are vehicle mounted parts. For additional supporting information, see truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide*.

Tools

- Digital Multimeter (DMM) (page 1224)

- 00-00956-08 – 180-pin Breakout Box (page 1222)
- Breakout Harness 4674 (EFC) (page 1231)
- International® Electronic Engine Terminal Test Kit (page 1227)

EFC Circuit Diagnostics

SPN	FMI	Condition	Possible Causes
None		Engine Fan does not operate	• EFC relay control circuit OPEN or shorted to GND • EFC relay coil GND circuit OPEN • Blown fuse • Failed relay

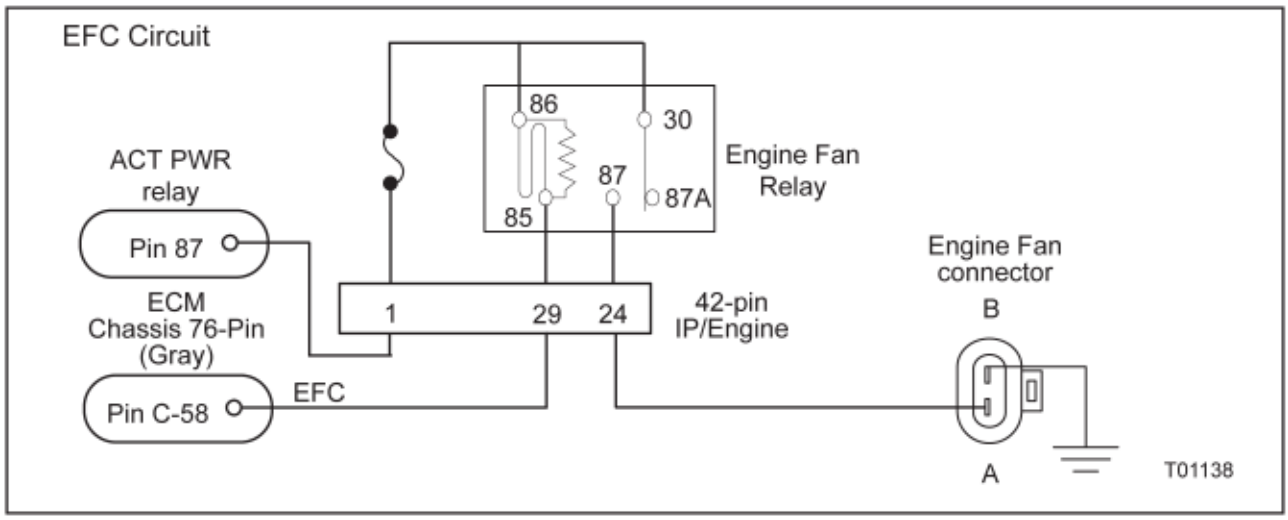


Figure 292 EFC circuit diagram

Voltage Check at EFC Connector – Output State Test

Disconnect EFC 2-pin connector. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment: < Less than, > Greater than
A to GND	0 to 0.25 V	If > 0.25 volts, check for short to PWR or EFC circuit for short to GND, or failed EFC relay.
B to GND	0 to 0.25 V	If > 0.25 volts, check for OPEN circuit.
Run Output State Test HIGH.		
A to GND	0 to 0.25 V	If > 0.25 volts, check for short to PWR, or EFC circuit for short to GND, or failed EFC relay.
Run Output State Test LOW.		
A to GND	B+	If < B+, check for OPEN circuit between relay and EFC, or EFC circuit for OPEN, or blown fuse, or failed relay. Go to Harness Resistance Check.
A to B	B+	If < B+, check GND for OPEN circuit. Do Harness Resistance Check.

Voltage Check at Relay – Output State Test

Connect Breakout Harness 4674 between relay and relay socket. Connect EFC and turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment: < Less than, > Greater than
30 to GND	B+	If < B+, check PWR circuit to relay switch for OPEN or short to GND, or blown fuse. See ACT PWR Relay.
86 to GND	B+	If < B+, check PWR circuit to relay coil for OPEN or short to GND, or blown fuse. See ACT PWR Relay.
Run Output State Test HIGH.		
85 to GND	B+	If < B+, check EFC circuit for short to GND. Go to Harness Resistance Check.
Run Output State Test LOW.		
85 to GND	0.06 to 2 V	If > 2 volts, check EFC circuit for OPEN. Go to Harness Resistance Check.
87 to GND	B+	If < B+, replace relay.

Harness Resistance Check

Turn ignition switch to OFF. Disconnect ECM. Leave relay disconnected. Connect 180-pin Breakout Box and relay harness.

Test Point	Specification	Comment: < Less than, > Greater than
C-58 to 85	< 5 Ω	If > 5 Ω, check for OPEN circuit between ECM and relay terminal.
87 to A (fan)	< 5 Ω	If > 5 Ω, check for OPEN circuit between relay terminal and A (fan).
30 to ACT PWR relay 87	< 5 Ω	If > 5 Ω, check ACT PWR for OPEN in circuit.
30 to GND	> 1 kΩ	If < 1 kΩ, check ACT PWR for short to GND.
86 to ACT PWR relay 87	< 5 Ω	If > 5 Ω, check ACT PWR for OPEN in circuit.
86 to GND	> 1 kΩ	If < 1 kΩ, check ACT PWR for short to GND.
See truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for fuse information.		

EFC Circuit Operation

The default state of the EFC is ON. B+ is needed to turn the fan OFF.

ECM Pin C-58 controls the EFC to shut off by supplying a ground path to the EFC relay coil Pin 85. ACT PWR powers the other side of the relay coil, Pin 86. ACT PWR is sent through the relay switch, which deactivates the EFC.

EFC Programmable Parameters

By using an EST, an authorized service technician can program the ECM to turn the EFC on for any desired temperature.

- Engine fan control – indicates to the on-board electronics whether or not the truck has the electronic engine fan control feature.
- A/C fan activation – allows fan activation through the ECM when requested from the BC during A/C operation.
- Disable – enables or disables the EFC feature.
- Fan on temperature – indicates at what coolant temperature the fan will be electronically activated.
- Fan off temperature – indicates at what coolant temperature the fan will be electronically deactivated.

Fault Detection / Management

An open or short to GND in the EFC can be detected by the ECM during an on-demand engine standard test. The AIT and ECT are continuously monitored. If a code is detected in the AIT or ECT circuit, the EFC is disabled and the engine fan remains on.

NOTE: Before diagnosing, verify that the vehicle has an electronic fan and that the ECM is programmed correctly.

EFP (Electric Fuel Pump)

SPN	FMI	Condition
94	0	Fuel Delivery Pressure above Critical (page 669)
94	1	Fuel Delivery Pressure below Critical (page 670)
931	3	EFP short to PWR (page 672)
931	4	EFP open load / circuit or short to GND (page 673)
931	11	EFP operation fault
931	19	EFP not detected on J1939

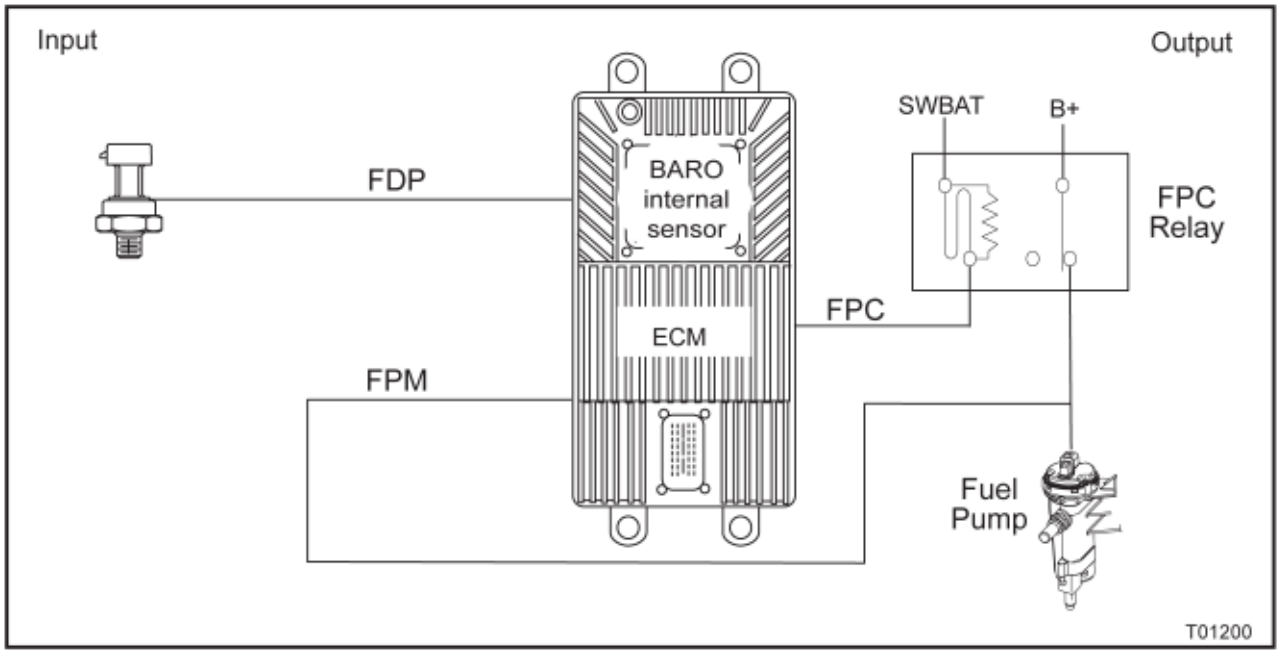


Figure 293 Function diagram for the EFP

The function diagram for the EFP includes the following:

- Engine Control Module (ECM)
  with Barometric Absolute Pressure (BARO) Internal Sensor
- Electric Fuel Pump (EFP)
- Fuel Pump Monitor (FPM)
- FDP Sensor

Function

The EFP supplies fuel to the engine at approximately 90 psi (620 kPa). The ECM drives the fuel pump directly, using H-Bridge driver.

NOTE: The Fuel Delivery Pressure (FDP) sensor is only capable of measuring up to 75 psi (517 kPa) of pressure, even though fuel pressure normally operates at 90 psi (621 kPa).

EFP Location

The EFP is located in the fuel filter module.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- 00-00956-08 – 180-pin Breakout Box (page 1222)
- Breakout Harness 6023 (EFP)
- Breakout Harness 4674 (Relay) (page 1231)
- ZTSE4681 – Fuel Pressure Gauge (page 1249)
- ZTSE4657 – Fuel Pressure Test Kit (page 1250)
- International® Electronic Engine Terminal Test Kit (page 1227)

EFP Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
94	0	Fuel Delivery Pressure (FDP) above Critical	• FDP above 145 psi (1000 kPa) with engine running • Restricted fuel regulator • Restricted fuel return line
94	1	Fuel Delivery Pressure below Critical	• FDP below 70 psi (483 kPa) • Dirty fuel filter • Aerated fuel • Restricted or open fuel supply line • Low or empty fuel supply tank • Biased low FDP sensor signal • Failed fuel pump
931	3	EFP short to PWR	• FPM circuit OPEN or short to PWR • Failed relay • Relay short to GND
931	4	EFP open load / circuit or short to GND	• FPM or Fuel Pump PWR circuit OPEN or short to GND • Failed relay
931	19	EFP not detected on J1939	• Open or shorted CAN circuit to fuel pump • Failed fuel pump

SPN 94 FMI 0 – Fuel Delivery Pressure above Critical

1. Connect Fuel Pressure Gauge and Fuel Pressure Test Adapter to fuel pressure test port at the intake manifold.
2. Turn ignition switch to ON. The fuel pump will run for 10 seconds.
3. Monitor Fuel Pressure Gauge while fuel pump is commanded ON.
   - If pressure is above 130 psi (896 kPa), check for restricted fuel regulator or fuel return line. See Fuel System (page 803).

SPN 94 FMI 1 – Fuel Delivery Pressure below Critical

1. Connect Fuel Pressure Gauge and Fuel Pressure Test Adapter to fuel pressure test port at the intake manifold.
2. Turn ignition switch to ON. The fuel pump will run for 10 seconds.
3. Monitor Fuel Delivery Pressure signal in ServiceMaxx™ software while fuel pump is commanded ON.
4. Monitor Fuel Pressure Gauge while fuel pump is commanded ON.
   - If Fuel Pressure Gauge displays pressure above 75 psi (517 kPa) and ServiceMaxx™ software displays pressure below 70 psi (483 kPa), check FDP sensor / circuit for fault. See FDP sensor in this section.
   - If Fuel Pressure Gauge displays pressure below 75 psi (517 kPa), continue to Fuel Pump Operational Check.

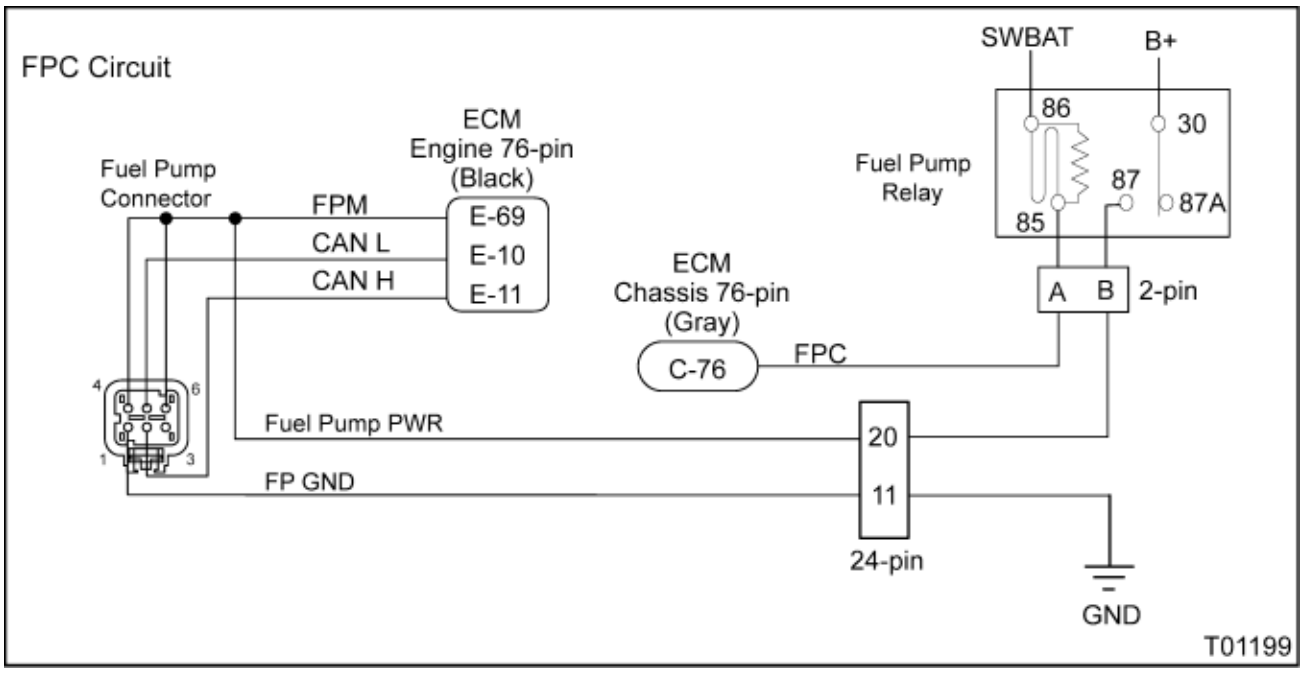


Figure 294 EFP Circuit Diagram

Voltage Checks at Relay

Connect Breakout Harness 4674 between relay and relay socket. Turn ignition switch ON. The fuel pump will only run for 10 seconds with switch in the ON position and with engine not running. Use DMM to measure voltage.

Test Point	Specification	Comment: < Less than, > Greater than
86 to GND	B+	If 0 volts, check power circuit to relay coil for OPEN or short to GND, or blown fuse. If < B+, check for failed circuitry between batteries and relay. Go to Harness Resistance Check.
30 to GND	B+	If 0 volts, check power circuit to relay switch for OPEN or short to GND, or blown fuse. If < B+, check for failed circuitry between batteries and relay. Go to Harness Resistance Check.
85 to GND	0 to 2 V	If > 2 volts, check EFP control circuit for OPEN or short to PWR. Go to Harness Resistance Check.
87 to GND	B+	If < B+, replace relay.

Fuel Pump Operational Check

Use DMM to measure voltage

Test Point	Specification	Comment: < Less than, > Greater than
1 to 4	B+	If < B+, check for circuit fault. Continue to Harness Voltage Checks.
1 to 6	B+	If < B+, check for circuit fault. Continue to Harness Voltage Checks.
1 to 2	2.5 V	If < 2.5 volts, check for circuit fault. Continue to Harness Voltage Checks.
1 to 5	2.5 V	If < 2.5 volts, check for circuit fault. Continue to Harness Voltage Checks.
If voltage is present when fuel pump is commanded ON, but fuel pressure gauge is below 70 psi (483 kPa), go to Fuel System (page 803) procedures.		

Harness Voltage Checks

Connect Breakout Harness 6023 to engine harness and leave pump fuel disconnected. Turn the ignition switch to the ON position. Fuel pump will only run for 10 seconds before commanded OFF. Use DMM to measure voltage.

Test Point	Specification	Comment: < Less than, > Greater than
1 to B+	B+	If < B+, Check for OPEN in EFP ground circuit.
4 and 6 to GND Checks	B+	If < B+, Check for OPEN EFP circuit or failed relay. Go to FP relay.

Harness Resistance Check

Connect Breakout Harness 6023 to engine harness and leave pump fuel disconnected. Connect Breakout Harness 4674 to relay and leave relay disconnected. Connect Breakout Box to ECM and leave ECM disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
4 and 6 to FP relay 87	< 5 Ω	If > 5 Ω, check for OPEN in fuel pump circuit.
4 and 6 to E-69	< 5 Ω	If > 5 Ω, check for OPEN in fuel pump monitor circuit.
1 to GND	< 5 Ω	If > 5 Ω, check for OPEN in fuel pump ground circuit.
C-76 to FP relay 85	< 5 Ω	If > 5 Ω, check for OPEN in fuel pump control circuit.
2 to E-11	< 5 Ω	If > 5 Ω, check for OPEN in CAN H circuit.
5 to E-10	< 5 Ω	If > 5 Ω, check for OPEN in CAN L circuit.

EFP Circuit Operation

The FDP sensor is a variable capacitance sensor supplied with a 5-volt VREF at Pin 2 from ECM Pin E-35. The sensor is grounded at Pin 1 from ECM Pin E-28. The sensor returns a variable voltage signal from Pin 3 to ECM Pin E-32.

Fault Detection / Management

The ECM continuously monitors the control system. If the sensor signal is higher or lower than expected, the ECM disregards the sensor signal and uses a calibrated default valve. The ECM will set a code, turn on the engine lamp, and run the engine in a default range.

SPN 94 FMI 0 - Fuel Delivery Pressure above Critical

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Fuel Delivery Pressure (FDP) is greater than expected.	FDP > 120 psi (827 kPa)	Key-On Engine-Running (KOER)

Fault Overview

Fault code sets when Fuel Delivery Pressure (FDP) is greater than 120 psi (827 kPa).

Lamp Reaction

No Malfunction Indicator Lamp (MIL) reaction.

Associated Faults

SPN 94 FMI 3 and 4

Fault Facts

This fault is used to detect installation of a 2010 [0 - 75 psi (0 - 517 kPa)] FDP sensor in a 2013+ [0 - 135 psi (0 - 931 kPa)] engine.

Drive Cycle to Determine Fault Status

Key-On Engine-Running (KOER)

Possible Causes

- Incorrect FDP sensor installed

Step 1	Check for associated fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 FMI 3 and 4 (FDP). Is EST DTC list free of SPN 94 FMI 3 and 4?		Yes: Go to Step 2. No: Repair SPN 94 FMI 3 and 4. After repairs are complete, retest for SPN 94 FMI 0.

Step 2	Monitor FDP sensor value using EST with ServiceMaxx™.	Decision
With Key-On Engine-Running (KOER), use EST with ServiceMaxx™ software to monitor FDP sensor value. Is FDP steady and above 120 psi (827 kPa)?		Yes: Replace FDP sensor with correct part number for engine. After repairs are complete, retest for SPN 94 FMI 0. No: Retest for SPN 94 FMI 0.

End Diagnostic Steps
After performing all diagnostic steps, if SPN 94 FMI 0 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

SPN 94 FMI 1 - Fuel Delivery Pressure below Critical

Condition / Description	Setting Criteria	Enable Conditions / Values
Fuel Delivery Pressure (FDP) below critical.	FDP < 30 psi in 10 seconds	Key-On Engine-Running (KOER)

Fault Overview

Fault code sets when Electronic Control Module (ECM) detects that Fuel Delivery Pressure (FDP) is below 30 psi (207 kPa).

Lamp Reaction

1 Trip MIL Active

Associated Faults

SPN 931 FMI 4 (EFP); SPN 94 FMI 18 (FDP)

Fault Facts

ICP is limited with this fault.

Drive Cycle to Determine Fault Status

Fuel Delivery Pressure (FDP) < 30 psi (207 kPa)

Possible Causes

- Recent fuel system service requiring priming
- Vehicle unused for long period of time requiring priming
- Diesel fuel
- Failed Fuel Pressure Regulator (FPR)
- Low fuel level in either tank (defective fuel level gauge or transfer pump)
- Restricted fuel supply line
- Restricted pickup tube in fuel tank
- Failed or incorrectly installed secondary fuel filter
- Failed Engine Fuel Pump (EFP)
- EFP circuit Open or high resistance
- EFP GND circuit Open

1. Key-On Engine-Off (KOEO).
2. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81).

Step 1	Check Fault Code Status	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 FMI 1 (EFP). Is SPN 94 FMI 1 pending or active?		Yes: Go to Fuel Fuel Delivery Pressure symptom (page 181). No: Repair SPN 94 FMI 1. After repairs are complete, retest SPN 94 FMI 1.

End Diagnostic Steps
After performing all diagnostic steps, if SPN 94 FMI 1 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

SPN 931 FMI 3 - EFP short to PWR

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Engine Fuel Pump (EFP) Power Supply Circuit Shorted to High Source	Diagnostic input Pin E-69 is set to 1	Key ON
		Fuel Pump relay has been commanded off by Engine Control Module (ECM) for time ≥ 2 seconds

Fault Overview

Lamp Reaction

Malfunction Indicator Lam (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

Fault Facts

Drive Cycle to Determine Fault Status

Key ON Engine OFF (fuel pump commanded OFF)

Possible Causes

- Relay stuck ON
- Relay control wire shorted to GND
- Relay output SCB

Step 1	Check Fault Code Status	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 931 FMI 3 (EFP).		Yes: Go to Fuel Fuel Delivery Pressure symptom (page 181).
Is SPN 931 FMI 3 pending or active?		No: Repair SPN 931 FMI 3. After repairs are complete, retest SPN 931 FMI 3.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 931 FMI 3 fault code diagnostics.

SPN 931 FMI 4 - EFP open load / circuit or short to GND

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Engine Fuel Pump (EFP) Power Supply Circuit Shorted to Low Source or Open	Diagnostic input Pin E-69 is set to 0 {No Voltage}	Key ON Fuel Pump relay has been commanded on by Engine Control Module for time ≥ 2 seconds

Fault Overview

Fault sets when Engine Control Module (ECM) Engine Fuel Pump (EFP) power supply circuit is Shorted to low source or Open.

Lamp Reaction

Malfunction Indicator Lam (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON and fuel pump commanded ON.

Possible Causes

- Fuel Pump relay open contacts
- Open wire from B+ to relay or Blown fuse
- Relay control wire open circuit
- EFP power wire open circuit
- EFP monitoring wire open circuit

Step 1	Check Fault Code Status	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 931 FMI 4 (EFP). Is SPN 931 FMI 4 pending or active?		Yes: Go to Fuel Fuel Delivery Pressure symptom (page 181). No: Repair SPN 931 FMI 4. After repairs are complete, retest SPN 931 FMI 4.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and the proper decision was made. Return to SPN 931 FMI 4 fault code diagnostics.

EGR Actuator (Exhaust Gas Recirculation)

SPN	FMI	Condition	Possible Causes	Actions
27	0	Exhaust Gas Recirculation Pressure (EGRP) fault: over temperature	• Exhaust Gas Recirculation (EGR) over heated • Low coolant flow through EGR • Failed EGR Cooler • Failed EGR valve	Pin-point Diagnostics (page 679)
27	3	EGRP signal Out of Range HIGH	• B+ over 18 volts to EGR valve • Jump start with 24-volt system or generator • Defective alternator • Battery charger on boost mode	Diagnostics are same as SPN 2791 FMI 3. See Step-based Diagnostics (page 692).
27	4	EGRP signal Out of Range LOW	• EGR valve defective power connection • High resistance contacts • Low battery voltage • Defective charging system	Diagnostics are same as SPN 2791 FMI 4. See Step-based Diagnostics (page 693).
27	7	EGRP does not agree with commanded position	• EGR valve motor internal duty cycle > 95 % • EGR valve motor stuck • Deposits on EGR valve • Stuck or sticking EGR valve	Diagnostics are same as SPN 2791 FMI 7. See Step-based Diagnostics (page 696).
27	14	EGR internal circuit failure	• EGR valve unable to seat closed • Stuck or sticking EGR valve	Diagnostics are same as SPN 2791 FMI 14. See Step-based Diagnostics (page 700).
2791	2	EGR valve communication fault	• EGR-P circuit fault • Failed EGR valve	Step-based Diagnostics (page 683)

SPN	FMI	Condition	Possible Causes	Actions
2791	3	EGRC short to PWR	• B+ over 18 volts to EGR valve • Jump start with 24-volt system or generator • Defective alternator • Battery charger on boost mode	Step-based Diagnostics (page 692)
2791	4	EGRC short to GND	• EGR valve defective power connection • High resistance contacts • Low battery voltage • Defective charging system	Step-based Diagnostics (page 693)
2791	7	EGR Valve unable to achieve commanded position	• EGR valve motor internal duty cycle > 95 % • EGR valve motor stuck • Deposits on EGR valve • Stuck or sticking EGR valve	Step-based Diagnostics (page 696)
2791	8	EGR valve not receiving ECM PWM signal	• EGR-C circuit fault • Failed EGR valve	Step-based Diagnostics (page 698)
2791	14	EGR valve Initialization Fault	• EGR valve unable to seat closed • Stuck or sticking EGR valve	Step-based Diagnostics (page 700)

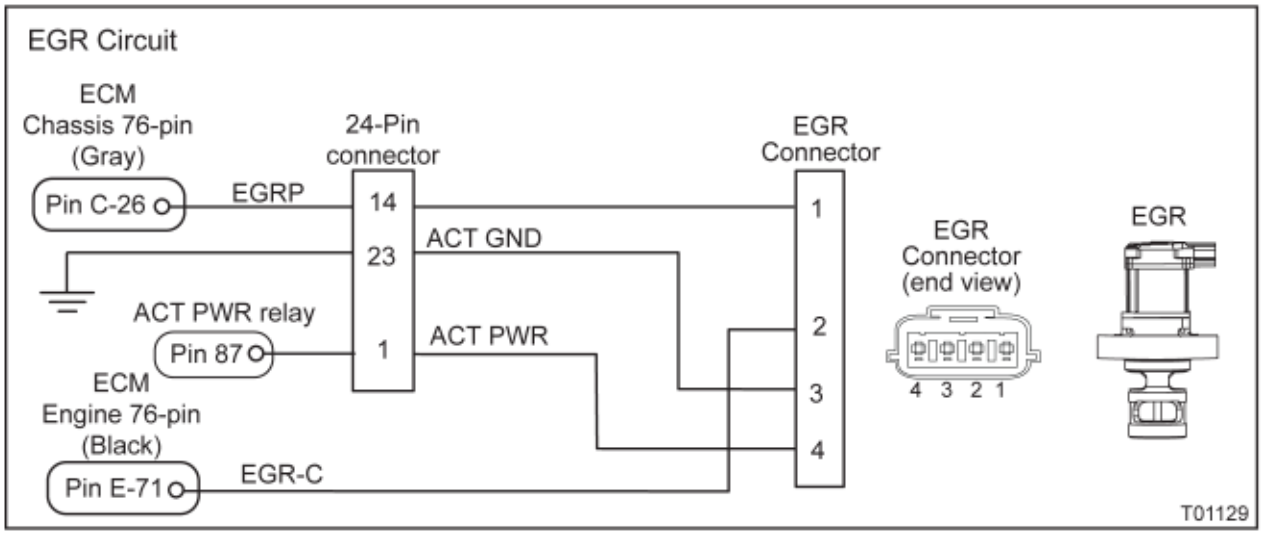
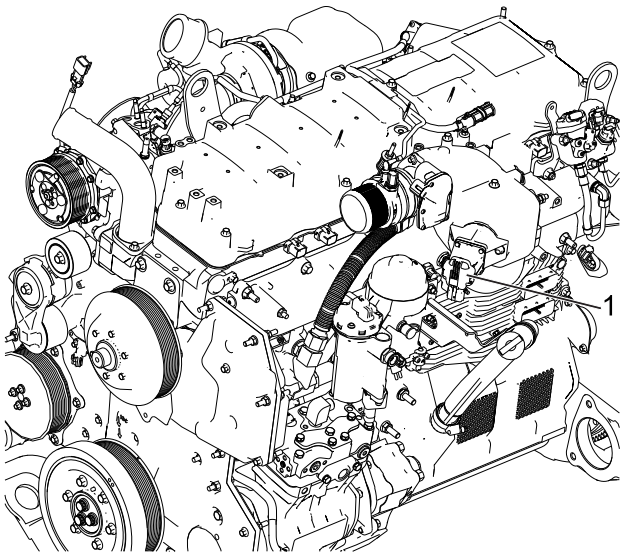


Figure 295 EGR Circuit Diagram

Overview

Nitrogen oxides (NO_X) in the atmosphere contribute to the production of smog. NO_X is formed in engines when temperatures in the combustion chamber get too hot.

The EGR system is used to reduce the amount of NO_X created by the engine. The EGR valve directs some exhaust into the intake stream to dilute the air-fuel mixture in the combustion chamber. This slows combustion and reduces the formation of NO_X.



0000061556

Figure 296 EGR Valve Location

1. EGR Valve

Tools

- EZ Tech® Electronic Service Tool (EST) – J-45067 (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- 00-00956-08 – 180-pin Breakout Box (page 1222)
- Breakout Harness 4948 (EGR) (page 1236)
- International® Electronic Engine Terminal Test Kit (page 1227)

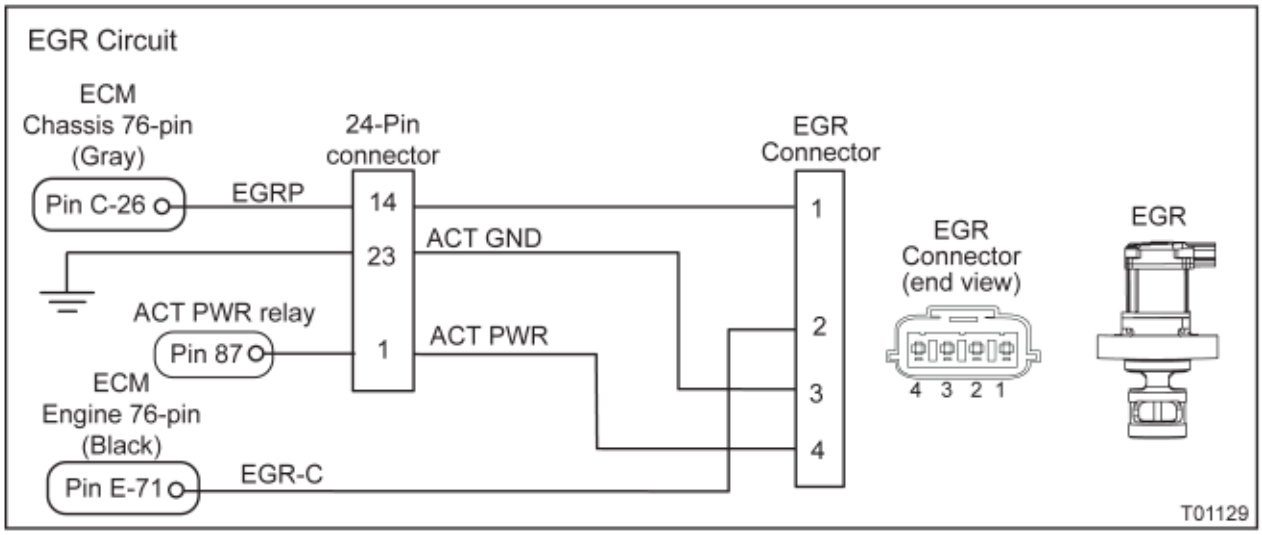


Figure 297 EGR Circuit Diagram

Pin-point Diagnostics With ServiceMaxx™ Software

Connector Voltage Check

Test Point	Specification Comment: < Less than, > Greater than	
Connect Breakout Harness 4948 to engine harness, leave EGR disconnected. Turn ignition switch to ON. Use DMM to measure voltage.		
4 to GND	B+	If < B+, check ACT PWR circuit for OPEN or short to GND, or blown fuse. Go to Harness Resistance Check.
3 to B+	B+	If < B+, check ACT PWR GND circuit for OPEN. Go to Harness Resistance Check.
1 to GND	5.0 ± 0.5 V	If < 4.5 volts, check EGR-P for OPEN circuit or short to GND.
		If > 5.5 volts, check for EGR-P short to power.

EGR Duty Cycle Operational Specifications – Output State Tests

Function	Test	Specification
EGR duty cycle percentages are displayed by EST with ServiceMaxx™, and can also be displayed on a Digital Multimeter (DMM) with duty cycle display capability.		
EGR Control (EGR-C)	Output State LOW	35 %
EGR-C	Output State HIGH	80 to 90 %
EGR Position (EGR-P)	Output State LOW	35 %
EGR–P	Output State HIGH	80 to 90 %

Harness Resistance Check

Test Point	Specification	Comment: < Less than, > Greater than
Turn ignition switch to OFF. Connect 180-pin Breakout Box and breakout harnesses to EGR actuator and ACT PWR relay. Leave ECM, EGR, and relay disconnected.		
1 to C-26	< 5 Ω	If > 5 Ω, check EGR-P for OPEN in circuit
2 to E-71	< 5 Ω	If > 5 Ω, check EGR-C for OPEN in circuit
3 to GND	< 5 Ω	If > 5 Ω, check ACT GND for OPEN in circuit
4 to relay 87	< 5 Ω	If > 5 Ω, check ACT PWR for OPEN in circuit

Verification Testing

Following verification tests are performed when directed in the Step-based Diagnostic procedures for EGR valve SPN / FMI codes.

EGR Valve Operation Verification Test

Perform this test to determine if an EGR valve fault code being diagnosed sets again.

NOTE: Allowing at least 30 seconds between Output State tests in step 3 and step 4 is critical. EGR valve tests will not finish without a minimum of 30 seconds between tests.

1. Reconnect EGR and TC2WC connectors if they were disconnected.
2. Turn key OFF for minimum of 45 seconds before testing.
3. Using EST with ServiceMaxx™ software, do KOEO Output State Low test (page 87), and wait 30 seconds for test to run.
4. Using EST with ServiceMaxx™ software, do KOEO Output State High test (page 87), and wait 30 seconds for the test to run.
5. Repeat step 3 and step 4 in sequence three more times, waiting 30 seconds for each test to run.
6. Determine if the applicable SPN / FMI fault code for the malfunction sets again after the fourth Output State High test.

EGR Valve Voltage Verification with High Pressure Turbocharger Wastegate Connected to Power

Perform this test to verify EGR valve operating voltage is correct with Turbocharger 2 Wastegate Control (TC2WC) connected to power.

1. Connect TC2WC connector if it was disconnected.
2. Disconnect EGR valve connector if it is connected.
3. Turn key ON.
4. Measure voltage from EGR valve connector Pin 4 (B+) to Pin 3 (GND).
5. Using the EST with ServiceMaxx™ software, do KOEO Output State Low (page 87) and Output State High (page 87) tests.
6. Determine if voltage supplied to EGR valve remains greater than 9 volts during the tests.

SPN 27 FMI 0 - EGRP fault: over temperature

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
EGRP fault: over temperature	TBD	TBD

Fault Overview

Fault sets when Engine Control Module (ECM) senses Exhaust Gas Recirculation Valve Position (EGRP) temperature is too high.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Road Test

Possible Causes

- Failed EGR valve

Step 1	Perform Exhaust Gas Recirculation (EGR) Valve Operational Test	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software. A. Key ON, clear codes. B. Key OFF, wait for EST screens to clear. C. Key ON, perform Exhaust Gas Recirculation (EGR) Valve Operational Test(page 240). Did EGR pass operational test with no fault codes?		Yes: System OK. After repairs are complete, retest for SPN 27 FMI 0. No: Replace EGR valve. After repairs are complete, retest for SPN 27 FMI 0.

End Diagnostic Tests
After performing all diagnostic steps, if SPN 27 FMI 0 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

SPN 27 FMI 14 - EGR internal circuit failure

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Engine Exhaust Gas Recirculation Valve Position sensor circuit faults as indicated by smart actuator	Position Sensor Output as indicated by all 3 Hall effect sensors = {Please refer to additional documentation for more details} Continuously at Low position OR Continuously at High Position	Key ON

Fault Overview

Fault sets when Engine Control Module (ECM) determines Exhaust Gas Recirculation (EGR) valve is not functioning properly when initialized.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

SPN / FMI: 2791/7

Fault Facts

Drive Cycle to Determine Fault Status

N/A

Possible Causes

- EGR valve unable to seat closed
- Stuck or sticking EGR valve

Step 1	Check for active or pending fault code.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software. A. Key ON, clear codes. B. Key OFF, wait for EST screens to clear. C. Key ON, check Diagnostic Trouble Code (DTC) list for SPN 27 FMI 14. Is EST DTC list SPN 27 FMI 14 active or pending?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Inspect connections at Exhaust Gas Recirculation (EGR) valve.	Decision
A. Key OFF. B. Disconnect EGR valve connector. C. Check EGR valve and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are EGR valve connector, harness, and terminals clean and undamaged?		Yes: Go to Step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 27 FMI 14.

Step 3	Exhaust Gas Recirculation (EGR) Operational Test.	Decision
Perform EGR Operational Test(page 240). Are there any active SPN 2791 or SPN 27 fault codes active?		Yes: Replace EGR valve. After repairs are complete, retest for SPN 27 FMI 14. No: System OK.

End Diagnostic Tests
After performing all diagnostic steps, if SPN 27 FMI 14 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

SPN 2791 FMI 2 - EGR valve communication fault

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Engine Exhaust Gas Recirculation (EGR) valve communication fault	Rising edge is not detected on Pulse Width Modulation (PWM) EGR valve feedback line for time > 0.0057 seconds	Key ON

Fault Overview

Fault sets when Engine Control Module (ECM) fails to detect rising edge of a response pulse on Exhaust Gas Recirculation (EGR) position signal line within 0.0057 seconds following commanded position change.

Lamp Reaction

Malfunction Indicator Lam (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

TBD

Possible Causes

- Exhaust Gas Recirculation Position (EGRP) circuit open
- EGRP circuit shorted to ground
- Actuator (ACT) power circuit open or blown fuse
- ACT power circuit shorted to ground
- Failed Exhaust Gas Recirculation (EGR) valve

Step 1	Check for active fault code.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 2791 FMI 2. Does EST DTC list free show SPN 2791 FMI 2 as active?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Inspect connections at Exhaust Gas Recirculation (EGR) valve.	Decision
A. Key OFF. B. Disconnect EGR valve connector. C. Check EGR valve and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are EGR valve connector, harness, and terminals clean and undamaged?		Yes: Go to Step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2791 FMI 2.

Step 3	Inspect connections at Turbocharger 2 Wastegate (TC2WG).	Decision
A. Key OFF. B. Disconnect TC2WG connector. C. Check TC2WG and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are TC2WG connector, harness, and terminals clean and undamaged?		Yes: Perform Pin-Point Tests (SPN 2791 FMI 2).(page 685) No: Repair connector, harness, or terminal damage. After repairs

	are complete, retest for SPN 2791 FMI 2.

Pin-Point Tests (SPN 2791 FMI 2)

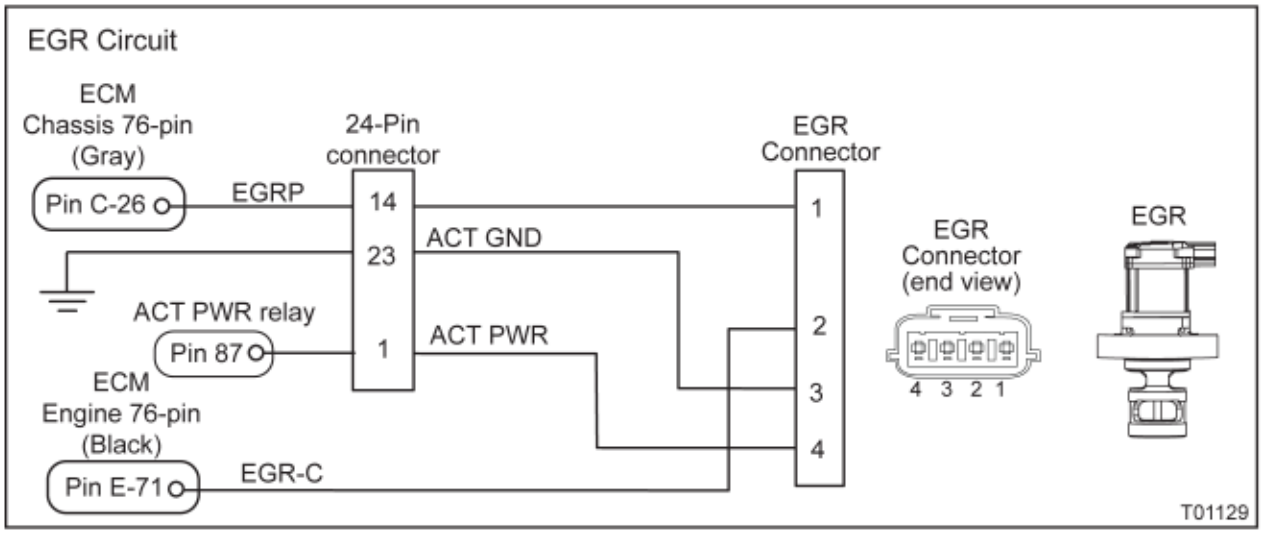


Figure 298 Exhaust Gas recirculation (EGR) Valve Circuit Diagram

See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE6003
- Breakout Harness ZTSE6016
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant, supporting J1939 and J1708)

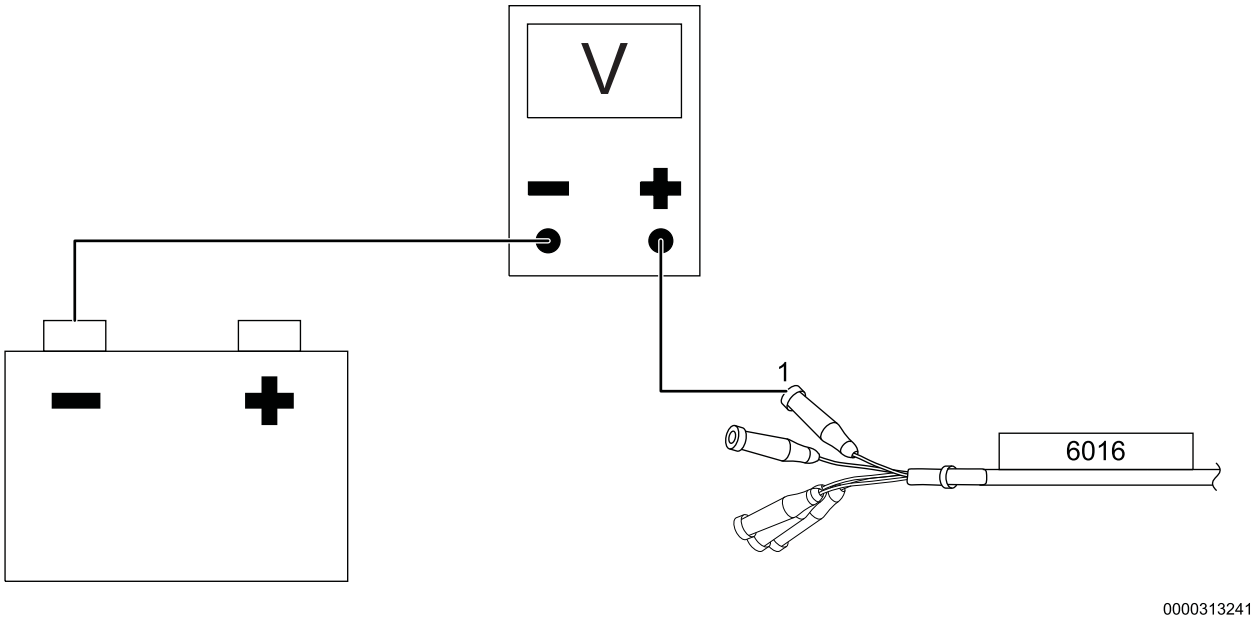


Figure 299 Test 1 Exhaust Gas Recirculation (EGR) Valve Voltage Check

Test 1 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE6016 to vehicle harness connector and leave Exhaust Gas Recirculation (EGR) valve disconnected. C. Key-On Engine-Off (KOEO).

Test 1	Specification
Use DMM to measure voltage between Breakout Harness ZTSE6016 pin-1 and known good ground.	Less than 5.5 volts
Decision	
Is voltage less than 5.5 volts?	Yes: Go to Test 2.
	No: Repair short to power between EGR valve connector pin-1 and Engine Control Module (ECM) Chassis 76-pin connector pin C-26. After repairs are complete, retest for SPN 2791 FMI 2.

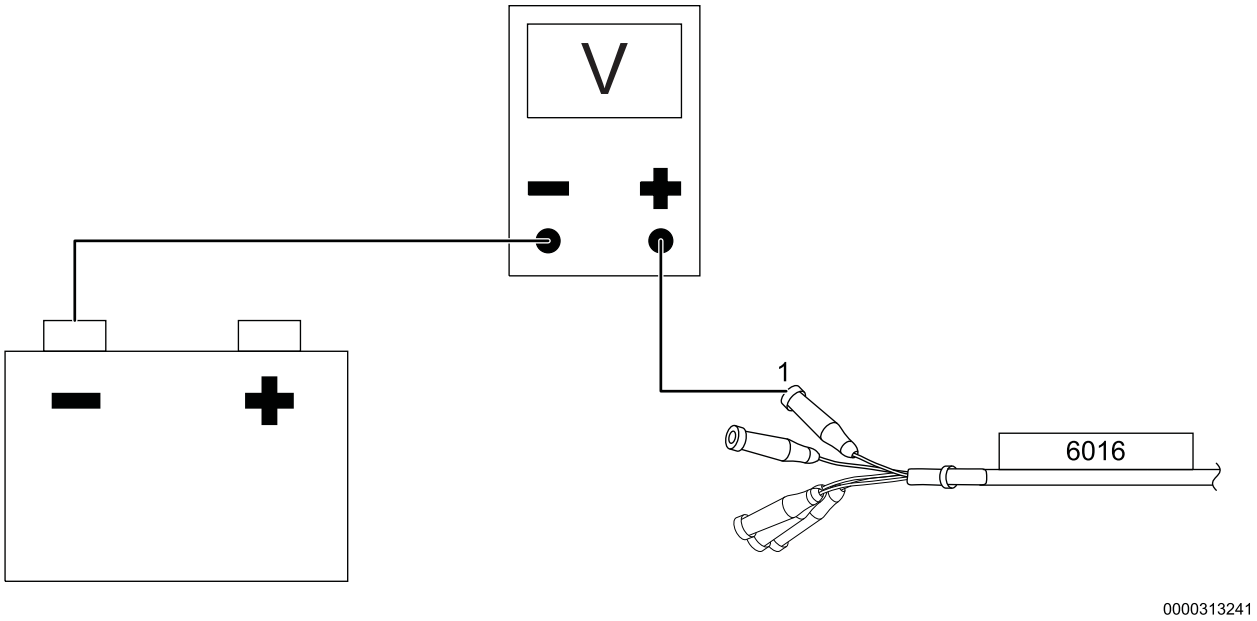


Figure 300 Test 2 Exhaust Gas Recirculation (EGR) Valve Voltage Check

Test 2 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE6016 to vehicle harness connector and leave Exhaust Gas Recirculation (EGR) valve disconnected. C. Key-On Engine-Off (KOEO).

Test 2	Specification
Use DMM to measure voltage between Breakout Harness ZTSE6016 pin-1 and known good ground.	Greater than 4.5 volts
Decision	
Is voltage greater than 4.5 volts?	Yes: Go to Test 4.
	No: Go to Test 3.

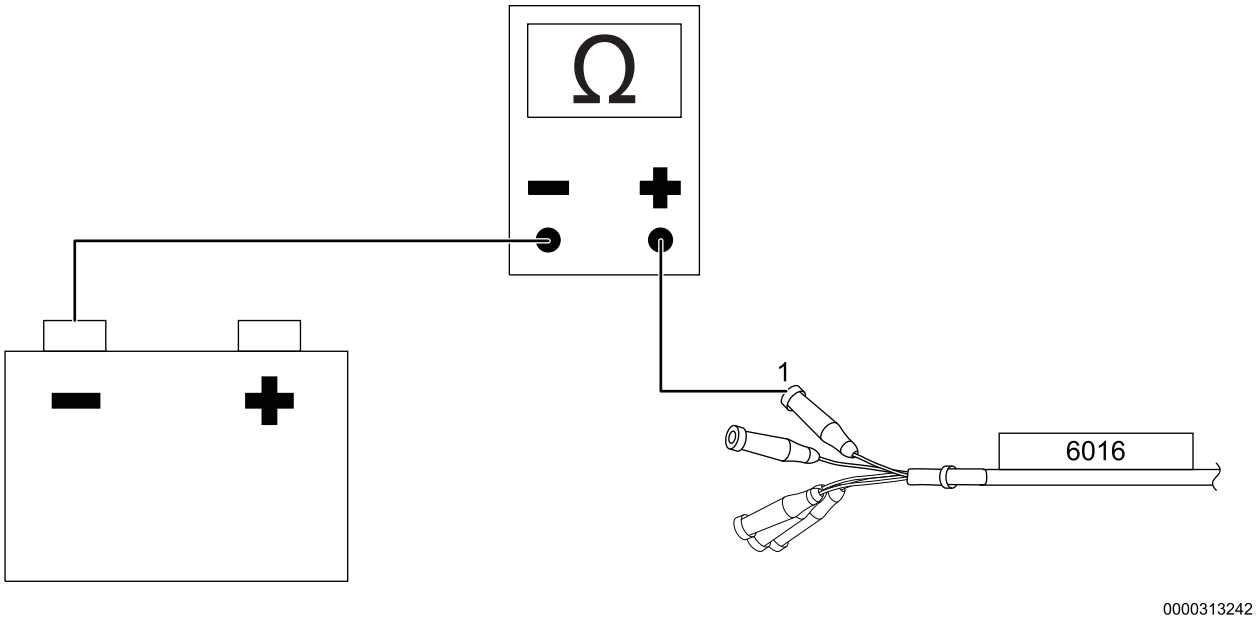


Figure 301 Test 3 Exhaust Gas Recirculation (EGR) Valve Resistance Check

Test 3 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE6016 to vehicle harness connector and leave Exhaust Gas Recirculation (EGR) valve disconnected. C. Key-On Engine-Off (KOEO).

Test 3	Specification
Use DMM to measure resistance between Breakout Harness ZTSE6016 pin-1 and known good ground.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Repair open circuit EGR valve connector pin-1 and Engine Control Module (ECM) Chassis 76-pin connector pin C-26. After repairs are complete, retest for SPN 2791 FMI 2.
	No: Repair short to ground between EGR valve connector pin-1 and ECM Chassis 76-pin connector pin C-26. After repairs are complete, retest for SPN 2791 FMI 2.

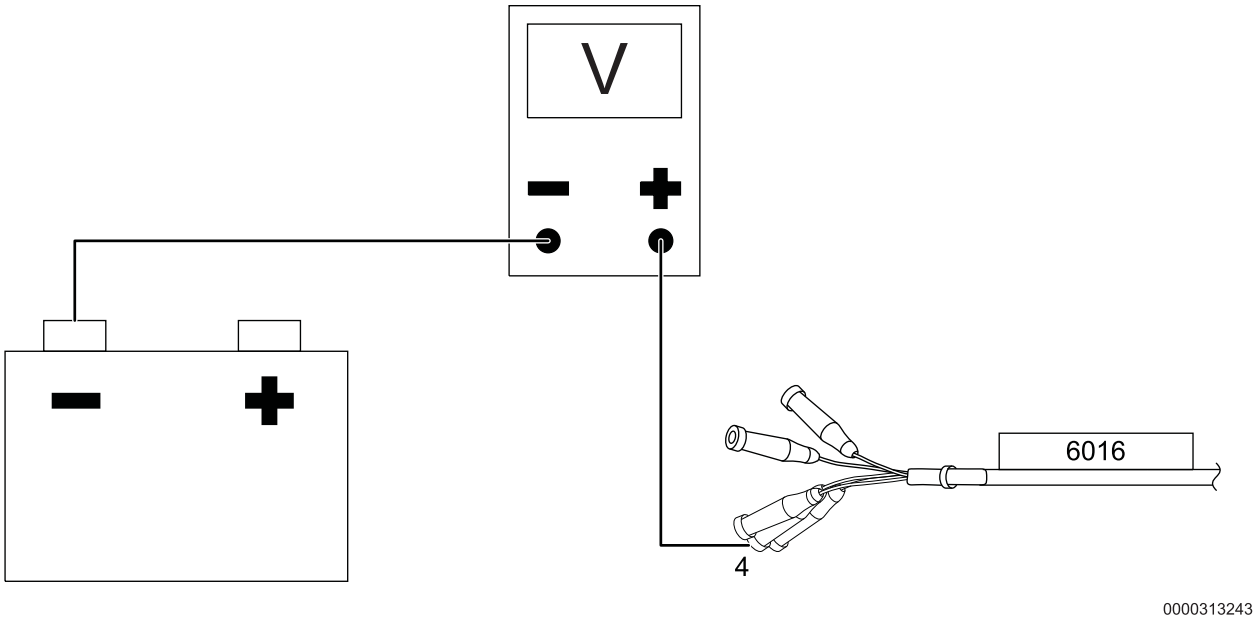


Figure 302 Test 4 Exhaust Gas Recirculation (EGR) Valve Voltage Check

Test 4 Setup
A. Key OFF. B. Disconnect Turbocharger 2 Wastegate (TC2WG) vehicle harness connector and leave wastegate disconnected. C. Connect Breakout Harness ZTSE6016 to vehicle harness connector and leave Exhaust Gas Recirculation (EGR) valve disconnected. D. Key-On Engine-Off (KOEO).

Test 4	Specification
Use DMM to measure voltage between Breakout Harness ZTSE6016 pin-4 and known good ground.	Greater than 9 volts
Decision	
Is voltage greater than 9 volts?	Yes: Go to Test 6.
	No: Go to Test 5.

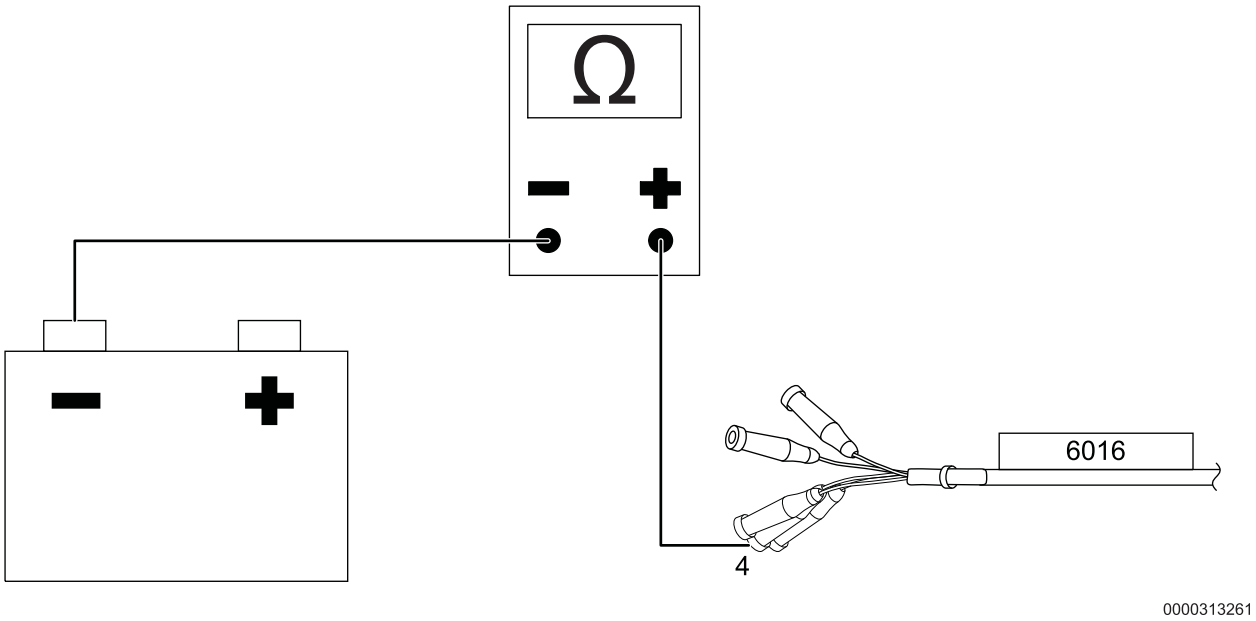


Figure 303 Test 5 Exhaust Gas Recirculation (EGR) Valve Resistance Check

Test 5 Setup
A. Key OFF. B. Disconnect Turbocharger 2 Wastegate (TC2WG) vehicle harness connector and leave wastegate disconnected. C. Connect Breakout Harness ZTSE6016 to vehicle harness connector and leave Exhaust Gas Recirculation (EGR) valve disconnected. D. Key-On Engine-Off (KOEO).

Test 5	Specification
Use DMM to measure resistance between Breakout Harness ZTSE6016 pin-4 and known good ground.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Repair open or blown fuse between Actuator Power (ACT PWR) relay pin-87 and EGR valve connector pin-4. After repairs are complete, retest for SPN 2791 FMI 2.
	No: Repair short to ground between ACT PWR relay pin-87 and EGR valve connector pin-4. After repairs are complete, retest for SPN 2791 FMI 2.

Test 6 Setup
A. Key OFF. B. Connect Turbocharger 2 Wastegate (TC2WG) vehicle harness connector to wastegate. C. Connect Exhaust Gas Recirculation (EGR) valve vehicle harness connector to EGR valve. D. Connect Electronic Service Tool (EST) to Diagnostic Connector (page 81).

Test 6	Specification
Perform EGR Valve Operation Verification Test. (page 240)	Faults clear
Decision	
Do faults clear?	Yes: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).
	No: Replace EGR valve. After repairs are complete, retest for SPN 2791 FMI 2.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 2791 FMI 2 fault code diagnostics.

SPN 2791 FMI 3 - EGRC short to PWR

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
EGR Valve supply voltage	[Voltage Supply to EGR Valve > 18 Volts for time =] 5 seconds	Key ON

Fault Overview

This fault sets when Exhaust Gas Recirculation (EGR) valve receives a voltage supply of greater than 18 volts for 5 seconds.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

None

Fault Facts

This fault sets when Exhaust Gas Recirculation (EGR) valve receives a voltage value that is greater than 18 volts. This is NOT an EGR valve problem; it is a voltage supply problem.

Drive Cycle to Determine Fault Status

Continuous

Possible Causes

- Charging system over voltage
- Use of battery charger on boost mode

Step 1	Check for active or pending fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software. A. Key ON, clear codes. B. Key OFF, wait for EST screens to clear. C. Key ON, start engine, measure battery voltage. Is battery voltage greater than 18 volts?		Yes: Repair charging system. After repairs are complete, retest for SPN 2791 FMI 3. No: System OK. After repairs are complete, retest for SPN 2791 FMI 3.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 2791 FMI 3 fault code diagnostics.

SPN 2791 FMI 4 - EGRC short to GND

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
EGR Valve supply voltage	[Voltage Supply to EGR Valve < 8 Volts for time =] 13 seconds	Key ON

Fault Overview

This fault sets when Exhaust Gas Recirculation (EGR) valve receives a voltage supply of less than 8 volts for 13 seconds.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

None

Fault Facts

This fault sets when Exhaust Gas Recirculation (EGR) valve receives a voltage value that is less than 8 volts. This is NOT an EGR valve problem; it is a voltage supply problem.

Drive Cycle to Determine Fault Status

Continuous

Possible Causes

- Low charging system voltage
- High resistance in ACT PWR circuit or relay
- High resistance in ACT GND circuit

Step 1	Check for active or pending fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software. A. Key ON, clear codes. B. Key OFF, wait for EST screens to clear. C. Key ON, start engine, measure battery voltage. Is battery voltage less than 8 volts?		Yes: Repair charging system. After repairs are complete, retest for SPN 2791 FMI 4. No: Perform pin-point tests(page 694).

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 2791 FMI 4 fault code diagnostics.

Pin-Point Tests (SPN 2791 FMI 4)

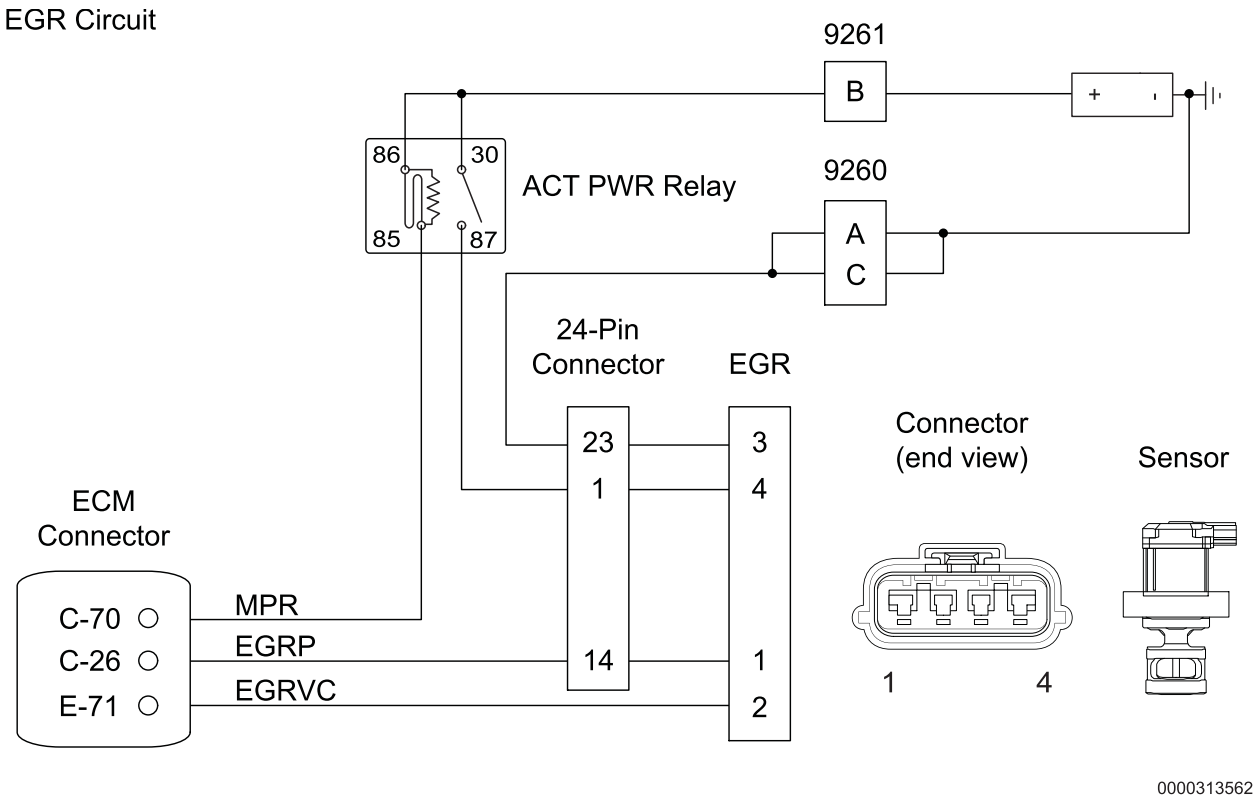


Figure 304 Exhaust Gas Recirculation (EGR) Circuit Diagram

See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4948
- Digital Multimeter (DMM)

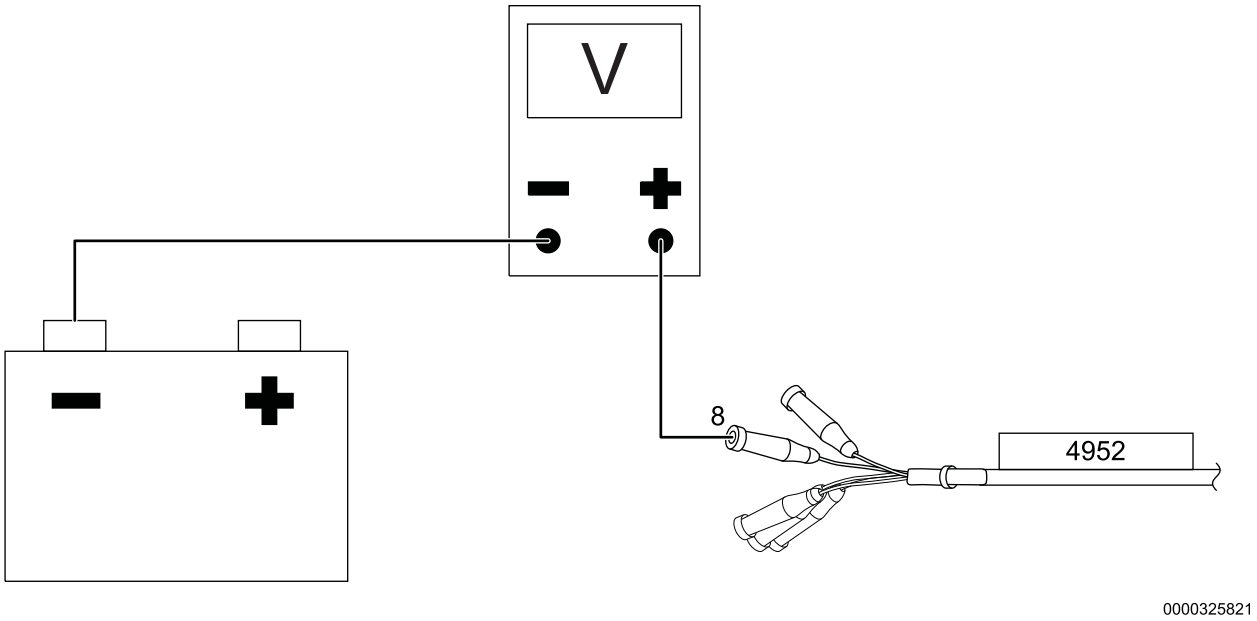


Figure 305 Test 1 Exhaust Gas Recirculation (EGR) Circuit Check

Test 1 Setup
A. Key OFF. B. Disconnect Exhaust Gas Recirculation (EGR) connector. C. Connect Breakout Harness ZTSE4948 to vehicle harness, leave EGR disconnected. D. Key ON.

Test 1	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4948 pin-4 and known good GND.	Less than 8 volts
Decision	
Is voltage less than 8 volts?	Yes: Repair high resistance in power circuit between pin-4 and ACT PWR relay. After repairs are complete, retest for SPN 2791 FMI 4.
	No: Repair high resistance in ground circuit between pin-3 and ACT GND circuit. After repairs are complete, retest for SPN 2791 FMI 4.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and the proper decision was made. Return to SPN 2791 FMI 4 fault code diagnostics.

SPN 2791 FMI 7 - EGR Valve unable to achieve commanded position

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Exhaust Gas Recirculation (EGR) valve control feedback error.	EGR valve motor duty cycle (motor duty cycle is calculated internally based on desired and actual EGR valve position) > 95% for 3 seconds continuously	Key ON 3 attempts per key cycle

Fault Overview

Fault code sets when Engine Control Module (ECM) determines Exhaust Gas Recirculation (EGR) valve is Not functioning properly when commanded.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive trips.

Associated Faults

SPN 2791 FMI 2, 3, 4, 8, and 14 (EGR)

Fault Facts

This fault is also used to detect EGR valve positive and negative deviation faults.

Drive Cycle to Determine Fault Status

TBD

Possible Causes

- Exhaust Gas Recirculation (EGR) valve motor internal duty cycle > 95 %
- EGR valve motor stuck
- Deposits on EGR valve
- Stuck or sticking EGR valve

Step 1	Check for associated fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 2791 FMI 2, 3, 4, 8, and 14 (EGR). Is EST DTC list free of SPN 2791 FMI 2, 3, 4, 8, and 14?		Yes: Go to Step 2. No: Repair SPN 2791 FMI 2, 3, 4, 8, and 14. After repairs are complete, retest for SPN 2791 FMI 7.

Step 2	Inspect connections at Exhaust Gas Recirculation (EGR) valve.	Decision
A. Key OFF. B. Disconnect EGR valve connector. C. Check EGR valve and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are EGR Valve connector, harness, and terminals clean and undamaged?		Yes: Go to Step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2791 FMI 7.

Step 3	Test for proper Exhaust Gas Recirculation (EGR) valve operation.	Decision
Perform EGR Valve Operation Verification Test (page 240). Is SPN 2791 FMI 7 Pending or Active in DTC list?		Yes: Replace EGR valve. Notify supervisor for further action. No: Fault no longer present at this time. After repairs are complete, retest for SPN 2791 FMI 7.

End Diagnostic Steps
After performing diagnostic steps, if SPN 2791 FMI 7 remains, verify if step was completed correctly and proper decision was made. Notify supervisor for further action.

SPN 2791 FMI 8 - EGR valve not receiving ECM PWM signal

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
PWM duty cycle from Engine Control Module to Smart EGR Valve Controller: Signal Failure	[PWM duty cycle command to EGR Valve controller < 4.001% OR > 97% for time =] 1 second	Key ON
	[PWM frequency command to EGR Valve controller < 175 Hz OR > 325 Hz for time =] 1 second	Key ON

Fault Overview

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Continuous

Possible Causes

- ACT PWR relay remaining on with Key-Off
- EGRP wire open
- EGRP wire short to GND
- Failed EGR valve

Step 1	Check for active or pending fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software. A. Key ON, clear codes. B. Key OFF, wait for EST screens to clear. C. Key ON, check Diagnostic Trouble Code (DTC) list for SPN 2791 FMI 8. Is EST DTC list SPN 2791 FMI 8 active or pending?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Perform EGR Valve Operation Verification Test (page 240).	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software. A. Key ON, clear codes. B. Key OFF, wait for EST screens to clear. Did EGR pass operational test with no fault codes?		Yes: System OK. After repairs are complete, retest for SPN 27 FMI 0. No: Replace EGR valve. After repairs are complete, retest for SPN 27 FMI 0.

SPN 2791 FMI 14 - EGR valve Initialization Fault

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Exhaust Gas Recirculation (EGR) valve position sensor initialization error.	EGR valve position error during EGR valve initialization > 45 steps (approximately 30% of movement range) EGR valve control initialization time > 1.6 seconds [Current on low side motor driver > 18 Amps for > 1 second] and number of occurrences in the same key cycle event = 3 minimum time between each attempt = 1 second Voltage at each of the EGR valve motor terminals ≤ 7 volts and number of occurrences in the same key cycle event = 3	Key ON

Fault Overview

Fault sets when Engine Control Module (ECM) determines Exhaust Gas Recirculation (EGR) valve is not functioning properly when initialized.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive trips.

Associated Fault

SPN 2791 FMI 7 (EGR valve)

Fault Facts

None

Drive Cycle to Determine Fault Status

TBD

Possible Causes

- Failed EGR valve

Step 1	Check for associated fault code.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 2791 FMI 7 (EGR valve). Is EST DTC list free of SPN 2791 FMI 7?		Yes: Go to Step 2. No: Repair SPN 2791 FMI 7. After repairs are complete, retest for SPN 2791 FMI 14.

Step 2	Inspect connections at Exhaust Gas Recirculation (EGR) valve.	Decision
A. Key OFF. B. Disconnect EGR valve connector. C. Check EGR valve and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are EGR valve connector, harness, and terminals clean and undamaged?		Yes: Go to Step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2791 FMI 14.

Step 3	Test for proper Exhaust Gas Recirculation (EGR) valve operation.	Decision
Perform EGR Valve Operation Verification Test (page 240). Is SPN 2791 FMI 14 active or pending?		Yes: Replace EGR valve. After repairs are complete, retest for SPN 2791 FMI 14. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

End Diagnostic Steps
After performing diagnostic steps, if SPN 2791 FMI 14 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

EGR Cooler (Exhaust Gas Recirculation)

SPN	FMI	Condition	Possible Causes	Actions
4752	4	Exhaust Gas Recirculation (EGR) cooler efficiency: EGR outlet temp above expected	• Plugged EGR cooler gas side • Plugged EGR cooler coolant side • Coolant contamination of gas side • Low coolant level • Failed water pump • Stuck bypass circuit • Excessive exhaust temperature • Biased Charge Air Cooler Outlet Temperature (CACOT) sensor • Biased Mass Air Flow (MAF) sensor • Biased temperature sensor • Restricted exhaust • MAF sensor auto-calibration • Incorrect MAF configuration Programmable Parameters (PP) • Intake Manifold Temperature (IMT) sensor biased	Step-based Diagnostics (page 704)

Tools

- EZ Tech® Electronic Service Tool (EST) – J-45067 (page 1226)

SPN 4752

FMI 4 – EGR Cooler Efficiency: EGR Outlet Temp Above Expected

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine Exhaust Gas Recirculation (EGR) Cooler effectiveness monitor	Simulated Engine Exhaust Gas Recirculation (EGR) Cooler outlet temperature {Simulated Engine EGR Cooler outlet temperature is estimated based on Engine Inlet Mass Air Flow, Engine Intake Manifold 1 Temperature and Engine Charge Air Cooler Outlet Gas temperature sensor} > Threshold value defined by Speed / Torque (Table A076) * Engine Air Inlet Temperature Modifier (Table A077) * Barometric Pressure Modifier (Table A078)	Particulate Filter Regeneration NOT Active	25.5 seconds
		Barometric Pressure ≥ 11 psi (73.5 kPa) AND ≤ 15 psi (103 kPa)	
		Engine Air Inlet Temperature (AIT) ≥ 19°F (-7°C) AND ≤ 140°F (60°C)	
		Power Take Off (PTO) Mode NOT Active	
		End Of Line Testing NOT Active	
		[Engine Brake (Retarder) NOT active	
		AND minimum wait time after retarder change of state has occurred] > 5 seconds	
		Engine Torque limitation NOT Active	
		Engine is NOT coasting (i.e., Throttle Cut OFF mode)	
		Battery Voltage ≥ 10.787 Volts AND ≤ 15.787 Volts	
		Engine Ignition Key is in "ON" position (Key ON)	
		Time after engine start ≥ 30 seconds	
		Engine Coolant Temperature (ECT) ≥ 68°F (20°C) AND ≤ 219°F (104°C)	
		[{Engine Torque (monitoring Zone 1)	

FMI 4 – EGR Cooler Efficiency: EGR Outlet Temp Above Expected (cont.)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		> 221 lb-ft (300 N·m) AND ≤ 1328 lb-ft (1800 N·m)	
		AND Engine Speed (monitoring Zone 1) > 900 rpm AND < 2000 rpm	
		AND minimum time engine has to spend in Monitoring Zone 1} ≥ 3 seconds	
		OR {Engine Torque (monitoring Zone 2) > 221 lb-ft (300 N·m) AND ≤ 1328 lb-ft (1800 N·m)	
		AND Engine Speed (monitoring Zone 2) > 900 rpm AND < 2000 rpm	
		AND minimum time engine has to spend in Monitoring Zone 2} ≥ 2 seconds	
		OR {Time spent in Monitoring Zone 3 defined by (Table A111)}] ≥ 1 seconds	
		Minimum time after engine stop verification > 2 seconds	
		Engine Exhaust Gas Recirculation (EGR) valve position > 38 %	
		Engine Exhaust Gas Recirculation (EGR) valve command > 20 %	
		SPN / FMIs 27/14, 51/3, 51/4, 51/7, 102/3, 102/4, 102/7, 102/18, 105/2, 105/3, 105/4, 108/3, 108/4, 110/2, 110/3, 110/4, 172/2, 172/3, 172/4, 2630/2, 2659/20, 2791/2,	

FMI 4 – EGR Cooler Efficiency: EGR Outlet Temp Above Expected (cont.)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		2791/3, 2791/4, 2791/7, 2791/8, 2791/14, 3464/11 are NOT Active	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the EGR outlet temperature is above normal operating range.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN / FMIs: 110/0, 110/15, 110/16, 110/18, 111/1, 111/2, 1209/0, and 2630/16.

Drive Cycle to Determine Fault Status

N/A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 4752 FMI 4 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 4752 FMI 4. No: Go to Step 3.

Step	Action	Decision
3	Inspect Exhaust Gas Recirculation (EGR) cooler for any external coolant or exhaust gas leaks. Are there no external leaks?	Yes: Go to Step 4. No: Repair external coolant and/or exhaust leak(s), retest for SPN 4752 FMI 4.

Step	Action	Decision
4	Test EGR cooler integrity. Perform EGR Cooler Inspection (page 110). Did EGR cooler pass pressure tests?	Yes: Go to Step 5.
		No: Repair or replace EGR cooler, as required. After repairs are complete, retest for SPN 4752 FMI 4.

Step	Action	Decision
5	Check EGR internal condition. Refer to *Engine Service Manual*, and remove EGR cooler for inspection. Inspect EGR cooler for plugged coolant and gas passages and internal coolant and exhaust gas leaks. Is the EGR cooler free of obstructions and internal leaks?	Yes: Go to Step 6.
		No: Clean, repair, or replace EGR cooler, as required. After repairs are complete, retest for SPN 4752 FMI 4.

Step	Action	Decision
6	Perform Mass Air Flow (MAF) sensor calibration. Do MAF Calibration Procedure using Electronic Service Tool (EST) with ServiceMaxx™ software (page 1101). **NOTE:** Ensure MAF calibration requirements are met and MAF calibration pre-checks are done before doing this procedure. Did MAF sensor calibration run successfully?	Yes: After doing all diagnostic steps, if SPN 4752 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Verify all MAF calibration requirements are met and MAF calibration pre-checks are done. Repeat MAF calibration. After repairs are complete, retest for SPN 4752 FMI 4.

NOTE: After doing all diagnostic steps, if SPN 4752 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

EGT Sensor (Exhaust Gas Temperature)

Overview of EGT Sensor Group

SPN	FMI	Description
173	2	EGT signal erratic, intermittent, or incorrect (page 710)
173	3	EGT signal Out of Range HIGH
173	4	EGT signal Out of Range LOW (page 717)

Overview

Exhaust Gas Temperature (EGT) sensor provides feedback signal to Engine Control Module (ECM) indicating exhaust gas temperature.

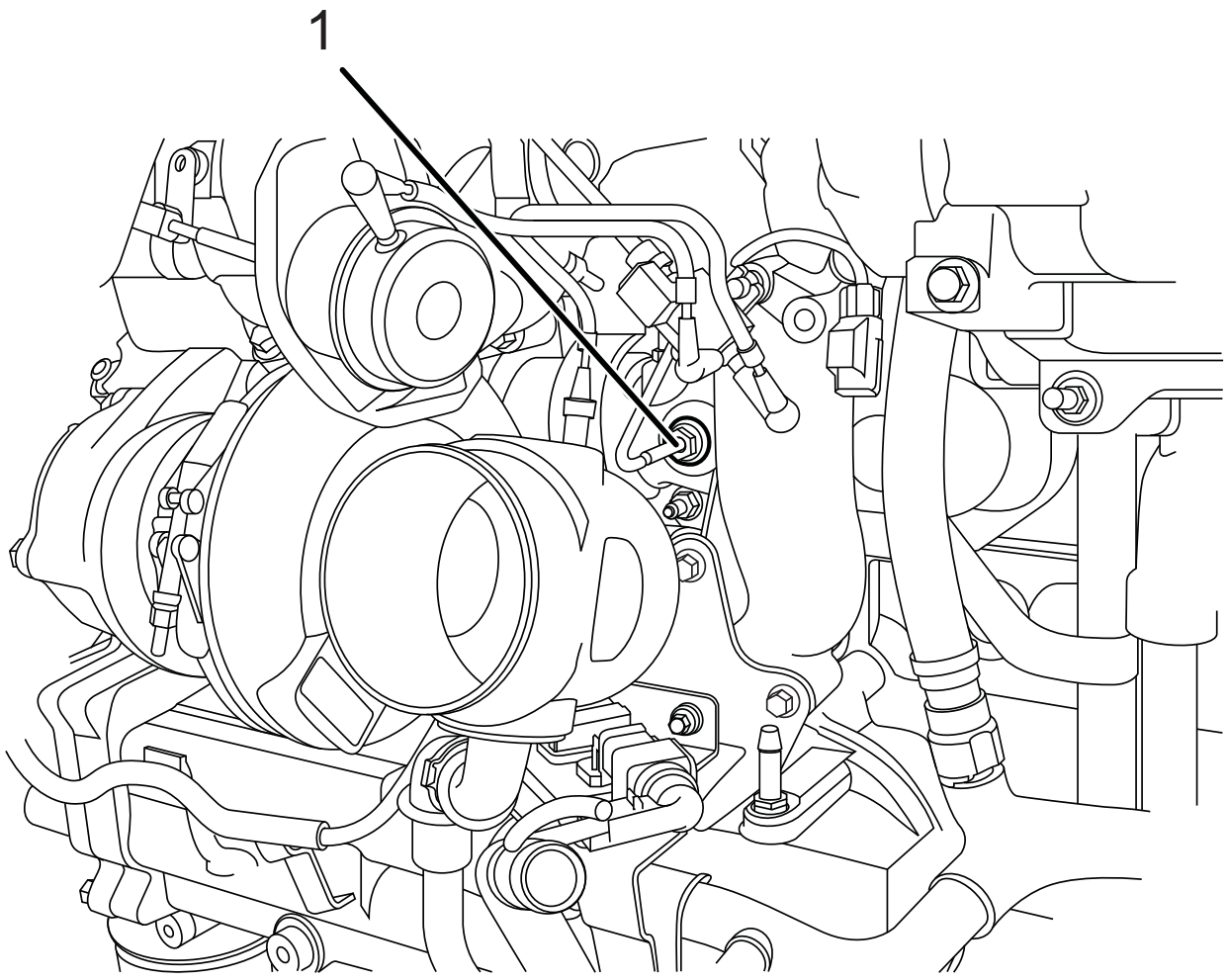


Figure 306 Exhaust Gas Temperature (EGT) Sensor Location

1. EGT sensor

SPN 173 FMI 2 - EGT signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Absolute difference between estimated and actual exhaust gas temperature	≥ Output of a Speed/Torque based table [Table A062] * Engine coolant temperature modifier [Table A063] * Ambient pressure modifier [Table A064]	Key ON Estimated exhaust gas temperature > 437°F (225°C)

Fault Overview

Fault sets when Engine Control Module senses absolute difference between estimated Exhaust Gas Temperature (EGT) of > 437°F (225°C) and actual EGT for 25.5 seconds.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON

Possible Causes

- Failed EGT sensor
- Failed wiring

Step 1	Check for active or pending fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 173 FMI 2. Is EST DTC list SPN 173 FMI 2 active or pending?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Inspect connections at Exhaust Gas Temperature (EGT) connector.	Decision
A. Key OFF. B. Disconnect EGT connector. C. Check EGT and connector terminals for: damaged or pinched wires; moisture or corroded terminals; loose, bent, or broken pins; or broken connector housing. Are EGT connector, harness, and terminals clean and undamaged?		Yes: Go to Step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 173 FMI 2.

Step 3	Inspect connections at Exhaust Gas Temperature (EGT) connector.	Decision
A. Key OFF. B. Connect Breakout Harness ZTSE4993 between pin-1 and pin-2 on EGT connector. C. Key-On Engine-Off (KOEO). Using EST with ServiceMaxx™ software, measure voltage between pin-1 and pin-2. Is voltage less than 0.5 volts?		Yes: Replace EGT sensor. After repairs are complete, retest for SPN 173 FMI 2. No: Go to step 4.

Step 4	Inspect connections at Exhaust Gas Temperature (EGT) connector.	Decision
A. Key OFF. B. Connect Breakout Harness ZTSE4993 between pin-1 and known good GND. C. Key-On Engine-Off (KOEO). Using EST with ServiceMaxx™ software, measure resistance. Is resistance less than 5 ohms?		Yes: Repair EGT signal wire. After repairs are complete, retest for SPN 173 FMI 2. No: Repair EGT SIG GND wire. After repairs are complete, retest for SPN 173 FMI 2.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 173 FMI 2 fault code diagnostics.

SPN 173 FMI 3 - EGT Signal Out of Range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Exhaust Gas Temperature (EGT) signal Out of Range High	EGT voltage > 4.8 volts	Key ON, engine running, and exhaust hot Estimated EGT > 437°F (225°C)

Fault Overview

Fault code sets when Engine Control Module (ECM) detects Exhaust Gas Temperature (EGT) is above maximum threshold.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when fault is detected during two consecutive trips.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON

Possible Causes

- Exhaust Gas Temperature (EGT) circuit OPEN
- EGT circuit short to PWR
- SIG GND Circuit OPEN
- Failed EGT Sensor

Step 1	Check for active or pending fault code.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 173 FMI 3. Is EST DTC list SPN 173 FMI 3 Active or Pending?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure.

Step 2	Inspect for Exhaust Gas Temperature (EGT) sensor for damage.	Decision
A. Key OFF. B. Disconnect EGT sensor connector. C. Inspect EGT connector for: damage, pinched wires, corroded terminals, loose, bent or broken pins, or broken connector housing. Is EGT connector, harness, and terminals clean and undamaged?		Yes: Go to Pin-Point Tests (SPN 173 FMI 3) (page 712). No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 173 FMI 3.

Pin-Point Tests (SPN 173 FMI 3)

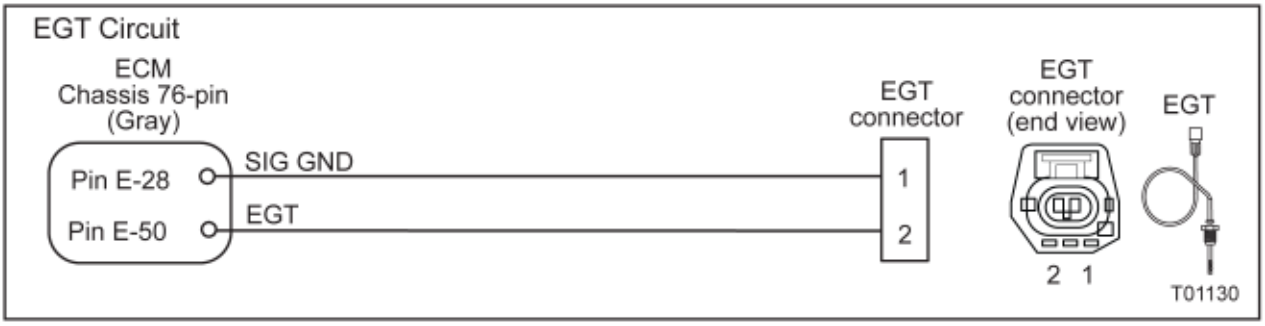


Figure 307 Exhaust Gas Temperature (EGT) Sensor Circuit Diagram

NOTE: See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

Tools Required

- Breakout Harness ZTSE4498
- Breakout Harness ZTSE4946
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)

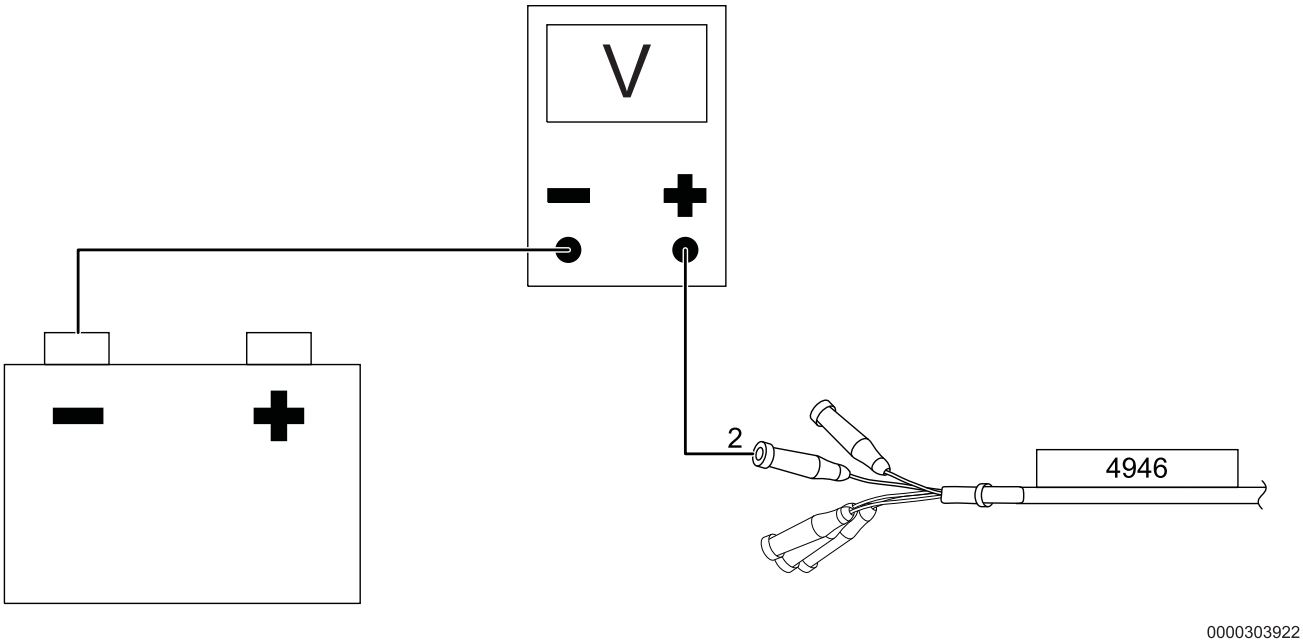
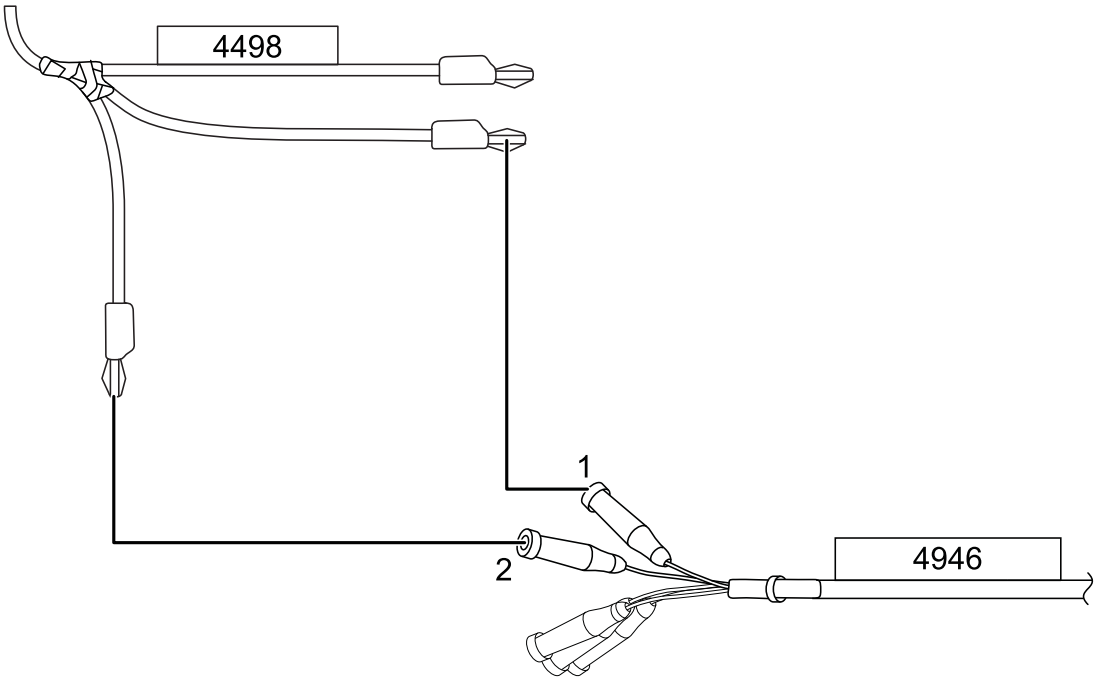


Figure 308 Test 1 Exhaust Gas Temperature (EGT) Circuit Voltage Check

Test 1 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4946 to vehicle harness and leave Exhaust Gas Temperature (EGT) sensor disconnected. C. Key ON.

Test 1	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4946 pin-2 and known good ground.	6 volts
Decision	
Is voltage greater than 6.0 volts?	Yes: Repair short to PWR between EGT pin-2 and Engine Control Module (ECM) pin E-50. After repairs are complete, retest for SPN 173 FMI 3.
	No: Go to Test 2.



0000303927

Figure 309 Test 2 Exhaust Gas Temperature (EGT) Circuit Check

Test 2 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4946 to Exhaust Gas Temperature (EGT) sensor connector and leave sensor disconnected. C. Using Breakout Harness ZTSE4498, short pin-1 and pin-2 of Breakout Harness ZTSE4946 together. D. Connect Electronic Service Tool (EST) to Vehicle Diagnostic Connector (page 81). E. Key ON. Log in to ServiceMaxx™ software. F. Start engine, get exhaust hot.

Test 2	Specification
With exhaust hot, use EST with ServiceMaxx™ software to clear Diagnostic Trouble Code (DTC) list.	SPN 173 FMI 4 sets after DTC list is cleared
Decision	
Does SPN 173 FMI 4 set after DTC list is cleared?	Yes: Replace EGT sensor. After repairs are complete, retest for SPN 173 FMI 3.
	No: Go to Test 3.

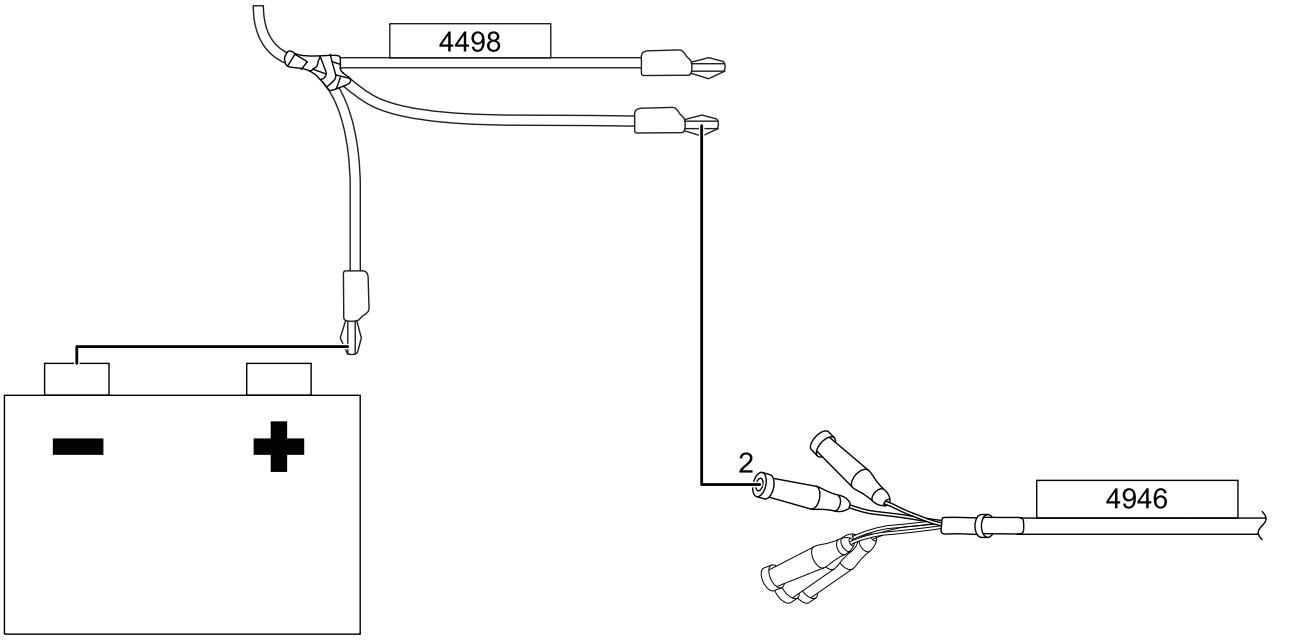


Figure 310 Test 3 Exhaust Gas Temperature (EGT) Circuit Check

Test 3 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4946 to Exhaust Gas Temperature (EGT) sensor connector and leave sensor disconnected. C. Using Breakout Harness ZTSE4498, short pin-2 of Breakout Harness ZTSE4946 to known good ground. D. Connect Electronic Service Tool (EST) to Vehicle Diagnostic Connector (page 81). E. Key ON. Log in to ServiceMaxx™ software. F. Start engine, get exhaust hot.

Test 3	Specification
With exhaust hot, use EST with ServiceMaxx™ software to clear DTC list.	SPN 174 FMI 4 sets after DTC list is cleared
Decision	
Does SPN 173 FMI 4 set after DTC list is cleared?	Yes: Repair Open between EGT pin-1 and ECM pin E-28. After repairs are complete, retest for SPN 173 FMI 3.
	No: Repair Open between EGT pin-2 and ECM pin E-50. After repairs are complete, retest for SPN 173 FMI 3.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 173 FMI 3 fault code diagnostics.

SPN 173 FMI 4 - EGT Signal Out of Range LOW

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Exhaust Gas Temperature (EGT) signal Out of Range Low	EGT voltage < 0.2 volts	Key-On Engine-Running (KOER) Engine Coolant Temperature (ECT) > -58°F (-50°C) Engine Speed ≥ 650 RPM Engine torque set point ≥ 20 N·m Minimum time spent in entry condition 3 and 4 ≥ 50 * 0.1 seconds

Fault Overview

Fault sets when Engine Control Module (ECM) determines Exhaust Gas Temperature (EGT) is below minimum allowable threshold for a predetermined amount of time.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive trips.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Key-On Engine-Running (KOER)

Possible Causes

- Exhaust Gas Temperature (EGT) circuit short to PWR
- Failed EGT sensor

Step 1	Check for active or pending fault code.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 173 FMI 4. Is EST DTC list SPN 173 FMI 4 Active or Pending?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Inspect connections at Exhaust Gas Temperature (EGT) sensor.	Decision
A. Key OFF. B. Disconnect EGT sensor. C. Inspect EGT connector for: damage, pinched wires, corroded terminals, loose, bent or broken pins, or broken connector housing. Is EGT connector, harness, and terminals clean and undamaged?		Yes: Perform Pin-Point Tests (page 718). No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 173 FMI 4.

End Diagnostic Steps
After performing diagnostic step, if SPN 173 FMI 4 remains, verify if step was completed correctly and proper decision was made. Notify supervisor for further action.

Pin-Point Tests (SPN 173 FMI 4)

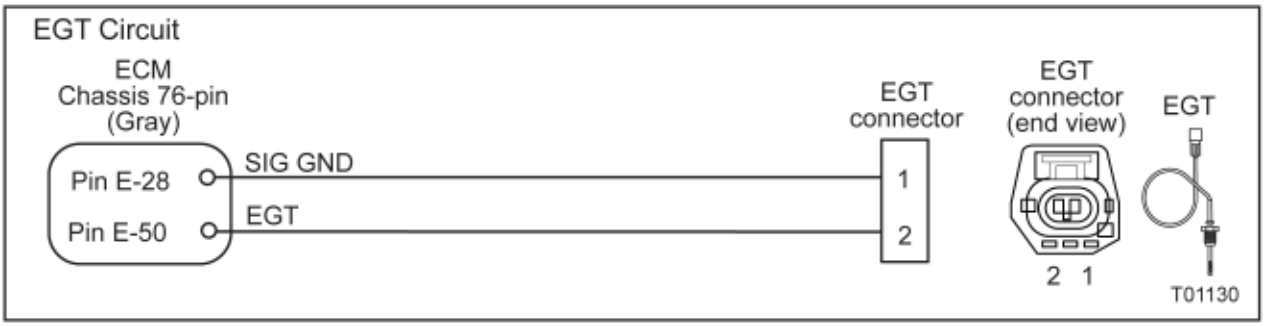


Figure 311 EGT Sensor Circuit Diagram

NOTE: See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

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

Test 1 Setup
A. Key OFF. B. Disconnect Exhaust Gas Temperature (EGT) sensor and leave sensor disconnected. C. Connect Electronic Service Tool (EST) to Vehicle Diagnostic Connector (page 81). D. Key ON. Log in to ServiceMaxx™ software.

Test 1	Specification
Using EST with ServiceMaxx™ software, clear Diagnostic Trouble Code (DTC) list.	SPN 173 FMI 3 sets after DTC list is cleared
Decision	
Does SPN 175 FMI 3 set after DTC list is cleared?	Yes: Replace EGT sensor. After repairs are complete, retest for SPN 173 FMI 4.
	No: Repair short to ground between EGT pin-2 and Engine Control Module (ECM) pin E-50. After repairs are complete, retest for SPN 173 FMI 4.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 173 FMI 4 fault code diagnostics.

Engine Idle Torque

SPN	FMI	Condition	Possible Causes	Actions
5395	0	Engine unable to achieve desired idle torque (too high)	• Non-Controller Area Network (CAN) Power Take Off (PTO) • Intake restriction • Exhaust restriction • Base engine compression issue	Step-based Diagnostics (page 721)
5395	1	Engine unable to achieve desired idle torque (too low)	• Alternate fuel source	Step-based Diagnostics (page 724)

Tools

- EZ Tech® Electronic Service Tool (EST) – J-45067 (page 1226)
- Digital Multimeter (DMM) (page 1224)

SPN 5395 FMI 0 Engine unable to achieve desired idle torque (too high)

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Idle fuel monitor - maximum	[Idle fueling > 199 mg/stroke ≥ 60 seconds	Engine in Idle State as defined by [Table A114] Accelerator Throttle pedal position 1 command < 4.98% Vehicle Speed < 1.2 mph (2 kph) Engine Coolant temperature > 158°F (70°C) Regen NOT Active PTO NOT Active Cold ambient protection controller is not active SPN 27 FMI 14; SPN 94 FMI 3 and 4; SPN 110 FMI 2, 3, and 4; SPN 132 FMI 0, 1, 3, and 4; SPN 164 FMI 0, 3, and 4; SPN 175 FMI 2, 3, and 4; SPN 191 FMI 3 and 4; SPN 636 FMI 2 and 7; SPN 651-656 FMI 4, 5, and 7; SPN 1189 FMI 3 and 4; SPN 2659 FMI 20; SPN 2791 FMI 2, 3, 4, 7, 8, and 14; SPN 3055 FMI 2; SPN 4257 FMI 7; SPN 5395 FMI 0, 1, 3, 4, and 5 are NOT Active

Fault Overview

Fault sets when Engine Control Module (ECM) monitoring idle fueling is greater than 199 mg/stroke for 60 seconds or more.

Time Requirement

Immediate

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

SPN 651 - 656 (INJ); SPN 4257 (INJ); SPN 1322 - 1328 FMI 31 (Engine)

Fault Facts

None

Drive Cycle to Determine Fault Status

Continuous

Possible Causes

- Aftermarket PTO installed
- Aftermarket PTO programmed incorrectly
- PTO engaged without command
- Intake restriction
- Exhaust restriction

Step 1	Check for active or pending fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software. A. Key ON, clear codes. B. Key OFF, wait for EST screens to clear. C. Key ON, check Diagnostic Trouble Code (DTC) list for SPN 5395 FMI 0. Is EST DTC list SPN 5395 FMI 0 active or pending?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Check for associated fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 651 - 656 (INJ); SPN 4257 (INJ); SPN 1322 - 1328 FMI 31 (Engine). Is EST DTC list free of SPN 651 - 656; SPN 4257; SPN 1322 - 1328 FMI 31?		Yes: Go to Step 3. No: Repair SPN 651 - 656; SPN 4257; SPN 1322 - 1328 FMI 31. After repairs are complete, retest for SPN 5395 FMI 0.

Step 3	Check for Intake air restriction.	Decision
Perform Intake Air Inspection. Is intake air restriction less than 25 in-Hg (84.7 kPa) at full load and at rated speed?		Yes: Go to Step 4. No: Repair intake air restrictions. After repairs are complete, retest for SPN 5395 FMI 0.

Step 4	Check for exhaust system restriction.	Decision
Inspect exhaust system for damage and restrictions. Is exhaust system free of any damage or restrictions?		Yes: Go to Step 5. No: Repair exhaust damage and restrictions. After repairs are complete, retest for SPN 5395 FMI 0.

Step 5	Check for aftermarket Power Take Off (PTO).	Decision
Inspect for installation of aftermarket PTO system. Was an aftermarket PTO system installed correctly?		Yes: Go to Step 6. No: Go to Step 7.

Step 6	Check for correctly programmed Power Take Off (PTO).	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Programmable Features PP75270(page 80). Verify aftermarket PTO system was programed correctly. Was Aftermarket PTO system programmed correctly?		Yes: Go to Step 7. No: After inspection is complete, notify supervisor with results for further action. After repairs are complete, retest for SPN 5395 FMI 0.

Step 7		Decision
Check for Power Take Off (PTO) engagement without command. Key ON Engine Running (KOER), monitor PTO output shaft rotation. Is PTO output shaft rotating without throttle?		Yes: Repair PTO unit. After repairs are complete, retest for SPN 5395 FMI 0. No: Retest for SPN 5395 FMI 0.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 5395 FMI 0 fault code diagnostics.

SPN 5395 FMI 1 Engine unable to achieve desired idle torque (too low)

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Idle fuel monitor - minimum	[Idle fueling < 1 mg/stroke for ≥ 60 seconds	Engine in Idle State as defined by [Table A114] Accelerator Throttle pedal position 1 command < 4.98% Vehicle Speed < 1.2 mph (2 kph) Engine Coolant temperature > 158°F (70°C) Regen NOT Active PTO NOT Active Cold ambient protection controller is not active SPN 27 FMI 14; SPN 94 FMI 3 and 4; SPN 110 FMI 2, 3, and 4; SPN 132 FMI 0, 1, 3, and 4; SPN 164 FMI 0, 3, and 4; SPN 175 FMI 2, 3, and 4; SPN 191 FMI 3 and 4; SPN 636 FMI 2 and 7; SPN 651-656 FMI 4, 5, and 7; SPN 1189 FMI 3 and 4; SPN 2659 FMI 20; SPN 2791 FMI 2, 3, 4, 7, 8, and 14; SPN 3055 FMI 2; SPN 4257 FMI 7; SPN 5395 FMI 0, 1, 3, 4, and 5 are NOT Active

Fault Overview

Fault sets when Engine Control Module (ECM) monitoring idle fueling is less than 1 mg/stroke for 60 seconds or more.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

SPN 651 - 656 (INJ); SPN 4257 (INJ); SPN 1322 - 1328 FMI 31 (Engine)

Fault Facts

None

Drive Cycle to Determine Fault Status

Continuous

Possible Causes

- Contaminated fuel
- Engine oil leak to intake

- Alternate fuel source
- Engine mechanical failure

Step 1	Check for active or pending fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software. A. Key ON, clear codes. B. Key OFF, wait for EST screens to clear. C. Key ON, check Diagnostic Trouble Code (DTC) list for SPN 5395 FMI 1. Is EST DTC list SPN 5395 FMI 1 active or pending?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Check for associated fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 651 - 656 (INJ); SPN 4257 (INJ); SPN 1322 - 1328 FMI 31 (Engine). Is EST DTC list free of SPN 651 - 656; SPN 4257; SPN 1322 - 1328 FMI 31?		Yes: Go to Step 3. No: Repair SPN 651 - 656; SPN 4257; SPN 1322 - 1328 FMI 31. After repairs are complete, retest for SPN 5395 FMI 1.

Step 3	Check for airborne combustibles.	Decision
Inspect for airborne combustibles (ex. propane saturated air, ether, etc.) near engine. Inspect air filter and intake system for stains, concentrations of contaminants, odors / smells from external fuel sources, and modifications. Is the engine intake system intact and free from any external fuel sources?		Yes: Go to Step 4. No: Repair source of combustibles. After repairs are complete, retest for SPN 5395 FMI 1.

Step 4	Check for contaminated fuel.	Decision
Inspect for contaminated fuel (alternate fuels other than Diesel fuel). Perform Fuel Quality Inspection. Is diesel fuel in good condition and Not contaminated?		Yes: Go to Step 5. No: Drain fuel tank, and fill with clean and / or known good diesel fuel. After repairs are complete, retest for SPN 5395 FMI 1.

Step 5	Check for oil in CAC.	Decision
Inspect high pressure turbocharger outlet piping for oil. Disconnect Charge Air Cooler (CAC) inlet to check for evidence of oil. Is CAC inlet free of engine oil?		Yes: Go to Step 6. No: Repair high pressure turbocharger. After repairs are complete, retest for SPN 5395 FMI 1.

Step 6	Check for oil in LPCAC.	Decision
Inspect low pressure turbocharger outlet piping for oil. Disconnect Low Pressure Charge Air Cooler (LPCAC) inlet for evidence of oil. Is LPCAC inlet free of engine oil?		Yes: Go to Step 7. No: Repair low pressure turbocharger. After repairs are complete, retest for SPN 5395 FMI 1.

Step 7	Check for mechanical failure.	Decision
Determine if the engine has a mechanical cylinder balance problem (compression loss). Perform Crankcase Pressure Test. Is crankcase pressure within specification?		Yes: Retest for SPN 5395 FMI 1. No: Repair base engine compression imbalance. After repairs are complete, retest for SPN 5395 FMI 1.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 5395 FMI 1 fault code diagnostics.

Engine Misfire

SPN	FMI	Condition	Possible Causes	Actions
1322	31	Engine Misfire Multiple Cylinders	• Oil growth • Aerated oil • EGR amount • Boost leaks • MAF drift • MAF auto-calibration • EGR distribution • Injector quantity and timing issues • ICP biased sensor • IMT sensor • Flying short circuits • Injector electrical checks • Cam lobe issues • Compression brake activating (if installed) during powered engine operation • Sticking EGR valve • ICP tracking issues • Aerated fuel • High-pressure oil system repairs (misfire after repairs)	Step-based Diagnostics (page 731)
1323 –1328	31	Engine Misfire Cylinder 1 through 6	• Oil growth • Aerated oil • EGR amount • Boost leaks • MAF drift • MAF auto-calibration • EGR distribution	Step-based Diagnostics (page 731)

	• Injector Quantity and Timing issues • ICP biased sensor • IMT sensor • Flying short circuits • Injector electrical checks • Cam lobe issues • Compression brake activating (if installed) during powered engine operation • Sticking EGR valve • ICP tracking issues • Aerated fuel • High-pressure oil system repairs (misfire after repairs)

Tools

- EZ Tech® Electronic Service Tool (EST) – J-45067 (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Cylinder Performance Analyzer (CPA) Tool – OE-11178
- CPA USB Cable – OE-11178-1
- CPA Black Cable – OE-11178-3
- CPA Yellow Cable – OE-11178-2
- Leak Detection Pump Tool – 12-452-01
- 1/2" High-pressure Adapter – 12-452-01-1
- 5/8" High-pressure Adapter – 12-452-01-2

SPN 1322 – 1328

FMI 31 – Engine Misfire – Multiple Cylinders

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Crankshaft acceleration indicates misfire on multiple cylinders	[Cylinder Balance Difference > Threshold defined by Engine speed and Engine Oil Temperature (EOT) (Table A027 - For vehicle in gear and Table A112 - for vehicle in Neutral)	Diesel Particulate Filter (DPF) Regeneration NOT Active	180 Injector Firing Events
	AND Cylinder balance pi control] >Threshold defined by Engine speed and Engine Oil Temperature (EOT) (Table A028)	End Of Line Testing NOT Active	
		Engine Coolant Temperature (ECT) > 86°F (30°C) AND < 248°F (120°C)	
		Engine Intake Manifold Pressure (IMP) < 17 psi (119.9 kPa)	
		Battery Voltage > 9 Volts	
		Mass fueling ≥ 1 mq/stk and ≤ 199.2 mq/stk	
		Vehicle Speed ≥ 0 mph (0 kph) and ≤ 3 mph (5 kph)	
		Engine Speed ≥ 650 rpm and ≤ 850 rpm	
		Filter Stabilization Time > 10 seconds	

FMI 31 – Engine Misfire – Multiple Cylinders (cont.)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		Fuel Pressure Control Valve (FPCV) command < 100 %	
		Engine Air Inlet Temperature (AIT) > -40°F (-40°C) and < 212°F (100°C)	
		Engine Fuel Temperature (EFT) > -58°F (-50°C)	
		Engine Oil Temperature (EOT) > -4°F (-20°C)	
		SPN / FMIs 27/14, 51/3, 51/4, 51/7, 94/3, 94/4, 102/3, 102/4, 102/7, 108/3, 108/4, 110/2, 110/3, 110/4, 110/17, 110/18, 132/0, 132/1, 132/3, 132/4, 164/0, 164/3, 164/4, 175/2, 175/3, 175/4, 191/3, 191/4, 636/2, 636/7, 651/4, 651/5, 651/7, 652/4, 652/5, 652/7, 653/4, 653/5, 653/7, 654/4, 654/5, 654/7, 655/4, 655/5, 655/7, 656/4, 656/5, 656/7, 1189/3, 1189/4, 2659/20, 2791/2, 2791/3, 2791/4, 2791/7, 2791/8, 2791/14,3055/2, 3464/11, 4257/7, 5395/0, 5395/1, 5543/3, 5543/4, 5543/5 are NOT Active	

FMI 31 – Engine Misfire – Single Cylinders

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Crankshaft acceleration indicates misfire on single cylinders	[Cylinder Balance Difference > Threshold defined by Engine speed and Engine Oil Temperature (EOT) (Table A029 - For vehicle in gear and Table A113 - for vehicle in Neutral)	Diesel Particulate Filter (DPF) Regeneration NOT Active	180 Injector Firing Events

FMI 31 – Engine Misfire – Single Cylinders (cont.)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
	AND Cylinder balance pi control] > Threshold defined by Engine speed and Engine Oil Temperature (EOT) (Table A030)	End Of Line Testing NOT Active	
		Engine Coolant Temperature (ECT) > 86°F (30°C) AND < 248°F (120°C)	
		Engine Intake Manifold Pressure (IMP) < 17 psi (119.9 kPa)	
		Battery Voltage > 9 Volts	
		Mass fueling ≥ 1 mq/stk AND ≤ 199.2 mq/stk	
		Vehicle Speed ≥ 0 mph (0 kph) and ≤ 3 mph (5 kph)	
		Engine Speed ≥ 650 rpm and ≤ 850 rpm	
		Filter Stabilization Time > 10 seconds	
		Regen NOT Active	
		Power Take-off (PTO) Mode NOT Active	
		Fuel Pressure Control Valve (FPCV) Command < 100 %	
		Engine Air Inlet Temperature (AIT)	

FMI 31 – Engine Misfire – Single Cylinders (cont.)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		> -40°F (-40°C) and < 212°F (100°C)	
		Engine Fuel Temperature (EFT) > -58°F (-50°C)	
		Engine Oil Temperature (EOT) > -4°F (-20°C)	
		SPN / FMIs 27/14, 51/3, 51/4, 51/7, 94/3, 94/4, 102/3, 102/4, 102/7, 108/3, 108/4, 110/2, 110/3, 110/4, 110/17, 110/18, 132/0, 132/1, 132/3, 132/4, 164/0, 164/3, 164/4, 175/2, 175/3, 175/4, 191/3, 191/4, 636/2, 636/7, 651/4, 651/5, 651/7, 652/4, 652/5, 652/7, 653/4, 653/5, 653/7, 654/4, 654/5, 654/7, 655/4, 655/5, 655/7, 656/4, 656/5, 656/7, 1189/3, 1189/4, 2659/20, 2791/2, 2791/3, 2791/4, 2791/7, 2791/8, 2791/14, 3055/2, 3464/11, 4257/7, 5395/0, 5395/1, 5543/3, 5543/4, 5543/5 are NOT Active	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines there is a balance difference between cylinders.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN / FMIs: 164/2, 164/15, 164/16, 164/17, 164/18, and 164/21

Drive Cycle to Determine Fault Status

N/A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 1322 – 1328 FMI 31 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for 1322 – 1328 FMI 31. No: Go to Step 3.

Step	Action	Decision
3	Test for failed injector. Do Key On Engine Off (KOEO) Injector Test (page 87). Did KOEO Injector Test pass?	Yes: Go to Step 6. No: Go to Step 4.

Step	Action	Decision
4	Test injector circuit resistance through valve cover and, if indicated, injector coil resistance. Do resistance checks (page 926). Are injector circuits inside the valve cover and / or injector coils within specifications?	Yes: Go to Step 6. No: Go to Step 5.

Step	Action	Decision
5	Isolate electrical failure to injector or harness. Remove valve cover, disconnect harness from injector, and do coil resistance checks on the suspect injector(s) (page 926). Does circuit operate properly?	Yes: Go to Step 6. No: Replace suspect injector or under-valve cover wiring harness as indicated. After repairs are complete, retest for SPN 1322 – 1328 FMI 31.

Step	Action	Decision
6	Inspect connections at injector circuits outside valve cover. With key OFF, disconnect injector circuits outside valve cover. Check each injector circuit and connector outside valve cover for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are each of the injector connectors, harnesses, and terminals clean and undamaged?	Yes: Go to Step 7. No: Repair any connector, harness, or terminal damage. After repairs are complete, retest for SPN 1322 – 1328 FMI 31.

Step	Action	Decision
7	Inspect air intake system, exhaust system, and air filter for restrictions, air leaks, or physical damage. Inspect air cleaner cleanliness and Mass Air Flow (MAF) sensor for dirt and oil residue. Inspect the fuel system from fuel tank to Aftertreatment Fuel Injector (AFI) valve for leaks or physical damage. Are air intake system, exhaust system, fuel system, and air filter free of restrictions, leaks, and physical damage?	Yes: Go to Step 8. No: Repair restrictions, air leaks, fuel leaks, or physical damage. After repairs are complete and retest for SPN 1322 – 1328 FMI 31.

Step	Action	Decision
8	Check for fuel level and fuel quality. Visually inspect by removing fuel cap from all tanks, check Water In Fuel (WIF) light, and sample for dirty or aerated fuel. Is there sufficient supply of good quality fuel?	Yes: Go to Step 9. No: Remove dirty or aerated fuel, fill with good quality fuel. After fuel replacement is complete, retest for SPN 1322 – 1328 FMI 31.

Step	Action	Decision
9	Check for oil level, oil quality, and aerated oil. Is there sufficient supply of good quality oil?	Yes: Go to Step 10 No: Remove dirty, aerated, or contaminated oil. Fill with good quality oil. After oil replacement is complete, retest for SPN 1322 – 1328 FMI 31.

Step	Action	Decision
10	Determine if Engine Compression Brake (ECB) is equipped and operating correctly. Using EST with ServiceMaxx™ software, do Engine Low Idle to High Idle (page 199) test while monitoring Brake Control Pressure (ECBP). Is ECBP less than 72 psi (500 kPa)?	Yes: Go to Step 11. No: Replace ECB valve. After replacement is complete, retest for SPN 1322 – 1328 FMI 31.

Step	Action	Decision
11	Calibrate MAF sensor. Do MAF Calibration Procedure (page 1101). Did the MAF auto-calibration succeed?	Yes: Go to Step 12. No: Perform test and procedures for a malfunctioning MAF sensor (page 675). After repairs are complete, retest for SPN 1322 – 1328 FMI 31.

Step	Action	Decision
12	Determine the cause of rough engine idle or misfire. Do Relative Compression Test (page 215). Are all engine cylinder performance readings similar?	Yes: Go to Step 13. No: Repair mechanical problem with cylinder(s) indicating low performance. After problem is repaired, retest for SPN 1322 – 1328 FMI 31.

Step	Action	Decision
13	Do Cylinder Performance Analyzer (CPA) Test (page 257) to evaluate cylinder performance issues. Evaluate performance concerns during hot idle, cold idle (optional), and a full load highway speed test. Did tests finish without identifying a suspect cylinder? **NOTE:** Due to the complexity of some of the codes, print out the CPA tool results for later use.	Yes: Go to HPOP CPA Test (page 287). No: Remove valve cover, check valve lash, and crank engine to verify cam shaft lobe operation and lift. Repair as required, and retest for SPN 1322 – 1328 FMI 31.

NOTE: After doing all diagnostic steps, if SPN 1322 – 1328 FMI 31 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

EOP Sensor (Engine Oil Pressure)

Overview of EOP Sensor Group

SPN	FMI	Description
100	3	EOP signal Out of Range HIGH (page 738)
100	4	EOP signal Out of Range LOW (page 741)

Overview

Engine Oil Pressure (EOP) sensor provides feedback signal to Engine Control Module (ECM) indicating engine oil pressure. During engine operation, ECM will monitor EOP signal to determine if oil pressure is satisfactory. If oil pressure is below desired pressure, ECM will turn on red engine lamp.

An optional feature, Engine Warning and Protection System (EWPS), can be enabled to warn engine operator and shut engine down when low engine oil pressure condition occurs.

SPN 100 FMI 3 - EOP signal Out of Range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Values
Engine Oil Pressure (EOP) signal Out of Range HIGH	None	None

Fault Overview

None

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during one drive cycle.

Associated Faults

SPN 3509 FMI 3 and 4 (VREF1)

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON

Possible Causes

- EOP circuit short to PWR
- SIG GND circuit Open
- Failed EOP sensor

Step 1	Check for active fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 100 FMI 3. Does EST DTC list show SPN 100 FMI 3 as Active or Pending?		Yes: Go to Step 2. Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79). After repairs are complete, retest for SPN 100 FMI 3.

Step 2	Check for associated fault codes.	Decision
Using EST with ServiceMaxx™ software, check DTC list for SPN 3509 FMI 3 and 4 (VREF1). Is EST DTC list free of SPN 3509 FMI 3 and 4?		Yes: Go to Step 3. No: Repair SPN 3509 FMI 3 and 4. After repairs are complete, retest for SPN 100 FMI 3.

Step 3	Inspect connections at Engine Oil Pressure (EOP) sensor.	Decision
A. Key OFF. B. Disconnect EOP sensor connector. C. Check EOP sensor and connector terminals for damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are EOP sensor connector, harness, and terminal clean and undamaged?		Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 100 FMI 3.

Step 4	Inspect connections at Engine Oil Pressure (EOP) sensor.	Decision
A. Key OFF. B. Disconnect EOP sensor connector. C. Check EOP sensor and connector terminals for damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Does SPN 100 FMI 3 set after DTC list is cleared?		Yes: Repair short to PWR between EOP sensor pin-3 and Engine Control Module (ECM) pin E-13. After repairs are complete, retest for SPN 100 FMI 3. No: Perform Pin-Point Tests (SPN 100 FMI 3). (page 739)

Pin-Point Tests (SPN 100 FMI 3)

EOP Circuit

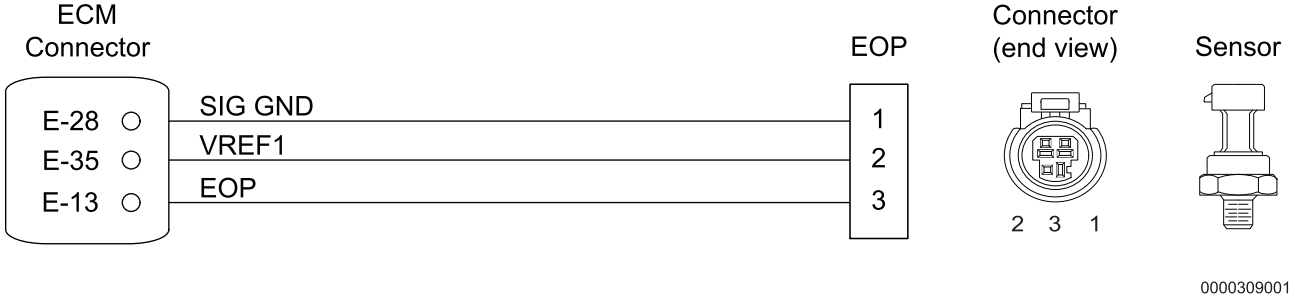


Figure 312 Engine Oil Pressure (EOP) Sensor Circuit Diagram

See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4850
- Digital Multimeter (DMM)

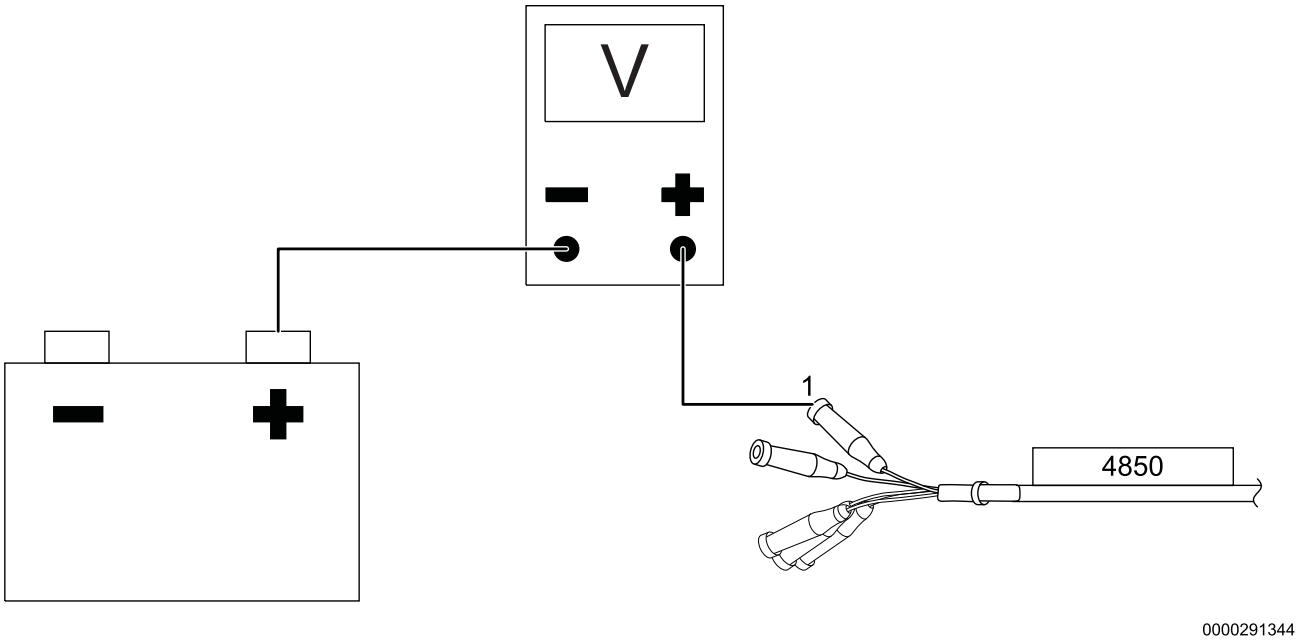


Figure 313 Test 1 Engine Oil Pressure (EOP) Circuit Voltage Check

Test 1 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4850 to Engine Oil Pressure (EOP) sensor vehicle harness connector and leave sensor disconnected. C. Key ON.

Test 1	Specification
Using DMM measure voltage between Breakout Harness ZTSE4850 pin-1 and PWR.	B+ ± 0.5 volts
Decision	
Is voltage B+ ± 0.5 volts.	Yes: Replace EOP sensor. After repairs are complete, retest for SPN 100 FMI 3.
	No: Repair Open between EOP sensor pin-1 and Engine Control Module (ECM) pin E-28. After repairs are complete, retest for SPN 100 FMI 3

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 100 FMI 3 fault code diagnostics.

SPN 100 FMI 4 - EOP Signal Out of Range LOW

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Engine Oil Pressure (EOP) signal Out of Range LOW.	None	Key ON

Fault Overview

Fault code sets when Engine Control Module (ECM) detects Engine Oil Pressure (EOP) signal is out of range low.

Lamp Reaction

None

Associated Faults

SPN 3509 FMI 3 and 4 (VREF1)

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON.

Possible Causes

- EOP circuit Open
- EOP circuit short to GND
- VREF1 circuit Open
- Failed EOP sensor

Step 1	Check for active or pending fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 100 FMI 4. Is EST DTC list SPN 100 FMI 4 active or pending?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79). After repairs are complete, retest for SPN 100 FMI 4.

Step 2	Check for associated fault codes.	Decision
Using EST with ServiceMaxx™ software, check DTC list for SPN 3509 FMI 3 and 4 (VREF1). Is EST DTC list free of SPN 3509 FMI 3 and 4?		Yes: Go to Step 3. No: Repair SPN 3509 FMI 3 and 4. After repairs are complete, retest for SPN 100 FMI 4.

Step 3	Inspect connections at Engine Oil Pressure (EOP) sensor.	Decision
A. Key OFF. B. Disconnect EOP sensor connector. C. Check EOP sensor and connector terminals for damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are EOP sensor connector, harness, and terminal clean and undamaged?		Yes: Perform Pin-Point Tests. (page 742) No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 100 FMI 4.

Pin-Point Tests (SPN 100 FMI 4)

EOP Circuit

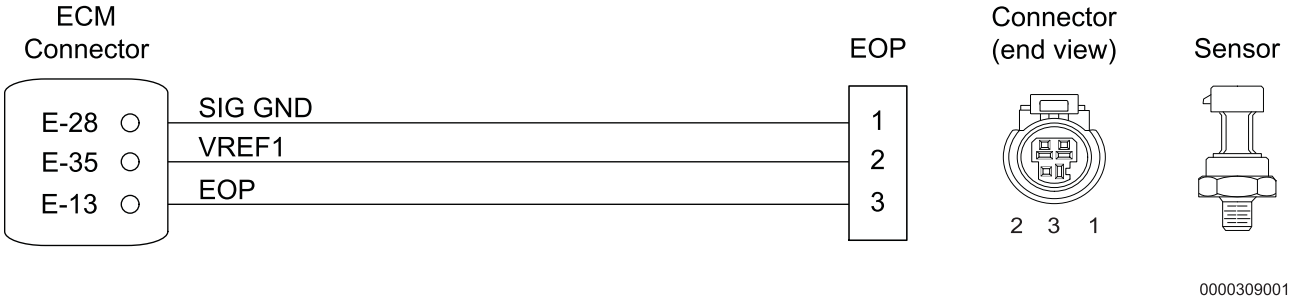


Figure 314 Engine Oil Pressure (EOP) Sensor Circuit Diagram

NOTE: See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4850
- 3-Banana Plug Harness ZTSE4498
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)

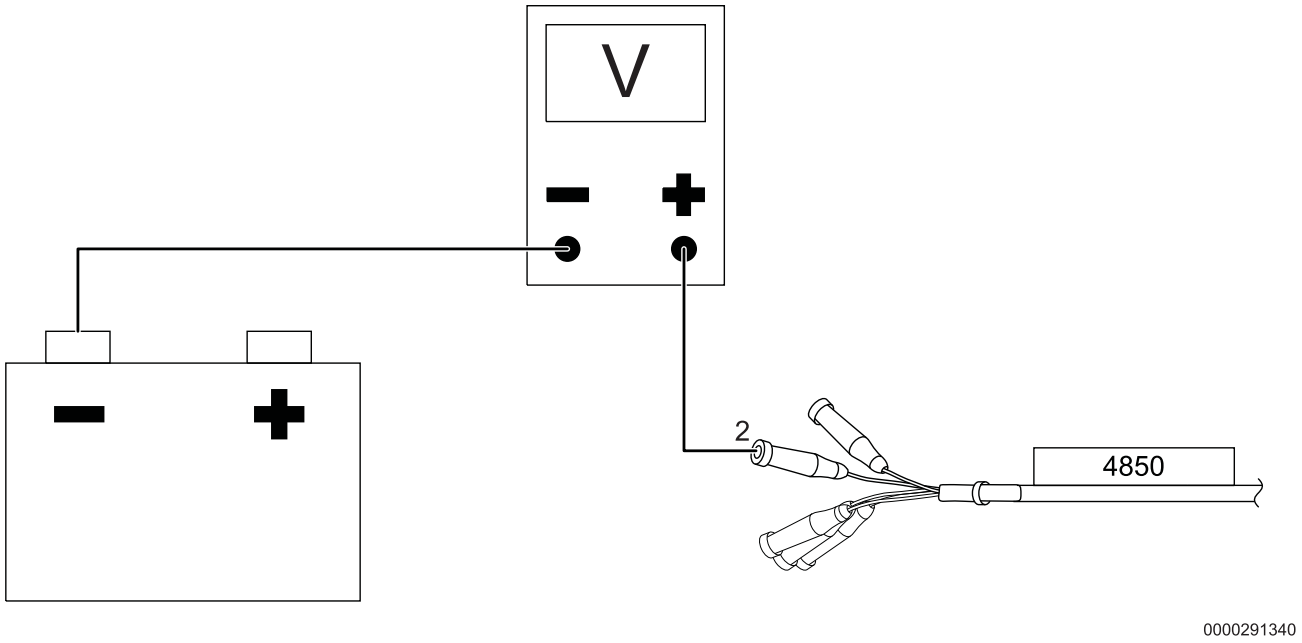
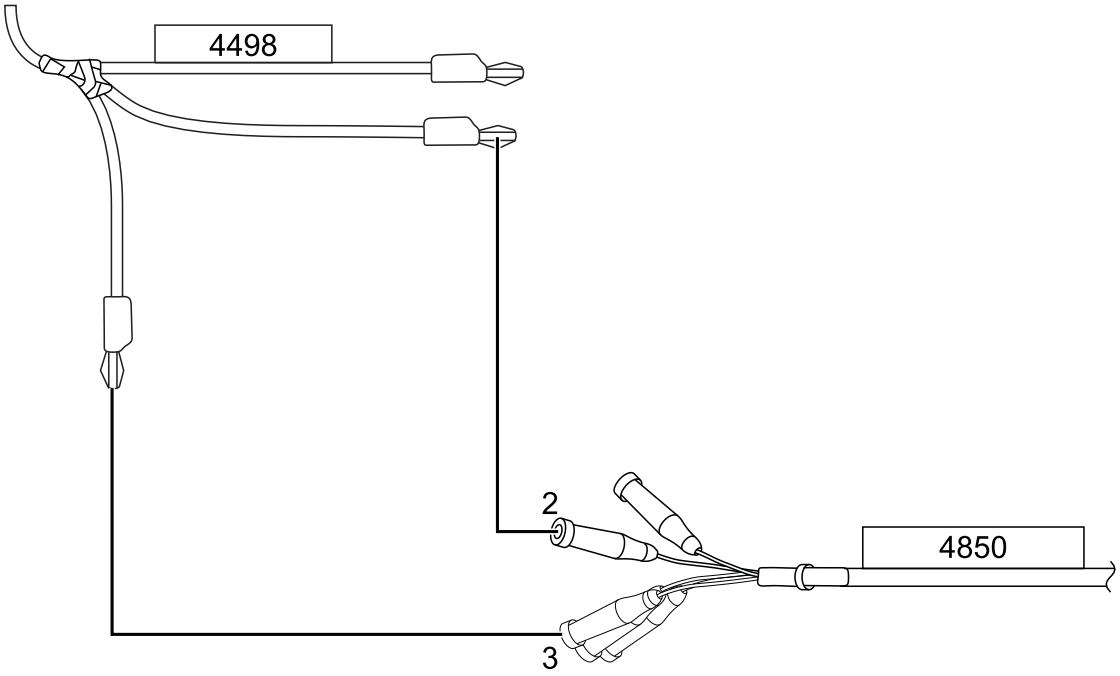


Figure 315 Test 1 VREF1 Voltage Check

Test 1 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4850 to vehicle harness and leave Engine Oil Pressure (EOP) sensor disconnected. C. Key ON.

Test 1	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4850 pin-2 and known good GND.	5 volts ± 1 volt
Decision	
Is voltage 5 volts ± 1 volt?	Yes: Go to Test 2.
	No: Repair Open between EOP pin-2 and Engine Control Module (ECM) pin E-35. After repairs are complete, retest for SPN 100 FMI 4.

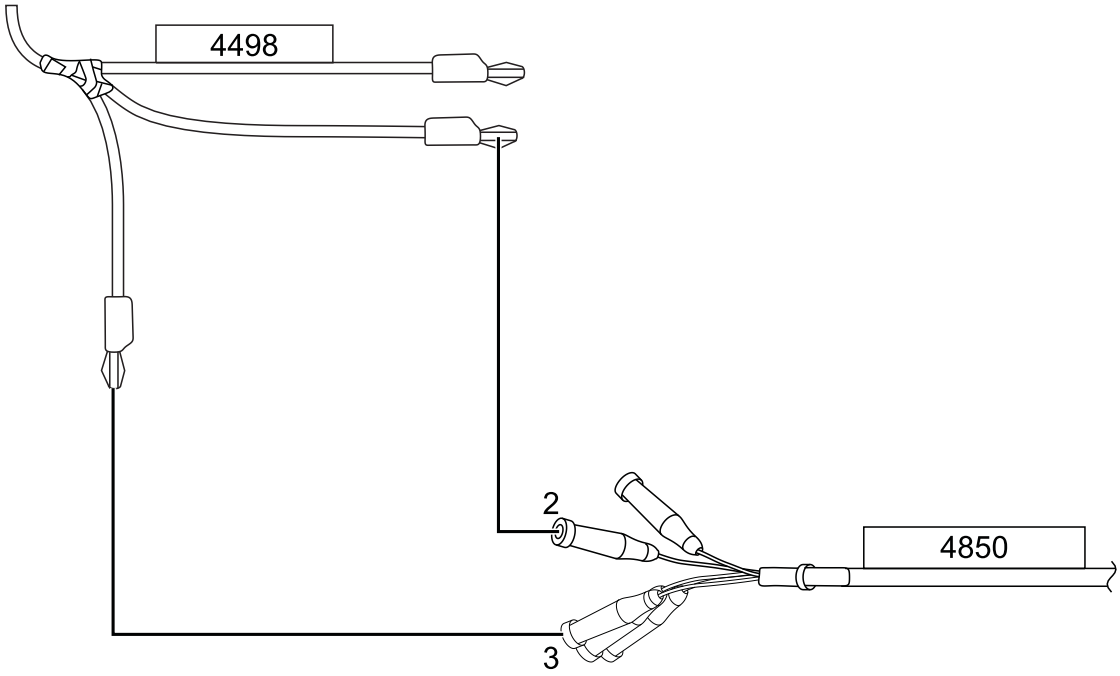


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Figure 316 Test 2 EOP Circuit Check

Test 2 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4850 to vehicle harness and leave EOP sensor disconnected. C. Using Breakout Harness ZTSE4498, short pin-2 and pin-3 of Breakout Harness ZTSE4850 together. D. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). E. Key ON. Log in to ServiceMaxx™ software.

Test 2	Specification
Using EST with ServiceMaxx™ software, clear Diagnostic Trouble Code (DTC) list.	SPN 100 FMI 3 sets in DTC list.
Decision	
Does SPN 100 FMI 3 set after DTC list is cleared?	Yes: Replace EOP sensor. After repairs are complete, retest for SPN 100 FMI 4.
	No: Go to Test 3



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Figure 317 Test 3 EOP Circuit Check

Test 3 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4850 to vehicle harness and leave EOP sensor disconnected. C. Using Breakout Harness ZTSE4498, short pin-2 and pin-3 of Breakout Harness ZTSE4850 together. D. Connect EST to vehicle Diagnostic Connector. E. Key ON. Log in to ServiceMaxx™ software.

Test 3	Specification
Using EST with ServiceMaxx™ software, clear DTC list.	SPN 3509 FMI 4 sets in DTC list.
Decision	
Does SPN 3509 FMI 4 set after DTC list is cleared?	Yes: Repair short to GND between EOP pin-3 and ECM pin E-13. After repairs are complete, retest for SPN 100 FMI 4.
	No: Repair Open between EOP pin-3 and ECM pin E-13. After repairs are complete, retest for SPN 100 FMI 4.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 100 FMI 4 fault code diagnostics.

EOT Sensor (Engine Oil Temperature)

SPN	FMI	Condition	Possible Causes	Actions
175	2	EOT signal erratic, intermittent, or incorrect	• Biased EOT circuit or sensor	Step-based Diagnostics (page 751)
175	3	EOT signal Out of Range HIGH	• EOT signal OPEN or short to PWR • SIG GND circuit OPEN • Failed EOT sensor	Step-based Diagnostics (page 753)
175	4	EOT signal Out of Range LOW	• EOT signal circuit short to GND • Failed EOT sensor	Step-based Diagnostics (page 759)
175	7	EOT not warming along with engine	• EOT disconnected from engine • Oil system module thermal valve assembly sticking	Step-based Diagnostics (page 761)

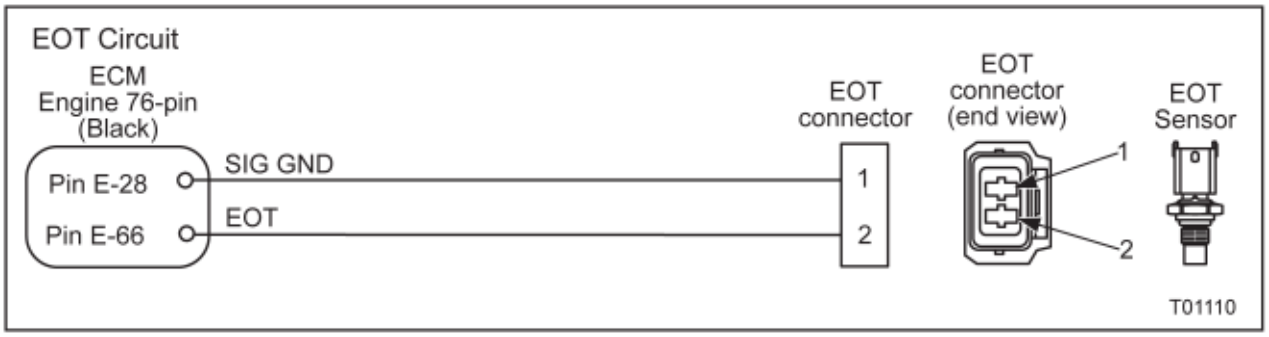


Figure 318 EOT Circuit Diagram

Overview

The EOT sensor provides a feedback signal to the ECM indicating engine oil temperature. The ECM monitors the EOT signal to control fuel quantity and timing throughout the operating range of the engine. The EOT signal allows the ECM to compensate for oil viscosity variations due to temperature changes in the operating environment, ensuring adequate power and torque are available for all operating conditions.

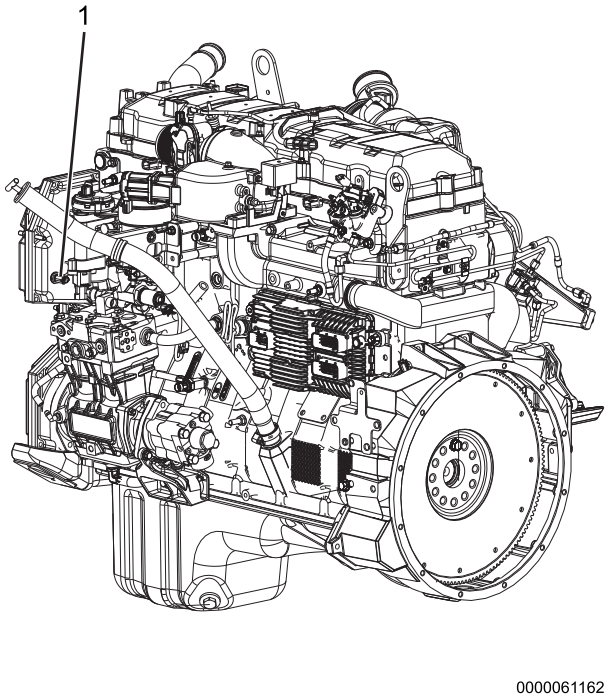


Figure 319 EOT Sensor Location

1. Engine Oil Temperature (EOT) sensor

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- 3-Banana Plug Harness (page 1228)
- 00-00956-08 – 180-pin Breakout Box (page 1222)
- Breakout Harness 4602 (EOT)(page 1230)
- International® Electronic Engine Terminal Test Kit (page 1227)

Pin-point Diagnostics

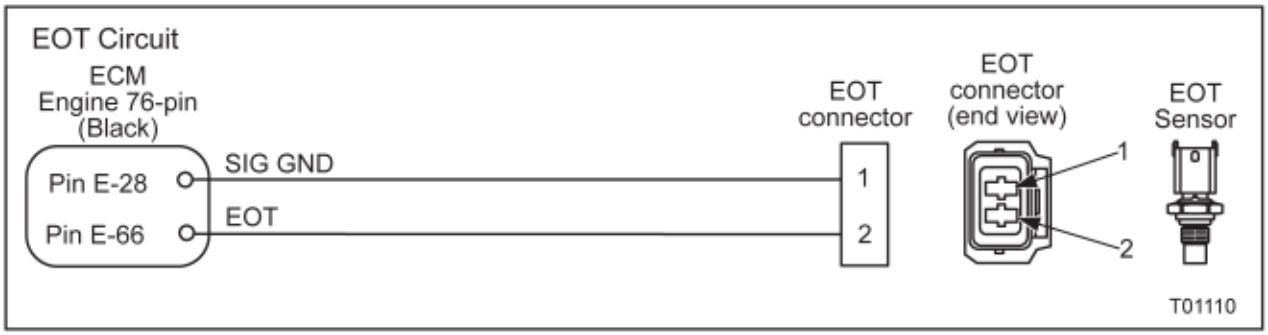


Figure 320 EOT Circuit Diagram

SPN 175 FMI 2 – EOT signal erratic, intermittent, or incorrect

Cold Soak Sensor Compare Check
Temperature values need to be measured after four hours cold soak.

1. Turn switch ON, engine OFF
2. Using ServiceMaxx™ software, open the Continuous Monitor session.
3. Compare EOT with ECT 1 and IMT. All temperature sensors should be within 59°F (15°C) of each other.
   - If any temperature sensor is 59°F (15°C) above or below other sensors, check for biased temperature sensor circuit or failed temperature sensor.
   - If the circuits are acceptable, replace the failed temperature sensor.

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST with ServiceMaxx™ software, open the Continuous Monitor session.
2. Monitor sensor voltage. Verify an active code for the sensor.
   - If code 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 code will go active.
   - If code is active, proceed to the next step.
3. Disconnect engine harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

4. Connect Breakout Harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect sensor breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use EST to verify correct code goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Specification	Comment
EST – Check code	SPN 175 FMI 3	If SPN 175 FMI 4 goes active, check EOT signal for short to GND. Go to Harness Resistance Check.
EST – Check code Short 3-Banana plug harness across 2 and GND	SPN 175 FMI 4	If SPN 175 FMI 3 goes active, check EOT signal for OPEN. Go to Harness Resistance Check.
EST – Check code Short 3-Banana plug harness across 1 and 2	SPN 175 FMI 4	If SPN 175 FMI 3 goes active, check SIG GND for OPEN. Go to Harness Resistance Check.
If checks are within specification, connect sensor and clear codes. If active code remains, replace sensor.		

Connector Voltage Check

Connect sensor Breakout Harness 4602. 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 or short to PWR.
2 to GND	4.6 to 5 V	If < 4.5 volts, check for OPEN or short to GND. Go to Harness Resistance Check.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-pin Breakout Box and sensor Breakout Harness 4602. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
1 to E-28	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to E-66	< 5 Ω	If > 5 Ω, check for OPEN circuit.

SPN 175 FMI 2 - EOT signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Comparison of Engine Oil Temperature 1 sensor to the following sensors after a calibrated adjustable cold-soak period (time). Sensor 1 to 4 are in Air group and 5 to 7 are in Liquid group. [1. Engine Intake Manifold 1 Temperature 2. Engine Air Intake Temperature 3. Engine Turbocharger 2 Compressor Intake Temperature 4. Engine Charge Air Cooler Outlet Temperature 5. Engine Coolant Temperature 7. Engine Fuel Temperature 1]	{Engine Intake Manifold 1 Temperature (Bias Hi) > Reference temperature value OR Engine Intake Manifold 1 Temperature (Bias low)} ≤ Reference temperature value Error threshold value for comparison of sensors in same media (Air to Air media): Used for Equilibrium and Reference value calculation > 59°F (15°C) Error threshold value for comparison of sensors in different media (Air to Liquid media): Used for Equilibrium and Reference value calculation > 59°F (15°C) Error threshold value for comparison of sensors in same media (Liquid to Liquid): Used for Equilibrium and Reference value calculation > 59°F (15°C) Error threshold value for comparison of sensors in different media (Liquid to Air or vice versa): Used for Equilibrium and Reference value calculation > 59°F (15°C) {NOTE: Reference temperature value calculation is explained in Operations Summary Document}	Key ON Engine Off timer ≥ 28800 seconds Engine Coolant Temperature ≥ -40°F (-40°C) Engine in Thermal Equilibrium Condition {Explained in operations summary document} [Similar sensors agree with other sensors with different group-index OR Faulty Sensor is alone in its group {i.e. No other sensor which measures the same media (in Liquid Path) is identified as a faulty sensor}]

Fault Overview

ECM Compares Engine Oil Temperature (EOT) sensor to Intake Manifold Temperature (IMT), Intake Air Temperature (IAT), Turbocharger 2 Compressor Intake Temperature (TC2CIT), Charge Air Cooler Outlet Temperature (CACOT), and Engine Coolant Temperature 1 (ECT1) sensors after calibrated adjustable cold-soak period (time).

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Initial Key ON

Possible Causes

- Failed EOT sensor
- Failed wiring

Step 1	Check for active or pending fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 175 FMI 2. Is EST DTC list SPN 175 FMI 2 active or pending?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Inspect connections at Engine Oil Temperature (EOT) connector.	Decision
A. Key OFF. B. Disconnect EOT connector. C. Check EOT and connector terminals for: damaged or pinched wires; moisture or corroded terminals; loose, bent, or broken pins; or broken connector housing. Are EOT connector, harness, and terminals clean and undamaged?		Yes: Go to Step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 175 FMI 2.

Step 3	Inspect connections at Engine Oil Temperature (EOT) connector.	Decision
A. Key OFF. B. Connect Breakout Harness ZTSE4993 between pin-1 and pin-2 on EOT connector. C. Key-On Engine-Off (KOEO). Using EST with ServiceMaxx™ software, measure voltage between pin-1 and pin-2. Is voltage less than 0.5 volts?		Yes: Replace EOT sensor. After repairs are complete, retest for SPN 175 FMI 2. No: Go to step 4.

Step 4	Inspect connections at Engine Oil Temperature (EOT) connector.	Decision
A. Key OFF. B. Connect Breakout Harness ZTSE4993 between pin-1 and known good GND. C. Key-On Engine-Off (KOEO). Using EST with ServiceMaxx™ software, measure resistance. Is resistance less than 5 ohms?		Yes: Repair EOT signal wire. After repairs are complete, retest for SPN 175 FMI 2. No: Repair EOT SIG GND wire. After repairs are complete, retest for SPN 175 FMI 2.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 175 FMI 2 fault code diagnostics.

SPN 175 FMI 3 - EOT signal Out of Range HIGH

Condition/Description	Setting Criteria	Enable Conditions / Values
Engine Oil Temperature 1 Sensor signal Out of Range High	Engine Oil Temperature 1 Sensor Voltage > 4.8 Volts (< -41°F [-40.58°C])	Key ON

Fault Overview

None

Time Requirements

5 seconds

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

None

Fault Facts

None

Drive Cycles

Key ON

Possible Causes

- Engine Oil Temperature (EOT) sensor signal circuit open or short to power
- EOT sensor signal circuit open

- EOT sensor ground circuit OPEN or high resistance
- Failed EOT sensor

WARNING: To prevent personal injury or death, be careful to avoid rotating parts (belts and fan) and hot engine surfaces.

Step 1	Check for associated fault code.	Decision
Using Electronic Service Tool (EST) from ServiceMaxx™ software, check for active fault codes SPN 175 FMI 3. Is EST DTC list free of SPN 175 FMI 3?		Yes: Go to Step 2. No: Drive vehicle and retest for SPN 175 FMI 3. If fault code does not return, notify supervisor for further action.

Step 2	Inspect connections at Engine Oil Temperature (EOT) sensor.	Decision
A. Key-On Engine-Off (KOEO) B. Disconnect EOT sensor connector. C. Check EOT sensor and connector terminals for damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are EOT sensor connector, harness, and terminals clean and undamaged?		Yes: Perform Pin-Point Tests (SPN 175 FMI 3) (page 755). No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 175 FMI 3.

Pin-Point Tests (SPN 175 FMI 3)

Engine Oil Temperature (EOT) Sensor Circuit

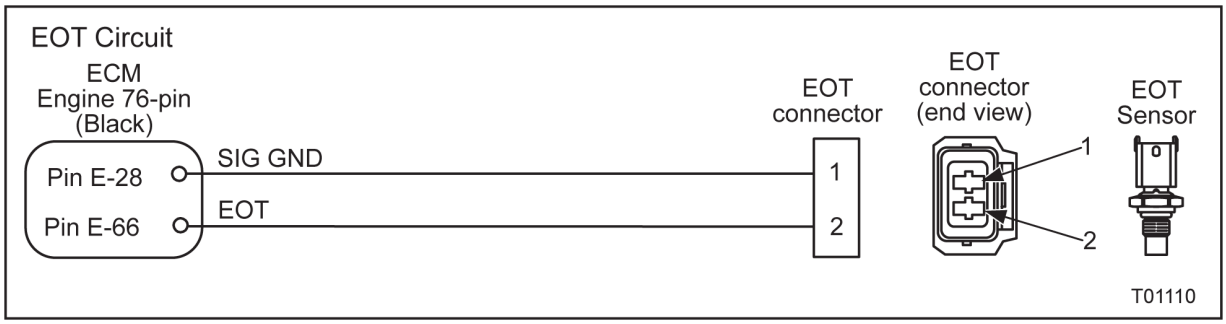


Figure 321 Engine Oil Temperature (EOT) Sensor Circuit Diagram

NOTE: See latest version of Navistar® N9 and N10 SCR Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4602
- Breakout Harness ZTSE4498
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- 180-pin Breakout Box

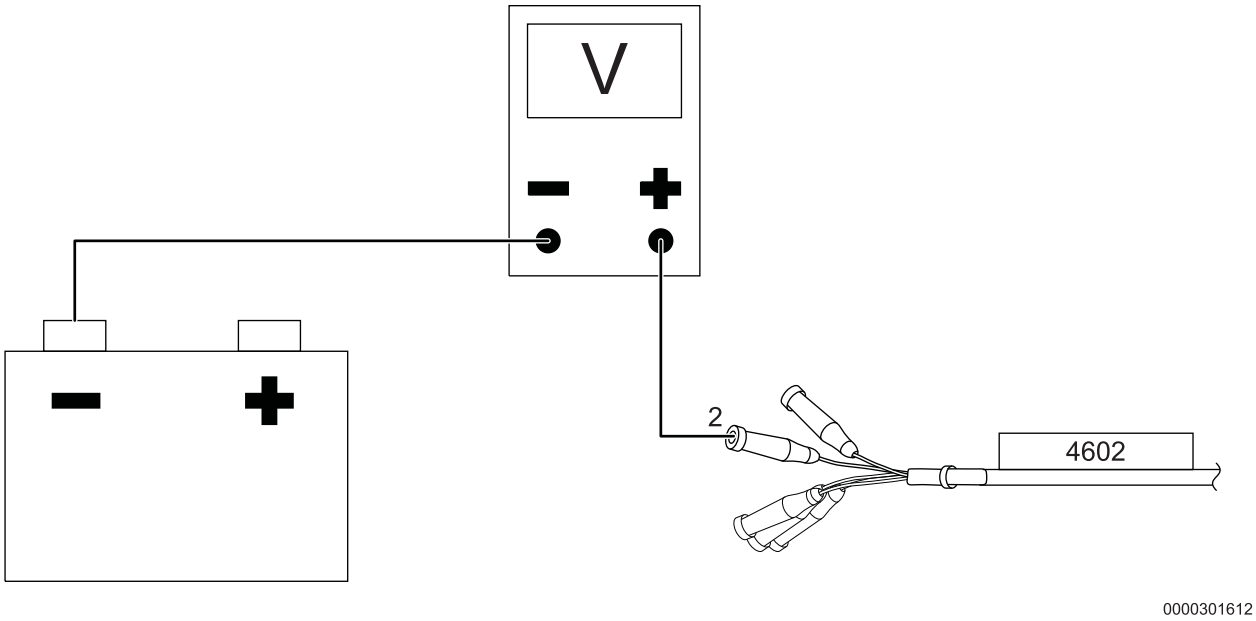


Figure 322 Test 1 Engine Oil Temperature (EOT) Circuit Voltage Check

Test 1 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4602 to Engine Oil Temperature (EOT) vehicle harness connector and leave EOT sensor disconnected. C. Key ON.

Test 1	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4602 pin-2 and known good ground.	6 volts
Decision	
Is voltage greater than 6 volts?	Yes: Repair EOT circuit for a short to power. After repairs are complete, retest for SPN 175 FMI 3.
	No: Go to Test 2.

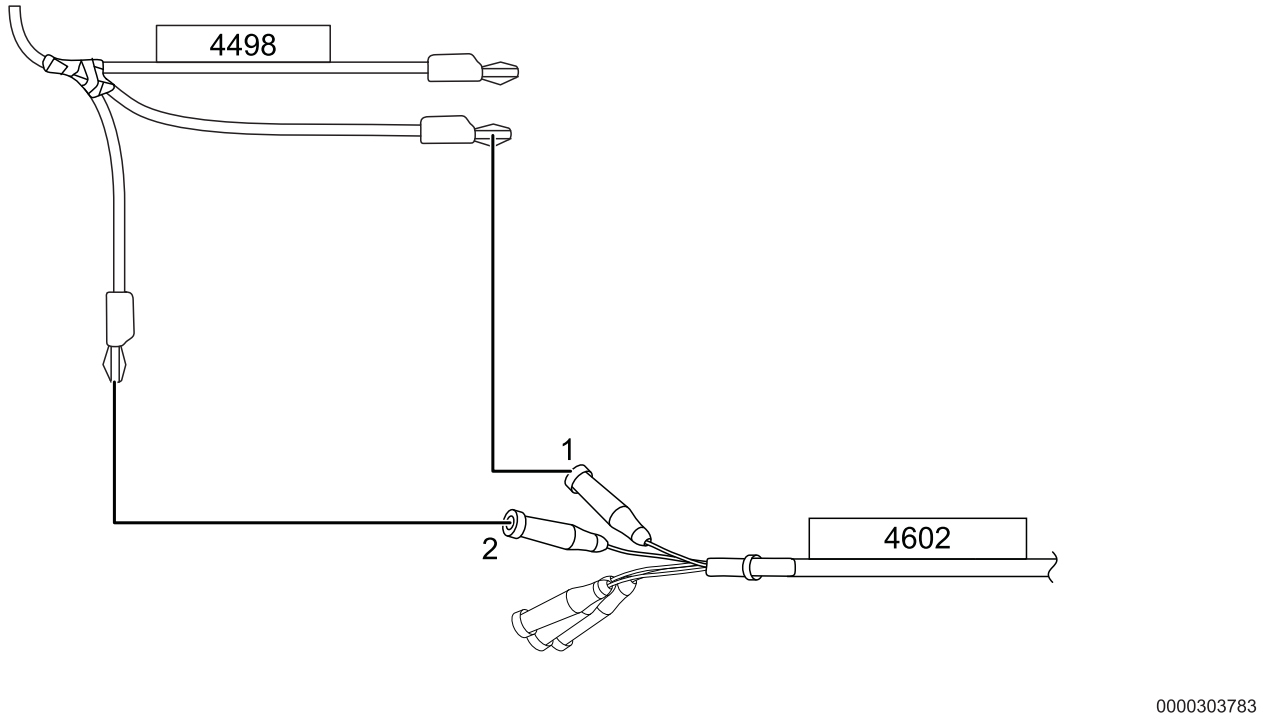
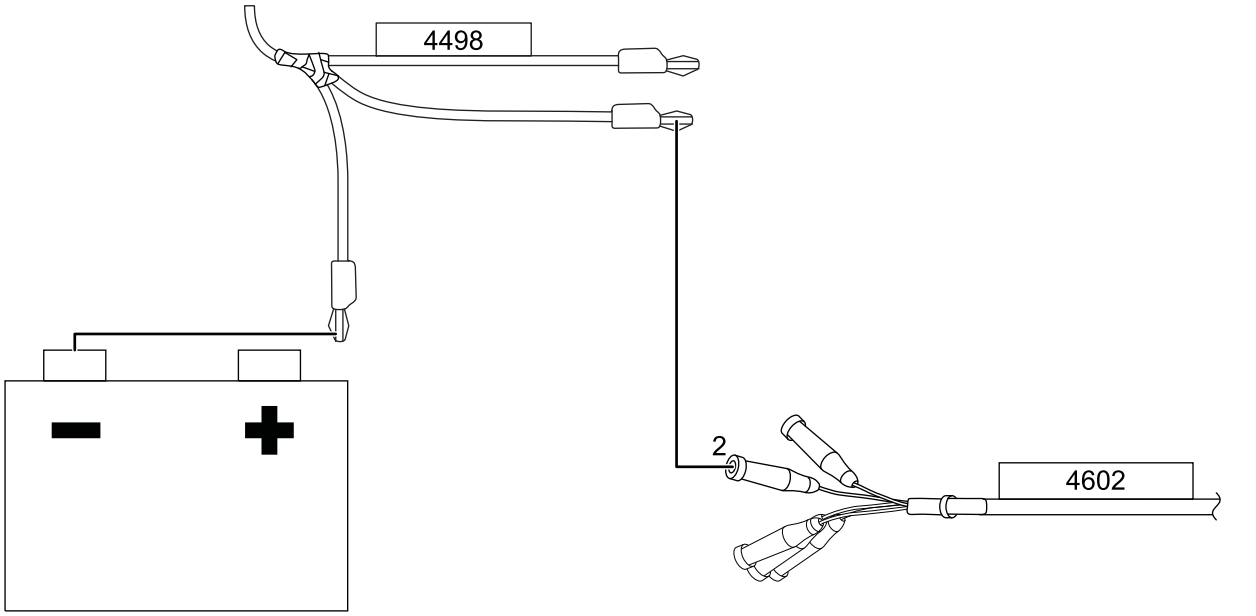


Figure 323 Test 2 Engine Oil Temperature (EOT) Sensor Circuit Check

Test 2 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4602 to Engine Oil Temperature (EOT) vehicle harness connector and leave EOT sensor disconnected. Use Breakout Harness ZTSE4498 to short pin-1 to pin-2. C. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). D. Key ON and log into ServiceMaxx™ software.

Test 2	Specification
Using Electronic Service Tool (EST) with ServiceMaxx™ software, clear Diagnostic Trouble Code (DTC) list.	None
Decision	
Is fault code SPN 175 FMI 4 active or pending?	Yes: Replace sensor. After repairs are complete, retest for SPN 175 FMI 3.
	No: Go to Test 3.



Test 3 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4498 to Engine Oil Temperature (EOT) sensor harness connector and short pin-2 to ground. C. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). D. Key ON and log into ServiceMaxx™ software.

Test 3	Specification
Using Electronic Service Tool (EST) with ServiceMaxx™ software, clear Diagnostic Trouble Code (DTC) list.	None
Decision	
Is fault code SPN 175 FMI 4 active or pending?	Yes: Repair open in signal ground circuit. After repairs are complete, retest for SPN 175 FMI 3.
	No: Repair open in signal circuit. After repairs are complete, retest for SPN 175 FMI 3.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and the proper decision was made. Return to SPN 175 FMI 3 fault code diagnostics.

SPN 175 FMI 4 - EOT signal Out of Range LOW

Condition/Description	Setting Criteria	Enable Conditions / Values
Engine Oil Temperature (EOT) sensor signal Out of Range Low	EOT sensor voltage < 0.171 Volts (> 161.9 °C)	Key ON

Fault Overview

Fault code sets when Engine Control Module (ECM) detects Engine Oil Temperature (EOT) signal is lower than expected.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

SPN 3509 FMI 3 and 4 (VREF1)

Fault Facts

None

Drive Cycles

Key ON

Possible Causes

- EOT circuit short to GND
- Failed EOT sensor

Step 1	Check for active or pending fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 175 FMI 4. Does EST DTC list show SPN 175 FMI 4 as active or pending?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Check for associated codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 3509 FMI 3 and 4 (VREF1). Is EST DTC list free of SPN 3509 FMI 3 and 4?		Yes: Go to Step 3. No: Repair SPN 3509 FMI 3 and 4 (VREF1). After repairs are complete, retest for SPN 175 FMI 3.

Step 3	Inspect connections at Engine Oil Temperature (EOT) sensor.	Decision
A. Key OFF. B. Disconnect EOT sensor. C. Inspect EOT sensor and connector terminals for: damaged or pinched wire; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the EOT sensor connector, harness, and terminals clean and undamaged?		Yes: Go to Pin-Point Test 1 (page 761). No: Repair or Replace connector or pins. After repairs are complete, retest for SPN 175 FMI 4.

Pin-Point Tests (SPN 175 FMI 4)

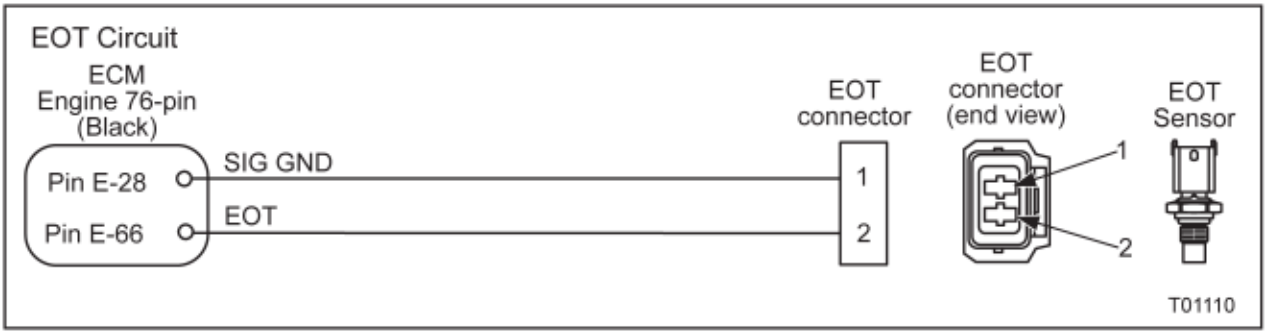


Figure 325 EOT Sensor Circuit Diagram

NOTE: See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4602
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Breakout Harness ZTSE4498

Test 1 Setup
A. Check for failed sensor. B. Key OFF. C. Disconnect EOT sensor. D. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). E. Key ON. Log in to ServiceMaxx™ software.

Test 1 EOT Resistance Check for short to GND	Specification
Using EST with ServiceMaxx™ software, clear Diagnostic Trouble Code (DTC) list.	DTC list SPN 175 FMI 3 sets
Decision	
Does SPN 175 FMI 3 set after DTC list is cleared?	Yes: Replace EOT sensor. After repairs are complete, retest for SPN 175 FMI 4.
	No: Repair short to GND between EOT pin-3 and ECM pin E1-63. After repairs are complete, retest for SPN 175 FMI 4.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and the proper decision was made. Return to SPN 175 FMI 4 fault code diagnostics.

SPN 175

FMI 7 – EOT not Warming Along with Engine

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
N/A			

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

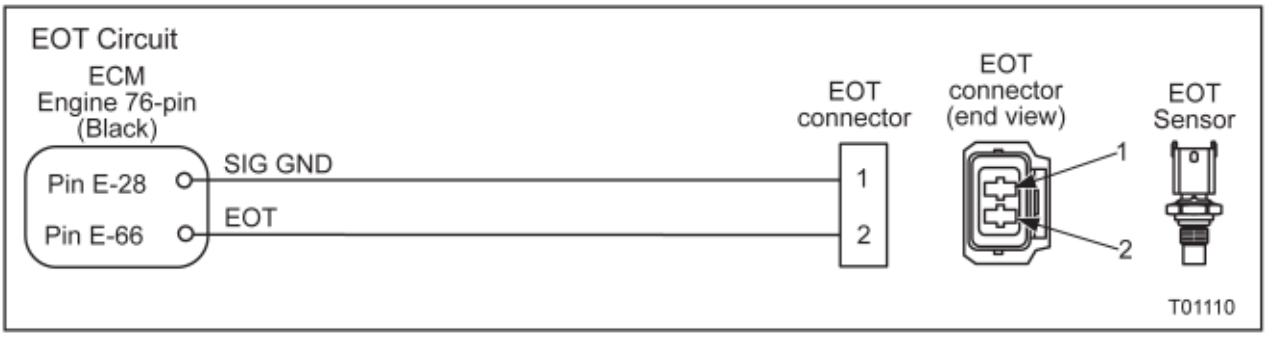


Figure 326 EOT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 175 FMI 7 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 175 FMI 7. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at Engine Oil Temperature (EOT) sensor. With Key OFF, disconnect EOT connector. Check EOT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are EOT connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 175 FMI 7

Step	Action	Decision
4	Test EOT circuits for open, short, or high resistance conditions. Do Connector Voltage Checks and resistance checks (page 750). Are EOT circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 175 FMI 7.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Do Key On Engine Off Continuous Monitor Test (page 87). Does circuit operate properly?	Yes: Go to Step 6.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 175 FMI 7.

Step	Action	Decision
6	Test EOT sensor. Connect breakout harness 4602 between EOT sensor and EOT sensor connector. Do KOEO voltage check of EOT sensor between EOT signal and ground. Is voltage within specification (page 1291)?	Yes: Go to Step 7.
		No: Replace EOT sensor. After repairs are complete, retest for SPN 175 FMI 7.

Step	Action	Decision
7	Test for EOT warming with the engine. Using EST with ServiceMaxx™ software, run engine until reaching normal operating temperature while monitoring EOT. Does EOT warm with engine?	Yes: After doing all diagnostic steps, if SPN 175 FMI 7 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace oil system module thermal valve assembly. After repair is complete, retest for SPN 175 FMI 7.

NOTE: After doing all diagnostic steps, if SPN 175 FMI 7 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

ETV (Engine Throttle Valve)

SPN	FMI	Condition	Possible Causes	Actions
51	0	Engine Throttle Position (ETP) fault: over temperature	• Charge Air Cooler (CAC) under cooling • Sensor or valve failure • Interstage cooler under cooling • Engine overheat	Step-based Diagnostics (page 770)
51	2	ETP does not agree with commanded position	• ETP signal fault • Engine Throttle Valve (ETV) failure	Pin-point Diagnostics (page 767)
51	3	ETP signal Out of Range HIGH	• Failed ETP feedback sensor • ETP signal Short Circuit to Battery • ETP signal return open	Step-based Diagnostics (page 773)
51	4	ETP signal Out of Range LOW	• Failed ETP • ETP Reference Voltage (VREF) open circuit • Signal circuit short to GND • Signal open • Disconnected connector	Step-based Diagnostics (page 775)
51	5	ETP open load / circuit	• Open circuit for intake throttle position power • Open circuit for intake throttle position ground • Open intake throttle circuit	Step-based Diagnostics (page 780)
51	7	ETP does not agree with commanded position	• Sticking or failed ETV	Pin-point Diagnostics (page 782)
51	11	ETP operation fault – under-Volt, over-Amp, over-Temp / ETP H-bridge Electrical Check	• Sticking or failed ETV • ETV failure	Pin-point Diagnostics (page 767)

SPN	FMI	Condition	Possible Causes	Actions
3464	3	Engine Throttle Control (ETC) short to PWR	• ETC circuit short to power • Failed ETV	Pin-point Diagnostics (page 767)
3464	4	ETC short to GND	• ETC circuit short to ground • Failed ETV	Pin-point Diagnostics (page 767)
3464	11	ETC operation fault	• Jammed sector gear • Stalled motor • Damaged butterfly valve • Ice water intrusion into electrical section in intake throttle	Step-based Diagnostics (page 785)

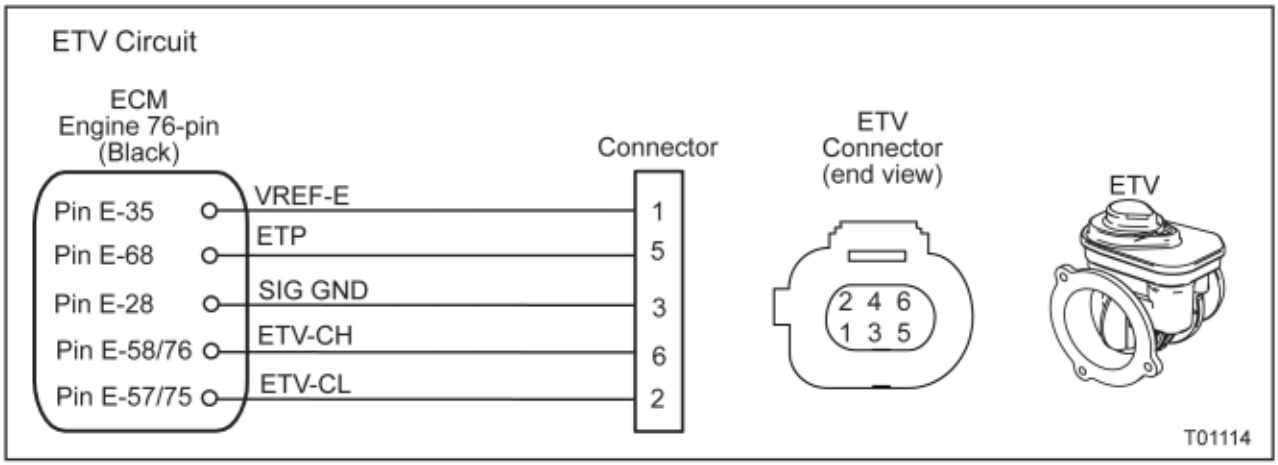


Figure 327 ETV Actuator Circuit Diagram

Overview

The ETV is used to control air/fuel mixture during a regeneration process of the Aftertreatment (AFT) system. The ETV is also used to insure a smooth engine shutdown by restricting airflow to the engine at shutdown.

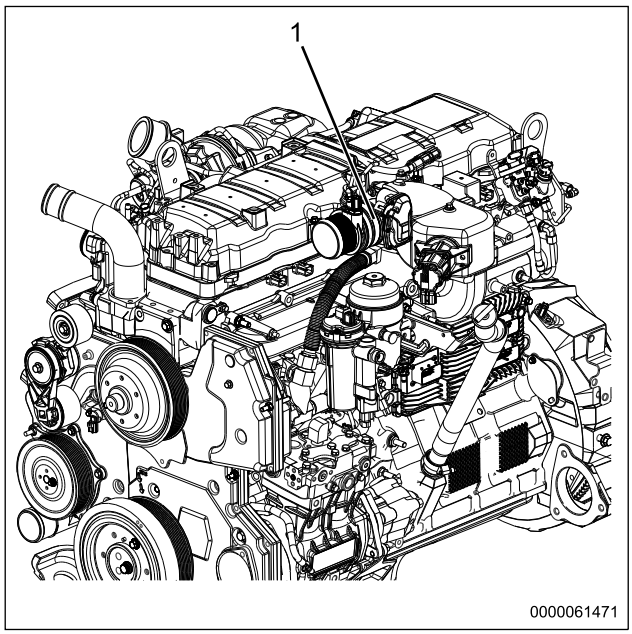


Figure 328 ETV Component Location

1. Engine Throttle Valve (ETV)

Tools

- EZ Tech® Electronic Service Tool (EST) – J-45067 (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- 00-00956-08 – 180-pin Breakout Box (page 1222)
- 3-Banana Plug Harness (page 1228)
- Breakout Harness 4735A (ETV) (page 1231)
- International® Electronic Engine Terminal Test Kit (page 1227)

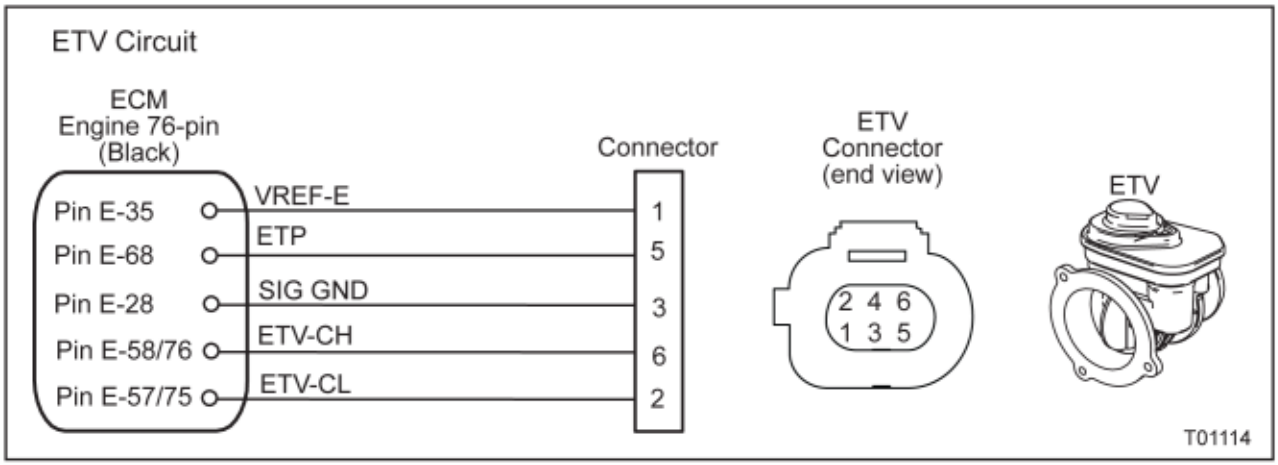


Figure 329 ETV Actuator Circuit Diagram

Pin-point 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 EST with ServiceMaxx™ software, open the Continuous Monitor session.
2. Verify sensor voltage is within KOEO specification. See APPENDIX A (page 1291).
3. Monitor sensor voltage. Verify an active code for the sensor.
   - If code 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 code will go active.
   - If code is active, proceed to the next step.
4. Disconnect engine harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

5. Connect breakout harness to engine harness. Leave sensor disconnected.

ETV Actuator Circuit Check

Connect breakout harness. Leave ETV disconnected. Turn ignition switch to ON. Use EST to monitor signal and DMM to measure voltage during Continuous Monitor test.

Test Point	Specification	Comment: < Less than, > Greater than
EST – Check code	SPN 3464 FMI 4	If SPN 3464 FMI 3, check ETP signal for short to PWR.
DMM – Measure volts 1 to GND	5 ± 0.5 V	If > 5.5 volts, check VREF for short to PWR. If < 4.5 volts, check VREF for OPEN or short to GND. Go to Harness Resistance Check.
EST – Check code Short breakout harness across 5 and 1	SPN 3464 FMI 3	If SPN 3464 FMI 4, check ETP signal for OPEN. Go to Harness Resistance Check.
DMM – Measure volts 3 to B+	B+	If < B+, check SIG GND for OPEN. Go to Harness Resistance Check.
DMM – Measure volts 2 to GND	B+	If < B+, check ETV-CL for OPEN or short to GND. Go to Harness Resistance Check.
DMM – Measure volts 6 to GND	B+	If < B+, check ETV-CH for OPEN or short to GND. Go to Harness Resistance Check.

ETV Actuator Pin-point Diagnostics

Connector Voltage Check

Connect breakout harness. Leave actuator disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment: < Less than, > Greater than
3 to GND	0 V	If > 0.25 volts, check SIG GND for short to PWR.
1 to GND	5 ± 0.5 V	If > 5.5 volts, check VREF for short to PWR. If < 4.5 volts, check VREF for OPEN or short to GND. Go to Harness Resistance Check.
5 to GND	0 V	If > 0.25 volts, check ETP for short to PWR. Go to Harness Resistance Check.
2 to GND	B+	If < B+, check ETV–CL for OPEN or short to GND. Go to Harness Resistance Check.
6 to GND	B+	If < B+, check ETV–CH for OPEN or short to GND. Go to Harness Resistance Check.
If checks are within specification, go to Connector Resistance Check to GND.		

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-pin Breakout Box and actuator breakout harness. Leave ECM and actuator disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
5 to E-68	< 5 Ω	If > 5 Ω, check ETP signal circuit for OPEN
3 to E-28	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN
2 to E-57	< 5 Ω	If > 5 Ω, check ETV-CL circuit for OPEN
2 to E-75	< 5 Ω	If > 5 Ω, check ETV-CL circuit for OPEN
6 to E-58	< 5 Ω	If > 5 Ω, check ETV-CH circuit for OPEN
6 to E-76	< 5 Ω	If > 5 Ω, check ETV-CH circuit for OPEN
1 to E-35	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN

SPN 51

FMI 0 – ETP Signal Erratic, Intermittent, or Incorrect

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
N/A			

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the Engine Throttle Position signal is erratic.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN / FMI: 2630/16

Drive Cycle to Determine Fault Status

N/A

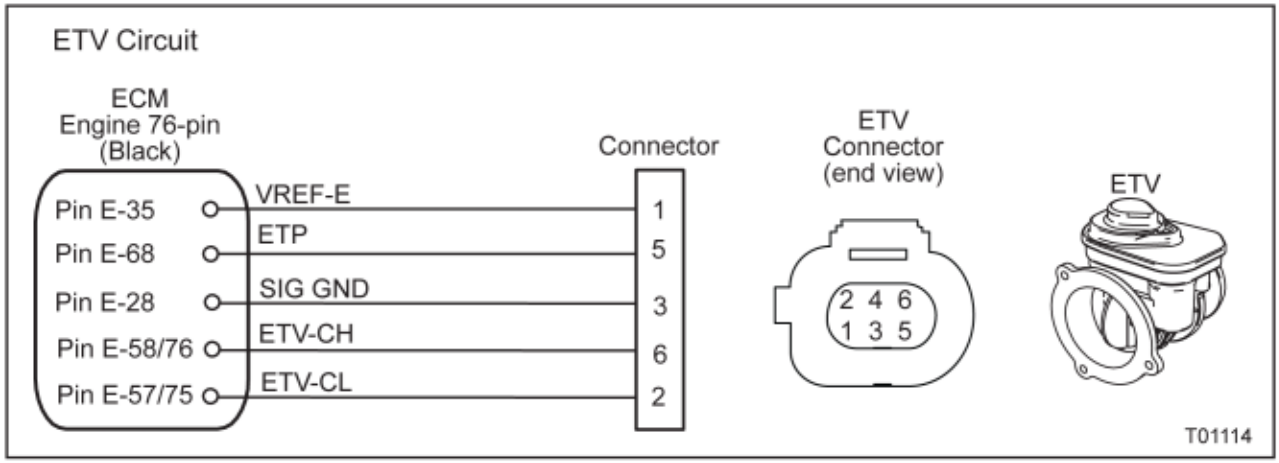


Figure 330 ETV Actuator Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for fault codes. Is SPN 51 FMI 0 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 51 FMI 0.
		No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit, inspect connections at Engine Throttle Valve (ETV) sensor. With key OFF, disconnect ETV sensor. Check ETV sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ETV sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 51 FMI 0.

Step	Action	Decision
4	Determine if ETV circuit is out of specification. Using Electronic Service Tool (EST), with ServiceMaxx™ software, select Test from tool bar. Select Key On Engine Off (KOEO) Tests and then Output State High from Test drop-down menu. Command actuator movement by clicking on the Start Test button. Monitor Engine Throttle Position and Engine Throttle control (ETC) in Actuator Window. Does ETP closely match ETC?	Yes: Go to Step 5.
		No: Replace ETV. After repairs are complete, retest for SPN 51 FMI 0.

Step	Action	Decision
5	Test ETV circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 768). Are ETV circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 6.
		No: Repair circuits as required. After repairs are complete, retest for SPN 51 FMI 0.

Step	Action	Decision
6	Park vehicle on level ground. Check coolant level as indicated on deaeration tank level window. Is level below deaeration tank fill level?	Yes: Fill the deaeration tank. See Coolant System Inspection in Engine Symptoms Diagnostics (page 120). After repairs are complete, retest for SPN 51 FMI 0.
		No: Go to step 7.

Step	Action	Decision
7	Inspect vehicle grille for obstructions that may reduce air flow to the Charge Air Cooler (CAC). Is vehicle grille free of obstructions?	Yes: Go to Step 8.
		No: Repair or remove obstruction from grille. After repairs are complete, retest for SPN 51 FMI 0.

Step	Action	Decision
8	Check engine fan, fan shroud, and air dams for damage and proper operation. Are engine fan, fan shroud, and air dams intact and operating properly?	Yes: Go to Step 9.
		No: Repair or replace engine fan, fan shroud, and/or air dams. After repairs are complete, retest for SPN 51 FMI 0.

Step	Action	Decision
9	Check CAC for oil, dirt, or other debris. Do CAC checks . the CAC system free of dirt, debris, or oil?	Yes: After doing all diagnostic steps, if SPN 51 FMI 0 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Clean CAC. After repairs are complete, retest for SPN 51 FMI 0.

NOTE: After doing all diagnostic steps, if SPN 51 FMI 0 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 51 FMI 3 - ETP signal Out of Range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Values
Engine Throttle Valve Position (ETP) sensor Out of Range High	Actuator Feedback Signal > 4.902 Volts	Key ON

Fault Overview

Fault code sets when Electronic Control Module (ECM) detects Engine Throttle Valve Position (ETP) signal is greater than 4.902 volts.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 3509 FMI 3 and 4

Drive Cycles

Key ON

Possible Causes

- ETP circuit short to PWR
- Failed ETP sensor

Step 1	Check for active fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 51 FMI 3 Does EST DTC list show SPN 51 FMI 3 as active or pending?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure .

Step 2	Check for associated fault codes.	Decision
Using EST with ServiceMaxx™ software, check DTC list for SPN 3509 FMI 3 and 4 (VREF1). Is EST DTC list free of SPN 3509 FMI 3 and 4?		Yes: Go to Step 2. No: Repair SPN 3509 FMI 3 and 4. After repairs are complete, retest for SPN 51 FMI 3.

Step 3	Inspect connections at Engine Throttle Valve Position (ETP) sensor.	Decision
A. Key OFF. B. Disconnect ETP connector. C. Check ETP connector and terminals for damaged or pinched wires; corroded terminals; or loose, bent, or broken connector housing. Are ETP connector, harness, and terminals clean and undamaged?		Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 51 FMI 3.

Step 4	Inspect connections at Engine Throttle Valve Position (ETP) sensor.	Decision
A. Key OFF. B. Disconnect Engine Throttle Valve Position (ETP) connector and leave ETP disconnected. C. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). D. Key ON. E. Log in to ServiceMaxx™. F. Using EST with ServiceMaxx™, clear DTC list. Does SPN 51 FMI 3 set after DTC list is cleared?		Yes: Repair short to PWR between ETP pin-5 and Engine Control Module (ECM) pin-68. After repairs are completed, retest for SPN 51 FMI 3. No: Replace ETP. After repairs are completed, retest for SPN 51 FMI 3.

End Diagnostic Steps
After performing all diagnostic steps, if SPN 51 FMI 3 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

SPN 51 FMI 4 - ETP signal Out of Range LOW

Condition / Description	Setting Criteria	Enable Conditions / Values
Engine Throttle Valve Position (ETP) sensor out of Range Low.	Actuator Feedback Signal < 0.352 Volts	Key ON

Fault Overview

Fault code sets when Electronic Control Module (ECM) detects that Engine Throttle Valve Position (ETP) circuit reading is less than 0.352 volts.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 3509 FMI 3 and 4 (VREF1)

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON.

Possible Causes

- ETP Signal short to GND
- VREF1 circuit Open
- ETP signal Open
- Failed ETP sensor

Step 1	Check for active fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 51 FMI 4. Does EST DTC show SPN 51 FMI 4 as active?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Check for associated faults.	Decision
Using EST with ServiceMaxx™ software, check DTC list for SPN 3509 FMI 3 and 4 (VREF1). Is EST DTC list free of SPN 3509 FMI 3 and 4?		Yes: Go to Step 3. No: Repair SPN 3509 FMI 3 and 4 . After repairs are complete, retest for SPN 51 FMI 4.

Step 3	Inspect connections at Engine Throttle Valve Position (ETP) connector.	Decision
A. Key OFF. B. Disconnect ETP connector. C. Check ETP and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are ETP connector, harness, and terminals clean and undamaged?		Yes: Perform Pin-Point Tests. (page 776) No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 51 FMI 4.

Pin-Point Tests (SPN 51 FMI 4)

ETV Circuit

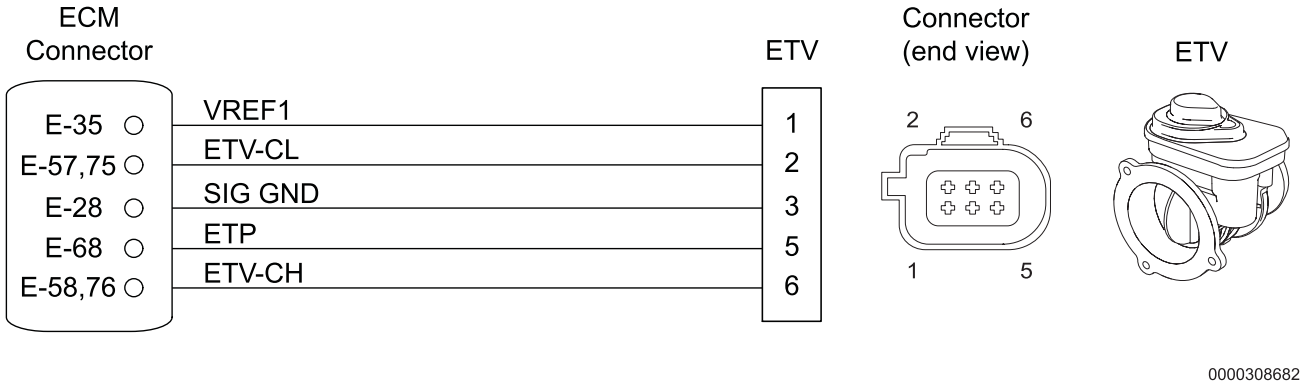


Figure 331 Engine Throttle Valve Position (ETP) circuit diagram

See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4735A
- Breakout Harness ZTSE4498
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP-1210B-compliant supporting J1939 and J1708)

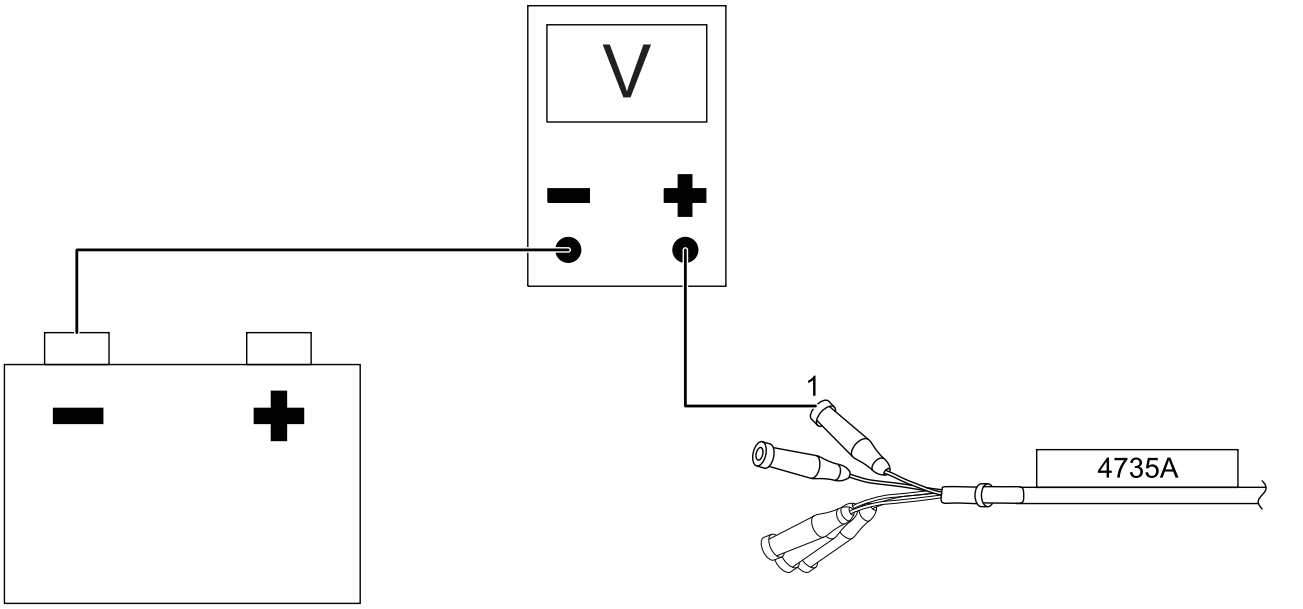


Figure 332 Test 1 VREF1 Circuit Voltage Check

Test 1 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4735A to Engine Throttle Valve Position (ETP) vehicle harness connector and leave ETP disconnected. C. Key ON.

Test 1	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4735A pin-1 and known good ground.	Voltage is 5 ± 1 volts
Decision	
Is voltage 5 ± 1 volts?	Yes: Go to Test 2.
	No: Repair Open between ETP pin-1 and Engine Control Module (ECM) pin E-35. After repairs are complete, retest for SPN 51 FMI 4.

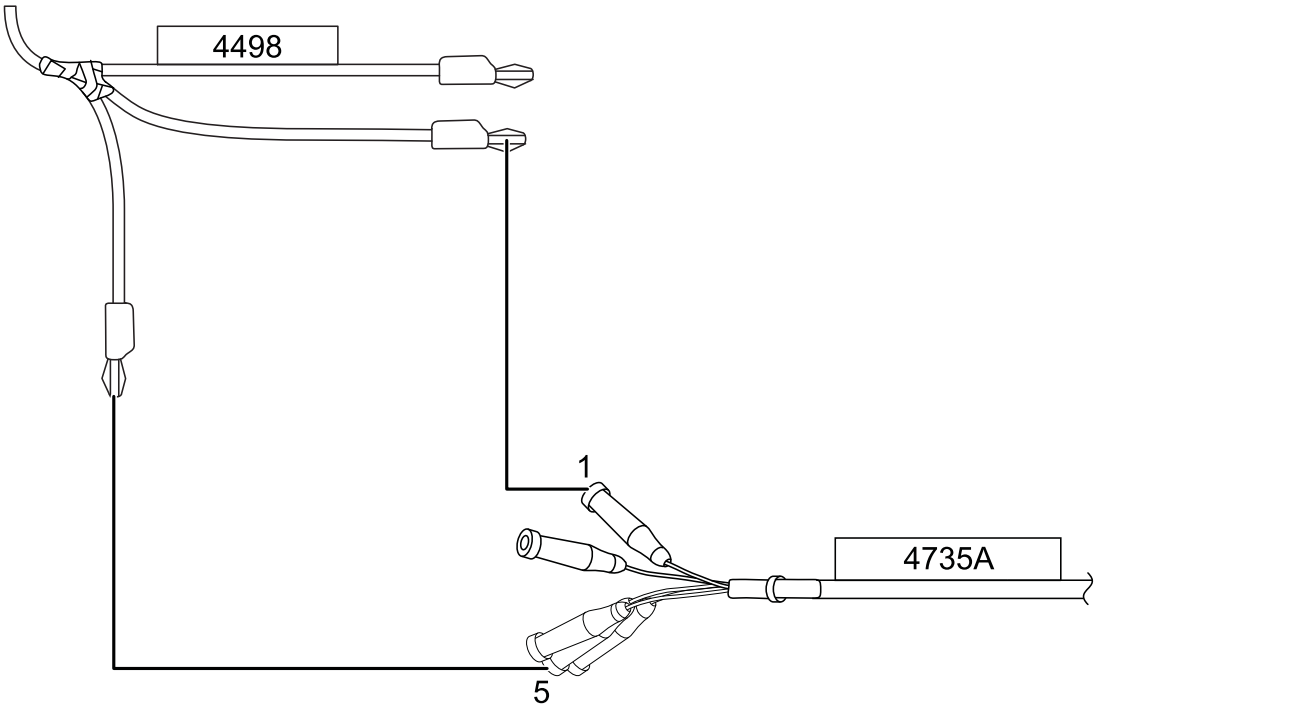


Figure 333 Test 2 Engine Throttle Valve Position (ETP) Sensor Circuit Check

Test 2 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4735A to Engine Throttle Valve Position (ETP) vehicle harness connector and leave ETP disconnected. C. Using Breakout Harness ZTSE4498, short pin-1 and pin-5 of Breakout Harness ZTSE4735A together. D. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). E. Key ON. Log in to ServiceMaxx™ software.

Test 2	Specification
Using EST with ServiceMaxx™ software, clear Diagnostic Trouble Code (DTC) list.	SPN 51 FMI 3 sets in DTC list.
Decision	
Does SPN 51 FMI 3 set after DTC is cleared?	Yes: Replace ETP. After repairs are complete, retest for SPN 51 FMI 4.
	No: Go to Test 3.

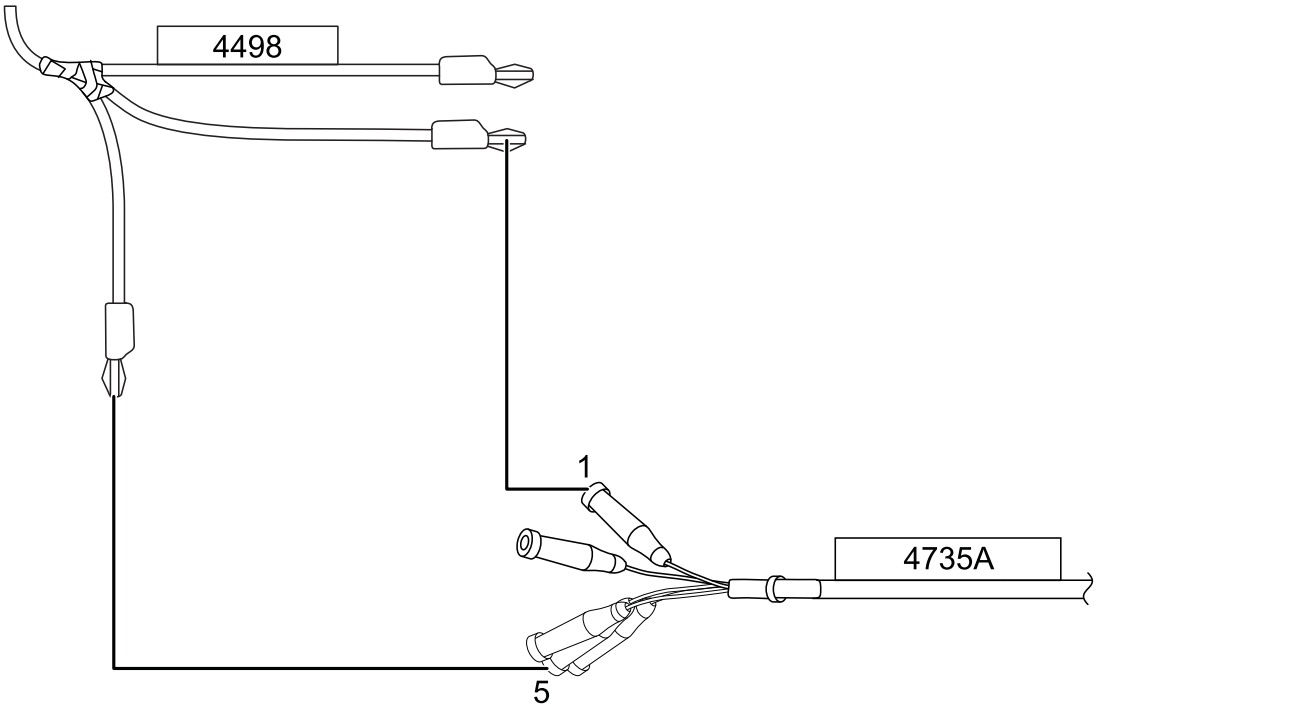


Figure 334 Pin-Point Test 3 Engine Throttle Valve Position (ETP) Sensor Circuit Check

Test 3 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4735A to Engine Throttle Valve Position (ETP) vehicle harness connector and leave ETP disconnected. C. Using Breakout Harness ZTSE4498, short pin-1 and pin-5 of Breakout Harness ZTSE4735A together. D. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). E. Key ON. Log in to ServiceMaxx™ software.

Test 3	Specification
Using EST with ServiceMaxx™ software, clear DTC list.	SPN 3509 FMI 4 sets in DTC list.
Decision	
Does SPN 3509 FMI 4 set after DTC is cleared?	Yes: Repair short to GND between ETP pin-5 and ECM pin E-43. After repairs are complete, retest for SPN 51 FMI 4.
	No: Repair Open between ETP pin-5 and ECM pin E-43. After repairs are complete, retest for SPN 51 FMI 4.

SPN 51

FMI 5 – ETP Open Load / Circuit

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
N/A			

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

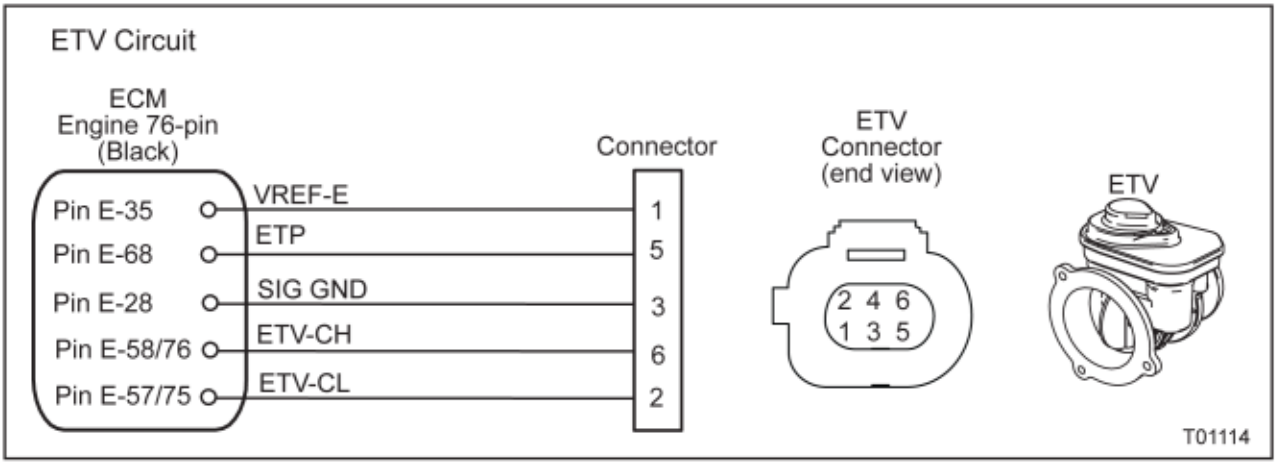


Figure 335 ETV Actuator Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for fault codes. Is SPN 51 FMI 5 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 51 FMI 5. No: Go to Step 3.

Step	Action	Decision
3	Inspect connections at the Engine Throttle Valve (ETV). With key OFF, disconnect ETV connector. Check ETV and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ETV connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 51 FMI 5.

Step	Action	Decision
4	Test ETV circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 768). Are ETV circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 51 FMI 5.

Step	Action	Decision
5	Determine if Engine Throttle Position (ETP) sensor is operating within specification. Connect breakout harness 4735A between ETV and ETV connector. Using EST with ServiceMaxx™ software, do Key On Engine Off Output State High Test (page 87) and Output State Low Test (page 87). Is voltage within specification (All Ratings, page 1291)?	Yes: After doing all diagnostic steps, if SPN 51 FMI 5 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace ETV. After repairs are complete, retest for SPN 51 FMI 5.

NOTE: After doing all diagnostic steps, if SPN 51 FMI 5 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 51 FMI 7 - ETP does not agree with commanded position

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Intake Throttle Position Sensor Fault (Positive error) OR Intake Throttle Position Sensor Fault (Negative error)	[Engine Throttle Position sensor Error {Actual MINUS Set point} > 10 %	Key ON Time after Engine Start > 10 seconds Engine Intake Throttle is in Closed Loop Control SPN/FMI 51/3 and 51/4 are Not active
	[Engine Throttle Position sensor Error {Actual MINUS Set point} < -15 %	Key ON Time after Engine Start > 10 seconds Engine Intake Throttle is in Closed Loop Control SPN/FMI 51/3 and 51/4 are Not active

Fault Overview

Engine Control Module (ECM) senses a positive or negative error in Engine Throttle Position (ETP) sensor based on actual throttle position minus throttle position set point after 25 seconds. ETP must be in closed loop control.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

None

Fault Facts

Vehicles that chronically experience this fault condition in cold weather may require use of winter fronts to help with issue. Note that an open SRTN does NOT set a circuit fault (Type 2 error) and does set a mechanically sticking fault (Type 1 error). The voltage is approximately constant 4 volts with an open SRTN.

Drive Cycle to Determine Fault Status

Key ON

Possible Causes

- Open Signal Return
- Sticking ETP valve
- Broken gears
- Frozen gears (water ingestion that turned to ice)

Step 1	Check for associated fault codes	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 51 FMI 7. Is EST DTC list free of SPN 51 FMI 7?		Yes: Go to Step 2. No: Repair SPN 51 FMI 7 faults. After repairs are complete, retest for SPN 51 FMI 7.

Step 2	Inspect Engine Throttle Valve Position (ETP).	Decision
Inspect ETP valve for signs moisture, condensation, or freezing. Is ETP valve dry and not frozen.		Yes: Perform Pin-Point Tests(page 783). No: Warm and dry ETP. Use winter front in cold weather to eliminate fault. After repairs are complete, retest for SPN 51 FMI 7.

Pin-Point Tests (SPN 51 FMI 7)

ETV Circuit

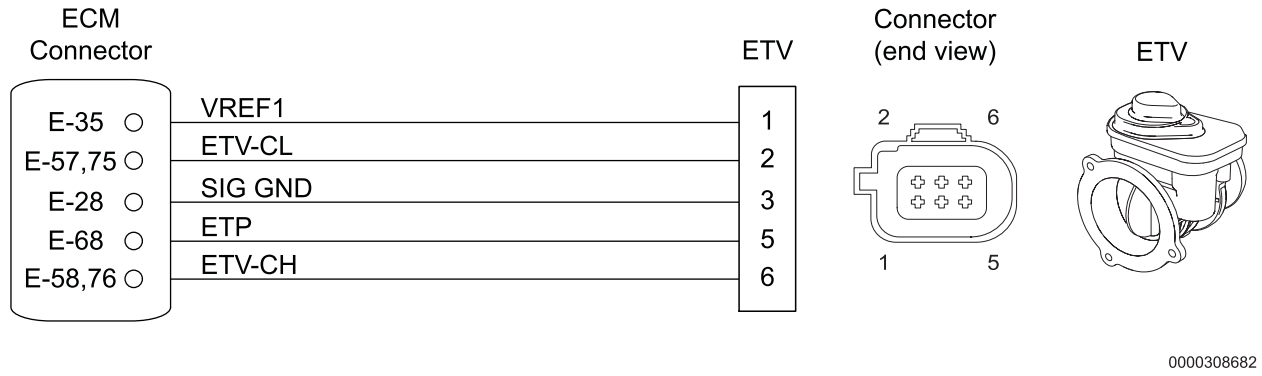


Figure 336 Engine Throttle Valve Position (ETP) Circuit Diagram

NOTE: See latest version of Navistar® N9 and N10 SCR Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)
- Digital Multimeter (DMM)
- Breakout Harness ZTSE4735A

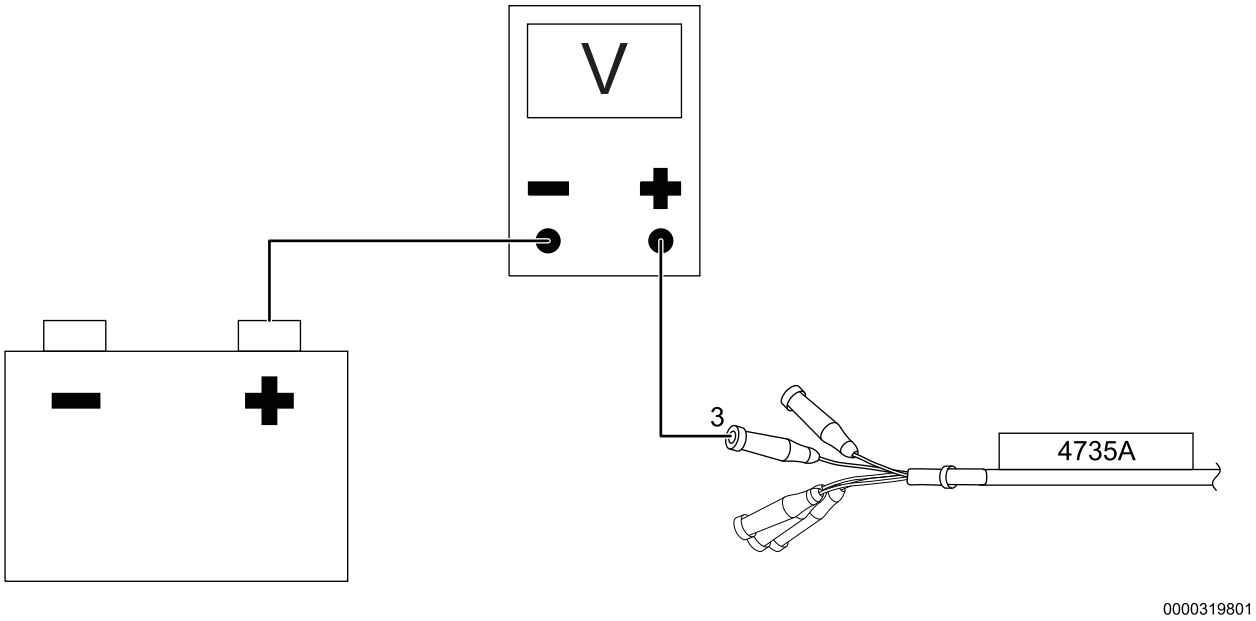


Figure 337 Test 1 Engine Throttle Valve Position (ETP) Circuit Voltage Check

Test 1 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4735A to vehicle connector and leave Engine Throttle Valve Position (ETP) disconnected. C. Key ON.

Test 1	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4735 pin-3 and PWR.	B+ ± 0.5 volts
Decision	
Is voltage B+ ± 0.5 volts?	Yes: Replace ETP. After repairs are complete, retest for SPN 51 FMI 7.
	No: Repair Open / High resistance. After repairs are complete, retest for SPN 51 FMI 7.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and the proper decision was made. Return to SPN 51 FMI 7 fault code diagnostics.

SPN 3464

FMI 11 – ETC Operation Fault

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Intake Throttle Actuator Control (ETC) Short circuit	Current through High or low side of H Bridge Driver > 8 Amps for 10 microseconds	Key ON SPN / FMIs 3509/3, 3509/4, 3510/3, 3510/4, 3511/3, and 3511/4 are NOT Active	0.05 seconds

Fault Overview

Fault sets when Engine Control Module (ECM) determines ETC is receiving more than 8 amps for longer than 10 microseconds.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

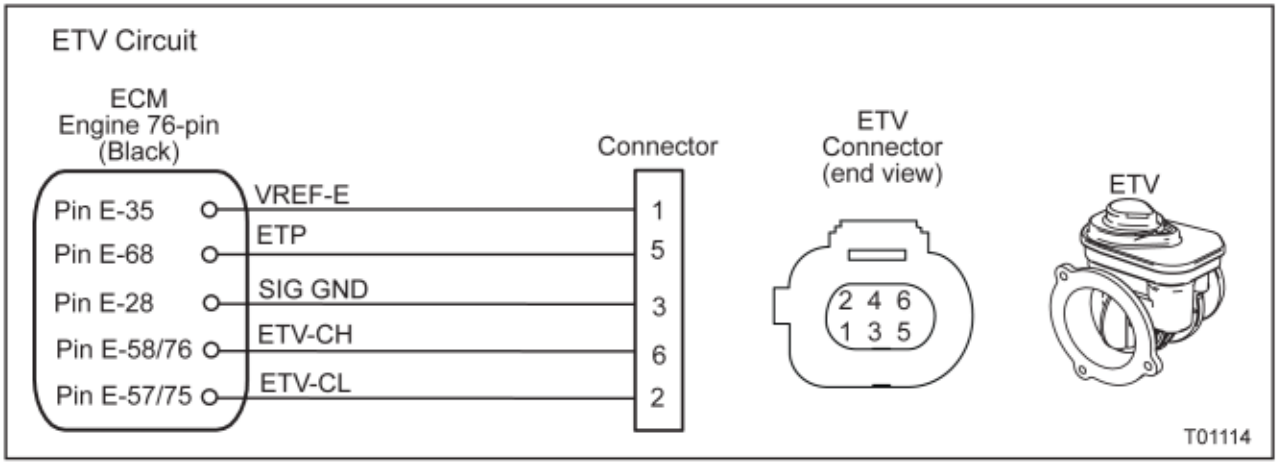


Figure 338 ETV Actuator Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for fault codes. Is SPN 3464 FMI 11 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 3464 FMI 11.
		No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit, inspect connections at the Engine Throttle Valve (ETV). With key OFF, disconnect ETV connector. Check ETV and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ETV connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3464 FMI 11.

Step	Action	Decision
4	Test ETV circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 768). Are ETV circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 5.
		No: Repair circuits as required. After repairs are complete, retest for SPN 3464 FMI 11.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Do Key On Engine Off Continuous Monitor Test (page 87). Are ETV circuits within specifications?	Yes: Go to Step 6.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuits as required. After repairs are complete, retest for SPN 3464 FMI 11.

Step	Action	Decision
6	Check for butterfly valve missing or unattached, butterfly and shaft damage, and evidence of icing. Do visual inspection of Engine Throttle Valve (ETV) in *Engine Service Manual*. Is butterfly valve condition satisfactory?	Yes: Go to Step 7.
		No: Replace ETV. After repairs are complete, retest for SPN 3464 FMI 11.

Step	Action	Decision
7	Determine if Engine Throttle Position (ETP) sensor is operating within specification. Connect breakout harness 4735A between ETV and ETV connector. Using EST with ServiceMaxx™ software, do Output State High Test (page 87) and Output State Low Test (page 87). Is voltage for Output State Test Low approximately 1.15 volts and Output State Test High approximately 3.0 volts?	Yes: After doing all diagnostic steps, if SPN 3464 FMI 11 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace ETV. After repairs are complete, retest for SPN 3464 FMI 11.

NOTE: After doing all diagnostic steps, if SPN 3464 FMI 11 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

EWPS (Engine Warning and Protection System)

SPN	FMI	Condition
100	1	Engine Oil System below Critical Pressure (page 794)
100	18	Engine Oil System below Warning Pressure (page 795)
110	0	Engine Coolant System above Critical Temperature
110	15	Engine Coolant System above Warning temperature (page 796)
110	16	Engine Coolant System Above OBD Maximum Temperature (page 797)
111	1	ECL below Warning/Critical Level (page 799)
175	15	Engine Oil System above Warning Temperature
190	0	Engine Over Speed – Most Severe Level

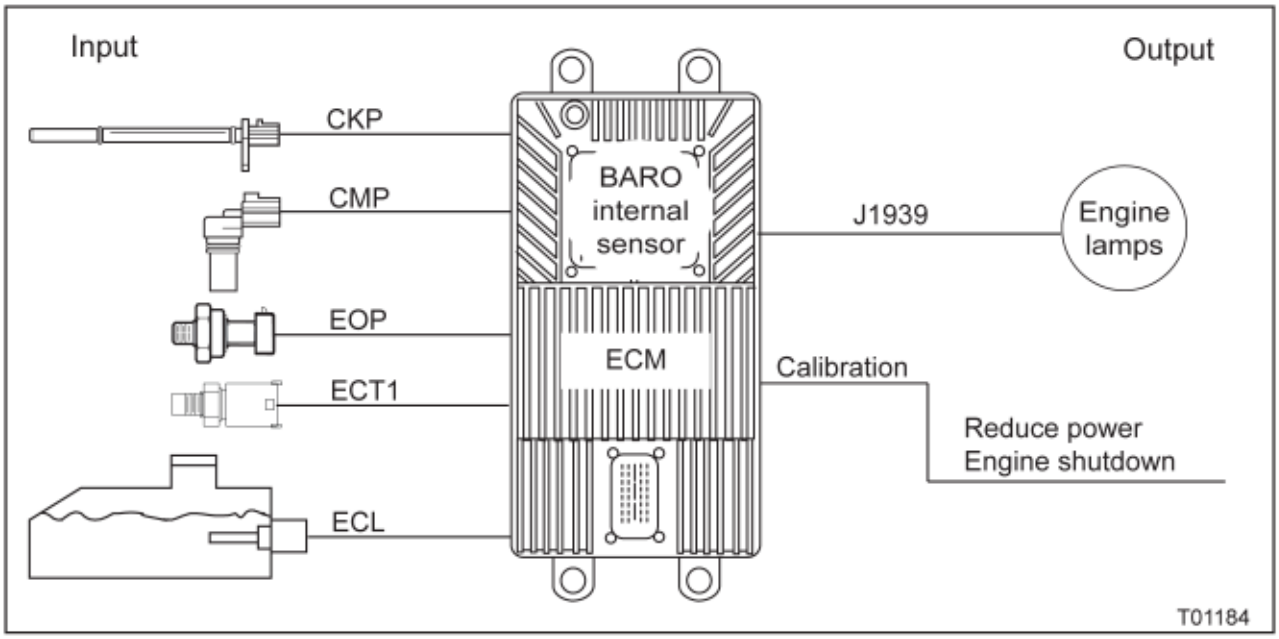


Figure 339 Function diagram for the EWPS

The function diagram for the EWPS includes the following:

- Engine Control Module (ECM)
  with Barometric Absolute Pressure (BARO) Internal Sensor
- Crankshaft Position (CKP) Sensor
- Camshaft Position (CMP) Sensor
- Engine Oil Pressure (EOP) Switch
- Engine Coolant Temperature 1 (ECT1) Sensor

- Engine Coolant Level (ECL) Sensor
- Engine Lamps

Function

The Engine Warning Protection System (EWPS) warns the operator of conditions that can damage the engine.

The Standard Warning System is the base system with which all engines are equipped. If one of these faults is detected, the ECM will illuminate the red OIL / WATER (OWL) lamp and set a corresponding SPN / FMI.

Standard Warning – No engine shutdown available.

- RPM – Engine over-speed warning
- ECT – Engine over-heat warning

The following optional features of the base system provide added warning or protection.

2-way Warning – No engine shutdown available.

- ECT – Engine over-heat warning
- EOP – Low engine oil pressure warning

3-way Warning – No engine shutdown available.

- ECT – Engine over-heat 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 over-heat critical protection
- EOP – Low engine oil pressure critical protection
- ECL – Low engine coolant level critical protection

Warning – Temperature above specific threshold will sound a buzzer, illuminate the red OWL and set an SPN / FMI.

Critical – Temperature above specific threshold will shutdown the engine and set an SPN / FMI. The operator has 30 seconds to safely pull vehicle off the road before the engine shuts off. A red STOP ENGINE warning lamp will illuminate when engine shutdown is approaching. The ECM allows the engine to be restarted and run for 30-second periods.

Event log – This feature will log occurrences of the event according to the engine hours and odometer readings.

EWPS Programmable Parameters

ENG-PROT-MODE

- 0 = Standard Warning
- 1 = 3-way Warning
- 2 = 3-way Protection
- 3 = 2-way Warning

Engine Coolant Warning Temp – Specifies temperature threshold. An OWL and warning buzzer will be turned on.

Engine Coolant Warning Temp – Specifies temperature threshold. An engine shutdown will be commanded.

EOP RPM Boundary 1 – Specifies at what RPM a specified oil pressure (engine oil critical pressure for region 1) should be detected.

EOP RPM Boundary 2 – Specifies at what RPM a specified oil pressure (engine oil critical pressure for region 2) should be detected.

EOP RPM Boundary 3 – Specifies at what RPM a specified oil pressure (engine oil critical pressure for region 3) should be detected.

EOP Warning Pressure Region 1 – Specifies the minimum oil pressure with engine speed greater than EOP RPM Boundary 1. Failure to meet set point will turn on the OIL / WATER lamp and warning buzzer.

EOP Warning Pressure Region 2 – Specifies the minimum oil pressure with engine speed greater than EOP RPM Boundary 1 but less than EOP RPM Boundary 2. Failure to meet set point will turn on the OWL and warning buzzer.

EOP Warning Pressure Region 3 – Specifies the minimum oil pressure with engine speed greater than EOP RPM Boundary 2 but less than EOP RPM Boundary 3. Failure to meet set point will turn on the OWL and warning buzzer.

Engine oil critical pressure for region 1 – Specifies the minimum oil pressure with engine speed greater than EOP RPM Boundary 1. Failure to meet set point will command an engine shutdown.

Engine oil critical pressure for region 2 – Specifies the minimum oil pressure with engine speed greater than EOP RPM Boundary 1 but less than EOP RPM Boundary 2. Failure to meet set point will command an engine shutdown.

Engine oil critical pressure for region 3 – Specifies the minimum oil pressure with engine speed greater than EOP RPM Boundary 2 but less than EOP RPM Boundary 3. Failure to meet set point will command an engine shutdown.

SPN 100 FMI 1
Engine Oil System below Critical Pressure

- SPN 100 FMI 1 is set by the ECM, when the engine oil pressure drops below the critical level while the engine is running. The specifications are:
  - 2 psi (14 kPa) @ 700 rpm
  - 5 psi (34 kPa) @ 1400 rpm
  - 22 psi (152 kPa) @ 2000 rpm
- For diagnostics, see Low Oil Pressure (page 123).
- SPN 100 FMI 1 can be set by an open, circuit short to voltage source in the EOP circuit, a loose or failed EOP switch, or low oil pressure.
- When SPN 100 FMI 1 is active, the red lamp flashes and sounds an audible signal.

SPN 100 FMI 18
Engine Oil System below Warning Pressure

- SPN 100 FMI 18 is set by the ECM, when engine oil pressure is lower than expected while the engine is running. The specifications for the warning are:
  - 5 psi (34 kPa) @ 700 rpm
  - 10 psi (69 kPa) @ 1400 rpm
  - 20 psi (138 kPa) @ 2000 rpm
- For diagnostics, see Low Oil Pressure (page 123).
- SPN 100 FMI 18 can be set by an open, circuit short to voltage source in the EOP circuit, a loose or failed EOP switch, or low oil pressure.
- When SPN 100 FMI 18 is active, the red lamp is illuminated.

SPN 110 FMI 0
Engine Coolant System above Critical Temperature

- SPN 110 FMI 0 is set by the ECM when the engine coolant temperature is above 240°F (116°C). The ECM illuminates the red lamp. When the temperature drops below 240°F (116°C), the SPN / FMI will become inactive. For diagnostics, see Coolant Over-Temperature (page 119).
- For high altitude applications 15 psi (103 kPa) radiator cap, SPN 110 FMI 0 is set by the ECM when the engine coolant temperature is above 246°F (119°C). When the temperature drops below 246°F (119°C), the SPN / FMI will become inactive.

SPN 110 FMI 15
Coolant System above Warning Temperature

- SPN 110 FMI 15 is set by the ECM when the engine coolant temperature is above 235°F (113°C). The ECM illuminates the red lamp (OWL for CF). When the temperature drops below 235°F (113°C) the SPN / FMI will become inactive. For diagnostics, see Coolant Over-Temperature (page 119).
- For high altitude applications 15 psi (103 kPa) radiator cap, SPN 110 FMI 15 is set by the ECM when the engine coolant temperature is above 240°F (116°C). When the temperature drops below 240°F (116°C), the SPN / FMI will become inactive.

SPN 110 FMI 16

Engine Coolant System Above OBD Maximum Temperature

- SPN 110 FMI 16 is set by the ECM when the engine coolant temperature is above 230°F (110°C). The ECM illuminates the red lamp (OWL for CF). When the temperature drops below 230°F (110°C) the SPN / FMI will become inactive. For diagnostics, see Coolant Over-Temperature (page 119).
- For high altitude applications 15 psi (103 kPa) radiator cap, SPN 110 FMI 16 is set by the ECM when the engine coolant temperature is above 237°F (114°C). When the temperature drops below 237°F (114°C), the SPN / FMI will become inactive.

SPN 111 FMI 1
ECL below Warning / Critical Level

- SPN 111 FMI 1 is set by the ECM when coolant is low. When the EWPS mode is 3-way protection and SPN 111 FMI 1 is active, the engine will shutdown. The ECM will log the engine hours and odometer reading at the time of occurrence. After the shutdown, the engine can be restarted for 30 seconds. When the coolant has returned to correct levels, SPN 111 FMI 1 will become active.

NOTE: If the coolant level is correct, do ECL Connector Voltage Test (page 578). An ECL signal shorted to ground can cause SPN 111 FMI 1.

SPN 175 FMI 15
Engine Oil System above Warning Temperature

- SPN 175 FMI 15 is set by the ECM when Engine Oil Temperature (EOT) is above 261°F (127°C). The ECM illuminates the red lamp (OWL). When the temperature drops below 261°F (127°C) the SPN / FMI will become inactive. For diagnostics, see Coolant Over-Temperature (page 119).

SPN 190 FMI 0
Engine Over Speed – Most Severe Level

- SPN 190 FMI 0 is set by the ECM when the engine rpm has exceeded 3200 rpm.
- SPN 190 FMI 0 can be set due to any of the following conditions:
  - Excessive engine speed in an unintended downshift.
  - Steep acceleration downhill without correct brake application.
  - External fuel source being ingested into air intake system.
- When SPN 190 FMI 0 is active, Amber Warning Lamp (AWL) will illuminate and engine hours and miles of the last two over speed occurrences will be recorded in the engine event log.

SPN 100 FMI 1 - Engine Oil System below Critical Pressure

Associated Faults

SPN 100 FMI 3 and 4

Fault Facts

This fault sets when Engine Warning Protection System (EWPS) detects Engine Oil Pressure (EOP) has fallen below a critical set point. This fault may be caused by actual low oil pressure or by a fault in EOP sensor circuit.

Drive Cycle to Determine Fault Status

Continuous (Engine Running)

Possible Causes

- Low oil level: oil leak, oil consumption, or incorrect servicing
- High oil level: incorrect servicing, fuel in oil, or coolant in oil
- Incorrect or biased EOP sensor or circuit
- Oil pressure regulator stuck open
- Broken, missing, or loose piston cooling jets
- Missing, damaged, or worn bearing inserts or camshaft bushings

- Scored / damaged oil pump
- Aeration
- Loose rocker arm bolt or worn rocker shaft

Step 1	Troubleshoot Low Oil Pressure issues.	Decision
Use Diagnostic Troubleshooting Procedures: 7.6 – Low Oil Pressure(page 123).		

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 100 FMI 1 fault code diagnostics.

SPN 100 FMI 18 - Engine Oil System below Warning Pressure

Associated Faults

SPN 100 FMI 1, 3, and 4

Fault Facts

This fault sets when Engine Warning Protection System (EWPS) detects Engine Oil Pressure (EOP) has fallen below desired set point. Fault may be caused by actual low oil pressure or by a fault in EOP sensor circuit.

Drive Cycle to Determine Fault Status

Continuous (Engine Running)

Possible Causes

- Low oil level: oil leak, oil consumption, or incorrect servicing
- High oil level: incorrect servicing, fuel in oil, or coolant in oil
- Incorrect or biased EOP sensor or circuit
- Oil pressure regulator stuck open
- Broken, missing, or loose piston cooling jets
- Missing, damaged, or worn bearing inserts or camshaft bushings
- Scored / damaged oil pump
- Aeration
- Loose rocker arm bolt or worn rocker shaft

Step 1	Troubleshoot Low Oil Pressure issues.	Decision
Use Diagnostic Troubleshooting Procedures: 7.6 – Low Oil Pressure(page 123).		

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 100 FMI 18 fault code diagnostics.

SPN 110 FMI 15 - Engine Coolant System above Warning Temperature

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Engine coolant at Engine Coolant Temperature 1 (ECT1) is above Warning temperature.	ECT1 > value programmed into Programmable Parameter (PP) 77012	Key-On Engine-Running (KOER)

Fault Overview

Fault code sets when Electronic Control Module (ECM) detects that engine coolant at Engine Coolant Temperature 1 (ECT1) is above Programmable Parameter (PP) 77012.

Lamp Reaction

Warning Lamp set and Warning buzzer turned ON.

Associated Faults

SPN 110 FMI 2, 3, 4 (ECT1)

Fault Facts

This fault sets when Engine Warning Protection System (EWPS) detects Engine Coolant Temperature 1 (ECT1) has risen above a critical set point. Fault may be caused by actual high coolant temperature or by a fault in ECT1 sensor circuit.

Drive Cycle to Determine Fault Status

Road Test

Possible Causes

- Incorrect value in Programmable Parameter (PP) 77012

Step 1		Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 110 FMI 2, 3, and 4 (ECT1). Is EST DTC list free of SPN 110 FMI 2, 3, and 4?		Yes: Go to Step 2. No: Repair SPN 110 FMI 2, 3, and 4. After repairs are complete, retest SPN 110 FMI 15.

Step 2	Troubleshoot Engine Coolant Temperature 1 (ECT1) issues.	Decision
Use Diagnostic Troubleshooting Procedures: 6.3 – Coolant Over-Temp(page 119).		

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 110 FMI 15 fault code diagnostics.

SPN 110 FMI 16 - Engine Coolant System Above OBD Maximum Temperature

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Engine Coolant Temperature (ECT1) stuck in range high monitor.	{Engine coolant temperature ≥ 219°F (104°C) AND time spent in high-speed torque zone as defined in [Table A103]} ≤ 400 seconds	Key ON Intake air temperature ≥ -40°F (-40°C) Engine coolant temperature at Startup {Calibrated Out} ≤ 460°F (238°C) [Engine Off soak time ≥ 7200 seconds OR Time spent in high-speed torque zone as defined by (Table A103) from previous driving cycle] ≤ 400 seconds Engine run mode active timer > 120 seconds Exhaust brake position control ≤ 99.97% Ambient pressure {calibrated out} > 1.068 psi (7.363 kPa) Accumulated power {Calibrated Out} > -100 joules/second NOT [{1. Mass of Fuel ≤ 28 mg/stk AND 2. Engine Speed} ≤ 740 RPM Condition 1 and 2 listed above true for at least] ≥ 300 seconds Intake air heater OFF Cold ambient protection mode not active NOT in active regeneration Power Take-off (PTO) mode NOT active [{Percentage time spent below ≤ 740 RPM within a drive cycle} < 0.35 * 100% OR Cumulative time spent below ≤ 740 RPM within a drive cycle] < 300 seconds Not active: SPN/FMIs 132/3, 132/4, 132/0, 132/1, 172/3, 172/4, 172/2, 1173/2, 2630/2, 108/3, 108/4, 4765/3, 4765/4, 110/3, 110/4, 110/2, 175/3, 1754, 175/2, 164/0, 164/3, 164/4, 651/4, 651/5, 652/4, 652/5, 653/4, 653/5, 654/4, 654/5, 655/4,

		655/5, 656/4, 656/5, 5395/0, 5395/1, 1173/16, 651/14, 652/14, 653/14, 654/14, 655/14, 656/14, 1323/31, 1324/31, 1325/31, 1326/31, 1327/31, 1328/31, 1322/31, 110/18, 4257/0, 4257/1, 164/16, 164/18, and 110/17

Fault Overview

Fault sets when ECT1 signal is stuck in range high.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

None

Fault Facts

This fault sets when Engine Warning Protection System (EWPS) detects Engine Coolant Temperature 1 (ECT1) has risen above a critical set point. Fault may be caused by actual high coolant temperature or by a fault in ECT1 sensor circuit.

Drive Cycle to Determine Fault Status

Road Test

Possible Causes

- Low coolant level
- Check for leaks or boiling out

Step 1	Troubleshoot Engine Coolant Temperature 1 (ECT1) issues.	Decision
Use Diagnostic Troubleshooting Procedures: 6.3 – Coolant Over-Temp(page 119).		

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 110 FMI 16 fault code diagnostics.

SPN 111 FMI 1 - ECL below Warning/Critical Level

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Engine Coolant Level (ELC) critically Low	[Engine coolant level switch voltage < 3.496 volts for time] > 7 seconds	Key ON Engine Running Engine Warning and Protection System Mode (EWPS_MODE[PP]) set to values 1, 2, or 4

Fault Overview

Fault sets when Engine Coolant Level (ELC) switch voltage is less than 3.496 volts for greater than 7 seconds.

Lamp Reaction

Red Stop Lamp will illuminate when this fault is detected during two trips.

Associated Faults

None

Fault Facts

This fault sets when Engine Warning Protection System (EWPS) detects Engine Coolant Level (ECL) has fallen below a minimum level. Fault may be caused by actual low coolant level or by a fault in Engine Coolant Level (ELC) sensor circuit. SPN 111 FMI 1 fault also sets RSL.

Drive Cycle to Determine Fault Status

Continuous (engine running)

Possible Causes

- Low coolant level - see Cooling System Diagnosis / Repair
- Sandwich possibility in degassing bottle

Step 1	Troubleshoot Engine Coolant Level (ECL) issues.	Decision
Use Diagnostic Troubleshooting Procedures: 6.2 - Coolant Loss(page 105).		

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 111 FMI 1 fault code diagnostics.

SPN 190 FMI 0 - Engine overspeed - Most Severe Level

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Engine speed reaches most severe level with Accelerator Pedal Position (APP) and Vehicle Speed Sensor (VSS) at 0% or 0.	Engine speed exceeds 2600 rpm with no fuel being requested	Vehicle speed < 0.1 mph APP < 0.1% RAPP < 0.1% Engine speed > 2600 rpm

Fault Overview

Fault sets only when a vehicle is stationary and engine speed reaches 2600 rpm with no fuel being requested by Engine Control Module (ECM). Once conditions are met, ECM will initiate a protection strategy. Engine Throttle Valve (ETV) and Exhaust Gas Recirculation (EGR) valve will be closed and fuel injectors disabled. Fuel Pressure Control Valve (FPCV) will open to relieve fuel rail pressure in case of injector tip damage. A full engine analysis needs to be completed to assess damage from excessive engine speed before engine can be started.

Lamp Reaction

Malfunction Indicator Lamp and Red Stop Lamp (RSL) will illuminate when this fault is detected.

Associated Faults

None

Fault Facts

SPN 190 FMI 0 is set by Engine Control Module (ECM) when engine rpm has exceeded 3,200 rpm.

Drive Cycle to Determine Fault Status

Continuous (engine running)

Possible Causes

- Excessive engine speed in an unintended downshift.
- Steep acceleration downhill without correct brake application.
- External fuel source being ingested into intake air system.

Step 1	Visual inspection of turbocharger outlet pipe.	Decision
Remove turbocharger outlet pipe and Charge Air Cooler (CAC) outlet pipe and inspect for oil. Is there excessive oil coming from high-pressure turbocharger?		Yes: Go to Step 2. No: Go to Step 7.

Step 2	Visually inspect engine.	Decision
Visually inspect engine block. Is there external damage to block?		Yes: Replace engine. Warranty policy applies. After repairs are complete, retest for SPN 190 FMI 0.
		No: Go to Step 3.

Step 3	Check parameter 58071 Maximum Trip RPM.	Decision
Use Electronic Service Tool (EST) with ServiceMaxx™ software to check parameter. Is parameter 58071 above 3,200 rpm?		Yes: Go to Step 4.
		No: Go to Step 5.

Step 4	Check if engine RPM is greater than 3,200.	Decision
Drop oil pan and inspect for block/liner damage. Is there damage to block or liner?		Yes: Repair or replace engine. Warranty policy applies. After repairs are complete, retest for SPN 190 FMI 0.
		No: Replace injectors, turbocharger cartridge, water pump, and clean Charge Air Cooler (CAC). Go to Step 6.

Step 5	Check if engine RPM is less than 3,200 rpm but greater than 2,600 rpm.	Decision
Drop oil pan and inspect for block/liner damage. Is there damage to block or liner?		Yes: Repair or replace engine. Warranty policy applies. After repairs are complete, retest for SPN 190 FMI 0.
		No: Replace injectors, turbocharger cartridge, water pump, and clean Charge Air Cooler (CAC). Go to Step 6.

Step 6	Check calibration.	Decision
Use EST with ServiceMaxx™ software to check calibration. Is calibration up to date?		Yes: Clear trip report and release truck to service. After repairs are complete, retest for SPN 190 FMI 0.
		No: Update calibration and release truck to service. After repairs are complete, retest for SPN 190 FMI 0.

Step 7	Visually inspect engine.	Decision
Visually inspect engine block. Is there damage to engine block?		Yes: Replace engine. Warranty policy applies. After repairs are complete, retest for SPN 190 FMI 0.
		No: Go to Step 8.

Step 8	Check parameter 58071 Maximum Trip RPM.	Decision
Use EST with ServiceMaxx™ software to check parameter.		Yes: Go to Step 9.
Is parameter 58071 above 3,200 rpm?		No: Clear trip report and release truck to service. After repairs are complete, retest for SPN 190 FMI 0.

Step 9	Check if engine RPM is greater than 3,200.	Decision
Drop oil pan and inspect for block/liner damage. Is there damage to block or liner?		Yes: Repair or replace engine. Warranty policy applies. After repairs are complete, retest for SPN 190 FMI 0.
		No: Replace water pump. Go to Step 6.

End Diagnostic Steps
After performing all diagnostic steps, if SPN 190 FMI 0 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

FDP Sensor (Fuel Delivery Pressure)

SPN	FMI	Condition	Possible Causes	Actions
94	2	FDP signal erratic, intermittent, or incorrect	• FDP sensor drift	Step-based Diagnostics (page 807)
94	3	FDP signal out of range high	• FDP signal circuit short to PWR • Failed FDP sensor	Step-based Diagnostics (page 810)
94	4	FDP signal out of range low	• FDP signal circuit OPEN or short to GND • VREF circuit OPEN • Failed FDP sensor	Step-based Diagnostics (page 813)
94	17	FDP Below Minimum	• Plugged fuel filter • Fuel aeration • Plugged strainer • Fuel lines • Pump / circuit failure • Leaks • Fuel tank standpipe cracked / broken	Step-based Diagnostics (page 819)
94	18	Fuel Delivery Pressure below min during cranking	• Recent fuel system service that required priming • Diesel fuel waxing or icing in cold temperatures • Low fuel level in either fuel tank • Vehicle unused for long period of time • Unseated fuel filter that causes fuel to drain back to tank • High resistance in fuel pump circuits • High resistance in FP GND circuit • Stuck Open fuel pressure regulator • Damaged fuel filter	Step-based Diagnostics (page 820)

SPN	FMI	Condition	Possible Causes	Actions
			• Completely plugged strainer • Failed fuel pump	

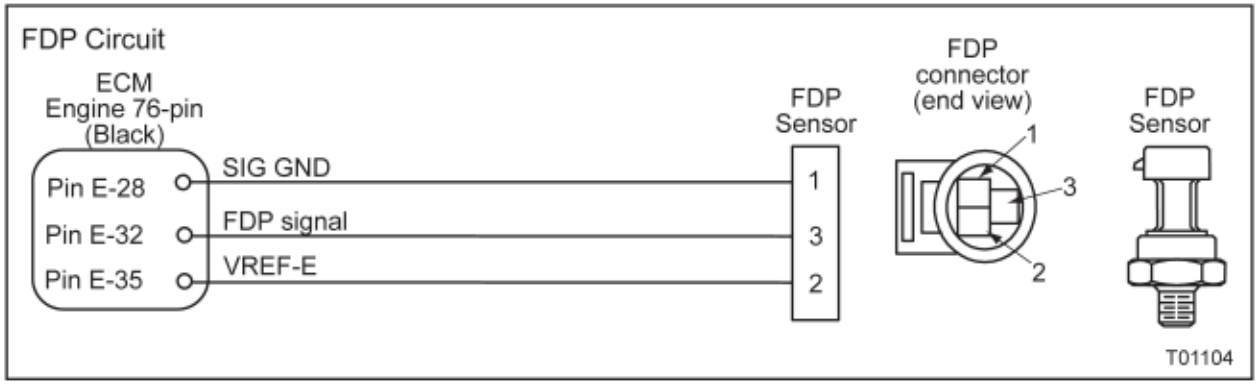


Figure 340 FDP Circuit Diagram

Overview

The FDP sensor provides a feedback signal to the ECM indicating engine fuel pressure. During engine operation, if pressure is not satisfactory, the ECM will turn on the amber FUEL lamp to alert the operator when the fuel filter needs servicing.

NOTE: The FDP sensor is only capable of measuring up to 75 psi (517 kPa) of pressure, even though fuel pressure normally operates at 90 psi (621 kPa).

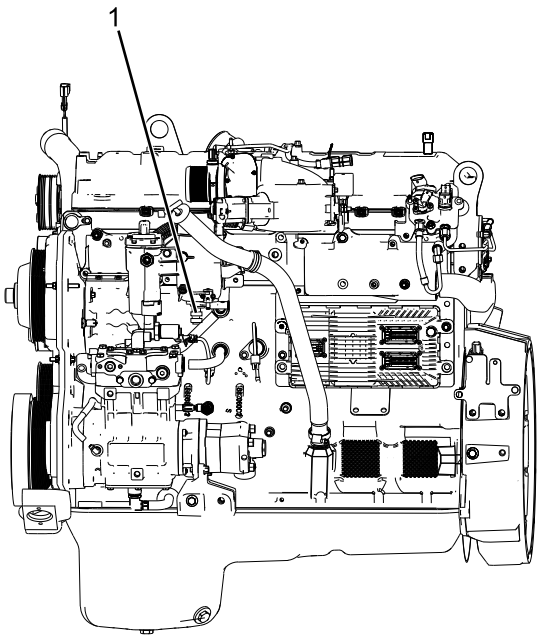


Figure 341 FDP Sensor Location

Tools

- EZ Tech® Electronic Service Tool (EST) – J-45067 (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- 00-00956-08 – 180-pin Breakout Box (page 1222)
- 3-Banana Plug Harness (page 1228)
- Breakout Harness 4850 (FDP) (page 1234)
- International® Electronic Engine Terminal Test Kit (page 1227)

Pin-point Diagnostics

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST and ServiceMaxx™ software, open the Continuous Monitor session.
2. Verify sensor voltage is within KOEO specification. See APPENDIX A (page 1291).
3. Monitor sensor voltage. Verify an active code for the sensor.
   - If code 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 code will go active.
   - If code is active, proceed to the next step.

4. Disconnect engine harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

5. Connect Breakout Harness 4850 to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect Breakout Harness 4850. Leave sensor disconnected. Turn ignition switch to ON. Use EST to verify correct code goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Specification	Comment: < Less than, > Greater than
EST – Check code	SPN 94 FMI 4	If SPN 94 FMI 3 is active, check EFP signal for short to PWR.
DMM – Measure volts 2 to GND	5 ± 0.5 V	If > 5.5 volts, check VREF for short to PWR. If < 4.5 volts, check VREF for OPEN or short to GND. Go to Harness Resistance Check.
EST – Check code Short breakout harness across 2 and 3	SPN 94 FMI 3	If SPN 94 FMI 4 is active, check FDP signal for OPEN or short to GND. Go to Harness Resistance Check.
DMM – Measure volt 1 to B+	B+	If < B+, check SIG GND for OPEN. Go to Harness Resistance Check.
If checks are within specification, connect sensor and clear codes. If active code remains, replace sensor.		

Connector Voltage Check

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 for OPEN in SIG GND circuit.
2 to GND	5 ± 0.5 V	If > 5.5 volts, check VREF for short to PWR. If < 4.5 volts, check VREF for OPEN or short to GND. Go to Harness Resistance Check.
3 to GND	0 V	If > 0.25 volts, check for short to PWR. Go to Harness Resistance Check.

Harness Resistance Check

Turn ignition switch to OFF. Disconnect ECM. Leave sensor disconnected. Connect 180-pin Breakout Box and Breakout Harness 4850. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
1 to E-28	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
2 to E-35	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN.
3 to E-32	< 5 Ω	If > 5 Ω, check EFP signal circuit for OPEN.

SPN 94

FMI 2 – FDP Signal Erratic, Intermittent, or Incorrect

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine Fuel Delivery Pressure (FDP) Sensor offset check	Engine Fuel Delivery Pressure (FDP) Sensor Voltage > 1.104 volts (> 33 psi [227.7 kPa])	1. Engine Coolant Temperature (ECT) > 19°F (-7°C)	1 second
		2. Barometric Pressure > 11 psi (75 kPa)	
		Time after entry conditions 1 and 2 listed above are satisfied ≥ 9.5 seconds	
		SPN / FMIs 94/3, 94/4, 931/3, 931/4, 931/19 are NOT Active	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the FDP signal value is incorrect when compared to other sensor values.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

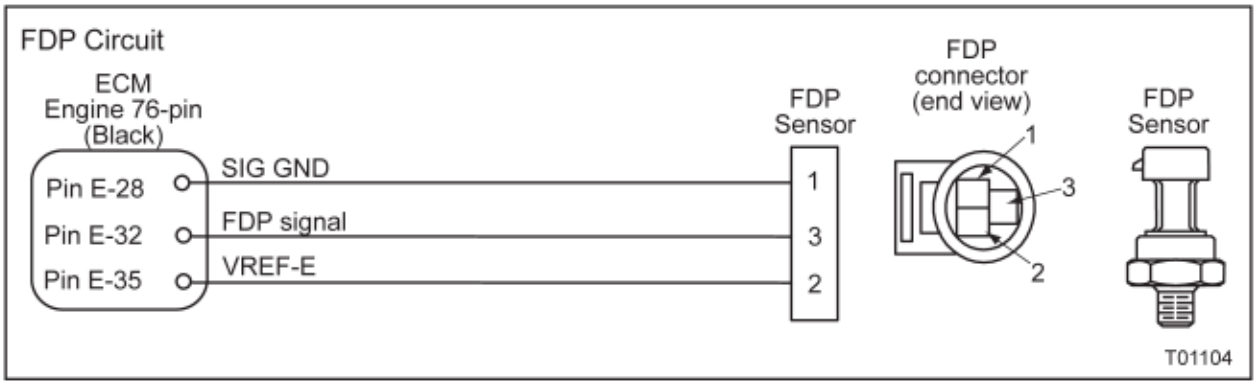


Figure 342 FDP Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 94 FMI 2 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 94 FMI 2. No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit, inspect connections at the fuel delivery pressure (FDP) sensor. With key OFF, disconnect FDP sensor connector. Check FDP sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the FDP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 94 FMI 2.

Step	Action	Decision
4	Test FDP sensor circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 806). Are FDP sensor circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 94 FMI 2.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Do the Key On Engine Off Continuous Monitor Test (page 87). Are FDP sensor circuits within specifications?	Yes: Go to Step 6. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuits as required. After repairs are complete, retest for SPN 94 FMI 2.

Step	Action	Decision
6	With KOEO, wait 30 seconds for fuel pressure to stabilize, turn key off, and observe FDP voltage using EST with ServiceMaxx™ software. Is FDP less than 1.104 volts? **NOTE:** Variable name in ServiceMaxx™ is S_FDP Volts	Yes: After doing all diagnostic steps, if SPN 94 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace FDP sensor. After repairs are complete, retest for SPN 94 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 94 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 94 FMI 3 - FDP signal Out of Range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Fuel Delivery Pressure (FDP) sensor voltage is greater than expected.	FDP sensor voltage > 4.912 Volts (152 psi {1049 kPa}) Pre-debounce time ≥ 10 seconds	Key ON Inactive: SPN 3509 FMI 3 and 4 (VREF1)

Fault Overview

Fault sets when Fuel Delivery Pressure (FDP) sensor signal voltage is greater than 4.912 volts (152 psi {1049 kPa}) for 5 seconds.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 3509 FMI 3 and 4 (VREF1)

Fault Facts

None

Drive Cycle

Key ON

Possible Causes

- FDP circuit short to PWR
- SIG GND circuit Open
- Failed FDP sensor

Step 1	Check for active fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 FMI 3. Does EST DTC list show SPN 94 FMI 3 as Active or Pending?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79). After repairs are complete, retest for SPN 94 FMI 3.

Step 2	Check for associated fault codes.	Decision
Using EST with ServiceMaxx™ software, check DTC list for SPN 3509 FMI 3 and 4 (VREF1). Is EST DTC list free of SPN 3509 FMI 3 and 4?		Yes: Go to Step 3. No: Repair SPN 3509 FMI 3 and 4. After repairs are complete, retest for SPN 94 FMI 3.

Step 3	Inspect connections at Fuel Delivery Pressure (FDP) sensor.	Decision
A. Key OFF. B. Disconnect FDP sensor connector. C. Check FDP sensor and connector terminals for damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are FDP sensor connector, harness, and terminal clean and undamaged?		Yes: Perform Pin-Point Tests SPN 94 FMI 3. (page 811) No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 94 FMI 3.

Pin-Point Tests (SPN 94 FMI 3)

FDP Circuit

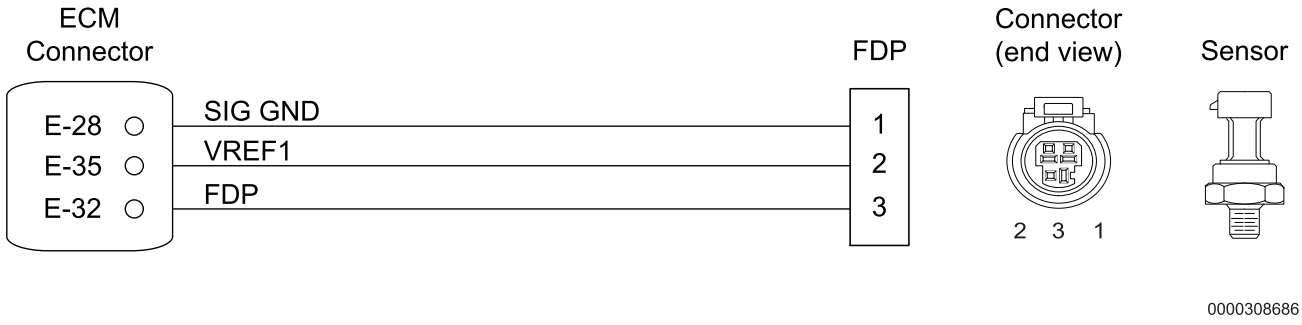


Figure 343 Fuel Delivery Pressure (FDP) Sensor Circuit Diagram

See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4850
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)

Test 1 Setup
A. Key OFF. B. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). C. Key ON. Log in to ServiceMaxx™ software. D. Disconnect Fuel Delivery Pressure (FDP) sensor vehicle harness connector.

Test 1	Specification
Using EST with ServiceMaxx™ software, clear Diagnostic Trouble Code (DTC) list.	SPN 94 FMI 3 sets in DTC list.
Decision	
Does SPN 94 FMI 3 set after DTC list is cleared?	Yes: Repair short to PWR between FDP pin-3 and Engine Control Module (ECM) pin E-32. After repairs are complete, retest for SPN 94 FMI 3.
	No: Go to Test 2.

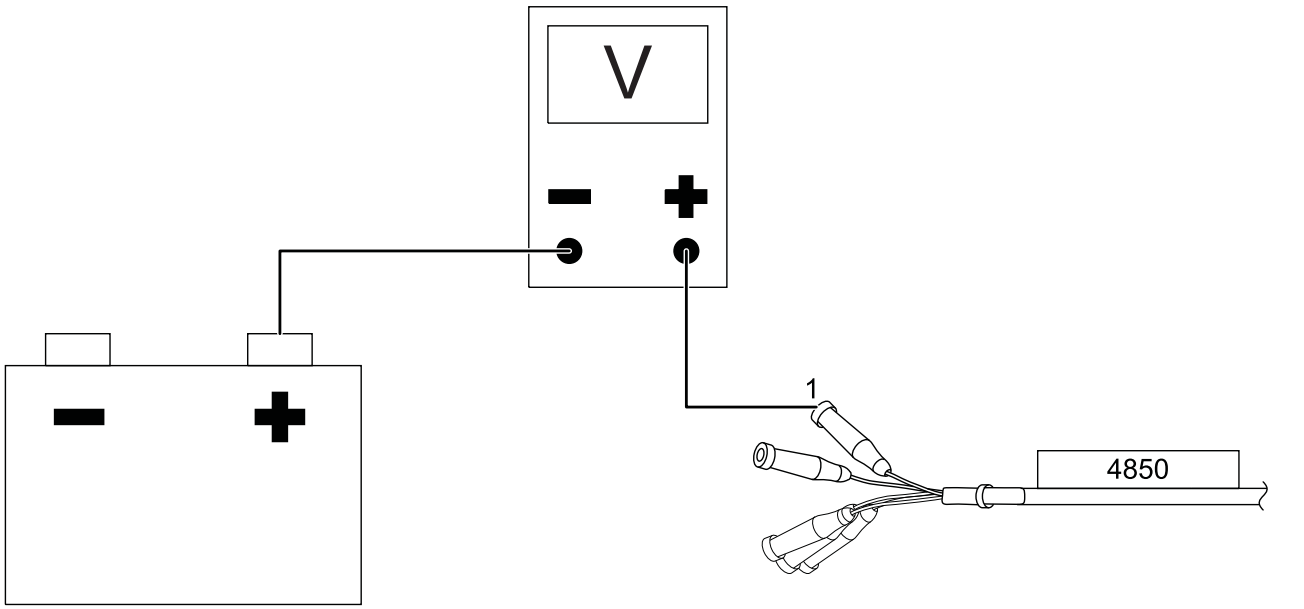


Figure 344 Test 2 SIG GND Circuit Check

Test 2 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4850 to Fuel Delivery Pressure (FDP) vehicle harness connector and leave sensor disconnected. C. Key ON.

Test 2	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4850 pin-1 and PWR	12 ± 0.5 volts
Decision	
Is voltage 12 ± 0.5 volts?	Yes: Replace FDP sensor. After repairs are complete, retest for SPN 94 FMI 3.
	No: Repair Open between FDP pin-1 and ECM pin E-28. After repairs are complete, retest for SPN 94 FMI 3.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 94 FMI 3 fault code diagnostics.

SPN 94 FMI 4 - FDP signal Out of Range LOW

Condition / Description	Setting Criteria	Enable Conditions / Values
Engine Fuel Delivery Pressure (FDP) Sensor Out of Range Low.	Engine Fuel Delivery Pressure Sensor Voltage < 0.093 Volts AND Pre-debounce time ≥ 10 seconds	Key ON Inactive: SPN 3509 FMI 3 and 4 (VREF 1)

Fault Overview

Fault sets when Fuel Delivery Pressure (FDP) sensor signal voltage is less than 0.093 volts for 5 seconds.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 3509 FMI 3 and 4 (VREF1)

Fault Facts

None

Drive Cycle

Key ON

Possible Causes

- FDP circuit Open
- FDP circuit short to GND

- VREF1 circuit Open
- Failed FDP sensor

Step 1	Check for active fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 FMI 4. Does EST DTC list show SPN 94 FMI 4 as Active or Pending?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79). After repairs are complete retest, for SPN 94 FMI 4.

Step 2	Check for associated fault codes.	Decision
Using EST with ServiceMaxx™ software, check DTC list for SPN 3509 FMI 3 and 4 (VREF1). Is EST DTC list free of SPN 3509 FMI 3 and 4?		Yes: Go to Step 3. No: Repair SPN 3509 FMI 3 and 4. After repairs are complete, retest for SPN 94 FMI 4.

Step 3	Inspect connections at Fuel Delivery Pressure (FDP) sensor.	Decision
A. Key OFF. B. Disconnect FDP sensor connector. C. Check FDP sensor and connector terminals for damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are FDP sensor connector, harness, and terminal clean and undamaged?		Yes: Perform Pin-Point Tests (SPN 94 FMI 3).(page 814) No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 94 FMI 4.

Pin-Point Tests (SPN 94 FMI 4)

FDP Circuit

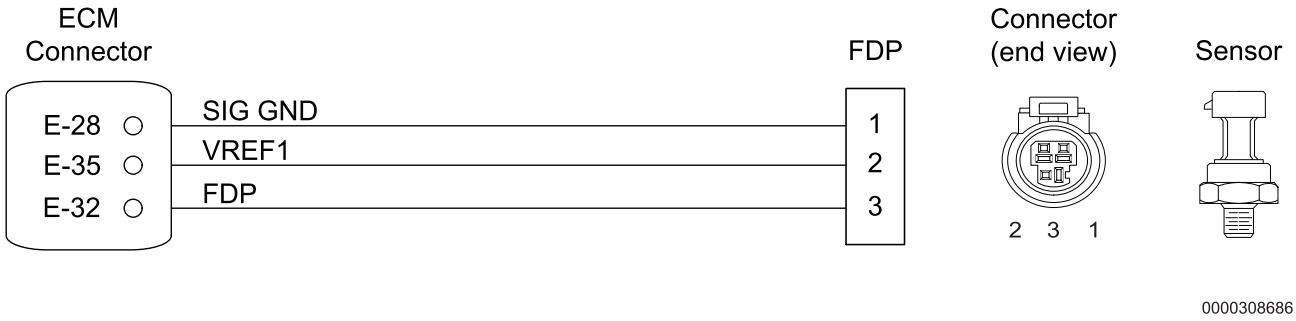


Figure 345 Fuel Delivery Pressure (FDP) Sensor Circuit Diagram

See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4850
- Breakout Harness ZTSE4498
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)

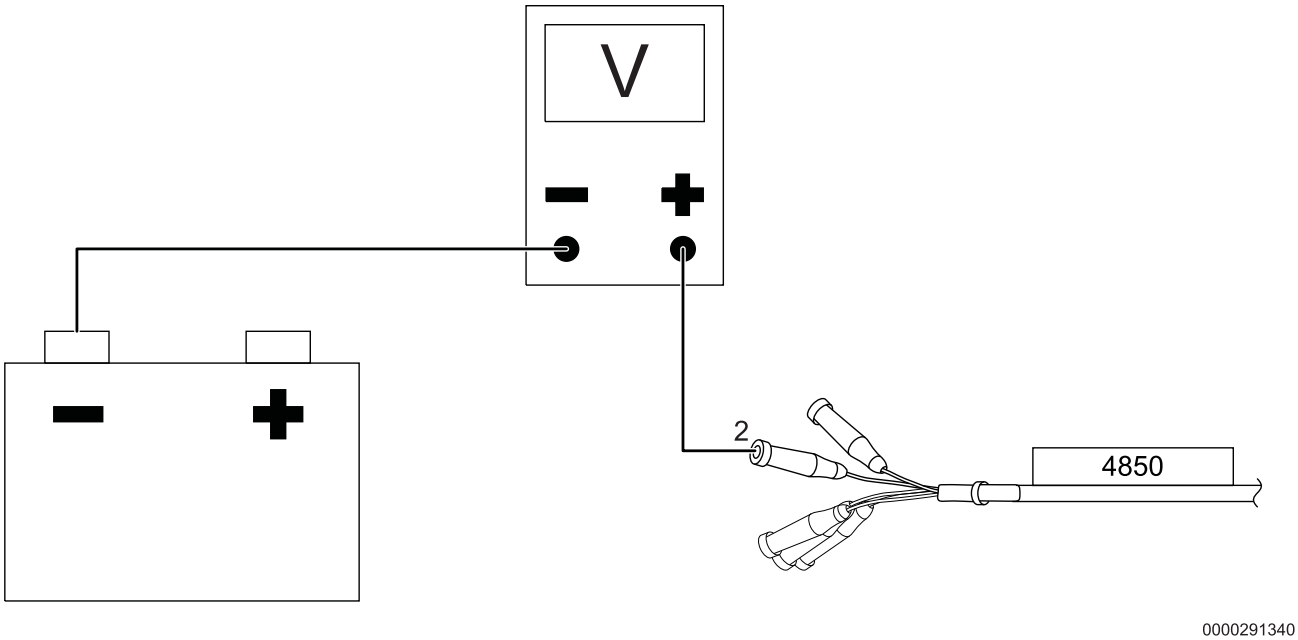
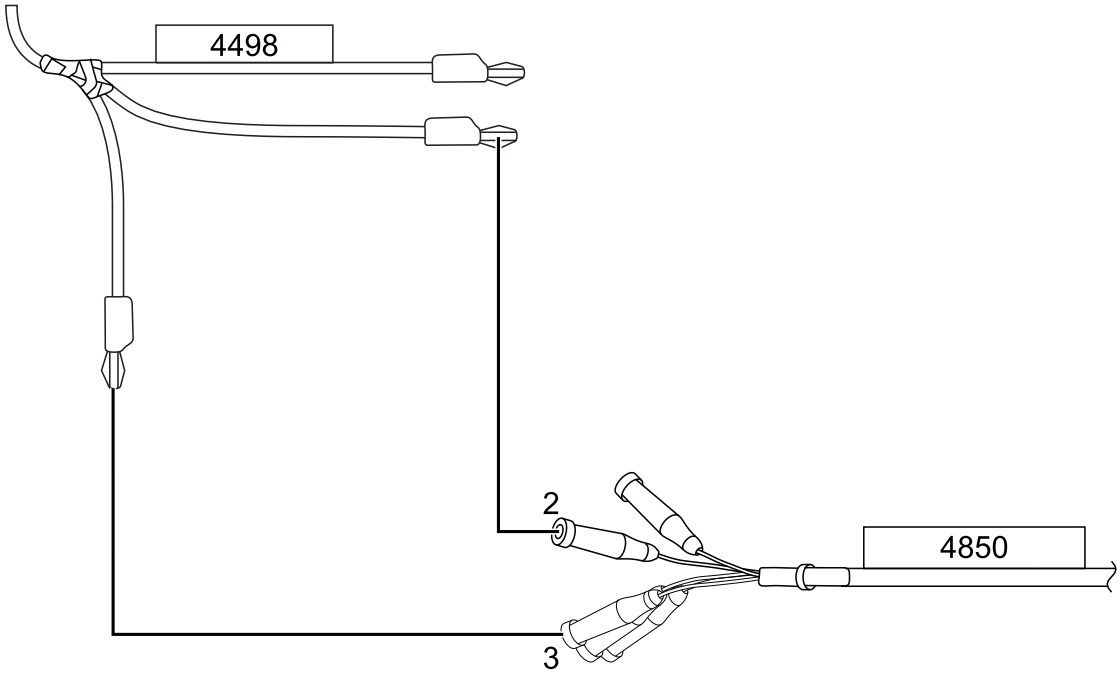


Figure 346 Test 1 VREF1 Circuit Voltage Check

Test 1 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4850 to Fuel Delivery Pressure (FDP) vehicle harness connector and leave sensor disconnected. C. Key ON.

Test 1	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4850 pin-2 and GND.	5 ± 1 volts
Decision	
Is voltage 5 ± 1 volts?	Yes: Go to Test 2.
	No: Repair Open between FDP pin-2 and Engine Control Module (ECM) pin E-35. After repairs are complete, retest for SPN 94 FMI 4

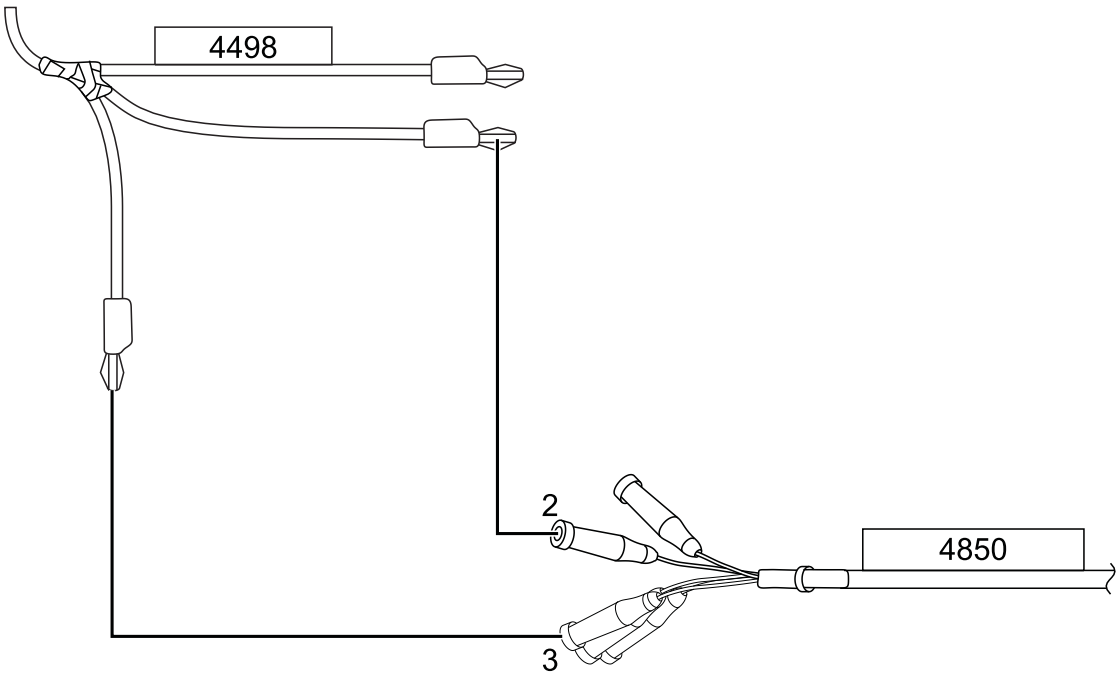


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Figure 347 Test 2 Fuel Delivery Pressure (FDP) Sensor Circuit Check

Test 2 Setup
A. Key OFF. B. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). C. Key ON. Log in to ServiceMaxx™ software. D. Connect Breakout Harness ZTSE4850 to Fuel Delivery Pressure (FDP) vehicle harness connector and leave sensor disconnected. E. Using Breakout Harness ZTSE4498, short pin-2 and pin-3 of Breakout Harness ZTSE4850 together.

Test 2	Specification
Using EST with ServiceMaxx™ software, clear DTC list.	SPN 94 FMI 3 sets in DTC list.
Decision	
Does SPN 94 FMI 3 set after DTC list is cleared?	Yes: Replace FDP sensor. After repairs are complete, retest for SPN 94 FMI 4.
	No: Go to Test 3.



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Figure 348 Test 3 FDP Sensor Circuit Check

Test 3 Setup
A. Key OFF. B. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). C. Key ON. Log in to ServiceMaxx™ software. D. Connect Breakout Harness ZTSE4850 to Fuel Delivery Pressure (FDP) vehicle harness connector and leave sensor disconnected. E. Using Breakout Harness ZTSE4498, short pin-2 and pin-3 of Breakout Harness ZTSE4850 together.

Test 3	Specification
Using EST with ServiceMaxx™ software, clear DTC list.	SPN 3509 FMI 4 sets in DTC list.
Decision	
Does SPN 3509 FMI 4 set in DTC list?	Yes: Repair short to ground between FDP pin-3 and ECM pin E-32. After repairs are complete, retest for SPN 94 FMI 4.
	No: Repair Open between FDP pin-3 and ECM pin E-32. After repairs are complete, retest for SPN 94 FMI 4.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 94 FMI 4 fault code diagnostics.

SPN 94 FMI 17 - Fuel Delivery Pressure below minimum

Condition/Description	Setting Criteria	Enable Conditions / Values
Fuel Delivery Pressure (FDP) below minimum	60 psi (414 kPa) in 45 seconds	> 600 rpm in 10 seconds

Fault Overview

None

Lamp Reaction

Wrench lamp will illuminate when this fault is active.

Associated Faults

SPN 931 FMI 4, SPN 94 FMI 18, and SPN 94 FMI 1

Fault Facts

Fault is normally caused by fuel filter needing to be changed.

Drive Cycles

Key On Engine Running (KOER).

Possible Causes

- Recent fuel system service requiring priming
- Vehicle unused for long period of time requiring priming
- Low fuel level
- Diesel fuel contamination
- Failed secondary (engine mounted) fuel filter
- Failed primary (chassis mounted) fuel filter
- Restricted strainer
- Restricted / leaking fuel supply
- Failed fuel pressure regulator

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

Step 1	Check Fault Code Status	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 FMI 17 (EFP). Is SPN 94 FMI 17 pending or active?		Yes: Go to Fuel Fuel Delivery Pressure symptom (page 181). No: Repair SPN 94 FMI 17. After repairs are complete, retest SPN 94 FMI 17.

End Diagnostic Steps
After performing all diagnostic steps, if SPN 94 FMI 17 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

SPN 94 FMI 18 - Fuel Delivery Pressure below minimum

Condition/Description	Setting Criteria	Enable Conditions / Values
Fuel Delivery Pressure (FDP) below minimum during engine cranking.	FDP < 45 psi (kpa) for 8 seconds	Engine cranking

Fault Overview

Fault code sets when Fuel Delivery Pressure (FDP) is below 45 psi for 8 seconds while engine is cranking.

Lamp Reaction

None

Associated Faults

SPN 931 FMI 4 (EFP)

Fault Facts

This fault may set due to fuel gelling, low fuel level, or recent engine service.

Drive Cycles

Engine Cranking

Possible Causes

- Recent fuel system service that required priming
- Diesel fuel waxing or icing in cold temperatures
- Low fuel level in either fuel tank
- Vehicle unused for long period of time
- Unseated fuel filter that causes fuel to drain back to tank
- High resistance in fuel pump circuits

- High resistance in FP GND circuit
- Stuck Open fuel pressure regulator
- Damaged fuel filter
- Completely plugged strainer
- Failed fuel pump

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

Step 1	Check Fault Code Status	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 FMI 18 (EFP).		Yes: Go to Fuel Fuel Delivery Pressure symptom (page 181).
Is SPN 94 FMI 18 pending or active?		No: Repair SPN 94 FMI 18. After repairs are complete, retest SPN 94 FMI 18.

End Diagnostic Steps
After performing all diagnostic steps, if SPN 94 FMI 18 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

IAH System (Intake Air Heater)

SPN	FMI	Condition
729	5	IAHC open load / circuit

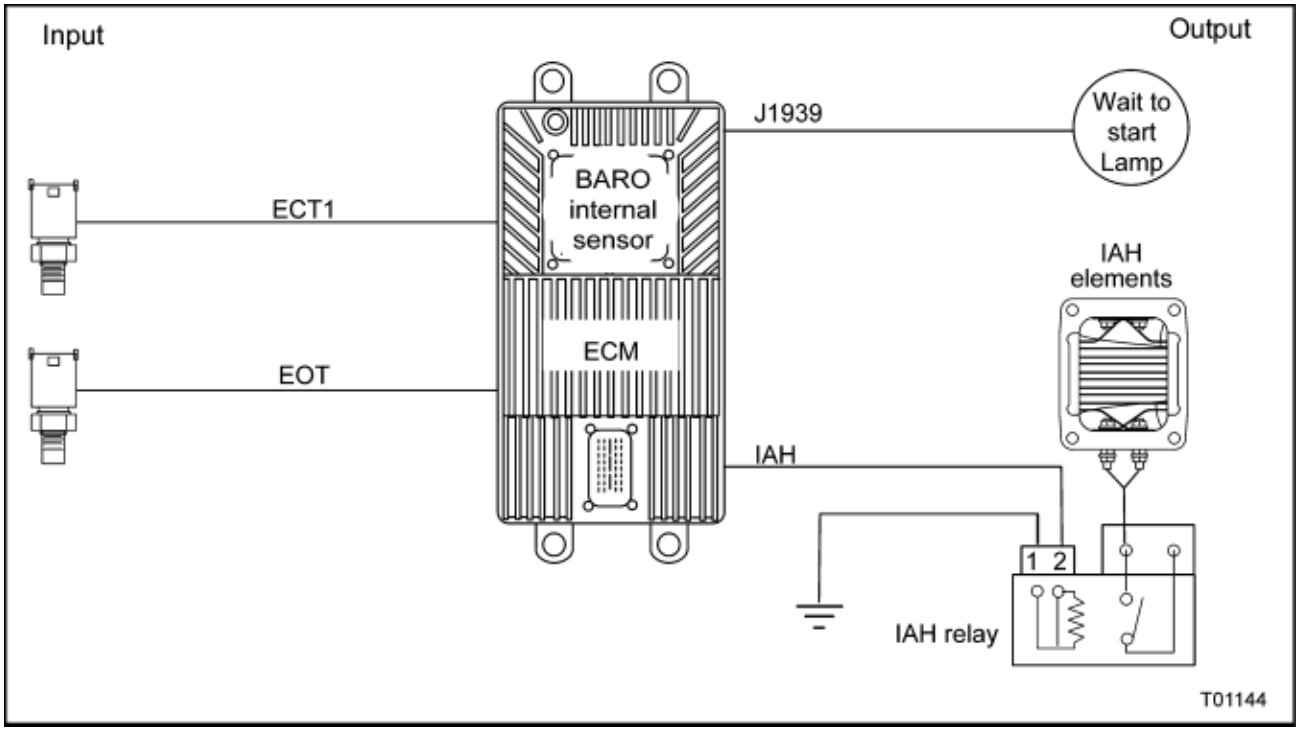


Figure 349 Function diagram for the IAH system

The function diagram for the IAH system includes the following:

- Engine Control Module (ECM)
  with Barometric Absolute Pressure (BARO) Internal Sensor
- Intake Air Heater (IAH) Relay
- Intake Air Heater (IAH) Element
- Engine Coolant Temperature 1 (ECT1) Sensor
- Engine Oil Temperature (EOT) Sensor
- Wait to Start Lamp

Function

The IAH system warms the incoming air supply prior to cranking to aid cold engine starting during warm-up. The IAH system also helps load the engine during a DPF regeneration.

Component Location

The IAH is installed in the intake manifold behind the inlet throttle body. The IAH relay is installed on the left side of the engine on the ECM bracket.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- nterface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- EXP-1000 HD by Midtronics (page 1225)
- Breakout Harness 6025 (IAH)
- 00-00956-08 – 180-pin Breakout Box (page 1222)

IAH Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
None		Inactive IAH	

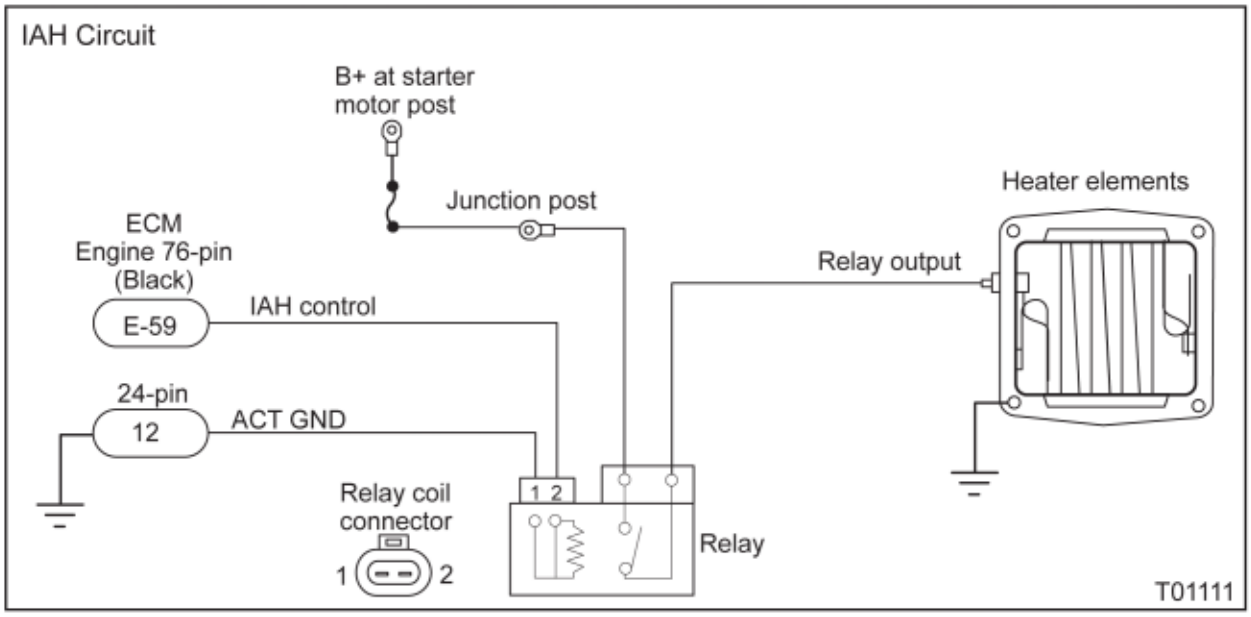


Figure 350 IAH circuit diagram

NOTE: For this procedure, run the KOEO Standard Test. Do not run the IAH test.

The KOEO Standard Test will enable the relay for two seconds every time the test is run. The IAH test only enables the relay twice for 45 seconds to prevent element overheating.

Amperage Draw Check

NOTE: Batteries must be fully charged before running this test.

Measure the amperage going to element. Run IAH Output State Test. Use a DMM with an amp probe. Set DMM to DCmV and zero amp clamp.

Test Point	Specification	Comment: < Less than, > Greater than
Element	125 amps ± 30 amps (within two seconds)	If 0 amps, go to Voltage Check on Relay Switch – Output State Test. If > 0 amps, but below specification, check for corroded terminals on relay, element, and power source. Go to Element Resistance Check.
If > 0 amps, but below specification, and element and wiring checks out acceptable, replace relay.		

Element Resistance Check

Turn ignition switch to OFF. Use a DMM to measure resistance from heater element to engine GND.

Test Point	Specification	Comment: < Less than, > Greater than
Element to GND	< 0.5 Ω	If > 0.5 Ω, replace failed heater element.

Voltage Check on Relay Switch – Output State Test

Turn ignition switch to OFF. Use DMM to measure voltage on relay B+ side.

Test Point	Specification	Comment: < Less than, > Greater than
Relay B+ side to GND	B+	If < B+, check large PWR circuit to relay for OPEN, corroded terminal, or blown fuse link.
Turn ignition switch to ON. Run KOEO Standard Test (IAH is commanded on for two seconds during this test). Use DMM to measure voltage when relay is commanded on.		
Relay Output side to GND	B+	If 0 volts, go to Voltage Check on Relay Coil – Output State Test.
Element to GND	B+	If < B+, check for corroded terminals on relay and element. Go to Amperage Check.

Voltage Check on Relay Coil – Output State Test

Disconnect relay connector. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment: < Less than, > Greater than
IAH Relay		
Pin 1 to B+	B+	If <B+, check for OPEN .
Pin 2 to GND	2. 74 V	If < 2 volts, check for OPEN or short to GND. Go to Harness Resistance Check – Relay Coil.
Run KOEO Standard Test (IAH is commanded on for two seconds during this test). Use DMM to measure voltage when relay is commanded on.		
IAH Relay		
Pin 2 to GND	B+	If < B+, check IAH control circuit for OPEN. Go to Harness Resistance Check – Relay Coil.
Pin 1 to 2	B+	If < B+ check GND circuit for OPEN. Go to harness Resistance Check.
If voltage checks at relay coil are acceptable, but voltage checks at relay switch failed, replace relay.		

Harness Resistance Check – Relay Coil Circuits

Turn ignition to OFF. Connect 180-pin Breakout Box. Leave ECM and relay disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
IAH Relay		
Pin 2 to E-59	< 5 Ω	If > 5 Ω, check IAH control circuit for OPEN.
Pin 1 to GND	< 5 Ω	If > 5 Ω, check ACT PWR GND for OPEN circuit.
E-59 to GND	> 1 kΩ	If < 1 kΩ, check IAH control for short to GND.

Harness Resistance Check – Relay Switch Circuits

Turn ignition to OFF. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
IAH Relay Output side to element	< 0.5 Ω	If > 0.5 Ω, check for OPEN circuit or corroded terminals.
Disconnect both battery GND cables. Use DMM to measure resistance.		
⚠ WARNING: To prevent personal injury or death, always disconnect main negative battery cable first. Always connect the main negative battery cable last.		
IAH Relay B+ side to battery positive post	< 0.5 Ω	If > 0.5 Ω, check for OPEN circuit or corroded terminals.
If circuits and element are within specifications, but failed amperage test, replace relay.		

IAH Circuit Operation

The ECM controls the WAIT TO START lamp and IAH element, based on ECT, EOT, and BARO (inside ECM). The WAIT TO START lamp (0 to 10 seconds) ON-time is independent from the IAH element (0 to 45 seconds) ON-time.

The ECM controls the WAIT TO START lamp through the J1939 to the EGC.

The ECM uses one relay to control the IAH element. The ECM will energize the relay by supplying power from Pin E-59 to Pin 2 on the relay coil. The relay coil is grounded at Pin 1 through Pin 12 of the 24-pin connector, from chassis harness ground. See vehicle electrical diagrams.

The power is supplied to the switch side of each relay from the starter motor through a fusible link. When the relay is energized, power is supplied to the heating element, which is grounded to the intake manifold.

SPN / FMIs

There are no SPN / FMIs for the IAH System.

SPN 729 FMI 5 - IAHC open load / circuit

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Intake Air Heater Driver Relay is Open Circuit, detected by Engine Control Module that drives Relay	Current on the driver < 8^{e-3} to 40^{e-3} Amps within 4^{e-3} seconds when gate is turned ON	Key ON No Power stage faults on the SPI chip SPN/FMI's 158/15 and 158/17 are NOT active

Fault Overview

Fault is set when Engine Control Module (ECM) detects Intake Air Heater (IAHC) Driver Relay is Open Circuit.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

SPN 158 FMI 15 and 17 (ECM PWR)

Fault Facts

None

Drive Cycle to Determine Fault Status

Continuous

Possible Causes

- Open in ACT GND circuit
- Open in IAHC circuit
- Failed IAH relay

Step 1	Check for associated fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 158 FMI 15 and 17 (ECM PWR). Is EST DTC list free of SPN 158 FMI 15 and 17?		Yes: Go to Step 2. No: Repair SPN 158 FMI 15 and 17. After repairs are complete, retest for SPN 729 FMI 5.

Step 2	Inspect connections Intake Air Heater (IAHC) Relay.	Decision
A. Key OFF B. Disconnect IAHC Relay. Check IAHC Relay and connector terminals for: damaged or pinched wires; moisture or corroded terminals; loose, bent, or broken pins; or broken connector housing. Are IAHC Relay connector, harness, and terminals clean and undamaged?		Yes: Perform Pin-Point Tests(page 828). No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 729 FMI 5.

Pin-Point Tests (SPN 729 FMI 5)

NOTE: See latest version of Navistar® N9 and N10 SCR Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE6025
- Digital Multimeter (DMM)

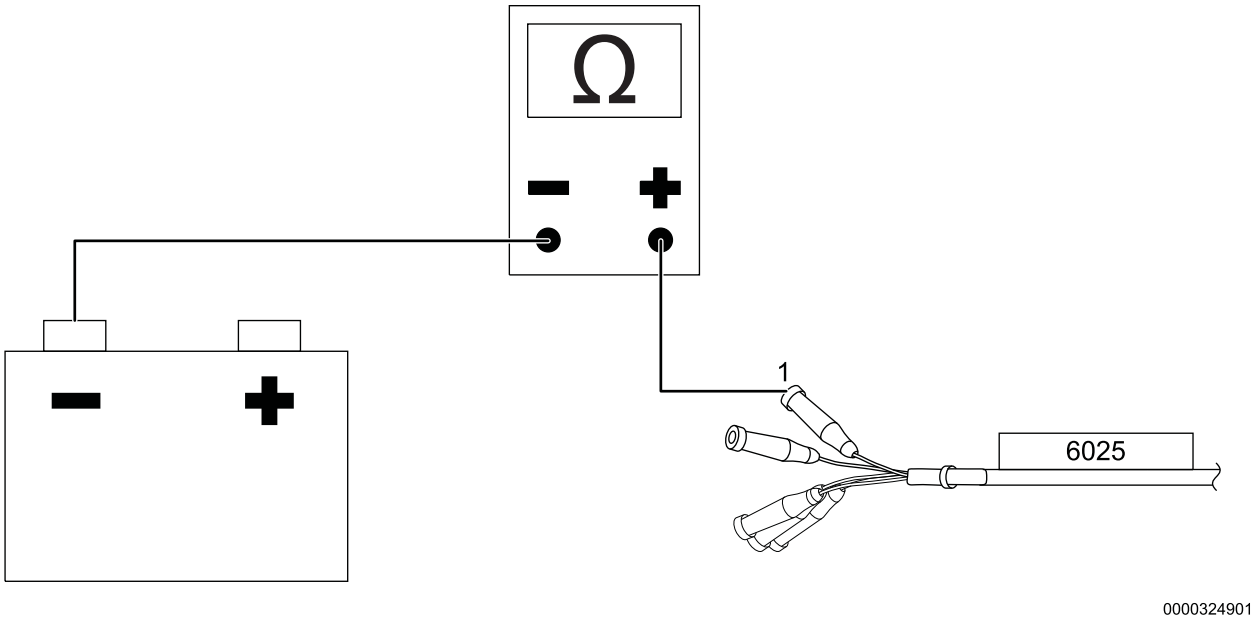
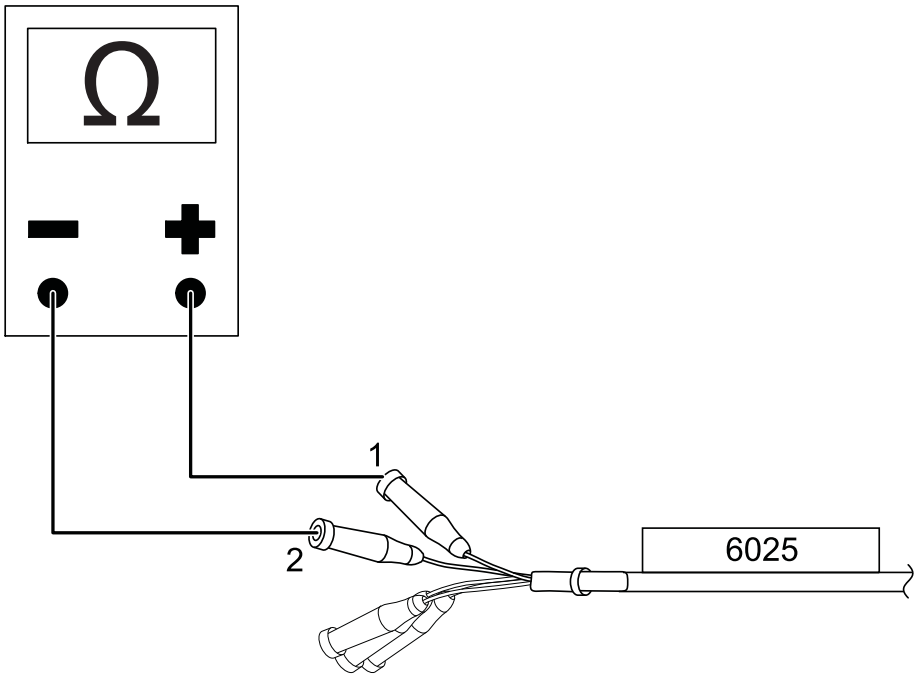


Figure 351 Test 1 Intake Air Heater (IAHC) Relay Circuit Resistance Check

Test 1 Setup
A. Key OFF. B. Disconnect ACM J2 connector. C. Connect breakout harness ZTSE6025 to vehicle harness and leave Intake Air Heater (IAHC) Relay disconnected D. Key ON.

Test 1	Specification
Use DMM to measure resistance between Breakout Harness ZTSE6025 pin-1 and known good GND.	Less than 5 ohms.
Decision	
Is resistance less than 5 ohms?	Yes: Go to Test 2.
	No: Repair Open between IAH relay pin-2 and GND. After repairs are complete, retest for SPN 729 FMI 5.



0000324921

Figure 352 Test 2 Intake Air Heater (IAHC) Relay Circuit Resistance Check

Test 2 Setup
A. Key OFF. B. Disconnect ACM J2 connector. C. Connect breakout harness ZTSE6025 to vehicle harness and leave Intake Air Heater (IAHC) Relay disconnected D. Key ON.

Test 2	Specification
Use DMM to measure resistance between Breakout Harness ZTSE6025 pin-1 and pin-2.	200 ± 100 ohms.
Decision	
Is resistance 200 ± 100 ohms?	Yes: Repair Open between IAH relay pin-2 and ECM pin E-59. After repairs are complete, retest for SPN 729 FMI 5.
	No: Replace IAH relay. After repairs are complete, retest for SPN 729 FMI 5.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and the proper decision was made. Return to SPN 729 FMI 5 fault code diagnostics.

ICP Sensor (Injection Control Pressure)

Overview of ICP Sensor Group

SPN	FMI	Condition
164	0	ICP above KOEO Spec (page 833)
164	3	ICP signal Out of Range HIGH (page 834)
164	4	ICP signal Out of Range LOW (page 844)

Overview

Injection Control Pressure (ICP) sensor provides feedback signal to Engine Control Module (ECM), indicating injection control pressure. ECM monitors ICP as engine is operating, to modulate Injection Pressure Regulator (IPR). This is a closed loop function in which ECM continuously monitors and adjusts for ideal ICP determined by conditions such as load, speed, and temperature.

GRAPHIC
PLACE
HOLDER

0000300422

Figure 353 ICP Sensor Location

SPN 164 FMI 0 - ICP above KOEO Specification

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Injection Control Pressure (ICP) sensor is offset.	Engine ICP > 217.5 psi (1.5 MPa)	Initial Key OFF Time delay after engine has stopped ≥ 2.55 seconds Inactive: SPN 164 FMI 3 and 4 (ICP); SPN 3509 FMI 3 and 4 (VREF 1)

Fault Overview

TBD

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive trips.

Associated Faults

SPN 164 FMI 3 and 4 (ICP); SPN 3509 FMI 3 and 4 (VREF 1)

Fault Facts

None

Drive Cycle to Determine Fault Status

Initial Key ON

Possible Causes

- Failed Injection Control Pressure (ICP) sensor

Step 1	Check for associated faults.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 164 FMI 3 and 4 (ICP); SPN 3509 FMI 3 and 4 (VREF 1). Is EST DTC list free of SPN 164 FMI 3 and 4; SPN 3509 FMI 3 and 4?		Yes: Go to Step 2. No: Repair SPN 164 FMI 3 and 4; SPN 3509 FMI 3 and 4. After repairs are complete, retest for SPN 164 FMI 0.

Step 2	Measure Injection Control Pressure (ICP).	Decision
A. Key-On Engine-Off (KOEO). B. Using EST with ServiceMaxx™, measure ICP. Is ICP greater than 217.5 psi (1.5 MPa)?		Yes: Replace ICP sensor. No: Diagnostics complete.

End Diagnostic Steps
After performing all diagnostic steps, if SPN 164 FMI 0 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

SPN 164 FMI 3 - ICP signal Out of Range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Injection Control Pressure (ICP) signal is out of range high.	ICP sensor voltage > 4.9 volts (> 5096.6 psi [35.14 MPa])	Key ON Inactive: SPN 3509 FMI 3 and 4 (VREF1)

Fault Overview

Fault code sets when Engine Control Module (ECM) detects Injection Control Pressure (ICP) signal greater than 4.9 volts.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 3509 FMI 3 and 4 (VREF1)

Fault Facts

Locking tabs on Injection Control Pressure (ICP) sensor connector fully seated.

Drive Cycle to Determine Fault Status

Key ON

Possible Causes

- ICP circuit Open
- ICP circuit short to PWR
- VREF1 circuit Open
- SIG GND circuit Open
- Damaged Under Valve Cover (UVC) harness
- Failed ICP sensor
- Broken Locking tab on harness connector

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

Step 1	Check for active or pending fault code.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 164 FMI 3. Is EST DTC list SPN 164 FMI 3 active or pending?		Yes: Go to Step 2.
		No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Check for associated fault codes.	Decision
Using EST with ServiceMaxx™ software, check DTC list for SPN 3509 FMI 3 and FMI 4 (VREF1). Is EST DTC list free of SPN 3509 FMI 3 and FMI 4?		Yes: Repair SPN 3509 FMI 3 and FMI 4. After repairs are complete, retest for SPN 3509 FMI 3 and FMI 4.
		No: Go to Step 3.

Step 3	Inspect Under Valve Cover (UVC) connector.	Decision
A. Key OFF. B. Disconnect UVC connector. C. Check UVC connector terminals for damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are UVC connector, harness, and terminal clean and undamaged?		Yes: Perform Pin-Point Tests (page 836). No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 164 FMI 3.

Step 4	Inspect Under Valve Cover (UVC) under valve connector.	Decision
A. Key OFF. B. Disconnect UVC valve harness connector. C. Remove valve cover. D. Check UVC harness connector terminals for damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are UVC harness connector, harness, and terminal clean and undamaged?		Yes: Perform Pin-Point Tests (page 836)Test 5. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 164 FMI 3.

Pin-Point Tests (SPN 164 FMI 3)

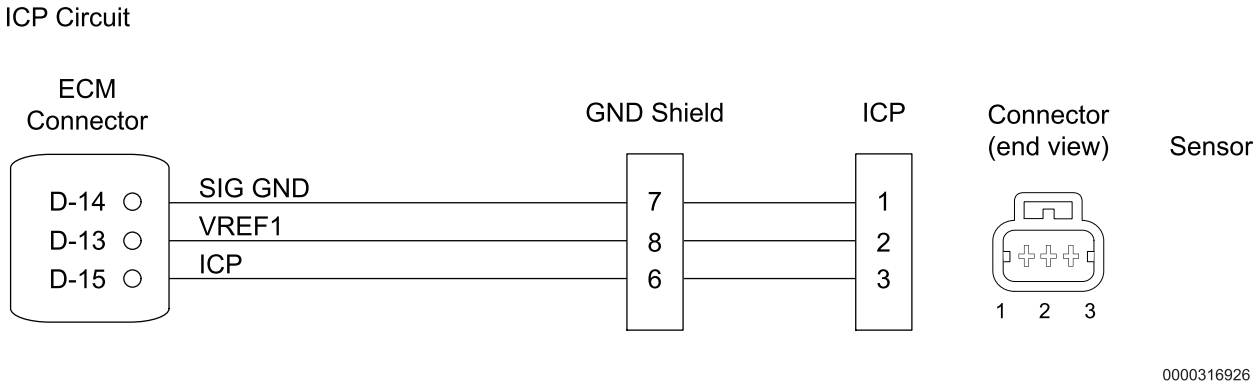


Figure 354 Injection Control Pressure (ICP) Sensor Circuit Diagram

NOTE: See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4498
- Breakout Harness ZTSE4686
- Breakout Harness ZTSE4793
- Digital Multimeter (DMM)

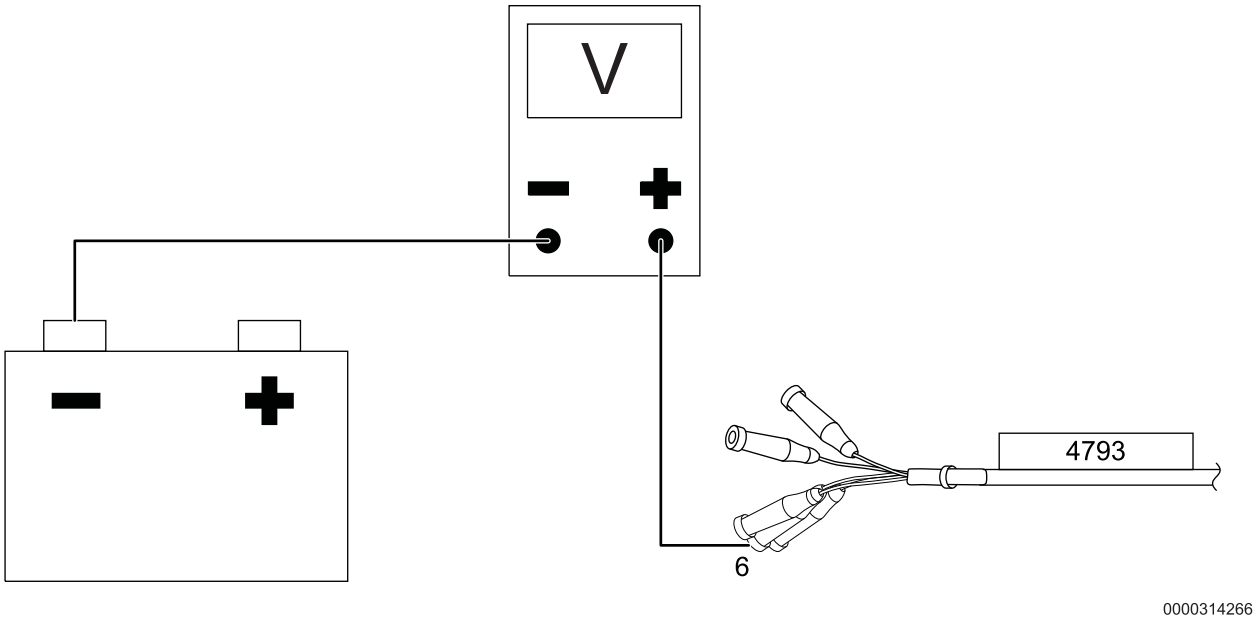


Figure 355 Test 1 Injection Control Pressure (ICP) Sensor Circuit Voltage Check

Test 1 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4793 to vehicle harness and leave Under Valve Cover (UVC) harness disconnected. C. Key ON.

Test 1	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4793 pin-6 and known good ground.	Greater than 5.5 volts
Decision	
Is voltage greater than 5.5 volts?	Yes: Repair short to PWR between UVC pin-6 and Engine Control Module (ECM) pin D-15. After repairs are complete, retest for SPN 164 FMI 3.
	No: Go to Test 2.

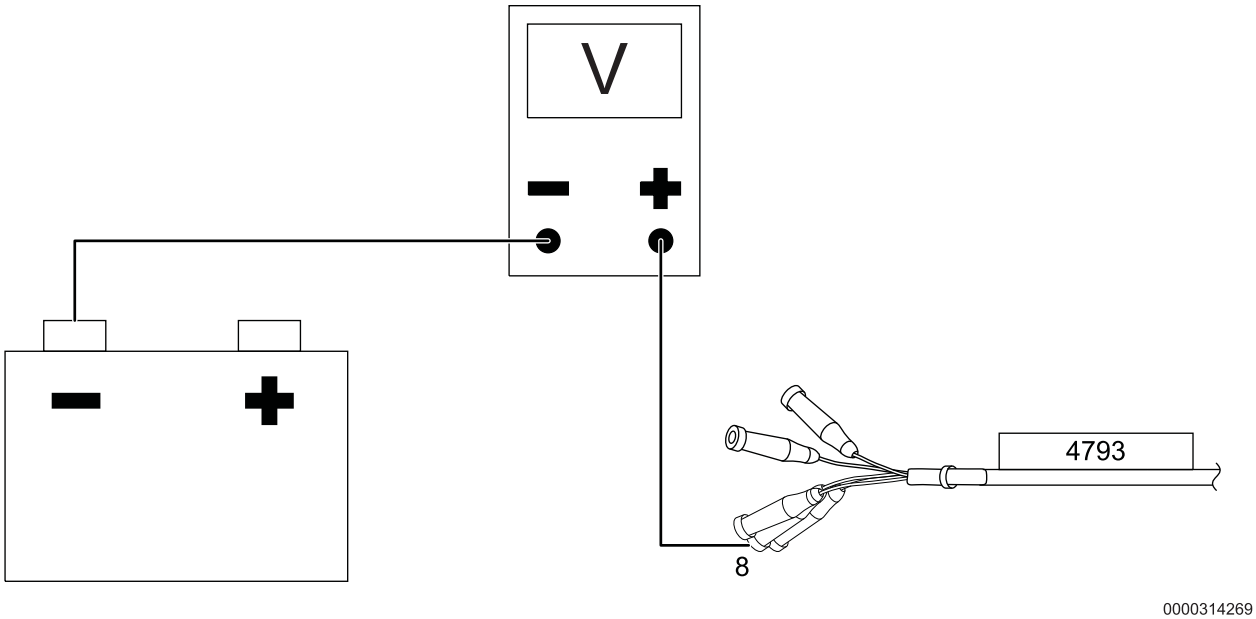


Figure 356 Test 2 Injection Control Pressure (ICP) Sensor Circuit Voltage Check

Test 2 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4793 to vehicle harness and leave Under Valve Cover (UVC) harness disconnected. C. Key ON.

Test 2	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4793 pin-8 and known good ground.	5 ± 0.5 volts
Decision	
Is voltage 5 ± 0.5 volts?	Yes: Go to Test 3.
	No: Repair Open between UVC pin-8 and ECM pin D-13. After repairs are complete, retest for SPN 164 FMI 3.

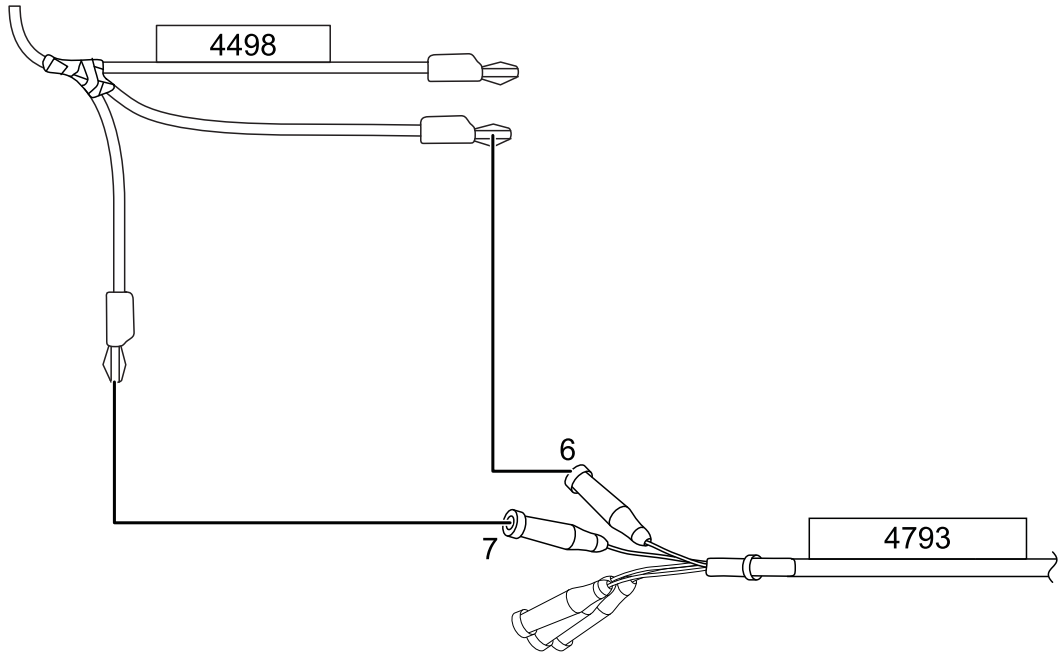


Figure 357 Test 3 Injection Control Pressure (ICP) Sensor Circuit Check

Test 3 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4793 to vehicle harness and leave Under Valve Cover (UVC) harness disconnected. C. Using breakout harness ZTSE4498, short pin-6 and pin-7 of breakout harness ZTSE4793 together. D. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81) E. Key ON. Log in to ServiceMaxx™ software.

Test 3	Specification
Using EST with ServiceMaxx™, clear Diagnostic Trouble Code (DTC) list.	SPN 164 FMI 4 sets in DTC list.
Decision	
Does SPN 164 FMI 4 set after DTC list is cleared	Yes: Go to step based Step 4.
	No: Go to Test 4.

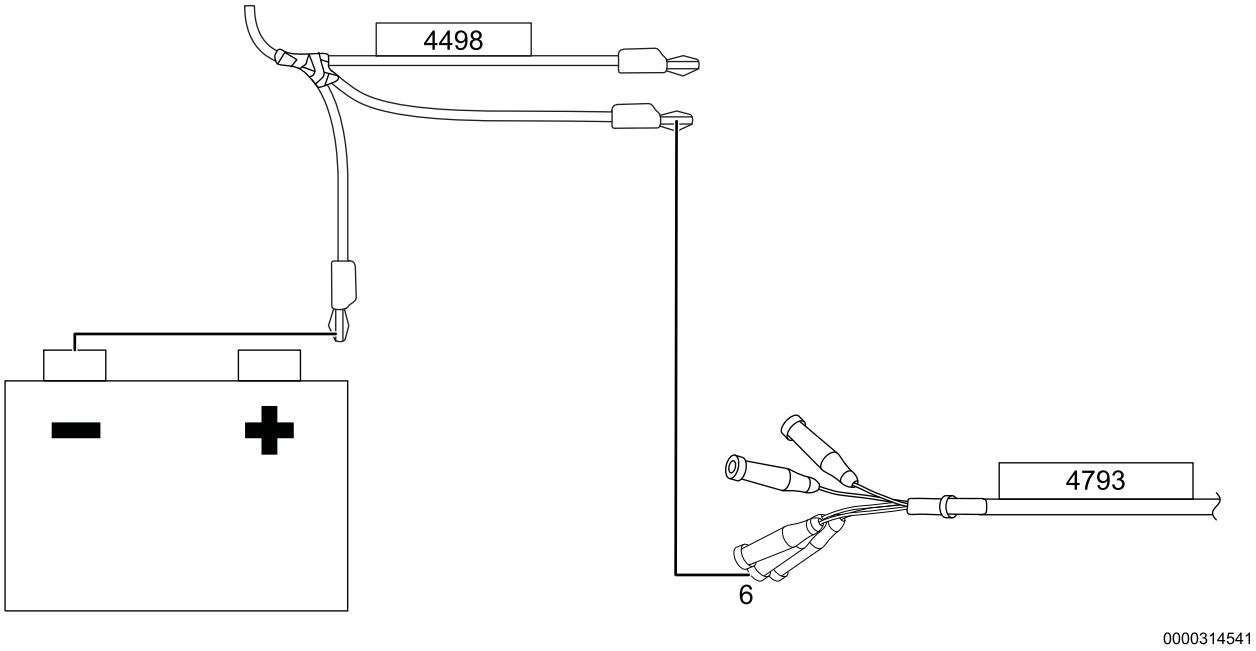


Figure 358 Test 4 Injection Control Pressure (ICP) Sensor Circuit Check

Test 4 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4793 to vehicle harness and leave Under Valve Cover (UVC) harness disconnected. C. Using breakout harness ZTSE4793, short pin-6 to known good GND. D. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81) E. Key ON. Log in to ServiceMaxx™ software.

Test 4	Specification
Using EST with ServiceMaxx™, clear Diagnostic Trouble Code (DTC) list.	SPN 164 FMI 4
Decision	
Does SPN 164 FMI 4 set after DTC list is cleared?	Yes: Repair Open between UVC pin-7 and ECM pin D-14. After repairs are complete, retest for SPN 164 FMI 3.
	No: Repair Open between UVC pin-6 and ECM pin D-15. After repairs are complete, retest for SPN 164 FMI 3.

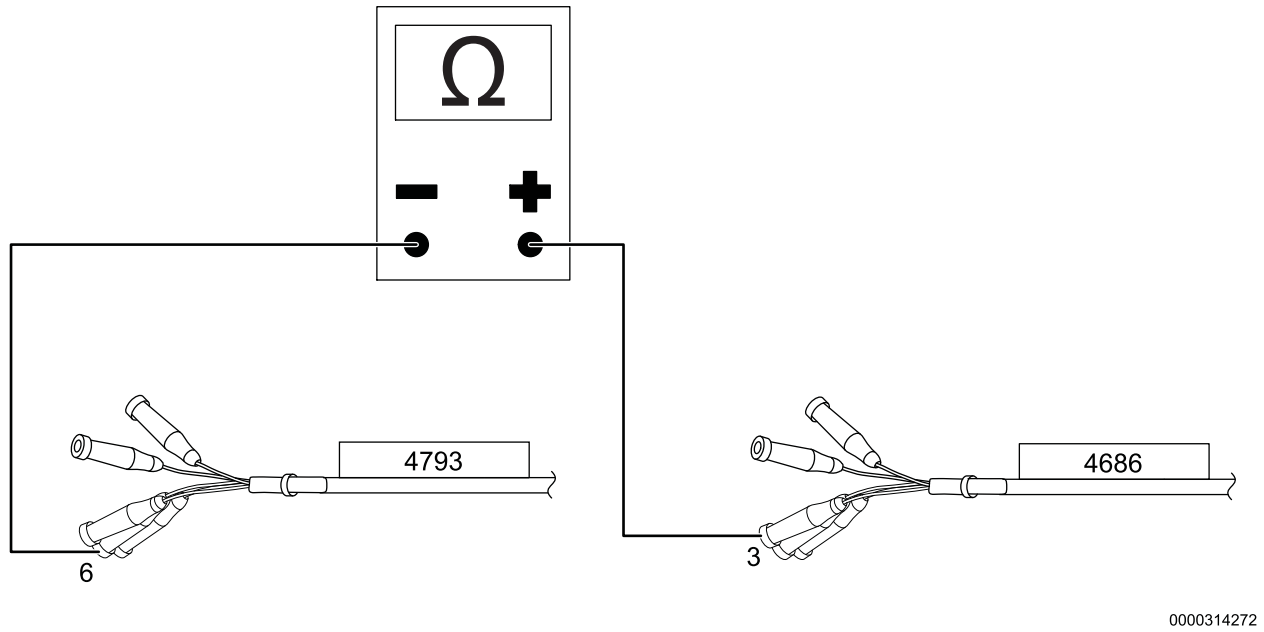


Figure 359 Test 5 Injection Control Pressure (ICP) Sensor Circuit Resistance Check

Test 5 Setup
A. Key OFF. B. Remove valve cover (*See Engine Service Manual*). C. Connect Breakout Harness ZTSE4793 to UVC harness and leave vehicle harness disconnected. D. Connect Breakout Harness ZTSE4686 to UVC harness leave Injection Control Pressure (ICP) sensor disconnected.

Test 5	Specification
Use DMM to measure resistance between Breakout Harness ZTSE4793 pin-6 and Breakout Harness ZTSE4686 pin-3.	Less than 5 ohms
Decision	
Is resistance less than 5 ohms?	Yes: Go to Step 6.
	No: Replace UVC harness. After repairs are complete, retest for SPN 164 FMI 3.

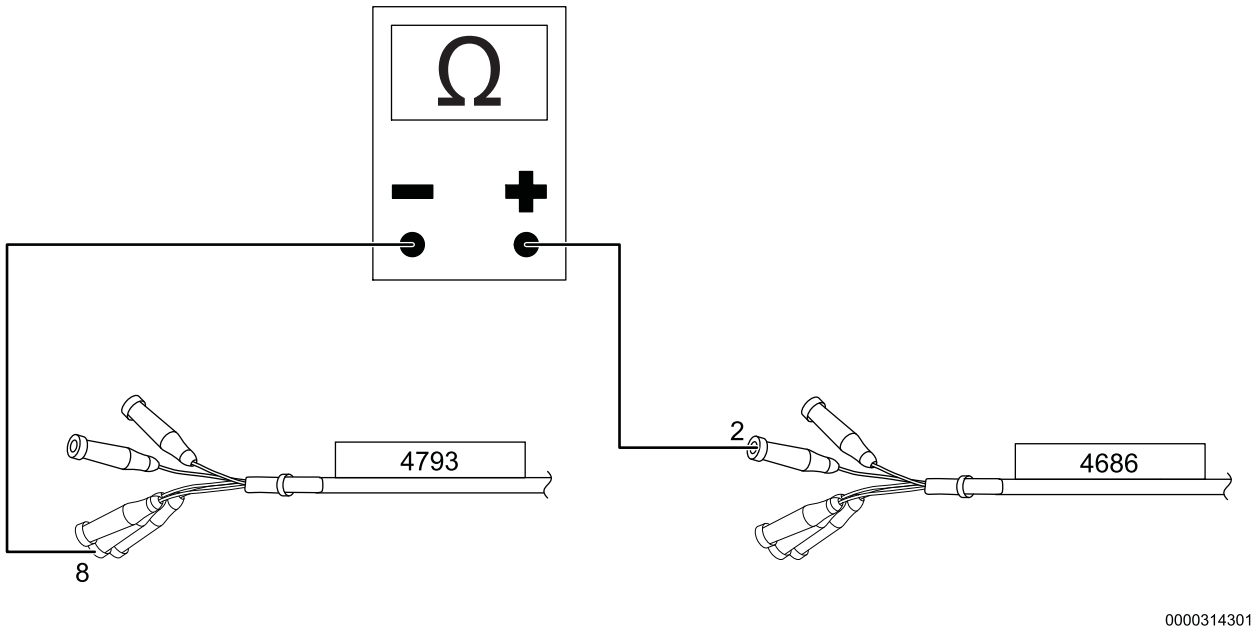


Figure 360 Test 6 Injection Control Pressure (ICP) Sensor Circuit Resistance Check

Test 6 Setup
A. Key OFF. B. Remove valve cover (*See Engine Service Manual*). C. Connect Breakout Harness ZTSE4793 to UVC harness and leave vehicle harness disconnected. D. Connect Breakout Harness ZTSE4686 to UVC harness and leave Injection Control Pressure (ICP) sensor disconnected.

Test 6	Specification
Use DMM to measure resistance between Breakout Harness ZTSE4793 pin-8 and Breakout Harness ZTSE4686 pin-2.	Less than 5 ohms
Decision	
Is resistance less than 5 ohms?	Yes: Go to Step 8.
	No: Replace UVC harness. After repairs are complete, retest for SPN 164 FMI 3.

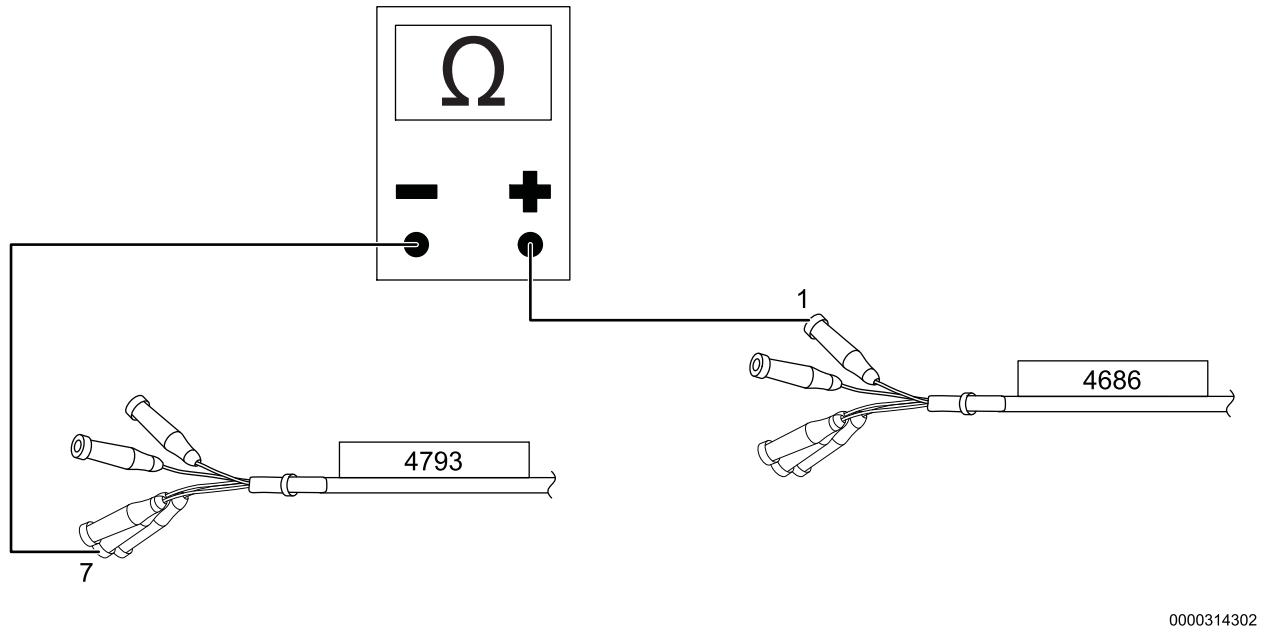


Figure 361 Test 7 Injection Control Pressure (ICP) Sensor Circuit Resistance Check

Test 7 Setup
A. Key OFF. B. Remove valve cover (*See Engine Service Manual*). C. Connect Breakout Harness ZTSE4793 to UVC harness and leave vehicle harness disconnected. D. Connect Breakout Harness ZTSE4686 to UVC harness leave Injection Control Pressure (ICP) sensor disconnected.

Test 7	Specification
Use DMM to measure resistance between Breakout harness ZTSE4793 pin-7 and Breakout Harness ZTSE4686 pin-1.	Less than 5 ohms
Decision	
Is resistance less than 5 ohms?	Yes: Replace ICP sensor. After repairs are complete, retest for SPN 164 FMI 3.
	No: Replace UVC harness. After repairs are complete, retest for SPN 164 FMI 3.

End Diagnostic Tests
After performing diagnostic steps, if SPN 164 FMI 3 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

SPN 164 FMI 4 - ICP signal Out of Range LOW

Condition / Description	Setting Criteria	Enable Conditions / Values
Injection Control Pressure (ICP) sensor signal is Out of Range Low.	ICP sensor voltage < 0.1 volt (< -1.133 MPa)	Key ON Inactive: SPN 3509 FMI 3 and 4

Fault Overview

Fault code sets when Injection Control Pressure (ICP) sensor signal is less than 0.1 volts.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive trips.

Associated Faults

SPN 3509 FMI 3 and 4 (VREF1)

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON

Possible Causes

- ICP circuit short to GND
- Failed ICP sensor

Step 1	Check for active or pending fault code.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 164 FMI 4. Is EST DTC list SPN 164 FMI 4 active or pending?		Yes: Go to Step 2. No: Go to intermittent diagnostic procedures (page 79).

Step 2	Check for associated fault codes.	Decision
Using EST with ServiceMaxx™ software, check DTC list for SPN 3509 FMI 3 and 4 (VREF). Does EST DTC list show SPN 3509 FMI 3 and 4 as active?		Yes: Repair SPN 3509 FMI 3 and 4. After repairs are complete, retest for SPN 164 FMI 4. No: Go to Step 3.

Step 3	Inspect connections at Under Valve Cover (UVC) harness connector for ICP sensor.	Decision
A. Key OFF. B. Disconnect UVC harness connector for ICP. C. Check UVC harness and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are UVC harness connector for ICP and connector terminals clean and undamaged?		No: Perform Pin-Point Test SPN 164 FMI 4 (page 845). No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 164 FMI 4.

Pin-Point Tests (SPN 164 FMI 4)

ICP Circuit

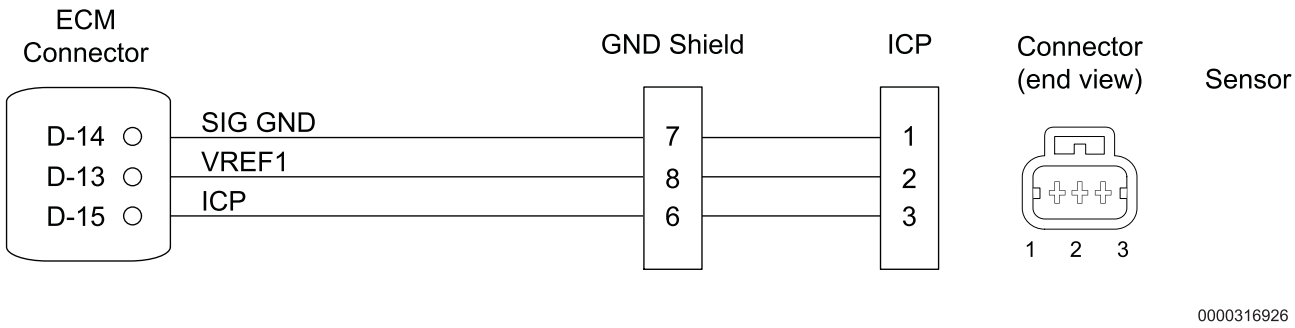


Figure 362 ICP Sensor Circuit Diagram

NOTE: See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4793 (UVC)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)

Test 1 Setup
• Key OFF. • Disconnect Under Valve Cover (UVC) harness for ICP sensor connector and leave disconnected. • Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). • Key ON. Log in to ServiceMaxx™ software.

Test 1	Specification
Disconnect UVC harness connector for ICP, use EST with ServiceMaxx™ software to monitor Diagnostic Trouble Code (DTC) list for SPN 164 FMI 4.	SPN 164 FMI 4
Decision	
Is fault code SPN 164 FMI 4 active?	Yes: Correct short to GND between UVC vehicle harness for ICP pin-6 and Engine Control Module (ECM) pin D-15.
	No: Go to Test 2.

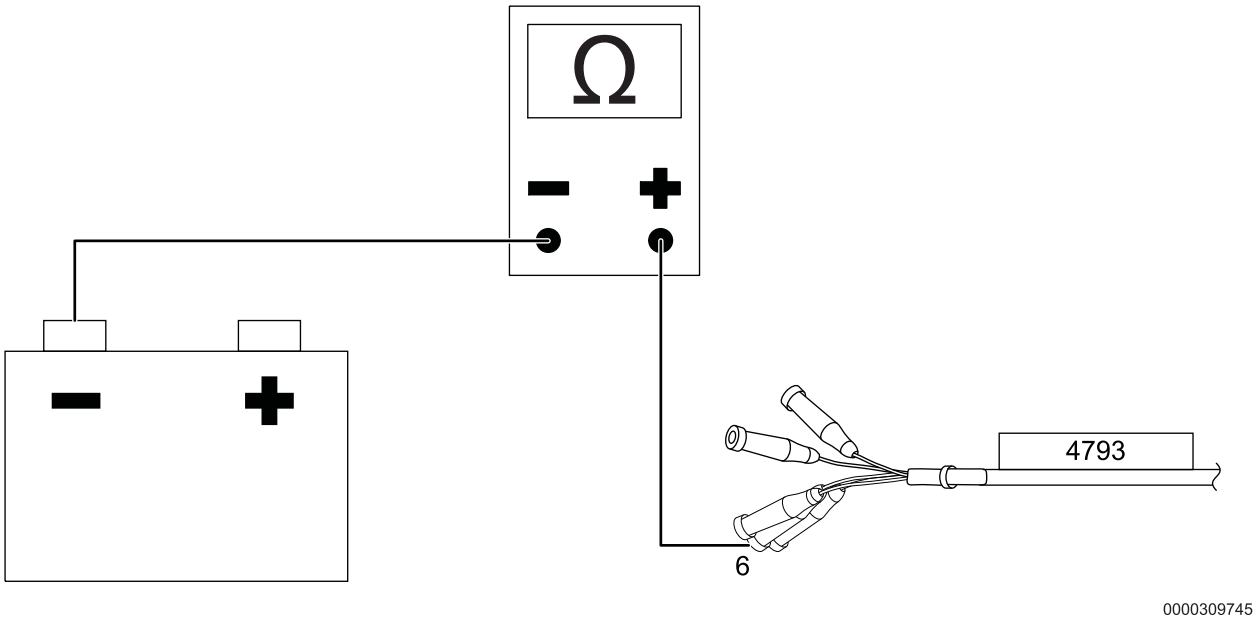


Figure 363 Pin-Point Test 2 ICP Sensor Circuit Resistance Check

Test 2 Setup
A. Key OFF. B. Connect Breakout harness ZTSE4793 to UVC engine harness connector that leads under valve cover and leave vehicle harness disconnected.

Test 2	Specification
Use DMM to measure resistance of between Breakout Harness ZTSE4793 pin-6 and known good ground.	0 ohms
Decision	
Is resistance approximately 0 ohms?	Yes: Repair short to GND between UVC vehicle harness for ICP pin-6 and Engine Control Module (ECM) pin D-15. After repairs are complete, retest for SPN 164 FMI 4.
	No: Replace ICP sensor. After repairs are complete, retest for SPN 164 FMI 4.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 164 FMI 4 fault code diagnostics.

ICP (Injection Control Pressure) System

SPN	FMI	Condition	Possible Causes	Actions
164	1	ICP unable to Build During Engine Cranking	• Injection Pressure Regulator (IPR) circuit fault • Failed IPR valve • ICP System leak • Failed High Pressure Pump	Step-based Diagnostics (page 854)
164	2	ICP signal erratic, intermittent, or incorrect	• Connections • Failed/biased sensor • Injector • Circuit • Sticking IPR valve	Step-based Diagnostics (page 856)
164	10	ICP signal abnormal rate of change	• Biased ICP sensor or circuit • ICP sensor or circuit fault • ICP valve or circuit fault	Pin-point Diagnostics (page 852)
164	13	ICP adaptation in-range fault	• ICP system leak • IPR valve or circuit fault • Failed High Pressure Pump	Pin-point Diagnostics (page 852)
164	15	ICP too high during test	• Biased ICP sensor or circuit • IPR circuit fault or failed (sticking) valve	Step-based Diagnostics (page 858)
164	16	ICP below setpoint	• Biased ICP sensor or circuit • IPR circuit fault or failed (sticking) valve	Step-based Diagnostics (page 859)

SPN	FMI	Condition	Possible Causes	Actions
164	17	ICP unable to build during test	• Biased ICP sensor or circuit • Trapped air in ICP system (after system was opened) • Aerated or contaminated engine oil • IPR circuit fault or failed (sticking) valve • High-pressure pump failure	Step-based Diagnostics (page 864)
164	18	ICP below desired level	• Biased ICP sensor or circuit • Trapped air in ICP system (after system was opened) • Aerated or contaminated engine oil • IPR circuit fault or failed (sticking) valve • High-pressure oil pump failure	Step-based Diagnostics (page 868)
164	20	ICP below desired level	• High-pressure oil pump • Puck seal leakage • Injector • Injector static leakage • ICP sensor O-ring leakage • Engine Compression Brake (ECB) sensor O-ring leakage • ECB relief valve stuck	Step-based Diagnostics (page 870)

SPN	FMI	Condition	Possible Causes	Actions
			• IPR valve sticking • Oil rail end cap seal leakage	
164	21	ICP above desired level	• Sticking IPR valve	Step-based Diagnostics (page 874)
3055	2	ICP/IPR adaptation in-range fault	• Oil level and quality • ICP system leak • IPR sensor or circuit fault • IPR valve sticking or stuck • Oil additive package worn out, foaming (overfilled) • High pressure oil pump worn out or leaking • High pressure oil leakage • Injector static leakage • Injector Oil Inlet Adapter (Puck) Assembly leakage • Engine brake control valve leakage	Step-based Diagnostics (page 876)

Overview

The ICP system is a mechanical hydraulic system, electronically controlled by the ECM to intensify fuel pressure in the fuel injectors. The ECM controls the IPR valve while monitoring the ICP sensor to provide the engine with the desired starting and operating pressures.

Tools

- EZ Tech® Electronic Service Tool (EST) – J-45067 (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Breakout Harness 4952 (page 1237)
- Digital Multimeter (DMM) (page 1224)
- Breakout Harness 4484 (page 1229)

ICP System Pin-point Diagnostics

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

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

SPN 164 FMI 1 – ICP unable to build during engine cranking

SPN 164 FMI 10 – ICP signal abnormal rate of change

SPN 164 FMI 13 – ICP adaptation in range fault

SPN 164 FMI 15 – ICP too high during test

SPN 164 FMI 16 – ICP below set point

SPN 164 FMI 17 – ICP unable to build during test

SPN 164 FMI 18 – ICP below desired level

SPN 3055 FMI 2 – ICP / IPR Adaptation In-range Fault

Pin-point ICP System Fault

1. Check repair history for recent ICP system repairs.

   Trapped air in the system from recent repair can cause erratic pressure. To purge air from system, find an open stretch of road and drive the vehicle for a minimum of 20 miles.
2. Check engine oil for correct level and grade. Inspect for contamination or debris.
3. Check for other active or inactive ICP codes. See ICP Sensor in this section and check ICP KOEO specification.
4. Check for IPR code by running KOEO Standard test. See IPR in this section and check harness connection.
5. Check for intermittent circuit faults on ICP sensor or IPR valve.

   Open Continuous monitor session and run Continuous monitor test. With engine at low idle, wiggle harness connection on the ICP, IPR, 24-pin, and 42-pin connectors.
6. Check for aerated oil at high idle. See APPENDIX A (page 1291).
7. Check the ICP system for leaks. See HARD START AND NO START DIAGNOSTICS .

SPN 164 FMI 1 – ICP Unable to Build Pressure During Cranking

Pin-point ICP System Fault

1. Check harness connection to ICP, IPR, and ECM.
2. Check repair history for recent ICP system repairs.
   - Trapped air in the system from recent repair can cause erratic pressure. To purge air from system, find an open stretch of road and drive the vehicle for a minimum of 20 miles.
3. Check engine oil for correct level and grade. Inspect for contamination or debris.

   Verify lube oil pressure and delivery to reservoir during engine crank. See HARD START AND NO START DIAGNOSTICS .
4. Check for other active or inactive ICP codes. See ICP Sensor (Injection Control Pressure) and check ICP KOEO specification (page 1291).
5. Check for IPR SPN / FMI by running KOEO Standard test. See IPR and check harness connection (page 1062).
6. Check for intermittent circuit faults on ICP sensor or IPR valve.

   Open Continuous monitor session and run Continuous monitor test. With engine at low idle, wiggle harness connection on the ICP, IPR, 24-pin, and 42-pin connectors.
7. Check the ICP system for leaks. See HARD START AND NO START DIAGNOSTICS .

SPN 164 FMI 1 - ICP Unable to Build During Engine Cranking

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Injection Control Pressure (ICP) is low during engine start.	ICP < 3.5 MPa	Key ON Number of engine revolutions to begin monitoring ≥ 15 revolutions, and monitoring ends after engine is running for ≥ 30 seconds Inactive: SPN 164 FMI 3 and 4 (ICP); and SPN 679 FMI 3 and 4 (IPR)

Fault Overview

Fault code sets when Injection Control Pressure (ICP) is lower than 3.5 MPa while engine is cranking for 2.5 seconds.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive trips.

Associated Faults

SPN 164 FMI 3 and 4 (ICP); and SPN 679 FMI 3 and 4 (IPR)

Fault Facts

Must perform Key-On Engine-Off (KOEO) procedure Fuel Pressure Adaptation Reset (page 92)in ServiceMaxx™ after repairs are complete. Make sure to remove and clean the High-Pressure (HP) oil rail and HP oil hose and fittings to remove contamination or debris if High-Pressure Oil Pump (HPOP) is replaced due to pump failure.

Drive Cycle to Determine Fault Status

Cranking

Possible Causes

- High-Pressure Oil Pump (HPOP)
- Restricted HPOP intake screen clogged
- Failed Injection Pressure Regulator (IPR) hydraulic and mechanical issues
- High-pressure oil leaks
- Failed fuel injectors
- IPR electrical circuit failures
- HP oil leaks at fuel injectors

Step 1	Check for active fault code.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 164 FMI 1 (ICP). Does EST DTC show fault code SPN 164 FMI 1 as Active or Pending?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Check for associated faults.	Decision
Using EST with ServiceMaxx™ software, check DTC list for SPN 164 FMI 3 and 4 (ICP); SPN 679 FMI 3 and 4 (IPR). Is EST DTC free of SPN 164 FMI 3 and 4; and SPN 679 FMI 3 and 4?		Yes: Go to Step 3. No: Repair SPN 164 FMI 3 and 4; SPN 674 FMI 4; and SPN 679 FMI 3 and 4. After repairs are complete, retest for SPN 164 FMI 1.

Step 3	Check engine oil level.	Decision
Perform Engine Oil and Quality Check (page 123). Is engine oil level within specifications and not contaminated?		Yes: Go to Step 4. No: Repair engine oil level and / or contamination symptom. After repairs are complete, retest for SPN 164 FMI 1.

Step 4	Inspect High-Pressure Oil Pump (HPOP) pump reservoir.	Decision
Loosen Engine Oil Temperature (EOT) sensor and verify that the HPOP reservoir has oil in it. Does the HPOP reservoir have oil in it?		Yes: Go to Step 5. No: Diagnose lubrication system.

Step 5	Test HPOP.	Decision
Perform Cylinder Performance Analyzer (CPA) High-Pressure Oil Pump (HPOP) Test (page 287). Follow on-screen instructions for test. When repairs are complete, perform the Fuel Pressure Adaptation Reset (page 92)procedure.		

End Diagnostic Steps
After performing all diagnostic steps, if SPN 164 FMI 1 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

SPN 164

FMI 2 – ICP Signal Erratic, Intermittent, or Incorrect

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
N/A			

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 164 FMI 2 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 164 FMI 2. No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit, inspect connections at Injection Control Pressure (ICP) sensor. With key OFF, disconnect ICP sensor connector at valve cover (8-pin UVC connector 1). Check ICP sensor valve cover connector and wiring harness connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are ICP sensor valve cover connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage outside valve cover. After repairs are complete, retest for SPN 164 FMI 2.

Step	Action	Decision
4	Test ICP circuits for open, short, or high resistance conditions. Connect breakout harness 4952 to wiring harness, and do connector voltage checks and resistance checks . Are ICP circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 164 FMI 2.

Step	Action	Decision
5	Test ICP circuit under valve cover. Do Under Valve Cover Resistance Check to Engine Ground . Is under-valve cover circuit within specification?	Yes: Go to Step 6. No: Repair under-valve cover circuit as required. After repairs are complete, retest for SPN 164 FMI 2.

Step	Action	Decision
6	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Reconnect to valve cover connector and do Key On Engine Off Continuous Monitor Test (page 87). Does circuit operate properly?	Yes: Go to Step 7. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 164 FMI 2.

Step	Action	Decision
7	Test ICP sensor. Attempt to start engine while monitoring the S_ICP Volts signal using the EST with ServiceMaxx™ software. Did the S_ICP Volts signal change more than 10 mV?	Yes: After doing all diagnostic steps, if SPN 164 FMI 2 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace ICP sensor. After repairs are complete, retest for SPN 164 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 164 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 164 FMI 15 - ICP too high during test

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
TBD	TBD	TBD

Fault Overview

TBD

Lamp Reaction

TBD

Associated Faults

SPN 164 FMI 1, 3, and 4 (ICP); SPN 679 FMI 3 and 4 (IPR); SPN 3055 FMI 2 (INJ)

Fault Facts

None

Drive Cycle to Determine Fault Status

TBD

Possible Causes

- Failed Injection Pressure Regulator (IPR) valve
- Contaminated Oil

Step 1	Inspect vehicle history for high-pressure oil system repairs	Decision
Determine if vehicle history included high-pressure oil system repairs. Were high-pressure oil system repairs recently performed?		Yes: Perform Key-On Engine-Off (KOEO) Procedure Fuel Pressure Adaptation Reset(page 92).
		No: Go to Step 2.

Step 2	Check for associated fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 164 FMI 1, 3, and 4 (ICP); SPN 679 FMI 3 and 4 (IPR); SPN 3055 FMI 2 (INJ). Is EST DTC list free of SPN 164 FMI 1, 3, and 4; SPN 679 FMI 3 and 4; and SPN 3055 FMI 2?		Yes: Go to Step 3.
		No: Repair SPN 164 FMI 1, 3, 4; SPN 679 FMI 3 and 4; and SPN 3055 FMI 2. After repairs are complete, retest for SPN 164 FMI 15.

Step 3	Check for engine oil problems.	Decision
Check engine oil level and condition. Is engine oil at proper level and in good condition?		Yes: Go to Step 4. No: Correct / repair engine oil problems. After repairs are complete, retest for SPN 164 FMI 15.

Step 4	Test High-Pressure Oil Pump (HPOP) IPR electrical circuit.	Decision
Perform Cylinder Performance Analyzer (CPA) - HPOP(page 287) Test. Does HPOP Test detect a problem with the IPR valve electrical circuit?		Yes: Repair IPR circuit. After repairs are complete, retest for SPN 164 FMI 15. No: Go to Step 5.

Step 5	Mechanically test the IPR valve hydraulic circuit.	Decision
Perform CPA - HPOP(page 287) Test. Does HPOP Test detect a problem with the IPR valve hydraulic circuit?		Yes: Replace IPR valve and perform Key-On Engine-Off (KOEO) Procedure Fuel Pressure Adaptation Reset(page 92). After repairs are complete, retest for SPN 164 FMI 15. No: Diagnostics complete.

End Diagnostic Steps
After performing diagnostic steps, if SPN 164 FMI 15 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

SPN 164 FMI 16 - ICP above desired level

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Comparison of measured Injection Control Pressure (ICP) value versus set point.	Engine ICP set point MINUS measured engine ICP ≥ threshold value based on speed / torque (Table A083)	1. Engine Injection Control Pressure in Close Loop Mode {Always in Close loop mode except when Limp Home mode is active} 2. Engine Oil Temperature (EOT) ≥ 95°F and ≤ 244°F (≥ 35°C and ≤ 118°C)

		Delay timer to activate diagnostics after entry conditions 1 and 2 mentioned above are met ≥ 15 seconds End of Line tests not active Engine Exhaust Brake or Vehicle Retarder NOT active Time after Engine Exhaust Brake or Vehicle Retarder state of change to not active > 5 seconds Torque limiting in Limp Home Mode is NOT active Fuel cut off in engine deceleration NOT active Battery voltage ≥ 9 volts and ≤ 16 volts Key ON Time after engine start is ≥ 30 seconds Engine Coolant Temperature (ECT) ≥ 68°F (20°C) AND ≤ 219°F (104°C) 132/3, 132/4, 636/7, 636/2, 110/3, 110/4, 110/2, 175/3, 175/4, 175/2, 164/0, 164/3, 164/4, 679/4, 679/3, 651/4, 651/5, 655/4, 652/5, 653/4, 653/5, 656/4, 654/5, 652/4, 655/5, 654/4, 656/5, 5543/3, 5543/5, 5543/4, 94/3, 94/4, 1189/3, 1189/4, 2791/2, 2791/7, 2791/14, 2791/14, 2791/14, 27/14, 2791/8, 2791/8, 2791/3, 2791/4, 5395/0, 5395/1, 2659/20, 4766/10, 110/17, 3055/2, 4257/7, 4257/7, 4257/7, 4257/7, 4257/7, 4257/7, and 4257/7 are NOT active

Fault Overview

None

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive trips.

Associated Faults

SPN 164 FMI 1, 3, and 4 (ICP); SPN 679 FMI 3 and 4 (IPR); SPN 3055 FMI 2 (INJ)

Fault Facts

None

Drive Cycle to Determine Fault Status

TBD

Possible Causes

- Restricted High-Pressure Oil Pump (HPOP) intake screen
- Failed HPOP
- Injection Pressure Regulator (IPR) electrical circuit
- Failed IPR
- Leaks in High-Pressure (HP) oil system
- Failed injectors and pucks

Step 1	Inspect vehicle history for High-Pressure (HP) oil system repairs	Decision
Determine if the vehicle history included HP oil system repairs. Were HP oil system repairs recently performed?		Yes: Perform the Key-On Engine-Off (KOEO) Procedure Fuel Pressure Adaptation Reset(page 92) procedure.
		No: Go to Step 2.

Step 2	Check for associated fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 164 FMI 1, 3, and 4 (ICP); SPN 679 FMI 3 and 4 (IPR); SPN 3055 FMI 2 (INJ). Is EST DTC list free of SPN 164 FMI 1, 3, and 4; SPN 679 FMI 3 and 4; and SPN 3055 FMI 2?		Yes: Go to Step 3.
		No: Repair SPN 164 FMI 1, 3, 4; SPN 679 FMI 3 and 4; and SPN 3055 FMI 2. After repairs are complete, retest for SPN 164 FMI 16.

Step 3	Check for engine oil problems.	Decision
Check engine oil level and condition. Is engine oil at proper level and in good condition?		Yes: Go to Step 4.
		No: Repair engine oil problems. After repairs are complete, retest for SPN 164 FMI 16.

Step 4	Inspect High-Pressure Oil Pump (HPOP) reservoir.	Decision
Inspect HPOP reservoir for appropriate engine oil level. Remove Engine Oil Temperature (EOT) sensor. Does engine oil drain from HPOP reservoir?		Yes: Reinstall EOT sensor. Go to Step 5 No: Clean passages going to HPOP reservoir. After repairs are complete, retest for SPN 164 FMI 16.

Step 5	Test HPOP Injection Pressure Regulator (IPR) electrical circuit.	Decision
Perform Cylinder Performance Analyzer (CPA) - High-Pressure Oil Pump (HPOP)(page 287) Test. Does HPOP Test detect a problem with the IPR valve electrical circuit?		Yes: Repair IPR circuit. After repairs are complete, retest for SPN 164 FMI 16. No: Go to Step 6.

Step 6	Mechanically test IPR valve hydraulic circuit.	Decision
Perform Cylinder Performance Analyzer (CPA) - High-Pressure Oil Pump (HPOP)(page 287) Test. Does HPOP Test detect a problem with IPR valve hydraulic circuit?		Yes: Replace IPR valve and perform Key-On Engine-Off (KOEO) Procedure Fuel Pressure Adaptation Reset(page 92). After repairs are complete, retest for SPN 164 FMI 16. No: Go to Step 7.

Step 7	Perform dead head test of HPOP.	Decision
Perform Cylinder Performance Analyzer (CPA)- High-Pressure Oil Pump (HPOP)(page 287) Test. Does HPOP test detect a problem with HPOP pump?		Yes: Go to Step 8. No: Go to Step 9.

Step 8	Inspect HPOP intake screen.	Decision
Remove HPOP pump and inspect intake screen for plugging and debris. Is debris plugging intake to HPOP?		Yes: Clean intake screen, repair source of debris, and perform Key-On Engine-Off (KOEO) Procedure Fuel Pressure Adaptation Reset(page 92). After repairs are complete, retest for SPN 164 FMI 16.

	No: Replace HPOP and perform KOEO Procedure Fuel Pressure Adaptation Reset(page 92). After repairs are complete, retest for SPN 164 FMI 16.

Step 9	Inspect injector spool valve.	Decision
Inspect injector spool valve for debris. Is debris present?		Yes: Clean injector spool valve. After repairs are complete, retest for SPN 164 FMI 16.
		No: Go to Step 10.

Step 10	Perform Injector Test.	Decision
Using EST with ServiceMaxx™ software, perform the Injector Test (Buzz test) to ensure all injectors function properly. Do all injectors function properly?		Yes: Go to Step 11.
		No: Repair / replace failed injector(s) perform KOEO Procedure Fuel Pressure Adaptation Reset(page 92). After repairs are complete, go to Step 11.

Step 11	Inspect HP oil system	Decision
Inspect HP oil rail, HP oil hose, and elbow connections for contamination or debris. Are contaminates or debris found in HP oil system?		Yes: Clean high-pressure oil rail, high-pressure oil hose, and elbow connection. After repairs are complete retest for SPN 164 FMI 16
		Replace all 6 injectors, pucks, and seals. Perform Key-On Engine-Off (KOEO) Procedure Fuel Pressure Adaptation Reset(page 92). After repairs are complete, retest for SPN 164 FMI 16

End Diagnostic Steps
After performing diagnostic steps, if SPN 164 FMI 16 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

SPN 164 FMI 17 - ICP unable to build during test

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
TBD	TBD	TBD

Fault Overview

None

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive trips.

Associated Faults

SPN 164 FMI 1, 3, and 4 (ICP); SPN 679 FMI 3 and 4 (IPR); SPN 3055 FMI 2 (INJ)

Fault Facts

None

Drive Cycle to Determine Fault Status

TBD

Possible Causes

- Restricted High-Pressure Oil Pump (HPOP) intake screen
- Failed HPOP
- Injection Pressure Regulator (IPR) electrical circuit
- Failed IPR
- Leaks in High-Pressure (HP) oil system
- Failed injectors and pucks

Step 1	Inspect vehicle history for HP oil system repairs	Decision
Determine if the vehicle history included high-pressure oil system repairs. Were HP oil system repairs recently performed?		Yes: Perform the Key-On Engine-Off (KOEO) Procedure Fuel Pressure Adaptation Reset(page 92) procedure.
		No: Go to Step 2.

Step 2	Check for associated fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 164 FMI 1, 3, and 4 (ICP); SPN 679 FMI 3 and 4 (IPR); SPN 3055 FMI 2 (INJ). Is EST DTC list free of SPN 164 FMI 1, 3, and 4; SPN 679 FMI 3 and 4; and SPN 3055 FMI 2?		Yes: Go to Step 3. No: Repair SPN 164 FMI 1, 3, 4; SPN 679 FMI 3 and 4; and SPN 3055 FMI 2. After repairs are complete, retest for SPN 164 FMI 17.

Step 3	Check for engine oil problems.	Decision
Check engine oil level and condition. Is engine oil at proper level and in good condition?		Yes: Go to Step 4. No: Repair engine oil problems. After repairs are complete, retest for SPN 164 FMI 17.

Step 4	Inspect HPOP reservoir.	Decision
Inspect HPOP reservoir for appropriate engine oil level. Remove Engine Oil Temperature (EOT) sensor. Does engine oil drain from HPOP reservoir?		Yes: Reinstall EOT sensor. Go to Step 5 No: Clean passages going to HPOP reservoir. After repairs are complete, retest for SPN 164 FMI 17.

Step 5	Check HPOP IPR electrical circuit.	Decision
Perform Cylinder Performance Analyzer (CPA) - HPOP(page 287) Test. Does HPOP Test detect a problem with the IPR valve electrical circuit?		Yes: Repair IPR circuit. After repairs are complete, retest for SPN 164 FMI 17. No: Go to Step 6.

Step 6	Mechanically test IPR valve hydraulic circuit.	Decision
Perform CPA - HPOP(page 287) Test. Does HPOP Test detect a problem with IPR valve hydraulic circuit?		Yes: Replace IPR valve and perform Key-On Engine-Off (KOEO) Procedure Fuel Pressure Adaptation Reset(page 92). After repairs are complete, retest for SPN 164 FMI 17. No: Go to Step 7.

Step 7	Perform dead head test of HPOP.	Decision
Perform CPA - HPOP(page 287) Test. Does HPOP test detect an issue with HPOP pump?		Yes: Go to Step 8. No: Go to Step 9.

Step 8	Inspect HPOP intake screen.	Decision
Remove HPOP pump and inspect intake screen for plugging and debris. Is debris plugging the intake to HPOP?		Yes: Clean intake screen, repair source of debris, and perform Key-On Engine-Off (KOEO) Procedure Fuel Pressure Adaptation Reset(page 92). After repairs are complete, retest for SPN 164 FMI 17. No: Replace HPOP and perform KOEO Procedure Fuel Pressure Adaptation Reset(page 92). After repairs are complete, retest for SPN 164 FMI 17.

Step 9	Inspect injector spool valve.	Decision
Inspect injector spool valve for debris. Is debris present?		Yes: Clean injector spool valve. After repairs are complete, retest for SPN 164 FMI 17. No: Go to Step 10.

Step 10	Perform the Injector Test.	Decision
Using EST with ServiceMaxx™ software, perform the Injector Test (Buzz test) to ensure all injectors function properly. Do all injectors function properly?		Yes: Go to Step 11. No: Repair / replace failed injector(s) perform KOEO Procedure Fuel Pressure Adaptation Reset(page 92). After repairs are complete, go to Step 11.

Step 11	Inspect HP oil system	Decision
Inspect HP oil rail, HP oil hose, and elbow connections for contamination or debris. Are contaminates or debris found in HP oil system?		Yes: Clean HP oil rail, HP oil hose, and elbow connection. After repairs are complete retest for SPN 164 FMI 17
		Replace all 6 injectors, pucks, and seals. Perform Key-On Engine-Off (KOEO) Procedure Fuel Pressure Adaptation Reset(page 92). After repairs are complete, retest for SPN 164 FMI 17

End Diagnostic Steps
After performing diagnostic steps, if SPN 164 FMI 17 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

SPN 164 FMI 18 - ICP below desired level

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Comparison of measured Injection Control Pressure (ICP) value versus set point.	Engine ICP set point MINUS measured engine ICP < threshold value based on speed / torque (Table A084)	1. Engine Injection Control Pressure in Close Loop Mode {Always in Close loop mode except when Limp Home mode is active} Engine Oil Temperature (EOT) ≥ 95°F and ≤ 244.4°F (≥ 35°C and ≤ 118°C) Delay timer to activate diagnostics after entry conditions 1 and 2 mentioned above are met ≥ 15 seconds End of Line tests not active Engine Exhaust Brake or Vehicle Retarder NOT active Time after Engine Exhaust Brake or Vehicle Retarder state of change to not active > 5 seconds Torque limiting in Limp Home Mode is NOT active Fuel cut off in engine deceleration NOT active Battery voltage ≥ 9 volts and ≤ 16 volts Key ON Time after engine start is ≥ 30 seconds Engine Coolant Temperature (ECT) ≥ 68°F (20°C) AND ≤ 219°F (104°C) 132/3, 132/4, 636/7, 636/2, 110/3, 110/4, 110/2, 175/3, 175/4, 175/2, 164/0, 164/3, 164/4, 679/4, 679/3, 651/4, 651/5, 655/4, 652/5, 653/4, 653/5, 656/4, 654/5, 652/4, 655/5, 654/4, 656/5, 5543/3, 5543/5, 5543/4, 94/3, 94/4, 1189/3, 1189/4, 2791/2, 2791/7, 2791/14, 2791/14, 2791/14, 27/14, 2791/8, 2791/8, 2791/3, 2791/4, 5395/0, 5395/1, 2659/20, 4766/10,

		110/17, 3055/2, 4257/7, 4257/7, 4257/7, 4257/7, 4257/7, 4257/7, and 4257/7 are NOT active

Fault Overview

TBD

Lamp Reaction

TBD

Associated Faults

SPN 164 FMI 1, 3, and 4 (ICP); SPN 3055 FMI 2 (INJ)

Fault Facts

None

Drive Cycle to Determine Fault Status

TBD

Possible Causes

- Include step to reset PP for ICP adaptation
- Fuel pressure adaptation necessary
- Failed Injection Pressure Regulator (IPR) valve
- High-Pressure Oil Pump (HPOP)

Step 1	Inspect vehicle history for High-Pressure (HP) oil system repairs	Decision
Determine if vehicle history included HP oil system repairs. Were HP oil system repairs recently performed?		Yes: Perform Key-On Engine-Off (KOEO) Procedure Fuel Pressure Adaptation Reset(page 92).
		No: Go to Step 2.

Step 2	Check for associated fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 164 FMI 1, 3, and 4 (ICP) and SPN 3055 FMI 2 (INJ). Is EST DTC list free of SPN 164 FMI 1, 3, and 4 and SPN 3055 FMI 2?		Yes: Go to Step 3.
		No: Repair SPN 164 FMI 1, 3, 4 and SPN 3055 FMI 2. After repairs are complete, retest for SPN 164 FMI 18.

Step 3	Check for engine oil problems.	Decision
Check engine oil level and condition. Is engine oil at proper level and in good condition?		Yes: Go to Step 4. No: Correct / repair engine oil problems. After repairs are complete, retest for SPN 164 FMI 18.

Step 4	Test HPOP Injection Pressure Regulator (IPR) electrical circuit.	Decision
Perform Cylinder Performance Analyzer (CPA) - HPOP(page 287) Test. Does HPOP Test detect a problem with IPR valve electrical circuit?		Yes: Repair IPR circuit. After repairs are complete, retest for SPN 164 FMI 18. No: Go to Step 5.

Step 5	Mechanically test the IPR valve hydraulic circuit.	Decision
Perform CPA - HPOP(page 287) Test. Does HPOP Test detect a problem with IPR valve hydraulic circuit?		Yes: Replace IPR valve and perform Key-On Engine-Off (KOEO) Procedure Fuel Pressure Adaptation Reset(page 92). After repairs are complete, retest for SPN 164 FMI 18. No: Diagnostics complete.

End Diagnostic Steps
After performing diagnostic steps, if SPN 164 FMI 18 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

SPN 164

FMI 20 – ICP Above Desired Level

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
N/A			

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 164 FMI 20 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 164 FMI 20. No: Go to Step 3.

Step	Action	Decision
3	**NOTE:** When performing this step do not completely unscrew the Engine Oil Temperature (EOT) sensor. Check high pressure oil reservoir oil level. Do High-Pressure Pump Reservoir Inspection . Does oil leak out around the EOT sensor threads?	Yes: Go to Step 4. No: Service the engine oil system to restore correct oil level (page 123). See Lubrication System in Engine Symptom Diagnostics. After repair is completed, retest for SPN 164 FMI 20.

Step	Action	Decision
4	Check high-pressure oil pressure while cranking. Do Injection Pressure Regulator (IPR) Control Test using Electronic Service Tool (EST) with ServiceMaxx™ software. Is high-pressure oil pressure within specification?	Yes: Go to Step 5. No: Go to Step 8.

Step	Action	Decision
5	Using terminal test kit, inspect connections at IPR valve and connector. With key OFF, disconnect IPR valve connector. Check IPR valve and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are IPR valve connector, harness, and terminals clean and undamaged?	Yes: Go to Step 6. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 164 FMI 20.

Step	Action	Decision
6	Test IPR valve circuit for open, short, or high resistance conditions. Do connector voltage checks, operational voltage check-output state test, and resistance checks (page 1061). Are IPR valve circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 7. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 164 FMI 20.

Step	Action	Decision
7	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Do Key On Engine Off Continuous Monitor Test (page 87). Does circuit operate properly?	Yes: Go to Step 8. No: Locate specific circuit causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 164 FMI 20.

Step	Action	Decision
8	Test high pressure pump operation. Do High-pressure Oil Pump Test . Does high-pressure oil pump perform within specification?	Yes: Go to Step 10. No: Go to Step 9.

Step	Action	Decision
9	Test high-pressure oil pump ability to reach maximum pressure. Do IPR Block-off test . Does high-pressure oil pump reach maximum specified pressure?	Yes: Replace IPR valve. After repair is complete, retest for SPN 164 FMI 20. No: Replace high-pressure oil pump. After repair is complete, retest for SPN 164 FMI 20.

Step	Action	Decision
10	Test high-pressure oil rail for leaks. Do High-pressure Oil Rail Leak Test . Is high-pressure oil free of leaks?	Yes: After doing all diagnostic steps, if SPN 164 FMI 20 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Repair high-pressure oil rail components as directed in the procedure.

Step	Action	Decision
		After repair is complete, retest for SPN 164 FMI 20.

NOTE: After doing all diagnostic steps, if SPN 164 FMI 20 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 164

FMI 21 – ICP Above Desired Level

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
N/A			

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN / FMIs: 164/0 and 679/4.

Drive Cycle to Determine Fault Status

N/A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 164 FMI 21 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 164 FMI 21. No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit, inspect connections at Injection Pressure Regulator (IPR) valve and connector. With key OFF, disconnect IPR valve connector. Check IPR valve and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are IPR valve connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 164 FMI 21.

Step	Action	Decision
4	Test IPR valve circuit for open, short, or high resistance conditions. Do connector voltage checks, operational voltage check-output state test, and resistance checks (page 1061). Are IPR valve circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 5. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 164 FMI 21.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Do Key On Engine Off Continuous Monitor Test (page 87). Does circuit operate properly?	Yes: Go to Step 6. No: Locate specific circuit causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 164 FMI 21.

Step	Action	Decision
6	Test IPR valve for short to GND. Do KOEO voltage test from IPR valve Pin 2 to GND. Is measured voltage greater than 0 volts?	Yes: After doing all diagnostic steps, if SPN 164 FMI 21 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace IPR valve. After repair is complete, retest for SPN 164 FMI 21.

NOTE: After doing all diagnostic steps, if SPN 164 FMI 21 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3055 FMI 2 - ICP / IPR Adaptation In-Range Fault

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Engine Fuel System Injection Pressure Control Valve adaptation monitor - High and Low	Engine Fuel System Injection Pressure Control Valve adaptation value < -20% OR > 20%	Fuel gradient threshold (Instantaneous difference between two consecutive fuel pressure data points) < 0.248 mg/stroke Engine speed gradient threshold < 100 RPM/second Engine Speed > 30 RPM Time after engine start > 30 seconds Engine Coolant temperature > 104°F (40°C) Maximum allowed rail pressure deviation during injection control pressure valve adaptation as defined by [Table A074] and per time period ≥ 1 second Time since last successful adaptation > 30 seconds Adaptation set points defined by [Table A075] Injection Control Valve Pressure mode enabled

Fault Overview

Fault code sets when fuel system Injection Pressure Control Valve adaptation value exceeds threshold values immediately.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive trips.

Associated Faults

SPN 164 FMI 3 and 4, and SPN 679 FMI 3 and 4

Fault Facts

This fault can set if a high-pressure oil system repair was completed and the "Fuel Pressure Adaptation Reset" procedure was not performed.

Drive Cycle to Determine Fault Status

TBD

Possible Causes

- Fuel Pressure Adaptation Reset procedure was not performed after high-pressure oil system repairs
- High-pressure oil system repair is necessary

Step 1	Check for active fault during engine cranking.	**Decision**
Monitor Diagnostic Trouble Code (DTC) list while attempting to start engine. Did SPN 164 FMI 1 fault set while cranking?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Check for associated fault codes.	**Decision**
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check DTC list for SPN 164 FMI 3 and 4, and SPN 679 FMI 3 and 4. Is EST DTC list free of SPN 164 FMI 3 and 4, and SPN 679 FMI 3 and 4?		Yes: Go to Step 2. No: Repair SPN 164 FMI 3 and 4, and SPN 679 FMI 3 and 4. After repairs are complete, retest for SPN 3055 FMI 2.

Step 3	Check for engine oil issues.	Decision
Check engine oil level and condition. Is engine oil at proper level and in good condition?		Yes: Go to Step 4. No: Correct / repair engine oil issues. After repairs are complete, retest for SPN 3055 FMI 2.

Step 4	Inspect High-Pressure Oil Pump (HPOP) reservoir to ensure there is enough fluid.	Decision
Check that reservoir has oil in it. Remove Engine Oil Temperature (EOT) sensor for observation. Does reservoir have oil in it?		Yes: Reinstall EOT sensor and then go to Step 5. No: Diagnose / repair lubrication system. After repairs are complete, retest for SPN 3055 FMI 2.

Step 5	Check High-Pressure Oil Pump (HPOP) Injection Pressure Regulator (IPR) electrical circuit.	Decision
Inspect IPR valve electrical circuit by connecting Cylinder Performance Analyzer (CPA) tool(page 257) to engine and perform CPA HPOP test(page 287). Is there a detected issue with IPR valve electrical circuit?		Yes: Diagnose / repair electrical circuit for the IPR valve. After repairs are complete, retest for SPN 3055 FMI 2. No: Go to Step 6.

Step 6	Mechanically test Injection Pressure Regulator (IPR) valve hydraulic circuit.	Decision
Hydraulically block off IPR return path by connecting Cylinder Performance Analyzer (CPA) tool(page 257) to engine and use IPR Plug Tester(Figure 607) to bring IPR valve hydraulic circuit under maximum pressure. Is there a detected issue with IPR valve hydraulic circuit?		Yes: Replace IPR valve and perform Key-On Engine-Off (KOEO) Procedure Fuel Pressure Adaptation Reset(page 92). After repairs are complete, retest for SPN 3055 FMI 2.
		No: Go to Step 7.

Step 7	Perform dead head test of High-Pressure Oil Pump (HPOP).	Decision
Connect Cylinder Performance Analyzer (CPA) tool(page 257) to engine and use Pressure Adapter Fitting and ICP Test Kit(Figure 605) isolating hydraulic system from HPOP to determine if it develops pressure when pump is dead headed. Does this test detect an issue with HPOP pump? **NOTE:** CPA tool has additional capabilities to determine HPOP failure modes, compared to a simple pressure specification.		Yes: Go to Step 8.
		No: Proceed to Steps 9 through 12.

Step 8	Inspect intake screen.	Decision
Remove High-Pressure Oil Pump (HPOP) pump and inspect intake screen for plugging and debris. Is debris plugging intake to HPOP? **NOTE:** Visual inspection determines whether or not debris on intake side of HPOP is cause of insufficient dead head pressure.		Yes: Clean intake screen (locate and repair source of debris) and perform Key-On Engine-Off (KOEO) Procedure Fuel Pressure Adaptation Reset(page 92). After repairs are complete, retest for SPN 3055 FMI 2.
		No: Replace HPOP and perform KOEO Procedure Fuel Pressure Adaptation Reset(page 92). After repairs are complete, retest for SPN 3055 FMI 2.

Step 9	Inspect injector spool valve.	Decision
Inspect injector spool valve for debris. Is debris present?		Yes: Clean debris and then go to Step 10. No: Go to Step 10.

Step 10	Perform Injector Test.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, perform Injector Test (Buzz test) to ensure all injectors function properly. Do all injectors function properly?		Yes: Go to Step 11. No: Repair / replace faulty injector(s) and then go to Step 11.

Step 11	Remove and clean injector plumbing.	Decision
Remove and clean high-pressure oil rail, high-pressure oil hose, and elbow connections to remove contamination or debris.		Go to Step 12.

Step 12	Injector replacement and reset.	Decision
Replace all six injectors, pucks, and seals. Perform Key-On Engine-Off (KOEO) Procedure Fuel Pressure Adaptation Reset(page 92).		Go to End Diagnostic Steps.

End Diagnostic Steps
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 3055 FMI 2 fault code diagnostics.

IMP Sensor (Intake Manifold Pressure)

SPN	FMI	Condition	Possible Causes	Actions
102	2	IMP signal erratic, intermittent, or incorrect	• Biased IMP circuit or sensor	Pin-point Diagnostics (page 887)
102	3	IMP signal Out of Range HIGH	• IMP signal circuit OPEN or short to PWR • SIG GND circuit OPEN • Failed IMP sensor	Pin-point Diagnostics (page 888)
102	4	IMP signal Out of Range LOW	• IMP signal circuit OPEN or short to GND • VREF-2 circuit OPEN • Failed IMP sensor	Pin-point Diagnostics (page 891)
102	7	IMP signal not responding as expected	• Biased IMP sensor or circuit	Pin-point Diagnostics (page 885)
102	10	Boost slow response fault	• Charge Air Cooler (CAC) or CAC hose leaking • CAC clogged (ice) • Turbocharger 2 (TC2) wastegate stuck or sticking open • Restricted intake air system • Exhaust leak • Exhaust Restriction • Failed turbocharger(s) • Wastegate linkage adjustment or leaking wastegate • Boost solenoid failure – open • Low fueling / under fueling • IMP sensor port blocked	Step-based Diagnostics (page 897)

SPN	FMI	Condition	Possible Causes	Actions
			• Biased Intake Manifold Temperature (IMT) sensor • Compressor coking • Valve lash • Exhaust Gas Recirculation (EGR) fault • Engine or valve train damage	
102	16	Over boost	• Wastegate stuck closed • Wastegate actuator boost supply line cracked over valve cover (under thermal wrap) • Control solenoid malfunction • Wastegate linkage adjustment • Air connection from solenoid to wastegate • Oetiker clamp failure or loose connection • Biased IMT sensor • IMT sensor full of soot (not responding fast) • MAF sensor • Biased Barometric Absolute Pressure (BARO) sensor • Intake throttle valve not following command • IMP sensor	Step-based Diagnostics (page 903)

SPN	FMI	Condition	Possible Causes	Actions
			• Valve lash	
102	18	Under boost	• CAC or CAC hose leaking • CAC clogged (ice) • TC2 wastegate stuck or sticking open • Restricted intake air system • Exhaust leak • Exhaust Restriction • Failed turbocharger(s) • Wastegate linkage adjustment or leaking wastegate • Boost solenoid failure – open • Low Fueling / under fueling • IMP sensor port blocked • Biased IMT sensor • Compressor coking • Valve lash • EGR fault • Engine or valve train damage	Step-based Diagnostics (page 908)

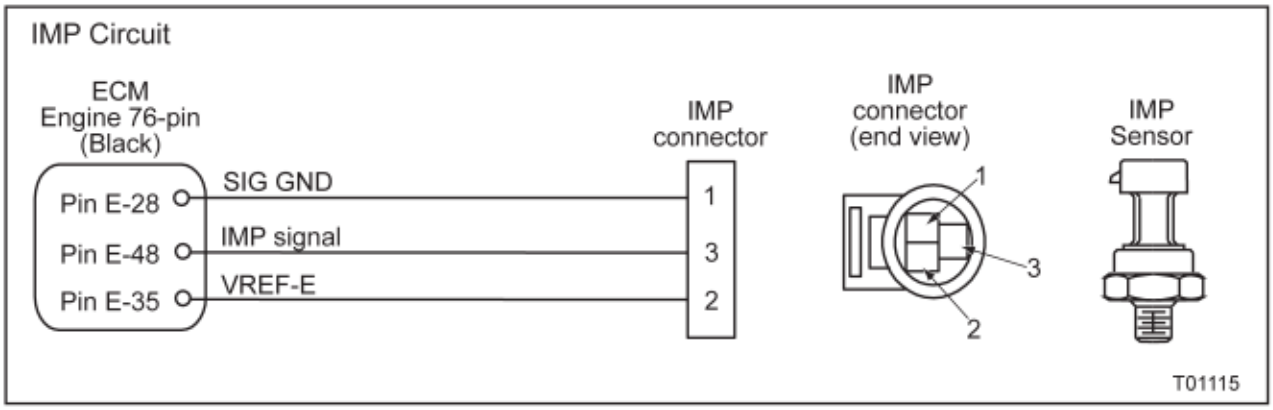


Figure 364 IMP circuit diagram

Overview

The Engine Control Module (ECM) uses the Intake Manifold Pressure (IMP) sensor signal to assist in calculation of the EGR percentage. The ECM monitors the IMP signal to determine intake manifold (boost) pressure. From this information, the ECM can optimize fuel rate and injection timing for all engine operating conditions.

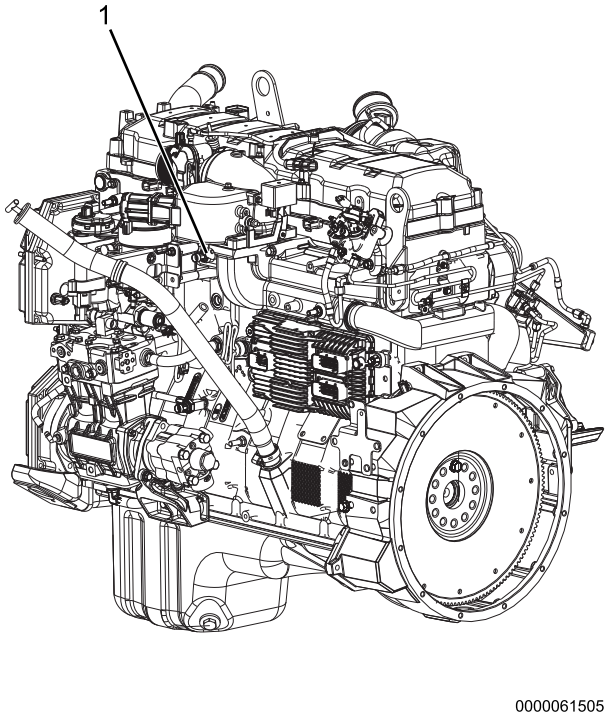


Figure 365 IMP Sensor Location

1. IMP Sensor

Tools

- EZ Tech® Electronic Service Tool (EST) – J-45067 (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- 00-00956-08 – 180-pin Breakout Box (page 1222)
- 3-Banana Plug Harness (page 1228)
- Breakout Harness 4850 (IMP) (page 1234)
- International® Electronic Engine Terminal Test Kit (page 1227)
- Breakout Harness 4834 (EBPV) (page 1234)

Pin-point Diagnostics

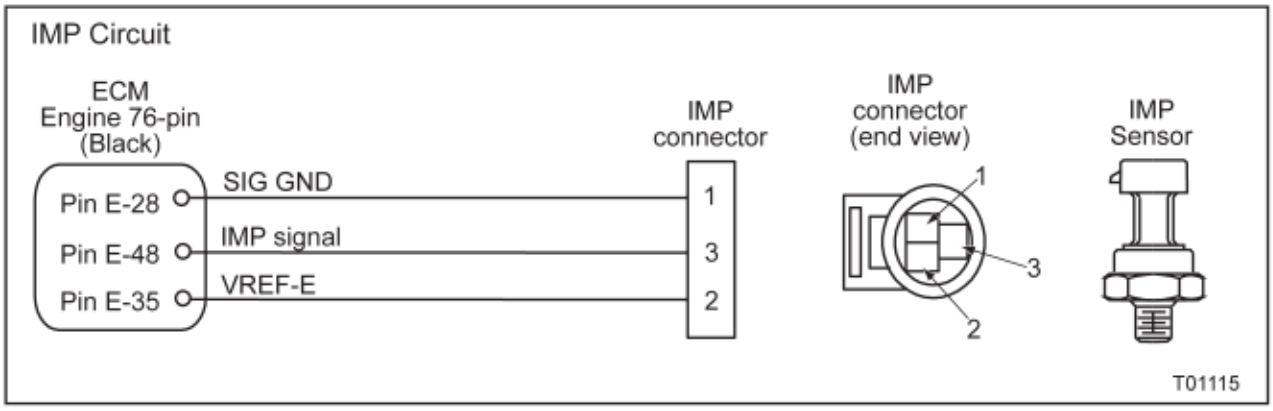


Figure 366 IMP circuit diagram

SPN 102 FMI 0 – IMP signal erratic, intermittent, or incorrect

Check for Biased sensor or circuit

1. Turn ignition switch to ON, engine OFF
2. Using ServiceMaxx™ software, open the Continuous Monitor session.
3. Verify S_IMP Volts are within specification. See APPENDIX A (page 1291).
   - If voltage is not within specification, check circuitry for poor continuity. If circuits are acceptable, replace IMP sensor.

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST and ServiceMaxx™ software, open the Continuous Monitor session.
2. Monitor sensor voltage. Verify an active code for the sensor.
   - If code 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 code will go active.
   - If code is active, go to the next step.
3. Disconnect engine harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

4. Connect Breakout Harness to engine harness. Leave sensor disconnected.

Sensor Circuit Check

Connect sensor breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use EST to verify correct code goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Specification	Comment: < Less than, > Greater than
EST – Check code	SPN 102 FMI 4	If SPN 102 FMI 3 is active, check IMP signal for short to PWR.
DMM – Measure volts 2 to GND	5 ± 0.5 V	If > 5.5 volts, check VREF for short to PWR. If < 4.5 volts, check VREF for OPEN or short to GND. Go to Harness Resistance Check.
EST – Check code Short breakout harness across 2 and 3	SPN 102 FMI 3	If SPN 102 FMI 4 is active, check IMP signal for OPEN or short to GND. Go to Harness Resistance Check.
DMM – Measure resistance 1 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Go to Harness Resistance Check.
If checks are within specification, connect sensor and clear codes. If active code remains, replace sensor.		

Connector Voltage Check

Connect breakout harness. 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	5 ± 0.5 V	If > 5.5 volts, check VREF for short to PWR. If < 4.5 volts, check VREF for OPEN or short to GND. Go to Harness Resistance Check.
3 to B+	B+	If < B+, check for short to PWR. Go to Harness Resistance Check.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-pin Breakout Box and sensor breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
1 to E-28	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
2 to E-35	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN.
3 to E-48	< 5 Ω	If > 5 Ω, check IMP signal circuit for OPEN.

SPN 102 FMI 2 - IMP signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Comparison of Engine Intake Manifold #1 Pressure with Barometric Pressure and Engine Exhaust Gas Pressure	[Absolute value of difference between Engine Intake Manifold #1 pressure and Barometric Pressure > 4.4 psi (30 kPa) AND Absolute value of difference between Engine Intake Manifold # 1 Pressure and Engine Exhaust Gas Pressure > 4.4 psi (30 kPa) AND Absolute value of difference between Barometric pressure and Engine Exhaust Gas Pressure > 4.4 psi (30 kPa) AND Engine Wastegate Actuator Position Command] < 100%	Key ON Time after Key ON > 0 seconds Battery Voltage > 9 Volts AND < 16 Volts [1. Engine Speed < 50 RPM 2. Engine Fuel Mass Command < 10 mg/stk 3. Engine Wastegate Actuator Position Command < 100% 4. Engine Throttle position command < 10% 5. Engine Exhaust Gas Recirculation Valve Position Command < 40% Minimum time entry conditions (1) through (5) - mentioned above are satisfied] > 20 * 0.1 seconds OR [Engine Speed < 100 RPM AND Engine Fuel Mass Command] < 100 mg/stk SPN FMI 108/3,108/4, 1209/3,1209/4,102/3 and 102/4 are NOT active

Fault Overview

Fault sets when absolute pressure difference between Intake Manifold Pressure (IMP) and Barometric Absolute Pressure (BARO) and absolute pressure difference between IMP and Exhaust Gas Pressure (EGP) absolute pressure difference between EGP and BARO are greater than 4.4 psi (30 kPa) for two seconds with Wastegate Actuator Position Command is less than 100%.

Time Requirements

2 seconds

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

SPN 3509 FMI 3 and 4

Fault Facts

IMP sensor cannot be compared to other similar sensors in SMX, because Intake Manifold Pressure (IMP) values cannot be negative, and IMP value is in gauge units.

Drive Cycle to Determine Fault Status

Initial Key ON

Possible Causes

- Defective sensor

Step 1	Check for active or pending fault code.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software. A. Key ON, clear codes. B. Key OFF, wait for EST screens to clear. C. Key ON, check Diagnostic Trouble Code (DTC) list for SPN 102 FMI 2. Is EST DTC list SPN 102 FMI 2 active or pending?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Check for associated fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 102 FMI 2. Is EST DTC list free of SPN 102 FMI 2?		Yes: Replace IMP sensor. After repairs are complete, retest for SPN 102 FMI 2. No: Repair SPN 102 FMI 2. After repairs are complete, retest for SPN 102 FMI 2.

End Diagnostic Tests
After performing all diagnostic steps, if SPN 102 FMI 2 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

SPN 102 FMI 3 - IMP signal Out of Range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Intake Manifold Pressure (IMP) signal Out of Range HIGH.	IMP sensor voltage > 4.8 volts (89 psi [613.3 kPa])	Key ON SPN 3509 FMI 3 and 4 are not active

Fault Overview

Fault code sets when Intake Manifold Pressure (IMP) is greater than 4.8 volts (89 psi {613.3 kPa}) for 2.55 seconds.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 3509 FMI 3 and 4

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON

Possible Causes

- IMP sensor signal circuit short to power
- Signal GND circuit Open
- Failed IMP sensor

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

Step 1	Check for associated fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 3509 FMI 3 and 4. Is EST DTC list free of SPN 3509 FMI 3 and 4?		Yes: Go to Step 2. No: Repair SPN 3509 FMI 3 and 4. After repairs are complete, retest for SPN 102 FMI 3.

Step 2	Inspect connections at Intake Manifold Pressure (IMP) sensor.	Decision
A. Key OFF. B. Disconnect IMP sensor connector. C. Check IMP sensor and connector terminals for damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are IMP sensor connector, harness, and terminal clean and undamaged?		Yes: Perform Pin-Point Tests (page 890). No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 102 FMI 3.

Pin-Point Tests (SPN 102 FMI 3)

IMP Circuit

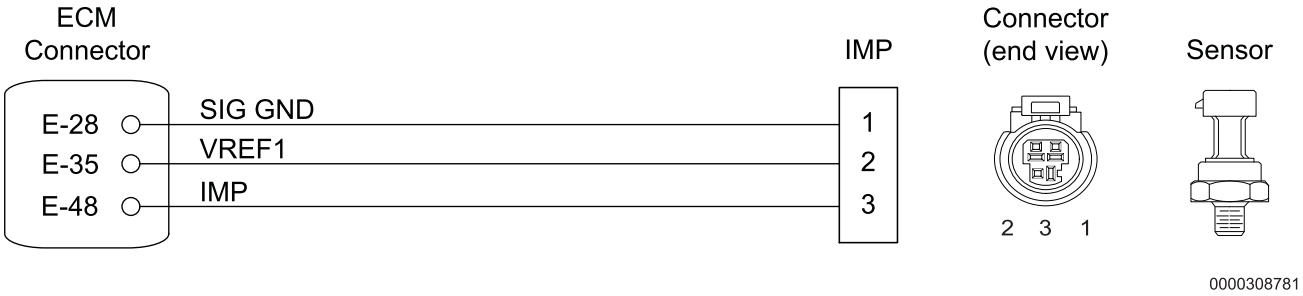


Figure 367 Intake Manifold Pressure (IMP) Sensor Circuit Diagram

NOTE: See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4850
- Breakout Harness ZTSE4498
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)

Test 1 Setup
A. Key OFF. B. Disconnect Intake Manifold Pressure (IMP) vehicle harness connector. C. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). D. Key ON. Log in to ServiceMaxx™ software.

Test 1	Specification
Using EST with ServiceMaxx™ software, clear Diagnostic Trouble Code (DTC) list.	SPN 102 FMI 3 sets in DTC list
Decision	
Does SPN 102 FMI 3 set after DTC list is cleared?	Yes: Repair short to power between IMP pin-3 and Engine Control Module (ECM) pin E-48. After repairs are complete, retest for SPN 102 FMI 3.
	No: Go to Test 2.

Test 2 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4850 to Intake Manifold Pressure (IMP) vehicle harness connector and leave sensor disconnected. C. Key ON.

Test 2	Specification
Using DMM, measure voltage between Breakout Harness ZTSE4850 and B+.	B+
Decision	
Is voltage B+?	Yes: Replace IMP sensor. After repairs are complete, retest for SPN 102 FMI 3.
	No: Repair Open between IMP sensor pin-1 and ECM pin E-28. After repairs are complete, retest for SPN 102 FMI 3.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 102 FMI 3 fault code diagnostics.

SPN 102 FMI 4 - IMP signal Out of Range LOW

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Intake Manifold Pressure (IMP) signal Out of Range LOW.	IMP voltage < 0.1899 volt	Key ON. SPN 3509 FMI 3 and 4 are not active

Fault Overview

Fault sets when Intake Manifold Pressure (IMP) voltage is less than 0.1899 volts (4 psi {31 kPa}) for 2.55 seconds.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 3509 FMI 3 and 4

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON.

Possible Causes

- Intake Manifold Pressure (IMP) signal circuit Open
- IMP signal circuit short to GND
- VREF1 circuit Open
- Failed IMP sensor

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

Step 1	Check for associated fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 3509 FMI 3 and 4. Is EST DTC list free of SPN 3509 FMI 3 and 4?		Yes: Go to Step 2. No: Repair SPN 3509 FMI 3 and 4. After repairs are complete, retest for SPN 3509 FMI 3 and 4.

Step 2	Inspect connections at Intake Manifold Pressure (IMP) sensor.	Decision
A. Key OFF. B. Disconnect IMP sensor connector. C. Check IMP sensor and connector terminals for damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are IMP sensor connector, harness, and terminal clean and undamaged?		Yes: Perform Pin-Point Tests (page 892). No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 102 FMI 4.

Pin-Point Tests (SPN 102 FMI 4)

IMP Circuit

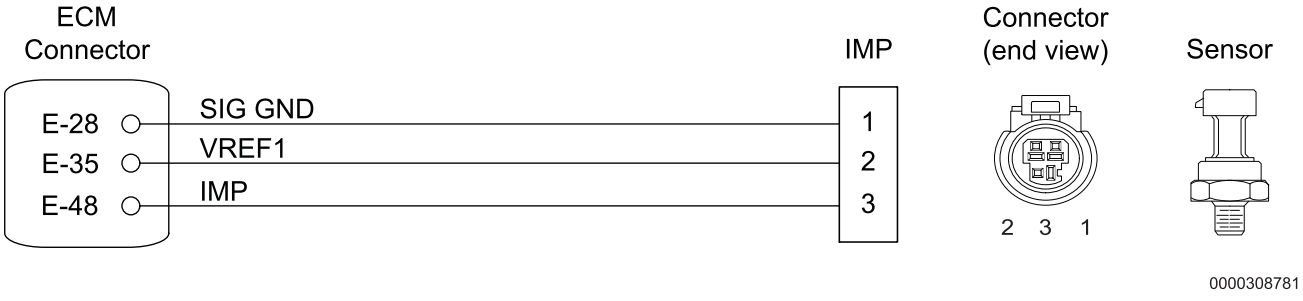


Figure 368 Intake Manifold Pressure (IMP) Sensor Circuit Diagram

NOTE: See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4850
- Breakout Harness ZTSE4498
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)

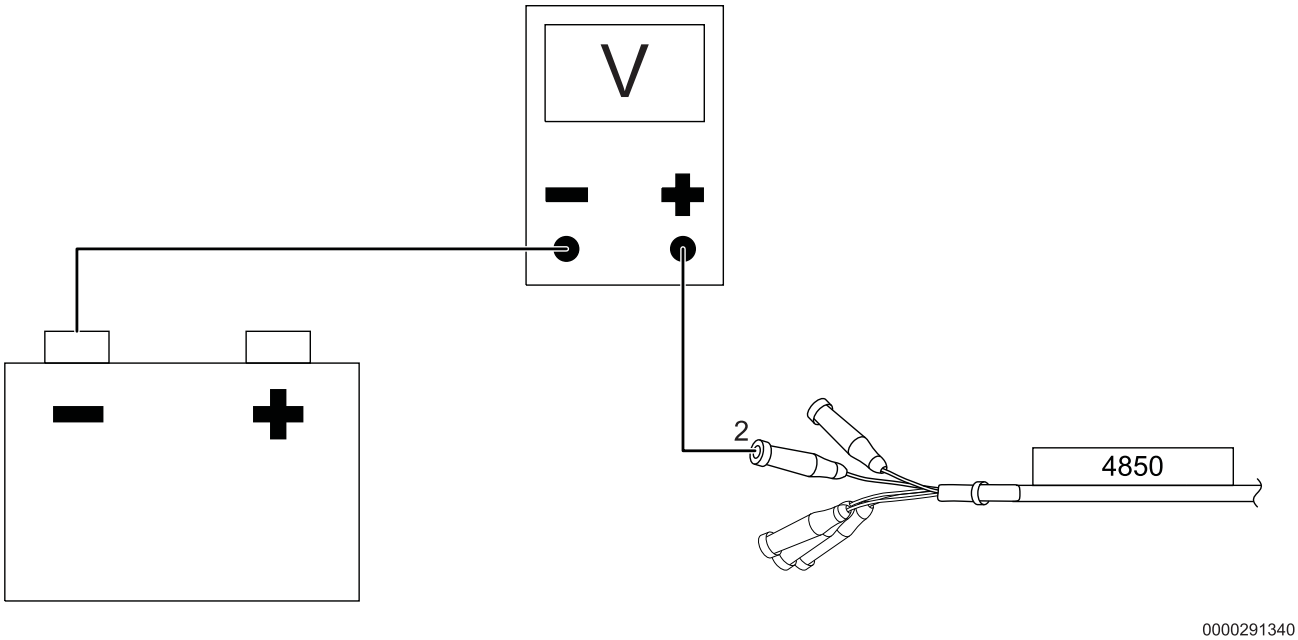
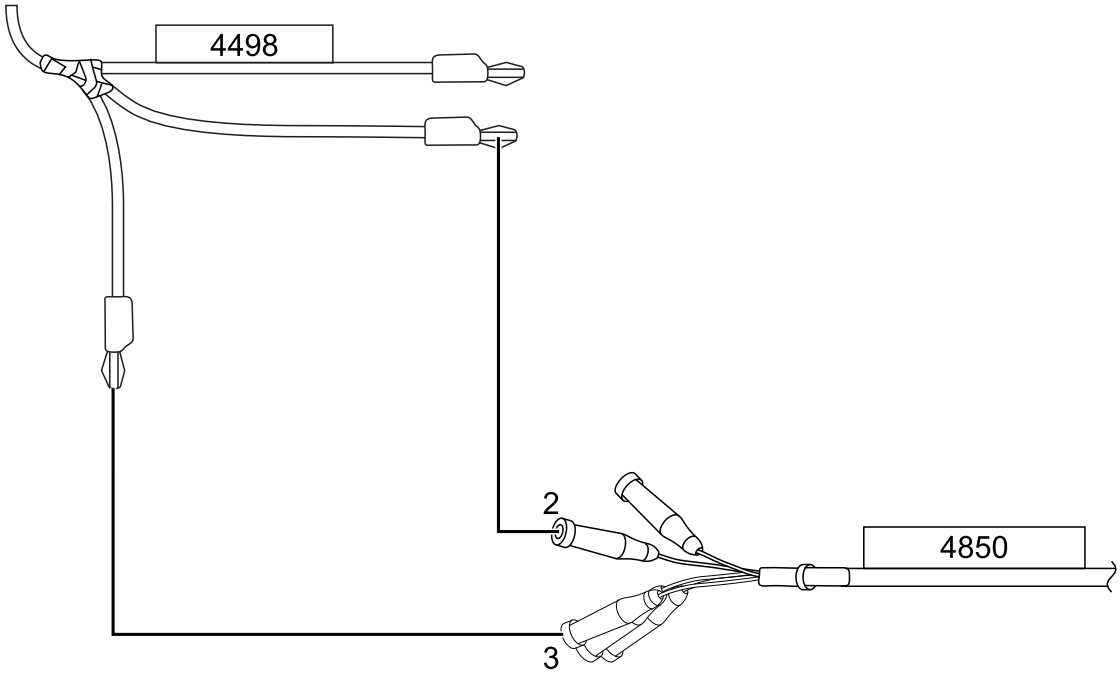


Figure 369 Test 1 Intake Manifold Pressure (IMP) Sensor Circuit Voltage Check

Test 1 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4850 to Intake Manifold Pressure (IMP) vehicle harness connector and leave sensor disconnected. C. Key ON.

Test 1	Specification
Using DMM, measure voltage between Breakout Harness ZTSE4850 pin-2 and known good GND.	5 ± 1 volts
Decision	
Is voltage 5 ± 1 volts?	Yes: Go to Test 2
	No: Repair Open between IMP pin-2 and Engine Control Module (ECM) pin E-35. After repairs are complete, retest for SPN 102 FMI 4.

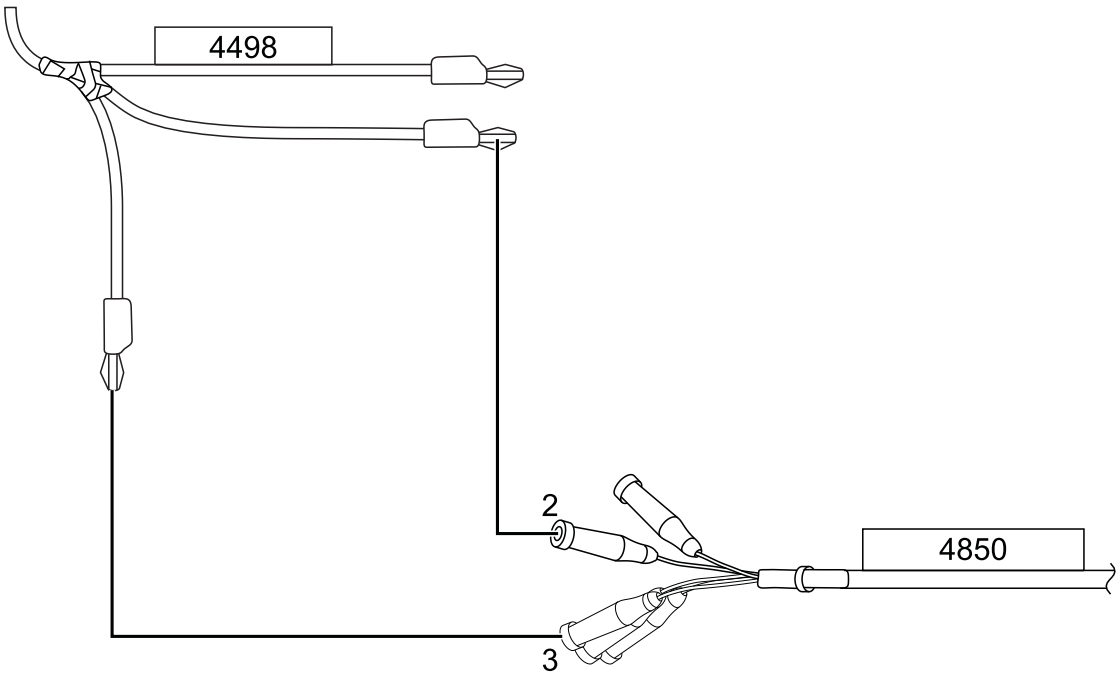


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Figure 370 Test 2 Intake Manifold Pressure (IMP) Sensor Circuit Check

Test 2 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4850 to Intake Manifold Pressure (IMP) vehicle harness connector and leave sensor disconnected. C. Using Breakout Harness ZTSE4498, short pin-2 and pin-3 of Breakout Harness ZTSE4850 together. D. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). E. Key ON. Log in to ServiceMaxx™ software.

Test 2	Specification
Using EST with ServiceMaxx™ software, clear Diagnostic Trouble Code (DTC) list.	SPN 102 FMI 3 sets in DTC list
Decision	
Does SPN 102 FMI 3 set after DTC list is cleared?	Yes: Replace IMP sensor. After repairs are complete, retest for SPN 102 FMI 4.
	No: Go to Test 3.



0000304541

Figure 371 Test 3 Intake Manifold Pressure (IMP) Sensor Circuit Check

Test 3 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4850 to Intake Manifold Pressure (IMP) vehicle harness connector and leave sensor disconnected. C. Using Breakout Harness ZTSE4498, short pin-2 and pin-3 of Breakout Harness ZTSE4850 together. D. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). E. Key ON. Log in to ServiceMaxx™ software.

Test 3	Specification
Using EST with ServiceMaxx™ software, clear DTC list.	SPN 3509 FMI 4 sets in DTC list.
Decision	
Does SPN 3509 FMI 4 set after DTC list is cleared?	Yes: Repair Short to ground between IMP pin-3 and Engine Control Module (ECM) pin E-48. After repairs are complete, retest for SPN 102 FMI 4.
	No: Repair Open between IMP pin-3 and ECM pin E-48. After repairs are complete, retest for SPN 102 FMI 4.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and the proper decision was made. Return to SPN 102 FMI 4 fault code diagnostics.

SPN 102

FMI 10 – Boost Slow Response Fault

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine Intake Manifold #1 Pressure (IMP) (Boost) Slow response monitor	Integral of Absolute Value of Engine Intake Manifold # 1 Pressure deviation from set point > 9400 * 0.1 * hPa * seconds	Particulate Filter Regeneration NOT Active	0.1 seconds
		Barometric Pressure ≥ 11 psi (73.5 kPa) AND ≤ 15 psi (103 kPa)	
		Engine Air Intake Temperature (AIT) ≥ 19°F (-7°C) AND ≤ 140°F (60°C)	
		Power Take Off (PTO) Mode NOT Active	
		End Of Line Testing NOT Active	
		[Engine Brake (Retarder) NOT active	
		AND minimum wait time after retarder change of state has occurred] > 5 seconds	
		Engine Torque limitation NOT Active	
		Engine is NOT coasting (i.e., Throttle Cut OFF mode)	
		Battery Voltage ≥ 10.787 Volts AND ≤ 15.787 Volts	
		Engine Ignition Key is in "ON" position (Key ON)	
		Time after engine start ≥ 30 seconds	
		Engine Speed > 1150 rpm	

FMI 10 – Boost Slow Response Fault (cont.)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		Engine Speed gradient > 10.01 rpm/second	
		Torque Set point > 277 lb-ft (375 N·m)	
		Torque Set point gradient ≥ 52 lb-ft/second (70 N·m/second)	
		Monitor enablement based on Engine Coolant Temperature (ECT) (Table A008)	
		Monitor enablement based on Barometric Pressure (Table A009)	
		Monitor enablement based on Barometric Pressure (Table A009)	
		Monitor enablement based on Engine Air Inlet Temperature (AIT) (Table A010)	
		Monitor enablement based on Turbocharger 2 Compressor Inlet Temperature (TC2CIT) (Table A011) {Not Applicable for DT466 Standard Torque Applications}	
		Engine Intake Manifold Pressure (IMP) 1 rate of change > Value described in Speed / Torque (Table A012) * Engine coolant modifier (Table A013) * Altitude modifier (Table A014)	
		SPN / FMIs 51/3, 51/4, 51/7, 102/3, 102/4, 102/7, 102/18, 105/2, 105/3, 105/4, 108/3, 108/4, 110/2, 110/3, 110/4, 132/0, 132/1, 132/3, 132/4, 172/2, 172/3, 172/4, 636/2, 636/7, 1173/2, 1189/3, 1189/4, 2630/2, 3464/11 are NOT Active	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the IMP does not maintain pressure.

Fault Detection / Management

The ECM continuously monitors the control system. If the sensor signal is higher or lower than expected, the ECM disregards the signal and uses a calibrated default value. The ECM sets an SPN / FMI, turns on the Warning Engine Lamp (WEL), and runs the engine in a default range.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN / FMI: 94/1, 102/2, 1209/0, 1209/3, and 1209/4.

Drive Cycle to Determine Fault Status

N/A

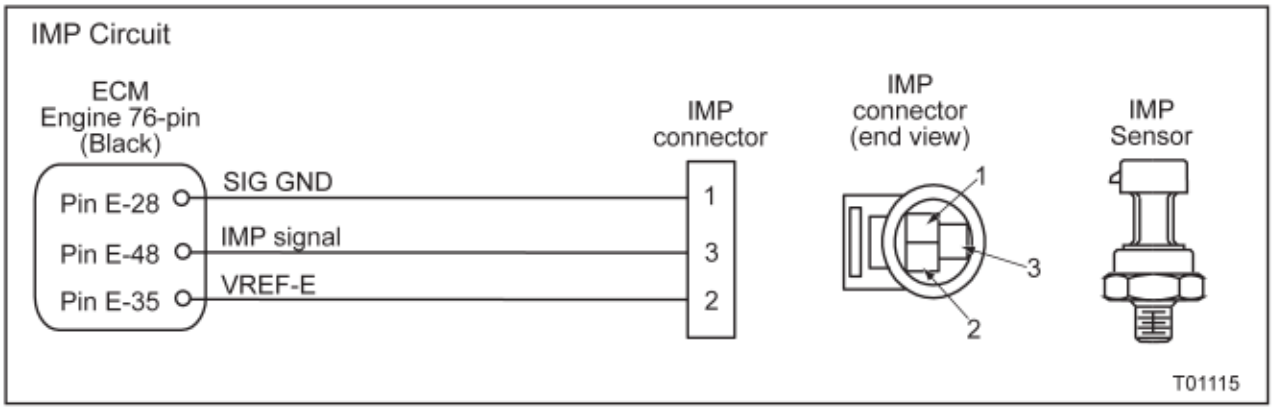


Figure 372 IMP Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 102 FMI 10 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 102 FMI 10. No: Go to Step 3.

Step	Action	Decision
3	Do visual inspection . a. Check all fluid levels and fuel quality. b. Inspect engine systems for problems such as leaks, open connections, and harness chafing. c. Check Charge Air Cooler (CAC) system for leaks, blockage, and contamination such as oil. d. Inspect electrical system for open connections, chafing, burned insulation. e. Inspect intake air system, including air cleaner, for leaks, damage, and restrictions. f. Inspect exhaust system for leaks or damage such as cracked exhaust manifold, leaking exhaust manifold joints and gaskets, leaking flanges and clamps, and damaged aftertreatment components. g. Inspect fuel system for leaks or damage. Are all items checked within specification?	Yes: Go to Step 4. No: Repair restrictions, air and exhaust leaks, fuel leaks, or physical damage. Restore fluid levels to their correct levels and replace fuel of questionable quality. After repairs are complete, retest for SPN 102 FMI 10.

Step	Action	Decision
4	Check Intake Manifold Pressure (IMP) sensor for damage or deposits. Visually inspect IMP sensor for damage and sensor port for clogging. Is IMP sensor free from damage and is the port open and free of deposits?	Yes: Go to Step 5. No: Replace IMP sensor. After repairs are complete, retest for SPN 102 FMI 10.

Step	Action	Decision
5	Visually inspect Intake Manifold Temperature (IMT) sensor for excessive deposits or damage. Is IMT sensor corroded, covered in deposits, or damaged?	Yes: Replace IMT sensor. After repair is complete, retest for SPN 102 FMI 10. No: Go to Step 6.

Step	Action	Decision
6	Determine if IMT sensor or circuits are out of specifications. Using EST with ServiceMaxx™ software, DMM, and required breakout harnesses, do IMT Cold Soak Sensor Compare Check, Sensor Circuit Checks, and IMT Pin-Point Diagnostics . Is IMT sensor within specifications?	Yes: Go to Step 7. No: Replace IMT sensor or repair circuit as required. After repairs are complete, retest for SPN 102 FMI 10.

Step	Action	Decision
7	Determine if turbochargers are ingesting oil. Inspect turbocharger compressor stages for evidence of coking. Are turbocharger compressor stages free of coking?	Yes: Go to Step 8. No: Investigate sources of oil in intake path. Do Crankcase Pressure test. Clean turbocharger compressor section to remove coking. After repairs are complete, retest for SPN 102 FMI 10.

Step	Action	Decision
8	Check turbocharger wastegate operation. Do Turbocharger 2 Wastegate Control (TC2WC) tests (page 208). Did TC2WC tests pass?	Yes: Go to Step 9. No: Repair or replace turbocharger wastegate components or turbocharger as necessary. After repairs are complete, retest for SPN 102 FMI 10.

Step	Action	Decision
9	Verify IMP signal changes when Exhaust Gas Recirculation (EGR) valve are commanded ON. Do Key ON Engine Running (KOER) Air Management Test (page 201), while monitoring IMP when EGR valve are commanded ON. Does IMP sensor signal change when EGR valve are commanded ON?	Yes: Go to Step 10. No: IMP Signal does NOT change when EITHER TC2WC or EGR valve are commanded ON: Go to Step 10.

Step	Action	Decision
10	Determine if Fuel Delivery Pressure (FDP), Injection Control Pressure (ICP), and Exhaust Back Pressure (EBP) are within specification. Do KOER Engine Low Idle to High Idle (page 199) procedure. Are FDP, ICP, and EBP within specification?	Yes: Go to Step 11. No: Do actions specified in the procedure to isolate and repair the cause of variance from specified values. After repairs are complete, retest for SPN 102 FMI 10.

Step	Action	Decision
11	Identify any cylinders which may have valve train issues or other mechanical conditions affecting performance. Do Relative Compression Test (page 215). Do all cylinders show similar performance?	Yes: Go to Step 12. No: Diagnose and repair cause of cylinder mechanical performance issues. After repairs are complete, retest for SPN 102 FMI 10.

Step	Action	Decision
12	Determine if Exhaust Back Pressure Valve (EBPV) is operating. With KOER, position an assistant to listen for EBPV operation when engine is shut down and do EBPV Operational Voltage Check (page 537). Did EBPV cycle three times when engine was shut down, and were voltages within specification?	Yes: Go to Step 13. No: Replace EBPV. After repairs are complete, retest for SPN 102 FMI 10.

Step	Action	Decision
13	Do MAF Calibration procedure using EST with ServiceMaxx™ software (page 1101). **NOTE:** Ensure MAF Calibration Requirements are met and MAF Calibration Pre-Checks are done prior to doing this procedure. Did MAF sensor calibration run successfully?	Yes: After doing all diagnostic steps, if SPN 102 FMI 10 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Verify all MAF calibration requirements are met and MAF calibration pre-checks are done. Repeat MAF calibration. After repairs are complete, retest for SPN 102 FMI 10.

NOTE: After doing all diagnostic steps, if SPN 102 FMI 10 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 102

FMI 16 – Over boost

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine Intake Manifold Pressure (IMP) too High	[Engine Intake Manifold Pressure (IMP) Value > Threshold described in Speed / Torque (Table A016) * Engine coolant modifier (Table A017) * Altitude modifier (Table A018) * Inlet air temperature modifier (Table A019) * Intake manifold temperature modifier (Table A020)	Diesel Particulate Filter (DPF) Regeneration NOT Active	2.5 seconds
	AND maximum value of rate based threshold counter] {Counter rate is dependent on Intake Manifold Pressure deviation from Threshold}] > 1350000 hPa * seconds	Barometric Pressure ≥ 11 psi (73.5 kPa) and ≤ 15 psi (103 kPa)	
		Engine Air Inlet Temperature (AIT) ≥ 19°F (-7°C) and ≤ 140°F (60°C)	
		Power Take Off (PTO) Mode NOT Active	
		End Of Line Testing NOT Active	
		[Engine Brake (Retarder) NOT active	
		AND minimum wait time after retarder change of state has occurred] > 5 seconds	
		Engine torque limitation not active	
		Engine is NOT coasting (i.e., Throttle Cut OFF mode)	
		Battery Voltage ≥ 10.787 Volts AND ≤ 15.787 Volts	
		Engine Ignition Key is in "ON" position (Key ON)	
		Time after engine start	

FMI 16 – Over boost (cont.)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		≥ 30 seconds	
		Engine Torque command ≤ 1328 lb-ft (1800 N·m)	
		Speed / Torque based enable (Table A015)	
		SPN / FMIs 27/14, 51/3, 51/4, 51/7, 94/3, 94/4, 102/3, 102/4, 102/7, 105/2, 105/3, 105/4, 108/3, 108/4, 110/2, 110/3, 110/4, 132/0, 132/1, 132/3, 132/4, 164/16, 164/18, 172/2, 172/3, 172/4, 636/2, 636/7, 651/4, 651/5, 651/14, 652/4, 652/5, 652/14, 653/4, 653/5, 653/14, 654/4, 654/5, 654/14, 655/4, 655/5, 655/14, 656/4, 656/5, 656/14, 1173/2, 1173/16, 1189/3, 1189/4, 2630/2, 2791/2, 2791/3, 2791/4, 2791/7, 2791/8, 2791/14, 3464/11, 4257/16, 4257/18, 5543/3, 5543/4, 5543/5 are NOT Active	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the IMP is too high.

Fault Detection / Management

The ECM continuously monitors the control system. If the sensor signal is higher or lower than expected, the ECM disregards the signal and uses a calibrated default value. The ECM sets an SPN / FMI, turns on the Warning Engine Lamp (WEL), and runs the engine in a default range.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

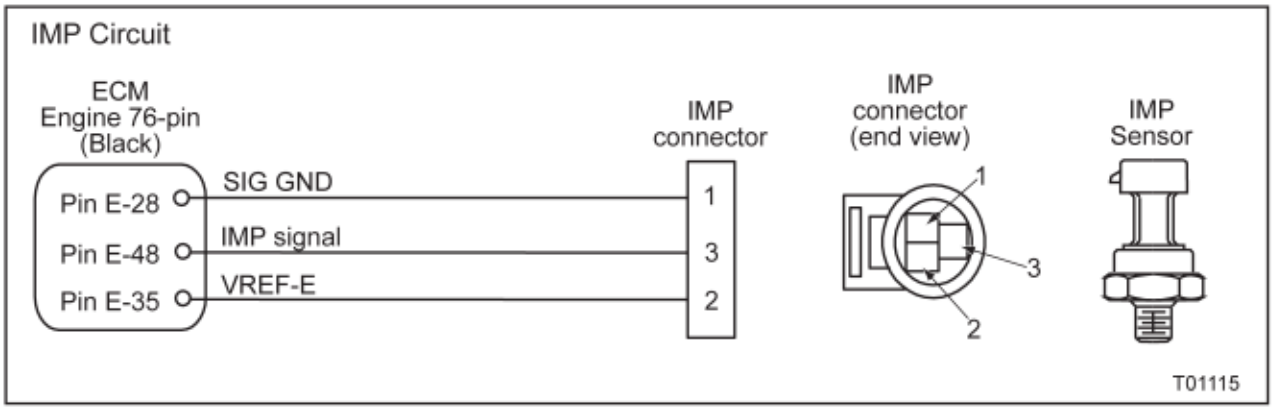


Figure 373 IMP Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 102 FMI 16 the only fault code active?	Yes: Go to Step 2.
		No: Repair any associated faults. After repairs are made, retest for SPN 102 FMI 16.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 102 FMI 16.
		No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit, inspect connections at the Intake Manifold Pressure (IMP) sensor. With key OFF, disconnect IMP sensor connector. Check IMP sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the IMP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 102 FMI 16.

Step	Action	Decision
4	Inspect connections at the Intake Manifold Temperature (IMT) sensor. With key OFF, disconnect IMT sensor connector. Check IMT sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are IMT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 5. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 102 FMI 16.

Step	Action	Decision
5	Check IMP and IMT sensors for excessive soot deposits. Remove IMP and IMT sensors from the intake manifold and visually inspect them. Are IMP and IMT sensor conditions acceptable?	Yes: Go to Step 6. No: Replace the IMP and/or IMT sensor. After repairs are complete, retest for SPN 102 FMI 16.

Step	Action	Decision
6	Determine if engine throttle valve (ETV) is operating correctly. Using EST with ServiceMaxx™ software, do Output State Low Test (page 87) and Output State High Test (page 87). Is voltage for Output State Test Low approximately 1.15 volts and for Output State Test High approximately 3.0 volts?	Yes: Go to Step 7. No: Replace ETV. After repairs are complete, retest for SPN 102 FMI 16.

Step	Action	Decision
7	Check turbocharger wastegate operation. Do KOEO Turbocharger 2 Wastegate Control (TC2WC) tests (page 208). Did TC2WC tests pass?	Yes: Go to Step 8. No: Repair or replace turbocharger wastegate components or turbocharger, as required. After repairs are complete, retest for SPN 102 FMI 16.

Step	Action	Decision
8	Check IMT sensor for bias. Do Cold Soak Sensor Compare Check . Compare IMT with other temperature sensor readings. Are all sensors within 59°F (15°C) of each other?	Yes: Go to Step 9. No: Replace IMT sensor. After repairs are complete, retest for SPN 102 FMI 16.

Step	Action	Decision
9	Check Electronic Control Module (ECM) Barometric Absolute Pressure (BARO) sensor for bias. Using EST with ServiceMaxx™ software, determine if the ECM is reporting SPN 108 FMI 2, 3, or 4. Are BARO sensor SPN / FMIs not reported?	Yes: Go to Step 10. No: Clear any reported SPN / FMIs. Cycle ignition switch and check for codes. If codes are still reported, replace the ECM. After repairs are complete, retest for SPN 102 FMI 16.

Step	Action	Decision
10	Identify cylinders which may have valve train issues or other mechanical conditions affecting performance. Do Relative Compression Test (page 215). Do all cylinders show similar performance?	Yes: Go to Step 11. No: Diagnose and repair cause of cylinder mechanical performance issues. After repairs are complete, retest for SPN 102 FMI 16.

Step	Action	Decision
11	Do MAF Calibration procedure (page 1101) using EST with ServiceMaxx™ software. **NOTE:** Ensure MAF calibration requirements are met and MAF calibration pre-checks are done before doing this procedure. Did MAF sensor calibration run successfully?	Yes: After doing all diagnostic steps, if SPN 102 FMI 16 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Verify all MAF calibration requirements are met and MAF calibration pre-checks are done. Repeat MAF calibration. After repairs are complete, retest for SPN 102 FMI 16.

NOTE: After doing all diagnostic steps, if SPN 102 FMI 16 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 102

FMI 18 – Under boost

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine Intake Manifold Pressure too Low {Under boost Monitor}	[Engine Intake Manifold Pressure < Threshold defined in Speed / Torque (Table A021) * Engine coolant modifier (Table A022) * Altitude modifier (Table A023) * Inlet air temperature modifier (Table A024) * Intake manifold temperature modifier (Table A025)	Diesel Particulate Filter (DPF) Regeneration NOT Active	0.1 second
	AND {Moving Mean average of measured Engine Inlet Air Mass Flow rate MINUS Modeled value of Engine Inlet Air Mass Flow rate > Threshold defined by Speed / Torque based [Table A108] * Ambient pressure modifier [Table A109] * Engine coolant temperature modifier [Table A110]	Barometric pressure ≥ 11 psi (73.5 kPa) ≤ 15 psi (103 kPa)	
	for time}] ≥ 55 seconds	Engine Air Inlet Temperature (AIT) ≥ 19°F (-7°C) and ≤ 140°F (60°C)	
		Power Take Off (PTO) Mode NOT Active	
		End Of Line Testing NOT Active	
		[Engine Brake (Retarder) NOT active	
		AND minimum wait time after retarder change of state has occurred] > 5 seconds	
		Engine Torque limitation NOT Active	

FMI 18 – Under boost (cont.)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		Engine is NOT coasting (i.e., Throttle Cut OFF mode)	
		Battery Voltage ≥ 10.787 Volts AND ≤ 15.787 Volts	
		Engine Ignition Key is in "ON" position (Key ON)	
		Time after engine start ≥ 30 seconds	
		EGR Valve feedback position ≤ 100 %	
		Speed / Torque based enable (Table A026)	
		Pre-debounce counter after Engine Intake Manifold Pressure (IMP) value is below modeled threshold value as defined in "Malfunction Criteria / Threshold Value" section > Speed / Torque (Table A097)	
		Absolute Engine Intake Manifold 1 Pressure (IMP) Gradient ≤ 7 psi/second (50 kPa/second)	
		Engine Speed Gradient ≤ 50 rpm/second	
		Engine Torque Gradient ≤ 56 lb-ft/second (76 N·m/second)	
		SPN / FMIs 27/14, 51/3, 51/4, 51/7, 94/3, 94/4, 102/3, 102/4, 102/7, 102/10, 105/2, 105/3, 105/4, 108/3, 108/4, 110/2, 110/3, 110/4, 132/0, 132/1, 132/3, 132/4, 164/16, 164/18, 172/2, 172/3, 172/4, 636/2, 636/7, 651/4, 651/5, 651/14, 652/4, 652/5, 652/14, 653/4, 653/5, 653/14, 654/4, 654/5, 654/14, 655/4, 655/5, 655/14,	

FMI 18 – Under boost (cont.)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		656/4, 656/5, 656/14, 1173/2, 1173/16, 1189/3, 1189/4, 2630/2, 2791/2, 2791/3, 2791/4, 2791/7, 2791/8, 2791/14, 3464/11, 4257/16, 4257/18, 5543/3, 5543/4, 5543/5 are NOT Active	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the intake manifold is not reaching desired pressure.

Fault Detection / Management

The ECM continuously monitors the control system. If the sensor signal is higher or lower than expected, the ECM disregards the signal and uses a calibrated default value. The ECM sets an SPN / FMI, turns on the Warning Engine Lamp (WEL), and runs the engine in a default range.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN / FMI: 94/1, 102/2, 1209/0, 1209/3, and 1209/4.

Drive Cycle to Determine Fault Status

N/A

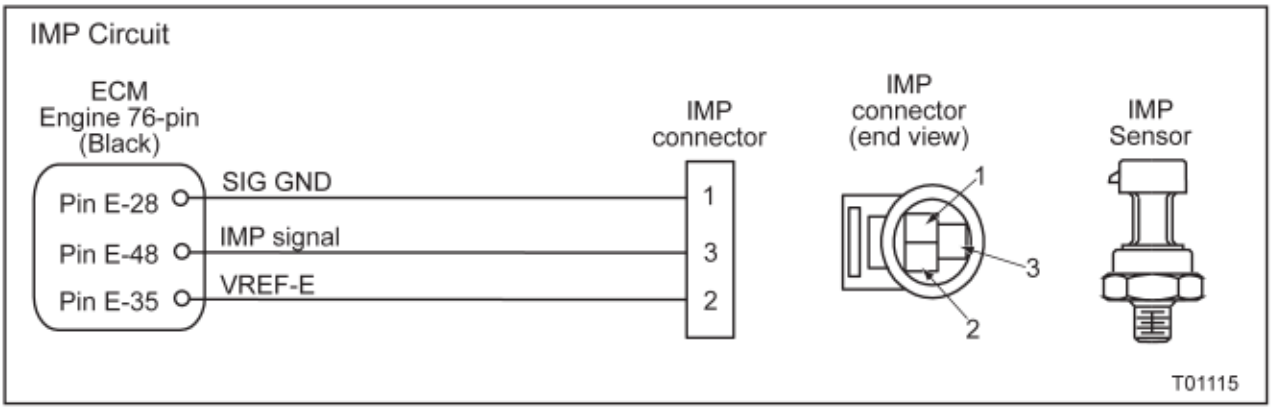


Figure 374 IMP Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 102 FMI 18 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 102 FMI 18. No: Go to Step 3.

Step	Action	Decision
3	Do visual inspection . a. Check all fluid levels and fuel quality. b. Inspect engine systems for problems such as leaks, open connections, and harness chafing. c. Check Charge Air Cooler (CAC) system for leaks, blockage, and contamination such as oil. d. Inspect electrical system for open connections, chafing, and burned insulation. e. Inspect intake air system, including air cleaner, for leaks, damage, and restrictions. f. Inspect exhaust system for leaks or damage such as cracked exhaust manifold, leaking exhaust manifold joints and gaskets, leaking flanges and clamps, and damaged aftertreatment components. g. Inspect fuel system for leaks or damage. Are all items checked within specification?	Yes: Go to Step 4. No: Repair restrictions, air and exhaust leaks, fuel leaks or physical damage. Restore fluid levels to their correct levels and replace fuel of questionable quality. After repairs are complete, retest for SPN 102 FMI 18.

Step	Action	Decision
4	Check Intake Manifold Pressure (IMP) sensor for damage or deposits. Visually inspect IMP sensor for damage and sensor port for clogging. Is IMP sensor free from damage and is the port open and free of deposits?	Yes: Go to Step 5. No: Replace IMP sensor. After repairs are complete, retest for SPN 102 FMI 18.

Step	Action	Decision
5	Visually inspect Intake Manifold Temperature (IMT) sensor for excessive deposits or damage. Is IMT sensor corroded, covered in deposits, or damaged?	Yes: Go to Step 6. No: Replace IMT sensor. After repair is complete, retest for SPN 102 FMI 18.

Step	Action	Decision
6	Determine if IMT sensor or circuits are out of specifications. Using EST with ServiceMaxx™ software, DMM, and required breakout harnesses, do IMT Cold Soak Sensor Compare Check, Sensor Circuit Checks, and IMT Pin-Point Diagnostics. Is IMT sensor within specifications?	Yes: Go to Step 7. No: Replace IMP sensor or repair circuit as required. After repairs are complete, retest for SPN 102 FMI 18.

Step	Action	Decision
7	Determine if turbochargers are ingesting oil. Inspect turbocharger compressor stages for evidence of coking. Are turbocharger compressor stages free of coking?	Yes: Go to Step 8. No: Investigate sources of oil in intake path. Do Crankcase Pressure test. Clean turbocharger compressor section to remove coking. After repairs are complete, retest for SPN 102 FMI 18.

Step	Action	Decision
8	Check turbocharger wastegate operation. Do Turbocharger 2 Wastegate Control (TC2WC) tests (page 208). Did TC2WC tests pass?	Yes: Go to Step 9. No: Repair or replace turbocharger wastegate components or turbocharger as necessary. After repairs are complete, retest for SPN 102 FMI 18.

Step	Action	Decision
9	Verify IMP signal changes when both TC2WC and Exhaust Gas Recirculation (EGR) valve are commanded ON. Do Key-On Engine-Running (KOER) Air Management Test (page 201), while monitoring IMP when both TC2WC AND EGR valve are commanded ON. Does IMP sensor signal change when both TC2WC AND EGR valve are commanded ON?	Yes: Go to Step 10. No: Do one of the following depending on when IMP signal changes: • IMP Signal changes ONLY when TC2WC is commanded ON: Do EGR Pin-point Diagnostics (page 679) and check for EGR issue.

Step	Action	Decision
		After repairs are complete, retest for SPN 102 FMI 18. • IMP Signal changes ONLY when EGR valve is commanded ON: Do TC2WC voltage and circuit checks (page 1165), and repair as required. After repairs are complete, retest for SPN 102 FMI 18. • IMP Signal does NOT change when EITHER TC2WC or EGR valve are commanded ON: Go to Step 10.

Step	Action	Decision
10	Determine if Fuel Delivery Pressure (FDP), Injection Control Pressure (ICP), and Exhaust Back Pressure (EBP) are within specification. Do KOER Engine Low Idle to High Idle procedure (page 199). Are FDP, ICP, and EBP within specification?	Yes: Go to Step 11. No: Do actions specified in the procedure to isolate and repair the cause of variance from specified values. After repairs are complete, retest for SPN 102 FMI 18.

Step	Action	Decision
11	Identify cylinders which may have valve train issues or other mechanical conditions affecting performance. Do Relative Compression Test . Do all cylinders show similar performance?	Yes: Go to Step 12. No: Diagnose and repair cause of cylinder mechanical performance issues. After repairs are complete, retest for SPN 102 FMI 18.

Step	Action	Decision
12	Determine if Exhaust Back Pressure Valve (EBPV) is operating. With KOER, position an assistant to listen for EBPV operation when engine is shut down and do EBPV Operational Voltage Check (page 537). Did EBPV cycle three times when engine was shut down, and were voltages within specification?	Yes: Go to Step 13. No: Replace EBPV. After repairs are complete, retest for SPN 102 FMI 18.

Step	Action	Decision
13	Do MAF Calibration procedure (page 1101) using EST with ServiceMaxx™ software. **NOTE:** Ensure MAF calibration requirements are met and MAF calibration pre-checks are done before doing this procedure. Did MAF sensor calibration run successfully?	Yes: After doing all diagnostic steps if SPN 102 FMI 18 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Verify all MAF calibration requirements are met and MAF calibration pre-checks are done. Repeat MAF calibration. After repairs are complete, retest for SPN 102 FMI 18.

NOTE: After doing all diagnostic steps, if SPN 102 FMI 18 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

IMT Sensor (Intake Manifold Temperature)

Overview of IMT Sensor Group

SPN	FMI	Condition
105	2	IMT signal Erratic, Intermittent, or Incorrect (page 916)
105	3	IMT signal Out of Range HIGH (page 918)
105	4	IMT signal Out of Range LOW (page 923)

Overview

Intake Manifold Temperature (IMT) sensor provides feedback signal to Engine Control Module (ECM) indicating manifold air temperature. ECM controls Exhaust Gas Recirculation (EGR) system based on air temperature in intake manifold. This aids in cold engine starting and warm-ups, and also reduces exhaust emissions.

SPN 105 FMI 2 - IMT signal Erratic, Intermittent, or Incorrect

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Comparison of Engine Intake Manifold 1 Temperature sensor to following sensors after calibrated adjustable cold-soak period (time). Sensor 1 to 4 are in Air group and 5 to 7 are in Liquid group. [1. Engine Intake Manifold 1 Temperature 2. Engine Air Intake Temperature 3. Engine Turbocharger 2 Compressor Intake Temperature 4. Engine Charge Air Cooler Outlet Temperature 5. Engine Coolant Temperature 6. Engine Oil Temperature 1 7. Engine Fuel Temperature 1]	{Engine Intake Manifold 1 Temperature (Bias Hi) > Reference temperature value OR Engine Intake Manifold 1 Temperature (Bias low)} ≤ Reference temperature value Error threshold value for comparison of sensors in same media (Air to Air media): Used for Equilibrium and Reference value calculation > 59°F (15°C) Error threshold value for comparison of sensors in different media (Air to Liquid media): Used for Equilibrium and Reference value calculation > 59°F (15°C) Error threshold value for comparison of sensors in same media (Liquid to Liquid): Used for Equilibrium and Reference value calculation > 59°F (15°C) Error threshold value for comparison of sensors in different media (Liquid to Air or vice versa): Used for Equilibrium and Reference value calculation {NOTE: Reference temperature value calculation is explained in Operations Summary Document}	Key ON Engine Off timer ≥ 28800 seconds Engine Coolant Temperature ≥ -40°F (-40°C) Engine in Thermal Equilibrium Condition {Explained in operations summary document} [Similar sensors agree with other sensors with different group-index OR Faulty Sensor is alone in its group {i.e. No other sensor which measures the same media (in Air Path) is identified as a faulty sensor}]

Fault Overview

ECM Compares Intake Manifold Temperature (IMT) sensor to Intake Air Temperature (IAT), Turbocharger 2 Compressor Intake Temperature (TC2CIT), Charge Air Cooler Outlet Temperature (CACOT), Engine Coolant Temperature 1 (ECT1), and Engine Oil Temperature (EOT) sensors after calibrated adjustable cold-soak period (time).

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Initial Key-On

Possible Causes

- Failed wiring
- Biased IMT sensor or circuit

Step 1	Check for active or pending fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 105 FMI 2. Is EST DTC list SPN 105 FMI 2 active or pending?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Inspect connections at Intake Manifold Temperature (IMT) connector.	Decision
A. Key OFF. B. Disconnect IMT connector. C. Check IMT and connector terminals for: damaged or pinched wires; moisture or corroded terminals; loose, bent, or broken pins; or broken connector housing. Are IMT connector, harness, and terminals clean and undamaged?		Yes: Go to Step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 105 FMI 2.

Step 3	Inspect connections at Intake Manifold Temperature (IMT) connector.	Decision
A. Key OFF. B. Connect Breakout Harness ZTSE4993 between pin-1 and pin-2 on IMT connector. C. Key-On Engine-Off (KOEO). Using EST with ServiceMaxx™ software, measure voltage between pin-1 and pin-2. Is voltage less than 0.5 volts?		Yes: Replace IMT sensor. After repairs are complete, retest for SPN 105 FMI 2. No: Go to step 4.

Step 4	Inspect connections at Intake Manifold Temperature (IMT) connector.	Decision
A. Key OFF. B. Connect Breakout Harness ZTSE4993 between pin-1 and known good GND. C. Key-On Engine-Off (KOEO). Using EST with ServiceMaxx™ software, measure resistance. Is resistance less than 5 ohms?		Yes: Repair IMT signal wire. After repairs are complete, retest for SPN 105 FMI 2. No: Repair IMT SIG GND wire. After repairs are complete, retest for SPN 105 FMI 2.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 105 FMI 2 fault code diagnostics.

SPN 105 FMI 3 - IMT signal Out of Range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Values
Intake Manifold Temperature (IMT) signal reading is greater than expected	IMT sensor reading > 4.80 volts	Key ON

Fault Overview

Fault Code sets when Engine Control Module (ECM) detects that Intake Manifold Temperature (IMT) signal is greater than 4.80 volts.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON.

Possible Causes

- IMT circuit Open
- IMT circuit short to PWR
- SIG GND circuit Open
- Failed IMT sensor

Step 1	Check for active fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 105 FMI 3. Does EST DTC list show SPN 105 FMI 3 as active?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Inspect connections at Intake Manifold Temperature (IMT) sensor.	Decision
A. Key OFF. B. Disconnect IMT sensor connector. C. Check IMT sensor and connector terminals for damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are IMT sensor connector, harness, and terminals clean and undamaged?		Yes: Perform Pin-Point Tests (page 919). No: Repair connector, harness, and / or terminal damage. After repairs are complete, retest for SPN 105 FMI 3.

Pin-Point Tests (SPN 105 FMI 3)

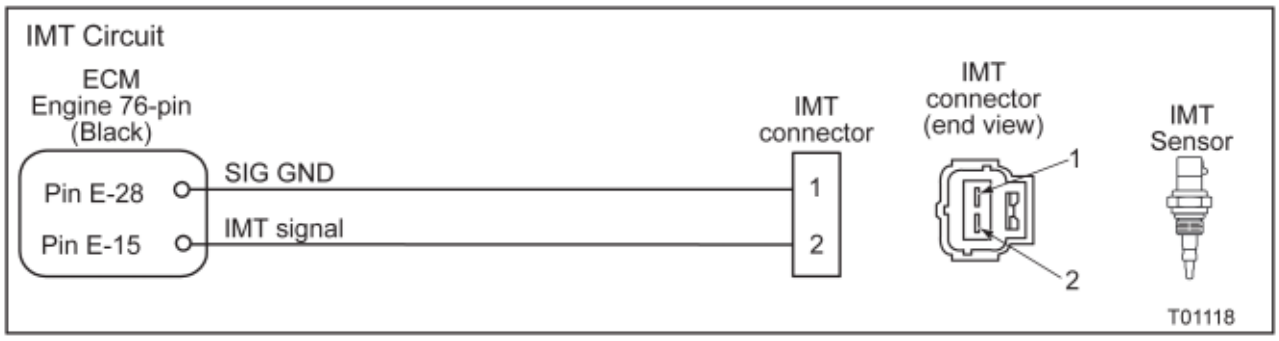


Figure 375 Intake Manifold Temperature (IMT) Sensor Circuit Diagram

NOTE: See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4993
- Breakout Harness 3-Banana Plug ZTSE4498
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)

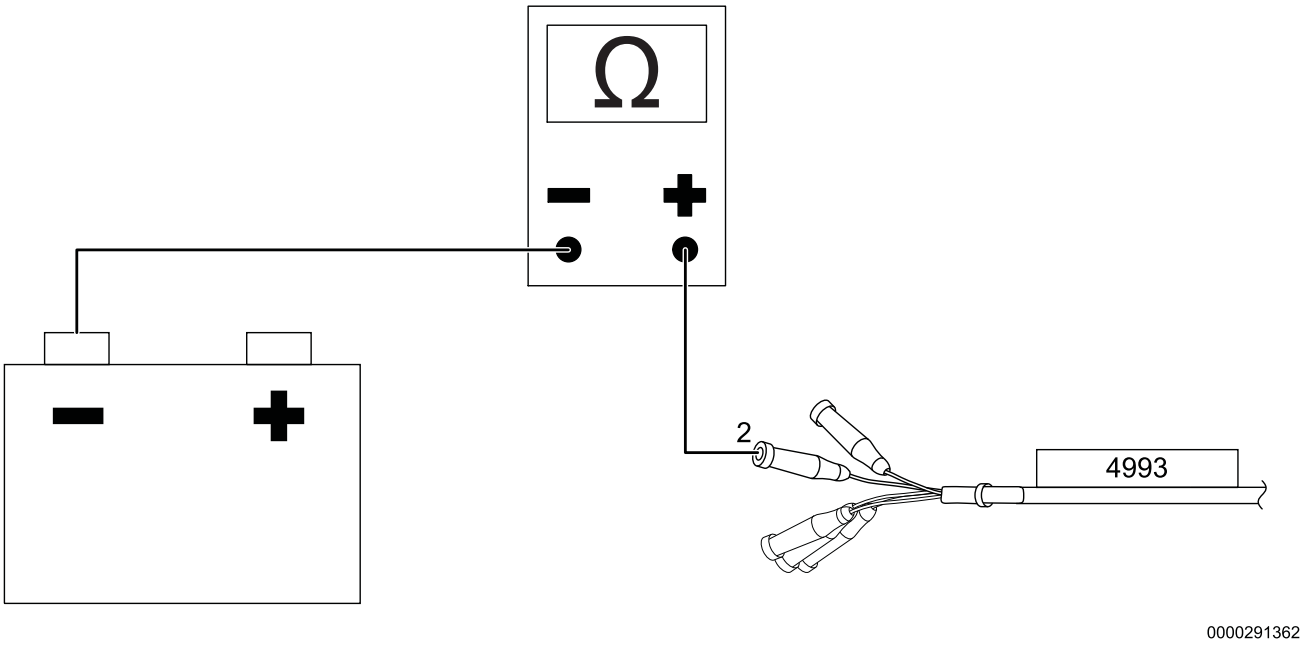
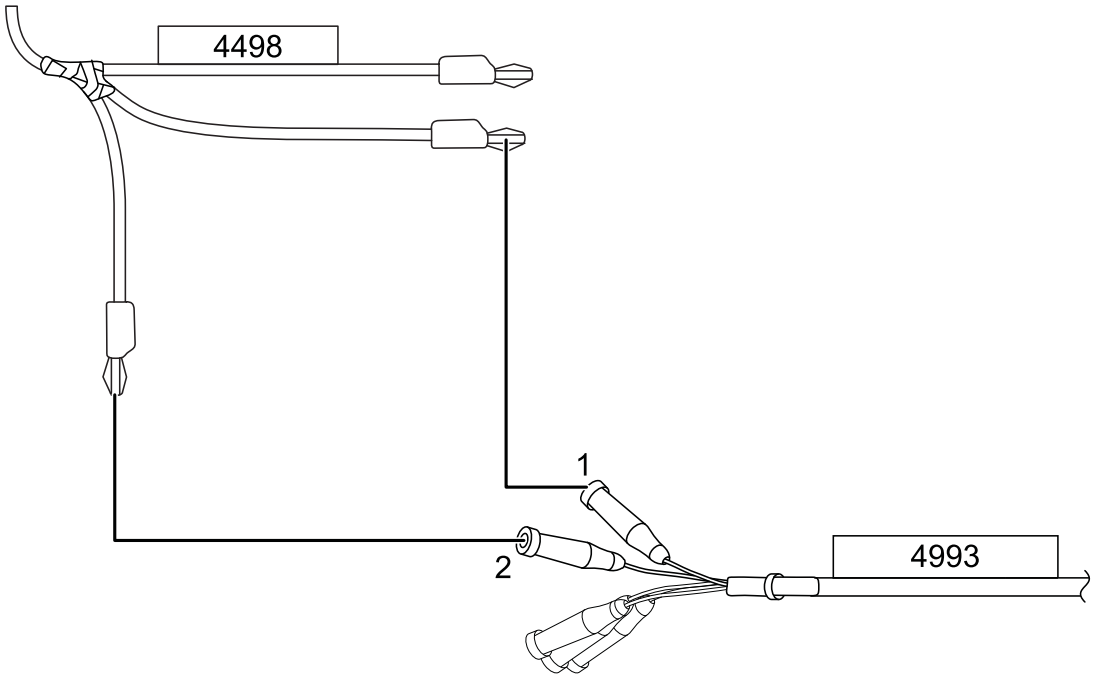


Figure 376 Test 1 Signal Circuit Check

Test 1 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4993 to vehicle harness connector and leave Intake Manifold Temperature (IMT) sensor disconnected. C. Key ON.

Test 1	Specification
Using DMM, measure voltage between Breakout Harness ZTSE4993 pin-2 and known good GND.	Greater than 6 volts
Decision	
Is voltage greater than 6 volts?	Yes: Repair short to PWR between IMT pin-2 and ECM pin E-15. After repairs are complete, retest for SPN 105 FMI 3.
	No: Go to Test 2.



0000301703

Figure 377 Test 2 IMT Signal Circuit Check

Test 2 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4993 to vehicle harness and leave IMT sensor disconnected. C. Using Breakout Harness ZTSE4498, short pin-1 and pin-2 of Breakout Harness ZTSE4993 together. D. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). E. Key ON. Log in to ServiceMaxx™ software

Test 2	Specification
Using EST with ServiceMaxx™ software, clear DTC list.	SPN 105 FMI 4 sets
Decision	
Does SPN 105 FMI 4 set after DTC list is cleared?	Yes: Replace IMT sensor. After repairs are complete, retest for SPN 105 FMI 3.
	No: Go to Test 3.

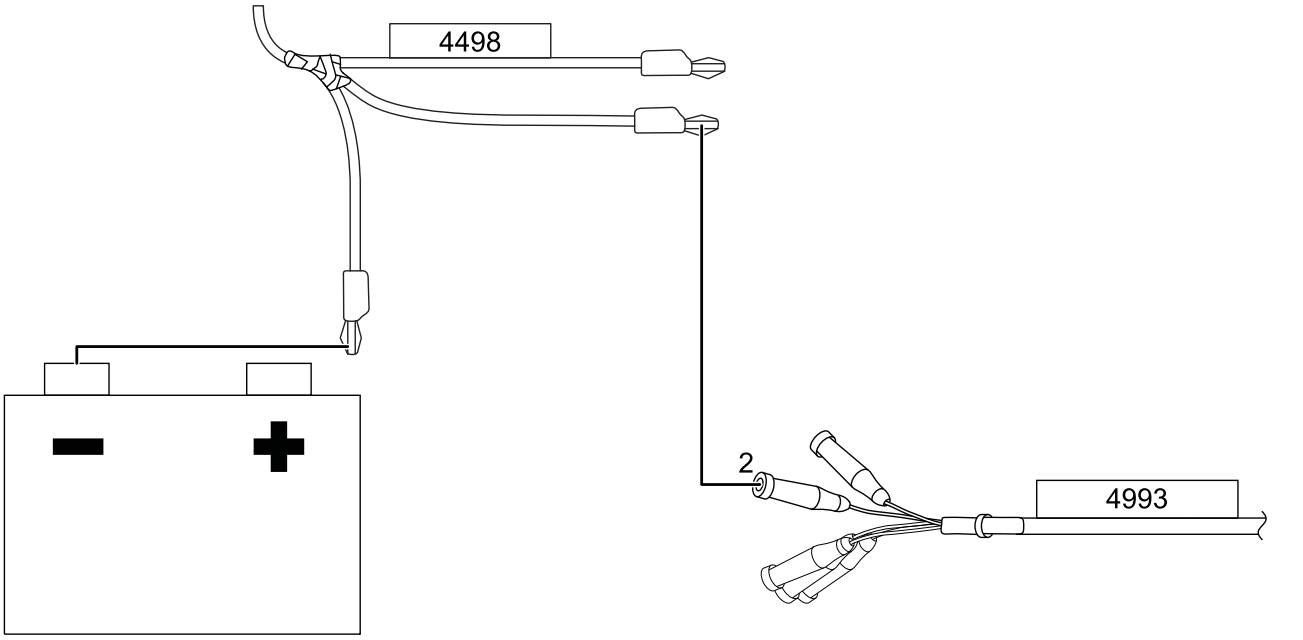


Figure 378 Test 3 Circuit Check

Test 3 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4993 to vehicle harness and leave IMT sensor disconnected. C. Using Breakout Harness ZTSE4498, short Breakout Harness ZTSE4993 pin-2 circuit to known good GND. D. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). E. Key ON. Log in to ServiceMaxx™ software

Test 3	Specification
Using EST with ServiceMaxx™ software, clear DTC list.	SPN 105 FMI 4 sets.
Decision	
Does SPN 105 FMI 4 set after DTC list is cleared?	Yes: Repair Open between IMT pin-1 and ECM pin E-28. After repairs are complete, retest for SPN 105 FMI 3.
	No: Repair Open between IMT pin-2 and ECM pin E-15. After repairs are complete, retest for SPN 105 FMI 3.

End Diagnostic Tests
After performing all tests, if no problem is found, verify each step was completed correctly and the proper decision was made. Return to SPN 105 FMI 3 fault code diagnostics.

SPN 105 FMI 4 - IMT signal Out of Range LOW

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Intake Manifold Temperature (IMT) signal voltage reading is less than expected.	IMT sensor reading < 0.16 volts	Key ON

Fault Overview

Fault Code sets when Engine Control Module (ECM) detects Intake Manifold Temperature (IMT) signal is less than 0.16 volts.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON

Possible Causes

- IMT signal circuit short to GND
- Failed IMT

Step 1	Check for associated fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 3509 FMI 3 and 4 (VREF1). Is EST DTC list free of SPN 3509 FMI 3 and 4?		Yes: Go to Step 2. No. Repair SPN 3509 FMI 3 and 4. After repairs are complete, retest for SPN 105 FMI 4.

Step 2	Inspect connections at Intake Manifold Temperature (IMT) sensor.	Decision
A. Key OFF. B. Disconnect IMT sensor connector. C. Check IMT sensor and connector terminals for damaged or pinched wires; corroded terminals; loose, bent, broken pins; or broken connector housing. Are IMT sensor connector, harness, and terminals clean and undamaged?		Yes: Perform Pin-Point Tests (SPN 105 FMI 4) (page 924). No: Repair connector, harness, and terminal damage. After repairs are complete, retest for SPN 105 FMI 4.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and the proper decision was made. Return to SPN 105 FMI 4 fault code diagnostics.

Pin-Point Tests (SPN 105 FMI 4)

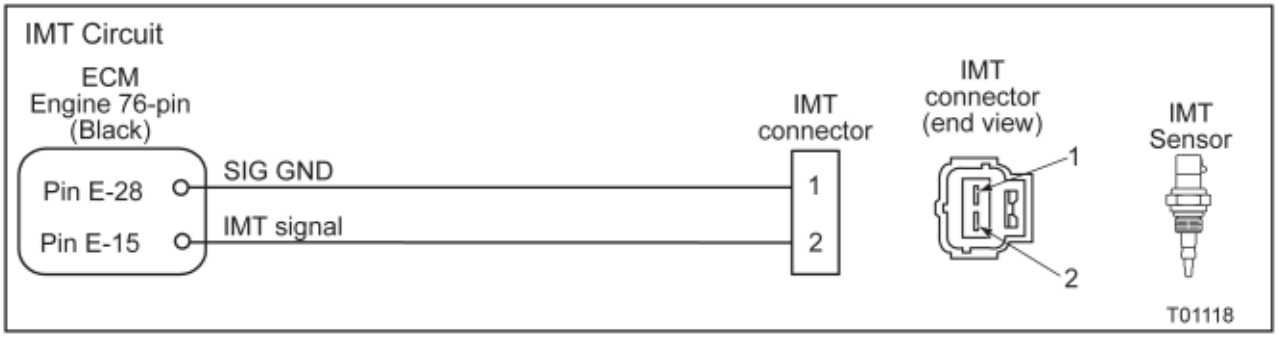


Figure 379 Intake Manifold Temperature (IMT) Sensor Circuit Diagram

NOTE: See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4993
- Breakout Harness ZTSE4498
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)

Test 1 Setup
A. Key OFF. B. Disconnect Intake Manifold Temperature (IMT) sensor and leave sensor disconnected. C. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). D. Key ON. Log in to ServiceMaxx™ software.

Test 1	Specification
Using EST with ServiceMaxx™ software, clear Diagnostic Trouble Code (DTC) list.	SPN 105 FMI 3
Decision	
Does SPN 105 FMI 3 set after DTC list is cleared?	Yes: Replace IMT sensor. After repairs are complete, retest for SPN 105 FMI 4.
	No: Repair short to GND between IMT connector pin-2 and Engine Control Module (ECM) pin E1-15. After repairs are complete, retest for SPN 105 FMI 4.

Injector Circuits

SPN	FMI	Condition	Possible Causes	Actions
651 – 656	4	Injector (#) open coil – short circuit	• Injector (#) open coil circuit short to GND • Injector (#) open coil circuit OPEN	Pin-point Diagnostics (page 931)
651 – 656	5	Injector (#) open coil – open circuit	• Injector (#) open coil circuit short to GND • Injector (#) open coil circuit OPEN	Pin-point Diagnostics (page 931)
651 – 656	7	Injector (#) Spool Motion Compensation Max Authority Reached	• Individual injector spool motion compensation exceeding maximum threshold • Mismatched Engine Control Module (ECM) programming	Step-based Diagnostics (page 944)
651 – 656	14	Injector (#) Fuel quantity/timing error	• Injector fuel or timing deviation • Spool to control valve body static leakage • Puck leakage • Backup ring and / or O-ring leakage at injector inlet • Injector damage • Biased Injection Control Pressure (ICP) sensor • Injector variability	Step-based Diagnostics (page 948)

			• Engine oil worn out • Compression loss • Bent connecting rod • Aerated oil • Exhaust Gas Temperature (EGT) sensor drift (biased sensor)	
2797	3	Injector Control Group 1 open coil short	Open coil short circuit on Injectors 1, 2, or 3	Pin-point Diagnostics (page 931)
2797	4	Injector Control Group 1 close coil short	Closed coil short circuit on Injectors 1, 2, or 3	Pin-point Diagnostics (page 931)
2797	6	Injector Control Group 1 Open coil – Short Circuit (INJ 1, 2, 3)	• Open coil short circuit on injectors 1, 2, or 3 • Closed coil short circuit on injectors 1, 2, or 3 • Shorted coil windings • UVC harness issues • Flying short circuits – wire guides • Harness short circuit to ground engine harness (not UVC)	Step-based Diagnostics (page 954)
2798	3	Injector Control Group 2 open coil short	Open coil short circuit on Injectors 4, 5, or 6	Pin-point Diagnostics (page 931)
2798	4	Injector Control Group 2 close coil short	Closed coil short circuit on Injectors 4, 5, or 6	Pin-point Diagnostics (page 931)
2798	6	Injector Control Group 2 Open coil – Short Circuit (INJ 4, 5, 6)	• Open coil short circuit on injectors 4, 5, or 6 • Closed coil short circuit on injectors 4, 5, or 6 • Shorted coil windings • UVC harness issues • Flying short circuits – wire guides	Step-based Diagnostics (page 998)

			• Harness short circuit to ground engine harness (not UVC)	
3659	4	Injector 1 close coil – short circuit	Injector closed coil circuit short to GND	Pin-point Diagnostics (page 931)
3659	5	Injector 1 close coil – open circuit	Injector closed coil circuit OPEN	Pin-point Diagnostics (page 931)
3660	4	Injector 2 close coil – short circuit	Injector closed coil circuit short to GND	Pin-point Diagnostics (page 931)
3660	5	Injector 2 close coil – open circuit	Injector closed coil circuit OPEN	Pin-point Diagnostics (page 931)
3661	4	Injector 3 close coil – short circuit	Injector closed coil circuit short to GND	Pin-point Diagnostics (page 931)
3661	5	Injector 3 close coil – open circuit	Injector closed coil circuit OPEN	Pin-point Diagnostics (page 931)
3662	4	Injector 4 close coil – short circuit	Injector closed coil circuit short to GND	Pin-point Diagnostics (page 931)
3662	5	Injector 4 close coil – open circuit	Injector closed coil circuit OPEN	Pin-point Diagnostics (page 931)
3663	4	Injector 5 close coil – short circuit	Injector closed coil circuit short to GND	Pin-point Diagnostics (page 931)
3663	5	Injector 5 close coil – open circuit	Injector closed coil circuit OPEN	Pin-point Diagnostics (page 931)
3664	4	Injector 6 close coil – short circuit	Close coil or open circuit fault	Pin-point Diagnostics (page 931)
3664	5	Injector 6 close coil – open circuit	Injector closed coil circuit OPEN	Pin-point Diagnostics (page 931)

Overview

The injector injects fuel into the cylinders. The ECM controls the timing and the amount of fuel being sprayed from each injector. The ECM also controls the ICP system to regulate fuel spray pressure.

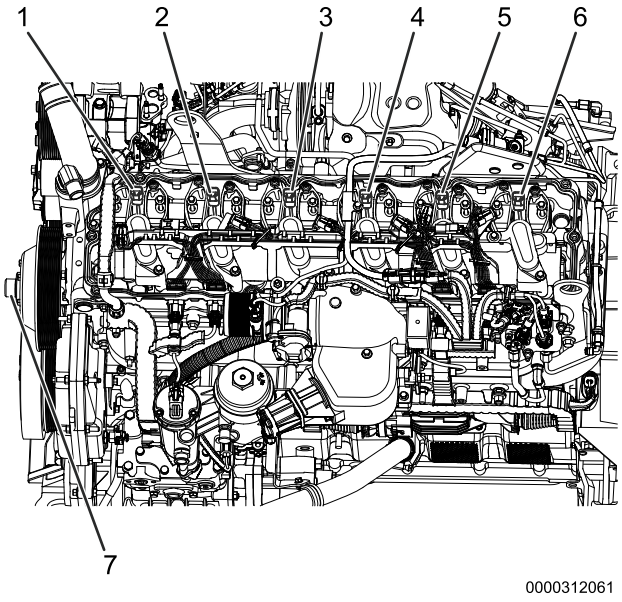


Figure 380 Injector Location

1. Injector 1
2. Injector 2
3. Injector 3
4. Injector 4
5. Injector 5
6. Injector 6
7. Water Pump

Tools

- EZ Tech® Electronic Service Tool (EST) – J-45067 (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- 00-00956-08 – 180-pin Breakout Box (page 1222)
- Breakout Harness 4793 (UVC) (page 1233)
- International® Electronic Engine Terminal Test Kit (page 1227)
- Breakout Harness 4484 (IPR) (page 1229)
- Cylinder Performance Analyzer (CPA) Tool
- CPA USB Cable
- CPA Black Cable
- CPA Yellow Cable
- Leak Detection Pump Tool
- 1/2" High-pressure Adapter

- 5/8" High-pressure Adapter

Pin-point Diagnostics With ServiceMaxx™ Software

Injector 1 Checks

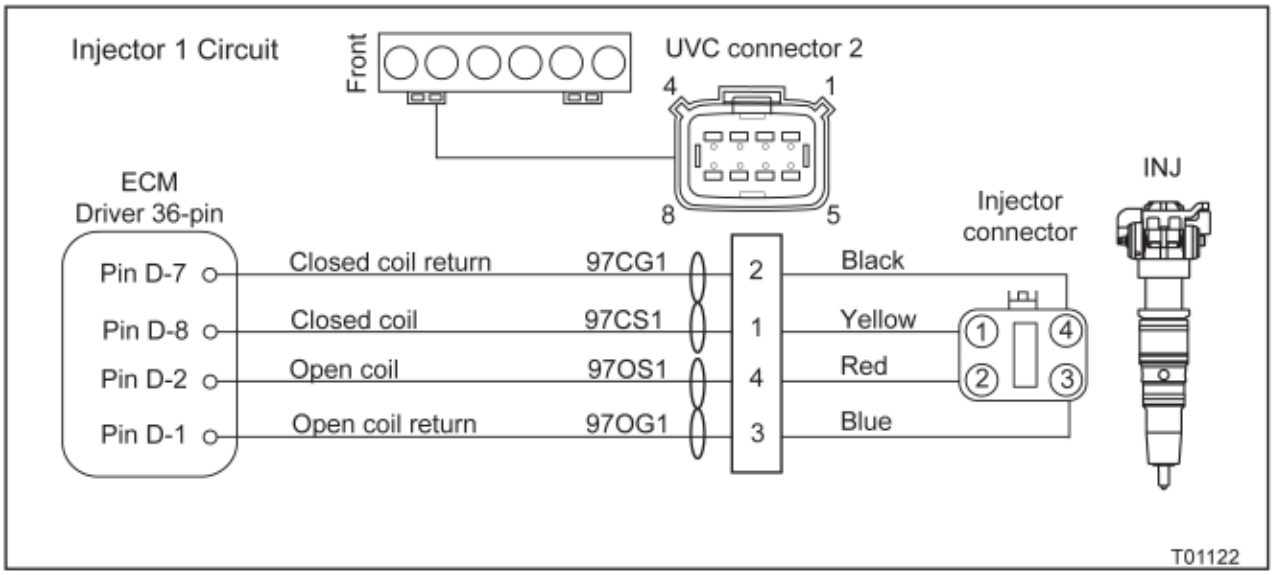


Figure 381 Injector 1 circuit diagram

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 prevent engine damage, turn the ignition switch OFF before disconnecting connectors. Failure to turn the ignition switch OFF will cause a voltage spike and damage to electrical components.

Injector 1 – Resistance Through Valve Cover Check

Turn ignition switch to OFF. Connect Breakout Harness 4793 to UVC connector 2. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
1 to GND	> 1 kΩ	
2 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
3 to GND	> 1 kΩ	
4 to GND	> 1 kΩ	

Injector 1 – Coil Resistance Checks

Turn ignition switch to OFF. Connect Breakout Harness 4793 to UVC connector 2. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
1 to 2	1.0 ± 0.5 Ω	If > 1.5 Ω, check for OPEN through injector.
3 to 4	1.0 ± 0.5 Ω	If > 1.5 Ω, check for OPEN through injector.
1 to 3	> 1 kΩ	If < 1 kΩ, check for cross-shorted circuits or injector coil for internal short.

Injector 1 – Harness Resistance Check

Turn ignition switch to OFF. Connect 180-pin Breakout Box to ECM 36-pin connector. Leave ECM and valve cover disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
D-1 to 3	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-1 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-2 to 4	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-2 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-7 to 2	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-7 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-8 to 1	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-8 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector 2 Checks

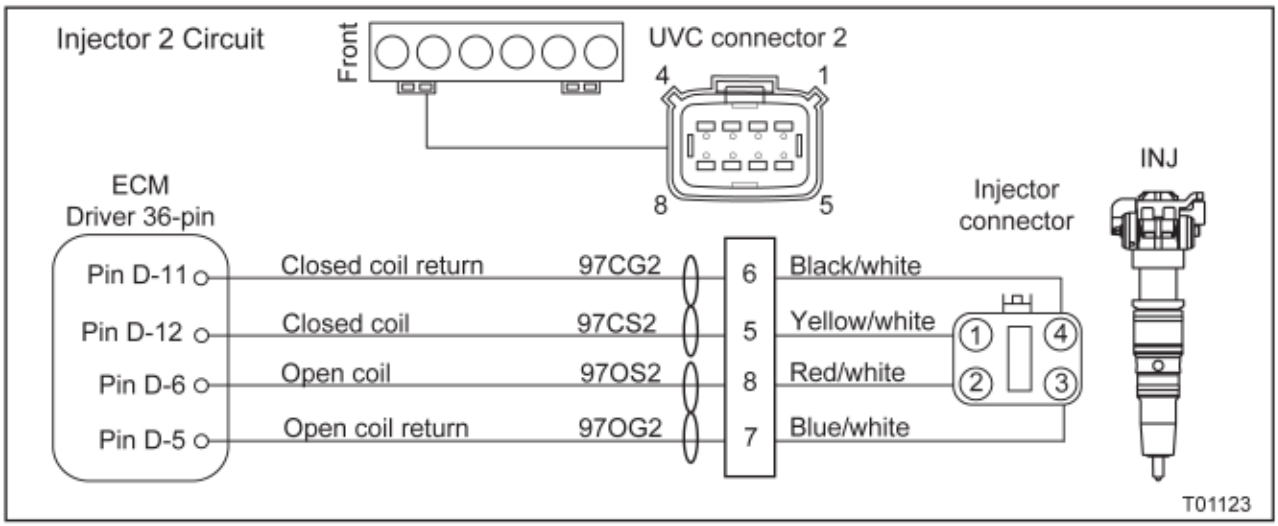


Figure 382 Injector 2 circuit diagram

Injector 2 – Resistance Through Valve Cover Check

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 prevent engine damage, turn the ignition switch OFF before disconnecting connectors. Failure to turn the ignition switch OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch to OFF. Connect Breakout Harness 4793 to the valve cover connector. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
5 to GND	> 1 kΩ	
6 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
7 to GND	> 1 kΩ	
8 to GND	> 1 kΩ	

Injector 2 – Coil Resistance Check

Turn ignition switch to OFF. Connect Breakout Harness 4793 to the valve cover connector. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
5 to 6	0.5 to 1.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
7 to 8	0.5 to 1.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
5 to 7	> 1 kΩ	If < 1 kΩ, check for cross shorted circuits or injector coil for internal short.

Injector 2 – Harness Resistance Check

Turn ignition switch to OFF. Connect 180-pin Breakout Box and injector circuit breakout to engine harness. Leave ECM and valve cover disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
D-5 to 7	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-5 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-6 to 8	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-6 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-11 to 6	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-11 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-12 to 5	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-12 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector 3 Checks

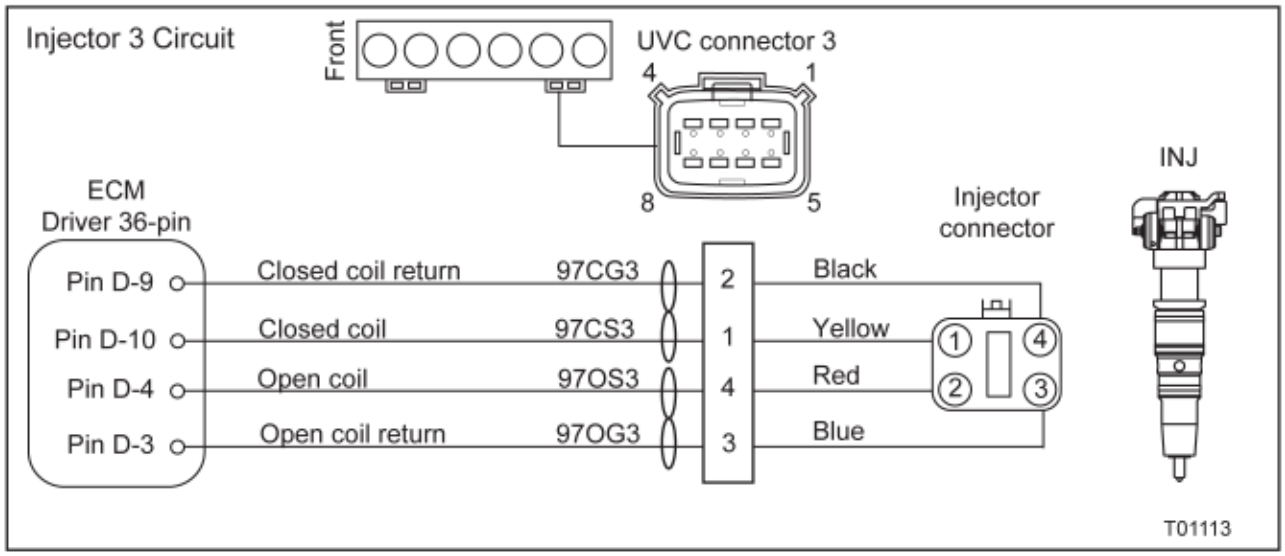


Figure 383 Injector 3 circuit diagram

Injector 3 – Resistance Through Valve Cover Check

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 prevent engine damage, turn the ignition switch OFF before disconnecting connectors. Failure to turn the ignition switch OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch to OFF. Connect Breakout Harness 4793 to valve cover connector. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
1 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
2 to GND	> 1 kΩ	
3 to GND	> 1 kΩ	
4 to GND	> 1 kΩ	

Injector 3 – Coil Resistance Check

Turn ignition switch to OFF. Connect Breakout Harness 4793 to the valve cover connector. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
1 to 2	0.5 to 1.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
3 to 4	0.5 to 1.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
1 to 3	> 1 kΩ	If < 1 kΩ, check for cross shorted circuits or injector coil for internal short.

Injector 3 – Harness Resistance Check

Turn ignition switch to OFF. Connect 180-pin Breakout Box and injector circuit breakout to engine harness. Leave ECM and UVC disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
D-3 to 3	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-3 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-4 to 4	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-4 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-9 to 2	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-9 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-10 to 1	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-10 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector 4 Checks

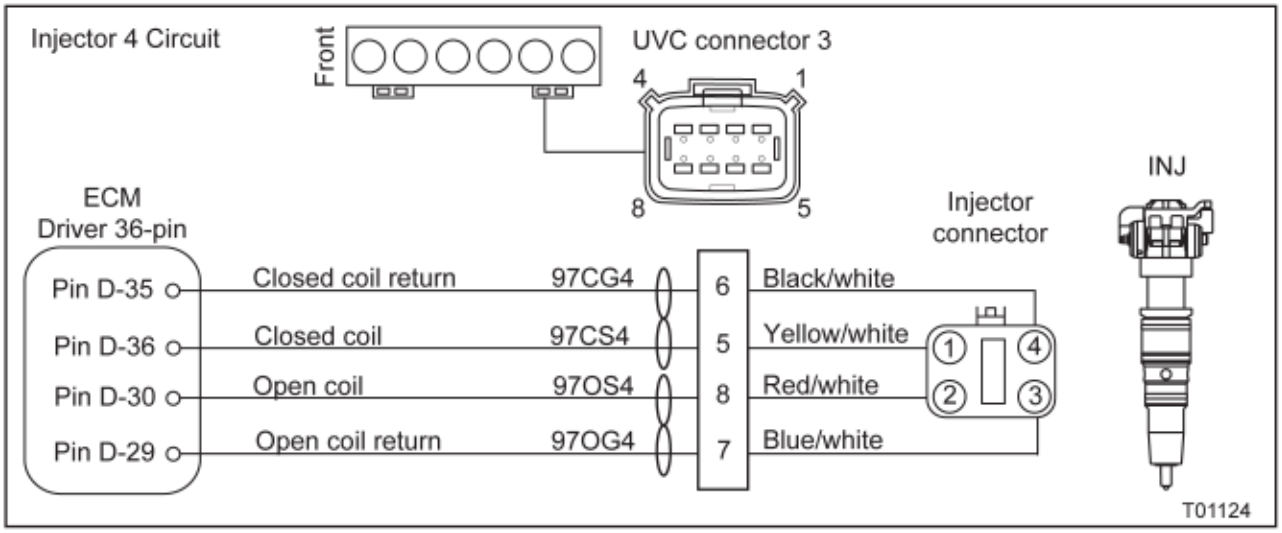


Figure 384 Injector 4 circuit diagram

Injector 4 – Resistance Through Valve Cover Check

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 prevent engine damage, turn the ignition switch OFF before disconnecting connectors. Failure to turn the ignition switch OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch to OFF. Connect Breakout Harness 4793 to the valve cover connector. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
5 to GND	> 1 kΩ	
6 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
7 to GND	> 1 kΩ	
8 to GND	> 1 kΩ	

Injector 4 – Coil Resistance Check

Turn ignition switch to OFF. Connect Breakout Harness 4793 to the valve cover connector. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
5 to 6	0.5 to 1.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
7 to 8	0.5 to 1.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
5 to 7	> 1 kΩ	If < 1 kΩ, check for cross shorted circuits or injector coil for internal short.

Injector 4 – Harness Resistance Check

Turn ignition switch to OFF. Connect 180-pin Breakout Box and injector circuit breakout to engine harness. Leave ECM and UVC disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
D-29 to 7	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-29 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-30 to 8	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-30 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-35 to 6	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-35 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-36 to 5	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-36 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector 5 Checks

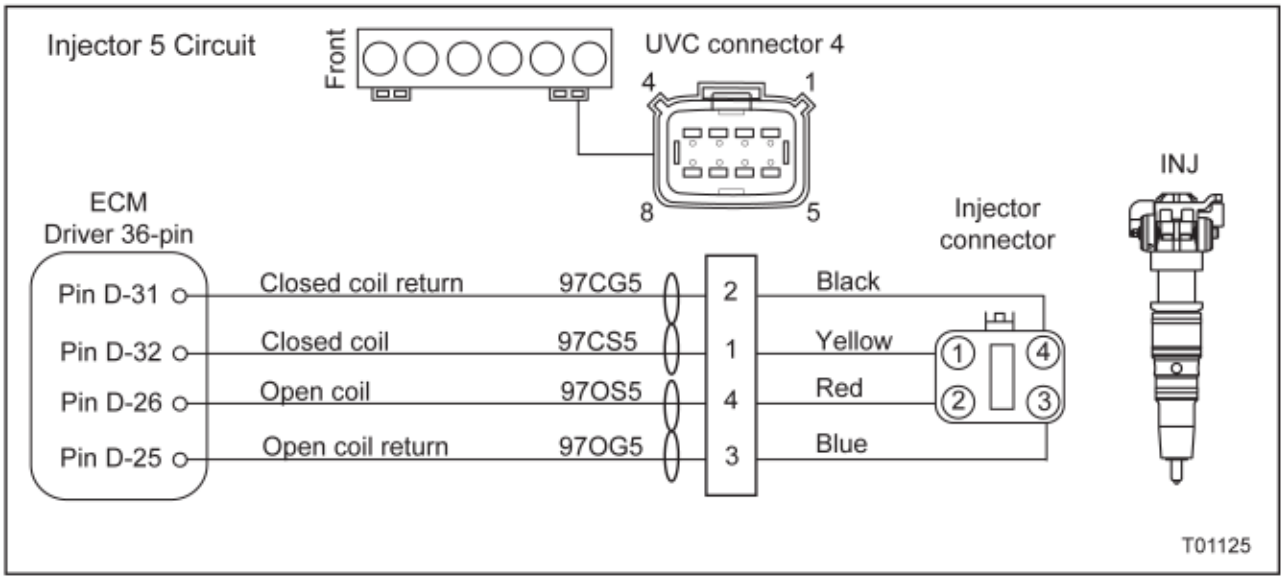


Figure 385 Injector 5 circuit diagram

Injector 5 – Resistance Through Valve Cover Check

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 prevent engine damage, turn the ignition switch OFF before disconnecting connectors. Failure to turn the ignition switch OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch to OFF. Connect Breakout Harness 4793 to the valve cover connector. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
1 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
2 to GND	> 1 kΩ	
3 to GND	> 1 kΩ	
4 to GND	> 1 kΩ	

Injector 5 – Coil Resistance Check

Turn ignition switch to OFF. Connect Breakout Harness 4793 to the valve cover connector. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
1 to 2	0.5 to 1.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
3 to 4	0.5 to 1.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
1 to 3	> 1 kΩ	If < 1 kΩ, check for cross shorted circuits or injector coil for internal short.

Injector 5 – Harness Resistance Check

Turn ignition switch to OFF. Connect 180-pin Breakout Box and injector circuit breakout to engine harness. Leave ECM and UVC disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
D-25 to 3	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-25 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-26 to 4	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-26 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-31 to 2	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-31 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-32 to 1	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-32 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector 6 Checks

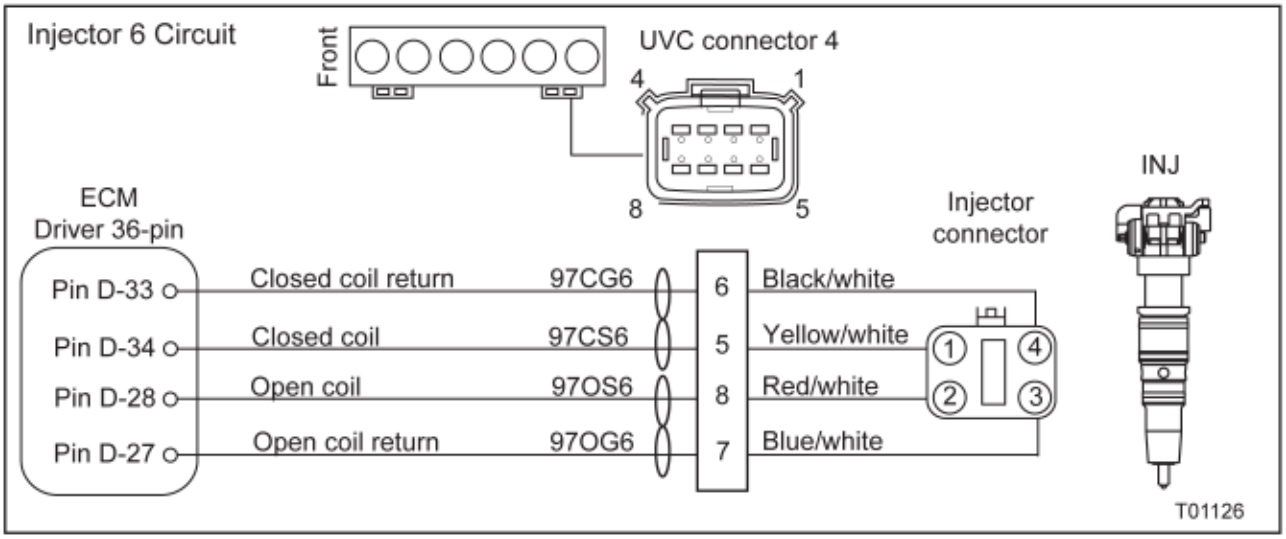


Figure 386 Injector 6 circuit diagram

Injector 6 – Resistance Through Valve Cover Check

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 prevent engine damage, turn the ignition switch OFF before disconnecting connectors. Failure to turn the ignition switch OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch to OFF. Connect Breakout Harness 4793 to the valve cover connector. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
5 to GND	> 1 kΩ	
6 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
7 to GND	> 1 kΩ	
8 to GND	> 1 kΩ	

Injector 6 – Coil Resistance Check

Turn ignition switch to OFF. Connect Breakout Harness 4793 to the valve cover connector. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
5 to 6	0.5 to 1.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
7 to 8	0.5 to 1.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
5 to 7	> 1 kΩ	If < 1 kΩ, check for cross shorted circuits or injector coil for internal short.

Injector 6 – Harness Resistance Check

Turn ignition switch to OFF. Connect 180-pin Breakout Box and injector circuit breakout to engine harness. Leave ECM and UVC disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
D-27 to 7	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-27 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-28 to 8	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-28 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-33 to 6	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-33 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D-34 to 5	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D-34 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Injector Circuit Operation

Each injector has an open and closed coil. The ECM controlling circuits run from the 36-pin driver connector, through the 8-pin UVC connector, to the injector 4-pin connector.

When a coil needs to be energized, the ECM turns on the high and low side driver. The high side output supplies the injectors with a power supply of 48 volts DC at 20 amps. The low side output supplies a return circuit to each injector coil.

High Side Drive Output

The ECM regulates the current at an average of 20 amps. When the current reaches 24 amps, the ECM shuts off the high side driver. When the current drops to 16 amps, the ECM turns on the high side driver.

Low Side Drive Return

The injector solenoids are grounded through the low side return circuits. The ECM monitors the low side return signal for diagnostic purposes and utilizes the fly-back current from the injector solenoids to help charge the drive capacitors internally to the ECM.

Fault Detection / Management

The ECM continuously monitors the amount of time (rising time) taken by each coil to draw 20 amps. The time is compared to calibrated values and the ECM determines if a circuit or injector fault exists. Each injector has six failure modes and three codes. A failure can occur on the open or closed coil circuit. When a fault is detected, a code will be set.

When a short to ground condition is detected on an injector (low or high side), the ECM discontinues power to the shorted injector and operates the engine on the remaining cylinders.

When the engine is running, the ECM can detect individual injector coil and shorts to ground or battery.

KOEO Injector Test

This test allows the operator to enable all injector coils when the engine is off, to verify circuit operation.

During this test, injector solenoids will click in numeric order, not the firing order. If one or more injectors can not be heard, the injector is not working due to a circuit fault, injector, or an ECM failure.

SPN 651 – 656

FMI 7 – Injector 1 through 6 Fuel Spool Motion Compensation Max Authority Reached

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Injector Spool Motion Compensation Max authority reached	Average filtered close end of motion adaptation time (Calculated based on back EMF) < 0.6 * e^{-3} seconds OR > 0.9 * e^{-3} seconds	Injection Control Pressure (ICP) > 3191 psi (22 MPa) AND < 4931 psi (34 MPa)	Immediate
		Engine Speed > 1500 rpm	
		Minimum number of close loop samples to calculate average value of adaptation ≥ 100 samples	
		Engine Oil Temperature (EOT) > 158°F (70°C)	
		Time between two consecutive adaptations ≥ 18,000 seconds	
		Main Injection Time duration ≥ 1 * e^{-3} seconds	
		Adaptive Waveform and Negative current strategy is OFF {Adaptive Waveform and Negative current strategy is described in Operations Summary document}	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the Injector spool motion compensation has reached its maximum allowable time limit.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

Step	Action	Decision
1	Retrieve engine repair history from ISIS® network, and identify if affected injector was replaced. Has affected injector NOT been recently replaced?	Yes: Go to Step 2.
		No: Using Electronic Service Tool (EST) with ServiceMaxx™ software, reset Engine Control Module (ECM) programmable parameter 'Cyl [affected injector number]: Close end of motion average time reference value has been properly measured'. After repairs are complete, retest for SPN 651 – 656 FMI 7.

Step	Action	Decision
2	Identify faulty injector from SPN for fault. **NOTE:** Final number of the SPN identifies the affected injector, and the name in ServiceMaxx™ identifies the cylinder in which the injector is installed. Is more than one injector affected?	Yes: Go to Step 1, and determine replacement history for additional affected injectors.
		No: Replace affected injector, and refer to Step 1 to reset the 'Cyl [affected injector number]: Close end of motion average time reference value has been properly measured' programmable parameter. After repairs are completed, retest for SPN 651 – 656 FMI 7.

NOTE: After doing all diagnostic steps, if SPN 651 – 656 FMI 7 remains, verify each step was completed correctly and proper decisions were made. Notify supervisor for further action.

SPN 651 – 656

FMI 14 – Injector 1 through 6 Fuel Quantity / Timing Error

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel Quantity, Pressure and Timing deviation HIGH for Single Injector. Comparison of cylinder balance difference between two consecutive cylinders. Cylinder balance difference is calculated based on segment time.	Cylinder balance difference (dimensionless quantity) > 0.7	Particulate Filter Regeneration NOT Active	0.25 seconds
	AND [Pattern detection cylinder balance difference value ≤ 0.05005	End Of Line Testing NOT Active	
	for = 3 cylinders]	Engine Coolant Temperature > 86°F (30°C) AND < 248°F (120°C)	
		Engine Manifold Pressure < 17 psi (119.9 kPa)	
		Battery Voltage > 9 Volts	
		Mass fueling ≥ 1 mg/strk) AND ≤ 199.2 mg/strk	
		Vehicle Speed ≥ 0 mph (0 kph) AND ≤ 3.1 mph (5 kph)	
		Engine Speed ≥ 650 rpm AND ≤ 850 rpm	
		Filter Stabilization Time > 10 seconds	
		Pressure Control Valve Command < 100 %	
		Engine Air Inlet Temperature > -40°F (-40°C) AND < 212°F (100°C)	
		Fuel Temperature	

FMI 14 – Injector 1 through 6 Fuel Quantity / Timing Error (cont.)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		> -58°F (-50°C)	
		Engine Oil Temperature (EOT) > -4°F (-20°C)	
		SPN / FMIs 27/14, 51/3, 51/4, 51/7, 94/3, 94/4, 108/3, 108/4, 110/2, 110/3, 110/4, 132/0, 132/1, 132/3, 132/4, 164/0, 164/3, 164/4, 175/2, 175/3, 175/4, 191/3, 191/4, 636/2, 636/7, 651/4, 651/5, 651/7, 652/4, 652/5, 652/7, 653/4, 653/5, 653/7, 654/4, 654/5, 654/7, 655/4, 655/5, 655/7, 656/4, 656/5, 656/7, 1189/3, 1189/4, 1322/31, 1323/31, 1324/31, 1325/31, 1326/31, 1327/31, 1328/31, 2659/20, 2791/2, 2791/3, 2791/4, 2791/7, 2791/8, 2791/14, 3055/2, 3464/11, 4257/7, 5395/0, 5395/1, 5543/3, 5543/4, 5543/5 are NOT Active	

FMI 14 – Injector 1 through 6 Fuel Quantity / Timing Error (Table 2)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel Quantity, Pressure and Timing deviation HIGH for Single Injector. Comparison of cylinder balance difference between two consecutive cylinders. Cylinder balance diff is calculated based on segment time.	Cylinder balance difference (dimensionless quantity) ≤ 0.75	Particulate Filter Regeneration NOT Active	0.25 seconds
	AND [Pattern detection cylinder balance difference value > 0.05005	End Of Line Testing NOT Active	
	for = 3 cylinders]	Engine Coolant Temperature > 86°F (30°C) AND < 248°F (120°C)	
		Engine Manifold Pressure < 17 psi (119.9 kPa)	
		Battery Voltage	

FMI 14 – Injector 1 through 6 Fuel Quantity / Timing Error (Table 2) (cont.)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		> 9 Volts	
		Mass fueling ≥ 1 mg/strk AND ≤ 199.2 mg/strk	
		Vehicle Speed ≥ 0 mph (0 kph) AND ≤ 3.1 mph (5 kph)	
		Engine Speed ≥ 650 rpm AND ≤ 850 rpm	
		Filter Stabilization Time > 10 seconds	
		Pressure Control Valve Command < 100 %	
		Engine Air Inlet Temperature > -40°F (-40°C) AND < 212°F (100°C)	
		Fuel Temperature > -58°F (-50°C)	
		Engine Oil Temperature (EOT) > -4°F (-20°C)	
		SPN / FMIs 27/14, 51/3, 51/4, 51/7, 94/3, 94/4, 108/3, 108/4, 110/2, 110/3, 110/4, 132/0, 132/1, 132/3, 132/4, 164/0, 164/3, 164/4, 175/2, 175/3, 175/4, 191/3, 191/4, 636/2, 636/7, 651/4, 651/5, 651/7, 652/4, 652/5, 652/7, 653/4, 653/5, 653/7, 654/4, 654/5, 654/7, 655/4, 655/5, 655/7, 656/4, 656/5, 656/7, 1189/3, 1189/4, 1322/31, 1323/31, 1324/31, 1325/31, 1326/31, 1327/31, 1328/31, 2659/20, 2791/2, 2791/3, 2791/4, 2791/7, 2791/8, 2791/14, 3055/2, 3464/11, 4257/7, 5395/0,	

FMI 14 – Injector 1 through 6 Fuel Quantity / Timing Error (Table 2) (cont.)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		5395/1, 5543/3, 5543/4, 5543/5 are NOT Active	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the injector timing is off when comparing the cylinder balance difference between two consecutive cylinders.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for fault codes. Is SPN 651 – 656 FMI 14 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 651 – 656 FMI 14. No: Go to Step 3.

Step	Action	Decision
3	Test for failed injector. Do Key On Engine OFF Injector Test (page 87). Did KOEO Injector Test pass?	Yes: Go to Step 6. No: Go to Step 4.

Step	Action	Decision
4	Test injector circuit resistance through valve cover and, if indicated, injector coil resistance. Do resistance checks (page 931). Are injector circuits inside the valve cover and injector coils within specifications?	Yes: Go to Step 6. No: Go to Step 5.

Step	Action	Decision
5	Isolate electrical failure to injector or harness. Remove valve cover, disconnect harness from injector, and do coil resistance checks (page 931) on the suspect injector. Are injector coils within specification?	Yes: Go to Step 6. No: Replace suspect injector or under-valve cover wiring harness as indicated. After repairs are complete, retest for SPN 651 – 656 FMI 14.

Step	Action	Decision
6	Using terminal test kit, inspect connections at injector circuits outside valve cover. With key OFF, disconnect injector circuits outside valve cover. Check each injector circuit and connector outside valve cover for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are each of the injector sensor connectors, harnesses, and terminals clean and undamaged?	Yes: Go to Step 7. No: Repair any connector, harness, or terminal damage. After repairs are complete, retest for SPN 651 – 656 FMI 14.

Step	Action	Decision
7	Inspect air intake system, exhaust system, and air filter for restrictions, leaks, or physical damage. Inspect air cleaner cleanliness and Mass Air Flow (MAF) sensor or dirt and oil residue. Inspect the fuel system from fuel tank to Aftertreatment Fuel Injector (AFI) valve for leaks or physical damage. Are air intake system, exhaust system, fuel system, and air filter free of restrictions, leaks, and physical damage?	Yes: Go to Step 8. No: Repair restrictions, air leaks, fuel leaks, or physical damage. After repairs are complete and retest for SPN 651 – 656 FMI 14.

Step	Action	Decision
8	Check for fuel level and fuel quality. Visually inspect by removing fuel cap from all tanks, check Water In Fuel (WIF) light, and sample for dirty or aerated fuel. Is there sufficient supply of good quality fuel?	Yes: Go to Step 9. No: Remove dirty or aerated fuel, fill with good quality fuel. After repairs are complete and retest for SPN 651 – 656 FMI 14.

Step	Action	Decision
9	Check for oil and oil quality, including oil level check and aerated oil. Is there sufficient supply of clean, non-aerated oil?	Yes: Go to Step 10. No: Remove dirty, aerated, or contaminated oil, fill with clean, non-aerated oil. After oil replacement is complete, retest for SPN 651 – 656 FMI 14.

Step	Action	Decision
10	Determine if Engine Compression Brake (ECB), if equipped. is operating correctly. Using EST with ServiceMaxx™ software, do Engine Low Idle to High Idle test (page 199) while monitoring Brake Control Pressure (ECBP). Is ECBP less than 218 psi (1.5 MPa)?	Yes: Go to Step 11. No: Replace ECB valve. After repairs are complete and retest for SPN 651 – 656 FMI 14.

Step	Action	Decision
11	Calibrate MAF sensor. Do MAF Calibration Procedure (page 1101). Did MAF auto-calibrated succeed?	Yes: Go to Step 12. No: Perform test and procedures for a malfunctioning MAF sensor (page 1103). After repairs are complete and retest for SPN 651 – 656 FMI 14.

Step	Action	Decision
12	Determine cause of rough engine idle. Do Relative Compression Test (page 92). Are all engine cylinder performance readings similar?	Yes: Go to Step 14. No: Go to Step 13.

Step	Action	Decision
13	Test cylinder performance further. Do Cylinder Performance Analyzer (CPA) test (see *IK1200812 Diagnosing Performance Related Symptoms Using the CPA Tool*) to evaluate cylinder performance issues. Evaluate performance concerns during hot idle, cold idle (optional), and a full load highway speed test. Did tests finish without identifying a suspect cylinder? **NOTE:** Due to the complexity of some of the codes, print out the CPA tool results for later use.	Yes: Go to Step 10. No: Remove valve cover, check valve lash, and crank engine to verify cam shaft lobe operation and lift (See Engine Service Manual). Repair as required, and retest for SPN 651 – 656 FMI 14.

Step	Action	Decision
14	Test for oil leaks under the valve cover. Using Leak Detection Pump Tool, test for oil leaking from or around ECB valve, center of oil rail to cylinder head, injector oil inlet adapters (puck), and ICP sensor. Are the listed items leak-free? Note: Some leakage around injector spool valves is normal.	Yes: After doing all diagnostic steps, if SPN 651 – 656 FMI 14 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Remove rail and replace any of the following as required: ECB valve, center of oil rail to cylinder head O-ring, leaking

Step	Action	Decision
		injector oil inlet adapter, and/or ICP sensor. After replacement is complete, retest for SPN 651 – 656 FMI 14.

NOTE: After doing all diagnostic steps, if SPN 651 – 656 FMI 14 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 2797 FMI 6 - Injector Control Group 1 Open coil - Short Circuit (INJ 1, 2, 3)

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Short circuit detection on Bank 0 Open coil {Bank 0: Injector Number 1, 2, and 3} Short circuit detection on Bank 0 Close coil {Bank 0: Injector Number 1, 2, and 3}	Driver indicates short circuit on Open coil. Current detected by driver > 50 Amps Driver indicates short circuit on Close coil. Current detected by driver > 50 Amps	Key ON, Engine Running Battery voltage > 9 Volts Injectors firing

Fault Overview

Fault code sets when short circuit is detected on Bank 0 (Injectors 1, 2, and 3) Open or Close coil.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive trips.

Associated Faults

SPN 651-653 FMI 4 and 5; SPN 3659-3661 FMI 4 and 5

Fault Facts

None

Drive Cycle to Determine Fault Status

Continuous

Possible Causes

- Fuel injector 1 Open circuit short to GND
- Fuel injector 1 Close circuit short to GND
- Fuel injector 1 Open circuit short to PWR
- Fuel injector 1 Close circuit short to PWR
- Fuel Injector 1 Open H shorted to Open L
- Fuel Injector 1 Close H shorted to Close L
- Fuel Injector 1 Close circuit shorted to Open circuit
- Failed Fuel Injector 1
- Fuel injector 2 Open circuit short to GND
- Fuel injector 2 Close circuit short to GND
- Fuel injector 2 Open circuit short to PWR
- Fuel injector 2 Close circuit short to PWR

- Fuel Injector 2 Open H shorted to Open L
- Fuel Injector 2 Close H shorted to Close L
- Fuel Injector 2 Close circuit shorted to Open circuit
- Failed Fuel Injector 2
- Fuel injector 3 Open circuit short to GND
- Fuel injector 3 Close circuit short to GND
- Fuel injector 3 Open circuit short to PWR
- Fuel injector 3 Close circuit short to PWR
- Fuel Injector 3 Open H shorted to Open L
- Fuel Injector 3 Close H shorted to Close L
- Fuel Injector 3 Close circuit shorted to Open circuit
- Failed Fuel Injector 3

Step 1	Check for active or pending fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software. A. Key ON, clear codes. B. Key OFF, wait for EST screens to clear. C. Key ON, check Diagnostic Trouble Code (DTC) list for SPN 2797 FMI 6. Is EST DTC list SPN 2797 FMI 6 active or pending?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Check for associated fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 651-653 FMI 4 and 5; SPN 3659-3661 FMI 4 and 5. Is EST DTC list free of SPN 651-653 FMI 4 and 5; SPN 3659-3661 FMI 4 and 5?		Yes: Go to Step 3. No: Repair SPN 651-653 FMI 4 and 5; SPN 3659-3661 FMI 4 and 5. After repairs are complete, retest for SPN 2797 FMI 6.

Step 3	Inspect connections at Under Valve Connector (UVC) connector 2.	Decision
A. Key OFF B. Disconnect UVC 2 C. Check UVC 2 and connector terminals for: damaged or pinched wires; moisture in terminals; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are UVC 2 connector, harness, and terminals clean and undamaged?		Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2797 FMI 6.

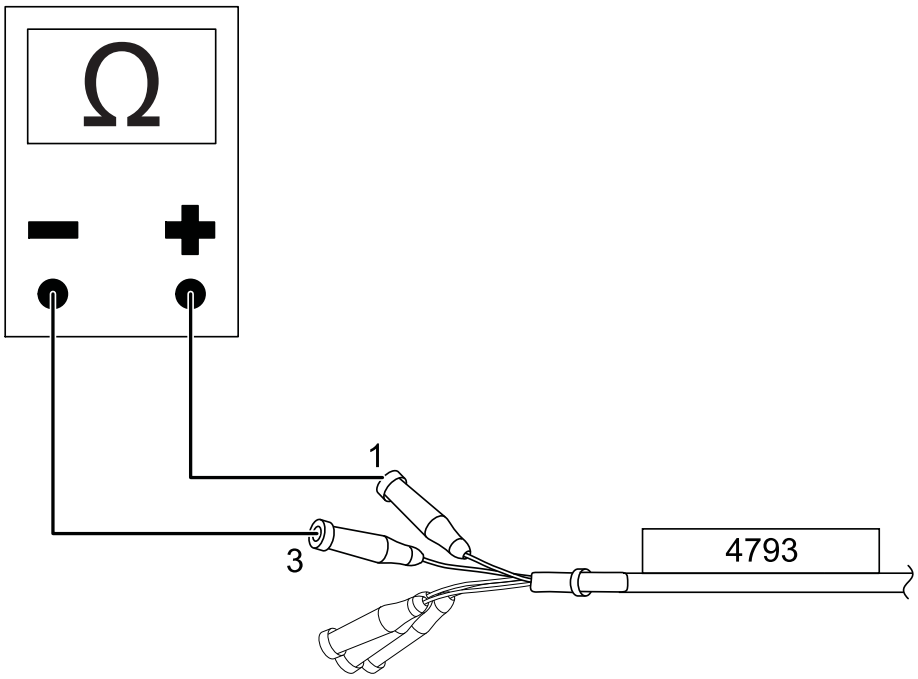
Step 4	Inspect connections at Under Valve Connector (UVC) connector 3.	Decision
A. Key OFF B. Disconnect UVC 3 C. Check UVC 3 and connector terminals for: damaged or pinched wires; moisture in terminals; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are UVC 3 connector, harness, and terminals clean and undamaged?		Yes: Perform pinpoint tests(page 956). No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2797 FMI 6.

Pin-Point Tests (SPN 2797 FMI 6)

See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4793
- Digital Multimeter (DMM)

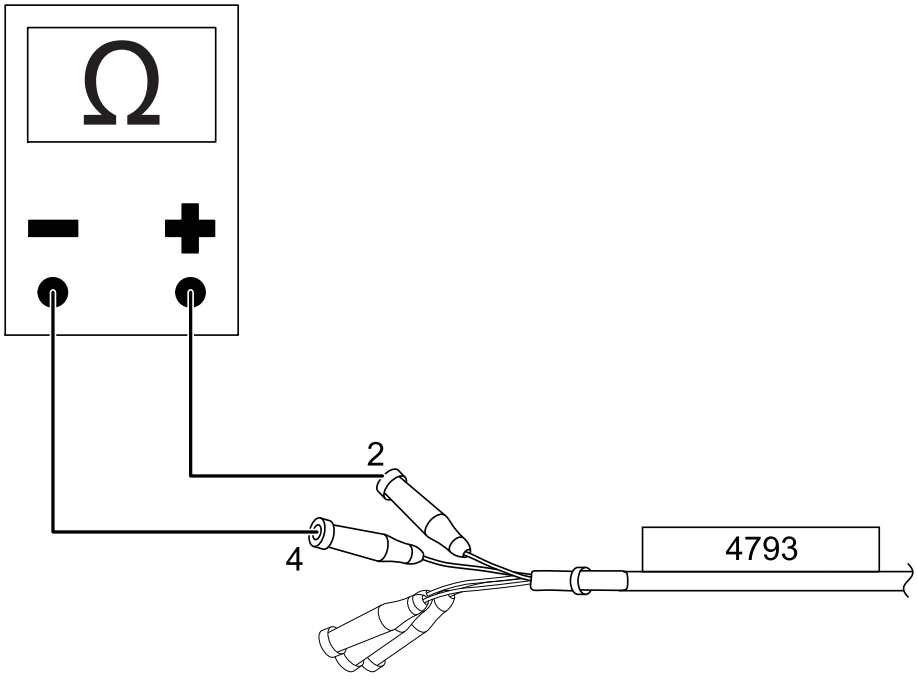


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Figure 387 Test 1 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 1 Setup
A. Key OFF. B. Disconnect Under Valve Connector (UVC) connector 2. C. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. D. Key ON.

Test 1	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-1 and pin-3.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 2.
	No: Repair short between circuits. After repairs are complete, retest for SPN 2797 FMI 6

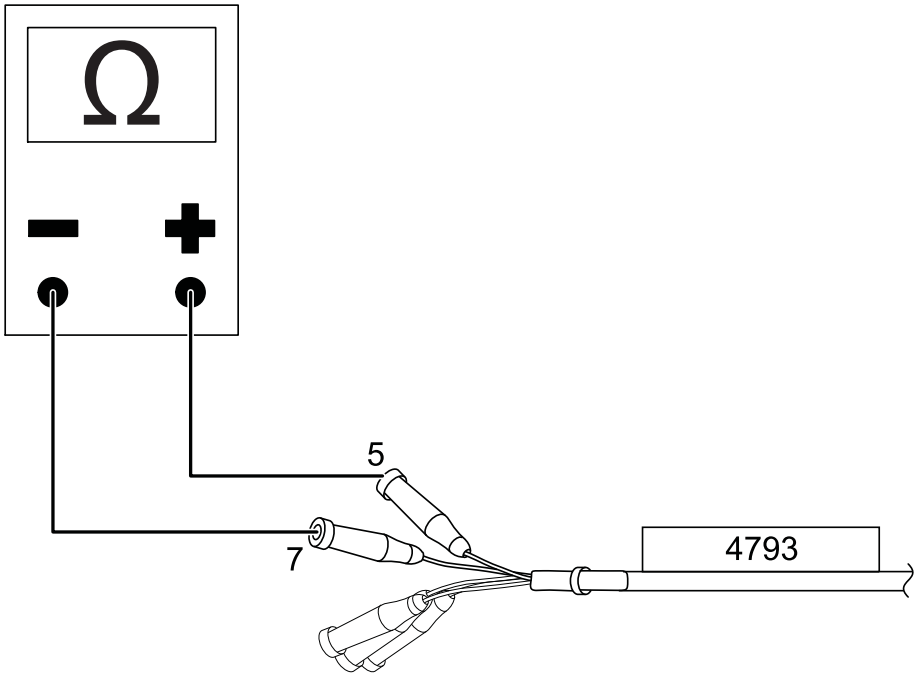


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Figure 388 Test 2 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 2 Setup
A. Key OFF. B. Disconnect Under Valve Connector (UVC) connector 2. C. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. D. Key ON.

Test 2	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-2 and pin-4.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 3.
	No: Repair short between circuits. After repairs are complete, retest for SPN 2797 FMI 6

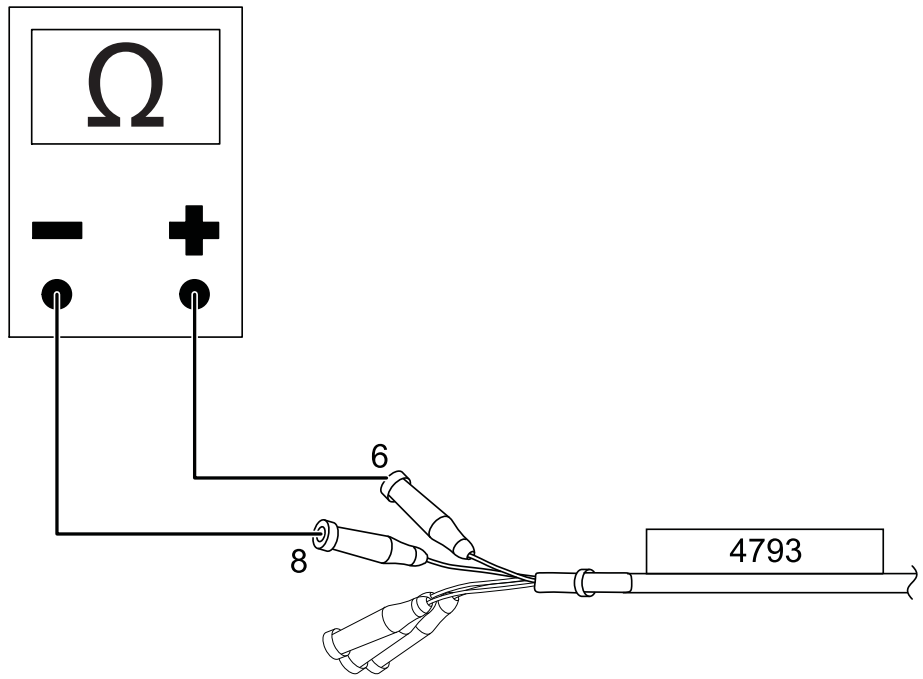


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Figure 389 Test 3 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 3 Setup
A. Key OFF. B. Disconnect Under Valve Connector (UVC) connector 2. C. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. D. Key ON.

Test 3	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-5 and pin-7.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 4.
	No: Repair short between circuits. After repairs are complete, retest for SPN 2797 FMI 6

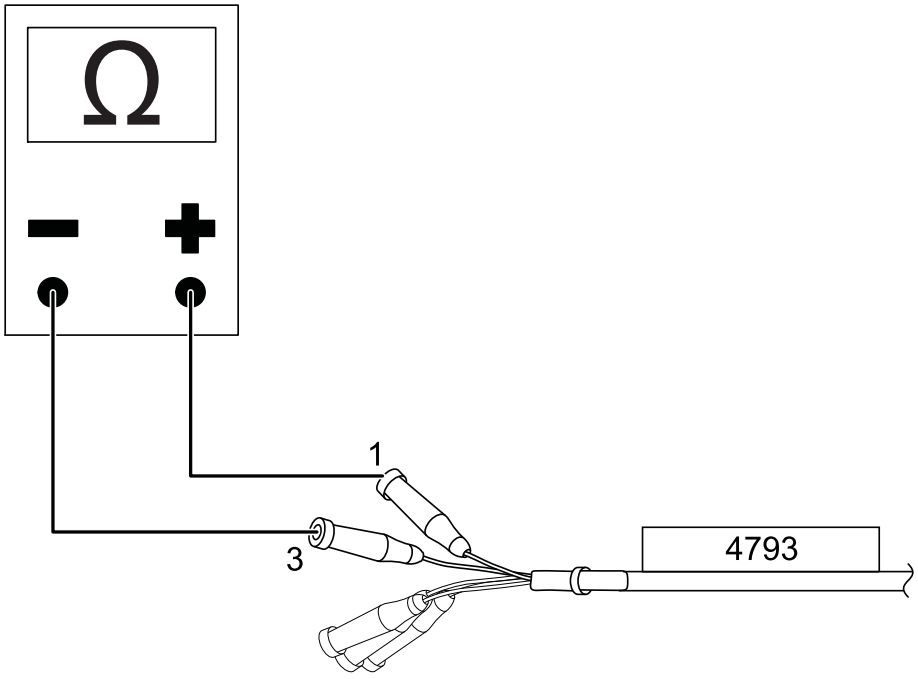


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Figure 390 Test 4 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 4 Setup
A. Key OFF. B. Disconnect Under Valve Connector (UVC) connector 2. C. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. D. Key ON.

Test 4	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-6 and pin-8.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 5.
	No: Repair short between circuits. After repairs are complete, retest for SPN 2797 FMI 6

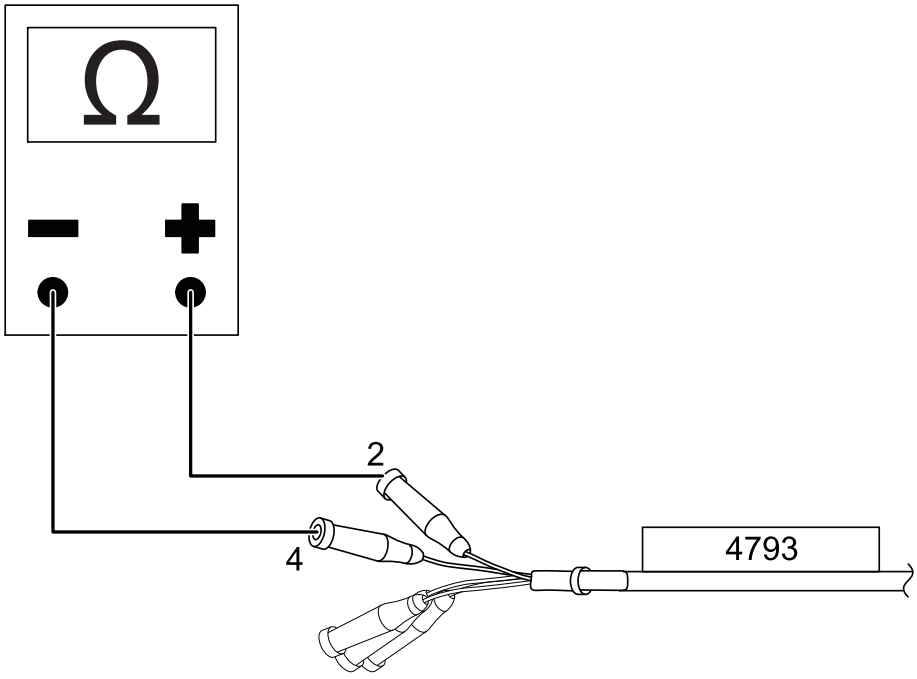


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Figure 391 Test 5 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 5 Setup
A. Key OFF. B. Disconnect Under Valve Connector (UVC) connector 3. C. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. D. Key ON.

Test 5	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-1 and pin-3.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 6.
	No: Repair short between circuits. After repairs are complete, retest for SPN 2797 FMI 6

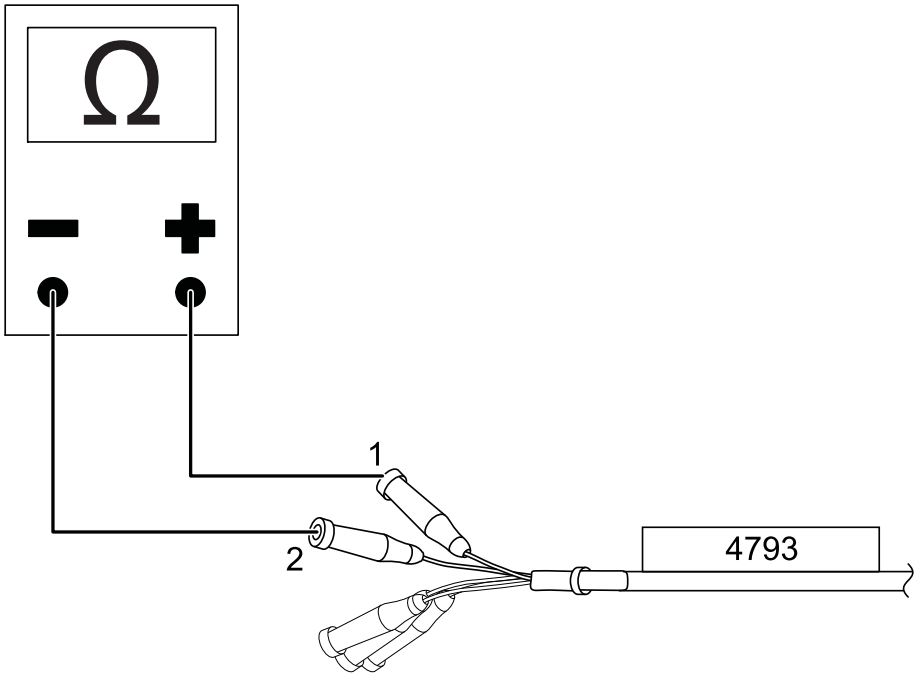


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Figure 392 Test 6 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 6 Setup
A. Key OFF. B. Disconnect Under Valve Connector (UVC) connector 3. C. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. D. Key ON.

Test 6	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-2 and pin-4.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 7.
	No: Repair short between circuits. After repairs are complete, retest for SPN 2797 FMI 6

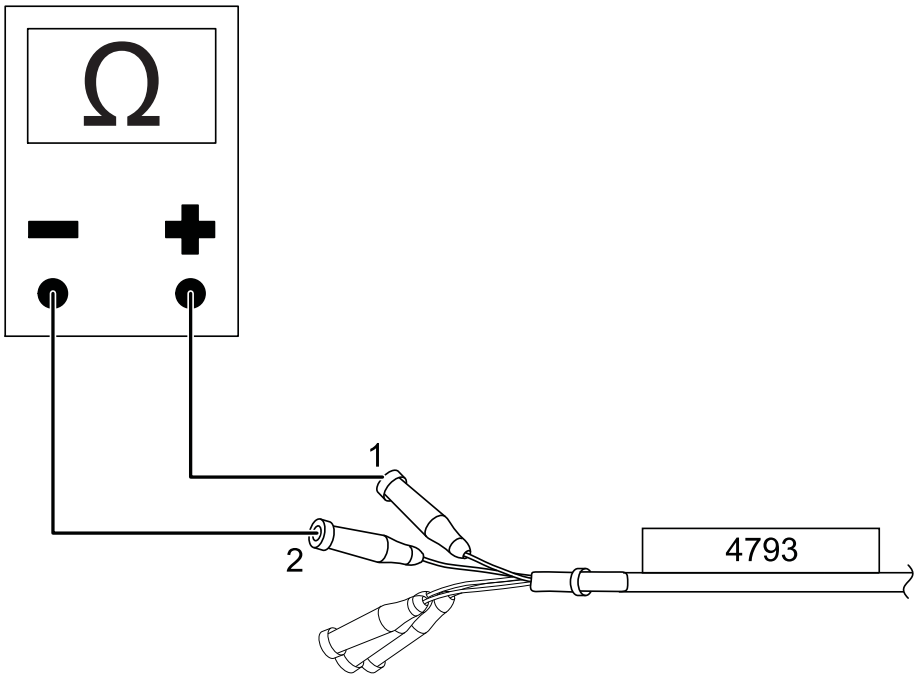


0000326341

Figure 393 Test 7 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 7 Setup
A. Key OFF. B. Disconnect Under Valve Connector (UVC) connector 2. C. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. D. Key ON.

Test 7	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-1 and pin-2.	1 ± 0.5 ohms
Decision	
Is resistance less than 0.5 ohms?	Yes: Go to Test 8.
	No: Go to Test 9.

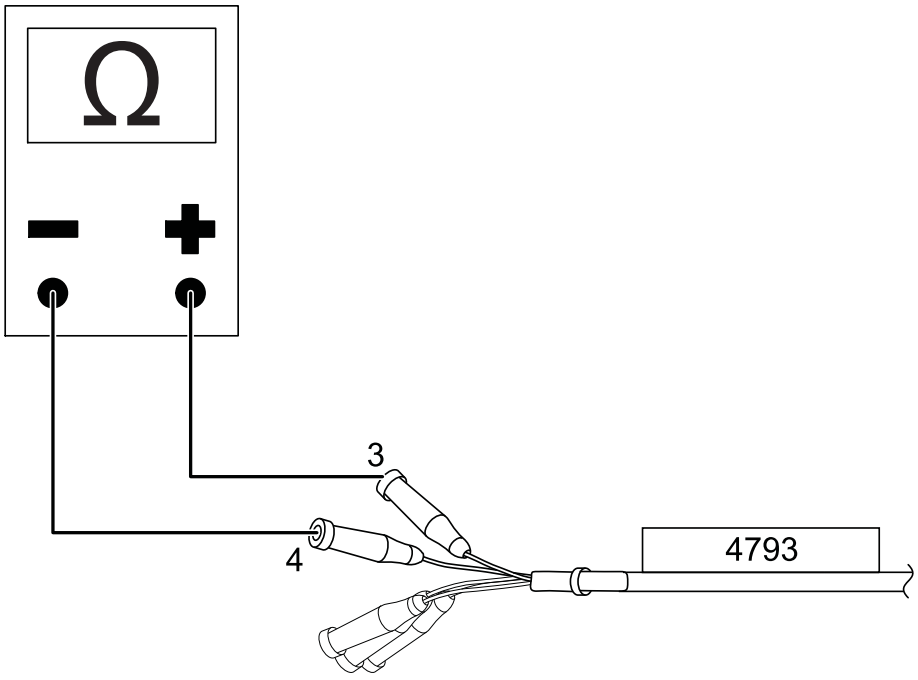


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Figure 394 Test 8 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 8 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 1. C. Disconnect Under Valve Connector (UVC) connector 2. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. E. Key ON.

Test 8	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-1 and pin-2.	1 ± 0.5 ohms
Decision	
Is resistance less than 0.5 ohms?	Yes: Repair short in injector 1 Close coil circuit. After repairs are complete, retest for SPN 2797 FMI 6.
	No: Replace fuel injector 1. After repairs are complete, retest for SPN 2797 FMI 6.

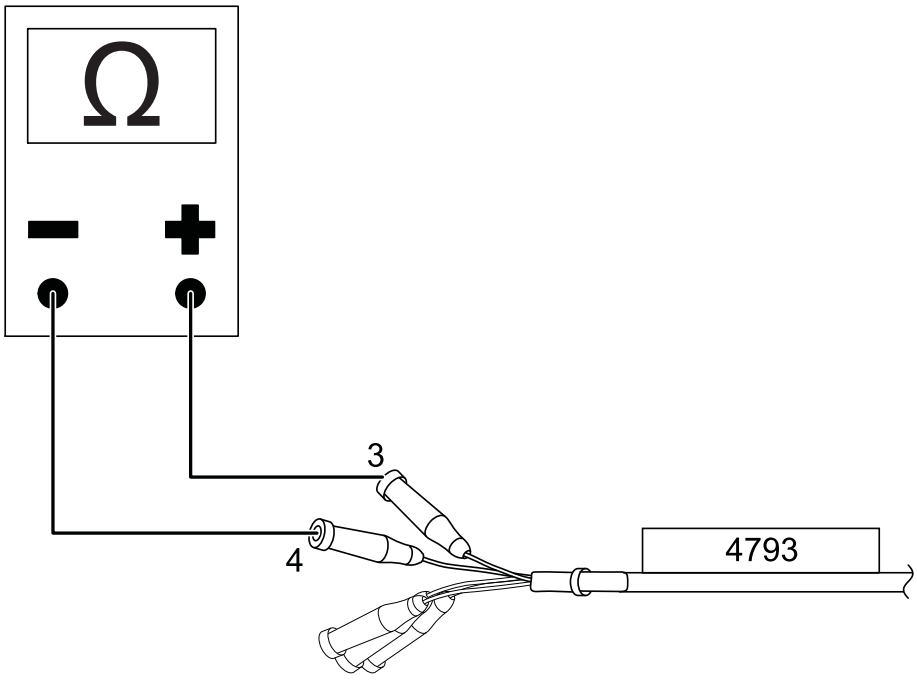


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Figure 395 Test 9 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 9 Setup
A. Key OFF. B. Disconnect Under Valve Connector (UVC) connector 2. C. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. D. Key ON.

Test 9	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-3 and pin-4.	1 ± 0.5 ohms
Decision	
Is resistance less than 0.5 ohms?	Yes: Go to Test 10.
	No: Go to Test 11.

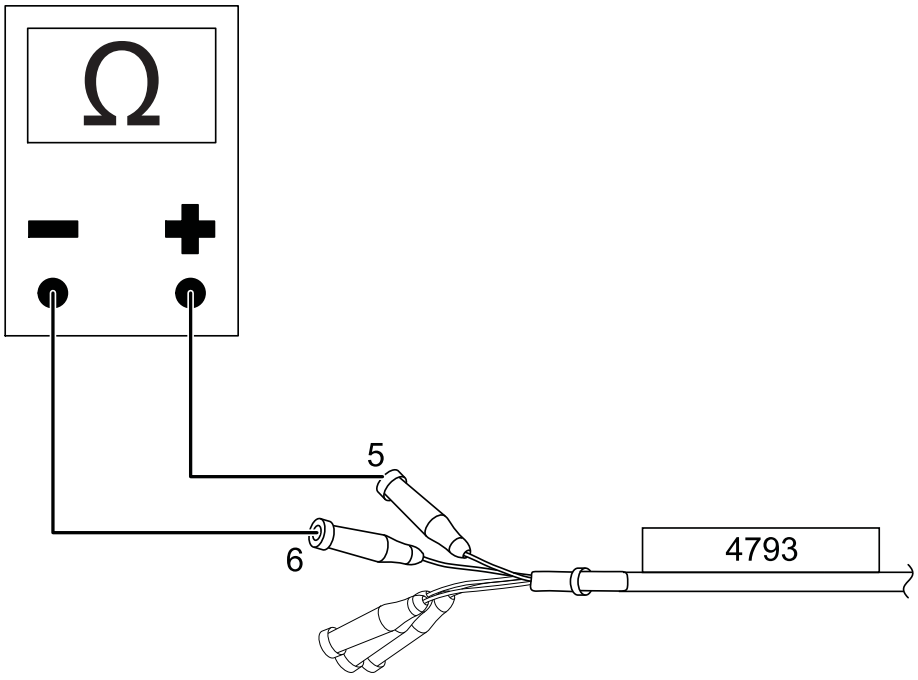


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Figure 396 Test 10 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 10 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 1. C. Disconnect Under Valve Connector (UVC) connector 2. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. E. Key ON.

Test 10	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-3 and pin-4.	1 ± 0.5 ohms
Decision	
Is resistance less than 0.5 ohms?	Yes: Repair short in injector 1 Open coil circuit. After repairs are complete, retest for SPN 2797 FMI 6.
	No: Replace fuel injector 1. After repairs are complete, retest for SPN 2797 FMI 6.

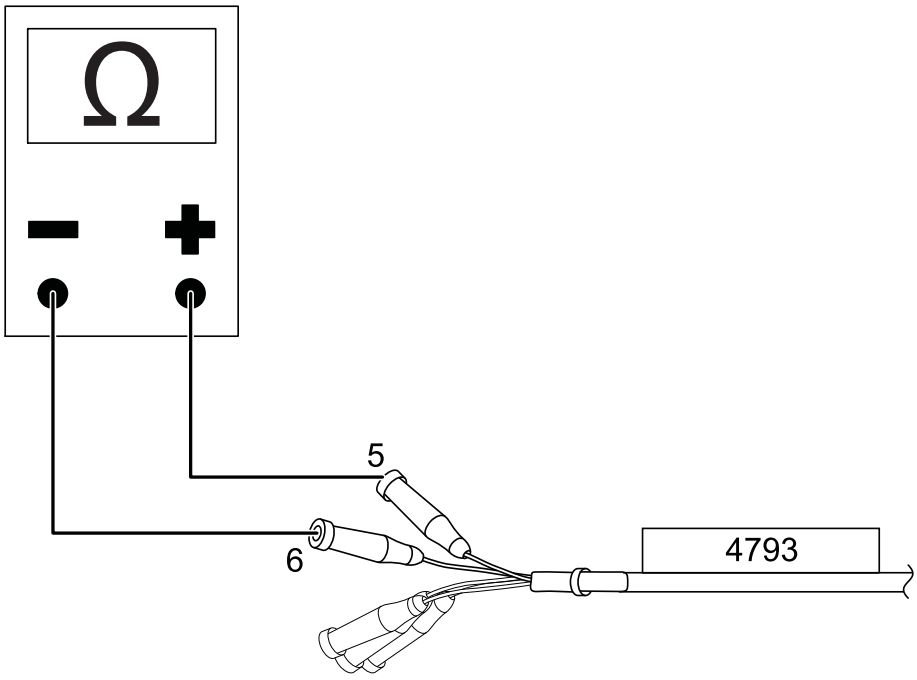


0000326381

Figure 397 Test 11 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 11 Setup
A. Key OFF. B. Disconnect Under Valve Connector (UVC) connector 2. C. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. D. Key ON.

Test 11	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-5 and pin-6.	1 ± 0.5 ohms
Decision	
Is resistance less than 0.5 ohms?	Yes: Go to Test 12.
	No: Go to Test 13.

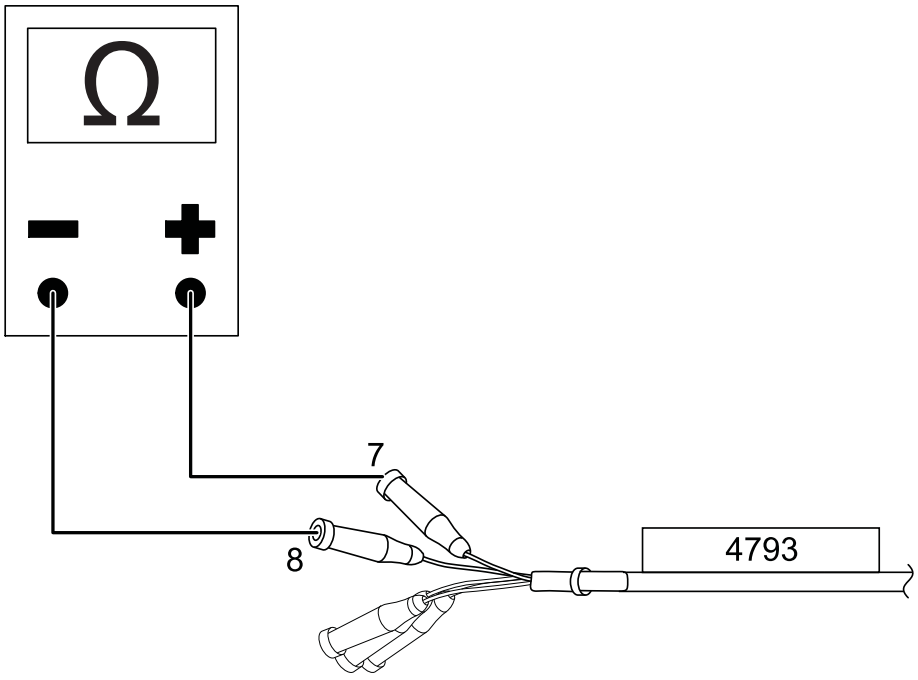


0000326381

Figure 398 Test 12 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 12 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 2. C. Disconnect Under Valve Connector (UVC) connector 2. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. E. Key ON.

Test 12	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-5 and pin-6.	1 ± 0.5 ohms
Decision	
Is resistance less than 0.5 ohms?	Yes: Repair short in injector 2 Close coil circuit. After repairs are complete, retest for SPN 2797 FMI 6.
	No: Replace fuel injector 2. After repairs are complete, retest for SPN 2797 FMI 6.

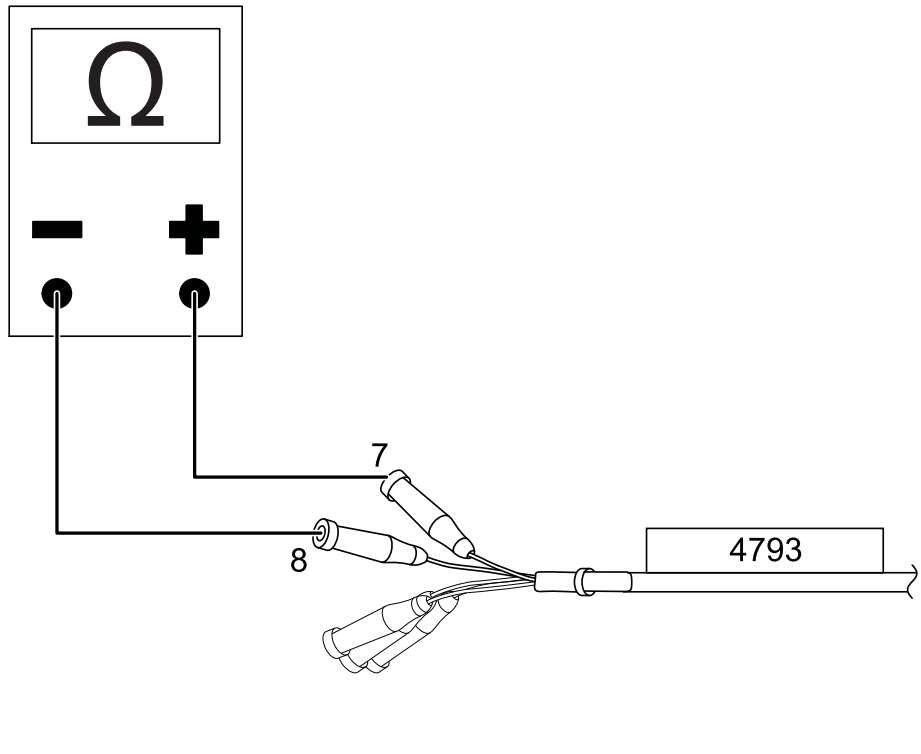


0000326401

Figure 399 Test 13 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 13 Setup
A. Key OFF. B. Disconnect Under Valve Connector (UVC) connector 2. C. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. D. Key ON.

Test 13	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-7 and pin-8.	1 ± 0.5 ohms
Decision	
Is resistance less than 0.5 ohms?	Yes: Go to Test 14.
	No: Go to Test 15.

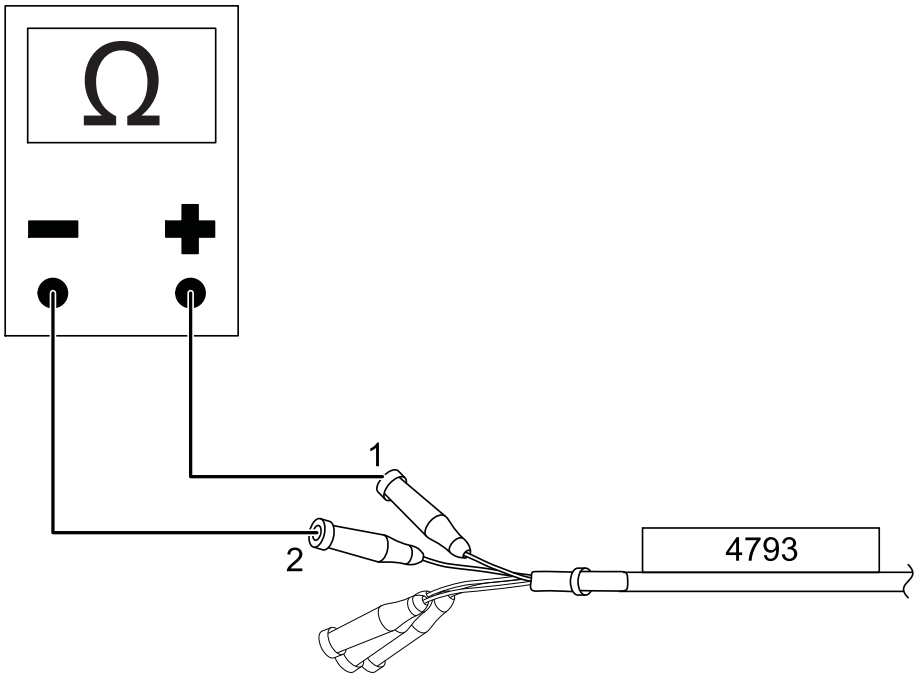


0000326401

Figure 400 Test 14 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 14 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 2. C. Disconnect Under Valve Connector (UVC) connector 2. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. E. Key ON.

Test 14	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-7 and pin-8.	1 ± 0.5 ohms
Decision	
Is resistance less than 0.5 ohms?	Yes: Repair short in injector 2 Open coil circuit. After repairs are complete, retest for SPN 2797 FMI 6.
	No: Replace fuel injector 2. After repairs are complete, retest for SPN 2797 FMI 6.

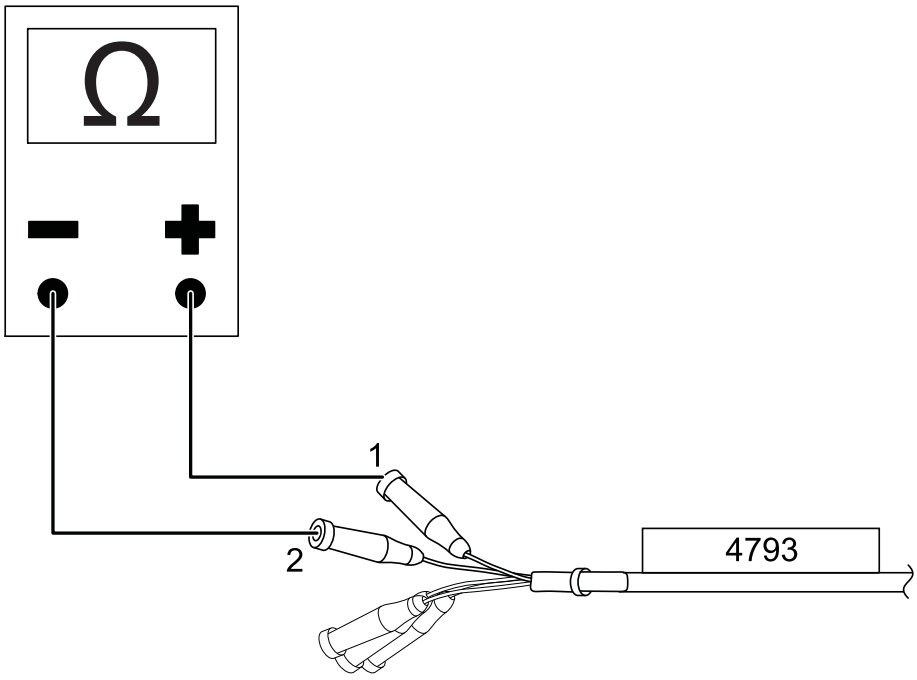


0000326341

Figure 401 Test 15 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 15 Setup
A. Key OFF. B. Disconnect Under Valve Connector (UVC) connector 3. C. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. D. Key ON.

Test 15	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-1 and pin-2.	1 ± 0.5 ohms
Decision	
Is resistance less than 0.5 ohms?	Yes: Go to Test 16.
	No: Go to Test 17.

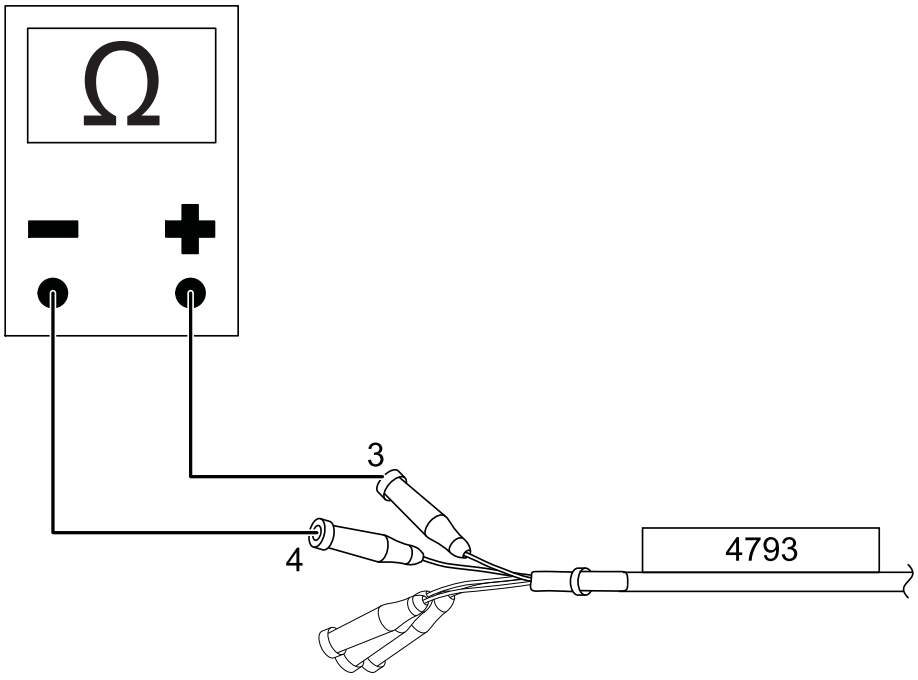


0000326341

Figure 402 Test 16 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 16 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 3. C. Disconnect Under Valve Connector (UVC) connector 3. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. E. Key ON.

Test 16	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-1 and pin-2.	1 ± 0.5 ohms
Decision	
Is resistance less than 0.5 ohms?	Yes: Repair short in injector 3 Close coil circuit. After repairs are complete, retest for SPN 2797 FMI 6.
	No: Replace fuel injector 3. After repairs are complete, retest for SPN 2797 FMI 6.

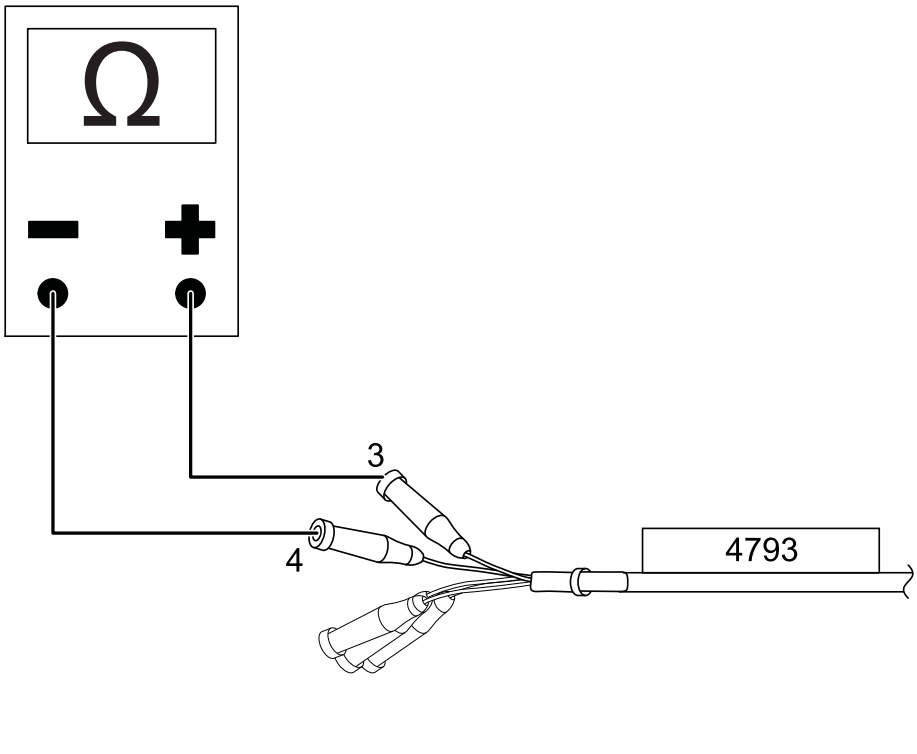


0000326361

Figure 403 Test 17 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 17 Setup
A. Key OFF. B. Disconnect Under Valve Connector (UVC) connector 3. C. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. D. Key ON.

Test 17	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-3 and pin-4.	1 ± 0.5 ohms
Decision	
Is resistance less than 0.5 ohms?	Yes: Go to Test 18.
	No: Go to Test 19.



0000326361

Figure 404 Test 18 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 18 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 3. C. Disconnect Under Valve Connector (UVC) connector 3. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. E. Key ON.

Test 18	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-3 and pin-4.	1 ± 0.5 ohms
Decision	
Is resistance less than 0.5 ohms?	Yes: Repair short in injector 3 Open coil circuit. After repairs are complete, retest for SPN 2797 FMI 6.
	No: Replace fuel injector 3. After repairs are complete, retest for SPN 2797 FMI 6.

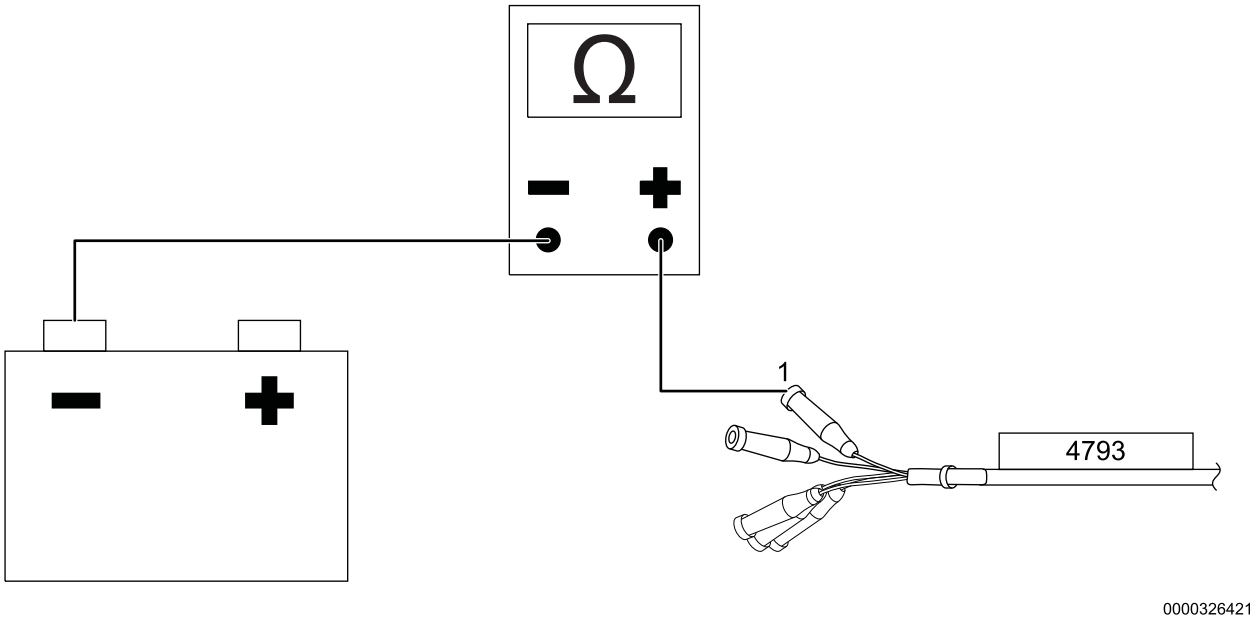


Figure 405 Test 19 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 19 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 1. C. Disconnect Under Valve Connector (UVC) connector 2. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. E. Key ON.

Test 19	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-1 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 20.
	No: Repair short to GND between Injector 1 pin-1 and ECM Driver pin D-8. After repairs are complete, retest for SPN 2797 FMI 6.

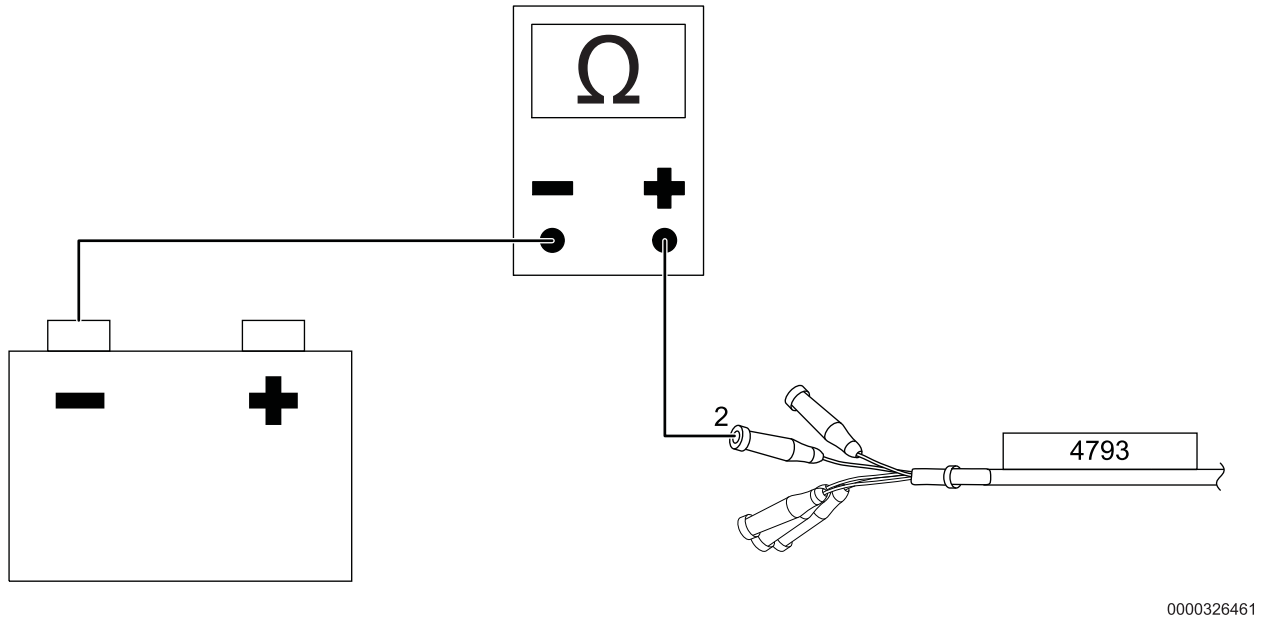


Figure 406 Test 20 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 20 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 1. C. Disconnect Under Valve Connector (UVC) connector 2. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. E. Key ON.

Test 20	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-2 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 21.
	No: Repair short to GND between Injector 1 pin-2 and ECM Driver pin D-7. After repairs are complete, retest for SPN 2797 FMI 6.

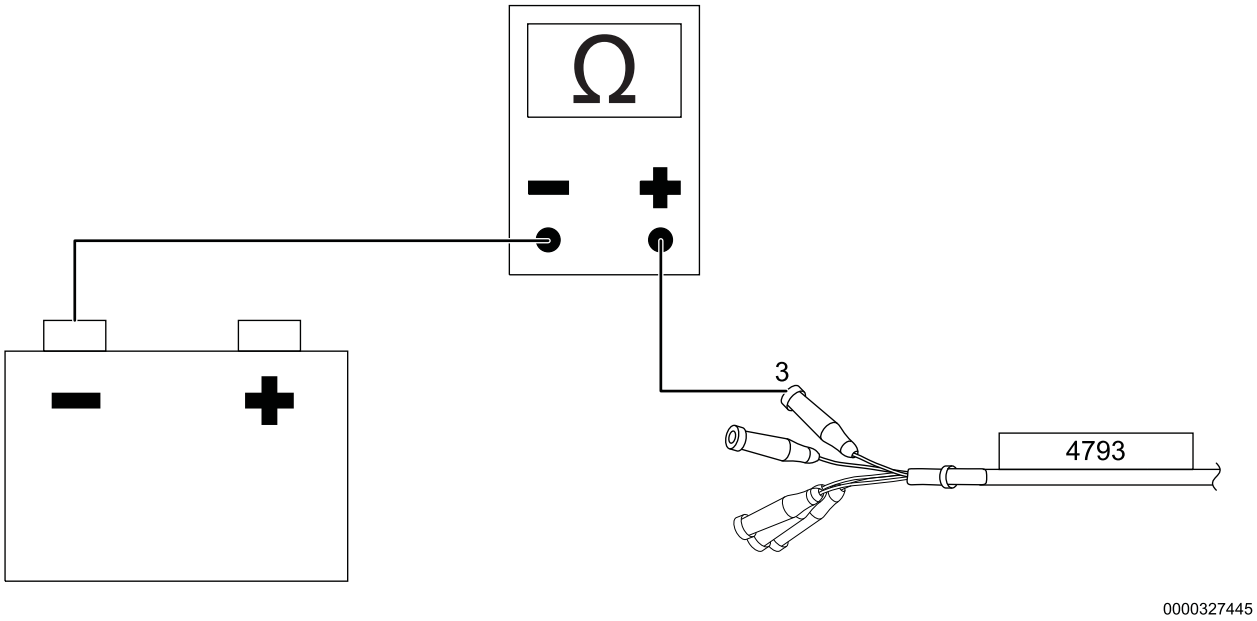


Figure 407 Test 21 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 21 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 1. C. Disconnect Under Valve Connector (UVC) connector 2. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. E. Key ON.

Test 21	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-3 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 22.
	No: Repair short to GND between Injector 1 pin-3 and ECM Driver pin D-1. After repairs are complete, retest for SPN 2797 FMI 6.

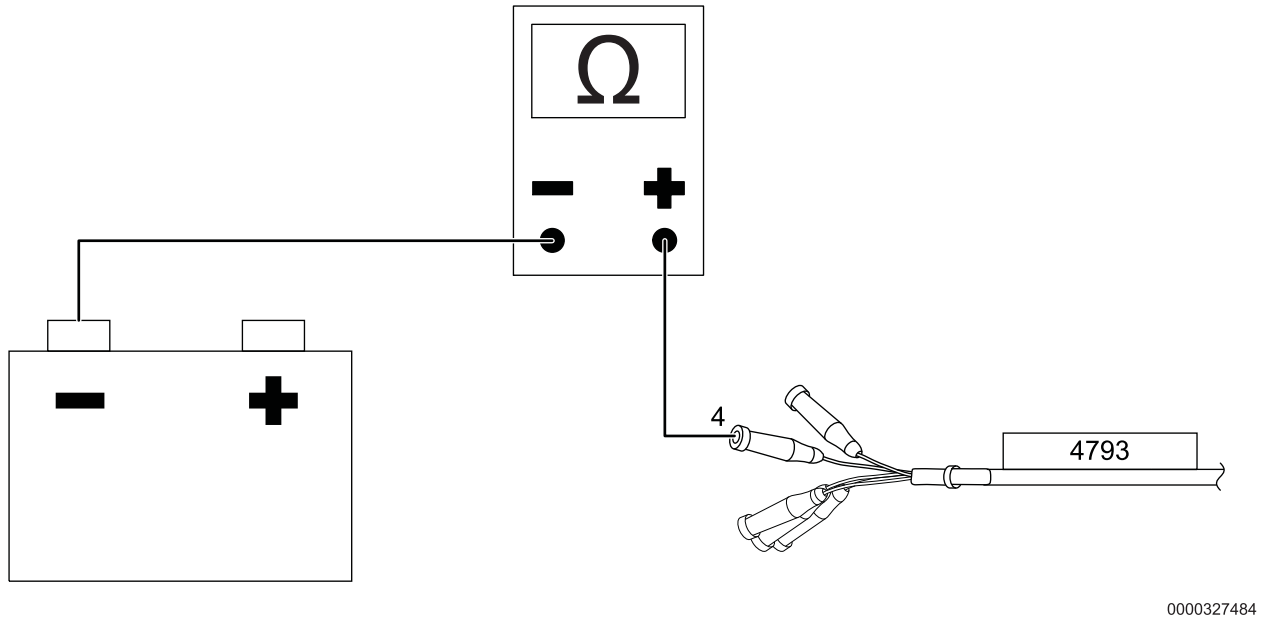


Figure 408 Test 22 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 22 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 1. C. Disconnect Under Valve Connector (UVC) connector 2. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. E. Key ON.

Test 22	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-4 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 23.
	No: Repair short to GND between Injector 1 pin-4 and ECM Driver pin D-2. After repairs are complete, retest for SPN 2797 FMI 6.

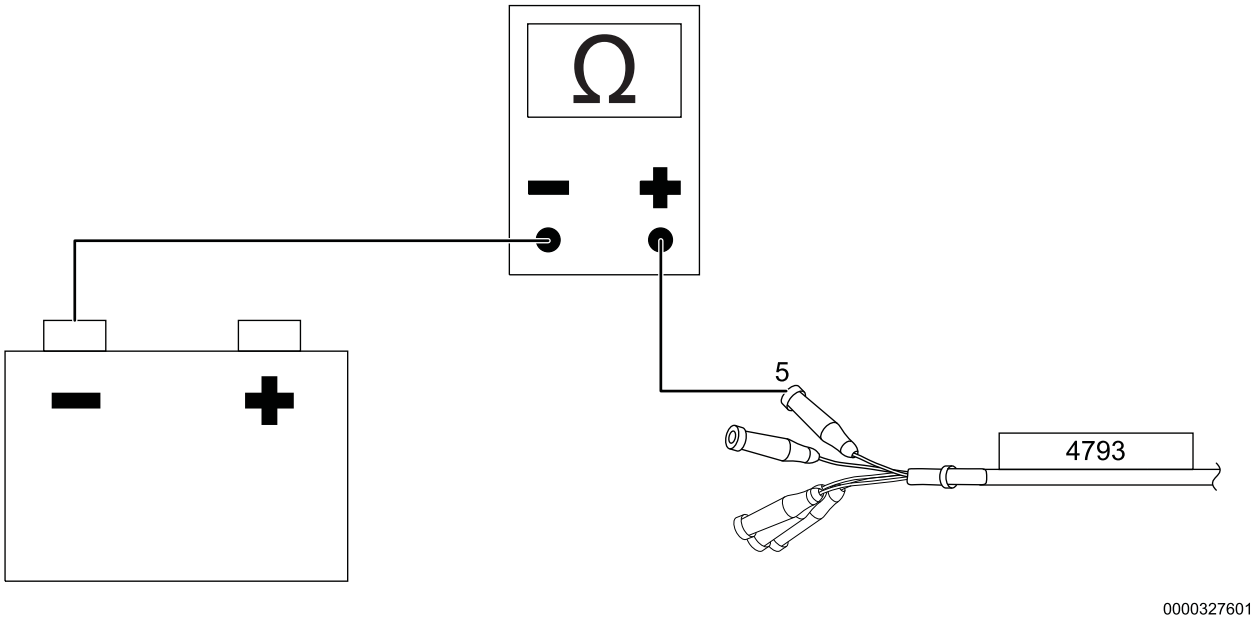


Figure 409 Test 23 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 23 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 2. C. Disconnect Under Valve Connector (UVC) connector 2. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. E. Key ON.

Test 23	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-5 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 24.
	No: Repair short to GND between Injector 2 pin-5 and ECM Driver pin D-12. After repairs are complete, retest for SPN 2797 FMI 6.

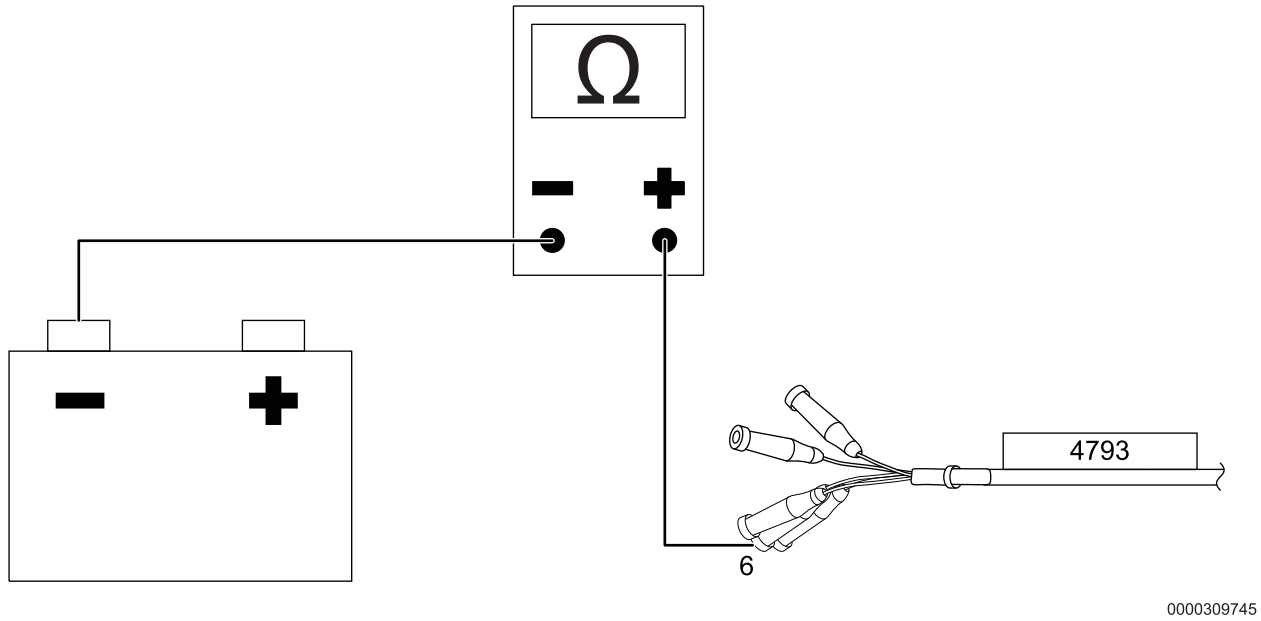


Figure 410 Test 24 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 24 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 2. C. Disconnect Under Valve Connector (UVC) connector 2. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. E. Key ON.

Test 24	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-6 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 25.
	No: Repair short to GND between Injector 2 pin-6 and ECM Driver pin D-11. After repairs are complete, retest for SPN 2797 FMI 6.

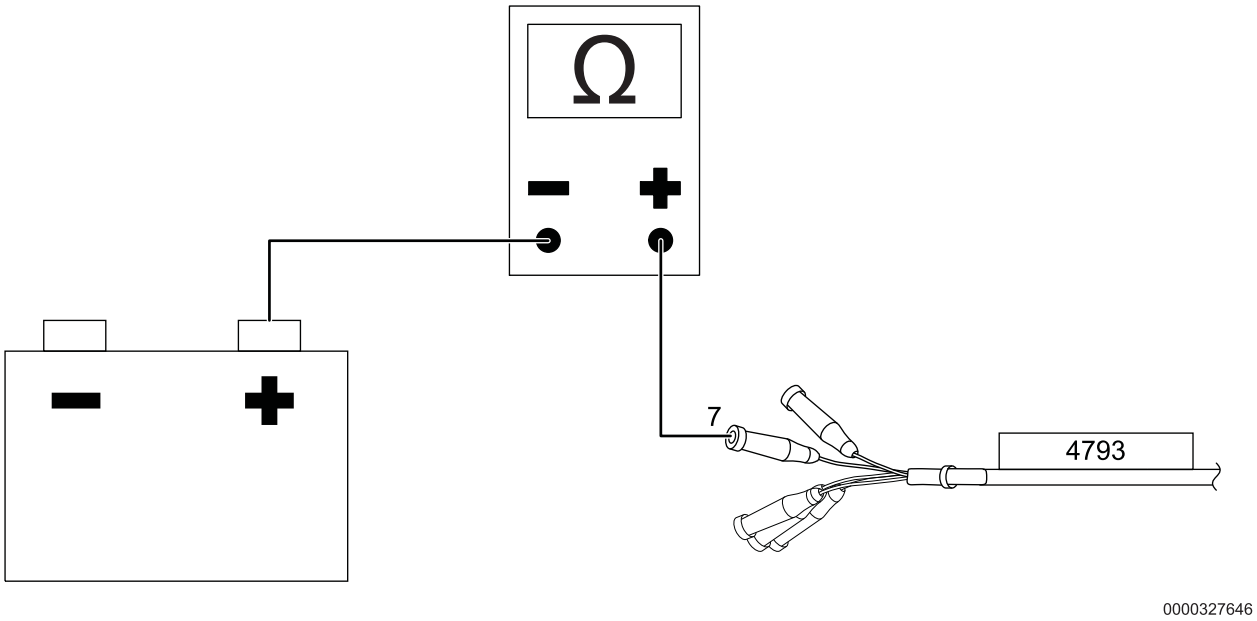


Figure 411 Test 25 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 25 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 2. C. Disconnect Under Valve Connector (UVC) connector 2. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. E. Key ON.

Test 25	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-7 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 26.
	No: Repair short to GND between Injector 2 pin-7 and ECM Driver pin D-5. After repairs are complete, retest for SPN 2797 FMI 6.

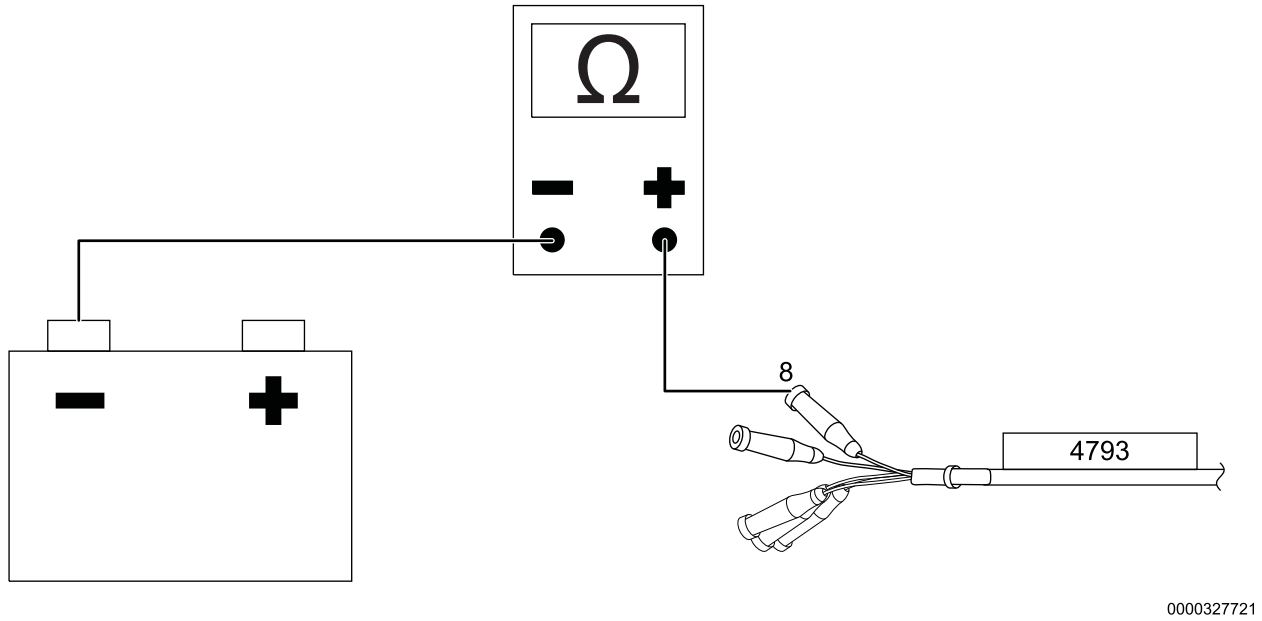


Figure 412 Test 26 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 26 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 2. C. Disconnect Under Valve Connector (UVC) connector 2. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. E. Key ON.

Test 26	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-8 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 27.
	No: Repair short to GND between Injector 2 pin-8 and ECM Driver pin D-6. After repairs are complete, retest for SPN 2797 FMI 6.

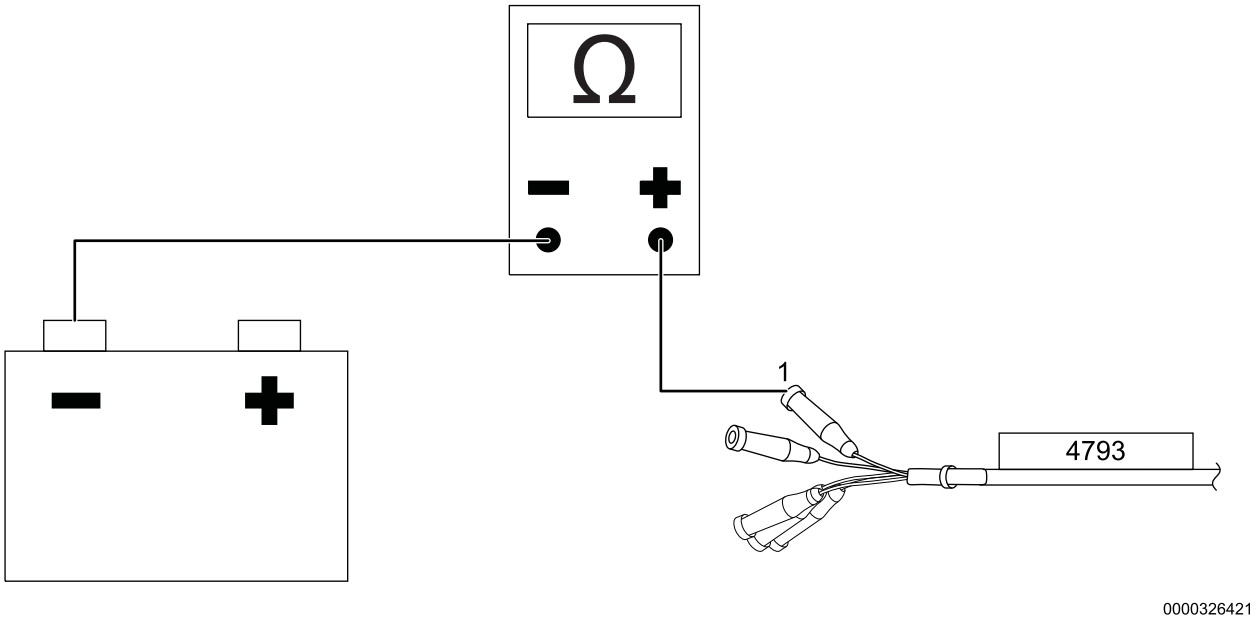


Figure 413 Test 27 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 27 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 3. C. Disconnect Under Valve Connector (UVC) connector 3. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. E. Key ON.

Test 27	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-1 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 28.
	No: Repair short to GND between Injector 3 pin-1 and ECM Driver pin D-10. After repairs are complete, retest for SPN 2797 FMI 6.

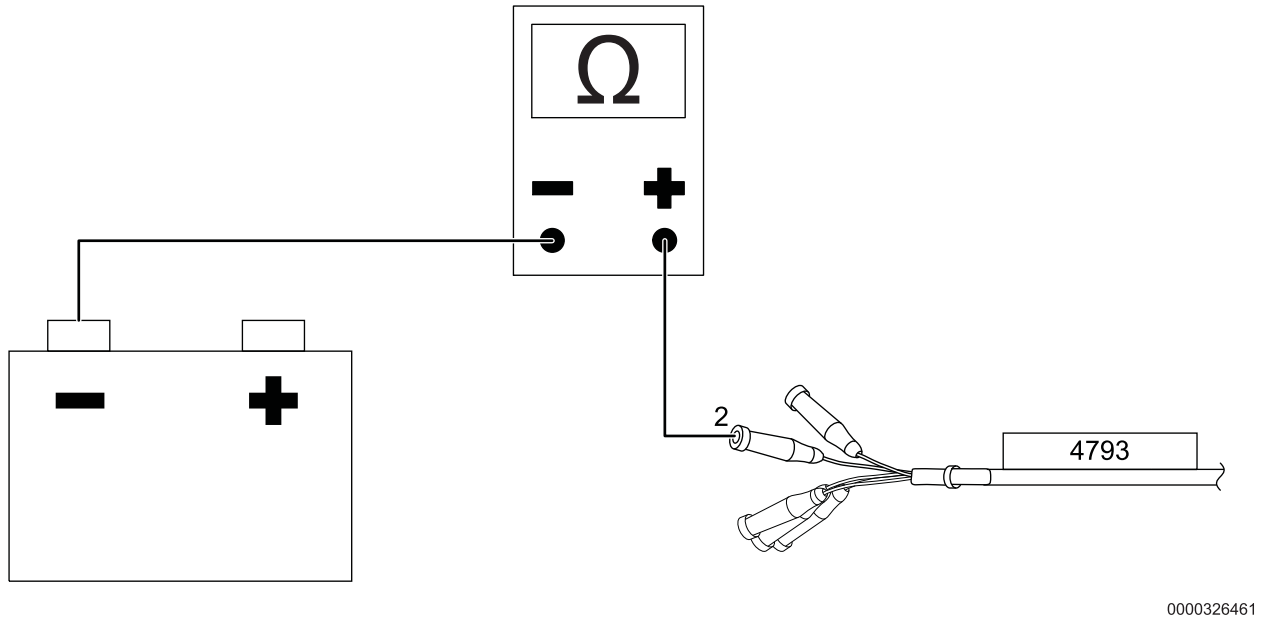


Figure 414 Test 28 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 28 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 3. C. Disconnect Under Valve Connector (UVC) connector 3. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. E. Key ON.

Test 28	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-2 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 29.
	No: Repair short to GND between Injector 3 pin-2 and ECM Driver pin D-9. After repairs are complete, retest for SPN 2797 FMI 6.

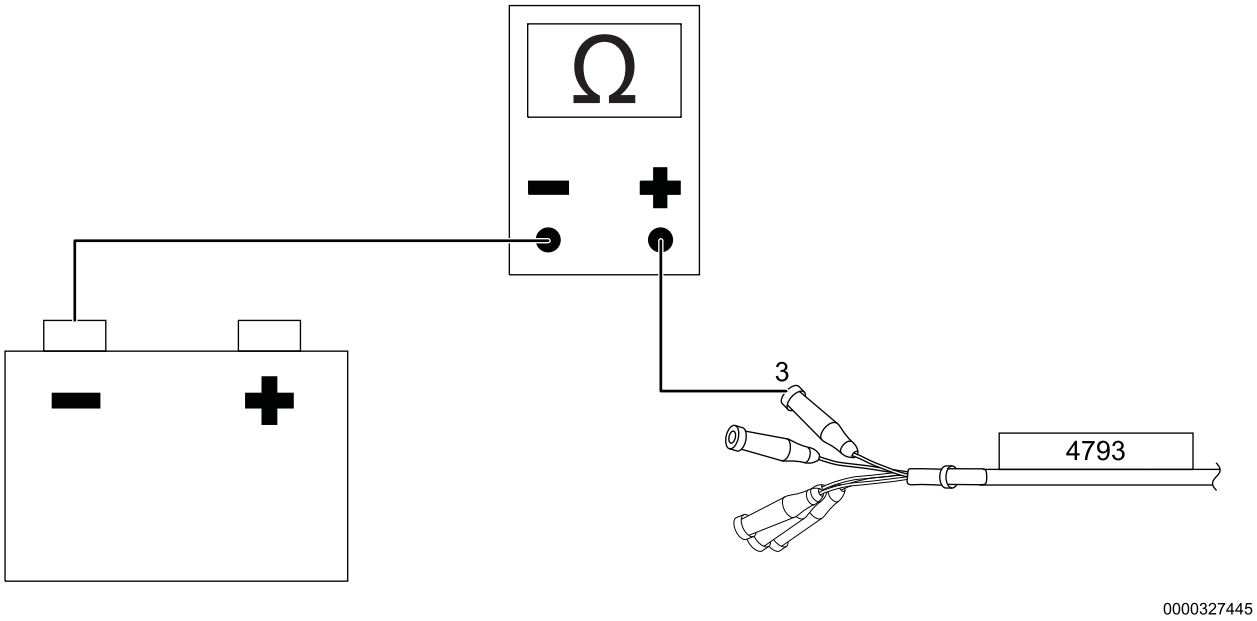


Figure 415 Test 29 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 29 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 3. C. Disconnect Under Valve Connector (UVC) connector 3. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. E. Key ON.

Test 29	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-3 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 30.
	No: Repair short to GND between Injector 3 pin-3 and ECM Driver pin D-3. After repairs are complete, retest for SPN 2797 FMI 6.

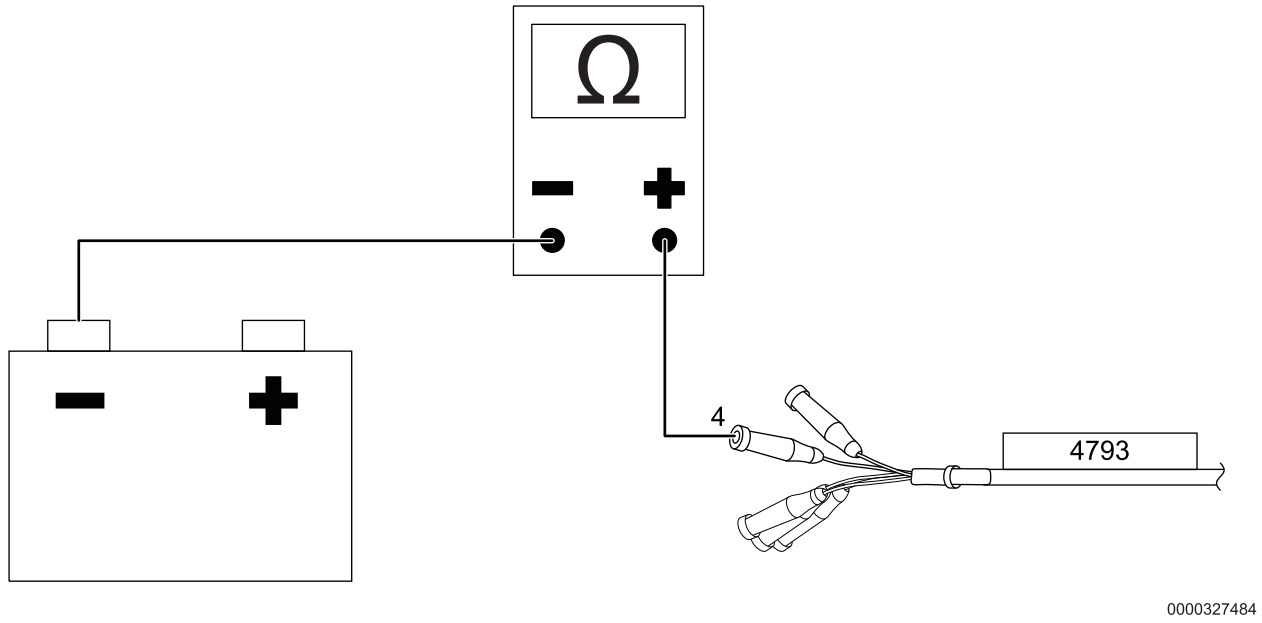


Figure 416 Test 30 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 30 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 3. C. Disconnect Under Valve Connector (UVC) connector 3. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. E. Key ON.

Test 30	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-4 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 31.
	No: Repair short to GND between Injector 3 pin-4 and ECM Driver pin D-4. After repairs are complete, retest for SPN 2797 FMI 6.

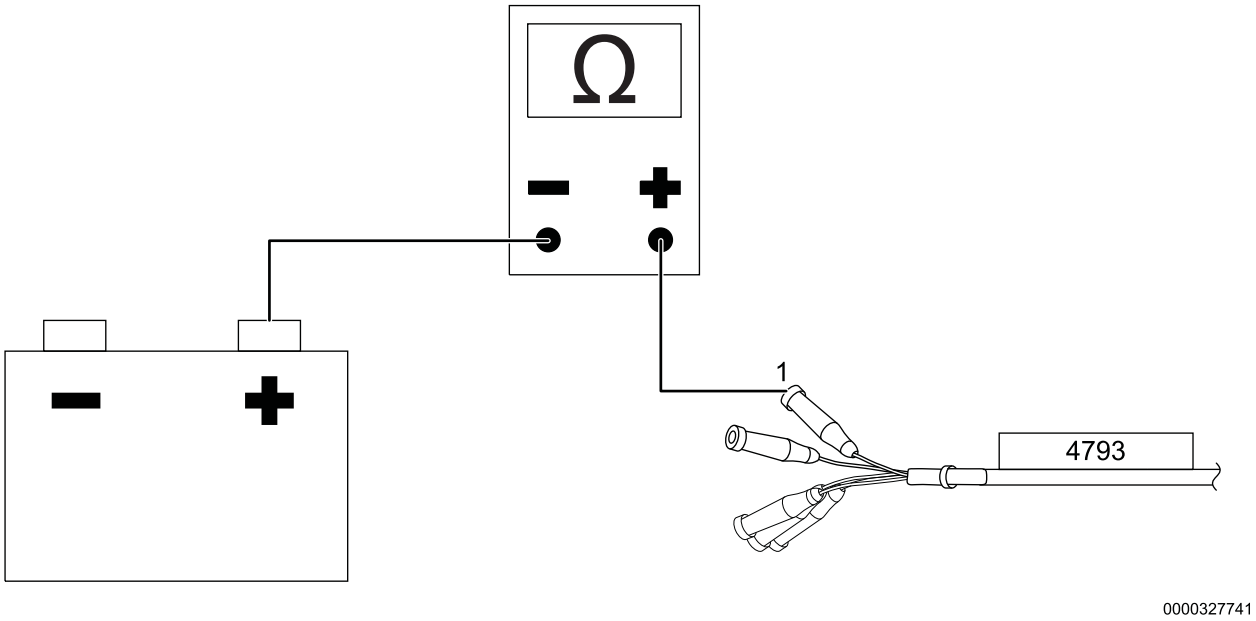


Figure 417 Test 31 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 31 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 1. C. Disconnect Under Valve Connector (UVC) connector 2. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. E. Key ON.

Test 31	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-1 and PWR.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 32.
	No: Repair short to PWR between Injector 1 pin-1 and ECM Driver pin D-8. After repairs are complete, retest for SPN 2797 FMI 6.

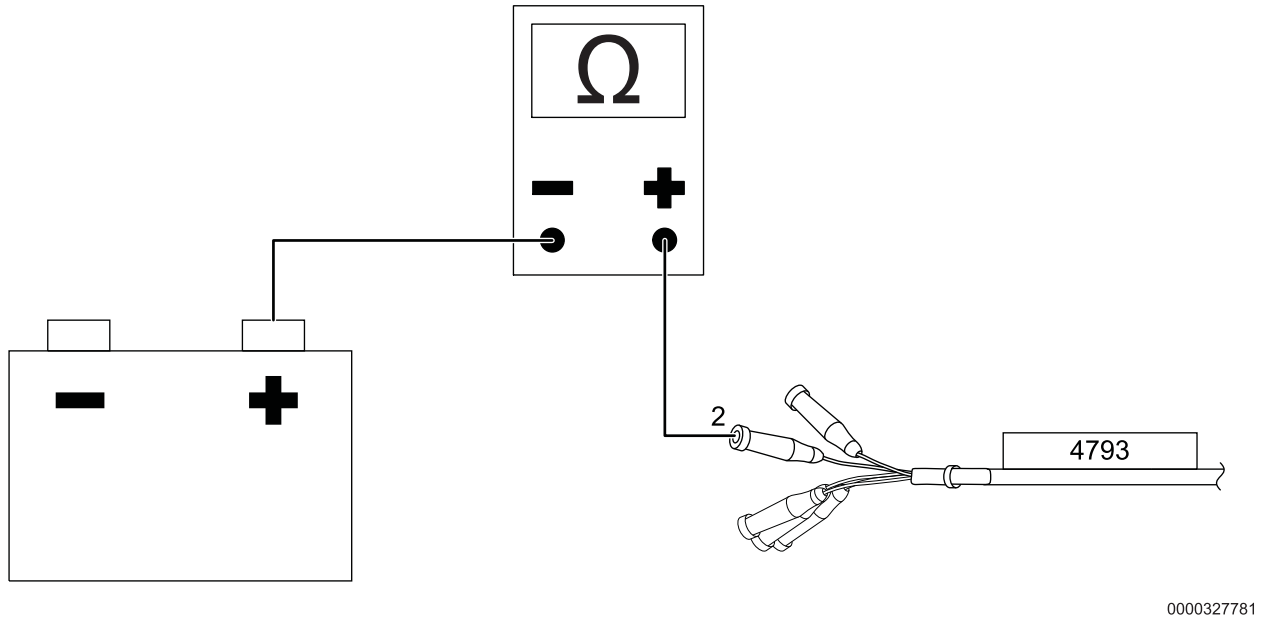


Figure 418 Test 32 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 32 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 1. C. Disconnect Under Valve Connector (UVC) connector 2. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. E. Key ON.

Test 32	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-2 and PWR.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 33.
	No: Repair short to PWR between Injector 1 pin-2 and ECM Driver pin D-7. After repairs are complete, retest for SPN 2797 FMI 6.

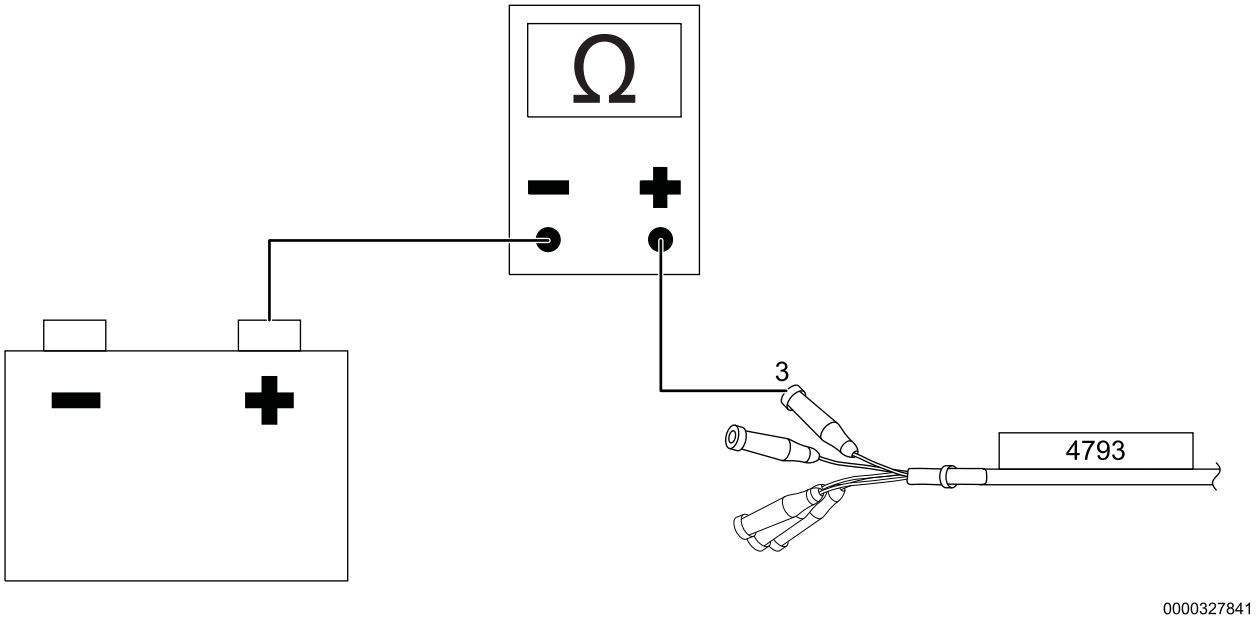


Figure 419 Test 33 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 33 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 1. C. Disconnect Under Valve Connector (UVC) connector 2. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. E. Key ON.

Test 33	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-3 and PWR.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 34.
	No: Repair short to PWR between Injector 1 pin-3 and ECM Driver pin D-1. After repairs are complete, retest for SPN 2797 FMI 6.

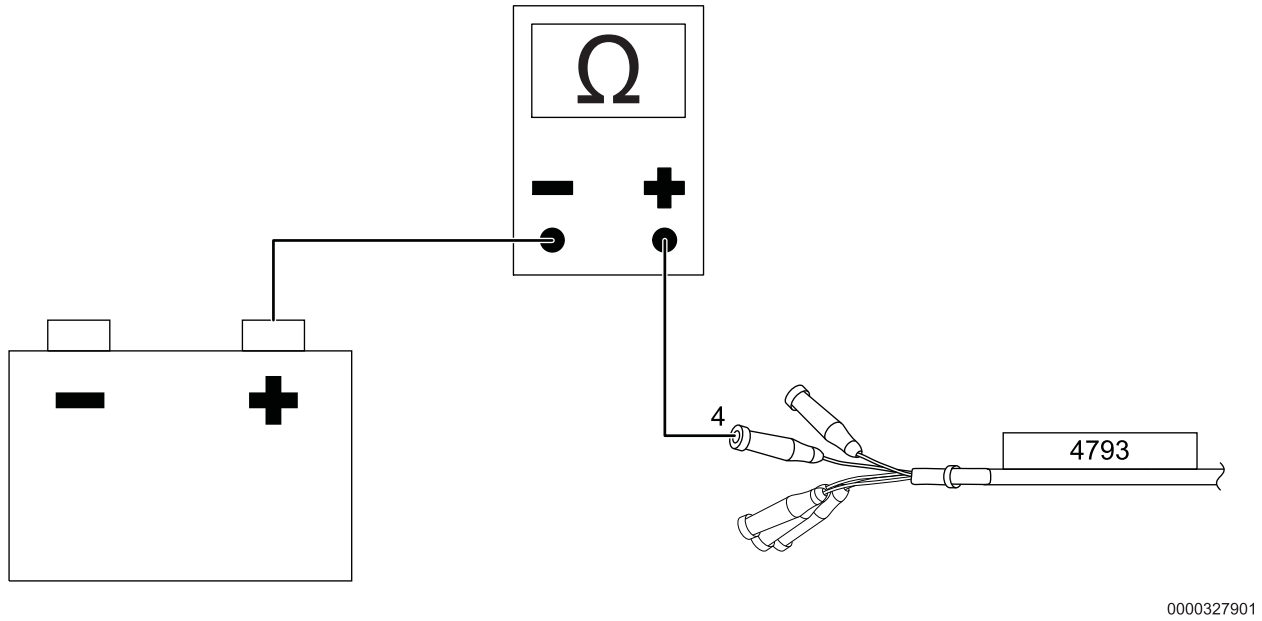


Figure 420 Test 34 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 34 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 1. C. Disconnect Under Valve Connector (UVC) connector 2. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. E. Key ON.

Test 34	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-4 and PWR.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 35.
	No: Repair short to PWR between Injector 1 pin-4 and ECM Driver pin D-2. After repairs are complete, retest for SPN 2797 FMI 6.

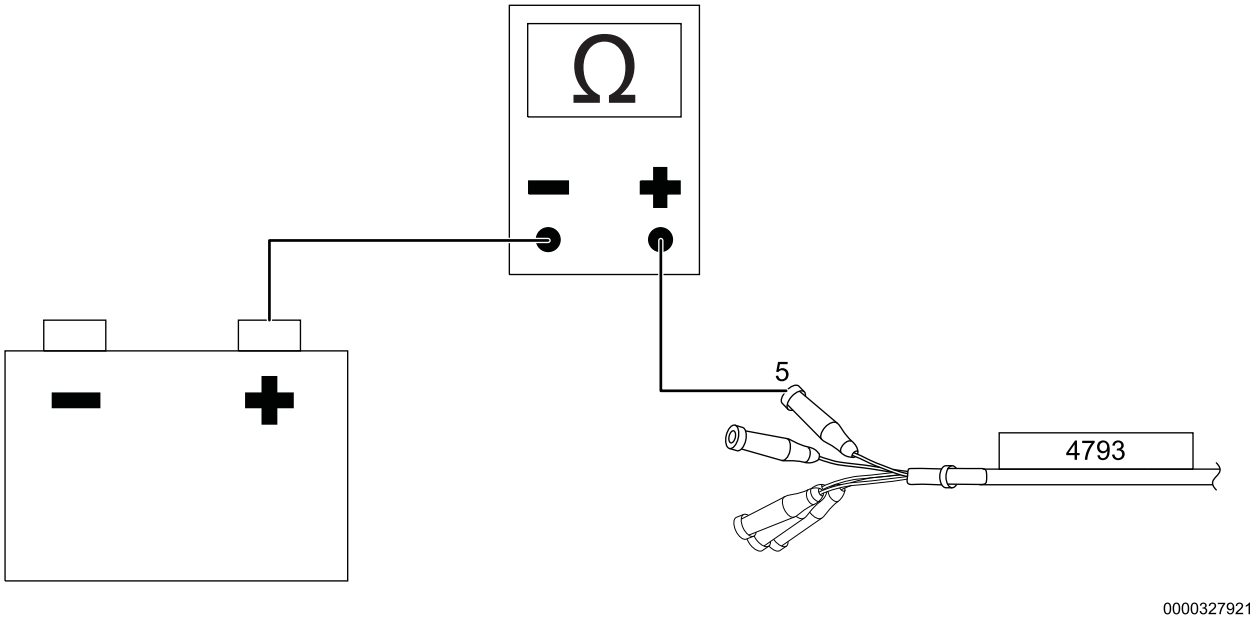


Figure 421 Test 35 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 35 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 2. C. Disconnect Under Valve Connector (UVC) connector 2. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. E. Key ON.

Test 35	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-5 and PWR.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 36.
	No: Repair short to PWR between Injector 2 pin-5 and ECM Driver pin D-12. After repairs are complete, retest for SPN 2797 FMI 6.

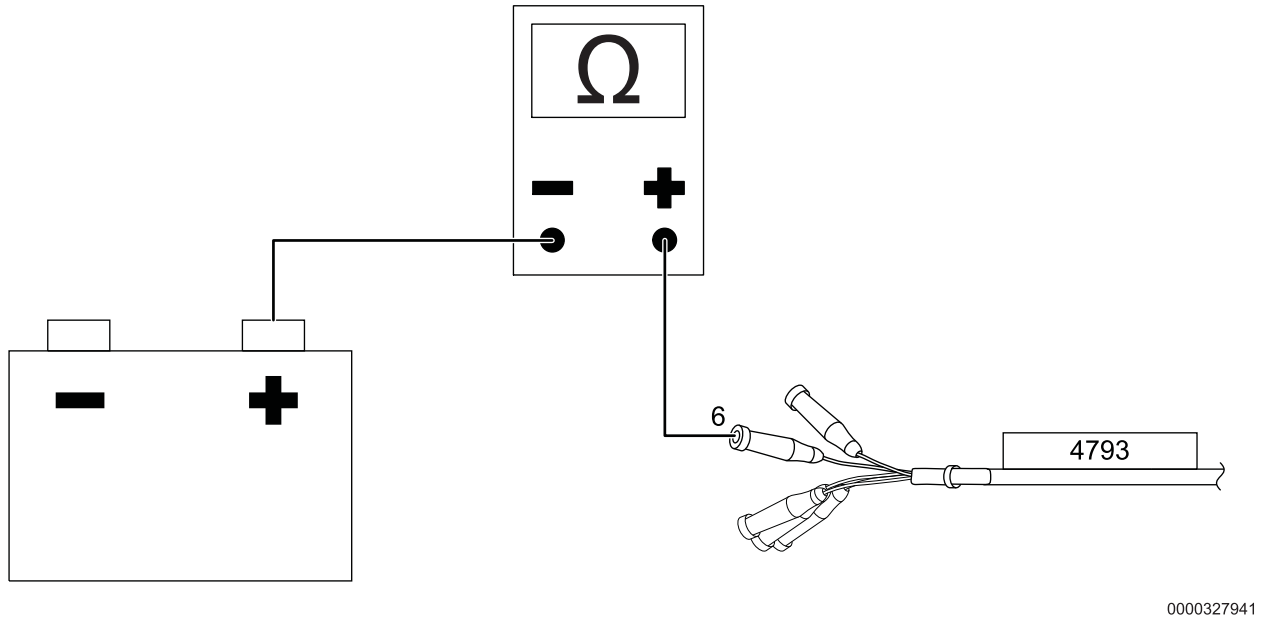


Figure 422 Test 36 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 36 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 2. C. Disconnect Under Valve Connector (UVC) connector 2. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. E. Key ON.

Test 36	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-6 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 36.
	No: Repair short to GND between Injector 2 pin-6 and ECM Driver pin D-11. After repairs are complete, retest for SPN 2797 FMI 6.

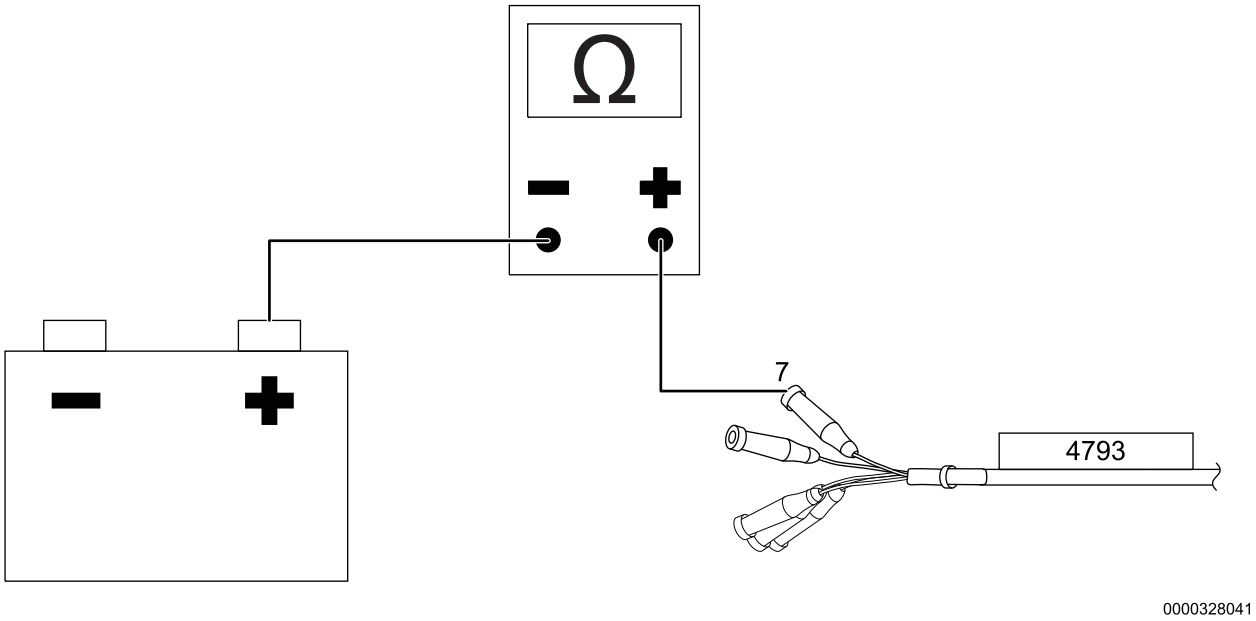


Figure 423 Test 37 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 37 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 2. C. Disconnect Under Valve Connector (UVC) connector 2. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. E. Key ON.

Test 37	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-7 and PWR.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 38.
	No: Repair short to PWR between Injector 2 pin-7 and ECM Driver pin D-5. After repairs are complete, retest for SPN 2797 FMI 6.

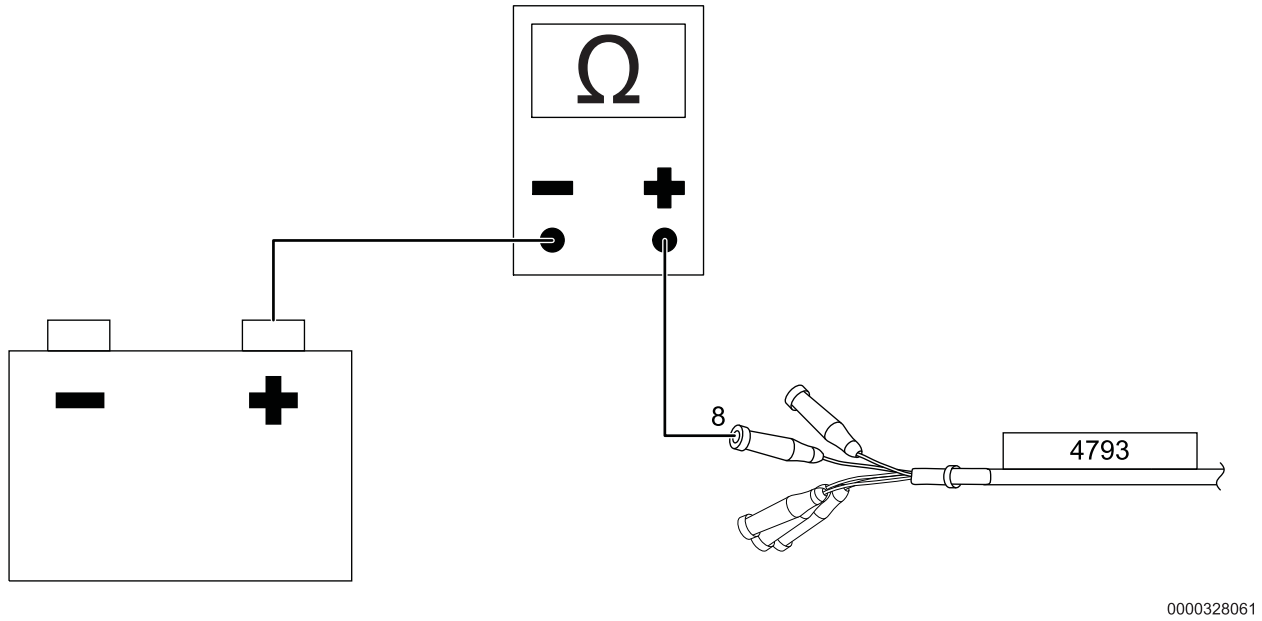


Figure 424 Test 38 Under Valve Connector (UVC) connector 2 Circuit Resistance Check

Test 38 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 2. C. Disconnect Under Valve Connector (UVC) connector 2. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 2 disconnected. E. Key ON.

Test 38	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-8 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 39.
	No: Repair short to GND between Injector 2 pin-8 and ECM Driver pin D-6. After repairs are complete, retest for SPN 2797 FMI 6.

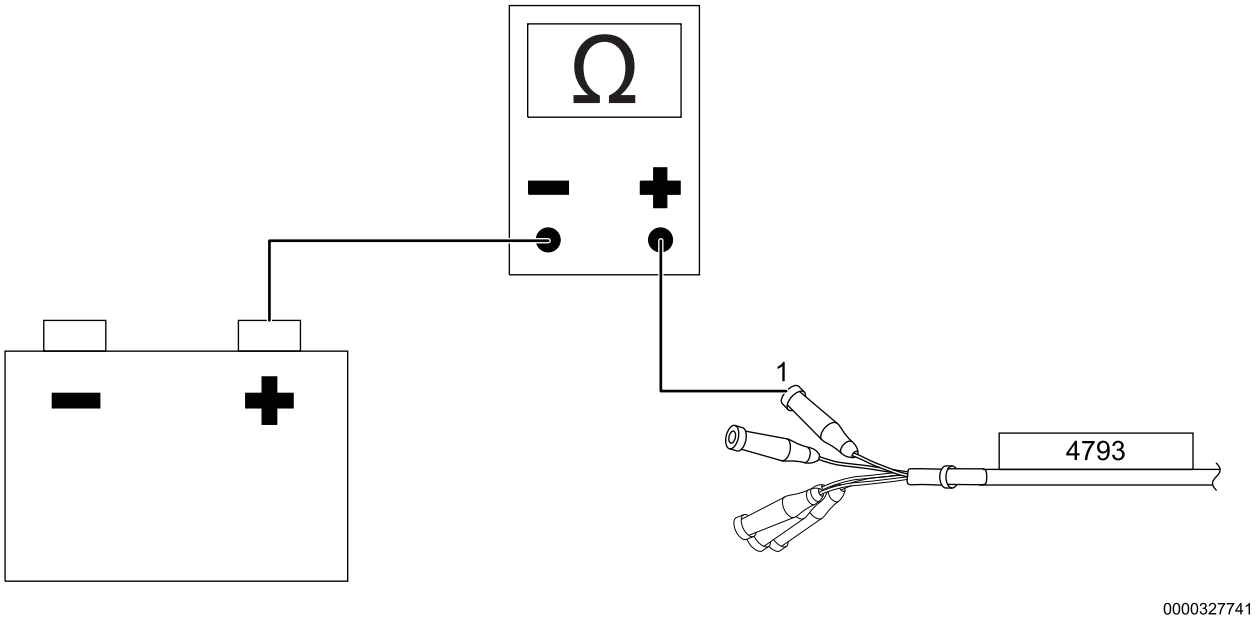


Figure 425 Test 39 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 39 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 3. C. Disconnect Under Valve Connector (UVC) connector 3. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. E. Key ON.

Test 39	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-1 and PWR.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 40.
	No: Repair short to PWR between Injector 3 pin-1 and ECM Driver pin D-10. After repairs are complete, retest for SPN 2797 FMI 6.

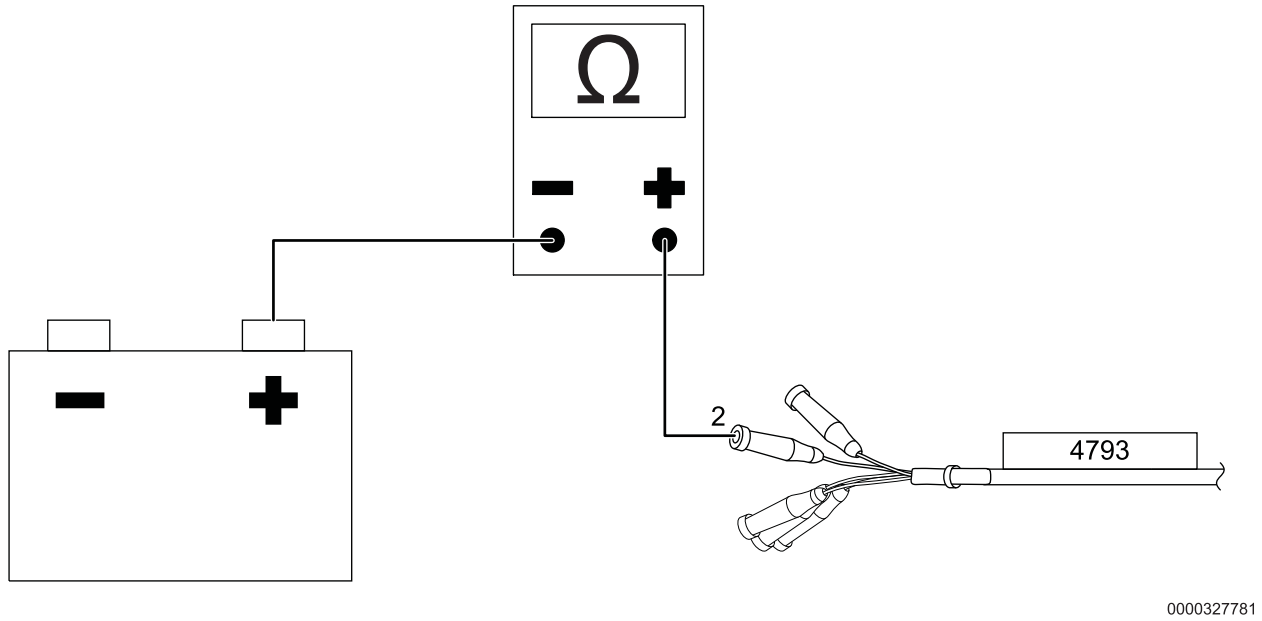


Figure 426 Test 40 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 40 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 3. C. Disconnect Under Valve Connector (UVC) connector 3. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. E. Key ON.

Test 40	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-2 and PWR.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 41.
	No: Repair short to PWR between Injector 3 pin-2 and ECM Driver pin D-9. After repairs are complete, retest for SPN 2797 FMI 6.

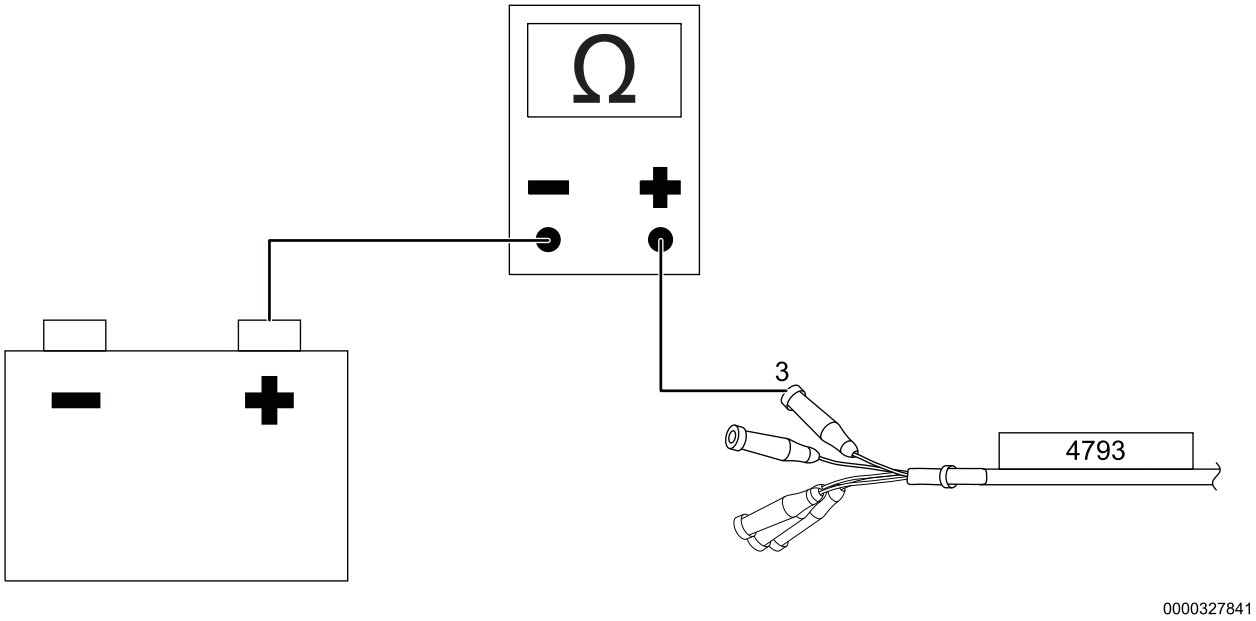


Figure 427 Test 41 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 41 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 3. C. Disconnect Under Valve Connector (UVC) connector 3. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. E. Key ON.

Test 41	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-3 and PWR.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Repair short to PWR between UVC connector 3 pin-4 and ECM Driver pin D-4. After repairs are complete, retest for SPN 2797 FMI 6.
	No: Repair short to PWR between Injector 3 pin-3 and ECM Driver pin D-3. After repairs are complete, retest for SPN 2797 FMI 6.

End Diagnostic Steps
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 2797 FMI 6 fault code diagnostics.

SPN 2798 FMI 6 - Injector Control Group 2 Open coil - Short Circuit (INJ 4, 5, 6)

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Short circuit detection on Bank 1 Open coil {Bank 1: Injector Number 4, 5 and 6} Short circuit detection on Bank 1 Close coil { Bank 1 : Injector Number 4, 5 and 6 }	Driver indicates short circuit on Open coil. Current detected by driver > 50 Amps Driver indicates short circuit on Close coil. Current detected by driver > 50 Amps	Key ON, Engine Running Battery voltage > 9 Volts Injectors firing

Fault Overview

Fault code sets when short circuit is detected on Bank 1 (Injectors 4, 5, and 6) Open or Close coil.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive trips.

Associated Faults

SPN 654-656 FMI 4 and 5; SPN 3662-3665 FMI 4 and 5

Fault Facts

None

Drive Cycle to Determine Fault Status

Continuous

Possible Causes

- Fuel injector 4 Open circuit short to GND
- Fuel injector 4 Close circuit short to GND
- Fuel injector 4 Open circuit short to PWR
- Fuel injector 4 Close circuit short to PWR
- Fuel Injector 4 Open H shorted to Open L
- Fuel Injector 4 Close H shorted to Close L
- Fuel Injector 4 Close circuit shorted to Open circuit
- Failed Fuel Injector 4
- Fuel injector 5 Open circuit short to GND
- Fuel injector 5 Close circuit short to GND
- Fuel injector 5 Open circuit short to PWR
- Fuel injector 5 Close circuit short to PWR

- Fuel Injector 5 Open H shorted to Open L
- Fuel Injector 5 Close H shorted to Close L
- Fuel Injector 5 Close circuit shorted to Open circuit
- Failed Fuel Injector 5
- Fuel injector 6 Open circuit short to GND
- Fuel injector 6 Close circuit short to GND
- Fuel injector 6 Open circuit short to PWR
- Fuel injector 6 Close circuit short to PWR
- Fuel Injector 6 Open H shorted to Open L
- Fuel Injector 6 Close H shorted to Close L
- Fuel Injector 6 Close circuit shorted to Open circuit
- Failed Fuel Injector 6

Step 1	Check for active or pending fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software. A. Key ON, clear codes. B. Key OFF, wait for EST screens to clear. C. Key ON, check Diagnostic Trouble Code (DTC) list for SPN 2798 FMI 6. Is EST DTC list SPN 2798 FMI 6 active or pending?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Check for associated fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 654-656 FMI 4 and 5; SPN 3662-3665 FMI 4 and 5. Is EST DTC list free of SPN 654-656 FMI 4 and 5; SPN 3662-3665 FMI 4 and 5?		Yes: Go to Step 3. No: Repair SPN 654-656 FMI 4 and 5; SPN 3662-3665 FMI 4 and 5. After repairs are complete, retest for SPN 2798 FMI 6.

Step 3	Inspect connections at Under Valve Connector (UVC) connector 3.	Decision
A. Key OFF B. Disconnect UVC 3 C. Check UVC 3 and connector terminals for: damaged or pinched wires; moisture in terminals; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are UVC 3 connector, harness, and terminals clean and undamaged?		Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2798 FMI 6.

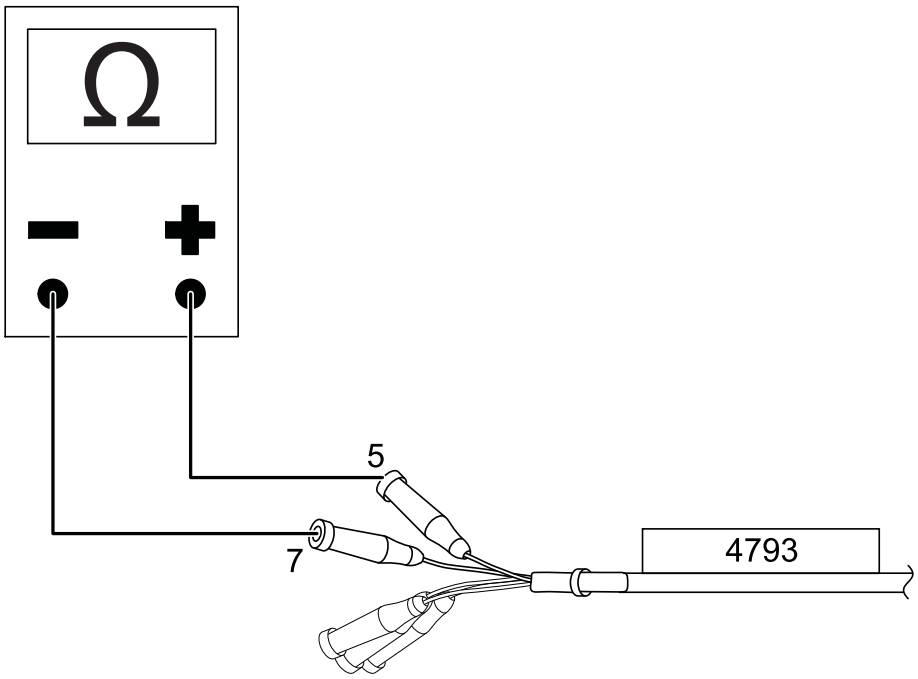
Step 4	Inspect connections at Under Valve Connector (UVC) connector 4.	Decision
	A. Key OFF B. Disconnect UVC 4 C. Check UVC 4 and connector terminals for: damaged or pinched wires; moisture in terminals; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are UVC 4 connector, harness, and terminals clean and undamaged?	Yes: Perform pinpoint tests(page 1000). No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2798 FMI 6.

Pin-Point Tests (SPN 2798 FMI 6)

See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4793
- Digital Multimeter (DMM)

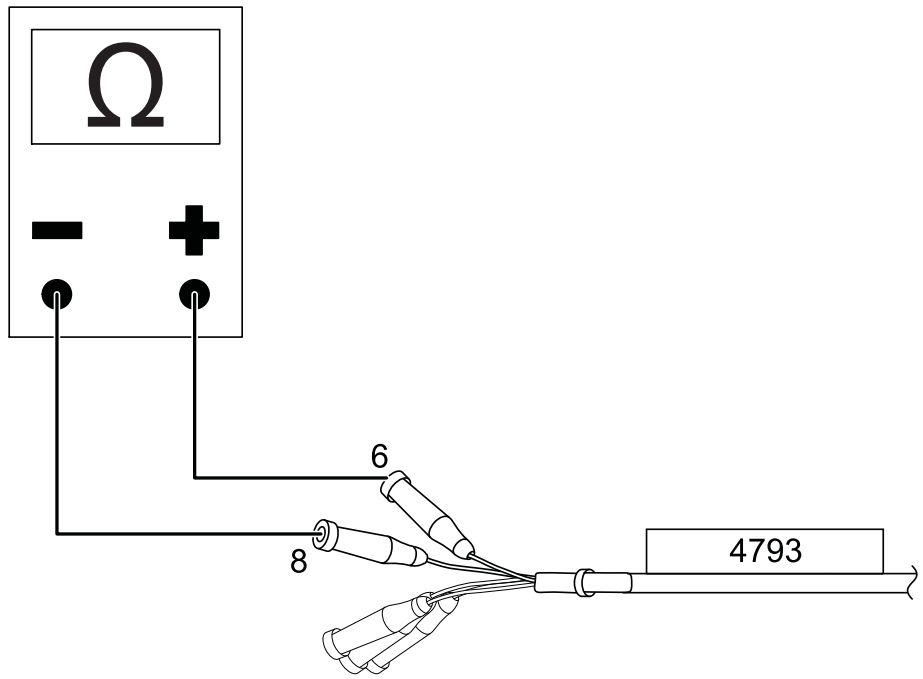


0000326281

Figure 428 Test 1 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 1 Setup
A. Key OFF. B. Disconnect Under Valve Connector (UVC) connector 3. C. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. D. Key ON.

Test 1	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-5 and pin-7.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 2.
	No: Repair short between circuits. After repairs are complete, retest for SPN 2798 FMI 6

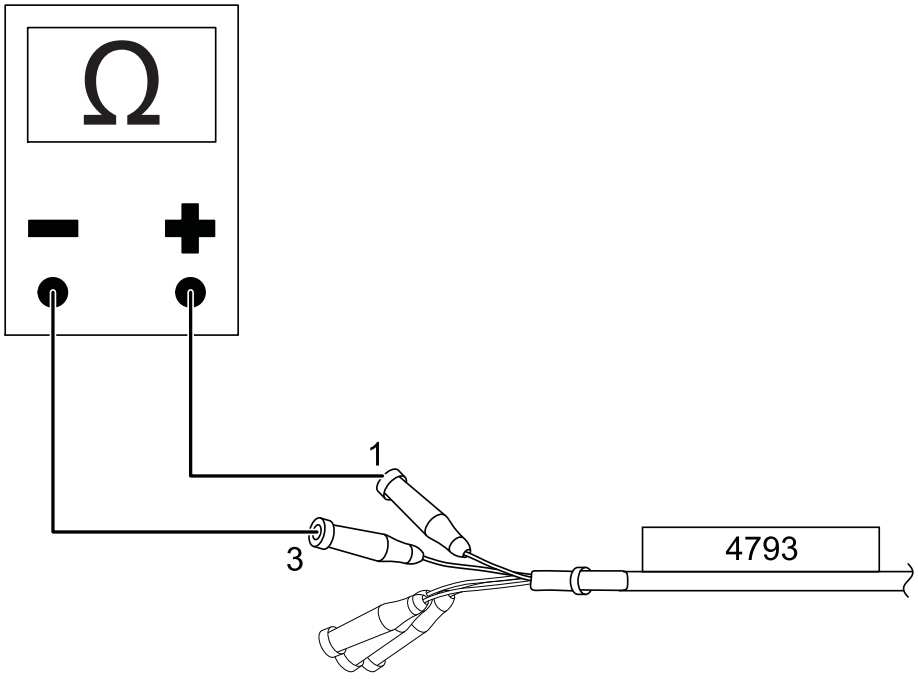


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Figure 429 Test 2 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 2 Setup
A. Key OFF. B. Disconnect Under Valve Connector (UVC) connector 3. C. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. D. Key ON.

Test 2	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-6 and pin-8.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 3.
	No: Repair short between circuits. After repairs are complete, retest for SPN 2798 FMI 6

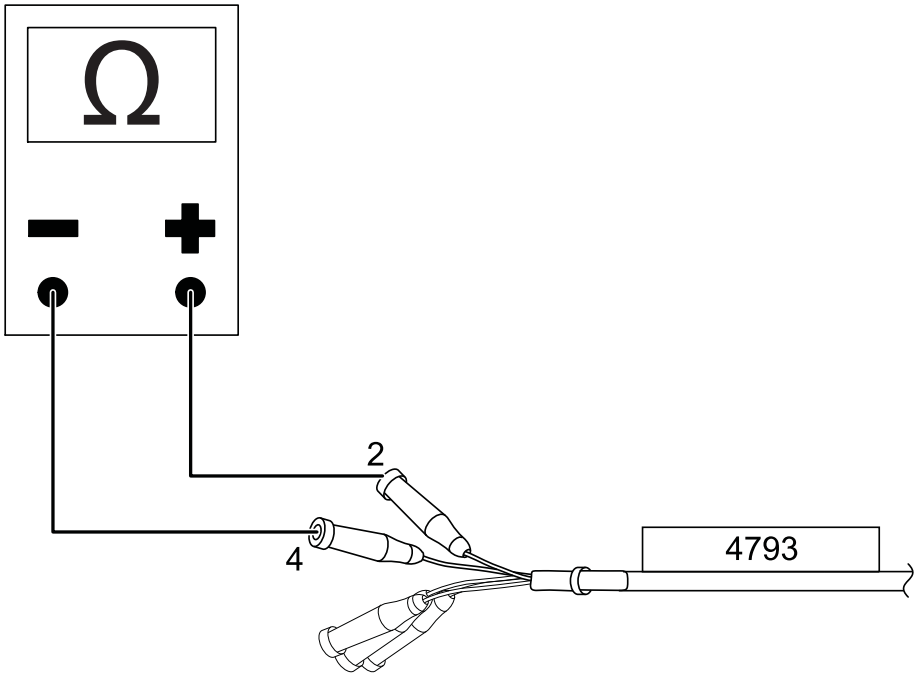


0000326241

Figure 430 Test 3 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 3 Setup
A. Key OFF. B. Disconnect Under Valve Connector (UVC) connector 4. C. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. D. Key ON.

Test 3	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-1 and pin-3.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 4.
	No: Repair short between circuits. After repairs are complete, retest for SPN 2798 FMI 6

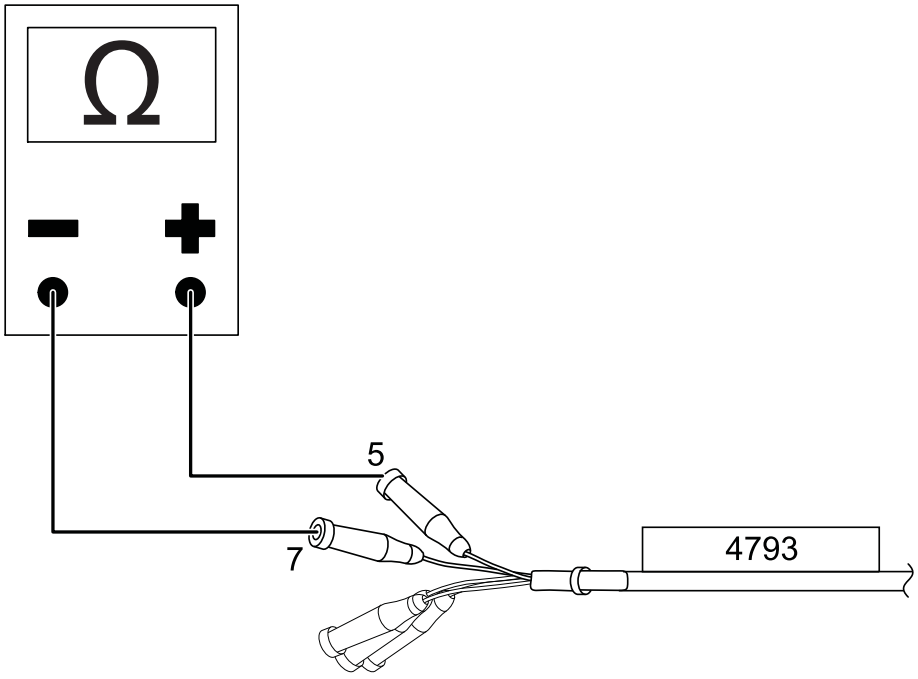


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Figure 431 Test 4 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 4 Setup
A. Key OFF. B. Disconnect Under Valve Connector (UVC) connector 4. C. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. D. Key ON.

Test 4	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-2 and pin-4.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 5.
	No: Repair short between circuits. After repairs are complete, retest for SPN 2798 FMI 6

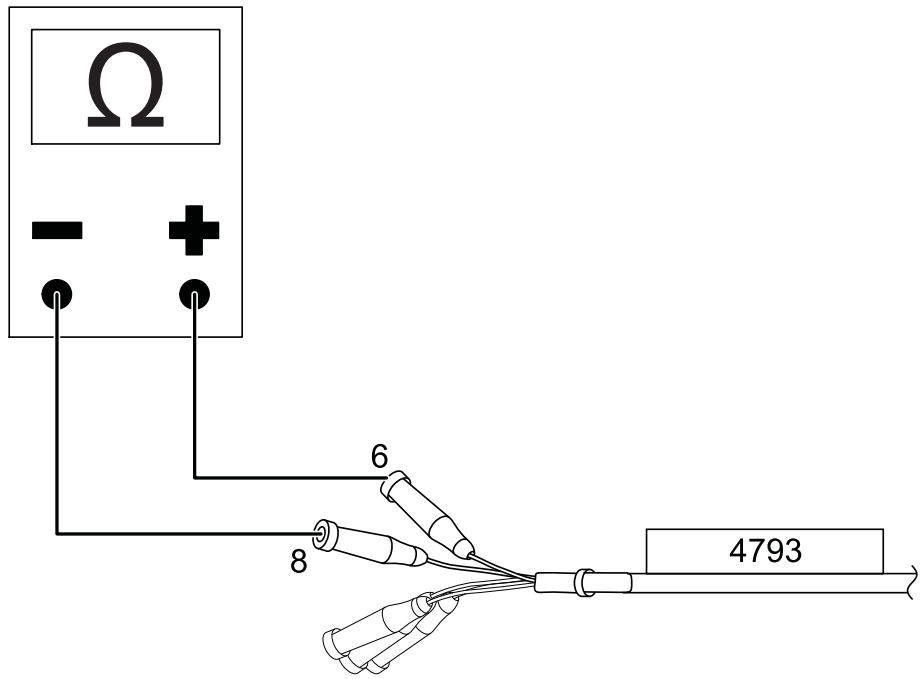


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Figure 432 Test 5 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 5 Setup
A. Key OFF. B. Disconnect Under Valve Connector (UVC) connector 4. C. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. D. Key ON.

Test 5	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-5 and pin-7.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 6.
	No: Repair short between circuits. After repairs are complete, retest for SPN 2798 FMI 6

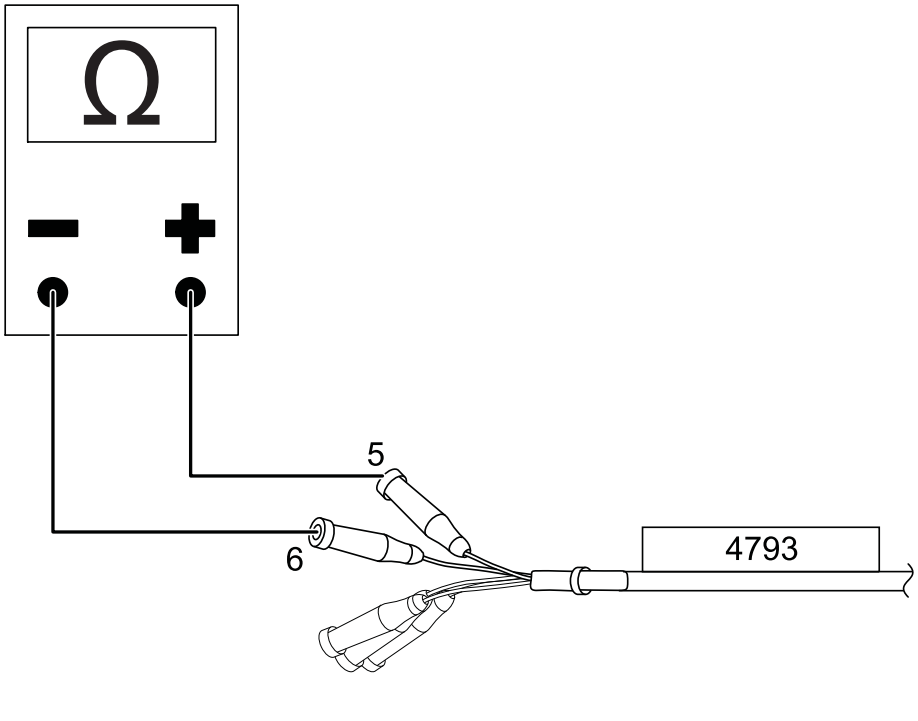


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Figure 433 Test 6 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 6 Setup
A. Key OFF. B. Disconnect Under Valve Connector (UVC) connector 4. C. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. D. Key ON.

Test 6	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-6 and pin-8.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 7.
	No: Repair short between circuits. After repairs are complete, retest for SPN 2798 FMI 6

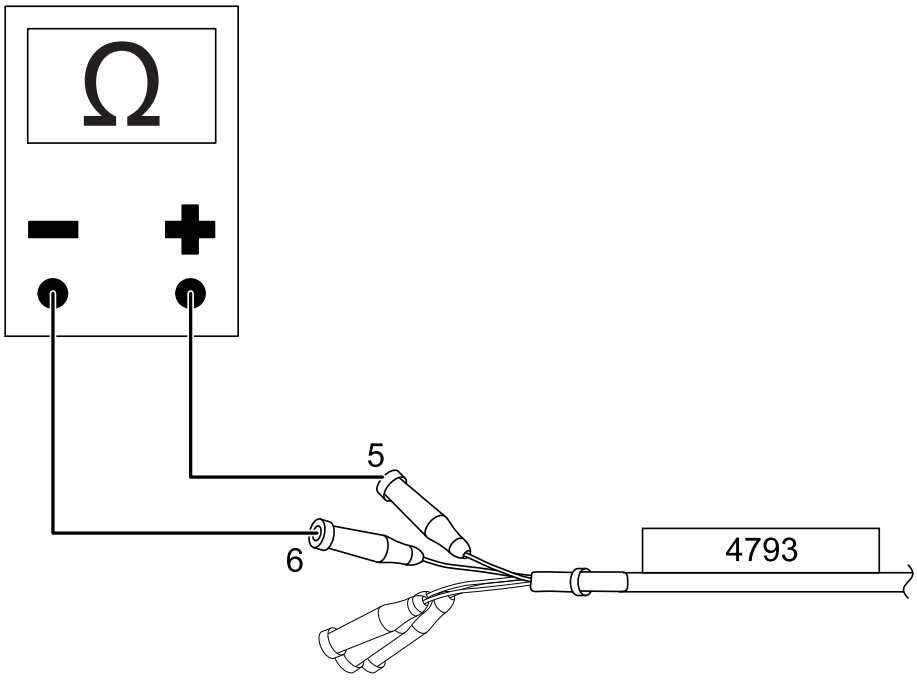


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Figure 434 Test 7 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 7 Setup
A. Key OFF. B. Disconnect Under Valve Connector (UVC) connector 3. C. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. D. Key ON.

Test 7	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-5 and pin-6.	1 ± 0.5 ohms
Decision	
Is resistance less than 0.5 ohms?	Yes: Go to Test 8.
	No: Go to Test 9.

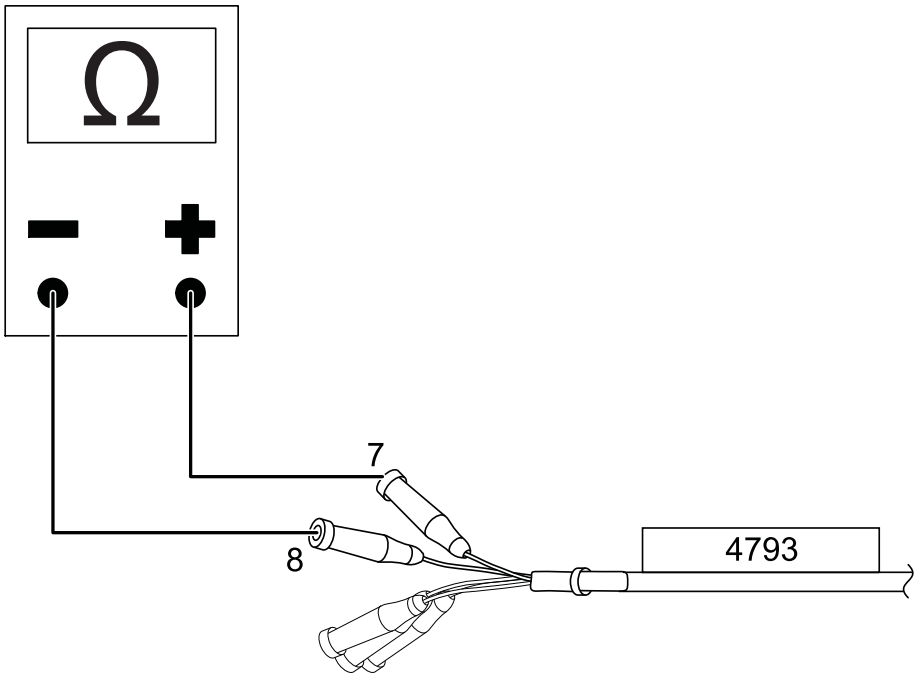


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Figure 435 Test 8 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 8 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 4. C. Disconnect Under Valve Connector (UVC) connector 3. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. E. Key ON.

Test 8	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-5 and pin-6.	1 ± 0.5 ohms
Decision	
Is resistance less than 0.5 ohms?	Yes: Repair short in injector 4 Close coil circuit. After repairs are complete, retest for SPN 2798 FMI 6.
	No: Replace fuel injector 4. After repairs are complete, retest for SPN 2798 FMI 6.

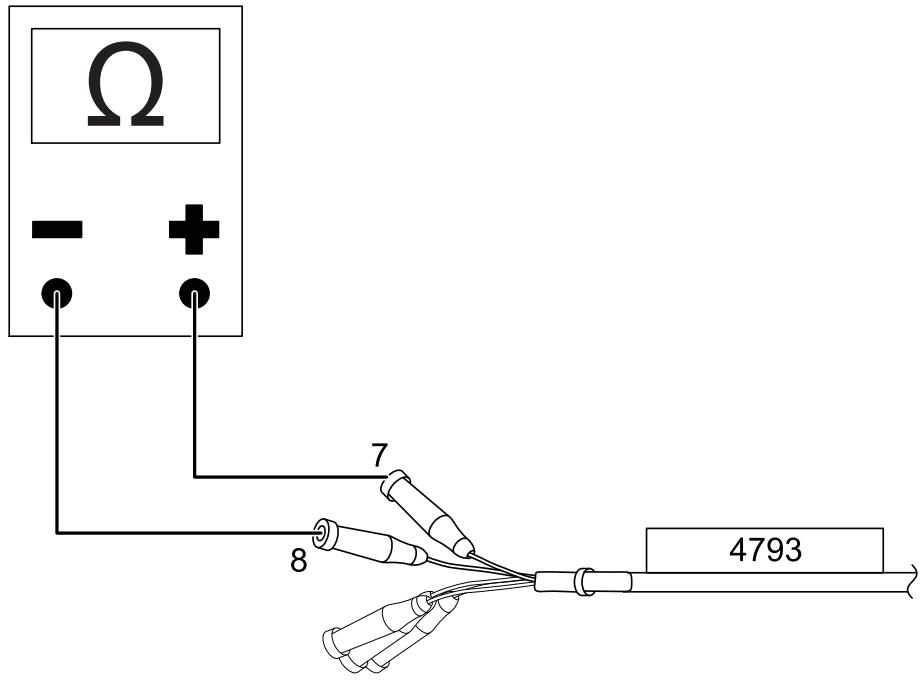


0000326401

Figure 436 Test 9 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 9 Setup
A. Key OFF. B. Disconnect Under Valve Connector (UVC) connector 3. C. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. D. Key ON.

Test 9	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-7 and pin-8.	1 ± 0.5 ohms
Decision	
Is resistance less than 0.5 ohms?	Yes: Go to Test 10.
	No: Go to Test 11.

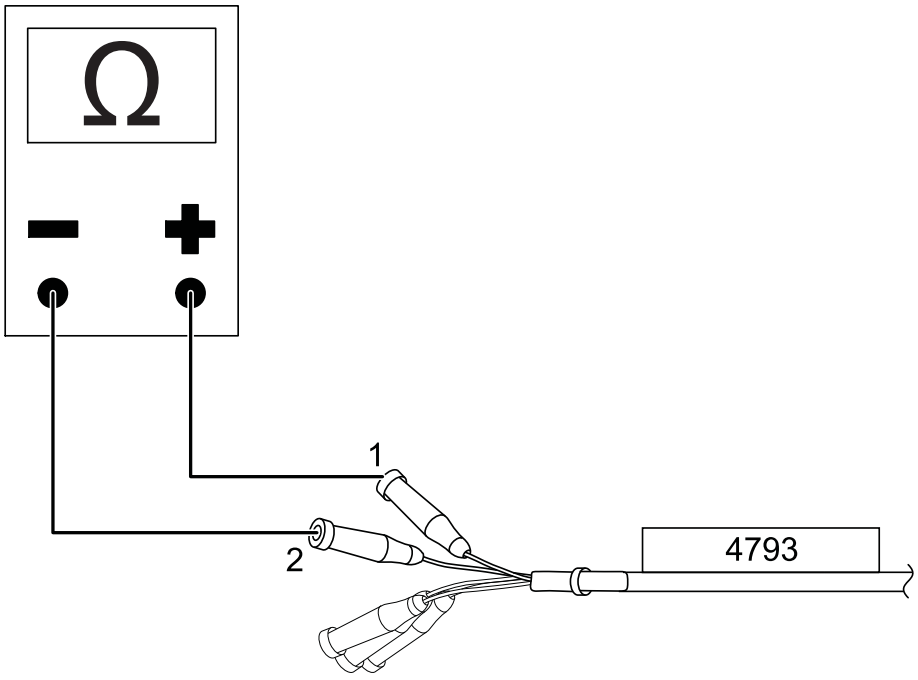


0000326401

Figure 437 Test 10 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 10 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 4. C. Disconnect Under Valve Connector (UVC) connector 3. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. E. Key ON.

Test 10	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-7 and pin-8.	1 ± 0.5 ohms
Decision	
Is resistance less than 0.5 ohms?	Yes: Repair short in injector 4 Open coil circuit. After repairs are complete, retest for SPN 2798 FMI 6.
	No: Replace fuel injector 4. After repairs are complete, retest for SPN 2798 FMI 6.

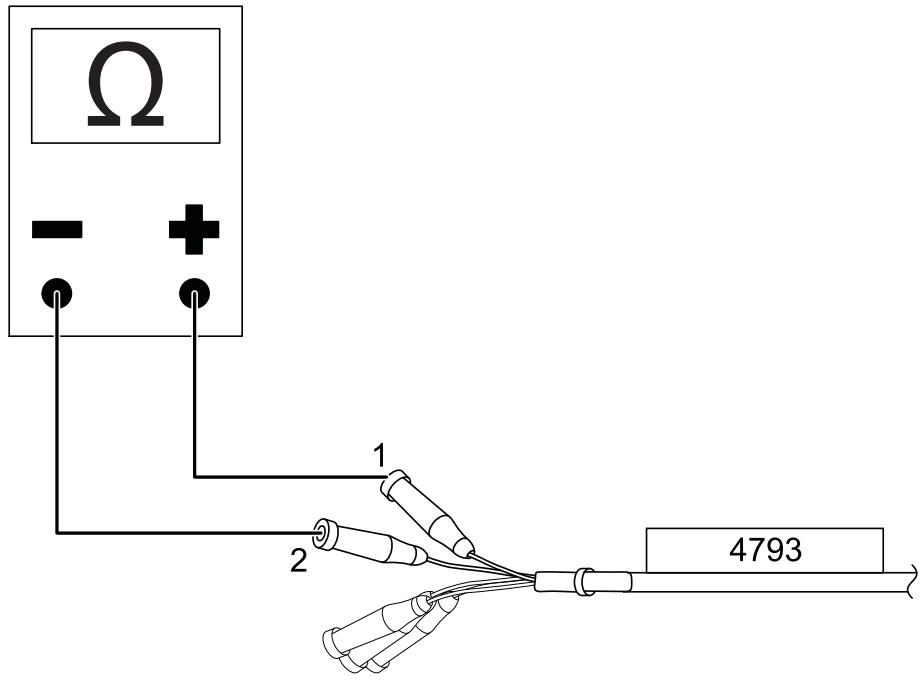


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Figure 438 Test 11 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 11 Setup
A. Key OFF. B. Disconnect Under Valve Connector (UVC) connector 4. C. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. D. Key ON.

Test 11	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-1 and pin-2.	1 ± 0.5 ohms
Decision	
Is resistance less than 0.5 ohms?	Yes: Go to Test 12.
	No: Go to Test 13.

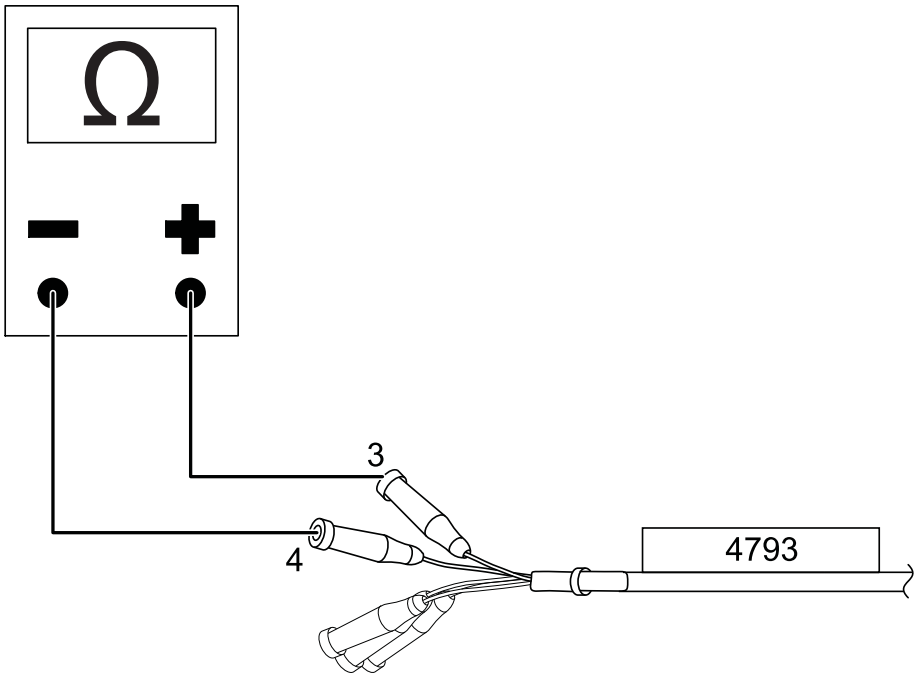


0000326341

Figure 439 Test 12 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 12 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 5. C. Disconnect Under Valve Connector (UVC) connector 4. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. E. Key ON.

Test 12	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-1 and pin-2.	1 ± 0.5 ohms
Decision	
Is resistance less than 0.5 ohms?	Yes: Repair short in injector 5 Close coil circuit. After repairs are complete, retest for SPN 2798 FMI 6.
	No: Replace fuel injector 5. After repairs are complete, retest for SPN 2798 FMI 6.

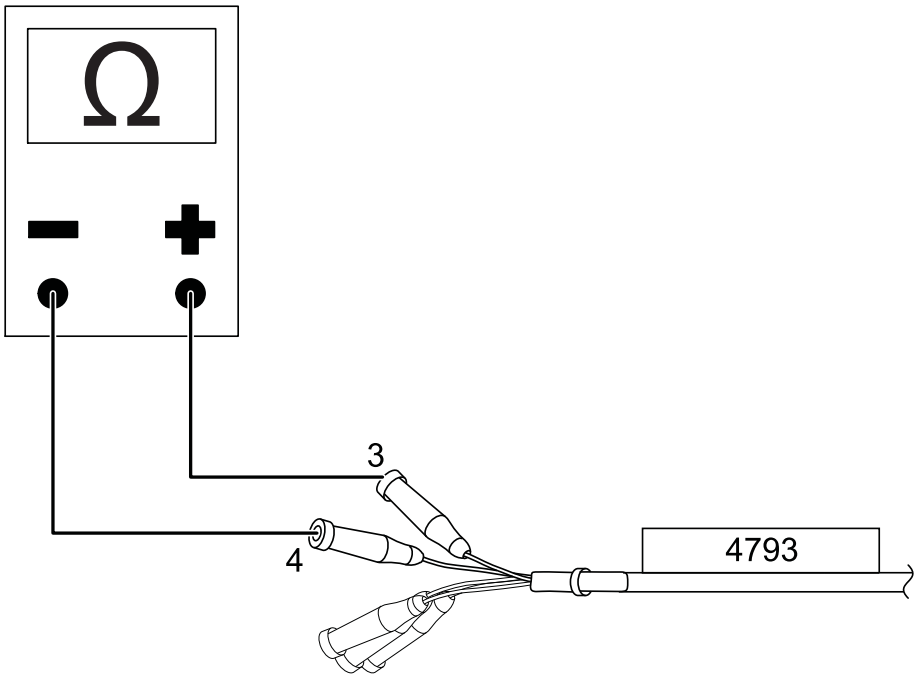


0000326361

Figure 440 Test 13 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 13 Setup
A. Key OFF. B. Disconnect Under Valve Connector (UVC) connector 4. C. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. D. Key ON.

Test 13	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-3 and pin-4.	1 ± 0.5 ohms
Decision	
Is resistance less than 0.5 ohms?	Yes: Go to Test 14.
	No: Go to Test 15.

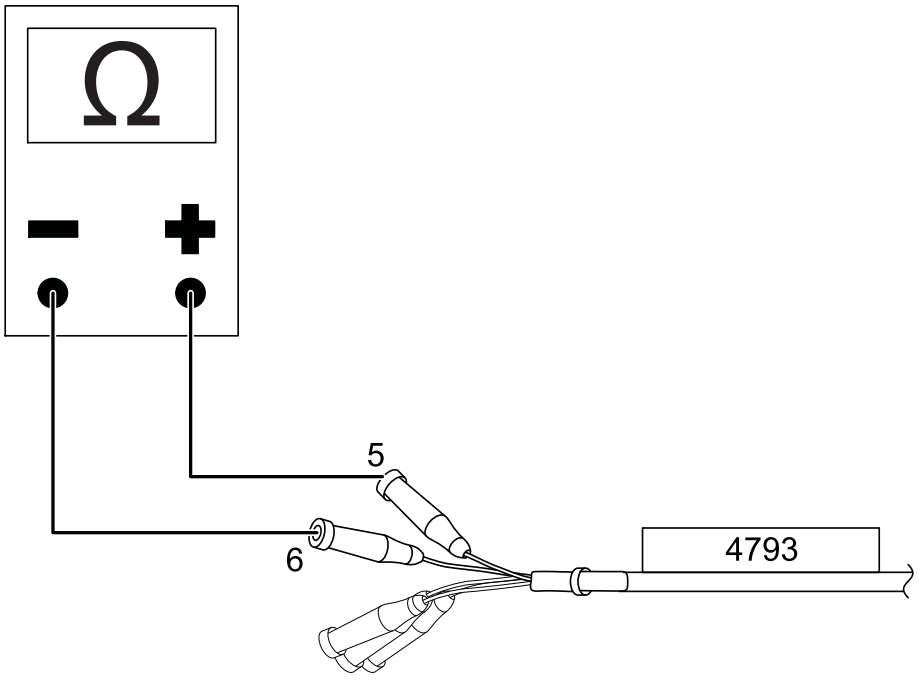


0000326361

Figure 441 Test 14 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 14 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 5. C. Disconnect Under Valve Connector (UVC) connector 4. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. E. Key ON.

Test 14	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-3 and pin-4.	1 ± 0.5 ohms
Decision	
Is resistance less than 0.5 ohms?	Yes: Repair short in injector 5 Open coil circuit. After repairs are complete, retest for SPN 2798 FMI 6.
	No: Replace fuel injector 5. After repairs are complete, retest for SPN 2798 FMI 6.

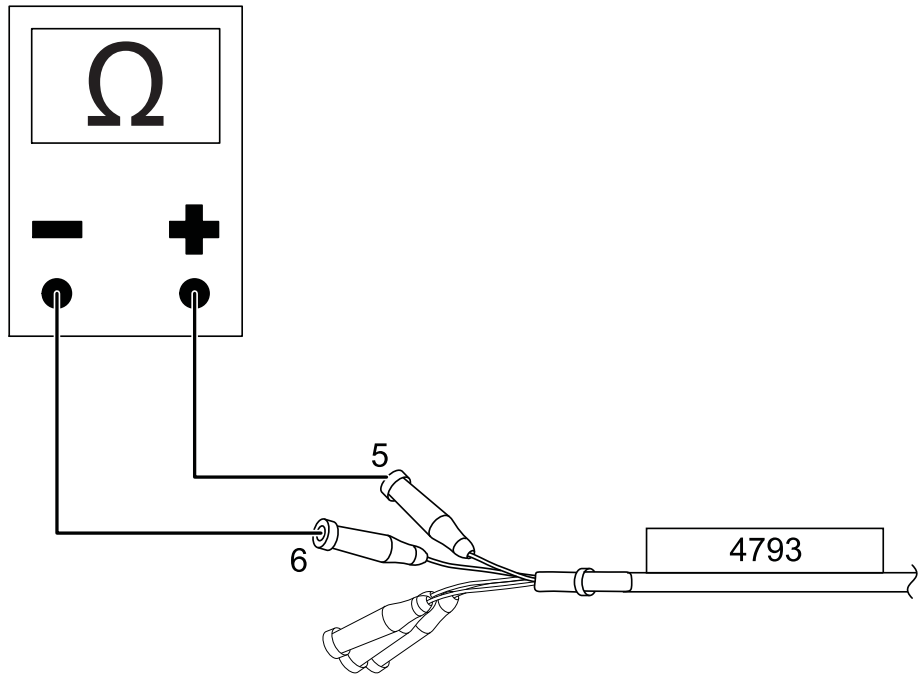


0000326381

Figure 442 Test 15 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 15 Setup
A. Key OFF. B. Disconnect Under Valve Connector (UVC) connector 4. C. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. D. Key ON.

Test 15	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-5 and pin-6.	1 ± 0.5 ohms
Decision	
Is resistance less than 0.5 ohms?	Yes: Go to Test 16.
	No: Go to Test 17.

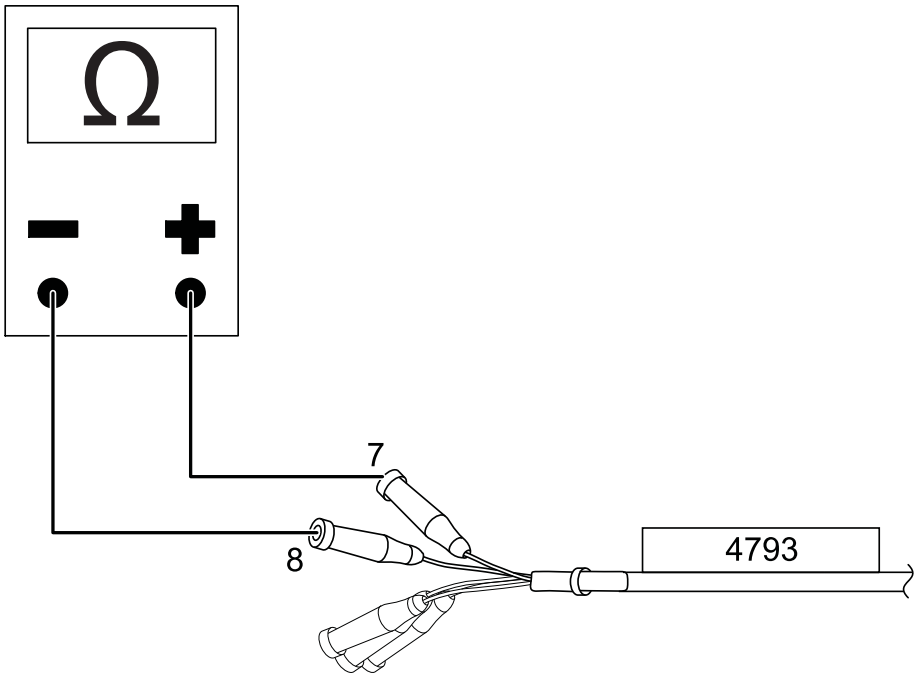


0000326381

Figure 443 Test 16 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 16 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 6. C. Disconnect Under Valve Connector (UVC) connector 4. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. E. Key ON.

Test 16	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-5 and pin-6.	1 ± 0.5 ohms
Decision	
Is resistance less than 0.5 ohms?	Yes: Repair short in injector 6 Close coil circuit. After repairs are complete, retest for SPN 2798 FMI 6.
	No: Replace fuel injector 6. After repairs are complete, retest for SPN 2798 FMI 8.

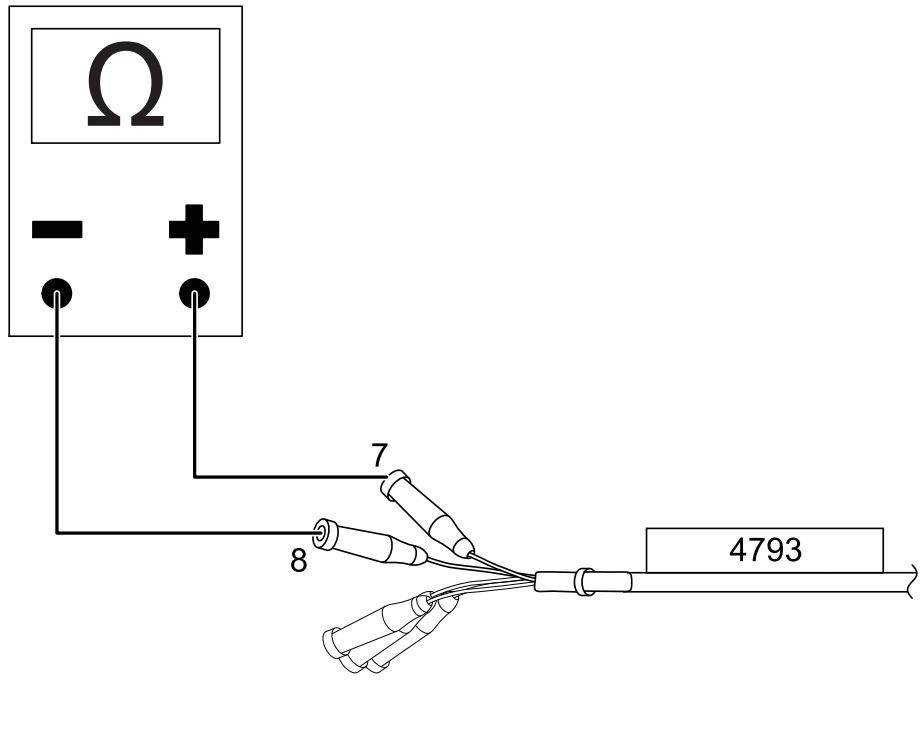


0000326401

Figure 444 Test 17 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 17 Setup
A. Key OFF. B. Disconnect Under Valve Connector (UVC) connector 4. C. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. D. Key ON.

Test 17	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-7 and pin-8.	1 ± 0.5 ohms
Decision	
Is resistance less than 0.5 ohms?	Yes: Go to Test 18.
	No: Go to Test 19.



0000326401

Figure 445 Test 18 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 18 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 6. C. Disconnect Under Valve Connector (UVC) connector 4. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. E. Key ON.

Test 18	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-7 and pin-8.	1 ± 0.5 ohms
Decision	
Is resistance less than 0.5 ohms?	Yes: Repair short in injector 6 Open coil circuit. After repairs are complete, retest for SPN 2798 FMI 6.
	No: Replace fuel injector 6. After repairs are complete, retest for SPN 2798 FMI 6.

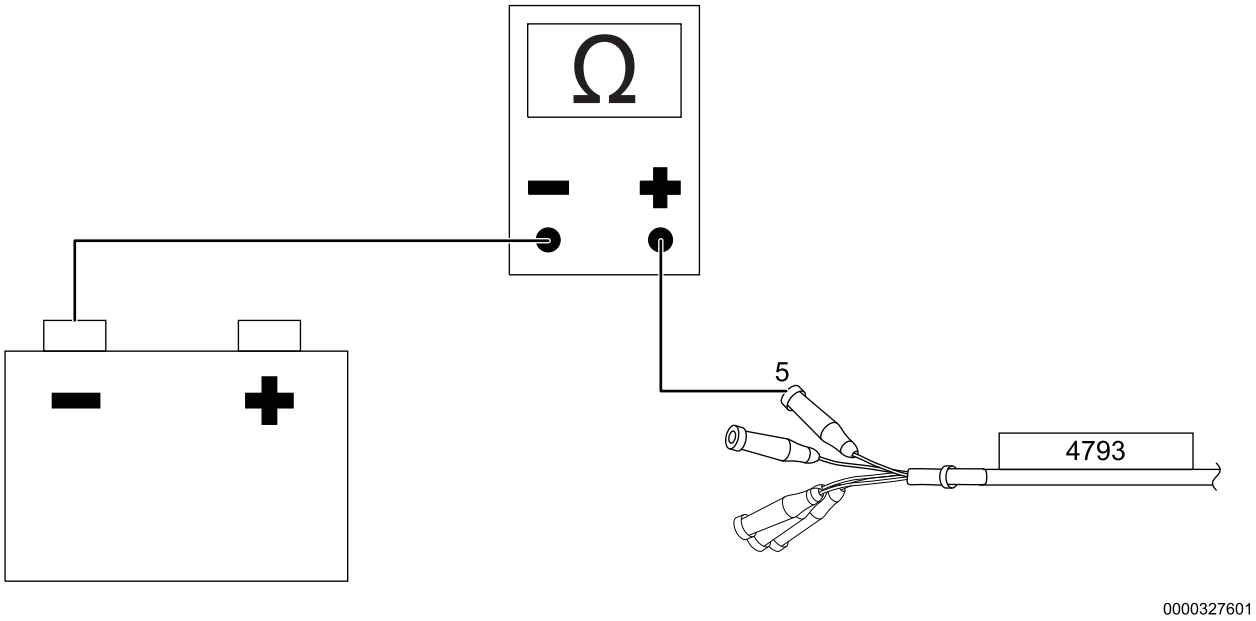


Figure 446 Test 19 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 19 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 4. C. Disconnect Under Valve Connector (UVC) connector 3. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. E. Key ON.

Test 19	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-5 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 20.
	No: Repair short to GND between Injector 4 pin-5 and ECM Driver pin D-36. After repairs are complete, retest for SPN 2798 FMI 6.

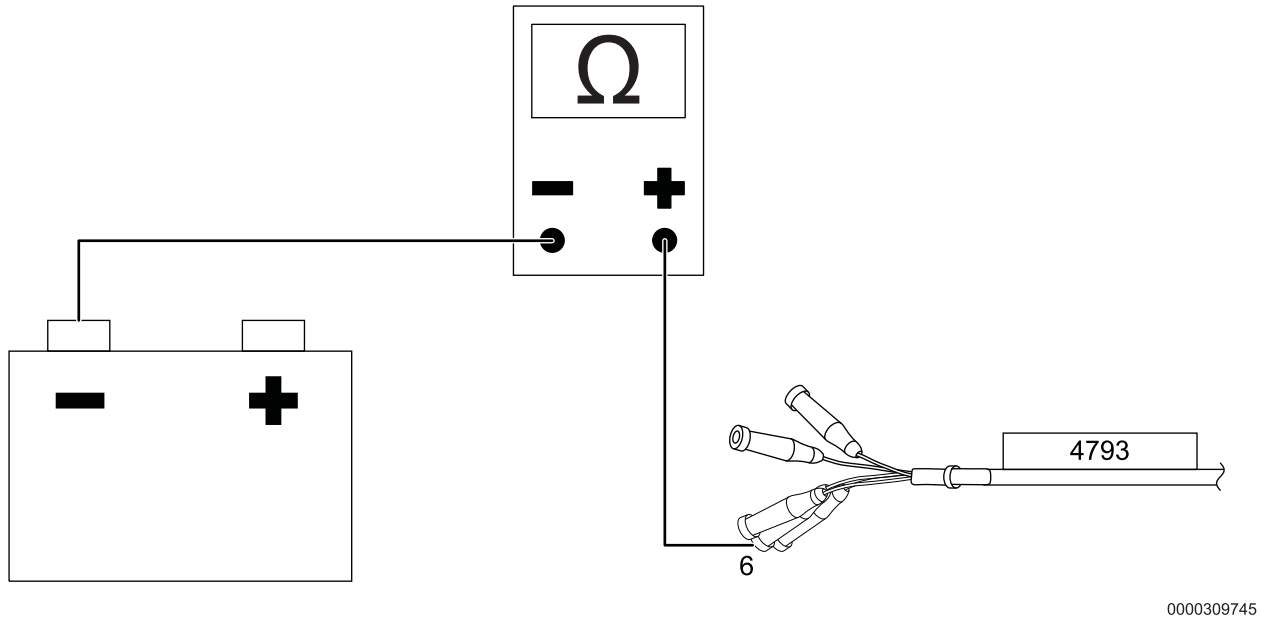


Figure 447 Test 20 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 20 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 4. C. Disconnect Under Valve Connector (UVC) connector 3. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. E. Key ON.

Test 20	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-6 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 21.
	No: Repair short to GND between Injector 4 pin-6 and ECM Driver pin D-35. After repairs are complete, retest for SPN 2798 FMI 6.

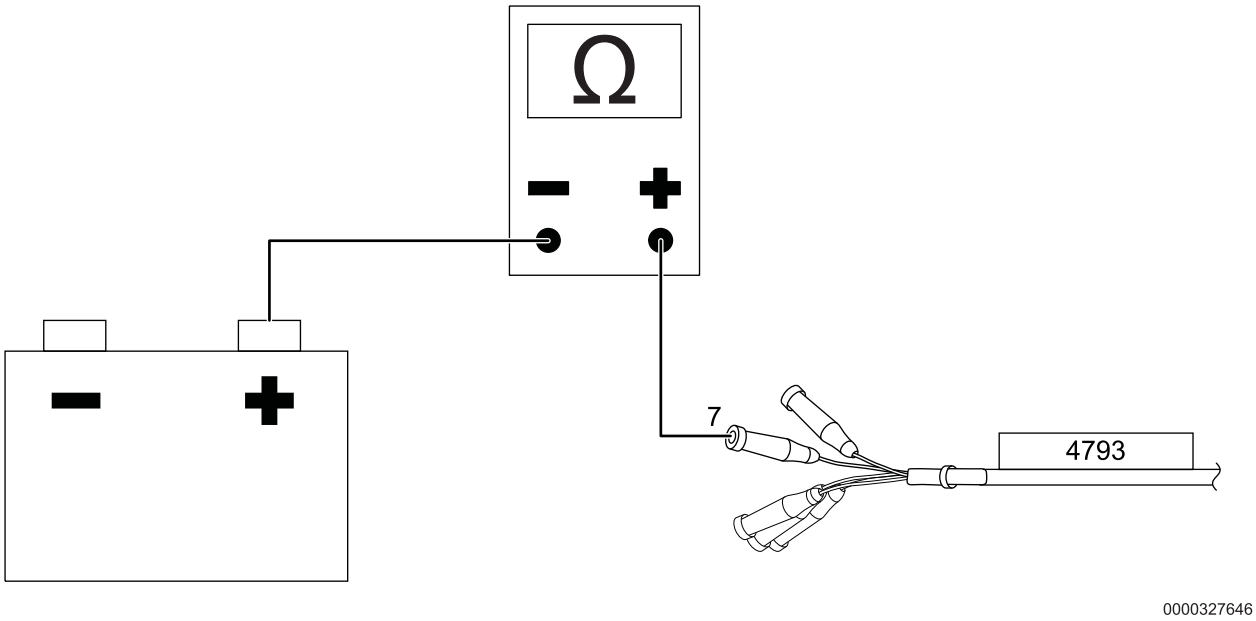


Figure 448 Test 21 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 21 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 4. C. Disconnect Under Valve Connector (UVC) connector 3. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. E. Key ON.

Test 21	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-7 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 22.
	No: Repair short to GND between Injector 4 pin-7 and ECM Driver pin D-29. After repairs are complete, retest for SPN 2798 FMI 6.

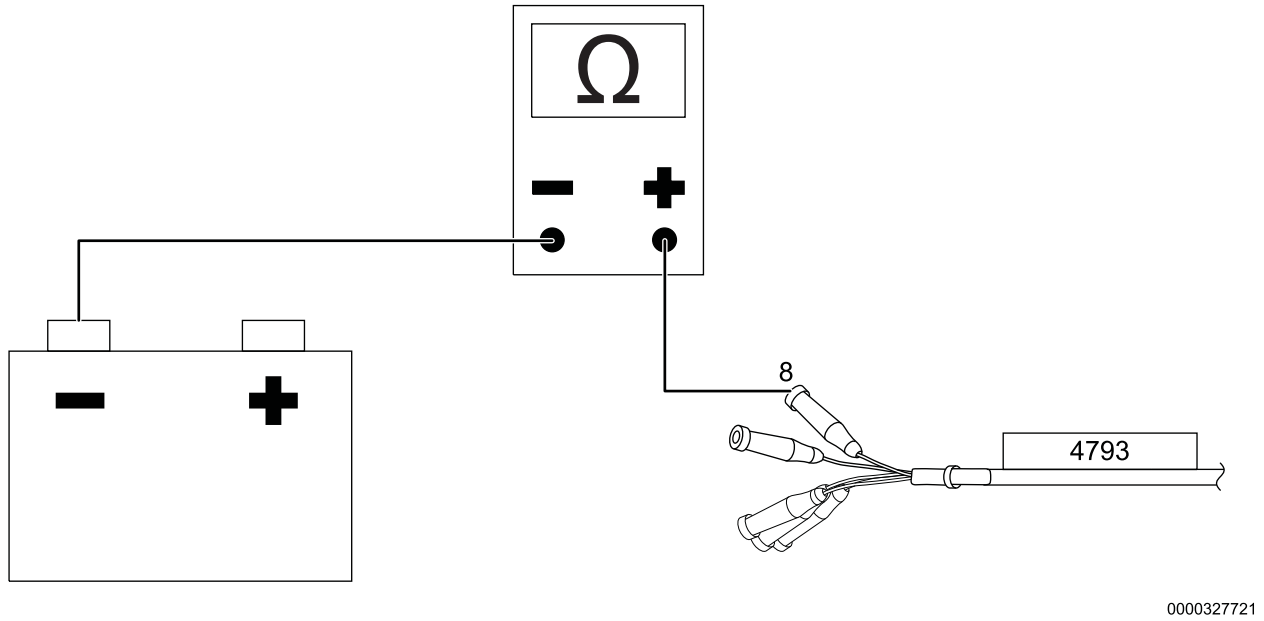


Figure 449 Test 22 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 22 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 4. C. Disconnect Under Valve Connector (UVC) connector 3. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. E. Key ON.

Test 22	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-8 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 23.
	No: Repair short to GND between Injector 4 pin-8 and ECM Driver pin D-30. After repairs are complete, retest for SPN 2798 FMI 6.

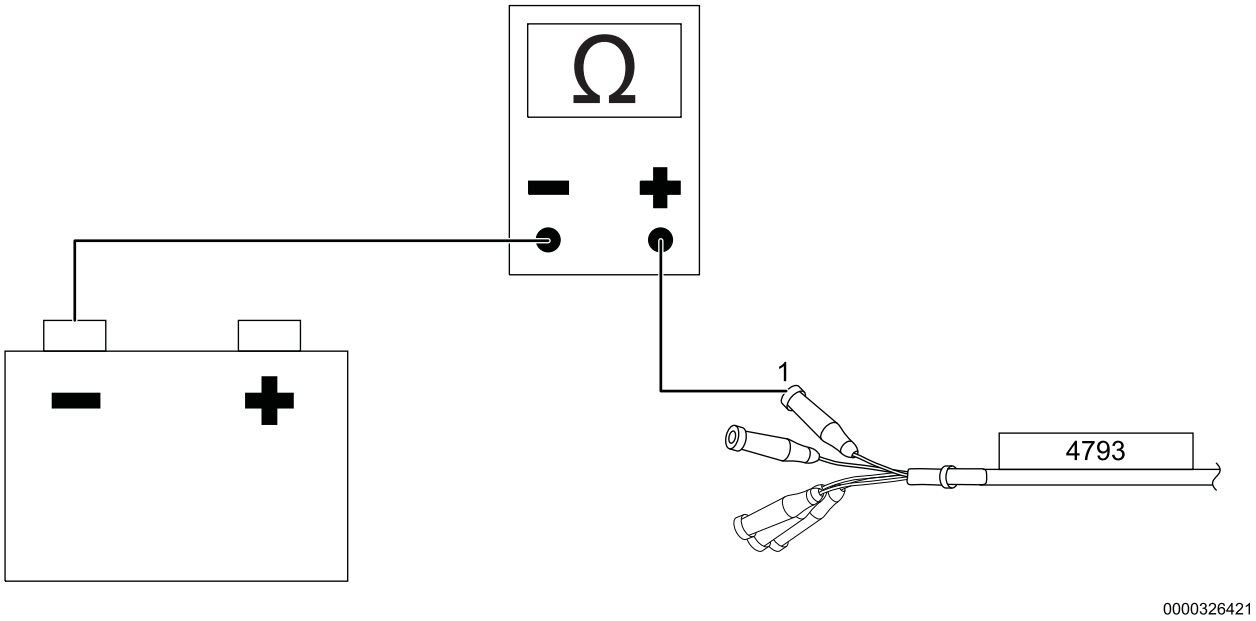


Figure 450 Test 23 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 23 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 5. C. Disconnect Under Valve Connector (UVC) connector 4. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. E. Key ON.

Test 23	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-1 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 24.
	No: Repair short to GND between Injector 5 pin-1 and ECM Driver pin D-32. After repairs are complete, retest for SPN 2798 FMI 6.

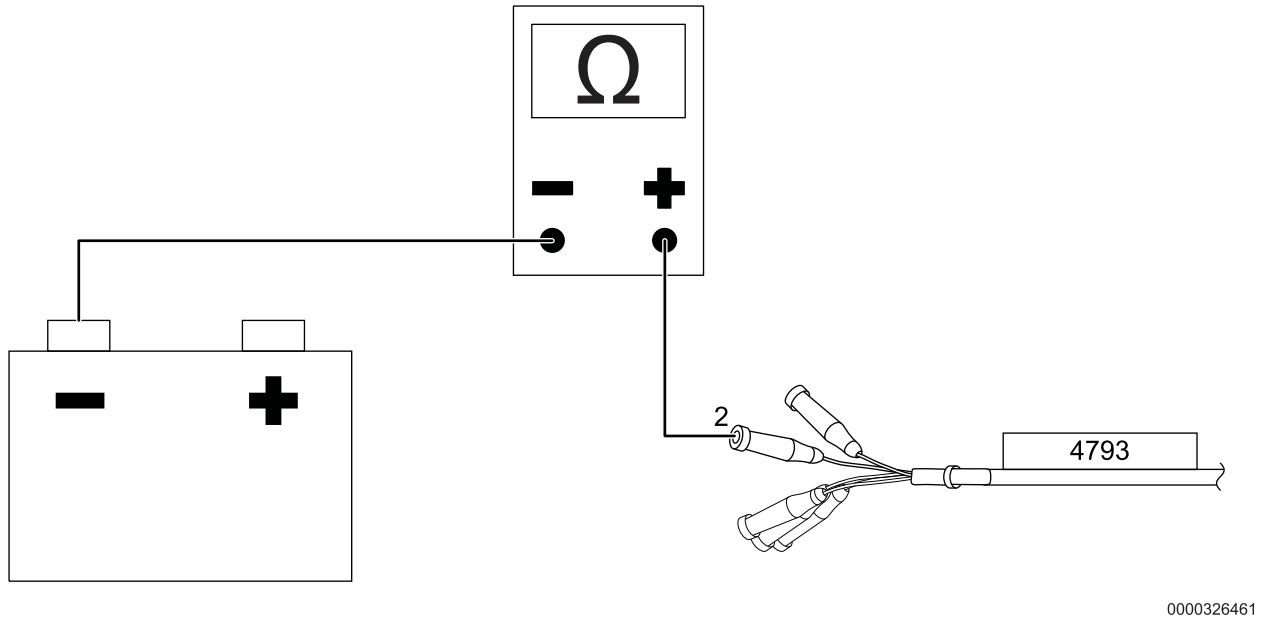


Figure 451 Test 24 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 24 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 5. C. Disconnect Under Valve Connector (UVC) connector 4. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. E. Key ON.

Test 24	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-2 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 25.
	No: Repair short to GND between Injector 5 pin-2 and ECM Driver pin D-31. After repairs are complete, retest for SPN 2798 FMI 6.

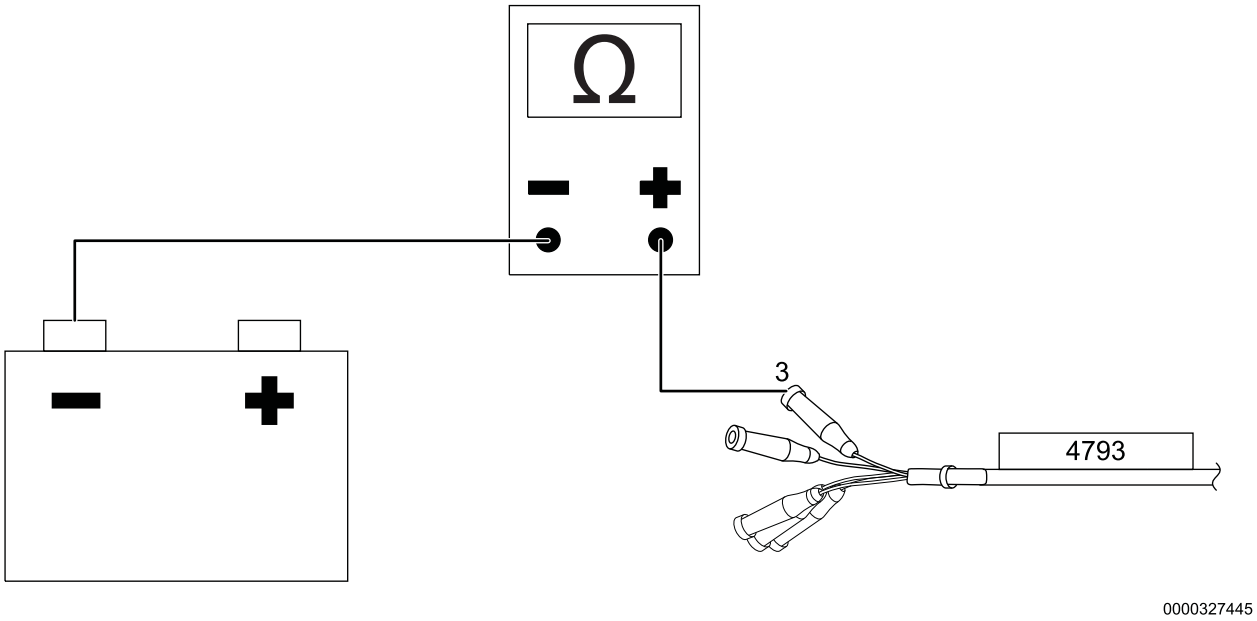


Figure 452 Test 25 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 25 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 5. C. Disconnect Under Valve Connector (UVC) connector 4. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. E. Key ON.

Test 25	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-3 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 26.
	No: Repair short to GND between Injector 5 pin-3 and ECM Driver pin D-25. After repairs are complete, retest for SPN 2798 FMI 6.

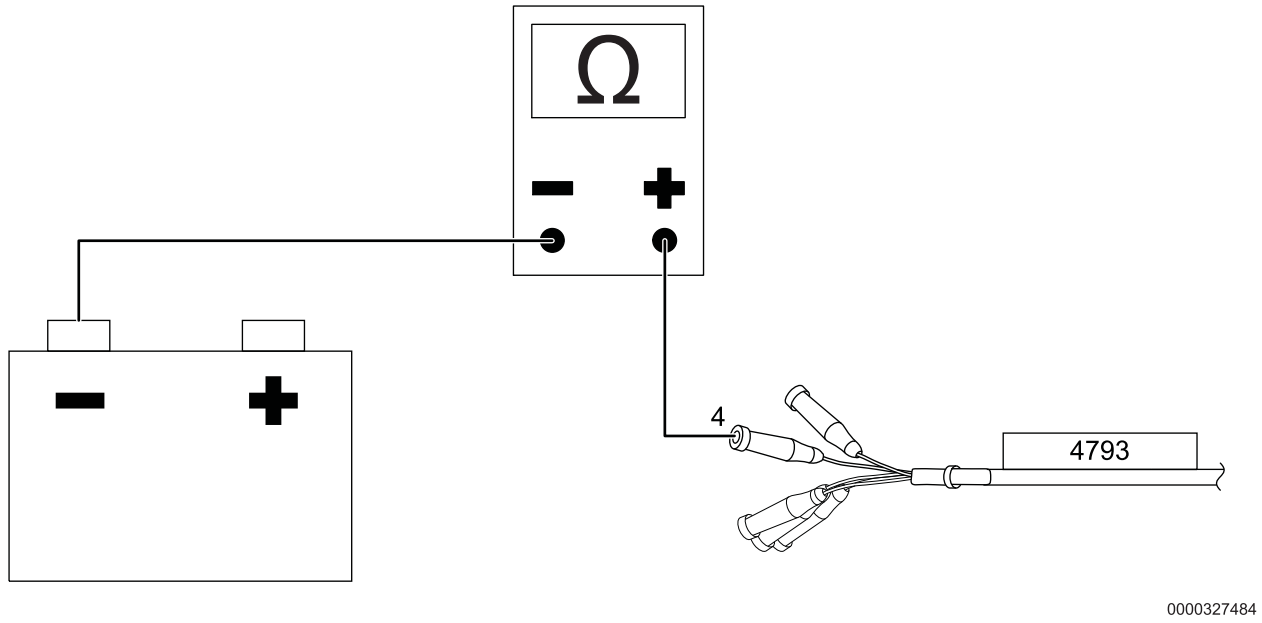


Figure 453 Test 26 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 26 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 5. C. Disconnect Under Valve Connector (UVC) connector 4. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. E. Key ON.

Test 26	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-4 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 27.
	No: Repair short to GND between Injector 5 pin-4 and ECM Driver pin D-26. After repairs are complete, retest for SPN 2798 FMI 6.

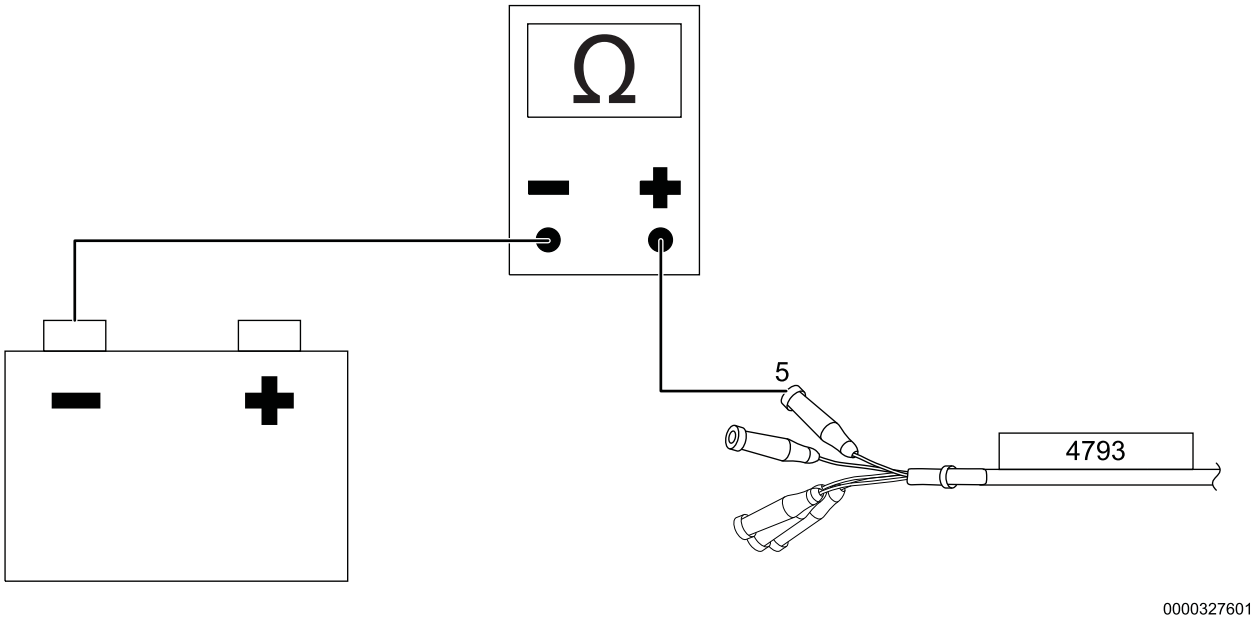


Figure 454 Test 27 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 27 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 6. C. Disconnect Under Valve Connector (UVC) connector 4. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. E. Key ON.

Test 27	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-5 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 28.
	No: Repair short to GND between Injector 6 pin-5 and ECM Driver pin D-34. After repairs are complete, retest for SPN 2798 FMI 6.

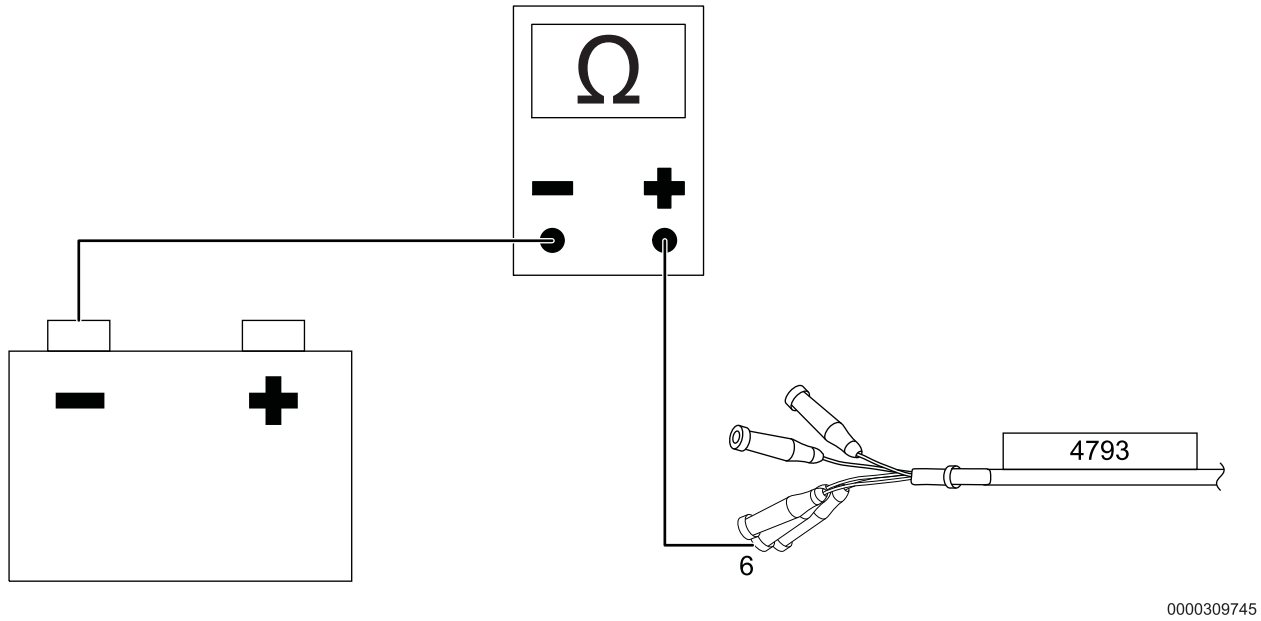


Figure 455 Test 28 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 28 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 6. C. Disconnect Under Valve Connector (UVC) connector 4. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. E. Key ON.

Test 28	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-6 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 29.
	No: Repair short to GND between Injector 6 pin-6 and ECM Driver pin D-33. After repairs are complete, retest for SPN 2798 FMI 6.

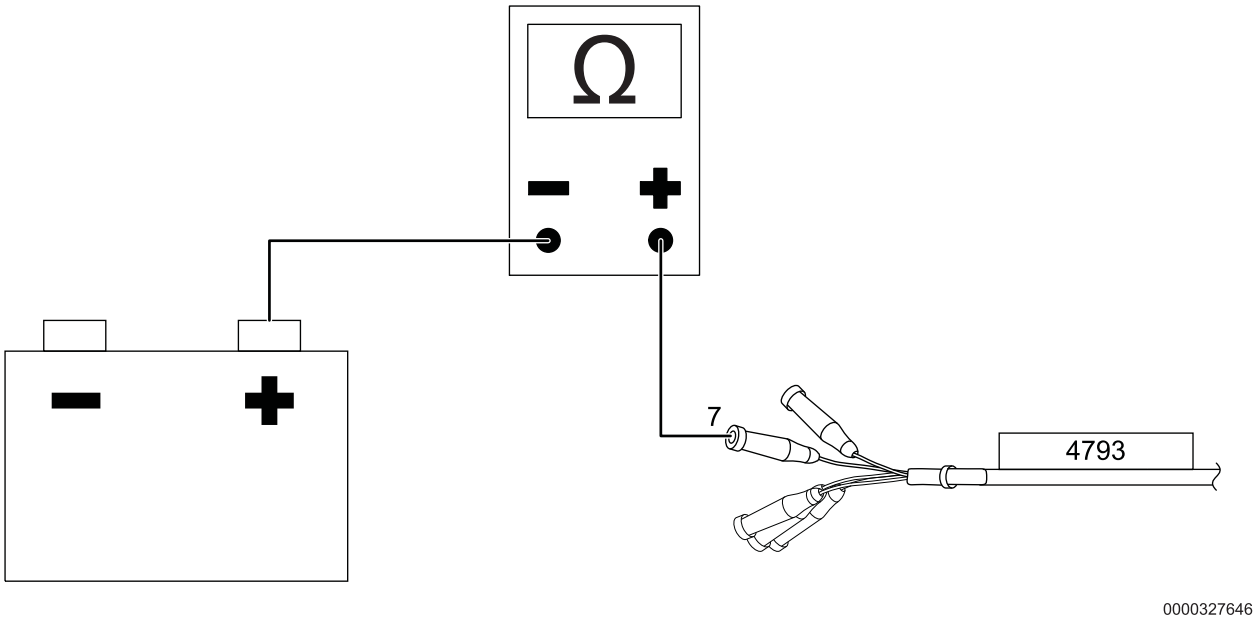


Figure 456 Test 29 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 29 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 6. C. Disconnect Under Valve Connector (UVC) connector 4. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. E. Key ON.

Test 29	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-7 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 30.
	No: Repair short to GND between Injector 6 pin-7 and ECM Driver pin D-27. After repairs are complete, retest for SPN 2798 FMI 6.

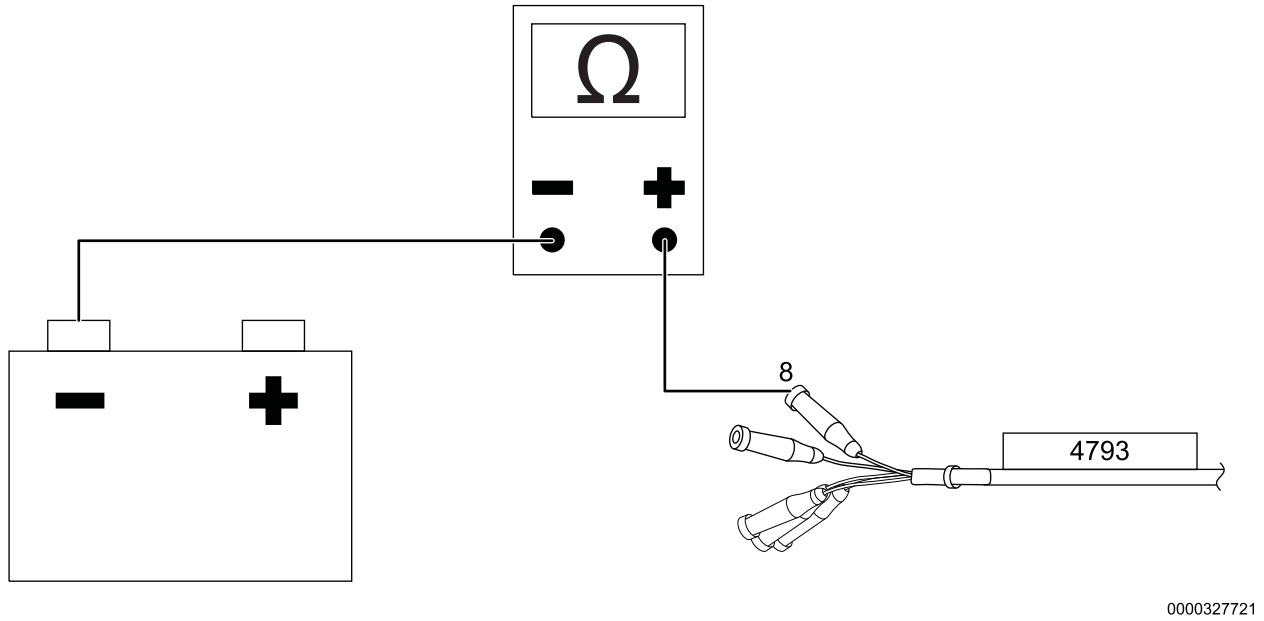


Figure 457 Test 30 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 30 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 6. C. Disconnect Under Valve Connector (UVC) connector 4. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. E. Key ON.

Test 30	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-8 and known good GND.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 31.
	No: Repair short to GND between Injector 6 pin-8 and ECM Driver pin D-28. After repairs are complete, retest for SPN 2798 FMI 6.

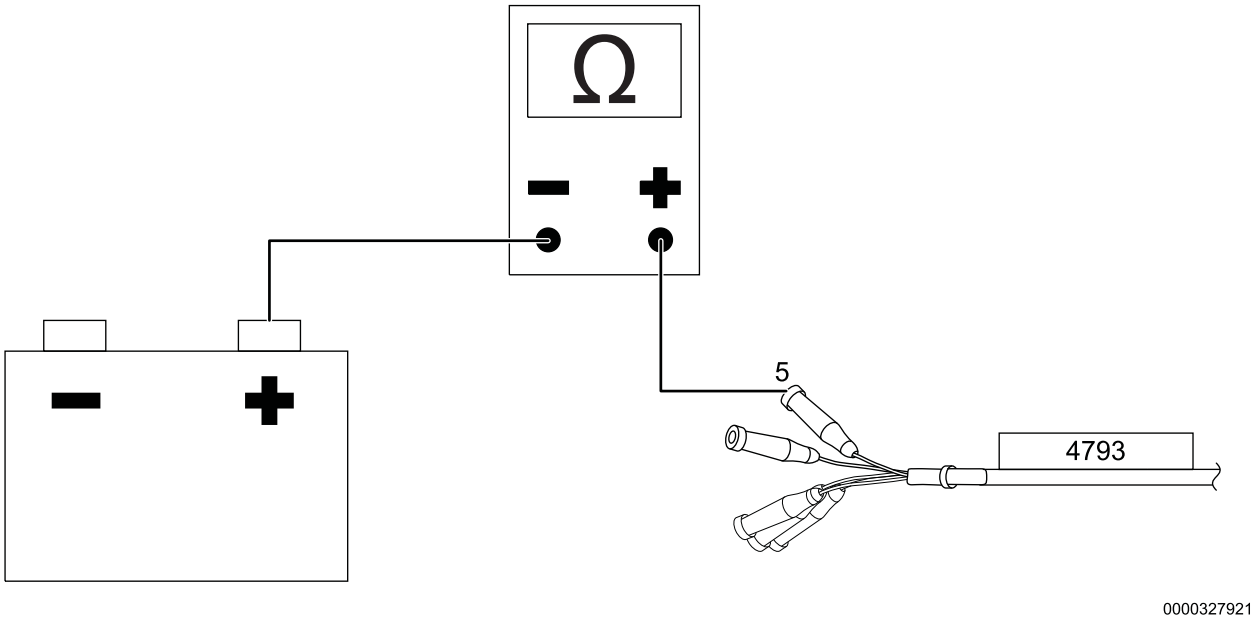


Figure 458 Test 31 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 31 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 4. C. Disconnect Under Valve Connector (UVC) connector 3. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. E. Key ON.

Test 31	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-5 and PWR.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 32.
	No: Repair short to PWR between Injector 4 pin-5 and ECM Driver pin D-36. After repairs are complete, retest for SPN 2798 FMI 6.

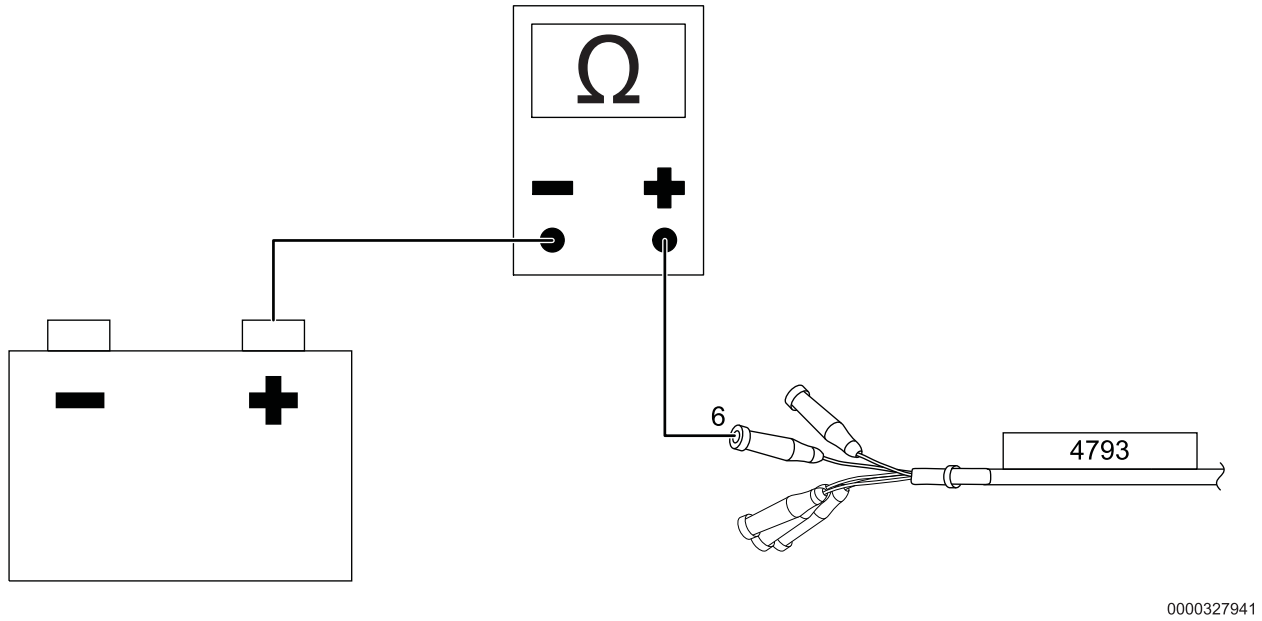


Figure 459 Test 32 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 32 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 4. C. Disconnect Under Valve Connector (UVC) connector 3. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. E. Key ON.

Test 32	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-6 and PWR.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 33.
	No: Repair short to PWR between Injector 4 pin-6 and ECM Driver pin D-35. After repairs are complete, retest for SPN 2798 FMI 6.

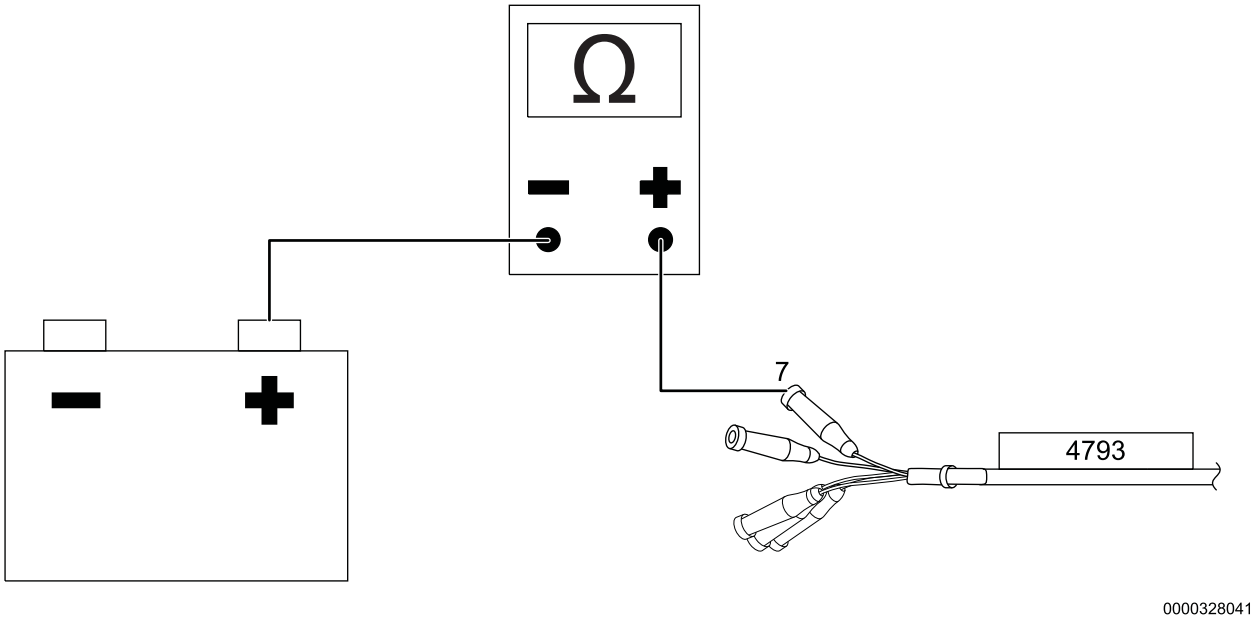


Figure 460 Test 33 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 33 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 4. C. Disconnect Under Valve Connector (UVC) connector 3. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. E. Key ON.

Test 33	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-7 and PWR.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 34.
	No: Repair short to PWR between Injector 4 pin-7 and ECM Driver pin D-29. After repairs are complete, retest for SPN 2798 FMI 6.

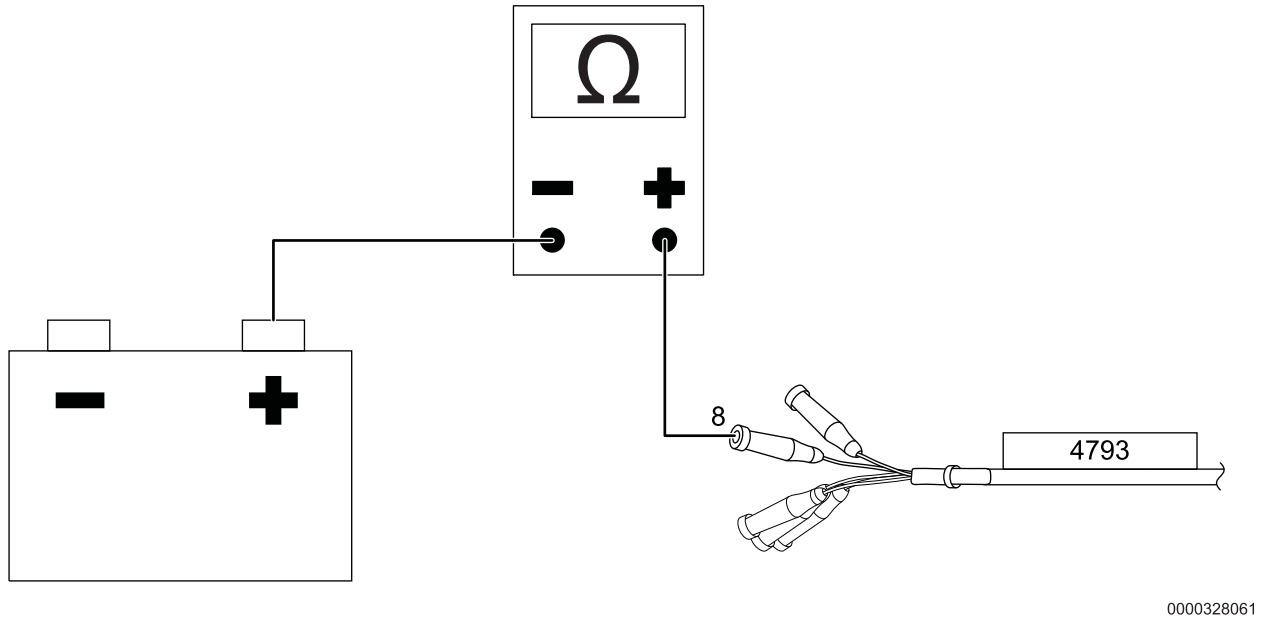


Figure 461 Test 34 Under Valve Connector (UVC) connector 3 Circuit Resistance Check

Test 34 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 4. C. Disconnect Under Valve Connector (UVC) connector 3. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 3 disconnected. E. Key ON.

Test 34	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-8 and PWR.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 35.
	No: Repair short to PWR between Injector 4 pin-8 and ECM Driver pin D-30. After repairs are complete, retest for SPN 2798 FMI 6.

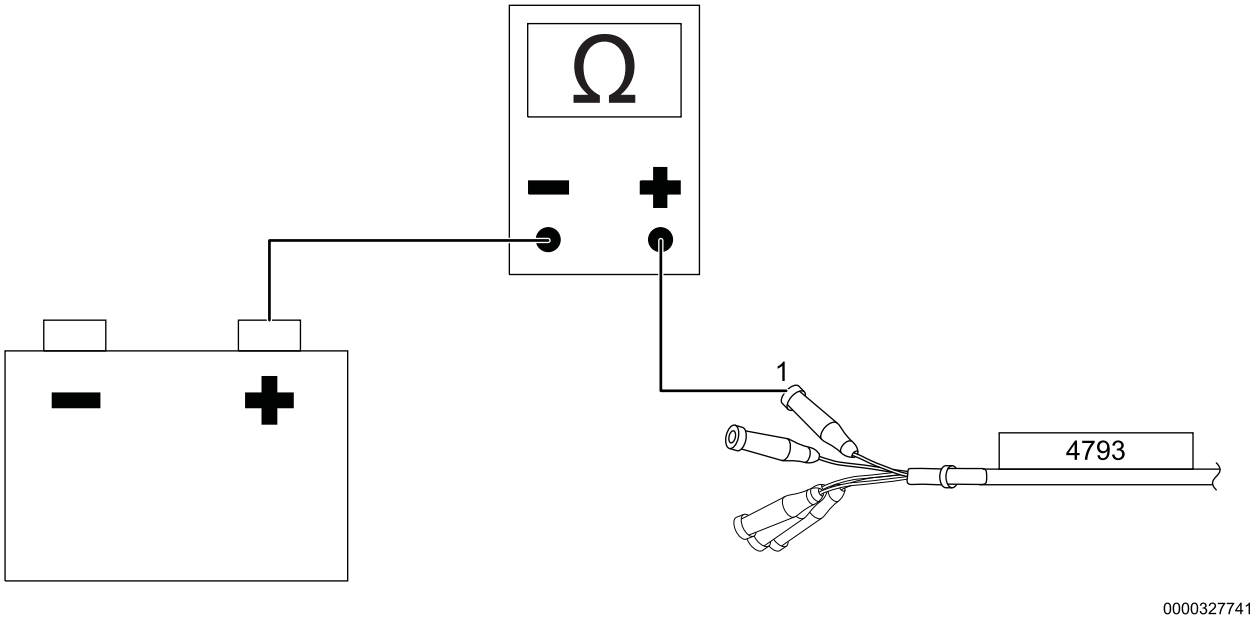


Figure 462 Test 35 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 35 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 5. C. Disconnect Under Valve Connector (UVC) connector 4. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. E. Key ON.

Test 35	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-1 and PWR.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 36.
	No: Repair short to PWR between Injector 5 pin-1 and ECM Driver pin D-32. After repairs are complete, retest for SPN 2798 FMI 6.

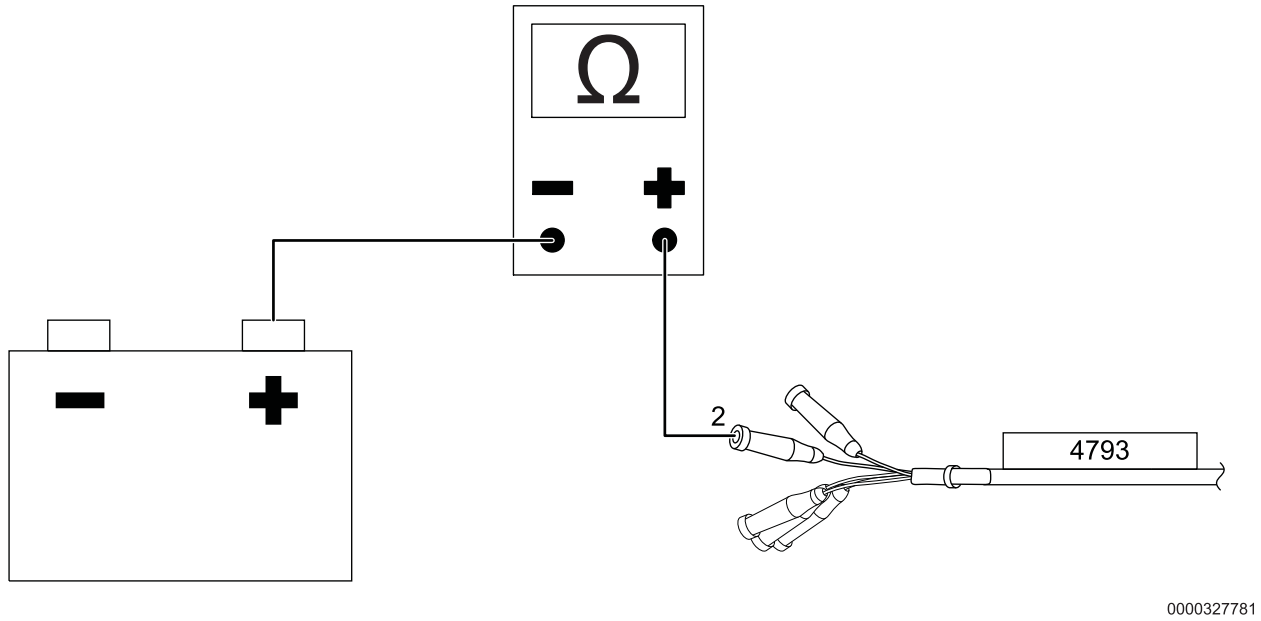


Figure 463 Test 36 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 36 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 5. C. Disconnect Under Valve Connector (UVC) connector 4. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. E. Key ON.

Test 36	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-2 and PWR.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 36.
	No: Repair short to PWR between Injector 5 pin-2 and ECM Driver pin D-31. After repairs are complete, retest for SPN 2798 FMI 6.

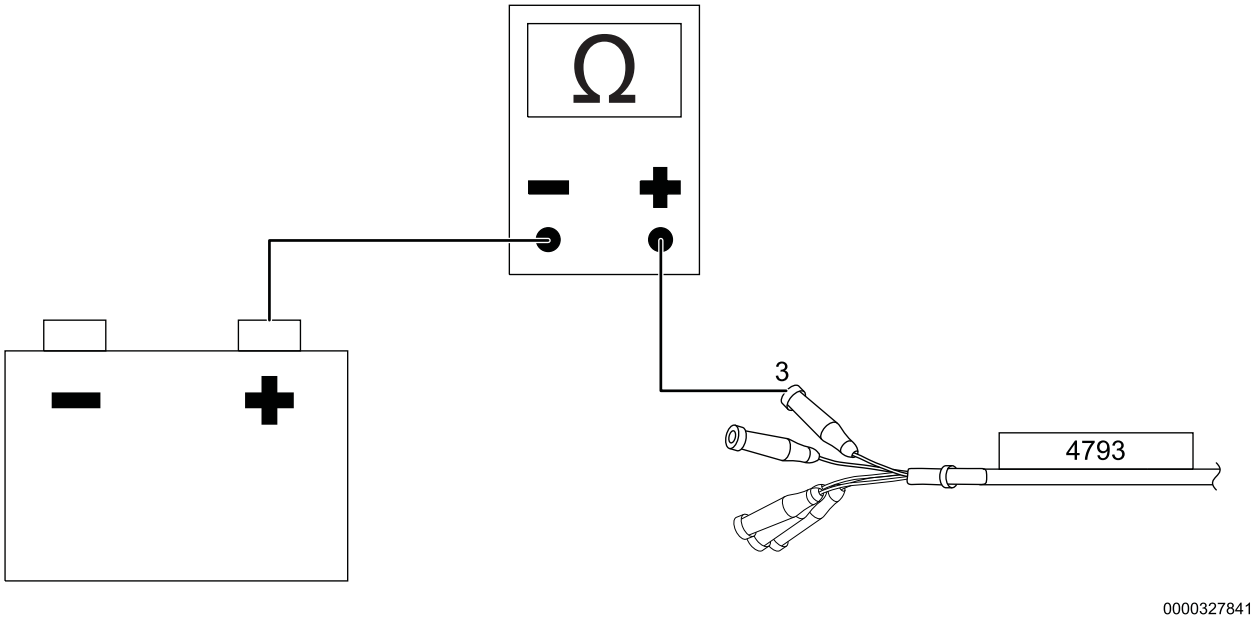


Figure 464 Test 37 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 37 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 5. C. Disconnect Under Valve Connector (UVC) connector 4. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. E. Key ON.

Test 37	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-3 and PWR.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 38.
	No: Repair short to PWR between Injector 5 pin-3 and ECM Driver pin D-25. After repairs are complete, retest for SPN 2798 FMI 6.

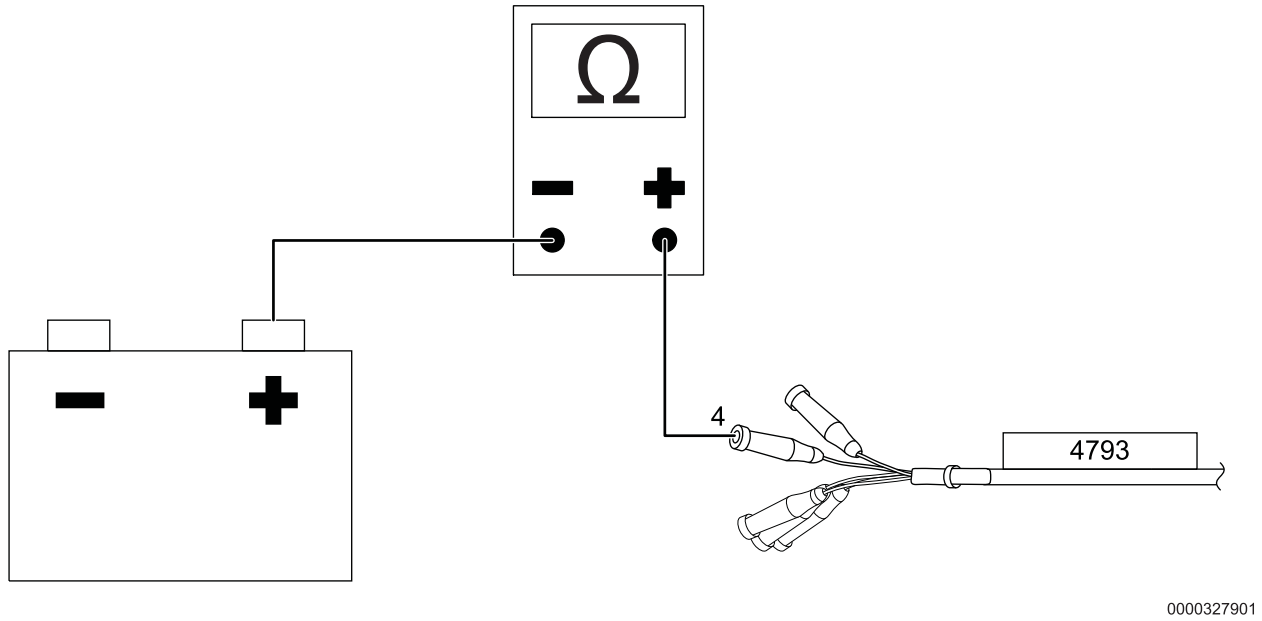


Figure 465 Test 38 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 38 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 5. C. Disconnect Under Valve Connector (UVC) connector 4. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. E. Key ON.

Test 38	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-4 and PWR.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 39.
	No: Repair short to PWR between Injector 5 pin-4 and ECM Driver pin D-26. After repairs are complete, retest for SPN 2798 FMI 6.

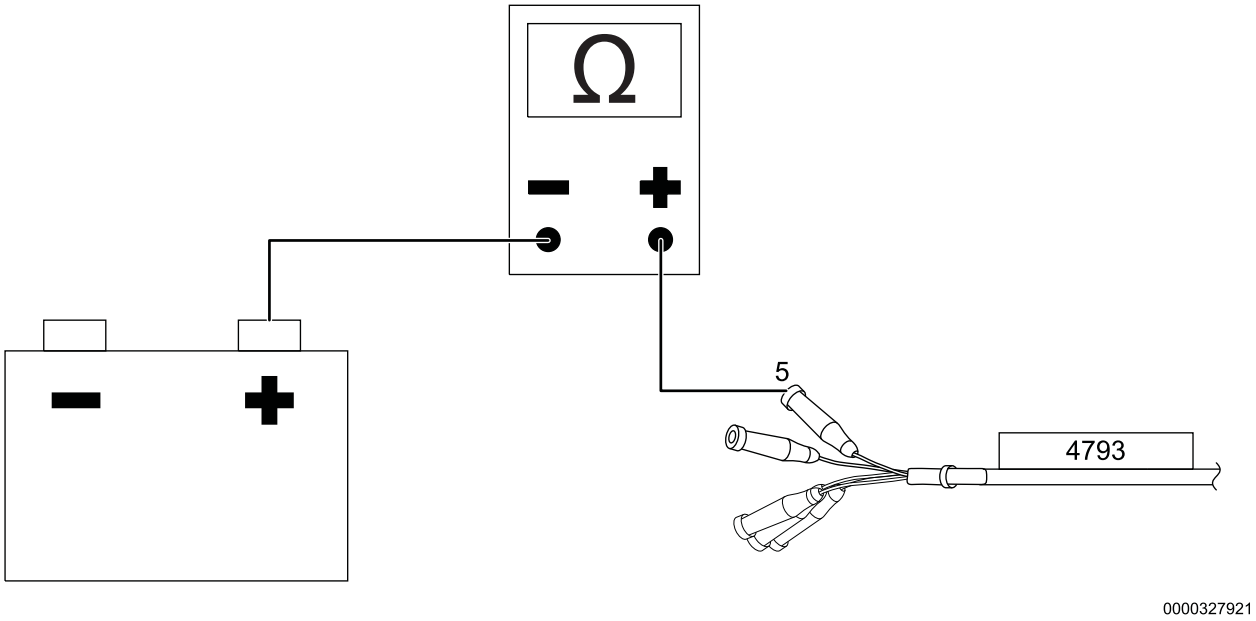


Figure 466 Test 39 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 39 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 6. C. Disconnect Under Valve Connector (UVC) connector 4. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. E. Key ON.

Test 39	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-5 and PWR.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 40.
	No: Repair short to PWR between Injector 6 pin-5 and ECM Driver pin D-34. After repairs are complete, retest for SPN 2798 FMI 6.

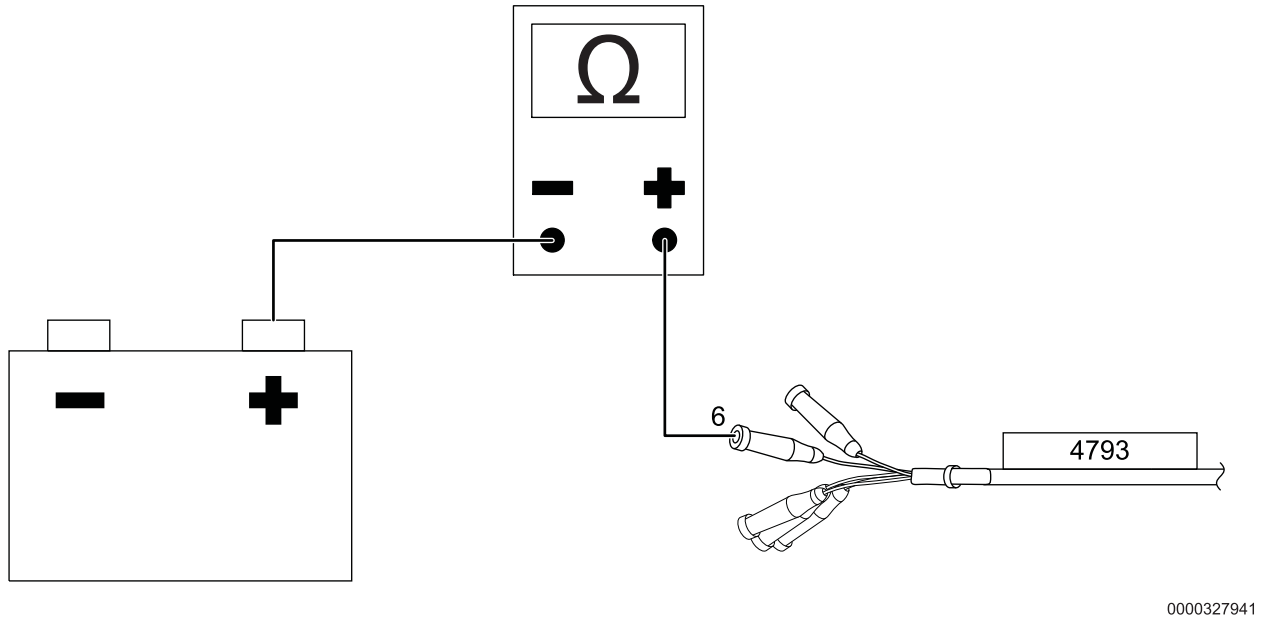


Figure 467 Test 40 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 40 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 6. C. Disconnect Under Valve Connector (UVC) connector 4. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. E. Key ON.

Test 40	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-6 and PWR.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Go to Test 41.
	No: Repair short to PWR between Injector 6 pin-6 and ECM Driver pin D-33. After repairs are complete, retest for SPN 2798 FMI 6.

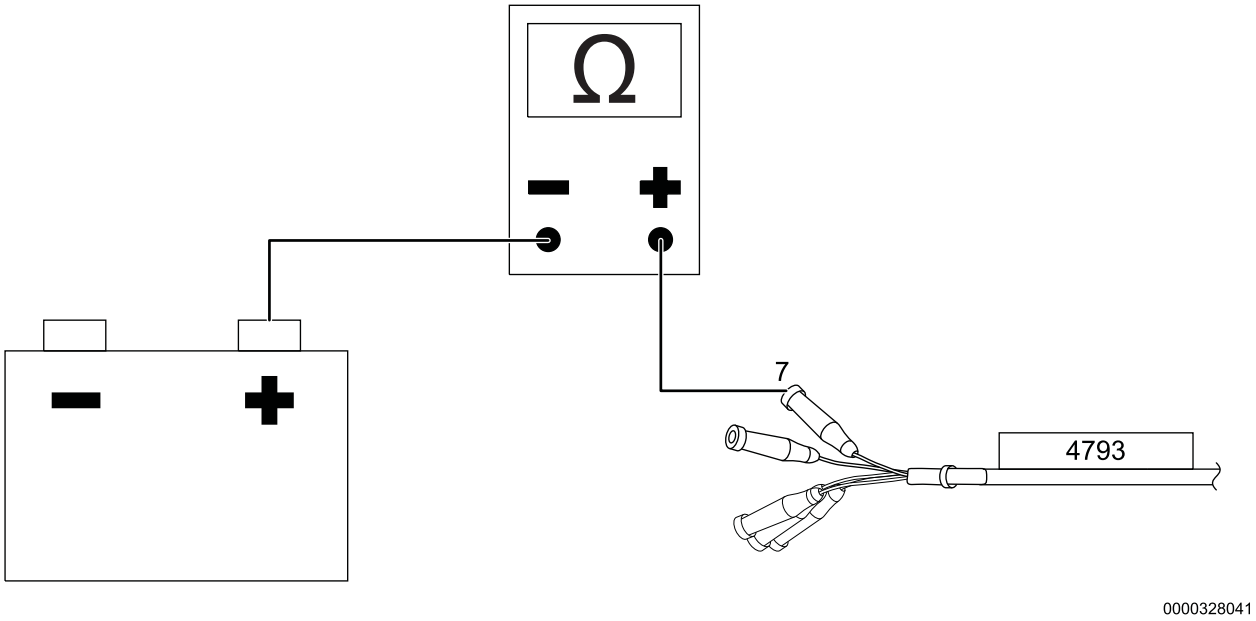


Figure 468 Test 41 Under Valve Connector (UVC) connector 4 Circuit Resistance Check

Test 41 Setup
A. Key OFF. B. Remove valve cover, disconnect Injector 6. C. Disconnect Under Valve Connector (UVC) connector 4. D. Connect Breakout Harness ZTSE4793 to vehicle harness and leave UVC connector 4 disconnected. E. Key ON.

Test 41	Specification
Using DMM measure resistance between Breakout Harness ZTSE4793 pin-7 and PWR.	Greater than 1000 ohms
Decision	
Is resistance greater than 1000 ohms?	Yes: Repair short to PWR between UVC connector 4 pin-4 and ECM Driver pin D-26. After repairs are complete, retest for SPN 2798 FMI 6.
	No: Repair short to PWR between Injector 6 pin-7 and ECM Driver pin D-27. After repairs are complete, retest for SPN 2798 FMI 6.

End Diagnostic Steps
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 2798 FMI 6 fault code diagnostics.

Injector Performance

SPN	FMI	Condition	Possible Causes	Actions
4257	7	Injector coking compensation factor reached maximum authority	• Injectors aging	Step-based Diagnostics (page 1044)
4257	16	Multiple injector high flow fault	• Injector fuel quantity drifted high • Biased (Injector Control Pressure (ICP) sensor • Biased Exhaust Gas Temperature (EGT) sensor • Biased Air Inlet Temperature (AIT) circuit	Step-based Diagnostics (page 1045)
4257	18	Multiple injector low flow fault	• Injector fuel quantity drifted low • Biased ICP sensor • Biased EGT sensor	Step-based Diagnostics (page 1054)

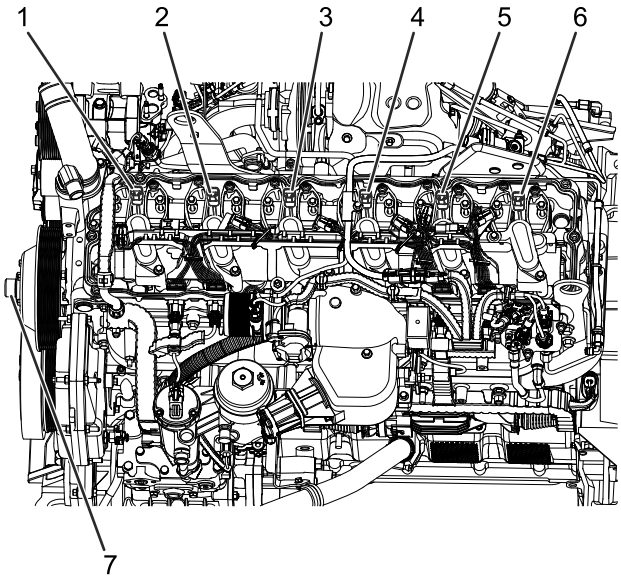


Figure 469 Sensor Location

1. Injector 1
2. Injector 2
3. Injector 3
4. Injector 4
5. Injector 5
6. Injector 6
7. Water Pump

Tools

- EZ Tech® Electronic Service Tool (EST) – J-45067 (page 1226)
- Fuel Pressure Gauge (ZTSE4681)
- Fuel Pressure Test Kit (ZTSE4657)

SPN 4257

FMI 7 – Injector coking compensation factor maximum authority reached

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Injector coking compensation factor maximum authority reached	Cumulative coking compensation value estimated by injector coking compensation factor accumulator model > 16 %	Key ON Monitor enablement based on speed / load (Table A095)	Immediate

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the injector coking compensation has reached its maximum level.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

Step	Action	Decision
1	Replace all injectors. Contact Technical Service for support to reset the correct programmable parameter for coking compensation.	

NOTE: After doing all diagnostic steps, if SPN 4257 FMI 7 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 4257

FMI 16 – Multiple Injector High Flow Fault.

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel Injection Quantity/Timing HIGH on ALL injectors	Measured Engine Exhaust Gas temperature (EGT) Value MINUS Modeled EGT value > Threshold defined as a function of speed / load [Table A098]	Particulate filter regeneration not active	10 seconds
		Barometric pressure ≥ 11 psi (73.5 kPa) and ≤ 15 psi (103 kPa)	
		Engine Air Inlet Temperature ≥ 19°F (-7°C) AND ≤ 140°F (60°C)	
		Power Take Off (PTO) Mode NOT Active	
		End Of Line Testing NOT Active	
		[Engine Brake (Retarder) NOT active	
		AND minimum wait time after retarder change of state has occurred] > 5 seconds	
		Engine Torque limitation NOT Active	
		Engine is NOT coasting (i.e., Throttle Cut OFF mode)	
		Engine Smoke limitation NOT Active	
		Battery Voltage ≥ 10.787 Volts AND ≤ 15.787 Volts	
		Engine Ignition Key is in "ON" position (Key ON)	
		Time after engine start ≥ 30 seconds	
		1. Engine Speed ≥ 1600 rpm	
		2. Engine Torque command	

FMI 16 – Multiple Injector High Flow Fault. (cont.)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		≥ 564 lb-ft (765 N·m)	
		3. Absolute value of Engine speed gradient < 39.99 rpm/second	
		4. Absolute value of Engine torque command gradient < 11lb-ft/second (15 N·m/second)	
		5. Aftertreatment DPF differential pressure < 1 psi (10 kPa)	
		6. Engine turbocharger 1 turbine outlet pressure MINUS Barometric pressure < 15 psi (130 kPa)	
		7. Engine turbocharger 1 turbine outlet pressure MINUS Intake Manifold Pressure < 4 psi (30 kPa)	
		8. Estimated DPF soot load < 100 hPa/m3	
		9. Engine Exhaust gas temperature > 437°F (225°C)	
		Delay timer after entry conditions 1 through 9 (listed above) are satisfied ≥ 6 seconds	
		SPN / FMIs 27/14, 51/3, 51/4, 51/7, 94/3, 94/4, 102/3, 102/4,	

FMI 16 – Multiple Injector High Flow Fault. (cont.)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		102/7, 102/16, 102/18, 105/2, 105/3, 105/4, 108/3, 108/4, 110/2, 110/3, 110/4, 132/0, 132/1, 132/3, 132/4, 164/0, 164/3, 164/4, 164/16, 164/18, 175/2, 175/3, 175/4, 636/2, 636/7, 651/4, 651/5, 651/7, 652/4, 652/5, 652/7, 653/4, 653/5, 653/7, 654/4, 654/5, 654/7, 655/4, 655/5, 655/7, 656/4, 656/5, 656/7, 1173/16, 1189/3, 1189/4, 1323/31, 1324/31, 1325/31, 1326/31, 1327/31, 1328/31, 1322/31, 2659/20, 2659/21, 2791/2, 2791/3, 2791/4, 2791/7, 2791/8, 2791/14, 3055/2, 3242/3, 3242/4, 3246/3, 3246/4, 3251/3, 3251/4, 3251/21, 3464/11, 3471/1, 3471/7, 3479/3, 3479/5, 3479/6, 3480/3, 3480/4, 3482/3, 3482/4, 3556/1, 3556/7, 3936/2, 3936/8, 3936/20, 4257/7, 4765/3, 4765/4, 4766/10, 5543/3, 5543/4, 5543/5 are NOT Active	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines more than one injector is flowing more fuel than expected.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN / FMIs: 27/0, 27/3, 27/4, 27/7, 27/11, 651/14, 652/14, 653/14, 654/14, 655/14, 656/14, 1209/0, 1209/2, 1209/3, 1209/4, 1209/7, 1209/31, 3251/0, 3251/2, 3251/10, 3251/14, 3387/20, 3388/20, 3389/20, 3390/20, 3391/20, 3392/20, 3387/21, 3388/21, 3389/21, 3390/21, 3391/21, and 3392/21.

Drive Cycle to Determine Fault Status

N/A

Step	Action	Decision
1	Commence four-hour cold soak for test in Step 12. Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for fault codes. Is SPN 4257 FMI 16 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 4257 FMI 16. No: Go to Step 3.

Step	Action	Decision
3	Inspect the fuel system from fuel tank to fuel injectors for restrictions, leaks, or physical damage. Is fuel system free of restrictions, leaks, and physical damage?	Yes: Go to Step 4. No: Repair restrictions, leaks, or physical damage. After repairs are complete, retest for SPN 4257 FMI 16.

Step	Action	Decision
4	Do visual inspection . Check all fluid levels and inspect engine systems for problems (leaks, open connections, harness chaffing, and etc.). Check engine oil, fuel level, fuel quality, engine coolant level, Charge Air Cooler (CAC) system (Use Freeze Frame information to determine if conditions may exist due to CAC icing), electrical system, intake air system (check for air cleaner restrictions), and exhaust system (check for evidence of miss-routed detector hoses, exhaust leaks, leaking Fey rings, cracked exhaust manifold, leaking exhaust manifold gaskets, leaking flanges, and V-band clamps). Are all items checked within specification?	Yes: Go to Step 5. No: Do corrective actions specified in test steps. After repairs are complete, retest for SPN 4257 FMI 16.

Step	Action	Decision
5	Inspect vehicle grille for obstructions that may reduce air flow to the CAC. Is vehicle grille free of obstructions? **NOTE:** According to service guidance, Navistar® does not recommend a usage of winter front.	Yes: Go to Step 6. No: Repair or remove obstruction from grille. After repairs are complete, retest for SPN 4257 FMI 16.

Step	Action	Decision
6	Check engine fan, fan shroud, and air dams for damage and proper operation. Are engine fan, fan shroud, and air dams intact and operating properly?	Yes: Go to Step 7. No: Repair or replace engine fan, fan shroud, and air dams as required. After repairs are complete, retest for SPN 4257 FMI 16.

Step	Action	Decision
7	Check CAC for oil, dirt, or other debris. Do CAC checks (page 193). Is the CAC system free of dirt, debris, or oil?	Yes: Go to Step 8. No: Clean CAC. After repairs are complete, retest for SPN 4257 FMI 18.

Step	Action	Decision
8	Connect CAC test kit, pressurize CAC to 25 to 35 psi (172 to 241 kPa), check for leakage. Is CAC free of leaks?	Yes: Go to Step 9. No: Repair CAC. After repairs are complete, retest for SPN 4257 FMI 18.

Step	Action	Decision
9	Using terminal test kit, inspect connections at Exhaust Gas Recirculate (EGR) valve, Exhaust Back Pressure (EBP) sensor, Fuel Injector Under Valve Cover (UVC) connectors, Exhaust Gas Temperature (EGT) sensor, and Injector Control Pressure (ICP) sensor. With key OFF, disconnect connectors and sensors. Check connectors and sensors for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are EGR valve, EBP sensor, fuel injector UVC connectors, ICP sensor, and EGT sensor connectors, harnesses, and terminals clean and undamaged?	Yes: Go to Step 10. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4257 FMI 16.

Step	Action	Decision
10	Test EBP and ICP sensors for intermittent circuit operation using EST with ServiceMaxx™ software. Do Key ON, Engine OFF Continuous Monitor Test (page 87). Verify sensor voltages are within specifications (page 1291). Are sensor voltages within specifications?	Yes: Go to Step 11. No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuits as required. After repairs are complete, retest for SPN 4257 FMI 16.

Step	Action	Decision
11	Test ICP and EGT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks EGT and ICP . Are ICP and EGT circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 12. No: Repair circuits as required. After repairs are complete, retest for SPN 4257 FMI 16.

Step	Action	Decision
12	Do Cold Soak Sensor Compare Check. Compare Intake Manifold Temperature (IMT) to Aftertreatment Fuel Inlet Temperature (AFTFT), Engine Coolant Temperature (ECT), Air Inlet Temperature (AIT), Turbocharger 2 Compressor Inlet Temperature (TC2CIT), Charge Air Cooler Outlet Temperature (CACOT), and Engine Oil Temperature (EOT) temperature sensors. All sensors should be within 59°F (15°C) of each other. Is IMT within 59°F (15°C) the other sensors?	Yes: Go to Step 13. No: Replace temperature sensors which are out of the acceptable range of variance. After repairs are complete, retest for SPN 4257 FMI 16.

Step	Action	Decision
13	During Cold Soak done in step 12, check EGT sensor minimum temperature, EGT sensor should be 284°F (140°C). Is EGT sensor at 284°F (140°C)?	Yes: Go to Step 14. No: Check EGT circuit for low resistance fault . Do any of the following based on test results: 1. Repair harness as required. 2. Replace EGT sensor if harness resistance check passes. After repairs are complete, retest for SPN 4257 FMI 16.

Step	Action	Decision
14	Check for evidence of excessive blow-by in crankcase. Do Crankcase Pressure Test (page 212). Are all items checked within specifications?	Yes: Go to Step 15. No: Do corrective actions specified in test steps. After repairs are complete, retest for SPN 4257 FMI 16.

Step	Action	Decision
15	Check for intermittent sensor operation or wiring faults. Connect EST with ServiceMaxx™ software to diagnostic connector, turn to KOEO. Run Key On Engine OffKey On Engine Off Continuous Monitor Test (page 87). Monitor Intake Manifold Pressure (IMP), Mass Air Flow (MAF), Barometric Pressure (BARO) sensor, and IMT sensor voltages and verify that no active SPN / FMI is present. **NOTE:** If sensor signal circuit is shorted or open, signal value will read N/A or Error. If code is inactive, monitor the signal while wiggling connector and all wires at suspected locations. If circuit is interrupted, the signal will spike. Are sensor voltages within specifications and NO code active?	Yes: Go to Step 16. No: Disconnect applicable sensor(s), inspect connector(s) for damaged pins or wires, repair as necessary. After repairs are complete, retest for SPN 4257 FMI 16.

Step	Action	Decision
16	Remove IMP and IMT sensors (*Engine Service Manual, Removal Section*). Inspect sensor ends for damage, excessive deposits, or clogged port (IMP sensor only). Are sensors free of damage, excessive deposits, and clogged port?	Yes: Go to Step 17. No: Replace sensor per installation section of Engine Service Manual. After repairs are complete, retest for SPN 4257 FMI 16.

Step	Action	Decision
17	Using EST with ServiceMaxx™ software, do Key On Engine Off Output Low State Test (page 87) and Output High State Test (page 87). Determine if Engine Throttle Valve (ETV) is following command. Is output within specification (page 1291)?	Yes: Go to Step 18. No: Replace ETV. After repairs are complete, retest for SPN 4257 FMI 16.

Step	Action	Decision
18	Verify IMP changes when Turbocharger 2 Wastegate Control (TC2WC) and EGR valve are commanded ON. Do Key On Engine Running Air Management Test (page 201) while monitoring IMP sensor signal. While monitoring IMP signal: • Does IMP pressure decrease when TC2WC is commanded On? • Does IMP pressure decrease when EGR valve is commanded On?	Yes: IMP signal does not change when any of the valves are commanded on. Go to step 19. No: IMP pressure decreases when TC2WC is commanded on. Do TC2WC test (page 1165). After repairs are complete, retest for SPN 4257 FMI 16. No: IMP pressure decreases when EGR is commanded on. Do EGR Pin-point Diagnostics (page 679).

Step	Action	Decision
		After repairs are complete, retest for SPN 4257 FMI 16.
		No: IMP pressure increases when EBPV is commanded on. Do Exhaust Back Pressure Valve (EBPV) test (page 537). After repairs are complete, retest for SPN 4257 FMI 16.

Step	Action	Decision
19	Check Exhaust Back Pressure Valve (EBPV) for proper function and sticking. Position an assistant to listen for EBPV operation when engine is shut down, and do EBPV Operational Voltage Check (page 537). Did EBPV cycle three times when engine was shut down, and were voltages within specification?	Yes: Go to step 20.
		No: Do EBPV diagnostics (page 535)following procedures in EBPV section. After repairs are complete, retest for SPN 4257 FMI 16.

Step	Action	Decision
20	Using EST with ServiceMaxx™ software, do Key On Engine Running Standard Test (page 87). Did KOER Standard Test run with no faults?	Yes: Go to Step 21.
		No: Refer to the diagnostic procedures for any reported faults and repair as required. After repairs are complete, retest for SPN 4257 FMI 16.

WARNING: To prevent personal injury or death, do not perform an On Board Filter Cleanliness Test (OBFCT) or Parked Regeneration if liquid oil or fuel is present or suspected to be present in the DPF. Liquid oil or fuel will ignite during an OBFCT causing fires or damage to the vehicle or other equipment.

Step	Action	Decision
21	Using EST with ServiceMaxx™ software, start an On Board Filter Cleanliness Test (OBFCT). Is OBFCT running without an Abort Message in ServiceMaxx™?	Yes: Go to Step 22.
		No: Correct Parked Regen Inhibitors and redo Step 21.

Step	Action	Decision
22	While running OBFCT, inspect for exhaust system for leaks or physical damage. Is exhaust system free of leaks and physical damage?	Yes: Go to Step 23.
		No: Repair leaks and physical damage as required. After repairs are complete, retest for SPN 4257 FMI 16.

Step	Action	Decision
23	After OBFCT is complete, does Diesel Particulate Filter Differential Pressure (DPFDP) signal measure below 0.5 psi (3 kPa) at high idle?	Yes: Go to Step 24.
		No: Remove DPF and inspect for restrictions. If restricted, have the DPF cleaned using the appropriate DPF cleaning equipment. After repairs are complete, retest for SPN 4257 FMI 16.

Step	Action	Decision
24	Do MAF Calibration procedure (page 1101) using EST with ServiceMaxx™ software. **NOTE:** Ensure MAF Calibration Requirements are met and MAF Calibration Pre-Checks are done prior to doing this procedure. Turn ignition switch to ON, engine OFF. Start ServiceMaxx™ software. Run Key On Engine Running Standard Test (page 87). Run MAF Sensor Calibrate procedure (page 1101). Start engine. Ensure engine operating temperature is at or above 176°F (80°C). Did the MAF sensor calibration run successfully?	Yes: Go to Step 25.
		No: verify all MAF calibration requirements are met and MAF calibration pre-checks are done and redo MAF calibration.

Step	Action	Decision
25	Do Valve Lash adjustment (see *Engine Service Manual*, Cylinder Head and Valve Train section). Is valve lash within specification?	Yes: After doing all diagnostic steps, if SPN 4257 FMI 16 remains, verify steps were completed correctly and proper decisions were made. Notify supervisor for further action.
		No: Using Engine Service Manual, adjust valves to specification. After repairs are complete, retest for SPN 4257 FMI 16.

NOTE: After doing all diagnostic steps, if SPN 4257 FMI 16 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 4257

FMI 18 – Multiple Injector Low Flow Fault.

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel Injection Quantity / Timing LOW on ALL injectors	Measured Engine Exhaust Gas temperature (EGT) Value MINUS Modeled EGT value < Threshold defined as a function of Speed / Torque [Table A099]	Particulate Filter Regeneration NOT Active	10 seconds
		Barometric Pressure ≥ 11 psi (73.5 kPa) AND ≤ 15 psi (103 kPa)	
		Engine Air Inlet Temperature ≥ 19°F (-7°C) AND ≤ 140°F(60°C)	
		Power Take Off (PTO) Mode NOT Active	
		End Of Line Testing NOT Active	
		[Engine Brake (Retarder) NOT active	
		AND minimum wait time after retarder change of state has occurred] > 5 seconds	
		Engine Torque limitation NOT Active	
		Engine is NOT coasting (i.e., Throttle Cut OFF mode)	
		Engine Smoke limitation NOT Active	
		Battery Voltage ≥10.787 Volts AND ≤ 15.787 Volts	
		Engine Ignition Key is in "ON" position (Key ON)	
		Time after engine start ≥ 30 seconds	
		1. Engine Speed ≥ 1600 rpm	
		2. Engine Torque command	

FMI 18 – Multiple Injector Low Flow Fault. (cont.)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		≥ 564 lb-ft (765 N·m)	
		3. Absolute value of Engine speed gradient < 40 rpm/seconds	
		4. Absolute value of Engine torque command gradient < 11 lb-ft/second (15 N·m/second)	
		5. Aftertreatment DPF differential pressure < 1 psi (10 kPa)	
		6. Engine turbocharger 1 turbine outlet pressure MINUS Barometric pressure < 19 psi (130 kPa)	
		7. Engine turbocharger 1 turbine outlet pressure MINUS Intake Manifold Pressure < 4 psi (30 kPa)	
		8. Estimated DPF soot load < 100 hPa/m3	
		9. Engine Exhaust gas temperature > 437°F (225°C)	
		Delay timer after entry conditions 1 through 9 (listed above) are satisfied ≥ 6 seconds	
		SPN / FMIs 27/14, 51/3, 51/4, 51/7, 94/3, 94/4, 102/3, 102/4, 102/7, 102/16, 102/18, 105/2,	

FMI 18 – Multiple Injector Low Flow Fault. (cont.)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		105/3, 105/4, 108/3, 108/4, 110/2, 110/3, 110/4, 132/0, 132/1, 132/3, 132/4, 164/0, 164/3, 164/4, 164/16, 164/18, 175/2, 175/3, 175/4, 636/2, 636/7, 651/4, 651/5, 651/7, 652/4, 652/5, 652/7, 653/4, 653/5, 653/7, 654/4, 654/5, 654/7, 655/4, 655/5, 655/7, 656/4, 656/5, 656/7, 1173/16, 1189/3, 1189/4, 1323/31, 1324/31, 1325/31, 1326/31, 1327/31, 1328/31, 1322/31, 2659/20, 2659/21, 2791/2, 2791/3, 2791/4, 2791/7, 2791/8, 2791/14, 3055/2, 3242/3, 3242/4, 3246/3, 3246/4, 3251/3, 3251/4, 3251/21, 3464/11, 3471/1, 3471/7, 3479/3, 3479/5, 3479/6, 3480/3, 3480/4, 3482/3, 3482/4, 3556/1, 3556/7, 3936/2, 3936/8, 3936/20, 4257/7, 4765/3, 4765/4, 4766/10, 5543/3, 5543/4, 5543/5 are NOT Active	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the determines more than one injector is flowing more fuel than expected.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN / FMIs: 651/14, 652/14, 653/14, 654/14, 655/14, 656/14, 3387/20, 3388/20, 3389/20, 3390/20, 3391/20, 3392/20, 3387/21, 3388/21, 3389/21, 3390/21, 3391/21, and 3392/21.

Drive Cycle to Determine Fault Status

N/A

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for fault codes. Is SPN 4257 FMI 18 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 4257 FMI 18.
		No: Go to Step 3.

Step	Action	Decision
3	Inspect the fuel system from fuel tank to fuel injectors for restrictions, leaks, or physical damage. Is fuel system free of restrictions, leaks, and physical damage?	Yes: Go to Step 4.
		No: Repair restrictions, leaks, or physical damage. After repairs are complete, retest for SPN 4257 FMI 18.

Step	Action	Decision
4	Check for fuel and fuel quality, including fuel level check. Visually inspect by removing fuel cap, check Water in Fuel (WIF) light, and sample for dirty or aerated fuel. Is there sufficient supply of good quality fuel?	Yes: Go to Step 5.
		No: Remove dirty or aerated fuel, fill with good quality fuel. After repairs are complete, retest for SPN 4257 FMI 18.

Step	Action	Decision
5	Using terminal test kit, inspect connections at Fuel Injector non-Under Valve Connectors and Engine Gas Temperature (EGT) and Injector Control Pressure (ICP) sensors. With key OFF, disconnect connectors and sensors. Check connectors and sensors for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are fuel injector non-UVC connectors, ICP, and EGT sensor connectors, harnesses, and terminals clean and undamaged?	Yes: Go to Step 6.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4257 FMI 18.

Step	Action	Decision
6	Test ICP sensor for intermittent circuit operation using EST with ServiceMaxx™ software. Do Key On Engine Off Continuous Monitor Test (page 87). Verify sensor voltages are within specifications (All Ratings, page 1291). Are sensor voltages within specifications?	Yes: Go to Step 7.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuits as required. After repairs are complete, retest for SPN 4257 FMI 18.

Step	Action	Decision
7	Test fuel injector (page 931), ICP , and EGT circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks. Are Fuel Injector, ICP, and EGT circuits within specifications?	Yes: Go to Step 8.
		No: Repair circuits as required. After repairs are complete, retest for SPN 4257 FMI 18.

Step	Action	Decision
8	Do Cold Soak. After cold soak, EGT sensor should be 284°F (140°C). Is EGT sensor at 284°F (140°C)?	Yes: Go to Step 9.
		No: Replace EGT. After repairs are complete, retest for SPN 4257 FMI 18.

Step	Action	Decision
9	Using EST with ServiceMaxx™ software, do Key On Engine Running Standard Test (page 87). If ICP is unable to perform within a set range, a SPN / FMI will be set. Did KOER Standard Test run satisfactory?	Yes: After doing all diagnostic steps, if SPN 4257 FMI 18 remains, verify each step was completed correctly and proper decisions were made. Notify supervisor for further action.
		No: Replace ICP. After repairs are complete, retest for SPN 4257 FMI 18.

NOTE: After doing all diagnostic steps, if SPN 4257 FMI 18 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

IPR (Injection Pressure Regulator)

SPN	FMI	Condition	Possible Causes	Actions
679	3	IPR short to PWR	• IPR circuit short to PWR	Step-based Diagnostics (page 1063)
679	4	IPR open or short to GND	• IPR circuit open or short to GND	Step-based Diagnostics (page 1066)
679	5	IPR open load / circuit	• IPR valve electrical connector disconnected • Open circuit to IPR valve power circuit • IPR circuit connector fretting	Step-based Diagnostics (page 1071)

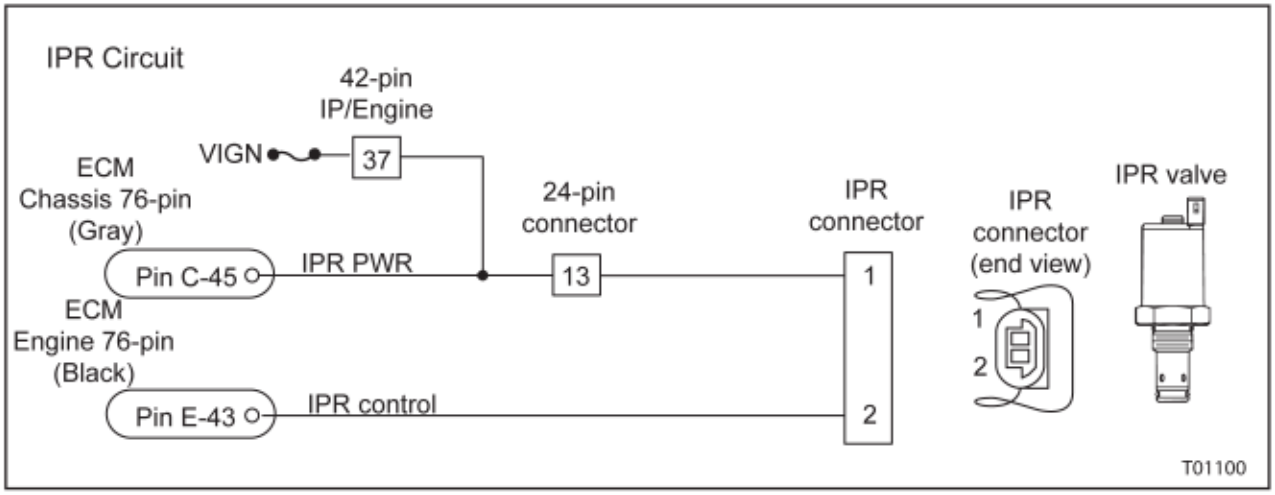


Figure 470 IPR Circuit Diagram

Overview

The IPR valve regulates oil pressure in the high-pressure injection control pressure system. The ICP system intensifies fuel pressure in the injectors. The ECM uses the ICP sensor to monitor system pressure and adjusts the IPR valve duty cycle to match engine requirements (starting, engine load, speed, and temperature).

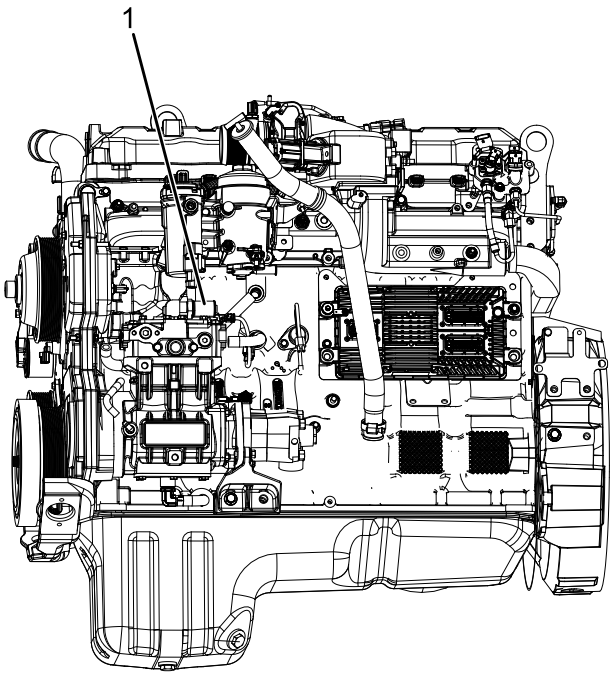


Figure 471 IPR Location

1. IPR

Tools

- EZ Tech® Electronic Service Tool (EST) – J-45067 (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- 00-00956-08 – 180-pin Breakout Box (page 1222)
- Breakout Harness 4484 (IPR) (page 1229)
- International® Electronic Engine Terminal Test Kit (page 1227)

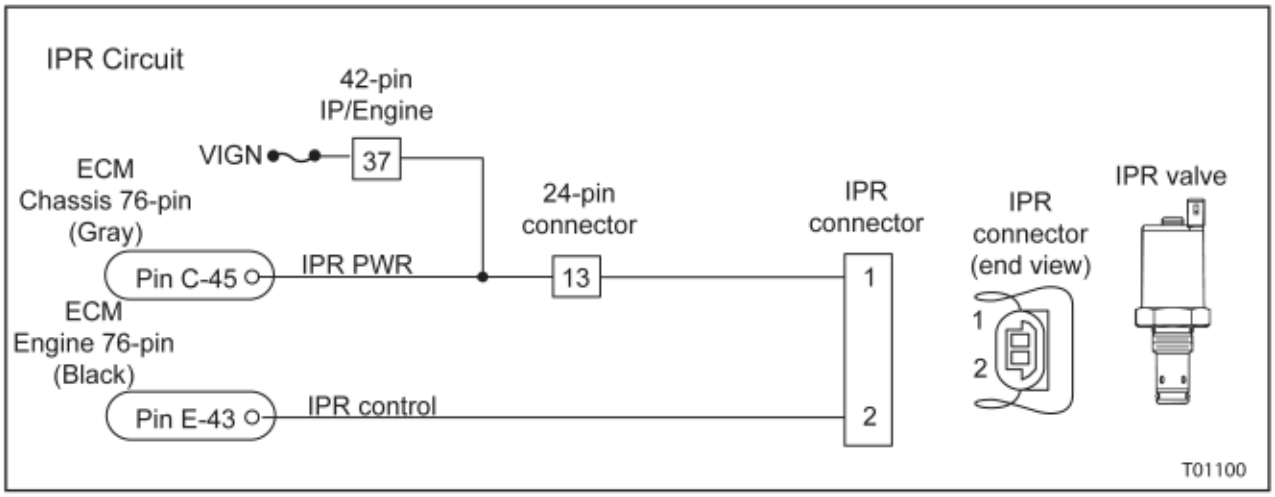


Figure 472 IPR Circuit Diagram

Pin-point Diagnostics

Connector Voltage Check

Connect Breakout Harness 4484. Leave IPR valve disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment: < Less than, > Greater than
1 to GND	B+	If < B+, check VIGN circuit for OPEN or short to GND, or blown fuse.
2 to GND	0 V	If > 0.25 volts, check IPR control circuit for short to PWR.

Operational Voltage Check – Output State Test

Connect Breakout Harness 4484 between ECM and IPR valve. Run KOEO Standard Test and Output State Test High and Low. Use DMM to measure voltage.

Test Point	Test	Spec.	Comment: < Less than, > Greater than
1 to GND	KOEO	B+	If < B+, check for OPEN circuit.
2 to GND	KOEO	B+	If < B+, check IPR coil for OPEN.
2 to GND	Output State LOW	B+	If < B+, check IPR control circuit for short to GND.
2 to GND	Output State HIGH	7.5 V	If > 7.5 volts, check IPR control circuit for OPEN or failed IPR coil. Go to Actuator and Harness Resistance check.

Actuator Resistance Check

Turn ignition switch to OFF. Connect Breakout Harness 4484 to IPR valve. Leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
1 to 2	5.5 ± 0.5 Ω	If out of specification, replace IPR valve.
1 to GND	> 1 kΩ	If < 1 kΩ, replace IPR valve.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-pin Breakout Box, Breakout Harness 4484, and 42-pin breakout harness. Leave ECM, IPR, and vehicle-side 42-pin connector disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
2 to E-43	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1k Ω	If < 1 kΩ, check for short to PWR.
1 to C-45	< 5 Ω	If > 5 Ω, check for OPEN circuit.
1 to 37 (42-pin)	< 5 Ω	If > 5 Ω, check for OPEN circuit.
1 to GND	> 1k Ω	If < 1 kΩ, check for short to PWR.

If all measurements are within specifications, check VIGN circuit to 42-pin IP / Engine connector on the chassis harness for OPEN.

SPN 679 FMI 3 - IPR Short to PWR

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Injection Pressure Regulator (IPR) valve is shorted to power.	IPR valve frequency > 65,535 Hz	Key ON B+ ≥ 9 volts and ≤ 14 volts

Fault Overview

Fault code sets when Electronic Control Module (ECM) detects Injection Pressure Regulator (IPR) valve frequency is greater than expected.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during one trip.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Initial Key ON

Possible Causes

- IPR circuit short to PWR
- Failed IPR

Step 1	Check for active or pending fault code.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 679 FMI 3 (IPR). Is EST DTC list SPN 679 FMI 3 active or pending?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Inspect connections at Injection Pressure Regulator (IPR) valve connector.	Decision
A. Key OFF. B. Disconnect IPR valve connector. C. Check IPR valve and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are IPR connector, harness, and terminals clean and undamaged?		Yes: Perform Pin-Point Test (page 1064). No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 679 FMI 3.

Pin-Point Tests (SPN 679 FMI3)

IPR Circuit

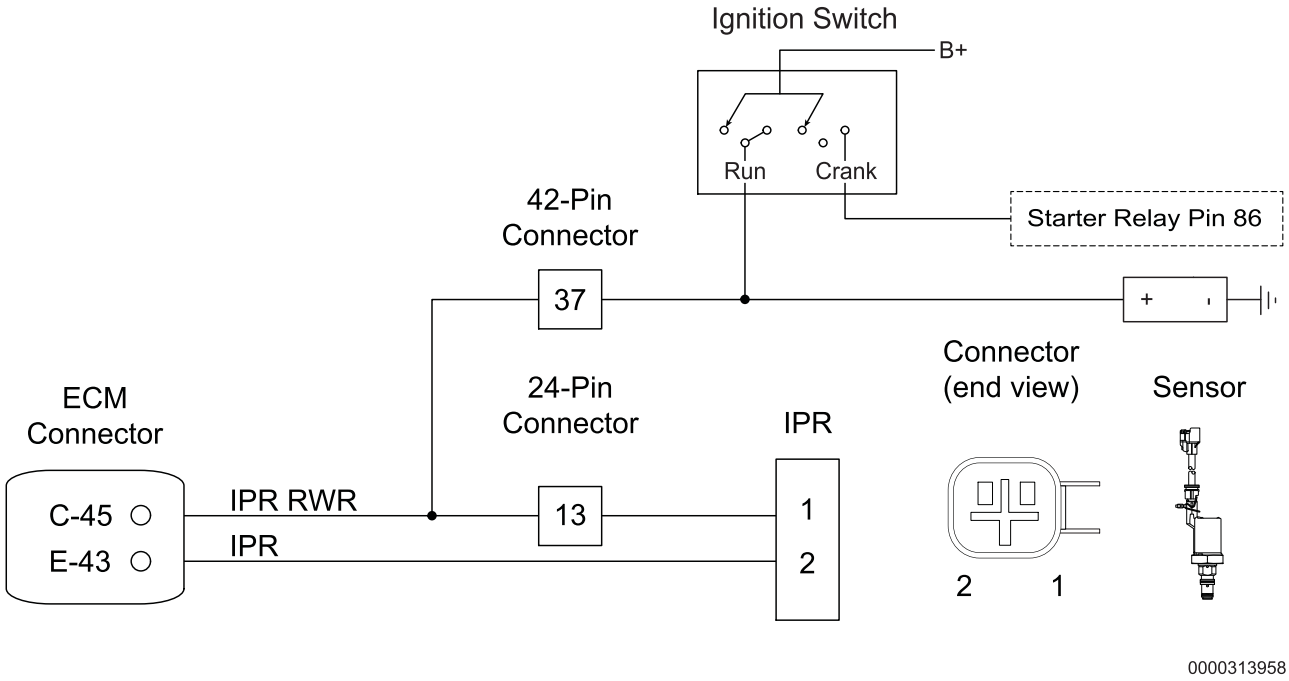


Figure 473 Injection Pressure Regulator (IPR) Valve Circuit Diagram

Tools Required

- Digital Multimeter (DMM)
- Injection Pressure Regulator (IPR) Breakout Harness 12-800-02

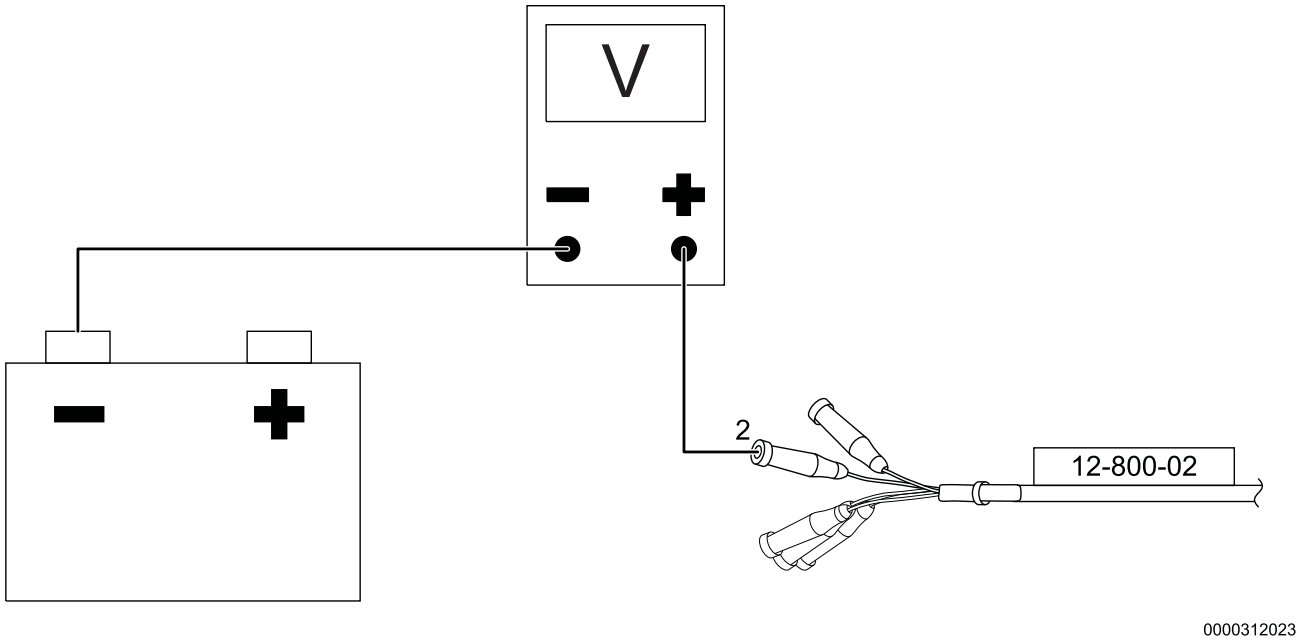


Figure 474 Test 1 Injection Pressure Regulator (IPR) Valve Voltage Check

Test 1 Setup
A. Key OFF. B. Connect Breakout Harness 12-800-02 to vehicle harness and leave Injection Pressure Regulator (IPR) valve disconnected. C. Key-On Engine-Off (KOEO).

Test 1	Specification
Use DMM to measure voltage between Breakout Harness 12-800-02 pin-2 and known good GND.	B+ ± 0.5 volts
Decision	
Is voltage B+ ± 0.5 volts?	Yes: Repair short to PWR between IPR valve pin-2 and Engine Control Module (ECM) pin E-43. After repairs are complete, retest for SPN 679 FMI 3.
	No: Replace IPR valve. After repairs are complete, retest for SPN 679 FMI 3.

End Diagnostic Tests
After performing all diagnostic steps, if SPN 679 FMI 3 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

SPN 679 FMI 4 - IPR Open or short to GND

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Injection Pressure Regulator (IPR) valve short to ground or open circuit	IPR valve frequency < 100 Hz	Key ON Battery Power ≥ 9 volts and ≤ 14 volts

Fault Overview

Fault code sets when Engine Control Module (ECM) detects Injection Pressure Regulation (IPR) valve frequency is less than 100 Hz.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during one trip.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Initial Key ON

Possible Causes

- IPR ground side switch circuit Open
- IPR ground side switch circuit shorted to GND
- IPR PWR circuit Open
- Failed IPR valve

Step 1	Check for active or pending fault codes.	Decision
Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 679 FMI 4 (IPR). Is EST DTC list SPN 679 FMI 4 active or pending?		Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Inspect connections at Injection Pressure Regulator (IPR) valve.	Decision
A. Key OFF. B. Disconnect IPR valve connector. C. Check IPR valve and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are IPR valve connector, harness, and terminals clean and undamaged?		Yes: Perform Pin-Point Test (page 1067). No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 679 FMI 4.

Pin-Point Tests (SPN 679 FMI 4)

IPR Circuit

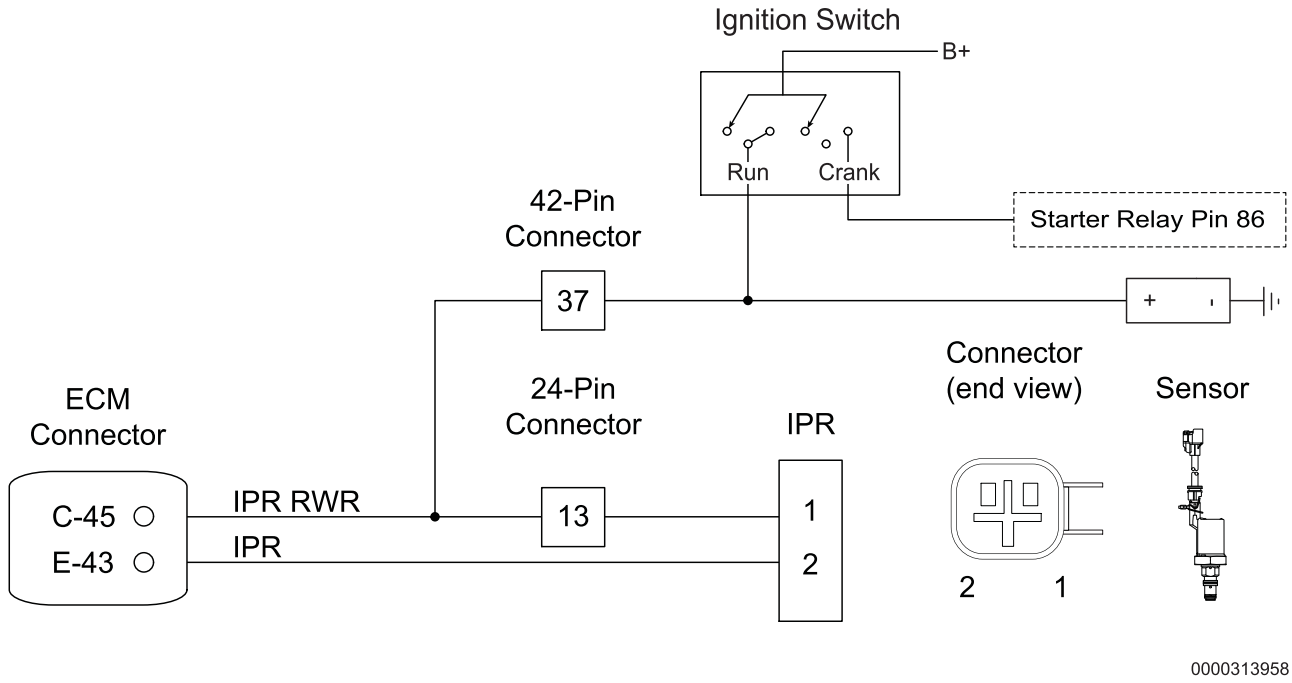


Figure 475 Injection Pressure Regulation (IPR) Valve Circuit Diagram

See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Digital Multimeter (DMM)
- Breakout Harness 12-800-02

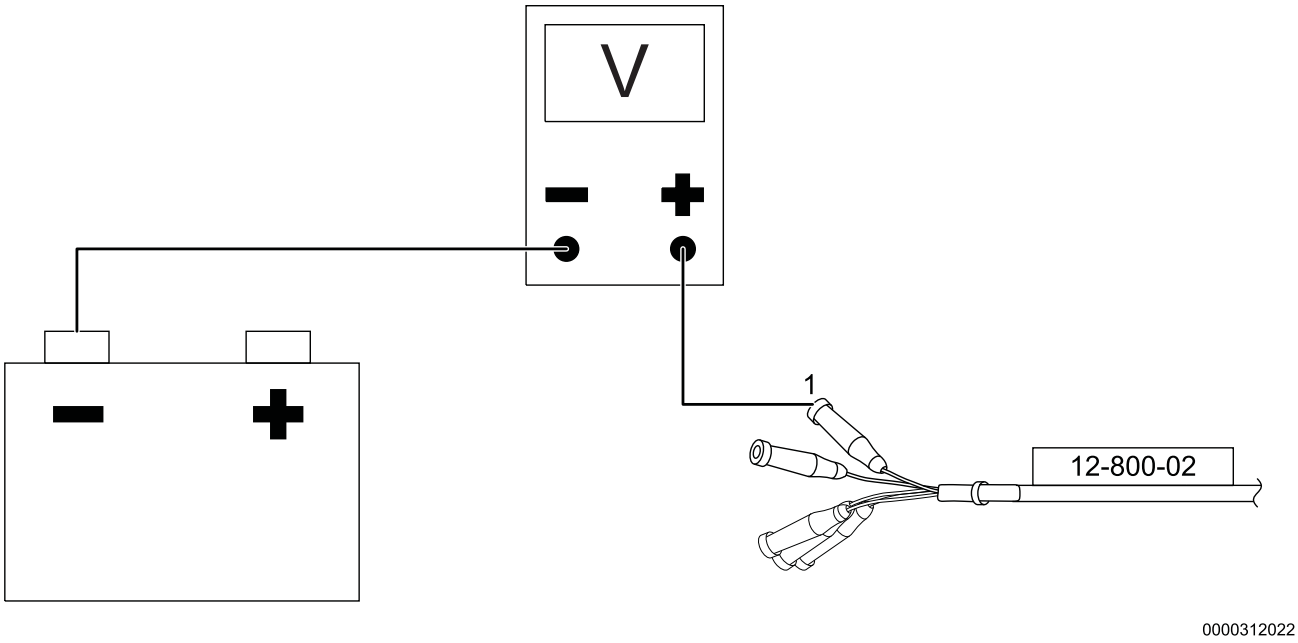


Figure 476 Test 1 Injection Pressure Regulation (IPR) Valve Voltage Check

Test 1 Setup
A. Key OFF. B. Connect Breakout Harness 12-800-02 to vehicle harness and leave Injection Pressure Regulator (IPR) valve disconnected. C. Key-On Engine-Off (KOEO).

Test 1	Specification
Use DMM to measure voltage between Breakout Harness 12-800-02 pin-1 and known good GND.	B+ ± 0.5 volts
Decision	
Is voltage B+ ± 0.5 volts?	Yes: Go to Test 2.
	No: Repair Open between IPR valve pin-1 and Engine Control Module (ECM) pin C-45. After repairs are complete, retest for SPN 679 FMI 4.

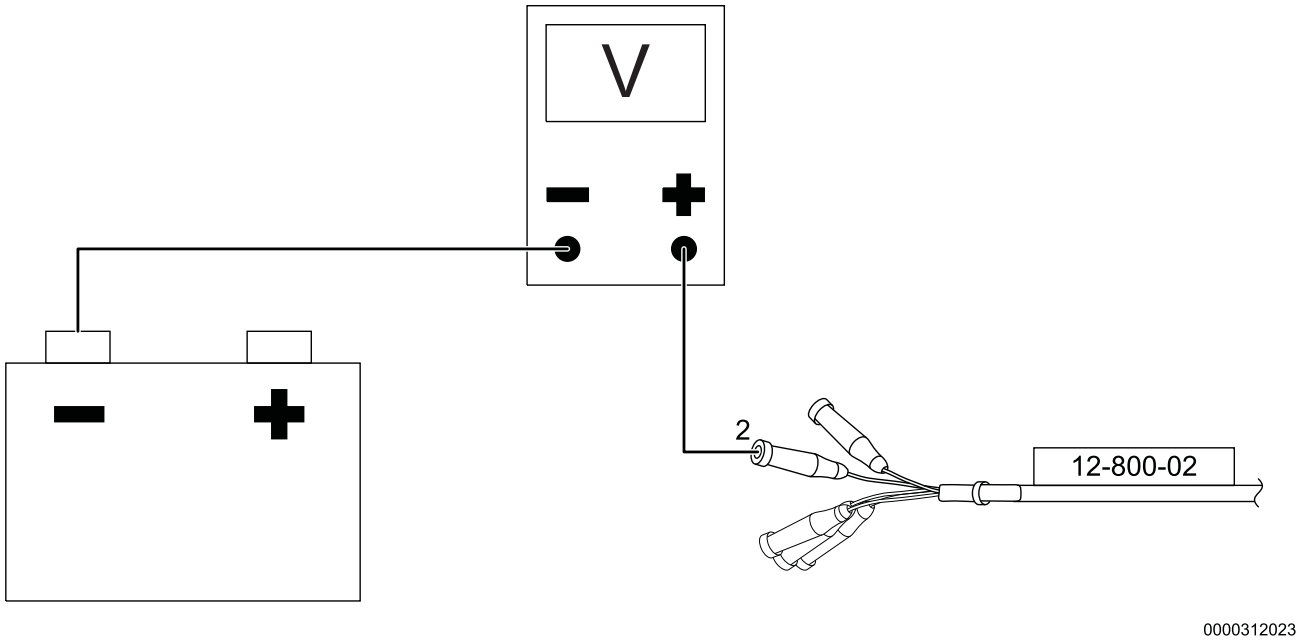


Figure 477 Test 2 Injection Pressure Regulation (IPR) Valve Voltage Check

Test 2 Setup
A. Key OFF. B. Connect Breakout Harness 12-800-02 to vehicle harness and leave IPR valve disconnected. C. KOEO.

Test 2	Specification
Use DMM to measure voltage between Breakout Harness 12-800-02 pin-2 and known good GND.	less than 0.5 volts
Decision	
Is voltage less than 0.5 volts?	Yes: Go to Test 3.
	No: Replace IPR valve. After repairs are complete, retest for SPN 679 FMI 4.

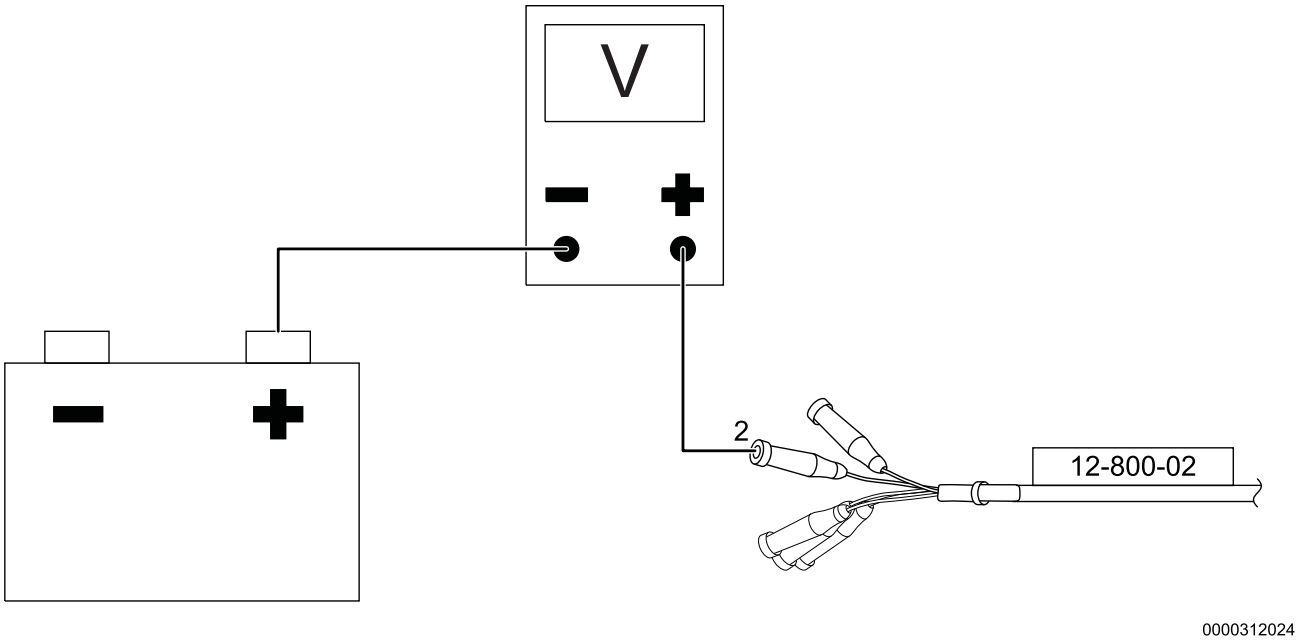


Figure 478 Test 3 Injection Pressure Regulation (IPR) Valve Voltage Check

Test 3 Setup
A. Key OFF. B. Connect Breakout Harness 12-800-02 to vehicle harness and leave Injection Pressure Regulation (IPR) valve disconnected. C. KOEO.

Test 3	Specification
Use DMM to measure voltage between Breakout Harness 12-800-02 pin-2 and PWR.	B+ ± 0.5 volts
Decision	
Is voltage B+ ± 0.5 volts?	Yes: Repair short to GND between IPR valve pin-2 and Engine Control Module (ECM) pin E-43. After repairs are complete, retest for SPN 679 FMI 4.
	No: Repair Open circuit between IPR valve pin-2 and ECM pin E-43. After repairs are complete, retest for SPN 679 FMI 4.

End Diagnostic Tests
After performing all diagnostic steps, if SPN 679 FMI 4 remains, verify if each step was completed correctly and proper decision was made. Notify supervisor for further action.

SPN 679

FMI 5 – IPR Open Load / Circuit

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
N/A			

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the Injection Pressure Regulator (IPR) has an open circuit.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

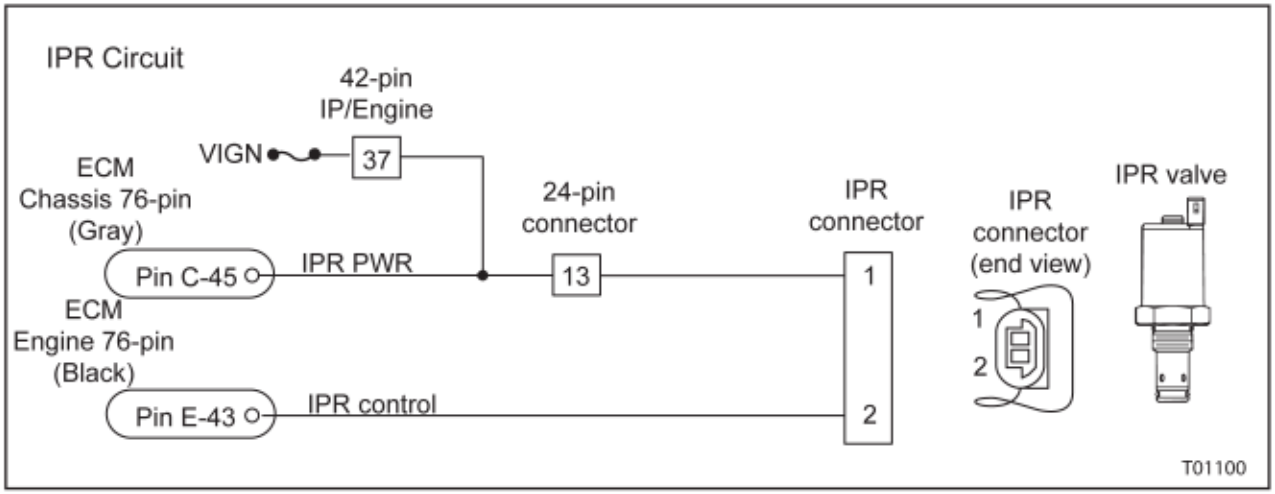


Figure 479 IPR Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for fault codes. Is SPN 679 FMI 5 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 679 FMI 5.
		No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit, inspect connections at Injection Pressure Regulator (IPR). With key OFF, disconnect IPR. Check IPR and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the IPR connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 679 FMI 5.

Step	Action	Decision
4	Test IPR circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 1061). Are IPR circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 5.
		No: Repair circuits as required. After repairs are complete, retest for SPN 679 FMI 5.

Step	Action	Decision
5	Do Operational Voltage check between ECM and IPR. Run Key On Engine On Output State Low Test (page 87) and Output State High Test (page 87). Are voltages within specification?	Yes: After doing all diagnostic steps, if SPN 679 FMI 5 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace IPR sensor. After repairs are complete retest for SPN 679 FMI 5.

NOTE: After doing all diagnostic steps, if SPN 679 FMI 5 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 593 FMI 31 - Engine Stopped by IST

Function

Idle Shutdown Timer (IST) allows Engine Control Module (ECM) to shut down engine during extended engine idle times.

Tools

- Digital Multimeter (DMM) (page 1224)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)



GOVERNMENT REGULATION: State and local regulations may limit engine idle time. Vehicle owner or operator is responsible for compliance with those regulations.

Idle Shutdown Warning

Thirty seconds before IST-defined engine shutdown, a vehicle instrument panel indicator activates. There are two types of indicators:

- Amber flashing idle shutdown indicator for multiplex electrical systems
- Red flashing indicator with audible alarm for non-multiplex electrical systems

This continues until the engine shuts down or the low idle shutdown timer is reset.

Engine Idle Shutdown Timer (IST) for California ESS Compliant Engines

Navistar® engines certified for sale in state of California (CA) conform to mandatory California Air Resources Board (CARB) Engine Shutdown System (ESS) regulations. Prior function of IST is available on CA ESS-exempt and federally-certified engines (school buses, emergency, and military vehicles).

Engine idle duration is limited for ESS-compliant engines as follows:

- When vehicle parking brake is set, idle shutdown time is limited to CARB requirement of 5 minutes.
- When vehicle parking brake is released, idle shutdown time is limited to CARB requirement of 15 minutes.

Duration of CARB-mandated values can be reduced by programming customer IST programmable parameter to value lower than 15 minutes. Adjusting this parameter reduces overall system shutdown time as follows:

- Adjusting parameter value between 5 and 15 minutes reduces idle shutdown time with vehicle parking brake released. Default value of 5 minutes for vehicle parking brake set condition remains unaffected.
- Adjusting parameter value between 2 and 5 minutes reduces idle time for both vehicle parking brake released and set conditions.

While IST is installed, idle shutdown time is factory-defaulted to 60 minutes and cannot be adjusted. If IST is enabled, Cold Ambient Protection (CAP) will not function.

NOTE: CARB IST feature is factory-programmed. Customers cannot turn IST off for ESS-compliant engines.

CARB Idle Shutdown Timer (IST) Conditions

The following conditions must be true for the idle shutdown timer to activate in all modes. Any change of the true state of one or more of these conditions will reset or disable the IST.

- Manual Diesel Particulate Filter (DPF) regeneration is inactive (not enabled).
- Steady drive-line state (no transition detected). No change in the state of the clutch switch (manual transmission) or transmission shifter between the in-gear position and neutral or park (Automatic transmission).
- Power Takeoff (PTO) remote mode disabled.
- Engine coolant temperature greater than 60°F (16°C).
- No active coolant temperature sensor diagnostic faults.
- No active Intake Air Temperature (IAT) sensor diagnostic faults.
- Engine is operating in run mode or in active diagnostic tool mode.
- Vehicle speed is less than 1.25 mph.
- No active vehicle speed diagnostic faults.
- PTO control is in OFF or Standby mode.
- Engine speed less than 700 rpm.
- Steady accelerator pedal position (no transition detected from any pre-set position).
- Steady brake pedal state (no transition detected from any pre-set state).
- Steady parking brake state (J1939) (no transition detected from any pre-set state).

Idle Shutdown Timer (IST) (Federal – Optional)

Idle time can be programmed from 5 to 120 minutes. While IST is installed, IST function will be active with the programmed shutdown time in effect. Parking brake transitions reset idler timer. If IST is enabled, Cold Ambient Protection (CAP) will not function.

Federal IST Conditions

Following conditions must be true for IST to activate. Any change to true state of one or more of these conditions will reset or disable IST.

Common Enable Conditions for All Federal IST Options

- Manual Diesel Particulate Filter (DPF) regeneration is inactive (not enabled).
- Steady drive-line state (no transition detected). No change in the state of the clutch switch (manual transmission) or transmission shifter between the in-gear position and neutral or park (Automatic transmission).
- Power Takeoff (PTO) remote mode disabled.
- Intake air temperature greater than 60°F (16°C) (MFG Default, Customer adjustable parameter).
- Intake air temperature lower than 112°F (44°C) (MFG Default, Customer adjustable parameter).
- Engine coolant temperature greater than 140°F (60°C).
- No active coolant temperature sensor diagnostic faults.

- No active Intake Air Temperature (IAT) sensor diagnostic faults.
- Engine is operating in run mode or in active diagnostic tool mode.
- Vehicle speed is less than 1.25 mph.
- Steady parking brake state (J1939). No transition detected from any pre-set state.

Additional operation options enable conditions depending on selected Federal IST operation mode:

Federal IST Mode 1: PTO Operation Option Enable Conditions

- Power Takeoff (PTO) control is in Off or Standby mode.
- Engine speed less than 750 rpm.
- Accelerator pedal position is less than 2%.
- No active accelerator pedal diagnostic faults.
- Steady brake pedal state (No transition detected).
- No active brake system diagnostic faults.

Federal IST Mode 2: No Load / Light Load Limit Option Enable Conditions

- Accelerator pedal position is less than 2%.
- No active accelerator pedal diagnostic faults.
- Steady brake pedal state (no transition detected).
- No active brake system diagnostic faults.
- Engine reported fuel usage (load) is less than Engine Control Module (ECM)-specified limit (factory-calibrated, not customer adjustable).

Federal IST Mode 3: Tamper Proof Option Enable Conditions

- Engine reported fuel usage (load) is less than Engine Control Module (ECM)-specified limit (factory-calibrated, not customer adjustable).
- Steady accelerator pedal position (no transition detected from any pre-set position).
- Steady brake pedal state (no transition detected from any pre-set state).

Fault Detection / Management

Idle Shutdown Timer (IST) SPN / FMI does not indicate system fault. SPN 593 FMI 31 will set when engine idle shutdown has shut down engine from Engine Control Module (ECM) command. IST feature must be enabled for SPN 593 FMI 31 to be displayed.

IAHC (Intake Air Heater Control)

SPN	FMI	Condition	Possible Causes	Actions
729	3	IAHC short to PWR	• Intake Air Heater Control (IAHC) relay control short to PWR • Failed relay	Step-based Diagnostics (page 1078)
729	4	IAHC short to GND	• IAHC short to GND	Step-based Diagnostics (page 1080)
729	5	IAHC open load / circuit	• IAHC circuit open	Step-based Diagnostics (page 1082)
729	18	IAH monitor fault: lack of heat in the intake manifold	• Defective wiring • Defective relay • Open circuit on heating element	Step-based Diagnostics (page 1085)

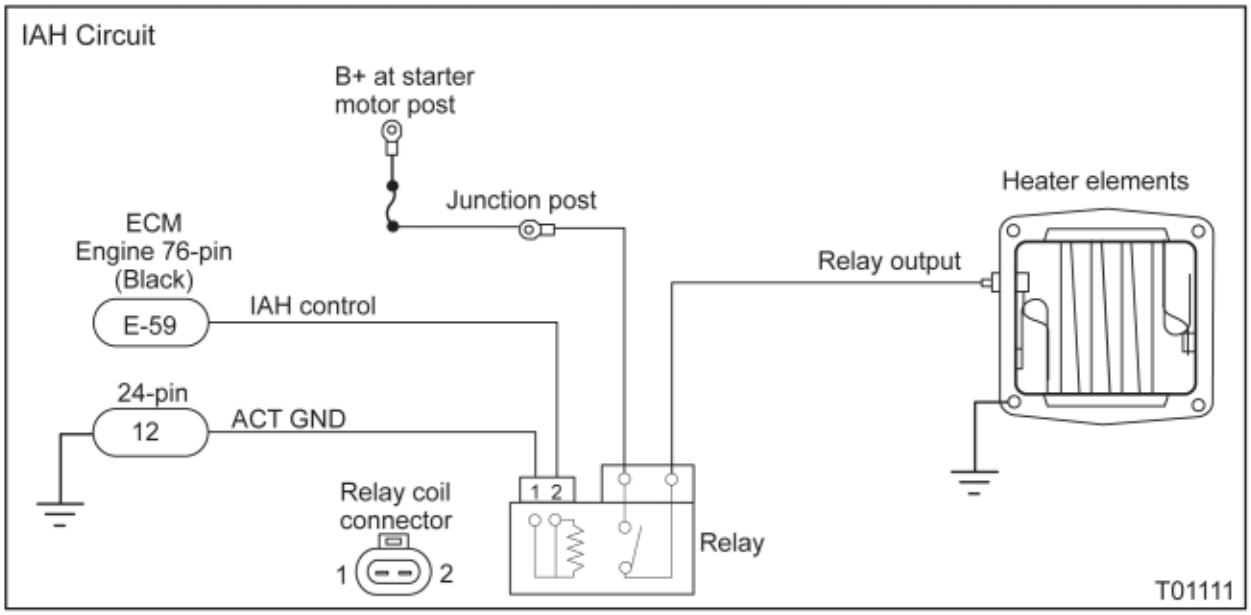


Figure 480 IAH Circuit Diagram

Overview

The Intake Air Heater (IAH) system warms the incoming air supply prior to cranking to aid cold engine starting during warm-up. The IAH system also helps load the engine during a Diesel Particulate Filter (DPF) regeneration.

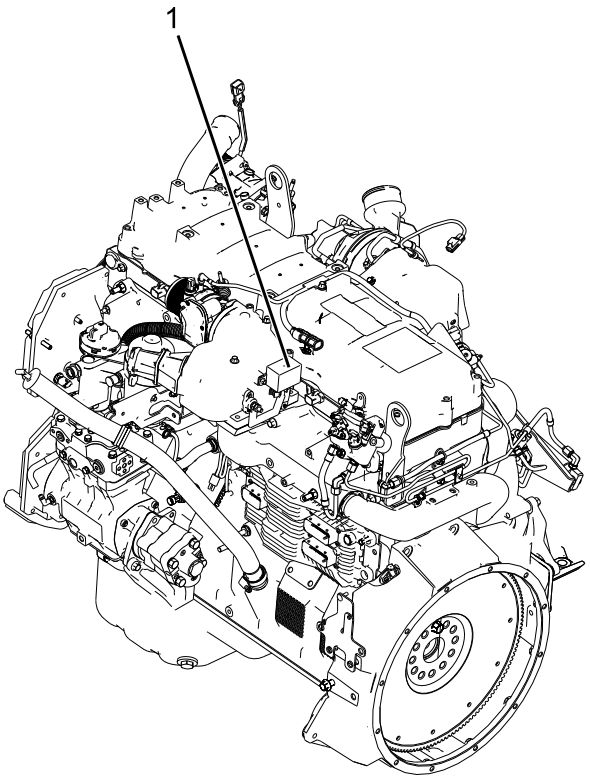


Figure 481 IAHC Relay Location

1. IAHC Relay

Tools

- EZ Tech® Electronic Service Tool (EST) – J-45067 (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)

SPN 729

FMI 3 – IAHC Short to PWR

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
The Inlet Air Heater (IAH) Driver Relay is shorted to Battery, detected by the ATIC chip that drives the Relay.	Voltage change at power-stage output while Intake air heater is commanded OFF < 3.5 Volts for time $150e^{-6}$ to $250e^{-6}$ seconds.	Key ON	2.5 seconds
		No Power-stage faults on the SPI chips	
		SPN / FMIs 158/15 and 158/17 are NOT active	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the IAH is shorted to B+.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

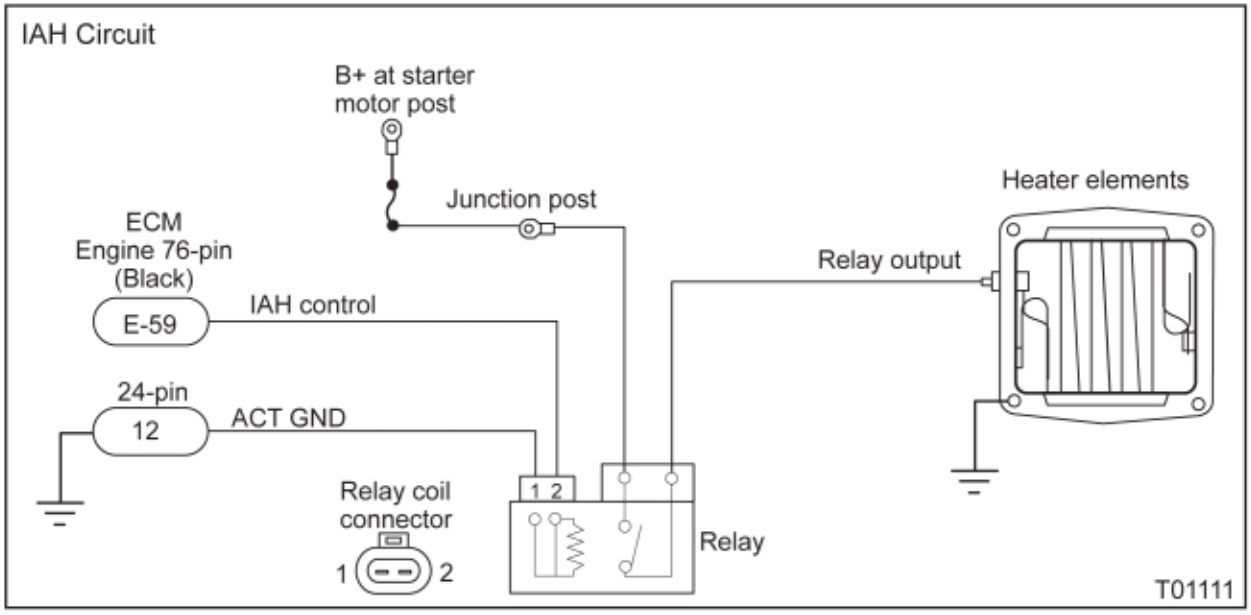


Figure 482 IAH Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 729 FMI 3 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 729 FMI 3. No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit, inspect connections at the Intake Air Heater (IAH). With key OFF, disconnect IAH connector. Check IAH and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the IAH connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 729 FMI 3.

Step	Action	Decision
4	Test IAH circuits for open, short, or high resistance conditions. Do connector Key On Engine Off (KOEO) Voltage Check on Relay Coil - Output State Test (page 825). Are IAH circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 729 FMI 3.

Step	Action	Decision
5	Test IAH relay for proper operation. Do Key On Engine Off Output State Intake Air Heater Test (page 87) to measure voltage between relay B+ and output screw terminals for 12 volts. Is voltage within specification?	Yes: After doing all diagnostic steps, if SPN 729 FMI 3 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Replace IAH relay. After repairs are complete, retest for SPN 729 FMI 3.

NOTE: After doing all diagnostic steps, if SPN 729 FMI 3 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 729

FMI 4 – IAHC Short to GND

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
The Inlet Air Heater (IAH) Driver Relay is shorted to Ground, detected by the ATIC chip that drives the Relay.	Current on the driver > 7 amps for $50e^{-6}$ seconds or > 14 amps for $5e^{-6}$ seconds.	Key ON	2.5 seconds
		No Power-stage faults on the SPI chips	
		SPN / FMIs 158/15 and 158/17 are NOT active	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the IAH is shorted to ground.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

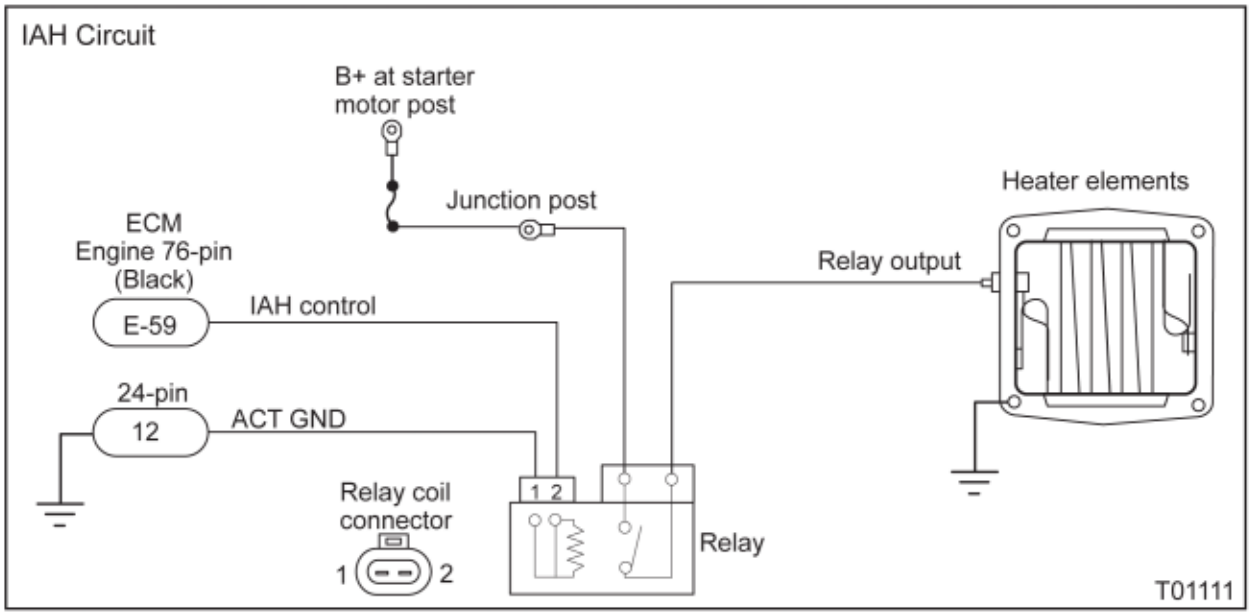


Figure 483 IAH Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 729 FMI 4 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 729 FMI 4. No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit, inspect connections at the Intake Air Heater (IAH). With key OFF, disconnect IAH connector. Check IAH and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the IAH connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 729 FMI 4.

Step	Action	Decision
4	Test IAH circuits for open, short, or high resistance conditions. With connector still disconnected, do Key On Engine Off Output State Intake Air Heater Test (page 87), monitoring voltage between Pin 2 and GND for B+ when IAH circuit is energized for 30 seconds. Is voltage within specifications?	Yes: After doing all diagnostic steps, if SPN 729 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Repair circuits as required. After repairs are complete, retest for SPN 729 FMI 4.

NOTE: After doing all diagnostic steps, if SPN 729 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 729

FMI 5 – IAHC Open Load / Circuit

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
The Inlet Air Heater (IAH) Driver Relay is Open Circuit, detected by the ATIC chip that drives the Relay.	Current on the driver < $8e^{-3}$ to $40e^{-3}$ Amps within $4e^{-3}$ seconds when gate is turned ON	Key ON	2.5 seconds
		No Power-stage faults on the SPI chips	
		SPN / FMIs 158/15 and 158/17 are NOT active	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the IAH relay has an open circuit.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

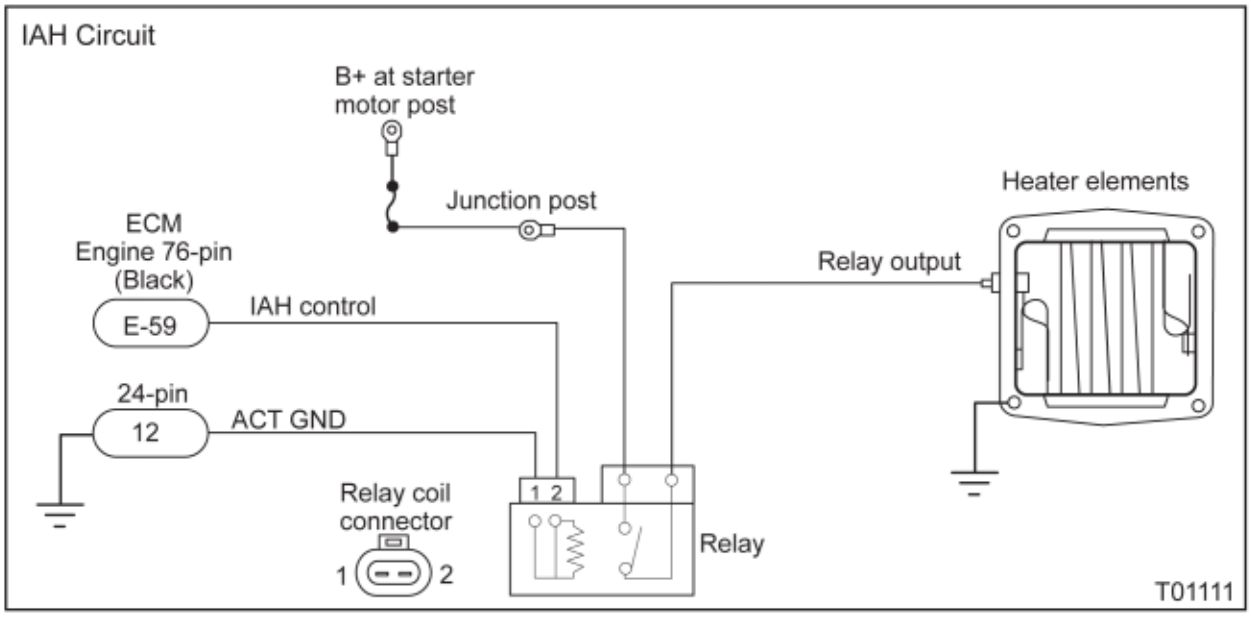


Figure 484 IAH Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 729 FMI 5 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 729 FMI 5. No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit, inspect connections at the Intake Air Heater (IAH). With key OFF, disconnect IAH connector. Check IAH and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the IAH connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 729 FMI 5.

Step	Action	Decision
4	Test IAH circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 825). Are IAH circuits within specifications? **NOTE:** 1. If voltage checks pass, doing resistance checks is not required. 2. Be sure voltage between pin 1 and B+ equals 12 volts. Less than 12 volts indicates IAH grounding is suspect.	Go to Step 5. No: Repair circuits as required. After repairs are complete, retest for SPN 729 FMI 5.

Step	Action	Decision
5	Test IAH control circuit for correct voltage during operation. Do Key On Engine Off Output State Intake Air Heater Test (page 87) while monitoring voltage between Pin 2 and GND with Digital Multimeter (DMM). Did DMM indicate 12 volts when the IAH was energized?	Yes: After doing all diagnostic steps, if SPN 729 FMI 5 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Repair circuits as required. After repairs are complete, retest for SPN 729 FMI 5.

NOTE: After doing all diagnostic steps, if SPN 729 FMI 5 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 729

FMI 18 – IAH Monitor Fault: Lack of heat in the Intake Manifold

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Inlet Air Heater (IAH) Rationality Monitor	Highest value of Engine Intake Manifold Temperature (IMT) measured within the monitoring window MINUS IMT measured at "Key ON" condition. > Threshold defined as a function of Engine Air Intake Temperature / Intake Air Heater 'ON' time (Table A079)	Key ON	0.1 seconds
	[Monitoring window starts when {Intake Air Heater ON rising edge is detected OR Engine speed > 0 RPM}	Engine Throttle position command ≥ -100 %	
	AND Ends after time] ≤ 20 seconds	Engine exhaust recirculation valve command position ≤ 90 %	
		[Engine Speed ≥ 100 RPM AND ≤ 3000 RPM	
		for Percent time] ≥ 50 %	
		Minimum time Intake Air Heater has been ON > 10 seconds	
		NOT [Engine Air Inlet Temperature (AIT) < 212°F (100°C)	
		AND Engine OFF timer > 0 seconds	
		AND {Engine Coolant temperature sensor MINUS Engine Air Inlet Temperature sensor}] > 41°F (5°C)	

FMI 18 – IAH Monitor Fault: Lack of heat in the Intake Manifold (cont.)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		SPN / FMIs 102/3, 102/4, 105/3, 105/4, 729/3, 729/4, and 729/5 are NOT active	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the IAH is not heating the air in the intake manifold.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

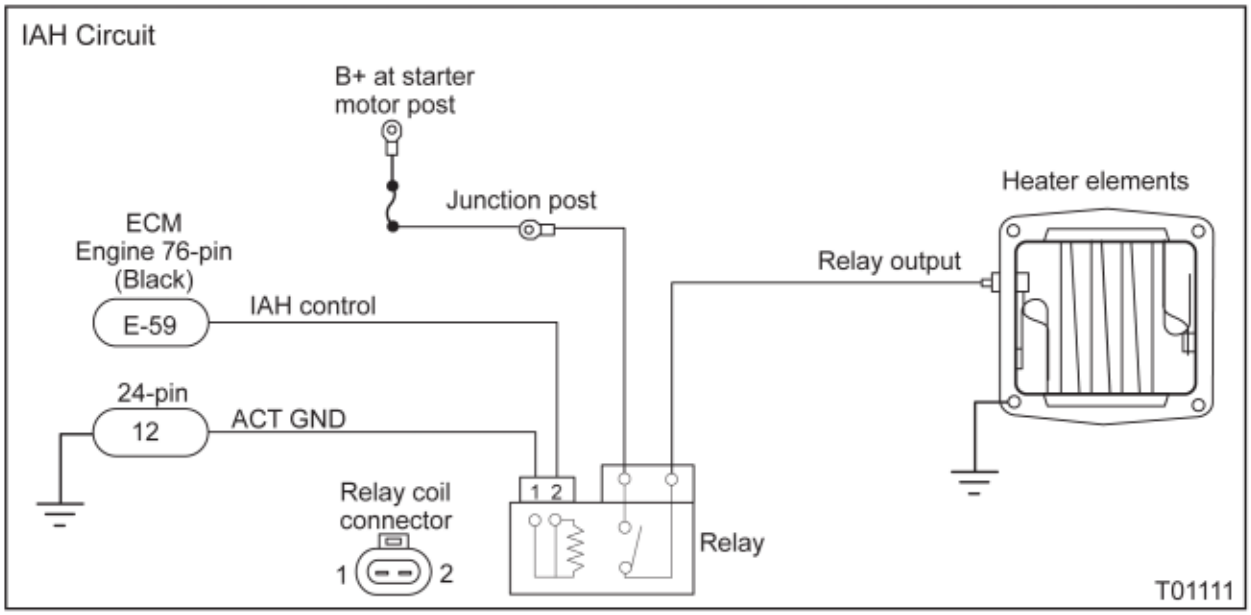


Figure 485 IAH Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 729 FMI 18 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 729 FMI 18.
		No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit, inspect connections at the Intake Air Heater (IAH). With key OFF, disconnect IAH connector. Check IAH and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the IAH connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4.
		No: Repair connector, harness, or terminal damage After repairs are complete, retest for SPN 729 FMI 18.

Step	Action	Decision
4	Test IAH circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 825). Are IAH circuits within specifications? **NOTE:** 1. If voltage checks pass, doing resistance checks is not required. 2. Be sure voltage between pin 1 and B+ equals 12 volts. Less than 12 volts indicates IAH grounding is suspect.	Go to Step 5.
		No: Repair circuits as required. After repairs are complete, retest for SPN 729 FMI 18.

Step	Action	Decision
5	Test IAH control circuit for correct voltage during operation. Do Key On Engine Off Output State Intake Air Heater Test (page 87) while monitoring voltage between Pin 2 and GND with Digital Multimeter (DMM). Did DMM indicate 12 volts when the IAH was energized?	Yes: Go to Step 6.
		No: Repair circuits as required. After repairs are complete, retest for SPN 729 FMI 18.

Step	Action	Decision
6	Using terminal test kit, inspect connections at the IMT sensor. With key OFF, disconnect IMT sensor connector. Check IMT sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are IMT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to Step 7.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 729 FMI 18.

Step	Action	Decision
7	Check IMT sensors for excessive soot deposits. Remove IMT sensors from the intake manifold and visually inspect them. Are IMT sensor conditions acceptable?	Yes: Go to Step 8.
		No: Replace the IMT sensor. After repairs are complete, retest for 729 FMI 18.

Step	Action	Decision
8	Determine if IMT sensor or circuits are out of specifications. Using EST with ServiceMaxx™ software, DMM, and required breakout harnesses, do IMT Cold Soak Sensor Compare Check, Sensor Circuit Checks, and Pin-point Diagnostics . Is IMT sensor within specifications?	Yes: After doing all diagnostic steps, if SPN 729 FMI 5 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Replace IMT sensor or repair circuit as required. After repairs are complete, retest for SPN 729 FMI 18.

NOTE: After doing all diagnostic steps, if SPN 729 FMI 18 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

J1939 Data Link

SPN	FMI	Condition
639	14	J1939 Data Link Error (ECM unable to transmit)
1213	19	DCU Error – J1939 communication fault

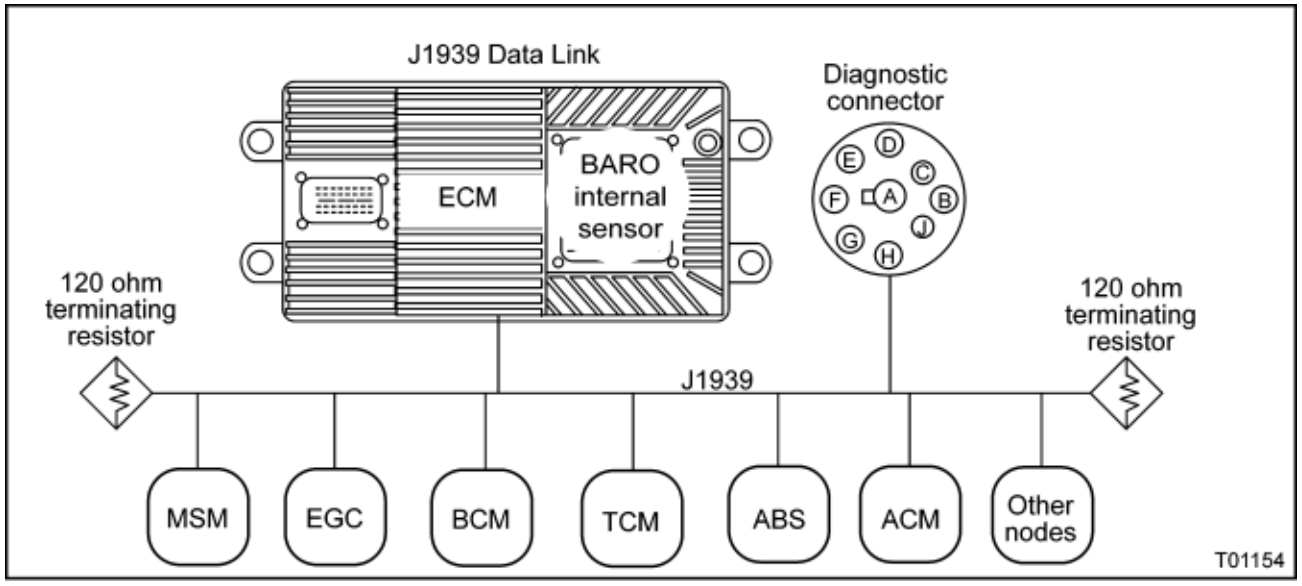


Figure 486 Function diagram for the J1939

The function diagram for the J1939 includes the following:

- Engine Control Module (ECM)
  with Barometric Absolute Pressure (BARO) Internal Sensor
- Transmission Control Module (TCM)
- Body Control Module (BCM)
- Multiplex System Module (MSM)
- Anti-lock Brake System (ABS)
- Electronic Gauge Cluster (EGC)
- Electronic Service Tool (EST)
- 120-ohm terminating resistors
- Doser Control Unit (DCU)
- Other nodes (modules)

Function

The J1939 data link provides a communications link with all connecting modules. The EST uses this network system to communicate with the ECM.

Location

The J1939 circuits run throughout the vehicle harness. The Diagnostic Connector is located under the dash on the driver's side.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- International® Electronic Engine Terminal Test Kit (page 1227)

J1939 Data Link Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
1231	14	J1939 Data Link Error (ECM unable to transmit)	• J1939 data link circuit fault
1213	19	DCU Error – J1939 communication fault	• DCU J1939 Communication circuit fault
None		No communication with EST	• B+ OPEN or shorted to GND • GND circuit OPEN • J1939 circuits OPEN or shorted to PWR or GND

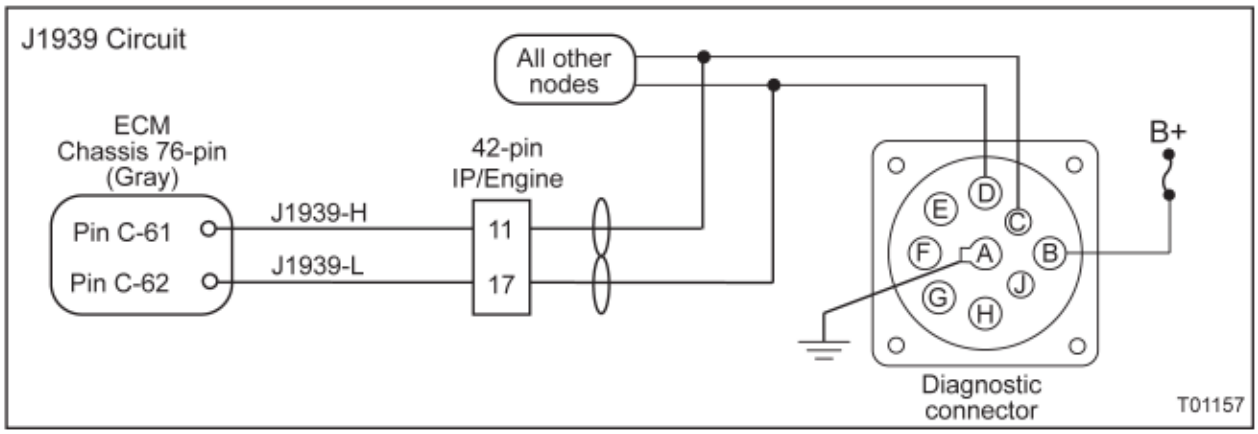


Figure 487 J1939 Data Link communication circuit diagram

Connector Voltage Check

Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment: < Less than, > Greater than
B to GND	B+	If < B+, check B+ circuit to Diagnostic Connector for OPEN or short to GND, or blown fuse.
B to A	B+	If < B+, check GND circuit to Diagnostic Connector for OPEN.
C to GND	1 to 4 V	The sum of C to GND and D to GND should equal 4 to 5 volts.
D to GND	1 to 4 V	The sum of D to GND and C to GND should equal 4 to 5 volts.

EST Communication Check

Turn ignition switch to ON. Connect EST to Diagnostic Connector. If the EST is unable to communicate with the ECM, disconnect each module individually until communication can be established.

NOTE:

- If communication to ECM is established, check J1939 data link circuits to disconnected module 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 ABS	See note.
Disconnect ESC	See note.
Disconnect MSM	See note.
Disconnect EGC	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 C-61	< 5 Ω	If > 5 Ω, check CAN-H for OPEN in circuit.
C to GND	> 1 kΩ	If < 1 kΩ, check CAN-L for short to GND.
D to C-62	< 5 Ω	If > 5 Ω, check CAN-L for OPEN in circuit.
D to GND	> 1 kΩ	If < 1 kΩ, check CAN-H for short to GND.
A to GND	< 5 Ω	If > 5 Ω, check GND for OPEN in circuit.

J1939 Data Link Circuit Operation

J1939 Data Link is a broadcast serial network, also known as the Drivetrain Datalink. The J1939 Data Link network provides a communication link between all connecting modules, sending and receiving digital messages.

The EST with ServiceMaxx™ software communicates with the ECM through the Diagnostic Connector. The EST, through the J1939 Data Link network, is able to retrieve codes, run diagnostic tests, and view signals from all inputs and outputs of the ECM.

J1939 Data Link supports the following functions:

- Transmission of engine parameter data
- Transmission and clearing of codes
- Diagnostics and troubleshooting
- Programming performance parameter values
- Programming engine and vehicle features

- Programming calibrations and strategies in the ECM

J1939 Data Link versus Private CAN

The J1939 Data Link network is setup to communicate with many different modules. The network branches off into many different locations with each path ending in a module connection or a 120-ohm terminating resistor. The termination resistors are used to reduce reflections.

The private CAN system is setup to only communicate between the ECM and specific engine controls.

Diagnostic Connector

The Diagnostic Connector provides an interface for the EST. The EST communicates with the joining modules through the J1939 Data Link network for diagnostics and module programming. The Diagnostic Connector is supplied with fused B+ at Pin B and GND at Pin A. CAN-H runs between ECM Pin C-61 and Diagnostic Connector Pin C. CAN-L between ECM Pin C-62 and Diagnostic Connector Pin D.

EGC

There are two types of EGC modules, one uses J1939 Data Link communications and the other uses ATA communications. The following information is sent through data communication:

- Engine lamp (red)
- Engine lamp
- Coolant level lamp
- Wait to start lamp
- Water In Fuel (WIF) lamp
- Speedometer
- Tachometer (TACH)
- Odometer / hourmeter
- Change oil message
- Oil pressure gauge
- Engine Oil Temperature (EOT) gauge
- Engine Coolant Temperature (ECT) gauge

BC or MSM Module

Many EGC lamps and driver-operated switches are wired to one of these modules, then communicated through J1939 Data Link to the ECM or EGC. Some of these control circuits include the following:

- Wait to start lamp
- Fuel pressure lamp
- Water In Fuel (WIF) lamp
- Aftertreatment (AFT) regeneration lamp
- Cruise control (CCS)
- Self-test input (cruise switches)
- Drive-line Disengagement Switch (DDS)
- Brake pedal (BC only) hard wired to the ECM on vehicles using the MSM module

- A/C Demand (ACD)
- Remote Accelerator Pedal (RPS)
- In-Cab PTO / throttle switch
- Aftertreatment (AFT) regeneration switch

Repair Information

The J1939 Data Link circuits use a twisted wire pair. All repairs must maintain one complete twist per inch along the entire length of the circuit. This circuit is polarized, one positive and one negative. Reversing the polarity of this circuit will disrupt communications.

MAF Sensor (Mass Air Flow)

SPN	FMI	Condition	Possible Causes	Actions
132	0	Engine Inlet Air Mass Flow Rate High	• Disconnected Charge Air Cooler (CAC) hoses or tubes after turbochargers • Mass Air Flow (MAF) auto-calibration • Water ingestion in air cleaner • MAF configuration Programmable Parameters (PP)	Step-based Diagnostics (page 1104)
132	1	Engine Inlet Air Mass Flow Rate Low	• Disconnected hose to air filter • MAF auto-calibration • Defective MAF sensor • MAF configuration PP • Restricted air filter • Restricted CAC or pipes • Failed Turbochargers	Step-based Diagnostics (page 1117)
132	3	MAF signal Out of Range HIGH	• MAF signal circuit OPEN or short to PWR • Failed MAF sensor	Pin-point Diagnostics (page 1102)
132	4	MAF signal Out of Range LOW	• MAF signal circuit short to GND • Failed MAF sensor	Pin-point Diagnostics (page 1102)
132	11	MAF sensor Calibration – Insufficient number of data points	• Engine condition not stable to accept MAF calibration • See MAF Calibration Pre-Checks	Step-based Diagnostics (page 1115)

SPN	FMI	Condition	Possible Causes	Actions
132	13	MAF sensor calibration Needed	• MAF sensor needs to be calibrated	Step-based Diagnostics (page 1116)
132	14	MAF sensor Calibration Failed	• Leak in intake air system • Leak in exhaust system • Failed MAF / AIT sensor	Pin-point Diagnostics (page 1102)
132	31	MAF Operation Fault	• Loss of power or GND, • Open signal wire, • Signal shorted to GND, • Signal shorted to battery, • Failed MAF sensor or circuit.	Step-based Diagnostics (SPN 132, page 1117)
172	2	AIT signal erratic, intermittent, or incorrect	• Biased Air Inlet Temperature (AIT) signal or circuit	Step-based Diagnostics (page 1120)
172	3	AIT signal Out of Range HIGH	• AIT signal circuit OPEN or short to PWR • SIG GND circuit OPEN • Failed AIT sensor	Step-based Diagnostics (page 1122)
172	4	AIT signal Out of Range LOW	• AIT signal circuit short to GND • Failed AIT sensor	Step-based Diagnostics (page 1128)

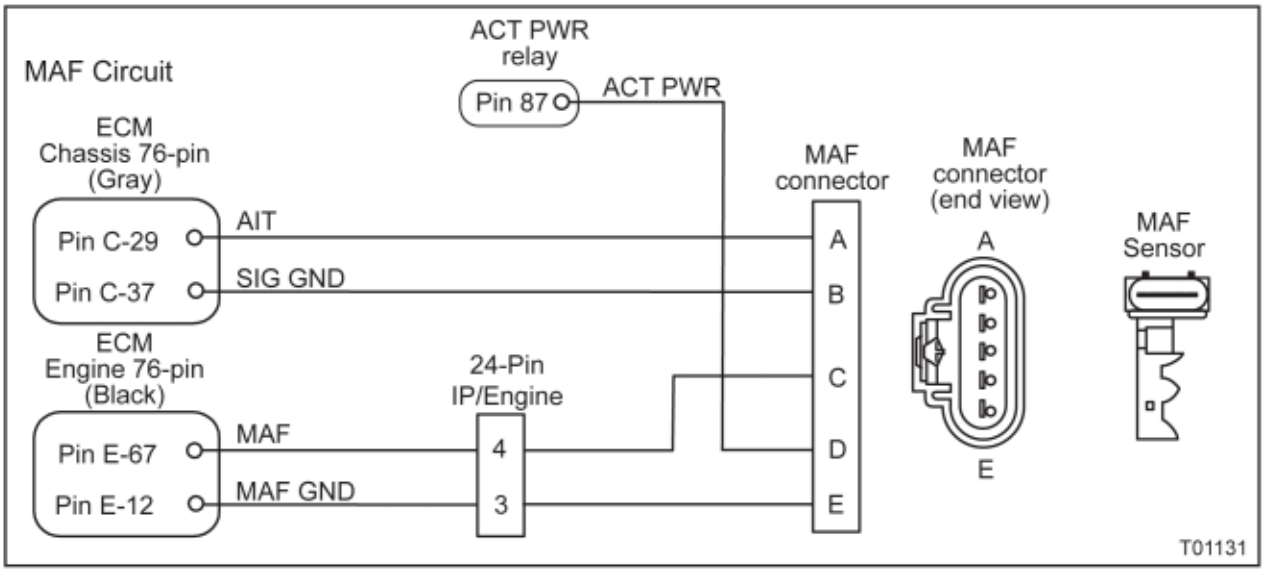


Figure 488 MAF / AIT Circuit Diagram

Overview

The MAF sensor directly monitors the air entering the engine. The MAF sensor also houses the AIT sensor, which is used with the MAF to calculate the amount and density of the incoming air. The ECM uses this information to calculate the correct amount of EGR during engine operation.

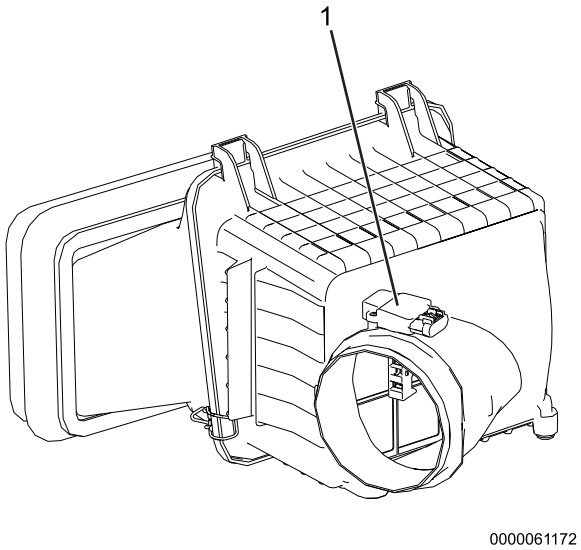


Figure 489 MAF / AIT Sensor Location

1. MAF / AIT Sensor

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- 00-00956-08 – 180-pin Breakout Box (page 1222)
- Breakout Harness 4960 (MAF) (page 1238)
- International® Electronic Engine Terminal Test Kit (page 1227)

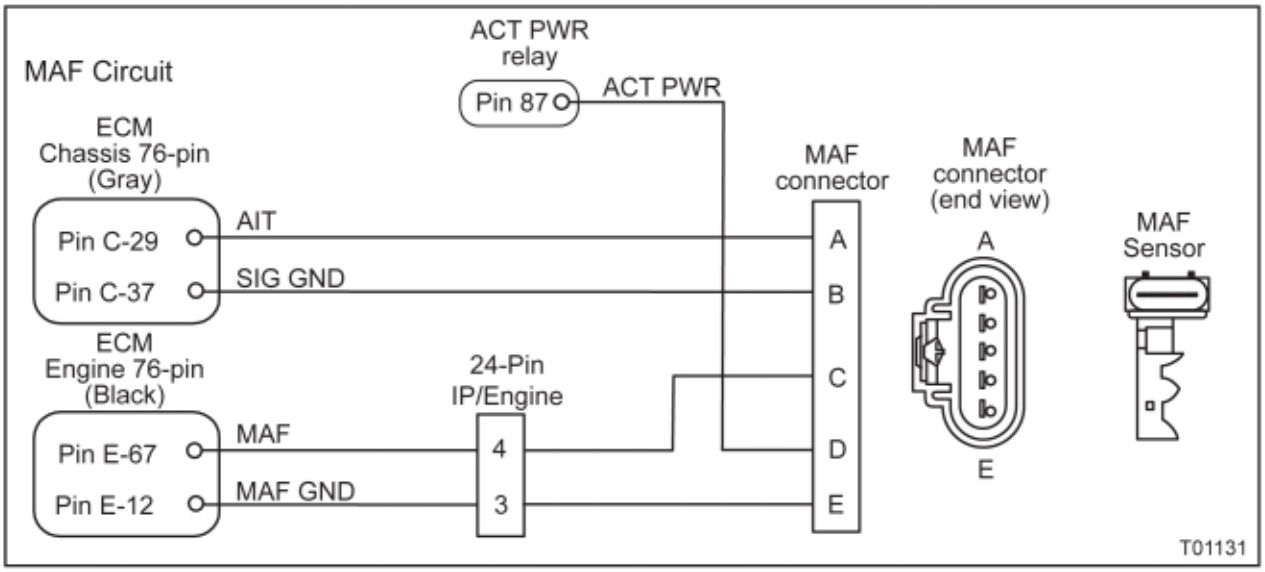


Figure 490 MAF / AIT Circuit Diagram

MAF Calibration Requirements

NOTE: Only run the MAF Calibration Procedure if one of the following conditions have occurred:

- SPN 132 FMI 13 is set
- ECM replacement
- Repair or replacement of MAF sensor or circuit
- Repair or replacement of Intake Manifold Pressure (IMP) sensor or circuit
- Repair or replacement of Intake Manifold Temperature (IMT) sensor or circuit
- Repair or replacement of intake air system
- Repair or replacement of CAC system
- Repair or replacement of turbocharger
- Repair or replacement of Engine Throttle Valve (ETV)
- Repair or replacement of EGR valve
- Repair base engine (cylinder head, pistons, camshaft)
- Engine replacement or rebuild

Continue to MAF Calibration Pre-Checks

MAF Calibration Pre-Checks

NOTE: Verify the following before running the MAF Calibration Procedure:

- No active fault codes, other than SPN 132 FMI 13
- Ambient Air Temperature (AAT) at or above 58°F (14°C)
- KOER Standard Test run at or above 158°F (70°C)
- Engine Oil Temperature (EOT) at or above 176°F (80°C)
- Engine Coolant Temperature (ECT) at or above 158°F (70°C)
- DPF Status = Regeneration Not Needed
- No leaks in intake air system
- No leaks in exhaust system
- No shop exhaust hose attached
- No engine performance issues
- No engine misfire issues
- Engine hood is closed
- Transmission in Park or Neutral
- Clutch disengaged
- Engine Fan OFF
- Parking brake ON
- Power Takeoff (PTO) disabled
- Air conditioning OFF
- Accelerator pedal not depressed
- MAF sensor within KOEO specification
- IMP sensor within KOEO specification
- IMT sensor within -22°F (-30°C) and 257°F (125°C)

Continue to MAF Calibration Procedure

MAF Calibration Procedure – Using ServiceMaxx™ Software

NOTE: Ensure MAF Calibration Requirements are met and MAF Calibration Pre-Checks are done, prior to doing this procedure.

1. Turn ignition switch to ON, engine OFF.
2. Start ServiceMaxx™ software.
3. Start engine. Ensure engine operating temperature is at or above 176°F (80°C).
4. Run KOER Standard Test.
5. Run MAF Sensor Calibrate procedure.
   - If calibration fails, verify all MAF Calibration Requirements (page 1100) are met and MAF Calibration Pre-Checks (page 1101) are done.

MAF Calibration Procedure – Using ServiceMaxx™ Software (cont.)

- If calibration is successful, clear previously active SPN 132 FMI 13, if present.

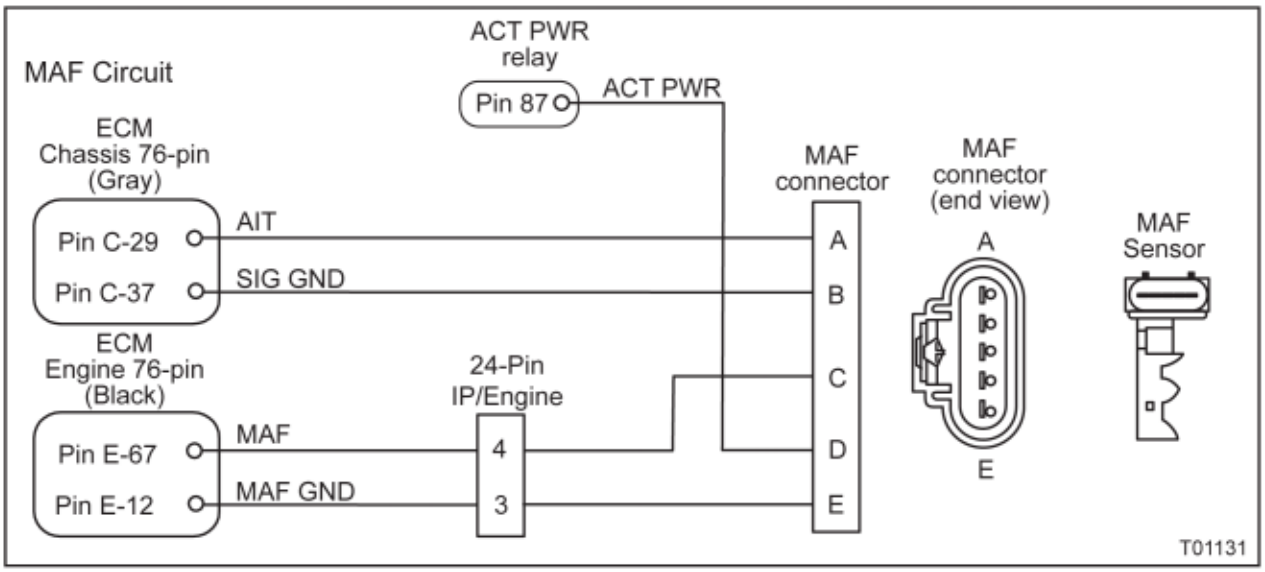


Figure 491 MAF / AIT Circuit Diagram

Pin-point Diagnostics With ServiceMaxx™ Software

WARNING: To prevent personal injury or death, be careful to avoid rotating parts (belts and fan) and hot engine surfaces.

1. Using ServiceMaxx™, monitor sensor voltage. Verify an active code for the sensor.
   - If code is inactive, monitor the signal while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the signal spikes and the code goes active.
   - If code is active, proceed to the next step.
2. Disconnect engine harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

3. Connect to engine harness. Leave sensor disconnected.

MAF Pin-point Diagnostics

Connector Voltage Check

Connect Breakout Harness 4960. Leave sensor disconnected. Turn ignition switch to ON, engine OFF. Use DMM to measure voltage. Use DMM to measure voltage.

Test Point	Specification	Comment
A to GND	4.6 to 5 V	If < 4.5 volts, check for OPEN AIT circuit or short to GND
B to B+	B+	If below B+ check for OPEN SR1 GND circuit.
C to GND	4.6 to 5 V	If < 5 volts, Check for OPEN MAF circuit or short to GND.
D to GND	B+	If < B+, Check for OPEN VPWR circuit.
E to B+	B+	If < B+, Check for OPEN MAF GND circuit.

If checks are within specifications, connect sensor and clear codes. If active codes remain, replace sensor.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-pin Breakout Box and Breakout Harness 4960. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment
A to C-29	< 5 Ω	If > 5 Ω, check for OPEN AIT circuit.
B to C-37	< 5 Ω	If > 5 Ω, check for OPEN SR1 GND circuit.
C to E-67	< 5 Ω	If > 5 Ω, check for OPEN MAF circuit.
E to E-12	< 5 Ω	If > 5 Ω, check for OPEN MAF GND circuit.

Extended Diagnostic Information

The MAF sensor produces a frequency of 30 – 50 Hz with 30 Hz being idle and 150 Hz at full throttle.

1. Monitor the MAF Hz. Record MAF sensor readings at KOEO and at idle, and again at various RPM ranges.
2. Compare the values against specifications.
3. Start from idle and increase the RPM while watching MAF reading. Increase should be steadily proportional to RPM change.
4. Perform the same checks while lightly tapping on the sensor, or heating the sensor with a blow dryer. Any fluctuation, or out of specification reading indicates a MAF sensor, or related wiring concern.
5. Repair and retest.

SPN 132

FMI 0 – Engine Inlet Air Mass Flow Rate High

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Comparison of modeled Engine Inlet Air Mass Flow rate with actual Engine Inlet Air Mass flow rate {Engine Inlet Air Mass Flow Rate High}	Moving Mean average of measured Engine Inlet Air Mass Flow rate MINUS Modeled value of Engine Inlet Air Mass Flow rate > Threshold defined by Speed / Torque based [Table A055] * Ambient pressure modifier [Table A056] * Engine coolant temperature modifier [Table A057]	Key ON	0.02 seconds
		Engine Running	
		Time after engine start ≥ 30 seconds	
		Particulate Filter Regeneration NOT Active	
		Barometric Pressure ≥ 11 psi (73.5 kPa) AND ≤ 15 psi (103 kPa)	
		Monitor entry condition based on speed / torque [Table A115]	
		Power Take Off (PTO) Mode NOT Active	
		End Of Line Testing NOT Active	
		[Engine Brake (Retarder) NOT active AND minimum wait time after retarder change of state has occurred] > 5 seconds	
		Engine Torque limitation NOT Active	
		Engine is in NOT in coasting (i.e., Throttle Cut OFF) mode	
		Battery Voltage ≥ 10.787 Volts AND ≤ 15.787 Volts	
		Engine Coolant Temperature ≥ 140°F (60°C)	
		1. Engine Speed Gradient ≤ 20.02 rpm/second	
		2. Engine Torque Gradient ≤ 35 lb-in/second (4 N·m/second)	

FMI 0 – Engine Inlet Air Mass Flow Rate High (cont.)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		3. Absolute Engine Intake Manifold # 1 Pressure Gradient <= 30.02 * 1 psi/second (5 kPa/second)	
		Minimum time in entry conditions 1, 2, and 3 to enable monitoring ≥ 1000 * 0.02 seconds	
		SPN / FMI 102/3, 102/4, 105/3, 105/4, 108/3, 108/4, 110/3, 110/4, 132/3, 132/4, 2791/3, 2791/4, 3509/3, 3509/4 are NOT Active	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the difference between MAF rate and measured MAF rate is incorrect and/or erratic.

Fault Detection / Management

The ECM continuously monitors the control system. If the sensor signal is higher or lower than expected, the ECM disregards the signal and uses a calibrated default value. The ECM sets an SPN / FMI, turns on the Warning Engine Lamp (WEL), and runs the engine in a default range.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN / FMIs: 2791/2, 2791/7, 2791/8, 2791/14, 27/0, 27/14

Drive Cycle to Determine Fault Status

N/A

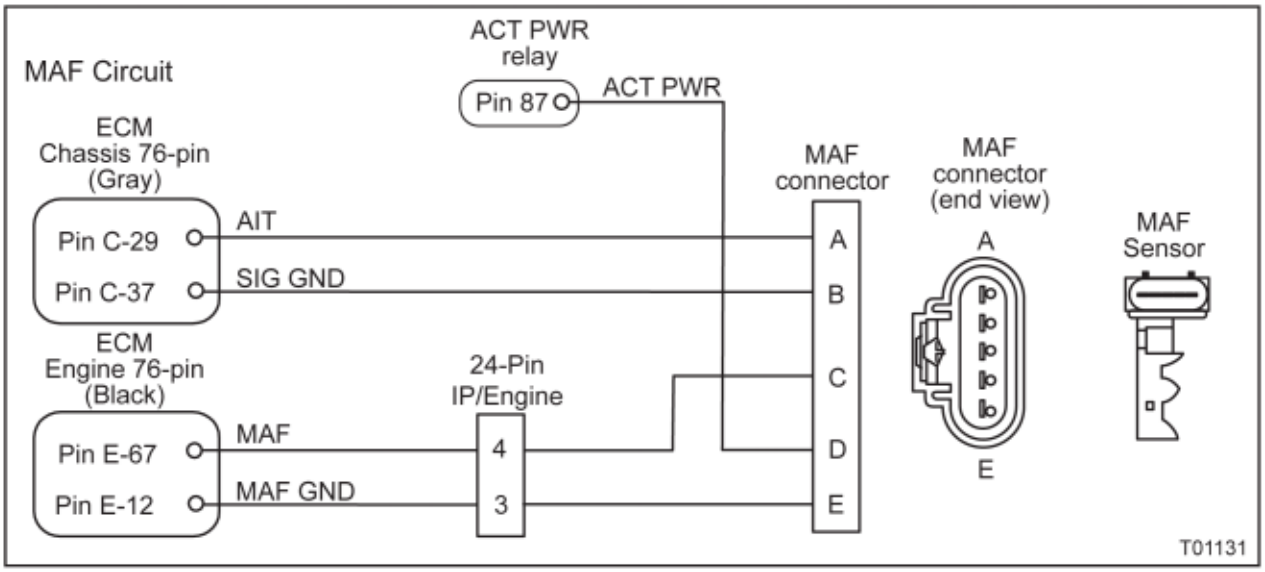


Figure 492 MAF / AIT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 132 FMI 0 the only fault code active?	Yes: Go to Step 3.
		No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 132 FMI 0.
		No: Go to Step 3.

Step	Action	Decision
3	Inspect air intake system and air filter for restrictions, air leaks, or physical damage. Do Intake Air (page 194) and Charge Air Cooler (CAC) System (page 193) checks. Is air intake system and air filter free of restrictions, leaks, and physical damage?	Yes: Go to Step 4.
		No: Repair intake air system or replace air filter. After repairs are complete, retest for SPN 132 FMI 0.

Step	Action	Decision
4	Using terminal test kit, inspect connections at Mass Air Flow / Air Inlet Temperature (MAF / AIT) sensor. With key OFF, disconnect MAF / AIT connector. Check MAF / AIT and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are MAF / AIT connector, harness, and terminals clean and undamaged?	Yes: Go to Step 5.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 132 FMI 0

Step	Action	Decision
5	Test MAF circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 1103). Are MAF circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 6.
		No: Repair circuits as required. After repairs are complete, retest for SPN 132 FMI 0.

Step	Action	Decision
6	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Do Key On Engine Off Continuous Monitor Test (page 87). Does circuit operate properly?	Yes: Go to Step 7.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 132 FMI 0.

Step	Action	Decision
7	Test for Exhaust Gas Recirculation (EGR) valve operating within specification. Connect Breakout Harness 4948 between EGR and EGR connector. Set Key OFF for minimum of 45 seconds before testing. Using EST with ServiceMaxx™ software, do Key On Engine Off Output State High Test (page 87) and Output State Low Test (page 87) four times while waiting 30 seconds for each test to run. Check for SPN 2791 FMI 7 or SPN 2791 FMI 14 fault setting after the fourth Output State High test. Did SPN 2791 FMI 7 or SPN 2791 FMI 14 fault not set?	Yes: If either SPN 2791 FMI 7 or 14 does not set, go to Step 8.
		No: Replace EGR valve. After repairs are complete, retest for SPN 132 FMI 0.

Step	Action	Decision
8	Calibrate MAF sensor. Do MAF calibration procedure (page 1101) using ServiceMaxx™ software. Did MAF Calibration complete successfully?	Yes: After doing all diagnostic steps, if SPN 132 FMI 0 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Refer to MAF / AIT Sensor End Diagnostics, SPN 132 FMI 0, MAF sensor calibration failed.

NOTE: After doing all diagnostic steps, if SPN 132 FMI 0 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 132

FMI 1 – Engine Inlet Air Mass Flow Rate Low

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Comparison of modeled Engine Inlet Air Mass Flow rate with actual Engine Inlet Air Mass flow rate {Engine Inlet Air Mass Flow Rate Low}	Moving Mean average of measured Engine Inlet Air Mass Flow rate MINUS Modeled value of Engine Inlet Air Mass Flow rate < Threshold defined by Speed / Torque based table [Table A058] * Ambient Pressure modifier [Table A059] * Engine coolant temperature modifier [Table A060]	Key ON	0.02 seconds
		Engine Running	
		Time after engine start ≥ 30 seconds	
		Particulate Filter Regeneration NOT Active	
		Barometric Pressure ≥ 11 psi (73.5 kPa) AND ≤ 15 psi (103 kPa)	
		Monitor entry condition based on speed / torque [Table A116]	
		Power Take Off (PTO) Mode NOT Active	
		End Of Line Testing NOT Active	
		[Engine Brake (Retarder) NOT active AND minimum wait time after retarder change of state has occurred] > 5 seconds	
		Engine Torque limitation NOT Active	
		Engine is in NOT in coasting (i.e., Throttle Cut OFF) mode	
		Battery Voltage ≥ 10.787 Volts AND ≤ 15.787 Volts	
		Engine Coolant Temperature ≥ 140°F (60°C)	
		1. Engine Speed Gradient ≤ 20.02 rpm/second	
		2. Engine Torque Gradient ≤ 35 lb-in/second (4 N·m/second)	
		3. Absolute Engine Intake Manifold # 1 Pressure Gradient	

FMI 1 – Engine Inlet Air Mass Flow Rate Low (cont.)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
		≤ 30.02 * 1 psi/second (5 kPa/second)	
		Minimum time in entry conditions 1,2 and 3 (listed above) to enable monitoring ≥ 1000 * 0.02 seconds	
		SPN / FMIs 102/3, 102/4, 105/3, 105/4, 108/3, 108/4, 110/3, 110/4, 132/3, 132/4, 2791/3, 2791/4, 3509/3, 3509/4 are NOT Active	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the deviation between MAF rate and measured MAF rate is below threshold.

Fault Detection / Management

The ECM continuously monitors the control system. If the sensor signal is higher or lower than expected, the ECM disregards the signal and uses a calibrated default value. The ECM sets an SPN / FMI, turns on the Warning Engine Lamp (WEL), and runs the engine in a default range.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

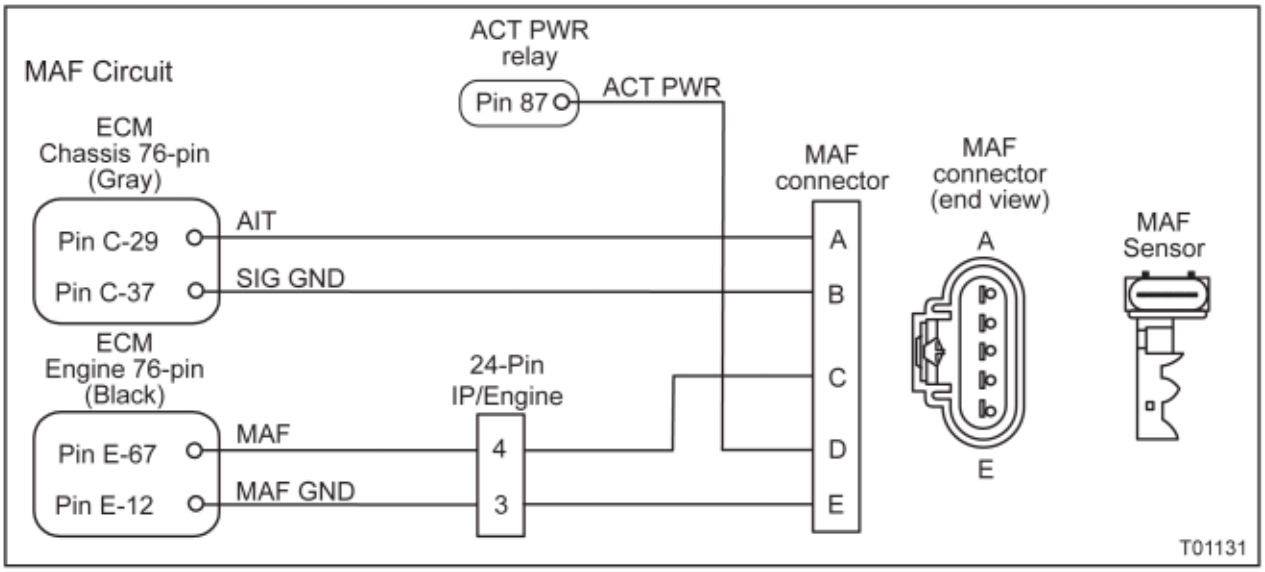


Figure 493 MAF / AIT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 132 FMI 1 the only fault code active?	Yes: Go to Step 3.
		No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 132 FMI 1.
		No: Go to Step 3.

Step	Action	Decision
3	Inspect air intake system and air filter for restrictions, air leaks, or physical damage. Do Intake Air (page 194) and Charge Air Cooler (CAC) System (page 193) checks. Is air intake system and air filter free of restrictions, leaks, and physical damage?	Yes: Go to Step 4.
		No: Repair intake air system or replace air filter. After repairs are complete, retest for SPN 132 FMI 1.

Step	Action	Decision
4	Using terminal test kit, inspect connections at Mass Air Flow / Air Inlet Temperature (MAF / AIT) sensor. With key OFF, disconnect MAF / AIT connector. Check MAF / AIT and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are MAF / AIT connector, harness, and terminals clean and undamaged?	Yes: Go to Step 5.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 132 FMI 1

Step	Action	Decision
5	Test MAF circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 1103). Are MAF circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 6.
		No: Repair circuits as required. After repairs are complete, retest for SPN 132 FMI 1.

Step	Action	Decision
6	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Do Key On Engine Off Continuous Monitor Test (page 87). Does circuit operate properly?	Yes: Go to Step 7.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 132 FMI 1.

Step	Action	Decision
7	Calibrate MAF sensor. Do MAF calibration procedure (page 1101) using ServiceMaxx™ software. Did MAF Calibration complete successfully?	Yes: Go to Step 8.
		No: Refer to MAF / AIT Sensor End Diagnostics, SPN 132 FMI 14, MAF sensor calibration failed.

Step	Action	Decision
8	Test Turbocharger 2 Wastegate Control (TC2WC) for proper operation. Do Turbocharger 2 Wastegate Control tests . Does wastegate operate as expected?	Yes: After doing all diagnostic steps, if SPN 132 FMI 1 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Repair leaking wastegate solenoid supply line or solenoid, or replace wastegate actuator or turbocharger, as indicated. After repairs are complete, retest for SPN 132 FMI 1.

NOTE: After doing all diagnostic steps, if SPN 132 FMI 1 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 132 FMI 11 - MAF Sensor Calibration – Insufficient number of data points

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Mass Air Flow (MAF) sensor auto-calibration has not completed successfully.	MAF auto-calibration has insufficient number of data points	Key ON

Fault Overview

Fault code sets when Electronic Control Module (ECM) detects MAF sensor did not successfully complete an auto-calibration routine.

Lamp Reaction

Amber Warning Lamp (AWL) illuminates when this fault is detected.

Associated Faults

None

Fault Facts

When MAF auto-calibration routine does not successfully complete, MAF sensor will need to be re-calibrated.

Drive Cycle to Determine Fault Status

Key ON.

Possible Causes

- Improperly calibrated MAF

Step 1	Run MAF sensor calibration.	Decision
	Perform MAF Sensor Calibration (page 1101) and clear fault code. Cycle ignition to Key OFF, then back to Key ON. Does SPN 132 FMI 11 set after DTC list is cleared?	Yes: Replace MAF sensor. After repairs are complete, retest MAF sensor.
		No: Diagnostics complete.

End Diagnostic Step
After performing diagnostic step, if SPN 132 FMI 11 remains, verify if step was completed correctly and proper decision was made. Notify supervisor for further action.

SPN 132 FMI 13 - MAF Sensor Calibration Needed

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Mass Air Flow (MAF) sensor needs to be re-calibrated after Engine Control Module (ECM) reprogramming.	ECM reprogrammed without re-calibrating the MAF.	Key ON

Fault Overview

Fault code sets when Engine Control Module (ECM) has been reprogrammed and Mass Air Flow (MA)F sensor needs to be re-calibrated.

Lamp Reaction

Amber Warning Lamp (AWL) illuminates when this fault is detected.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON

Possible Causes

- Improperly calibrated MAF

Step 1	Run MAF sensor calibration and check for fault code.	Decision
	Perform MAF Sensor Calibration (page 1101) and clear fault code. Cycle ignition to Key OFF, then back to Key ON. Does SPN 132 FMI 13 set after DTC list is cleared?	Yes: Replace MAF sensor. After repairs are complete, retest MAF sensor.
		No: Diagnostics complete.

End Diagnostic Step
After performing diagnostic step, if SPN 132 FMI 13 remains, verify if step was completed correctly and proper decision was made. Notify supervisor for further action.

SPN 132

FMI 31 – MAF Operation Fault

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine Inlet Air Mass Flow Rate Short to Power, Short to GND or Open Circuit	Falling edges detected by Pulse Input Measurement driver (MAF sensor frequency). 0	Key ON	0.2 seconds
		Battery Voltage > 8 Volts	
		Computed Battery Voltage > 8 Volts	
		Engine Speed ≥ 0 RPM	

Fault Overview

N/A

Fault Detection / Management

The ECM continuously monitors the control system. If the sensor signal is higher or lower than expected, the ECM disregards the signal and uses a calibrated default value. The ECM sets an SPN / FMI, turns on the Warning Engine Lamp (WEL), and runs the engine in a default range.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

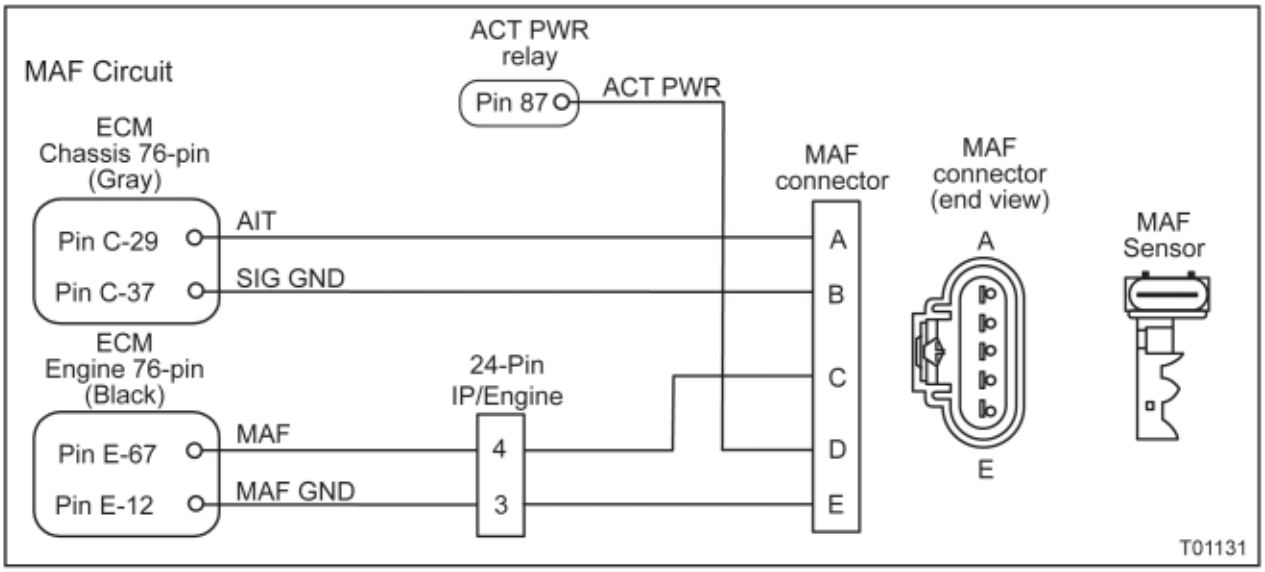


Figure 494 MAF / AIT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 132 FMI 31 the only fault code active?	Yes: Go to Step 3.
		No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 132 FMI 31.
		No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit, inspect connections at Mass Air Flow / Air Intake Temperature (MAF / AIT) sensor. Key OFF, disconnect MAF / AIT sensor. Check MAF / AIT sensor and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are MAF / AIT connector, harness, and terminals clean and undamaged?	Yes: Go to Step 4.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 132 FMI 31

Step	Action	Decision
4	Test MAF circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 1103). Are MAF circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 5.
		No: Repair circuits as required. After repairs are complete, retest for SPN 132 FMI 31.

Step	Action	Decision
5	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Do Key On Engine Off Continuous Monitor Test (page 87). Verify sensor voltages are within specifications. Does circuit operate properly?	Yes: After doing all diagnostic steps, if SPN 132 FMI 31 remains active, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuit as required, and retest for SPN 132 FMI 31.

NOTE: After doing all diagnostic steps, if SPN 132 FMI 31 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 172 FMI 2 - IAT signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Comparison of Engine Intake Air Temperature sensor to the following sensors after a calibrated adjustable cold-soak period (time). Sensor 1 to 4 are in Air group and 5 and 6are in Liquid group [1. Engine Intake Manifold 1 Temperature 2. Engine Air Intake Temperature 3. Engine Turbocharger 2 Compressor Intake Temperature 4. Engine Charge Air Cooler Outlet Temperature 5. Engine Coolant Temperature 6. Engine Oil Temperature 1]	{Engine Intake Manifold 1 Temperature (Bias Hi) > Reference temperature value OR Engine Intake Manifold 1 Temperature (Bias low)} ≤ Reference temperature value Error threshold value for comparison of sensors in same media (Air to Air media): Used for Equilibrium and Reference value calculation > 59°F (15°C) Error threshold value for comparison of sensors in different media (Air to Liquid media): Used for Equilibrium and Reference value calculation > 59°F (15°C) Error threshold value for comparison of sensors in same media (Liquid to Liquid): Used for Equilibrium and Reference value calculation > 59°F (15°C) Error threshold value for comparison of sensors in different media (Liquid to Air or vice versa) : Used for Equilibrium and Reference value calculation > 59°F (15°C) {NOTE: Reference temperature value calculation is explained in Operations Summary Document}	Key ON Engine Off timer ≥ 28800 seconds Engine Coolant Temperature ≥ -40°F (-40°C) Engine in Thermal Equilibrium Condition {Explained in operations summary document} [Similar sensors agree with other sensors with different group-index OR Faulty Sensor is alone in its group {i.e. No other sensor which measures the same media (in Air Path) is identified as a faulty sensor}]

Fault Overview

ECM compares Intake Air Temperature (IAT) sensor to Intake Manifold Temperature (IMT), Turbocharger 2 Compressor Intake Temperature (TC2CIT), Charge Air Cooler Outlet Temperature (CACOT), Engine Coolant Temperature 1 (ECT1), and Engine Oil Temperature (EOT) sensors after calibrated adjustable cold-soak period (time).

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Initial Key ON

Possible Causes

- Failed IAT sensor
- Failed Wiring

Step 1	Check for active or pending fault codes.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 172 FMI 2. Is EST DTC list SPN 172 FMI 2 active or pending?	Yes: Go to Step 2.
		No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Inspect connections at Intake Air Temperature (IAT) connector.	Decision
	A. Key OFF. B. Disconnect IAT connector. C. Check IAT and connector terminals for: damaged or pinched wires; moisture or corroded terminals; loose, bent, or broken pins; or broken connector housing. Are IAT connector, harness, and terminals clean and undamaged?	Yes: Go to Step 3.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 172 FMI 2.

Step 3	Inspect connections at Intake Air Temperature (IAT) connector.	Decision
	A. Key OFF. B. Connect Breakout Harness ZTSE4993 between pin-1 and pin-2 on IAT connector. C. Key-On Engine-Off (KOEO). Using EST with ServiceMaxx™ software, measure voltage between pin-1 and pin-2. Is voltage less than 0.5 volts?	Yes: Replace IAT sensor. After repairs are complete, retest for SPN 172 FMI 2. No: Go to step 4.

Step 4	Inspect connections at Intake Air Temperature (IAT) connector.	Decision
	A. Key OFF. B. Connect Breakout Harness ZTSE4993 between pin-1 and known good GND. C. Key-On Engine-Off (KOEO). Using EST with ServiceMaxx™ software, measure resistance. Is resistance less than 5 ohms?	Yes: Repair IAT signal wire. After repairs are complete, retest for SPN 172 FMI 2. No: Repair IAT SIG GND wire. After repairs are complete, retest for SPN 172 FMI 2.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 172 FMI 2 fault code diagnostics.

SPN 172 FMI 3 - IAT Signal Out of Range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Intake Air Temperature (IAT) sensor signal Out of Range High.	IAT sensor voltage > 4.8 Volts (< 111.16 °F {-43.98 °C})	Key ON

Fault Overview

Fault code sets when Electronic Control Module (ECM) detects Intake Air Temperature (IAT) sensor voltage is greater than 4.8 volts for 2.5 seconds.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive trips.

Associated Faults

None

Fault Facts

IAT sensor is located inside the Mass Air Flow (MAF) sensor assembly.

Drive Cycle to Determine Fault Status

Key ON

Possible Causes

- Intake Air Temperature (IAT) circuit Open
- IAT circuit shorted to PWR
- SIG GND circuit Open
- Failed IAT sensor

Step 1	Check for active or pending fault code.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 172 FMI 3. Is EST DTC list SPN 172 FMI 3 active or pending?	Yes: Go to Step 2.
		No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Inspect Mass Air Flow (MAF) sensor connector for damage.	Decision
	A. Key-On Key-Off. B. Disconnect MAF sensor connector. C. Inspect MAF connector for: damage, pinched wires, corroded terminals, loose, bent or broken pins, or broken connector housing. Is MAF connector, harness, and terminals clean and undamaged?	Yes: Perform Pin-Point Tests (SPN 172 FMI 3) (page 1124).
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 172 FMI 3.

End Diagnostic Tests
After performing diagnostic step, if SPN 172 FMI 3 remains, verify if step was completed correctly and the proper decision was made. Notify supervisor for further action.

Pin-Point Tests (SPN 172 FMI 3)

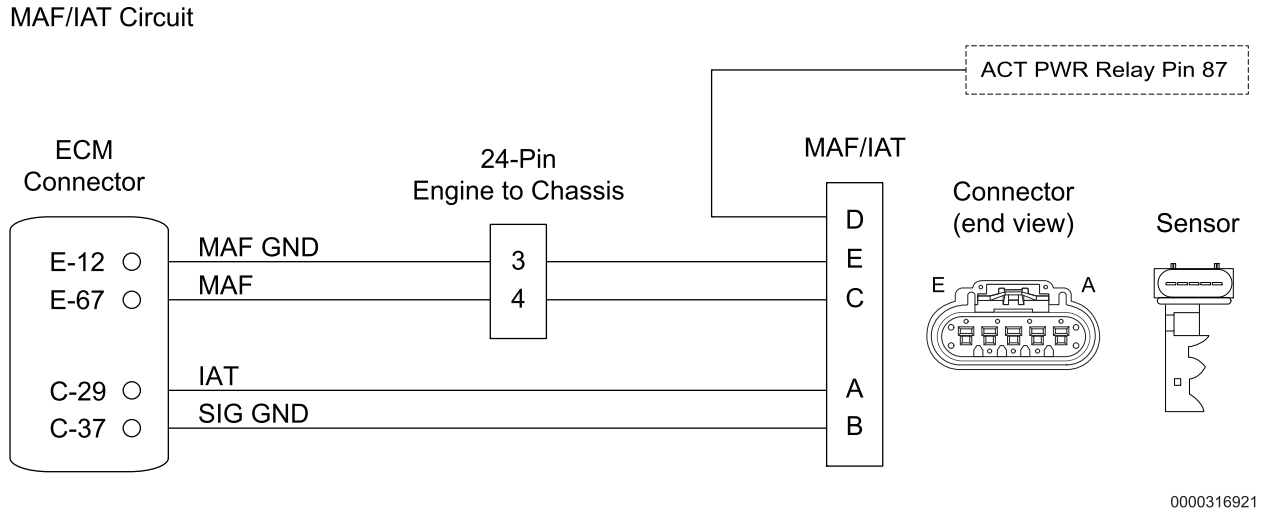


Figure 495 Mass Air Flow (MAF) / Intake Air Temperature (IAT) Sensor Circuit Diagram

NOTE: See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4498
- Breakout Harness ZTSE4960
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)

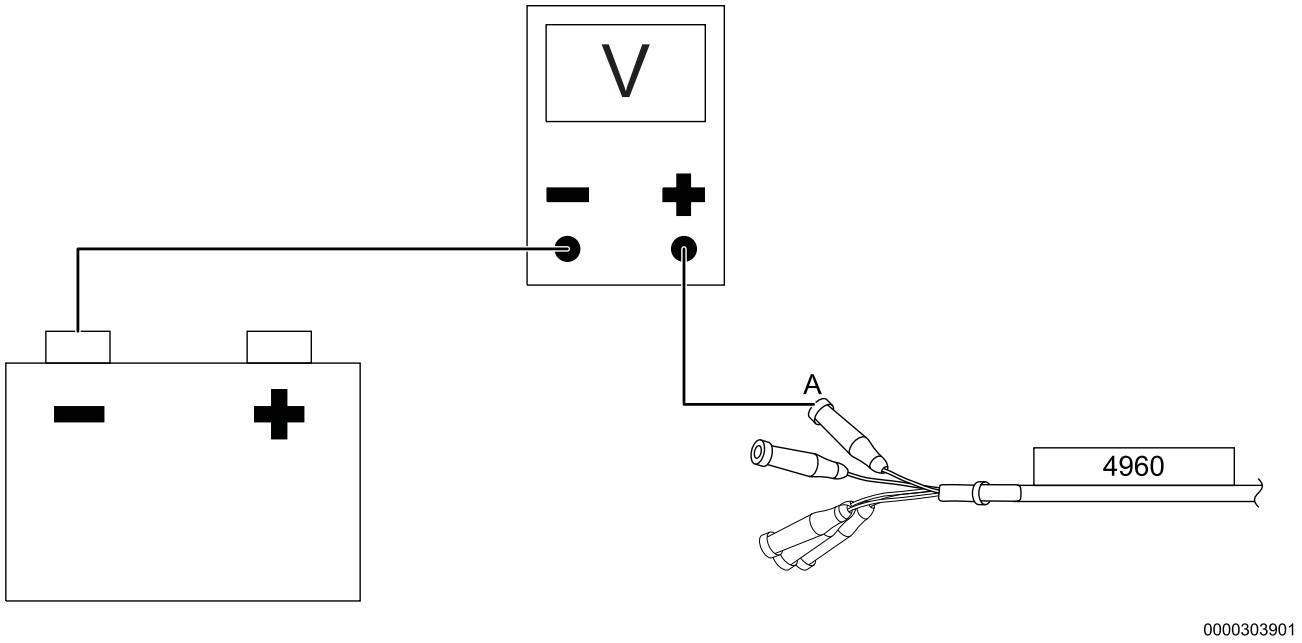


Figure 496 Test 1 Intake Air Temperature (IAT) Circuit Voltage Check

Test 1 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4960 to vehicle harness connector and leave Mass Air Flow (MAF) sensor disconnected. C. Key ON.

Test 1	Specification
Using DMM, measure voltage between Breakout Harness ZTSE4960 pin-A and known good ground.	< 6 volts
Decision	
Is voltage greater than 6 volts?	Yes: Repair short to PWR between Engine Control Module (ECM) pin C-29 and MAF pin-A. After repairs are complete, retest for SPN 172 FMI 3.
	No: Go to Test 2.

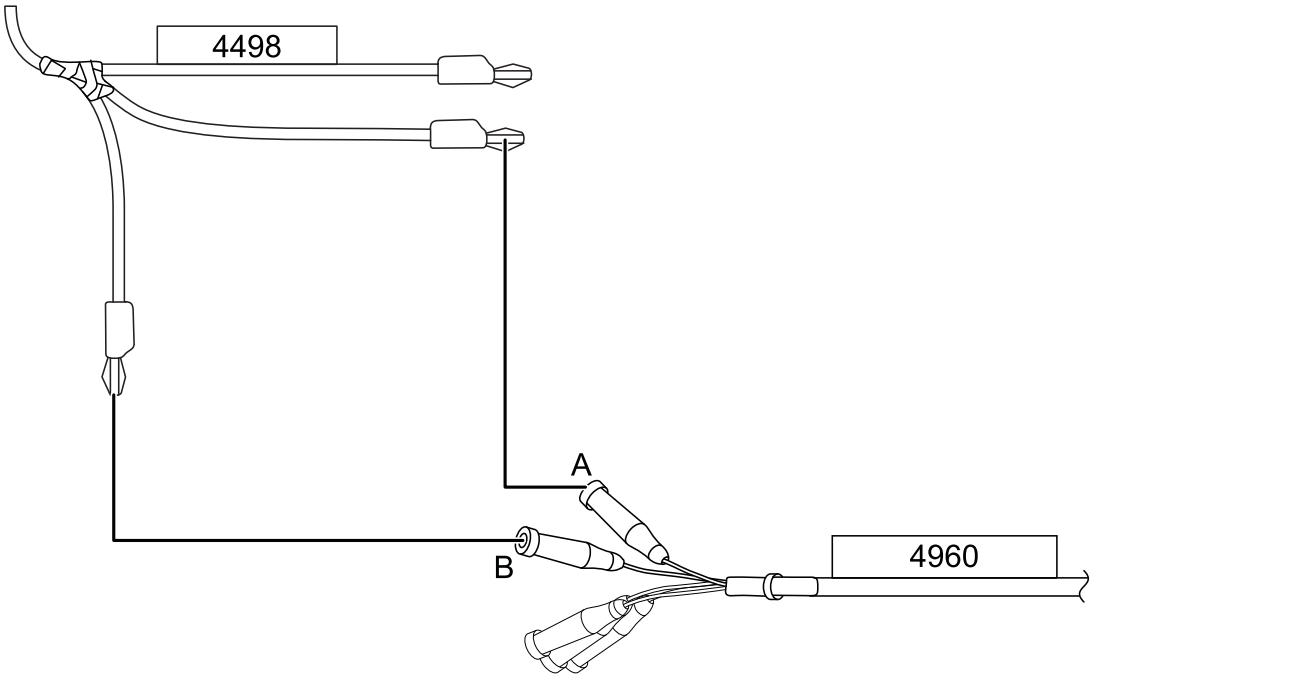


Figure 497 Test 2 Intake Air Temperature (IAT) Circuit Check

Test 2 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4960 to vehicle harness connector and leave Mass Air Flow (MAF) sensor disconnected. C. Using Breakout Harness ZTSE4498, short pin A and pin B of Breakout Harness ZTSE4960 together. D. Connect Electronic Service Tool (EST) to Vehicle Diagnostic Connector (page 81). E. Key ON. Log in to ServiceMaxx™ software.

Test 2	Specification
Using EST with ServiceMaxx™ software, clear Diagnostic Trouble Code (DTC) list.	SPN 172 FMI 4 sets after DTC list is cleared
Decision	
Does SPN 172 FMI 4 set after DTC list is cleared?	Yes: Replace MAF sensor. After repairs are complete, retest for SPN 172 FMI 3.
	No: Go to Test 3.

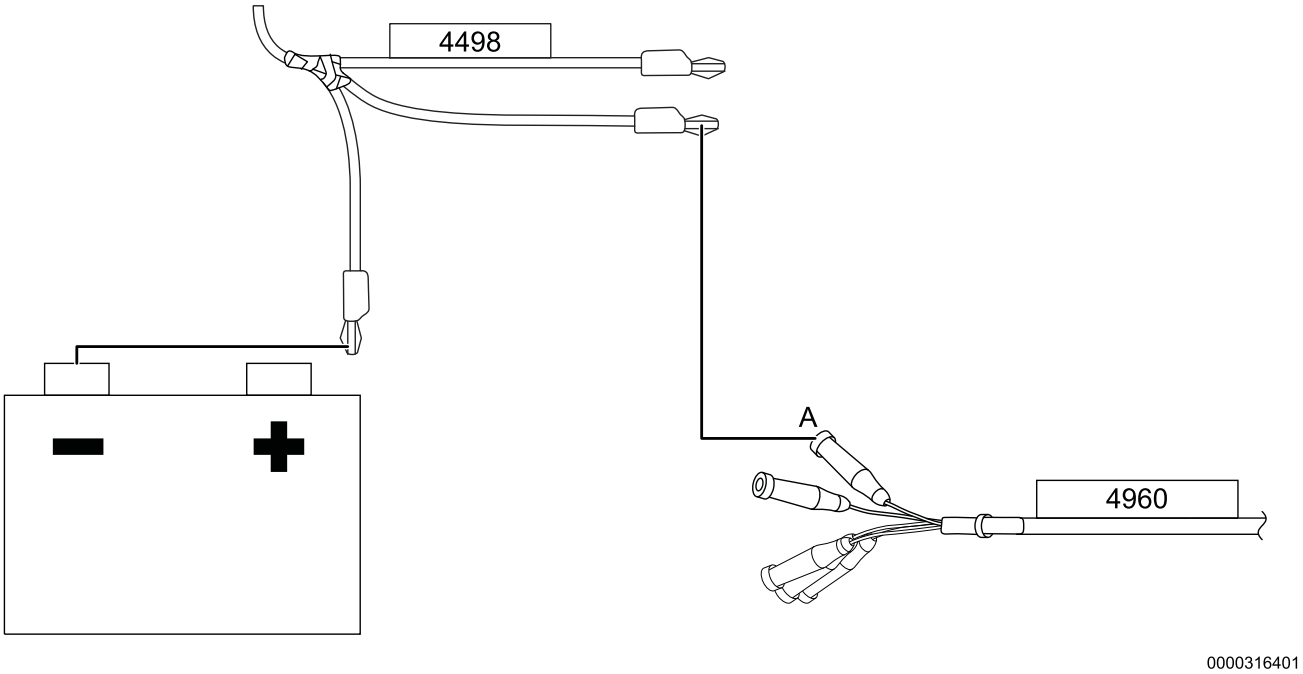


Figure 498 Test 3 Intake Air Temperature (IAT) Circuit Check

Test 3 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4960 to vehicle harness connector and leave Mass Air Flow (MAF) sensor disconnected. C. Using Breakout Harness ZTSE4498, short pin A of Breakout Harness ZTSE4960 to known good ground. D. Connect Electronic Service Tool (EST) to Vehicle Diagnostic Connector (page 81). E. Key ON. Log in to ServiceMaxx™ software.

Test 3	Specification
Using EST with ServiceMaxx™ software, clear DTC list.	SPN 172 FMI 4 sets after DTC list is cleared
Decision	
Does SPN 172 FMI 4 set after DTC list is cleared?	Yes: Repair Open between Engine Control Module (ECM) pin C-37 and MAF pin-B. After repairs are complete, retest for SPN 172 FMI 3.
	No: Repair Open between ECM pin C-29 and MAF pin-A. After repairs are complete, retest for SPN 172 FMI 3.

End Pin-Point Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 172 FMI 3 fault code diagnostics.

SPN 172 FMI 4 - IAT Signal Out of Range LOW

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Intake Air Temperature (IAT) voltage signal Out of Range Low.	IAT sensor voltage < 0.12 Volts (> 273.6°F [134.2°C])	Key ON

Step 1	Check for active or pending fault code.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 172 FMI 4. Is EST DTC list SPN 172 FMI 4 active or pending?	Yes: Go to Step 2. No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Inspect connections at Mass Air Flow (MAF) sensor.	Decision
	A. Key OFF. B. Disconnect MAF sensor connector. C. Inspect MAF connector for: damage, pinched wires, corroded terminals, loose, bent or broken pins, or broken, connector housing. Is MAF connector, harness, and terminals clean and undamaged?	Yes: Go to Pin-Point Tests (page 1129). No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 172 FMI 4.

Pin-Point Tests (SPN 172 FMI 4)

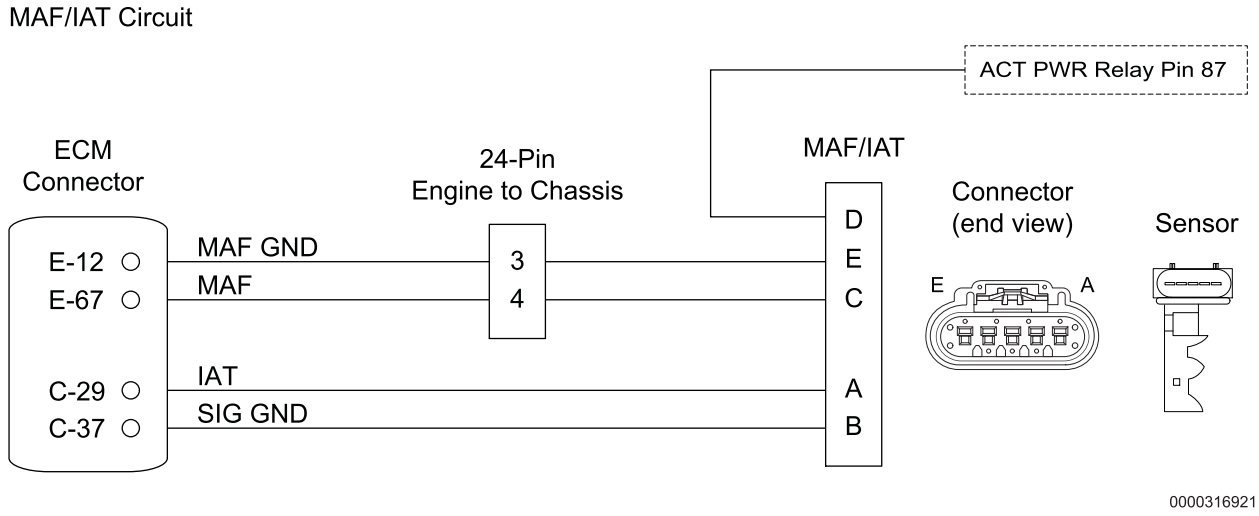


Figure 499 Mass Air Flow (MAF) Sensor Circuit Diagram

NOTE: See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

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

Test 1 Setup
A. Key OFF. B. Disconnect Mass Air Flow (MAF) sensor. C. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). D. Key ON. Log in to ServiceMaxx™ software.

Test 1	Specification
Using EST with ServiceMaxx™ software, clear Diagnostic Trouble Code (DTC) list.	SPN 172 FMI 3 sets after DTC list is cleared
Decision	
Does SPN 172 FMI 3 set after DTC list is cleared?	Yes: Replace MAF sensor. After repairs are complete, retest for SPN 172 FMI 4.
	No: Repair short to ground between MAF pin-A and Engine Control Module (ECM) Pin C-29. After repairs are complete, retest for SPN 172 FMI 4.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 172 FMI 4 fault code diagnostics.

Service Interval Messages

SPN	FMI	Condition	Possible Causes
1378	31	Change Engine Oil Service Interval	• Change oil and re-set interval counter

Service Interval Messages Operation

The service interval messages are displayed on the instrument cluster message center and include engine oil and fuel filter change reminders.

The change oil reminder can be programmed for kilometers, miles, hours, or calculated fuel consumption. This 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.

There fuel filter change message displays when the fuel filter needs replacement due to high filter restriction.

TC2WG (Turbocharger 2 Wastegate)

SPN	FMI	Condition	Possible Causes	Actions
1189	3	TC2WG short to PWR	• TC2WG control shorted to B+	Step-based Diagnostics
1189	4	TC2WG short to GND	• TC2WG control short to GND	Step-based Diagnostics

Tools

- EZ Tech® Electronic Service Tool (EST) – J-45067 (page 1226)
- Digital Multimeter (DMM) (page 1224)
- Breakout Harness 4831 (page 1233)

Pinpoint Diagnostics

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST with ServiceMaxx™ software, open the Continuous Monitor Session.
2. Monitor sensor voltage. Verify an active code for the sensor.
   - If code 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 code will go active.
   - If code is active, proceed to the next step.
3. Disconnect engine harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

4. Connect Breakout Harness 4946 to engine harness. Leave sensor disconnected.

Voltage Check at TC2WG Connector – Output State Test

Disconnect TC2WG 2-pin connector. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment: < Less than, > Greater than
1 to GND	B+	If < B+, check ACT PWR circuit for OPEN.
2 to GND	4 to 4.4 V	If < 2 volts, check for short to GND or open.
		If > 8 volts, check TC2WG circuit for short to PWR.
Run Output State Test HIGH.		
2 to B+	0 to 0.25 V	If > 0.25 volts, check TC2WG circuit for short to GND.
Run Output State Test LOW.		
2 to B+	B+	If < B+, check TC2WG circuit for OPEN or short to PWR. Go to Harness Resistance Checks.
1 to 2	B+	If < B+, check ACT PWR circuit for OPEN. Go to Harness Resistance Checks.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-pin Breakout Box. Leave ECM and TC2WG disconnected.

Test Point	Specification	Comment: < Less than, > Greater than
E–73 to 2	< 5 Ω	If > 5 Ω, check TC2WG for OPEN circuit.
E–73 to GND	> 1 kΩ	If < 1 kΩ, check TC2WG circuit for short to GND.
1 to relay pin 87	< 5 Ω	If > 5 Ω, check ACT PWR for OPEN in circuit.
1 to GND	> 1 kΩ	If < 1 kΩ, check ACT PWR for short to GND.

SPN 1189 FMI 3 - TC2WG short to PWR

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Turbocharger 2 Wastegate (TC2WG) shorted to power (PWR).	Current through TC2WG circuit > 1 amp for 20 microseconds, or > 2 amp for 2 microseconds	Engine Turbocharger 2 Wastegate Drive position command (PWM frequency) for short circuit to battery detection ≥ 0.003 % Battery power ≥ 9 volts

Fault Overview

Fault code sets when Electronic Control Module (ECM) determines that Turbocharger 2 Wastegate Position (TC2WG) circuit is shorted to a power source for 25.5 seconds. TC2WG circuit current is greater than 1 amp for 20 microseconds or greater than 2 amps for 2 microseconds.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during one trip.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON

Possible Causes

- TC2WG ground side switch circuit short to PWR
- Failed Turbocharger 2 Wastegate (TC2WG) valve

Step 1	Check for active or pending fault codes.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 1189 FMI 3. Is EST DTC list SPN 1189 FMI 3 active or pending?	Yes: Go to Step 2.
		No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Inspect connections at Turbocharger 2 Wastegate Position (TC2WG) connector.	Decision
	A. Key OFF. B. Disconnect TC2WG connector. C. Check TC2WG and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are TC2WG connector, harness, and terminals clean and undamaged?	Yes: Perform Pin-Point Test (SPN 1189 FMI 3) (page 1135). No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 1189 FMI 3.

Pin-Point Tests SPN 1189 FMI 3

TC2WG Circuit

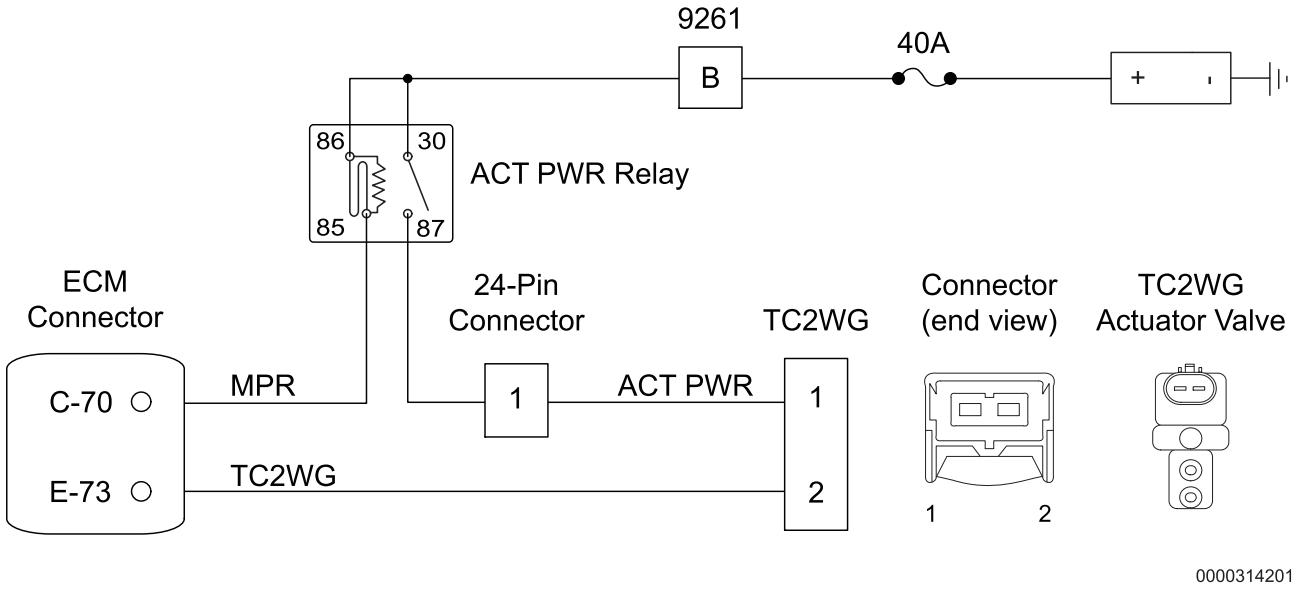


Figure 500 TC2WG Circuit Diagram

See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Digital Multimeter (DMM)
- Breakout Harness (TC2WG) ZTSE4831

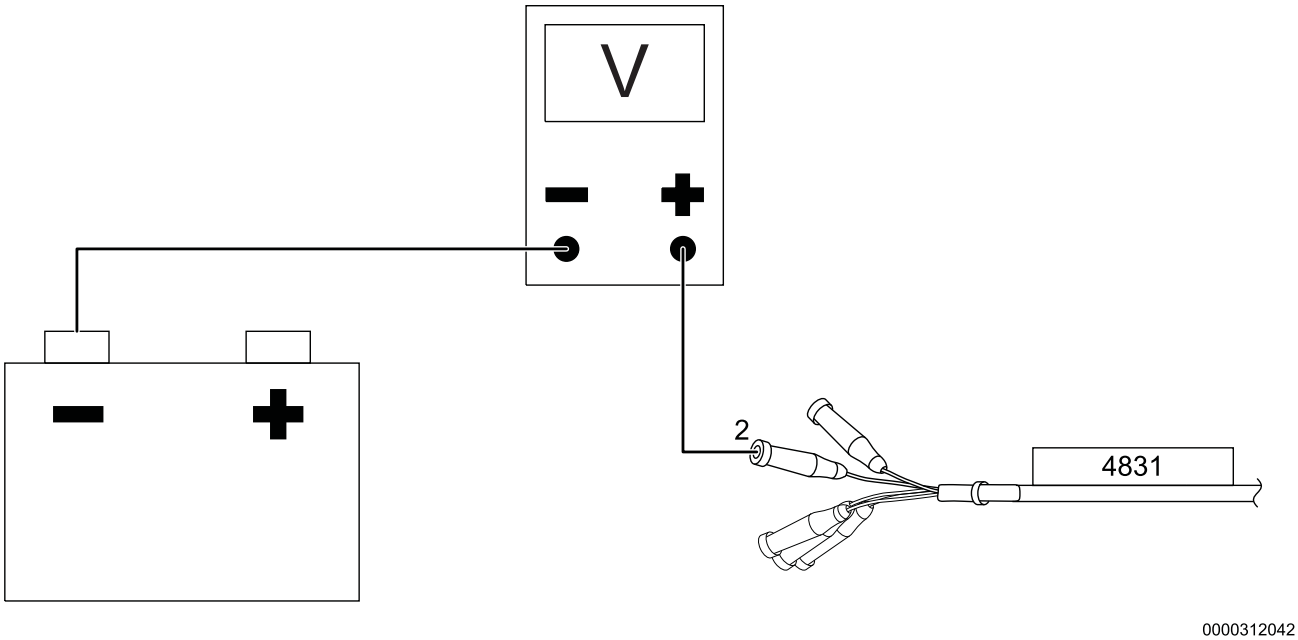


Figure 501 Test 1 Turbocharger 2 Wastegate Position (TC2WG) Actuator Valve Voltage Check

Test 1 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4831 to vehicle harness and leave Turbocharger 2 Wastegate (TC2WG) actuator valve disconnected. C. Key-On Engine-Off (KOEO).

Test 1	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4831 pin-2 and known good GND.	B+ ± 0.5 volts
Decision	
Is voltage B+ ± 0.5 volts?	Yes: Repair short to PWR between TC2WG pin-2 and Engine Control Module (ECM) pin E-73. After repairs are complete, retest for SPN 1189 FMI 3.
	No: Replace TC2WG Actuator valve. After repairs are complete, retest for SPN 1189 FMI 3.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 1189 FMI 3 fault code diagnostics.

SPN 1189 FMI 4 - TC2WG Open or short to GND

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Turbocharger 2 Wastegate (TC2WG) circuit shorted to ground or open circuit.	Voltage at power stage output < 2.175 volts Voltage at power stage output > 2.9 volts and < 3.2 volts	Key ON Battery power ≥ 9 volts Turbocharger 2 Wastegate (TC2WG) drive position command (PWM frequency) for short circuit to ground detection {Calibrated out} ≤ 99.5 % TC2WG drive position command (PWM frequency) for open loop detection ≥ 0.003 %

Fault Overview

Fault code sets when Engine Control Module (ECM) determines that Turbocharger 2 Wastegate Position (TC2WG) circuit is shorted to ground or open.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two consecutive trips.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON

Possible Causes

- Turbocharger 2 Wastegate Position (TC2WG) ground side switch circuit open
- TC2WG ground side switch circuit shorted to GND
- ACT PWR circuit Open
- Failed TC2WG

Step 1	Check for active or pending fault codes.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 1189 FMI 4. Is EST DTC list SPN 1189 FMI 4 active or pending?	Yes: Go to Step 2.
		No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Inspect connections at Turbocharger 2 Wastegate Position (TC2WG) connector.	Decision
	A. Key OFF. B. Disconnect TC2WG connector. C. Check TC2WG and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are TC2WG connector, harness, and terminals clean and undamaged?	Yes: Perform Pin-Point Test (SPN 1189 FMI 4) (page 1138).
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 1189 FMI 4.

Pin-Point Tests (SPN 1189 FMI 4)

TC2WG Circuit

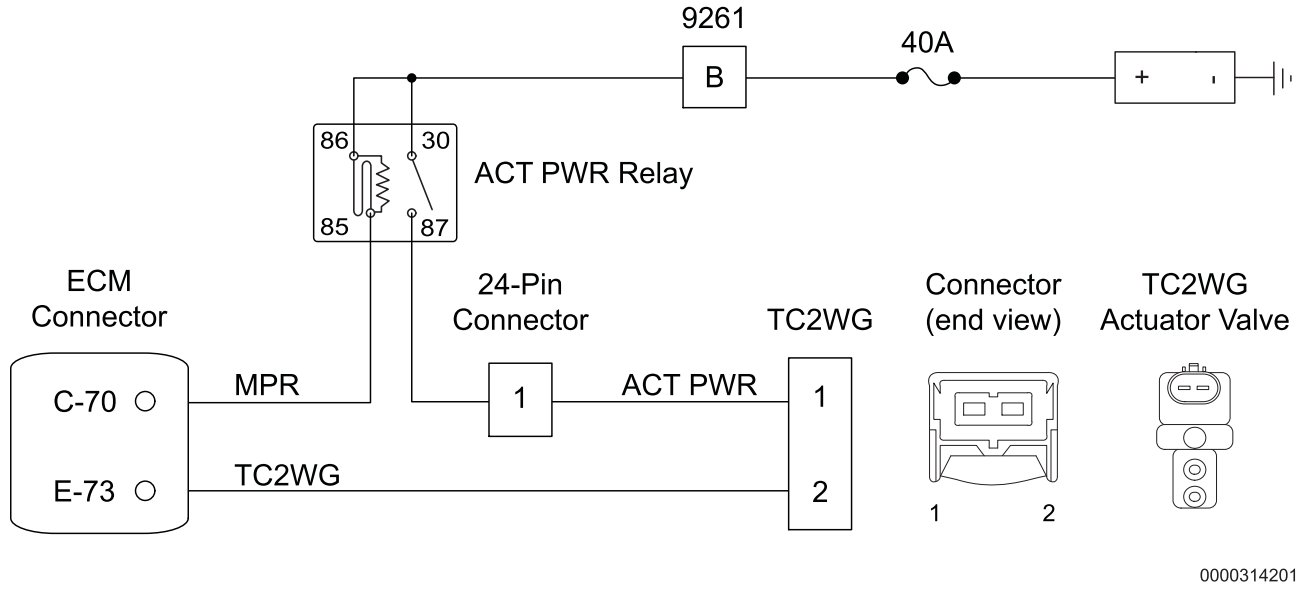


Figure 502 Turbocharger 2 Wastegate (TC2WG) Circuit Diagram

See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Digital Multimeter (DMM)
- TC2WG Breakout Harness ZTSE4831

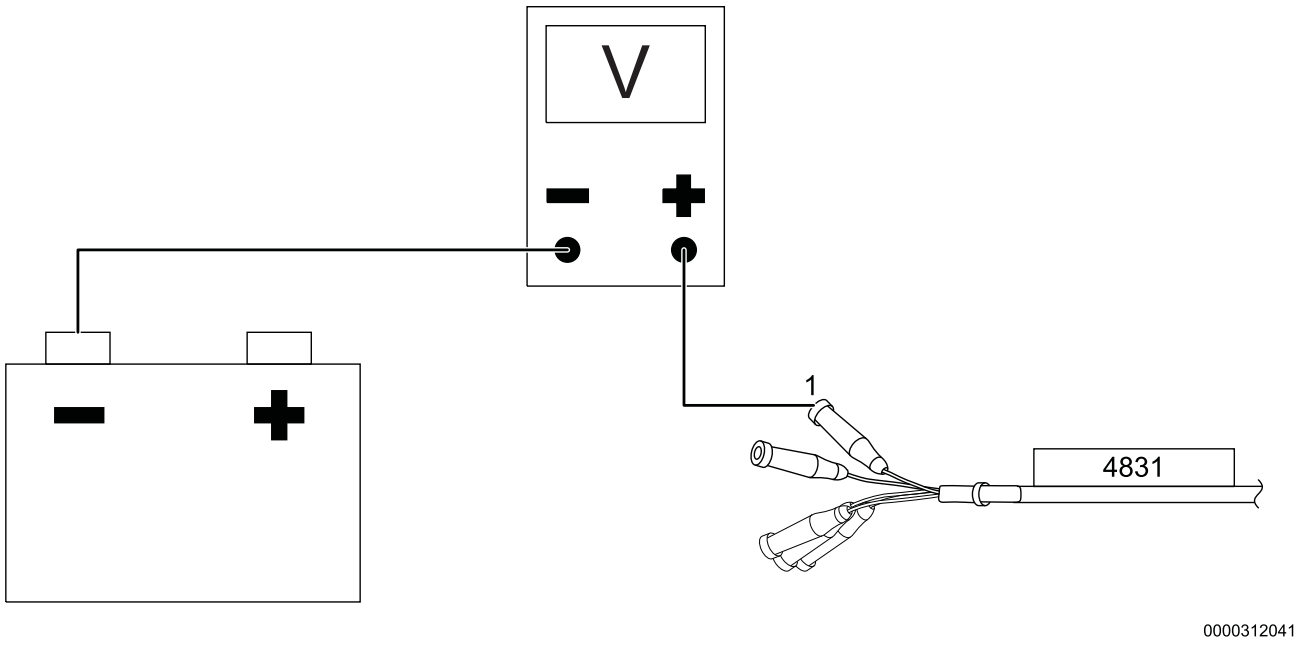


Figure 503 Test 1 Turbocharger 2 Wastegate Position (TC2WG) Voltage Check

Test 1 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4831 to vehicle harness and leave Turbocharger 2 Wastegate (TC2WG) disconnected. C. Key-On Engine-Off (KOEO).

Test 1	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4831 pin-1 and known good ground.	B+ ± 0.5 volt
Decision	
Is voltage B+ ± 0.5 volt?	Yes: Go to Test 2.
	No: Repair Open circuit between TC2WG pin-1 and ACT PWR Relay pin-87. After repairs are complete, retest for SPN 1189 FMI 4.

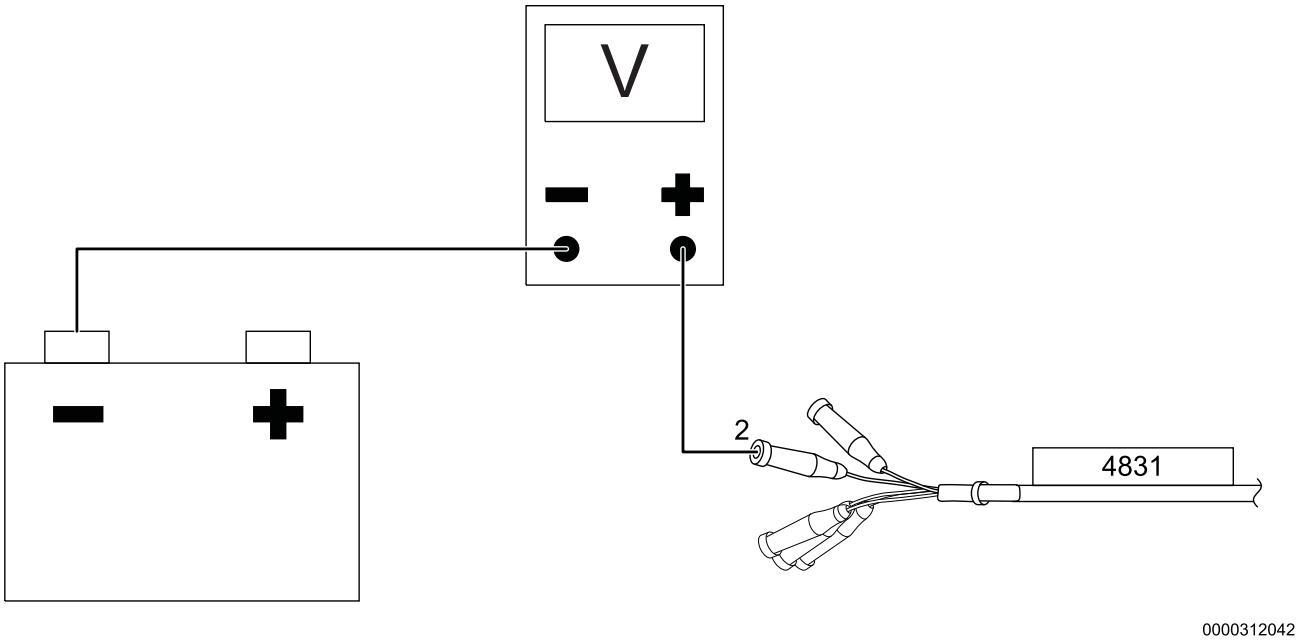


Figure 504 Test 2 Turbocharger 2 Wastegate Position (TC2WG) Voltage Check

Test 2 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4831 to vehicle harness and leave Turbocharger 2 Wastegate Position (TC2WG) disconnected. C. KOEO.

Test 2	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4831 pin-2 and known good ground.	less than 0.5 volts
Decision	
Is voltage less than 0.5 volts?	Yes: Go to Test 3.
	No: Replace TC2WG actuator valve. After repairs are complete, retest for SPN 1189 FMI 4.

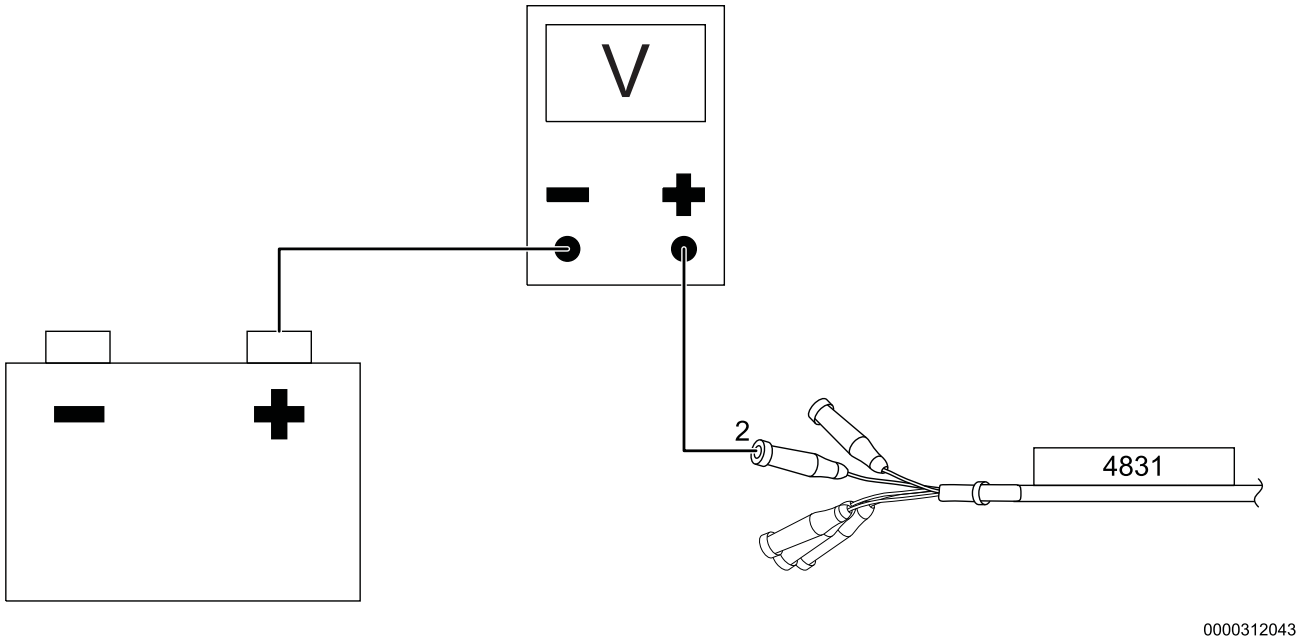


Figure 505 Test 3 Turbocharger 2 Wastegate Position (TC2WG) Voltage Check

Test 3 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4831 to vehicle harness and leave Turbocharger 2 Wastegate Position (TC2WG) disconnected. C. KOEO.

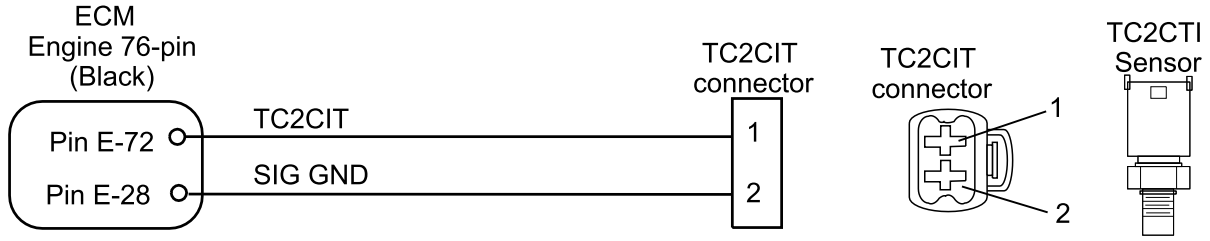
Test 3	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4831 pin-2 and PWR.	± 0.5 volt of battery voltage
Decision	
Is voltage within 0.5 volt of battery voltage?	Yes: Repair short to GND between TC2WG pin-2 and ECM pin E-73. After repairs are complete, retest for SPN 1189 FMI 4.
	No: Repair Open between TC2WG pin-2 and ECM pin E-73. After repairs are complete, retest for SPN 1189 FMI 4.

TC2CIT (Turbocharger 2 Compressor Inlet Temperature)

SPN	FMI	Condition	Possible Causes	Actions
1173	2	TC2CIT signal erratic, intermittent or incorrect	• Biased Turbocharger 2 Compressor Inlet Temperature (TC2CIT) sensor or circuit • High resistance in circuit • Shorted sensor • Shorted wiring	Step-based Diagnostics (page 1147)
1173	3	TC2CIT signal out of range high	• Disconnected connector • Signal open • Signal short to battery • Signal return open • Open circuit TC2CIT sensor	Step-based Diagnostics (page 1150)
1173	4	TC2CIT signal out of range low	• Signal short to ground • Shorted TC2CIT sensor	Step-based Diagnostics (page 1155)
1173	16	TC2CIT signal above desired (interstage CAC under cooling)	• Low or aerated coolant • Restricted coolant flow to Interstage Cooler (ISC) • Fouled ISC charge air path • Excessive boost pressure • High ambient temperatures at air cleaner inlet • Poor coolant circulation • Coolant bypass circuit stuck or sticking thermostat	Step-based Diagnostics (page 1158)

SPN	FMI	Condition	Possible Causes	Actions
			• Biased Intake Manifold Temperature (IMT) sensor • Biased Air Inlet Temperature (AIT) sensor • Biased Charge Air Cooler Outlet Temperature (CACOT) sensor • Biased Mass Air Flow (MAF) sensor • Biased Barometric Pressure (BARO) sensor • Biased Intake Manifold Pressure (IMP) sensor	

TC2CIT Circuit



0000061621

Figure 506 TC2CIT Circuit Diagram

Overview

The Turbocharger 2 Compressor Inlet Temperature (TC2CIT) sensor provides a feedback signal to the Engine Control Module (ECM) indicating the temperature of the charge air leaving the compressor of the high-pressure turbocharger.

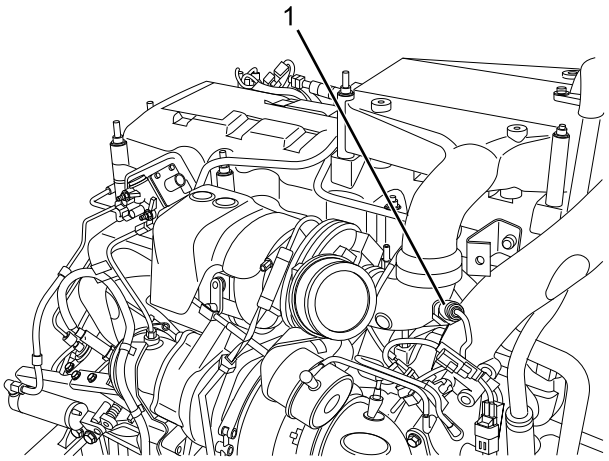


Figure 507 Sensor Location

1. TC2CIT Sensor

Tools

- EZ Tech® Electronic Service Tool (EST) – J-45067 (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- Breakout Harness 4993 (IMT and TC2CIT) (page 1238)
- International® Electronic Engine Terminal Test Kit (page 1227)

TC2CIT Circuit

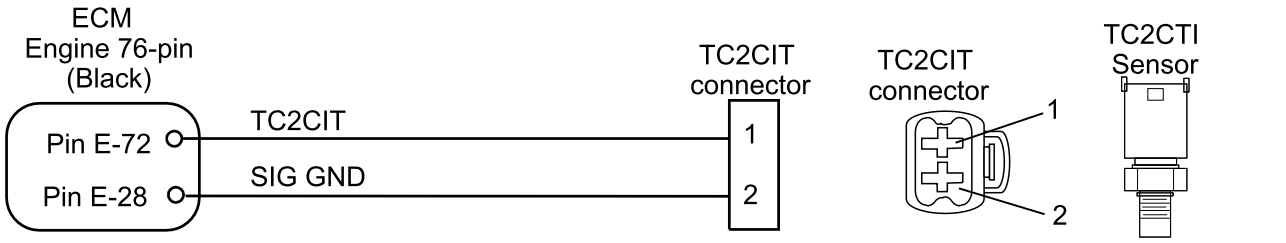


Figure 508 TC2CIT Circuit Diagram

Pin-point Diagnostics With ServiceMaxx™ Software

Cold Soak Sensor Compare Check
Temperature values need to be measured after four hours cold soak.

1. Turn switch ON, engine OFF
2. Using ServiceMaxx™ software, open the Continuous Monitor session.
3. Compare TC2CIT to AFTFIT, IMT, AIT, CACOT, and EOT. All sensors should be within 68°F (20°C) of each other.
   - If any temperature sensor is above or below of other sensors. Check for poor circuitry going to failed temperature sensor.
   - If the circuits are okay, then replace failed temperature sensor.

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST with ServiceMaxx™ software, open the Continuous Monitor Session.
2. Monitor sensor voltage. Verify an active code for the sensor.
   - If code 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 code will go active.
   - If code is active, proceed to the next step.
3. Disconnect engine harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

4. Connect Breakout Harness 4993 to engine harness. Leave sensor disconnected.

Connector Voltage Check

Connect sensor Breakout Harness 4993 to engine harness. 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 or short to PWR. Go toHarness Resistance Check (page 1146).
2 to GND	4.6 to 5 V	If < 4.5 volts, check for OPEN or short to GND. Go to Harness Resistance Check (page 1146). If > 5 volts and < 8 volts, check that DMM leads art connected correctly If > 8 volts, check for short to B+.

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect Breakout Harness 4993. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment: < Less than, > Greater than
1 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit. Go toHarness Resistance Check (page 1146).
2 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND. Go toHarness Resistance Check (page 1146).

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-pin Breakout Box and sensor Breakout Harness 4993. Leave ECM and sensor disconnected.

Test Point	Specification	Comment: < Less than, > Greater than
1 to E-72	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to E-28	< 5 Ω	If > 5 Ω, check for OPEN circuit.

SPN 1173 FMI 2 - TC2CIT signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Comparison of Engine Turbocharger 2 Compressor Inlet Temperature sensor to following sensors after a calibrated adjustable cold-soak period (time). Sensor 1 to 4 are in Air group and 5 to 7 are in Liquid group. [1. Engine Intake Manifold 1 Temperature 2. Engine Air Inlet Temperature 3. Engine Turbocharger 2 Compressor Inlet Temperature 4. Engine Charge Air Cooler Outlet Temperature 5. Engine Coolant Temperature 6. Engine Oil Temperature 1]	{Engine Intake Manifold 1 Temperature (Bias Hi) > Reference temperature value. OR Engine Intake Manifold 1 Temperature (Bias low)} ≤ Reference temperature value. Error threshold value for comparison of sensors in same media (Air to Air media): Used for Equilibrium and Reference value calculation > 59°F (15°C) Error threshold value for comparison of sensors in different media (Air to Liquid media): Used for Equilibrium and Reference value calculation > 59°F (15°C) Error threshold value for comparison of sensors in same media (Liquid to Liquid): Used for Equilibrium and Reference value calculation > 59°F (15°C) Error threshold value for comparison of sensors in different media (Liquid to Air or vice versa) : Used for Equilibrium and Reference value calculation > 59°F (15°C) {NOTE: Reference temperature value calculation is explained in Operations Summary Document}	Key ON Engine Off timer ≥ 28800 seconds Engine Coolant Temperature ≥ -40°F (-40°C) Engine in Thermal Equilibrium Condition {Explained in operations summary document} [Similar sensors agree with other sensors with different group-index OR Faulty Sensor is alone in its group {i.e. No other sensor which measures the same media (in Air Path) is identified as a faulty sensor}]

Fault Overview

ECM compares Turbocharger 2 Compressor Intake Temperature (TC2CIT) sensor to Intake Manifold Temperature (IMT), Intake Air Temperature (IAT), Charge Air Cooler Outlet Temperature (CACOT), Engine Coolant Temperature 1 (ECT1), and Engine Oil Temperature (EOT) sensors after calibrated adjustable cold-soak period (time).

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Initial Key ON.

Possible Causes

- Failed TC2CIT sensor
- Failed wiring

Step 1	Check for active or pending fault codes.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 1173 FMI 2. Is EST DTC list SPN 1173 FMI 2 active or pending?	Yes: Go to Step 2.
		No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Inspect connections at Turbocharger 2 Compressor Intake Temperature (TC2CIT) connector.	Decision
	A. Key OFF. B. Disconnect TC2CIT connector. C. Check TC2CIT and connector terminals for: damaged or pinched wires; moisture or corroded terminals; loose, bent, or broken pins; or broken connector housing. Are TC2CIT connector, harness, and terminals clean and undamaged?	Yes: Go to Step 3.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 1173 FMI 2.

Step 3	Inspect connections at Turbocharger 2 Compressor Intake Temperature (TC2CIT) connector.	Decision
	A. Key OFF. B. Connect Breakout Harness ZTSE4993 between pin-1 and pin-2 on TC2CIT connector. C. Key-On Engine-Off (KOEO). Using EST with ServiceMaxx™ software, measure voltage between pin-1 and pin-2.	Yes: Replace TC2CIT sensor. After repairs are complete, retest for SPN 1173 FMI 2.

Is voltage less than 0.5 volts?	
	No: Go to step 4.

Step 4	Inspect connections at Turbocharger 2 Compressor Intake Temperature (TC2CIT) connector.	Decision
	A. Key OFF. B. Connect Breakout Harness ZTSE4993 between pin-1 and known good GND. C. Key-On Engine-Off (KOEO). Using EST with ServiceMaxx™ software, measure resistance. Is resistance less than 5 ohms?	Yes: Repair TC2CIT signal wire. After repairs are complete, retest for SPN 1173 FMI 2.
		No: Repair TC2CIT SIG GND wire. After repairs are complete, retest for SPN 1173 FMI 2.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and proper decision was made. Return to SPN 1173 FMI 2 fault code diagnostics.

SPN 1173 FMI 3 - TC2CIT Signal Out of Range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Values
Turbocharger 2 Compressor Intake Temperature (TC2CIT) sensor signal reading is greater than expected	TC2CIT sensor voltage > 4.805 volts {< -49°F (-45°C)}	Key ON

Fault Overview

Fault Code sets when Engine Control Module (ECM) detects that Turbocharger 2 Compressor Intake Temperature (TC2CIT) signal is greater than 4.8 volts.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON

Possible Causes

- Turbocharger 2 Compressor Intake Temperature (TC2CIT) circuit Open
- TC2CIT circuit short to PWR
- SIG GND circuit Open
- Failed TC2CIT sensor

Step 1	Check for active or pending fault codes.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 1173 FMI 3. Is EST DTC list SPN 1173 FMI 3 active or pending?	Yes: Go to Step 2.
		No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Inspect connections at Turbocharger 2 Compressor Intake Temperature (TC2CIT) sensor.	Decision
	A. Key OFF. B. Disconnect TC2CIT sensor connector. C. Check TC2CIT sensor and connector terminals for damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are TC2CIT sensor, connector, harness, and terminals clean and undamaged?	Yes: Perform Pin-Point Tests SPN 1173 FMI 3 (page 1151). No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 1173 FMI 3.

End Diagnostic Tests
After performing all diagnostic steps, if SPN 1173 FMI 3 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Pin-Point Tests (SPN 1173 FMI 3)

TC2CIT Circuit

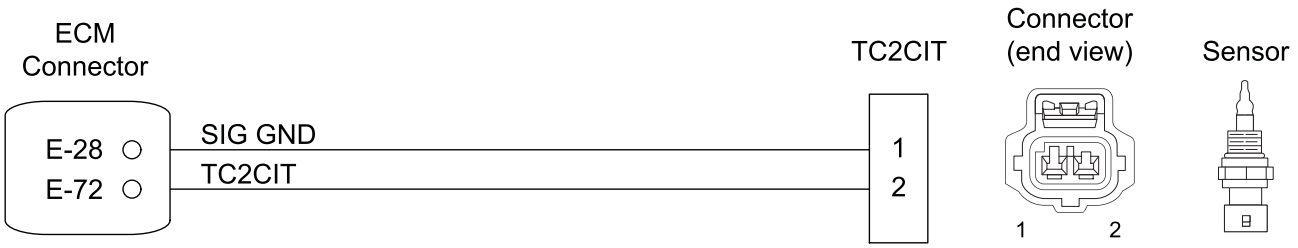


Figure 509 Turbocharger 2 Compressor Intake Temperature (TC2CIT) Sensor Circuit Diagram

NOTE: See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4993
- Breakout Harness Banana Plug ZTSE4498
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B-compliant supporting J1939 and J1708)

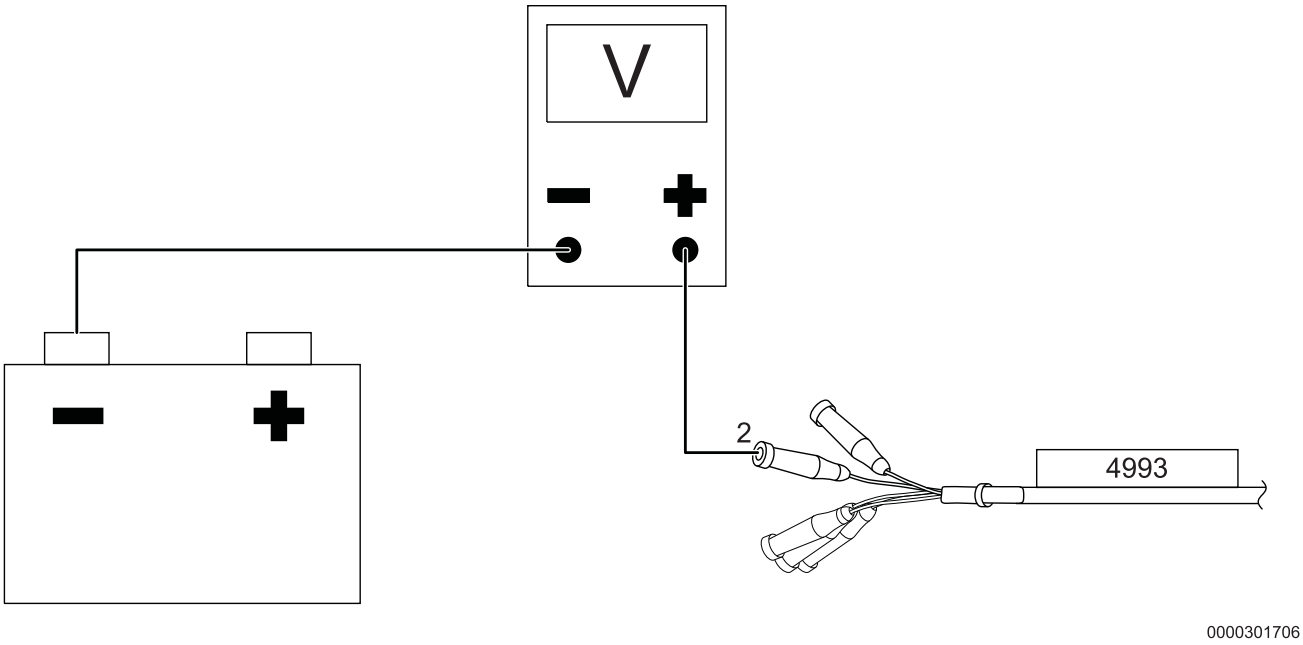
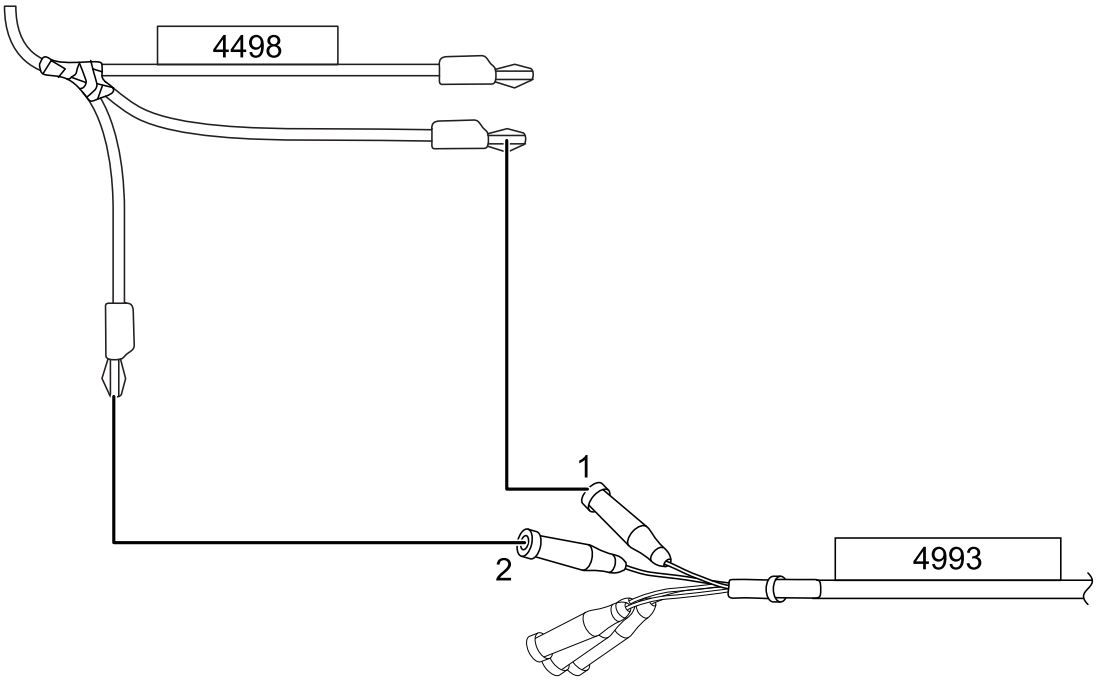


Figure 510 Test 1 Turbocharger 2 Compressor Intake Temperature (TC2CIT) Circuit Voltage Check

Test 1 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4993 to vehicle harness connector and leave Turbocharger 2 Compressor Intake Temperature (TC2CIT) sensor disconnected. C. Key ON.

Test 1	Specification
Using DMM, measure voltage between Breakout Harness ZTSE4993 pin-2 and ground.	Less than 6 volts
Decision	
Is voltage greater than 6 volts?	Yes: Repair short to PWR between TC2CIT pin-2 and Engine Control Module (ECM) pin E-72. After repairs are complete, retest for SPN 1173 FMI 3.
	No: Go to Test 2.



0000301703

Figure 511 Test 2 Turbocharger 2 Compressor Intake Temperature (TC2CIT) Sensor Circuit Check

Test 2 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4993 to vehicle harness and leave TC2CIT sensor disconnected. C. Using Breakout Harness ZTSE4498, short pin-1 and pin-2 of Breakout Harness ZTSE4493 together. D. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). E. Key ON, log in to ServiceMaxx™ software.

Test 2	Specification
Using EST with ServiceMaxx™, clear DTC list.	SPN 1173 FMI 4 sets
Decision	
Does SPN 1173 FMI 4 set after DTC list is cleared?	Yes: Replace TC2CIT sensor. After repairs are complete, retest for SPN 1173 FMI 3.
	No: Go to Test 3.

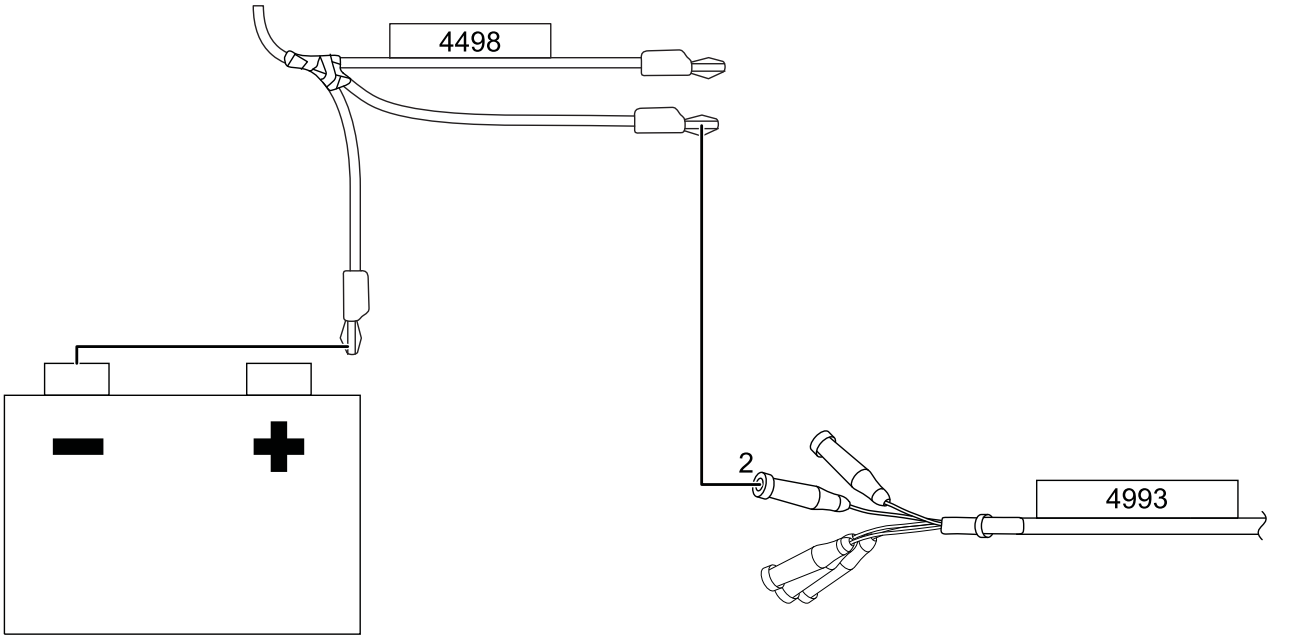


Figure 512 Test 3 Turbocharger 2 Compressor Intake Temperature (TC2CIT) Sensor Circuit Check

Test 3 Setup
A. Key OFF. B. Connect Breakout Harness ZTSE4993 to vehicle harness and leave TC2CIT sensor disconnected. C. Using Breakout Harness ZTSE4498, short Breakout Harness ZTSE4993 pin-2 to ground. D. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). E. Key ON, log in to ServiceMaxx™ software.

Test 3	Specification
Using EST with ServiceMaxx™, clear DTC list.	SPN 1173 FMI 4 sets
Decision	
Does SPN 1173 FMI 4 set after DTC list is cleared?	Yes: Repair Open between TC2CIT pin-1 and ECM pin E-28. After repairs are complete, retest for SPN 1173 FMI 3.
	No: Repair Open between TC2CIT pin-2 and ECM pin E-72. After repairs are complete, retest for SPN 1173 FMI 3.

End Diagnostic Tests
After performing all tests, if no problem is found, verify each step was completed correctly and the proper decision was made. Return to SPN 1173 FMI 3 fault code diagnostics.

SPN 1173 FMI 4 - TC2CIT Signal Out of Range LOW

Condition/Description	Setting Criteria	Enable Conditions/ Values
Turbocharger 2 Compressor Intake Temperature (TC2CIT) signal reading is lower than expected.	TC2CIT sensor reading < 0.195 volts (> 397°F [203°C])	Key ON

Fault Overview

Fault code sets when Engine Control Module (ECM) detects Turbocharger 2 Compressor Intake Temperature (TC2CIT) signal is less than 0.195 volts.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Key ON

Possible Causes

- Turbocharger 2 Compressor Intake Temperature (TC2CIT) circuit short to GND
- Failed TC2CIT

Step 1	Check for active or pending fault codes.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 1173 FMI 4. Is EST DTC list SPN 1173 FMI 4 active or pending?	Yes: Go to Step 2.
		No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Step 2	Inspect connections at Turbocharger 2 Compressor Intake Temperature (TC2CIT) sensor.	Decision
	A. Key OFF. B. Disconnect TC2CIT sensor connector. C. Check TC2CIT sensor and connector terminals for damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are TC2CIT sensor, connector, harness, and terminals clean and undamaged?	Yes: Perform Pin-Point Tests (SPN 1173 FMI 4) (page 1156). No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 1173 FMI 4.

End Diagnostic Tests
After performing all diagnostic steps, if SPN 1173 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Pin-Point Tests (SPN 1173 FMI 4)

TC2CIT Circuit

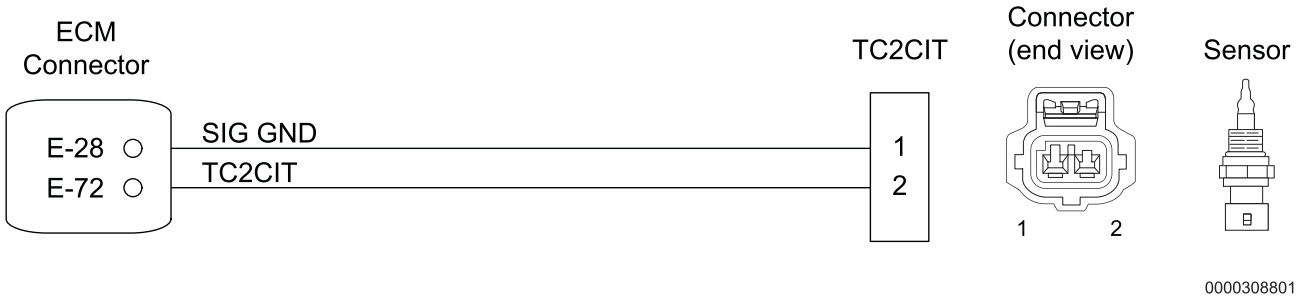


Figure 513 Turbocharger 2 Compressor Intake Temperature (TC2CIT) Sensor Circuit Diagram

NOTE: See latest version of Navistar® N9 and N10 Engine and Aftertreatment Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

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

Test 1 Setup
A. Key OFF. B. Disconnect Turbocharger 2 Compressor Intake Temperature (TC2CIT) sensor. C. Connect Electronic Service Tool (EST) to vehicle Diagnostic Connector (page 81). D. Key ON. Log in to Servicemaxx™ software.

Test 1	Specification
Using EST with ServiceMaxx™software, clear DTC list.	SPN 1173 FMI 3 sets in DTC list
Decision	
Does SPN 1173 FMI 3 set in DTC list?	Yes: Replace TC2CIT sensor. After repairs are complete, retest for SPN 1173 FMI 3.
	No: Repair short to GND between TC2CIT pin-2 and Engine Control Module (ECM) pin E-72. After repairs are complete, retest for SPN 1173 FMI 3.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and the proper decision was made. Return to SPN 1173 FMI 4 fault code diagnostics.

SPN 1173

FMI 16 – TC2CIT Signal Above Desired (Interstage CAC Under Cooling)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Low pressure charge air cooler effectiveness	Turbocharger # 2 Compressor Inlet temperature value MINUS Engine Inlet Air temperature value > Threshold defined by Speed / Torque (Table A001) * Mass Air Flow modifier (Table A002) * Coolant Temperature modifier (Table A003) * Inlet Air Temperature modifier (Table A004) * Atmospheric Pressure modifier (Table A005)	Particulate Filter Regeneration NOT Active	25.5 seconds
		Barometric Pressure ≥ 11 psi (73.5 kPa) AND ≤ 15 psi (103 kPa)	
		Power Take Off (PTO) Mode NOT Active	
		End Of Line Testing NOT Active	
		[Engine Brake (Retarder) NOT Active > 5 seconds	
		Engine Torque limitation NOT Active	
		Engine is NOT coasting (i.e., Throttle Cut OFF mode)	
		Vehicle speed ≥ 2 MPH	
		Battery Voltage ≥10.787 Volts AND ≤ 15.787 Volts	
		Engine Ignition Key is in "ON" position (Key ON)	
		Time after engine start ≥ 30 seconds	
		Engine Coolant Temperature ≥ 68°F (20°C) AND ≤ 230°F (110°C)	
		Monitor Enablement based on Speed / Torque (Table A006)	
		Monitor Enablement based on Engine Air Inlet Temperature (Table A007)	
		SPN / FMIs 102/3, 102/4, 102/7, 102/16, 105/2, 105/3, 105/4, 108/3, 108/4, 110/2, 110/3, 110/4, 132/0, 132/1, 132/3, 132/4, 172/3, 172/2, 172/4, 191/3, 191/4, 651/4, 651/5, 652/4, 652/5, 653/4,	

FMI 16 – TC2CIT Signal Above Desired (Interstage CAC Under Cooling) (cont.)

		653/5, 654/4, 654/5, 655/4, 655/5, 656/4, 656/5, and 1173/2 are NOT Active.	

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the TC2CIT signal value is above desired when compared to other related sensor signal values.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Fault Fact

This SPN/FMI can be set when high ambient temperatures are present around the air cleaner inlet.

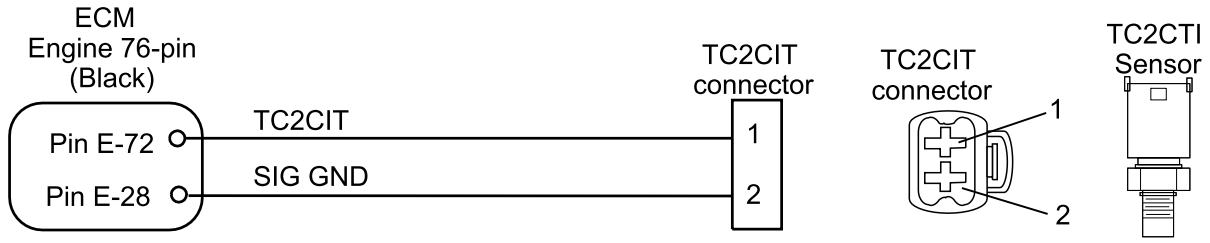
Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

TC2CIT Circuit



0000061621

Figure 514 TC2CIT Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 1173 FMI 16 the only fault code active?	Yes: Go to Step 3.
		No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 1173 FMI 16.
		No: Go to Step 3.

Step	Action	Decision
3	Park vehicle on level ground. Check coolant level as indicated on deaeration tank level window. Is level at deaeration tank fill level?	Yes: Go to Step 4.
		Fill deaeration tank (page 120). After repairs are complete, retest for SPN 1173 FMI 16.

Step	Action	Decision
4	Inspect air intake system and engine coolant system for restrictions, leaks, or physical damage. Is intake system and engine coolant free of restrictions, leaks, and physical damage?	Yes: Go to Step 5.
		No: Repair restrictions, leaks, or physical damage. After repairs are complete, retest for SPN 1173 FMI 16.

Step	Action	Decision
5	Start four hour cold soak for Step 7. Using terminal test kit, inspect connections at TC2CIT, Intake Manifold Temperature (IMT), Air Inlet Temperature (AIT), Charge Air Cooler Outlet Temperature (CACOT), MAF, and Intake Manifold Pressure (IMP) sensors. With key OFF, disconnect sensors. Check sensors and connectors for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are sensor connectors, harnesses, and terminals clean and undamaged?	Yes: Go to Step 6.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 1173 FMI 16.

Step	Action	Decision
6	Test TC2CIT (page 1146), IMT , CACOT (page 439), MAF / AIT (page 1102), and IMP (page 886) circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks. Are circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 7. No: Repair circuits as required. After repairs are complete, retest for SPN 1173 FMI 16.

Step	Action	Decision
7	Do Cold Soak Sensor Compare Check (page 1145). Compare TC2CIT to Aftertreatment Fuel Inlet Temperature (AFTFIT), IMT, AIT, CACOT, and Engine Oil Temperature (EOT) sensors. All sensors should be within 59°F (15°C) of each other. Is TC2CIT within 59°F (15°C) the other sensors?	Yes: Go to Step 8. No: Replace sensor that is not within specification. After repairs are complete, retest for SPN 1173 FMI 16.

Step	Action	Decision
8	Check Low Temperature Radiator (LTR) thermostat for operation. Start engine, monitor LTR thermostat outlet hose to LTR. Thermostat outlet hose temperature should start to increase at 194°F (90°C). Does hose temperature increase when engine has warmed to normal operating temperature?	Yes: Go to Step 9. Replace LTR thermostat. After repairs are complete, retest for SPN 1173 FMI 16.

Step	Action	Decision
9	Check for coolant overflowing deaeration tank or coolant degrading, Do Coolant Over Flow procedure (page 105). Did Coolant Over Flow procedure complete satisfactory?	Yes: Go to Step 10. No: Do corrective actions in the over flow procedure. After repairs are complete, retest for SPN 1173 FMI 16.

Step	Action	Decision
10	Test wastegate for proper operation. Do Turbocharger 2 Wastegate Control test . Do operational test, Turbocharger 2 Wastegate Control Solenoid test, and Isolated Actuator test. Does Wastegate operate as expected?	Yes: Replace IMP sensor. After repairs are complete, retest for SPN 1173 FMI 16. Go to Step 11.
		No: Replace Turbocharger or Wastegate Air Supply Solenoid as required. After repairs are complete, retest for SPN 1173 FMI 16.

Step	Action	Decision
11	Check condition of Interstage Cooler (ISC). Do Interstage Cooler Inspection (page 110). Do ISC and cooling system pass inspection?	Yes: Go to Step 12.
		No: Replace ISC or repair cooling system as required. After repairs are complete, retest for SPN 1173 FMI 16.

Step	Action	Decision
12	Do MAF Calibration procedure using EST with ServiceMaxx™ software. **NOTE:** Insure MAF calibration requirements are met and MAF Calibration Pre-checks are done prior to doing this procedure. Did MAF Sensor Calibration run successfully?	After doing all diagnostic steps, if SPN 1173 FMI 16 remains, verify each step was completed correctly and proper decisions were made. Notify supervisor for further action.
		No: Verify all MAF Calibration Requirements are met and MAF Calibration Pre-checks are done. Repeat MAF Calibration. After repairs are complete, retest for SPN 1173 FMI 16.

NOTE: After doing all diagnostic steps, if SPN 1173 FMI 16 remains verify each step was completed correctly and proper decisions were made. Notify supervisor for further action.

TC2WC Solenoid (Turbocharger 2 Wastegate Control)

SPN	FMI	Condition
1189	3	TC2WC short to PWR
1189	4	TC2WC open or short to GND
1189	5	TC2WC open load / circuit

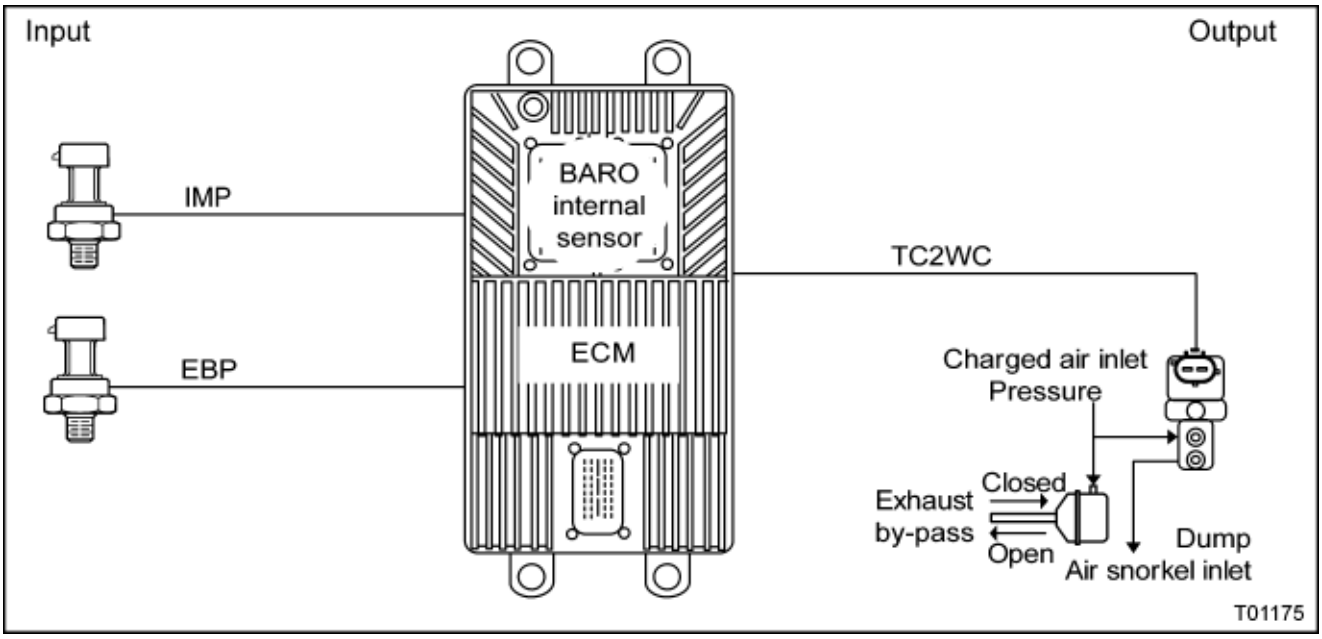


Figure 515 Function diagram for the TC2WC

The function diagram for the Turbocharger 2 Wastegate Control (TC2WC) solenoid includes the following:

- Engine Control Module (ECM)
  with Barometric Absolute Pressure (BARO) Internal Sensor
- Turbocharger 2 Wastegate Control (TC2WC)
- Intake Manifold Pressure (IMP) Sensor
- Exhaust Back Pressure (EBP) Sensor

Function

The ECM commands the TC2WC to control the turbocharger pneumatic actuator.

Location

The TC2WC is installed on the air inlet elbow.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)

- Digital Multimeter (DMM) (page 1224)
- International® Electronic Engine Terminal Test Kit (page 1227)

TC2WC Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
1189	3	TC2WC short to PWR	• TC1 solenoid circuit short to PWR
1189	4	TC2WC open or short to GND	• TC1 solenoid circuit open or short to GND
1189	5	TC2WC open load / circuit	• TC1 solenoid circuit OPEN

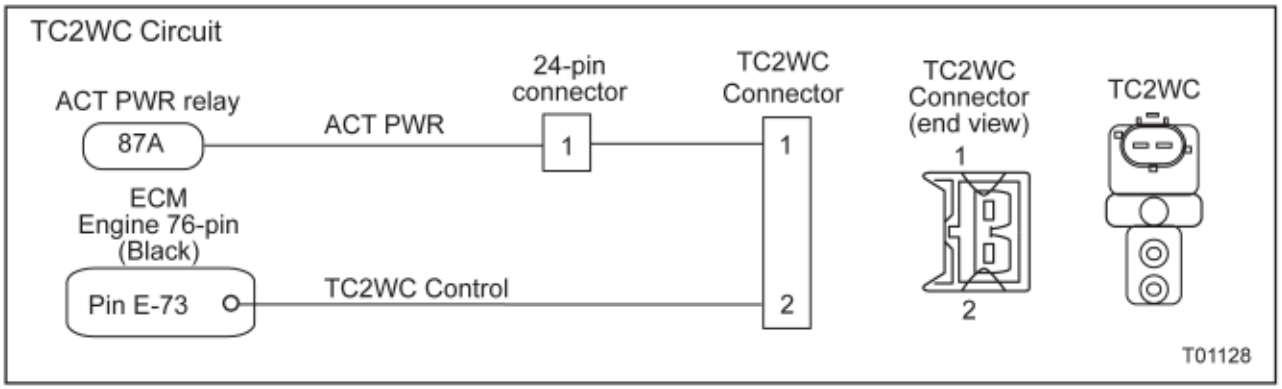


Figure 516 TC2WC circuit diagram

Voltage Check at TC2WC Connector – Output State Test

Disconnect TC2WC 2-pin connector. Turn ignition switch to ON. Use DMM to measure voltage.		
Test Point	**Specification**	**Comment: < Less than, > Greater than**
1 to GND	B+	If < B+, check ACT PWR for OPEN circuit.
2 to GND	0 to 0.25 V, check	If > 0.25 volts, check TC2WC circuit for short to PWR.
Run Output State Test HIGH.		
2 to B+	0 to 0.25 V	If > 0.25 volts, check TC2WC circuit for short to GND.
Run Output State Test LOW.		
2 to B+	B+	If < B+, check TC2WC circuit for OPEN or short to PWR. Go to Harness Resistance Checks.
1 to 2	B+	If < B+, check ACT PWR circuit for OPEN. Go to Harness Resistance Check.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-pin Breakout Box. Leave ECM and TC2WC disconnected.

Test Point	Specification	Comment: < Less than, > Greater than
E-73 to 2	< 5 Ω	If > 5 Ω, check TC2WC for OPEN circuit.
E-73 to GND	> 1 kΩ	If < 1 kΩ, check TC2WC circuit for short to GND.
1 to relay pin 87	< 5 Ω	If > 5 Ω, check ACT PWR for OPEN in circuit.
1 to GND	> 1 k Ω	If < 1 k Ω, check ACT PWR for short to GND.

TC2WC Circuit Operation

The TC2WC is supplied ACT PWR at Pin 1. The ECM grounds Pin E-73 to control the TC2WC at Pin 2.

Fault Detection/Management

The TC2WC solenoid does not set any circuit fault code. Only Air Management Fault Codes are used to detect a problem with this system.

Transfer Case Circuit

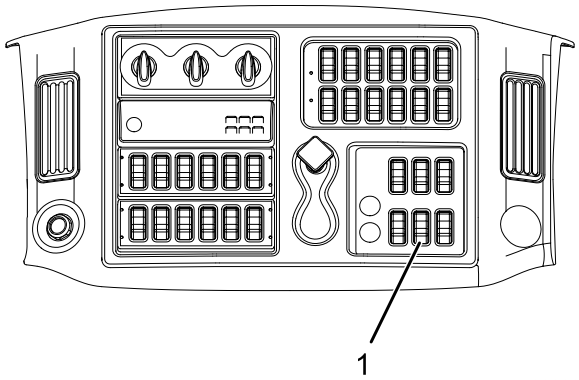
SPN	FMI	Condition	Possible Causes	Actions
2796	2	Transfer case switch or circuit fault	• Transfer Case Switch (XCS) not responding via CAN • Non-Controller Area Network (CAN) XCS stuck in range	Step-based Diagnostics (page 1169)

XCS Circuit



0000061617

Figure 517 Transfer Case Circuit Diagram



0000060870

Figure 518 Transfer Case Switch

1. Transfer case switch

Tools

- EZ Tech® Electronic Service Tool (EST) – J-45067 (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- International® Electronic Engine Terminal Test Kit (page 1227)

Pin-Point Diagnostics

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

XCS Circuit

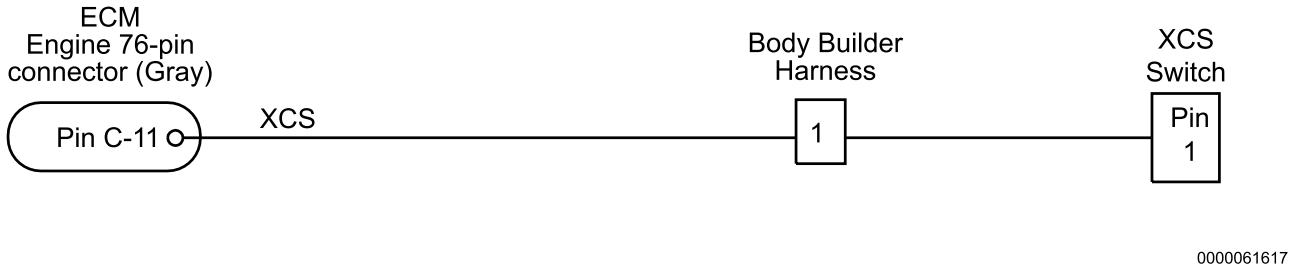


Figure 519 Transfer Case Circuit Diagram

Connector Voltage Check

Connect sensor Breakout Harness to engine harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment: < Less than, > Greater than
TBD to B+	B+	If < B+, check for OPEN or short to PWR.
TBD to GND	4.6 to 5 V	If < 4.5 volts, check for OPEN or short to GND. Go to Harness Resistance Check.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-pin Breakout Box and sensor Breakout Harness. Leave ECM and sensor disconnected.

Test Point	Specification	Comment: < Less than, > Greater than
1 to TBD	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to TBD	< 5 Ω	If > 5 Ω, check for OPEN circuit.

SPN 2796 FMI 2 – Transfer Case Switch or Circuit Fault

FMI 5 – IPR Open Load / Circuit

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
N/A			

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

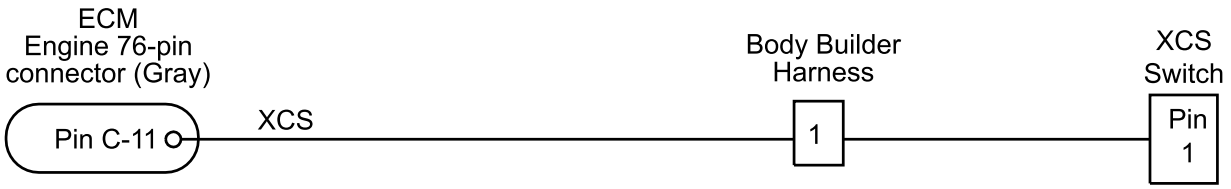
Associated Faults

N/A

Drive Cycle to Determine Fault Status

N/A

XCS Circuit



0000061617

Figure 520 Transfer Case Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for fault codes. Is SPN 2796 FMI 2 the only fault code active?	Yes: Go to Step 3. No: Go to Step 2.

Step	Action	Decision
2	Review fault codes retrieved in Step 1. Are any fault codes listed in associated faults?	Yes: Repair associated faults. After repairs are complete, retest for SPN 2796 FMI 2. No: Go to Step 3.

Step	Action	Decision
3	Using terminal test kit, inspect connections at Transfer Case Switch (XCS). With key OFF, disconnect XCS. Check XCS and connector for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are XCS connectors, harnesses, and terminals clean and undamaged?	Yes: Go to Step 4.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2796 FMI 2.

Step	**Action**	**Decision**
4	Test for intermittent circuit operation using EST with ServiceMaxx™ software. Do Key On Engine Off Continuous Monitor Test (page 87). Are the sensor voltages within specification (page 1291)?	Yes: Go to Step 5.
		No: Locate specific circuit component causing erratic or intermittent operation. Perform voltage and resistance checks in this section. Repair circuits as required. After repairs are complete, retest for SPN 2796 FMI 2.

Step	**Action**	**Decision**
5	Test XCS circuits for open, short, or high resistance conditions. Do connector voltage checks and resistance checks (page 1168). Are XCS circuits within specifications? **NOTE:** If voltage checks pass, doing resistance checks is not required.	Yes: Go to Step 6.
		No: Replace XCS. After repairs are complete retest for SPN 2796 FMI 2.

Step	Action	Decision
6	Connect Interface cable (RP1210B compliant supporting J1939 and J1708) between EST and Engine Control Module (ECM). Do KOEO voltage check of J1939 signal and ground. Is voltage within specification (page 1317)?	Yes: After doing all diagnostic steps, if SPN 2796 FMI 2 remains, verify each step was completed correctly and proper decisions were made. Notify supervisor for further action.
		No: Replace J1939 cable. After repairs are complete retest for SPN 2796 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 2796 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

VREF (Reference Voltage)

SPN	FMI	Condition
3509	3	VREF1 voltage above maximum (page 1179)
3509	4	VREF1 voltage below minimum (page 1186)
3510	3	VREF2 voltage above maximum
3510	4	VREF2 voltage below minimum
3511	3	VREF3 voltage above maximum
3511	4	VREF3 voltage below minimum

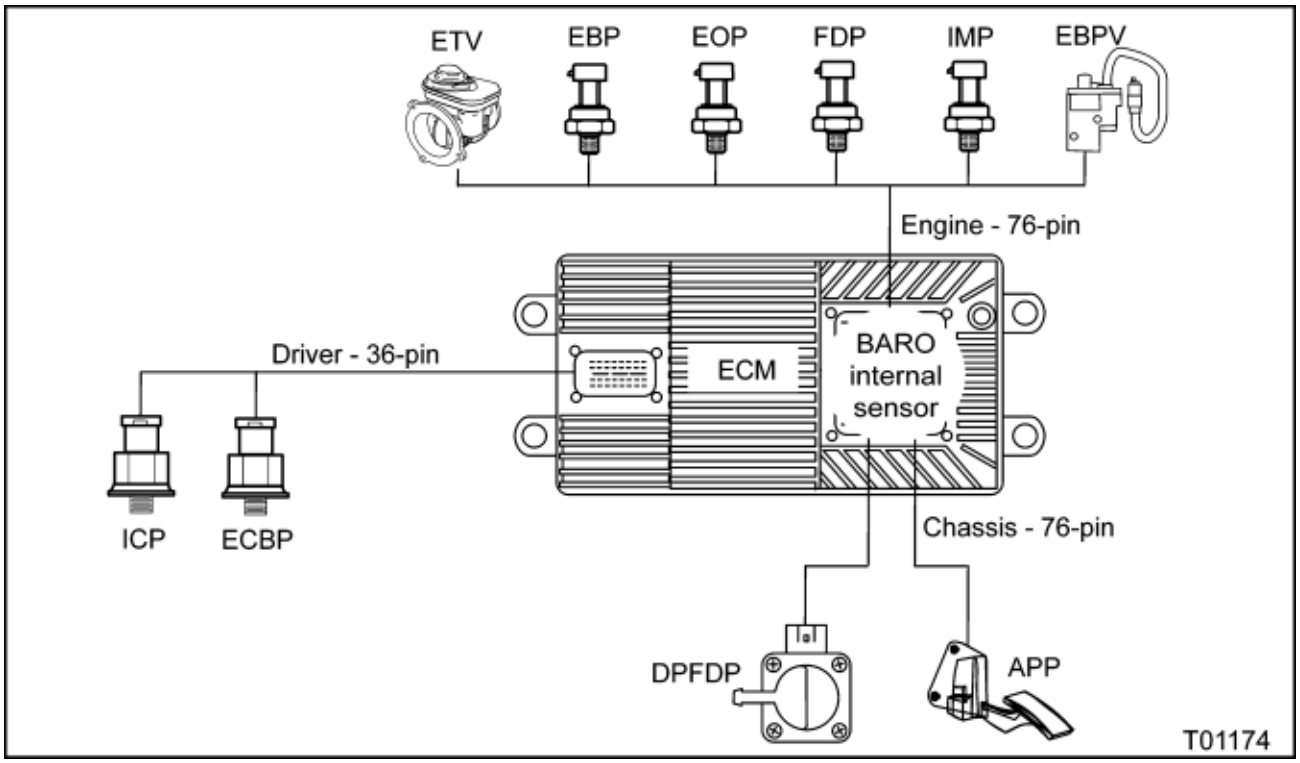


Figure 521 Function diagram for the VREF

The function diagram for the VREF includes the following:

- Engine Control Module (ECM)
  with Barometric Absolute Pressure (BARO) Internal Sensor
- Injection Control Pressure (ICP) Sensor
- Engine Compression Brake Pressure (ECBP) Sensor
- Engine Throttle Valve Position (ETVP) Sensor
- Exhaust Back Pressure (EBP) Sensor
- Engine Oil Pressure (EOP) Sensor
- Engine Fuel Pressure (EFP) Sensor
- Intake Manifold Pressure (IMP) Sensor
- DPF Differential Pressure (DPFDP) Sensor
- Accelerator Pedal Position (APP)
- Fuel Delivery Pressure (FDP)

NOTE: The IAP sensor was deleted just before product release. This sensor (present or not) is not monitored by the ECM and can only cause a problem if it's internally shorted or the VREF circuit supplying the sensor is shorted.

Function

The VREF circuit is a 5-volt reference point supplied by the ECM, and provides power to all 3-wire sensors.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)
- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- Digital Multimeter (DMM) (page 1224)
- 00-00956-08 – 180-pin Breakout Box (page 1222)
- Breakout Harness
- International® Electronic Engine Terminal Test Kit (page 1227)

VREF Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
3509	3	VREF1 voltage above maximum	• VREF circuit short to PWR
3509	4	VREF1 voltage below minimum	• VREF circuit short to GND • Failed sensor causing short to GND on VREF circuit
3510	3	VREF2 voltage above maximum	• VREF circuit short to PWR
3510	4	VREF2 voltage below minimum	• VREF circuit short to GND • Failed sensor causing short to GND on VREF circuit
3511	3	VREF3 voltage above maximum	• VREF circuit short to PWR
3511	4	VREF3 voltage below minimum	• VREF circuit short to GND • Failed sensor causing short to GND on VREF circuit

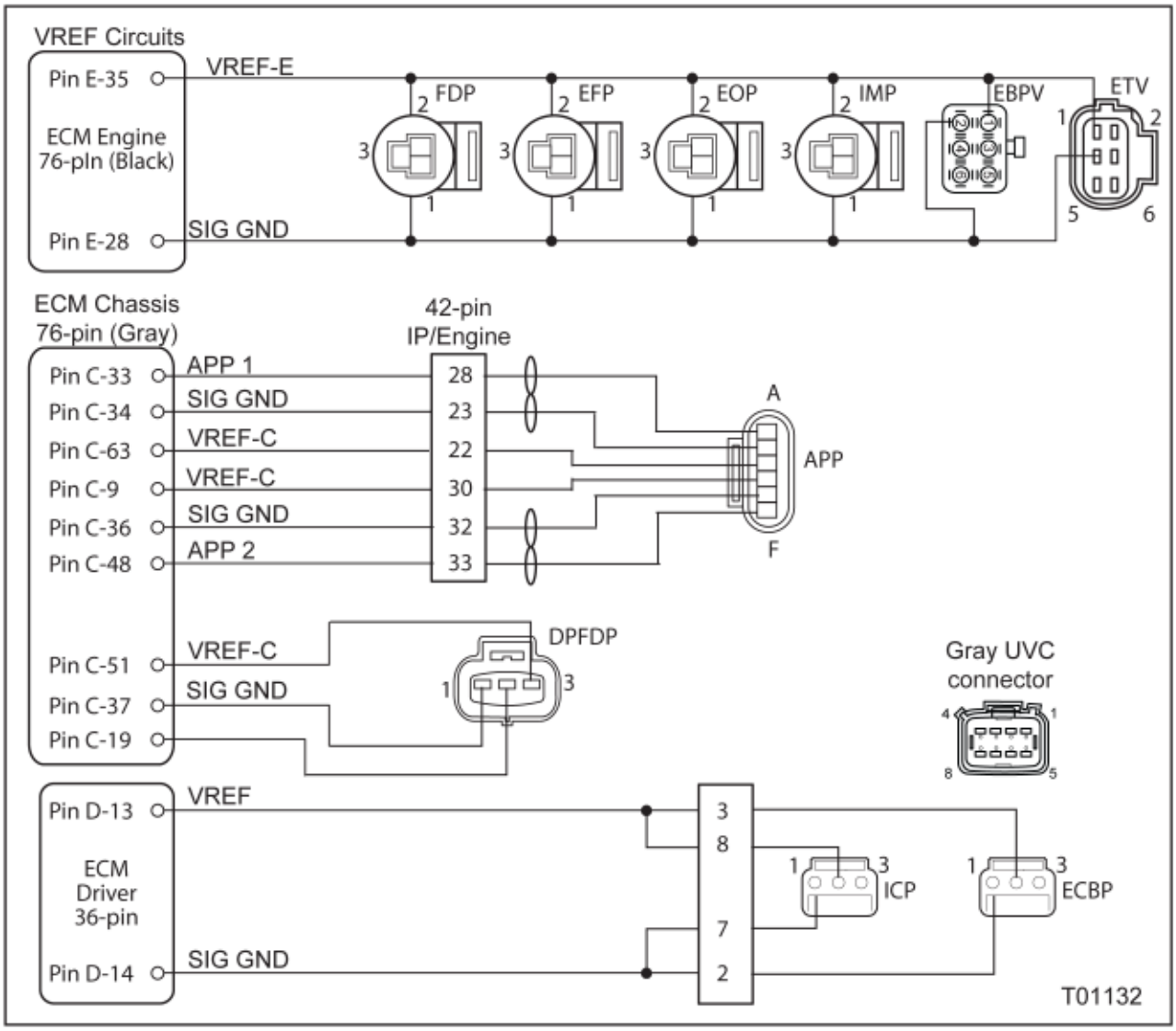


Figure 522 VREF circuit diagram

VREF Voltage Check

If multiple 3-wire sensor codes are set, turn ignition switch to ON. Disconnect each sensor one at a time. Use DMM to measure voltage.

NOTE:

- If VREF is not present, but returns after disconnecting a sensor, inspect sensor for internal short to GND.
- If VREF is not present after all 3-wire sensors are disconnected, check for a short circuit between ECM and sensors.

Test Point	Specification	Comment
APP C to GND	5 ± 0.5 V	See note.
DPFDP 3 to GND	5 ± 0.5 V	See note.
EBP 2 to GND	5 ± 0.5 V	See note.
EFP 2 to GND	5 ± 0.5 V	See note.
EOP 2 to GND	5 ± 0.5 V	See note.
IMP 2 to GND	5 ± 0.5 V	See note.
ETVP G to GND	5 ± 0.5 V	See note.
ECBP (option) 3 to GND	5 ± 0.5 V	If this sensor caused VREF to go below specification, see note. Check under-valve-cover harness for a short to GND or an internal shorted sensor.
ICP 8 to GND	5 ± 0.5 V	If this sensor caused VREF to go below specification, see note. Check under-valve-cover harness for a short to GND or an internal shorted sensor.
IAP C to GND	5 ± 0.5 V	If VREF present after disconnected the sensor. Leave sensor disconnected. If VREF is not present after all 3-wire sensors are disconnected, check for short circuit between ECM and all 3-wire sensors.

Connector Resistance Check to GND

Turn ignition switch to OFF. Disconnect each sensor, one at a time. Use DMM to measure resistance.

NOTE:

- If resistance is below 1 kΩ, but goes above 1 kΩ after disconnecting a sensor, inspect sensor for internal short to GND.
- If resistance is below 1 kΩ after all 3-wire sensors are disconnected, check for short to GND between ECM and sensors.

Test Point	Specification	Comment
APP1 C to GND	> 1 kΩ	See note.
APP2 D to GND	> 1 kΩ	See note.
DPFDP 3 to GND	> 1 kΩ	See note.
EBP 2 to GND	> 1 kΩ	See note.
FDP 2 to GND	> 1 kΩ	See note.
EOP 2 to GND	> 1 kΩ	See note.
IMP 2 to GND	> 1 kΩ	See note.
ETVP G to GND	> 1 kΩ	See note.
ECBP (option) 3 to GND	> 1 kΩ	If this sensor caused VREF to go below specification, see note. Check under-valve-cover harness for a short to GND or an internal shorted sensor.
ICP 8 to GND	> 1 kΩ	If this sensor caused VREF to go below specification, see note. Check under-valve-cover harness for a short to GND or an internal shorted sensor.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and breakout harness. Leave ECM and all 3-wire sensors disconnected. Use DMM to measure resistance.

Sensor	Test Point	Specification	Comment: < Less than, > Greater than
APP			
VREF3	C to C-63	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	B to C–34		
DPFDP			
VREF	3 to C-51	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	1 to C-37		
EBP			
VREF1	2 to E-35	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	1 to E-28		
EFP			
VREF1	2 to E-35	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	1 to E-28		
EOP			
VREF1	2 to E-35	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	1 to E-28		
IMP			
VREF1	2 to E-35	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	1 to E-28		
ETVP			
VREF1	G to E-35	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	C to E-28		
ECBP (option)			
VREF	3 to D-13	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	2 to D-14		
ICP			
VREF	8 to D-13	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	7 to D-14		

VREF Circuit Operation

NOTE: See truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for APP and DPFDP sensor circuit diagrams.

The ECM supplies VREF at Pin E-35 (engine connector), C-63 and C-51 (chassis connector), and D-13 (driver connector) when the ignition switch is on.

VREF provides power to all 3-wire sensors on the engine and the vehicle mounted APP. The ECM also provides these sensors with a ground point, the SIG GND circuit. Sensor signal voltage is generated between these two reference points based on the pressure or position the sensor is designed to measure.

Fault Detection / Management

When a VREF circuit is open, each sensor on that circuit will set a code. When a VREF circuit is shorted to PWR or GND, a VREF code will be set.

NOTE: After removing connector, inspect for damaged pins, corrosion, or loose pins. Repair as required.

SPN 3509 FMI 3 - VREF1 voltage above maximum

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Sensor supply voltage 1 above maximum	Sensor supply voltage 1 (VCC_1) > 5.498 Volts	Key ON

Fault Overview

Fault sets when Engine Control Module (ECM) senses VREF1 sensor supply voltage is greater than 5.498 volts.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

None

Fault Facts

None

Drive Cycle to Determine Fault Status

Continuous

Possible Causes

- Short to PWR in engine harness
- Short to PWR in UVC harness (if equipped with ECB)
- Short to PWR in ETV
- Short to PWR in EBPC

Step 1	Check for active or pending fault codes.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software. A. Key ON, clear codes. B. Key OFF, wait for EST screens to clear. C. Key ON, check Diagnostic Trouble Code (DTC) list for SPN 3509 FMI 3. Is EST DTC list SPN 3509 FMI 3 active or pending?	Yes: Perform Pin-Point Tests(page 1180). No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Pin-Point Tests (SPN 3509 FMI 3)

See latest version of Navistar® N9 and N10 SCR Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4850
- Breakout Harness ZTSE4952
- Digital Multimeter (DMM)

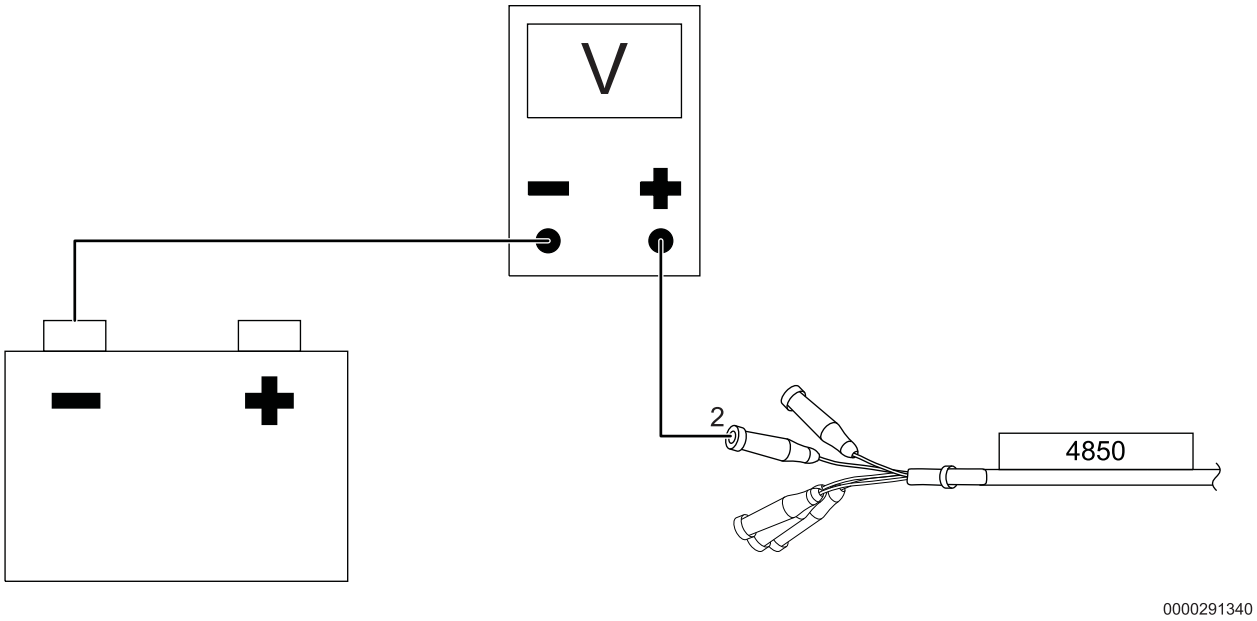


Figure 523 Test 1 Exhaust Back Pressure (EBP) Circuit Voltage Check

Test 1 Setup
A. Key OFF. B. Disconnect Exhaust Back Pressure (EBP) sensor connector. C. Connect breakout harness ZTSE4850 to vehicle harness and reconnect EBP sensor connector. D. Key ON.

Test 1	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4850 pin-2 and known good GND.	Greater than 5.5 volts.
Decision	
Is voltage greater than 5.5 volts?	Yes: Go to Test 2.
	No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

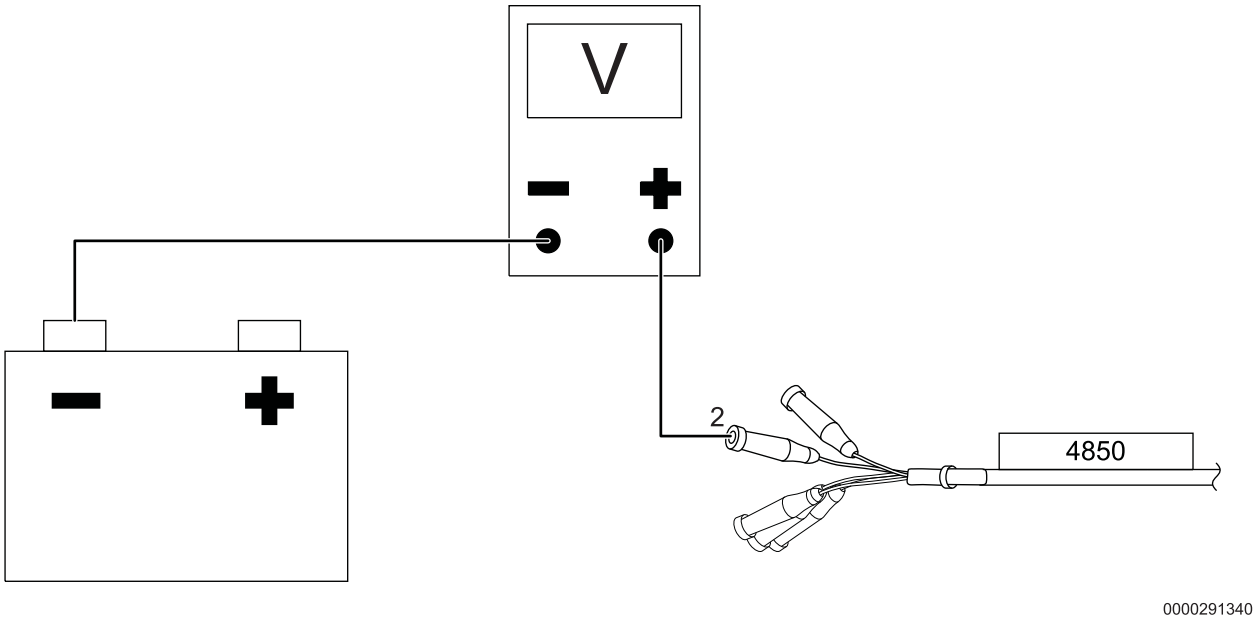


Figure 524 Test 2 Exhaust Back Pressure (EBP) Circuit Voltage Check

Test 2 Setup
A. Key OFF. B. Disconnect Engine Control Module (ECM) 36-pin driver connector. C. Disconnect Exhaust Back Pressure (EBP) sensor connector. D. Connect breakout harness ZTSE4850 to vehicle harness, reconnect EBP sensor connector, and leave ECM 36-pin connector disconnected. E. Key ON.

Test 2	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4850 pin-2 and known good GND.	Greater than 5.5 volts.
Decision	
Is voltage greater than 5.5 volts?	Yes: Go to Test 4.
	No: Go to Test 3.

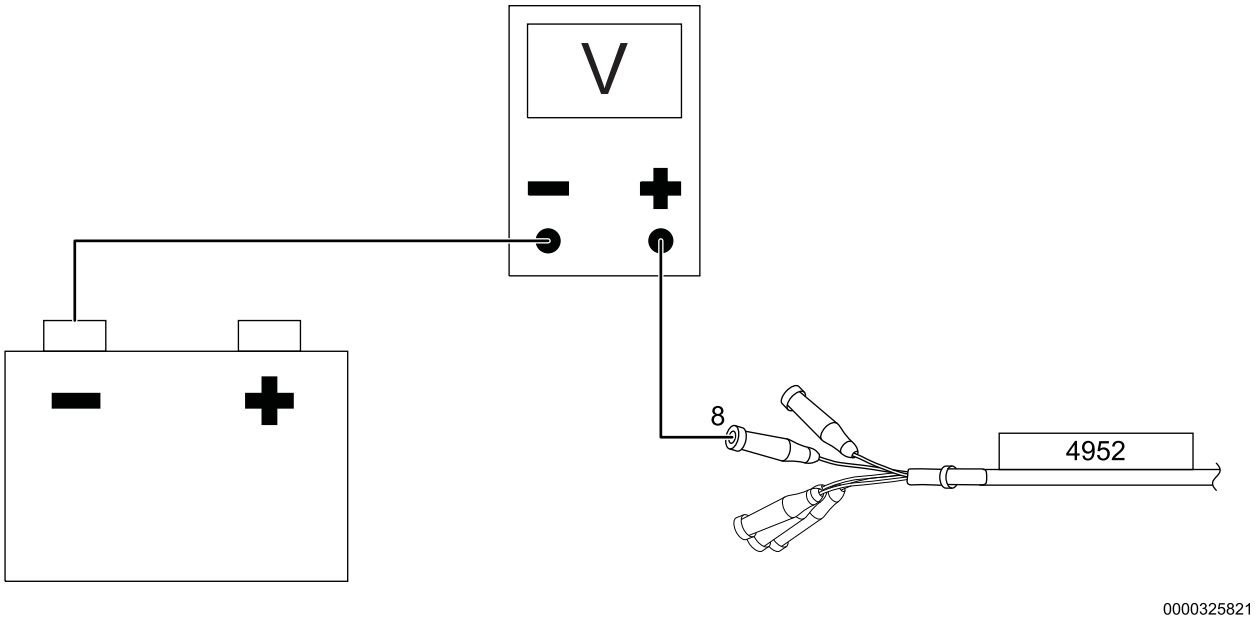


Figure 525 Test 3 Under Valve Connector (UVC) Circuit Voltage Check

Test 3 Setup
A. Key OFF. B. Reconnect Engine Control Module (ECM) 36-pin driver connector. C. Disconnect Under Valve Connector (UVC) connector. D. Connect breakout harness ZTSE4952 to vehicle harness and leave UVC connector disconnected. E. Key ON.

Test 3	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4952 pin-8 and known good GND.	Greater than 5.5 volts.
Decision	
Is voltage greater than 5.5 volts?	Yes: Repair engine harness for a Short between ECM pin D-13 and PWR. After repairs are complete, retest for SPN 3509 FMI 3.
	No: Repair UVC harness for a Short between pin-5 and pin-8 OR pin-5 and pin-3. After repairs are complete, retest for SPN 3509 FMI 3.

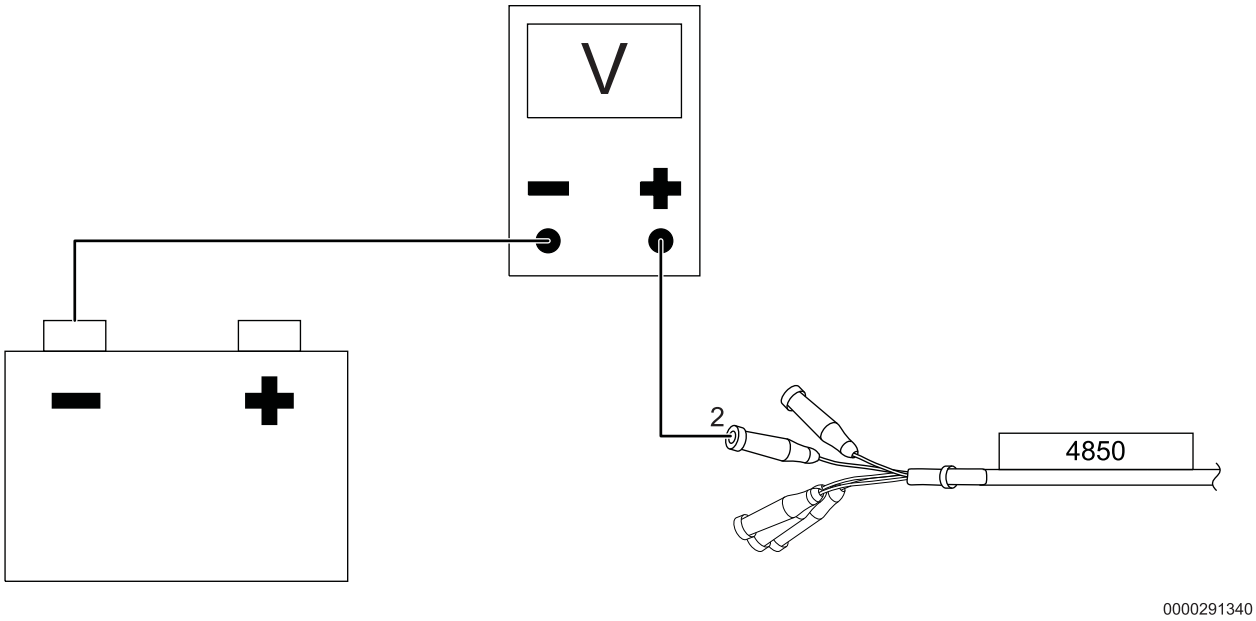


Figure 526 Test 4 Exhaust Back Pressure (EBP) Circuit Voltage Check

Test 4 Setup
A. Key OFF. B. Disconnect Turbocharger 1 Turbine Outlet Pressure (TC1TOP) connector. C. Disconnect Exhaust Back Pressure (EBP) sensor connector. D. Connect breakout harness ZTSE4850 to vehicle harness, reconnect EBP sensor connector, and leave TC1TOP connector disconnected. E. Key ON.

Test 4	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4850 pin-2 and known good GND.	Greater than 5.5 volts.
Decision	
Is voltage greater than 5.5 volts?	Yes: Replace TC1TOP sensor. After repairs are complete, retest for SPN 3509 FMI 3.
	No: Go to Test 5.

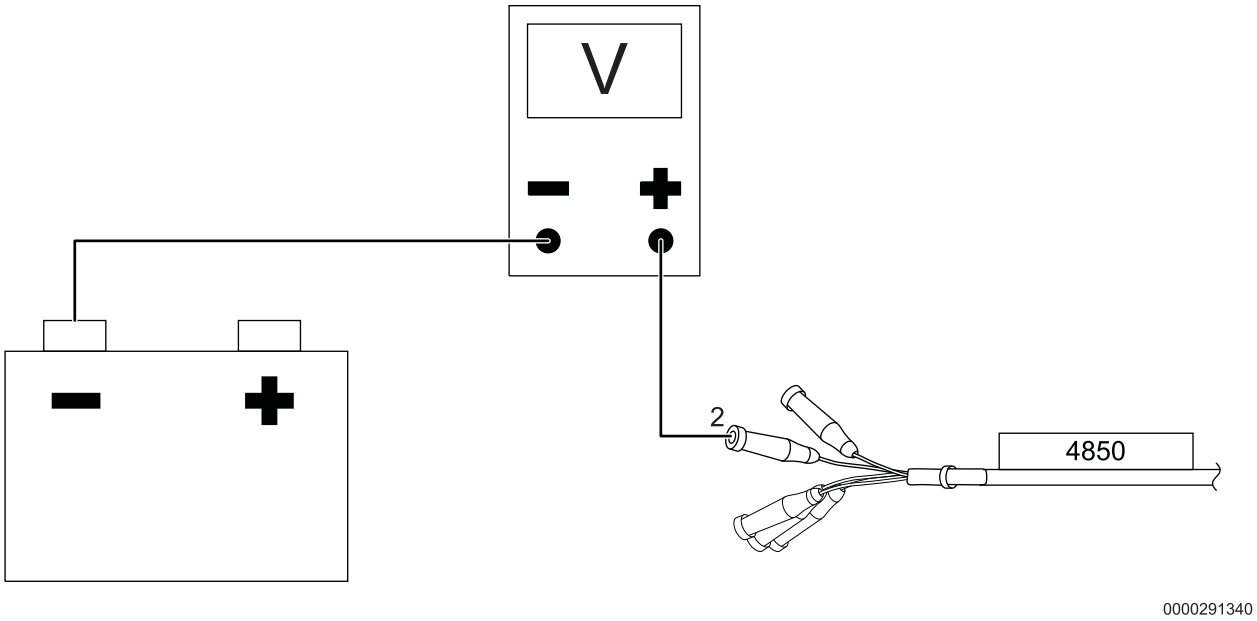


Figure 527 Test 5 Exhaust Back Pressure (EBP) Circuit Voltage Check

Test 5 Setup
A. Key OFF. B. Disconnect Engine Throttle Valve Position (ETP) connector. Reconnect Turbocharger 1 Turbine Outlet Pressure (TC1TOP) connector. C. Disconnect Exhaust Back Pressure (EBP) sensor connector. D. Connect breakout harness ZTSE4850 to vehicle harness, reconnect EBP sensor connector, and leave ETP connector disconnected. E. Key ON.

Test 5	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4850 pin-2 and known good GND.	Greater than 5.5 volts.
Decision	
Is voltage greater than 5.5 volts?	Yes: Replace ETP sensor. After repairs are complete, retest for SPN 3509 FMI 3.
	No: Repair Short to PWR in engine harness to pin E-35. After repairs are complete, retest for SPN 3509 FMI 3.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and the proper decision was made. Return to SPN 3509 FMI 3 fault code diagnostics.

SPN 3509 FMI 4 - VREF1 voltage below minimum

Condition / Description	Setting Criteria	Enable Conditions / Condition Values
Sensor supply Voltage 1 below minimum	Sensor supply voltage 1 (VCC_1) < 4.502 Volts	Key ON

Fault Overview

Fault sets when Engine Control Module (ECM) senses VREF1 sensor supply voltage is less than 4.502 volts.

Lamp Reaction

Malfunction Indicator Lamp (MIL) will illuminate when this fault is detected during two trips.

Associated Faults

None

Fault Facts

Wiring harness routing to all sensors are very important. Make sure that wiring harnesses are routed properly to avoid contact with serpentine belt or pulleys.

Drive Cycle to Determine Fault Status

Continuous

Possible Causes

- Short to GND in engine harness
- Short to GND in UVC harness
- Defective ETV
- Defective EBPC
- Defective: EOP, IMP, EBP, FDP, ICP, or BCP (optional) sensors

Step 1	Check for active or pending fault codes.	Decision
	Using Electronic Service Tool (EST) with ServiceMaxx™ software. A. Key ON, clear codes. B. Key OFF, wait for EST screens to clear. C. Key ON, check Diagnostic Trouble Code (DTC) list for SPN 3509 FMI 4. Is EST DTC list SPN 3509 FMI 4 active or pending?	Yes: Perform Pin-Point Tests(page 1187). No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

Pin-Point Tests (SPN 3509 FMI 3)

See latest version of Navistar® N9 and N10 SCR Wiring Schematic Form 0000003481 for additional circuit information.

Tools Required

- Breakout Harness ZTSE4850
- Breakout Harness ZTSE4952
- Digital Multimeter (DMM)

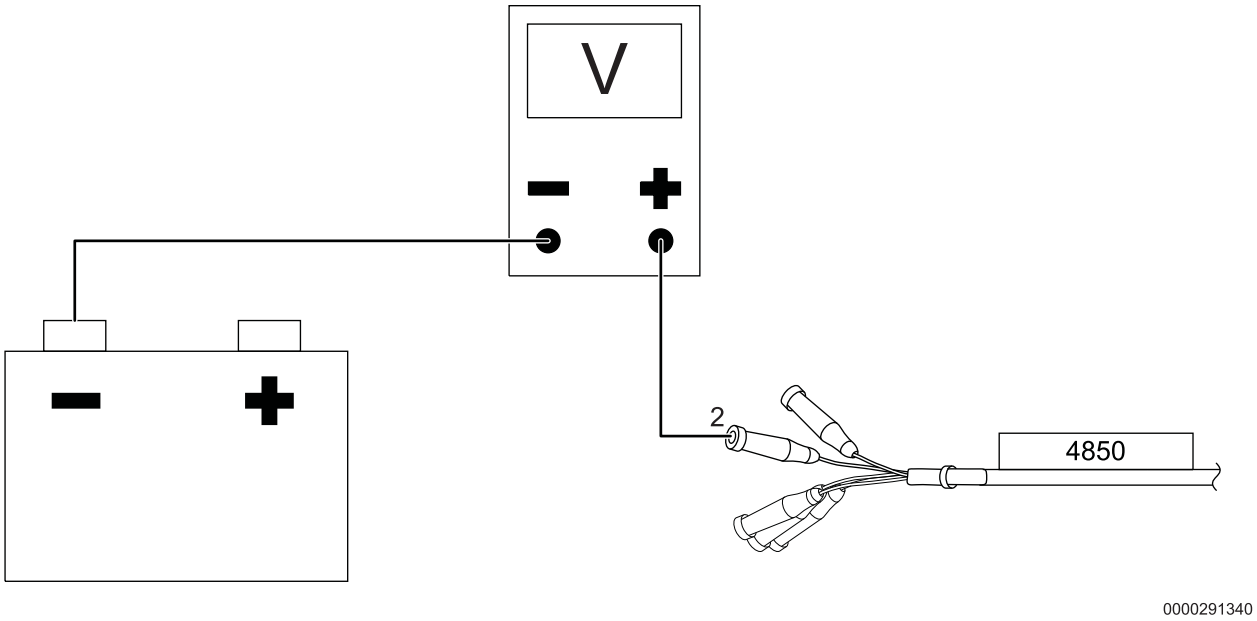


Figure 528 Test 1 Exhaust Back Pressure (EBP) Circuit Voltage Check

Test 1 Setup
A. Key OFF. B. Disconnect Exhaust Back Pressure (EBP) sensor connector. C. Connect breakout harness ZTSE4850 to vehicle harness and reconnect EBP sensor connector. D. Key ON.

Test 1	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4850 pin-2 and known good GND.	Less than 4.5 volts.
Decision	
Is voltage less than 4.5 volts?	Yes: Go to Test 2.
	No: Go to Intermittent or Inactive Fault Diagnostic Procedure (page 79).

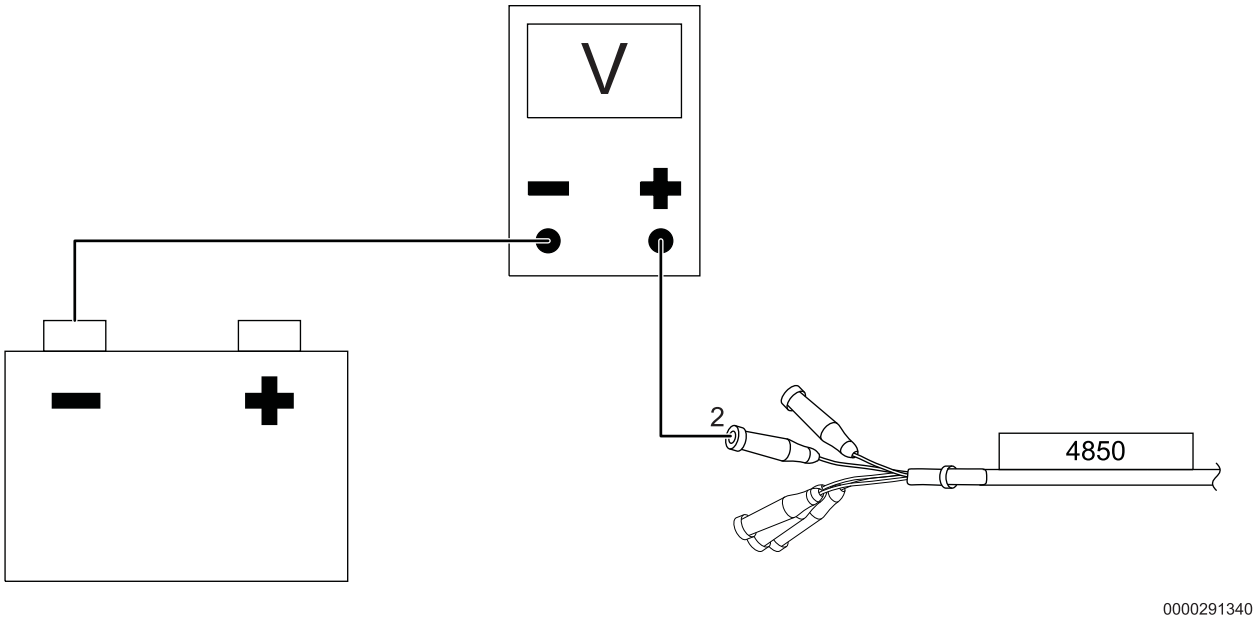


Figure 529 Test 2 Exhaust Back Pressure (EBP) Circuit Voltage Check

Test 2 Setup
A. Key OFF. B. Disconnect Engine Control Module (ECM) 36-pin driver connector. C. Disconnect Exhaust Back Pressure (EBP) sensor connector. D. Connect breakout harness ZTSE4850 to vehicle harness and reconnect EBP sensor connector. E. Key ON.

Test 2	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4850 pin-2 and known good GND.	Less than 4.5 volts.
Decision	
Is voltage less than 4.5 volts?	Yes: Go to Test 6.
	No: Go to Test 3.

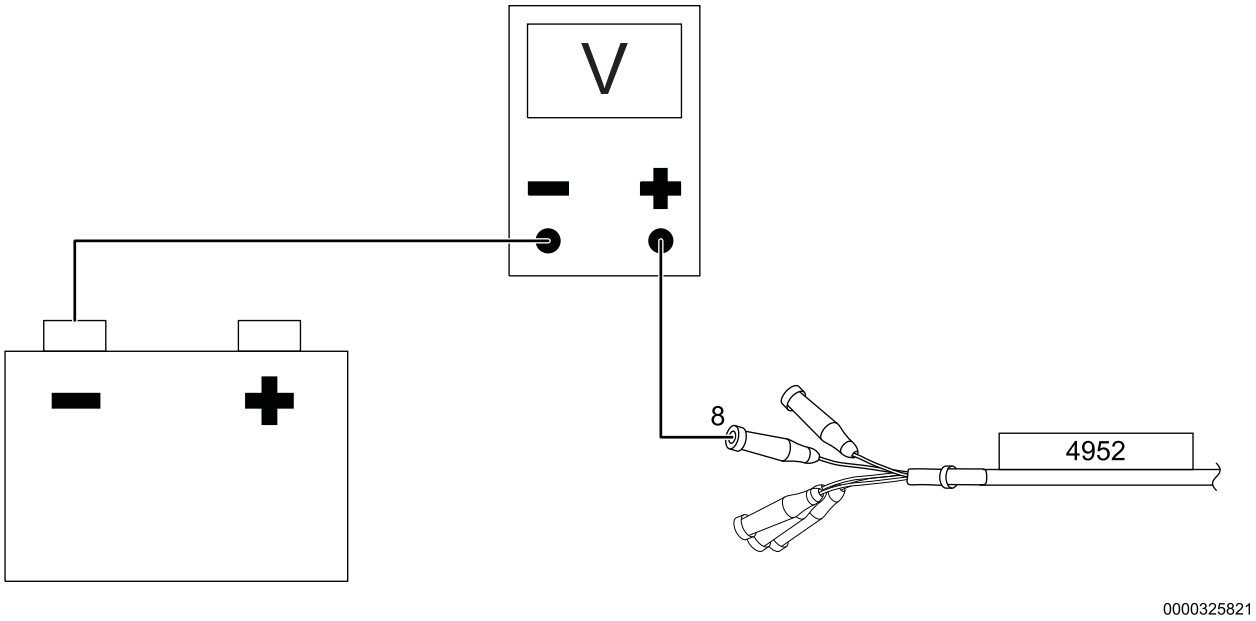


Figure 530 Test 3 Under Valve Connector (UVC) Circuit Voltage Check

Test 3 Setup
A. Key OFF. B. Reconnect Engine Control Module (ECM) 36-pin driver connector. C. Disconnect Under Valve Connector (UVC) connector. D. Connect breakout harness ZTSE4952 to vehicle harness and leave UVC connector disconnected. E. Key ON.

Test 3	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4952 pin-8 and known good GND.	Less than 4.5 volts.
Decision	
Is voltage less than 4.5 volts?	Yes: Repair engine harness for a Short between ECM pin D-13 and GND. After repairs are complete, retest for SPN 3509 FMI 4.
	No: Go to Test 4.

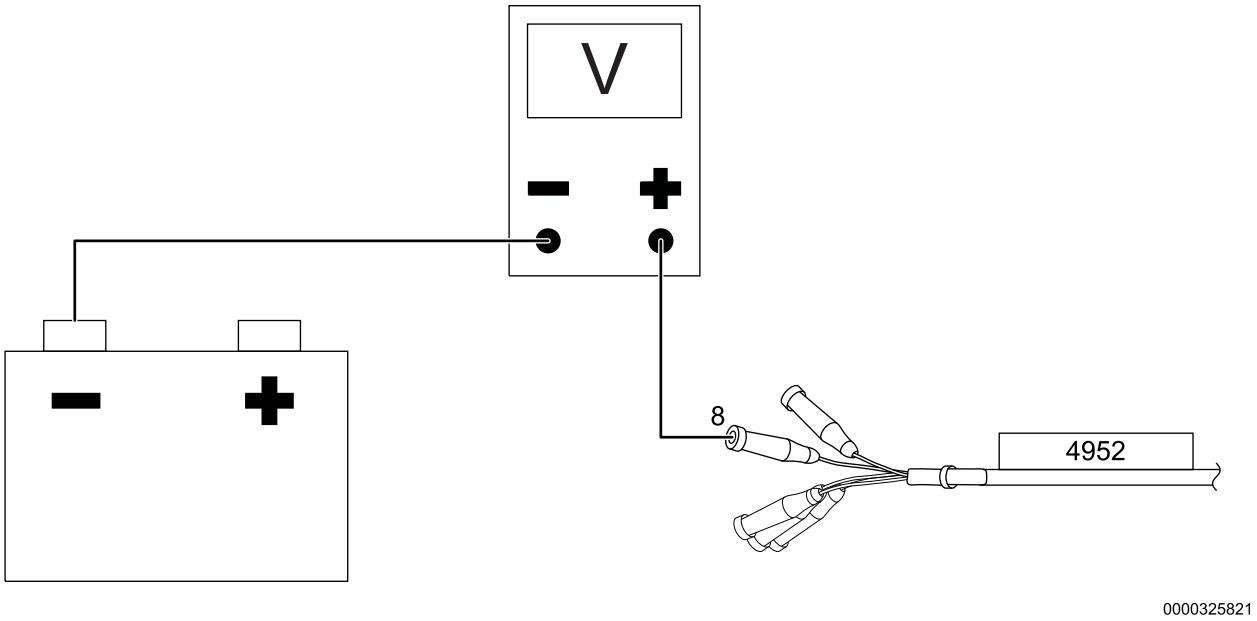


Figure 531 Test 4 Under Valve Connector (UVC) Circuit Voltage Check

Test 4 Setup
A. Key OFF. B. Remove valve cover. C. Disconnect Under Valve Connector (UVC) connector. D. Connect breakout harness ZTSE4952 to vehicle harness and leave UVC connector disconnected. E. Disconnect Injection Control Pressure (ICP) connector. F. Key ON.

Test 4	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4952 pin-8 and known good GND.	Less than 4.5 volts.
Decision	
Is voltage less than 4.5 volts?	Yes: Go to Step 5.
	No: Replace ICP sensor. After repairs are complete, retest for SPN 3509 FMI 4.

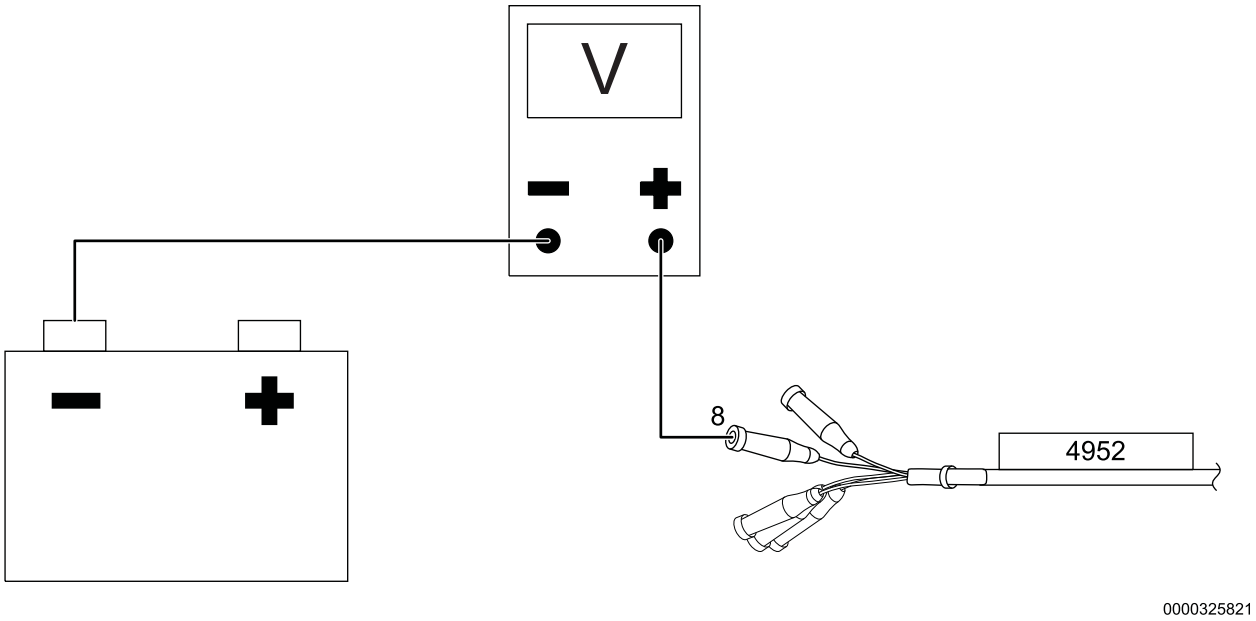


Figure 532 Test 5 Under Valve Connector (UVC) Circuit Voltage Check

Test 5 Setup
A. Key OFF. B. Remove valve cover C. Disconnect Under Valve Connector (UVC) connector. D. Connect breakout harness ZTSE4952 to vehicle harness and leave UVC connector disconnected. E. Reconnect Injection Control Pressure (ICP) connector. Disconnect Brake Control Pressure (BCP) connector. F. Key ON.

Test 5	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4952 pin-8 and known good GND.	Less than 4.5 volts.
Decision	
Is voltage less than 4.5 volts?	Yes: Repair UVC harness. After repairs are complete, retest for SPN 3509 FMI 4.
	No: Replace BCP sensor. After repairs are complete, retest for SPN 3509 FMI 4.

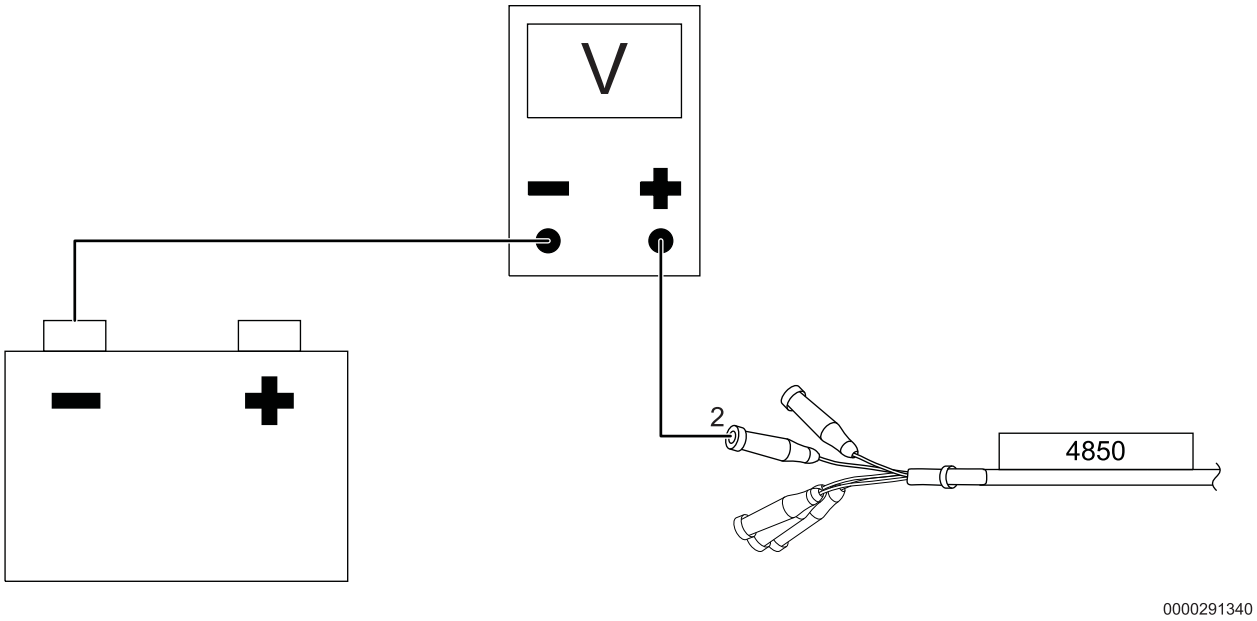


Figure 533 Test 6 Exhaust Back Pressure (EBP) Circuit Voltage Check

Test 6 Setup
A. Key OFF. B. Reconnect Brake Control Pressure (BCP) connector. Replace valve cover. C. Disconnect Turbocharger 1 Turbine Outlet Pressure (TC1TOP) connector. D. Disconnect Exhaust Back Pressure (EBP) sensor connector. E. Connect breakout harness ZTSE4850 to vehicle harness, reconnect EBP sensor connector, and leave TC1TOP disconnected. F. Key ON.

Test 6	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4850 pin-2 and known good GND.	Less than 4.5 volts.
Decision	
Is voltage less than 4.5 volts?	Yes: Go to Step 7.
	No: Replace TC1TOP sensor. After repairs are complete, retest for SPN 3509 FMI 4.

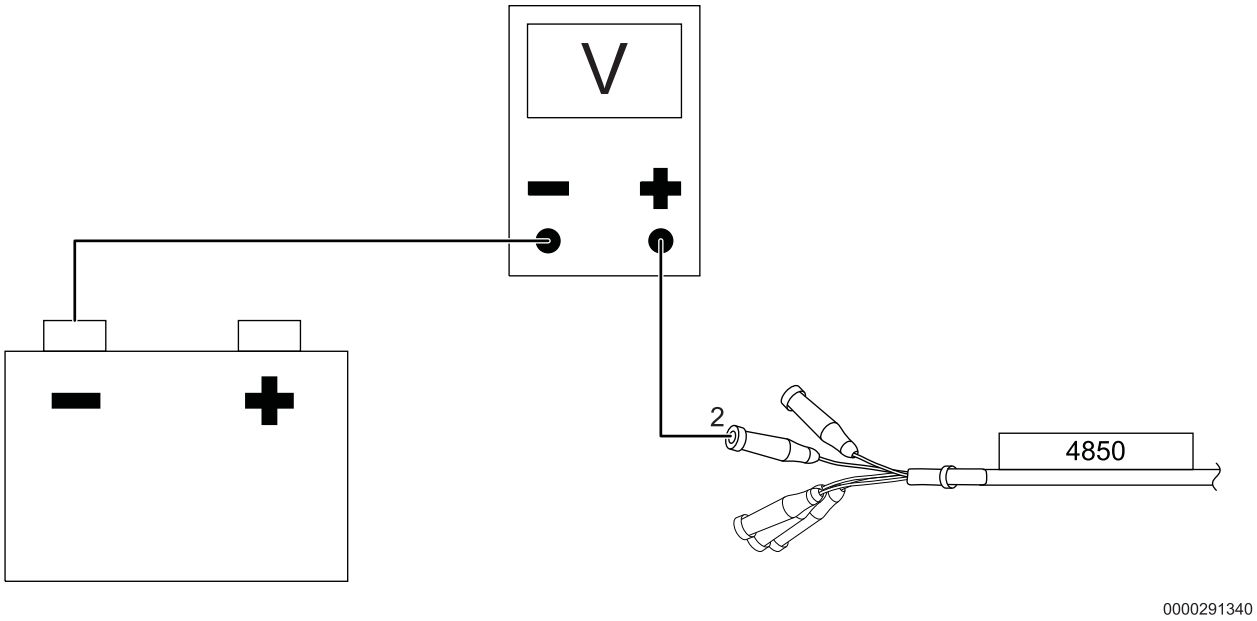


Figure 534 Test 7 Exhaust Back Pressure (EBP) Circuit Voltage Check

Test 7 Setup
A. Key OFF. B. Disconnect Engine Throttle Valve Position (ETP) connector. Reconnect Turbocharger 1 Turbine Outlet Pressure (TC1TOP) connector. C. Disconnect Exhaust Back Pressure (EBP) sensor connector. D. Connect breakout harness ZTSE4850 to vehicle harness, reconnect EBP sensor connector, and leave ETP disconnected. E. Key ON.

Test 7	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4850 pin-2 and known good GND.	Less than 4.5 volts.
Decision	
Is voltage less than 4.5 volts?	Yes: Go to Step 8.
	No: Replace ETP sensor. After repairs are complete, retest for SPN 3509 FMI 4.

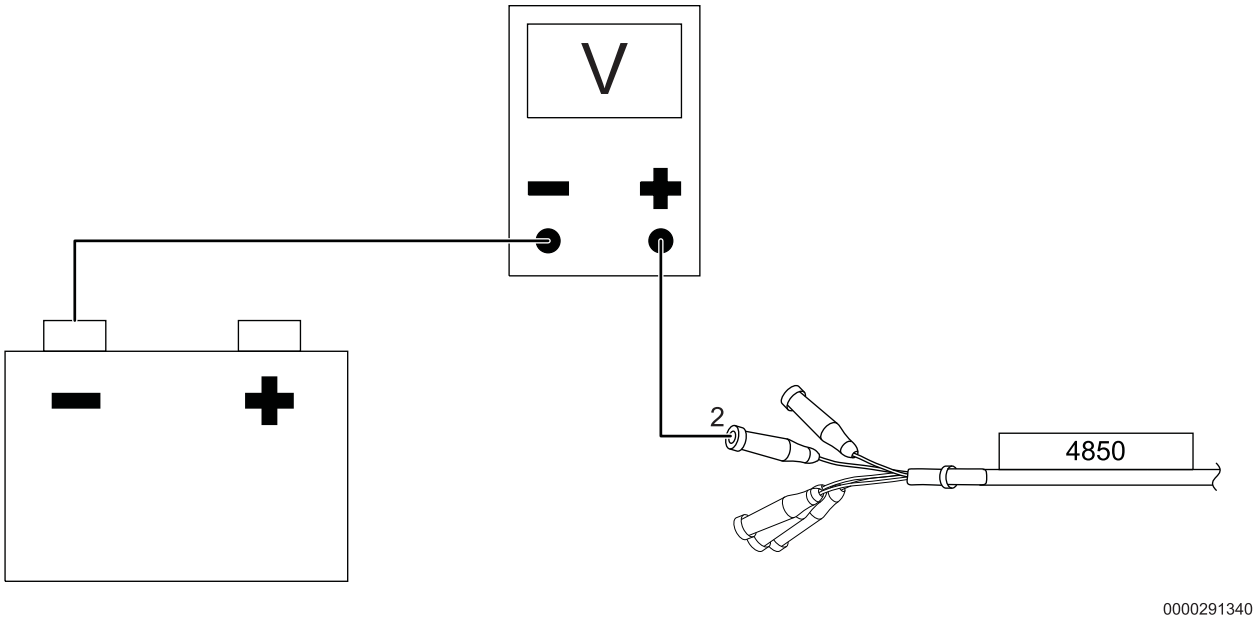


Figure 535 Test 8 Exhaust Back Pressure (EBP) Circuit Voltage Check

Test 8 Setup
A. Key OFF. B. Disconnect Fuel Delivery Pressure (FDP) connector. Reconnect Engine Throttle Valve Position (ETP) connector. C. Disconnect Exhaust Back Pressure (EBP) sensor connector. D. Connect breakout harness ZTSE4850 to vehicle harness, reconnect EBP sensor connector, and leave FDP disconnected. E. Key ON.

Test 8	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4850 pin-2 and known good GND.	Less than 4.5 volts.
Decision	
Is voltage less than 4.5 volts?	Yes: Go to Step 9.
	No: Replace FDP sensor. After repairs are complete, retest for SPN 3509 FMI 4.

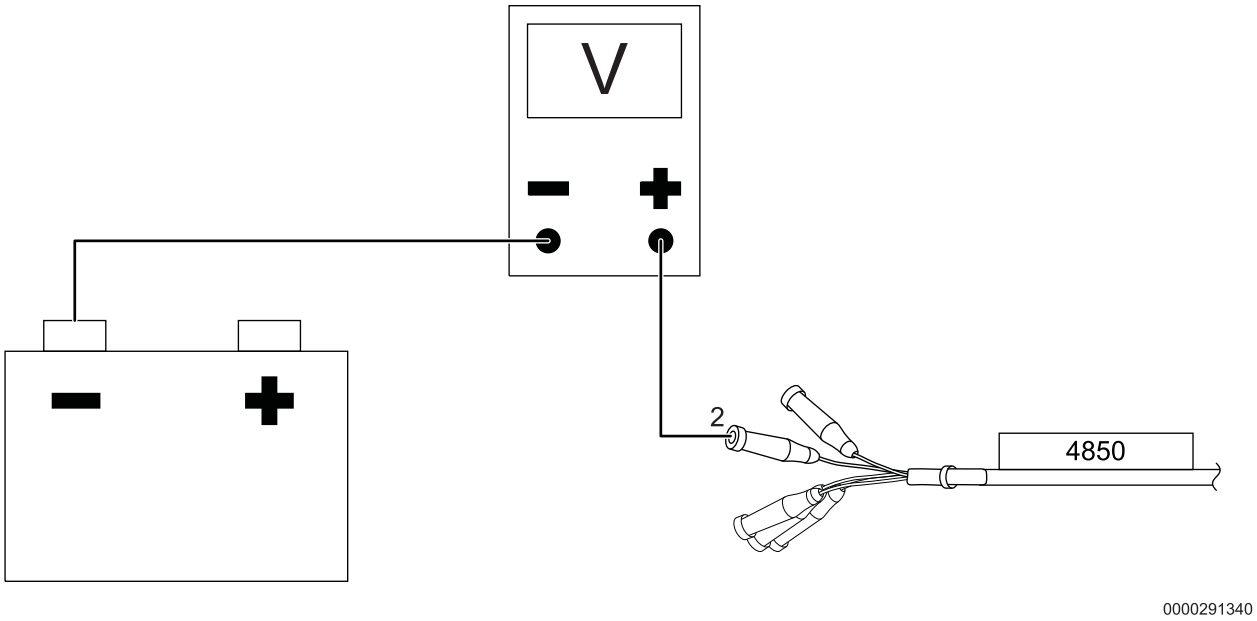


Figure 536 Test 9 Exhaust Back Pressure (EBP) Circuit Voltage Check

Test 9 Setup
A. Key OFF. B. Disconnect Engine Oil Pressure (EOP) connector. Reconnect Fuel Delivery Pressure (FDP) connector. C. Disconnect Exhaust Back Pressure (EBP) sensor connector. D. Connect breakout harness ZTSE4850 to vehicle harness, reconnect EBP sensor connector, and leave EOP disconnected. E. Key ON.

Test 9	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4850 pin-2 and known good GND.	Less than 4.5 volts.
Decision	
Is voltage less than 4.5 volts?	Yes: Go to Step 10.
	No: Replace EOP sensor. After repairs are complete, retest for SPN 3509 FMI 4.

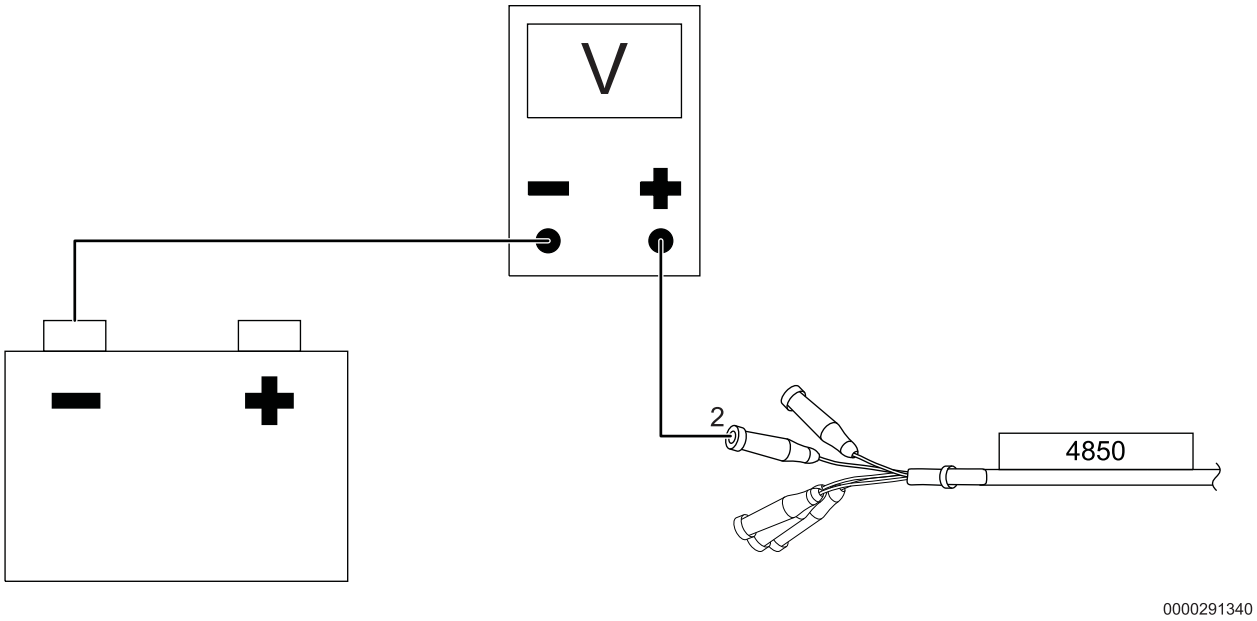


Figure 537 Test 10 Exhaust Back Pressure (EBP) Circuit Voltage Check

Test 10 Setup
A. Key OFF. B. Disconnect Intake Manifold Pressure (IMP) connector. Reconnect Engine Oil Pressure (EOP) connector. C. Disconnect Exhaust Back Pressure (EBP) sensor connector. D. Connect breakout harness ZTSE4850 to vehicle harness, reconnect EBP sensor connector, and leave IMP disconnected. E. Key ON.

Test 10	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4850 pin-2 and known good GND.	Less than 4.5 volts.
Decision	
Is voltage less than 4.5 volts?	Yes: Go to Step 11.
	No: Replace IMP sensor. After repairs are complete, retest for SPN 3509 FMI 4.

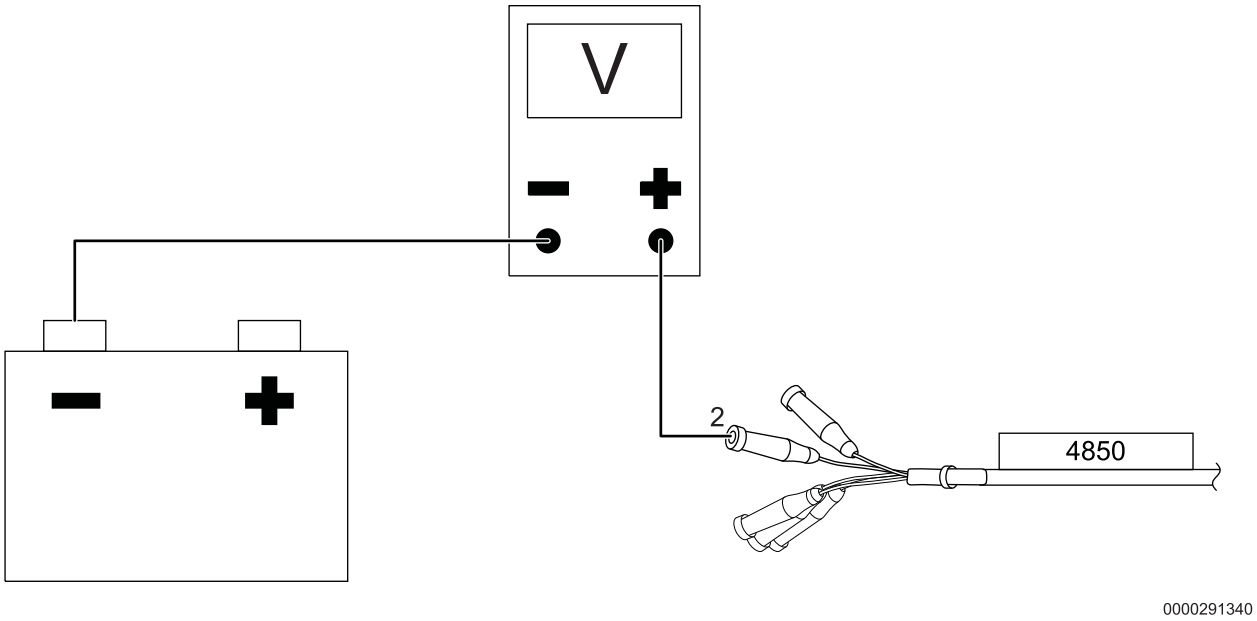


Figure 538 Test 11 Exhaust Back Pressure (EBP) Circuit Voltage Check

Test 11 Setup
A. Key OFF. B. Disconnect Exhaust Back Pressure (EBP) sensor connector. Reconnect Intake Manifold Pressure (IMP) connector. C. Connect breakout harness ZTSE4850 to vehicle harness and leave EBP sensor disconnected. D. Key ON.

Test 11	Specification
Use DMM to measure voltage between Breakout Harness ZTSE4850 pin-2 and known good GND.	Less than 4.5 volts.
Decision	
Is voltage less than 4.5 volts?	Yes: Repair short to GND in engine harness to Pin E-35. After repairs are complete, retest for SPN 3509 FMI 4.
	No: Replace EBP sensor. After repairs are complete, retest for SPN 3509 FMI 4.

End Diagnostic Tests
After performing all tests, if no problem is found, verify if each step was completed correctly and the proper decision was made. Return to SPN 3509 FMI 4 fault code diagnostics.

WIF Sensor (Water In Fuel)

SPN	FMI	Condition
4192	3	WIF signal Out of Range HIGH
4192	4	WIF signal Out of Range LOW
4192	5	WIF signal Open or Short to PWR
4192	31	Water in Fuel Detected

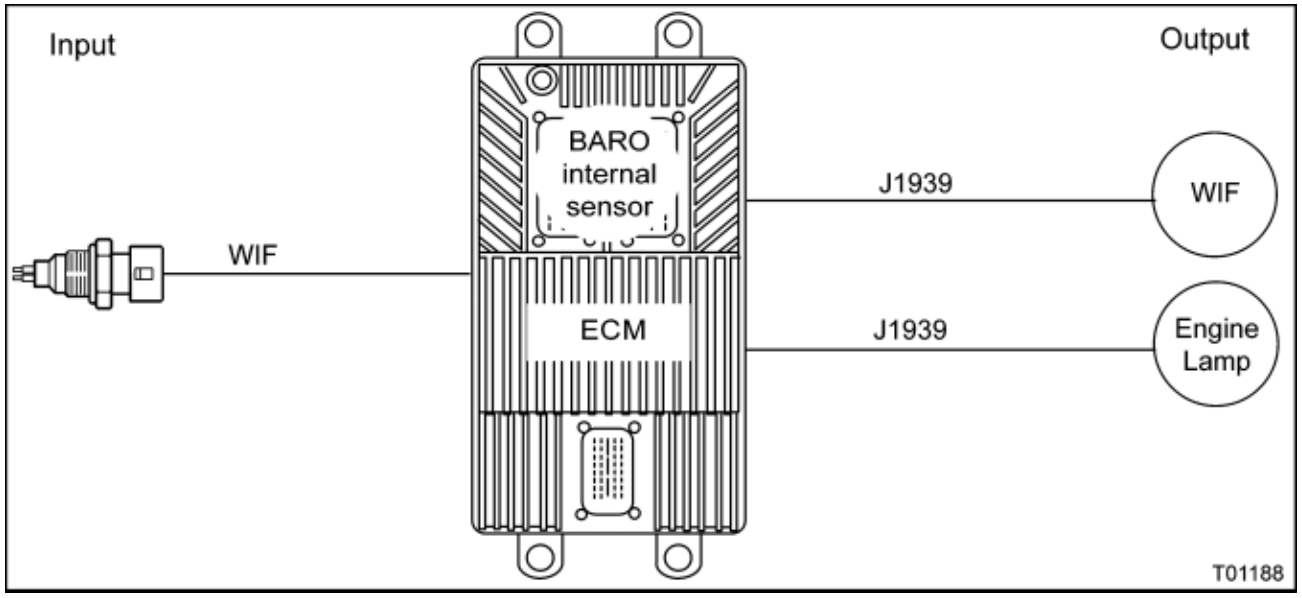


Figure 539 Function diagram for the WIF

The function diagram for the WIF includes the following:

- Engine Control Module (ECM)
  with Barometric Absolute Pressure (BARO) Internal Sensor
- Water In Fuel (WIF) Sensor
- Engine Lamp
- Water In Fuel (WIF) Lamp

Function

The WIF sensor provides a feedback signal to the ECM when water is detected in the fuel supply. If water is detected, the ECM will alert the operator by illuminating the water in fuel lamp. If a circuit fault is detected, a code will set and the engine lamp will illuminate.

Sensor Location

The WIF sensor is located in the fuel filter housing.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software (page 1226)

- Interface cable (RP1210B compliant supporting J1939 and J1708) (page 1228)
- 00-00956-08 – 180-pin Breakout Box (page 1222)
- Breakout Harness 6002 (WIF) (page 1239)

WIF Pin-point Diagnostics

SPN	FMI	Condition	Possible Causes
4192	3	WIF signal Out of Range HIGH	• WIF circuit short to PWR
4192	4	WIF signal Out of Range LOW	• WIF circuit short to GND
4192	5	WIF signal Open or Short to Pwr	• WIF circuit OPEN or short to PWR
4192	31	Water in fuel detected	• Water detected in primary fuel filter housing

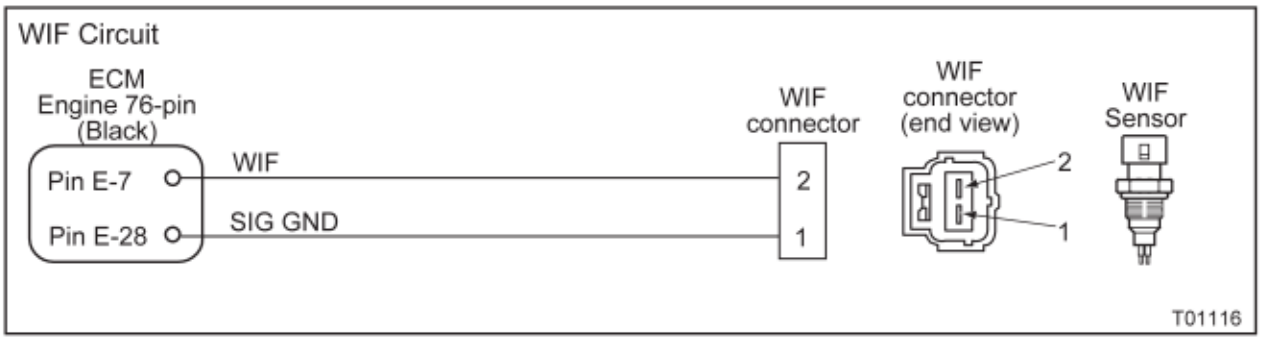


Figure 540 WIF circuit diagram

1. Drain a fuel sample from the water drain valve on the primary fuel filter housing. See Draining Water From Fuel Filter Assembly in *Engine Service Manual*.
   - If water is present, drain all the water out of the system.
   - If no water is present in the fuel sample, continue to next step.
2. Using EST with ServiceMaxx™ software, open the Switch Monitor session.

   NOTE: The WIF signal will read YES if there is water in the fuel filter housing, or if the WIF signal circuit is shorted high.
   - If code is inactive, monitor the signal while wiggling the connector and all wires at suspected locations. If the circuit is interrupted, the signal will change from No to Yes and the code will go active.
   - If code is active, go to the next step.
3. Disconnect engine harness from sensor.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

4. Connect breakout harness to engine harness. Leave sensor disconnected.

Voltage Check

Disconnect WIF sensor connector. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment: < Less than, > Greater than
A to GND	5 ± 0.5 V	If < 4.5 volts, check for OPEN circuit.
B to GND	B+	If < B+, check for OPEN 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 GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
1 to C2-42	< 5 Ω	If > 5 Ω, check for OPEN circuit.

WIF Circuit Operation

The WIF sensor is supplied with a 5-volt VREF at pin 2 from the ECM pin E-7. The sensor is grounded at Pin 1 from ECM Pin E-28. The WIF signal is 4.6 volt at normal state and below 4 volts when water is detected.

Fault Detection/Management

The ECM continuously monitors the WIF sensor. If voltage drops below 4 volts, a code will set and the water in fuel lamp will be illuminated. Three other codes are set if there is a fault with the circuit or sensor.

Table of Contents

Diagnostic Trouble Codes.....1205

Diagnostic Trouble Codes

SPN	FMI	Circuit	Condition Description
27	0	EGR (page 675)	EGRP fault: over temperature
27	3	EGR (page 675)	EGRP signal Out of Range HIGH (Applicable to 2010 only)
27	4	EGR (page 675)	EGRP signal Out of Range LOW (Applicable to 2010 only)
27	7	EGR (page 675)	EGRP does not agree with commanded position (Applicable to 2010 only)
27	14	EGR (page 675)	EGR internal circuit failure
51	0	ETV (page 764)	Engine Throttle Position (ETP) fault: Over temperature
51	2	ETV (page 764)	ETP does not agree with commanded position
51	3	ETV (page 764)	ETP signal Out of Range HIGH
51	4	ETV (page 764)	ETP signal Out of Range LOW
51	5	ETV (page 764)	ETP open load / circuit
51	7	ETV (page 764)	ETP does not agree with commanded position
51	11	ETV (page 764)	ETP operation fault- underVolt, overAmp, overTemp/ ETP H-bridge Electrical Check (Applicable to 2010 only)
91	2	APP (page 411)	APP1 and APP2 signal conflict
91	3	APP (page 411)	APP1 signal Out of Range HIGH
91	4	APP (page 411)	APP1 signal Out of Range LOW
94	0	EFP (page 665)	Fuel Delivery Pressure above Critical
94	1	EFP (page 665)	Fuel Delivery Pressure below Critical
94	2	EFP (page 665)	FDP signal erratic, intermittent, or incorrect
94	3	FDP (page 803)	FDP signal Out of Range HIGH
94	4	FDP (page 803)	FDP signal Out of Range LOW
94	17	FDP (page 803)	FDP Below Minimum
94	18	FDP (page 803)	Fuel Delivery Pressure below minimum during cranking
100	1	EWPS (page 788)	Engine Oil System below Critical Pressure
100	3	EOP (page 737)	EOP signal Out of Range HIGH
100	4	EOP (page 737)	EOP signal Out of Range LOW
100	18	EWPS (page 788)	Engine Oil System below Warning Pressure
102	2	IMP (page 880)	IMP signal erratic, intermittent, or incorrect
102	3	IMP (page 880)	IMP signal Out of Range HIGH

SPN	FMI	Circuit	Condition Description
102	4	IMP (page 880)	IMP signal Out of Range LOW
102	7	IMP (page 880)	IMP signal not responding as expected
102	10	IMP (page 880)	Boost slow response fault
102	16	IMP (page 880)	Overboost
102	18	IMP (page 880)	Underboost
105	2	IMT (page 915)	IMT signal erratic, intermittent, or incorrect
105	3	IMT (page 915)	IMT signal Out of Range HIGH
105	4	IMT (page 915)	IMT signal Out of Range LOW
108	2	ECM Self (page 614)	BARO signal erratic, intermittent, or incorrect
108	3	ECM Self (page 614)	BARO signal Out of Range HIGH
108	4	ECM Self (page 614)	BARO signal Out of Range LOW
110	0	EWPS (page 788)	Engine Coolant System above Critical Temperature
110	2	ECT1 (page 629)	ECT1 signal erratic, intermittent, or incorrect
110	3	ECT1 (page 629)	ECT1 signal Out of Range HIGH
110	4	ECT1 (page 629)	ECT1 signal Out of Range LOW
110	7	ECT1 (page 629)	ECT1 and EOT Temperature Conflict
110	15	EWPS (page 788)	Engine Coolant System above Warning Temperature
110	16	EWPS (page 788)	Engine Coolant System Above OBD Maximum Temperature
110	17	ECT1 (page 629)	Engine Coolant System Below OBD Monitoring Temperature
110	18	ECT1 (page 629)	Engine Coolant System Below closed loop minimum temperature
111	1	EWPS (page 788)	ECL below Warning/Critical Level
111	2	ECL (page 577)	ECL signal erratic, intermittent, or incorrect
132	0	MAF (page 1096)	Engine Inlet Air Mass Flow Rate High
132	1	MAF (page 1096)	Engine Inlet Air Mass Flow Rate Low
132	3	MAF (page 1096)	MAF signal Out of Range HIGH
132	4	MAF (page 1096)	MAF signal Out of Range LOW
132	11	MAF (page 1096)	MAF Sensor Calibration – Insufficient number of data points
132	13	MAF (page 1096)	MAF Sensor Calibration Needed
132	14	MAF (page 1096)	MAF Sensor Calibration Failed
132	31	MAF (page 1096)	MAF Operation Fault
158	15	ECM PWR (page 580)	ECM Switched voltage too HIGH
158	17	ECM PWR (page 580)	ECM Switched voltage too LOW

SPN	FMI	Circuit	Condition Description
164	0	ICP (page 833)	ICP above KOEO Spec
164	1	ICP SYS (page 849)	ICP Unable to Build During Engine Cranking
164	2	ICP SYS (page 849)	ICP signal erratic, intermittent, or incorrect
164	3	ICP (page 833)	ICP signal Out of Range HIGH
164	4	ICP (page 833)	ICP signal Out of Range LOW
164	10	ICP SYS (page 849)	ICP signal abnormal rate of change
164	13	ICP SYS (page 849)	ICP adaptation In-Range fault (Applicable to 2010 only)
164	15	ICP SYS (page 849)	ICP too high during test
164	16	ICP SYS (page 849)	ICP below setpoint
164	17	ICP SYS (page 849)	ICP unable to build during test
164	18	ICP SYS (page 849)	ICP below desired level
164	20	ICP SYS (page 849)	ICP below desired level
164	21	ICP SYS (page 849)	ICP above desired level
172	2	MAF, AIT (page 1096)	AIT signal erratic, intermittent, or incorrect
172	3	MAF, AIT (page 1096)	AIT signal Out of Range HIGH
172	4	MAF, AIT (page 1096)	AIT signal Out of Range LOW
173	2	EGT (page 709)	EGT signal erratic, intermittent, or incorrect
173	3	EGT (page 709)	EGT signal Out of Range HIGH
173	4	EGT (page 709)	EGT signal Out of Range LOW
175	2	EOT (page 747)	EOT signal erratic, intermittent, or incorrect
175	3	EOT (page 747)	EOT signal Out of Range HIGH
175	4	EOT (page 747)	EOT signal Out of Range LOW
175	7	EOT (page 747)	EOT not warming along with engine
175	15	EWPS (page 788)	Engine Oil System above Warning Temperature
188	0	Engine Idle Speed	Engine unable to achieve desired idle speed (too high)
188	1	Engine Idle Speed	Engine unable to achieve desired idle speed (too low)
190	0	EWPS (page 788)	Engine Overspeed - Most Severe Level
191	3	TOSS (page 592)	TOSS/VSS signal out of range HIGH
191	4	TOSS (page 592)	TOSS/VSS signal out of range LOW
518	2	Torque Limitation (page 601)	Torque Limitation - Too High ECT
521	2	APP (page 411)	Brake applied while APP applied
521	19	APP (page 411)	Brake switch circuit fault (Applicable to 2010 only)

SPN	FMI	Circuit	Condition Description
593	31	IST (page 1073)	Engine stopped by IST
596	19	CCS (page 457)	Cruise Control Enable Switch not detected on J1939
597	2	Brake SW (page 605)	Brake switch or circuit fault
597	19	Brake SW (page 605)	Brake switch not detected on J1939
609	3	DCU (page 468)	DCU Switched voltage too HIGH
609	4	DCU (page 468)	DCU Switched voltage too LOW
609	12	DCU (page 468)	DCU Internal chip Error
609	19	DCU (page 468)	DCU not detected on J1939
628	12	ECM Self (page 614)	ECM Memory Error
629	0	ECM Self (page 614)	ECM Error - CPU Load Excessively HIGH
629	8	ECM Self (page 614)	ECM Error - Engine Off Timer Fault
629	12	ECM Self (page 614)	ECM Internal chip Error
636	2	CMP (page 463)	CMP and CKP Synchronization Error
636	7	CMP (page 463)	CMP to CKP incorrect reference
637	8	CKP (page 460)	CKP signal noise
637	10	CKP (page 460)	CKP signal Inactive
639	14	J1939 (page 1089)	J1939 Data Link Error (ECM unable to transmit)
651	4	INJ (page 926)	Injector 1 open coil - short circuit
651	5	INJ (page 926)	Injector 1 open coil - open circuit
651	7	INJ (page 926)	Injector 1 Spool Motion Compensation Max Authority Reached
651	14	INJ (page 926)	Injector 1 Fuel quantity/timing error
652	4	INJ (page 926)	Injector 2 open coil - short circuit
652	5	INJ (page 926)	Injector 2 open coil - open circuit
652	7	INJ (page 926)	Injector 2 Spool Motion Compensation Max Authority Reached
652	14	INJ (page 926)	Injector 2 Fuel quantity/timing error
653	4	INJ (page 926)	Injector 3 open coil - short circuit
653	5	INJ (page 926)	Injector 3 open coil - open circuit
653	7	INJ (page 926)	Injector 3 Spool Motion Compensation Max Authority Reached
653	14	INJ (page 926)	Injector 3 Fuel quantity/timing error
654	4	INJ (page 926)	Injector 4 open coil - short circuit
654	5	INJ (page 926)	Injector 4 open coil - open circuit
654	7	INJ (page 926)	Injector 4 Spool Motion Compensation Max Authority Reached

SPN	FMI	Circuit	Condition Description
654	14	INJ (page 926)	Injector 4 Fuel quantity/timing error
655	4	INJ (page 926)	Injector 5 open coil - short circuit
655	5	INJ (page 926)	Injector 5 open coil - open circuit
655	7	INJ (page 926)	Injector 5 Spool Motion Compensation Max Authority Reached
655	14	INJ (page 926)	Injector 5 Fuel quantity/timing error
656	4	INJ (page 926)	Injector 6 open coil - short circuit
656	5	INJ (page 926)	Injector 6 open coil - open circuit
656	7	INJ (page 926)	Injector 6 Spool Motion Compensation Max Authority Reached
656	14	INJ (page 926)	Injector 6Fuel quantity/timing error
679	3	IPR (page 1059)	IPR short to PWR
679	4	IPR (page 1059)	IPR open or short to GND
679	5	IPR (page 1059)	IPR open load / circuit
729	3	IAHC (page 1076)	IAHC short to PWR
729	4	IAHC (page 1076)	IAHC short to GND
729	5	IAHC (page 1076)	IAHC open load / circuit
729	18	IAHC (page 1076)	IAH monitor fault: lack of heat in the intake manifold
931	3	EFP (page 665)	EFP short to PWR
931	4	EFP (page 665)	EFP open load/circuit or short to GND
931	11	EFP (page 665)	EFP operation fault
931	19	EFP (page 665)	EFP not detected on J1939
974	3	RAPP (page 411)	Remote APP signal Out of Range HIGH
974	4	RAPP (page 411)	Remote APP signal Out of Range LOW
1136	0	ECM Self (page 614)	ECM Error – over temperature
1173	2	TC2CIT (page 1142)	TC2CIT signal erratic, intermittent or incorrect
1173	3	TC2CIT (page 1142)	TC2CIT signal out of range high
1173	4	TC2CIT (page 1142)	TC2CIT signal out of range low
1173	16	TC2CIT (page 1142)	TC2CIT signal above desired (interstage CAC under cooling)
1189	3	TC2WG (page 1132)	TC2WG short to PWR
1189	4	TC2WG (page 1132)	TC2WG short to GND
1189	3	TC2WC (page 1163)	TC2WC short to PWR
1189	4	TC2WC (page 1163)	TC2WC open or short to GND
1189	5	TC2WC (page 1163)	TC2WC open load/circuit

SPN	FMI	Circuit	Condition Description
1209	0	AMS (page 393)	EBP above desired level
1209	1	EBP (page 519)	EBP below desired level
1209	2	EBP (page 519)	EBP signal erratic, intermittent, or incorrect
1209	3	EBP (page 519)	EBP signal Out of Range HIGH
1209	4	EBP (page 519)	EBP signal Out of Range LOW
1209	7	AMS (page 393)	EBP signal not responding as expected
1231	19	DCU (page 468)	DCU Error - J1939 communication fault
1322	31	Engine Misfire (page 727)	Engine Misfire Multiple Cylinders
1323	31	Engine Misfire (page 727)	Engine Misfire Cylinder 1
1324	31	Engine Misfire (page 727)	Engine Misfire Cylinder 2
1325	31	Engine Misfire (page 727)	Engine Misfire Cylinder 3
1326	31	Engine Misfire (page 727)	Engine Misfire Cylinder 4
1327	31	Engine Misfire (page 727)	Engine Misfire Cylinder 5
1328	31	Engine Misfire (page 727)	Engine Misfire Cylinder 6
1378	31	Service (page 1131)	Change Engine Oil Service Interval
1387	31	ECM Self Diagnostics (page 614)	Altitude reference adder fault
1659	20	ECT1 (page 629)	ECT1 below expected: Check Thermostat
2623	3	APP (page 411)	APP2 signal Out of Range HIGH
2623	4	APP (page 411)	APP2 signal Out of Range LOW
2630	2	CACOT (page 437)	CACOT Signal Erratic, Intermittent, or Incorrect
2630	3	CACOT (page 437)	CACOT signal out of range HIGH
2630	4	CACOT (page 437)	CACOT signal out of range LOW
2630	16	CACOT (page 437)	CACOT Undercooling
2659	10	AMS (page 393)	EGR Slow Response Fault
2659	14	AMS (page 393)	Service Tool Test - EBP was unable to detect EGR movement
2659	20	AMS (page 393)	EGR High Flow Rate detected
2659	21	AMS (page 393)	EGR Low Flow Rate detected
2791	2	EGR (page 675)	EGR valve communication fault
2791	3	EGR (page 675)	EGRP signal Out of Range HIGH
2791	4	EGR (page 675)	EGR valve communication fault
2791	7	EGR (page 675)	EGR valve communication fault
2791	8	EGR (page 675)	EGR valve not receiving ECM PWM signal
2791	14	EGR (page 675)	EGR valve Initialization Fault
2796	2	Transfer Case (page 1167)	Transfer case switch or circuit fault

SPN	FMI	Circuit	Condition Description
2797	3	INJ (page 926)	Injector Control Group 1 open coil short (Applicable to 2010 only)
2797	4	INJ (page 926)	Injector Control Group 1 close coil short (Applicable to 2010 only)
2797	6	INJ (page 926)	Injector Control Group 1 Open coil - Short Circuit (INJ 1, 2, 3)
2798	3	INJ (page 926)	Injector Control Group 2 open coil short (Applicable to 2010 only)
2798	4	INJ (page 926)	Injector Control Group 2 close coil short (Applicable to 2010 only)
2798	6	INJ (page 926)	Injector Control Group 2 Open coil - Short Circuit (INJ 4, 5, 6)
3055	2	INJ SYS (page 849)	ICP/IPR adaptation in-range fault
3242	2	DPFIT (page 502)	DPFIT signal erratic, intermittent, or incorrect
3242	3	DPFIT (page 502)	DPFIT signal Out of Range HIGH
3242	4	DPFIT (page 502)	DPFIT signal Out of Range LOW
3242	7	DPFIT (page 502)	DPFIT sensor or circuit fault
3242	10	DPFIT (page 502)	DPFIT signal abnormal rate of change
3242	20	DPFIT (page 502)	DPFIT signal drifted high
3242	21	DPFIT (page 502)	DPFIT signal drifted low
3246	2	DPFOT (page 515)	DPFOT signal erratic, intermittent, or incorrect
3246	3	DPFOT (page 515)	DPFOT signal Out of Range HIGH
3246	4	DPFOT (page 515)	DPFOT signal Out of Range LOW
3246	7	DPFOT (page 515)	DPFOT not warming along with engine
3246	20	AFT SYS (page 346)	DPFOT signal drifted HIGH
3246	21	AFT SYS (page 346)	DPFOT signal drifted low
3251	0	AFT SYS (page 346)	DPFDP excessively high (plugged filter)
3251	2	AFT SYS (page 346)	DPFDP signal erratic, intermittent, or incorrect
3251	3	DPFDP (page 493)	DPFDP signal Out of Range HIGH
3251	4	DPFDP (page 493)	DPFDP signal Out of Range LOW
3251	10	DPFDP (page 493)	DPFDP in range stuck fault
3251	14	AFT SYS (page 346)	DPFDP sensor pressure hoses reversed
3251	21	AFT SYS (page 346)	DPFDP excessively LOW (Sensor/circuit fault or missing DPF)
3387	20	Cyl Bal (page 466)	Cyl 1 Balance maximum limit exceeded

SPN	FMI	Circuit	Condition Description
3387	21	Cyl Bal (page 466)	Cyl 1 Balance below minimum limit
3388	20	Cyl Bal (page 466)	Cyl 2 Balance maximum limit exceeded
3388	21	Cyl Bal (page 466)	Cyl 2 Balance below minimum limit
3389	20	Cyl Bal (page 466)	Cyl 3 Balance maximum limit exceeded
3389	21	Cyl Bal (page 466)	Cyl 3 Balance below minimum limit
3390	20	Cyl Bal (page 466)	Cyl 4 Balance maximum limit exceeded
3390	21	Cyl Bal (page 466)	Cyl 4 Balance below minimum limit
3391	20	Cyl Bal (page 466)	Cyl 5 Balance maximum limit exceeded
3391	21	Cyl Bal (page 466)	Cyl 5 Cyl Balance below minimum limit
3392	20	Cyl Bal (page 466)	Cyl 6 Balance maximum limit exceeded
3392	21	Cyl Bal (page 466)	Cyl 6 Balance below minimum limit
3464	3	ETV (page 764)	ETC short to PWR
3464	11	ETV (page 764)	ETC short to GND
3464	31	ETV (page 764)	Intake Throttle Actuator Control Short circuit
3464	4	ETV (page 764)	ETC short to GND
3471	1	AFTFD (page 321)	AFT Fuel Pressure 1 below desired (Low system pressure)
3471	7	AFTFD (page 321)	AFT Fuel Doser Valve not responding as expected
3471	10	AFTFD (page 321)	AFT Fuel Doser Valve abnormal rate of change
3479	3	AFTFD (page 321)	AFT Fuel Doser Valve short to PWR
3479	4	AFTFD (page 321)	AFT Fuel Doser Valve short to GND
3479	5	AFTFD (page 321)	AFT fuel doser valve open / load circuit
3479	6	AFTFD (page 321)	AFT fuel doser valve high side short circuit
3480	3	AFTFIS (page 535)	AFTFP1 signal Out of Range HIGH
3480	4	AFTFIS (page 535)	AFTFP1 signal Out of Range LOW
3482	3	AFTFSV (page 342)	AFT Fuel Shutoff Valve short to PWR
3482	4	AFTFSV (page 342)	AFT Fuel Shutoff Valve short to GND
3482	7	AFTFSV (page 342)	AFT Fuel Shutoff Valve not responding as expected (Applicable to 2010 only)
3509	3	VREF (page 1172)	VREF 1 voltage above maximum
3509	4	VREF (page 1172)	VREF 1 voltage below minimum
3510	3	VREF (page 1172)	VREF 2 voltage above maximum
3510	4	VREF (page 1172)	VREF 2 voltage below minimum
3511	3	VREF (page 1172)	VREF 3 voltage above maximum
3511	4	VREF (page 1172)	VREF 3 voltage below minimum

SPN	FMI	Circuit	Condition Description
3512	14	DCU VREF (page 478)	DCU VREF 1 or 2 voltage above or below normal
3556	0	AFT SYS (page 346)	AFT Fuel Pressure 2 below Warning Pressure
3556	1	AFT SYS (page 346)	AFT Fuel Pressure 2 below desired (Possible system leak)
3556	7	AFT SYS (page 346)	AFT Fuel Injector not responding as expected
3659	4	INJ (page 926)	Injector 1 close coil – short circuit
3659	5	INJ (page 926)	Injector 1 close coil – open circuit
3660	4	INJ (page 926)	Injector 2 close coil – short circuit
3660	5	INJ (page 926)	Injector 2 close coil – open circuit
3661	4	INJ (page 926)	Injector 3 close coil – short circuit
3661	5	INJ (page 926)	Injector 3 close coil – open circuit
3662	4	INJ (page 926)	Injector 4 close coil: short circuit
3662	5	INJ (page 926)	Injector 4 close coil – open circuit
3663	4	INJ (page 926)	Injector 5 close coil – short circuit
3663	5	INJ (page 926)	Injector 5 close coil – open circuit
3664	4	INJ (page 926)	Injector 6 close coil – short circuit
3664	5	INJ (page 926)	Injector 6 close coil – open circuit
3719	0	AFT SYS (page 346)	DPF Soot Load – Highest (level 3/3)
3719	15	AFT SYS (page 346)	DPF Soot Load – Lowest (level 1/3)
3719	16	AFT SYS (page 346)	DPF Soot Load – Moderate (level 2/3)
3936	0	AFT SYS (page 346)	DPF Soot Load – Severe De-Rate
3936	2	AFT SYS (page 346)	DOC/DPF Inlet unable to achieve light off temperature
3936	8	AFT SYS (page 346)	DPF regenerations are occurring too frequently
3936	14	AFT SYS (page 346)	DPF Regen duration above limit
3936	20	AFT SYS (page 346)	DOC inlet unable to achieve light off temperature
4077	3	AFTFP2 (page 338)	AFTFP2 signal Out of Range HIGH
4077	4	AFTFP2 (page 338)	AFTFP2 signal Out of Range LOW
4077	10	AFTFP2 (page 338)	AFTFP2 signal abnormal rate of change (Applicable to 2010 only)
4192	3	WIF (page 1199)	WIF signal Out of Range HIGH
4192	4	WIF (page 1199)	WIF signal Out of Range LOW
4192	5	WIF (page 1199)	WIF signal Open or Short to PWR
4192	31	WIF (page 1199)	Water in fuel detected
4227	7	CCOSS (page 456)	CC Oil Separator Speed: Not spinning

SPN	FMI	Circuit	Condition Description
4257	7	Injector Performance (page 1042)	Injector coking compensation factor reached maximum authority
4257	16	Injector Performance (page 1042)	Multiple injector high flow fault
4257	18	Injector Performance (page 1042)	Multiple injector low flow fault
4287	0	ECBP (page 556)	ECBP above desired level
4287	1	ECBP (page 556)	ECBP below desired level
4287	3	ECBP (page 556)	ECBP signal Out of Range HIGH
4287	4	ECBP (page 556)	ECBP signal Out of Range LOW
4752	4	EGR Cooler (page 702)	Exhaust Gas Recirculation (EGR) cooler efficiency: EGR outlet temp above expected
4765	2	DOCIT (page 493)	DOCIT signal erratic, intermittent, or incorrect
4765	3	DOCIT (page 493)	DOCIT signal Out of Range HIGH
4765	4	DOCIT (page 493)	DOCIT signal Out of Range LOW
4765	7	DOCIT (page 493)	DOCIT not increasing with engine temp
4765	20	DOCIT (page 493)	DOCIT signal drifted HIGH
4765	21	DOCIT (page 493)	DOCIT signal drifted LOW
4766	10	AFT System (page 346)	DOCOT below minimum desired during regen
5319	31	AFT System (page 346)	DPF incomplete regeneration
5395	0	Engine Idle Torque (page 720)	Engine unable to achieve desired idle torque (too high)
5395	1	Engine Idle Torque (page 720)	Engine unable to achieve desired idle torque (too low)
5456	2	AFTFIS (page 535)	Aftertreatment Fuel Inlet Temperature (AFTFIT) signal erratic, intermittent, or incorrect
5456	3	AFTFIS (page 535)	AFTFT signal Out of Range HIGH
5456	4	AFTFIS (page 535)	AFTFT signal Out of Range LOW
5541	1	EBPV (page 535)	TC1TOP pressure below minimum
5541	2	EBPV (page 535)	TC1TOP signal erratic, intermittent or incorrect
5541	3	EBPV (page 535)	TC1TOP signal Out of Range HIGH
5541	4	EBPV (page 535)	TC1TOP signal Out of Range LOW
5543	3	EBPV (page 535)	EBPC short to PWR
5543	4	EBPV (page 535)	EBPC short to GND
5543	5	EBPV (page 535)	EBPC open load/circuit

Name	ProStar	LCF	Comments
Warn Engine Lamp (WEL)	Amber	Amber	The Warn Engine lamp will illuminate when a non-emissions fault is detected in the engine control system.
Malfunction Indicator Lamp (MIL)	Amber	Amber	The Malfunction Indicator lamp will illuminate when an emissions fault is detected in the engine control system
Stop Engine / Water and Oil Lamp (OWL)	Red	Red	The STOP engine lamp will illuminate when a critical engine condition is detected by the engine control system. (Coolant over temp, Low oil pressure, Low coolant level, Critically Over-Loaded DPF)
DPF Regeneration Lamp (Regen)	Amber	Amber	The DPF regeneration lamp will illuminate when the DPF is reaching various stages of overloading. The lamp will not be illuminated when the system is performing an ordinary active or inactive DPF Regeneration. This light being on is a requirement to enable a stationary regeneration.
HOT Exhaust Lamp	Amber	Amber	The HOT Exhaust lamp will illuminate when the exhaust system temperature goes above 400 F with vehicle speed less then 5 mph

K35294

Figure 541 Warning Lamps

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Electrical Tools

24-Pin IP Engine Cable

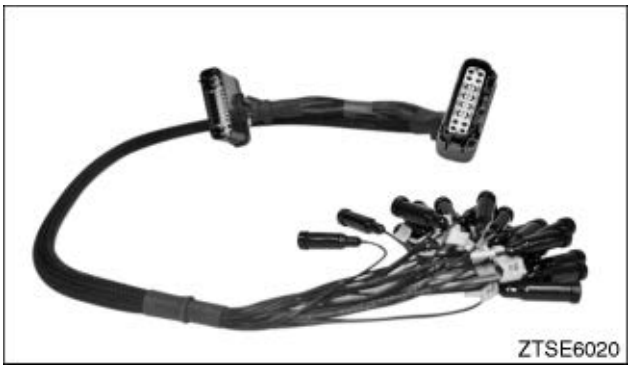


Figure 542 ZTSE6020

The 24-pin IP Engine Cable is used to test the 24-pin connector circuits.

Radiator Pressure Test Kit

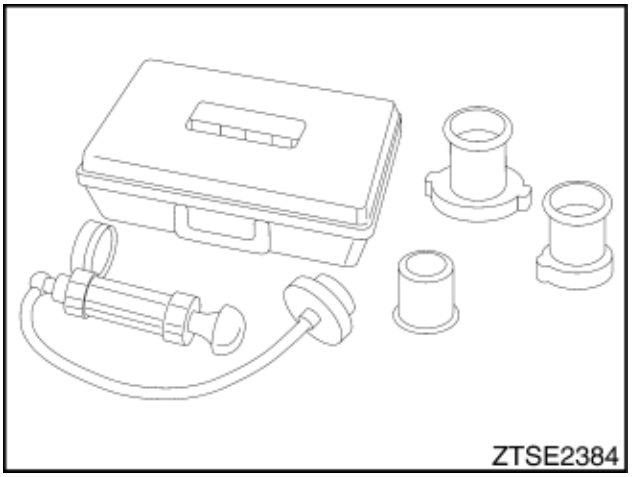


Figure 543 ZTSE2384

The Radiator Pressure Test Kit is used to check pressure caps and cooling systems. The pressure gauge indicates if the pressure cap holds the correct pressure and whether the cooling system has leaks or holds pressure.

36-Pin Injector Driver Cable



Figure 544 3036

The 36-Pin Injector Driver Cable with breakout box overlay (pin identifier) sheet is used with the 180-Pin Breakout Box to test the injector circuits to the ECM with no ECM connection.

42-Pin Engine to Chassis Interface Cable

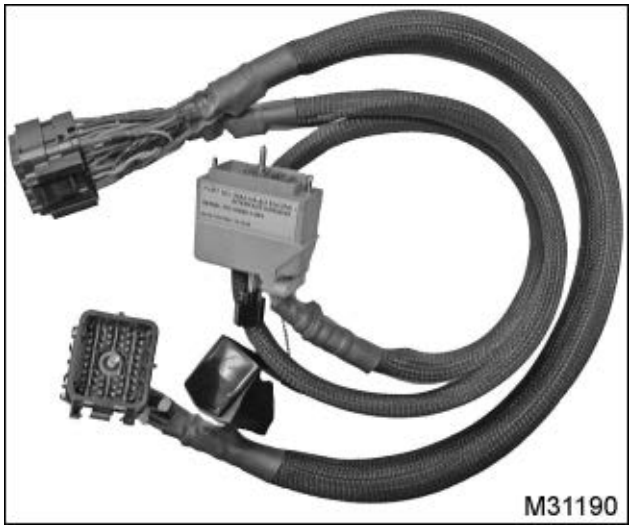


Figure 545 00–00979–01

The 42-pin Engine to Chassis Interface Cable with breakout box overlay (pin identifier) sheet is used with the 180-pin Breakout Box to test the 42-pin connector circuits.

76-Pin Engine and Chassis Cables



Figure 546 3152-N4-8\3

The 76-pin Engine and Chassis Cables (2 cables) with breakout box overlay (pin identifier) sheet are used with the 180-Pin Breakout Box. These jumpers are used to test the circuits going to the engine and chassis 76-pin connectors on the ECM.

180-Pin Breakout Box

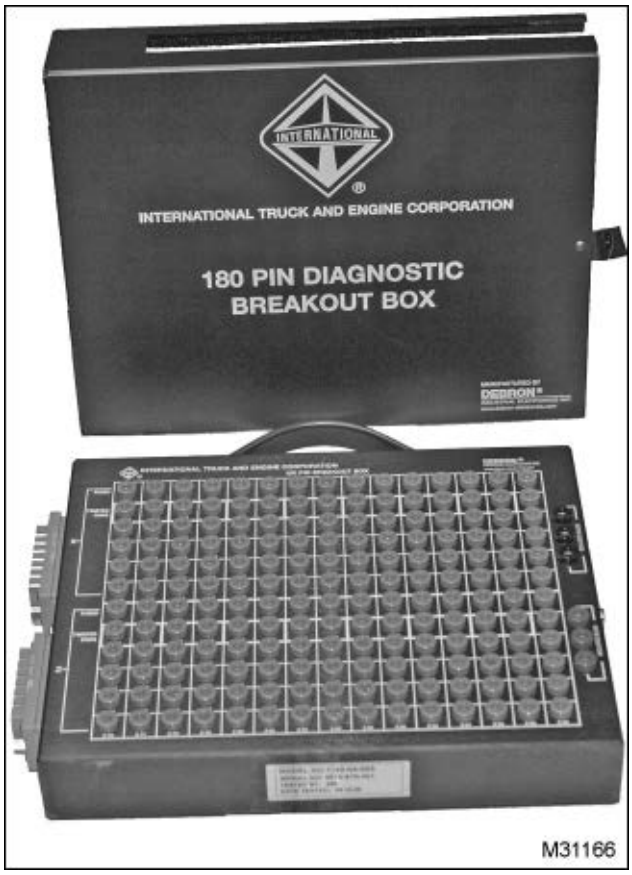


Figure 547 00–00956–08

The 180-Pin Breakout Box allows testing of electronic control system components without disturbing connections or piercing wire insulation to access various signal voltages in the electronic control system.

CAUTION: To prevent damage to the breakout box, the breakout box is used for measurement only, not to activate or control circuits. High current levels passing through the breakout box will burn out the internal circuitry.

This box is universal and can adapt to any control system by means of a unique jumper harness. Each jumper harness is a separate part, complete with a 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.

Amp Clamp ZTSE4575



Figure 548 ZTSE4575

The Amp Clamp ZTSE4575 is used to measure amperage draw for the Intake Air Heater (IAH).

Digital Multimeter (DMM)



Figure 549 ZTSE4357

The DMM is used to troubleshoot electrical components, sensors, injector solenoids, relays, and wiring harnesses. The DMM has a high input impedance that allows testing of sensors while the engine is running, without loading the circuit being tested. This ensures the signal voltage measurement will not be affected by the voltmeter.

EXP-1000 HD by Midtronics



Figure 550 EXP-1000 HD INTL

The EXP-1000 HD by Midtronics is used to measure amperage draw for the intake air heater.

EZ-Tech® Electronic Service Tool (EST)

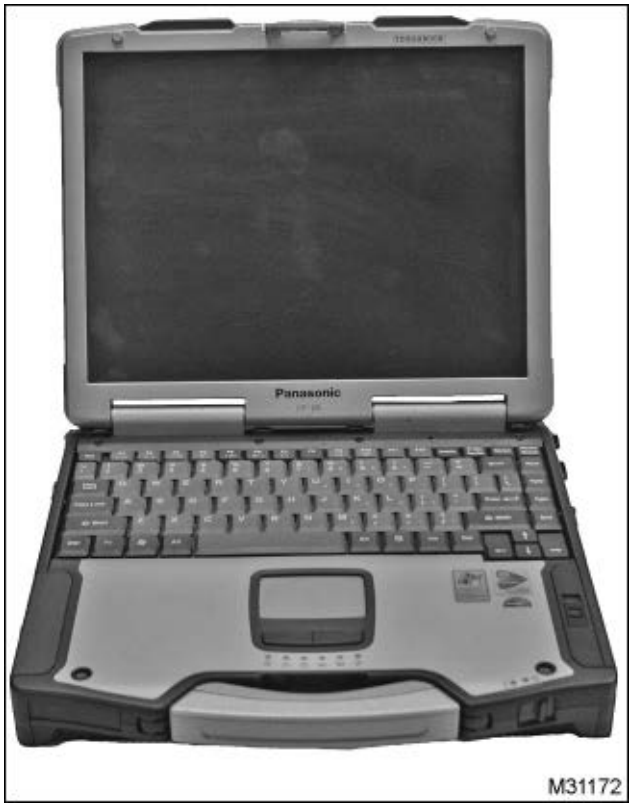


Figure 551 3114492C1

The EST is used to run ServiceMaxx™ software for diagnosing and troubleshooting engine and vehicle problems.

The 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.

International® Electronic Engine Terminal Test Kit ZTSE4435C



Figure 552 ZTSE4435C

The International® Electronic Engine Terminal Test Kit ZTSE4435C is used to access circuits in the connector harness and allows for the use of a Digital Multimeter (DMM) without damaging the harness connectors. The probes may also be used as a guide to determine whether the harness connector is retaining correct tension on the mating terminal.

Interface cable (RP1210B compliant supporting J1939 and J1708)



Figure 553 Interface cable (RP1210B compliant supporting J1939 and J1708)

The Interface cable (RP1210B compliant supporting J1939 and J1708) is used to connect the EST to ECM. The Interface cable (RP1210B compliant supporting J1939 and J1708) is an alternative to the NAVCoM Interface Kit.

3-Banana Plug Harness

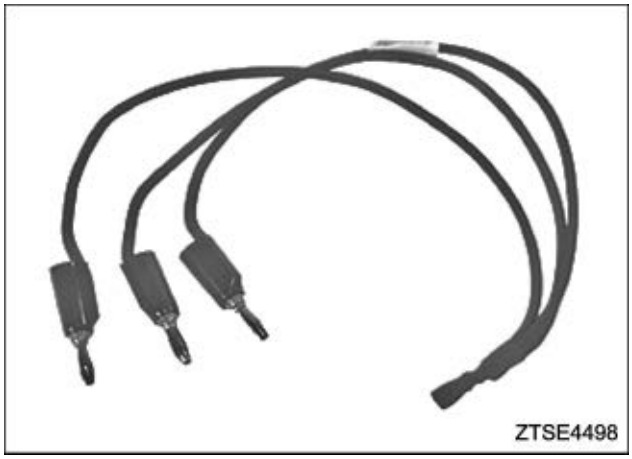


Figure 554 ZTSE4498

The 3-Banana Plug Harness is used for sensor end diagnostics of sensor circuits.

500-Ohm Resistor Harness



Figure 555 ZTSE4497

The 500-Ohm Resistor Harness is used for sensor end diagnostics of sensor circuits.

Breakout Harness ZTSE4484 (IPR)

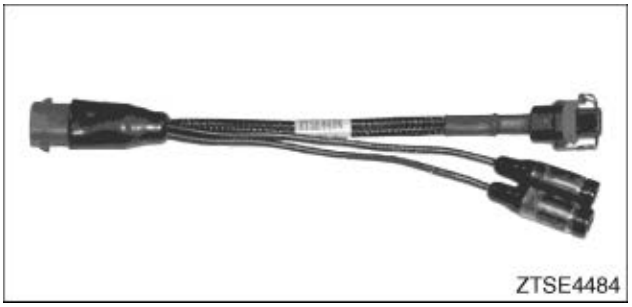


Figure 556 ZTSE4484

Breakout Harness ZTSE4484 is used to measure the voltage and resistance on circuits that go to the Engine Injection Control Pressure Regulator (IPR).

Breakout Harness ZTSE4485A (APP)

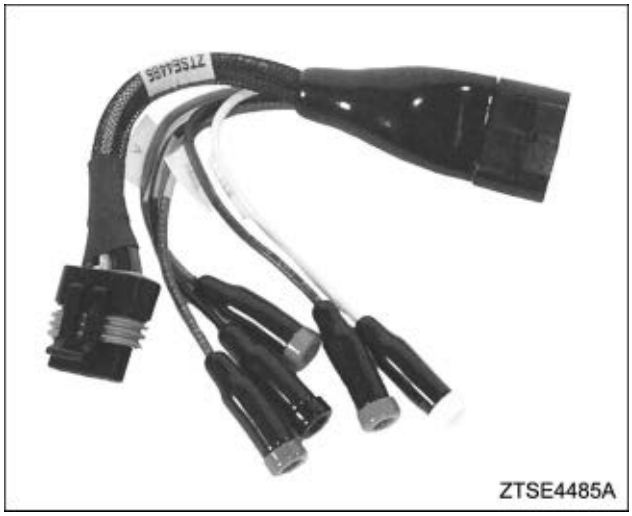


Figure 557 ZTSE4485A

Breakout Harness ZTSE4485A is used to measure voltage and resistance on circuits that go to the Accelerator Pedal Position (APP) sensor.

Breakout Harness ZTSE4602 (EOT, ECT1, and AFTFSV)

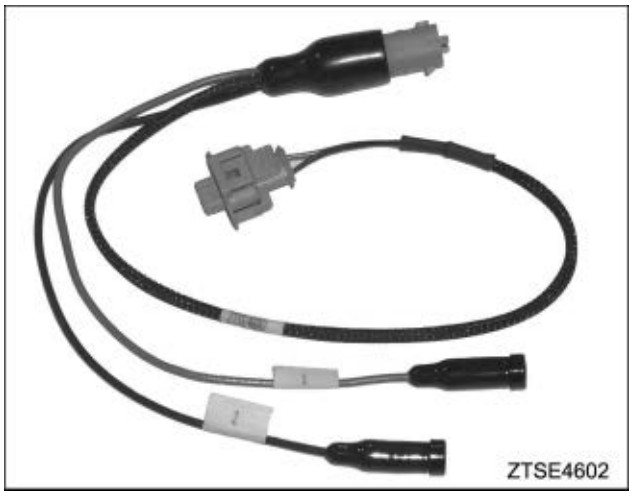


Figure 558 ZTSE4602

Breakout Harness ZTSE4602 is used to measure voltage and resistance on circuits that go to the Engine Oil Temperature (EOT), Engine Coolant Temperature 1 (ECT1), and Aftertreatment Fuel Shutoff Valve (AFTFSV).

Breakout Harness ZTSE4674 (ECM and ACT PWR Relays)

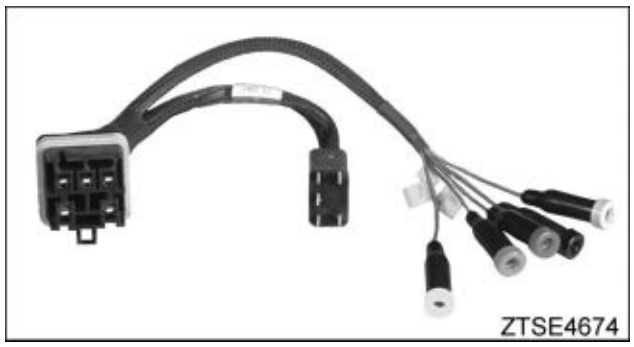


Figure 559 ZTSE4674

Breakout Harness ZTSE4674 is used to measure voltage and resistance on circuits that go to the Engine Control Module (ECM) and Actuator (ACT) PWR relays.

Breakout Harness ZTSE4735A (ETV)



Figure 560 ZTSE4735A

Breakout Harness ZTSE4735A is used to measure voltage and resistance on circuits connected to the Engine Throttle Valve (ETV).

Breakout Harness ZTSE4760A (DOCIT, DPFIT, and DPFOT)

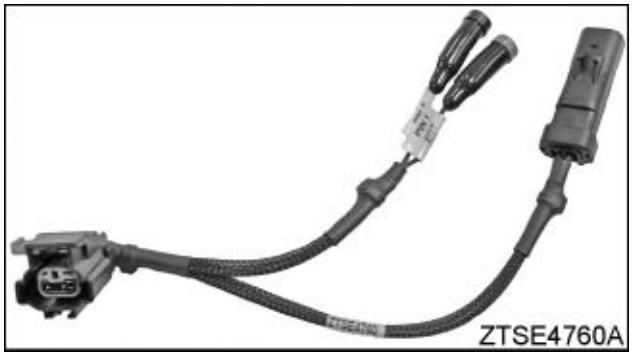


Figure 561 ZTSE4760A

Breakout Harness ZTSE4760A is used to measure voltage and resistance on circuits that go to the Diesel Oxidation Catalyst Intake Temperature (DOCIT), Diesel Particulate Filter Intake Temperature (DPFIT), and Diesel Particulate Filter Outlet Temperature (DPFOT) sensors.

Breakout Harness ZTSE4761A (DPFDP)

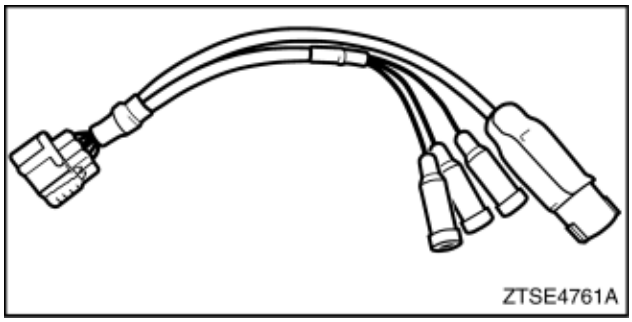
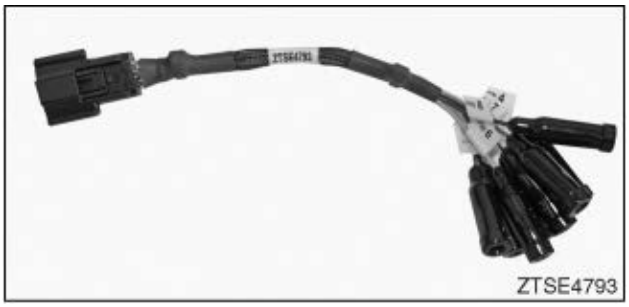


Figure 562 ZTSE4761A

Breakout Harness ZTSE4761A is used to measure voltage and resistance on circuits that go to the Diesel Particulate Filter Differential Pressure (DPFDP) sensor.

Breakout Harness 4793 (UVC)



Breakout Harness 4793 is used to measure voltage and resistance on circuits connected to the Under Valve Cover (UVC) Wiring-Injector solenoids.

Breakout Harness ZTSE4830 (AFTFIS)

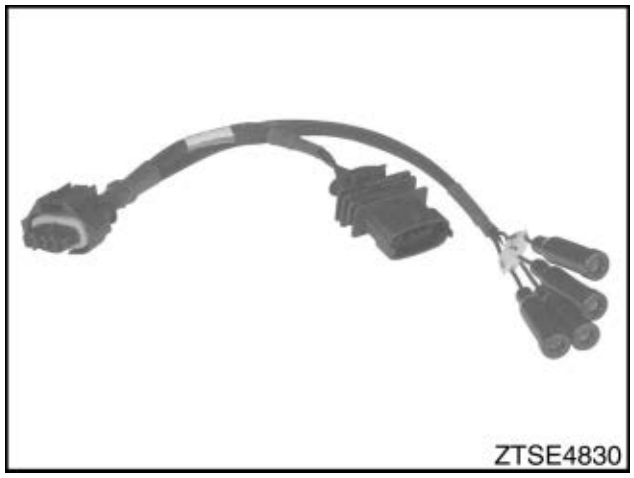


Figure 564 ZTSE4830

Breakout Harness ZTSE4830 is used to measure voltage and resistance on circuits connected to the Aftertreatment Fuel Inlet Sensor (AFTFIS).

Breakout Harness ZTSE4831 (TC2WG)



Figure 565 ZTSE4831

Breakout Harness ZTSE4831 is used to measure voltage and resistance on circuits connected to the Turbocharger 2 Wastegate Control Actuator (TC2WG).

Breakout Harness ZTSE4834 (EBPV)

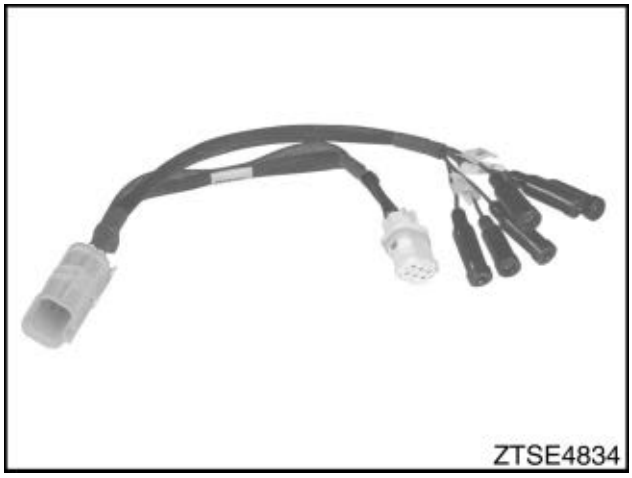


Figure 566 ZTSE4834

Breakout Harness ZTSE4834 is used to measure voltage and resistance on circuits connected to the Exhaust Back Pressure Valve (EBPV).

Breakout Harness ZTSE4850 (IMP, ICP, EOP, FDP, and EBP)

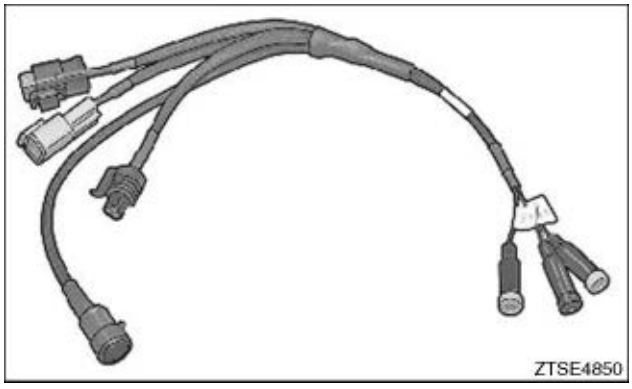


Figure 567 ZTSE4850

Breakout Harness ZTSE4850 is used to measure voltage and resistance on circuits connected to the Intake Manifold Pressure (IMP), Injection Control Pressure (ICP), Engine Oil Pressure (EOP), Fuel Delivery Pressure (FDP), and Exhaust Back Pressure (EBP) sensors.

Breakout Harness ZTSE4908 (EFAN)

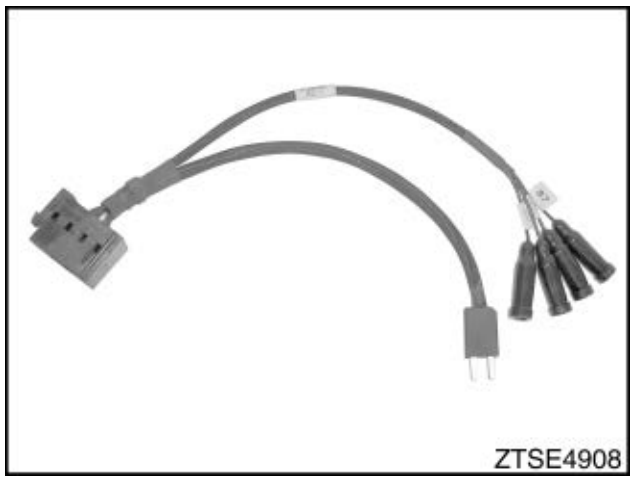


Figure 568 ZTSE4908

Breakout Harness ZTSE4908 is used to measure voltage and resistance on circuits to the Starter Relay and Engine Fan (EFAN) relay.

Breakout Harness ZTSE4946 (EGT)



Figure 569 ZTSE4946

Breakout Harness ZTSE4946 enables the technician to quickly connect a voltmeter and read voltage signals for the Exhaust Gas Temperature (EGT) sensor.

Breakout Harness ZTSE4948 (EGR)



Figure 570 ZTSE4948

Breakout Harness ZTSE4948 is used to measure voltage and resistance on circuits that go to the Exhaust Gas Recirculation (EGR) valve.

Breakout Harness ZTSE4950 (CKP)



Figure 571 ZTSE4950

Breakout Harness ZTSE4950 is used to measure voltage and resistance on circuits connected to the Crankshaft Position (CKP) sensor.

Breakout Harness ZTSE4951 (CMP)

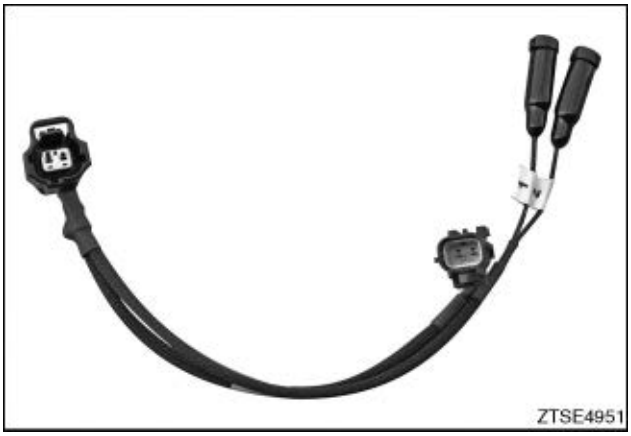


Figure 572 ZTSE4951

Breakout Harness ZTSE4951 is used to measure voltage and resistance on circuits connected to the Camshaft Position (CMP) sensor and the Crankcase Oil Separator Speed (CCOSS) sensor.

Breakout Harness ZTSE4952 (ICP, ECB, and ECBP)



Figure 573 ZTSE4952

Breakout Harness ZTSE4952 is used to measure continuity of the Injection Control Pressure (ICP) sensor, Engine Compression Brake (ECB), and the Engine Compression Brake Pressure (ECBP) sensor.

Breakout Harness 4960 (MAF)



Figure 574 ZTSE4960

Breakout Harness 4960 is used to measure voltage and resistance on circuits that go to the Mass Air Flow (MAF) sensor.

Breakout Harness ZTSE4993 (IMT)

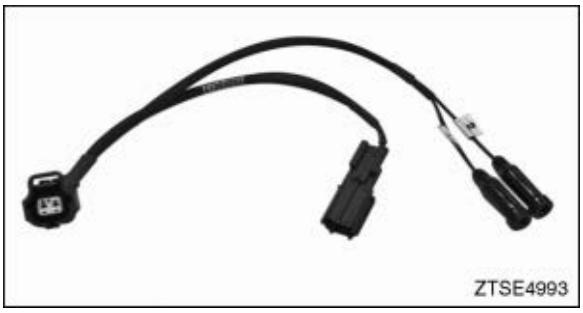


Figure 575 ZTSE4993

Breakout Harness ZTSE4993 is used to measure voltage and resistance on circuits that go to the Intake Manifold Temperature (IMT), Charge Air Cooler Outlet Temperature (CACOT) Sensor and High Pressure Turbo Intake Temperature (HPCIT) sensor.

Breakout Harness ZTSE6002 (WIF)

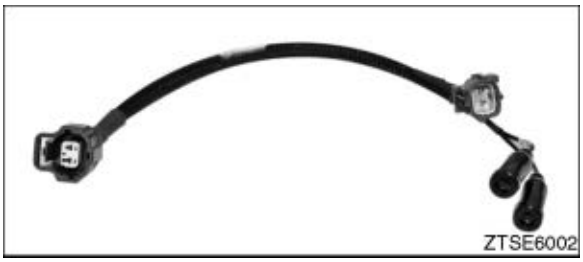


Figure 576 ZTSE6002

Breakout Harness ZTSE6002 is used to measure voltage and resistance on circuits that go to the Water In Fuel (WIF) sensor.

Breakout Harness ZTSE6020 (24-pin)

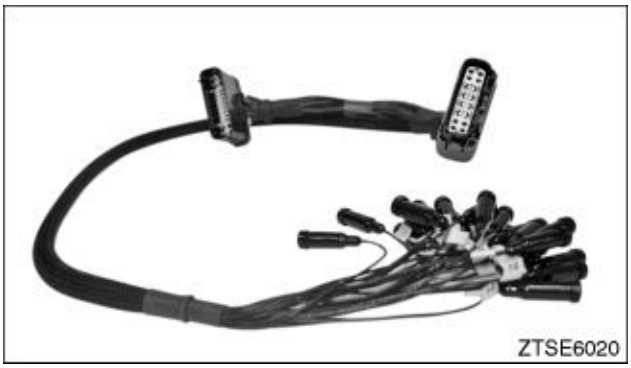


Figure 577 ZTSE6020

Breakout Harness ZTSE6020 is used to measure voltage and resistance on circuits that go to the 24-pin Engine / IP connector.

Breakout Harness ZTSE6021 (AFTFD)

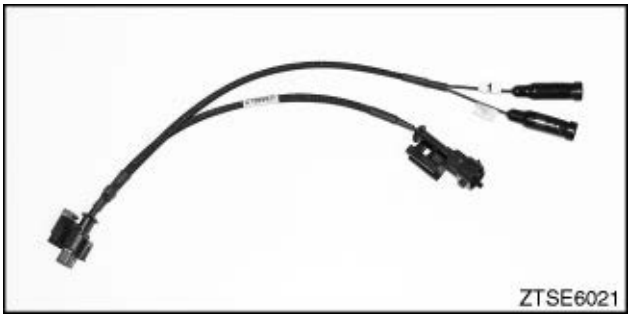


Figure 578 ZTSE6021

Breakout Harness ZTSE6021 is used to measure voltage and resistance on circuits connected to the Aftertreatment Fuel Doser (AFTFD).

Breakout Harness ZTSE6023 (EFP)



Figure 579 ZTSE6023

Breakout Harness ZTSE6023 is used to measure voltage and resistance on circuits that go to the Electronic Fuel Pump (EFP).

Breakout Harness ZTSE6025 (IAH)



Figure 580 ZTSE6025

Breakout Harness ZTSE6025 is used to measure voltage and resistance on circuits that go to the Intake Air Heater (IAH) relay.

Breakout Harness ZTSE6027 (AFTFP)



Figure 581 ZTSE6027

Breakout Harness ZTSE6027 is used to measure voltage and resistance on circuits that go to the Aftertreatment (AFT) Fuel Pressure (AFTFP) sensor.

Under Valve Cover (UVC) ZTSE4793

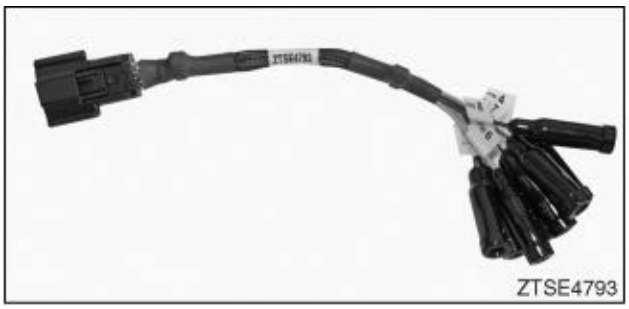


Figure 582 ZTSE4793

UVC Wiring (for injector solenoids, ICP sensor, SCB sensor and Engine Compression Brake Pressure (ECBP) Sensor).

DEF Tank Heat Coolant Flow Valve ZTSE4827



Figure 583 ZTSE4827

Diesel Exhaust Fluid Dosing Unit (DEFDU) ZTSE4828

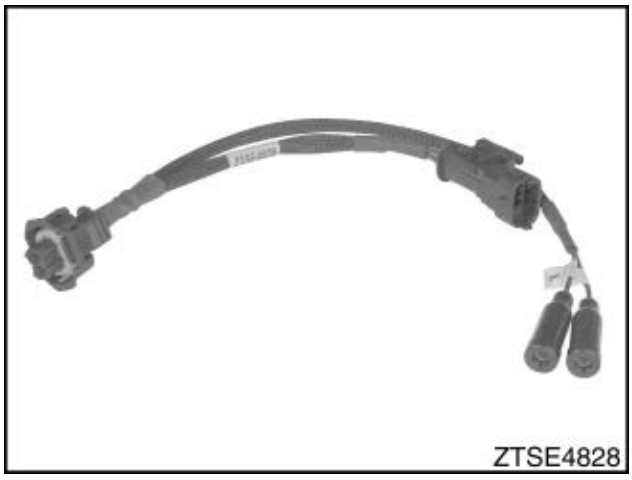


Figure 584 ZTSE4828

Mass Air Flow (MAF) Sensor ZTSE4960

Mechanical Tools

Charge Air Cooler Test Kit

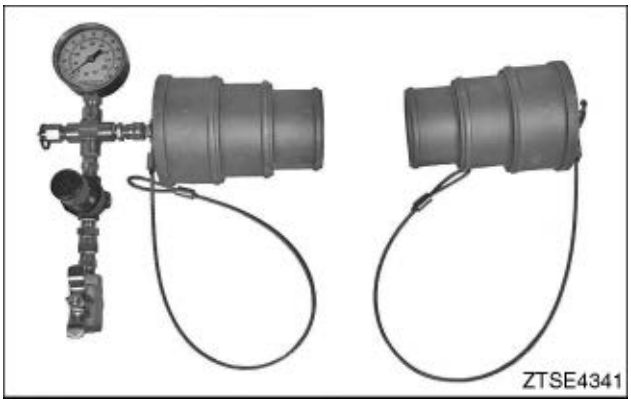


Figure 586 ZTSE4341

The Charge Air Cooler Test Kit is used to pressurize the charge air cooler and piping to check for leaks.

Clean Fuel Tank Tool

GRAPHIC PLACE HOLDER

Figure 587 TBD

The Clean Fuel Tank Tool is used to provide a clean, alternative fuel source to aid in the diagnosis of the fuel system.

Combustion in Cooling System Tester



The Combustion in Cooling System Tester is used in testing for signs of combustion gas present in coolant system.

Crankcase Pressure Test Tool

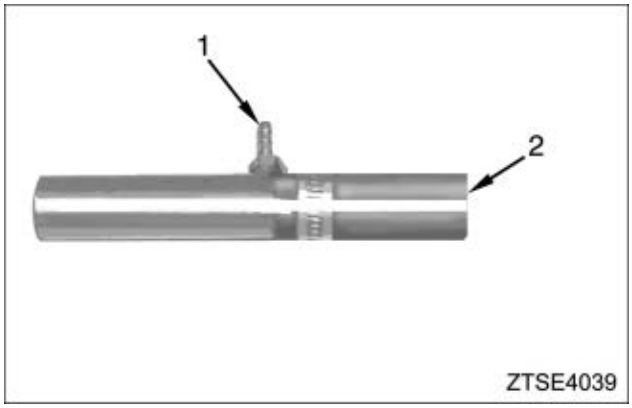


Figure 589 ZTSE4039 (0.406 in. diameter)

1. To magnehelic gauge or manometer
2. To valve cover

The Crankcase Pressure Test Tool is used to measure combustion gas flow from the valve cover and may be used with the magnehelic gauge or Slack Tube® manometer.

Use the pressure readings obtained with this adapter as the main source of engine condition. Use oil consumption trend data if the pressure readings are over the specified limits. Neither changes in oil consumption trends nor crankcase diagnostic pressure trends can establish a specific problem. These changes only indicate that a problem exists.

Digital Manometer



Figure 590 Obtain locally

The Digital Manometer is used to measure low vacuum due to intake restriction or low crankcase pressure. A variety of digital manometers are available for purchase locally. The Water Manometer kit (ZTSE2217A) is an alternative to the Digital Manometer

EGR Cooler Leak Detection Kit



Figure 591 KL 20030 NAV

1. KL 20040 NAV (2010 MaxxForce® 7)
2. KL 20020 NAV (2007 MaxxForce® DT, 9, and 10)
3. KL 20030 NAV (2010 MaxxForce® DT, 9, and 10)

The EGR Cooler Leak Detection Test Kit is used to pressure test the Exhaust Gas Recirculation (EGR) cooler for leaks. KL 20020 NAV contains the plastic case with the EGR Cooler Leak Detection Test Kit for the 2007 MaxxForce® DT, 9, and 10. KL 20040 NAV is an add-on kit that contains the EGR Cooler Leak Detection Test Kit for the 2010 MaxxForce® 7. KL 20030 NAV is an add-on kit that contains the EGR Cooler Leak Detection Test Kit the 2010 MaxxForce® DT, 9, and 10. The three test kits can be purchased separately.

EGR Mixing Bowl Guide Pins



Figure 592 ZTSE4945

The EGR mixing Bowl guide pins are used while installing the EGR mixing bowl to not damage the gasket.

EGR Valve Puller



Figure 593 ZTSE4941

The EGR valve puller is used to removed the EGR valve without damaging the valve.

Fuel Inlet Restriction and Aeration Tool



Figure 594 ZTSE6009

The Fuel Inlet Restriction and Aeration Tool is used to check for pressure and aerated fuel in the low-fuel pressure system.

Fuel/Oil Pressure Test Coupler



Figure 595 ZTSE4526

The Fuel / Oil Pressure Test Coupler is used with the fuel pressure test fitting for an easy connection to measure fuel pressure.

Fuel Pressure Gauge

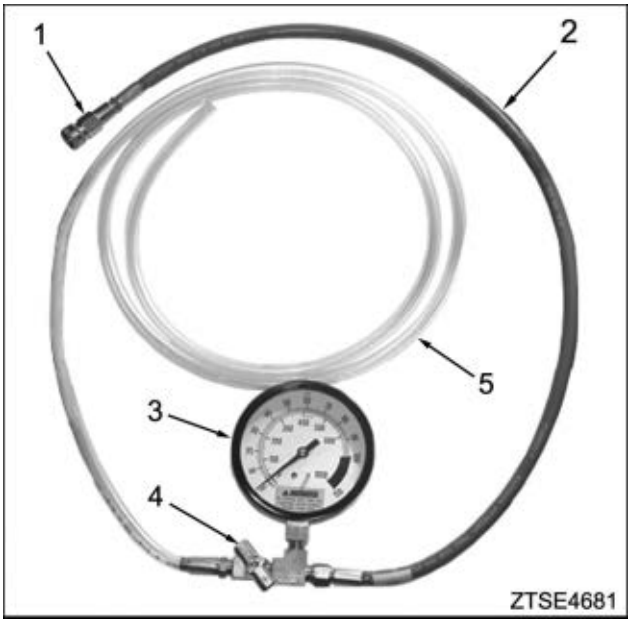


Figure 596 ZTSE4681

1. Quick disconnect check valve
2. Fuel test line
3. Fuel Pressure Gauge
4. Inline shut-off valve
5. Clear test line

The Fuel Pressure Gauge is used to check for fuel pressure and aerated fuel in the low-fuel pressure system.

Fuel Pressure Test Kit



Figure 597 ZTSE4657

1. Compression fitting 1/8 NPT
2. 90° elbow
3. Quick disconnect check valve
4. Fuel pressure test adapter

The Fuel Pressure Test Kit includes a quick disconnect check valve and fittings that can be used to make a test line to check fuel pressure at the high-pressure fuel rail.

Fuel Test Fitting



Figure 598 ZTSE4692

The fuel test fitting is used to measure fuel inlet restriction or fuel pressure.

When measuring fuel inlet restriction, the fitting is installed at the diagnostic port (inlet-side) of the fuel filter housing.

When measuring fuel pressure, the fitting can be installed on the fuel rail instead of the Shrader valve.

The Fuel/Oil Pressure Test Coupler can then be connected to the fuel test fitting to measure fuel pressure or fuel inlet restriction.

High Pressure Test Gauge

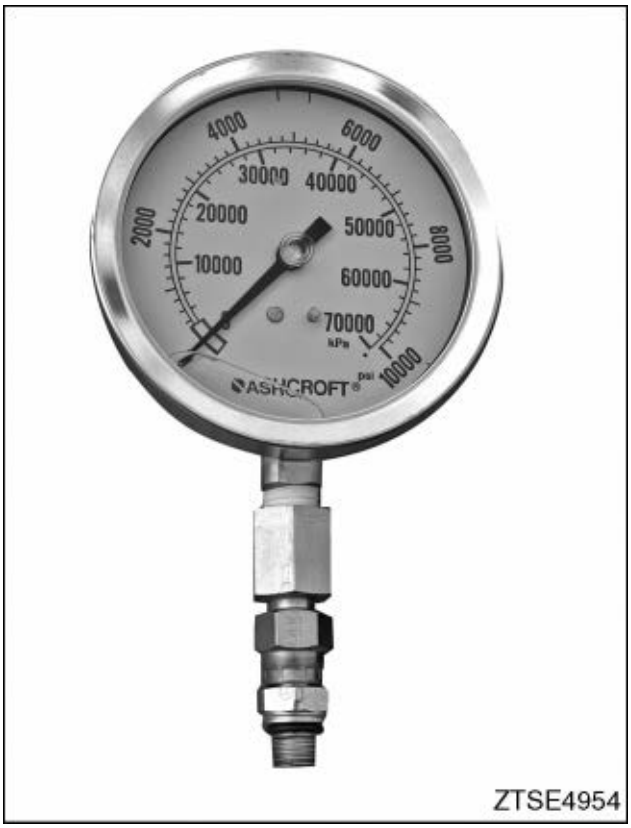


Figure 599 ZTSE4954

The High Pressure Test Gauge is used with the ICP Adapter Pressure Test Fitting (ZTSE4927) to measure injection control pressure coming out of the high-pressure pump.

Pressure Test Kit

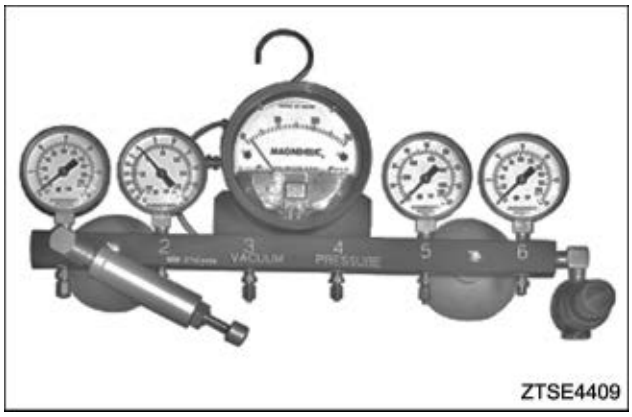


Figure 600 ZTSE4409

The Pressure Test Kit is used to measure intake manifold (boost) pressure, fuel system inlet restriction, fuel pressure, oil pressure, air cleaner intake restriction, and crankcase pressure.

- 0 to 200 kPa (0 to 30 psi) measures intake manifold pressure.
- 0-30 in Hg vacuum /0 to 200 kPa (0 to 30 psi) compound gauge measures fuel system inlet restriction and intake manifold pressure.

  0-30 in H_2O 0 to 7.5 kPa (0 to 1 psi) maximum pressure magnehelic gauge measures crankcase pressure and air inlet restriction.
- 60 to 1100 kPa (0 to 160 psi) gauge may be used to check the fuel pressure and oil pressure.

CAC Block Off Kit

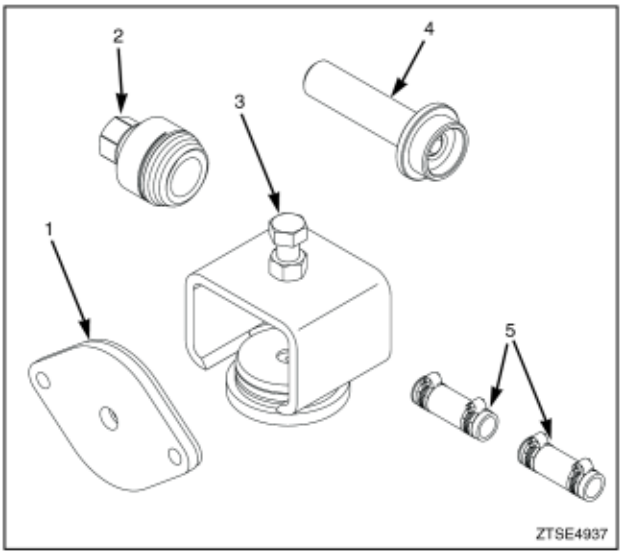


Figure 601 ZTSE4937

1. Test plate
2. Seal Remover
3. Test plug
4. Seal installer
5. Test cap

The CAC Block Off Kit is used to pressure test the interstage cooler (if available) and check for leaks.

Oil Cooler Test Plate



Figure 602 ZTSE4939

The Oil Cooler Test Plate is used to test the integrity of the oil cooler.

High Pressure Test Gauge

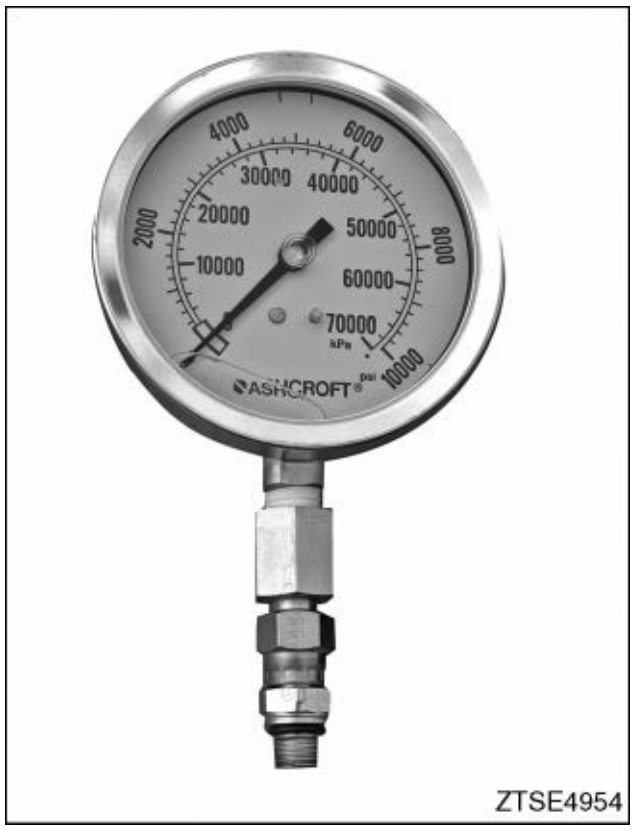


Figure 603 ZTSE4954

The High Pressure Test Gauge is used with the ICP Adapter Pressure Test Fitting (ZTSE4927) to measure injection control pressure coming out of the high-pressure pump.

ICP Adapter Pressure Test Fitting



Figure 604 ZTSE4927

The ICP Adapter Pressure Test Fitting is used with the High Pressure Test Gauge (ZTSE4954) to measure injection control pressure coming out of the high-pressure pump.

ICP Test Kit

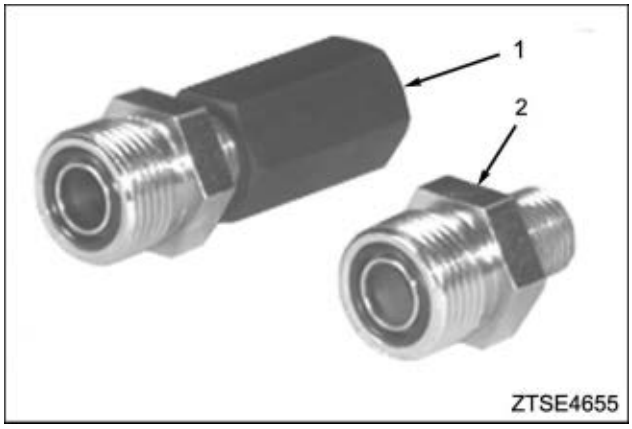


Figure 605 ZTSE4655

1. Fitting 13/16 - 16 NPT
2. ICP sensor adapter

NOTE: Sensor for test has to be acquired locally.

The ICP Test Kit is used to check ICP system diagnostics. The ICP adapter is used with an ICP sensor and the Under Valve Cover (UVC) gasket breakout harness to check the integrity of the high-pressure pump and IPR. The fitting is adapted to an air line to pressurize the UVC components and check for leaks.

Inline Shut-off Valve



Figure 606 Part No. 221406

The Inline Shut-off Valve is used to make a test line to check for aerated oil, specifically at the EOT sensor port. The Shut-Off valve can also be used to make a test line assembly to check for aerated fuel.

IPR Plug Tester

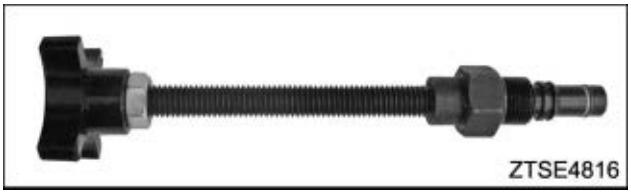


Figure 607 ZTSE4816

The IPR Plug Tester is used to check the high-pressure pump for inability to reach maximum injection control pressure.

Pressure Vacuum Module



Figure 608 Locally available

The Pressure Vacuum Module is used for pressure and vacuum measurements. A variety of pressure vacuum modules are available for purchase locally.

Turbo Lifting Bracket

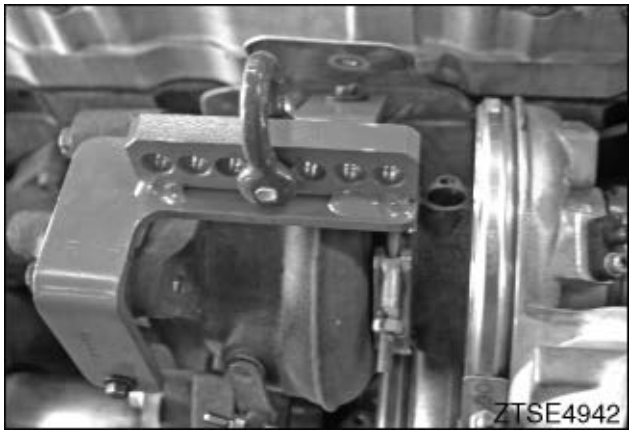


Figure 609 ZTSE4942

The Turbo Lifting Bracket is used to aid in the removal of the turbo assembly.

Slack Tube® Manometer

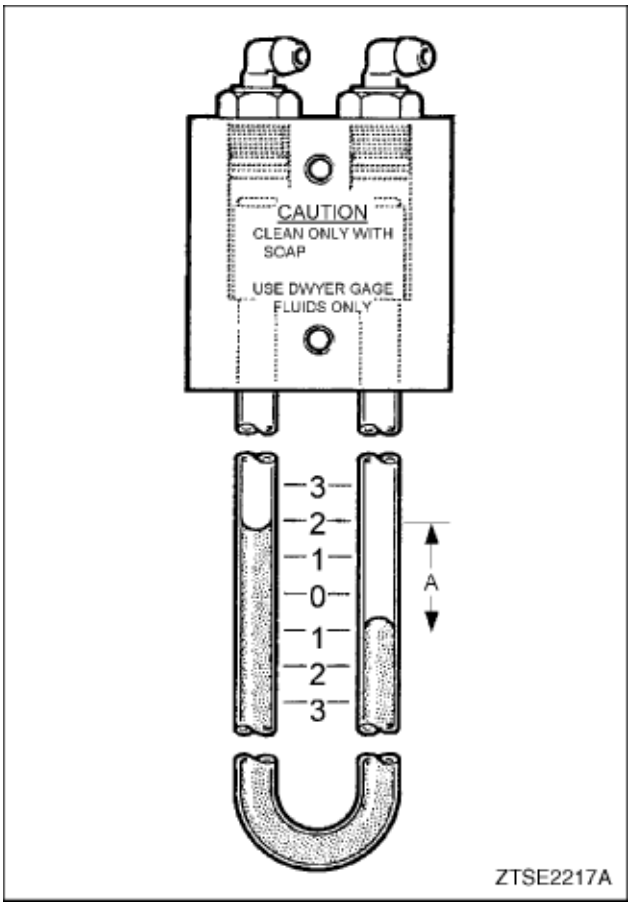


Figure 610 ZTSE2217A

The Slack Tube® Manometer is a U-shaped tube with a scale mounted between the legs of the tube. When the portability of the Pressure Test Kit is not required, this manometer is used to measure low vacuum for intake restriction, low pressure for crankcase, or exhaust back pressure.

Filling

Fill the manometer with water before checking pressure. Use only distilled water. Add some colored water vegetable dye so the scale can be read more easily. With both legs of the manometer open to the atmosphere, fill the tube until the top of the fluid column is near the zero mark on the scale. Shake the tube to eliminate any air bubbles.

Installing, Reading, and Cleaning

1. Support the manometer vertically. Make sure the fluid level is in line with the zero indicator on the graduated scale.
2. Connect one leg of the manometer to the source of the pressure or vacuum. Leave the other leg open to atmospheric pressure.
3. Start the engine and allow it to reach normal operating temperature. Then run the engine to high idle. The manometer can be read after 10 seconds.

4. Record the average position of the fluid level when it is above and below the zero indicator. Add the two figures together. The sum of the two is the total column of fluid (distance A). This represents the crankcase pressure in inches of water (in-H_2O).

   At times, both columns of the manometer will not travel the same distance. This is no concern if the leg is not connected to the pressure or the vacuum source is open to the atmosphere.

5. Compare the manometer reading with engine specifications.

6. When the test is done, clean the tube thoroughly using soap and water. Avoid liquid soaps and solvents.

UV Leak Detection Kit



Figure 611 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 612 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

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
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
AFTFD-H – Aftertreatment Fuel Doser High
AFTFD-L – 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
AFTFS-H – Aftertreatment Fuel Shutoff High
AFTFS-L – 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
ATA-H – American Trucking Association Link High
ATA-L – 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
CAN-H – Controller Area Network High
CAN-L – Controller Area Network Low
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
CKP-H – Crankshaft Position High
CKP-L – Crankshaft Position Low
CKPO – Crankshaft Position Out
cm – Centimeter
CMP – Camshaft Position
CMP-H – Camshaft Position High
CMP-L – 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
DCU – Doser Control Unit
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
EOL – Engine Oil Level
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
ETC-H – Engine Throttle Control High
ETC-L – Engine Throttle Control Low
ETP – Engine Throttle Position
ETV – Engine Throttle Valve
ETV-H – Engine Throttle Valve High
ETV-L – Engine Throttle Valve Low
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

H_2O – Water
HC – Hydrocarbons
HCI – Hydrocarbon Injection
HEST – High Exhaust System Temperature
HFCM – Horizontal Fuel Conditioning Module
Hg – Mercury
hp – Horsepower
HPCAC – High-Pressure Charge Air Cooler
HPCR – High-Pressure Common Rail
HPFP – High-Pressure Fuel Pump
hr – Hour
HS – Humidity Sensor
Hyd – Hydraulic

IAH – Intake Air Heater
IAHC – Intake Air Heater Control
IAHD – Intake Air Heater Diagnostic
IAHR – Intake Air Heater Relay
IAT – Intake Air Temperature
IC – Integrated Circuit
ICP – Injection Control Pressure
ICPR – Injection Control Pressure Regulator
ICG1 – Injector Control Group 1
ICG2 – Injector Control Group 2
ID – Inside Diameter
IDM – Injector Driver Module
IGN – Ignition
ILO – Injector Leak Off
IMP – Intake Manifold Pressure
IMT – Intake Manifold Temperature
in – Inch
inHg – Inch of mercury
inH_2O – Inch of water
INJs – Injectors
IPR – Injection Pressure Regulator
IPR PWR – Injection Pressure Regulator Power
ISC – Interstage Cooler
ISIS® – International® Service Information Solutions

IST – Idle Shutdown Timer
ITP – Internal Transfer Pump
ITV – Intake Throttle Valve
ITV-H – Intake Throttle Valve High control
ITV-L – Intake Throttle Valve Low control
ITVP – Intake Throttle Valve Position
IVS – Idle Validation Swtich

J1939-H – J1939 Data Link High
J1939-L – 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
lb – Pounds of force
lb/s – Pounds per second
lb ft – Pounds of force per foot
lb in – Pounds of force per inch
lbm – Pounds of mass
LPCAC – Low-pressure Charge Air Cooler
LSD – Low Sulfur Diesel

m – Meter
m/s – Meters per second
MAF – Mass Air Flow
MAF GND – Mass Air Flow Ground
MAG – Magnetic
MAP – Manifold Absolute Pressure
MAP / IAT – Manifold Absolute Pressure / Intake 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
N·m – 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
TC2CIT – Turbocharger 2 Compressor Inlet Temperature
TC1TOP – Turbocharger 1 Turbine Outlet Pressure
TC2TOP – Turbocharger 2 Turbine Outlet Pressure
TC2WG – Turbocharger 2 Wastegate
TC2WC – Turbocharger 2 Wastegate Control
TCAPE – Truck Computer Analysis of Performance and Economy
TCM – Transmission Control Module
TCWC – Turbocharger Wastegate Control
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
VREF1 – Reference Voltage Engine
VREF2 – Reference Voltage Chassis
VREF3 – Reference Voltage Chassis
VREF4 – Reference Voltage Aftertreatment
VSO – Vehicle Speed Output
VSO or VSS_CAL – Vehicle Speed Output
VSS – Vehicle Speed Sensor
VSS_CAL or VSO – Vehicle Speed Output

VSS-H – Vehicle Speed Sensor High
VSS-L – Vehicle Speed Sensor Low

WTSL – Wait to Start Lamp
WEL – Warn Engine Lamp
WIF – Water In Fuel
WIFL – Water In Fuel Lamp
WTEC – World Transmission Electronically Controlled automatic transmissions (Allison)

XCS – Transfercase
XMSN – Transmission

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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 – See Charge Air Cooler.

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.

Aftertreatment Fuel Doser (AFTFD) – A part of the Downstream Injection (DSI) unit that sends pressurized fuel to the Aftertreatment Fuel Injector (AFI) to inject fuel into the exhaust pipe.

Aftertreatment Fuel Inlet Sensor (AFTFIS) – A sensor that monitors fuel temperature in the DSI system and provides constant feedback to the ECM.

Aftertreatment Fuel Pressure 2 Sensor (AFTP2) – A sensor that monitors fuel pressure in the DSI system and provides constant feedback to the ECM.

Aftertreatment Fuel Shutoff Valve (AFTFSV) – A valve used to prevent fuel flow to the Aftertreatment Fuel Injector (AFI), and prevents all uncontrolled fuel delivery for the Aftertreatment system during an AFTFD valve malfunction.

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 Air Temperature (AAT) sensor – A sensor that sends an ambient air temperature signal to the ECM.

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)

American Trucking Association (ATA) Datalink – A serial datalink specified by the American Trucking Association and the SAE.

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.

Barometric Absolute Pressure (BAP) sensor – A sensor built into the ECM that provides barometric pressure information to the ECM.

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)

Brake On/Off (BOO) switch – A switch located on the brake pedal lever, that provides a brake pedal position signal to the ECM.

Brake Pressure Switch (BPS) – A switch located in the brake pressure line that provides a brake pedal position signal to the ECM.

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) – A heat exchanger mounted in the charge air path between the turbocharger and engine intake manifold. The charge air cooler reduces the charge air temperature by transferring heat from the charge air to a cooling medium (usually air).

Charge Air Cooler 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 Flow Valve (CFV) – The CFV is ECM controlled and redirects coolant through the fuel cooler, based on EFT, when directed.

Coolant level switch – A switch sensor used to monitor coolant level.

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.

Cruise Control Switches (CCS) – A set of switches used for cruise control, Power TakeOff (PTO), and remote hand throttle system.

Current – The flow of electrons passing through a conductor. Measured in amperes.

Cylinder Balance – An ECM control strategy to even-out the power contributions of each power cylinder.

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.

Diamond Logic Builder (DLB) – The diagnostics software for chassis related components and systems.

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.

Diesel Oxidation Catalyst Inlet Temperature sensor (DOCIT) – A sensor that provides DOC inlet temperature signal to the ECM.

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 Particulate Filter Differential Pressure (DPFDP) sensor – A sensor that measures pressure difference between the inlet and outlet of the DPF and provides feedback to the ECM.

Diesel Particulate Filter Inlet Temperature sensor (DPFIT) – A sensor that provides DOC inlet temperature signal to the ECM.

Diesel Particulate Filter Outlet Temperature sensor (DPFOT) – A sensor that provides DOC outlet temperature signal to the ECM.

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 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 Gas Temperature (EGT) – The temperature of exhaust gases.

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.

Failure Mode Indicator (FMI) – Identifies the fault or condition effecting the individual component.

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.

Filter restriction – A blockage, usually from contaminants, that prevents the flow of fluid through a filter.

Flash code – See **Diagnostic Trouble Code (DTC)**.

Fuel Cooler Control Valve – A valve used to redirect coolant through the fuel cooler.

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.

Idle Shutdown Timer (IST) – An engine calibration that allows the ECM to shut down the engine during extended engine idle times.

Injection Control Pressure (ICP) sensor – Provides a feedback signal to the ECM indicating injection control pressure.

Injection Pressure Regulator (IPR) valve – A valve that is used to maintain desired injection control pressure.

Intake 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 though the Fuel Volume Control Valve (FVCV). The ITP also provides fuel for cooling and lubrication of the HPFP. Fuel is rerouted as pump return flow through the HPFP cooling and lubrication valve. Pressure is maintained at the inlet of the HPFP piston pump by an ITP regulator.

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.

Malfunction Indicator Lamp (MIL) – An indicator lamp in the Electronic Instrument Cluster that will illuminate when a detected emissions fault occurs.

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.

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.

Output Shaft Speed (OSS) sensor – A sensor mounted to the rear of the transmission that supplies a vehicle speed signal to the ECM. The ECM uses this signal to control PTO, road speed limiting, and cruise control. Automatic transmissions use this signal for shift scheduling.

Oxides of Nitrogen (NOx) – 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.

Radiator Shutter Enable (RSE) – A feature that uses various input signals to open or close radiator shutters by energizing or de-energizing a solenoid that controls an air or hydraulic cylinder.

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.

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.

Remote Accelerator Pedal Position (RAPP) – A feature that allows the operator to set and maintain a constant engine speed from outside the vehicle cab. This feature may also be known as Remote Engine Speed Control (RESC). Control over engine speed is accomplished by using remote mounted switches to turn on the RESC and select the desired engine speed.

Remote Engine Speed Control (RESC) – See Remote Accelerator Pedal Position.

Reserve capacity – Time in minutes that a fully charged battery can be discharged to 10.5 volts at 25 amperes.

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.

Starter Motor Control (SMC) – An ECM function that prevents starter engagement while the engine is running (above a set calibrated rpm), when the automatic transmission is in gear, or when the manual transmission clutch pedal is not depressed.

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 2 Compressor Inlet Temperature (TC2CIT) sensor – The TC2CIT sensor is a thermistor-based sensor that monitors the temperature of charge air entering the HP turbocharger.

Turbocharger Outlet Temperature (TCOT) sensor – A sensor that provides a turbocharger outlet temperature signal to the ECM.

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 2 Wastegate (TC2WG) solenoid – Controls the TC2WG actuator by regulating the amount of charge air pressure supplied to the TC2WG actuator. The TC2WG solenoid is controlled by signals from the ECM in response to engine speed, required fuel quantity, boost, exhaust back-pressure, and altitude. The TC2WG actuator is part of the turbocharger assembly.

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 Output (VSO) – A vehicle speed signal sent to the EGC through the J1939 network.

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

Pressure Sensors

Key-On Engine-Off

Barometric Absolute Pressure	See Local Weather Conditions
Engine Compression Brake Pressure (if applicable)	0.15 to 0.35 volt
Engine oil pressure (2010 Emissions Model Year)	-3.0 to 3.0 psi (-20.68 to 20.68 kPa)
Engine oil pressure (2013 Emissions Model Year)	-2.34 to 2.34 psi (-16.10 to 16.10 kPa)
Exhaust back pressure	-1.38 to 1.38 psi (-9.49 to 9.49 kPa)
Diesel Particulate Filter Differential Pressure (DPFDP)	0.47 to 0.91 volt
Injection Control Pressure (ICP)	0.15 to 0.35 volt
Intake Manifold Pressure (IMP)	-1.38 to 1.38 psi (-9.49 to 9.49 kPa)
Fuel delivery pressure with fuel pump on and using a mechanical gauge.	70 to 100 psi (483 to 689 kPa)

Example TC1TOP (Actual) Calculations

Maximum TC1TOP Signal Value During Cranking	TC1TOP KOEO Signal Value	Maximum - TC1TOP Signal Value During Cranking TC1TOP KOEO Signal Value = TC1TOP (Actual)
15.7 psi (108 kPa)	14.7 psi (101 kPa)	15.7 psi (108 kPa) - 14.7 psi (101 kPa) = 1 psi (7 kPa)
1 psi (7 kPa)	0 psi (0 kPa)	1 psi (7 kPa) - 0 psi (0 kPa) = 1 psi (7 kPa)
-13 psi (-89 kPa)	-14 psi (-96 kPa)	-13 psi (-89 kPa) - (-14) psi (-96 kPa) = 1 psi (7 kPa)

Position Sensors

Key-On Engine-Off

Accelerator Pedal Position 1 (APP1) (Not Depressed)	0 % Nominal
Accelerator Pedal Position 2(APP2) (Not Depressed)	0 % Nominal
Accelerator Pedal Position 1 (APP1) (Not Depressed)	1.10 volt Nominal
Accelerator Pedal Position 1 (APP1) (Not Depressed)	0.56 volt Nominal
Accelerator Pedal Position 1 (APP1) (Fully Depressed)	100 % Nominal
Accelerator Pedal Position 2 (APP2) (Fully Depressed)	100 % Nominal
Accelerator Pedal Position 1 (APP1) (Fully Depressed)	4.30 volt Nominal
Accelerator Pedal Position 2 (APP2) (Fully Depressed)	2.14 volt Nominal
EGR Valve Control	35% = Closed 90% = Open
EGR Position	35% = Closed 90% = Open
Engine Throttle Position	0 % Nominal

Engine Cranking

Cranking rpm (min)	130 rpm
20 seconds maximum crank time per attempt. Wait 2 to 3 minutes before repeating.	
Battery voltage (min based on ECM drop out)	9 V
Injection control pressure (min to start engine)	5 MPa (725 psi) / 0.95 V
EGR control	35 %
Fuel delivery pressure with fuel pump on and using a mechanical gauge.	70 to 100 psi (483 to 689 kPa)

Temperature Sensors

Low Idle, no load, stabilized engine operating temperature

Engine coolant temperature (at thermostat opening)	85 °C (185 °F) ± 2.78 °C (5 °F)
	1.26 V ± 0.4 V
Engine oil temperature should not go 5.5 °C (10 °F) above engine coolant temperature.	
Intake Manifold Temperature	66 °C (150 °F) ± 5.5 °C (10 °F)

Pressure - check with sensor and mechanical gauge

Low Idle, no load, stabilized engine operating temperature

Engine oil pressure (min with gauge)	214 kPa (31 psi) / 2.19 V
Fuel delivery pressure (gauge)	621 kPa (90 psi) ± 10 psi
Mass air flow sensor	3140 Hz ± 100 Hz

High Idle, Parasitic load, at stabilized operating temperature

Fuel delivery pressure (gauge)	621 kPa (90 psi) ± 10 psi
Mass air flow sensor	7064 Hz ± 100 Hz

Actuator Output State Test

Injector pressure regulator valve	Output state LOW – 0%
	Output state HIGH – 90%
Exhaust gas recirculation valve	Output state LOW – 35%
	Output state HIGH – 80 to 90%
Engine throttle valve	Output state LOW – 0%
	Output state HIGH – 50%
Engine throttle valve position	Output state LOW – 1.12 V
	Output state HIGH – 4.7 V
Exhaust brake solenoid	Output state LOW – 0%
	Output state HIGH – 100%

Full load, ECM rated speed at highway, stabilized operating temperature

Air cleaner restriction (max)	6.2 kPa (25 in H_2O)
Fuel delivery pressure (gauge)	621 kPa (90 psi) ± 10 psi
Mass air flow sensor	4612 Hz (min)
	8138 Hz (max)

Component Specifications

Temperature Sensor (ECT)	
Temperature at -18 °C (0 °F)	4.62 V / 247 kΩ ± 12.4 kΩ
Temperature at 0 °C (32 °F)	4.37 V / 96 kΩ ± 4.8 kΩ
Temperature at 21 °C (70 °F)	3.78 V / 36 kΩ ± 1.8 kΩ
Temperature at 65 °C (150 °F)	1.93 V / 6.3 kΩ ± 0.3 kΩ
Temperature at 93 °C (200 °F)	0.99 V / 2.6 kΩ ± 0.12 kΩ
Temperature Sensor (EOT)	
Temperature at -18 °C (0 °F)	4.62 V / 247 kΩ ± 12.4 kΩ
Temperature at 0 °C (32 °F)	4.37 V / 96 kΩ ± 4.8 kΩ
Temperature at 21 °C (70 °F)	3.78 V / 36 kΩ ± 1.8 kΩ
Temperature at 65 °C (150 °F)	1.93 V / 6.3 kΩ ± 0.3 kΩ
Temperature at 93 °C (200 °F)	0.99 V / 2.6 kΩ ± 0.12 kΩ
Temperature Sensor (IMT)	
Temperature at -18 °C (0 °F)	4.64 V / 269 kΩ
Temperature at 0 °C (32 °F)	4.40 V / 99 kΩ
Temperature at 21 °C (70 °F)	3.80 V / 36 kΩ
Temperature at 65 °C (150 °F)	1.89 V / 6.2 kΩ
Temperature at 93 °C (200 °F)	0.99 V / 2.5 kΩ
Temperature Sensor (AIT)	
Temperature at -18 °C (0 °F)	4.44 V / 250 kΩ ± 1.27 kΩ
Temperature at 0 °C (32 °F)	3.87 V / 95.8 kΩ ± 0.47 kΩ
Temperature at 21 °C (70 °F)	2.82 V / 35.9 kΩ ± 0.17 kΩ
Temperature at 65 °C (150 °F)	0.908 V / 6.335 Ω ± 81 Ω
Temperature Sensors (DOCIT, DPFIT, DPFOT)	
Temperature at 21 °C (70 °F)	0.88 V / 216 Ω
Temperature at 65 °C (150 °F)	0.99 V / 250 Ω
Temperature at 93 °C (200 °F)	1.06 V / 270 Ω
Temperature at 204 °C (400 °F)	1.30 V / 352 Ω

Component Specifications (cont.)

Temperature at 482 °C (900 °F)	1.76 V / 542 Ω
Other Components	
CMP sensor	850 Ω
CKP sensor	420 Ω ± 140 Ω
Injector coil	0.575 Ω ± 0.575 Ω

Crankcase Pressure

High idle no load - max. using ZTSE4039	1.5 kPa (6 in. H_2O)

TC2WC Rod Extension

Air pressure at 81.7 kPa (11.85 PSI)	Rod extension 4.1 mm (0.16 in.)
Air pressure at 120.7 kPa (17.5 PSI)	Rod extension 10.2 mm (0.4 in.)
Air pressure at 148.2 kPa (21.5 PSI)	Rod extension 14 mm (0.55 in.)

MaxxForce® DT (7.6L)

215 hp @ 2200 rpm (12NUK)

MaxxForce® DT/215 hp @ 2200 rpm / 560 ft•lb @ 1300 rpm	
50 state 2010 Model Year (MY)	
Engine unit code	12NUK
Engine model	MaxxForce® DT/215
Engine Family Rating Code (EFRC)	1121
Injection timing	Nonadjustable
High idle speed - manual transmission	2600 rpm
High idle speed - automatic transmission	2600 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	0 kPa (0 psi)
Exhaust back pressure	2 kPa (0.29 psi) / 0.74 V
Injection control pressure	5.9 MPa (859 psi) / 1.07 V
EGR Control	35 % to 80 %
Engine Throttle Position	0%
High Idle, no load, stabilized engine operating temperature	
Intake Manifold Pressure	69 to 97 kPa (10 to 14 psi)
Exhaust back pressure	179 kPa (26 psi) / 2.16 V
Injection control pressure	10.69 MPa (1550 psi) / 1.72 V
EGR Control	35 % to 80 %
Engine Throttle Position	0%
Torque converter stall (automatic transmission)	2000 rpm or greater @ 5 seconds or less
Full load, ECM rated speed at highway, stabilized engine operating temperature	
Intake manifold pressure	193 kPa (28 psi)
Exhaust back pressure	290 kPa (42 psi)
Injection control pressure	31 MPa (4525 psi)

EGR control	35% to 80%
Engine Throttle Position	0%

230 hp @ 2200 rpm (12NUL)

MaxxForce® DT/230 hp @ 2200 rpm / 620 ft•lb @ 1300 rpm	
50 state 2010 Model Year (MY)	
Engine unit code	12NUL
Engine model	MaxxForce® DT/230
Engine Family Rating Code (EFRC)	1141
Injection timing	Nonadjustable
High idle speed - manual transmission	2600 rpm
High idle speed - automatic transmission	2600 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	0 kPa (0 psi)
Exhaust back pressure	1.3 kPa (0.19 psi) / 0.74 V
Injection control pressure	6 MPa (877 psi) / 1.07 V
EGR control	35% to 80%
Engine Throttle Position	0%
High Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	60 kPa (8.7 psi)
Exhaust back pressure	118 kPa (17.1 psi) / 2.16 V
Injection control pressure	12.2 MPa (1777 psi) / 2.62 V
EGR control	35% to 80%
Engine Throttle Position	0%
Torque converter stall (automatic transmission)	2000 rpm or greater @ 5 seconds or less
Full load, ECM rated speed at highway, stabilized engine operating temperature	
Intake manifold pressure	207 kPa (30 psi)
Exhaust back pressure	247 kPa (35.85 psi)
Injection control pressure	30.3 MPa (4401 psi)
EGR control	35% to 80%
Engine Throttle Position	0%

230 hp @ 2200 rpm (12NUM)

MaxxForce® DT/230 hp @ 2200 rpm / 660 ft•lb @ 1300 rpm	
50 state 2010 Model Year (MY)	
Engine unit code	12NUM
Engine model	MaxxForce® DT/230
Engine Family Rating Code (EFRC)	1151
Injection timing	Nonadjustable
High idle speed - manual transmission	2600 rpm
High idle speed - automatic transmission	2600 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	0 kPa (0 psi)
Exhaust back pressure	2 kPa (0.29 psi) / 0.74 V
Injection control pressure	5.9 MPa (859 psi) / 1.07 V
EGR Control	35% to 80%
Engine Throttle Position	0%
High Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	97 kPa (14 psi)
Exhaust back pressure	179 kPa (26 psi) / 2.16 V
Injection control pressure	17 MPa (2518 psi) / 2.62 V
EGR Control	35% to 80%
Engine Throttle Position	0%
Torque converter stall (automatic transmission)	2000 rpm or greater @ 5 seconds or less
Full load, ECM rated speed at highway, stabilized engine operating temperature	
Intake manifold pressure	207 kPa (30 psi)
Exhaust back pressure	290 kPa (42 psi)
Injection control pressure	31 MPa (4525 psi)
EGR Control	35% to 80%
Engine Throttle Position	0%

245 hp @ 2200 rpm (12NUN)

MaxxForce® DT/245 hp @ 2200 rpm / 660 ft•lb @ 1300 rpm	
50 state 2010 Model Year (MY)	
Engine unit code	12NUN
Engine model	MaxxForce® DT/245
Engine Family Rating Code (EFRC)	2111
Injection timing	Nonadjustable
High idle speed - manual transmission	2600 rpm
High idle speed - automatic transmission	2600 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	0 kPa (0 psi)
Exhaust back pressure	2 kPa (0.32 psi) / 0.74 V
Injection control pressure	7 MPa (1005 psi) / 1.21 V
EGR Control	35% to 80%
Engine Throttle Position	0%
High Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	76 kPa (11 psi)
Exhaust back pressure	186 kPa (27 psi) / 2.22 V
Injection control pressure	9 MPa (1244 psi) / 1.43 V
EGR Control	35% to 80%
Engine Throttle Position	0%
Torque converter stall (automatic transmission)	2000 rpm or greater @ 5 seconds or less
Full load, ECM rated speed at highway, stabilized engine operating temperature	
Intake manifold pressure	221 kPa (32 psi)
Exhaust back pressure	393 kPa (57 psi)
Injection control pressure	30 MPa (4337 psi)
EGR Control	35% to 80%
Engine Throttle Position	0%

260 hp @ 2200 rpm (12NUP)

MaxxForce® DT/260 hp @ 2200 rpm / 660 ft•lb @ 1300 rpm	
50 state 2010 Model Year (MY)	
Engine unit code	12NUP
Engine model	MaxxForce® DT/260
Engine Family Rating Code (EFRC)	2121
Injection timing	Nonadjustable
High idle speed - manual transmission	2600 rpm
High idle speed - automatic transmission	2600 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	0 kPa (0 psi)
Exhaust back pressure	2 kPa (0.32 psi) / 0.74 V
Injection control pressure	7 MPa (1005 psi) / 1.21 V
EGR Control	35% to 80%
Engine Throttle Position	0%
High Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	76 kPa (11 psi)
Exhaust back pressure	193 kPa (28 psi) / 2.2 V
Injection control pressure	17 MPa (2480 psi) / 1.4 V
EGR Control	35% to 80%
Engine Throttle Position	0%
Torque converter stall (automatic transmission)	2000 rpm or greater @ 5 seconds or less
Full load, ECM rated speed at highway, stabilized engine operating temperature	
Intake manifold pressure	221 kPa (32 psi)
Exhaust back pressure	386 kPa (56 psi)
Injection control pressure	31 MPa (4496 psi)
EGR Control	35% to 80%
Engine Throttle Position	0%

270 hp @ 2200 rpm (12NUR)

MaxxForce® DT/270 hp @ 2200 rpm / 860 ft•lb @ 1300 rpm	
50 state 2010 Model Year (MY)	
Engine unit code	12NUR
Engine model	MaxxForce® DT/270
Engine Family Rating Code (EFRC)	2131
Injection timing	Nonadjustable
High idle speed - manual transmission	2600 rpm
High idle speed - automatic transmission	2600 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	0 kPa (0 psi)
Exhaust back pressure	2 kPa (0.32 psi) / 0.74 V
Injection control pressure	7 MPa (1005 psi) / 1.21 V
EGR Control	35% to 80%
Engine Throttle Position	0%
High Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	76 kPa (11 psi)
Exhaust back pressure	207 kPa (30 psi) / 2.39 V
Injection control pressure	9 MPa (1306 psi) / 1.4 V
EGR Control	35% to 80%
Engine Throttle Position	0%
Torque converter stall (automatic transmission)	2000 rpm or greater @ 5 seconds or less
Full load, ECM rated speed at highway, stabilized engine operating temperature	
Intake manifold pressure	248 kPa (36 psi)
Exhaust back pressure	393 kPa (57 psi)
Injection control pressure	32 MPa (4569 psi)
EGR Control	35% to 80%
Engine Throttle Position	0%

285 hp @ 2200 rpm (12NUS)

MaxxForce® DT/280 hp @ 2200 rpm / 860 ft•lb @ 1300 rpm	
50 state 2010 Model Year (MY)	
Engine unit code	12NUS
Engine model	MaxxForce® DT/280
Engine Family Rating Code (EFRC)	2141
Injection timing	Nonadjustable
High idle speed - manual transmission	2600 rpm
High idle speed - automatic transmission	2600 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	0 kPa (0 psi)
Exhaust back pressure	2 kPa (0.32 psi) / 0.74 V
Injection control pressure	7 MPa (1005 psi) / 1.21 V
EGR Control	35% to 80%
Engine Throttle Position	0%
High Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	83 kPa (12 psi)
Exhaust back pressure	214 kPa (31 psi) / 2.4 V
Injection control pressure	9 MPa (1305 psi) / 1.5 V
EGR Control	35% to 80%
Engine Throttle Position	0%
Torque converter stall (automatic transmission)	2000 rpm or greater @ 5 seconds or less
Full load, ECM rated speed at highway, stabilized engine operating temperature	
Intake manifold pressure	248 kPa (36 psi)
Exhaust back pressure	386 kPa (56 psi)
Injection control pressure	32 MPa (4609 psi)
EGR Control	35% to 80%
Engine Throttle Position	0%

300 hp @ 2200 rpm (12NUT)

MaxxForce® DT/280 hp @ 2200 rpm / 860 ft•lb @ 1300 rpm	
50 state 2010 Model Year (MY)	
Engine unit code	12NUT
Engine model	MaxxForce® DT/280
Engine Family Rating Code (EFRC)	2151
Injection timing	Nonadjustable
High idle speed - manual transmission	2600 rpm
High idle speed - automatic transmission	2600 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	0 kPa (0 psi)
Exhaust back pressure	2 kPa (0.32 psi) / 0.74 V
Injection control pressure	7 MPa (1005 psi) / 1.21 V
EGR Control	35% to 80%
Engine Throttle Position	0%
High Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	76 kPa (11 psi)
Exhaust back pressure	193 kPa (28 psi) / 2.27 V
Injection control pressure	9 MPa (1307 psi) / 1.5 V
EGR Control	35% to 80%
Engine Throttle Position	0%
Torque converter stall (automatic transmission)	2000 rpm or greater @ 5 seconds or less
Full load, ECM rated speed at highway, stabilized engine operating temperature	
Intake manifold pressure	248 kPa (36 psi)
Exhaust back pressure	386 kPa (56 psi)
Injection control pressure	32 MPa (4588 psi)
EGR Control	35% to 80%
Engine Throttle Position	0%

MaxxForce® 9 (9.3L)

300 hp @ 2000 rpm (12NUU)

MaxxForce® 9/300 hp @ 2000 rpm / 860 ft•lb @ 1200 rpm	
50 state 2010 Model Year (MY)	
Engine unit code	12NUU
Engine model	MaxxForce® 9/300
Engine Family Rating Code (EFRC)	5121
Injection timing	Nonadjustable
High idle speed - manual transmission	2400 rpm
High idle speed - automatic transmission	2400 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	0 kPa (0 psi)
Exhaust back pressure	4 kPa (0.6 psi) / 0.75 V
Injection control pressure	6 MPa (853 psi) / 1.09 V
EGR Control	35% to 80%
Engine Throttle Position	0%
High Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	159 kPa (23 psi)
Exhaust back pressure	352 kPa (51 psi) / 3.55 V
Injection control pressure	15 MPa (2228 psi) / 2.35 V
EGR Control	35% to 80%
Engine Throttle Position	0%
Torque converter stall (automatic transmission)	2000 rpm or greater @ 5 seconds or less
Full load, ECM rated speed at highway, stabilized engine operating temperature	
Intake manifold pressure	248 kPa (36 psi)
Exhaust back pressure	365 kPa (53 psi)
Injection control pressure	32 MPa (4640 psi)

EGR Control	35% to 80%
Engine Throttle Position	0%

315 hp @ 2000 rpm (12NUV)

MaxxForce® 9/315 hp @ 2000 rpm / 950 ft•lb @ 1200 rpm	
50 state 2010 Model Year (MY)	
Engine unit code	12NUV
Engine model	MaxxForce® 9/315
Engine Family Rating Code (EFRC)	5131
Injection timing	Nonadjustable
High idle speed - manual transmission	2400 rpm
High idle speed - automatic transmission	2400 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	0 kPa (0 psi)
Exhaust back pressure	4 kPa (0.6 psi) / 0.75 V
Injection control pressure	6 MPa (853 psi) / 1.09 V
EGR Control	35% to 80%
Engine Throttle Position	0%
High Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	159 kPa (23 psi)
Exhaust back pressure	352 kPa (51 psi) / 3.55 V
Injection control pressure	15 MPa (2228 psi) / 2.35 V
EGR Control	35% to 80%
Engine Throttle Position	0%
Torque converter stall (automatic transmission)	2000 rpm or greater @ 5 seconds or less
Full load, ECM rated speed at highway, stabilized engine operating temperature	
Intake manifold pressure	248 kPa (36 psi)
Exhaust back pressure	365 kPa (53 psi)
Injection control pressure	32 MPa (4640 psi)
EGR Control	35% to 80%
Engine Throttle Position	0%

315 hp @ 2000 rpm (12NUW)

MaxxForce® 9/315 hp @ 2000 rpm / 950 ft•lb @ 1200 rpm	
50 state 2010 Model Year (MY)	
Engine unit code	12NUW
Engine model	MaxxForce® 9/330
Engine Family Rating Code (EFRC)	5151
Injection timing	Nonadjustable
High idle speed - manual transmission	2400 rpm
High idle speed - automatic transmission	2400 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	0 kPa (0 psi)
Exhaust back pressure	4 kPa (0.6 psi) / 0.75 V
Injection control pressure	6 MPa (853 psi) / 1.09 V
EGR Control	35% to 80%
Engine Throttle Position	0%
High Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	159 kPa (23 psi)
Exhaust back pressure	352 kPa (51 psi) / 3.55 V
Injection control pressure	15 MPa (2228 psi) / 2.35 V
EGR Control	35% to 80%
Engine Throttle Position	0%
Torque converter stall (automatic transmission)	2000 rpm or greater @ 5 seconds or less
Full load, ECM rated speed at highway, stabilized engine operating temperature	
Intake manifold pressure	248 kPa (36 psi)
Exhaust back pressure	365 kPa (53 psi)
Injection control pressure	32 MPa (4640 psi)
EGR Control	35% to 80%
Engine Throttle Position	0%

MaxxForce® 10 (9.3L)

310 hp @ 2000 rpm (12NUX)

MaxxForce® 10/310 hp @ 2000 rpm / 1050 ft•lb @ 1200 rpm	
50 state 2010 Model Year (MY)	
Engine unit code	12NUX
Engine model	MaxxForce® 10/310
Engine Family Rating Code (EFRC)	6121
Injection timing	Nonadjustable
High idle speed - manual transmission	2400 rpm
High idle speed - automatic transmission	2400 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	0 kPa (0 psi)
Exhaust back pressure	4 kPa (0.6 psi) / 0.75 V
Injection control pressure	6 MPa (853 psi) / 1.09 V
EGR Control	35% to 80%
Engine Throttle Position	0%
High Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	159 kPa (23 psi)
Exhaust back pressure	352 kPa (51 psi) / 3.55 V
Injection control pressure	15 MPa (2228 psi) / 2.35 V
EGR Control	35% to 80%
Engine Throttle Position	0%
Torque converter stall (automatic transmission)	2000 rpm or greater @ 5 seconds or less
Full load, ECM rated speed at highway, stabilized engine operating temperature	
Intake manifold pressure	248 kPa (36 psi)
Exhaust back pressure	365 kPa (53 psi)
Injection control pressure	32 MPa (4640 psi)

EGR Control	35% to 80%
Engine Throttle Position	0%

330 hp @ 2000 rpm (12NUY)

MaxxForce® 10/330 hp @ 2000 rpm / 1150 ft•lb @ 1200 rpm	
50 state 2010 Model Year (MY)	
Engine unit code	12NUY
Engine model	MaxxForce® 10/330
Engine Family Rating Code (EFRC)	6131
Injection timing	Nonadjustable
High idle speed - manual transmission	2400 rpm
High idle speed - automatic transmission	2400 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	0 kPa (0 psi)
Exhaust back pressure	4 kPa (0.6 psi) / 0.75 V
Injection control pressure	6 MPa (853 psi) / 1.09 V
EGR Control	35% to 80%
Engine Throttle Position	0%
High Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	159 kPa (23 psi)
Exhaust back pressure	352 kPa (51 psi) / 3.55 V
Injection control pressure	15 MPa (2228 psi) / 2.35 V
EGR Control	35% to 80%
Engine Throttle Position	0%
Torque converter stall (automatic transmission)	2000 rpm or greater @ 5 seconds or less
Full load, ECM rated speed at highway, stabilized engine operating temperature	
Intake manifold pressure	248 kPa (36 psi)
Exhaust back pressure	365 kPa (53 psi)
Injection control pressure	32 MPa (4640 psi)
EGR Control	35% to 80%
Engine Throttle Position	0%

350 hp @ 2000 rpm (12NUZ)

MaxxForce® 10/350 hp @ 2000 rpm / 1150 ft•lb @ 1200 rpm	
50 state 2010 Model Year (MY)	
Engine unit code	12NUZ
Engine model	MaxxForce® 10/350
Engine Family Rating Code (EFRC)	6151
Injection timing	Nonadjustable
High idle speed - manual transmission	2400 rpm
High idle speed - automatic transmission	2400 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	0 kPa (0 psi)
Exhaust back pressure	4 kPa (0.6 psi) / 0.75 V
Injection control pressure	6 MPa (853 psi) / 1.09 V
EGR Control	35% to 80%
Engine Throttle Position	0%
High Idle, no load, stabilized engine operating temperature	
Intake manifold pressure	159 kPa (23 psi)
Exhaust back pressure	352 kPa (51 psi) / 3.55 V
Injection control pressure	15 MPa (2228 psi) / 2.35 V
EGR Control	35% to 80%
Engine Throttle Position	0%
Torque converter stall (automatic transmission)	2000 rpm or greater @ 5 seconds or less
Full load, ECM rated speed at highway, stabilized engine operating temperature	
Intake manifold pressure	248 kPa (36 psi)
Exhaust back pressure	365 kPa (53 psi)
Injection control pressure	32 MPa (4640 psi)
EGR Control	35% to 80%
Engine Throttle Position	0%

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Signal Values.....**1317**

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 1291) for actuator output voltages, sensor values, and component specifications in a wide range of conditions.

Chassis 76 Pin Connector			
ECM Pin	**Abbreviation**	**Circuit Name**	**KOEO**
C-1, 3, 5	ECM PWR	ECM Power	B+
C-2, 4, 6	ECM GND	ECM Ground	0 V
C-7	ECI	Engine Crank Inhibit	0 V
C-8	DOCIT	DOC Inlet Temperature	0.90 V
C-9, 51, 63	VREF-C	Voltage Reference	5.00 V
C-10	ATA-L	ATA Communication Link Low	0.77 V – 1.30 V
C-11	XCS	Transfercase	2.75 V
C-16	RPRE	Remote Preset PTO	0 V
C-17	DOCOT	DOC Outlet Temperature	0.90 V
C-19	DPFDP	DPF Differential Pressure	0.72 V
C-21	OWL	Oil Warn Lamp	4.41 V
C-22	WEL	Warn Engine Lamp	4.41 V
C-25	ATA-H	ATA Communication Link High	3.05 V – 4.00 V
C-26	EGRP	Exhaust Gas Recirculation Position	1.79 V
C-27	VREF-B	Voltage Reference Body	5.00 V
C-29	AIT	Air Inlet Temperature	2.47 V
C-31	SWBAT	Switch Battery	B+
C-33	APP1	Accelerator Pedal Position 1	1.10 V
C-34, 36	SIG GND-C	Signal Ground Chassis	0 V
C-35	SIG GND-B	Signal Ground Body	0 V
C-42	ECL	Engine Coolant Level	0 V
C-45	IPR PWR	IPR Power	B+
C-48	APP2	Accelerator Pedal Position 2	0.53 V
C-49	RAS	Resume Accel Switch	0 V
C-50	RAPP	Remote Accelerator Pedal Position	0 V
C-53	VSS-L	Vehicle Speed Signal Low	2.75 V
C-54	VSS-H	Vehicle Speed Signal High	2.75 V
C-58	EFC	Engine Fan Control	4.41 V

Chassis 76 Pin Connector			
ECM Pin	**Abbreviation**	**Circuit Name**	**KOEO**
C-60	RVAR	Remote Variable PTO	0 V
C-61	J1939-H	J1939 Data Link High	2.57 V
C-62	J1939-L	J1939 Data Link Low	2.39 V
C-65	TDE	Transmission Driveline Engaged	0 V
C-67	DPFOT	DPF Outlet Temperature	0.92 V
C-70	MPR	Main Power Relay	0.76 V
C-71	TACH	Tachometer	B+
C-72	VSO	Vehicle Speed Output	B+
C-76	FPC	Fuel Pump Control	B+

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 1291) for actuator output voltages, sensor values, and component specifications in a wide range of conditions.

Engine 76 Pin Connector			
ECM Pin	**Abbreviation**	**Circuit Name**	**KOEO**
E-7	WIF	Water In Fuel	4.66 V
E-12	MAF GND	Mass Airflow Ground	0 V
E-13	EOP	Engine Oil Pressure	0.56 V
E-15	IMT	Intake Manifold Temperature	2.67 V
E-20	EBP	Exhaust Back Pressure	0.74 V
E-24	CMP-H	Camshaft Position High	2.48 V
E-25	CKP-H	Crankshaft Position High	2.50 V
E-28	SIG GND-E	Signal Ground Engine	0 V
E-32	FDP	Fuel Delivery Pressure	0.73 V
E-33	ECT1	Engine Coolant Temperature 1	3.27 V
E-41	CKP-L	Crankshaft Position Low	2.50 V
E-42	CMP-L	Camshaft Position Low	2.28 V
E-43	IPR	Injection Pressure Regulator	B+
E-45	EBPV	Exhaust Back Pressure Valve	0.52 V
E-48	IMP	Intake Manifold Pressure	0.73 V
E-50	EGT	Exhaust Gas Temperature	4.65 V
E-56	TC2TOP	Turbocharger 2 Turbine Outlet Pressure	0 V
E-57, 75	ETC-L	Engine Throttle Control Low	B+
E-58, 76	ETC-H	Engine Throttle Control High	B+
E-59	IAH-C	Intake Air Heater Control	2.86 V
E-66	EOT	Engine Oil Temperature	3.44 V
E-67	MAF	Mass Airflow	2.69 V
E-68	ETP	Engine Throttle Position	1.12 V
E-69	FPM	Fuel Pump Monitor	0 V
E-71	EGRC	Exhaust Gas Recirculation Control	3.95 V
E-73	TC2WC	Turbocharger 2 Wastegate Control	B+

NOTE: Voltage measurements were taken with the ignition Key ON, Engine OFF (KOEO) and the breakout harness connected between the gray valve cover connector and engine harness.

Gray 8 Pin UVC Connector			
ECM Pin	**Abbreviation**	**Circuit Name**	**KOEO**
1	ECBP	Engine Compression Brake Pressure	0.27 V
2, 7	SIG GND-E	Signal Ground Engine	0 V
3, 8	VREF-E	Voltage Reference Engine	5.00 V
4	ECB1	Engine Compression Brake 1	0 V
6	ICP	Injection Control Pressure	0.27 V

NOTE: Voltage measurements were taken with the ignition Key ON, Engine OFF (KOEO) and the 24-pin breakout harness connected between the 24-pin connector and engine harness.

Downstream Injection (DSI) System			
24-Pin	**Abbreviation**	**Circuit Name**	**KOEO**
5	AFTFIT	AFT Fuel Inlet Temperature	5.44 V
6, 15	AFT VREF	AFT Voltage Reference	5.00 V
7	AFTFP1	AFT Fuel Pressure 1	4.79 V
8, 16	AFT SIG GND	AFT Signal Ground	0 V
9	AFTFD-H	AFT Fuel Doser High	6.07 V
10	AFTFD-L	AFT Fuel Doser Low	0 V
17	AFTFP2	AFT Fuel Pressure 2	5.44 V
18	AFTFS-H	AFT Fuel Shutoff High	6.08 V
19	AFTFS-L	AFT Fuel Shutoff Low	-0.35 V

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Technical Service Information (TSI) letters are periodically published to inform service technicians of product enhancements and field service issues. File TSIs in this section for supplemental reference.