DIAGNOSTIC MANUAL
2007 MaxxForce® DT, 9, and 10 Engine
EPA 07 - US, Canada, Mexico

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2007 MaxxForce® DT, 9, and 10 Engine

Navistar, Inc.

2701 Navistar Drive, Lisle, IL 60532 USA

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Revision 1
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Highlights

Table 1 Summary of Changes

Location	Reason
Turbochargers section	Removed figure and text regarding inspection of turbocharger on bench
VGT (Variable Geometry Turbocharger) Actuator section	Fixed wrong tool called out in Tools

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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

1171939R4	MaxxForce® DT, 9, and 10 *Engine Operation and Maintenance Manual*
EGES-335–2	MaxxForce® DT, 9, and 10 *Service Manual*
0000002581	MaxxForce® DT, 9, and 10 *Diagnostic Manual*
EGED-375	MaxxForce® DT, 9, and 10 *Hard Start and No Start Diagnostics Form*
EGED-380	MaxxForce® DT, 9, and 10 *Performance Diagnostics Form*
EGED-385	MaxxForce® DT, 9, and 10 *Electronic Control Systems Form*

Technical Service Literature is revised periodically and mailed automatically to “Revision Service” subscribers. If a technical publication is ordered, the latest revision will be supplied.

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

Service Diagnosis

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

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

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

Prerequisites for Effective Diagnosis

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

Technical Service Literature required for Effective Diagnosis

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

Safety Information

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

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

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

Safety Terminology

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

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

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

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

Safety Instructions

Work Area

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

Safety Equipment

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

Protective Measures

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

Vehicle

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

Engine

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

Fire Prevention

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

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

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

Batteries

- Always disconnect the main negative battery cable first.
- Always connect the main negative battery cable last.
- Avoid leaning over batteries.
- Protect your eyes.

- Do not expose batteries to open flames or sparks.
- Do not smoke in workplace.

Compressed Air

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

Tools

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

Fluids Under Pressure

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

Fuel

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

Removal of Tools, Parts, and Equipment

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

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Engine Identification

Engine Serial Number

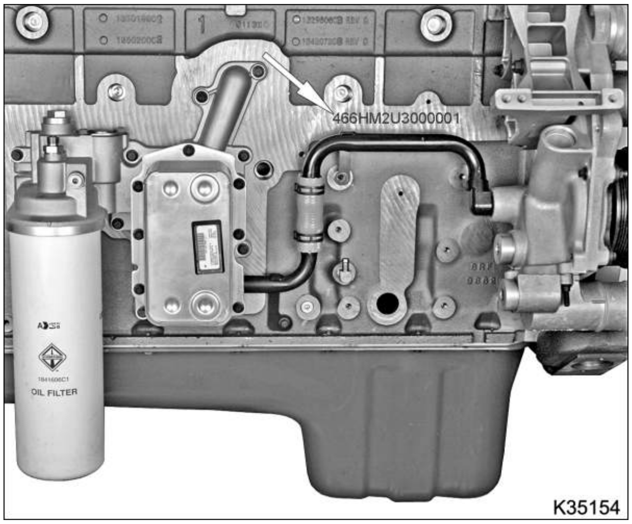

Figure 1 Engine serial number

The engine serial number is in two locations:

- Stamped on a crankcase pad on the right side of the crankcase below the cylinder head.
- On the engine emission label on the valve cover.

Engine Serial Number Examples

MaxxForce® DT: 466HM2U3000001

MaxxForce® 9 and 10: 570HM2U3000001

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 3000001

Engine Emission Label

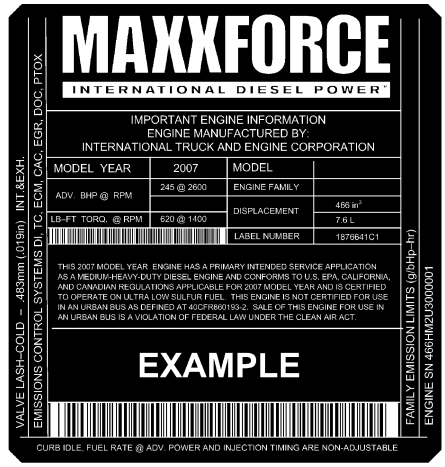

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Figure 2 U.S. Environmental Protection Agency (EPA) exhaust emission label (example)

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	7.6 L (466 in^3)
MaxxForce® 9 and 10 displacement	9.3 L (570 in^3)
Bore (sleeve diameter)	116.6 mm (4.59 in)
Stroke	
• MaxxForce® DT	119 mm (4.68 in)
• MaxxForce® 9 and 10	146 mm (5.75 in)
Compression ratio	
• MaxxForce® DT	16.9 : 1
• MaxxForce® 9 and 10	17.2 : 1
Aspiration	VGT turbocharged and Charge Air Cooled (CAC)
Rated power @ rpm[1]	
• MaxxForce® DT	245 bhp @ 2600 rpm
• MaxxForce® 9	310 bhp @ 2200 rpm
• MaxxForce® 10	310 bhp @ 2200 rpm
Peak torque @ rpm[1]	
• MaxxForce® DT	620 lbf·ft @ 1400 rpm
• MaxxForce® 9	950 lbf·ft @ 1200 rpm
• MaxxForce® 10	1050 lbf·ft @ 1200 rpm
Engine rotation (facing flywheel)	Counterclockwise
Combustion system	Direct injection turbocharged
Fuel system	Electro-hydraulic injection
Total engine weight (oil and accessories)	
• MaxxForce® DT	881 kg (1,943 lbs)
• MaxxForce® 9 and 10	905 kg (1,995 lbs)
Cooling system capacity (engine only)	12.8 L (13.5 qts US)
Lube system capacity (including filter)	28 L (30 qts US)
Lube system capacity (overhaul only, with filter)	33 L (35 qts US)
Firing order	1-5-3-6-2-4

1 Example ratings shown. See Performance Specifications appendix in Diagnostic Manual for additional ratings.

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 use an offset piston axis and centered combustion bowls. Crown markings show correct piston orientation in the crankcase.

The one piece crankcase uses replaceable wet cylinder sleeves that are sealed by a single crevice seal. 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 gerotor 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 water supply housing serves as the mounting bracket for the Freon® compressor. Mounting capabilities for a dual Freon® compressor are available as an option. The pad mounting design of the alternator and Freon® compressor brackets provide easy removal and improved durability.

The low-pressure fuel supply pump draws fuel from the fuel tank through the fuel filter housing. The housing includes a strainer, filter, primer pump, drain valve, Water in Fuel (WIF) sensor, and Engine Fuel Pressure (EFP) sensor. If equipped, an optional fuel heater element is located in the fuel filter housing. 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 a programmed value of water is collected in the fuel filter housing, the instrument panel's amber FUEL FILTER lamp will illuminate. The collected water must be removed immediately. The water is drained by using the drain valve located on the fuel filter housing.

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.

The Variable Geometry Turbocharger (VGT) has actuated vanes in the turbine housing. These vanes modify exhaust gas flow through the VGT. The ECM commands the VGT in response to boost and exhaust back pressure for various engine speeds and load conditions.

The Inlet Air Heater (IAH) system warms the incoming air supply prior to cranking to aid cold engine starting and reduce white smoke during warm-up. 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.

Optional Features

Optional features available include the following:

- Air compressor
- Power Takeoff (PTO)
- Engine or 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.

The front cover has a mounting flange available for PTO accessories. The air compressor drive gear train is used with a spline adapter and provides power for front mounted PTO accessories.

The Diamond Logic® engine brake is available for all engine displacements. The engine brake is a compression release brake system that provides additional braking performance. The operator can control the engine brake for different operating conditions.

The Diamond Logic® exhaust brake system is also available for all engine displacements. The exhaust brake uses the turbocharger to restrict exhaust flow for additional braking. The operator can control the exhaust brake for different operating conditions.

Optional Cold Climate Features

Optional cold climate features available include the following:

- Oil pan heater
- Coolant heater
- Fuel heater

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

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

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

The fuel heater is installed in the fuel filter header 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 Diesel Oxidation Catalyst (DOC) burns oxygen and hydrocarbons in the exhaust stream.
- The Diesel Particulate Filter (DPF) captures and burns particulates in the exhaust stream.

Engine Component Locations

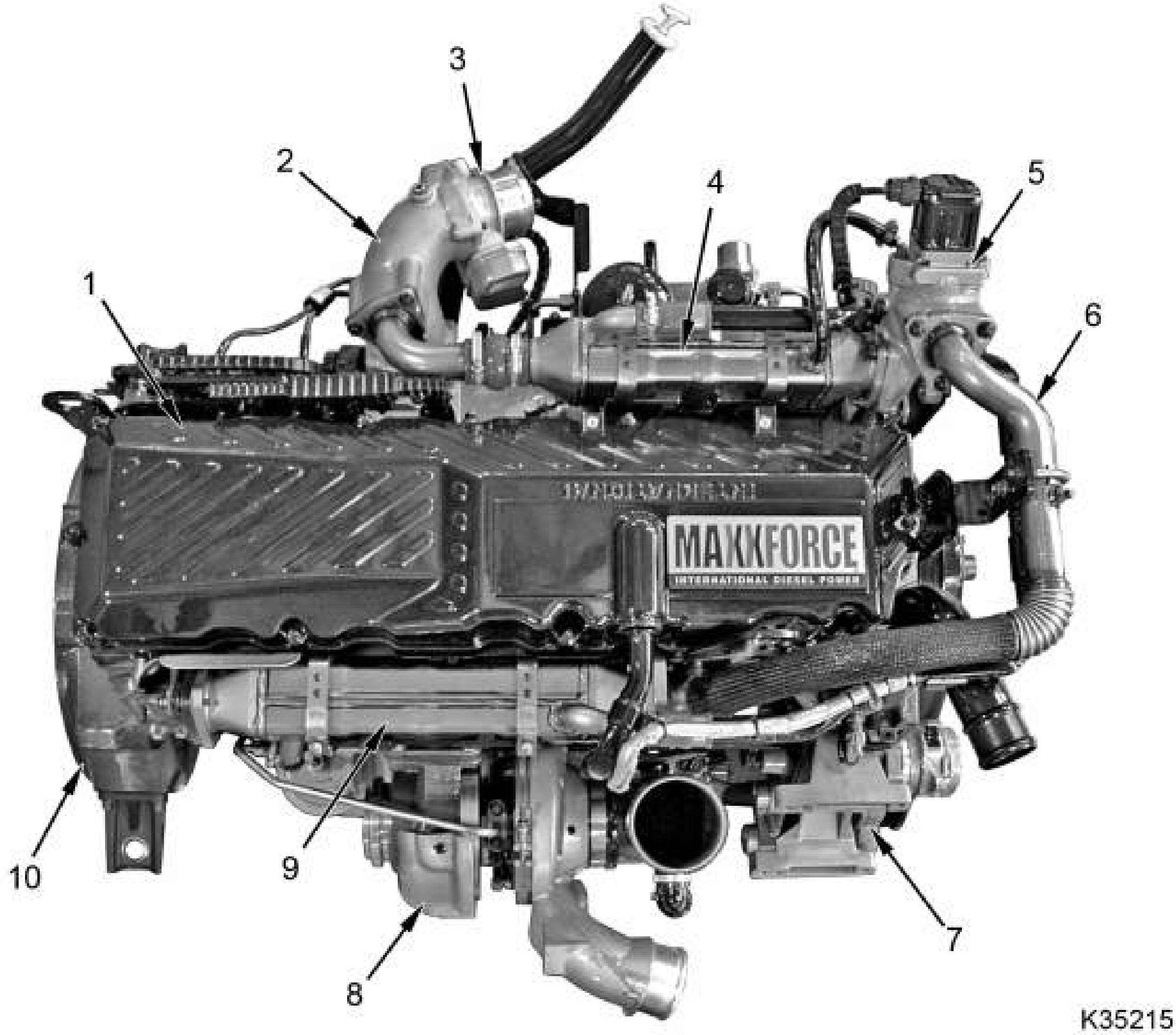

Figure 3 Component location – top

1. Valve cover
2. EGR and inlet air mixer duct
3. Intake throttle assembly
4. Intake side EGR cooler
5. EGR valve manifold assembly
6. EGR tube assembly
7. Alternator bracket
8. Variable Geometry Turbocharger (VGT) assembly
9. Exhaust side EGR cooler
10. Flywheel housing

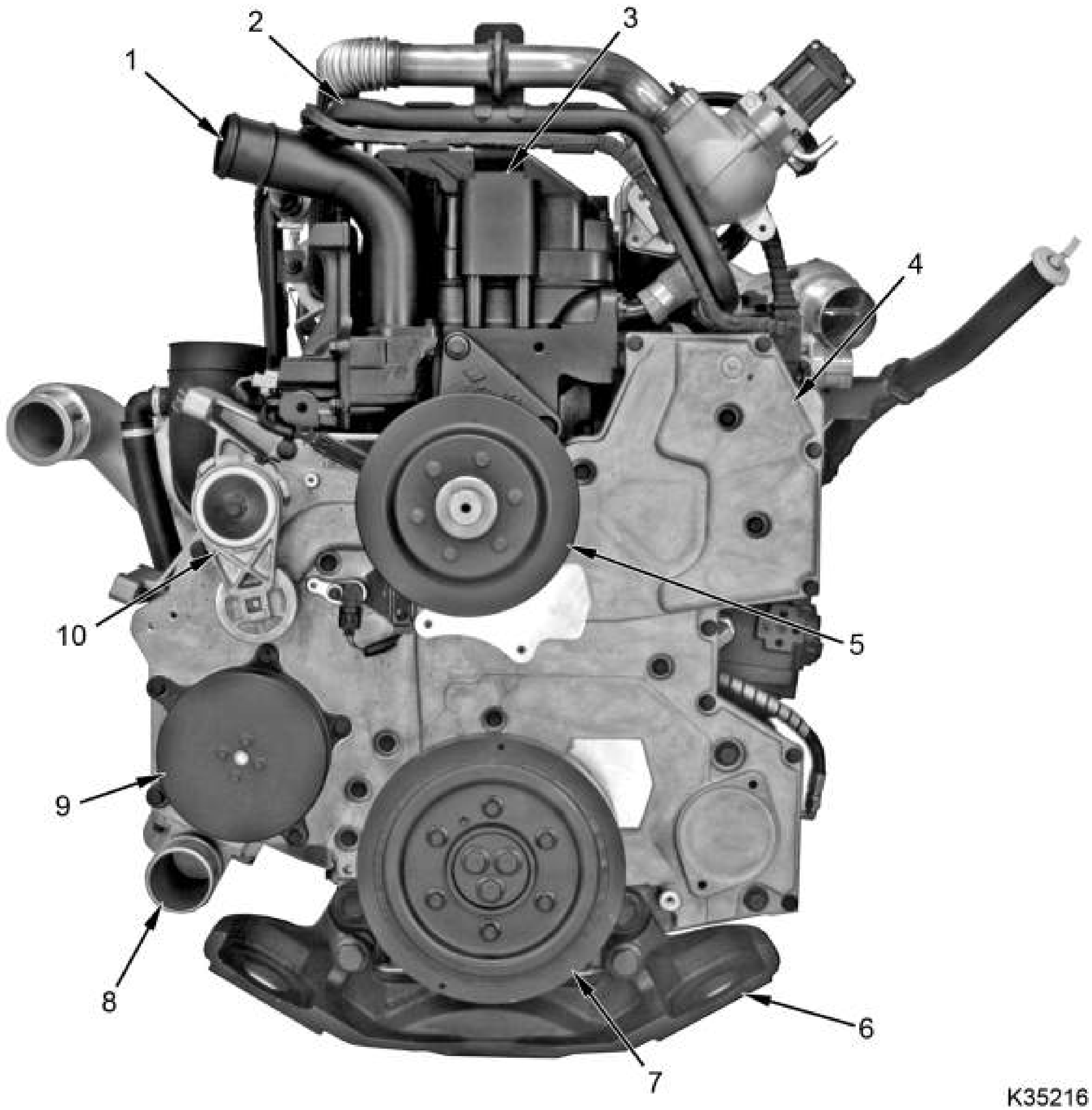

Figure 4 Component location – front

1. Water outlet tube assembly
2. Coolant crossover tube assembly (EGR)
3. Tube support
4. Front cover
5. Fan drive pulley
6. Front engine mounting bracket
7. Vibration damper assembly
8. Water inlet elbow
9. Water pump pulley
10. Automatic belt tensioner

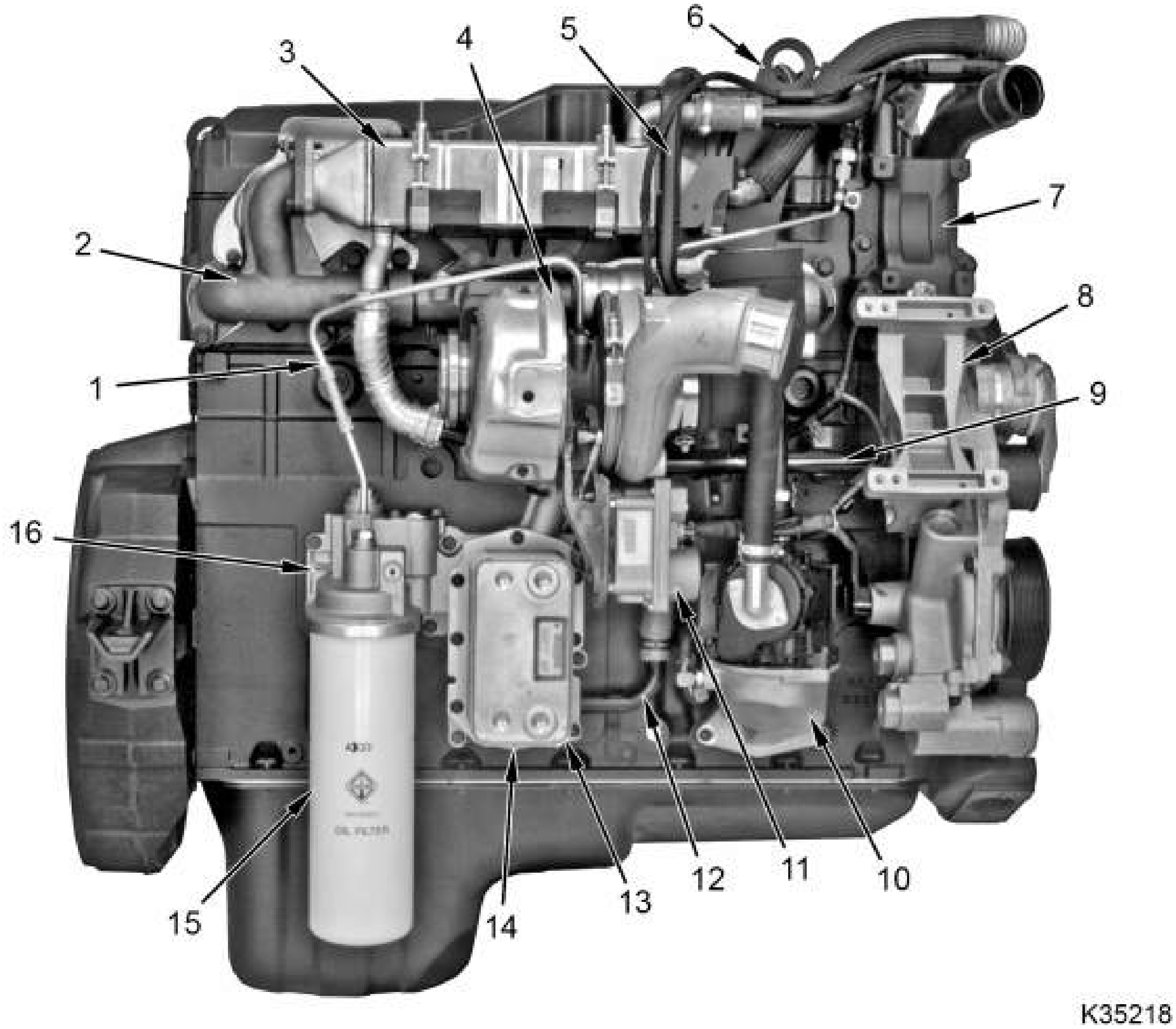

Figure 5 Component location – right

1. Turbocharger oil supply tube assembly
2. Exhaust manifold
3. Exhaust side EGR cooler
4. Variable Geometry Turbocharger (VGT) assembly
5. Breather inlet tube assembly
6. Lifting eye
7. Water supply housing (Freon® compressor mount)
8. Alternator bracket
9. EGR coolant supply tube
10. Crankcase breather assembly with turbine
11. VGT actuator
12. Coolant tube (oil system module)
13. Cooler heat exchanger
14. M18 plug assembly (coolant drain)
15. Oil filter
16. Oil system module assembly

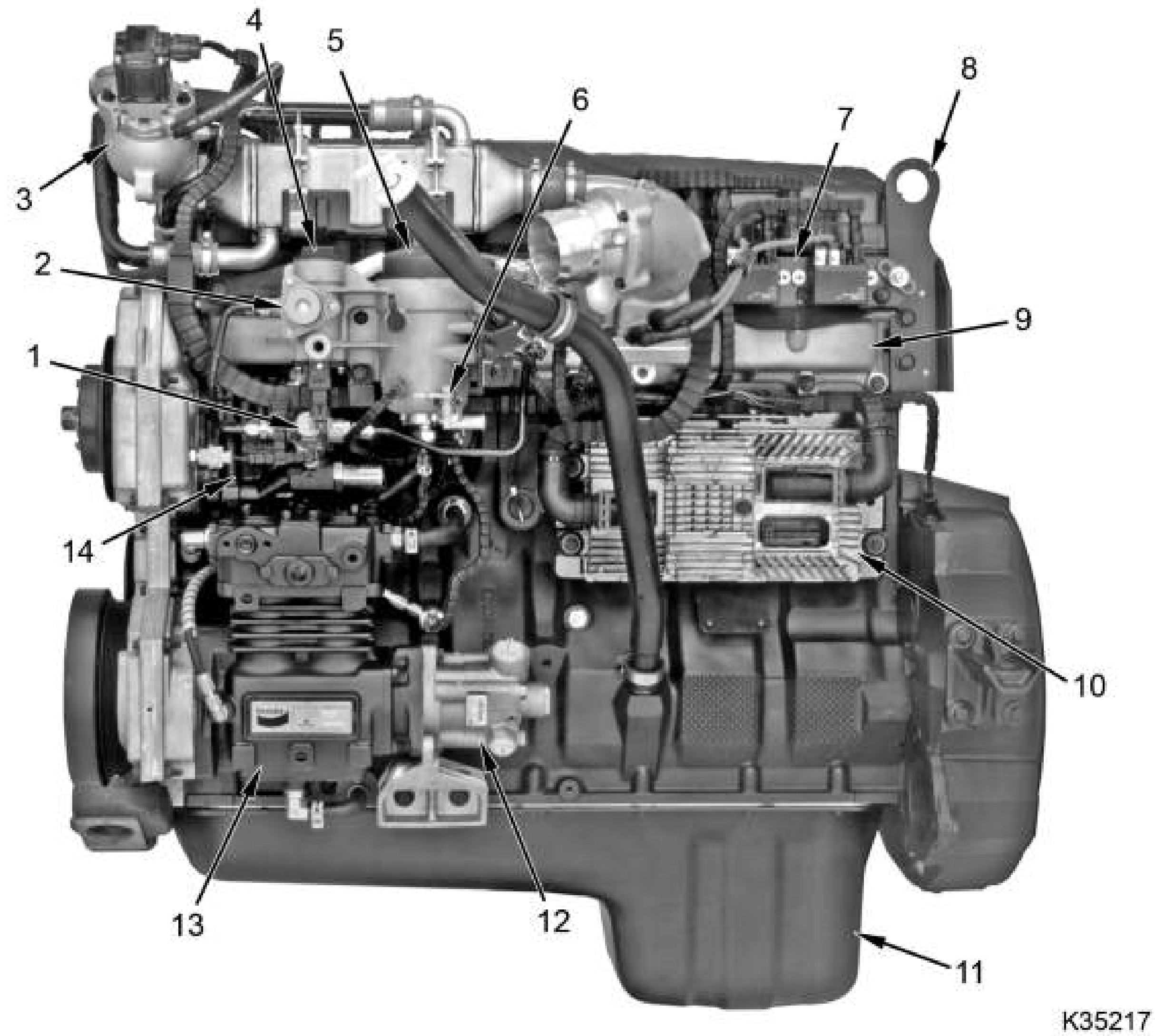

Figure 6 Component location – left

1. Low-pressure fuel pump
2. Priming pump (fuel)
3. EGR valve manifold assembly
4. Fuel strainer cap
5. Fuel filter cap
6. Water drain valve
7. Intake Air Heater (IAH) relay assembly
8. Lifting eye
9. Intake manifold
10. Electronic Control Module (ECM)
11. Oil pan
12. Power steering pump assembly
13. Air compressor assembly
14. High-pressure oil pump

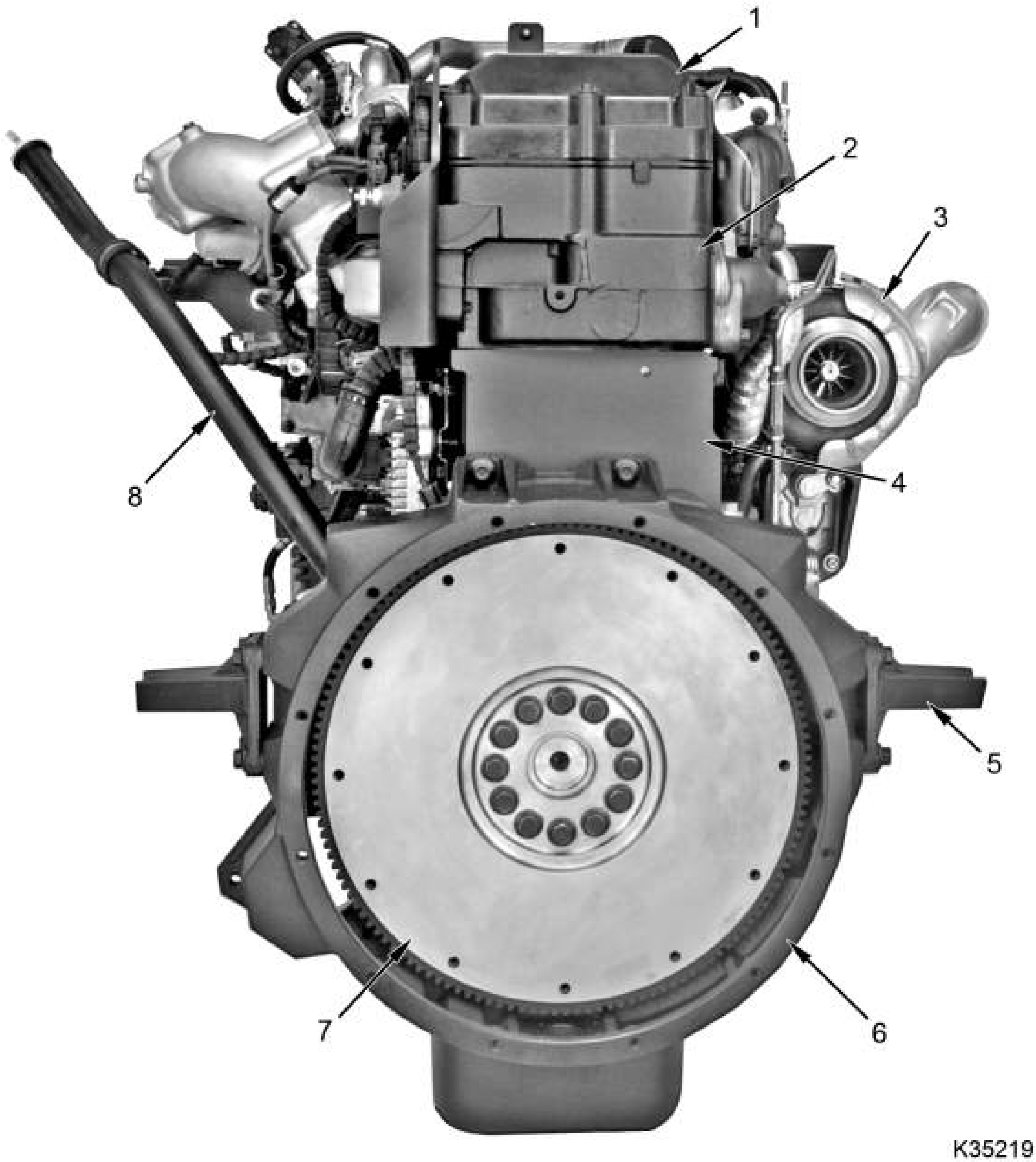

Figure 7 Component location – rear

1. Valve cover
2. Cylinder head
3. VGT assembly
4. Crankcase
5. Rear engine mounting bracket (2)
6. Flywheel housing
7. Flywheel
8. Oil filler tube

Air Management System

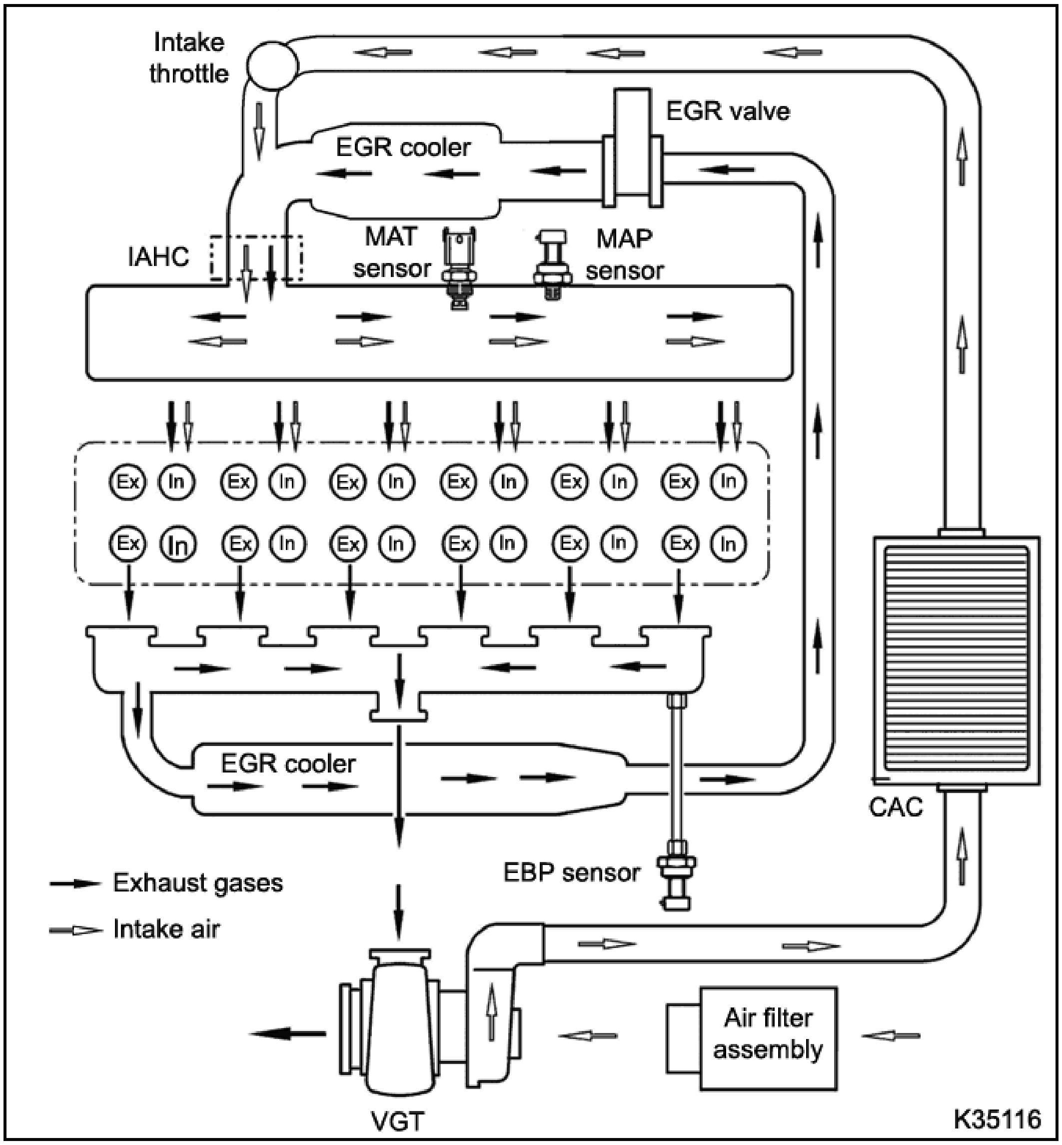

Figure 8 Air management system

The Air Management System includes the following:

- Air filter assembly
- Variable Geometry Turbocharger (VGT)
- Charge Air Cooler (CAC)
- Intake throttle valve
- Exhaust Gas Recirculation (EGR)
- Intake manifold and EGR mixer
- Inlet Air Heater Control (IAHC)
- Exhaust and intake valves
- Exhaust system
- Diamond Logic® exhaust and engine brake
- Diesel Particulate Filter (DPF – Aftertreatment System)

Air Flow

Air flows through the air filter assembly and enters the VGT. The VGT compressor increases the pressure, temperature, and density of the intake air before it enters the CAC. Cooled compressed air flows from the CAC into the inlet throttle valve and EGR mixer duct.

If the EGR control valve is open, exhaust gas will pass through the EGR system and mix with the filtered intake air. This mixture flows through the inlet air heater and into the intake manifold.

If the EGR control valve is closed, only filtered intake air will flow through the inlet air heater and into the intake manifold.

After combustion gases exit through the exhaust valves and ports, the gas is forced through the exhaust manifold to the EGR system and VGT.

Some gas flows through the EGR system, which is controlled by the EGR valve. The remaining gas flows to the VGT turbine.

The turbo vanes control flow and pressure of exhaust gas. This controls the speed of the compressor wheel, which is connected to the turbine wheel by a shaft. The VGT compressor wheel compresses the filtered air.

Exhaust gases exit the turbocharger, flow into the exhaust piping to the aftertreatment system, and are released from the exhaust tail pipe.

Air Management Components

Charge Air Cooler (CAC)

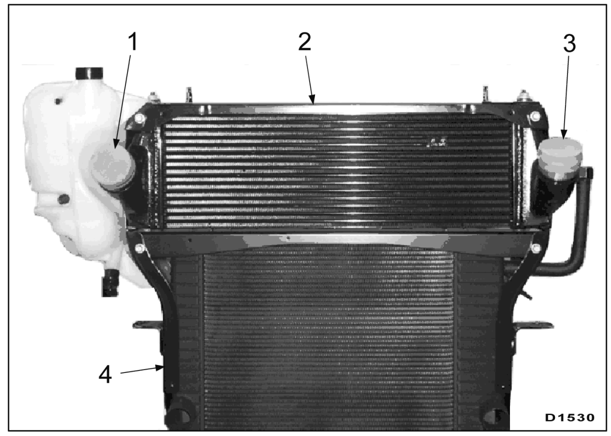

Figure 9 CAC

1. Air outlet
2. CAC
3. Air inlet
4. Radiator

The chassis mounted CAC is mounted on top of the radiator. Air from the turbocharger passes through a network of heat exchanger tubes before entering the engine intake system. Outside air flowing over the heat exchanger tube fins cools the charge air. Cooling the charge air increases the density and improves the air to fuel ratio during combustion.

Exhaust Gas Recirculation (EGR) System

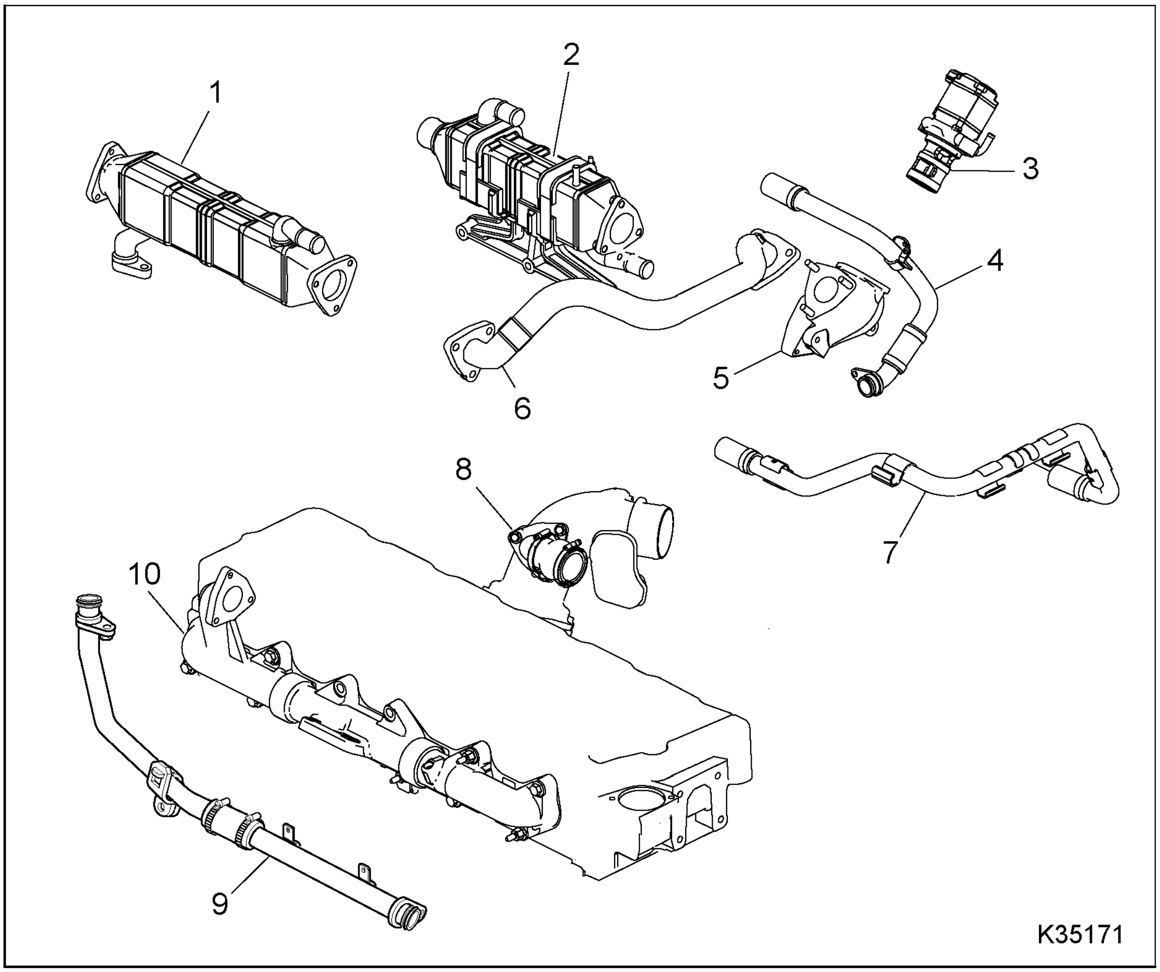

Figure 10 EGR system

1. Exhaust side EGR cooler
2. Intake side EGR cooler
3. EGR valve
4. EGR coolant return tube assembly
5. EGR valve manifold
6. EGR tube assembly
7. Coolant crossover tube assembly
8. EGR metering tube
9. EGR coolant supply tube
10. Exhaust manifold

The EGR system includes the following:

- Exhaust manifold
- EGR exhaust side cooler
- Exhaust gas crossover tube
- Electrical control system
- EGR control valve
- EGR intake side cooler
- EGR mixer duct
- Intake manifold

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

Metered exhaust gas from the exhaust manifold flows into the exhaust side EGR cooler. Cooled exhaust gas flows through the exhaust tube assembly to the EGR control valve.

When the EGR is commanded, the EGR control valve opens and allows cooled exhaust gas to enter the intake side EGR cooler for further cooling. This exhaust gas is directed into the EGR mixer duct where it is mixed with filtered intake air.

EGR Control Valve

Figure 11 EGR control 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 EGR valve manifold on the top front 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 is shut by a spring. The valve assembly has two poppet valves on a common shaft.

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

EGR Closed Loop System

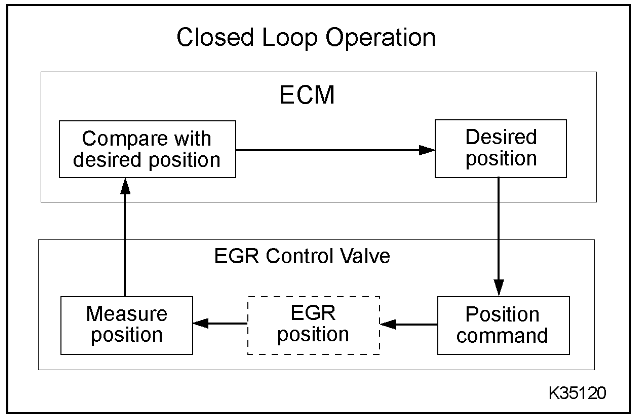

Figure 12 EGR closed loop system

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

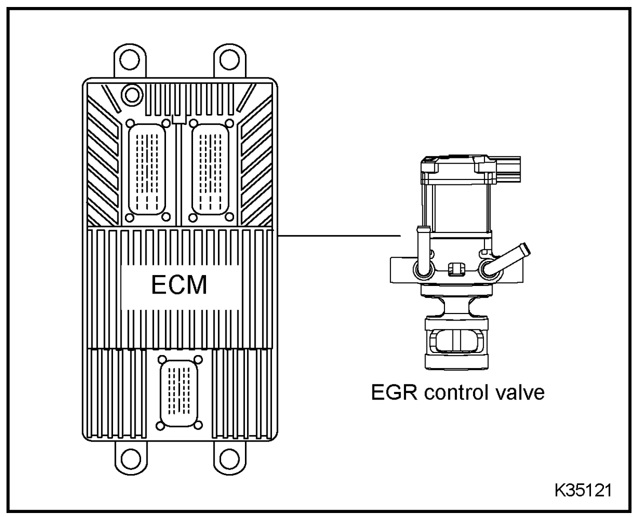

Figure 13 EGR control

Variable Geometry Turbocharger (VGT)

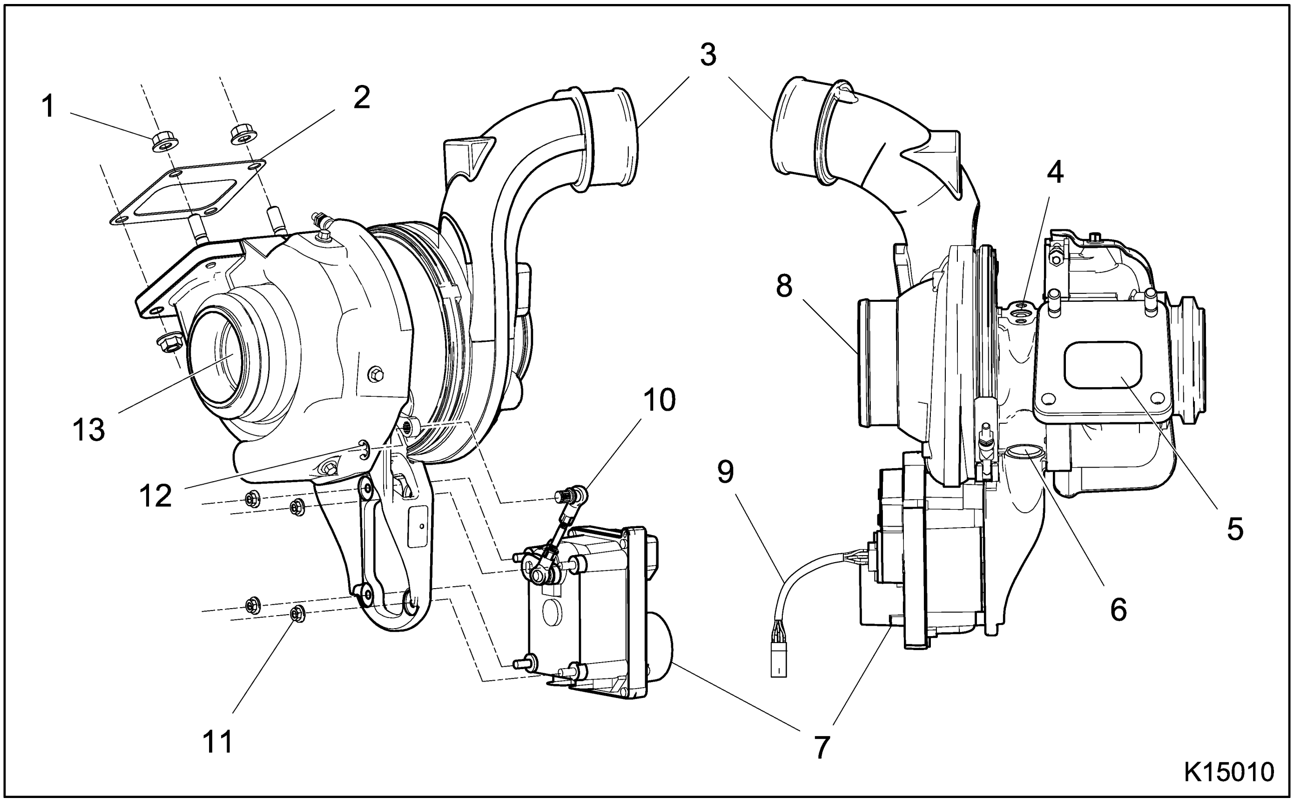

Figure 14 VGT components

1. M10 nut (4)
2. Turbo mounting gasket
3. Compressor outlet
4. Oil supply port
5. Turbine inlet
6. Oil drain port
7. VGT actuator
8. Compressor inlet
9. VGT actuator harness
10. VGT actuator linkage
11. M6 serrated lock nut (4)
12. E-clip
13. Turbine outlet

The VGT responds to engine load. During heavy load, an increased flow of exhaust gases turns the turbine wheel faster. The increased speed turns the compressor impeller faster and supplies greater air quantity and boost pressure to the intake manifold. When engine load is light, the flow of exhaust gases decreases which causes reduction in air volume and boost pressure.

The VGT has actuated vanes in the turbine housing. These vanes modify flow characteristics of the exhaust gases through the VGT to further control boost pressures for various engine speeds and load conditions.

VGT Closed Loop System

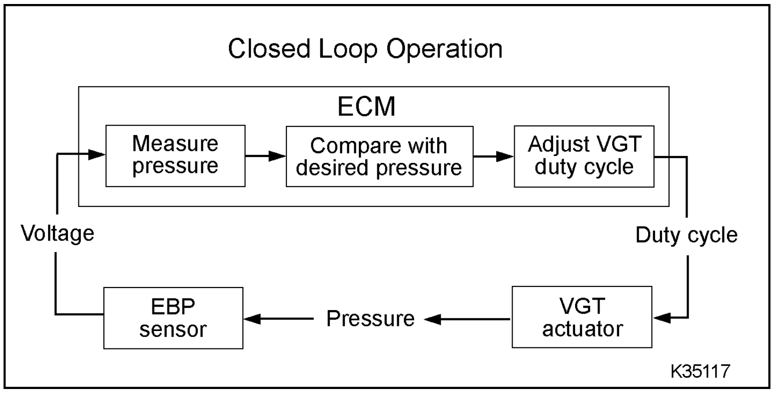

Figure 15 VGT closed loop system

The VGT is a closed loop system that uses the EBP sensor to provide feedback to the ECM. The EBP sensor continuously monitors exhaust system back pressure while the ECM adjusts VGT position to match engine requirements.

VGT Control

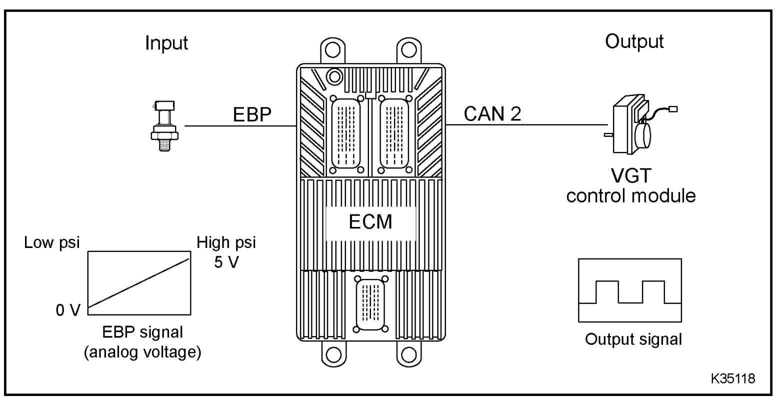

Figure 16 VGT control

The VGT actuator is a control module located below the turbocharger. The internal microchip controls a DC motor which rotates a crank lever that adjusts vane position in the turbine housing. The position of the vanes is based on the VGT signal sent from the ECM.

Moveable vanes are mounted around the inside circumference of the turbine housing. A unison ring links all the vanes together. When the unison ring moves, all vanes will move to the same position. Unison ring movement occurs when the crank lever in the VGT actuator moves.

Exhaust gas flow can be regulated, depending on required exhaust system back-pressure, to match engine speed and load. As demand for exhaust system back-pressure increases, the ECM increases the VGT signal to the VGT actuator. When exhaust system back-pressure demand is reduced, the ECM decreases the VGT signal to the VGT actuator.

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 the level of soot accumulation in the Diesel Particulate Filter (DPF) and adapts engine operating characteristics to compensate for increased back pressure
- Controls engine operating parameters to make regeneration automatic.
- Maintains vehicle and engine performance during regeneration

Sensors

Sensors produce an electronic signal based on temperature and pressure. It is used by the control system to regulate the aftertreatment function.

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

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
- Oxidizes NO into NO_2 for passive DPF regeneration

Diesel Particulate Filter (DPF)

The DPF does the following:

- Captures and temporarily stores carbon-based particulates in a filter
- Allows for oxidation (regeneration) of stored particulates once loading gets to a particular level (pressure drop)
- Provides the required exhaust back pressure drop for engine performance
- 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's Manual* and the vehicle visor placard.

Fuel Management System

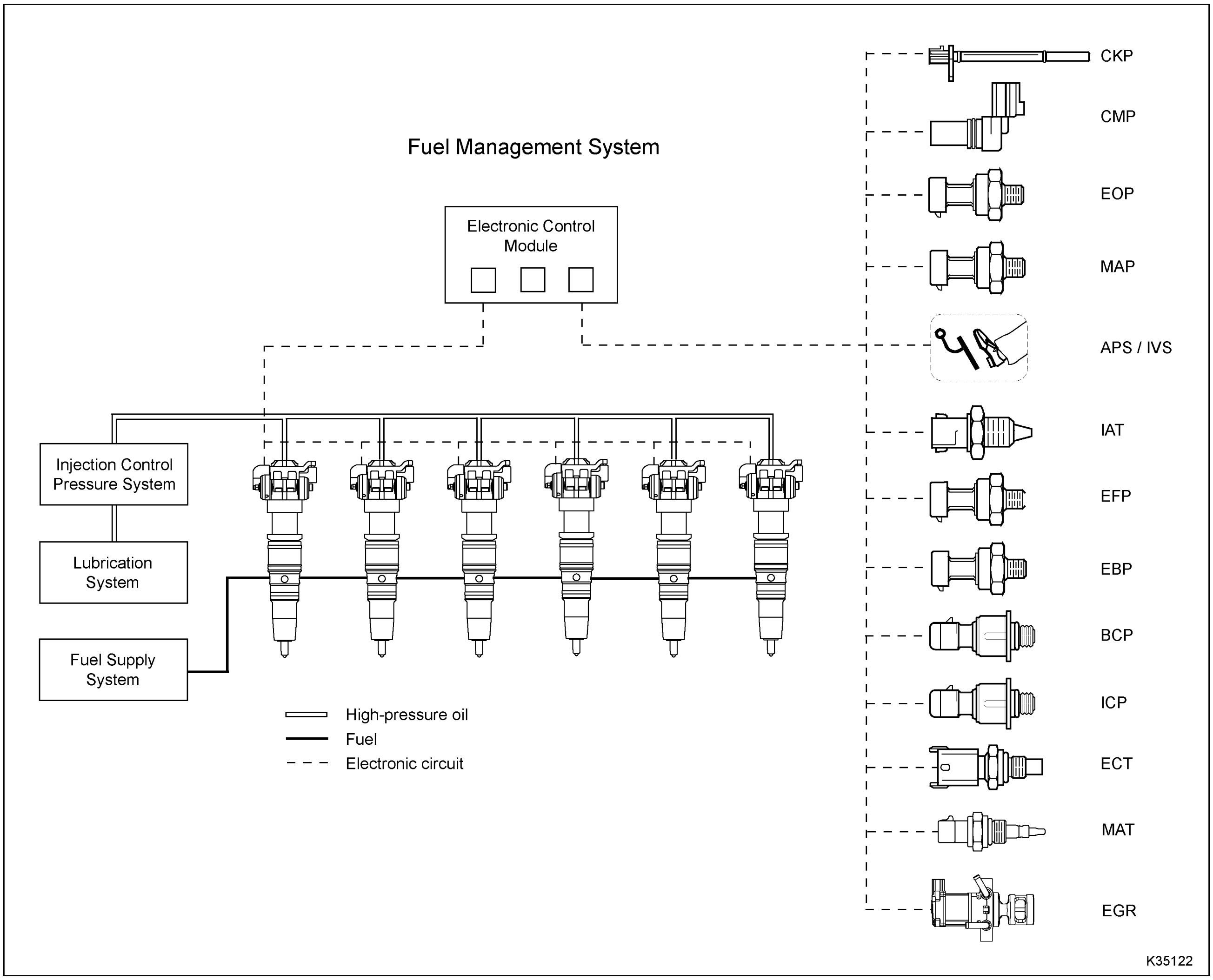

Figure 17 Fuel management system

The fuel management system includes the following:

- Lubrication system
- Injection Control Pressure (ICP) system
- Diamond Logic® engine brake
- Fuel supply system
- Fuel injectors
- Electronic control system

ICP System

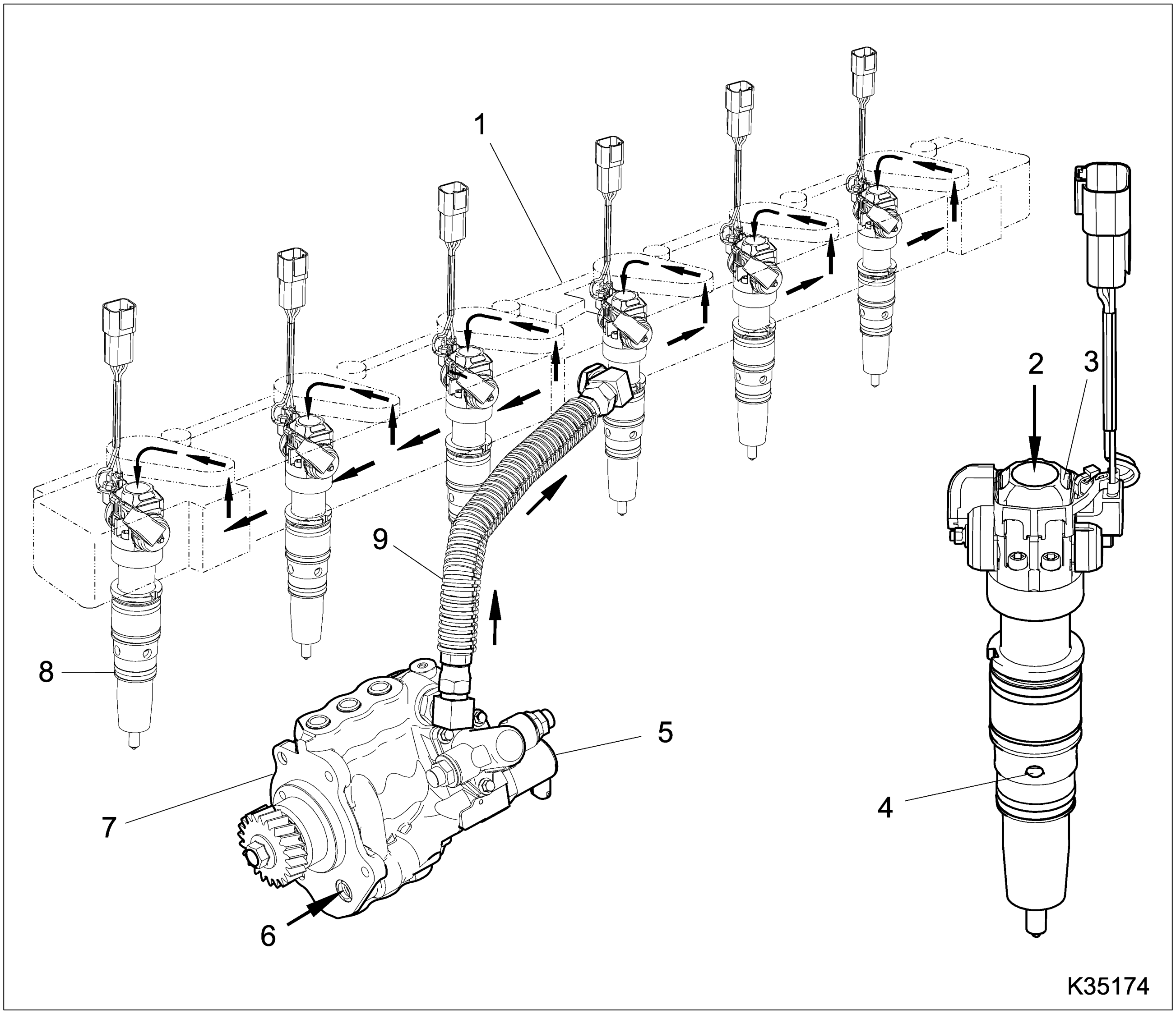

Figure 18 ICP system

1. High-pressure oil manifold
2. Injector oil inlet from high-pressure oil manifold
3. Oil outlet (2)
4. Fuel inlet port (4)
5. Injection Pressure Regulator (IPR) valve
6. Oil inlet from front cover reservoir
7. High-pressure oil pump assembly
8. Fuel injector assembly (6)
9. High-pressure oil hose

High-Pressure Oil Flow

The lubrication system constantly refills 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 gear driven from the front of the engine.

High-pressure oil is directed to the high-pressure oil hose, cylinder head passage, and high-pressure oil manifold, which is located beneath the valve cover.

High-pressure oil is used by the fuel injectors to inject, pressurize, and atomize 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 Engine 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 brake is activated.

ICP Closed Loop System

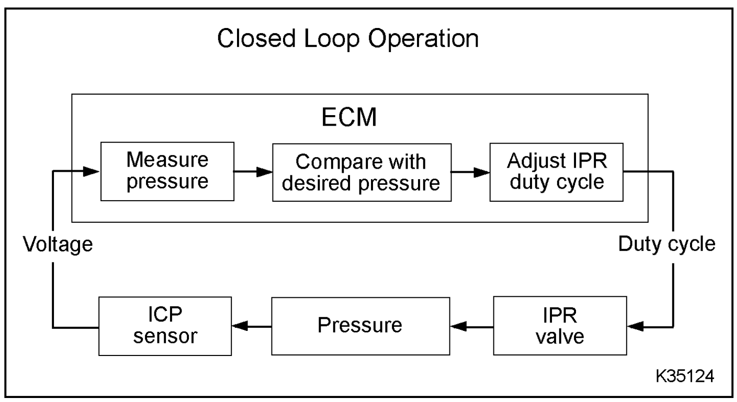

Figure 19 ICP closed loop system

The ICP system is a closed loop system that uses the ICP sensor to continuously provide injection control pressure feedback to the ECM. The ECM commands the IPR duty cycle to adjust ICP pressure to match engine requirements.

ICP Control System

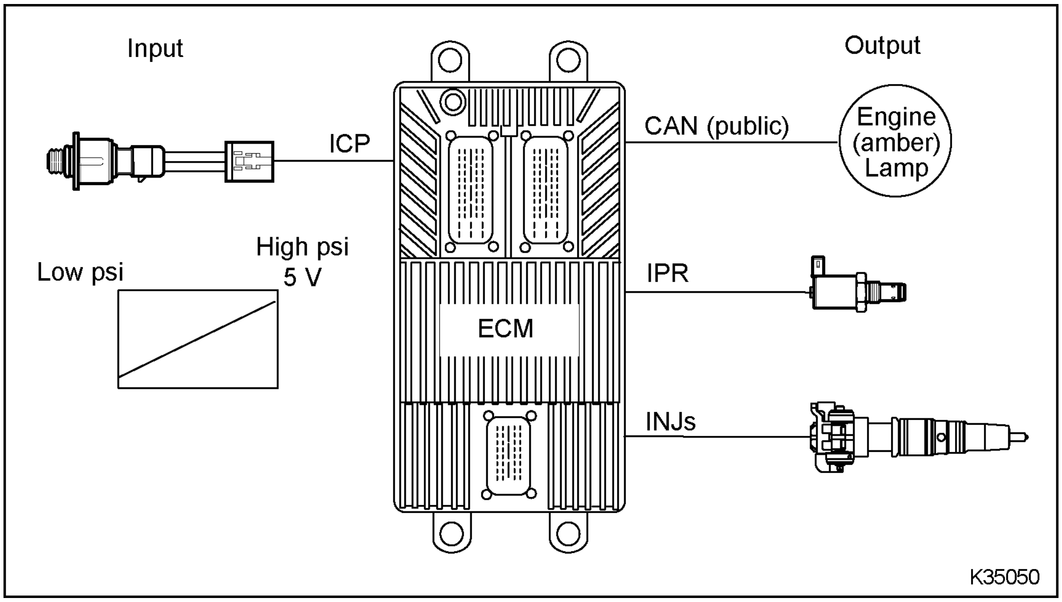

Figure 20 ICP sensor control system

The IPR solenoid receives a pulse-width modulated signal from the ECM. This indicates the on and off time the IPR control valve is energized. The pulse is calibrated to control ICP pressure which ranges from 5 MPa (725 psi) up to 32 MPa (4,650 psi).

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

As demand for injection control pressure increases, the ECM increases the pulse-width modulation to the IPR solenoid. When demand for injection control pressure decreases, the duty cycle to the IPR solenoid decreases and more oil is allowed to flow to the drain orifice.

When the injection control pressure electrical signal is out-of-range, the ECM sets a Diagnostic Trouble Code (DTC). The ECM will not set DTCs if an injection control pressure signal corresponds to an in-range valve for injection control pressure for a given operating condition.

When ICP signals that are out-of-range, the ECM ignores out-of-range signals and go 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

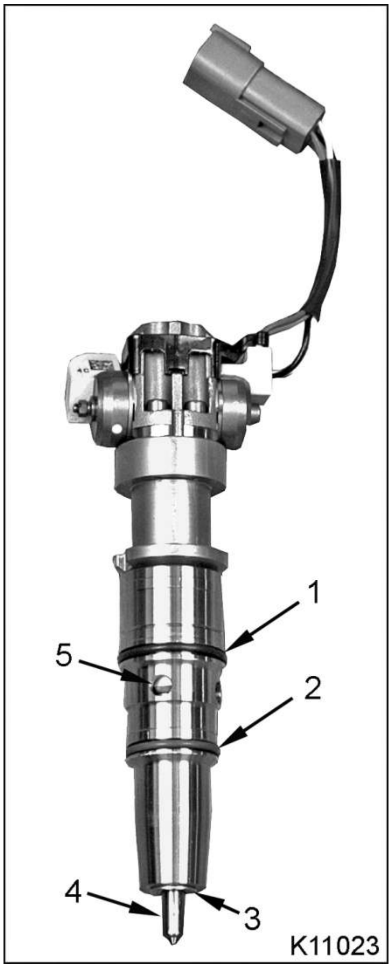

Figure 21 Fuel injector

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

Fuel Injector Features

Two 48 volt, 20 amp coils control a spool valve that directs oil flow in and out of the injector. The injector coils are turned on for approximately 800 μs (microseconds). Each injector has a single four pin connector that couples 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 7.1 times greater in surface area than the plunger, the injection pressure is also 7.1 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 7.1 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) of 28 MPa (4,075 psi). 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

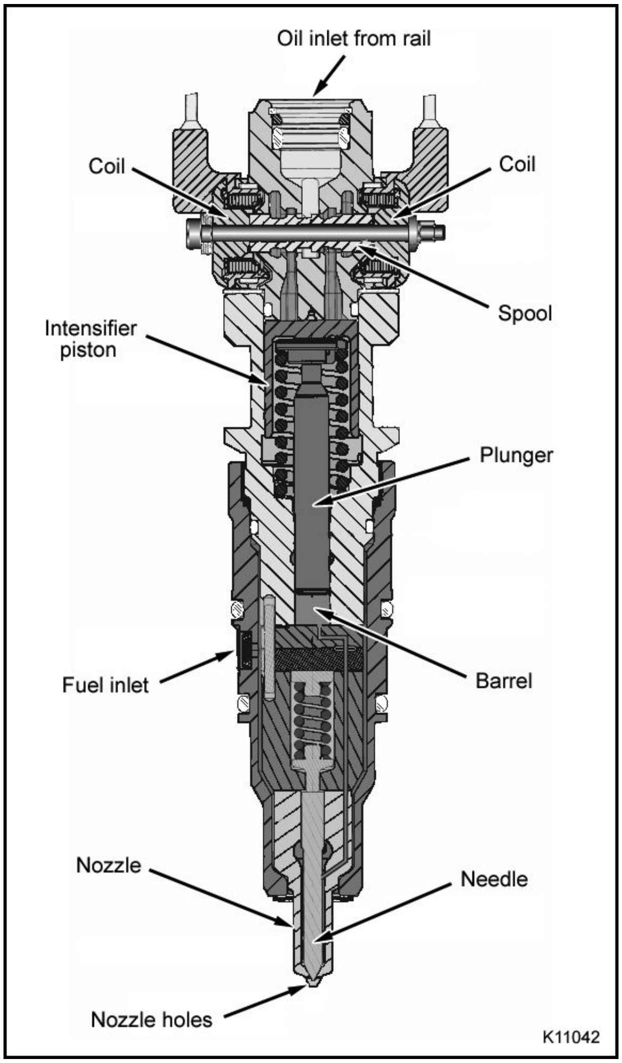

Figure 22 Fuel injector cross section

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 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 onto its seat.

Fuel Supply System

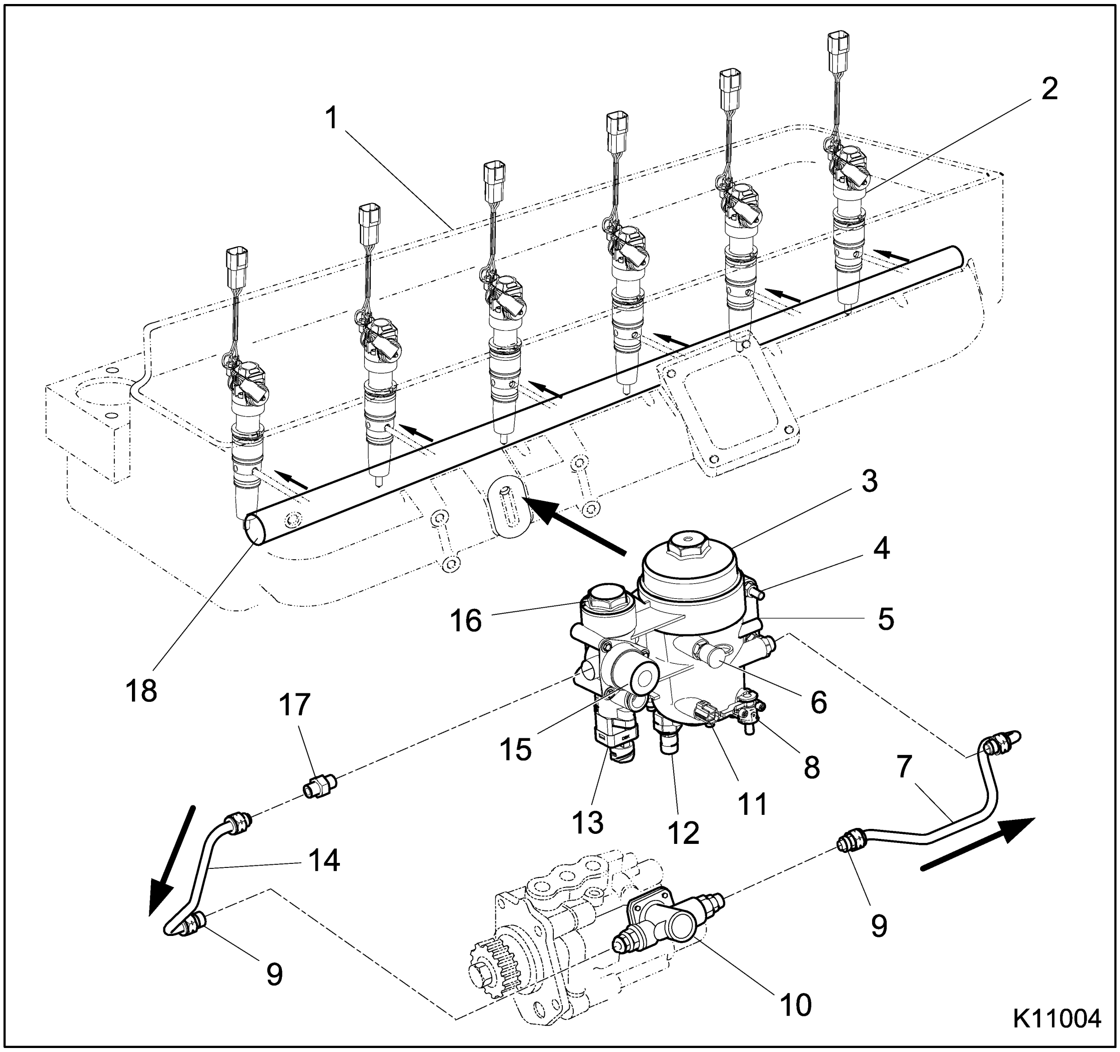

Figure 23 Low-pressure fuel system

1. Cylinder head
2. Fuel injector assembly (6)
3. Fuel filter cap
4. M8 x 75 stud bolt
5. Fuel filter header assembly
6. Diagnostic coupling assembly and dust cap
7. Transfer pump outlet tube assembly
8. Water drain valve
9. 3/8 tube sleeve (2 each tube)
10. Low-pressure fuel pump
11. Water In Fuel (WIF) sensor
12. Engine Fuel Pressure (EFP) sensor
13. Fuel heater (optional)
14. Transfer pump inlet tube assembly
15. Primer pump
16. Fuel strainer cap
17. Fitting assembly with check valve
18. Low-pressure fuel rail (cast in intake manifold)

Fuel Supply System Flow

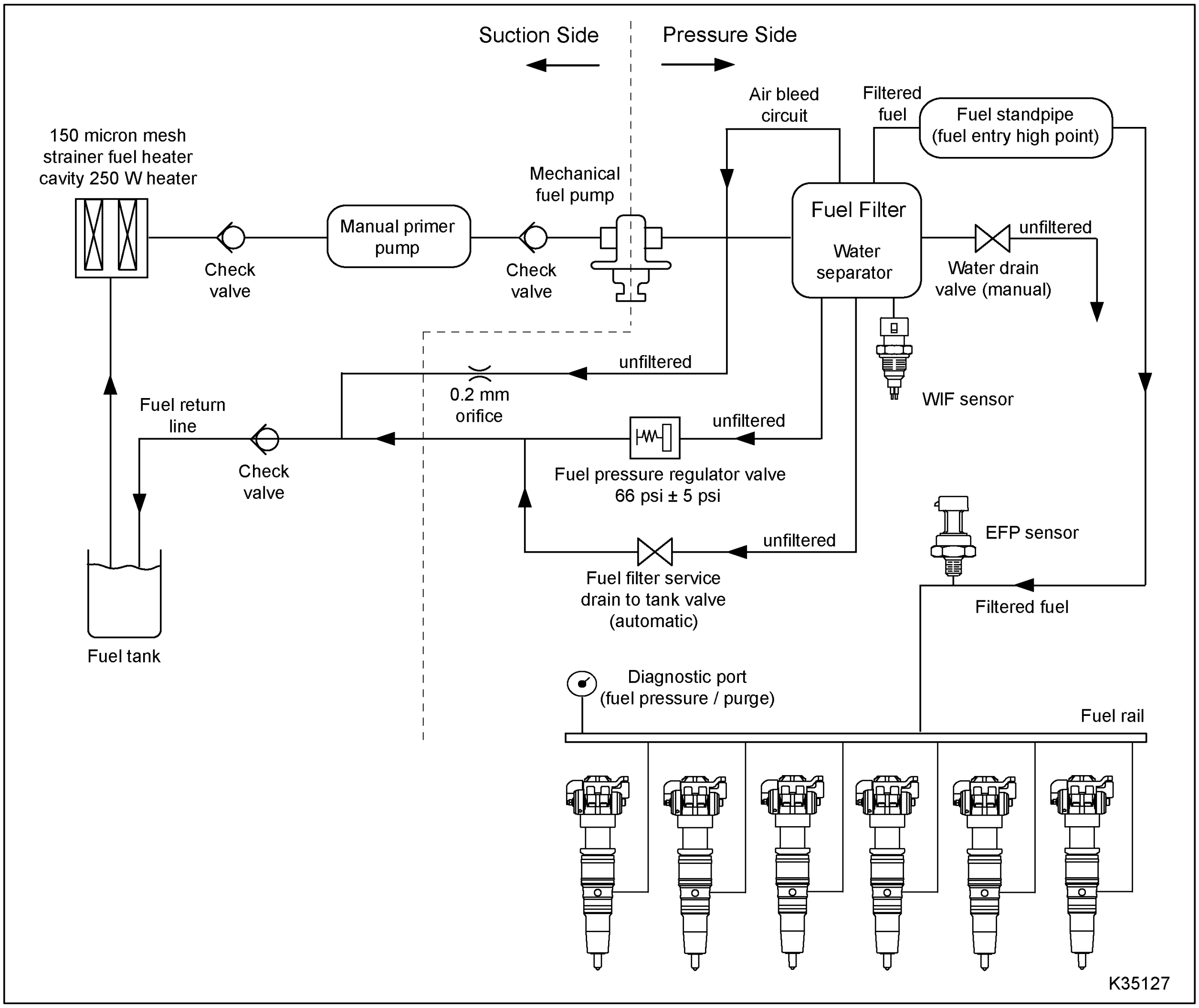

Figure 24 Fuel flow

The low-pressure fuel pump draws fuel through the fuel lines from the fuel tank. Fuel enters the fuel filter header assembly and passes through the 150 micron strainer.

An optional 250 watt electric heating element is available to warm incoming fuel to prevent waxing and improve cold weather performance. The heater is located in the base of the fuel strainer.

Fuel flows from the strainer through the low-pressure fuel pump to the fuel filter for further conditioning.

Fuel flows through the 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.

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.

When the maximum amount of water is collected in the element cavity, the WIF sensor sends a signal to the Engine Control Module (ECM). The ECM will turn on the amber FUEL FILTER lamp located on the instrument panel.

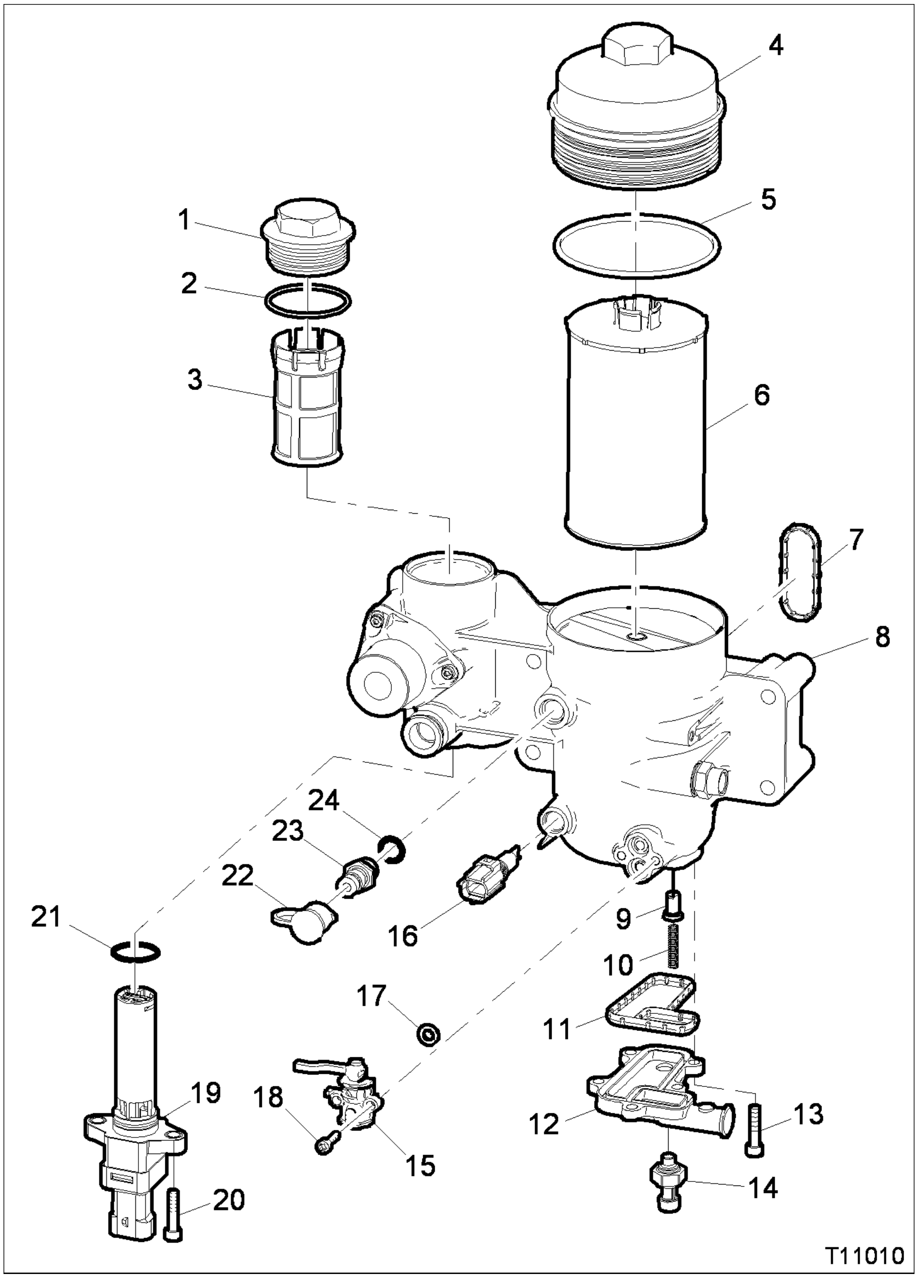

Figure 25 Fuel filter header assembly

1. Strainer lid
2. O-ring gasket
3. Fuel strainer element
4. Fuel filter cap
5. O-ring gasket
6. Fuel filter element
7. Irregular molded gasket
8. Filter assembly housing
9. Fuel pressure regulator valve assembly
10. Fuel pressure regulator valve spring
11. Cover plate seal
12. Cover plate
13. M6 screw (5)
14. Engine Fuel Pressure (EFP) sensor
15. Water drain valve assembly
16. Water In Fuel (WIF) sensor
17. O-ring
18. M5 screw (2)
19. 250 Watt fuel heater assembly (optional)
20. M6 screw (2)
21. Heater O-ring gasket
22. Dust cap
23. Diagnostic coupling assembly
24. O-ring

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 header assembly. The regulator valve is calibrated to open at 455 kPa ± 34 kPa (66 psi ± 5 psi) to regulate and 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, an automatic drain-to-tank valve is opened. Fuel present in the filter housing then drains out and back to the tank to provide improved cleanliness during servicing.

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

Filtered fuel flows from the fuel filter header assembly into the fuel rail. The fuel rail is an integral part of the intake manifold. The 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 inside the fuel injectors.

Engine Lubrication System

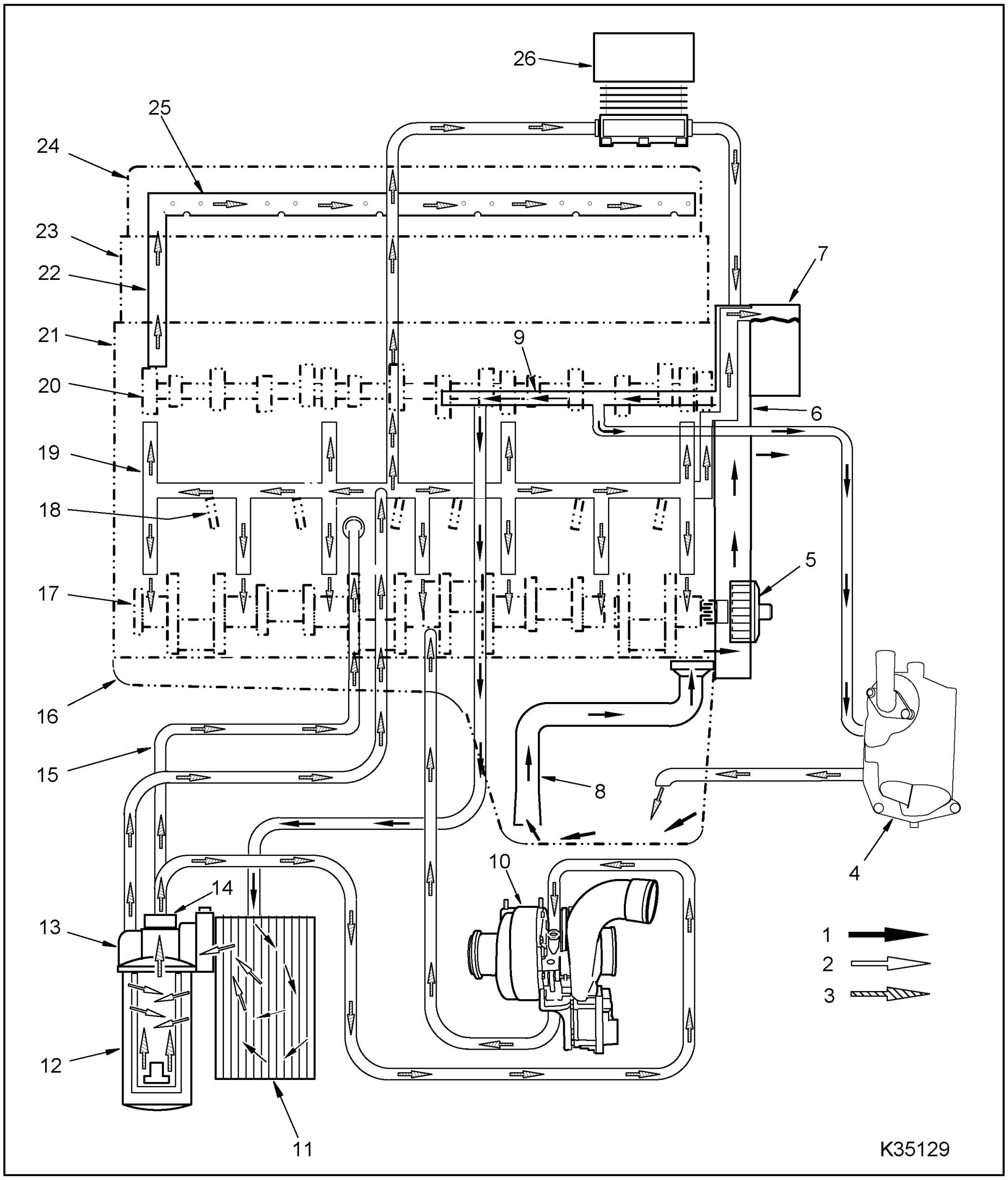

Figure 26 Lubrication system

1. Unfiltered oil
2. Cooled unfiltered oil
3. Filtered oil
4. Crankcase breather assembly
5. Gerotor oil pump
6. Front cover
7. Reservoir for high-pressure oil pump
8. Pick-up tube
9. Unfiltered oil gallery
10. Variable Geometry Turbocharger (VGT)
11. Oil cooler
12. Oil filter
13. Oil system module assembly
14. Oil pressure regulator relief valve
15. Regulator relief valve drain to crankcase
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
26. Air compressor (optional)

Oil Flow

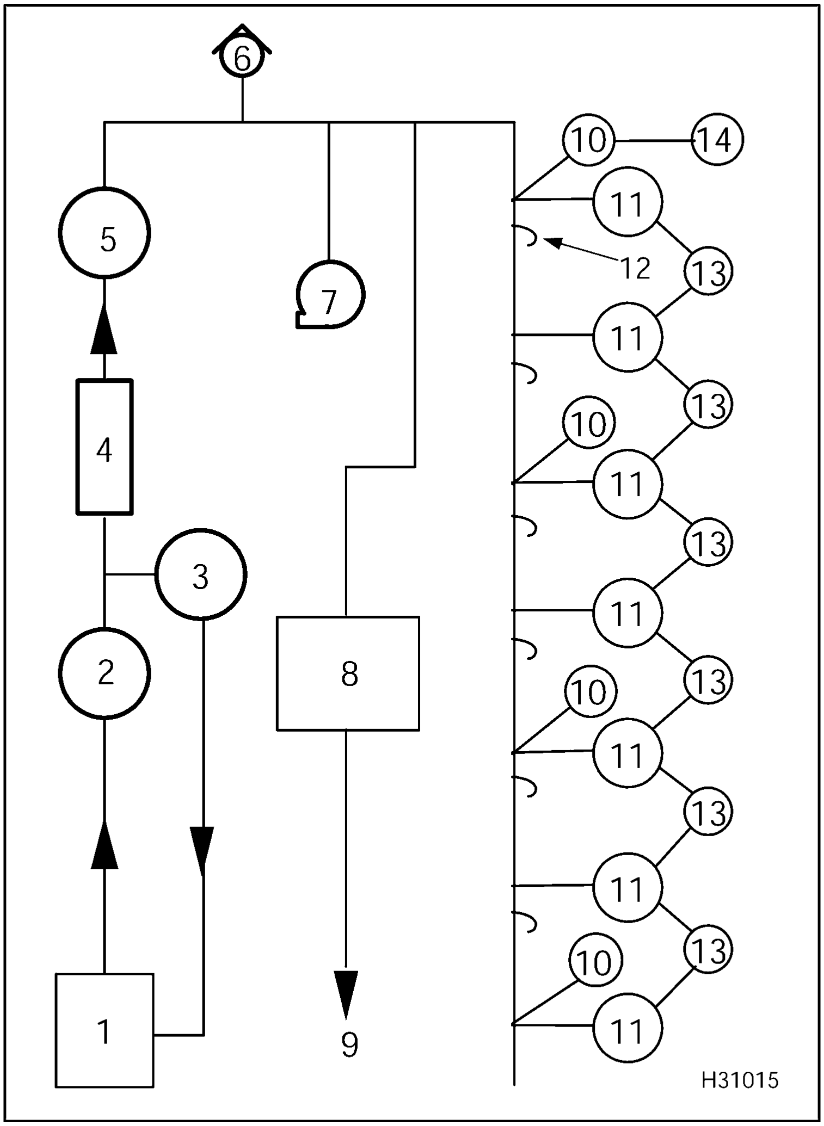

Figure 27 Lubrication system

1. Sump
2. Oil pump
3. Crankcase breather assembly
4. Oil cooler
5. Oil filter
6. Oil pressure regulator valve
7. Variable Geometry Turbocharger (VGT)
8. Oil reservoir for high-pressure pump
9. To high-pressure oil system
10. Cam bearing
11. Main bearings
12. Piston cooling tube (6)
13. Connecting rods
14. Rocker arm shaft

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 at the oil system module assembly is controlled by the oil thermal valve assembly.

The thermal valve assembly 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 valve assembly begins to open. This allows unfiltered oil to flow into the oil cooler and oil filter.

When the oil temperature is hot, the thermal valve assembly allows 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 system module assembly) opens and allows oil to bypass the filter to maintain engine lubrication. The filter bypass valve opens when pressure reaches 345 kPa (50 psi).

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 379 kPa (55 psi).

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 from the main oil gallery exits upwards through a passage at the rear of the crankcase. Oil flows through a passage in the cylinder head and enters the hollow rocker shaft which lubricates the rocker arms.

The crankcase breather assembly is driven by unfiltered oil pressure taken from the right side of the crankcase. Oil flows from the crankcase into the breather assembly. Passages direct the oil through a pressed brass nozzle that controls oil flow into a drive wheel. Oil drains into the base and mixes with waste 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 system module assembly to the center housing of the turbocharger. Oil drains back to the oil pan through a drain tube connected to the crankcase.

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

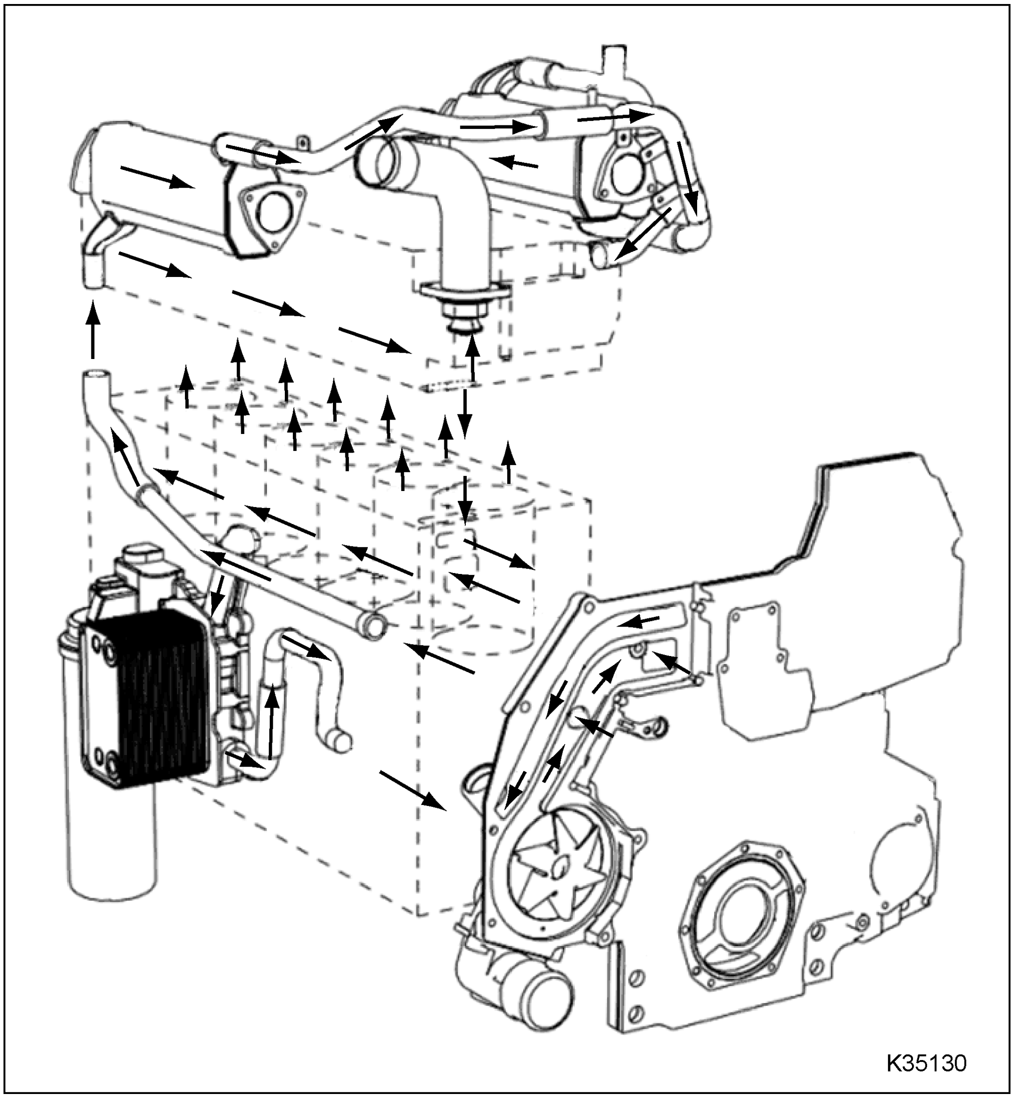

Figure 28 Cooling system components and flow

The engine cooling system includes the following:

- Chassis mounted radiator
- Fan
- Water inlet elbow
- Front engine covers
- Water pump
- Crankcase
- Cylinder sleeves
- Cylinder head
- Oil system module assembly
- Air compressor
- Thermostat
- Dual EGR coolers
- EGR control valve
- Surge tank
- Coolant heater

Cooling System Flow

Coolant is drawn from the radiator through an inlet elbow and front cover by the water pump. The water pump pushes coolant into two passages in the front cover.

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

Swirling coolant flow in the cylinder liner jackets directs coolant through passages in the 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. Depending on coolant temperature, the thermostat can direct in two directions to exit 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 from the engine into the radiator.

Coolant passes through the radiator and is cooled by moving air from the coolant fan. The coolant will return to the engine through the inlet elbow.

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

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

The exhaust side EGR cooler receives coolant from the water pump through a supply tube. Coolant passes between the EGR cooler plates, travels parallel to the exhaust flow, and exits into another coolant tube. Coolant is supplied to the intake side EGR cooler from this tube. Coolant passes between the EGR cooler plates, parallel to the exhaust flow, and exits into the coolant return tube which connects to the cylinder head water jacket. The deaeration port on the top of the intake side EGR cooler directs coolant and trapped air through the EGR valve and towards the coolant surge tank.

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 performance and fuel economy during start-up. The coolant heater is located on the left side of the crankcase, in front of the Electronic Control Module (ECM).

Thermostat Operation

The thermostat has two outlets. One directs coolant to the radiator when the engine is at operating temperature. The other directs coolant to the water pump until the engine reaches operating temperature. The thermostat begins to open at 88 °C (190 °F) and is fully open at 96 °C (205 °F).

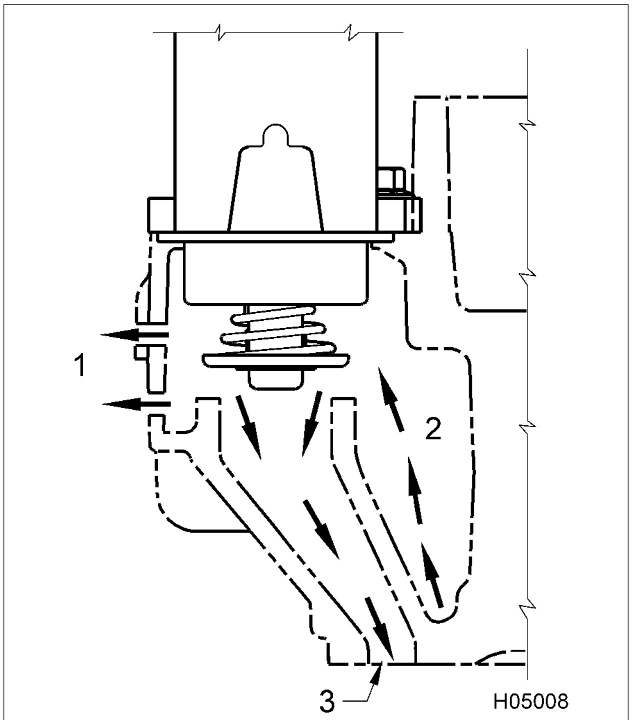

Figure 29 Thermostat closed

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

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

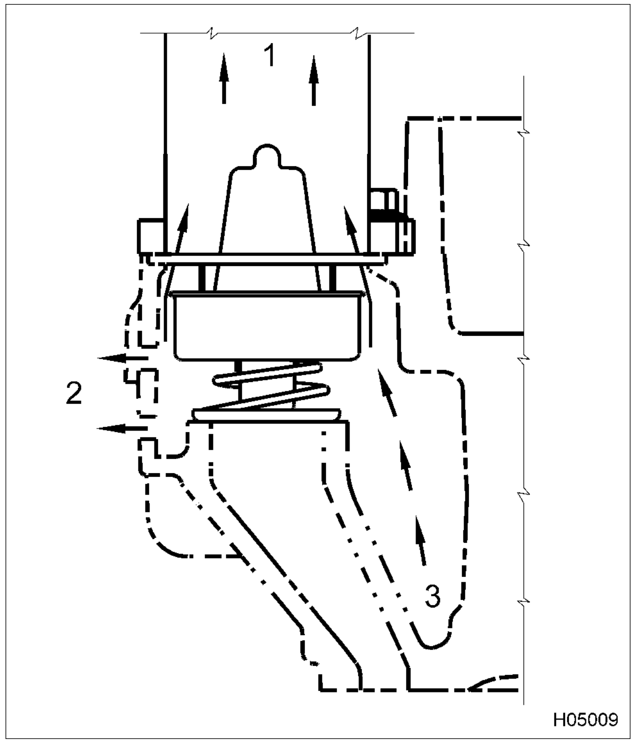

Figure 30 Thermostat open

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

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

Electronic Control System

Electronic Control System Components

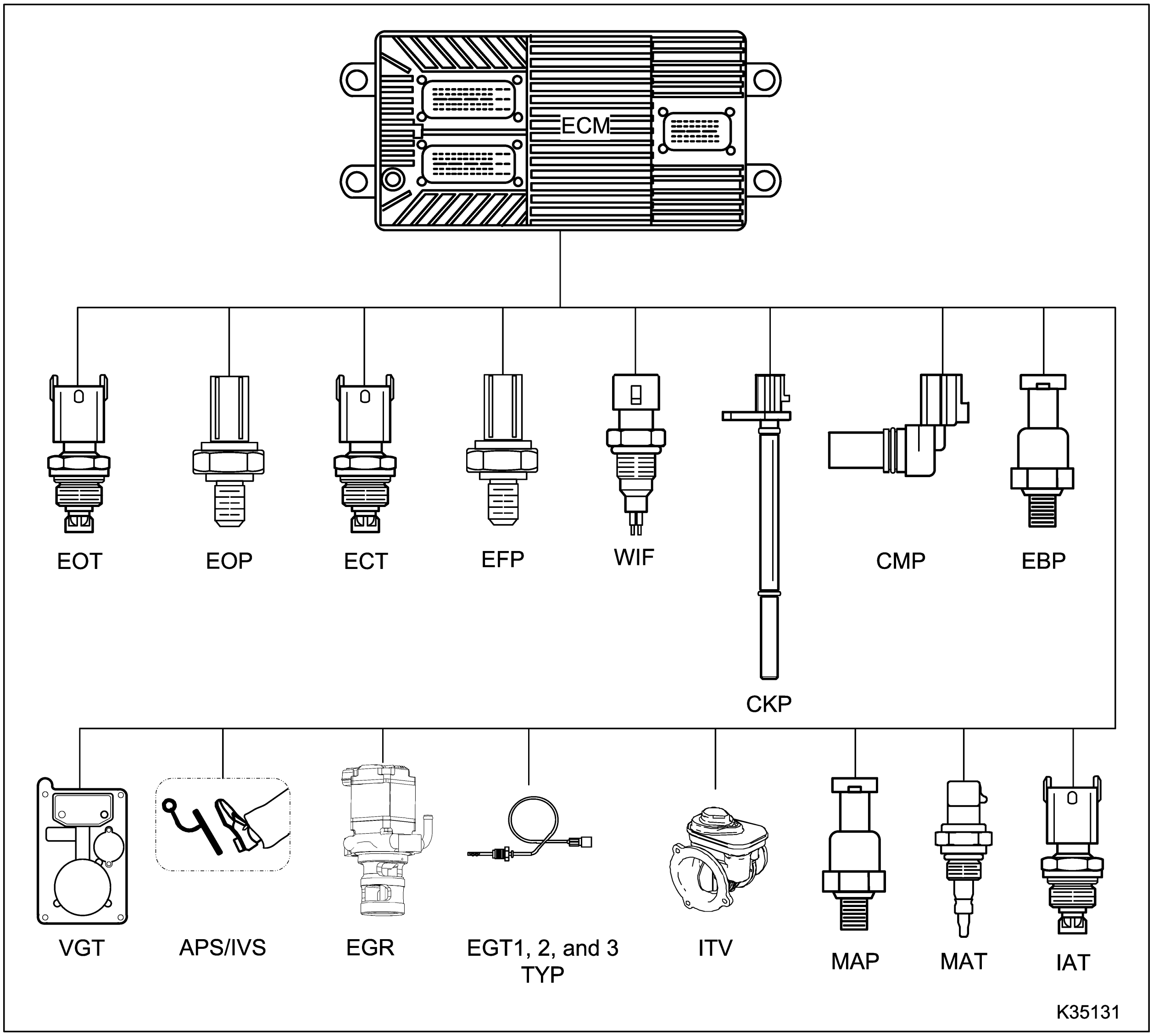

Figure 31 Electronic Control System

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:

- Provide Reference Voltage (VREF)
- Condition input signals
- Process and stores control strategies
- Control actuators

Reference Voltage (VREF)

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

The ECM supplies three independent circuits for VREF:

- VREF supplies 5 volts to engine sensors
- VREF supplies 5 volts to vehicle aftertreatment
- VREF supplies 5 volts to fuel injector control

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.

Microprocessor

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

Continuous calculations in the ECM occur at two different levels or speeds: Foreground and Background.

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

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

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

Microprocessor Memory

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

ROM

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

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

RAM

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

- Engine temperature
- Engine rpm
- Accelerator pedal position

Actuator Control

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

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

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

Actuators

The ECM controls engine operation with the following:

- Exhaust Gas Recirculation (EGR) valve
- Intake Air Heater (IAH) relay
- Intake throttle control and throttle position
- Turbo actuator

EGR Valve

The EGR valve controls the flow of exhaust gases to the intake manifold.

The EGR valve receives the desired valve position from the ECM for exhaust gas recirculation. The EGR valve provides feedback to the ECM on the valve position.

The EGR valve constantly monitors the valve position and temperature. When an EGR control error is detected, the EGR valve sends a message to the ECM and a DTC is set.

IAH Relays

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

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

The ECM activates the IAH relay. The relay delivers VBAT to the heater elements for a set time, depending on engine coolant temperature and altitude. The ground circuit is supplied directly from the battery ground at all times.

Intake Throttle Actuator and Position Sensor

The intake throttle valve controls the flow of inlet air to regulate operating temperature for exhaust aftertreatment.

The integral intake throttle actuator controls the intake throttle valve.

The intake throttle actuator receives the desired intake 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.

Engine and Vehicle Sensors and Switches

Thermistor Sensors

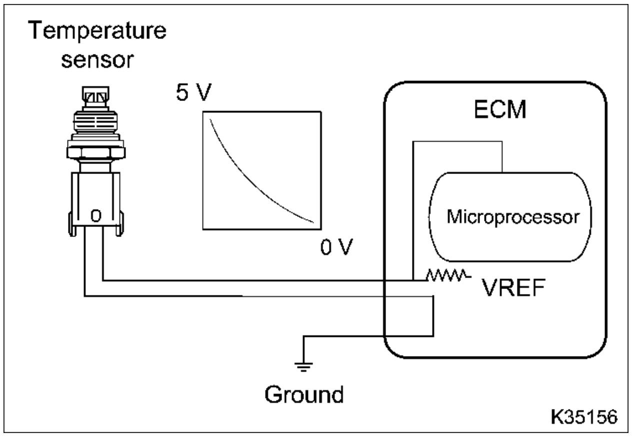

Figure 32 Thermistor

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:

- Aftertreatment temperature sensors
- Engine Coolant Temperature (ECT) sensor
- Engine Oil Temperature (EOT) sensor
- Inlet Air Temperature (IAT) sensor
- Manifold Air Temperature (MAT) sensor

Aftertreatment Sensors

Three Aftertreatment System sensors:

- Exhaust Gas Temperature (EGT) 1 sensor
- EGT 2 sensor
- EGT 3 sensor

The EGT 1 sensor provides a feedback signal to the ECM indicating Diesel Oxidation Catalyst (DOC) inlet temperature. The EGT 1 sensor is the first temperature sensor installed past the turbocharger and just before the DOC.

The EGT 2 sensor provides a feedback signal to the ECM indicating Diesel Particulate Filter (DPF) inlet temperature. The EGT 2 sensor is the second temperature sensor installed past the turbocharger and just after the DOC.

The EGT 3 sensor provides a feedback signal to the ECM indicating DPF outlet temperature. The EGT 3 sensor is the third temperature sensor installed past the turbocharger and just after the DPF.

During a catalyst regeneration, the ECM will monitor all three sensors along with the Exhaust Gas Recirculation (EGR) System and Intake Throttle Valve (ITV).

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 water supply housing (Freon® compressor bracket), to the right of the flat idler pulley assembly.

EOT Sensor

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

IAT Sensor

The ECM monitors the IAT signal to control injector timing and fuel rate during cold starts. The ECM also uses the IAT signal to control EGR position and intake throttle control. The IAT sensor is installed in the air filter housing.

MAT Sensor

The ECM monitors the MAT signal for EGR operation. The MAT sensor is located in the intake manifold, to the right of the MAP sensor.

Variable Capacitance Sensors

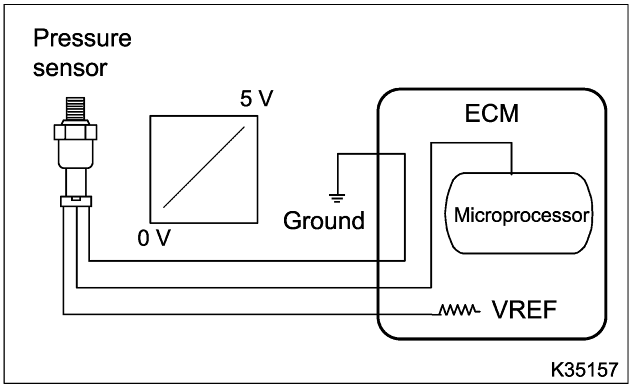

Figure 33 Variable capacitance sensor

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

The sensor is connected to the ECM by the VREF, signal, and signal ground wires.

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

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:

- Exhaust Gas Differential Pressure (EGDP) sensor
- Engine Fuel Pressure (EFP) sensor
- Engine Oil Pressure (EOP) sensor
- Exhaust Back Pressure (EBP) sensor
- Manifold Air Pressure (MAP) sensor

EGDP Sensor

The EGDP sensor provides a feedback signal to the ECM indicating the pressure difference between the inlet and outlet of the particulate filter. During a catalyst regeneration, the ECM will monitor this sensor along with three Aftertreatment System thermistor sensors, the EGR System, and the Intake Throttle Valve (ITV).

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

EFP Sensor

The ECM uses the EFP sensor signal to monitor engine fuel pressure and give an indication when the fuel filter needs to be changed. The EFP sensor is installed in the fuel filter housing on the left 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 left side of the crankcase, below the left side of the fuel filter housing.

EBP Sensor

The ECM monitors the exhaust pressure so that the ECM can control the VGT, EGR, and intake throttle systems. The sensor provides feedback to the ECM for closed loop control of the Variable Geometry Turbocharger (VGT). The EBP sensor is installed in a bracket mounted on the water supply housing (Freon® compressor bracket).

MAP Sensor

The ECM monitors the MAP signal to determine intake manifold pressure (boost). This information is used to control the turbocharger boost. The MAP sensor is installed in the intake manifold, left of the MAT sensor.

Magnetic Pickup Sensors

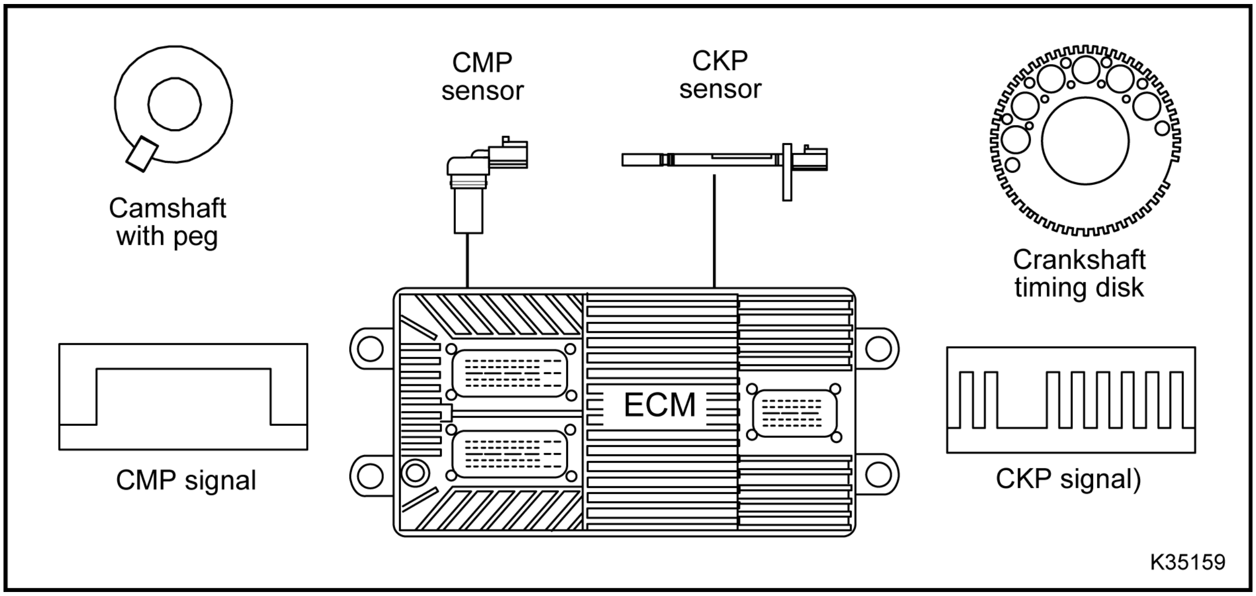

Figure 34 Magnetic pickup sensors

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.

Micro Strain Gauge (MSG) Sensors

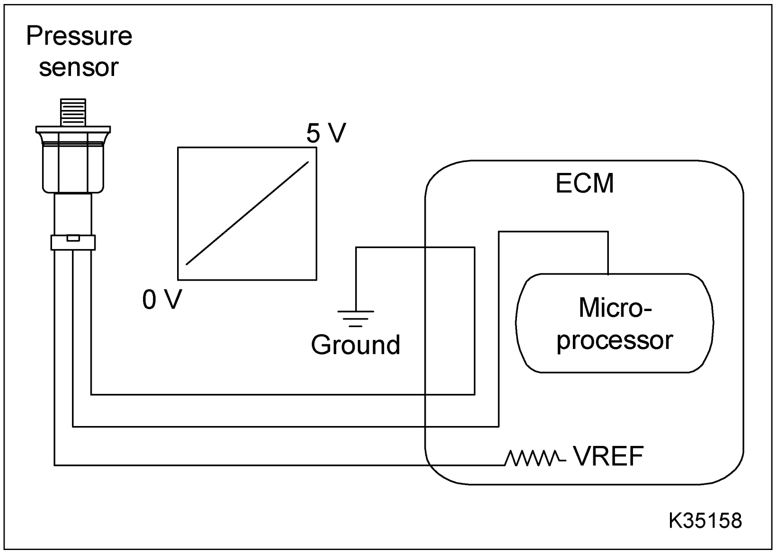

Figure 35 MSG sensor

A Micro Strain Gauge (MSG) sensor measures pressure. 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.

The sensor is connected to the ECM by the VREF, signal, and signal ground wires.

The sensor is powered by VREF received 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.

Inline six engine micro strain gauge type sensors include the following:

- Brake Control Pressure (BCP)
- Injection Control Pressure (ICP)

BCP

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

Potentiometer

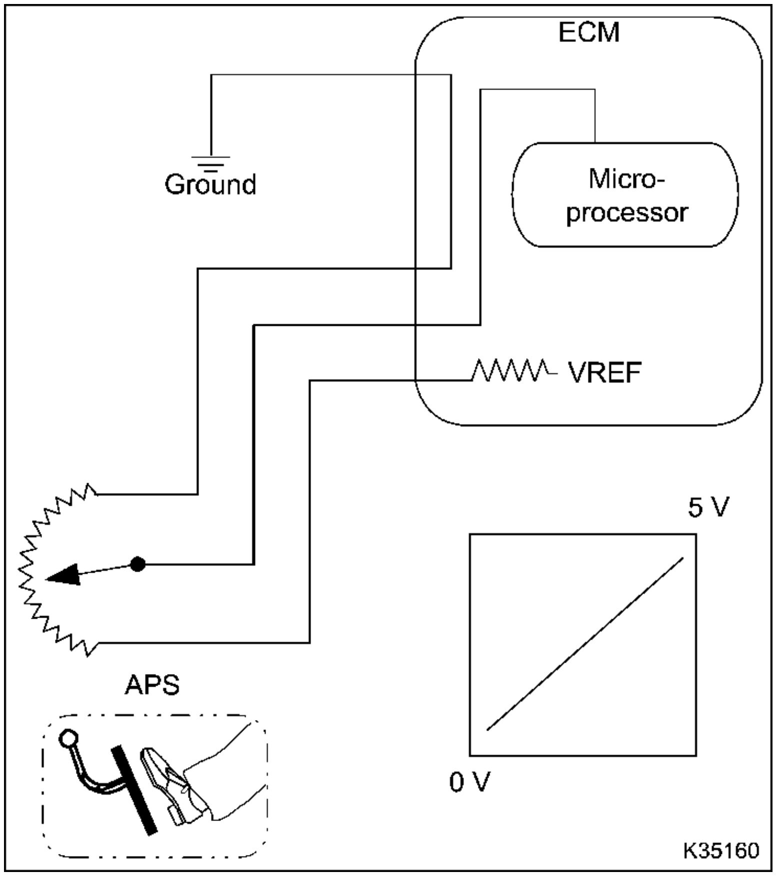

Figure 36 Potentiometer

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.

The engine has one potentiometer, the Accelerator Position Sensor (APS).

APS

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

Switches

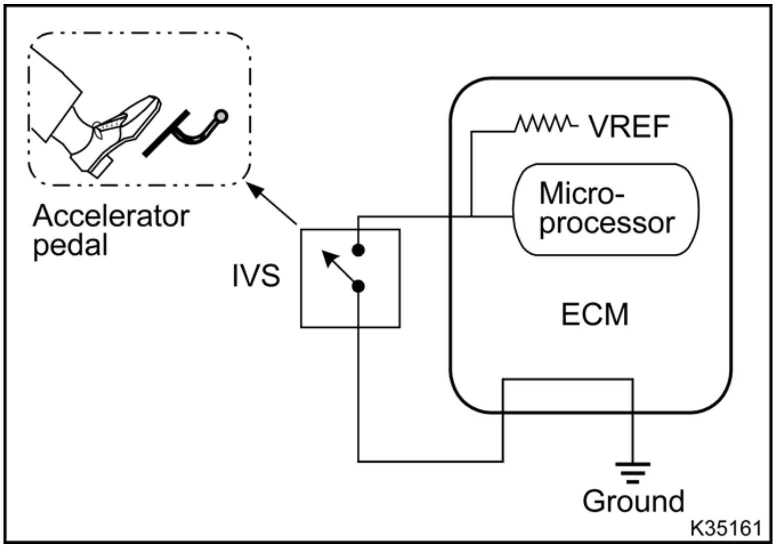

Figure 37 Switch

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)
- Idle Validation Switch (IVS)
- 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.

IVS

The IVS is a redundant switch that provides the ECM with a signal that verifies when the APS is in the idle position.

WIF

A Water In Fuel (WIF) sensor in the element cavity of the fuel filter housing detects water. When enough water accumulates in the element cavity, the WIF sensor signal changes to the Electronic Control Module (ECM). The ECM sends a message to illuminate the amber water and fuel lamp, alerting the operator. The WIF is installed in the base of the fuel filter housing.

Intake Throttle Valve

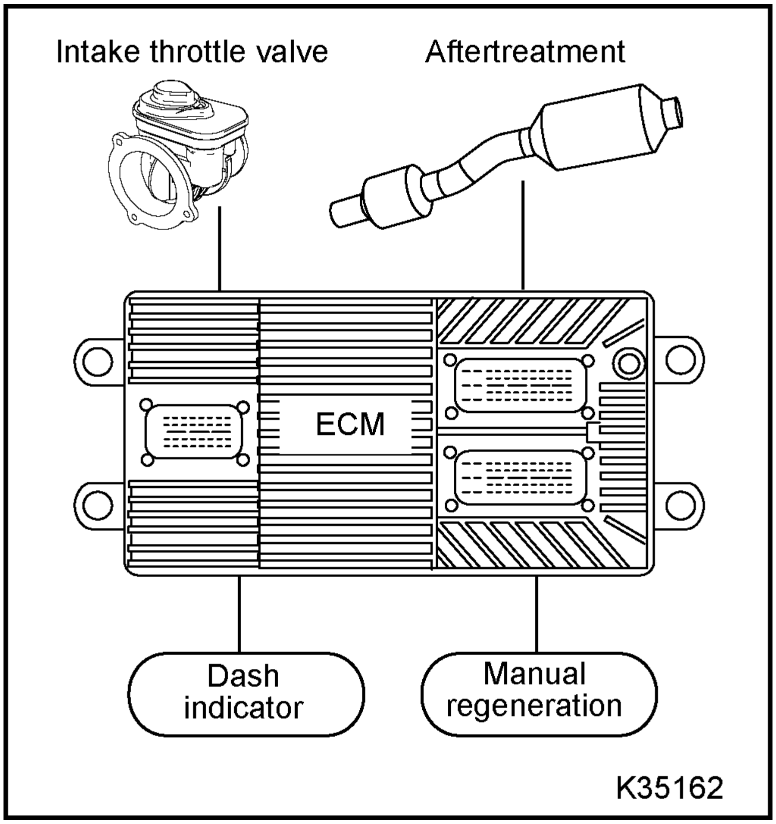

Figure 38 Intake throttle control system

The intake throttle valve is controlled to limit inlet air to the intake manifold. Reducing the air flow to the intake manifold increases fuel in the exhaust. The increased fuel in the exhaust is used for regeneration in the aftertreatment system.

The aftertreatment control system controls engine operating parameters to automate regeneration. It manages aftertreatment system temperatures, and monitors and controls the intake throttle valve to control the Air/Fuel ratio of the exhaust stream. It also maintains vehicle and engine performance during regenerations.

Diamond Logic® Brake System

The Diamond Logic® brake system is available for all engine displacements.

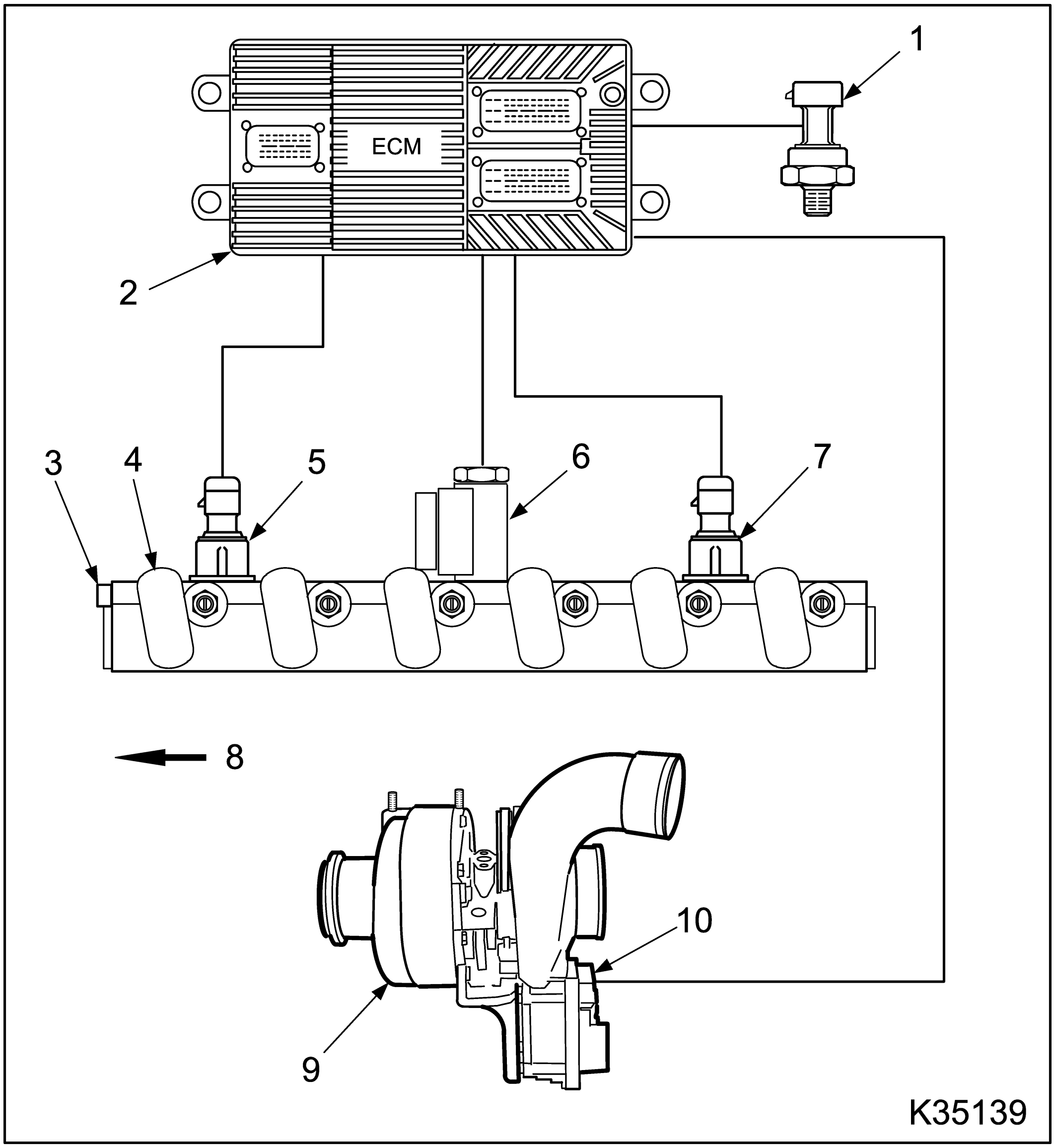

Figure 39 Diamond Logic® brake system

1. Exhaust Back Pressure (EBP) sensor
2. Electronic Control Module (ECM)
3. Brake pressure relief valve
4. High-pressure oil manifold
5. Brake Control Pressure (BCP) sensor
6. Brake Shut-off Valve (BSV) assembly
7. Injection Control Pressure (ICP) sensor
8. Front of engine
9. Variable Geometry Turbocharger (VGT)
10. VGT control module

BCP

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

BSV

The BSV controls pressure entering the brake oil gallery from the high-pressure oil manifold gallery. This activates the brake actuator pistons and opens the exhaust valves. The BSV is located 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. The ECM deactivates the engine brake by shutting off power to the BSV. 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 measures exhaust back pressure. The ECM monitors the exhaust back pressure signal and commands the VGT and EGR systems to open or close to most restrictive position.

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.

VGT

The ECM commands the VGT vanes to the closed (most restrictive) position during exhaust and engine brake operation. This exhaust restriction increases exhaust back pressure.

Brake Operation Modes

The Diamond Logic® brake system offers three modes of operation based on terrain, driving conditions, or driver preference.

Coast Mode

When the coast mode is selected the brake system will activate 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 latched mode is selected the brake system will activate when the driver releases the accelerator pedal. The brake system will deactivate when the drivers depresses the accelerator or clutch pedals. The brake system will also deactivate when the engine speed is below a set rpm.

Cruise Mode

When the cruise mode is selected 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.

Exhaust Brake System

The exhaust brake is an exhaust back pressure brake system that provides improved braking performance.

The operator can enable the brake function by toggling a dash mounted switch to ON or OFF.

The exhaust brake replaces the older style mechanical brake that was added into the exhaust system. No additional parts or wiring are required. The system uses the existing VGT and ECM programming to enable this feature.

Operation

The exhaust brake system retards vehicle speed during deceleration or braking. During operation, the ECM commands the VGT vanes to the most restrictive position and increases exhaust back pressure. The exhaust restriction absorbs vehicle momentum. When the brake is disabled the VGT vane position opens and engine operation returns to normal.

Engine Brake System

The engine brake is a compression release brake system that provides enhanced braking performance. The exhaust brake is an integrated engine brake system component. However, the exhaust brake can not be used independently.

The operator can enable the brake function by toggling a dash mounted switch to ON or OFF and selecting a desired level. There are three brake level choices that accommodate terrain, driving conditions, or driver preference.

Operation

The engine brake system retards vehicle speed during deceleration or braking. During engine brake operation, high-pressure oil is used to force the exhaust valves partially open. An integrated high-pressure oil manifold and brake shut-off valve distribute high-pressure oil to each brake piston. These brake pistons hold the exhaust valves open.

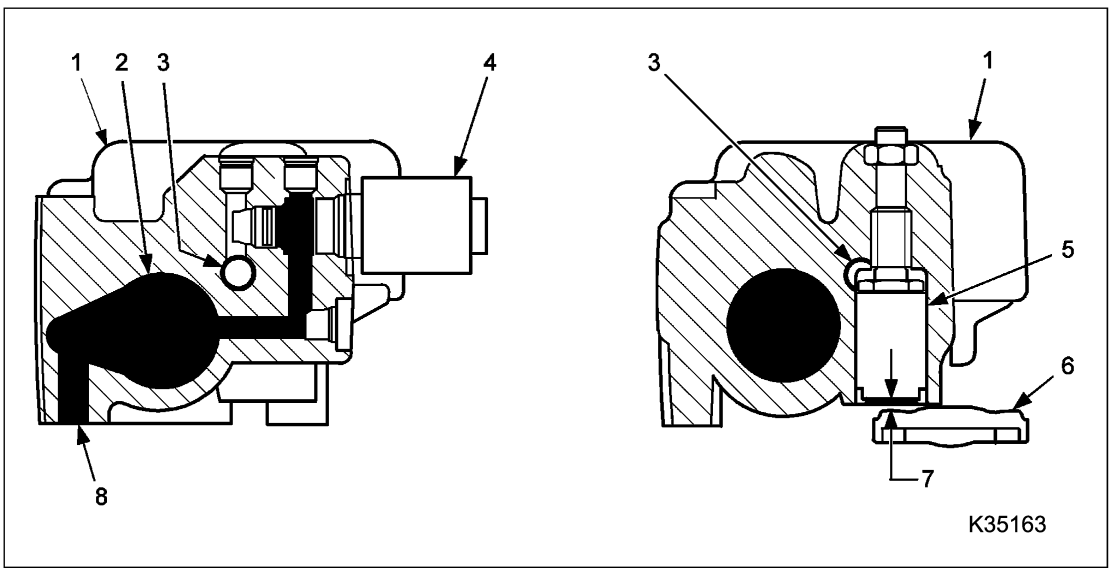

Figure 40 Brake shut-off valve and brake actuator– OFF

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

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

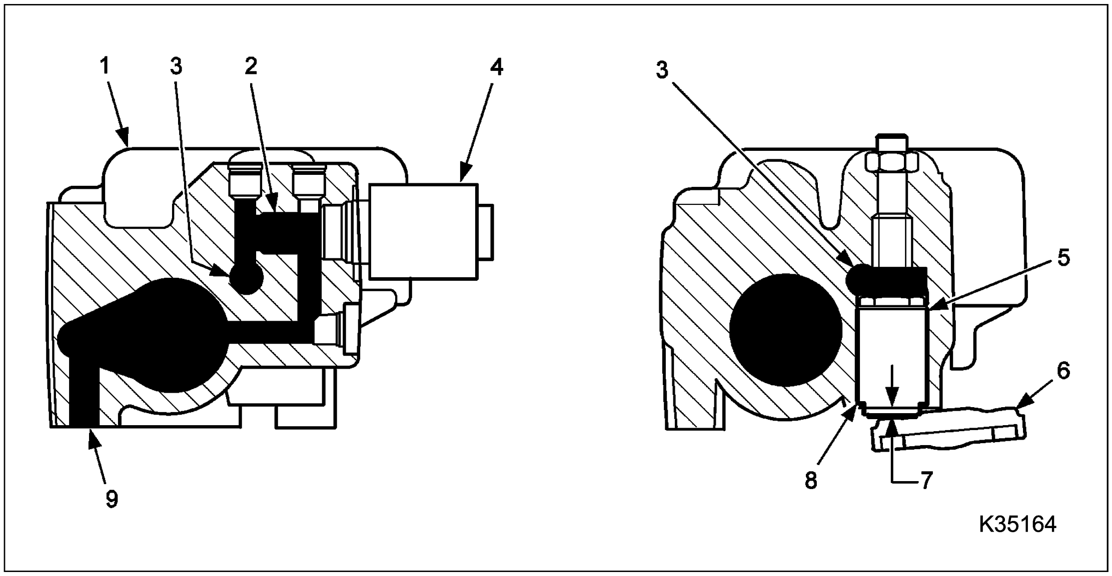

Figure 41 Brake shut-off valve and brake actuator– ON

1. High-pressure oil manifold
2. High-pressure oil flow to brake oil gallery
3. Brake oil gallery
4. Brake shut-off valve assembly
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.

- ABS (inactive)
- RPM (greater than 1200)
- APS (less than 5%)
- Idle validation
- EOT (greater than or equal to 60 °C [140 °F])
- Operator input switches (On/Off) (power selection – Low, Med, High)

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

When the engine brake is activated, the ECM provides the power to activate the brake shut-off 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.

The VGT vanes also move to restrict exhaust air flow. The combination of the compression release and exhaust restriction absorbs vehicle momentum.

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 brake shut-off valve to deactivate the engine brake. Residual brake gallery pressure initially bleeds from the actuator bore. When brake gallery pressure bleeds down to 6895 kPa (1000 psi), the brake pressure relief valve opens, and oil drains back to sump.

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Standard Features

Electronic Governor Control

Navistar engines are electronically controlled for all operating ranges.

American Trucking Association (ATA) Datalink

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

The ATA datalink supports:

- Transmission of engine parameter data.
- Transmission and clearing of Diagnostic Trouble Codes (DTCs).
- Diagnostics and troubleshooting.
- Programming performance parameter values.
- Programming engine and vehicle features.
- Programming calibrations and strategies in the ECM.

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

Service Diagnostics

The EST provides diagnostic information using the ATA datalink. The recommended EST is the EZ-Tech® with MasterDiagnostics® software provided by International.

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

Event Logging System

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

Electronic Speedometer and Tachometer

The engine control system calibrates vehicle speed up to 157,157 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 through the Drivetrain Datalink (CAN 1) and to the EST through the ATA datalink.

Aftertreatment System

The Aftertreatment System, part of the larger Exhaust System, processes engine exhaust so that it meets tailpipe emission requirements. The Aftertreatment System traps particulate matter (soot) and prevents it from leaving the tail pipe.

For additional information, see AFT System (page 209) in “Electronic Control Systems Diagnostics” section of this manual.

Engine Fuel Pressure (EFP) Monitor

The EFP monitors fuel pressure and indicates when the fuel filter needs to be serviced. For additional information, see EFP Sensor (page 292) in “Electronic Control Systems Diagnostics” section of this manual.

Inlet Air Heater (IAH)

The IAH feature improves engine start-up in cold weather. 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 338) in “Electronic Control Systems Diagnostics” section of this manual.

Fast Idle Advance

Fast idle advance increases engine idle speed up to 750 rpm for faster warm-up to operating temperature. This occurs by the ECM monitoring the EOT sensor and adjusting the fuel injector operation accordingly.

Low idle speed is increased when the engine oil temperature is between 15 °C (59 °F) at 700 rpm to below -10 °C (14 °F) at 750 rpm.

Cold Ambient Protection (CAP)

CAP protects 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 the engine rpm to a programmed value when the ambient air temperature is at or below 0 °C (32 °F) and the engine coolant temperature is below 65 °C (149 °F) while the engine has been idling with no load for more than 5 minutes.

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

Coolant Temperature Compensation

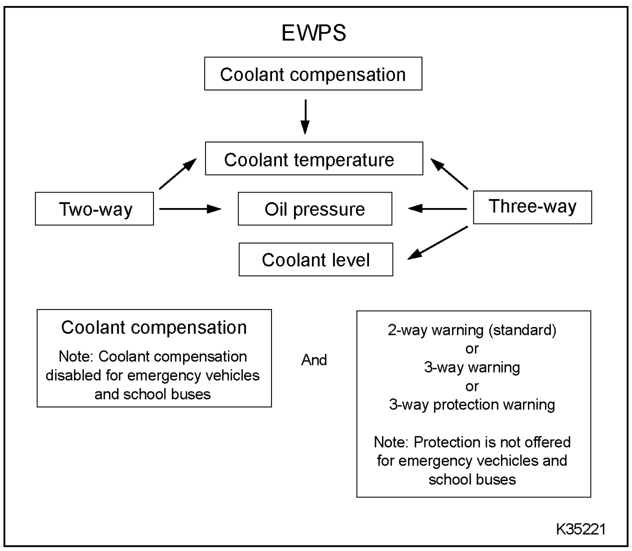

Figure 42 Coolant Temperature Compensation

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 107 °C (225 °F). A rapid reduction of 15 percent is achieved when engine coolant temperature reaches approximately 110 °C (230 °F).

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 263) in “Electronic Control Systems Diagnostics” section of this manual.

Change Engine Oil Interval Message

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 EST.

Optional Features

Road Speed Limiting

Vehicle road speed can be limited to a maximum speed as programmed by the customer. An EST is required for programming.

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.

Diamond Logic® Brake System

Navistar offers an optional exhaust and engine brake to enhance braking capabilities. For detailed feature description, see Diamond Logic® Brake System in “Engine Systems” section of this manual.

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.

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 Electronic 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 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 5 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 (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 in all 2008 engines. If the IST is enabled, the Cold Ambient Protection (CAP) will not function.

For additional information, see IST System (page 378) in “Electronic Control Systems Diagnostics” section of this manual.

Electronic Fan (EFAN)

Engine electronics allow for the operation of an electronic fan or an air fan solenoid. For additional information, see EFAN Control in “Electronic Control Systems Diagnostics” section of this manual.

Radiator Shutter Enable (RSE)

The RSE keeps the engine warm during cold weather operation. The RSE enables faster warm-up of the cab and faster windshield defrosting. For additional information, see RSE in “Electronic Control Systems Diagnostics” section of this manual.

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MasterDiagnostics® Software

Open Application

1. Connect interface cable to the vehicle diagnostic connector and the Electronic Service Tool (EST).
2. From the EZ-Tech® opening screen select Engine Diags button, and then select the Service Assistant button from the drop-down menu.
3. Turn ignition switch to ON. Do not start the engine.

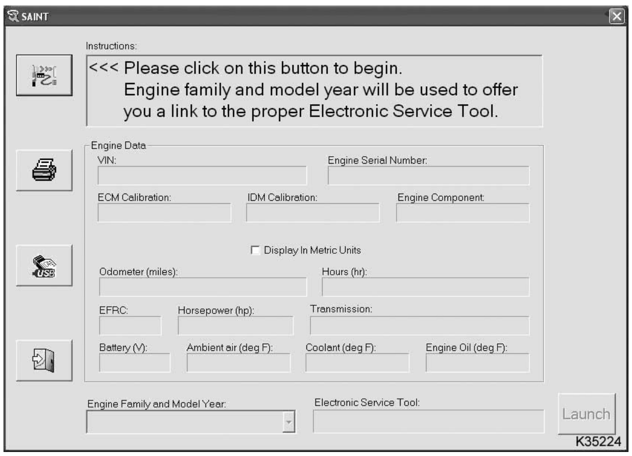


Figure 43 Diagnostic window

NOTE: If the EST does not communicate with the vehicle, refer to the IC4 Interface Device Self Test (page 64).

4. Select the button indicated on the Service Assistant screen to establish communication with the vehicle.

Choose COM Device

1. Select COM.

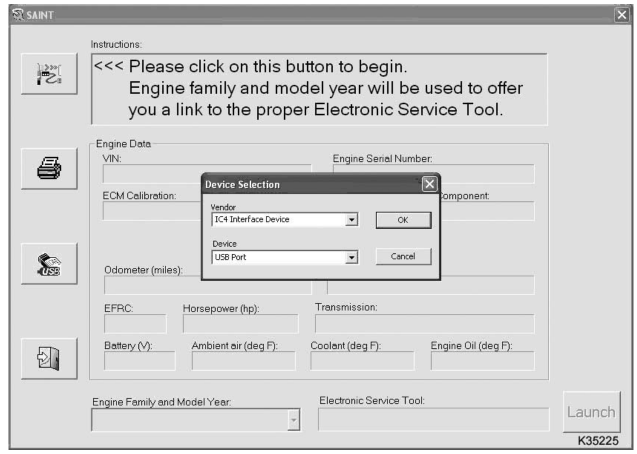


Figure 44 Diagnostic COM selection

2. Select Interface Cable and EST port
3. Select OK.

Retrieve Engine Information

1. Follow the on-screen instructions.
2. Select Connect.
3. Verify that collected data matches the engine being diagnosed.
4. MasterDiagnostics® will display the detected Engine Family and model year. The EST version is also displayed.

Open Diagnostic Form

1. Select Hard Start No Start or Performance form for diagnostic issue to investigate.
2. Select Launch.
3. Selected diagnostic form will appear. Interactive testing and recording is enabled.

Open MasterDiagnostics® Software

1. Engine family and model year should match engine being diagnosed. If incorrect, use drop down menu to select correct engine family and model year.
2. Select Launch.
3. The Service Assistant will display on EST.

Electronic Service Tool (EST) Communication Diagnostics

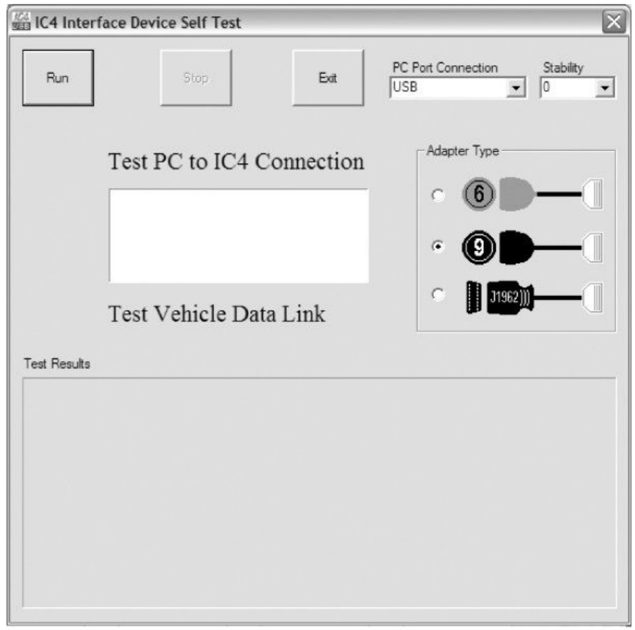
IC4 Interface Device Self Test

1. Connect the interface cable to the diagnostic connector and the EST.
2. Turn ignition switch to ON. Do not start the engine.

P08263

Figure 45 Vehicle diagnostics folder

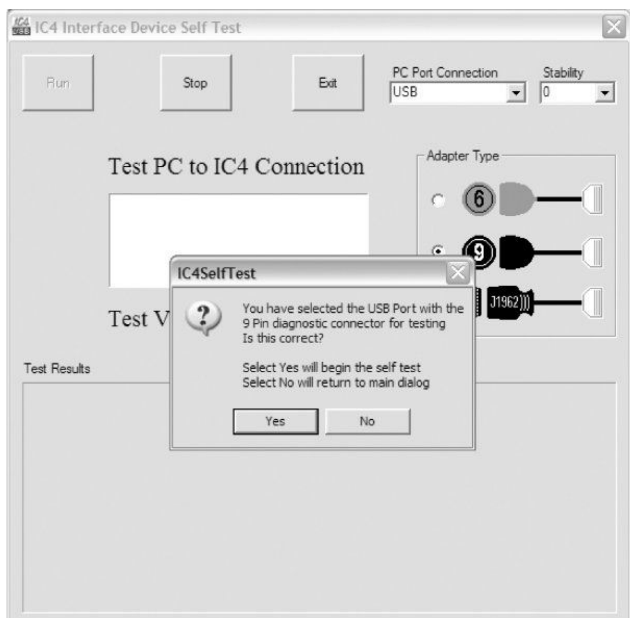
3. From the EST desktop open the Vehicle Diagnostics folder.
4. Double-click the IC4 Self Test icon.



P08242

Figure 46 Self Test Run command

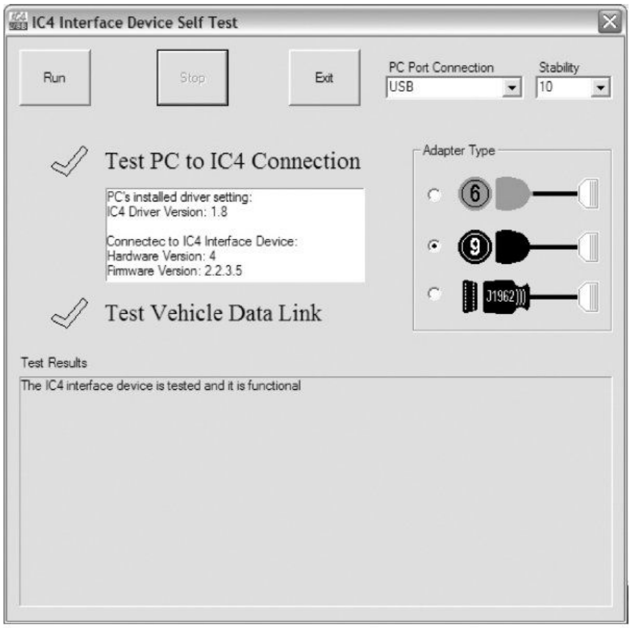
5. Select Run button.



P08243

Figure 47 Connector confirmation

6. Verify the correct interface connector is selected.



P08244

Figure 48 Test result

NOTE: If the connection could not be established, follow the instructions on the self test window.

7. The test result is displayed in the lower half of the self test window.

Communications (COM)

Open Communications

Figure 49 COM open

1. Select COM from the menu bar.
2. Select Open from the drop down menu.

Figure 50 COM open confirmation

3. A green light and flashing red light indicates a successful communication link has been established.

   If green and red flashing light is not visible, COM is not available.

Close Communications

Figure 51 COM close

1. Select COM from the menu bar.
2. Select Close from the drop down menu.

Diagnostic Trouble Codes (DTCs)

Reading DTCs with EST

1. Turn ignition switch to ON. Do not start the engine.
2. Open EST to establish communication.

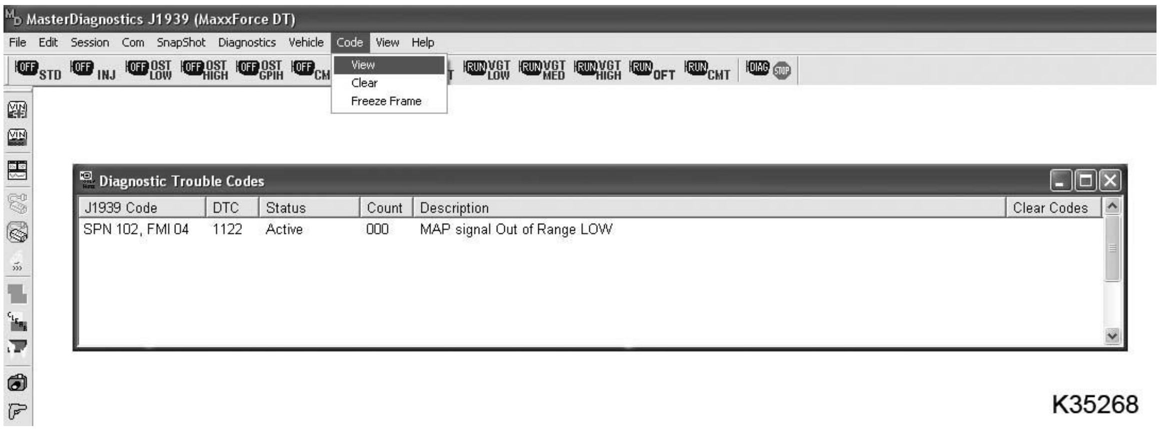


Figure 52 Viewing DTCs

3. Select Code from the menu bar.
4. Select View from the menu.
5. The DTC window will display active and inactive DTCs stored in the ECM.

DTC Help Menu

1. Double-click desired DTC to launch the Help program.

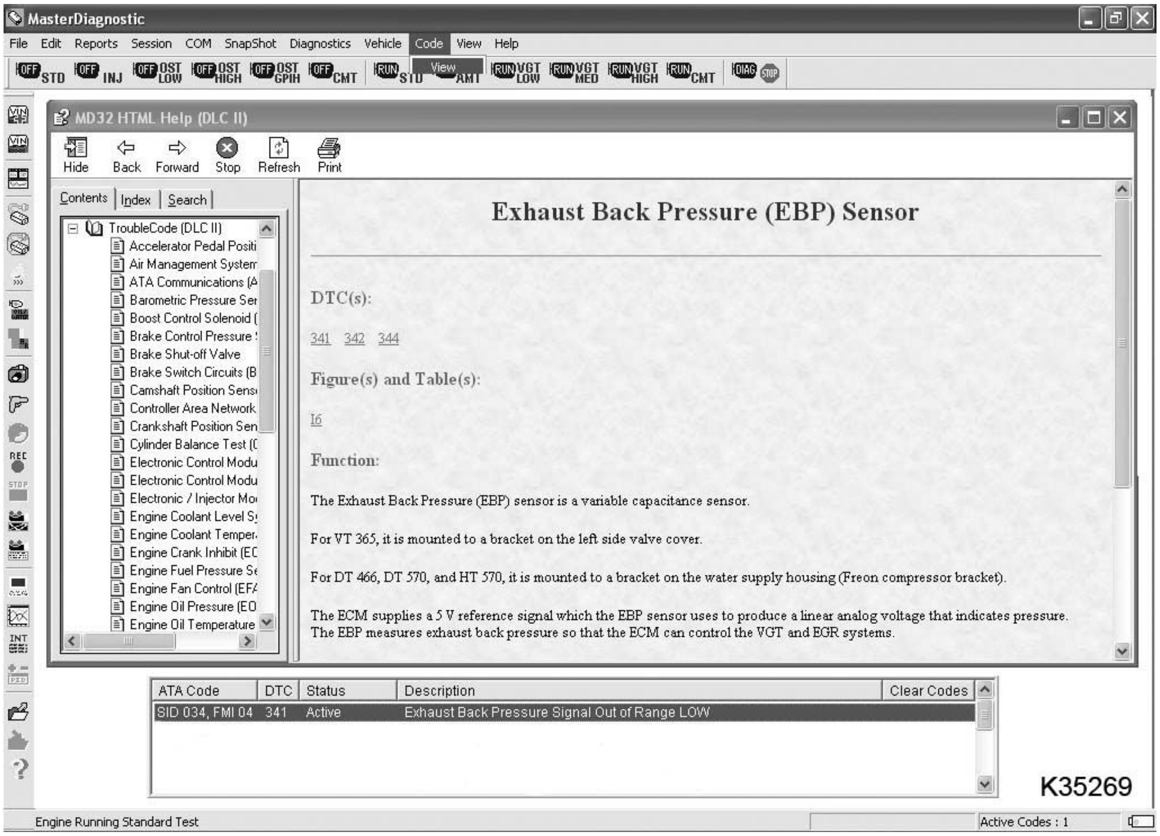


Figure 53 DTC Help Menu

2. The Help program will display information for the circuit associated to the DTC.

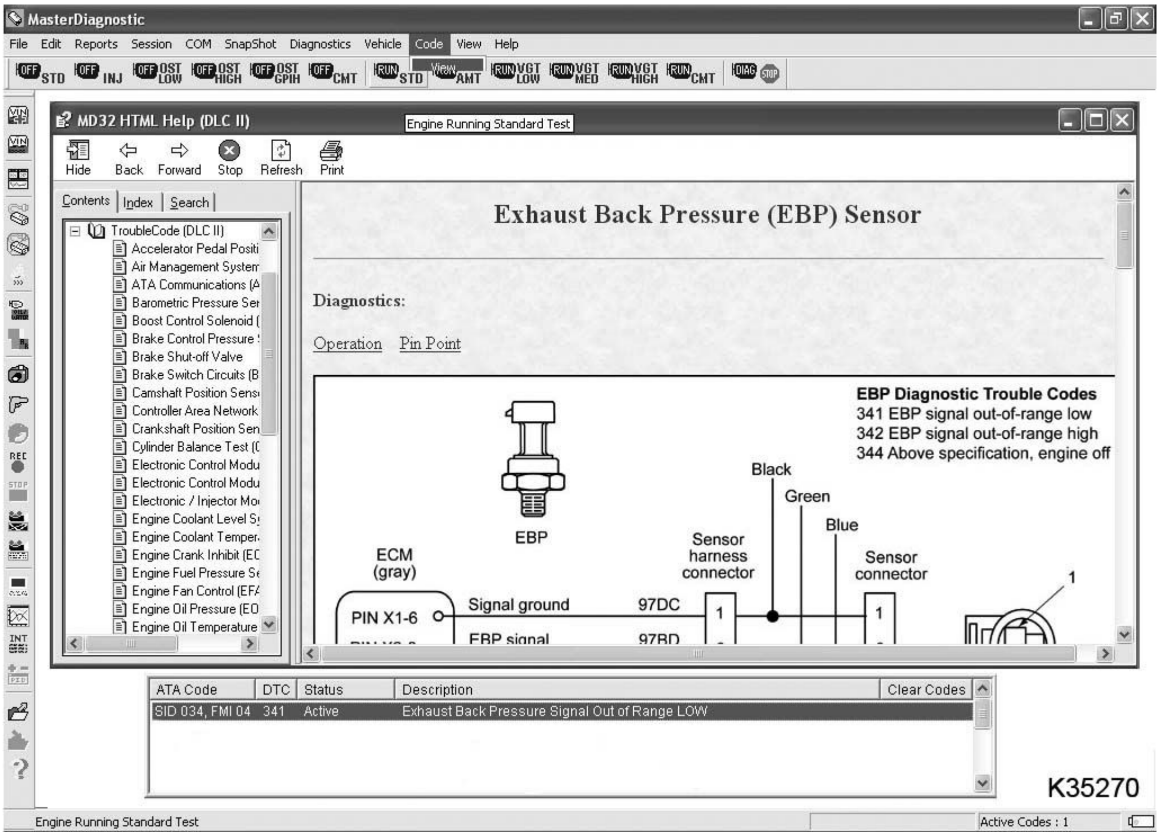


Figure 54 DTC Help Menu – Circuit Information

3. Select the DTC number from the list to display specific information.

Clearing DTCs

1. Turn ignition switch to ON. Do not start engine.
2. Open MasterDiagnostics® and establish communication with the vehicle.

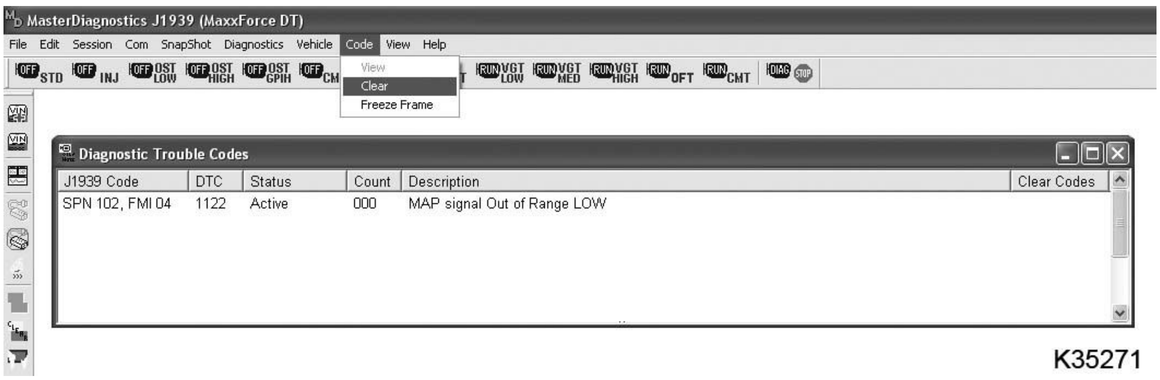


Figure 55 Clearing DTCs

3. Select Code from the menu bar.
4. Select Clear from the drop-down menu.
5. DTCs are cleared from the control module's memory. Active codes may return if the fault conditions remain.

Session Files

All session files are pre-configured with set parameters and graphs. If parameters and graphs are added or modified, the window layout changes and the data may no longer fit on the EST screen. Always select No when prompted to save the session before closing.

Opening Session File

1. Turn ignition switch to ON. Do not start the engine.
2. Open MasterDiagnostics® to establish communication.

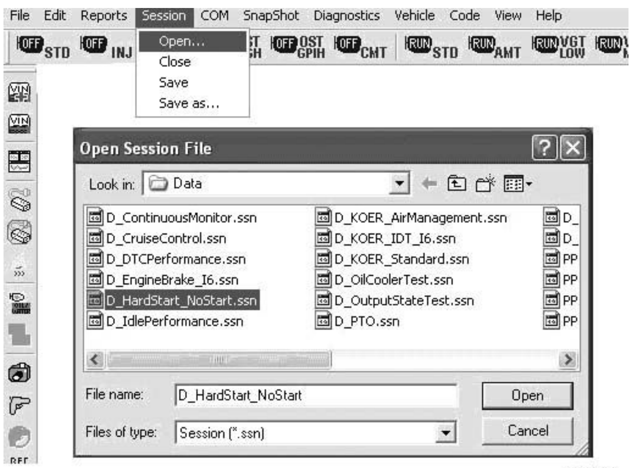


Figure 56 Open session file

3. Select Session from the menu bar.
4. Select Open from the drop down menu.
5. Choose the desired session file located within Open Session File window.
6. Select Open.

Adding and Deleting Session Parameter Identifiers (PIDs)

1. Open desired session file.

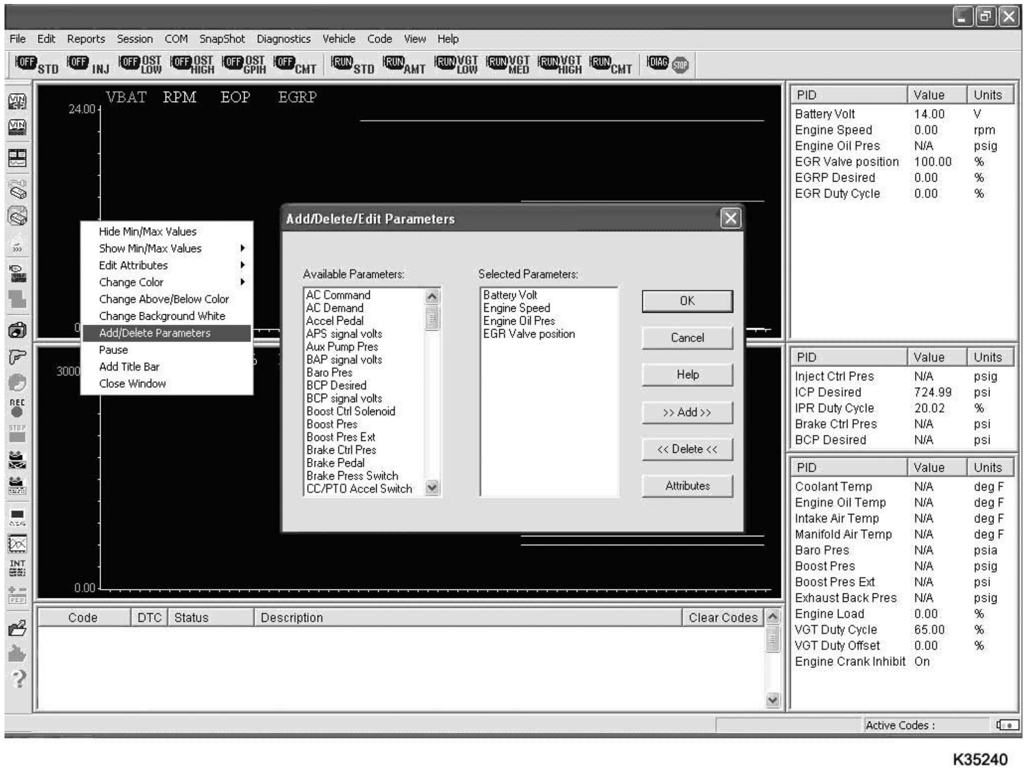


Figure 57 Add/Delete/Edit PIDs

2. On the session file, click the window where PIDs are to be added or edited.
3. Select Edit from the menu bar, or right click the desired window.
4. Select Add/Delete/Edit Parameters from the menu.

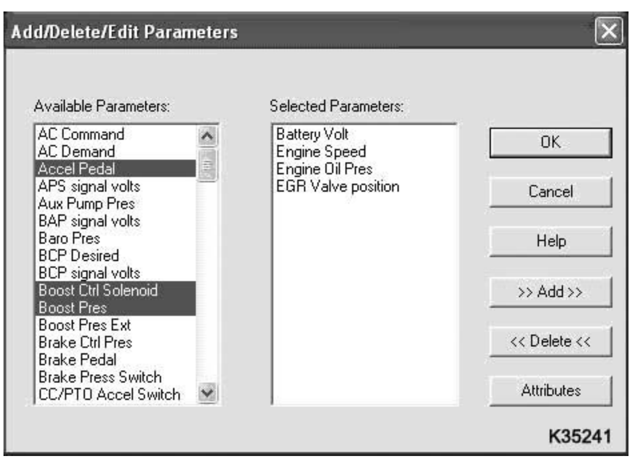


Figure 58 Selecting additional PIDS

5. Select additional PIDs in the left column.
6. Select Add to move selected PIDs to the right column.

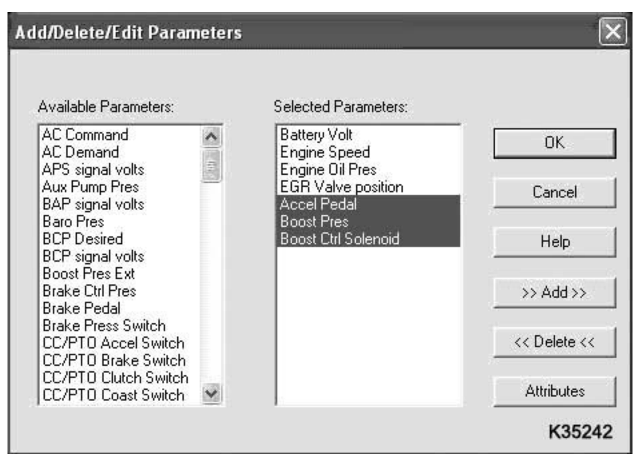


Figure 59 Additional PIDS added to session

7. To delete PIDs from the session, select the PIDs to remove from Selected Parameters and then select Delete.

8. Select OK to return to the session file.

Closing Session File

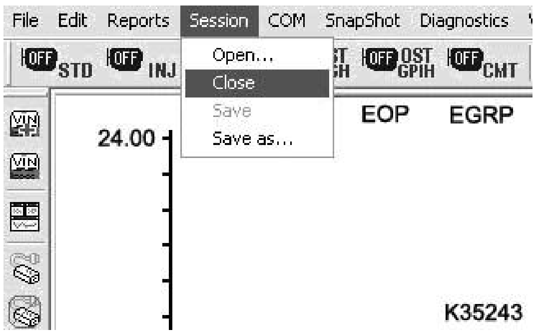


Figure 60 Closing session file

1. Select Session from the menu bar.
2. Select Close from the drop down menu.

NOTE: By selecting Yes, closing the session risks altering the default session setup.

3. Select No when prompted to save the session before closing.

VIN+ Session

The VIN+ provides VIN, the control module's calibration, engine serial number, transmission information, stored DTCs, and some other preset parameters. The information contained in the VIN+ session can be used to fill in part of the Hard Start and No Start Diagnostic Form.

1. Turn ignition switch to ON. Do not start the engine.
2. Open MasterDiagnostics® and establish communication with the vehicle.

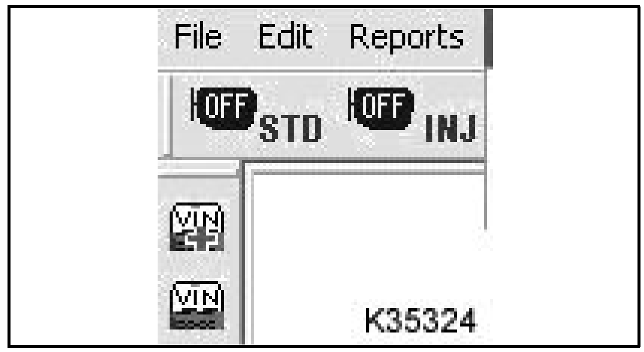


Figure 61 Select VIN+ icon

3. Select the VIN+ icon.

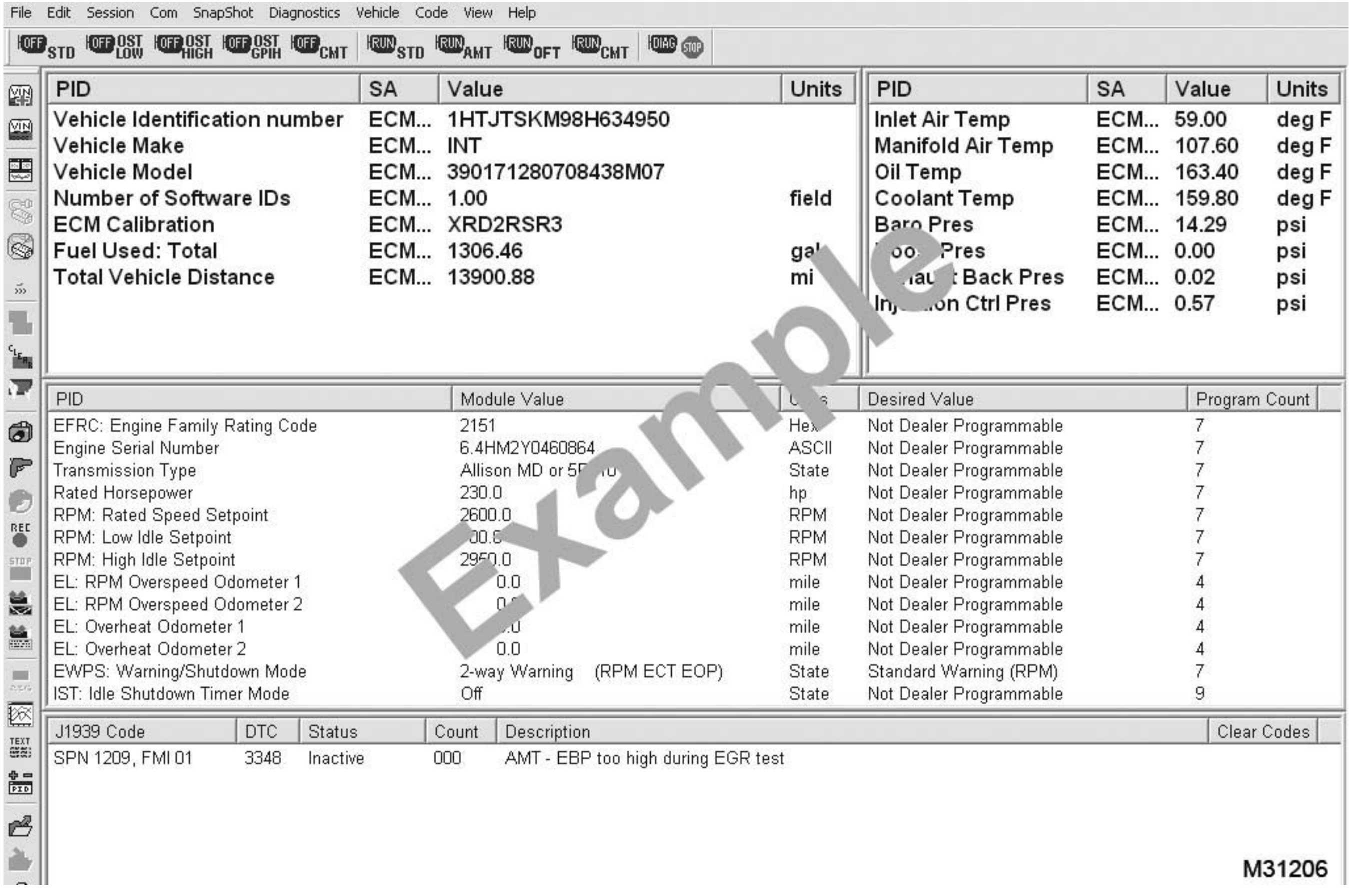


Figure 62 VIN+ session (example)

4. The VIN+ session is displayed on screen.

Snapshots

Opening Specific Snapshots

1. Open MasterDiagnostics® to establish communication.
2. Open desired session file.

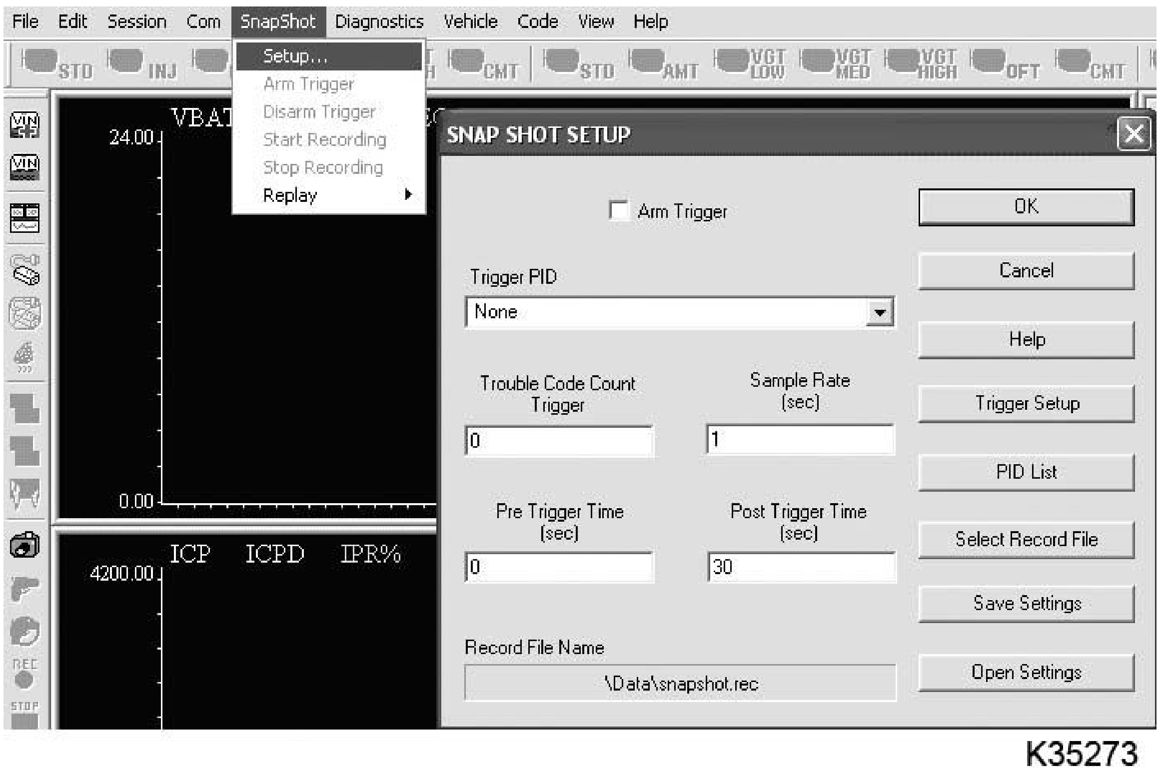


Figure 63 Opening specific snapshot

3. Select Snapshot from the menu bar.
4. Select Setup from the drop-down menu.
5. To modify default settings, refer to other snapshot setup steps in this section.

Opening Basic Snapshots

Opening a basic snapshot requires that all settings be adjusted to obtain a useful snapshot.

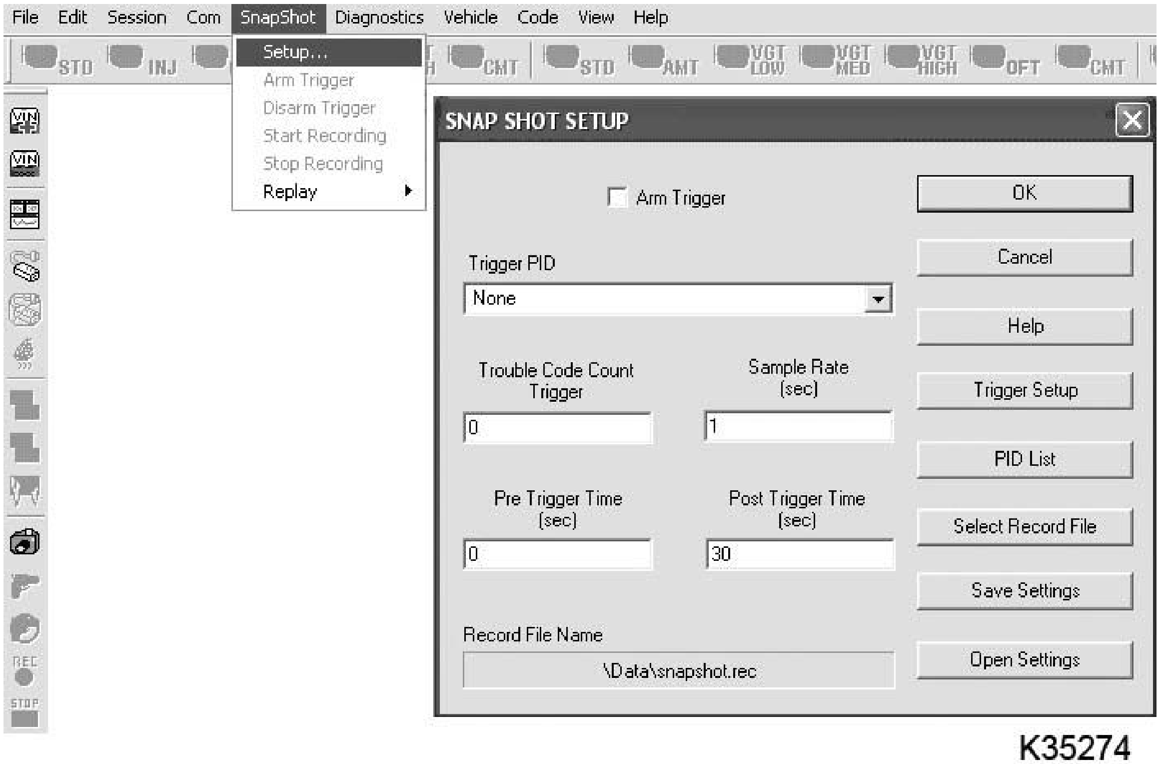


Figure 64 Opening basic snapshot

1. Select Snapshot from the menu bar.
2. Select Setup from the drop-down menu.

Snapshot Set-Up

Snapshot Trigger using Active DTCs

Snapshots can be triggered at the desired number of active DTCs. This is useful for road trip diagnostics.

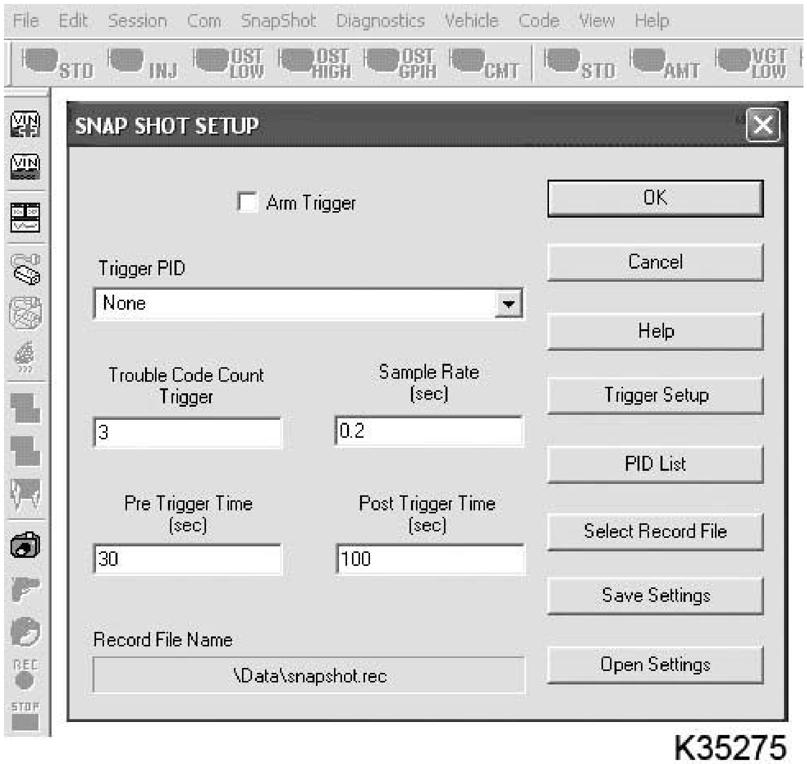


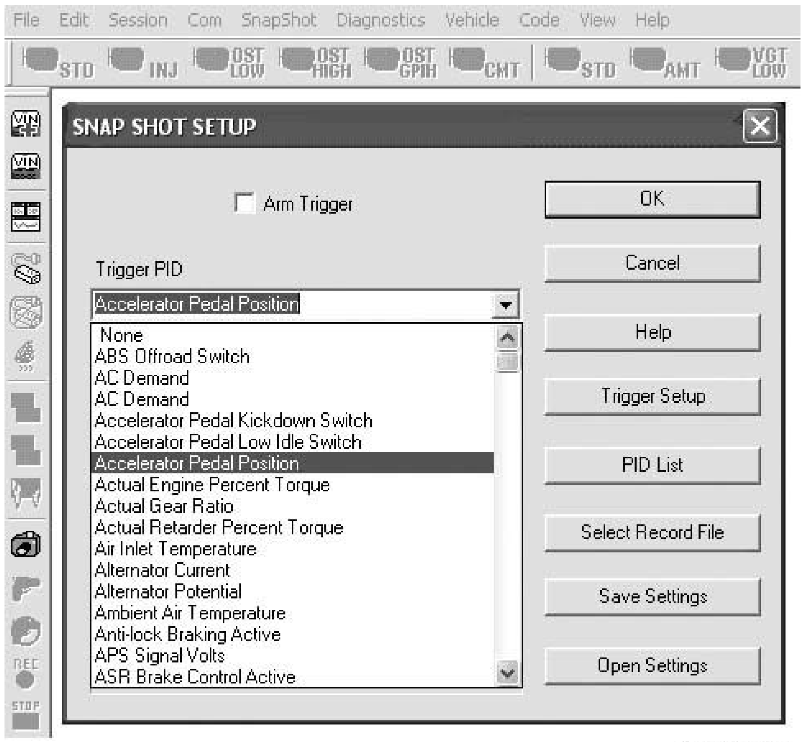
Figure 65 Snapshot for active DTC trigger

1. Enter None in Trigger PID drop-down menu.
2. Enter desired number of active DTCs in Trouble Code Count Trigger field
3. Check Arm Trigger box in Snap Shot Setup window.

Figure 66 Arm trigger box

Snapshot Trigger using Parameter Identifier (PID)

Snapshots can be triggered by desired PID values. This is useful for workshop or road trip diagnostics.



K35277

Figure 67 Selecting PID trigger

1. Select desired PID in the Trigger PID drop-down menu.
2. Select Trigger Setup button.

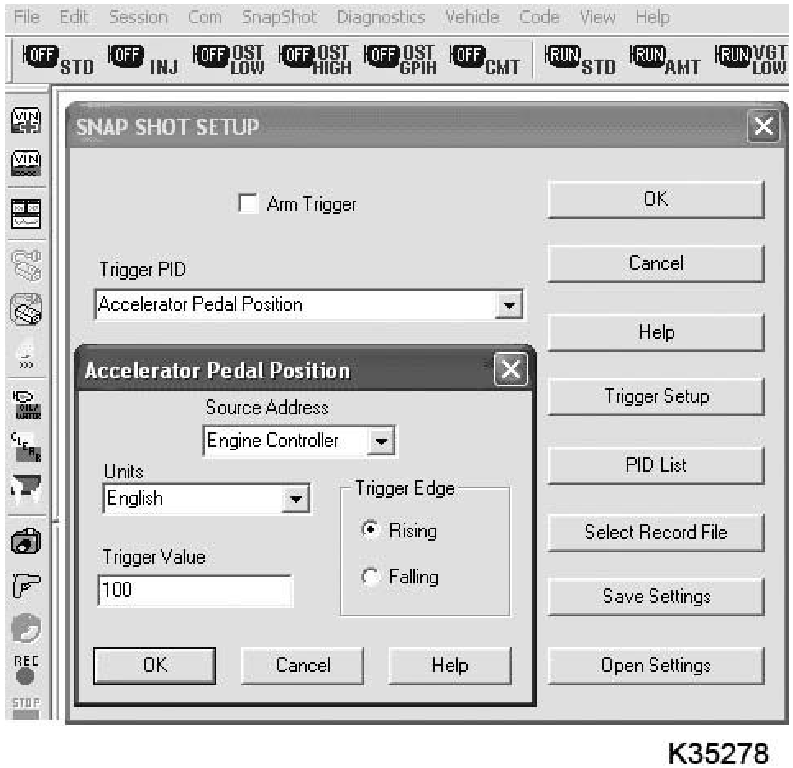


Figure 68 PID trigger set-up

3. Adjust units, trigger value, and trigger edge.
   - Units can be switched between decimal and metric values.
   - Trigger Value will set the PID value that begins snapshot recording.

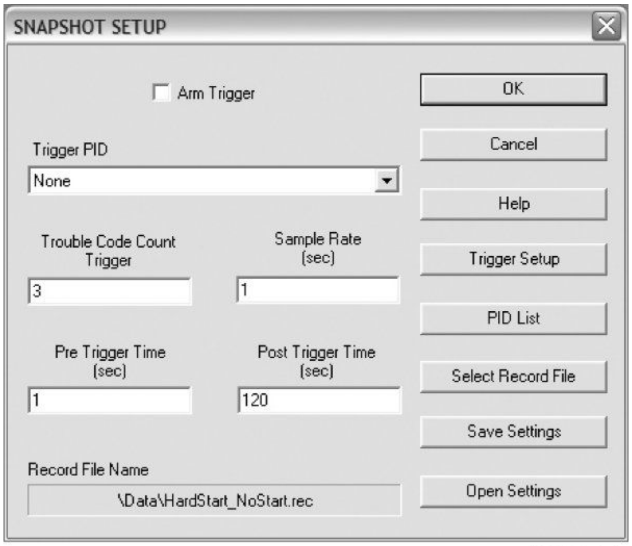
     Example: Trigger using APS at 100 percent will start the recording when the APS reaches 100 percent.
   - Trigger Edge can be switched between rising and falling. Rising edge is used if the PID value starts lower than the Trigger value. Falling edge is used if the PID value starts higher than the Trigger value.
4. Select OK button on the Trigger Setup window.

Figure 69 Arm trigger box

5. Check Arm Trigger box in the Snapshot Setup window.

Sample Rates, Pre-Trigger, and Post-Trigger Times

Snapshot timing and intervals can be changed for the desired recording situation.



P08264

Figure 70 Adjusting snapshot times

1. Enter desired time interval in the Sample Rate box.

   Sample Rate adjusts the interval for each recording.

   Example: Entering 0.2 will record PID list data every two-tenths of a second for a total of five frames per second.

   NOTE: Use smaller sample rates for most snapshots to maximize snapshot precision. Larger sample rates are useful when recording for lengthy periods of time.

2. Enter desired time (seconds) in Pre-Trigger box.

   Pre-Trigger sets time to begin snapshot recording prior to trigger event.

   Example: Entering 30 enables the snapshot recording to begin 30 seconds before the trigger event occurs.

   NOTE: Pre-Trigger is useful when recording conditions before a diagnostic event or fault occurs.

3. Enter desired time (seconds) in Post-Trigger box.

   Post-Trigger sets time to stop snapshot recording after the trigger event is completed.

   Example: Entering 100 enables the snapshot recording to continue for 100 seconds after the trigger event is completed.

Snapshot PID List

Verify the snapshot PID list contains each PID of concern. Adding or deleting PIDs from the PID session list does not alter the snapshot PID list.

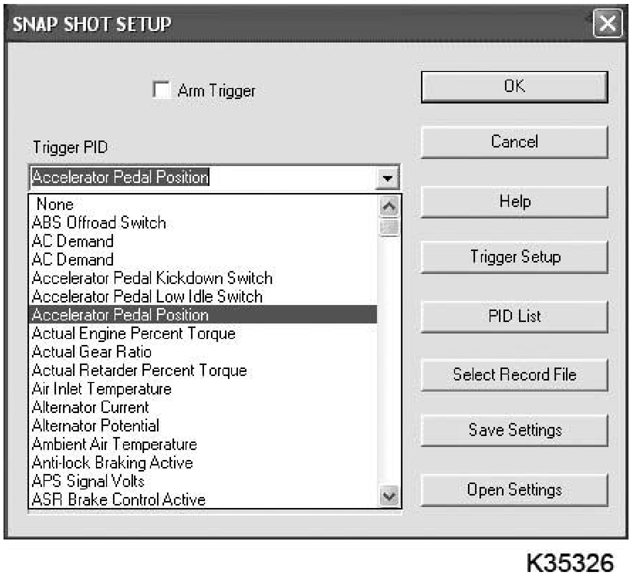


Figure 71 Selecting PIDs to record

1. Select PID List button from the Snapshot Setup window.

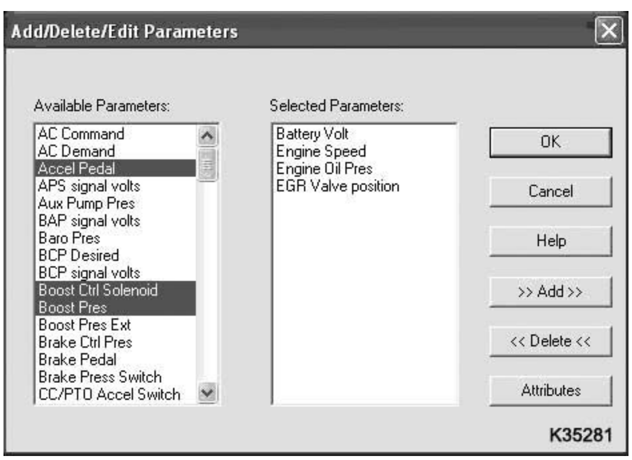


Figure 72 Selecting additional PIDS for snapshot

2. Select additional PIDs in the left column.

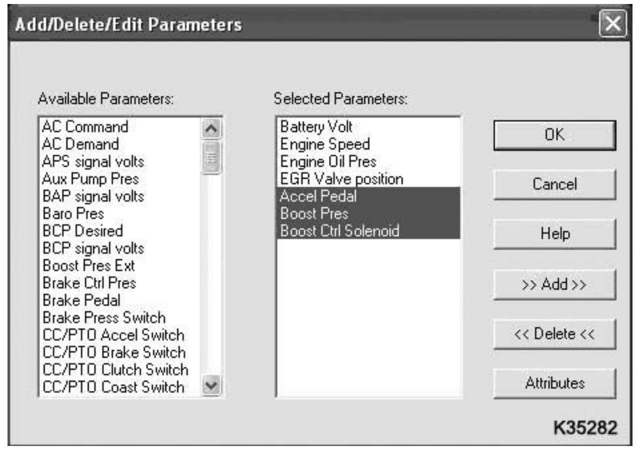


Figure 73 Additional PIDS added to snapshot

3. Select the ADD button to move the selected PIDs to the right column.
4. To delete PIDs from the snapshot, select the PIDs to remove from Selected Parameters and then select Delete.
5. Select the OK button to return to the Snapshot Setup window.

Rename REC Files

Changing the name of the REC file can assist in finding the file for review or data exchange for technical help. Default will save the REC file with a generic name and overfile when new snapshot is recorded. The default name can be changed to a VIN or ID label for example.

Figure 74 Naming REC file

1. Select the Record File button from the Snapshot Setup window.
2. Type the desired file name in the dialog box.
3. Select the Save button and save file in desired directory. After save is complete, program will return to the Snapshot Setup window.

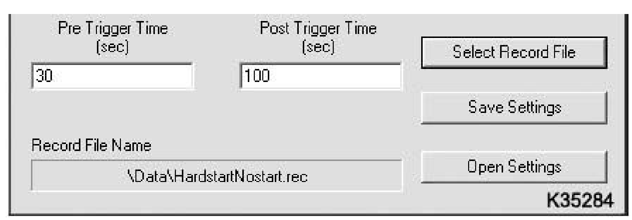


Figure 75 Verify REC file name

4. Verify that the Record File Name dialog box matches the changes.

Manual Trigger Snapshots

1. Open MasterDiagnostics® to establish communication.
2. Open desired session file.
3. Open desired snapshot. Setup for desired recording.
4. Select snapshot REC button on the side toolbar.

Figure 76 Recording active

5. The recording status changes to active and the REC button is displayed on the status bar at the bottom of the screen.

NOTE: The snapshot recording can be stopped at anytime if required.

6. Select snapshot STOP button on the side toolbar.

   The recording status will change to inactive.

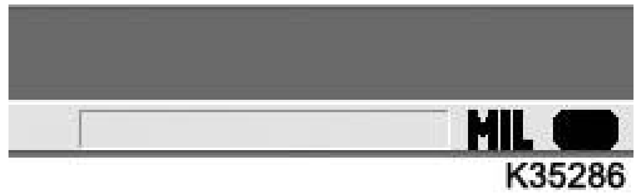


Figure 77 Recording not active

7. The recording status changes to inactive and the REC button is no longer displayed on the status bar at the bottom of the screen.

Replay Snapshot Graphic

1. Open MasterDiagnostics®.

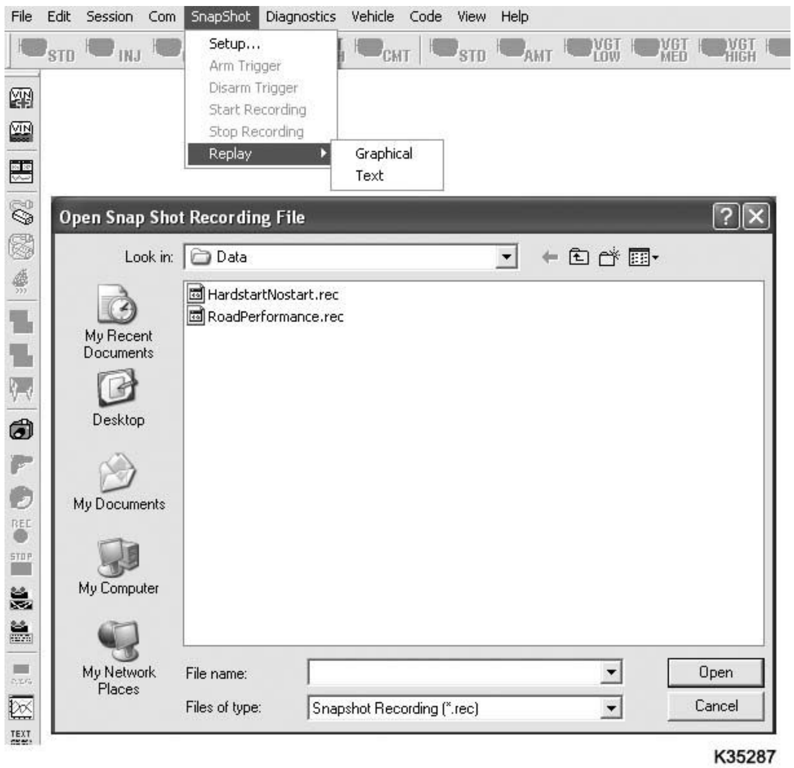


Figure 78 Replaying REC file

2. Select Snapshot from the menu.
3. Select Replay from the drop down menu, then select Graphical or Text.

   NOTE: Selecting Graphical replays the recording in the form of a graph. Selecting Text replays the recording in the form of a chart.
4. Select the desired snapshot file.
5. Select Open.

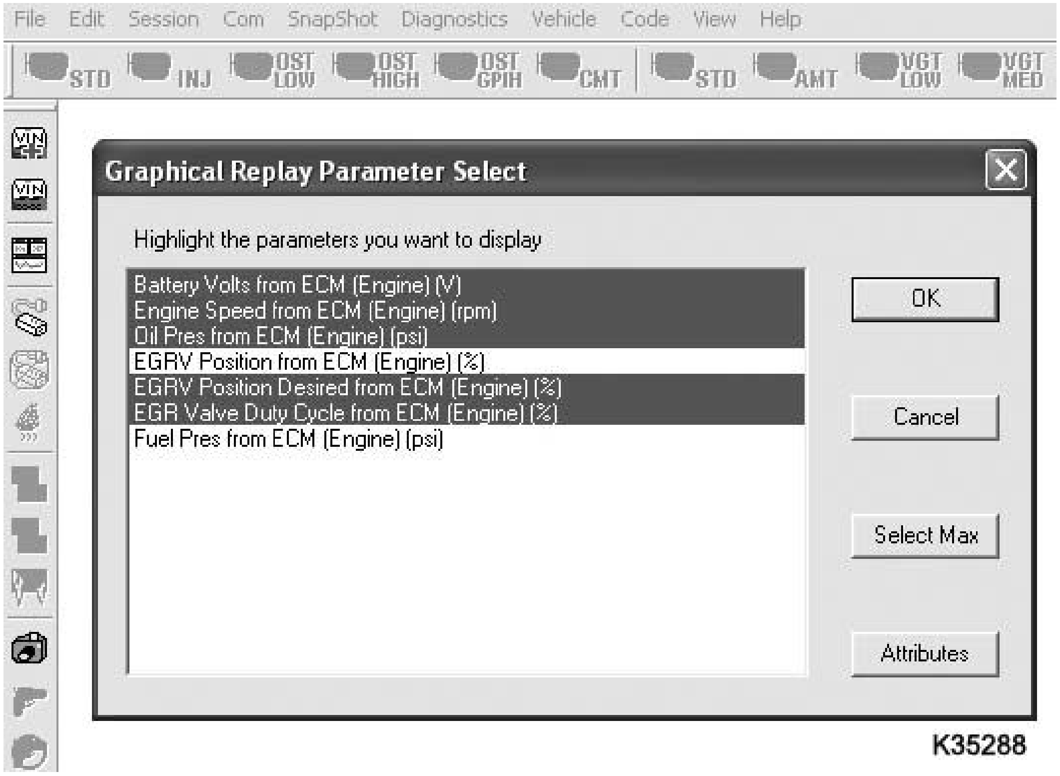


Figure 79 Selecting PIDs to replay

6. Select desired PIDs. Select the Max button to select all recorded PIDs.
7. Select the OK button.

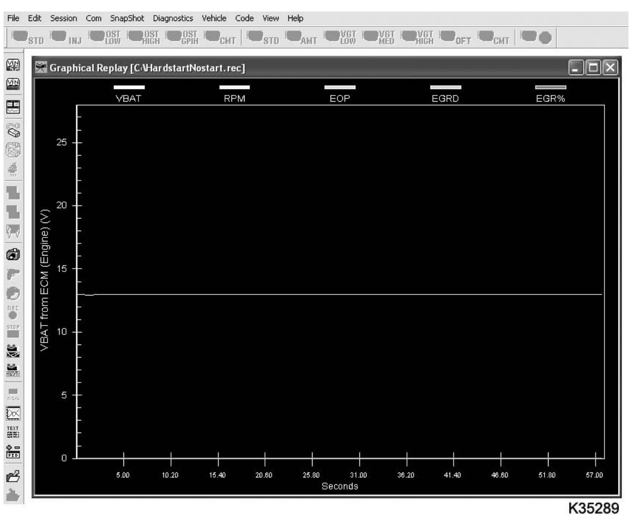


Figure 80 REC file graph view

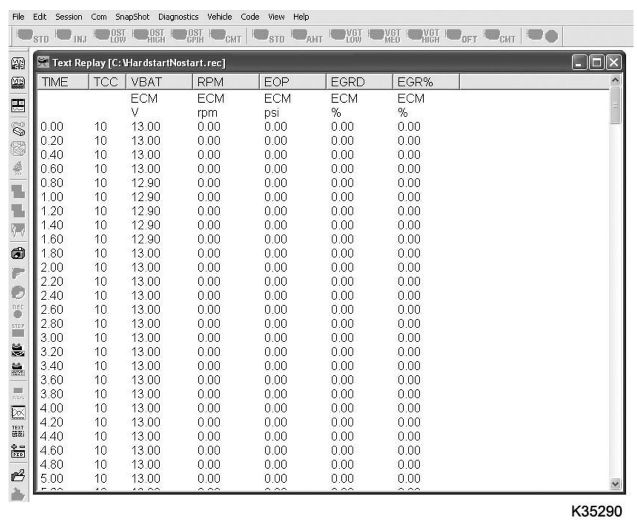


Figure 81 REC file text view

8. The graph or text replay of the recording is displayed.

Diagnostic Tests

Key-On Engine-Off Tests

Standard Test

The KOEO Standard test is done by the ECM. The technician runs this test by using the EST with MasterDiagnostics® software.

During the KOEO Standard test, the ECM does an internal test of its processing components and memory followed by an Output Circuit Check (OCC). The OCC evaluates the electrical condition of the circuits, not mechanical or hydraulic performance of the systems. By operating the ECM output circuits and measuring each response, the Standard test detects shorts or opens in the harnesses, actuators, and ECM. If a circuit fails the test, a fault is logged and a DTC is set.

The ECM checks the IPR, BSV, EFAN, and RSE circuits.

When the OCC is done, the DTC window will display DTCs that identify the problem.

1. Turn ignition switch to ON. Do not start engine.
2. Open COM port or select a session.

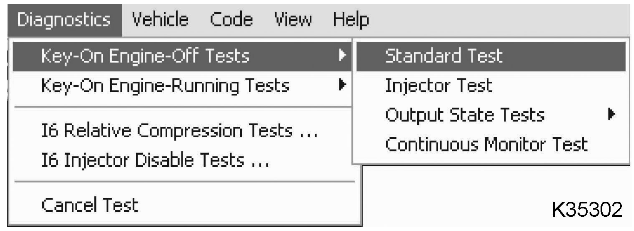


Figure 82 Standard test menu

3. Select Key-On Engine-Off Tests and Standard Test from the drop down menu.
4. Follow the on-screen instructions.
5. To cancel test, select Diagnostics from menu bar, then Cancel Test.

NOTE: When using the EST to do KOEO or KOER diagnostic tests, Standard test is always selected and run first. If the ignition switch is not cycled, the Standard test does not have to be run again.

Injector Test

NOTE: The Standard test must be done before doing the Injector test.

The Injector test diagnoses electrical problems in ECM wiring or injectors. Before doing the Injector test, DTCs should be accessed, noted, and cleared. This allows DTCs to be displayed as Active DTCs.

During the Injector test, the ECM actuates the injectors in numerical order (1 through 6), not in firing order. The ECM monitors the electrical circuit for each injector, evaluates the performance of the injector coils, and checks the operation of the electrical circuit. If an electronic component in the injector drive circuit fails the expected parameters, the ECM logs the fault. A DTC will be set and sent to the EST.

NOTE: The technician can monitor injector operation by listening to the sound of each injector when activated by the ECM. During Hard Start and No Start conditions, when oil is very cold and thick, injectors may be hard to hear.

The DTC window will display DTCs that identify the problem.

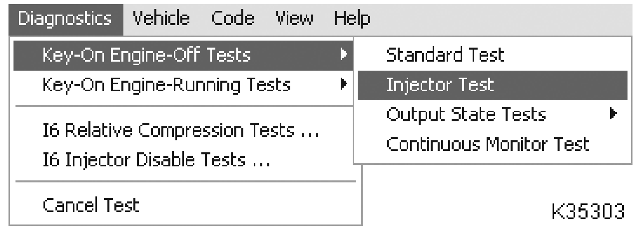


Figure 83 Injector test menu

1. Turn ignition switch to ON. Do not start engine.
2. Open COM port or select a session.
3. Select Key-On Engine-Off Tests and Injector Test from the drop down menu.
4. Follow the on-screen instructions.
5. To cancel test, select Diagnostics from menu bar, then Cancel Test.

Output State Low Test

The Output State Low test allows the technician to diagnose the operation of the output signals and actuators.

In the Output State Low test mode, the ECM pulls down the output voltage to the low state. This grounds the low side driver circuits and actuates the output components controlled by the ECM.

During Output State Low test, the output of the circuit in question can be monitored with a DMM. The DMM measures a low voltage state as the outputs are toggled. The actual voltage will vary with the circuit tested.

NOTE: A breakout box or breakout harness and a DMM are required to monitor the suspected circuit or actuator. DTCs are not set by the ECM during this test.

The following actuators are activated when toggled low during the test:

- IPR valve
- EFAN relay
- RSE
- EGR valve
- ITV
- VGT

1. Turn ignition switch to ON.

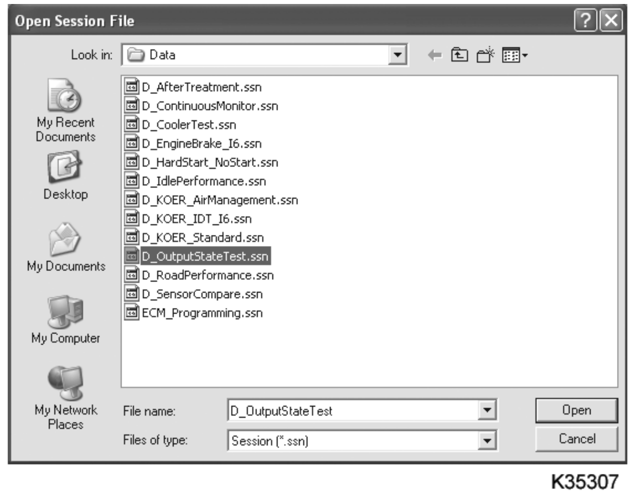


Figure 84 Output state test session

2. Open session and select D_OutputStateTest session from menu.

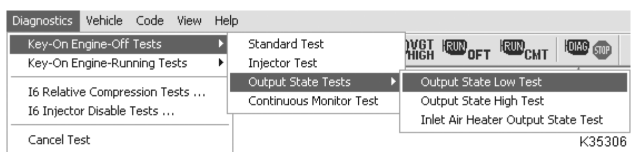


Figure 85 Output state low test menu

3. Select Key-On Engine-Off Tests. From the drop down menu, select Output State Tests, then select Output State Low Test.
4. Follow the on-screen instructions.
5. To cancel test, select Diagnostics from menu bar, then Cancel Test.

Output State High Test

The Output State High test allows the technician to diagnose the operation of the output signals and actuators.

In the Output State High test mode, the ECM pulls up the output voltage to the high state. This energizes the control high side driver circuits and actuates the output components controlled by the ECM.

During this test, the output of the circuit in question is monitored with a DMM. The DMM measures a high voltage state, as the outputs are toggled. The actual voltage will vary with the circuit tested.

NOTE: A breakout box or breakout harness and a DMM are required to monitor the suspected circuit or actuator. DTCs are not set by the ECM during this test.

The VGT and Brake Shut-off valve actuators are activated when toggled high during the test.

1. Turn ignition switch to ON. Do not start engine.

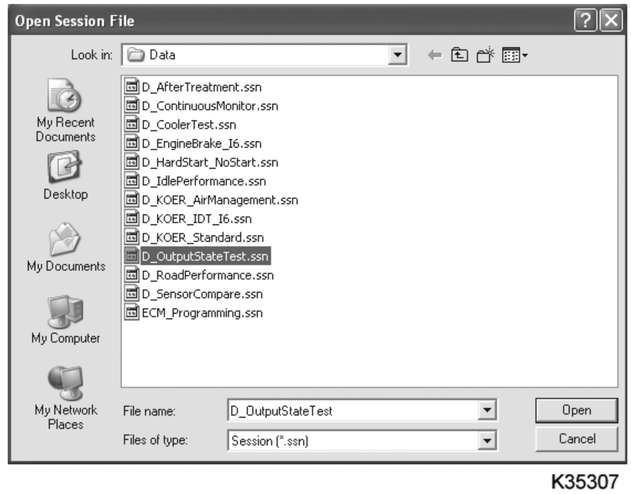


Figure 86 Output state test session

2. Open session and select D_OutputStateTest session from menu.

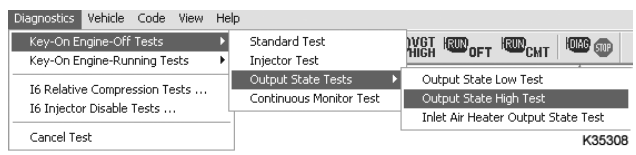


Figure 87 Output state high test menu

3. Select Key-On Engine-Off Tests. From the drop down menu, select Output State Tests, then select Output State High Test.
4. Follow the on-screen instructions.
5. To cancel test, select Diagnostics from menu bar, then Cancel Test.

Inlet Air Heater Output State Test

The Inlet Air Heater Output State test allows the technician to determine if the Inlet Air Heater System is operating correctly.

The inlet air heater relay operation is activated for 30 seconds. A DMM and current clamp are used to measure the time the relay is on and the amperage that is drawn for the inlet air heater.

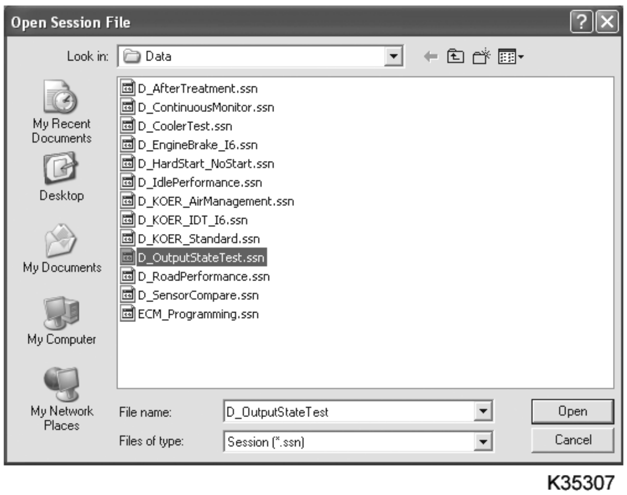


Figure 88 Output state test session

1. Open session and select D_OutputStateTest session from menu.

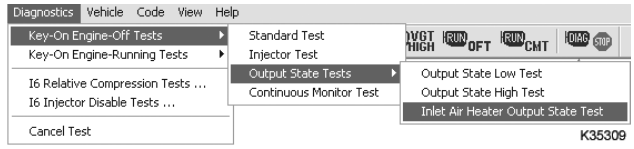


Figure 89 Inlet air heater output state test menu

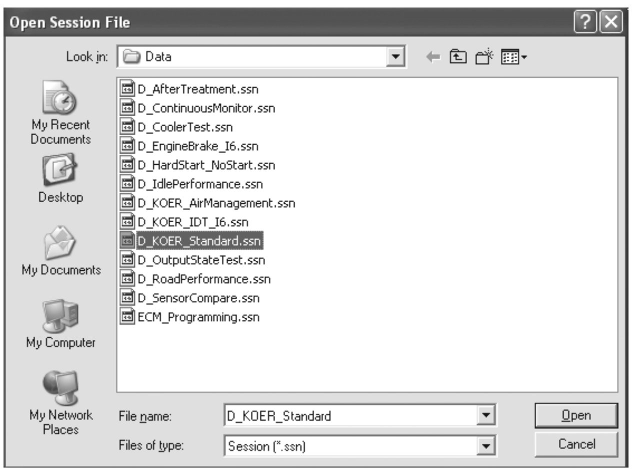
2. Select Key-On Engine-Off Tests. From the drop down menu, select Output State Tests, then select Inlet Air Heater Output State Test.
3. Follow the on-screen instructions.
4. To cancel test, select Diagnostics from menu bar, then Cancel Test.

Key-On Engine-Running Tests

Standard Test

During the KOER Standard test, the ECM commands the IPR through a step test to determine if the ICP system is performing as expected. The ECM monitors signal values from the ICP sensor and compares those values to the expected values. When the Standard test is done, the ECM returns the engine to normal operation and transmits DTCs set during the test.

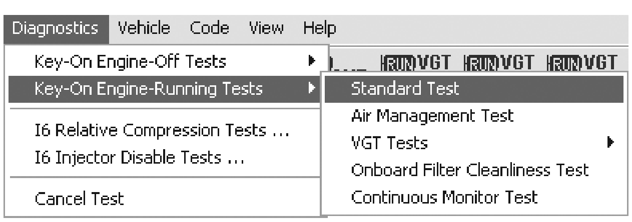
NOTE: Ensure that engine is above minimum operating temperature of 70 °C (158 °F) before starting test.



K35312

Figure 90 KOER standard session menu

1. Turn ignition switch to ON.
2. Open session and select D_KOER_Standard session from menu.
3. Start engine and run until minimum engine coolant temperature of 70 °C (158 °F) is reached.



K35311

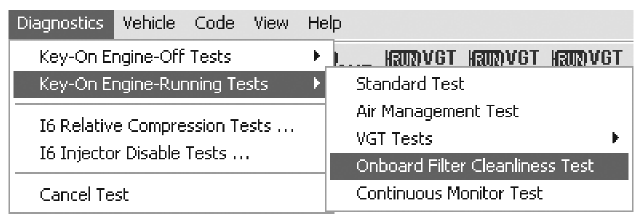
Figure 91 Standard test menu

4. Select Key-On Engine-Running Tests and Standard Test from the drop down menu.
5. Follow the on-screen instructions.
   - The ECM will start the KOER Standard Test by commanding the engine speed to rise to a predetermined level.
   - When the test is finished, the ECM will return the engine speed to low idle.

Engine Aftertreatment Test

The Exhaust Aftertreatment Test allows the technician to determine if the exhaust aftertreatment system is operating correctly.

1. Open MasterDiagnostics® and establish communication with the vehicle.
2. If needed, open a desired session file.



K35313

Figure 92 Engine aftertreatment test menu

3. Start the engine.

   NOTE: Ensure that the engine is above minimum operating temperature (70 °C [158 °F]) before starting On-Board Filter Cleanliness Test.

4. Select Key-On Engine-Running Tests, then the On-Board Filter Cleanliness Test from the drop-down menu.

   The ECM will start the On-Board Filter Cleanliness Test and command the engine to accelerate to a default engine speed to prepare for regeneration.

   The ECM will monitor the effects of the regeneration system by using feedback signals from the temperature and pressure sensors.

5. Follow the on-screen instructions.
6. To cancel test, select Diagnostics from menu bar, then Cancel Test.

Air Management Test

The Air Management Test allows the technician to determine if the intake, exhaust, VGT, and EGR systems are operating correctly.

During the Air Management test, the ECM commands the VGT control actuator and EGR actuator through a step test sequence to determine if actuators and the Air Management System are performing as expected. The ECM monitors the feedback signal values from the EBP sensor and compares those values to the expected values.

If a fault is detected the test will end, engine operation will return to normal, and a DTC will be set. If there are no faults, the test will be completed and engine operation will return to normal.

NOTE: Ensure that engine is above minimum operating temperature of 70 °C (158 °F) before starting test.

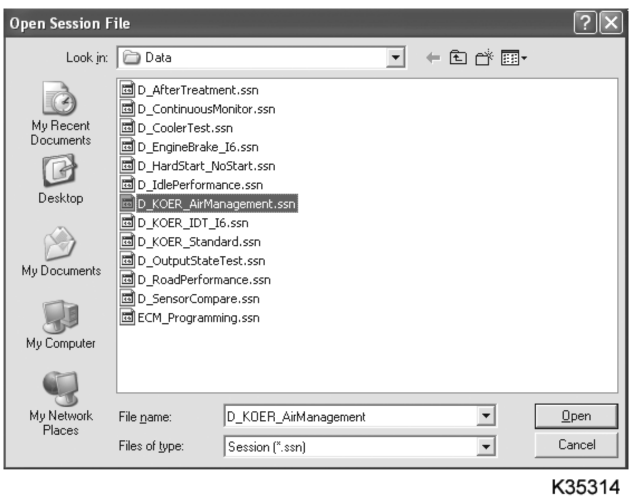


Figure 93 Air management session

1. Open session and select D_KOER_AirManagement session from menu.

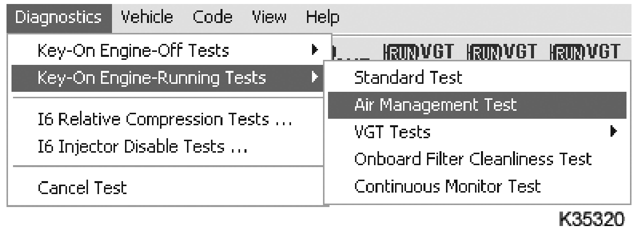


Figure 94 Air management menu

2. Select Key-On Engine-Running Tests and Air Management Test from the drop down menu.

   The ECM will start the KOER Standard Test by commanding the engine speed to rise to a predetermined level. When the test is finished, the ECM will return the engine speed to low idle.

3. Follow the on-screen instructions.

VGT Test

The VGT test is a manual test that allows the technician to set the VGT duty cycle to low, medium, or high and inspect the exhaust system for leaks.

NOTE: Ensure that engine is above minimum operating temperature of 70 °C (158 °F) before starting test.

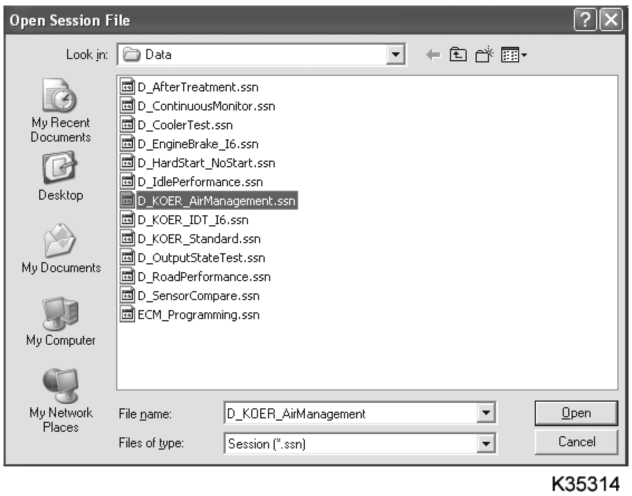


Figure 95 Air management session

1. Open session and select D_KOER_AirManagement session from menu.

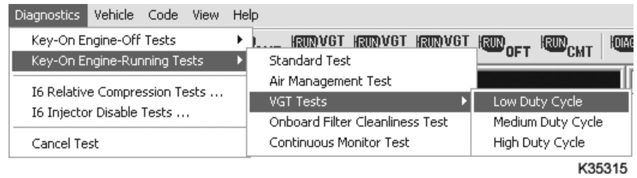


Figure 96 VGT duty cycle test menu

2. Select Key-On Engine-Running test. From the drop down menu, select VGT tests (low, medium, or high duty cycle).
3. Use the following recommended duty cycle sequence to check turbocharger operation between VGT duty cycle:
   - Low to medium
   - Medium to high
   - High to low
   - Low to high
4. Select Low Duty Cycle. Select Run to command the ECM to begin the test.
5. Select the next desired duty cycle. Select Run.

Continuous Monitoring – Troubleshooting Intermittent Connections

The Continuous Monitor test is very helpful in troubleshooting intermittent connections between the control modules and sensors. The key must be ON and the engine can be OFF or running.

The continuous monitor session monitors all sensor voltages. Sensors that read N/A are not turned on in the control module.

1. Open MasterDiagnostics® and establish communication with the vehicle.
2. Open the D_ContinuousMonitor session.

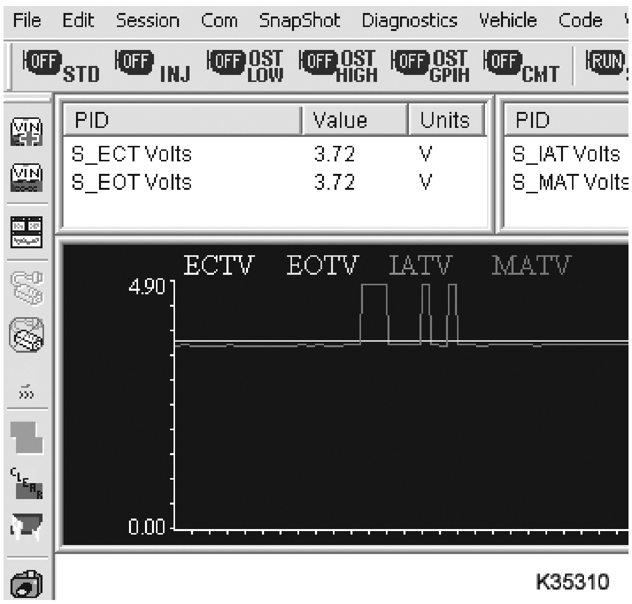


Figure 97 Continuous monitoring

NOTE: All sensors active in the software are reading an actual value. Refer to the DTC pin-point test to find the minimum or maximum value that sets the fault code being diagnosed.

3. Monitor the graphs on the screen while wiggling the connectors and wires at all suspected problem locations.

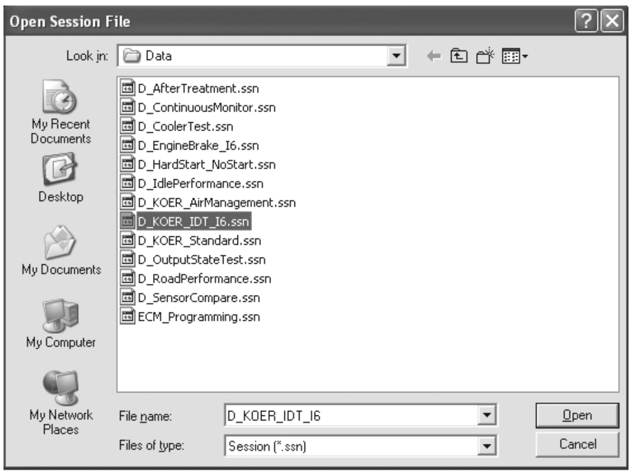
NOTE: Refer to the electrical information to find all circuits that might cause the intermittent problem.

4. Disconnect and inspect connectors for damage, corrosion, or loose pins. Repair if necessary.
5. To cancel test, select Diagnostics from menu bar, then Cancel Test.

Injector Disable Test

The Injector Disable tests allows the technician to shut off injectors to determine the cause of rough engine idle. This test is used in conjunction with Relative Compression test to identify an injector problem or a mechanical problem.

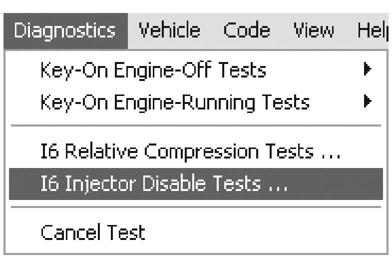
NOTE: The Injector Disable test can be run only when engine temperature reaches 70 °C (158 °F) or higher. The EOT indicator will change from red to green when engine temperature reaches acceptable temperature.



K35317

Figure 98 Injector disable session

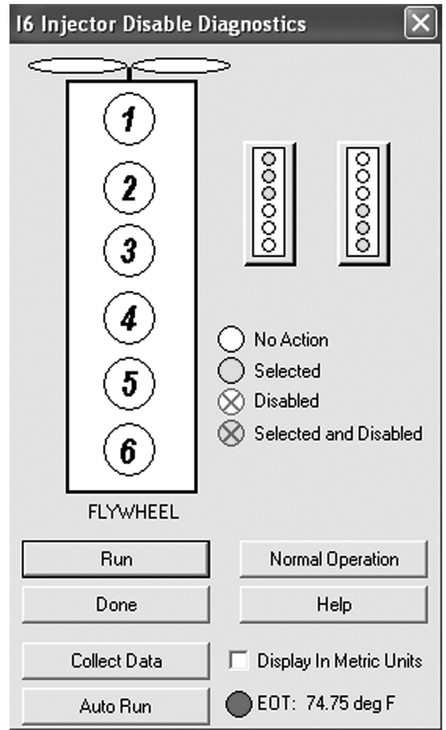
1. Open session and select D_IDT_I6 session from menu.



K35318

Figure 99 Injector disable test menu

2. Select Diagnostics from menu bar and I6 Injector Disable Test from drop down menu.

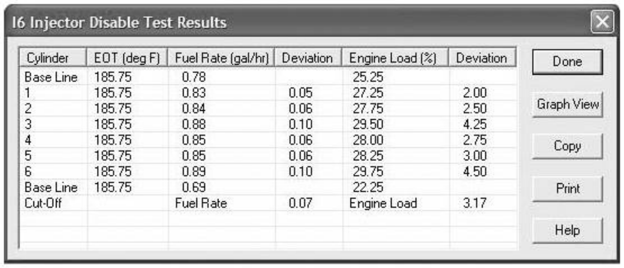


K35319

Figure 100 Injector disable test

3. Select cylinder number and select Run. The selected injector will be disabled and engine noise should change.
4. Select Normal Operation. The selected injector will be enabled and engine noise should return to previous state of operation.
5. Repeat steps 3 and 4 for the remaining cylinders.
6. To cancel test, select Diagnostics from menu bar, then Cancel Test.

Auto Run Feature



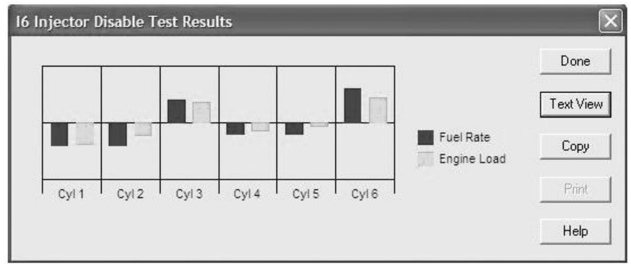
I6 Injector Disable Test Results

Cylinder	EOT (deg F)	Fuel Rate (gal/hr)	Deviation	Engine Load (%)	Deviation
Base Line	185.75	0.78		25.25	
1	185.75	0.83	0.05	27.25	2.00
2	185.75	0.84	0.06	27.75	2.50
3	185.75	0.88	0.10	29.50	4.25
4	185.75	0.85	0.06	28.00	2.75
5	185.75	0.85	0.06	28.25	3.00
6	185.75	0.89	0.10	29.75	4.50
Base Line	185.75	0.69		22.25	
Cut-Off		Fuel Rate	0.07	Engine Load	3.17

Done
Graph View
Copy
Print
Help

H31242

Figure 101 Injector disable test results (auto run - text view)



H31243

Figure 102 Injector disable test results (auto run - graph view)

During Auto Run, injectors are shutoff one at a time (1 through 6 numerical sequence). Baseline data and results for each cylinder is displayed in the window (Text View) for Injector Disable test results. Test data for each cylinder can also be viewed by selecting the (Graph View). When finished the engine will return to normal operation.

Relative Compression

The Relative Compression test is used in conjunction with the Injector Disable test to distinguish between and an injector or mechanical problem.

The test provides the difference between the fastest and slowest crankshaft speed, during the power stroke of each cylinder, to reflect relative cylinder compression.

As the engine is cranked, the ECM uses the CMP and CKP sensor signals to measure crankshaft speed, as piston reaches two points: Top Dead Center (TDC) compression and about 30 degrees after TDC compression.

When the piston approaches TDC, crankshaft speed should be slower because of compression resistance. As the piston passes TDC, compression resistance dissipates and crankshaft speed increases.

At TDC compression, the cylinder reaches its highest compression and resistance to crankshaft rotation (crankshaft speed is the slowest). A cylinder with low compression will have less resistance to crankshaft rotation. Crankshaft speed will be faster than normal.

About 30 degrees after TDC, crankshaft speed should be fastest because compression has dissipated. On a cylinder that has low compression, crankshaft speed will be close to, or less than crankshaft speed at TDC.

At TDC of each power cylinder, and about 30 degrees past TDC, the ECM collects data for crankshaft speed.

The TDC value is subtracted from the value about 30 degrees after TDC and is recorded for each cylinder.

Example

200 rpm (30 degrees after TDC) - 180 rpm (TDC) = 20 rpm

The EST will display a value on the screen for each cylinder.

Example

Relative Compression	Value
Cylinder 1 Relative Compression	18
Cylinder 2 Relative Compression	22
Cylinder 3 Relative Compression	24
Cylinder 4 Relative Compression	20
Cylinder 5 Relative Compression	21
Cylinder 6 Relative Compression	22

Compare the speed difference value of each cylinder with the other cylinder values. A cylinder with a speed difference lower than the other cylinders indicates a suspect cylinder. Test value of 18 for cylinder one indicates a suspect cylinder.

If a cylinder value is zero or a much lower than other cylinders and this cylinder is a non-contributor (identified in the Injector Disable Test), check for a mechanical problem.

Example

Relative Compression	Value
Cylinder 1 Relative Compression	5
Cylinder 2 Relative Compression	22
Cylinder 3 Relative Compression	24
Cylinder 4 Relative Compression	20
Cylinder 5 Relative Compression	21
Cylinder 6 Relative Compression	0

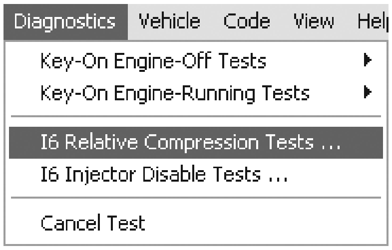
If TDC rpm is greater than rpm 30 degrees after TDC, the EST will display 0.

If the test value for a power cylinder is 0, the cylinder is suspect.

If the test value for a power cylinder is significantly below 15 rpm, the cylinder is suspect.

Test value 5 for cylinder 1 indicates a suspect cylinder. Test value 0 for cylinder 6 indicates a suspect cylinder.

The EST will indicate when the Relative Compression test is done. The engine will stop cranking and the EST will display test results.



K35316

Figure 103 Relative compression test menu

1. Select Diagnostics from the menu bar.
2. Select I6 Relative Compression Tests from the drop down menu.
3. Follow the on-screen instructions.
4. Interpret results.
   - If a Relative Compression test and Injector Disable test identify a suspect cylinder, check for a mechanical problem.
   - If a Relative Compression test does not identify a suspect cylinder, but the Injector Disable test does, replace suspect injector(s).

Reset Engine Change Oil Message

Reset Message with EST

1. Set parking brake.
2. Turn ignition switch to ON. Do not start the engine.
3. Open MasterDiagnostics® to establish communication.
4. Open session file window.
5. Select PP_ServiceInterval.ssn file.
6. Select Open.
7. Right click in the session window.
8. Select enter Password from pop-up menu.
9. Enter password in dialog box.
10. Select OK.
11. Right click on SI: Service Interval Reset parameter to display pop-up menu.
12. Select Program from the pop-up menu. The Edit Parameter window will open.
13. Click the arrow in the New Value dialog box.
14. Select Yes in the pull-down menu.
15. Select OK.
16. Verify that the following changes have been made to SI: Service Interval Reset parameter and accepted by the ECM:
    - Module Value has changed from No to Yes.
    - Original number in Program Count has increased by one.
17. Oil change interval has been set. Close session window.

General Information

Installed MasterDiagnostics® Version

1. Open MasterDiagnostics® on EST computer.
2. Select Help from the menu bar.
3. Select About from the drop-down menu.
4. The software release version is displayed.

Approved Interface Cable

1. Current approved interface cables are verified for full functionality for the MasterDiagnostics® software.

   NOTE: Unapproved or outdated interface cables may have limited or no functionality or low accuracy.
2. The Tech Central representative may ask which interface cable is being used in addition to the diagnostic issues.

Table of Contents

Description

Diagnostic test procedures help technicians find problems systematically and quickly to avoid unnecessary repairs. In this section, diagnostic and test procedures help identify causes for known 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, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

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

Combustion Leaks to Coolant

Symptom

Combustion leaks to coolant can be identified by coolant overflowing from deaeration tank or air bubbles in the coolant.

Tools

- Radiator pressure testing kit
- Plastic surge tank cap adapter
- Cylinder head test plate
- Water supply housing pressure adapter
- Thermostat opening pressure adapter (cylinder head)
- Hose pinch-off pliers (2)
- EGR cooler test plates (2)

Possible Causes

- Failed injector sleeve
- Failed air compressor
- Failed head gasket
- Failed EGR coolers
- Cracked cylinder sleeve or cavitation
- Improperly adjusted liner protrusion

The likely cause of combustion gas leakage to the cooling system is past the injector sleeve in the cylinder head. A failed cylinder head gasket or cracked cylinder sleeve is possible. However, this should not be considered unless there is evidence of engine overheating or high engine mileage without proper coolant conditioning.

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

Procedure

1. Is the engine equipped with an air compressor?
   - If yes, do step 2.
   - If no, do step 3.

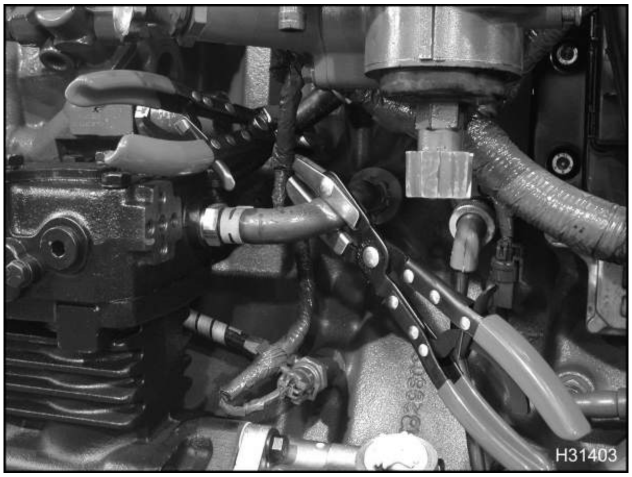


Figure 104 Air compressor coolant hoses

2. Close off both coolant hoses for the air compressor with hose pinch-off pliers. Test the system again.
   - If coolant continues overflowing from the deaeration tank, do step 3.
   - If coolant stops overflowing from deaeration tank, repair or replace the air compressor.
3. Remove injectors following the procedure in the *Engine Service Manual*.

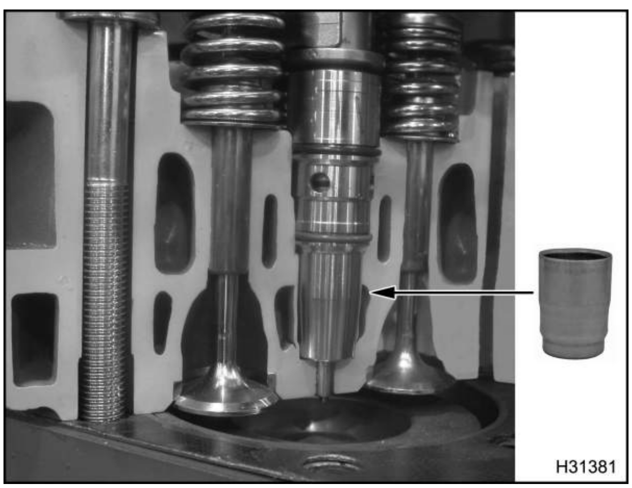


Figure 105 Cylinder head cut-away with injector sleeve

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.

4. Install radiator pressure tester with the appropriate adapter.
5. Pressurize cooling system to 96 kPa (14 psi).
6. Look for coolant leaking around the injector sleeve and into the cylinder bore.
   - If a leak is noticed, replace the leaking injector sleeve and test again.
   - If no leak is noticed, replace all six injector sleeves and test again.
   - If coolant continues to flow into cylinders after all injector sleeves were replaced, do step 7.
7. Remove cylinder head from engine, perform all inspections, and pressure test cylinder head to verify leak path. Follow the procedure in the *Engine Service Manual*.

   NOTE: A cylinder with coolant will typically be cleaner than other cylinders.

   - Inspect cylinder head gasket for coolant leaks.
   - Verify crankcase and cylinder head surface flatness using a straight edge and feeler gauge.
   - Check cylinder liner protrusion. Follow the procedure in the *Engine Service Manual*.
8. Test the cylinder head with pressure test plate to validate the repair.

Coolant Leak to Exhaust/Intake

Symptoms

- Loss of coolant without visible leaks
- Coolant odor in the exhaust
- Coolant dripping from the exhaust system
- Aftertreatment system failure
- Overheating
- Hydraulic cylinder lock
- Deposits on IAH elements
- VGT actuator linkage stuck

Tools

- Regulated compressed air
- Water supply housing pressure adapter
- Radiator pressure testing kit and plastic surge cap adapter
- EGR cooler pressure test plates (2)

Possible Causes

- Failed EGR coolers
- Failed injector sleeve
- Leaking intake side cylinder head cup plugs
- Cylinder head porosity

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

EGR Cooler Inspection

Procedure

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

Figure 106 EGR tube assembly (exhaust side)

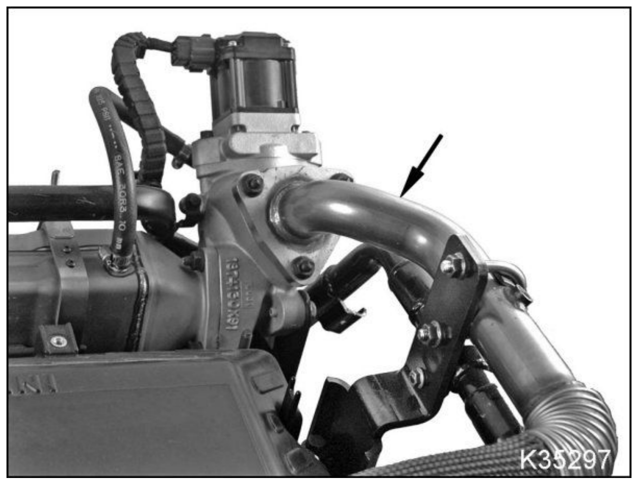


Figure 107 EGR tube assembly (intake side)

1. Remove EGR tube assembly, inlet/EGR mixer duct, and EGR metering tube following the procedure in the *Engine Service Manual*.
2. Check for presence of coolant in EGR coolers, tube and EGR valve manifold.
3. Plug in the coolant heater (if available) to warm the coolant.

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.

4. Install radiator pressure tester with surge cap adapter.
5. Pressurize cooling system to 96 kPa (14 psi).

NOTE: If pressure drops rapidly without visible coolant leaks, coolant may be leaking from the exhaust side EGR cooler into the exhaust manifold.

6. Check for coolant leak at the exhaust side EGR cooler outlet at the crossover pipe.
   - If coolant leak is identified, do step 7.
   - If leak is not identified, do step 8.
7. Drain coolant from the cooling system and remove the exhaust side EGR cooler following the procedure in the EGES-450 *Engine Service Manual*.
   - Attach K-Line 20020 EGR Leak Detection Kit to the exhaust side EGR cooler following the procedure for EGR cooler pressure testing in the *Engine Service Manual*.
   - Apply 70 psi of a regulated air pressure and submerge EGR cooler into a tank of warm water. Apply 70 psi for 5 minutes.
   - If EGR cooler does not hold pressure and air bubbles appear, replace the exhaust side EGR cooler following procedure in the *Engine Service Manual*.
   - If EGR cooler holds pressure and air bubbles do not appear, do step 8.
8. Remove EGR hose at the rear of the intake side EGR cooler near the ITV.
9. Check outlet of the intake side EGR cooler for coolant leak:
   - If coolant leak is not identified reassemble the EGR system following procedure in the *Engine Service Manual*; proceed to the Injector Sleeve Inspection.
   - If coolant leak is identified, do step 10.
10. Drain coolant from the cooling system and remove the intake side EGR cooler following procedure in the *Engine Service Manual*.
    - Attach K-Line 20020 EGR Leak Detection Kit to the intake side EGR cooler following the procedure for EGR cooler pressure testing in the *Engine Service Manual*.
    - Apply 70 psi of a regulated air pressure and submerge EGR cooler into a tank of warm water. Apply 70 psi for 5 minutes.
    - If EGR cooler does not hold pressure and air bubbles appear, replace intake side EGR cooler following procedure in the *Engine Service Manual*.
    - If EGR cooler holds pressure and air bubbles do not appear, go to the Injector Sleeve Inspection.

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. Use a radiator pressure tester to pressurize cooling system to 96 kPa (14 psi).
4. 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 *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 *Engine Service Manual*.

  Test again to validate repair.

  If leak continues, go to Cylinder Head Leak Test.

Cylinder Head Leak Test

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

1. Remove the valve cover following the procedure in the *Engine Service Manual*.

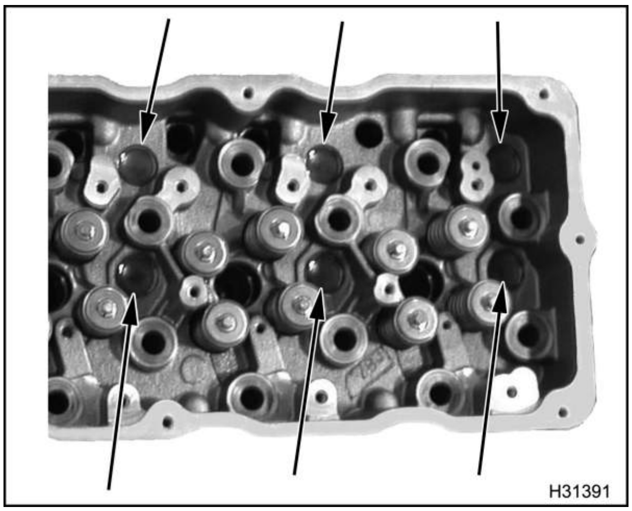


Figure 108 Cylinder head (top) cup plugs

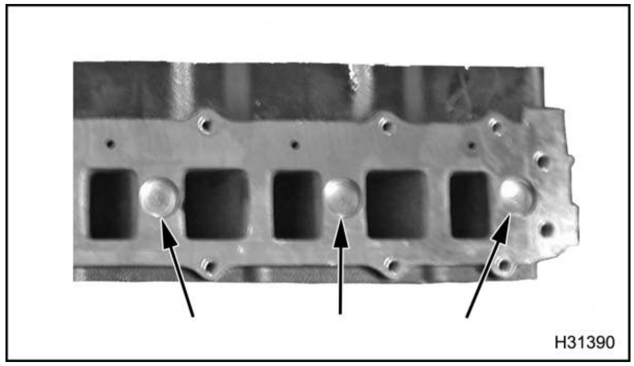


Figure 109 Cylinder head (intake side) cup plugs

2. Plug in the coolant heater to warm the coolant.
3. Pressurize the cooling system to 96 kPa (14 psi).
4. Inspect the entire cylinder head for cracks or leaks at the cup plugs.
   - If a leak is noticed, repair or replace.
   - If no leaks are noticed, do step 5.
5. Drain coolant from system.
6. Remove cylinder head from engine following the procedures in the *Engine Service Manual*.
7. Inspect and pressure test the cylinder head following the procedures in the *Engine Service Manual*.
   - Inspect cylinder head gasket for damage at sealing points that may have caused a leak. Verify crankcase and cylinder head surface flatness using a straightedge and feeler gauge. Replace the head gasket. Repair or replace the cylinder head if necessary.
   - Inspect the cylinder head for cracks in the coolant passages. Repair or replace.
8. 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 dark-gray or black sludgy appearance. The crankcase may also be overfilled.

Tools

- Radiator pressure testing kit
- Plastic surge tank cap adapter
- Cylinder head test plate
- Water supply housing pressure adapter
- Thermostat opening pressure adapter (cylinder head)
- Straightedge
- Feeler gauge
- EGR cooler test plates

Possible Causes

- Accessory leak (water cooled air compressor)
- Injector sleeve leak
- Cylinder head cup plug failure
- Crevice seal (liner O-ring)
- Cylinder head gasket leak
- Front cover gasket damage
- Front cover, cylinder head or crankcase porosity
- Failed EGR cooler

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

Coolant System Inspection

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 dark-gray or black sludgy appearance.
   - If coolant in the oil is not verified, an oil sample can be taken for analysis.
2. When oil contamination is verified, plug in cylinder block heater to warm coolant.
3. Is the engine equipped with an air compressor?
   - If yes, do steps 4 through 7.
   - If no, continue with step 8.

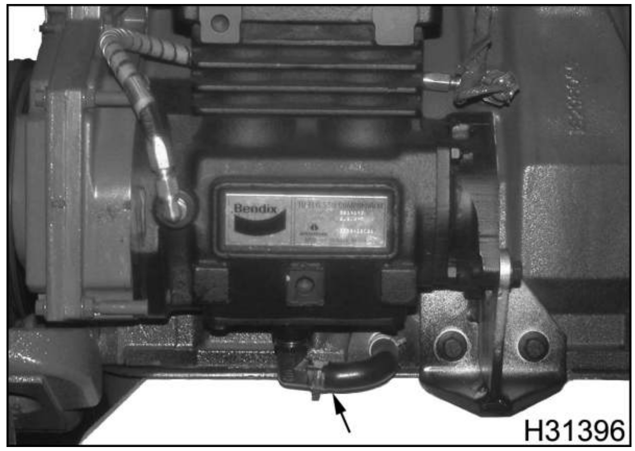


Figure 110 Air compressor oil drain-back hose

4. Remove air compressor oil drain-back hose from the bottom of compressor.

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.

5. Install radiator pressure tester with the appropriate adapter.
6. Pressurize the cooling system to 96 kPa (14 psi).

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, do 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. Install radiator pressure tester with the appropriate adapter.

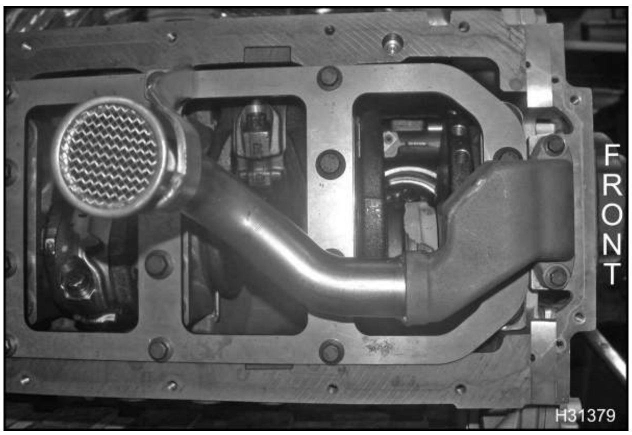


Figure 111 Bottom of engine

11. Pressurize cooling system to 96 kPa (14 psi). Look for coolant leaks.
    - If the engine does not have an air compressor, and is leaking from the front cover area or the oil pick-up tube, do Front Cover Inspection (page 108).
    - If a leak is noticed between the cylinder sleeve and piston, replace the injector sleeve for that cylinder. Follow the 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 the 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 105).
    - If no leak is noticed, leave pressure and heat on cooling system overnight and check the following day.
    - If no leak is noticed after overnight pressure test, do the following sequential tests until problem is found:
      A. Front Cover Inspection (page 108)
      B. Cylinder Head Leak Test (page 105)
12. After any repairs are complete, test the cooling system again to validate the repair.

Front Cover Inspection

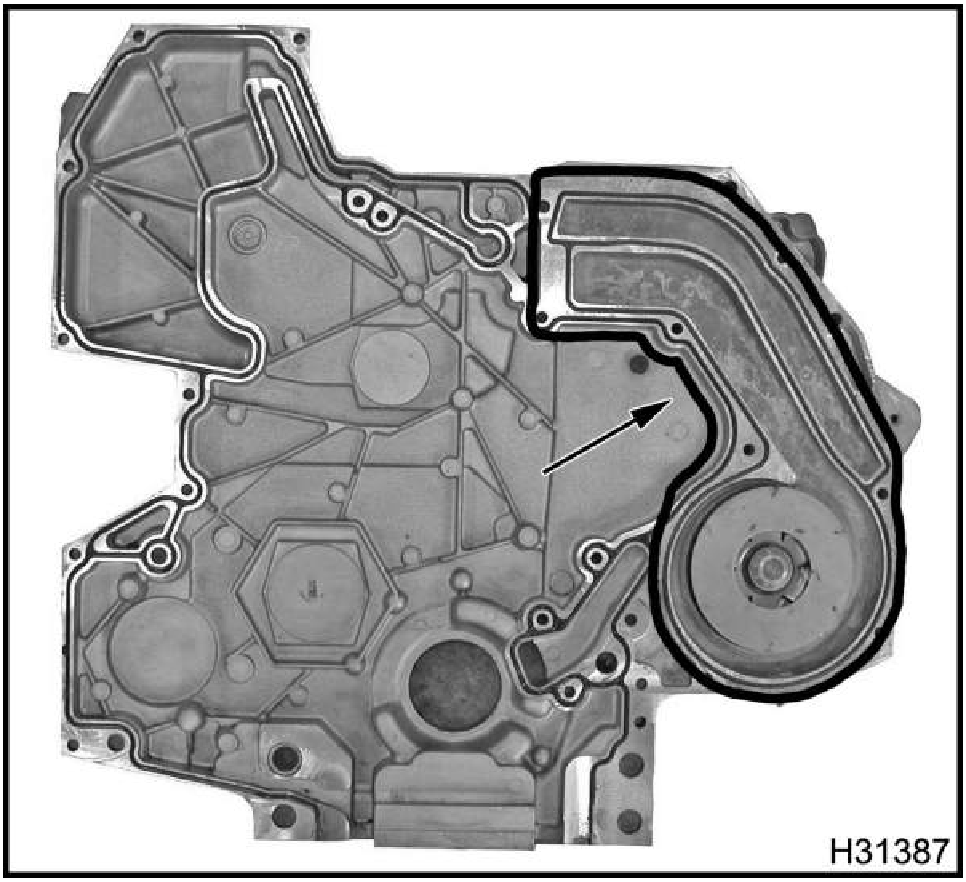


Figure 112 Front cover coolant leak location

1. Remove front cover and inspect gaskets and sealing surfaces following the procedure in the *Engine Service Manual*. Check front cover and crankcase with straight edge and feeler gauge. Repair or replace as required.
2. Test the cooling system again after any repair to validate the repair.

Coolant Over-temperature

Symptoms

When the coolant temperature is above 107 °C (224 °F), a DTC will be set and the control system will command less fueling. A power loss may also occur.

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

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

Tools

- Radiator pressure test kit and adapter
- Regulated compressed air
- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM) with thermocouple

Possible Causes

- 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
- Inoperative electric cooling fan
- Instrument panel gauge error
- Engine Coolant Temperature (ECT) sensor biased
- Incorrect radiator
- Missing coolant thermostat
- Chassis effects, transmission, after-market equipment

Coolant System Inspection

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

Figure 113 Deaeration tank components

1. Deaeration tank
2. Deaeration tank cap
3. MAXIMUM coolant level mark
4. ADD coolant level mark

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 123).

2. Inspect for coolant leaks. Check for external leaks from coolant hoses, radiator, heater core, 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 106) in this section.
   - If no leaks are found, continue with step 3.

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. Fill cooling system to the maximum coolant level mark.
4. Start the engine.

WARNING: To prevent personal injury or death, be careful when purging air from cooling system.

5. Purge all air out of system by opening the coolant dearation line at the EGR valve. Reconnect line when coolant appears.
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 9.
7. Install radiator pressure tester with the appropriate adapter.
8. Pressurize the cooling system to 96 kPa (14 psi).
   - If coolant is leaking externally, identify the leak and repair.
   - If coolant is not leaking externally, but the pressure is dropping, see Coolant Leak to Exhaust/Intake (page 103) and Coolant in Lube Oil (page 106) in this section.
9. Inspect the condition of the following items: cooling fan blade, shroud, accessory drive belt, accessory drive belt tensioner, cooling fan drive clutch, operation of electric or air fan, and radiator.

   CAUTION: To prevent engine damage, do not dent radiator fins with the wand of a high pressure washer.

   - 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.
   - If no problems are identified, go to Temperature Sensor Validation Test (page 111) in this section.

Temperature Sensor Validation Test

1. Install EST and check for active and inactive DTCs related to engine coolant over-temp conditions.
   - If any DTCs remain relating to coolant over-temp condition, correct DTC before continuing.
   - If no DTCs exist, continue with step 2.
2. Using the EST, compare Engine Coolant Temperature (ECT), Engine Oil Temperature (EOT), and Manifold Air Temperature (MAT) with Key On Engine Off. All of the sensors should read within 2 °C (5 °F) of each other.

   NOTE: This is only accurate if done after a cold soak of at least 8 hours on the engine.
3. Install a manual gauge or DMM with a thermocouple in the intake side EGR cooler outlet port, operate the engine, and use the EST to monitor ECT.
4. Run engine up to an operating temperature of at least 70 °C (158 °F). Try to duplicate the operator's coolant over-temp concern. Monitor the ECT using the EST, instrument panel coolant temperature gauge, and the mechanical or electrical gauge.
   - If instrument panel coolant temperature gauge reads a different temperature than the EST and test gauge, refer to the *Electrical System Troubleshooting Guide* for the appropriate model and year of vehicle.
   - If test gauge and EST read values with a difference greater than ± 3 °C (± 5 °F), see ECT Sensor (page 282) in “Electronic Control Systems Diagnostics” section of this manual.
   - If the gauge is reading correctly and the engine is running over-temperature, go to Cooling System Operating Pressure Test (page 111) in this section.

Cooling System Operating Pressure Test

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

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 pressure is higher than the pressure rating of the cooling system cap, go to Combustion Leaks to Coolant (page 101) in this section.
   - If pressure gauge reading is below pressure rating of system, replace the thermostat.

Fuel System

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

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

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

Priming Fuel System

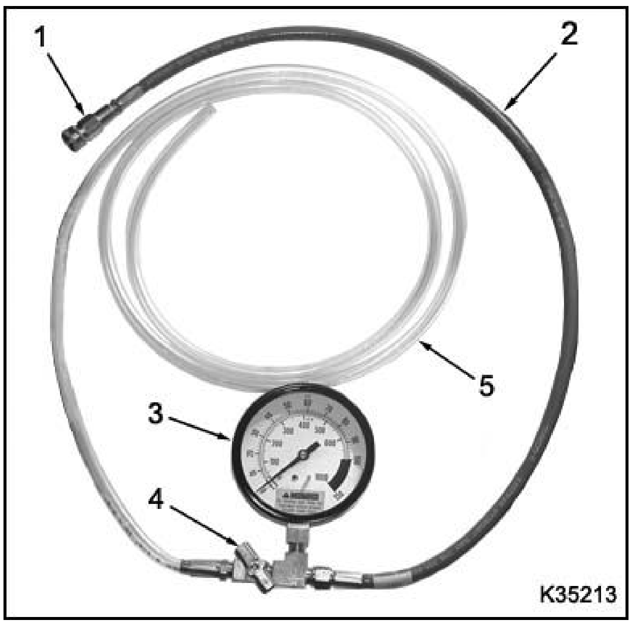


Figure 114 Fuel Pressure Gauge assembly

1. Quick disconnect check valve
2. Fuel test line
3. Fuel Pressure Gauge
4. Inline shut-off valve
5. Clear test line

If engine runs out of fuel or the fuel filter header has been drained, do the following:

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

1. Install Fuel Pressure Gauge assembly quick disconnect check valve on engine fuel Shrader valve.
2. Open gauge assembly inline shut-off valve.

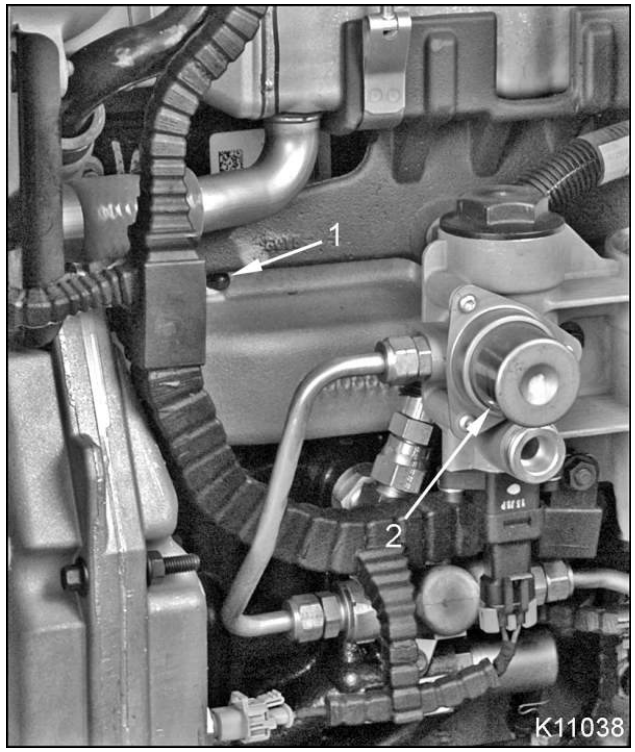


Figure 115 Fuel Shrader valve and priming pump

1. Fuel Shrader valve (fuel pressure test port and air bleed)
2. Fuel priming pump

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

3. Push fuel primer pump until an air-free stream of fuel comes out the clear test line.
4. Collect fuel in a suitable container.
5. Close the gauge assembly inline shut-off valve.

6. Start engine and check for fuel leaks. If fuel is leaking, turn off engine and repair leaks. Refer to engine starting procedures in the *Engine Operation and Maintenance Manual*.
7. Turn off engine. Remove Fuel Pressure Gauge assembly. Dispose of fuel.

Fuel Pressure, Aeration, and Supply

Symptom

Fuel aeration will exhibit one or more of the following characteristics:

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

Tools

- Fuel Pressure Test Gauge
- 1 to 5 gallon bucket
- Fuel pump supply line
- Fuel filter housing supply line fitting
- Fuel Pressure Test Adapter
- Fuel/Oil Pressure Test Coupler

Possible Causes

- Leaks in fuel supply to fuel pump
- Loose fuel injector hold down
- Missing/damaged stainless steel injector gasket
- Failed fuel lift pump

Fuel Pressure and Aeration

Purpose

To check for correct fuel pressure and aerated fuel

NOTE: Plugged supplemental filters or separators mounted on vehicle will influence fuel pressure, restriction, and aeration.

Tools

- Fuel Pressure Gauge
- Fuel Pressure Test Kit
- Clear fuel container

Possible Causes

- Fuel filter or strainer blocked
- Fuel grade incorrect for cold temperatures
- Fuel supply line damage, restriction, or blockage
- Failed fuel tank transfer pump
- Failed fuel regulator valve
- Failed fuel pump
- Air leak in suction side fuel line or filter assembly
- Combustion gases entering fuel supply system

Procedure

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

1. See "Performance Specifications" (page 465) appendix in this manual for correct specification.

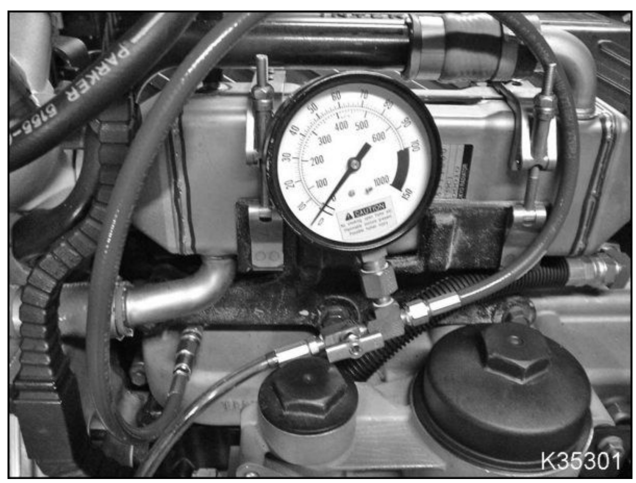


Figure 116 Fuel Pressure Gauge

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

2. Connect fuel pressure valve, fuel pressure gauge with shut-off valve, and a clear 3/8” diameter hose to the fuel test valve.
3. Route clear hose into a drain pan.
4. Start or crank engine for 20 seconds. Measure fuel pressure with shut-off valve closed. Open the shut-off valve to check for aeration.
5. Record results on Diagnostic Form.
6. Run engine at low idle. Measure fuel pressure with shut-off valve closed. Open the shut-off valve to check for aeration.
7. Record results on Diagnostic Form.
8. Run engine at high idle. Measure fuel pressure with shut-off valve closed. Open the shut-off valve to check for aeration.
9. Record results on Diagnostic Form.
10. If the vehicle has automatic transmission, set the parking brake and apply service brakes.
11. Put transmission in drive and press accelerator to the floor for no more than 10 seconds.

    Measure fuel pressure with the shut-off valve closed.
12. Record results on Diagnostic Form.

- If fuel pressure is in specification with no aeration, no repair is required.
- If fuel pressure is below specification, see Fuel Filter Housing Pressure (page 114) in this section of manual.
- If fuel is aerated, see Alternate Fuel Supply to Filter Housing (page 117) in this section of manual.

Fuel Filter Housing Pressure

Purpose

To check for correct fuel pressure in filter housing and inspect fuel filter

NOTE: EFP sensor reading is not the pressure reading in the filter cavity.

Tools

- Fuel/Oil Pressure Test Adapter
- Fuel Pressure Test Kit
- Fuel Pressure Test Gauge

Procedure

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

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

1. Check fuel pressure from the pressure test valve located on the front of the fuel filter housing.

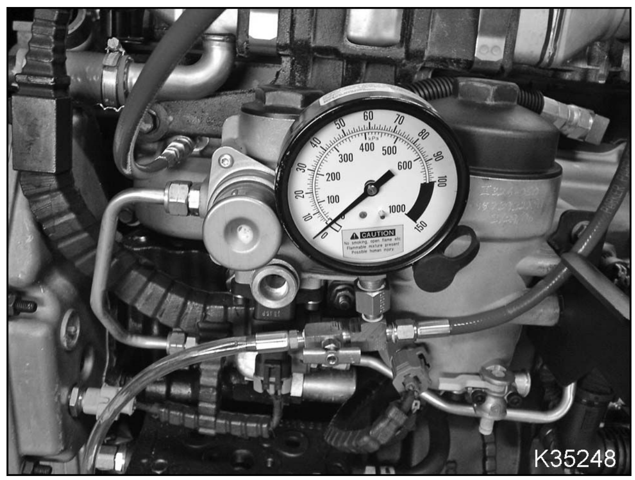


Figure 117 Fuel Pressure Gauge

2. Connect Fuel/Oil Pressure Test Adapter and Fuel Pressure Test Gauge with shut-off valve to the fuel test valve.
3. Crank engine for 20 seconds. Measure fuel pressure with shut-off valve closed.
    - If fuel pressure is in specification, replace the fuel filter element and clean strainer filter.
    - If fuel pressure is below specification, go to Fuel Inlet Restriction (page 115) in this section of manual.

Fuel Inlet Restriction

Purpose

To check for fuel supply system restriction

Tools

- Fuel Inlet Restriction Adapter
- Gauge Bar Tool

Possible Causes

- Fuel supply line damage or blockage
- Fuel grade incorrect for cold temperature

Procedure

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

1. See "Performance Specifications" (page 465) appendix in this manual for correct specification.
2. Check for fuel inlet restriction from the fuel strainer located on the fuel filter housing.

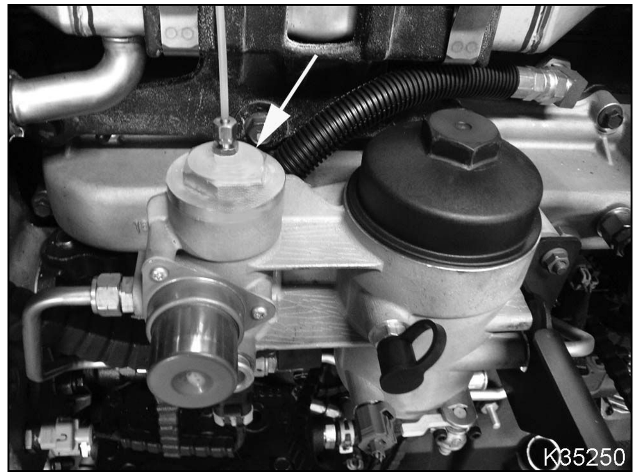


Figure 118 Fuel strainer cap

3. Remove fuel strainer cap.
4. Connect the Fuel Inlet Restriction Adapter and test line.
5. Route test line from engine bay to the cab.
6. Connect 0-30 in-Hg vacuum gauge to test line.
7. Measure high-idle fuel inlet restriction reading and compare to specification.
8. Record results on Diagnostic Form.
   - If fuel inlet restriction is in specification, go to next test.
   - If fuel inlet restriction is out of specification, go to Alternate Fuel Supply to Fuel Filter Housing (page 117) test in this section of manual.

Fuel Pump Operation

Purpose

To check proper fuel pump operation

Tools

- Vacuum pump and gauge kit
- Fuel Pressure Test Kit
- Fuel Pressure Test Gauge
- Test hose and clamp or cone adapter

Procedure

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

1. Connect fuel pressure valve adapter, fuel pressure gauge with shut-off valve, and a clear 3/8” diameter hose to fuel test valve.
2. Open the shut-off valve.

   NOTE: A closed shut-off valve during the test will yield incorrect values.

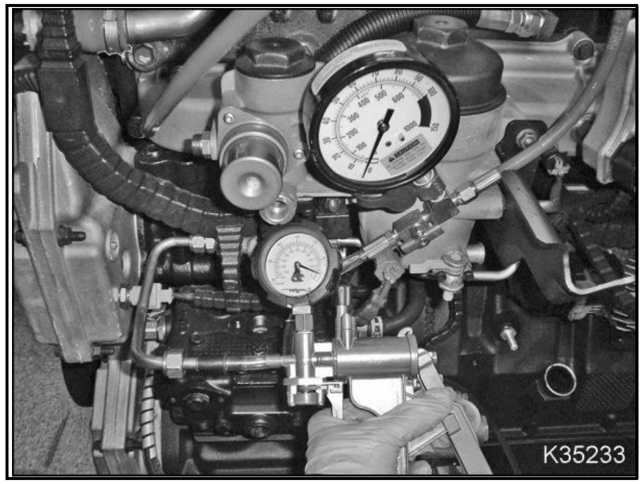


Figure 119 Fuel pump with vacuum nozzle

3. Disconnect fuel pump supply line from the fuel filter housing.
4. Connect test hose to fuel supply and secure with clamp. A cone adapter (included with vacuum pump kit) may also be used. The adapter fits on the end of the fuel supply line.
5. Insert vacuum pump nozzle into the fuel supply line. Ensure the integrity of the seal during the test.
6. Crank engine for a maximum of 20 seconds.
   - If vacuum reading is greater than 12 in-Hg, the pump is operating correctly. Go to Alternate Fuel Supply to Fuel Filter Housing (page 117) in this section of the manual.
   - If vacuum reading is less than 12 in-Hg, replace the fuel pump. Test fuel pressure again at intake manifold test valve.

Alternate Fuel to Fuel Pump Test

Purpose

To check for restriction or aeration in the fuel pump fuel supply

Tools

- Fuel Pressure Test Kit
- Fuel Pressure Test Gauge
- Clear test hose and clamps
- Spare fuel pump supply line

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

Procedure

1. Remove fuel pump supply line.
2. Make a test fuel line. Use spare fuel line. Ensure sleeve seals are in good shape.

   Cut the line in half. Use test fuel line section that supplies the fuel pump. Install clear plastic line in place of removed section. Secure plastic line with clamp.
3. Connect the test fuel line between the fuel pump inlet and an alternative fuel source.
4. Connect fuel gauge to the intake manifold fuel test valve.
5. Crank engine for maximum of 20 seconds.

   Check for signs of aeration in the clear test line.

   - If fuel is aerated, remove the test set-up from the fuel pump inlet. Repair or replace the fuel filter housing. Test fuel aeration at intake manifold test valve.
   - If the fuel is not aerated, go to Combustion Leaks to Fuel (page 118) in this section of manual.

Alternate Fuel Supply to Fuel Filter Housing

Purpose

To check for restriction or aeration in the fuel filter assembly fuel supply

Tools

- Vacuum pump and gauge kit
- Fuel Pressure Test Kit
- Fuel Pressure Test Gauge
- Clear test hose and clamps
- Clear container of fuel
- Spare fuel filter housing supply line

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

Procedure

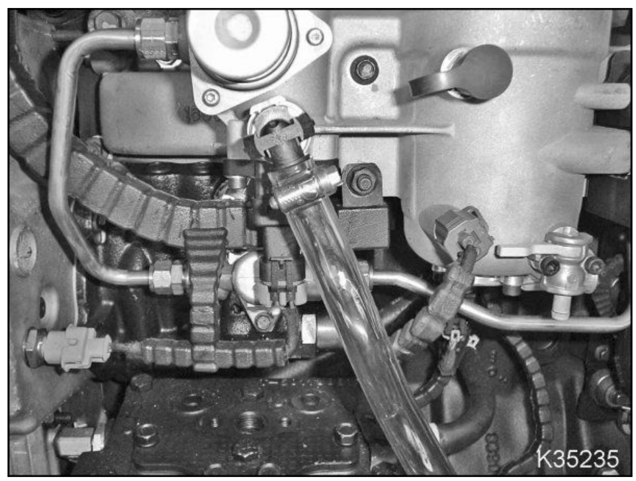


Figure 120 Fuel filter housing test

1. Disconnect the supply line from the filter housing.
2. Make a test fuel line. Use a male 90 degree fuel line fitting and install a clear plastic line long enough to reach an alternative fuel source.
3. Connect the test fuel line between the fuel filter housing inlet and alternative fuel source.
4. Connect fuel pressure gauge to the intake manifold fuel test valve.

5. Crank the engine for a maximum 20 seconds.

   Measure fuel pressure with the shut-off valve closed. Open the shut-off valve to check for aeration.

   - If fuel pressure is below specification, replace fuel filter housing. Test again at intake manifold test valve.
   - If fuel pressure is in specification, and fuel is not aerated, repair the restriction or leak between the fuel filter housing and the fuel tank.
   - If fuel is aerated, go to Alternate Fuel Supply to Fuel Pump Test (page 117) in this section of manual.

Combustion Leaks to Fuel

1. Remove the valve cover following the procedure in the *Engine Service Manual*.
2. Check all injector hold-down clamps for correct torque.
3. Remove all injectors. Inspect and clean following the procedure in the *Engine Service Manual*. Replace injector O-rings and install injectors following the procedure in the *Engine Service Manual*.

   NOTE: An injector with carbon build-up typically indicates a loose injector.
4. Test for fuel aeration to validate the repair. Go to Fuel Pressure and Aeration (page 113) in this section of manual.

Lubrication System

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

WARNING: To prevent personal injury or death, 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.

Low Oil Pressure

Symptom

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

- Red ENGINE lamp
- DTCs for EOP or ICP fault
- Engine knock
- Engine hard start or no start condition
- Engine loss of power

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Gauge bar tool
- Air Regulator
- Shut-off valve

Possible Causes

- Instrument panel gauge error
- 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
- Stuck oil pressure regulator
- Scored/damaged oil pump
- EOP sensor biased
- Broken, missing or loose piston cooling tube(s)
- 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

Oil Inspection

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

1. Park vehicle on level ground.
2. Check oil level with oil level gauge.

   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.

   NOTE: If the oil level is too low, the fuel injectors will not work correctly. If the oil level is above the operating range, the engine has been incorrectly serviced, fuel is in the oil, or coolant is in the oil.

   - Engine oil level will vary depending on temperature of engine.
   - If oil level is low, fill to the correct level.
3. Inspect oil for thickening and odor.

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

   - If oil level is at the correct level and not contaminated, do step 4.

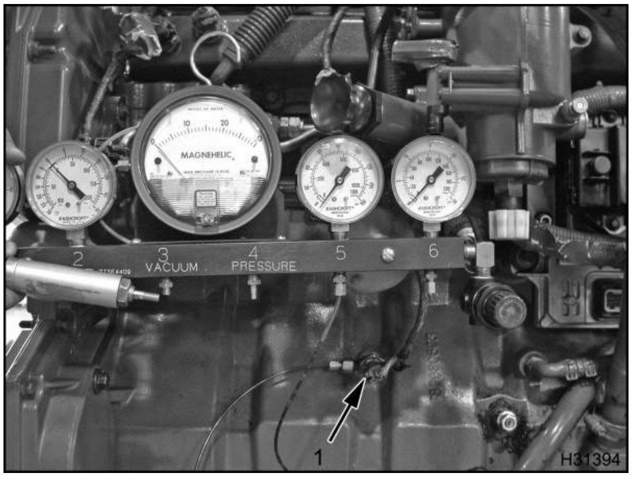


Figure 121 Gauge bar tool installed

1. EOP sensor fitting

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

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

4. Connect a 0 psi to 160 psi pressure gauge 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.
5. 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 in this Manual, go to Oil Pressure Regulator Inspection (page 120) in this section.
   - If oil pressure reads within specification listed in Appendix A in this Manual, compare mechanical gauge readings with instrument panel gauge and Engine Oil Pressure (EOP) value on the Electronic Service Tool (EST).
   - If mechanical gauge and EST read values with a difference greater than ± 14 kPa (± 2 psi), see EOP Sensor (page 323) in “Electronic Control Systems Diagnostics” section of this manual.
   - If instrument panel engine oil pressure gauge reads a different value than the EST and mechanical gauge refer to the *Electrical System Troubleshooting Guide* for the model and year of vehicle.

Oil Pressure Regulator Inspection

Figure 122 Oil pressure regulator

1. Remove and inspect oil pressure regulator as described in the *Engine Service Manual*.
   - The oil pressure regulator piston should move freely in its bore.
   - If oil pressure regulator is functional and passes inspection, install regulator following the procedure in the *Engine Service Manual*. Go to Oil and Crankcase Inspection (page 121) in this section.

Oil and Crankcase Inspection

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

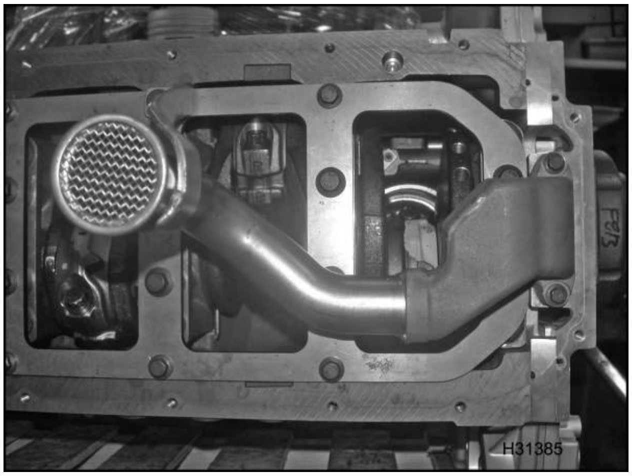


Figure 123 Bottom of engine

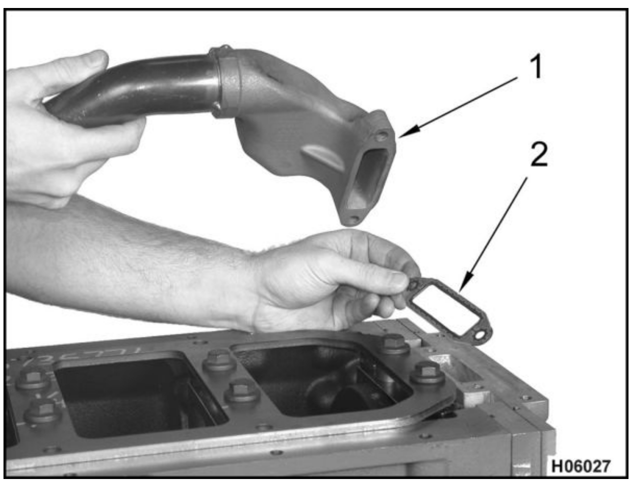


Figure 124 Oil pickup tube assembly and gasket

1. Oil pickup tube assembly
2. Gasket

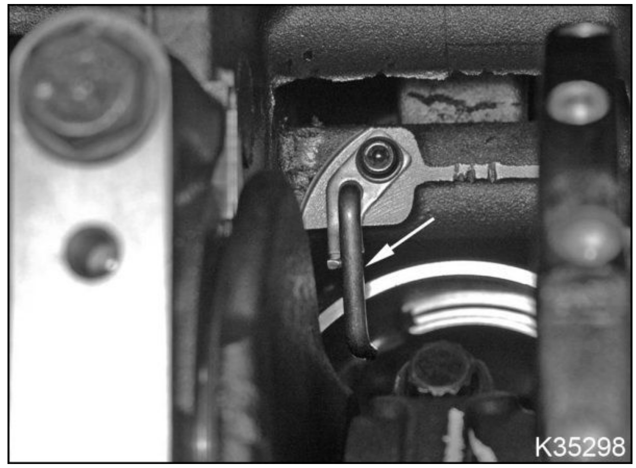


Figure 125 Piston cooling tube

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

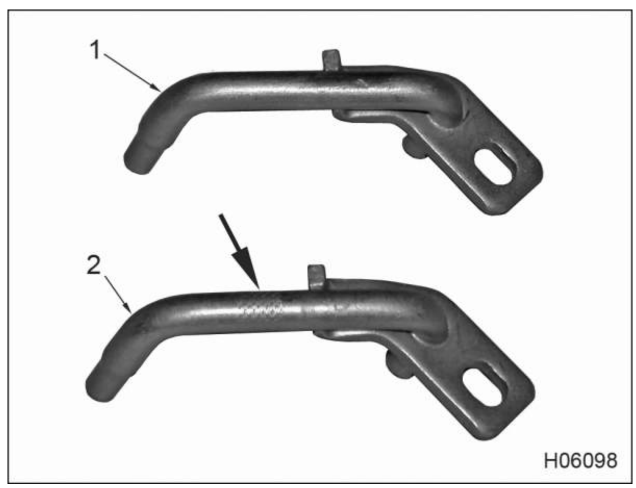


Figure 126 Piston cooling tubes

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

4. Verify correct piston cooling tubes are installed for the engine displacement.

Oil Pump Inspection

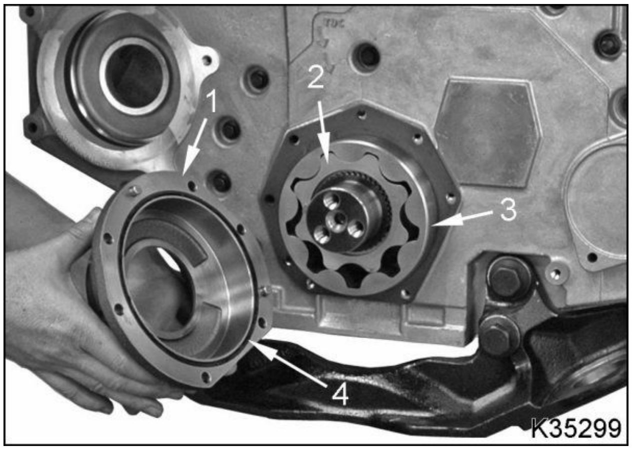


Figure 127 Oil pump housing cover

1. 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, deep scratches, 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 122) in this section.

Front Cover Inspection

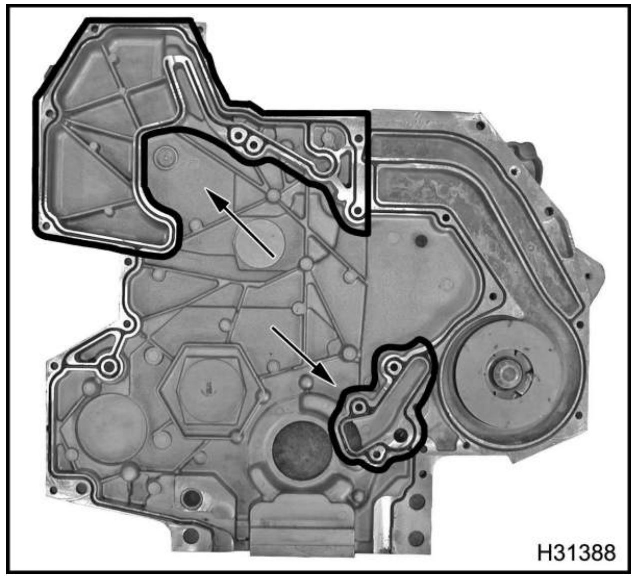


Figure 128 Front cover oil pressure leak locations

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 and test.

Lube Oil in Coolant

Symptom

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

Tools

- Oil cooler pressure test plate
- Air pressure regulator

Possible Causes

- Failed oil cooler

Procedure

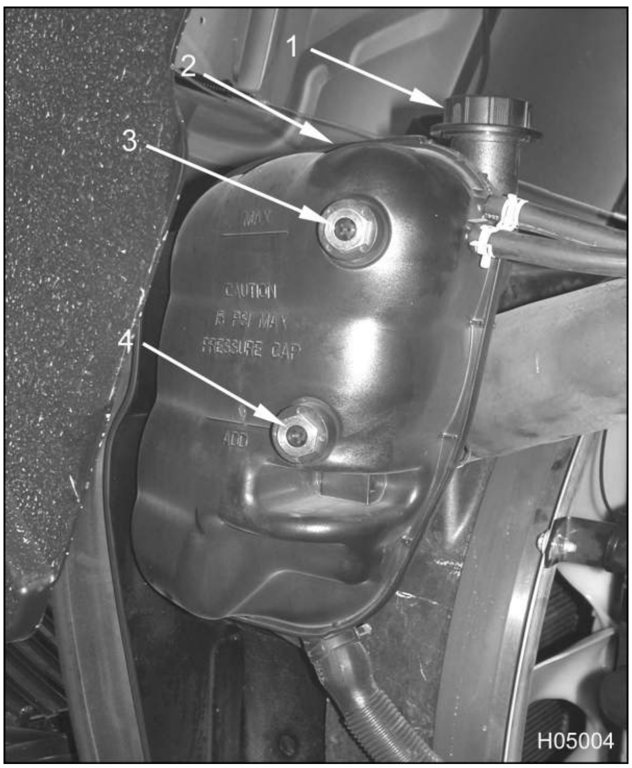


Figure 129 Deaeration tank fill position

1. Deaeration tank
2. Deaeration tank cap
3. MAXIMUM coolant level mark
4. ADD coolant level mark

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. Verify if coolant is contaminated by inspecting deaeration tank for presence of oil.
2. Place a coolant drain pan under the oil system module.

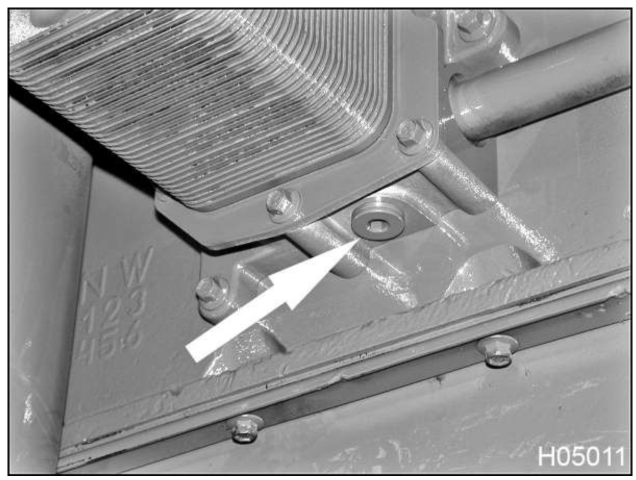


Figure 130 Coolant drain plug

3. Remove the coolant drain plug located at the bottom of the oil system module. Drain coolant. This procedure will drain the entire cooling system.

   NOTE: Replace O-ring with a new O-ring when installing the coolant drain plug.

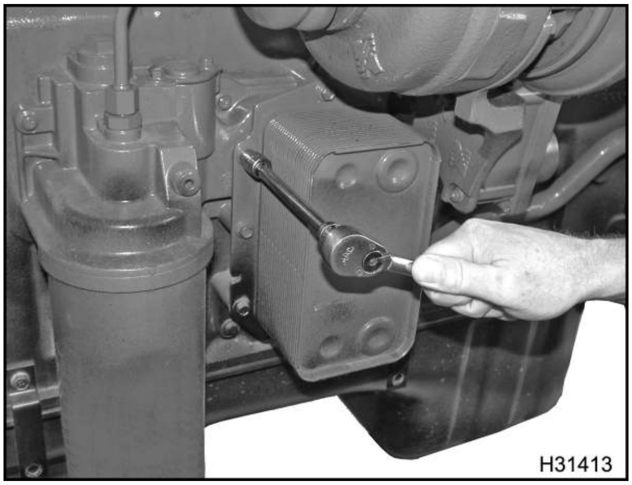


Figure 131 Removing oil cooler

4. Remove the eight bolts (M8 x 20) securing the oil cooler to the oil cooler housing. Separate the oil cooler from the oil cooler housing.

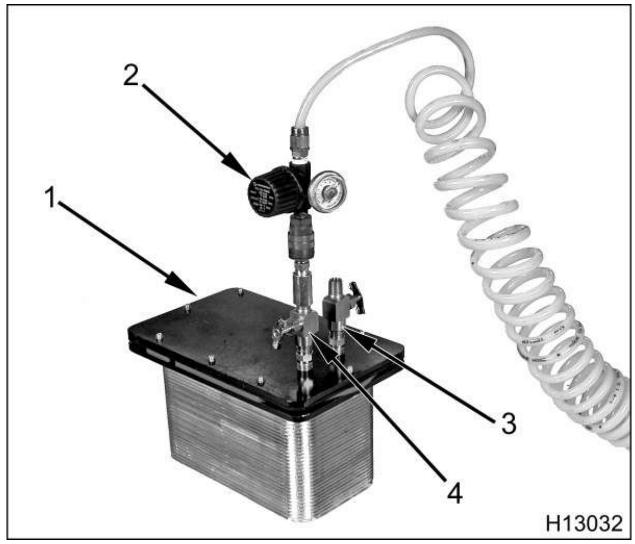


Figure 132 Checking the oil cooler for internal leakage

1. Test plate set
2. Air pressure regulator
3. Coolant port (open)
4. Oil port

5. Pressure test the oil cooler following the procedure in the *Engine Service Manual*. If a leak is noticed, replace the oil cooler.

Table of Contents

Diagnostic Form EGED-375

Hard Start and No Start Diagnostics
International® MaxxForce® DT, 9, and 10
2007 through 2009 Model Years

Technician ______	Miles ______	Transmission:	Ambient temperature ______	Engine SN ______	ECM Calibration ______
Date ______	Hours ______	Manual ____ Auto ____	Coolant temperature ______	Engine HP ______	Turbocharger ______
Unit No. ______	EFRC ______	Build date ______	Complaint ______	VIN ______	

WARNING
To prevent personal injury or death, read all safety instructions in the "Safety Information" section of International MaxxForce DT, 9, and 10 *Diagnostics Manual* EGES-370-1 before doing procedures on this form.

Header Information and Specifications

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

See EGES-370-1 Appendix A Performance Specifications for EFRC, injector number, and turbocharger number.

Use Performance Specifications to fill in the specifications needed for some tests.

See "Hard Start and No Start Diagnostics" for detailed information on these procedures which can be found in *Engine Diagnostics Manual* EGES-370-1.

Do Required Test Procedures in sequence and do Special Test Procedures when needed.It is not necessary to complete the rest of the form after the problem has been found and corrected.

Required Test Procedures

1. Initial Ignition Switch ON (Do not crank.)

- ☐ Listen for injectors to pre-cycle buzz. (Time is temperature dependent.)
- ☐ Look for WAIT TO START lamp to come on. (2-10 seconds, temperature dependent.)
- ☐ Look for WATER IN FUEL lamp or dash message.

Comments

- If the INJ did not pre-cycle, do Test 5.
- If the WATER IN FUEL is displayed, go to Test 4 and take a fuel sample.

2. Engine Cranking

- ☐ Cranking above 100 rpm. (Instrument panel)
- ☐ Oil pressure increased. (Instrument panel)

Specification	Actual

- If cranking rpm is below specification, check batteries and starting system.
- If oil pressure does not increase, check oil.

3. Visual Inspection

- ☐ Check all fluid levels.
- ☐ Inspect electrical harness and connections.
- ☐ Inspect air filter minder.
- ☐ Inspect for exhaust damage.

Fuel	Oil	Coolant	Electrical	Air

Note: Engine will not start if the IPR valve, CMP, or CKP sensor is disconnected.

4. DTCs and ECM Calibration

- ☐ Open VIN-Plus session with EST (Verify ECM software matches vehicle).

Active DTCs	Inactive DTCs

- If ECM software does not match, reprogram the ECM.
- If any DTCs are set, correct fault before continuing.

5. EST Data List

- ☐ Enter KOEO values in KOEO column.
- ☐ Crank engine for 20 seconds and enter values in the Cranking Actual column.

PID	KOEO	Cranking Spec	Cranking Actual
VBAT			
RPM			
EFP			
ICP			
EGRP			
BCP			

- If VBAT is below spec, do Main Power Voltage at ECM test.
- If rpm is below spec, check starting system.
- If EOP is below spec, see Low Oil Pressure in Section 4.
- If EGRP is above 0%, do test 7.
- If BCP is out-of-range, see BCP Sensor in "Electronic Control System Diagnostics" section of EGES-370-1.

6.1 KOEO Standard Test

- ☐ Use EST to run KOEO Standard Test.

DTCs

If any DTCs are set, correct fault code before continuing.

6.2 KOEO Injector Test

- ☐ Use EST to run KOEO Injector Test.

DTCs

If any DTCs are set, correct fault before continuing.

7. EGR Valve and ITV Operation

- ☐ Turn the ignition switch to ON. (Do not start engine)
- ☐ Run KOEO Output State Low and High tests.

PID	Specification	Actual
EGR (close position)	0 to 5 %	
EGR (open position)	95 to 100 %	
ITV (close position)	0 to 5 %	
ITV (open position)	45 to 55 %	

If out of specification, see ITV or EGR in Section 7 of EGES-370-1.

Special Test Procedures

Main Power Voltage to ECM

- ☐ Connect breakout harness between ECM main power relay and power distribution center.
- ☐ Crank engine for a maximum of 20 seconds. Use a DMM to measure voltage to ECM.
- ☐ Check voltage between connector Pin 87 and ground.

Specification	Actual
9 volts (Minimum)	

Inlet Air Heater System

- ☐ Use an amp clamp to measure amperage on each heater element.
- ☐ Run Intake Heater Output state test and record measurement after 2 sec.
- ☐ If amperage reading is not to specification for Amperage Draw test, do all remaining tests for that circuit.

Note: Later models have only one relay and heater element.

Test	Air Heater Wire Spec	Element 1	Element 2
Amperage Draw	125 ± 10 amps		
Voltage at Element	BATT V		
Element Continuity		☐ Yes ☐ No	☐ Yes ☐ No
Wiring Harness Continuity and Resistance	< 5 ohms		
Relay Operation Battery feed Relay output	 B+ B+		

Fuel Quality

- ☐ Take a fuel sample from filter housing drain port.

Comments

- If fuel is contaminated with water, icing, gasoline, kerosene, etc., clean fuel system as necessary to remove all contaminants.
- If fuel is clean, do Fuel Pressure and Aeration test.

Note: If engine was run out of fuel, ensure the system is primed.

Fuel Pressure and Aeration

- ☐ Connect fuel gauge to fuel pressure test port on intake manifold.
- ☐ Start or crank engine for 20 seconds.
- ☐ Measure fuel pressure with shut-off valve closed, open shut-off valve to check for aeration.

Pressure	Spec	Low idle	High idle
0-160 psi gauge			
Is fuel aerated?			

- If pressure is high and pulsating, see Combustion Leaks to Fuel in Section 4 of EGES-370-1.
- If fuel is aerated, check for leaks in suction side to the pump.
- If pressure is below specification and not aerated, replace filter and test again.
- If pressure is still low after changing filter, do Fuel Inlet Restriction test.

Fuel Inlet Restriction

Note: Test is only valid if engine starts and achieves high idle.

- ☐ Connect 0-30 in-Hg vacuum gauge and fuel inlet restriction adaptor to fuel strainer housing.
- ☐ Start engine and accelerate to high idle.

Restriction	Specification	Actual
0-30 in Hg vac gauge		

- If restriction is above specification, check lines between tank and pump for blockage.
- If fuel pressure is low and not restricted, inspect and clean regulator valve. Test again.
- If fuel pressure is still low after cleaning regulator, replace fuel pump.

ICP Unplugged Test

- ☐ Disconnect ICP sensor from engine harness.
- ☐ Crank engine for 20 seconds maximum.

If engine starts, see ICP Sensor in Section 7 of EGES-370-1.

Injection Control Pressure (ICP) System Test

- ☐ Use EST to monitor ICP and EOP.
- ☐ Crank engine for 20 seconds maximum.

PID	Specification	Actual
ICP		
EOP		

- If ICP and EOP are below specification, remove EOT sensor and check oil level in high-pressure pump reservoir.
- If EOP is below specification and reservoir is low, check lube oil system.
- If EOP is in specification, but ICP is below spec, then do IPR Control System Test.

IPR Control System Test

- ☐ Disconnect IPR harness connector and inspect for faulty connection. Repair as required.
- ☐ Connect IPR breakout tee to IPR valve. Leave engine harness disconnected.
- ☐ Connect IPR breakout tee to B+ and ground.
- ☐ Turn ignition switch ON. Do not start engine.
- ☐ Open Hard Start and No Start session.
- ☐ Crank engine for 20 seconds maximum.
- ☐ Monitor ICP and record results.

PID	Specification	Actual
ICP		

- If ICP is below specification or engine does not start, do High-pressure Oil Pump Test.
- If ICP is above specification or engine starts, see IPR in Section 7 of EGES-370-1.

High-pressure Oil Pump Test

- ☐ Retain previous test set-up.
- ☐ Remove high-pressure hose from cylinder head and connect test ICP sensor to hose.
- ☐ Connect breakout tee between MAP harness and test ICP sensor.

Note: MAP sensor connector only being used in this test for VREF and SIG GND circuits.

- ☐ Use DMM to monitor ICP sensor signal voltage.
- ☐ Crank engine for 20 seconds maximum.

PID	Specification	Actual
ICP		

- If ICP is above specification, do High-pressure Oil Rail Leak Test.
- If ICP is below specification, do IPR Block-off Test.

IPR Block-Off Test

- ☐ Retain previous test set-up.
- ☐ Remove IPR valve from high-pressure oil pump.
- ☐ Install IPR block-off tool.
- ☐ Use DMM to monitor ICP sensor signal voltage.
- ☐ Crank engine for 20 seconds maximum.

PID	Specification	Actual
ICP		

- If results are out of specification, replace the high-pressure pump.
- If results are in specification, replace IPR valve.

High-pressure Oil Rail Leak Test

- ☐ Retain previous test set-up.
- ☐ Install the high-pressure hose to the cylinder head.
- ☐ Crank engine for 20 seconds maximum.
- ☐ Inspect high-pressure oil rail for leaks while cranking.

Comments

Repair where ever oil is leaking heavy from.

K35328

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

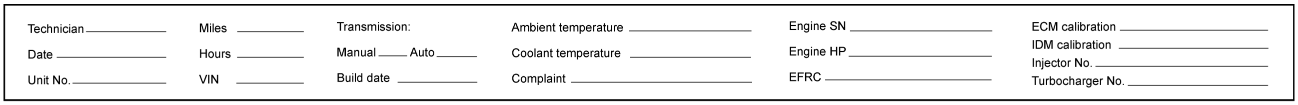
This Diagnostics Manual section shows detailed instructions of the tests on the form. The manual should be used with the form and referenced for supplemental test information. Use the form as a worksheet to record test results.

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

See appendices for Diagnostic Trouble Codes (DTCs) and performance specifications.

Diagnostic Form EGED-375 is available in 50 sheet pads. To order technical service literature, contact your International® dealer.

Header Information



Technician ____ Miles ____ Transmission: Ambient temperature ____ Engine SN ____ ECM calibration ____

Date ____ Hours ____ Manual ____ Auto ____ Coolant temperature ____ Engine HP ____ IDM calibration ____

Unit No. ____ VIN ____ Build date ____ Complaint ____ EFRC ____ Injector No. ____

Turbocharger No. ____

D31536

Enter Header Information

1. Technician
2. Date
3. Unit No. (dealer's quick reference number)
4. Customer complaint (interview driver)

Enter Vehicle Information

The Vehicle Identification Number (VIN) is located on the VIN plate. The VIN information can be obtained in ISIS®.

5. VIN – the last 8 digits (verify to VIN plate)
6. Build date (verify to VIN plate)
7. Engine hp
8. ECM calibration
9. Transmission type
10. Engine SN

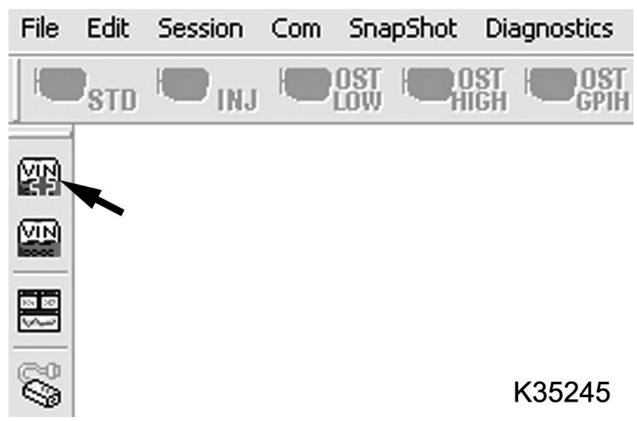
Enter Performance Specification Information

11. See “Performance Specifications” (page 465) appendix in this manual or TSI to obtain the following header information:

NOTE: Performance specifications are periodically published in TSI format to support new model year products. Check service bulletin listing on ISIS® for appropriate model year application.

- Engine Family Rating Code (EFRC)
- Injector No.
- Turbocharger No.

Verify ECM Calibration with Vehicle Specifications



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12. Using the EST with MasterDiagnostics®, open the VIN session by selecting the VIN+ icon.

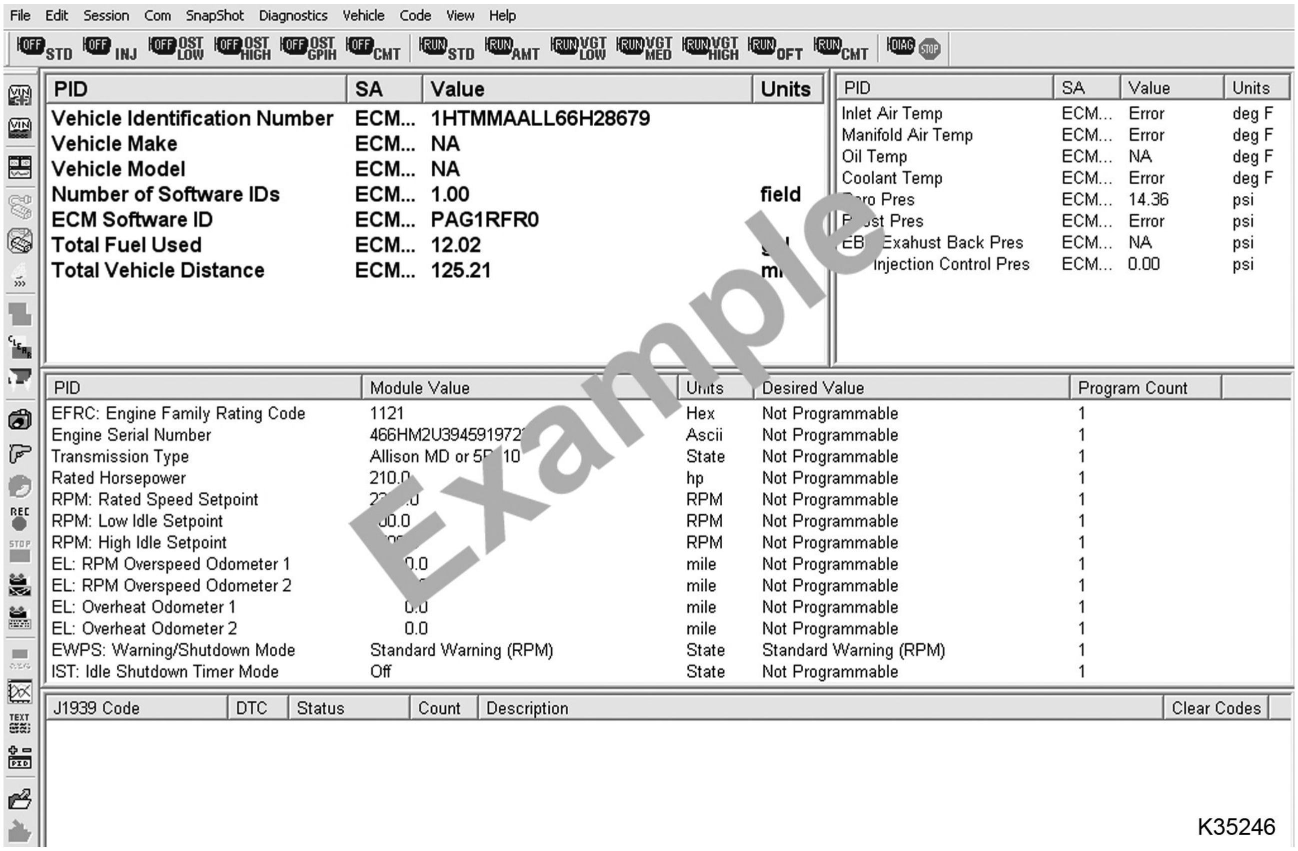


Figure 136 VIN session (example)

13. Verify the following match vehicle specification:
    - VIN
    - ECM calibration
    - Rated HP
    - EFRC
    - Transmission
    - Engine SN

    Note: The engine serial number is located on the engine block, on the right side of the crankcase below the cylinder head. It is also located on the engine emission label on the valve cover.

14. Enter the following information:
    - Odometer (miles)
    - Engine hours
    - Intake air temperature
    - Coolant temperature

Required Test Procedures

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

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

1. Initial Ignition Switch ON (Do not start)

Purpose

To determine if the ECM is powered up and if water is in the fuel supply

Tools

- None

Possible Causes

WAIT TO START lamp does not illuminate

- No key power (VIGN)
- Failed ECM ground circuit
- No power from main power relay to ECM
- ECM failure
- Amber WAIT TO START lamp is out (will not cause hard start or no start).
- CAN 1 link to instrument panel is not working (will not cause hard start or no start).

No injector pre-cycle

- No key power (VIGN)
- ICP sensor bias high
- Failed ECM ground circuit
- No power from main power relay to ECM
- CAN 2 link is not working.
- ECM failure

No turbocharger pre-cycle

- No key power (VIGN)
- No power from ECM main power relay
- Failed actuator power circuit (will not cause hard start or no start)
- Failed actuator power ground circuit (will not cause hard start or no start)
- Failed Variable Geometry Turbocharger (VGT) actuator (will not cause hard start or no start)
- Failed VGT turbocharger (will not cause hard start or no start)

WATER IN FUEL lamp illuminates

- Water in fuel
- Electrical circuit failure

Procedure

1. Turn ignition switch to ON. (Do not start the engine.) Check or listen for the following:
   - WAIT TO START lamp
   - Injector pre-cycle (Shop noise can drown out the sound of injector pre-cycle.)
   - Turbocharger pre-cycle
   - WATER IN FUEL lamp
2. If the turbocharger and injector pre-cycle, and the WAIT TO START lamp and WATER IN FUEL lamp come on and off, continue to the next diagnostic test.
3. If pre-cycle noise was not heard or missed, cycle the ignition switch and listen again.
   - If pre-cycle noise is still not heard, the ECM may not be powered up. Check for DTCs. If the EST is not communicating with the ECM, do Main Power Voltage to ECM test in this section of manual.
   - If the turbocharger did not pre-cycle, there may be an open circuit. Check the engine 16-way connector. Check for DTCs.
4. If the water in fuel light turns on and stays on, do Fuel test in this section of manual.

2. Engine Cranking

Purpose

Determine if crankshaft rotates at correct rpm, if oil pressure is correct, and if instrument panel is receiving signals

Tools

- None

Possible Causes

Engine will not turn over

- Low or no battery power
- No key power (VIGN)
- Insufficient power to ECM
- Starting system failure
- Circuit fault for Engine Crank Inhibit (ECI)
- Cylinder hydraulic lock
- Cylinder mechanical lock (timing incorrect; valve/piston contact)

Insufficient rpm

- Low battery power
- Starter motor problem
- Incorrect oil viscosity
- Cold temperature

Insufficient oil pressure

- Oil gauge error on instrument panel (will not cause hard start or no start)
- Low oil level: oil leak, oil consumption, or incorrect servicing
- High oil level: incorrect servicing, fuel in oil, coolant in oil
- Incorrect oil viscosity
- Stuck oil pressure regulator
- Scored or damaged oil pump/front cover
- Engine Oil Pressure (EOP) sensor biased
- Incorrect EOP sensor
- EOP circuit or sensor problems
- Broken, missing, or loose piston cooling tubes
- Missing, damaged, or worn bearing inserts
- Missing, damaged, or worn camshaft bushings
- Lifter missing (will also have performance problems)

Procedure

1. Turn ignition switch to START.
2. Check rpm on instrument panel. Record results on Diagnostic Form.
   - If engine speed is below specification, the engine will not start. Check batteries and DTCs if engine seems to be turning over fast enough to start and no rpm is noticed on instrument panel.
3. Check oil pressure (instrument panel). Record results on Diagnostic Form.
   - If oil pressure does not build while cranking the engine, oil may not be feeding the high-pressure oil system. Check oil level.

3. Visual Inspection

Purpose

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

Tools

- Inspection lamp

Engine Oil

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

   NOTE: Engine should not be running. Allow engine to cool down for 15 minutes to ensure oil has been stabilized.

2. Use oil level gauge to verify engine oil level.
3. Record results on Diagnostic Form.
   - If level is to specification, no repair is required.
   - If level is below specification, inspect for leaks, oil consumption, or improper servicing.
   - If level is above specification, inspect for fuel dilution, coolant contamination, or improper servicing.

Fuel Level

1. Park vehicle on level ground.

   NOTE: Engine should not be running.

2. Use dash gauge to verify fuel level. Inspect fuel tank fill ports.
3. Record results on Diagnostic Form.
   - If level is to specification, and no tank contamination is evident, no repair is required.
   - If level is below dash gauge reading, inspect for leaks, fuel dilution, inoperable tank transfer pump, or improper servicing.

Engine Coolant Level

1. Park vehicle on level ground.

   NOTE: Engine should not be running. Ensure coolant temperature has stabilized to safe temperature.

2. Check coolant level as indicated on surge tank level window.
3. Record results on Diagnostic Form.
   - If level is at surge tank fill level, and no tank contamination is evident, no repair is required.
   - If level is below surge tank fill level, inspect for leaks, coolant in the oil, coolant in combustion exhaust, or improper servicing.

Charge Air Cooler (CAC) System

1. Inspect CAC system, including intercooler and piping for leaks.
2. Inspect all CAC connections and clamps.
   - If CAC system is in specification, no repair is required.
   - If CAC system issue is found, repair as required.

Electrical System

1. Inspect electrical system (engine and vehicle) for poor or loose connections.
   - If electrical system is to specification, no repair is required.
   - If electrical system issue is found, repair as required.

Exhaust System

1. Inspect exhaust system (engine and vehicle) for leaks or damage.
   - If exhaust system is to specification, no repair is required.
   - If exhaust system issue is found, repair as required.

4. DTCs and ECM Calibration

Purpose

To verify the ECM calibration matches the vehicle and identify DTCs

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable

Checking ECM Calibration

1. Turn ignition switch ON, engine OFF.
2. Using the EST with MasterDiagnostics® software, open the VIN-Plus session. Select the VIN+ icon.
3. Verify that the vehicle information on the ECM matches the vehicle. See Verify ECM Calibration with Vehicle Specifications (page 128) in this section of manual.
4. Record calibration level on Diagnostic Form.

Checking for DTCs

CAN code: Codes associated with a Suspect Parameter Number (SPN) and Failure Mode Indicator (FMI)

DTC: Diagnostic Trouble Code

Status: Indicates active or inactive DTCs

- **Active**: With the ignition switch on, active indicates a DTC for a condition currently in the system. When the ignition switch is turned off, an active DTC becomes inactive. (If a problem remains, the DTC will be active on the next ignition switch cycle and the EST will display active/inactive.)
- **Inactive**: With the ignition switch on, inactive indicates a DTC for a condition during a previous key cycle. When the ignition switch is turned to OFF, inactive DTCs from a previous ignition switch cycle remain in the ECM memory until cleared.
- **Active/Inactive:** With the ignition switch on, active/inactive indicates a DTC for a condition currently in the system and was present in previous key cycles, if the codes were not cleared.

Description: Defines each DTC

1. Record all active or inactive DTCs on Diagnostic Form.
   - If no DTCs are set, continue to next test.
   - Correct any active DTCs, if related to performance. See “Electronic Control Systems Diagnostics” (page 187) section of this manual.
   - Investigate any inactive DTCs that affect performance.

5. EST Data List

NOTE: See "Diagnostic Software Operation" section in this manual for specific EST software procedures to do this test.

Purpose

To determine if engine systems meet operating specifications to start engine

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable

Procedure

1. Turn ignition switch to ON. Do not start engine.
2. Using the EST with MasterDiagnostics® software, open the HardStart_NoStart session.
   - Battery volts (VBAT)
   - Engine speed (RPM)
   - Fuel delivery pressure (EFP) (if installed)
   - Injection control pressure (ICP)
   - Exhaust Gas Recirculation Position (EGRP)
   - Brake Control Pressure (BCP)
3. Monitor KOEO readings.
4. Record results on Diagnostic Form.
5. Crank the engine for a maximum of 20 seconds.
6. Record results on the Diagnostic Form.
   - If results are in specification, continue to the next test.
   - If VBAT readings are not in specification, do Main Power Voltage to ECM test.
   - If RPM readings are not in specification, check vehicle starting and charging systems.
   - If EFP readings are not in specification, do Fuel Pressure and Aeration (Fuel System) test.
   - If ICP readings are not in specification, do Injection Control Pressure test.
   - If EGRP readings are not in specification, do EGR Valve and ITV Operation test.
   - If BCP readings are not in specification, go to BCP Sensor (Brake Control Pressure) in section 7.

6. KOEO Tests

6.1 Standard Test

NOTE: See “Diagnostic Software Operation” section in this manual for specific EST software procedures to do this test.

Purpose

To inspect for electrical malfunctions detected by the ECM self-test and Output Circuit Check (OCC)

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable

Possible Causes

- Failed electrical components or circuitry
- OCC faults detected by ECM.

Procedure

1. Turn ignition switch to ON. Do not start engine.
2. Open COM device.
3. Select Key-On Engine-Off Tests. Select Standard Test from the drop down menu.
4. Follow the on-screen instructions.
5. Record all DTCs on Diagnostic Form. See “Diagnostic Trouble Codes” (page 493) appendix in this manual for DTCs.
   - If no DTCs are detected, no repair is required.
   - If DTCs are detected, correct problems causing the DTCs.
6. Clear DTCs.
7. Run the KOEO Standard Test again.

6.2 KOEO Injector Test

NOTE: See “Diagnostic Software Operation” section in this manual for specific EST software procedures to do this test.

Purpose

To inspect for fuel injector malfunctions by energizing them sequentially

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable

Possible Causes

- Open or short in injector circuits
- Poor ECM power or ground
- Failed injector coil
- Failed ECM

Procedure

1. Turn ignition switch to ON. Do not start engine.
2. Open COM device.
3. Select Key-On Engine-Off Tests and Injector Test from the drop down menu.
4. Listen for injectors to pre-cycle spool, then cycle in order of cylinder position.
5. Listen again for injectors to pre-cycle spool, then cycle in reverse order of cylinder position.
6. Record DTCs on Diagnostic Form. See “Diagnostic Trouble Codes” (page 493) appendix in this manual for DTCs.
   - If no problems are detected, no repair is required.
   - If problems are detected, correct problems causing the DTCs.
7. Clear DTCs.
8. Run the KOEO Injector Test again.

7. EGR Valve and ITV Operation

NOTE: See “Diagnostic Software Operation” section in this manual for specific EST software procedures to do this test.

Purpose

To inspect for EGR valve and ITV malfunctions

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable

Possible Causes

- Valve motion interference
- Failed electrical circuits or components

Procedure

1. Turn ignition switch to ON.
2. Open COM device.
3. Select Key-On Engine-Off Tests. From the drop down menu, select Output State Tests, then select Output State Low Test.
4. Record EGR valve and ITV positions on Diagnostic Form.
5. Select Key-On Engine-Off Tests. From the drop down menu, select Output State Tests, then select Output State High Test.
6. Record EGR valve and ITV positions on Diagnostic Form.
   - If readings are in specification, no repair is required.
   - If readings are not in specification, correct issue. Test again to validate repair.

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, 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, read all safety instructions in the "Safety Information" section of this manual.

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

Main Power Voltage to ECM

Purpose

To inspect for incorrect power supplied to operate the ECM

Tools

- Relay Breakout Harness
- Digital Multimeter (DMM)

Possible Causes

Low battery voltage

- Failed batteries
- High-resistance at battery cable connections
- Wiring to the ECM

Low or no battery voltage to the ECM

- High-resistance or an open power feed circuit to the ECM or ECM main power relay.
- The ECM power circuit fuse in battery box may be open.
- ECM main power relay may have failed.
- VIGN circuit problem
- Failed ECM

Procedure

NOTE: Ensure the ignition switch (VIGN) is turned OFF when disconnecting and connecting ECM connectors.

1. Remove ECM relay from the power distribution box.
2. Install breakout harness connectors between the distribution box and ECM relay.
3. Turn ignition switch to ON.
4. Connect DMM leads to correct breakout harness pin-outs.

   See ECM PWR (page 271) in "Electronic Control Systems Diagnostics" section of this manual for pin-outs.
5. Crank the engine for a maximum of 20 seconds.
6. Record results on Diagnostic Form.

Inlet Air Heater (IAH) System

NOTE: See "Diagnostic Software Operation" section in this manual for specific EST software procedures to do this test.

Purpose

To inspect IAH assembly for malfunction

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- Amp Clamp

Possible Causes

- Failed wiring harness or connection
- Poor ground connection
- Failed relay
- Failed element
- Failed ECM
- ECM not programmed for IAH

Amperage Draw

Procedure

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

NOTE: Inspect for damaged, loose or corroded terminals. Repair if necessary.

Figure 137 Amp Clamp

1. Install Amp Clamp around one of the two heater element feed wires.
2. Turn ignition switch to ON.

NOTE: When using the EST to do KOEO or KOER diagnostic tests, Standard Test is always selected and run first. If the ignition switch is not cycled, the Standard Test does not have to be run again.

3. Select Diagnostics from the menu bar.
4. Select Key-On Engine-Off Tests from the drop down menu.
5. From the KOEO Diagnostics menu, select Inlet Air Heater, then select Run to start the test.
6. Use the DMM and Amp Clamp to measure amperage for both feed wires. Record results on Diagnostic Form.
   - If amperage draw for both circuits meets specifications, do not continue with test. The Inlet Air Heater system is working correctly.
   - If both circuits are not operational, confirm that the ECM is programmed and enabled for the Inlet Air Heater.
   - When a failed circuit has been identified, check that circuit only.
   - If amperage draw does not meet specification, continue with test 9.2 – Voltage at Element Terminal.

Voltage at Element

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

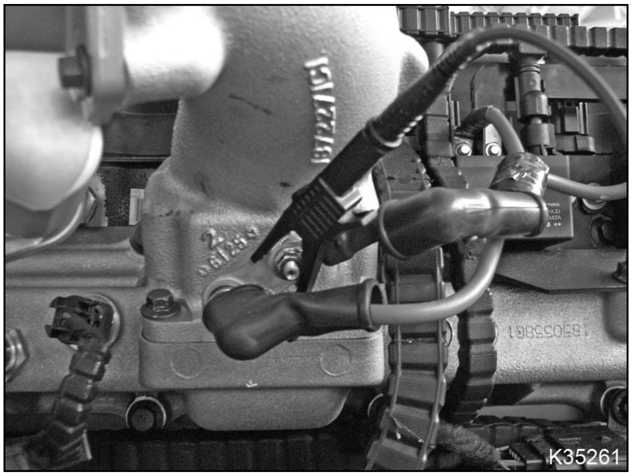


Figure 138 Element terminal

1. Connect DMM positive lead to the element terminal that is out of specification.

Figure 139 Ground terminal (left side of crankcase)

2. Connect DMM negative lead to the ground terminal.
3. Turn ignition switch to ON.
4. Select Diagnostics from the menu bar.
5. Select Key-On Engine-Off Tests from the drop down menu.

   NOTE: When using the EST to do KOEO or KOER diagnostic tests, Standard Test is always selected and run first. If the ignition switch is not cycled, the Standard Test does not have to be run again.
6. From the KOEO Diagnostics menu, select Inlet Air Heater, then select Run to start the test.
7. Use the DMM to measure voltage.
8. Record results on Diagnostic Form.
   - If voltage is B+, do Element Continuity test.
   - If voltage is not B+, do Wiring Harness Continuity and Resistance.

Element Continuity

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

When the voltage at element is B+, check the continuity of the element terminal to ground.

1. Turn ignition switch to OFF.
2. Use DMM to check resistance.

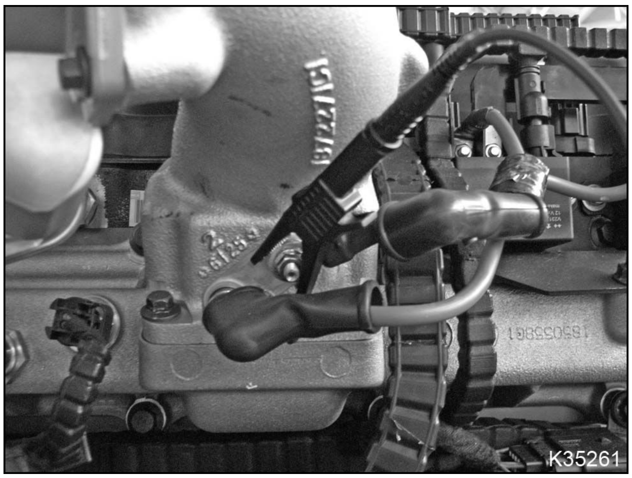


Figure 140 Element terminal

3. Connect DMM positive lead to the element terminal that is not to specification.

Figure 141 Ground terminal (left side of crankcase)

4. Connect DMM negative lead to the ground terminal.
5. Record results on Diagnostic Form.
   - If the element does not have continuity to ground, replace the element.
   - If the element has continuity, verify the previous Inlet Air Heater test.

Wiring Harness Continuity and Resistance

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

When the voltage at element is not B+, measure the resistance (continuity) between the element and relay.

1. Turn ignition switch to OFF.
2. Use the DMM to check wiring harness continuity and measure resistance.

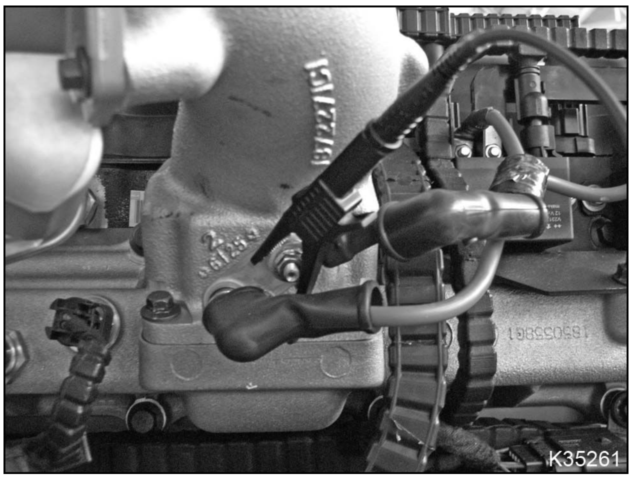


Figure 142 Element terminal

3. Connect DMM negative lead to the element terminal that is not B+.

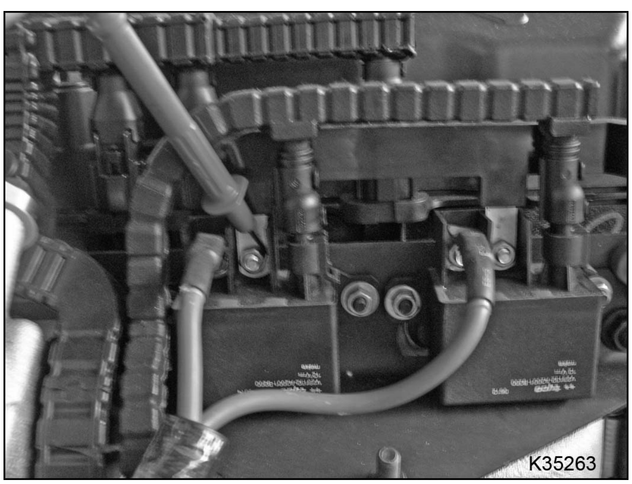


Figure 143 Relay terminal

NOTE: Engines could be wired differently, having wiring harness connectors secured to different relay terminals. Trace wiring harness from element to the relay, to be sure that the correct relay terminal is being tested.

4. Contact DMM positive lead to relay terminal.
5. Record results on Diagnostic Form.
   - If wiring resistance is > 5 Ω, repair or replace, if necessary.
   - If wiring resistance is < 5 Ω, continue with test Relay Operation.

Relay Operation

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

Figure 144 Ground terminal (left side of crankcase)

1. Connect DMM negative lead to the ground terminal, on the left side of crankcase or known, good ground in the cab.

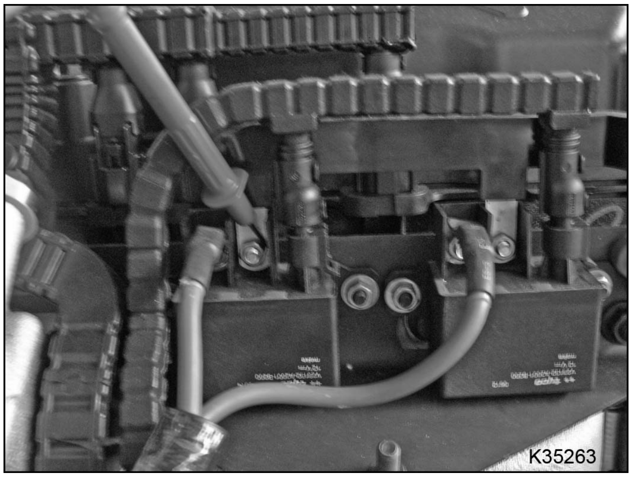


Figure 145 Relay terminal

NOTE: Engines could be wired differently, having wiring harness connectors secured to different relay terminals. Trace wiring harness from battery to the relay, to be sure that the correct relay terminal is being tested.

2. Contact DMM positive lead to relay terminal of battery feed to relay.
3. Record results on Diagnostic Form.
   - If DMM voltage at relay terminal is B+, continue with step 4 and measure relay output to element.
   - If voltage of relay terminal is less than B+, repair or replace wire from starter to relay. Retest to verify repair.
4. Turn ignition switch to ON.
5. Contact DMM positive lead to relay output terminal, relay to element.
6. Select Diagnostics from the menu bar.
7. Select Key-On Engine-Off Tests from the drop down menu.

   NOTE: When using the EST to do KOEO or KOER diagnostic tests, Standard Test is always selected and run first. If the ignition switch is not cycled, the Standard Test does not have to be run again.
8. From the KOEO Diagnostics menu, select Inlet Air Heater, then select Run to start the test.
9. Record results on Diagnostic Form.
   - If both relays are not operational, confirm that the ECM is programmed and enabled for the Inlet Air Heater.
   - If both relays are not operational or the voltage is not B+, and the ECM programming is correct, see IAH System in “Electronic Control Systems Diagnostics” section of this manual.

Fuel System

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

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

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.

Fuel Quality

Purpose

To check for poor fuel quality or contaminants

Tools

- Clear container (approximately 1 liter or 1 quart)

Possible Causes

- Debris, water, or ice in the fuel system
- Oil, gasoline, or kerosene present in fuel tank
- Fuel grade incorrect for cold temperature

Procedure

1. Ensure engine is OFF. Allow engine fuel pressure to achieve safe pressures (0 psi to 50 psi) before taking a sample.

Figure 146 Fuel sample

2. Place clear container at the base of fuel drain valve or install a hose on the fuel drain valve.
3. Route the hose into a clear container.
4. Open fuel drain valve.

   NOTE: If fuel sample does not drain immediately, press pump primer button with drain valve open to help start draining process.
5. Check for water, waxing, icing, sediment, gasoline, or kerosene.
   - If the fuel quality is satisfactory, no action is required.
   - If the fuel quality is questionable, correct the issue. Take another sample to verify fuel quality.

Fuel Pressure and Aeration

Purpose

To check for incorrect fuel pressure and aerated fuel

NOTE: Plugged supplemental filters or separators mounted on vehicle will influence fuel pressure, restriction, and aeration.

NOTE: Fuel aeration will not be visible by using the EFP sensor in place of special test tools.

Tools

- Fuel Pressure Gauge
- Fuel Pressure Test Kit
- Clear fuel container

Possible Causes

- Fuel filter or strainer blocked
- Fuel grade incorrect for cold temperatures
- Fuel supply line damage or blockage
- Failed fuel tank transfer pump
- Failed fuel regulator valve
- Failed fuel pump
- Air leak in suction side fuel line or filter assembly
- Combustion gases entering fuel supply system

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

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

Procedure

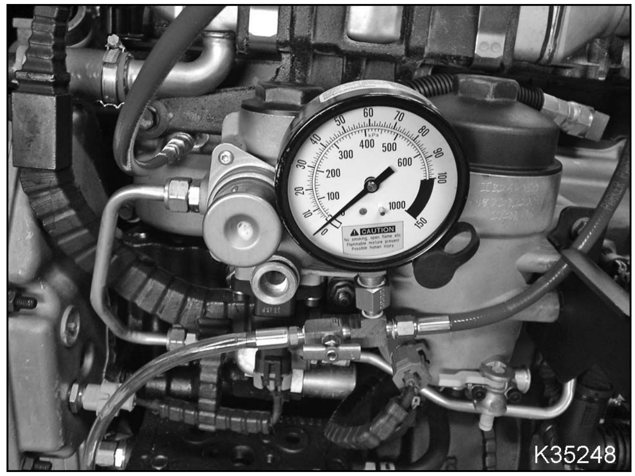


Figure 147 Fuel Pressure Gauge

1. Connect fuel pressure valve, fuel pressure gauge with shut-off valve, and a clear 3/8" diameter hose to the fuel test valve.
2. Route clear hose into a drain pan.
3. Start or crank engine for 20 seconds. Measure fuel pressure with shut-off valve closed. Open the shut-off valve to check for aeration.
4. Record results on Diagnostic Form.

- If fuel pressure is in specification with no aeration, no repair is required.
- If fuel pressure is below specification, see Fuel Filter Housing Pressure (page 114) in "Engine Symptoms Diagnostics" section of this manual.
- If fuel is aerated, see Alternate Fuel Supply to Fuel Filter Housing (page 117) in "Engine Symptoms Diagnostics" section of this manual.

Fuel Inlet Restriction

Purpose

To check for fuel supply system restriction

Tools

- Fuel Inlet Restriction Adapter
- Gauge Bar Tool

Possible Causes

- Fuel supply line damage or blockage
- Fuel grade incorrect for cold temperature

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.

Procedure

1. Ensure engine is OFF. Allow engine fuel pressure to achieve safe pressures (0 psi to 50 psi) before removing fuel strainer cap.

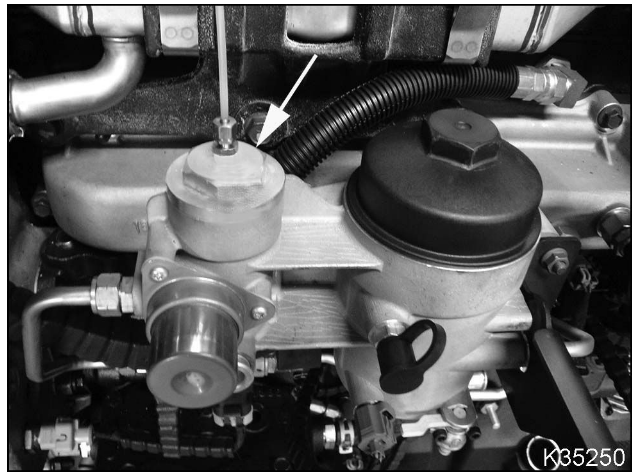


Figure 148 Fuel strainer cap

2. Remove fuel strainer cap.
3. Connect the Fuel Inlet Restriction Tool and test line.
4. Connect 0–30 in-Hg vacuum gauge to the test line.
5. Take high-idle fuel inlet restriction reading. Compare to specification.
   - If the fuel inlet restriction meets specification, and you still have low fuel pressure, see Fuel Pump Operation in “Engine Symptoms Diagnostics” section of this manual.
   - If the fuel inlet restriction exceeds specification, see Alternative Supply to Filter Housing in “Engine Symptoms Diagnostics” section of this manual.

Injection Control Pressure

ICP Unplugged Test

Purpose

To check for biased ICP sensor or sensor circuit problem

Tools

- None

Possible Causes

- ICP circuit problems
- Biased ICP sensor

Procedure

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

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

1. Install IPR and engine harness.
2. Leave valve cover removed from previous test.
3. Unplug ICP sensor from engine harness.
4. Crank engine for a maximum of 20 seconds.
   - If engine starts, see ICP Sensor (page 349) in “Electronic Control Systems Diagnostics” section of this manual or replace biased ICP sensor.

ICP System Test

NOTE: See “Diagnostic Software Operation” section in this manual for specific EST software procedures to do this test.

Purpose

To check for ICP system or IPR malfunction and inspect for aerated oil

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable

Possible Causes

- Aerated engine oil
- Lube oil system problems

Procedure

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

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

1. Turn ignition switch to ON. Do not start engine.
2. Open COM device.
3. Open Hard Start No Start session.
4. Crank engine for 20 seconds maximum. Monitor ICP and EOP while cranking.
5. Record results on Diagnostic Form.
   - If ICP and EOP are below specification, remove EOT sensor and verify if oil is in high-pressure oil reservoir.
   - If EOP is in specification, and oil reservoir is full, continue to the next test.
   - If EOP is below specification, and oil reservoir is empty, inspect lube oil system.
   - If EOP is in specification, and oil reservoir is empty, inspect for blockage to reservoir.

IPR Control System Test

NOTE: See "Diagnostic Software Operation" section in this manual for specific EST software procedures to do this test.

Purpose

To check for ICP system or IPR malfunction and inspect for aerated oil

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- IPR Breakout Tee

Possible Causes

- Corroded or damaged IPR circuits
- Poor B+ and ground supplied to IPR

Procedure

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

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

1. Remove IPR harness connector. Inspect for connection problems.
2. Record connection problems on the Diagnostic Form.
   - If connection appears in tact, continue to next step.
   - If connection is unacceptable, repair as required. Test again to validate repair. Continue to next step.

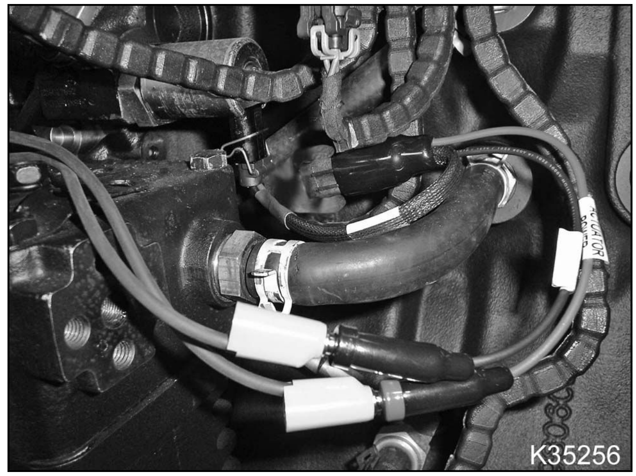


Figure 149 IPR Breakout Tee installed

3. Connect IPR breakout tee to the IPR valve.

   NOTE: Do not connect the IPR breakout to the IPR valve and engine harness. This will result in blown fuses when applying B+ and ground.
4. Connect IPR breakout tee to B+ and ground.
5. Turn ignition switch to ON. Do not start engine.
6. Open COM device.
7. Open Hard Start No Start session.
8. Crank the engine for 20 seconds maximum.
9. Record ICP results on Diagnostic Form.
   - If ICP reading is out of specification, continue with next test.
   - If ICP reading is in specification, correct IPR circuits. Test again to validate repair.

High-Pressure Oil Pump Test

NOTE: See “Diagnostic Software Operation” section in this manual for specific EST software procedures to do this test.

Purpose

To check high-pressure pump and IPR for inability to reach maximum injection control pressure

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- IPR Breakout Tee
- Pressure Sensor Breakout Tee
- Adapter tools
- ICP test sensor

Possible Causes

- Low engine oil pressure
- High-pressure oil system leak
- Failed IPR valve
- Failed high-pressure oil pump

Procedure

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

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

1. Retain IPR breakout tee with B+ and ground connections from previous test.
2. Remove high-pressure hose from the cylinder head fitting.

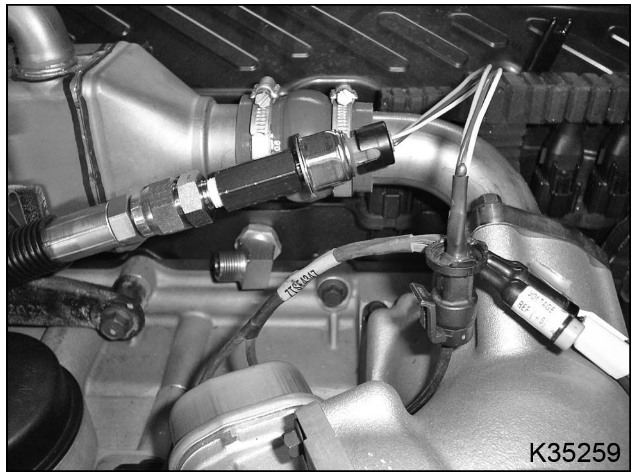


Figure 150 ICP adapter and test sensor installed

3. Install ICP adapter tools and ICP test sensor.
4. Disconnect MAP sensor.
5. Install Pressure Sensor Breakout Tee to engine harness only.
6. Route breakout harness to the ICP test sensor. Connect to ICP test sensor.
7. Use a DMM to monitor ICP sensor signal voltage.

   NOTE: MAP sensor signal voltage can also be monitored by the diagnostics software.
8. Crank the engine for a maximum of 20 seconds.
9. Record the ICP test sensor voltage on Diagnostic Form.

   Continue to the next test.

IPR Block-Off Test

NOTE: See "Diagnostic Software Operation" section in this manual for specific EST software procedures to do this test.

Purpose

To check high-pressure pump and IPR for inability to reach maximum injection control pressure

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Pressure Sensor Breakout Tee
- Adapter tools
- ICP test sensor
- IPR block-off tool

Possible Causes

- Failed IPR valve

Procedure

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

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

1. Retain set-up and adapter tools from previous test.
2. Remove IPR valve from high-pressure oil pump.

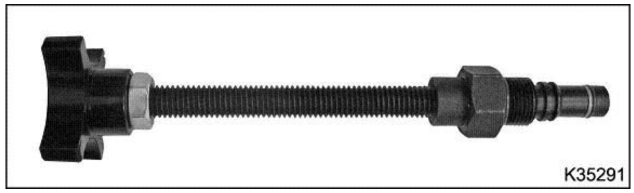


Figure 151 IPR block-off tool

3. Install IPR block-off tool.
4. Use DMM to monitor ICP sensor signal voltage.

   NOTE: MAP sensor signal voltage can also be monitored by the diagnostic software.
5. Crank engine for 20 seconds maximum.
6. Record the ICP test sensor voltage on Diagnostic Form.
   - If results are out of specification, replace the high-pressure pump.
   - If results are in specification, replace IPR valve. Test again to validate repair.

High-Pressure Oil Rail Leak Test

Purpose

To check for high-pressure oil rail leaks under the valve cover

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Pressure Sensor Breakout Tee
- Adapter tools
- ICP test sensor
- IPR block-off tool

Possible Causes

- High-pressure oil rail supply O-ring leak
- Fuel injector supply O-ring leak
- Porous or cracked high-pressure oil rail

Procedure

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

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

1. Retain set-up, adapter tools, and IPR block-off tool from previous test.
2. Install the high-pressure hose to the cylinder head.
3. Remove engine valve cover following the procedure in *Engine Service Manual*.
4. Crank engine for a maximum of 20 seconds.
5. Inspect the high-pressure oil rail for excessive leaks while cranking the engine.
6. Record the results on Diagnostic Form.
   - If no leaks are found, continue to the next test.
   - If leaks are found, correct problems. Test again to validate repairs.

Table of Contents

Diagnostic Form EGED-380

MAXXFORCE
INTERNATIONAL DIESEL POWER

Performance Diagnostics
International® MaxxForce® DT, 9, and 10
2007 through 2009 Model Years

Technician ____________ Miles ________ Transmission: Ambient temperature ________________ Engine SN ________________ ECM Calibration ________________
Date ____________ Hours ________ Manual ____ Auto ____ Coolant temperature ________________ Engine HP ________________ Turbocharger ________________
Unit No. ____________ EFRC ________ Build date __________ Complaint ________________ VIN ________________

⚠ WARNING
To prevent personal injury or death, read all safety instructions in the "Safety Information" section of International MaxxForce DT, 9, and 10 *Engine Diagnostics Manual* EGES-370-1 before doing procedures on this form.

Header Information and Specifications

1. If instrument panel warning lamp is illuminated, do DTCs and ECM Calibration test. Record any active DTCs related to complaint. Return to Visual Inspection. Continue with remaining tests, noting DTCs.
2. Look up the VIN on ISIS for build date, engine hp, engine serial number, ECM calibration, and transmission.
3. See Performance Specifications for EFRC, injector number, and turbocharger number.
4. Use Performance Specifications to fill in the specifications needed for some tests.
5. See "Performance Diagnostics" in EGES-370-1. Use figures and additional information to do each test or procedure.
6. Do all tests in sequence unless directed otherwise. It is not necessary to complete the rest of the form after the problem has been found and corrected.

1. Visual Inspection
☐ Check all fluid levels.
☐ Inspect electrical harness and connections.
☐ Inspect air filter minder.
☐ Inspect for obvious exhaust damage.

Fuel	Oil	Coolant	Electrical	Air

Note: Engine will not start if the IPR valve, CMP, or CKP sensor is disconnected.

2.1 Fuel Quality
☐ Take a fuel sample from filter housing drain port.

Comments

- If fuel is contaminated with water, icing, gasoline, kerosene, etc., clean fuel system as necessary to remove all contaminates.
- If fuel is clean, do Fuel Pressure and Aeration test.

Note: If engine was run out of fuel, ensure the system is primed.

2.2 Fuel Pressure and Aeration
☐ Connect fuel gauge to fuel pressure test port on intake manifold.
☐ Start engine, measure fuel pressure with shut-off valve closed, open shut-off valve to check for aeration.

Pressure	Spec	Low idle	High idle
0-160 psi gauge			
Is fuel aerated?			

- If pressure is high and pulsating, see Combustion Leaks to Fuel in Section 4 of EGES-370-1.
- If fuel is aerated, check for leaks in suction side to the pump.
- If pressure is below specification and not aerated, replace filter and test again.
- If pressure is still below specification after changing filter, do Fuel Inlet Restriction test.

2.3 Fuel Inlet Restriction
Note: Test is only valid if engine starts and achieves high idle.
☐ Connect 0-30 in-Hg vacuum gauge and fuel inlet restriction adaptor to fuel strainer housing.
☐ Start engine and accelerate to high idle.

Restriction	Specification	Actual
0-30 in Hg vac gauge		

- If restriction is above specification, check lines between tank and pump for blockage.
- If fuel pressure is low and not restricted, inspect and clean regulator valve. Test again.
- If fuel pressure is still low after cleaning regulator, replace fuel pump.

3. Sensor Compare
☐ Open Vin plus session with EST.
☐ Verify pressure sensors are within specification.
☐ Verify EOT and ECT are within 8 °C (15 °F) of each other.
☐ Verify accelerator pedal travels from 0% to 100%.

Sensor	Spec.	actual	Sensor	Spec	actual
ECT			EBP		
EOT			EOP		
MAT			EGDP		
ICP			EGT1		
BAP			EGT2		
MAP			EGT3		

If any results are out of specification, see EGES 370-1 Section 7.

4. DTCs and ECM Calibration
☐ Open VIN session with EST. (Verify ECM software matches vehicle.)

Active DTCs	InActive DTCs

- If ECM software does not match, reprogram the ECM.
- If any DTCs are set, correct fault before continuing.

5. KOEO Standard Test
☐ Use EST to run KOEO Standard Test.

DTCs

If any DTCs are set, correct fault code before continuing.

6. EGR Valve and ITV Operation
☐ Turn the ignition switch to ON. (Do not start engine)
☐ Run KOEO Output State Low and High tests.

PID	Specification	Actual
EGR (close position)	0 to 5 %	
EGR (open position)	95 to 100 %	
ITV (close position)	0 to 5 %	
ITV (open position)	45 to 55 %	

If out of specification, see ITV or EGR in Section 7 of EGES-370-1.

7. KOEO Injector Test
☐ Use EST to run KOEO Injector Test.

DTCs

If any DTCs are set, correct fault before continuing.

8. KOER Standard Test
☐ Use EST to run KOER Standard Test.

Active DTCs

If any DTCs are set, correct fault before continuing.

9.1 Air Management Test
☐ Use EST to run Air Management Test.

DTCs

If any DTCs are set, correct fault before continuing.

9.2 VGT Test
☐ Use EST to toggle turbocharger operation and monitor EBP and MAP.

Did EBP and MAP change for transition?	Yes	No
Low to medium		
Medium to high		
High to low		
Low to high		

- If no change was monitored during transition, then go to VGT Actuator Linkage Test.
- If change was seen during transition, then go to Torque Converter Stall test.

9.3 VGT Actuator Linkage Test
☐ Turn ignition switch to ON.
☐ Monitor VGT linkage movement.
Note: Linkage should have full range of upward and downward movement. A short pause should be noticed before completing full upward motion.
- If no problems are detected, continue on.
- If a problem is detected, correct problem and retest.

☐ Turn ignition switch to OFF.
☐ Manually move the VGT linkage through a full range of movement.
- If no problems are detected, continue to next test.
- If a problem is detected, correct problem and retest.

10. Torque Converter Stall (Automatic only)
☐ Set parking brake and apply service brake.
☐ Put transmission in drive.
☐ Push accelerator to the floor, no longer then 5 seconds. Monitor the time it takes to get to maximum rpm.
☐ Record rpm and time.

Condition	Specification	Actual
Stall rpm		
Time (Idle to stall in seconds)		

- If minimum rpm is reached within specified time for a launch concern, **do not continue with Performance Diagnostics tests**.
- If rpm is low or was not reached within specified time, continue

11. Road Test (Full load, rated speed)
☐ Connect fuel gauge to fuel filter housing test port.
☐ Open Performance session using EST.
☐ Verify coolant temperature is above 70 °C (158 °F).
☐ Run engine at full load, rated speed.
☐ Record snapshot during road test. Playback snapshot and record data taken at 100% load at rated speed.

Measurement	Specification	Actual
Engine load	100%	
RPM		
MAP		
EBP		
ICP		
Fuel pressure		

- If MAP and EBP are above specification, a biased BARO sensor or failed turbocharger are suspect.
- If EBP is above specification and MAP is below specification, check for exhaust restriction.
- If ICP can not achieve minimum, check ICP system.
- If fuel pressure falls below specification, replace fuel filter and clean strainer. Test again.

12. Injector Disable
☐ Use EST to run injector disable diagnostics to identify suspect cylinders.

Selected Cylinder	EOT	Average Fuel Rate	Deviation	Average Engine Load	Deviation
Baseline					
1					
2					
3					
4					
5					
6					
Cut-off values:		Fuel rate		Engine load	

If any cylinder is suspect, do Relative Compression test.

13. Relative Compression
☐ Turn ignition switch to ON.
☐ Use EST to run Relative Compression Test.
☐ Crank engine following EST instructions.

Relative Compression Test	Value
Cylinder 1 Relative Compression	
Cylinder 2 Relative Compression	
Cylinder 3 Relative Compression	
Cylinder 4 Relative Compression	
Cylinder 5 Relative Compression	
Cylinder 6 Relative Compression	

- If a Relative Compression Test and Injector Disable Test identify a suspect cylinder, check for a mechanical problem.
- If a Relative Compression Test does not identify a suspect cylinder, but the Injector Disable Test does, replace suspect injector.

14. Crankcase Pressure
Note: Engine coolant temperature must be above 70 °C (158 °F).
☐ Measure at left valve cover with crankcase pressure test adapter.
☐ Measure at high idle and no load.

Restrictor Tool	Specification	Actual
0-30 in Hg vac gauge		

(Continue to Side 2)

K35327

Engine diagnostic forms assist technicians in troubleshooting Navistar diesel engines. The diagnostic tests help technicians find problems to avoid unnecessary repairs.

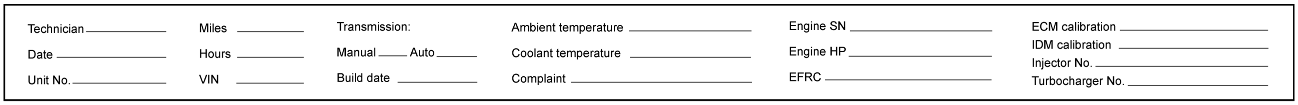
This section shows detailed instructions of the tests on the form. The manual should be used with the form and referenced for supplemental test information. Use the form as a worksheet to record all test results.

Do all tests in sequence, unless otherwise stated. Doing a test out of sequence can cause incorrect results. If a problem was found and corrected, it is not necessary to complete the remaining tests.

See appendices for Diagnostic Trouble Codes (DTCs) and engine specifications.

Diagnostic Form EGED-380 is available in 50 sheet pads. To order technical service literature, contact your International® dealer.

Header Information



D31536

Enter Header Information

1. Technician
2. Date
3. Unit No. (dealer's quick reference number)
4. Customer complaint

Enter Vehicle Information

The Vehicle Identification Number (VIN) is required to complete steps 5 through 9. The VIN can be obtained in ISIS.

5. VIN – the last 8 digits (verify to VIN plate)
6. Build date (verify to VIN plate)
7. Engine hp
8. ECM calibration
9. Transmission
10. Engine SN

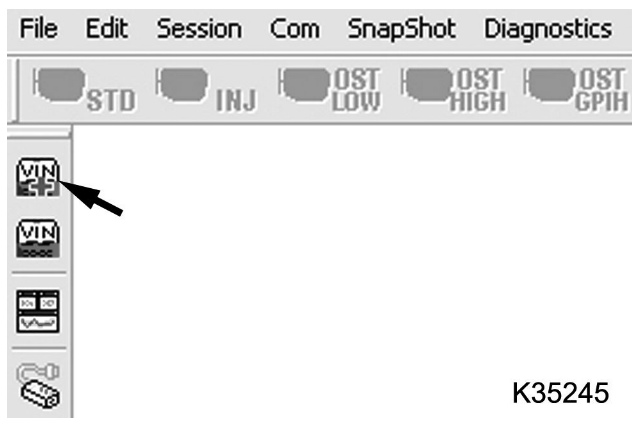
Enter Performance Specification Information

11. See “Performance Specifications” (page 465) appendix in this manual to obtain the following header information:

NOTE: Performance specifications are periodically published in TSI format to support new model year products. Check service bulletin listing on ISIS® for appropriate model year application.

- Engine Family Rating Code (EFRC)
- ECM calibration
- Injector No.
- Turbocharger No.

Verify ECM Calibration with Vehicle Specifications



12. Using the EST with MasterDiagnostics®, open the VIN session by selecting the VIN+ icon.

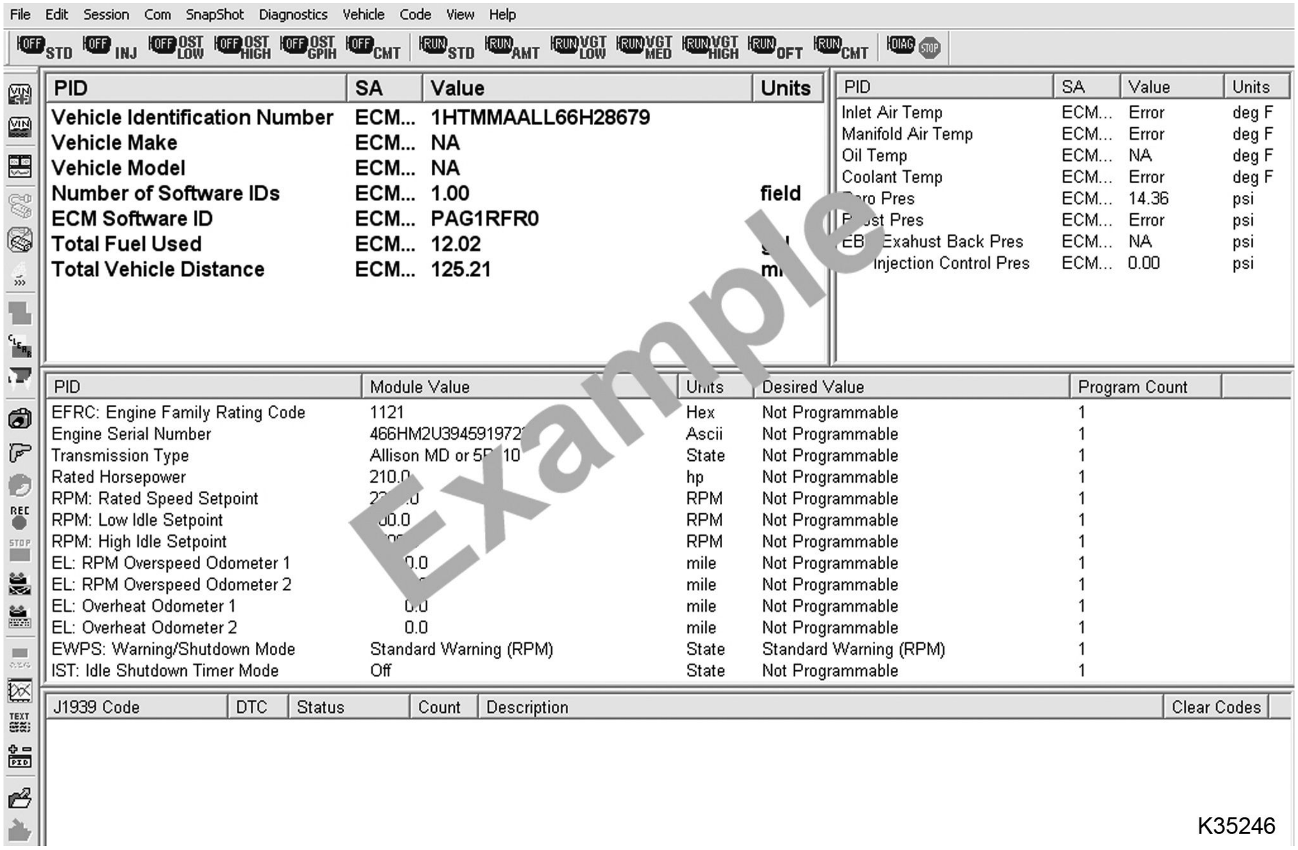


Figure 155 VIN session (example)

13. Verify the following match vehicle specification:
    - VIN
    - ECM calibration
    - Rated hp
    - EFRC
    - Engine SN

    Note: The engine serial number is located on the engine block, below the left rear cylinder head. It is also located on the valve cover engine emission label.

    - Transmission
14. Enter the following information:
    - Odometer (miles)
    - Engine hours
    - Intake air temperature
    - Coolant temperature

Test Procedures

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

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

1. Visual Inspection

Purpose

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

Tools

- Inspection lamp

Engine Oil

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

   NOTE: Engine should not be running. Allow engine to cool down for 15 minutes to ensure oil has been stabilized.

2. Use oil level gauge to verify engine oil level.
3. Record results on Diagnostic Form.
   - If level is to specification, no repair is required.
   - If level is below specification, inspect for leaks, oil consumption, or improper servicing.
   - If level is above specification, inspect for fuel dilution, coolant contamination, or improper servicing.

Fuel Level

1. Park vehicle on level ground.

   NOTE: Engine should not be running.

2. Use dash gauge to verify fuel level. Inspect fuel tank fill ports.
3. Record results on Diagnostic Form.
   - If level is to specification, and no tank contamination is evident, no repair is required.
   - If level is below dash gauge reading, inspect for leaks, fuel dilution, inoperable tank transfer pump, or improper servicing.

Engine Coolant Level

1. Park vehicle on level ground.

   NOTE: Engine should not be running. Ensure coolant temperature has stabilized to safe temperature.

2. Check coolant level as indicated on surge tank level window.
3. Record results on Diagnostic Form.
   - If level is to surge tank fill level, and no tank contamination is evident, no repair is required.
   - If level is below surge tank fill level, inspect for leaks, coolant in the oil, coolant in combustion exhaust, or improper servicing.

Charge Air Cooler (CAC) System

1. Inspect CAC system, including intercooler and piping for leaks.
2. Inspect all CAC connections and clamps.
   - If CAC system is in specification, no repair is required.
   - If CAC system issue is found, repair as required.

Electrical System

Inspect electrical system (engine and vehicle) for poor or loose connections.

- If electrical system is to specification, no repair is required.
- If electrical system issue is found, repair as required.

Exhaust System

Inspect exhaust system (engine and vehicle) for leaks or damage.

- If exhaust system is to specification, no repair is required.
- If exhaust system issue is found, repair as required.

2. Fuel System

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

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

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

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

2.1 Fuel Quality

Purpose

To check for poor fuel quality or contaminants

Tools

- Clear container (approximately 1 liter or 1 quart)

Possible Causes

- Debris, water, or ice in the fuel system
- Oil, gasoline, or kerosene present in fuel tank
- Fuel grade incorrect for cold temperature

Procedure

1. Ensure engine is OFF. Allow engine fuel pressure to achieve safe pressures (0 psi to 50 psi) before taking a sample.

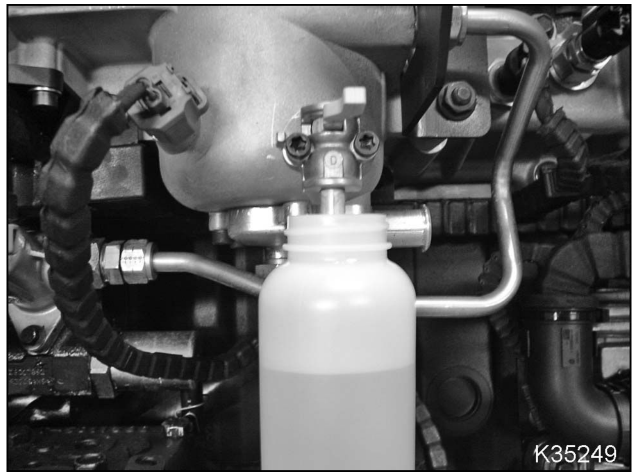


Figure 156 Fuel sample

2. Place clear container at the base of fuel drain valve or install a hose on the fuel drain valve.
3. Route the hose into a clear container.
4. Open fuel drain valve.

   NOTE: If fuel sample does not drain immediately, press pump primer button with drain valve open to help start draining process.
5. Check for water, waxing, sediment, gasoline, or kerosene.
   - If the fuel quality is satisfactory, no action is required.
   - If the fuel quality is questionable, correct the issue. Take another sample to verify fuel quality.

2.2 Fuel Pressure and Aeration

Purpose

To check for incorrect fuel pressure and aerated fuel

NOTE: Plugged supplemental filters or separators mounted on vehicle will influence fuel pressure, restriction, and aeration.

NOTE: Substituted EFP sensor reading has low aeration visibility without special service tools.

Tools

- Fuel Pressure Gauge
- Fuel Pressure Test Kit
- Clear fuel container

Possible Causes

- Fuel filter or strainer blocked
- Fuel grade incorrect for cold temperatures
- Fuel supply line damage or blockage
- Failed fuel tank transfer pump
- Failed fuel regulator valve
- Failed fuel pump
- Air leak in suction side fuel line or filter assembly
- Combustion gases entering fuel supply system

Procedure

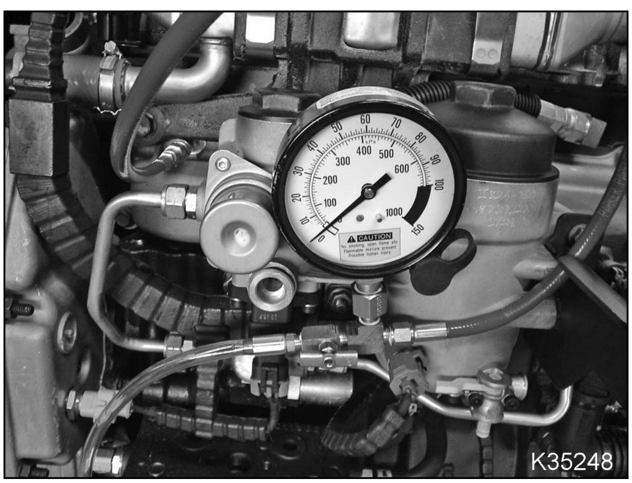


Figure 157 Fuel Pressure Gauge

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

1. Connect fuel pressure valve, fuel pressure gauge with shut-off valve, and a clear 3/8" diameter hose to the fuel test valve.
2. Route clear hose into a drain pan.
3. Start or crank engine for 20 seconds. Measure fuel pressure with shut-off valve closed. Open the shut-off valve to check for aeration.
4. Record results on Diagnostic Form.
5. Run engine at high idle. Measure fuel pressure with shut-off valve closed. Open the shut-off valve to check for aeration.
6. Record results on Diagnostic Form.
7. If the vehicle has automatic transmission, set the parking brake and apply service brakes.

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.

8. Put transmission in drive and press accelerator to the floor for no more than 10 seconds.

   Measure fuel pressure with the shut-off valve closed.
9. Record results on Diagnostic Form.

- If fuel pressure is in specification with no aeration, no repair is required.
- If fuel pressure is below specification, see Filter Cavity Pressure in "Engine Symptoms Diagnostics" section of this manual.
- If fuel is aerated, see Alternative Supply to Filter Housing in "Engine Symptoms Diagnostics" section of this manual.

2.3 Fuel Inlet Restriction

Purpose

To check for fuel supply system restriction

Tools

- Fuel Inlet Restriction Adapter
- Gauge Bar Tool

Possible Causes

- Fuel supply line damage or blockage
- Fuel grade incorrect for cold temperature

Procedure

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

1. Check for fuel inlet restriction from the fuel strainer located on the fuel filter housing.

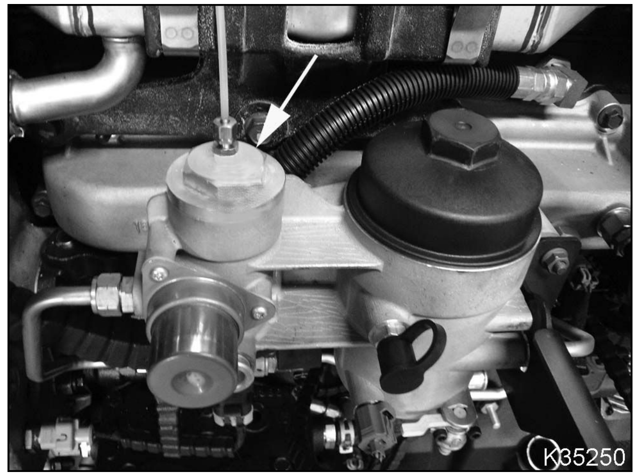


Figure 158 Fuel strainer cap

2. Remove fuel strainer cap.
3. Connect the Fuel Inlet Restriction Adapter and test line.
4. Route test line from engine bay to the cab.
5. Connect 0-30 in-Hg vacuum gauge to test line.
6. Measure high-idle fuel inlet restriction reading and compare to specification.
7. Record results on Diagnostic Form.
   - If fuel inlet restriction is in specification, go to next test.
   - If fuel inlet restriction is out of specification, see Alternative Supply to Filter Housing in “Engine Symptoms Diagnostics” section of this manual.

3. Sensor Compare

NOTE: See “Diagnostic Software Operation” section in this manual for specific EST software procedures to do this test.

Purpose

To check for sensor malfunction while running KOEO Continuous Monitor test

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable

Possible Causes

- Failed sensor circuits.
- Biased or damaged sensor

Procedure

1. Turn ignition switch to ON. Do not start engine.
2. Open COM device.
3. Open Vin+ session.
4. Select Key-On Engine-Off (KOEO) Tests and Continuous Monitor Test from the drop down menu.
5. Check for normal KOEO sensor values.
6. Record results on Diagnostic Form.
   - If engine has not been run for 8 hours or more, the Engine Coolant Temperature (ECT), Engine Oil Temperature (EOT), and Manifold Air Temperature (MAT) should be within about 2 °C (5 °F) of each other. The Intake Air Temperature (IAT) could be a few degrees higher or lower due to faster outside engine temperature change.
   - The Injection Control Pressure (ICP) values may fluctuate and affect performance. Electromagnetic Interference (EMI) or ground shift can cause a small voltage shift that does not indicate a problem.

     If voltage shift causes the signal to exceed 690 kPa (100 psi), see ICP Sensor (page 349) .
   - Engine Oil Pressure (EOP), Manifold Air Pressure (MAP), and Exhaust Back Pressure (EBP) values may fluctuate as much as 7 kPa (1 psi). Electromagnetic Interference (EMI) or ground shift can cause a small voltage shift that does not indicate a problem.
   - Barometric Absolute Pressure (BAP) values should equal the barometric reading for your region.
7. Verify if sensor values are normal.
   - If out of specification, see “Electronic Control Systems Diagnostics” (page 187) section of this manual for the applicable sensor out of specification.
   - If sensors are in specification, no repair is required. Continue to next test.

4. DTCs and ECM Calibration

Purpose

- To verify the ECM calibration matches the vehicle
- To determine if the ECM has detected DTCs indicating conditions that could cause engine problems

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable

Checking ECM Calibration

1. Turn ignition switch ON, engine OFF.
2. Using the EST with MasterDiagnostics® software, open the VIN+ session. Select the VIN+ icon.
3. Verify that the vehicle information on the ECM matches the vehicle. See Verify ECM Calibration with Vehicle Specifications (page 128) in this section of manual.
4. Record calibration level on Diagnostic Form.

Checking for DTCs

CAN code: Codes associated with a Suspect Parameter Number (SPN) and Failure Mode Indicator (FMI)

DTC: Diagnostic Trouble Code

Status: Indicates active or inactive DTCs

- **Active**: With the ignition switch on, active indicates a DTC for a condition currently in the system. When the ignition switch is turned off, an active DTC becomes inactive. (If a problem remains, the DTC will be active on the next ignition switch cycle and the EST will display active/inactive.)
- **Inactive**: With the ignition switch on, inactive indicates a DTC for a condition during a previous key cycle. When the ignition switch is turned to OFF, inactive DTCs from a previous ignition switch cycle remain in the ECM memory until cleared.
- **Active/Inactive:** With the ignition switch on, active/inactive indicates a DTC for a condition currently in the system and was present in previous key cycles, if the codes were not cleared.

Description: Defines each DTC

1. Record all active or inactive DTCs on Diagnostic Form.
   - If no DTCs are set, continue to next test.
   - Correct any active DTCs, if related to performance. See “Electronic Control Systems Diagnostics” (page 187) section of this manual.
   - Investigate any inactive DTCs that affect performance.

5. KOEO Standard Test

NOTE: See “Diagnostic Software Operation” section in this manual for specific EST software procedures to do this test.

Purpose

To inspect for electrical malfunctions detected by the ECM self-test and Output Circuit Check (OCC)

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable

Possible Causes

- Failed electrical components or circuitry
- OCC faults detected by ECM.

Procedure

1. Turn ignition switch to ON. Do not start engine.
2. Open COM device.
3. Select Key-On Engine-Off Tests. Select Standard Test from the drop down menu.
4. Follow the on-screen instructions.
5. Record all DTCs on Diagnostic Form. See “Diagnostic Trouble Codes” (page 493) appendix in this manual for DTCs.
    - If no DTCs are detected, no repair is required.
    - If DTCs are detected, correct problems causing the DTCs.
6. Clear DTCs.
7. Run the KOEO Standard Test again.

6. EGR Valve and ITV Operation

NOTE: See “Diagnostic Software Operation” section in this manual for specific EST software procedures to do this test.

Purpose

To inspect for EGR valve and ITV malfunction

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable

Possible Causes

- Valve motion interference
- Failed electrical circuits or components

Procedure

1. Turn ignition switch to ON.
2. Open COM device.
3. Select Key-On Engine-Off Tests. From the drop down menu, select Output State Tests, then select Output State Low Test.
4. Record EGR valve and ITV positions on Diagnostic Form.
5. Select Key-On Engine-Off Tests. From the drop down menu, select Output State Tests, then select Output State High Test.
6. Record EGR valve and ITV positions on Diagnostic Form.
    - If readings are in specification, no repair is required.
    - If readings are not in specification, correct issue. Test again to validate repair.

7. KOEO Injector Test

NOTE: See “Diagnostic Software Operation” section in this manual for specific EST software procedures to do this test.

Purpose

To inspect for fuel injector malfunctions by energizing them sequentially

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable

Possible Causes

- Open or short in injector circuits
- Poor ECM power or ground
- Failed injector coil
- Failed ECM

Procedure

1. Turn ignition switch to ON. Do not start engine.
2. Open COM device.
3. Select Key-On Engine-Off Tests and Injector Test from the drop down menu.
4. Listen for injectors to pre-cycle spool, then cycle in order of cylinder position.
5. Listen again for injectors to pre-cycle spool, then cycle in reverse order of cylinder position.
6. Record DTCs on Diagnostic Form. See “Diagnostic Trouble Codes” (page 493) appendix in this manual for DTCs.
   - If no problems are detected, no repair is required.
   - If problems are detected, correct problems causing the DTCs.
7. Clear DTCs.
8. Run the KOEO Injector Test again.

8. KOER Standard Test

NOTE: See “Diagnostic Software Operation” section in this manual for specific EST software procedures to do this test.

Purpose

To inspect for engine sensors and IPR malfunctions within specified operating ranges

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable

Possible Causes

- ICP oil leak
- Sensor and actuator circuit problems
- Failed engine sensors or actuators
- Low oil supply to high-pressure pump reservoir
- High-pressure pump failure

Procedure

1. Turn ignition switch to ON. Do not start engine.

   NOTE: Ensure that engine is above minimum operating temperature of 70 °C (158 °F) before starting test.
2. Open COM device.
3. Select Key-On Engine-Running Tests and Standard Test from the drop down menu.
4. Follow the on-screen instructions.
   - The ECM will start the KOER Standard Test by commanding the rpm to rise to a predetermined level.
   - When the test is finished, the ECM will return the rpm to low idle.
5. Record DTCs on Diagnostic Form. See “Diagnostic Trouble Codes” (page 493) appendix in this manual for DTCs.
   - If no DTCs are detected, no repair is required.
   - If DTCs are detected, correct the problems causing DTCs.
6. Clear DTCs.
7. Run the KOER Standard Test again.

9. KOER Air Management Test

NOTE: See “Diagnostic Software Operation” section in this manual for specific EST software procedures to do this test.

9.1 Air Management Test

Purpose

To check for intake, exhaust, VGT, and EGR system malfunctions

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable

Possible Causes

- Intake/exhaust leak or restriction
- Blocked EBP tube assembly
- EBP/MAP sensor biased or damaged
- Failed EGR control valve
- Failed VGT actuator or turbocharger

Procedure

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

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

1. Turn ignition switch to ON.
2. Open COM device.
3. Open KOER_AirManagement session.
4. Select Key-On Engine-Running test. From the drop down menu, select Air Management test.

   The ECM will start the air management test. The engine is commanded to accelerate to a predetermined rpm. The ECM will monitor the effects of the VGT and EGR system by using feedback signals from the EBP sensor.

   - If no problem is detected, the test will run to completion and resume low idle rpm.
   - If a problem is detected, the ECM will cancel the test, set a DTC, and resume low idle rpm.
5. Record results on Diagnostic Form.
   - If no problems are detected, no repair is required.
   - If a problem is detected, do the VGT Test.

9.2 VGT Test

Purpose

To check for VGT malfunction

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable

Procedure

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

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

1. Turn ignition switch to ON.
2. Open COM device.
3. Open KOER_AirManagement session.
4. Select Key-On Engine-Running (KOER) test. From the drop down menu, select VGT tests (low, medium, or high).
5. Use the following recommended duty cycle sequence to check turbocharger operation between VGT duty cycle:
   - Low to medium
   - Medium to high
   - High to low
   - Low to high
6. Select Low Duty Cycle. Click Run to command the ECM to begin the test.
7. Select the next desired duty cycle. Click Run.
8. Record results on Diagnostic Form.
9. Continue through the recommended sequence.
   - If no change was monitored during transition, then do VGT Actuator Linkage Test.
   - If change was seen during transition, do Torque Converter Stall Test.

9.3 VGT Actuator Linkage Test

Possible Causes

- Intake/exhaust leak or restriction
- Blocked EBP tube assembly
- EBP/MAP sensor biased or damaged
- Failed EGR control valve
- Failed VGT actuator or turbocharger

Procedure

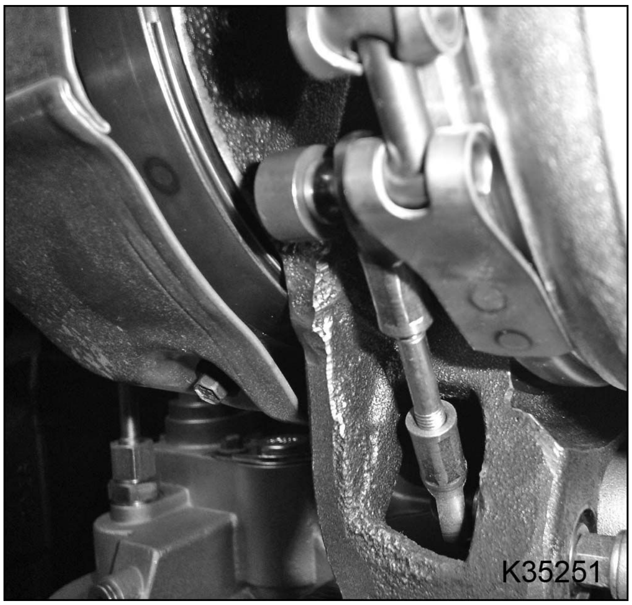


Figure 159 VGT linkage upward position

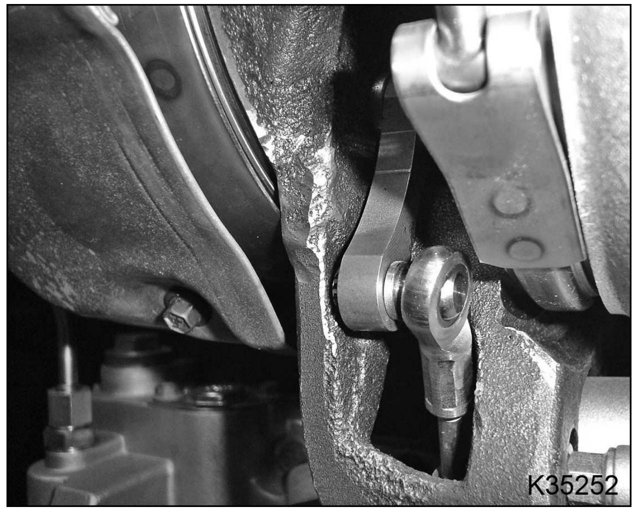


Figure 160 VGT linkage downward position

1. Turn ignition switch to ON. Have another technician monitor VGT linkage movement.

   The linkage should have full range of downward and upward motion. A short pause should be noticed shortly before completing full upward motion.
2. Check the pre-cycle three times with a minimum of 15 seconds key-off time between tests.

   The linkage should move through the pre-cycle freely without noise or vibration.
3. Turn ignition switch to OFF. Wait for ECM to power off (15 seconds).
4. Manually move the turbocharger linkage through a full range of motion.

   The linkage should move freely.
5. Move the linkage completely downward and release. The linkage should return upward and slightly bounce back to resting position.
   - If no problems are detected, no repair is required.
   - If a problem is detected, continue to next step.
6. Remove the linkage. With the linkage removed manually move VGT actuator through full range of motion. If no problem is found, replace turbocharger. If linkage does not move freely, replace VGT actuator.

10. Torque Converter Stall (Automatic only)

Purpose

To check for engine inability to meet specified stall rpm within specified time

Tools

- None

Possible Causes

- Intake or exhaust restriction
- Boost or exhaust system leak
- Biased engine sensors
- Low supply fuel pressure
- Low injection control pressure
- EGR control valve issue
- Turbocharger issue
- Engine brake issue
- Fuel injector issue
- Power cylinder issue

Procedure

CAUTION: To prevent drive train damage, do not do this test for more than 10 seconds at a time or more than twice back to back. If doing twice – wait 2 minutes between tests.

1. Turn ignition switch to ON. Start the engine.
2. Set parking brake and apply service brake.

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.

3. Put transmission in drive.
4. Press accelerator pedal to the floor. Begin timing until TACH stops moving.
5. Record stall rpm and time to reach stall rpm on Diagnostic Form.
   - If no problems are found, no action is required.
   - If stall rpm is below specification, or stall time is above specification, continue to next test.

11. Road Test (Full load, rated speed)

NOTE: See “Diagnostic Software Operation” section in this manual for specific EST software procedures to do this test.

Purpose

To check for unacceptable engine performance at full load and rated speeds by means of maximum boost, minimum fuel pressure, and minimum injection control pressure

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable

Unacceptable Boost Possible Causes

- Boost leaks
- Restricted intake or exhaust
- Control system faults
- Biased BAP, EBP, ICP or MAP sensors
- Power cylinder condition
- Low fuel pressure
- Low injection control pressure
- Failed EGR valve
- Failed turbocharger
- Failed fuel injectors

Unacceptable Injection Control Pressure Possible Causes

- Low-pressure or aeration of lube oil
- Incorrect feedback from APS or ICP sensor
- High-pressure rail leaks
- Fuel injector oil leaks
- IPR middle seal leak
- Circuit faults (ICP, IPR, BCP)
- Failed high-pressure pump
- Failed fuel injectors

Unacceptable Fuel Pressure Possible Causes

- Fuel filter or strainer blockage
- Incorrect fuel grade for cold climate
- Debris, water, or ice in fuel system
- Oil, gasoline, or kerosene present in fuel system
- Combustion gases entering fuel system
- Fuel supply line leak, damage, or blockage
- Air leak in suction side fuel line or filter assembly
- Failed fuel tank transfer pump
- Failed fuel regulator valve
- Failed fuel pump

Procedure

1. Turn ignition switch to ON and start engine.

   NOTE: Ensure the engine is above minimum operating temperature of 70 °C (158 °F) before recording crankcase pressure.

2. Open COM device.
3. Open Road Performance session.
4. Set the Road Performance snapshot to record at 0.2 second interval for the following PIDs:
   - Engine speed (rpm)
   - Boost pressure (MAP)
   - Exhaust back pressure (EBP)
   - Fuel delivery pressure (EFP)
   - Injection control pressure (ICP)
   - Engine load (EL %)
5. Find an open stretch of road. Start snapshot recording. When driving conditions are safe, select a suitable gear, press accelerator pedal fully to the floor, and accelerate to rated speed at 100% load.
6. When road test is complete, stop snapshot recording.
7. Save snapshot for review and future reference.
8. Replay snapshot in graphic or text view to review results for RPM, MAP, EBP, EFP, ICP, and EL %.
   - Pay close attention to rated HP and peak TQ rpm.
   - EL % should be near 100 percent.
9. Record results on Diagnostic Form.
   - If results are in specification, no repair is required.
   - If results are out of specification, correct problems. Test again to validate repairs.

12. Injector Disable

NOTE: See "Diagnostic Software Operation" section in this manual for specific EST software procedures to do this test.

Purpose

To determine the cause of rough engine idle

NOTE: The Injector Disable test is used in conjunction with Relative Compression to distinguish between an injector problem or a mechanical problem.

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable

Possible Causes

- Open or short injector wiring
- Scuffed or failed injector
- Failed ECM
- Power cylinder issue

Procedure

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: Before doing this test, all preceding tests must be completed.

1. Turn ignition switch to ON.
2. Open COM device.
3. Select Diagnostics from menu bar.
4. Select I6 Injector Disable Test from drop down menu.

   NOTE: Run Injector Disable Test only when engine temperature reaches 70 °C (158 °F) or higher.

   The EOT indicator will change from red to green when engine temperature reaches 70 °C (158 °F) or higher.
5. Select cylinder number and select Run. (Injector selected will be disabled and engine noise should change.)
6. Record results on Diagnostic Form.
7. Select Normal Operation. Injector will be enabled and engine noise should return to previous state of operation.
8. Repeat steps 6 and 7 for the remaining cylinders.

   NOTE: Listen for tone changes from cylinder to cylinder.

   - If test does not identify a suspect cylinder, do Relative Compression Test in this section.
   - If test identifies a suspect cylinder, do Relative Compression Test. Do not attempt to repair injectors without completing Injector Disable and Relative Compression test first.

13. Relative Compression

NOTE: See “Diagnostic Software Operation” section in this manual for specific EST software procedures to do this test.

Purpose

To check for low cylinder compression

NOTE: Batteries must be fully charged before doing this test. If multiple tests are required, use a battery charger to prevent battery drain.

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable

Possible Causes

- Incorrect valve lash adjustment
- Loose fuel injector
- Valve train damage
- Power cylinder damage

Procedure

1. Turn ignition switch to ON. Do not start the engine.
2. Open COM device.
3. Select Diagnostics from the menu bar and I6 Relative Compression Tests from the drop down menu.
4. Follow the on-screen instructions.
5. Record results on Diagnostic Form.
   - If the Relative Compression Test or Injector Disable test do not identify a suspect cylinder, no action is required.
   - If the Relative Compression Test and Injector Disable test identify a suspect cylinder, check for cylinder mechanical issue.
   - If only the Injector Disable test identifies a suspect cylinder, check for injector issue first.

14. Crankcase Pressure

Purpose

To check for unacceptable condition of the power cylinders

Tools

- Gauge Bar Tool
- Crankcase Pressure Test Adapter
- Heater hose pliers

Possible Causes

- Restricted or incorrect sized orifice in Crankcase Pressure Test Adapter
- Dirt in air induction system
- Power cylinder wear or damage
- Valve seal and guide wear or damage
- Failed air compressor
- Failed turbocharger

Procedure

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

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

1. Remove crankcase ventilation breather inlet tube.

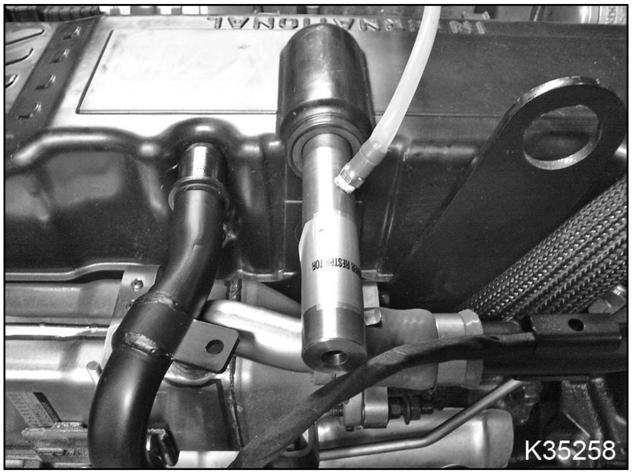


Figure 161 Crankcase Pressure Test Adapter installed

2. Insert Crankcase Pressure Test Adapter into the valve cover grommet.
3. Connect test line from the Crankcase Pressure Test Adapter to the gauge.

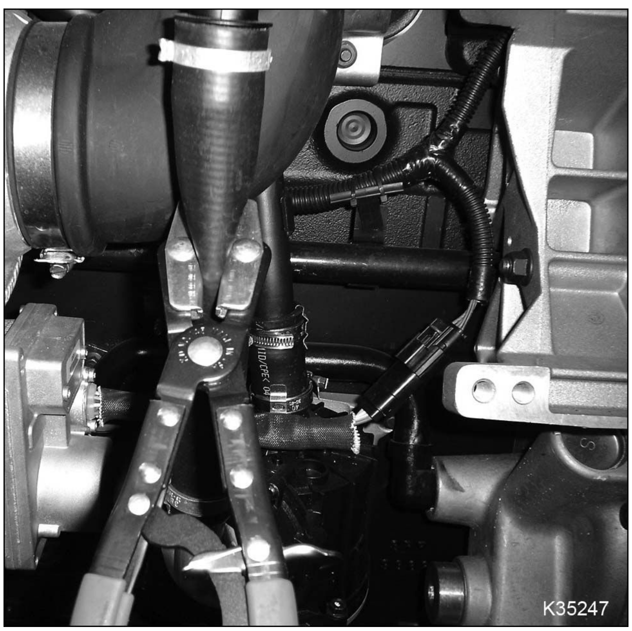


Figure 162 Breather tube clamped

4. Clamp off crankcase ventilation breather outlet tube with heater hose pliers.

NOTE: Ensure the engine is above minimum operating temperature of 70 °C (158 °F) before recording crankcase pressure.

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. Run engine at high idle (no load) rpm. Allow the gauge reading to stabilize before taking the pressure reading.
6. Record crankcase pressure on Diagnostic Form.
   - If pressure is in specification, no repair is required.
   - If pressure is out of specification, continue to next step.

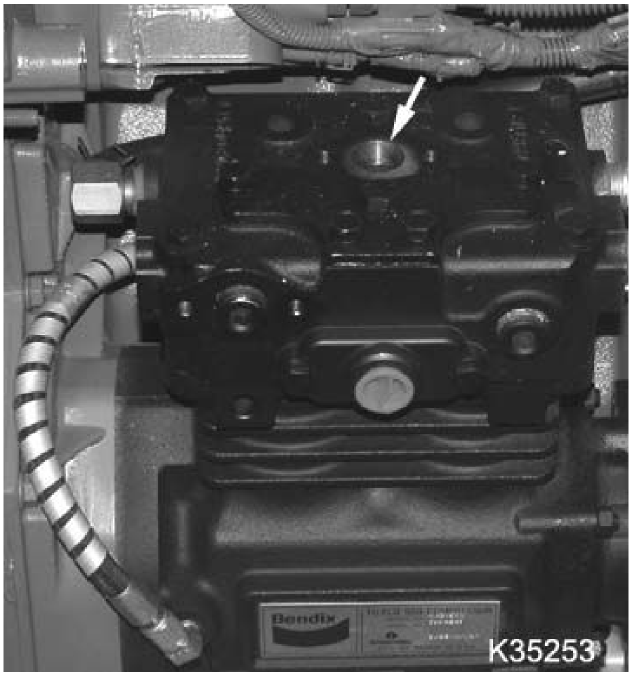


Figure 163 Air compressor discharge port

7. If engine has an air compressor, remove discharge line and test again.
   - If pressure is above specification, go to next step.
   - If pressure is below specification, compressed air is leaking into the crankcase. Repair or replace air compressor.
8. Disconnect VGT actuator and test again.

   If pressure is below specification, repair VGT and test again.
9. Do Relative Compression to pinpoint suspect cylinders.

15. Intake Restriction

Purpose

To check for restrictions causing hard start or no start conditions

Tools

- Engine or dash mounted air restriction indicator
- Gauge Bar Tool
- Spare air brake hose and adapter fittings

Possible Causes (Option 1 and 2)

- Restricted air filter inlet and ducts
- Restricted, dirty, or collapsed air filter element
- Leaking or damaged CAC couplings
- Restricted or collapsed inlet piping or hoses
- Exhaust system damage
- Restricted or full Diesel Particulate Filter (DPF)

Option 1

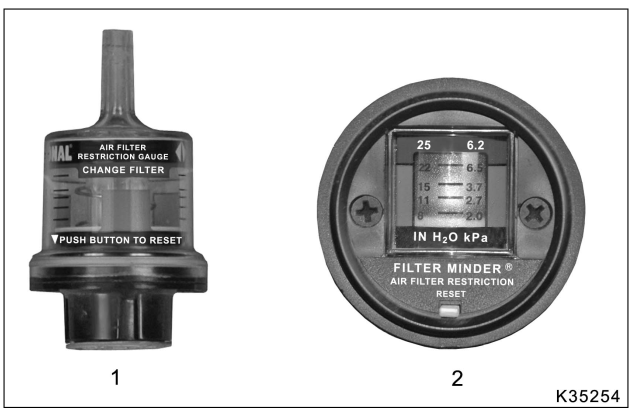


Figure 164 Air cleaner restriction indicators

1. Mounted on air cleaner
2. Mounted on instrument panel

1. Locate air restriction indicator. Run engine at high idle, no load.
2. Record intake restriction on Diagnostic Form.
   - If restriction is not apparent, no repair is required.
   - If restriction is detected, repair as required. Test again to validate repair.

Option 2

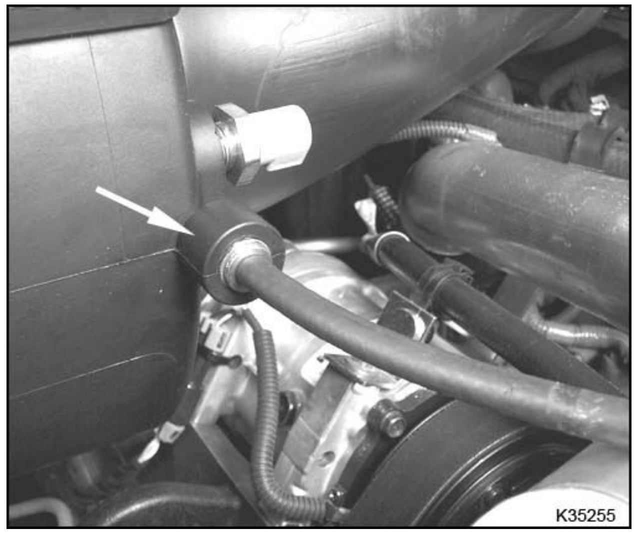


Figure 165 Air filter housing tap

1. Install spare length of air brake hose, threaded adapter, and Gauge Bar Tool to the air filter housing.
2. Run engine at high idle, no load.
3. Record intake restriction on Diagnostic Form.
   - If restriction is not apparent, no repair is required.
   - If restriction is detected, repair as required. Test again to validate repair.

16. Exhaust Restriction

Purpose

To check for exhaust system restrictions

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable

Possible Causes

- Damaged or biased EBP sensor
- Restricted or collapsed exhaust piping
- Restricted or damaged exhaust components
- VGT issue

Procedure

1. Turn ignition switch to ON.
2. Open COM device.
3. Open KOER_AirManagement session.
4. Unplug EGR valve harness to EGR connection during the test. Ignore the DTC that will be set.

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. Start and run engine at high idle, no load.
6. Record exhaust back pressure on Diagnostic Form.
   - If exhaust back pressure is in specification, reconnect EGR valve and clear DTCs. No repair is required.
   - If exhaust back pressure is above specification, continue to next step.
7. Remove exhaust pipe from turbocharger outlet and test again.
   - If exhaust back pressure is in specification, reconnect EGR valve, clear DTCs, and repair issue between turbocharger outlet and tailpipe.
   - If exhaust back pressure is above specification, reconnect exhaust pipe, reconnect EGR valve, clear DTCs, and repair issue with VGT.

17. Injection Control Pressure

17.1 ICP System Test

NOTE: See “Diagnostic Software Operation” section in this manual for specific EST software procedures to do this test.

Purpose

To check for ICP system or IPR malfunction and inspect for aerated oil

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable (page 430)

Possible Causes

- Aerated engine oil

Procedure

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: Ensure that engine is above minimum operating temperature of 70 °C (158 °F) before starting test.

1. Turn ignition switch to ON. Do not start engine.
2. Open COM device.
3. Open KOER_RoadPerformance session.
4. Monitor ICP readings for the following engine conditions:
   - KOEO
   - KOER low idle
   - KOER high idle
5. Record results on Diagnostic Form.
6. Monitor ICP reading after achieving high idle for 2 minutes.
7. Take an oil sample and inspect for aeration.
8. Record ICP reading and aeration results on Diagnostic Form.
   - If results are in specification, continue to next test.
   - If results are out of specification, correct the issue. Test again to validate the repair.

17.2 IPR Control System Test

NOTE: See "Diagnostic Software Operation" section in this manual for specific EST software procedures to do this test.

Purpose

To check for ICP system or IPR malfunction and inspect for aerated oil

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- IPR Breakout Tee

Possible Causes

- Corroded or damaged IPR circuits
- Poor B+ and ground supplied to IPR

Procedure

1. Remove IPR harness connector. Inspect for connection problems.
2. Record connection problems on the Diagnostic Form.
   - If connection appears in tact, continue to next step.
   - If connection is unacceptable, repair as required. Test again to validate repair. Continue to next step.

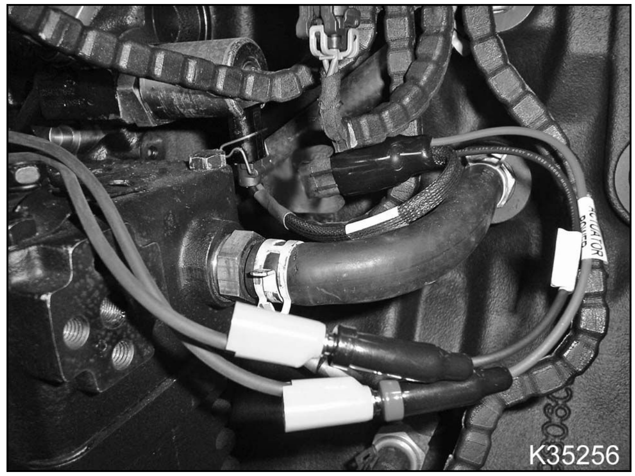


Figure 166 IPR Breakout Tee installed

3. Connect the IPR breakout tee to the IPR valve.

   NOTE: Connecting the IPR breakout tee to the IPR valve and engine harness will result in blown fuses when applying B+ and ground.
4. Connect IPR breakout tee to B+ and ground.
5. Turn ignition switch to ON. Do not start engine.
6. Open COM device.
7. Open KOER_RoadPerformance session.

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.

8. Crank the engine for 20 seconds maximum.
9. Record ICP results on Diagnostic Form.
   - If ICP reading is out of specification, continue with next test.
   - If ICP reading is in specification, correct IPR circuits. Test again to validate repair.

17.3 High-Pressure Oil Pump Test

NOTE: See “Diagnostic Software Operation” section in this manual for specific EST software procedures to do this test.

Purpose

To check high-pressure pump and IPR for inability to reach maximum injection control pressure

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- IPR Breakout Tee
- Pressure Sensor Breakout Tee
- Adapter tools
- ICP test sensor

Possible Causes

- Low engine oil pressure
- High-pressure oil system leak
- Failed IPR valve
- Failed high-pressure oil pump

Procedure

1. Retain IPR breakout tee with B+ and ground connections from previous test.
2. Remove high-pressure hose from the cylinder head fitting.

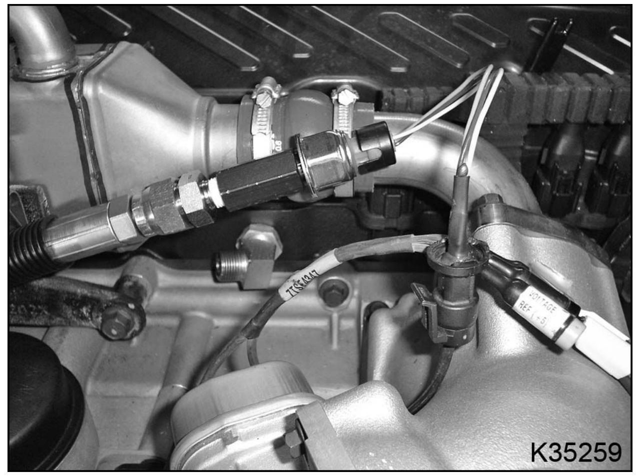


Figure 167 ICP adapter and test sensor installed

3. Install ICP adapter tools and ICP test sensor.
4. Disconnect MAP sensor.
5. Install Pressure Sensor Breakout Tee to engine harness only.
6. Route breakout harness to the ICP test sensor. Connect to ICP test sensor.
7. Use a DMM to monitor ICP sensor signal voltage.

   NOTE: MAP sensor signal voltage can also be monitored by the diagnostics software.

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.

8. Crank the engine for a maximum of 20 seconds.
9. Record the ICP test sensor voltage on Diagnostic Form.

   Continue to the next test.

17.4 IPR Block-Off Test

NOTE: See “Diagnostic Software Operation” section in this manual for specific EST software procedures to do this test.

Purpose

To check high-pressure pump and IPR for inability to reach maximum injection control pressure

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Pressure Sensor Breakout Tee
- Adapter tools
- ICP test sensor
- IPR block-off tool

Possible Causes

- Failed IPR valve

Procedure

1. Retain set-up and adapter tools from previous test.
2. Remove IPR valve from high-pressure oil pump.

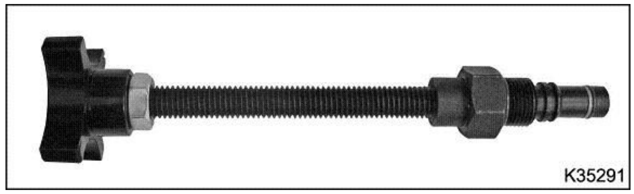


Figure 168 IPR block-off tool installed

3. Install IPR block-off tool.

   Use DMM to monitor ICP sensor signal voltage.

   NOTE: MAP sensor signal voltage can also be monitored by the diagnostic software.

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

4. Crank engine for 20 seconds maximum.
5. Record the ICP test sensor voltage on Diagnostic Form.
   - If results are out of specification, continue to the next test.
   - If results are in specification, replace IPR valve. Test again to validate repair.

17.5 High-Pressure Oil Rail Leak Test

Purpose

To check for high-pressure oil rail leaks under the valve cover

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Pressure Sensor Breakout Tee
- Adapter tools
- ICP test sensor
- IPR block-off tool

Possible Causes

- High-pressure oil rail supply O-ring leak
- Fuel injector supply O-ring leak
- Porous or cracked high-pressure oil rail

Procedure

1. Retain set-up, adapter tools, and IPR block-off tool from previous test.
2. Remove engine valve cover following the procedure in *Engine Service Manual*.

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

3. Crank engine for a maximum of 20 seconds.
4. Inspect the high-pressure oil rail for excessive leaks while cranking the engine.
5. Record the results on Diagnostic Form.
   - If no leaks are found, continue to the next test.
   - If leaks are found, correct problems. Test again to validate repairs.

18. Valve Lash and Engine Brake Lash

NOTE: If Tests 1-18 meet specifications, engine operation is good: Test 19 is not necessary.

Purpose

- To check for out-of-specification valve lash for intake and exhaust valves
- To check for out-of-specification actuator lash for Diamond Logic® engine brake

Tools

- Feeler gauge
- Straight-blade screwdriver
- Open end wrench (two sizes)
- Torque wrench
- Crows foot (two sizes)

Possible Causes

- Worn valve train
- Worn valve seat or valve face
- Worn actuator in Diamond Logic® engine brake
- Improper servicing

Valve Lash for Intake and Exhaust Valves

The crankshaft is rotated twice during valve lash adjustment procedure.

- Six valves are adjusted when piston 1 is at Top Dead Center (TDC) compression.
- Six valves are adjusted when piston 6 is at Top Dead Center (TDC) compression.

If engine is equipped with a Diamond Logic® engine brake, corresponding engine brake actuator lash can be adjusted when piston 1 and 6 are at TDC compression.

NOTE: Engine brake lash adjustments are not required when adjusting valve lash.

Adjusting Valve Lash

1. Remove valve cover and EGR tube support bracket following procedure in *Engine Service Manual*.

2. Turn the crankshaft in the direction of engine rotation to remove gear lash. Position piston 1 at TDC compression by observing cylinder 6 rocker arms in overlap as the vibration damper timing mark approaches the TDC mark on the front cover. Cylinder 6 exhaust valve will be closing (coming up) and the intake valve will be starting to open (going down).
3. If piston 1 is at TDC compression, see Chart 1 (Chart 1) and do steps 4, 5, and 6.

Chart 1 Valve and brake lash adjustments (inches) with piston 1 at TDC compression

Cylinder 1		Cylinder 2		Cylinder 3		Cylinder 4		Cylinder 5		Cylinder 6	
Intake 1	Exhaust 2	Intake 3	Exhaust 4	Intake 5	Exhaust 6	Intake 7	Exhaust 8	Intake 9	Exhaust 10	Intake 11	Exhaust 12
0.019	0.019	0.019			0.019	0.019			0.019		
Brake 0.019				Brake 0.019				Brake 0.019			

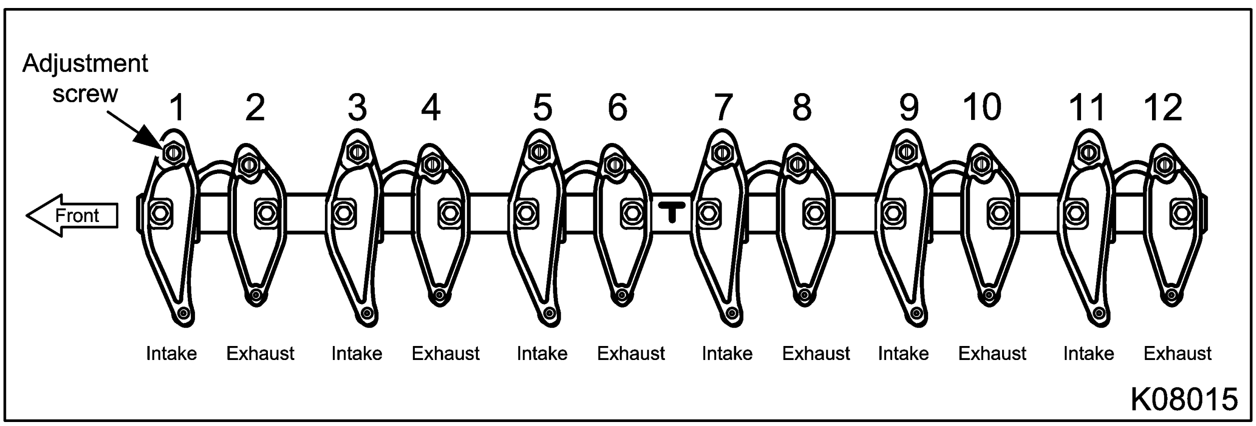


Figure 169 Valve lash adjustment

Chart 2 Valve and brake lash adjustments (inches) with piston 6 at TDC compression

Cylinder 1		Cylinder 2		Cylinder 3		Cylinder 4		Cylinder 5		Cylinder 6	
Intake 1	Exhaust 2	Intake 3	Exhaust 4	Intake 5	Exhaust 6	Intake 7	Exhaust 8	Intake 9	Exhaust 10	Intake 11	Exhaust 12
			0.019	0.019			0.019	0.019		0.019	0.019
		Brake 0.019				Brake 0.019				Brake 0.019	

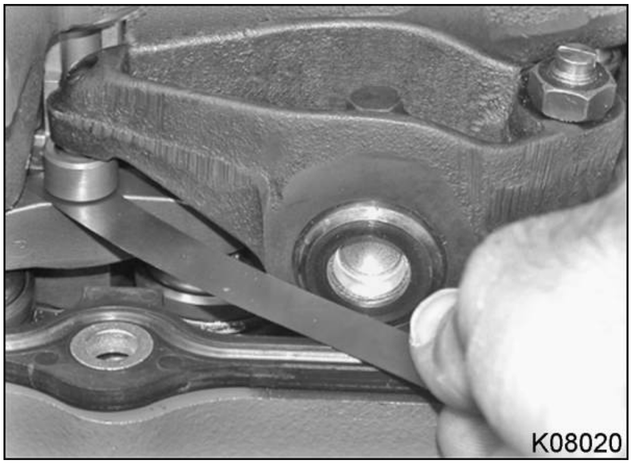


Figure 170 Valve lash measurement

4. Measure valve lash when the engine is cold. Put a 0.48 mm (0.019 in) feeler gauge between the rocker arm pivot foot and the valve bridge. A light drag should be felt on the feeler gauge. If adjustment is required, loosen lock nut and turn valve adjustment screw until a light drag is felt.
5. When valve lash is set, tighten valve adjustment screw lock nut to 27 N·m (20 lbf·ft) and remove feeler gauge. Check lash again. A light drag should be felt on the feeler gauge. If drag is too tight or loose, repeat steps 4 and 5.

   If engine is equipped with a Diamond Logic® engine brake, corresponding brake actuator lash can be adjusted before rotating crankshaft.
6. Turn crankshaft 360° in the direction of engine rotation to remove gear lash. Position piston 6 at TDC compression by observing cylinder 1 rocker arms in overlap as the vibration damper timing mark approaches the TDC mark on the front cover.
7. If piston 6 is at TDC compression, see Chart 2 and do steps 4, 5, and 6.
8. Install valve cover and EGR tube support bracket following procedure in *Engine Service Manual*.

Brake Lash

Crankshaft is rotated twice during brake lash adjustment procedure.

- Three brake actuator pistons are adjusted when piston 1 is at Top Dead Center (TDC) compression.
- Three brake actuator pistons are adjusted when piston 6 is at Top Dead Center (TDC) compression.

Corresponding intake and exhaust valve lash can be adjusted when piston 1 and 6 are at TDC compression.

NOTE: Valve lash adjustments are not required when adjusting engine brake lash.

1. Remove valve cover and EGR tube support bracket following procedure in *Engine Service Manual*.
2. Turn the crankshaft in the direction of engine rotation to remove gear lash. Position piston 1 at TDC compression by observing cylinder 6 rocker arms in overlap as the vibration damper timing mark approaches the TDC mark on the front cover. Cylinder 6 exhaust valve will be closing (coming up) and the intake valve will be starting to open (going down).
3. If piston 1 is at TDC compression, see Chart 1 and do steps 4, 5, and 6 for cylinders 1, 3, and 5.

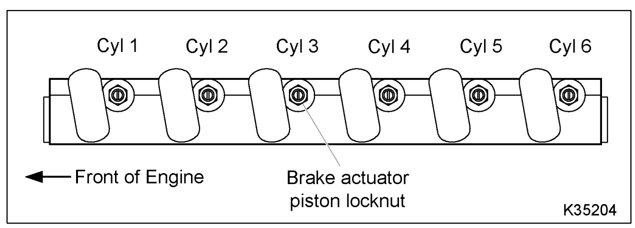


Figure 171 High-pressure oil manifold (brake)

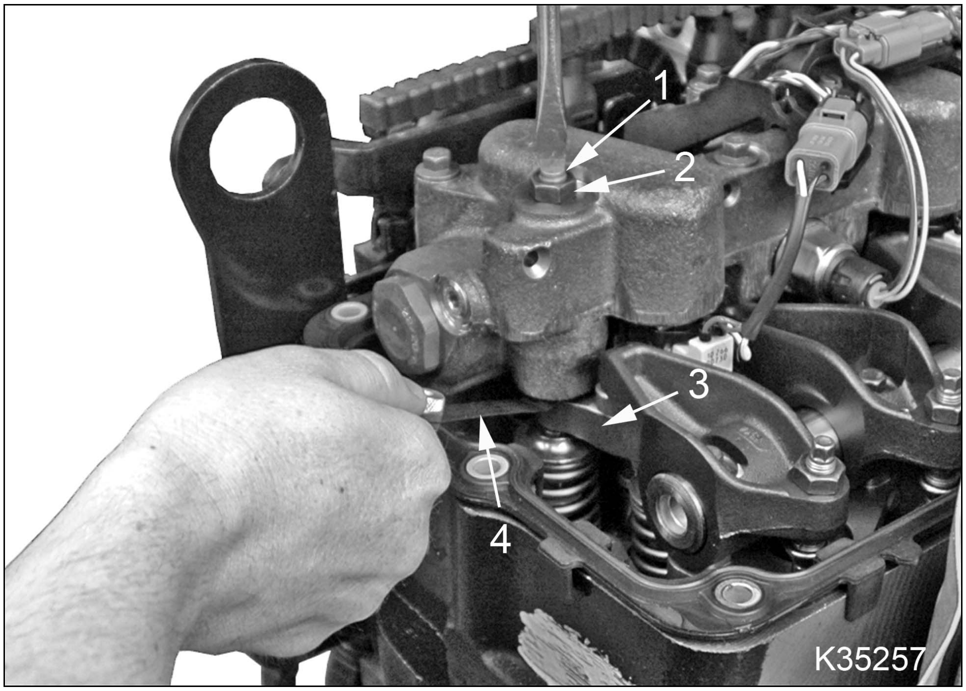


Figure 172 Brake lash measurement

1. Brake actuator piston screw
2. Brake actuator piston locknut
3. Valve bridge
4. Feeler gauge

4. Measure brake lash when engine is cold. Put a 0.48 mm (0.019 in) feeler gauge between the brake actuator piston and valve bridge. Check lash again. A light drag on the feeler gauge should be felt. If adjustment is required, loosen actuator piston locknut and turn actuator piston screw.
5. When brake lash is set, tighten actuator piston locknut to 27 N·m (20 lbf·ft) and remove feeler gauge. Check lash again. A light drag on the feeler gauge should be felt. If drag is too tight or loose, repeat steps 4 and 5.

   Corresponding valve lash can be adjusted before rotating crankshaft.
6. Turn the crankshaft 360° in the direction of engine rotation to remove gear lash. Position piston 6 at TDC compression by observing cylinder 1 rocker arms in overlap as the vibration damper timing mark approaches the TDC mark on the front cover.
7. If piston 6 is at TDC compression, see Chart 2 and do steps 4, 5, and 6.
8. Install valve cover and EGR tube support bracket following procedure in *Engine Service Manual*.

Table of Contents

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:

- DTC with possible cause
- Circuit diagram
- Component function
- Circuit operation
- Component location
- Diagnostic tool list
- Sensor End Diagnostics (with MasterDiagnostics® software)
- Pin-point Diagnostics (without MasterDiagnostics® software)
- Harness resistance check
- Operational voltage check (most components)

Electronic Control System Diagnostics Form

EGED-385 Diagnostic Form Example

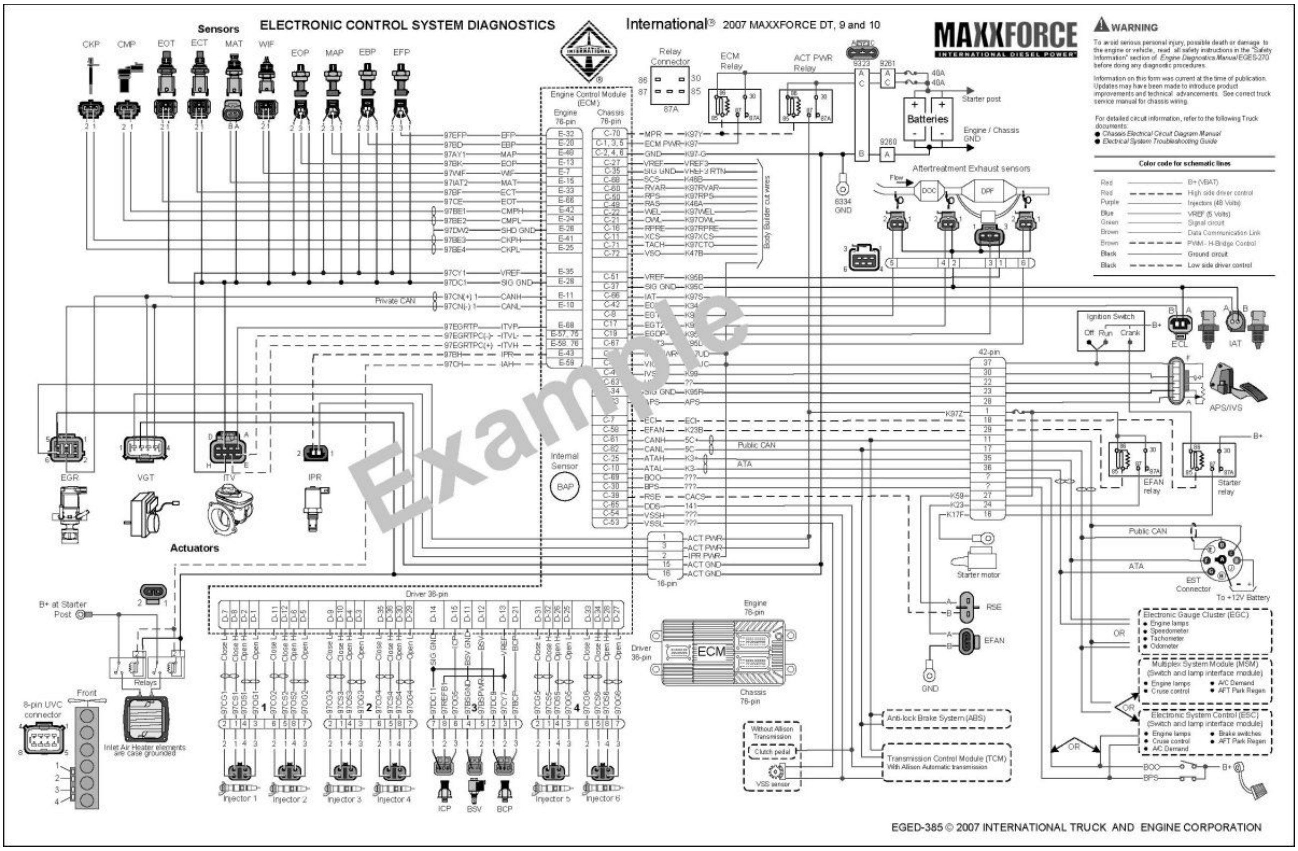


Figure 173 EGED-385 (Front Side)

Engine diagnostic forms assist technicians in troubleshooting Navistar diesel engines. Diagnostic schematics and signal values help technicians find problems to avoid unnecessary repairs.

The front side of the Electronic Control System Diagnostics form consists of a circuit diagram for electrical components mounted on the engine side and vehicle side. For a detailed description of vehicle circuits, circuit numbers, or connector and fuse locations, see truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide*. The back side of the form consists of signal values.

Diagnostic Form EGED-385 is available in 50 sheet pads. To order technical service literature, contact your International® dealer.

Sensor and Actuator Locations

Engine Mounted Components

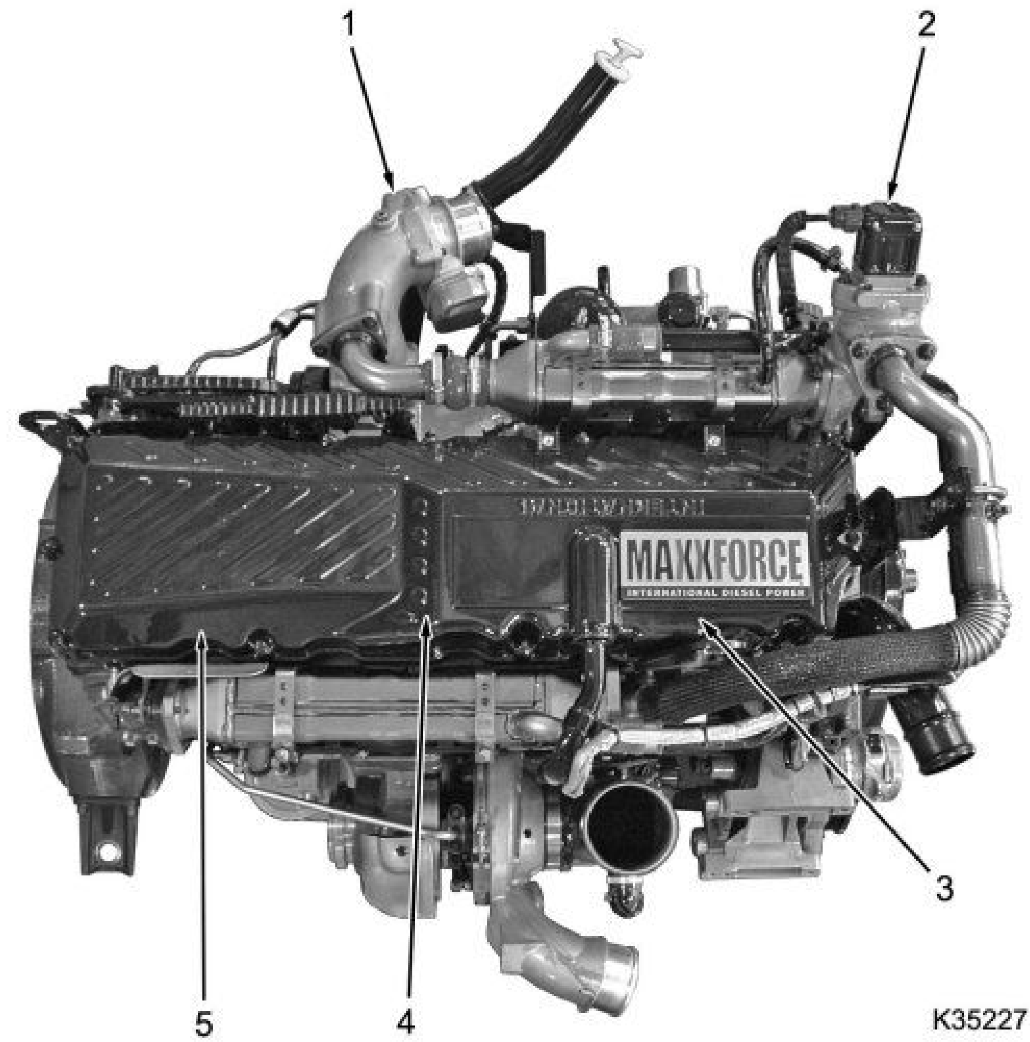


Figure 174 Component location – top

1. Intake Throttle Valve (ITV)
2. Exhaust Gas Recirculation (EGR) actuator
3. Brake Control Pressure (BCP) sensor (under valve cover)
4. Brake Shut-off Valve (BSV) (under valve cover)
5. Injection Control Pressure (ICP) sensor (under valve cover)

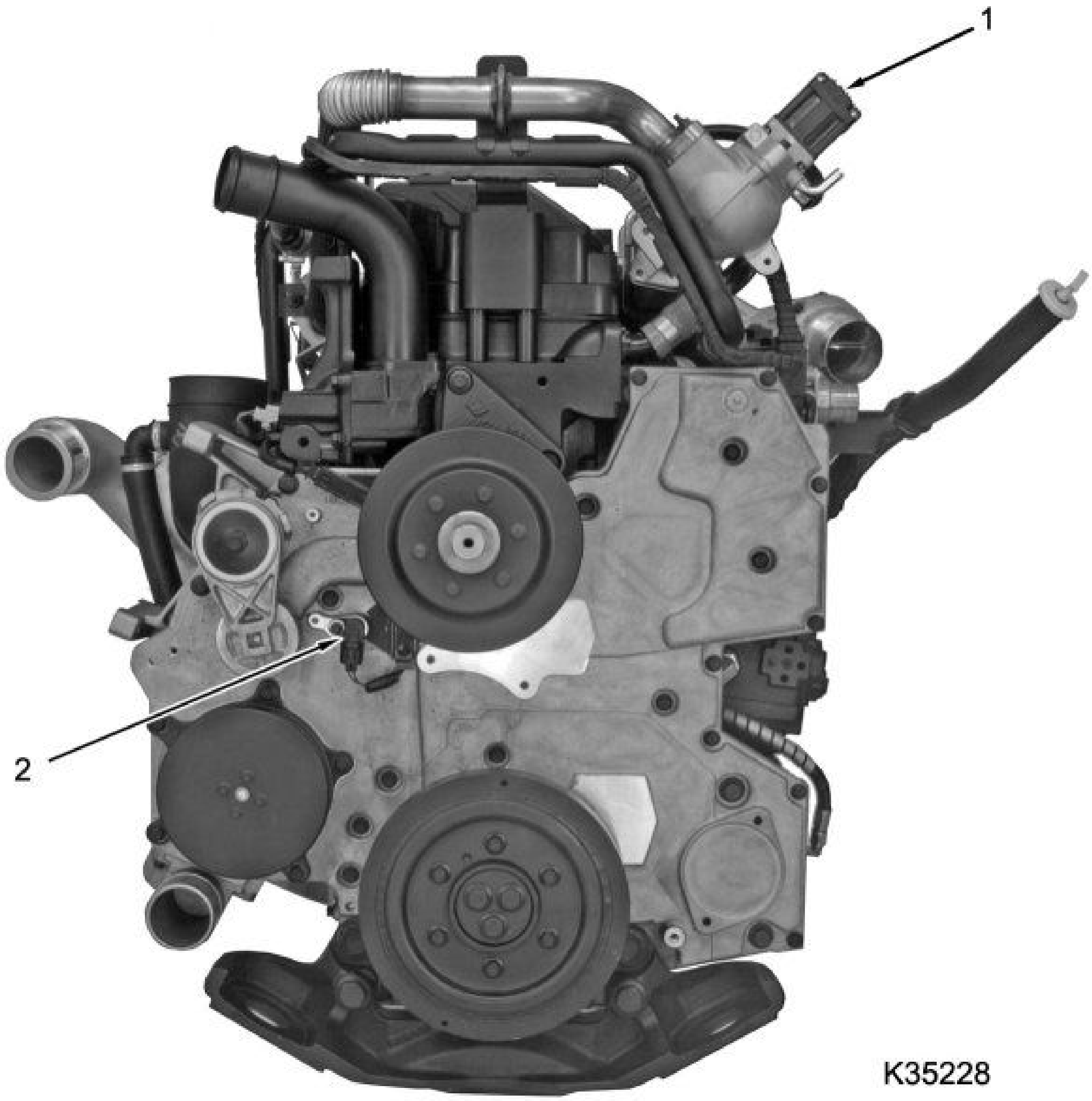


Figure 175 Component location – front

1. Exhaust Gas Recirculation (EGR) actuator
2. Camshaft Position (CMP) sensor

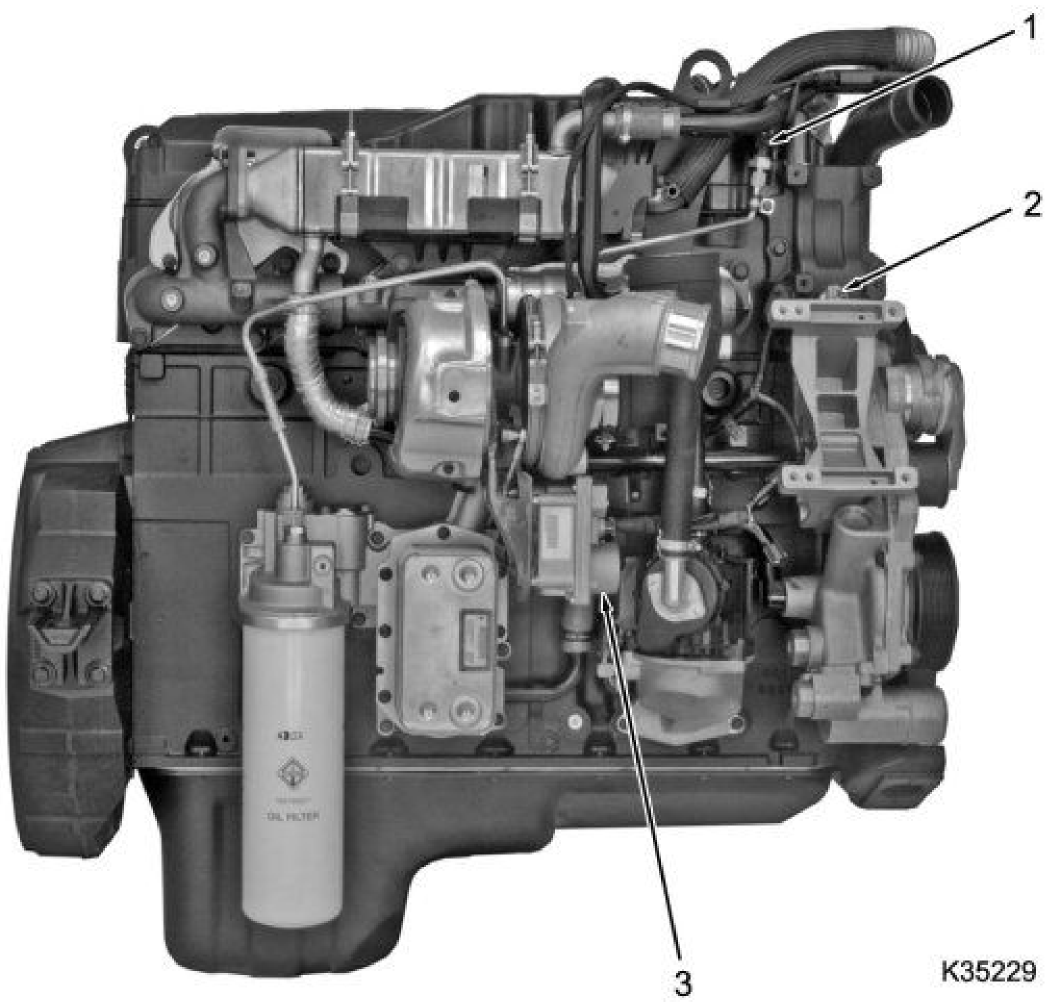


Figure 176 Component location – right

1. Exhaust Back Pressure (EBP) sensor
2. Engine Coolant Temperature (ECT) sensor
3. Variable Geometry Turbocharger (VGT) actuator

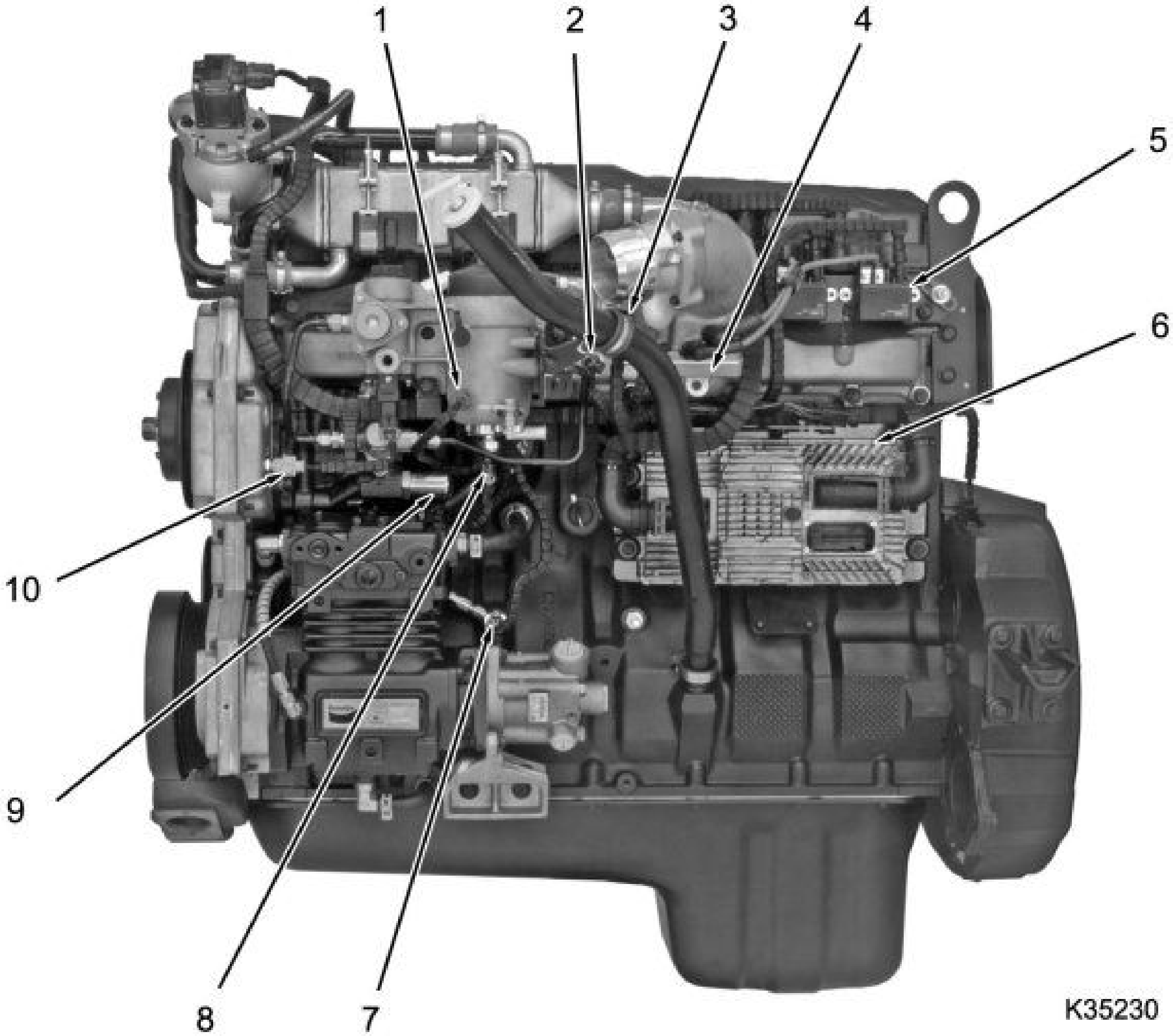


Figure 177 Component location – left

1. Water in Fuel (WIF) sensor
2. Manifold Absolute Pressure (MAP) sensor
3. Manifold Air Temperature (MAT) sensor
4. Intake Air Heater (IAH) grid
5. IAH relays
6. Engine Control Module (ECM)
7. Engine Oil Pressure (EOP) sensor
8. Engine Fuel Pressure (EFP) sensor
9. Injection Pressure Regulator (IPR)
10. Engine Oil Temperature (EOT) sensor

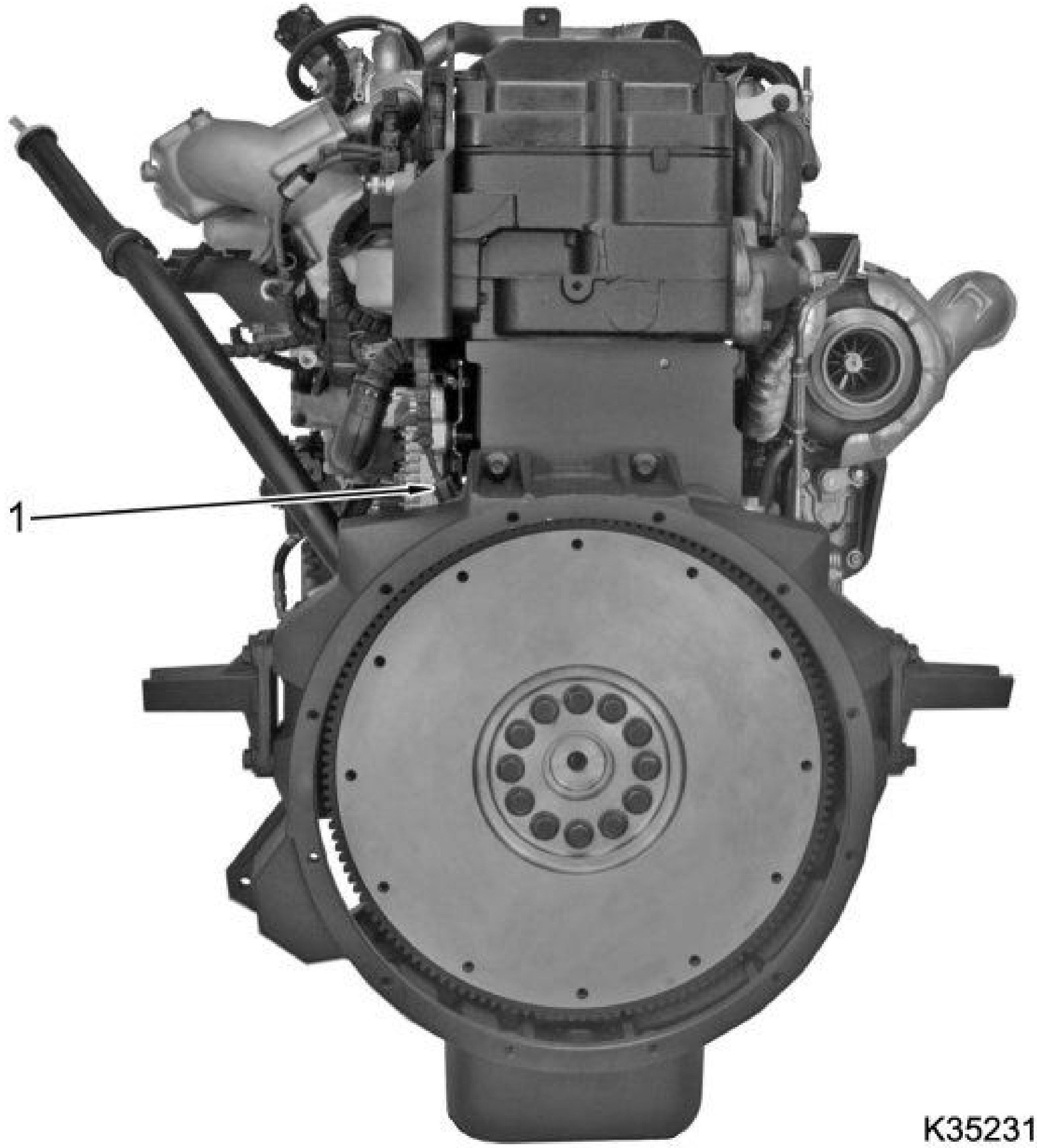


Figure 178 Component location – rear

1. Crankshaft Position (CKP) sensor

Vehicle Mounted Components

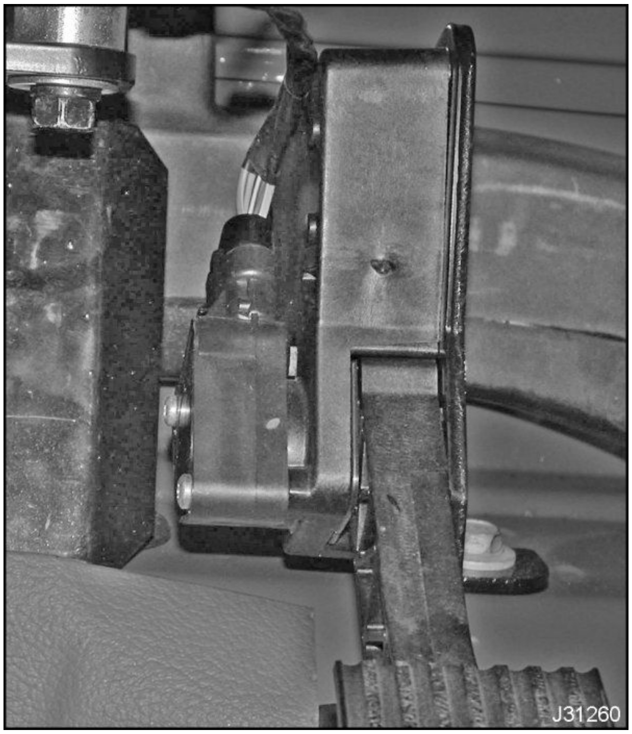


Figure 179 APS/IVS sensor

The APS/IVS sensor is mounted on the accelerator pedal.

Diagnostic Procedure Process

Description

The test procedures in this section are written based on the assumption that there is a DTC 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 you 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

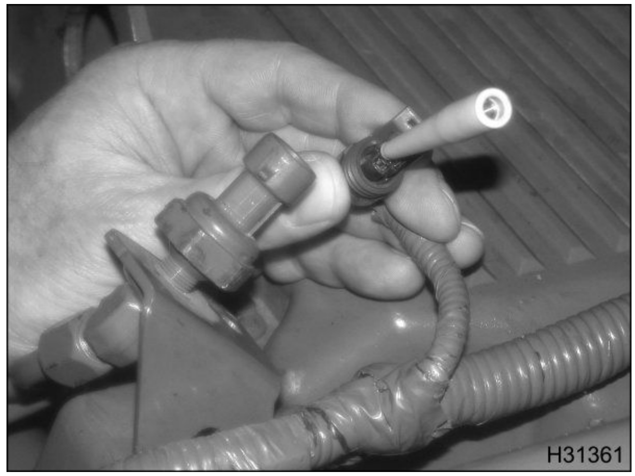


Figure 180 Pin grip check

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 Adapter Kit.

Diagnostics with EST

Sensors can be diagnosed quickly using an EST with MasterDiagnostics® software. The tool monitors sensor signal back to the ECM while testing the sensor's harness connection. Start this procedure with Sensor End Diagnostics.

Actuators can be diagnosed using an EST with MasterDiagnostics® 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 by only using a DMM. Start this test procedure with Pin-point Diagnostics.

Sensor End Diagnostics (with MasterDiagnostics®)

Sensor End Diagnostics (2-Wire)

1. Connect the EST to the EST connector.
2. Turn ignition switch to ON. Leave engine OFF.
3. Start MasterDiagnostics® software.
4. Open the Continuous Monitor session. This session lists all engine sensors.

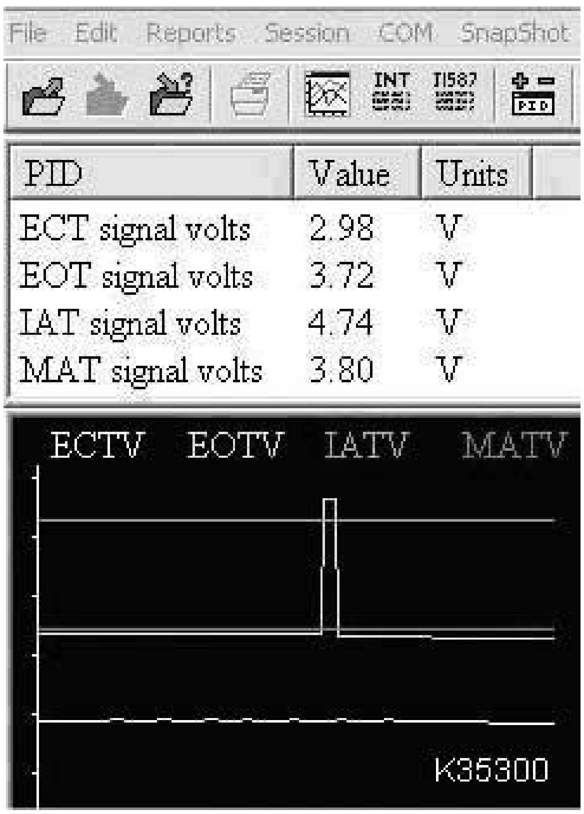


Figure 181 Sensor voltage

5. Monitor the sensor voltage and verify that an active DTC is present.

   NOTE: If sensor signal circuit is shorted or open, the PID value will read NA or Error.

   - If the code is inactive, monitor the PID 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 correct DTC goes active when corresponding fault is induced.

Test Point	Spec	Comments
EST – Check DTC	DTC 1312	If DTC 1311 is active, check EOT signal for short to GND. Do Harness Resistance Check.

- If corresponding DTC does not go active, repair short to ground on the sensor signal circuit. Do Harness Resistance Check if additional assistance is needed in diagnosing fault.
- If corresponding DTC goes active, continue to next test point.

7. Short 3-banana plug harness across the sensor signal circuit and engine ground.
8. The corresponding DTC should go active, unless the sensor signal circuit is open.

Example

Test Point	Spec	Comments
EST – Check DTC Short 3-banana plug harness across 2 and GND	DTC 1311	If DTC 1312 is active, check EOT signal for OPEN. Do Harness Resistance Checks.

- If corresponding DTC does not go active, repair open in sensor signal circuit. Do Harness Resistance Check if additional assistance is needed in diagnosing fault.
- If corresponding DTC goes active, continue to next test point.

9. Short 3-banana plug harness across the sensor signal circuit and SIG GND circuit.
10. The corresponding DTC should go active, unless the SIG GND circuit is open.

Example

Test Point	Spec	Comments
EST – Check DTC Short 3-banana plug harness across 1 and 2	DTC 1311	If DTC is active, check SIG GND for OPEN. Do Harness Resistance Checks.

- If corresponding DTC 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 okay, continue to the last step.

11. Connect the sensor and clear the DTCs, 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 DTCs. If active code remains, replace sensor.

Sensor End Diagnostics (3-Wire)

1. Connect the EST to the EST connector.
2. Turn ignition switch to ON. Leave engine OFF.
3. Start MasterDiagnostics® software.
4. Run Continuous Monitor session. (This session lists all engine sensors.)

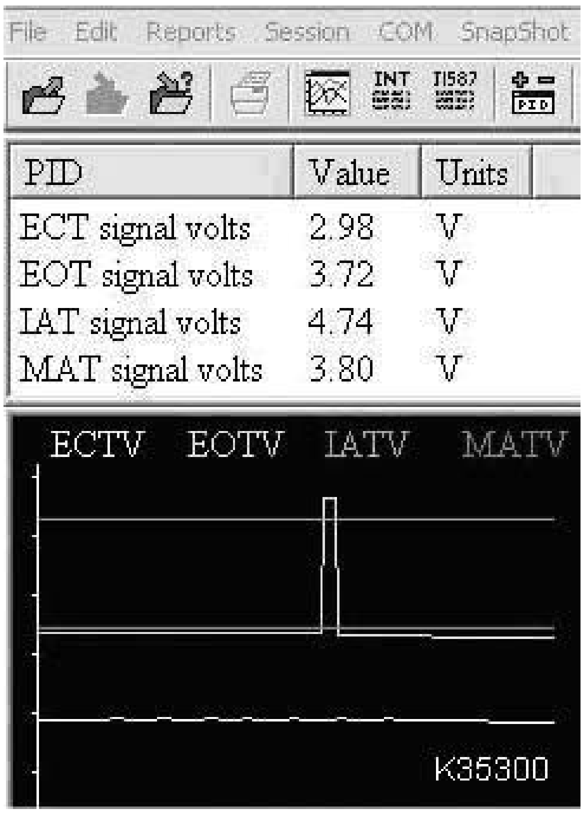


Figure 182 Sensor voltage

5. Monitor the sensor voltage and verify that an active DTC is present.

   NOTE: If sensor signal circuit is shorted or open, the PID value will read NA or Error.

   - If the code is inactive, monitor the PID 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	Comments
EST – Check DTC	DTC 1122	If DTC 1121 is active, check MAP signal for short to PWR

- If corresponding DTC does not go active, repair short to voltage on sensor signal circuit.
- If corresponding DTC goes active, continue to next test point.

7. Use a DMM to measure voltage on the VREF circuit. Voltage should read 5 volts, unless VREF is open or shorted to ground, or a voltage is greater than VREF.

Example

Test Point	Spec	Comments
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 Checks.

- 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 corresponding DTC should go active, unless the sensor signal circuit is open.

Example

Test Point	Spec	Comments
EST – Check DTC Short breakout harness across 2 and 3	DTC 1121	If DTC 1121 is active, check MAP signal for OPEN or short to GND. Do Harness Resistance Checks.

- If corresponding DTC does not go active, repair open in sensor signal circuit. Do Harness Resistance Check if additional assistance is needed in diagnosing fault.
- If corresponding DTC 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 ohm, unless the SIG GND is open.

Example

Test Point	Spec	Comments
DMM – Measure resistance 1 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Checks.

- 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 okay, continue to the last step.

11. Connect the sensor and clear the DTCs. 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 DTCs. If active code remains, replace sensor.

Pin-point Diagnostics (without MasterDiagnostics® software)

1. Connect breakout harness to the engine harness. Leave sensor disconnected.
2. Turn ignition switch to ON. Leave the 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 Checks.

- If the circuit is not within specification, the comment area will list possible cause or direct you 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 you 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 EST connector.
4. Turn ignition switch to ON. Leave engine off.
5. Start MasterDiagnostics® software.
6. Open the Output State session. This session allows you to monitor the state of all engine actuators.
7. Run the Output State test (high or low) or Glow Plug / Intake Air Heater test.
8. Use a DMM to measure voltage on each circuit to engine ground.

Example

Test Point	Test	Spec	Comment
A to GND	KOEO	B+	If < B+, check for OPEN circuit
B to GND	KOEO	B+	If < B+, check actuator coil for OPEN.
B to GND	Output State HIGH	B+	If < B+, check actuator control circuit for short to GND.
B to GND	Output State LOW	7.5 V	If > 7.5 V, check actuator control circuit for OPEN or short to PWR or failed across coil.

- If any circuit is not within specification, the comment area will list possible cause or direct you 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 a 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 EST with MasterDiagnostics® software.
4. Run the Continuous Monitor test.
5. Verify actual sensor or actuator readings are within specification.

Example

Test Point	Condition	DMM	PID
APS	Foot off pedal	0.64 V ± 0.5 V	0%
A to GND or C-48 to GND	Pedal to floor	3.85 V ± 0.5 V	102%
IVS	Foot off pedal	0 V	0 V
D to GND or C-47 to GND	Pedal to floor	B+	B+

Circuit Diagnostics

ACT PWR Relay (Actuator Power)

DTC	SPN	FMI	Condition
	None		No engine actuator power supplied from vehicle harness to engine harness.

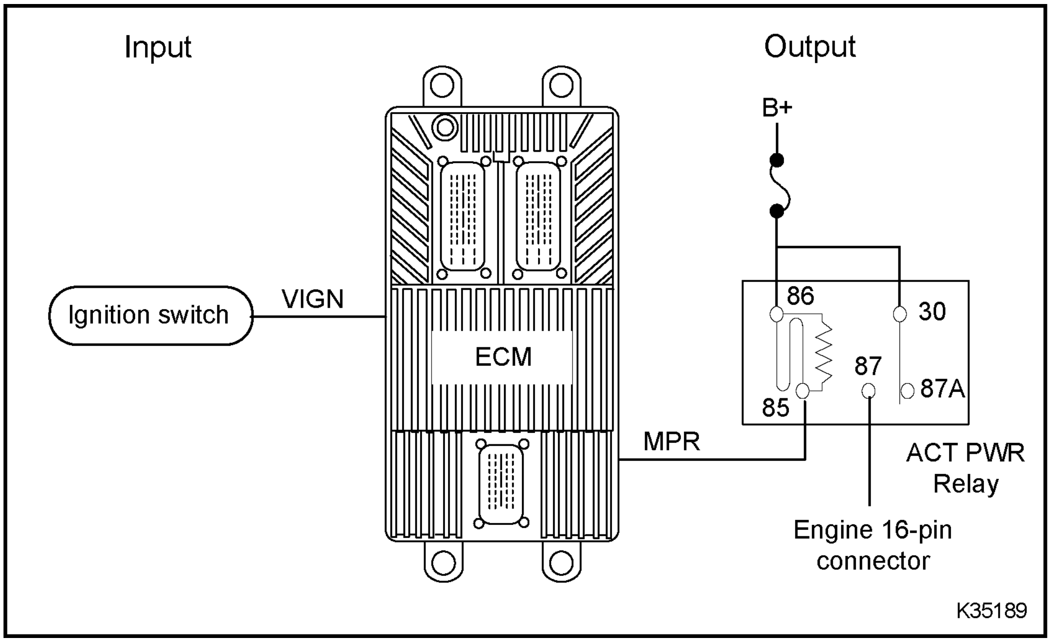


Figure 183 Function diagram for the ACT PWR

The function diagram for ACT PWR relay includes the following:

- Electronic Control Module (ECM)
- ACT PWR relay
- Ignition switch or power relay
- Battery
- Fuses

Function

The ACT PWR circuit supplies the engine mounted actuators with switched battery voltage.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- Breakout Box (page 426)
- Relay Breakout Harness (page 431)
- Terminal Test Adapter Kit (page 432)

ACT PWR Relay Pin-point Diagnostics

DTC	Condition	Possible Causes
None	No power supplied at engine 16-pin connector.	• Power loss to ECM • Blown fuse • Poor electrical connections (ECM PWR, ECM GND, or VIGN)

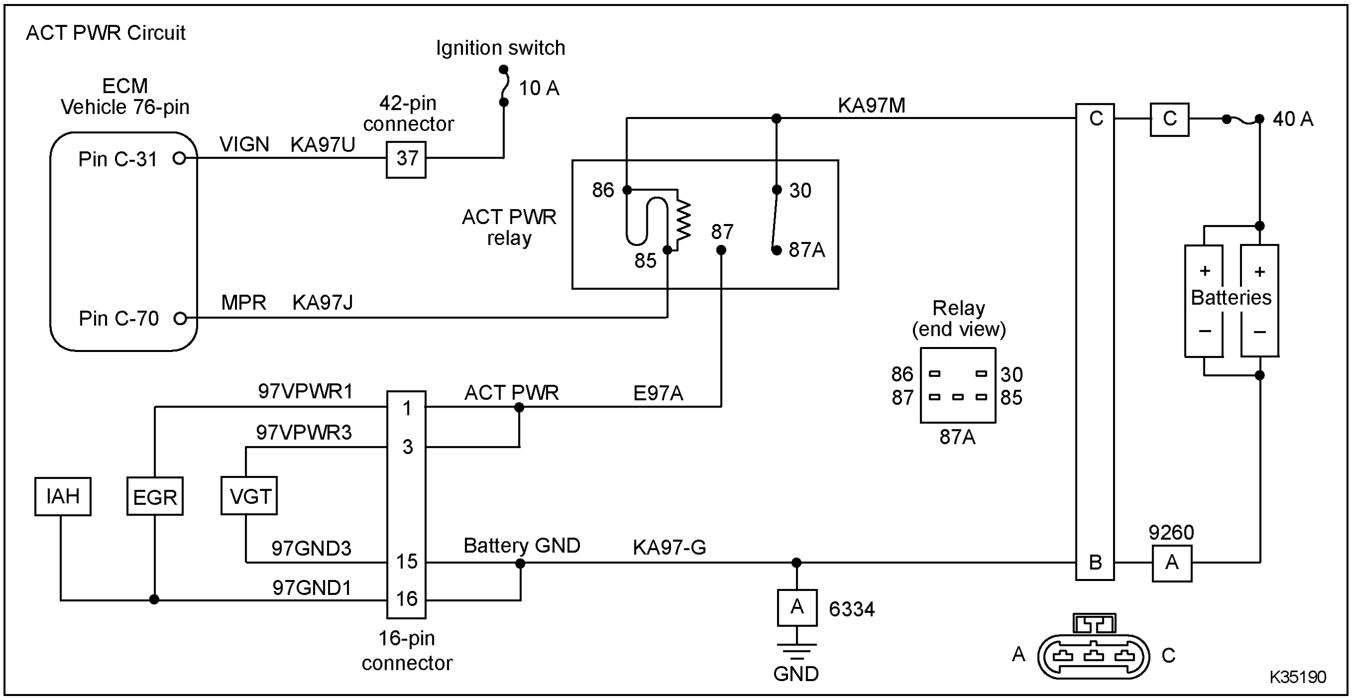


Figure 184 ACT PWR circuit diagram

1. Verify that 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 271) in this section of manual.
   - If the ECM is powered, but there is no power going to the 16-pin connector, proceed to the next step.
2. Disconnect the engine to vehicle 16-pin connector.

NOTE: Inspect connector for damaged pins, corrosion, or loose pins. Repair if necessary.

3. Do Voltage Checks at 16-Pin Connector.

Voltage Checks at 16-Pin Connector

Connect breakout harness to 16-pin connector. Leave the engine harness disconnected. Turn ignition switch ON. Use DMM to measure voltage.

CAUTION: To avoid engine damage, turn the ignition switch to OFF before removing main power relay or any ECM connector supplying power to the ECM. Failure to turn the ignition switch to OFF will cause a voltage spike and damage to electrical components.

Test Point	Spec	Comment
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 16	B+	If < B+, check for OPEN ACT PWR GND circuit.
2 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.
2 to 15	B+	If < B+, check for OPEN ACT PWR GND circuit.

Voltage Checks at Relay

Connect breakout harness between relay and relay socket. Turn ignition switch ON. Use DMM to measure voltage.

Test Point	Spec	Comment
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. Do Harness Resistance Check on Relay Power Circuits (page 208) .
30 to GND	B+	If 0 V, 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. Do Harness Resistance Check on Relay Power Circuits (page 208).
85 to GND	0 V to 2 V	If > 2 V, check MPR control circuit for OPEN or short to PWR. Do Main Power Relay Resistance Check (page 207).
87 to GND	B+	If < B+, replace relay.
		If B+, check for OPEN circuit between relay and the 16-pin connector. Do Harness Resistance Check on Relay Power Circuits (page 208).

Main Power Relay Resistance Check

Turn ignition switch to OFF. Connect breakout box and breakout harness. Leave ECM, ECM PWR, and ACT PWR relay disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
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.

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	Spec	Comment
30 to battery positive post	< 5 Ω	If > 5 Ω, check for OPEN circuit, corroded terminals, or blown fuse.
Relay (30) to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
86 to battery positive post	< 5 Ω	If > 5 Ω, check for OPEN circuit, corroded terminals, or blown fuse.
Relay (86) to GND	> 1 kΩ	< 1 kΩ, check for short to GND.

ACT PWR Circuit Operation

The ACT PWR relay is controlled by the ECM, similar to the way the ECM controls it's relay. 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 VIGN power at Pin C-31. 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 (16-pin connector).

Pin 15 and Pin 16 on the 16-pin connector are ACT GND circuits.

Fault Detection / Management

No DTCs are set for ACT PWR circuit failure. If ACT PWR is lost, VGT and EGR will set KOEO Standard Test DTCs.

AFT System (Aftertreatment)

DTC	SPN	FMI	Condition
2687	8302	1	DPF, low flow resistance
2688	8302	0	DPF over temperature - possible filter damage
2772	3524	0	Excessive time a manual inhibit was set for DPF regen
2782	8317	13	DPF servicing required
2783	8318	13	DPF load: above warning level
2784	8319	13	DPF load: above critical level 1 - engine de-rate
2785	8320	13	DPF load: above critical level 2 - further engine de-rate
3786	8326	2	DPF Test - test unsuccessful

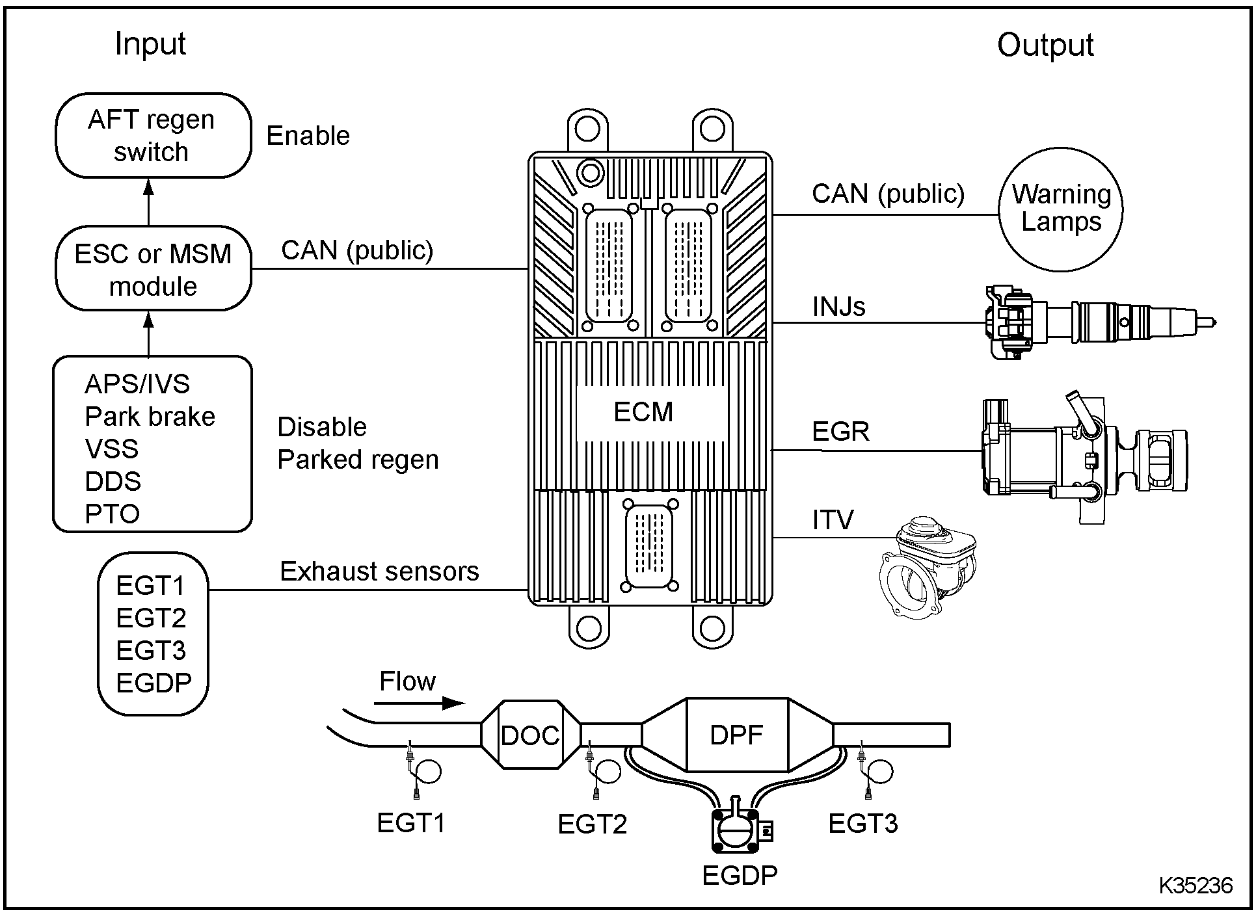


Figure 185 Function diagram for AFT System

The function diagram for the AFT System includes the following:

- Engine Control Module (ECM)
- Diesel Oxidation Catalyst (DOC)
- Diesel Particulate Filter (DPF)
- Exhaust Gas Temperature 1 (EGT1) sensor

- Exhaust Gas Temperature 2 (EGT2) sensor
- Exhaust Gas Temperature 3 (EGT3) sensor
- Exhaust Gas Differential Pressure (EGDP) sensor
- Fuel Injectors (INJs)
- Exhaust Gas Recirculation (EGR)
- Intake Throttle Valve (ITV)
- Warning lamps
- Inhibit regeneration switch
- Electronic System Control (ESC) body module
- Multiplex System Module (MSM) body module
- Accelerator Position Sensor (APS) / Idle Validation Switch (IVS)
- VSS
- Driveline Disconnect Switch (DDS)
- Power Takeoff (PTO)

Function

The Aftertreatment System is designed to decrease the exhaust particulate emissions leaving the tailpipe. The DPF captures particulate matter (soot) and ash from the exhaust. Eventually soot and ash exceeds DPF capacity and must be removed. Soot build-up is removed by heating the filter until the soot turns into carbon dioxide gas. This is the DPF regeneration process. Ash build-up is periodically removed from the filter by a special cleaning machine.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)

AFT System Diagnostics

DTC	Condition	Possible Causes
2687	DPF, low flow resistance	• Biased EGDP sensor • Leaks in EGDP sensor hose • Reversed pressure lines on EGDP sensor • Exhaust leak before DPF • Damaged DPF
2688	DPF over temperature - possible filter damage	• Biased high EGT2 sensor • Restricted DPF • Restricted exhaust • Engine over-fueling
2772	Excessive time a manual inhibit was set for DPF regen	• Operator has set the inhibit switch to Off for too long.
2782	DPF servicing required	• DPF needs to regenerate
2783	DPF load: above warning level	
2784	DPF load: above critical level 1 - engine de-rate	
2785	DPF load: above critical level 2 - further engine de-rate	
3786	DPF Test - test unsuccessful	• Other active DTCs • Over-full DPF – service required

Alert Levels of DPF Soot Loading

There are four levels of indication that the DPF is accumulating a level of soot and needs to be cleaned, each with an increasing urgency for action.

Levels	Conditions	Action
Regeneration lamp on solid	Exhaust regeneration required	Drive on highway at highway speeds so the system can auto-regenerate. OR Start a parked regeneration to prevent loss of power.
Regeneration lamp flashing	DPF is full	Pull vehicle safely off roadway and start a parked regeneration to prevent loss of power.
Regeneration lamp flashing Warn Engine lamp on solid Audio alarm beeps 5 times every minute	DPF is full engine performance is limited	Pull vehicle safely off roadway and start a parked regeneration to prevent engine stopping.

Alert Levels of DPF Soot Loading (cont.)

Regeneration lamp flashing Engine STOP lamp on solid Audio alarm beeps continuously	DPF is overfull engine may shutdown soon	Pull vehicle safely off roadway turn on flashers, place warning devices and STOP ENGINE, DO NOT USE Parked Regeneration. Call for service.
When the High Exhaust System Temperature lamp is illuminated, the exhaust is above 400 °C (750 °F) and a regeneration could be in process.		

DTC 2687 – DPF, low flow resistance

DTC 2687 is set when the measured DPF differential pressure is less than a minimum value for a certain exhaust flow rate.

Pin-point AFT System Fault

1. Inspect exhaust and EGDP sensor for damage. Check for leaks in exhaust or EGDP sensor hose. Check that EGDP sensor hoses are not reversed.
2. Check for active EGDP sensor DTCs. See EGDP Sensor (page 297) in this section of the manual.
3. Check for damaged DPF. Remove and inspect for cracks that could allow exhaust gas to bypass the filter.

DTC 2688 – DPF over temperature - possible filter damage

DTC 2688 is set when the temperature before or after the DPF is greater than the calibrated limit.

Pin-point AFT System Fault

1. Inspect EGT sensors for damage.
2. Inspect exhaust system for damage that could cause restriction.
3. Verify EGT sensors are within specification. See "Performance Specifications" (page 465) appendix in this manual.
4. Check engine performance and verify engine is not over-fueling.
5. Check for damaged DPF. Remove and inspect for blockage.

DTC 2782 – DPF servicing required

DTC 2782 is set when Level 1 DPF soot loading is above 80% full and a DPF regeneration is required.

Pin-point AFT System Fault

1. Check for active DTCs that could prevent AFT system regeneration.
2. Drive vehicle at highway speeds for 20 to 30 minutes until the regeneration lamp is not illuminated or do a Parked Regeneration. See Manual Parked Regeneration procedure in this section.

DTC 2783 – DPF load: above warning level

DTC 2783 is set when Level 2 DPF soot loading is 100% full and a DPF regeneration is required.

Pin-point AFT System Fault

1. Check for active DTCs that could prevent AFT System regeneration.
2. Do a Parked Regeneration. See Manual Parked Regeneration procedure in this section.

DTC 2784 – DPF load: above critical level 1 - engine de-rate

DTC 2784 is set when Level 3 DPF soot loading is over 100% full and engine de-rate has been enabled. DPF regeneration is required.

Pin-point AFT System Fault

1. Check for active DTCs that could prevent AFT System from regenerating.
2. Do a Parked Regeneration. See Manual Parked Regeneration procedure in this section.

DTC 2785 – DPF load: above critical level 2 - further engine de-rate

DTC 2785 is set when level 4 DPF soot loading is overfull and engine shutdown is enabled.

Pin-point AFT System Fault

1. Remove DPF and service the filter.
2. Check for active DTCs that could prevent the AFT System from regenerating.
3. Do an Onboard Cleanliness Test to reset soot and ash monitors. See Onboard Cleanliness Test procedure.

DTC 3786 – DPF Test - test unsuccessful

DTC 3786 is set when a Parked Regeneration can not regenerate the DPF

Pin-point AFT System Fault

1. Check for the following active DTCs: 1114, 1115, 1141, 1142, 1299, 1311, 1312, 1397, 1398, 1742, 1741, 2159, 2544, 2545, 2673, 2674
2. If only DTC 3786 is set after doing a Parked Regeneration, remove the DPF and service the filter.

AFT System Operation

When driving at high speeds or with heavy loads, the exhaust is hot enough to convert the soot to ash.

When driving at lower speeds or lighter loads, the exhaust is typically not hot enough to convert the soot to ash. In these situations, the engine control system will increase the exhaust temperature and the particulate matter can be converted to ash.

Automatic regeneration occurs when driving. The operator is not required to do anything to start regeneration.

An automatic regeneration is not possible during frequent stops or low operating speeds. If a regeneration is required in these conditions, a manual parked regeneration must be done.

Active Rolling Regeneration

When the ECM determines the DPF needs to be regenerated, the aftertreatment lamp illuminates. The ECM will control the engine operation to increase exhaust temperature. This enables the DPF to convert accumulated particulate matter to ash.

The following entry conditions are required for active rolling regeneration:

- No disabling DTCs (1741, 1742, 2673, or 2674)
- ECT above 75 °C (170 °F)
- PTO not active; Standby mode OK
- Inhibit regeneration switch not active
- EGT1 below 500 °C (932 °F)
- EGT2 below 650 °C (1202 °F)
- EGT3 below 750 °C (1382 °F)

Manual Parked Regeneration

Manual parked regeneration occurs when the operator requests the control system to do a stationary regeneration. Exhaust temperature is increased and particulate matter is converted to ash.

The following entry conditions are required for manual parked regeneration:

- DPF lamp ON, signaling need to regenerate
- No disabling DTCs (1114, 1115, 1141, 1142, 1299, 1311, 1312, 1397, 1398, 1742, 1741, 2159, 2544, 2545, 2673, 2674)
- ECT above 75 °C (170 °F) (Inline six applications)
- ECT above 65 °C (150 °F) (V applications)
- Engine running
- Vehicle speed below 2 mph
- Parking brake must be set
- Brake pedal not depressed
- Accelerator pedal not depressed
- PTO not active
- Driveline disengaged
- Inhibit regeneration switch in OFF position
- EGT2 and EGT3 below 500 °C (932 °F)

Manual Parked Regeneration Procedure

⚠ WARNING: To prevent personal injury or death, make certain the vehicle is safely off the roadway, away from people, and flammable materials or structures. The regeneration process creates an elevated exhaust temperature.

It is necessary to do a Parked Regeneration when the exhaust filter indication (level 2) is ON or the engine will lose power and shut down.

To start Parked Regeneration (cleaning) of exhaust DPF, do the following steps:

1. Park the vehicle safely off the road and away from flammable materials and vapors.
2. Before starting parked regeneration (using ON/PARKED REGEN switch), the following conditions must be in place:
   - Parking brake must be set
   - Transmission must be in neutral or park
   - Engine coolant temperature must be minimum 71 °C (160 °F)
   - Accelerator, foot brake, or clutch pedal (if equipped) must not be depressed
3. Press the ON position of the ON/PARKD REGEN switch to initiate the regeneration cycle.

   The engine speed will automatically ramp up to a preset rpm. The switch indicator will illuminate when the cycle has started. If the indicator is blinking, verify all conditions in Step 2 are met. If the indicator cycle switch continues blinking, cycle the switch.

   The regeneration cycle will last approximately 20 minutes.
4. When the regeneration cycle is complete, the indicator switch will turn off. The engine rpm will return to normal idle and all exhaust filter indicators will turn off. The vehicle is now ready for normal driving operation.

Diesel Oxidation Catalyst (DOC)

The DOC converts fuel to heat for DPF regeneration.

Diesel Particulate Filter (DPF)

The DPF filters and stores particulate matter (soot) and ash (non-combustibles) from leaving the tailpipe.

Regeneration

Regeneration is the process of converting particulate matter trapped in the DPF to ash.

Passive Rolling Regeneration

Passive rolling regeneration occurs when the engine provides sufficient temperature through the exhaust gases to convert the particulate matter to ash.

Onboard Cleanliness Test (EST enabled)

The onboard cleanliness test performs a manual regeneration and measures DPF ash/soot levels before and after test. This test is required after a DPF has been serviced or replaced to reset DPF monitors.

Parked Regeneration Switch

The parked regeneration switch enables the operator to request a stationary regeneration for the DPF.

Inhibit Regeneration Switch (optional)

The inhibit regeneration switch enables the operator to cancel and prevent a DPF regeneration.

DPF Soot Loading Percentage

ECM calculation of the soot level in DPF.

DPF Ash Loading Percentage

ECM calculation of the ash level in DPF.

DPF Status Lamp

The DPF status lamp provides information on need to regenerate the DPF. Several levels of status are available. The lamp will change states from OFF to solid-ON to flashing. The lamp is used in combination with the Check Engine and Stop Engine lamps.

High Exhaust System Temperature Indicator (HEST)

The HEST alerts the operator when the exhaust temperature is elevated above 400 °C (750 °F). This may or may not be due to DPF regeneration.

AMS (Air Management System)

DTC	SPN	FMI	Condition
2351	7129	1	EBP below desired level
2352	7129	0	EBP above desired level
2388	2659	0	EGR flow excessive - possible leak to atmosphere
2389	2659	1	EGR flow insufficient - possible plugged system
3338	7129	17	KOER STD - EBP unable to build during test
3339	7129	15	KOER STD - EBP too high during test
3346	1209	0	AMT - EBP unable to build during EGR test
3348	1209	1	AMT - EBP too high during EGR test

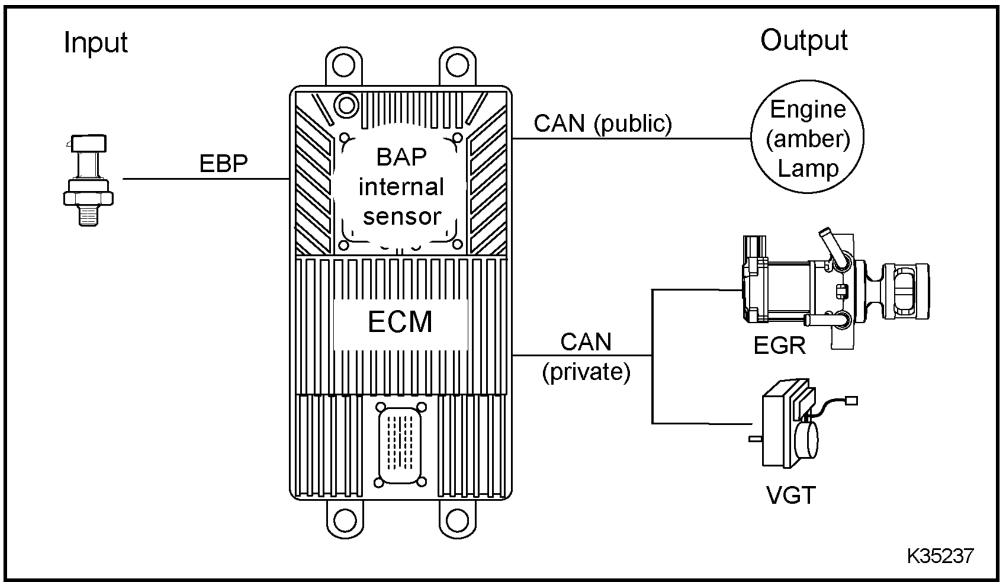


Figure 186 Function diagram for AMS

The Air Management System (AMS) includes the following:

- Electronic Control Module (ECM)
- Barometric Absolute Pressure (BAP) internal sensor
- Exhaust Back Pressure (EBP) sensor
- Variable Geometry Turbocharger (VGT) actuator
- Exhaust Gas Recirculation (EGR) actuator
- Engine warning lamp (amber)

Function

The Air Management test controls the VGT and EGR through a open and closed positioning sequence while monitoring the EBP sensor. If the EBP does not meet the expected range, a DTC will be set.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)

AMS Diagnostics

DTC	Condition	Possible Causes
2351 3338	EBP below desired level KOER STD - EBP unable to build during test	• CAC system leaks • Exhaust or intake air system leaks • Biased EBP circuit or sensor • Turbocharger vanes sticking
2352 3339	EBP above desired level KOER STD - EBP too high during test	• Biased EBP circuit or sensor • Restricted exhaust system • Turbocharger vanes sticking
2388	EGR flow excessive - possible leak to atmosphere	• Restricted air flow (intake or exhaust) • Charge air cooler (CAC) system leaks (hoses and cooler) • Biased EGR valve position sensor • Biased EBP circuit or sensor • Biased MAP circuit or sensor • EGR valve sticking or stuck
2389	EGR flow insufficient - possible plugged system	• Restricted air flow (intake or exhaust) • Restricted EGR cooler • Biased EGR valve position sensor • Biased EBP circuit or sensor • Biased MAP circuit or sensor • EGR valve sticking or stuck
3346	AMT - EBP unable to build during EGR test	• EGR valve inoperative or sticking • Biased EBP circuit or sensor • EBP sensor or tube plugged • Restricted exhaust system
3348	AMT - EBP too high during EGR test	• Biased EBP circuit or sensor • Exhaust or intake air system leaks • Inoperative EGR valve • Failed turbocharger

DTC 2351 - EBP below desired level

The DTC will set when EBP is 10 psi below desired level.

DTC 3338 - KOER STD - EBP unable to build during test.

This DTC will set when EBP is 10 psi below desired level during the KOER Standard Test.

Pin-point AMS Fault

1. Check for other active or inactive EBP, MAP, VGT or EGR DTCs. Repair any fault before continuing with this procedure.
2. Check for biased sensor. Verify BAP, MAP and EBP are within KOEO Specification. See KOEO in “Performance Specifications” appendix of this manual.
3. Check VGT operation. Run KOEO Standard test while visually inspecting VGT lever for full open and close movement.
4. Check EGR operation. Monitor EGRP PID and run KOEO Output State test HIGH and LOW. See “EGR Actuator (Exhaust Gas Recirculation)” in this section of manual.
5. Check intake and exhaust system for leaks.

DTC 2352 - EBP above desired level

DTC 2352 is set when EBP is 10 psi above desired level.

DTC 3339 - KOER STD - EBP too high during test.

This DTC will set when EBP is 4 psi above desired level during the KOER Standard Test.

Pin-point AMS Fault

1. Check for other active or inactive EBP, MAP, VGT or EGR DTCs. Repair any fault before continuing with this procedure.
2. Check for biased sensor. Verify BAP, MAP and EBP are within KOEO Specification. See KOEO in “Performance Specifications” appendix of this manual.
3. Check VGT operation. Run KOEO Standard test while visually inspecting VGT lever for full open and close movement.
4. Check EGR operation. Monitor EGRP PID and run KOEO Output State test HIGH and LOW. See “EGR Actuator (Exhaust Gas Recirculation)” in this section of manual.
5. Check for restricted exhaust. See “AFT (Aftertreatment) System” in this section of manual.

DTC 2388 - EGR flow excessive - possible leak to atmosphere

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, MAP, VGT or EGR DTCs. Repair any fault before continuing with this procedure.
2. Check for biased sensor. Verify BAP, MAP and EBP are within KOEO Specification. See KOEO in “Performance Specifications” appendix of this manual.
3. Check EGR operation. Monitor EGRP PID and run KOEO Output State test HIGH and LOW. See “EGR Actuator (Exhaust Gas Recirculation)” in this section of manual.

DTC 2389 - EGR flow insufficient - possible plugged system

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, MAP, VGT or EGR DTCs. Repair any fault before continuing with this procedure.
2. Check for biased sensor. Verify BAP, MAP and EBP are within KOEO Specification. See KOEO in “Performance Specifications” appendix of this manual.
3. Check for restricted EGR cooler. See Restricted EGR Cooler in “Engine Symptoms Diagnostics” section of this manual.
4. Check EGR operation. Monitor EGRP PID and run KOEO Output State test HIGH and LOW. See EGR Actuator (Exhaust Gas Recirculation) in this section of manual.
5. Check for restricted exhaust. Performance specification at Full load rated speed.

DTC 3346 - AMT - EBP unable to build during EGR test

This DTC 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 DTCs. See EBP Sensor in this section of manual and check EBP KOEO specification.
2. Check for plugged EBP sensor or tubing.
3. Check for active or inactive DTCs, see appropriate pin-point test.
4. Check EGR valve, see EGR pin-point test and run output high and low, while monitoring EGRP sensor.
5. Check for restricted exhaust system.

DTC 3348 - AMT - EBP too high during EGR test

This DTC is set if EBP does not meet expected response during the EGR portion of the Air Management Test.

Pin-point AMS Fault

1. Check for other active or inactive EBP, MAP, VGT, or EGR DTCs. Repair any faults before continuing with this procedure.
2. Check for biased sensor. Verify that BAP, MAP, and EBP are within KOEO specification. See KOEO in “Performance Specification” appendix of this manual.
3. Check EGR operation. Monitor EGRP PID. Run KOEO Output State test HIGH and LOW. See EGR Actuator in this section of manual.
4. Check intake and exhaust system for leaks.

AMS Operation

The Air Management test checks the operation of the VGT and EGR by actuating each component open and closed while monitoring the effect it has on exhaust back pressure using the EBP sensor. The test sequence is carried out as follows:

The ECM monitors the BARO sensor as a base line for zeroing the MAP and EBP signals.

VGT portion

The ECM commands the EGR valve to close, then increases engine idle speed to 1000 rpm. The VGT vanes are commanded to open and EBP is allowed to stabilize (EBP is expected to drop). The VGT vanes are then commanded to close and EBP is allowed to stabilize (EBP is expected to increase). If pressure results do not match expected values for either condition, a DTC is set, the engine will return to 700 rpm, and the test will complete without running the EGR portion.

NOTE: Although commanding the EGR to close, it may be stuck partially open and cause EBP values to be lower than expected. This would cause the VGT portion of the test to fail. If this is suspected, the operation of the EGR valve should be visually inspected while doing the Output State tests.

If the VGT portion of the test completes without fault, no DTC is set, and the test will continue for the EGR portion.

EGR portion

The EGR valve and VGT vanes are still closed, the ECM increases engine idle speed to 1200 rpm and EBP is allowed to stabilize (EBP is expected to increase). The EGR is then commanded open and EBP is allowed to stabilize (EBP is expected to drop). The EGR is then commanded closed and EBP is allowed to stabilize (EBP is expected to increase). If pressure results do not match expected values for either position, a DTC is set, the engine will return to 700 rpm, and the test is complete.

APS/IVS (Accelerator Position Sensor and Idle Validation Switch)

DTC	SPN	FMI	Condition
1131	91	4	APS signal out-of-range LOW
1132	91	3	APS signal out-of-range HIGH
1133	91	2	APS in-range fault
1134	91	7	APS and IVS disagree
1135	558	11	IVS signal fault

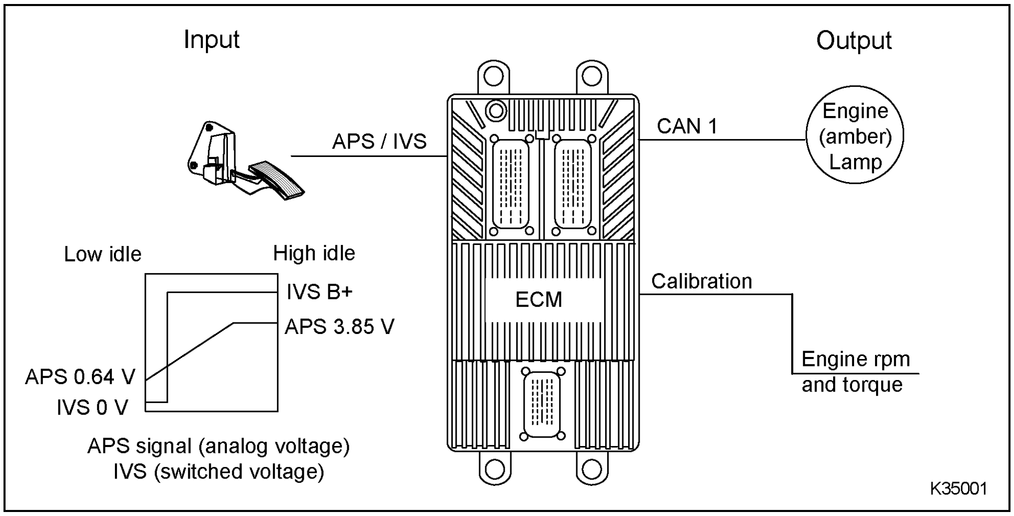


Figure 187 Function diagram for the APS/IVS

The function diagram for the APS/IVS includes the following:

- Accelerator Position Sensor and Idle Validation Switch (APS/IVS)
- Electronic Control Module (ECM)
- Engine lamp (amber)

Function

The APS/IVS sensor is controlled by the operator. The ECM uses this sensor to control engine acceleration based off of the operator's demand for power.

Sensor Location

The APS/IVS sensor is installed in the cab on the accelerator pedal.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- 3-Banana Plug Harness (page 425)
- Breakout Box (page 426)
- APS/IVS Breakout Harness (page 427)
- Terminal Test Adapter Kit (page 432)

APS/IVS Sensor End Diagnostics

DTC	Condition	Possible Causes
1131	APS signal out-of-range LOW	• APS signal OPEN or shorted to GND • VREF circuit OPEN or shorted to GND • Failed sensor
1132	APS signal out-of-range HIGH	• APS signal shorted to PWR • SIG GND circuit OPEN • Failed sensor
1133	APS in-range fault	• Circuit fault • Failed sensor
1134	APS and IVS disagree	• Circuit fault • Failed sensor
1135	IVS circuit fault	• IVS circuit OPEN or shorted to GND or PWR • Failed sensor

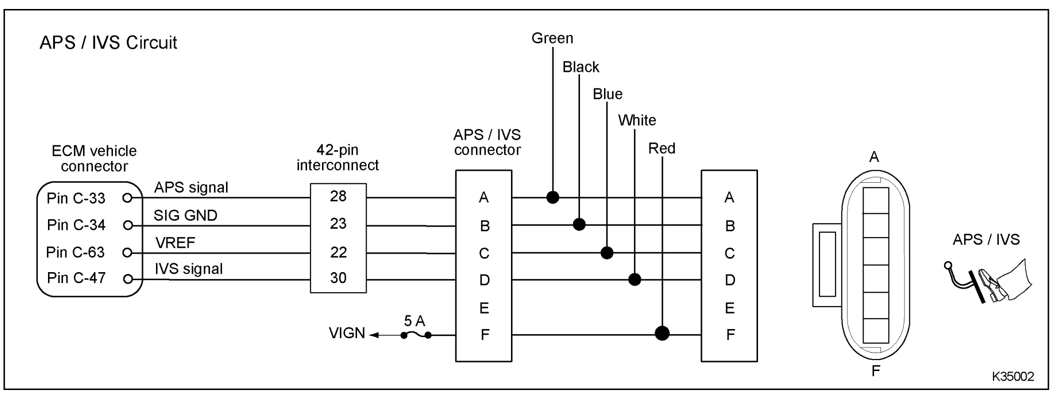


Figure 188 APS/IVS circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Verify sensor voltage is within KOEO specification. See “Performance Specification” section.
3. Monitor sensor voltage. Verify an active DTC for the sensor.
   - If code is inactive, monitor the PID while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID will spike and the DTC 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.

Sensor Circuit Check

Connect sensor breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use EST to verify correct DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST – Check DTC	DTC 1131	If DTC 1132 is active, check APS signal for short to PWR.
DMM – Measure volts C to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 227).
EST – Check DTC Short breakout harness across A and C	DTC 1132	If DTC 1131 is active, check APS signal for OPEN. Do Harness Resistance Check (page 227).
DMM – Measure resistance B to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 227).
DMM – Measure voltage D to GND	0 V	If > 0.25 V, check IVS circuit for short to PWR.
DMM – Measure voltage F to GND	B+	If < B+, check for OPEN circuit or blown fuse.

If checks are within specification, connect sensor, clear DTCs, and cycle the pedal a few times. If active code returns, replace sensor.

APS/IVS Pin-point Diagnostics

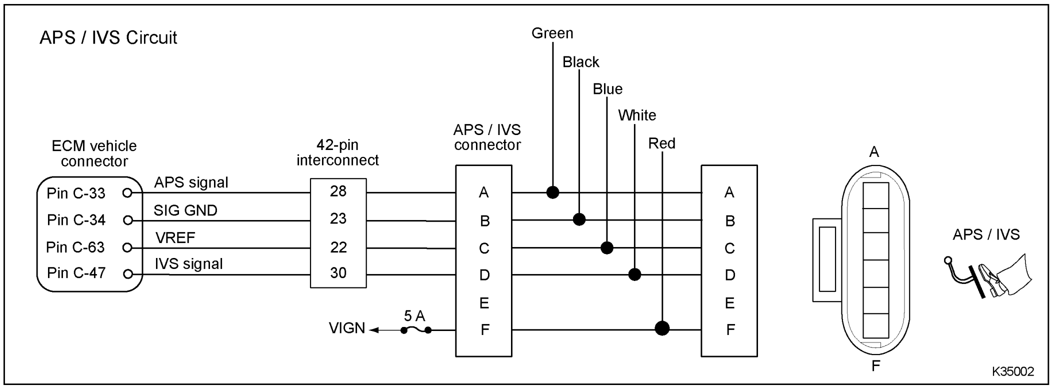


Figure 189 APS/IVS circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
A to GND	0 V	If > 0.25 V, check for short to PWR.
B to GND	0 V	If > 0.25 V, check for short to PWR.
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 (page 227).
D to GND	0 V	If > 0.25 V, check for short to PWR. Do Harness Resistance Check (page 227).
F to GND	B+	If < B+, check for OPEN or blown fuse.

Connector Resistance Check to Engine GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
A to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
B to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit.
C to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
D to GND	500 Ω to 600 Ω	If < 500 Ω, check for short to GND.
F to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Harness Resistance Check

Turn ignition switch to OFF. Disconnect both battery GND cables. Connect breakout box and breakout harness. Leave ECM and sensor disconnected. 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	Spec	Comment
A to C-33	< 5 Ω	If > 5 Ω, check APS 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 circuit for OPEN.
D to C-47	< 5 Ω	If > 5 Ω, check IVS signal circuit for OPEN.
F to Fuse	< 5 Ω	If > 5 Ω, check PWR circuit for OPEN.

Operational Voltage Check

Connect breakout box or breakout harness between ECM and sensor. Turn ignition switch ON. Use DMM to measure voltage and EST to read PID.

Test Point	Condition	DMM	PID
APS	Foot off pedal	0.64 V ± 0.5 V	0%
A to GND or C-33 to GND	Pedal to floor	3.85 V ± 0.5 V	100%
IVS	Foot off pedal	0 V	Low idle
D to GND or C-47 to GND	Pedal to floor	B+	Off idle

APS/IVS Circuit Operation

The APS/IVS is integrated into one component and mounted on the pedal. The APS/IVS switch can be replaced without replacing the complete assembly.

The ECM determines accelerator pedal position by processing input signals from the APS and the IVS.

APS

The APS is a potentiometer sensor that is supplied with a 5 V reference voltage at Pin C from ECM Pin C-63. The sensor is grounded at Pin B from ECM Pin C-34. The sensor returns a variable voltage signal from Pin A to ECM Pin C-33.

IVS

The IVS is an ON / OFF switch that is supplied B+ on Pin F from the VIGN fuse. The switch sends and ON or OFF idle voltage signal from Pin D to ECM Pin C-47.

APS Auto-Calibration

The ECM auto-calibrates the APS signal every time the ignition key is turned on. The ECM "learns" the lowest and highest pedal positions allowing for maximum pedal sensitivity. When the key is turned off, this information is lost until the next key cycle where the process is repeated. No accelerator pedal adjustment is needed with this feature.

Fault Detection / Management

When the key is on, the ECM continuously monitors the APS/IVS circuits for expected voltages. It also compares the APS and IVS signals for conflict. If a conflict occurs, the ECM will set a Diagnostic Trouble Code (DTC).

Any malfunction of the APS/IVS sensor circuit will illuminate the amber engine lamp. If the ECM detects an APS signal Out of Range HIGH or LOW, the engine will ignore the APS signal and operate at low idle. If a disagreement in the state of IVS and APS is detected by the ECM and the ECM determines that it is an IVS fault, the ECM will only allow a maximum of 50% APS to be commanded. If the ECM cannot discern if it is an APS or IVS fault, the engine will be allowed to operate at low idle only.

NOTE: If multiple APS/IVS DTCs are present, verify that the APS/IVS part number is correct for the specific vehicle model.

NOTE: If elevated low idle rpm is experienced after replacing the pedal assembly or APS/IVS sensor, and there are no DTCs present, check pedal assembly or APS/IVS sensor part numbers for correctness.

ATA (American Trucking Association) Datalink

DTC	SPN	FMI	Condition
None			No communication to EGC

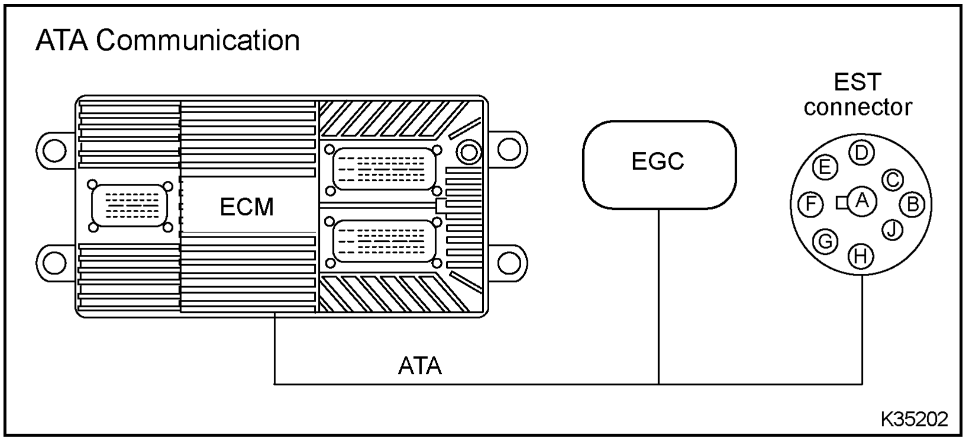


Figure 190 Function diagram for ATA

The function diagram for ATA includes the following:

- Electronic Control Module (ECM)
- Electronic Gauge Cluster (EGC)
- Electronic Service Tool (EST) connector

Function

The ATA data link provides communication between the ECM and an ATA compatible EGC module. The EST tool can access this data link at the EST connector.

Location

The ATA circuits are connected to the ECM, EGC and EST connector. The EST connector is located under the dash on the driver's side.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- Terminal Test Adapter Kit (page 432)

ATA Pin-point Diagnostics

DTC	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

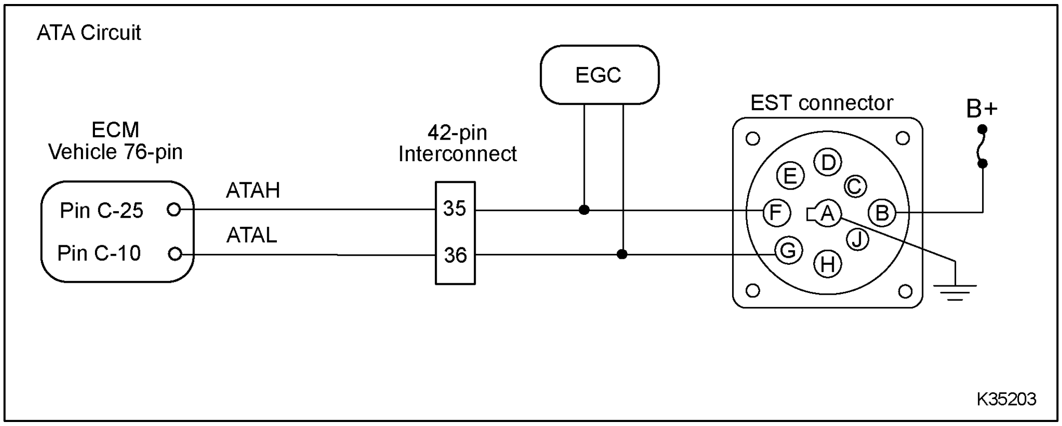


Figure 191 ATA circuit diagram

Connector Voltage Check - EST

Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
B to GND	B+	If < B+, check B+ circuit to EST connector for OPEN or short to GND, or blown fuse.
B to A	B+	If < B+, check GND circuit to EST connector for OPEN.
F to GND	1 V to 4 V	The sum of F to GND and G to GND should equal 4 V to 5 V.
G to GND	1 V to 4 V	The sum of G to GND and F to GND should equal 4 V to 5 V.
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 breakout box. Leave ECM disconnected.

Test Point	Spec	Comment
F to C-25	< 5 Ω	If > 5 Ω, check ATAH for OPEN in circuit
F to GND	> 1 kΩ	If < 1 kΩ, check ATAH for short to GND
G to C-10	< 5 Ω	If > 5 Ω, check ATAL for OPEN in circuit
G to GND	> 1 kΩ	If < 1 kΩ, check ATAL for short to GND
A to GND	< 5 Ω	If > 5 Ω, check GND for OPEN in circuit

ATA Operation

EST Connector

The fuse protected B+ signal is supplied to the EST connector through Pin B and ground is through Pin A. American Trucking Association High (ATAH) signal runs from ECM Pin C-25 and EST connector Pin F. American Trucking Association Low (ATAL) signal runs from ECM Pin C-10 and EST connector Pin G.

EGC

There are two types of EGC modules, one uses CAN communication and the other uses ATA communication. The following information is sent through data communication:

- Engine lamp (red)
- Engine lamp (amber)
- Coolant level lamp
- Wait to start lamp
- Water in fuel lamp
- Speedometer
- Tachometer
- Odometer / hourmeter
- Change oil message
- Oil pressure gauge
- Engine oil temperature gauge
- Engine coolant temperature gauge

Fault Detection / Management

There are no engine DTCs for ATA communication faults. See 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.

BCP Sensor (Brake Control Pressure)

DTC	SPN	FMI	Condition
1126	7139	4	BCP signal out-of-range LOW
1127	7139	3	BCP signal out-of-range HIGH

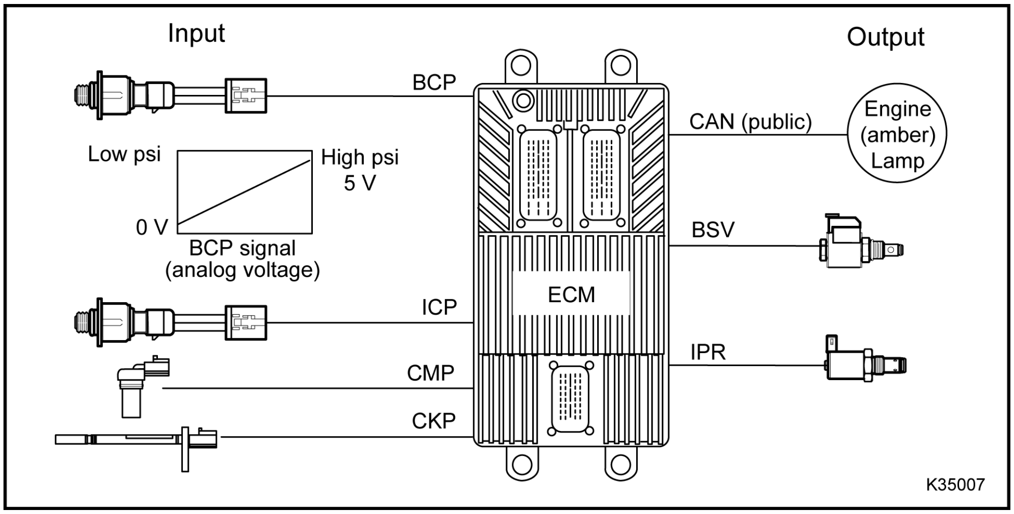


Figure 192 Function diagram for the BCP sensor

The function diagram for the BCP sensor includes the following:

- Brake Control Pressure (BCP) sensor
- Injection Control Pressure (ICP) sensor
- Camshaft Position (CMP) sensor
- Crankshaft Position (CKP) sensor
- Injection Pressure Regulator (IPR)
- Brake Shut-off Valve (BSV)
- Electronic Control Module (ECM)
- Engine lamp (amber)

Function

The Diamond Logic® Engine Brake is a compression style brake that works in conjunction with the ICP system to control exhaust valve closing during engine braking.

The BCP sensor provides a feedback signal to the ECM indicating brake control pressure. The ECM monitors the BCP signal during engine normal and braking operation to determine if the compression brake system is working without fault.

Sensor Location

The BCP sensor is installed in the high-pressure oil rail, under the valve cover.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- 3-Banana Plug Harness (page 425)
- Breakout Harness Kit
- Terminal Test Adapter Kit (page 432)

BCP Sensor End Diagnostics

DTC	Condition	Possible Causes
1126	BCP signal out-of-range LOW	• BCP signal circuit OPEN or short to GND • VREF circuit OPEN or short to GND • Failed sensor
1127	BCP signal out-of-range HIGH	• BCP signal circuit short to PWR • Failed sensor

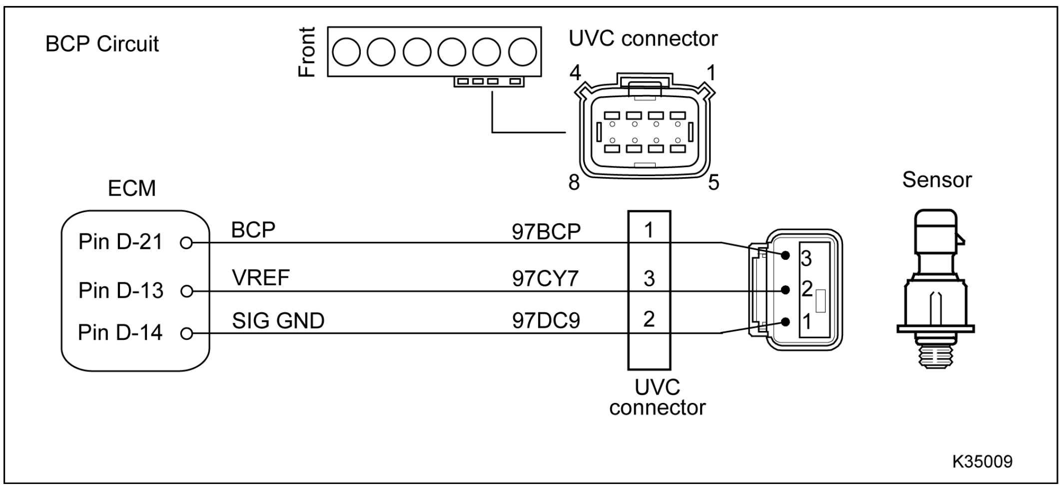


Figure 193 BCP circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Verify sensor voltage is within KOEO specification. See "Performance Specification" section.
3. Monitor sensor voltage. Verify an active DTC for the sensor.
   - If code is inactive, monitor the PID while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID will spike and the DTC 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.

Sensor Circuit Check

Connect UVC breakout harness to engine harness. Leave valve cover gasket disconnected. Turn ignition switch to ON. Use EST to verify correct DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST – Check DTC	DTC 1126	If DTC 1127 is active, check BCP signal for short to GND.
DMM – Measure resistance 2 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 236).
EST – Check DTC Short breakout harness across 1 and 3	DTC 1127	If DTC 1126 is active, check BCP signal for OPEN. Do Harness Resistance Check (page 236).
DMM – Measure volts 3 to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 236).

If checks are within specification, connect sensor and clear DTCs. If active code remains, check under valve cover harness for OPENs or shorts. If okay, replace sensor.

BCP Pin-point Diagnostics

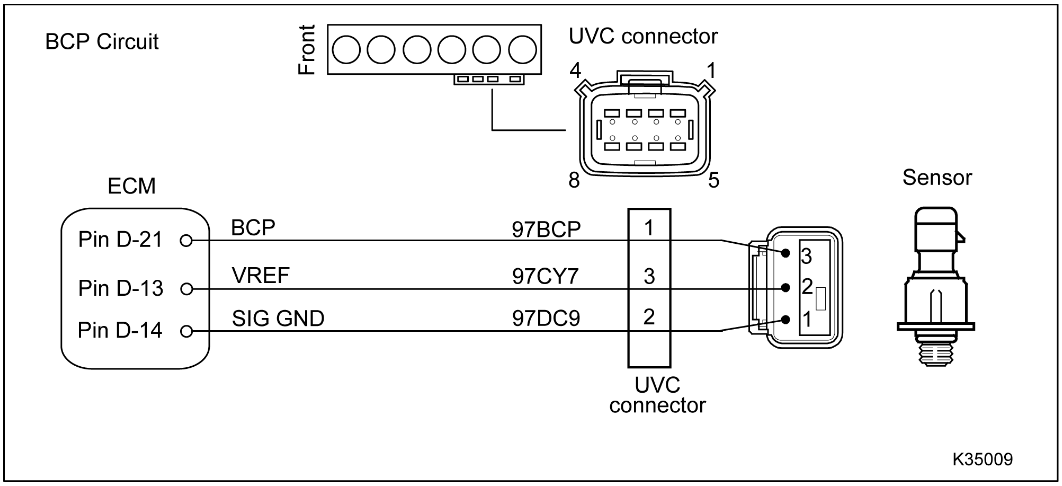


Figure 194 BCP circuit diagram

Connector Voltage Check

Connect UVC breakout harness to engine harness. Leave valve cover gasket disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	5 V	If < 5 V, check for short to GND.
2 to GND	0 V	If > 0.25 V, check for short to PWR.
3 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 (page 236).

Connector Resistance Check to Engine GND

Turn ignition switch to OFF. Connect UVC breakout harness to engine harness. Leave valve cover gasket disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
2 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit.
3 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Under Valve Cover Resistance Check

Connect UVC breakout harness to valve cover gasket, leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
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 UVC 8-pin connector (3rd to rear) and the ECM 36-pin driver connector. Connect breakout box. Leave ECM and valve cover gasket disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to D-21	< 5 Ω	If > 5 Ω, check BCP 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.

BCP Circuit Operation

The BCP sensor is a micro-strain gauge sensor that is supplied with a 5 V reference voltage at Pin 2 from ECM Pin D-13. The sensor is grounded at Pin 1 from ECM Pin D-14. The sensor returns a variable voltage signal from Pin 3 to ECM Pin D-21.

Fault Detection / Management

The ECM continuously monitors the signal of the ICP sensor to determine if the signal is within an expected range.

When the engine is running, the ECM compares engine brake control pressure to injection control pressure and BCP desired. When the brake is activated, brake control pressure will equal injection control pressure.

If the brake control pressure does not match injection control pressure, the ECM will disable the engine brake. A DTC will be set, and the amber engine lamp will be illuminated.

When the engine brake is not active and the ECM detects an undesired value, the ECM will set a DTC and the amber engine lamp will be illuminated.

A brake control valve that is stuck open or closed can also cause a fault. The brake shut-off valve and the BCP sensor circuit should both be diagnosed.

BOO/BPS (Brake On/Off) / (Brake Pressure Switch)

DTC	SPN	FMI	Condition
1222	597	2	Brake switch circuit fault
2159	8365	7	Brake applied while APS applied

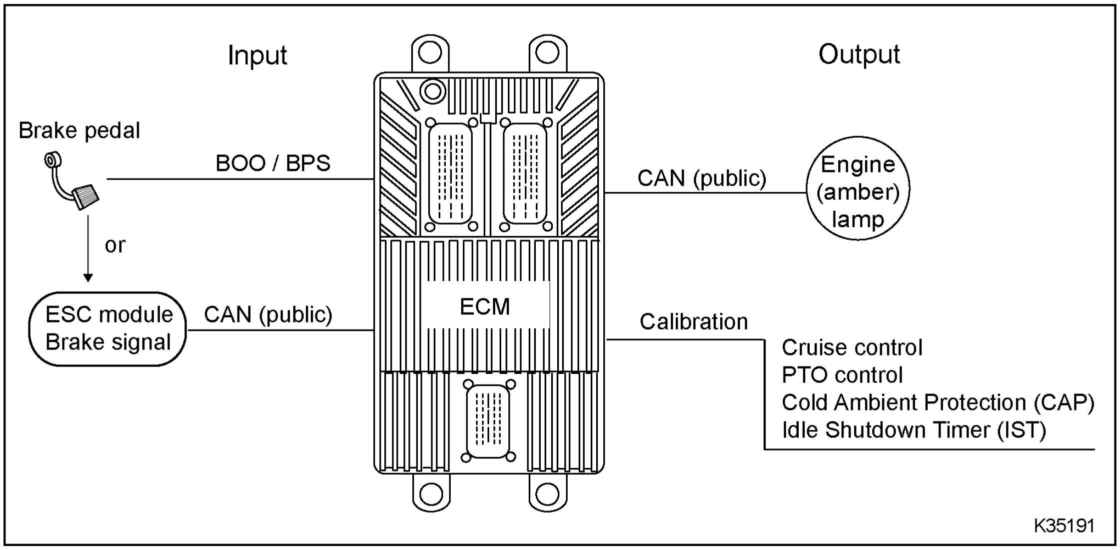


Figure 195 Function diagram for brake switch circuits

The function diagram for the brake switch circuits includes the following:

- Brake ON/OFF (BOO) switch
- Brake Pressure Switch (BPS)
- Electronic Control Module (ECM)
- Engine lamp (amber)
- Output - cancels cruise control
- Output - cancels Power Takeoff (PTO) control
- Output - cancels Cold Ambient Protection (CAP)
- Output - cancels Idle Shutdown Timer (IST)

Function

The brake switch circuit signals the ECM when the brakes are applied. The information is used to disengage the cruise control and PTO functions. The brake signal will interrupt the CAP feature and will reset the time interval for the IST feature.

Location

The Brake On/Off (BOO) switch is located on the brake pedal lever. The Brake Pressure Switch (BPS) is located on the brake pressure line.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- Breakout Box (page 426)
- Terminal Test Adapter Kit (page 432)

Brake Switch Circuits Pin-point Diagnostics

DTC	Condition	Possible Cause
1222	Brake switch circuit fault	• OPEN in B+ circuit to the switches or blown fuse • BPS circuit OPEN or shorted to PWR or GND • Failed switch
2159	Brake applied while APS applied	• Is set when APS and brakes are applied when vehicle speed is above 10 mph and engine speed is above 1500 rpm.

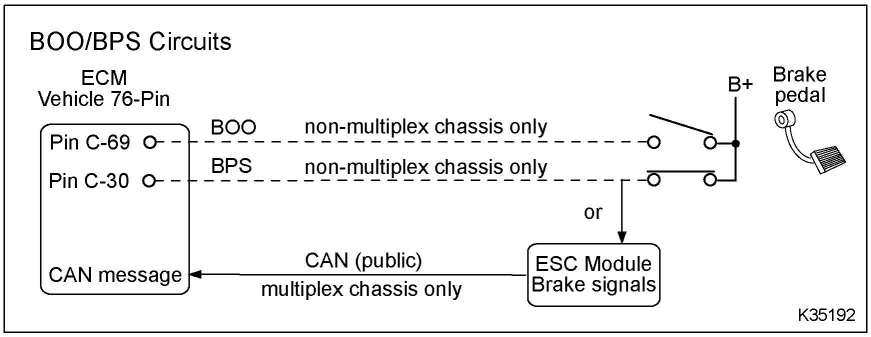


Figure 196 Brake switch circuit diagram

Brake Switch Circuits

Turn ignition switch to ON. Connect EST to EST connector. Open Switch session to monitor BOO and BPS PIDs (BOO applies only to non-multiplex chassis).

Test Point	Spec	Comments
BOO	Normal state = Released Pedal depressed = Applied	If not within specification, check for blown fuse, open circuit, short to ground, short to power, or failed switch.
BPS	Normal state = Released Pedal depressed = Applied	If not within specification, check for blown fuse, open circuit, short to ground, short to power, or failed switch.

See *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide Electrical Circuit Diagram Manual* for circuit information. If the brake circuits are hard-wired to the ECM and do not go through the ESC module, do Voltage Check (page 239).

Voltage Check

Disconnect BOO and BPS switches (BOO applies only to non-multiplex chassis). Turn ignition switch ON. Use DMM to measure voltage.

Test Point	Spec	Comments
BOO		
B+ side	B+	If < B+, check for OPEN or shorted circuit, or blown fuse
Signal side	0 V	If > 0.5 V, check for short to PWR
BPS		
B+ side	B+	If < B+, check for OPEN or shorted circuit, or blown fuse
Signal side	0 V	If > 0.5 V, check for short to PWR

Harness Resistance Check

Turn ignition switch OFF, Connect breakout box, Leave ECM, BOO and BPS disconnected (BOO applies only to non-multiplex chassis). Use DMM to measure resistance.

Test Point	Spec	Comments
BOO		
C-69 to switch	< 5 Ω	If > 5 Ω, check for OPEN circuit
C-69 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND
BPS		
C-30 to switch	< 5 Ω	If > 5 Ω, check for OPEN circuit
C-30 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND

Brake Switch Circuit Operation

Fault Detection/Management

The ECM continuously monitors the state of the brake switch or switches. If a fault is detected on the brake switch circuit, a DTC will be set.

On multiplex vehicles, the BPS circuit is wired directly to the ESC module and the state of the switch is communicated to the ECM through the public CAN network.

BSV (Brake Shut-off Valve)

DTC	SPN	FMI	Condition
2546	7121	1	BCP below desired
2547	7121	0	BCP above desired

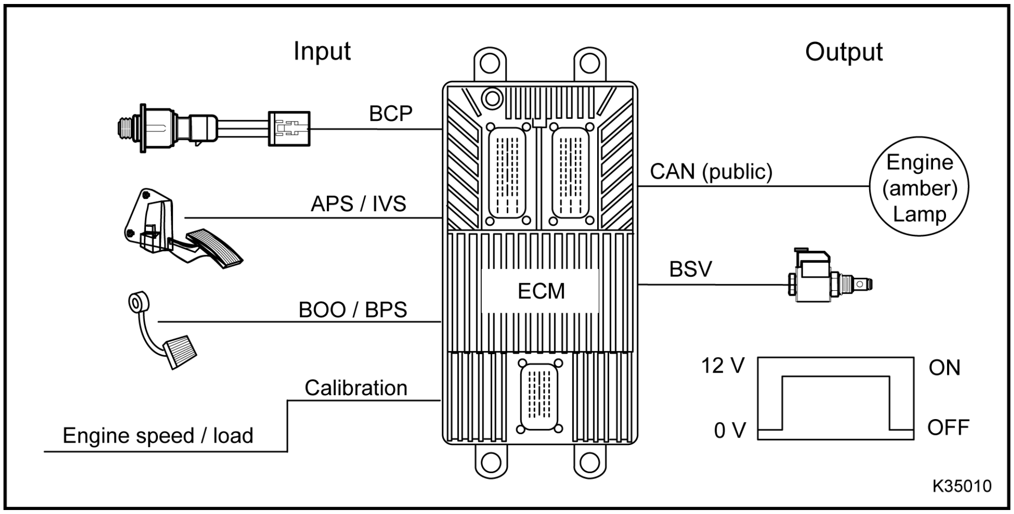


Figure 197 Function diagram for the BSV

The function diagram for the BSV includes the following:

- Brake Control Pressure (BCP) sensor
- Accelerator Position / Idle Validation (APS/IVS) sensors
- Electronic Control Module (ECM)
- Vehicle brake switches (BOO/BPS)
- Brake Shut-off Valve (BSV)
- Engine lamp (amber)

Function

The Diamond Logic® Engine Brake is a compression style brake that works in conjunction with the ICP system to control exhaust valve closing during engine braking.

The BSV 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 BSV is located in the center of the high-pressure oil rail.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- Breakout Harness
- 500 Ohm Resistor Harness (page 426)
- Breakout Box (page 426)
- Terminal Test Adapter Kit (page 432)

BSV Pin-point Diagnostics

DTC	Condition	Possible Causes
2546	BCP below desired	• Bias low EBP sensor • EBP sensor circuit fault • Valve control circuit OPEN or shorted to GND • GND circuit to valve OPEN • Failed BSV
2547	BCP above desired	• Bias high EBP sensor • EBP sensor circuit fault • Valve control circuit shorted to PWR • Failed BSV

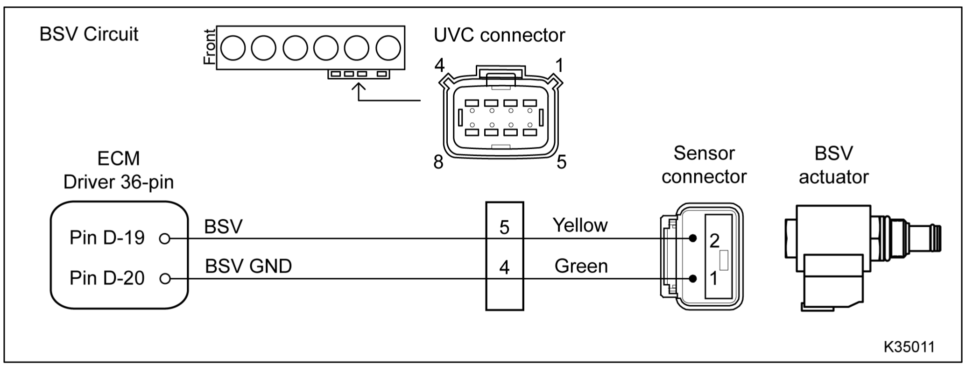


Figure 198 BSV circuit diagram

Connector Voltage Check

Connect breakout harness. Leave valve cover gasket disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
4 to GND	0 V	If > 0.25 V, check BSV circuit for short to PWR.
5 to GND	1.78 V	If > 1.5 V, check BSV GND circuit for short to GND.

Connector Resistance Checks to GND

Turn ignition switch to OFF. Connect breakout harness to engine harness. Leave valve cover gasket disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
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 to valve cover gasket. Leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
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 Ω ± 2 Ω	If out of specification, check UVC harness for OPEN circuits or shorts to GND. If UVC circuits are okay, replace the BSV.

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and breakout harness. Leave ECM and valve cover harness disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
4 to D-20	< 5 Ω	If > 5 Ω, check for OPEN circuit.
5 to D-19	< 5 Ω	If > 5 Ω, check for OPEN circuit.

BSV Circuit Operation

The BSV consists of a solenoid and valve assembly and is located in the high-pressure rail between the ICP oil gallery and the brake oil gallery.

The brake shut-off valve is supplied with ground at Pin 1 through Pin 4 of the valve cover gasket from ECM Pin D-20. The ECM controls the engine brake by supplying 12 volts through Pin 5 of the valve cover gasket to Pin 2 of the BSV.

When the engine brake is activated, the ECM provides power to activate the BSV 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 BSV. Residual brake gallery pressure initially bleeds from the actuator bore. When brake gallery pressure reaches 6.9 MPa (1000 psi), 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 BCP desired. When the brake is activated, brake control pressure will equal injection control pressure.

If the brake control pressure does not match injection control pressure, the ECM will disable the engine brake, a DTC will be set, and the amber engine lamp will be illuminated.

When the engine brake is not active and the ECM detects an undesired value, the ECM will set a DTC and the amber engine lamp will be illuminated.

The Output Circuit Check (OCC) can detect open or shorted circuits to the BSV during KOEO Standard Test.

A bias BCP sensor can also cause a fault. The brake shut-off valve and the BCP sensor circuit should both be diagnosed.

CAN Communications (Controller Area Network) (Public)

DTC	SPN	FMI	Condition
2232	8331	7	Resume normal speed control due to momentary CAN loss
2544	8329	7	ECM unable to send CAN messages
2545	8330	7	ECM not receiving body controller CAN messages

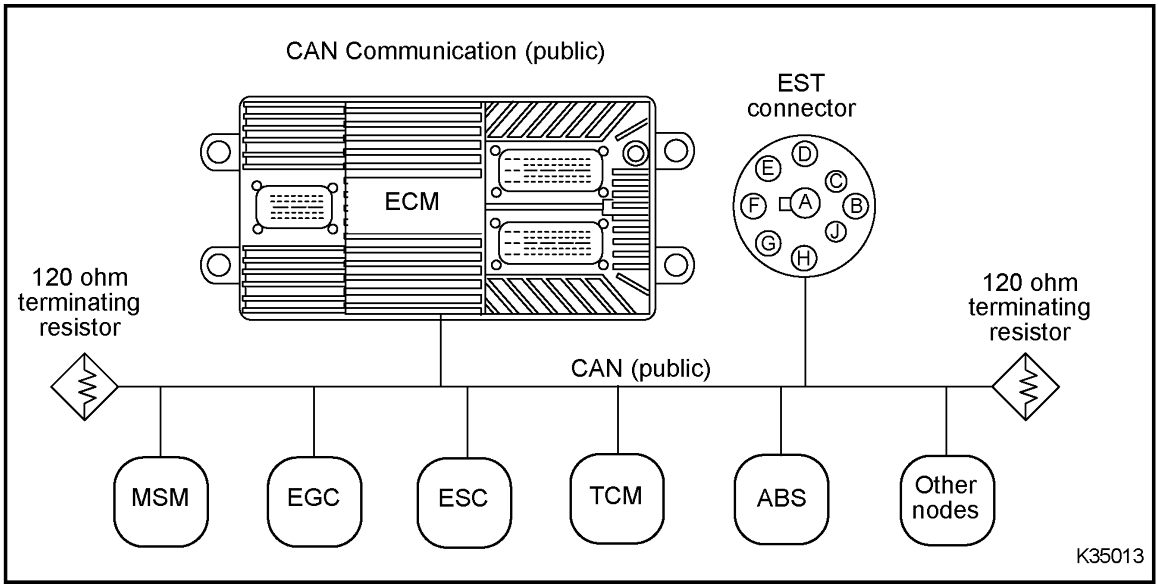


Figure 199 Function diagram for the CAN

The function diagram for the CAN includes the following:

- Electronic Control Module (ECM)
- Transmission Control Module (TCM)
- Electronic System Control (ESC) body controller
- Multiplex System Module (MSM) body
- Antilock Brake System (ABS)
- Electronic Gauge Cluster (EGC)
- Electronic Service Tool (EST)
- 120 ohm terminating resistors
- Other nodes (modules)

Function

The public CAN network provides a communication link between all connecting modules. The EST uses this network system to communicate with the ECM.

Location

The public CAN circuits run throughout the vehicle harness. The EST connector is located under the dash on the driver's side.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- Terminal Test Adapter Kit (page 432)

CAN (Public) Pin-point Diagnostics

DTC	Condition	Possible Causes
2232	Resume normal speed control due to momentary CAN loss	CAN communication fault between ECM and TCM
2544	ECM unable to send CAN messages	• CAN circuit OPEN on ECM • ECM not powering up or failed module
2545	ECM not receiving body controller CAN messages	CAN circuits OPEN or shorted to PWR or GND
None	No communication with EST	• B+ OPEN or shorted to GND • GND circuit OPEN • CAN circuits OPEN or shorted to PWR or GND

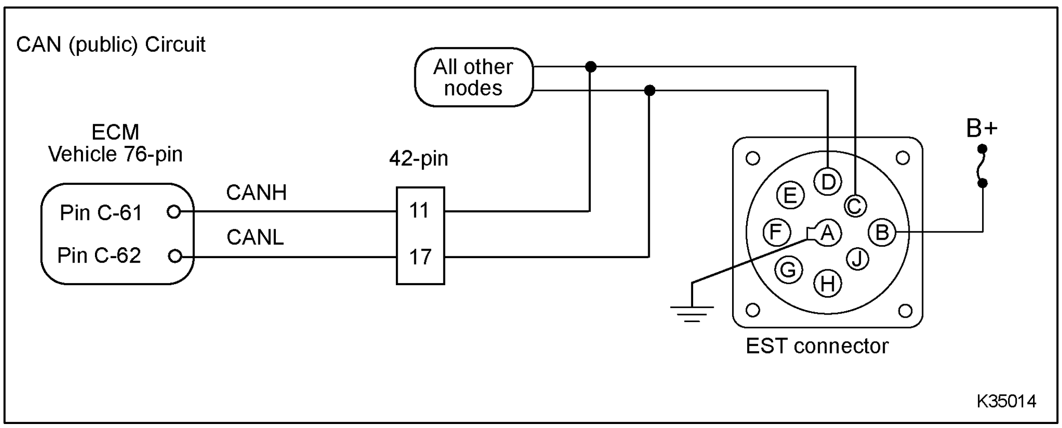


Figure 200 CAN communication circuit diagram

Connector Voltage Check

Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
B to GND	B+	If < B+, check B+ circuit to EST connector for OPEN or short to GND, or blown fuse.
B to A	B+	If < B+, check GND circuit to EST connector for OPEN.
C to GND	1 V to 4 V	The sum of C to GND and D to GND should equal 4 V to 5 V.
D to GND	1 V to 4 V	The sum of D to GND and C to GND should equal 4 V to 5 V.

EST Communication Check

Turn ignition switch to ON. Connect EST to EST 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 CAN 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 breakout box. Leave ECM disconnected.

Test Point	Spec	Comment
C to C-61	< 5 Ω	If > 5 Ω, check CANH for OPEN in circuit.
C to GND	> 1 kΩ	If < 1 kΩ, check CANL for short to GND.
D to C-62	< 5 Ω	If > 5 Ω, check CANL for OPEN in circuit.
D to GND	> 1 kΩ	If < 1 kΩ, check CANH for short to GND.
A to GND	< 5 Ω	If > 5 Ω, check GND for OPEN in circuit.

CAN (Public) Circuit Operation

CAN is a J1939 serial bus system, also known as the Drivetrain Datalink. The public CAN network provides a communication link between all connecting modules, sending and receiving messages.

The EST with MasterDiagnostics® software communicates with the ECM through the EST connector. The EST, through the public CAN network, is able to retrieve DTCs, run diagnostic tests, and view PIDs from all inputs and outputs of the ECM.

CAN public supports the following functions:

- Transmission of engine parameter data
- Transmission and clearing of DTCs
- Diagnostics and troubleshooting
- Programming performance parameter values
- Programming engine and vehicle features
- Programming calibrations and strategies in the ECM

Public CAN versus Private CAN

The public CAN 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.

EST Connector

The EST connector provides an interface for the EST. The EST communicates with the joining modules through the CAN network for diagnostics and module programming. The EST connector is supplied with fused B+ at Pin B and GND at Pin A. Public CAN + runs between ECM Pin C-61 and EST connector Pin C. Public CAN - between C-62 and EST connector Pin D.

EGC

There are two types of EGC modules, one uses CAN communications and the other uses ATA communications. The following information is sent through data communication:

- Engine lamp (red)
- Engine lamp (amber)
- Coolant level lamp
- Wait to start lamp
- Water in fuel lamp
- Speedometer
- Tachometer
- Odometer / hourmeter
- Change oil message
- Oil pressure gauge
- Engine oil temperature gauge
- Engine coolant temperature gauge

ESC or MSM Module

Many EGC lamps and driver operated switches are wired to one of these modules, then communicated through public CAN to the ECM or EGC. Some of these control circuits include the following:

- Wait to start lamp
- Fuel pressure lamp
- Water in fuel lamp
- Aftertreatment regeneration lamp
- Cruise control
- Self-test input (cruise switches)
- Driveline Disengagement Switch (DDS)
- Brake pedal (ESC only) hard wired to the ECM on vehicles using the MSM module
- AC Demand (ACD)
- Remote Accelerator Pedal (RPS)
- In-Cab PTO / throttle switch
- Aftertreatment regeneration switch

Repair Information

The public CAN 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.

CCS (Cruise Control System)

DTC	SPN	FMI	Condition
None			

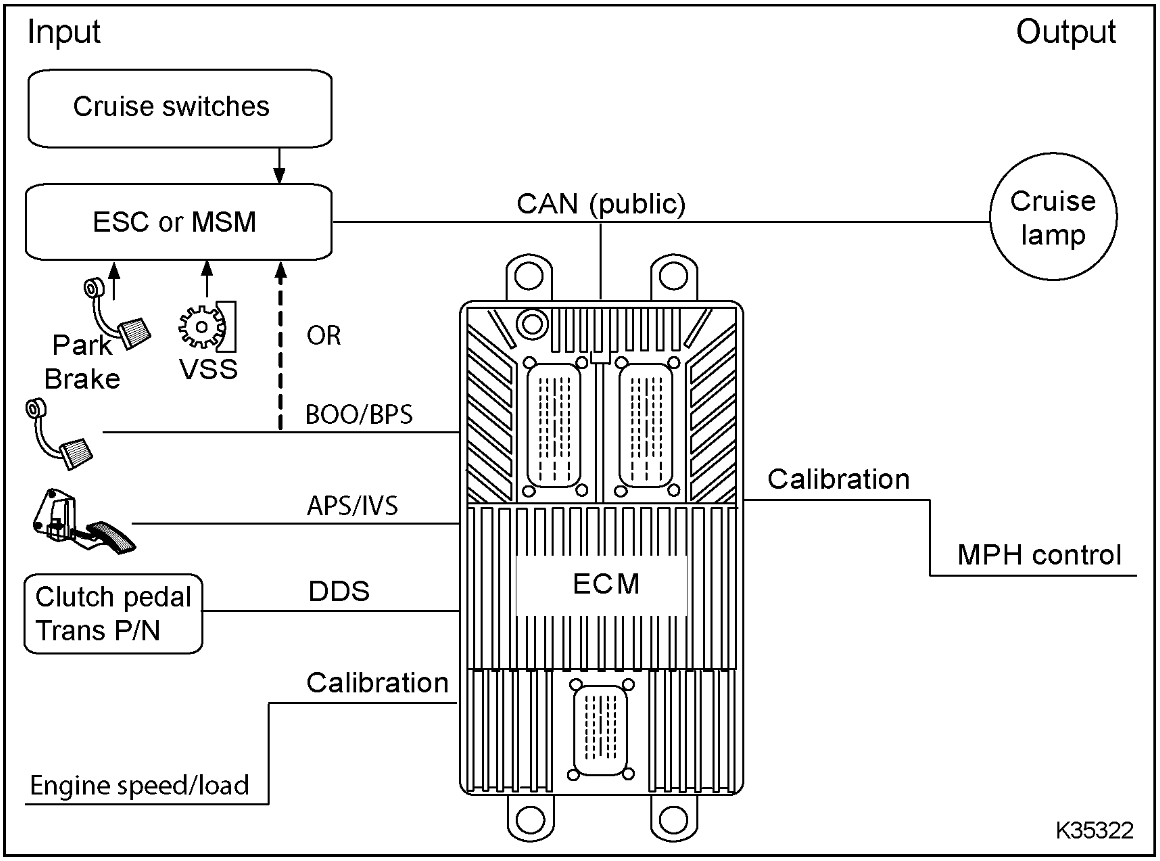


Figure 201 Function diagram for cruise control system

The function diagram for the cruise control system includes the following:

- Electronic System Control (ESC) body module
- Multiplex System Module (MSM) body module
- Cruise control switches
- Driveline Disconnect Switch (DDS)
- Electronic Control Module (ECM)
- Accelerator Position Sensor and Idle Validation Switch (APS/IVS)
- Brake On/Off (BOO) switch
- Brake Pressure Switch (BPS)
- Park brake switch
- Vehicle Speed Sensor (VSS)
- Cruise lamp

Function

Cruise control 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 to deactivate after cruise has been set.

Location

The cruise control switches are wired to the body controller (ESC or MSM). The switch state is communicated to the ECM through the public CAN network.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)

Cruise Control System Pin-point Diagnostics

DTC	Condition	Possible Causes
None		

Switch Checks

Turn ignition switch to ON. Connect the EST to the EST connector. Open the cruise control session to monitor PIDs (BOO only applies to non-multiplex chassis).

NOTE:

- If not within specification, diagnose switch interface with ESC or MSN module. See *Chassis Electrical Circuit Diagnostic Manual* and *Electrical System Troubleshooting Guides*.
- If within specification, go to next test point.

Test Point	Spec	Comments
BOO	Normal state = Released Depressed = Applied	If not within specification, Go to BOO/BPS Pin-point Test (page 238)
BPS	Normal state = Released Depressed = Applied	If not within specification, Go to BOO/BPS Pin-point Test (page 238)
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 okay, go to road test.		

CKP Sensor (Crankshaft Position)

DTC	SPN	FMI	Condition
1144	8021	8	CKP signal noise detected
1146	8064	12	CKP Signal Inactive
1147	8064	2	CKP incorrect signal signature
4553	8022	12	CKP signal inactive
4554	8022	7	CKP loss of sync
4555	8064	8	CKP signal noise detected
4556	8022	8	CKP period too short
4611	8021	13	CKP signature one tooth off

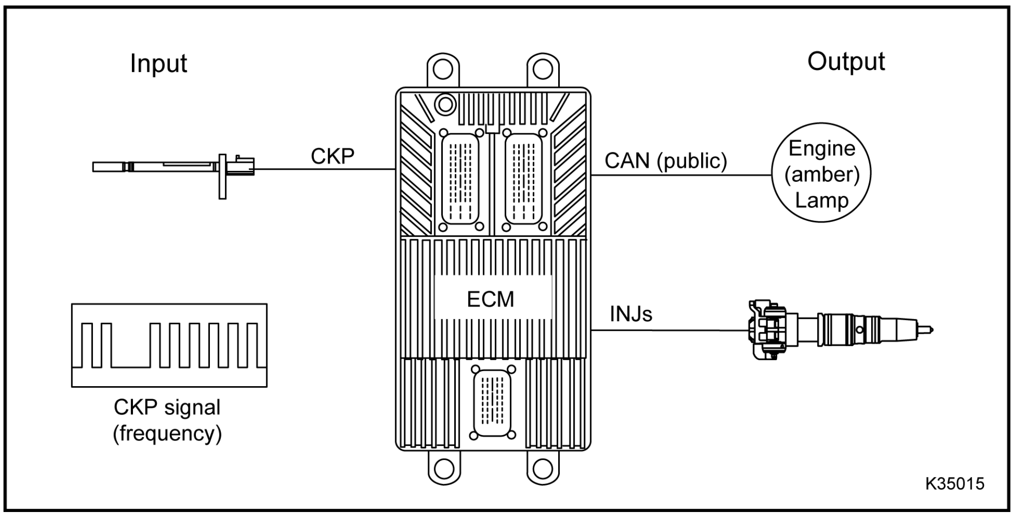


Figure 202 Function diagram for the CKP sensor

The function diagram for the CKP sensor includes the following:

- Crankshaft Position (CKP) sensor
- Electronic Control Module (ECM)
- Fuel injector (INJ)
- Engine lamp (amber)

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 position.

Sensor Location

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

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- Breakout Box (page 426)
- Terminal Test Adapter Kit (page 432)

CKP Pin-point Diagnostics

DTC	Condition	Possible Causes
1144	CKP signal noise detected	• OPEN or shorted CKP circuits
1146	CKP Signal inactive	• Electrical noise detected on CKP signal
1147	CKP incorrect signal signature	• Failed sensor
4553	CKP signal inactive	
4554	CKP loss of sync	
4555	CKP signal noise detected	
4556	CKP period too short	
4611	CKP signature one tooth off	

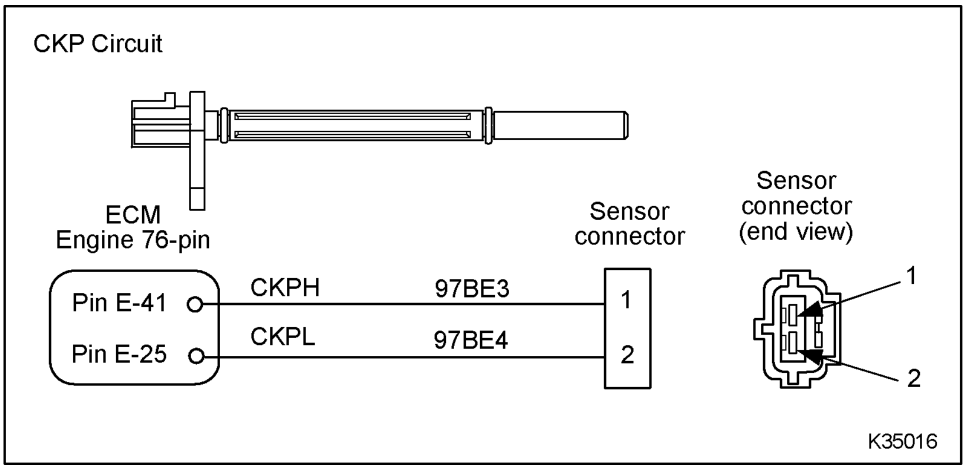


Figure 203 CKP circuit diagram

Sensor and Circuit Resistance Check

Turn ignition switch to OFF. Connect breakout box. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
E-25 to E-41	800 Ω to 1 kΩ	If < 800 Ω, check for failed sensor. Do Harness Resistance Check (page 251). If > 1 kΩ, check for OPEN circuit or failed sensor. Do Harness Resistance Check (page 251).

Harness Resistance Check

Turn ignition switch to OFF. Disconnect harness from sensor. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
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.

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

Operational Checks

Connect breakout box between ECM and sensor. Use DMM set to AC Volts-Hz

Test Point	Condition	Spec
E-41 to E-25	Engine crank	100 Hz to 250 Hz (100 rpm to 250 rpm)
	Low idle	5.50 Hz to 6.50 Hz (650 rpm to 700 rpm)
	High idle	2600 Hz 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 CKP negative E–25 and CKP positive 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 Injection Control Pressure (ICP) to verify the engine is rotating. If the CKP signal is inactive during this time a DTC will be set. Electrical noise can also be detected by the ECM, if the level is sufficient to effect engine operation a corresponding DTC will be set. An inactive CKP signal will cause a no start condition.

CMP Sensor (Camshaft Position)

DTC	SPN	FMI	Condition
1143	8021	2	CMP signal incorrect for CKP sync
4551	8021	12	CMP signal inactive
4552	8022	2	CMP loss of sync
4612	8021	7	CMP to CKP incorrect reference

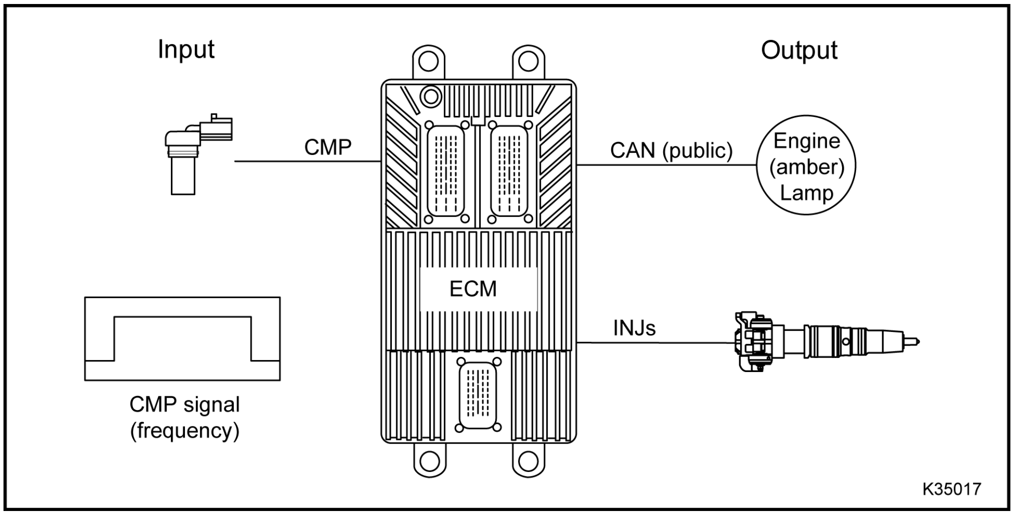


Figure 204 Function diagram for the CMP sensor

The function diagram for the CMP sensor includes the following:

- Camshaft Position (CMP) sensor
- Electronic Control Module (ECM)
- Fuel Injector (INJ)
- Engine lamp (amber)

Function

The CMP sensor provides the ECM with a camshaft speed and position signal. The ECM uses this signal with the CKP signal to calculate engine speed and position.

Sensor Location

The CMP sensor is installed in the front cover, above and to the right of the water pump pulley

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- Breakout Box (page 426)
- Terminal Test Adapter Kit (page 432)

CMP Pin-point Diagnostics

DTC	Condition	Possible Causes
1143	CMP signal incorrect for CKP sync	• OPEN or shorted CMP circuits
4551	CMP signal inactive	• Electrical noise detected on CMP circuit
4552	CMP loss of sync	• Failed sensor
4612	CMP to CKP incorrect reference	

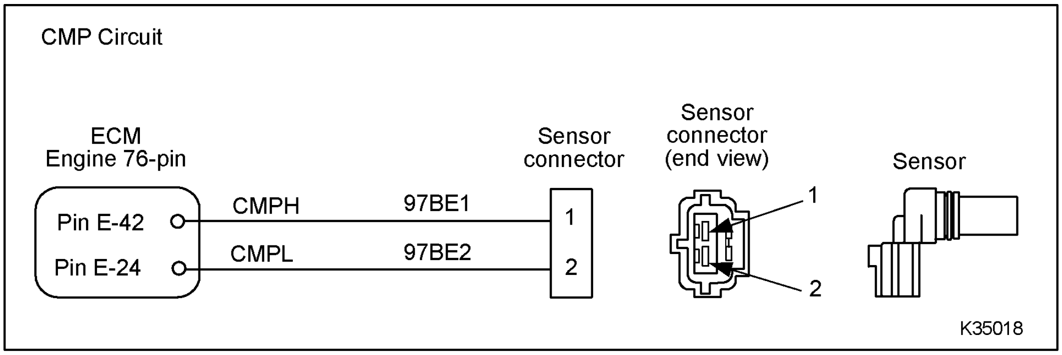


Figure 205 CMP circuit diagram

Sensor and Circuit Resistance Check

Turn ignition switch to OFF. Connect breakout box. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
E-24 to E-42	300 Ω to 400 Ω	If < 300 Ω, check for failed sensor. Do Harness Resistance Check .
		If > 400 Ω, check for OPEN circuit or failed sensor. Do Harness Resistance Check .

Harness Resistance Check

Turn ignition switch to OFF. Disconnect harness from sensor. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
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.

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

Operational Checks

Connect breakout box between ECM and sensor. Use DMM set to AC volts – RPM2.

Test Point	Condition	Spec
E-42 to E-24	Engine crank	100 rpm to 250 rpm
	Low idle	650 rpm 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 CMP negative E–24 and CMP positive 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 DTC will be set. Electrical noise can also be detected by the ECM. If the level is sufficient to effect engine operation, a corresponding DTC will be set. An inactive CMP signal will cause a no start condition.

Cylinder Balance

DTC	SPN	FMI	Condition
4561 - 4566	8001 -8006	0	Cyl (#) balance below min limit
4571 - 4576	8001 - 8006	0	Cyl (#) balance max limit exceeded

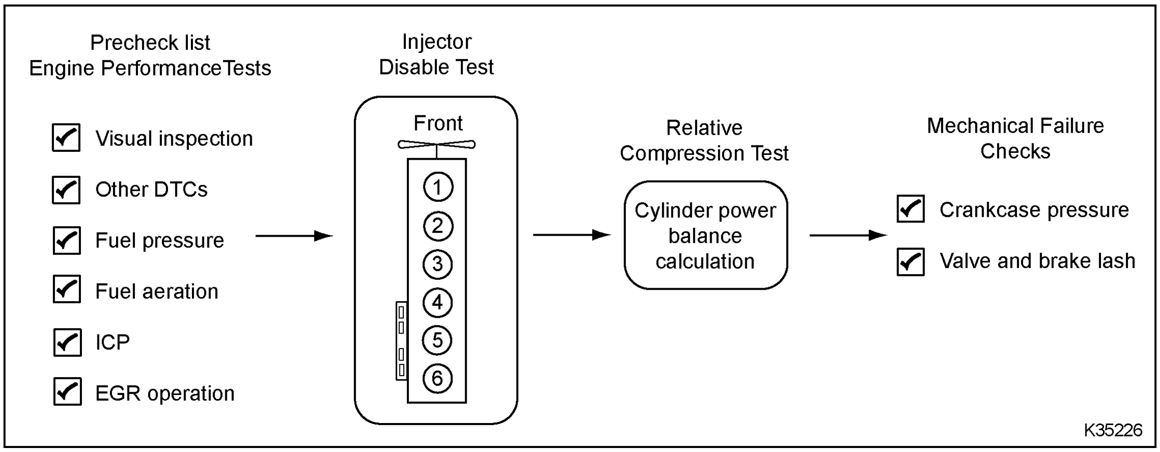


Figure 206 Function diagram for the cylinder balance

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 rail pressure. Variations in these factors can cause unevenness in torque and horsepower from one cylinder to the next. Power cylinder unevenness also causes increased engine noise and vibration, especially at low idle 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 crankshaft position 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 unbalance by using fuel quantity compensation through adjustments of the pulse width values for each fuel injector. This method of compensation is repeated until all error quantities are close to zero causing all cylinders to contribute the same amount.

Cylinder Balance Diagnostics

DTC	Condition	Possible Causes
4561–4566	Cyl (#) balance below min limit	• Electrical fault
4571–4576	Cyl (#) balance max limit exceeded	• Low fuel pressure
		• Aerated fuel
		• Contaminated fuel
		• EGR valve stuck open
		• Injection control system
		• Failed injector
		• Base engine compression imbalance

DTC 4561–4566 – Cylinder (#) balance below min limit

DTC 4571–4576 – Cylinder (#) balance max limit exceeded

The ECM continuously calculates the balance of each cylinder during normal engine operation. If a cylinder is under or over performing, a cylinder balance DTC will be 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 DTCs that could cause a cylinder imbalance.
   - If injector electrical faults are set, diagnose the electrical fault before diagnosing a cylinder imbalance.
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 shut-off valve. See Fuel Pressure and Aeration test in the "Hard Start and No Start" section of this manual.
4. Check ICP pressure and voltage.
   - Check ICP voltage at KOEO.

     See "Performance Specifications" (page 465) appendix in this manual for specification.
   - Check ICP system pressure during KOER. Run KOER Standard Test.

     See "Performance Specifications" (page 465) appendix in this manual for specification.
5. Inspect EGR valve. Verify valve is not stuck open.
   - Run KOEO Standard Test
   - Run KOER Air Management Test.

Repair any faults found in any of the preceding checks before continuing.

1. Run KOER Injector Disable Test to identify imbalanced cylinder.
2. Run Relative Compression Test to verify if cylinder imbalance is mechanical issue or injector issue.

   If the Relative Compression Test fails the same cylinder as indicated by Injector Disable Test, the fault is a mechanical failure.
   - Check crankcase pressure.
   - Check valve lash and brake lash (if equipped).

EBP Sensor (Exhaust Back Pressure)

DTC	SPN	FMI	Condition
3341	1209	4	EBP signal out-of-range LOW
3342	1209	3	EBP signal out-of-range HIGH

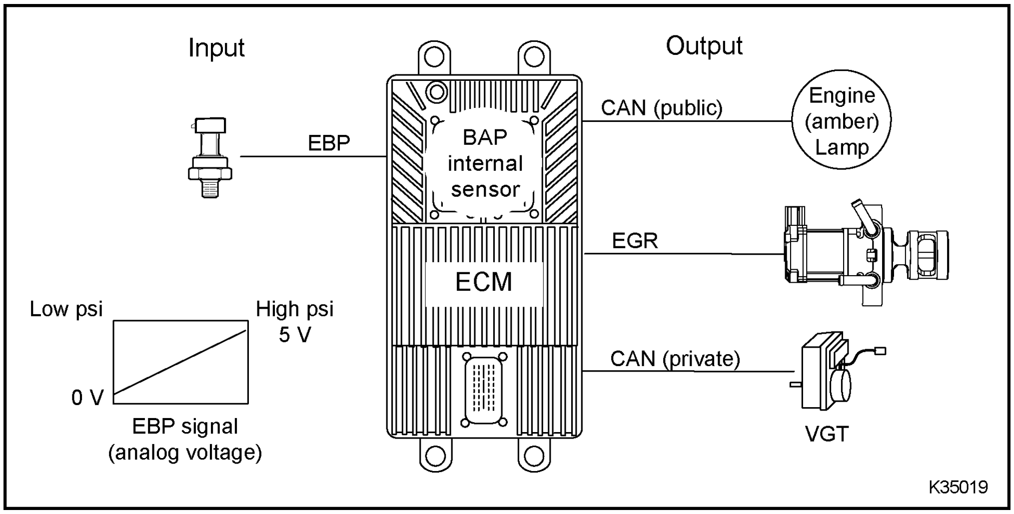


Figure 207 Function diagram for the EBP sensor

The function diagram for the EBP sensor includes the following:

- Exhaust Back Pressure (EBP) sensor
- Electronic Control Module (ECM)
  - Barometric Absolute Pressure (BAP) internal sensor
- Variable Geometry Turbocharger (VGT)
- Exhaust Gas Recirculation (EGR) valve
- Engine lamp (amber)

Function

The EBP sensor measures exhaust back pressure that allows the ECM to control the VGT and EGR systems.

Sensor Location

The EBP sensor is installed in a bracket at the top right rear of the engine.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- 3-Banana Plug Harness (page 425)
- Breakout Box (page 426)
- Pressure Sensor Breakout Harness (page 431)
- Terminal Test Adapter Kit (page 432)

EBP Sensor End Diagnostics

DTC	Condition	Possible Causes
3341	EBP signal out-of-range LOW	• EBP signal circuit OPEN or short to GND • VREF circuit OPEN or short to GND • Failed sensor
3342	EBP signal out-of-range HIGH	• EBP signal circuit short to PWR • Failed sensor

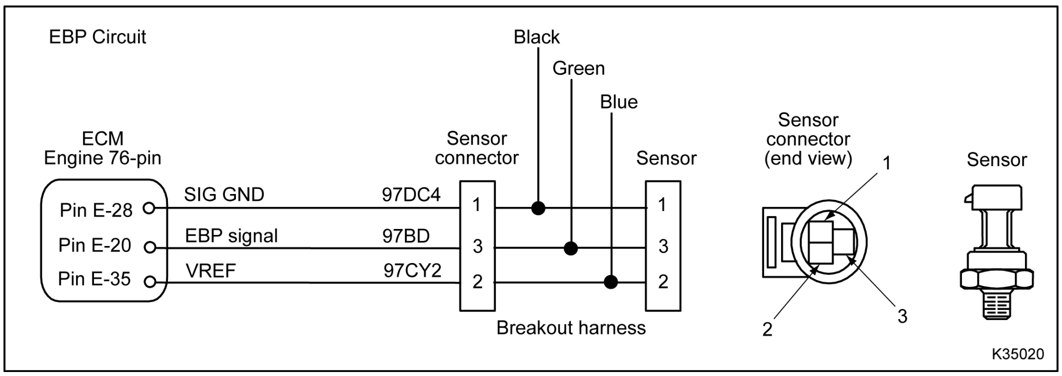


Figure 208 EBP circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Verify sensor voltage is within KOEO specification. See "Performance Specification" section.
3. Monitor sensor voltage. Verify an active DTC for the sensor.
   - If code is inactive, monitor the PID while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID will spike and the DTC 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.

Sensor Circuit Check

Connect sensor breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use EST to verify correct DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST – Check DTC	DTC 1341	If DTC 1342 is active, check EBP signal for short to PWR
DMM – Measure volts 2 to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 262).
EST – Check DTC Short breakout harness across 2 and 3	DTC 1342	If DTC 1341 is active, check EBP signal for OPEN or short to GND. Do Harness Resistance Check (page 262).
DMM – Measure resistance 1 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 262).
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace sensor.		

EBP Pin-point Diagnostics

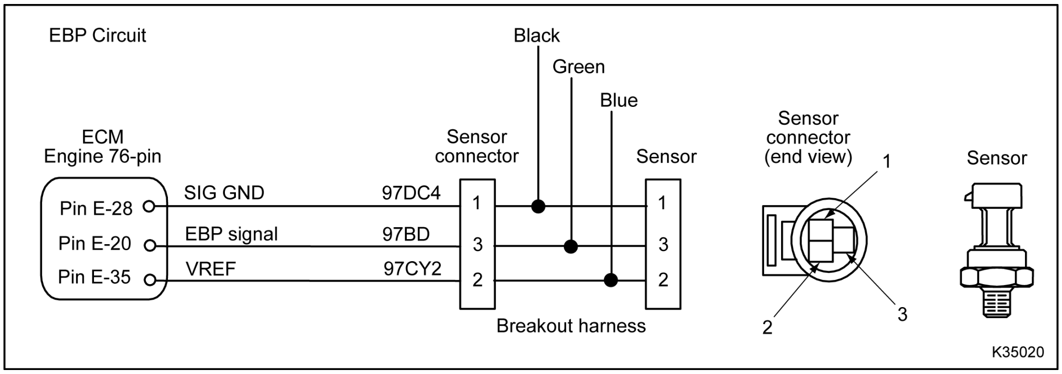


Figure 209 EBP circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	0 V	If > 0.25 V, check for short to PWR.
2 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 (page 262).
3 to GND	0 V	If > 0.25 V, check for short to PWR. Do Harness Resistance Check (page 262).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit.
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. Connect breakout box and sensor breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
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 that is supplied with a 5 V 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 BAP 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 DTC, turn on the warning lamp, and run the engine in a default range.

The EGR valve will close and the ECM will rely on the VGT pre-programmed values.

ECI Circuit (Engine Crank Inhibit)

DTC	SPN	FMI	Condition
None			Engine starter motor will not engage

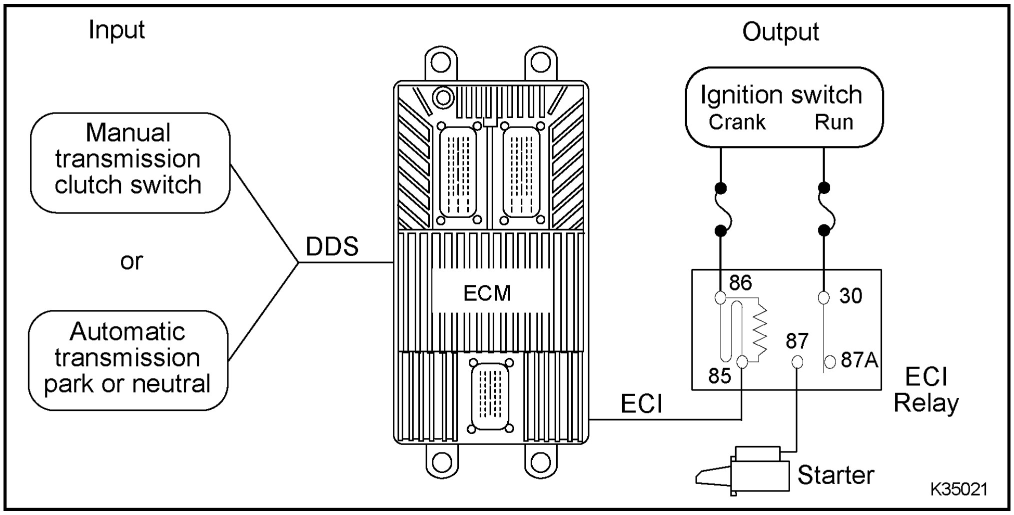


Figure 210 ECI function diagram

The function diagram for the ECI circuit consists of the following:

- Electronic Control Module (ECM)
- Starter
- Starter relay
- Engine Crank Inhibit (ECI) Circuit
- Driveline Disengagement Switch (DDS)
- Thermal overcrank protection switch

Function

The Engine Crank Inhibit (ECI) is a function of the ECM. It prevents starter engagement while the engine is running (above a set calibrated rpm) or 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 overcrank 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 428)
- Breakout Box (page 426)
- Relay Breakout Harness (page 431)

ECI Circuit Diagnostics

DTC	Condition	Possible Causes
None	Engine starter motor will not engage	• Transmission in gear • Clutch pedal not depressed • No power to automatic transmission module • No power to ECM • Blown fuse • Failed ECI relay • OPEN DDS circuit • OPEN ECI circuit • Failed ignition switch • Failed starter motor

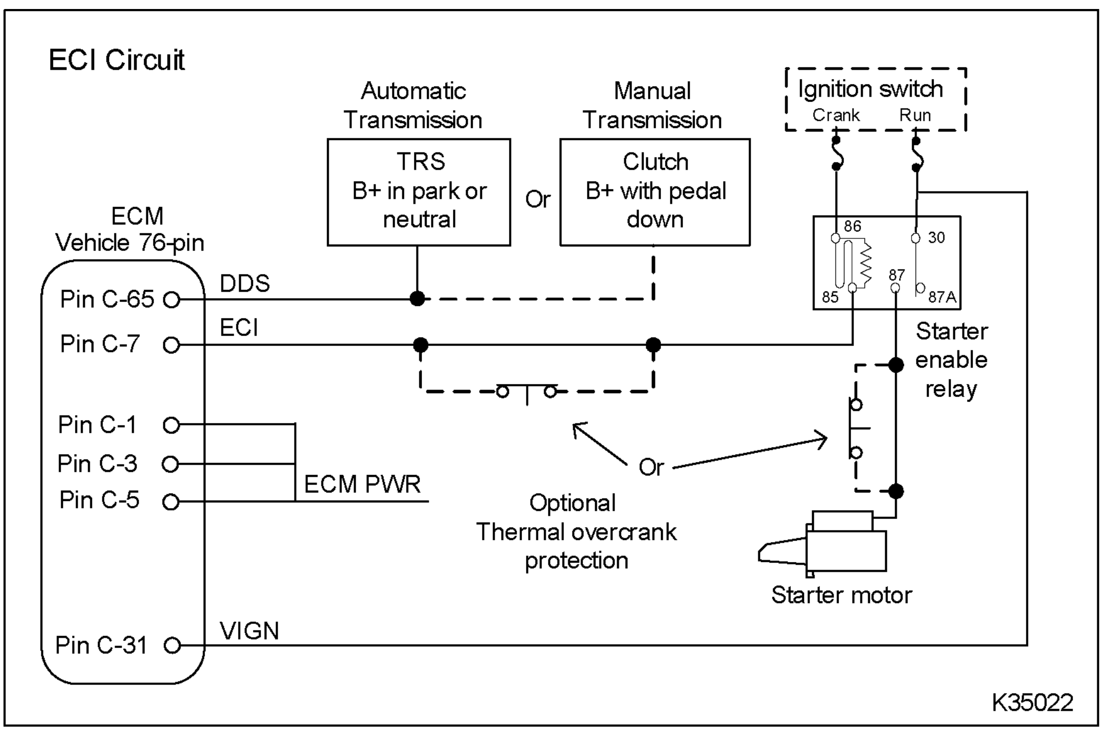


Figure 211 ECI circuit diagram

For additional circuit information see truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide*.

Voltage Check at Relay

Connect relay breakout harness between relay and relay socket. Turn ignition switch ON. Use DMM to measure voltage.

Test Point	Spec	Comment
30 to GND	B+	If < B+, check power circuit to relay switch for OPEN or short to GND, or blown fuse.
Turn ignition switch to CRANK. Use DMM to measure voltage.		
86 to GND	B+	If < B+, check power circuit to relay coil for OPEN or short to GND, blown fuse, or possible failed ignition switch.
85 to GND	< 2 V	If B+, check ECI control circuit for OPEN or failed thermal overcrank protection switch. If 4 V to 5 V, check DDS circuit to ECM and do Voltage Check at ECM .
87 to GND	B+	If < B+, replace relay. If B+, check voltage at starter.

Voltage Check at ECM

Connect breakout box between ECM and vehicle harness. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
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. See ECM PWR (page 271) 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. See ECM PWR (page 271) 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 V, check ECM programming.

Harness Resistance Check – ECM to Relay

Turn ignition switch to OFF. Connect breakout box and relay harness. Leave ECM and relay disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
85 to C-7	< 5 Ω	If > 5 Ω, check ECI control circuit for OPEN or possible failed thermal overcrank 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 overcrank protection switch.
87 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND.

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. 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.	

Operational Voltage Check

Connect breakout box between ECM and chassis harness. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	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.
Turn ignition switch to the crank position. Use DMM to measure voltage.		
ECI C-7 to PWR	0 V	ECM Control - Engine Crank Inhibit enabled
	B+	ECM Control - Engine Crank Inhibit disabled

ECI Circuit Operation

The ECM controls the starting system. The clutch switch or transmission neutral switch provide 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 Driveline Disengagement Switch (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

When the ignition switch is turned to the crank position, VIGN is supplied to the relay coil (Pin 86).

ECI Circuit

The ECM controls starter disable with the ECI circuit. Pin C-7 to relay coil Pin 85. Open or B+ will disable the relay. 0 V (GND) will enable the relay.

Electronic Control Module (ECM)

When the ECM recognizes that the engine is not running and the driveline 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 driveline 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 start position supplies current to energize the relay at Pin 86. If the engine is not running and the driveline is not engaged, the ECM Pin C-7 will enable the relay by suppling a ground to Pin 85 of the relay. When the relay is closed, current passes through the relay to the pin on the starter solenoid.

Clutch Switch

Manual transmissions use the clutch switch to supply a signal to the ECM indicating that the driveline is disengaged. A 12 V signal on the Driveline Disengagement Switch (DDS) circuit indicates that the clutch is disengaged. A 0 V signal indicates that 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 driveline is disengaged. Vehicles programmed for Allison AT/MT transmissions receive a 12 V signal on the DDS circuit indicating that the transmission is out of gear. A 0 V signal indicates that the transmission is in gear. When the transmission is in gear no power is available to the ECI 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 V to Pin 86 of the starter relay. Pin C-65 of the ECM receives 12 V from the WTEC auto neutral relay when the transmission is shifted to neutral or auto neutral.

Fault Detection / Management

There are no DTCs associated with the ECI system.

ECL Switch (Engine Coolant Level)

DTC	SPN	FMI	Condition
1236	111	2	ECL in-range circuit fault

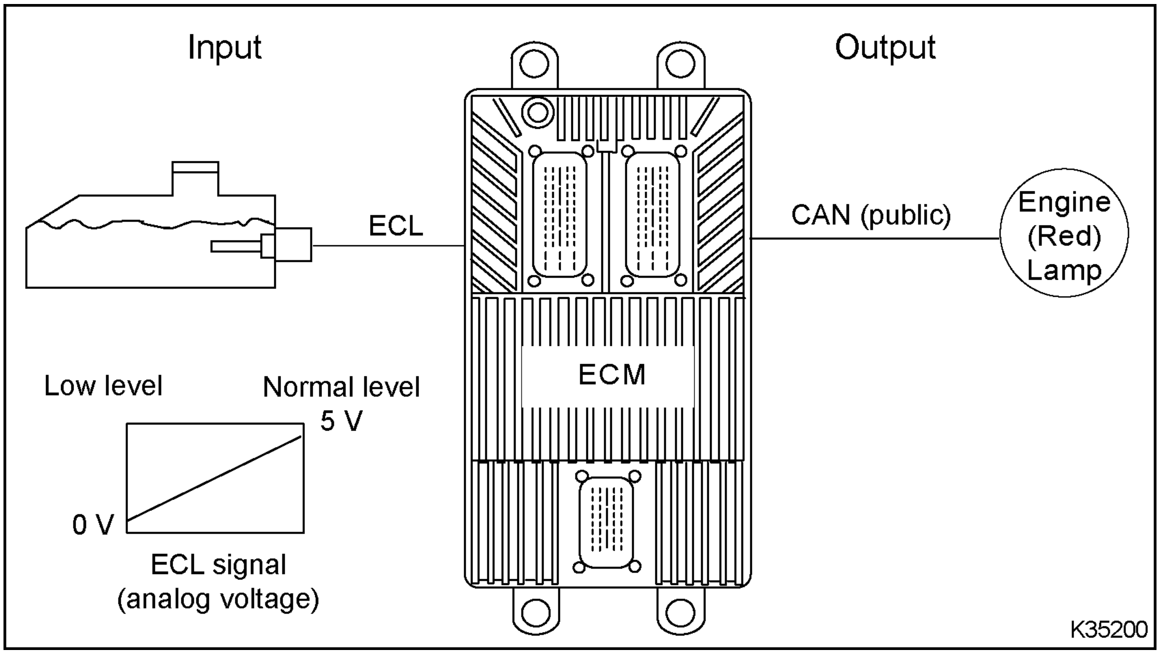


Figure 212 Function diagram for the ECL system

The function diagram for the ECL switch includes the following:

- Engine Coolant Level (ECL) switch
- Engine Control Module (ECM)
- Engine lamp (red)

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 plastic deaeration tank.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- Breakout Box (page 426)

ECL Pin-point Diagnostics

DTC	Condition	Possible Causes
1236	ECL in-range circuit fault	• ECL circuit OPEN or shorted to GND or PWR • Failed switch

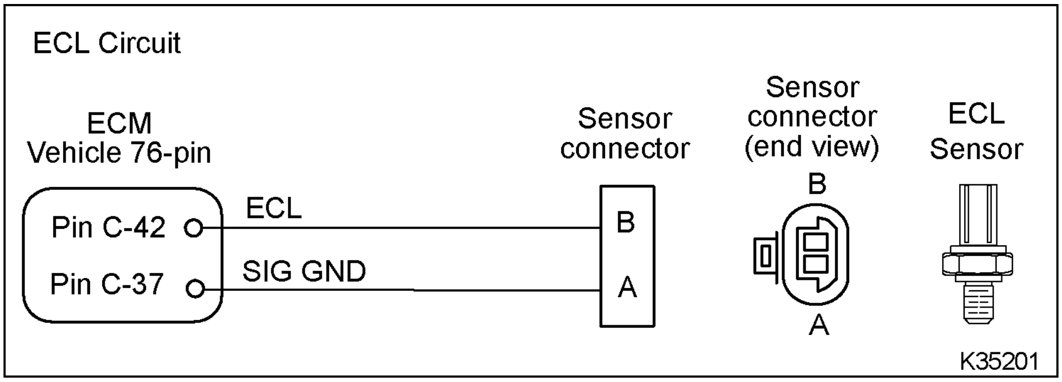


Figure 213 ECL circuit diagram

Connector Voltage Check

Disconnect ECL switch. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
A to GND	0 V	If > 0.25 V, check for short to PWR.
B to GND	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 270).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect breakout harness. Leave switch disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
A to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit.
B to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Switch Resistance Check

Disconnect ECL connector and measure across switch.

Test Point	Spec	Comment
A to B	> 1 kΩ (full)	If < 1 kΩ, replace switch
A to B	< 5 Ω (empty)	If > 5 Ω, replace switch

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
A to C-37	< 5 Ω	If > 5 Ω, check for OPEN circuit.
B to C-42	< 5 Ω	If > 5 Ω, check for OPEN circuit.

ECL Circuit Operation

The ECL switch uses a floating ball with a magnetic switch. When the coolant level is full, the float will rise and the magnet will pull the level switch open. This allows a 5 volt signal at ECM Pin C-42. When the level is low, the switch will close and ECM Pin C-42 will be 0 volts.

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 DTC will be set.

ECM PWR (Electronic Control Module Power)

DTC	SPN	FMI	Condition
1112	168	3	B+ out-of-range HIGH
1113	168	4	B+ out-of-range LOW

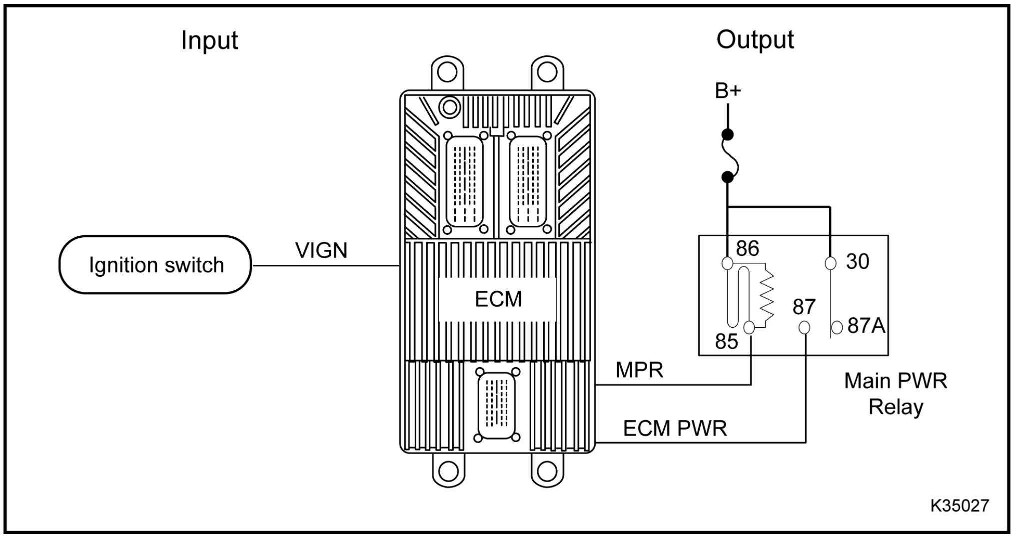


Figure 214 Function diagram for the ECM PWR

The function diagram for ECM PWR includes the following:

- Electronic Control Module (ECM)
- ECM main power relay
- Ignition switch or power relay
- Battery
- Fuses

Function

The ECM requires battery power to operate the electronic control system 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 located on the left side of the engine, just below the intake manifold.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- Breakout Box (page 426)
- Relay Breakout Harness (page 431)
- Terminal Test Adapter Kit (page 432)

ECM PWR Pin-point Diagnostics

DTC	Condition	Possible Causes
1112	B+ out-of-range HIGH	• Jump starting using more than system voltage • Batteries wired incorrectly
1113	B+ out-of-range LOW	• Low discharged batteries • Inoperative alternator • High resistance in ECM powering circuits (ECM PWR, ECM GND, or VIGN)

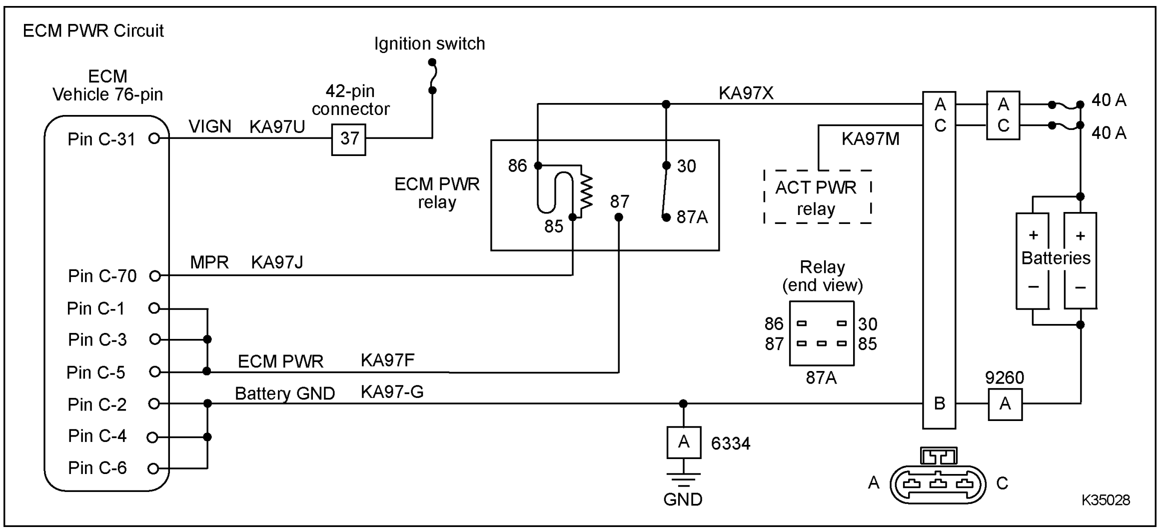


Figure 215 ECM PWR circuit diagram

NOTE: Reference the truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for vehicle side electrical system.

Voltage Checks at Relay

Connect relay breakout harness between relay and relay socket. Turn ignition switch ON. Use DMM to measure voltage.

CAUTION: To avoid engine damage, turn the ignition switch to OFF before removing main power relay or any ECM connector supplying power to the ECM. Failure to turn the ignition switch to OFF will cause a voltage spike and damage to electrical components.

Test Point	Spec	Comment
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. Do Harness Resistance Check (page 274).
30 to GND	B+	If 0 V, 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. Do Harness Resistance Check (page 274).
85 to GND	0 V to 2 V	If > 2 V, check MPR control circuit for OPEN or short to PWR. Do Harness Resistance Check (page 274).
87 to GND	B+	If < B+, replace relay.
		If B+, check ECM PWR and ECM GND circuits at the ECM. Do Voltage Checks at ECM (page 273).

Voltage Checks at ECM

Connect breakout box between ECM and vehicle harness. Turn ignition switch ON. Use DMM to measure voltage.

Test Point	Spec	Comment
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	If voltage is present, check for OPEN circuit. Do Harness Resistance Check (page 274).
C-4 to GND	0 V	
C-6 to GND	0 V	
C-70 to GND	0 V to 2 V	If > 2 V, check MPR control circuit for OPEN or short to PWR. Do Harness Resistance Check (page 274).
C-1 to GND	B+	If < B+, check for OPEN circuit, failed relay, or blown fuse. Do Harness Resistance Check (page 274).
C-3 to GND	B+	
C-5 to GND	B+	

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and relay breakout harness. Leave ECM, ECM PWR relay, and ACT PWR relay disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
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	Spec	Comment
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-31. This signals the ECM to provide a ground path from Pin C-70 to 85 to switch the ECM main power 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 V or more than 17.5 V, a Diagnostic Trouble Code (DTC) will be set.

ECM Self Diagnostics (Electronic Control Module)

DTC	SPN	FMI	Condition
1151	108	3	BAP signal out-of-range HIGH
1152	108	4	BAP signal out-of-range LOW
5382	1136	0	ECM Error - over temperature
5618	8334	2	ECM Error - SPI-BUS error 1
5619	8334	12	ECM Error - SPI-BUS error 2
5627	8333	12	ECM Error - Checksum program
5628	8333	2	ECM Error - Checksum dataset
5632	8254	12	ECM Error - RAM/CPU self test fault
5633	8254	0	ECM Error - CPU Load above maximum
5634	8336	12	ECM Error - MQPS daisy chain failure
5635	8337	12	ECM Error - OCT daisy chain failure
5636	8338	12	ECM Error - QPS daisy chain failure
5641	86	14	ECM Error - CC monitoring
5642	94	14	ECM Error - Fuel Cut Off monitoring
5643	183	14	ECM Error - Post Inj monitoring
5644	190	2	ECM Error - Engine speed limitation
5645	7253	7	ECM Error - EEPROM failure
5646	190	14	ECM Error - Engine Speed monitoring
5647	558	14	ECM Error - PVS monitoring
5648	976	14	ECM Error - PTO monitoring
5649	1136	14	ECM Error - A/D conversion monitoring
5651	7132	14	ECM Error - MFMA monitoring
5652	8240	14	ECM Error - NVMY monitoring
5653	8300	14	ECM Error - PPS monitoring
5654	8329	14	ECM Error - CAN monitoring
5655	8332	14	ECM Error - Service Tool monitoring
5656	8335	14	ECM Error - Processor monitoring

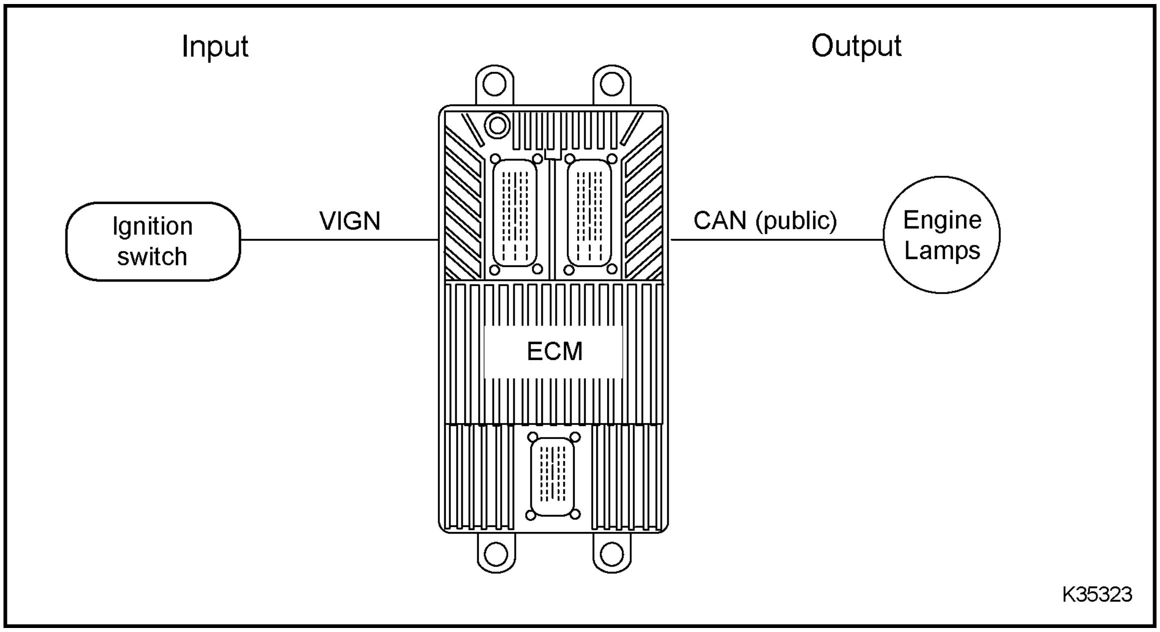


Figure 216 Function diagram for the ECM

The ECM does the following:

- Monitors and controls engine operation and performance
- Enables Power Takeoff and cruise control
- Communicates engine and vehicle information to instrument cluster
- Enables electronically controlled transmission (if equipped)
- Enables diagnostic programming tools

Fault Detection / Management

The ECM automatically performs diagnostic self-checks. The ECM self-test includes memory, programming, and internal power supply checks. The ECM will detect internal Diagnostic Trouble Codes (DTCs) depending on the severity of the problem. Additionally, the ECM provides DTC management strategies to permit limited engine and vehicle operation.

ECM Self Diagnostic Trouble Codes (DTCs)

DTC 1151 - BAP signal out-of-range HIGH

Checks whether the signal from the BAP sensor is above the maximum threshold.

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 1152 - BAP signal out-of-range LOW

Checks whether the signal from the BAP sensor is below the minimum threshold.

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 5382 - ECM Error - over temperature

Pin-point ECM Self Diagnostic Fault

1. Correct any abnormal condition of ECM overheating.
2. If DTC is set in cool conditions, then replace ECM.

DTC 5618 - ECM Error - SPI-BUS error 1

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 5619 - ECM Error - SPI-BUS error 2

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 5627 - ECM Error - Checksum program

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 5628 - ECM Error - Checksum dataset

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 5632 - ECM Error - Random Access Memory (RAM) - CPU self-test fault

Internal ECM problem, RAM memory fault, causes an engine no start.

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 5633 - ECM Error - CPU Load above maximum

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 5634 - ECM Error - MQPS daisy chain failure

Indicates an error occurred in the ECM.

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 5635 - ECM Error - OCT daisy chain failure

Indicates an error occurred in the ECM.

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 5636 - ECM Error - QPS daisy chain failure

Indicates an error occurred in the ECM.

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 5641 - ECM Error - CC monitoring

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 5642 - ECM Error - Fuel Cut Off monitoring

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 5643 - ECM Error - Post Inj monitoring

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 5644 - ECM Error - Engine speed limitation

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 5645 - ECM Error - EEPROM failure

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 5646 - ECM Error - Engine Speed monitoring

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 5647 - ECM Error - PVS monitoring

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 5648 - ECM Error - PTO monitoring

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 5649 - ECM Error - A/D conversion monitoring

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 5651 - ECM Error - MFMA monitoring

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 5652 - ECM Error - NVMY monitoring

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 5653 - ECM Error - PPS monitoring

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 5654 - ECM Error - CAN monitoring

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 5655 - ECM Error - Service Tool monitoring

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

DTC 5656 - ECM Error - Processor monitoring

Indicates the ECM software is corrupted.

Pin-point ECM Self Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM.

ECT Sensor (Engine Coolant Temperature)

DTC	SPN	FMI	Condition
1114	110	4	ECT signal out-of-range LOW
1115	110	3	ECT signal out-of-range HIGH

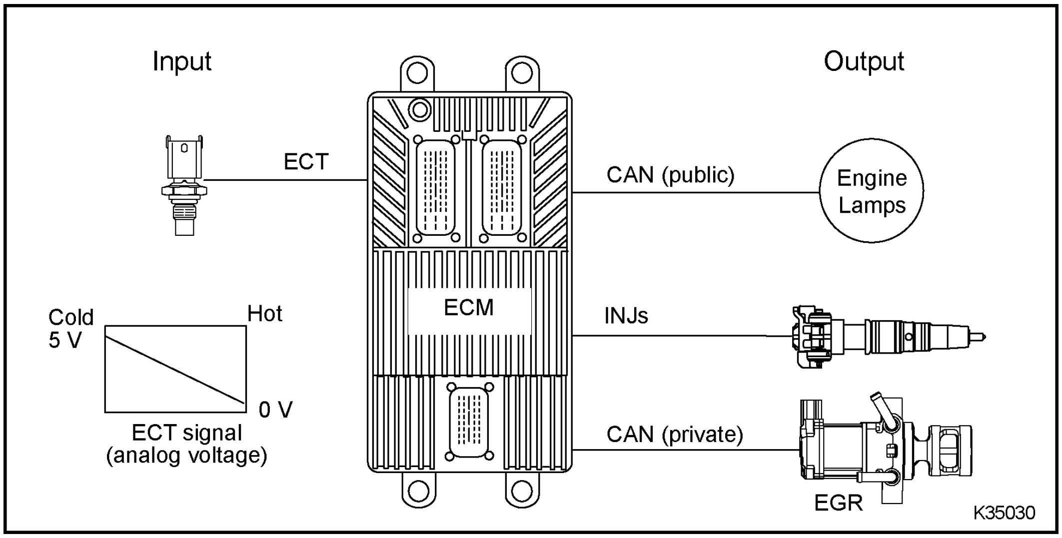


Figure 217 Function diagram for the ECT sensor

The function diagram for the ECT sensor includes the following:

- Engine Coolant Temperature (ECT) sensor
- Electronic Control Module (ECM)
- Exhaust Gas Recirculation (EGR) valve
- Fuel injector (INJ)
- Engine lamps (amber and red)

Function

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 Engine Warning and Protection System (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 shut down the engine.

Sensor Location

The ECT sensor is installed in the water supply housing (Freon® compressor bracket), right of the flat idler pulley assembly.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- 3-Banana Plug Harness (page 425)
- Breakout Box (page 426)
- Temperature Sensor Breakout Harness (page 432)
- Terminal Test Adapter Kit (page 432)

ECT Sensor End Diagnostics

DTC	Condition	Possible Causes
1114	ECT signal out-of-range LOW	• ECT signal circuit short to GND • Failed sensor
1115	ECT signal out-of-range HIGH	• ECT signal OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor

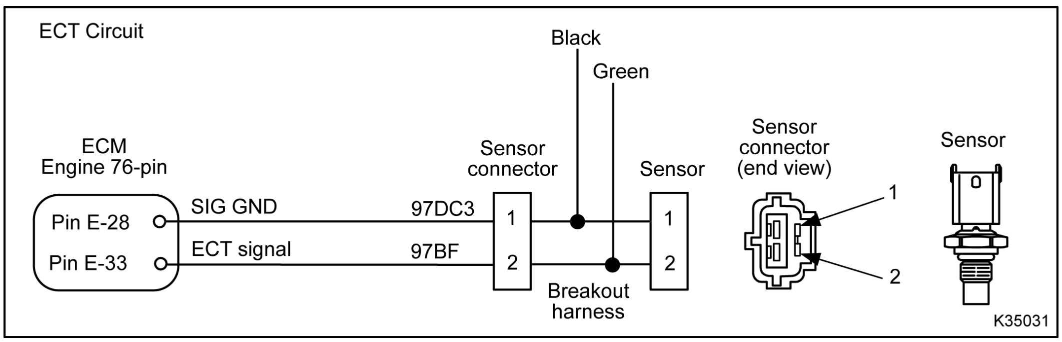


Figure 218 ECT circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Monitor sensor voltage. Verify an active DTC for the sensor.
   - If code is inactive, monitor the PID while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID will spike and the DTC 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 DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST – Check DTC	DTC 1115	If DTC 1114 is active, check ECT signal for short to GND. Do Harness Resistance Check (page 286).
EST – Check DTC Short 3 banana plug harness across 2 and GND	DTC 1114	If DTC 1115 is active, check ECT signal for OPEN. Do Harness Resistance Check (page 286).
EST – Check DTC Short 3 banana plug harness across 1 and 2	DTC 1114	If DTC 1115 is active, check SIG GND for OPEN. Do Harness Resistance Check (page 286).
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace sensor.		

ECT Pin-point Diagnostics

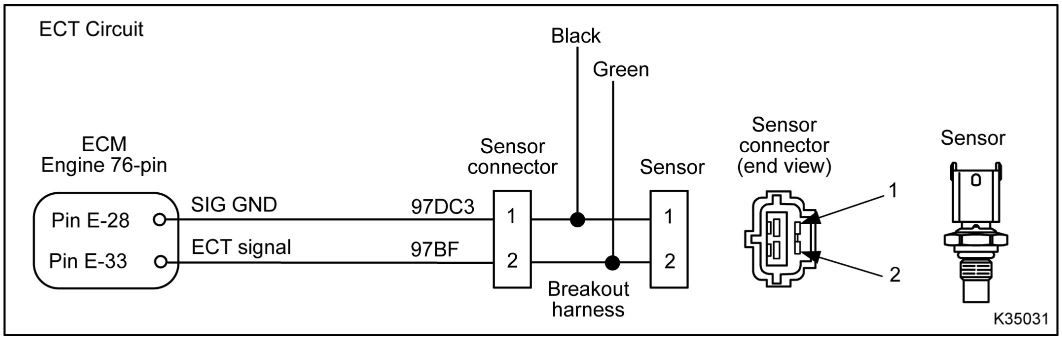


Figure 219 ECT circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	0 V	If > 0.25 V, check for short to PWR.
2 to GND	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 286).

Connector Resistance Checks to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

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	Spec	Comment
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.

ECT Circuit Operation

The ECT is a thermistor sensor that is supplied with a 5 V reference voltage at Pin 2 from ECM Pin E–33.

The sensor is grounded at Pin 1 from ECM Pin E–28. As the coolant temperature increases, the resistance of the thermistor decreases. This causes the signal voltage to decrease.

Coolant Temperature Compensation

Coolant temperature compensation reduces fuel delivery if ECT is above cooling system specifications.

The reduction in fuel delivery begins when ECT reaches approximately 107 °C (225 °F). A reduction of 15% will be achieved as the ECT reaches approximately 110 °C (230 °F).

Fuel reduction is calibrated to a maximum of 30% before standard engine warning or optional warning/protection is engaged. If warning or shutdown occurs, a DTC is stored in the ECM memory.

NOTE: Coolant temperature compensation may be disabled in emergency vehicles that require 100% power on demand.

Engine Warning and Protection (EWPS)

The EWPS is an optional feature that can be enabled or disabled. When enabled, the EWPS will warn the operator of an overheat condition and can be programmed to shut down the engine.

The red engine lamp will illuminate when ECT reaches approximately 109 °C (228 °F). A warning buzzer will sound when ECT reaches approximately 112 °C (234 °F). The engine will shut down when the ECT reaches approximately 112 °C (234 °F), if 3-way protection is enabled.

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 value. The ECM will set a DTC, turn on the amber engine lamp, and run the engine in a default range.

When this occurs, the EWPS, CAP, IST, cold idle advance, and coolant temperature compensation features are disabled.

EFAN Control (Engine Fan Control)

DTC	SPN	FMI	Condition
None			

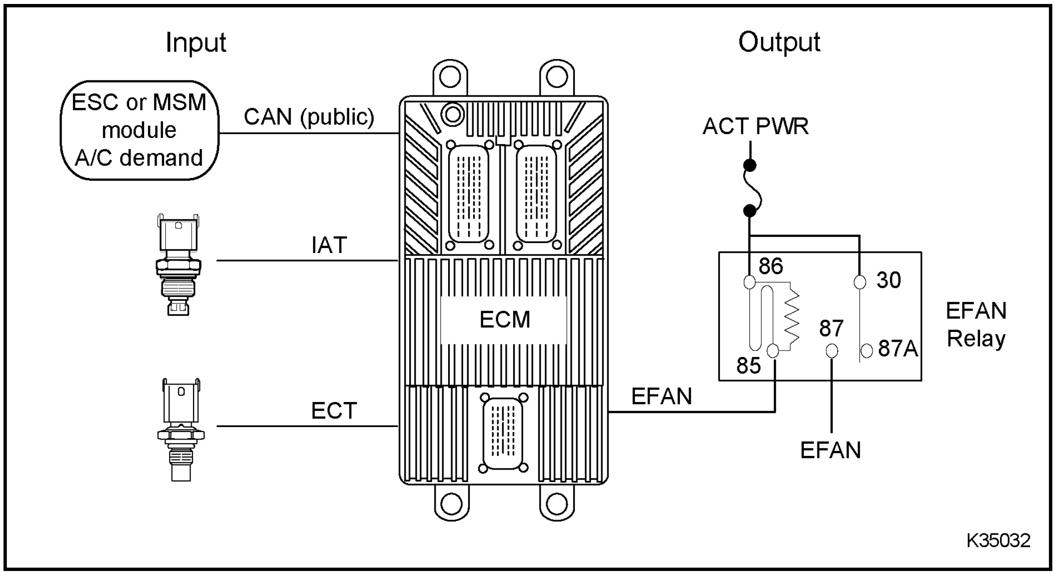


Figure 220 Function diagram for EFAN

The function diagram for EFAN includes the following:

- Engine Fan (EFAN) control
- Electronic Control Module (ECM)
- Electronic System Control (ESC) module
- Multiplex System Module (MSM)
- Engine Coolant Temperature (ECT) sensor
- Intake Air Temperature (IAT) sensor
- Electronic System Controller (ESC)
- Engine Fan (EFAN) relay

Function

The purpose of the engine fan is to allow a higher air flow through the radiator when the A/C is on or when the ECT or IAT 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 428)
- Breakout Box (page 426)
- Relay Breakout Harness (page 431)
- Terminal Test Adapter Kit (page 432)

EFAN Circuit Diagnostics

DTC	Condition	Possible Causes
None	EFAN does not cycle ON or OFF	• EFAN relay control circuit OPEN or shorted to GND • EFAN relay coil GND circuit OPEN • Blown fuse • Failed relay

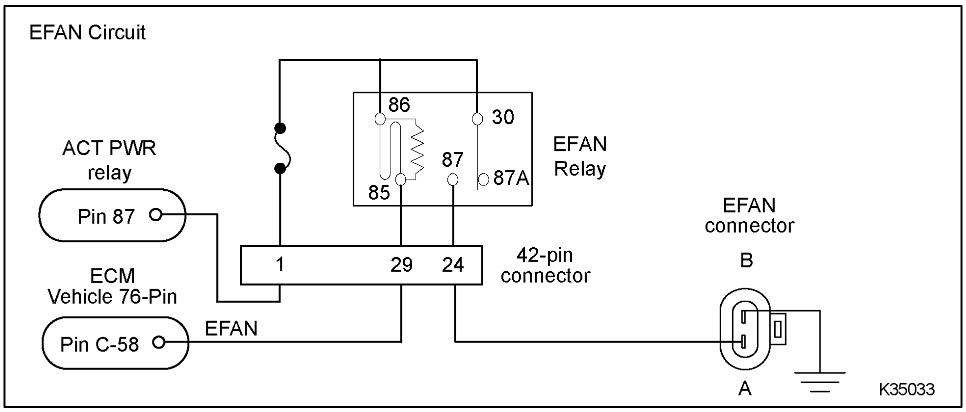


Figure 221 EFAN circuit diagram

Voltage Check at EFAN Connector - Output State Test

Disconnect EFAN 2-pin connector. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
A to GND	0 V to 0.25 V	If > 0.25 V, check for short to PWR or EFAN control circuit for short to GND, or failed EFAN relay.
B to GND	0 V to 0.25 V	If > 0.25 V, check for OPEN circuit.
Run Output State Test HIGH.		
A to GND	0 V to 0.25 V	If > 0.25 V, check for short to PWR, or EFAN control circuit for short to GND, or failed EFAN relay.
Run Output State Test LOW.		
A to GND	B+	If < B+, check for OPEN circuit between relay and EFAN, or EFAN control circuit for OPEN, or blown fuse, or failed relay. Do Harness Resistance Check (page 290).
A to B	B+	If < B+, check GND circuit for OPEN. Do Harness Resistance Check (page 290).

Voltage Check at Relay - Output State Test

Connect breakout harness between relay and relay socket. Connect EFAN and turn ignition switch ON. Use DMM to measure voltage.

Test Point	Spec	Comment
30 to GND	B+	If < B+, check power circuit to relay switch for OPEN or short to GND, or blown fuse. See ACT PWR Relay.
86 to GND	B+	If < B+, check power 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 EFAN control circuit for short to GND. Do Harness Resistance Check (page 290).
Run Output State Test LOW.		
85 to GND	0.06 V to 2 V	If > 2 V, check EFAN control circuit for OPEN. Do Harness Resistance Check (page 290).
87 to GND	B+	If < B+, replace relay.

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and relay harness. Leave ECM and relay disconnected.

Test Point	Spec	Comment
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.		

EFAN Circuit Operation

The default state of the EFAN is ON. B+ is needed to turn the fan OFF.

ECM Pin C-58 controls the EFAN to shut off by supplying a ground path to the EFAN 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 EFAN.

EFAN Programmable Parameters

By using an EST, an authorized service technician can program the ECM to turn the EFAN 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 ESC during A/C operation.
- Disable - enables or disables the EFAN feature.
- Fan on temperature - indicates at what coolant temperature that the fan will be electronically activated.
- Fan off temperature - indicates at what coolant temperature that the fan will be electronically deactivated.

Fault Detection / Management

An open or short to ground in the EFAN can be detected by the ECM during an on-demand engine standard test. The IAT and ECT are continuously monitored. If a DTC is detected in the IAT or ECT circuit, the EFAN control 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 Sensor (Engine Fuel Pressure)

DTC	SPN	FMI	Condition
1136	94	4	EFP signal out-of-range LOW
1137	94	3	EFP signal out-of-range HIGH
2371	94	0	Fuel pressure above normal
2372	94	1	Fuel pressure below normal

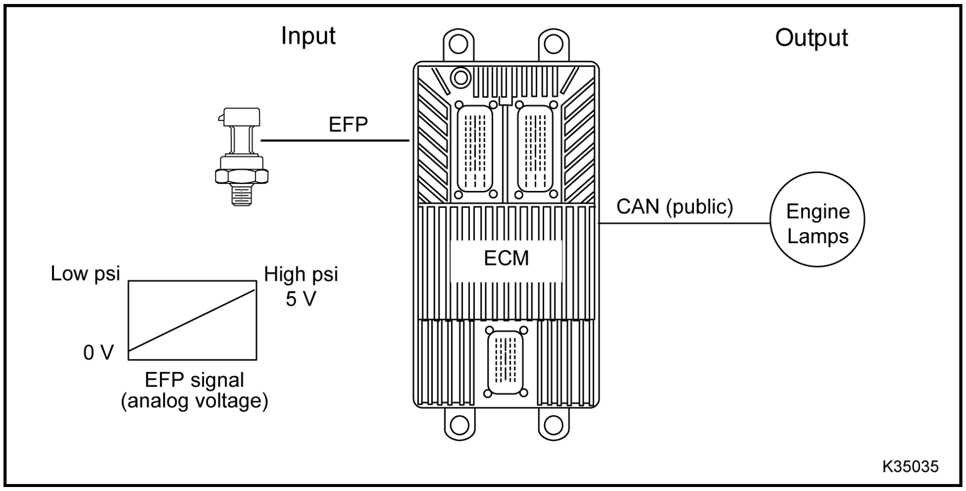


Figure 222 Function diagram for the EFP sensor

The function diagram for the EFP sensor includes the following:

- Engine Fuel Pressure (EFP) sensor
- Electronic Control Module (ECM)
- Engine lamp (amber)
- Fuel Filter lamp (amber)

Function

The EFP 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.

Sensor Location

The EFP sensor is installed in the fuel filter housing on the left side of the crankcase.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- 3-Banana Plug Harness (page 425)
- Breakout Box (page 426)
- Pressure Sensor Breakout Harness (page 431)
- Terminal Test Adapter Kit (page 432)

EFP Sensor End Diagnostics

DTC	Condition	Possible Causes
1136	EFP signal out-of-range LOW	• EFP signal circuit OPEN or short to GND • VREF circuit OPEN or short to GND • Failed sensor
1137	EFP signal out-of-range HIGH	• EFP signal circuit short to PWR • Failed sensor
2371	Fuel pressure above normal	• SIG GND circuit OPEN • VREF short to PWR • Debris in fuel regulator • Biased circuit/sensor
2372	Fuel pressure below normal	• Low fuel pressure • Dirty fuel filter • Fuel inlet restriction • Debris in fuel regulator • Failed fuel pump • Bias circuit / sensor

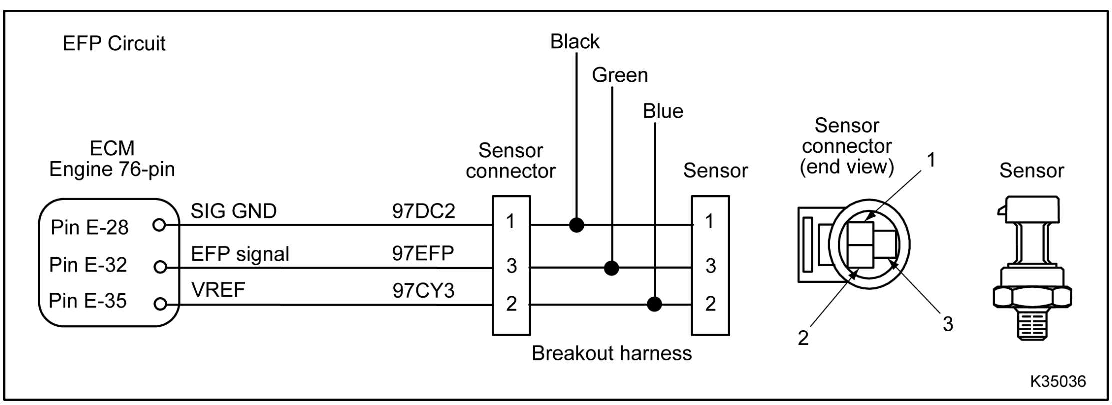


Figure 223 EFP circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Verify sensor voltage is within KOEO specification. See “Performance Specification” section.
3. Monitor sensor voltage. Verify an active DTC for the sensor.
   - If code is inactive, monitor the PID while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID will spike and the DTC 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.

Sensor Circuit Check

Connect sensor breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use EST to verify correct DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST – Check DTC	DTC 1136	If DTC 1137 is active, check EFP signal for short to PWR
DMM – Measure volts 2 to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 296).
EST – Check DTC Short breakout harness across 2 and 3	DTC 1137	If DTC 1136 is active, check EFP signal for OPEN or short to GND. Do Harness Resistance Check (page 296).
DMM – Measure resistance 1 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 296).
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace sensor.		

EFP Pin-point Diagnostics

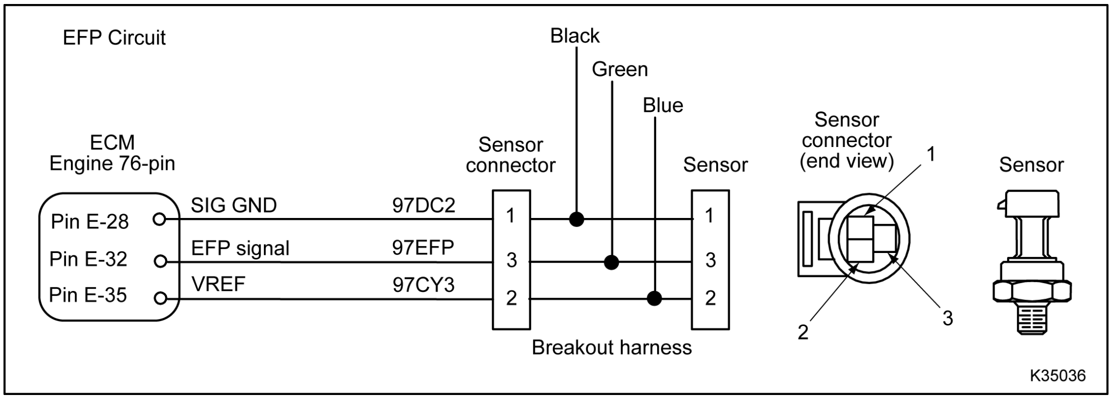


Figure 224 EFP circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	0 V	If > 0.25 V, check for short to PWR.
2 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 (page 296).
3 to GND	0 V	If > 0.25 V, check for short to PWR. Do Harness Resistance Check (page 296).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit.
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. Connect breakout box and sensor breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
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.

EFP Circuit Operation

The EFP sensor is a variable capacitance sensor that is supplied with a 5 V 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-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 value. The ECM will set a DTC, turn on the amber engine lamp, and run the engine in a default range.

EGDP Sensor (Exhaust Gas Differential Pressure)

DTC	SPN	FMI	Condition
1729	3251	4	EGDP signal out-of-range LOW
1731	3251	3	EGDP signal out-of-range HIGH
2699	3251	1	EGDP below desired level
2732	3251	2	EGDP stuck in-range fault
2733	3251	10	EGDP mismatch between key-on/off

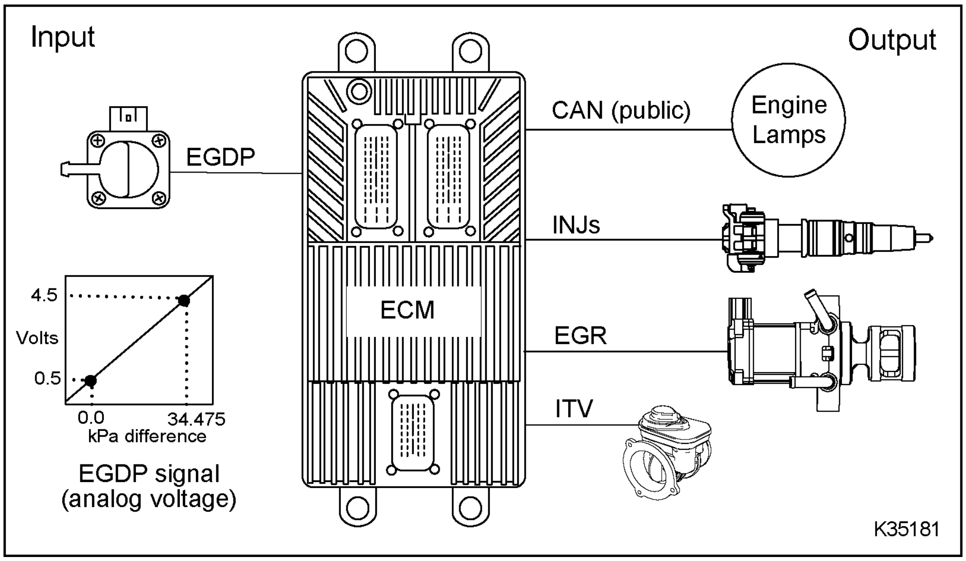


Figure 225 Function diagram for the EGDP sensor

The function diagram for the EGDP sensor includes the following:

- Exhaust Gas Differential Pressure (EGDP) sensor
- Electronic Control Module (ECM)
- Exhaust Gas Recirculation (EGR)
- Intake Throttle Valve (ITV)
- Fuel injector (INJ)
- Engine lamp (amber)
- Regeneration lamp

Function

The EGDP 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 EGT1, EGT2, EGT3, EGRP and ITVP.

Sensor Location

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

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- 3-Banana Plug Harness (page 425)
- Breakout Box (page 426)
- Breakout Harness (page 430)
- Terminal Test Adapter Kit (page 432)

EGDP Sensor End Diagnostics

DTC	Condition	Possible Causes
1729	EGDP signal out-of-range LOW	• EGDP signal OPEN or short to GND • Failed sensor
1731	EGDP signal out-of-range HIGH	• EGDP signal short to PWR • SIG GND circuit OPEN • Failed sensor
2699	EGDP below desired level	• EGDP sensor tubes restricted, open, or assembled incorrectly • Biased circuit or sensor
2732	EGDP stuck in-range fault	• EGDP sensor tubes restricted or open
2733	EGDP mismatch between key-on/off	• Biased circuit or sensor

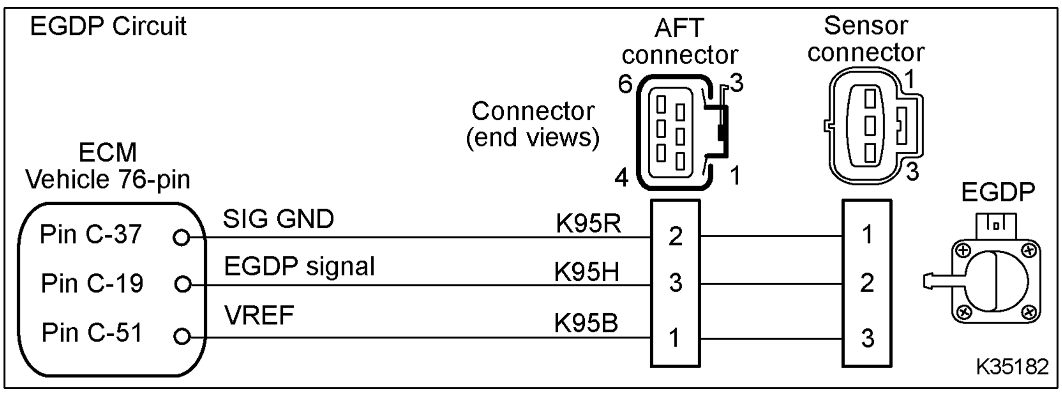


Figure 226 EGDP circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Verify sensor voltage is within KOEO specification. See “Performance Specification” section.
3. Monitor sensor voltage. Verify an active DTC for the sensor.
   - If code is inactive, monitor the PID while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID will spike and the DTC 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.

Sensor Circuit Check

Connect sensor breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use EST to verify correct DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC	DTC 1729	If DTC 1731 is active, check EGDP signal for short to PWR.
DMM - Measure volts 3 to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 302).
EST - Check DTC Short breakout harness across 2 and 3	DTC 1731	If DTC 1729 is active, check EGDP signal for OPEN. Do Harness Resistance Check (page 302).
DMM - Measure resistance 1 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 302).
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace sensor.		

EGDP Pin-point Diagnostics

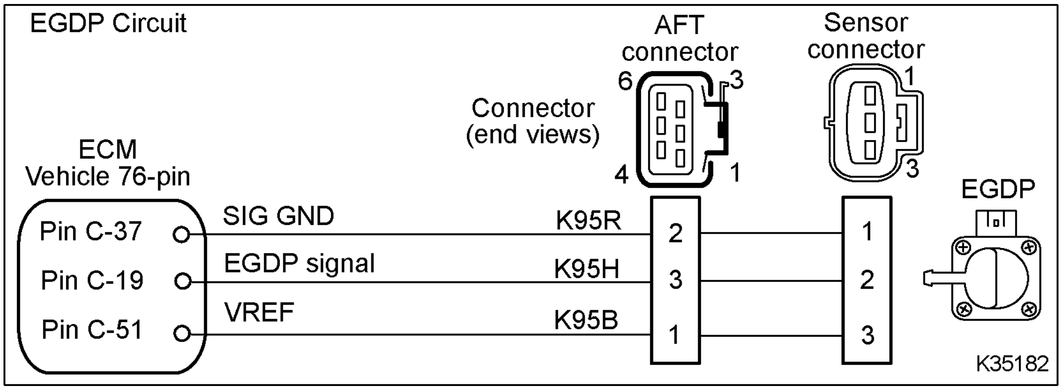


Figure 227 EGDP circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	0 V	If > 0.25 V, check for short to PWR.
3 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 (page 302).
2 to GND	0 V	If > 0.25 V, check for short to PWR. Do Harness Resistance Check (page 302).

Connector Resistance Checks to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit.
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. Connect breakout box and breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
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 EGDP signal circuit for OPEN
3 to C-51	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN

EGDP Circuit Operation

The EGDP is a differential pressure sensor that is supplied with a 5 V reference voltage 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.

EGR Actuator (Exhaust Gas Recirculation)

DTC	SPN	FMI	Condition
1362	412	0	EGR valve internal high circuit failure
1363	412	1	EGR valve internal low circuit failure
1396	7137	12	EGRV Initialization Fault
1397	7137	4	EGR position in-range fault
1398	8327	7	EGR unable to achieve desired position
2368	8146	7	EGR valve communication fault
2391	2791	11	EGR valve internal circuit failure
2392	7138	6	EGR duty cycle above limit
2393	7137	2	EGR position sensor fault
2394	8146	2	EGR valve not receiving ECM CAN messages
2395	7317	3	EGRH OCC self-test failed
2396	7317	4	EGRL OCC self-test failed

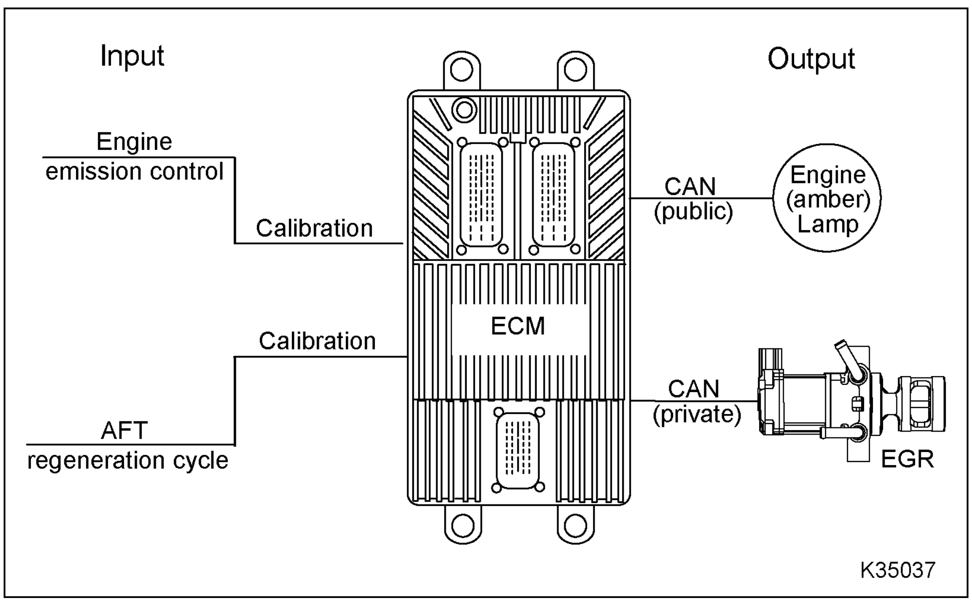


Figure 228 Function diagram for the EGR actuator

The function diagram for the EGR actuator includes the following:

- Electronic Control Module (ECM)
- Exhaust Gas Recirculation (EGR) actuator
- Engine lamp (amber)

Function

Oxides of nitrogen (NO_X) in the atmosphere contribute to the production of smog. NO_X is formed 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. Exhaust gases that have already burned do not burn again. The EGR valve recirculates exhaust back into the intake stream. This will cool the combustion process and reduce the formation of NO_X.

Component Location

The EGR valve is installed in the EGR manifold between the throttle body and the intake manifold.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- EGR Valve Breakout Harness (page 429)
- Breakout Box (page 426)
- Terminal Test Adapter Kit (page 432)

EGR Pin-point Diagnostics

DTC	Condition	Possible Causes
1362	EGR valve internal high circuit failure	• Private CAN circuits OPEN or short to PWR or GND
1363	EGR valve internal low circuit failure	• OPEN PWR or GND circuits to EGR valve
1396	EGRV Initialization Fault	• Failed EGR valve
1397	EGR position in-range fault	
1398	EGR position stuck in-range fault	
2368	EGR valve communication fault	
2391	EGR valve internal circuit failure	
2392	EGR duty cycle above limit	
2393	EGR position sensor fault	
2394	EGR valve not receiving ECM CAN messages	
2395	EGRH OCC self-test failed	
2396	EGRL OCC self-tested failed	

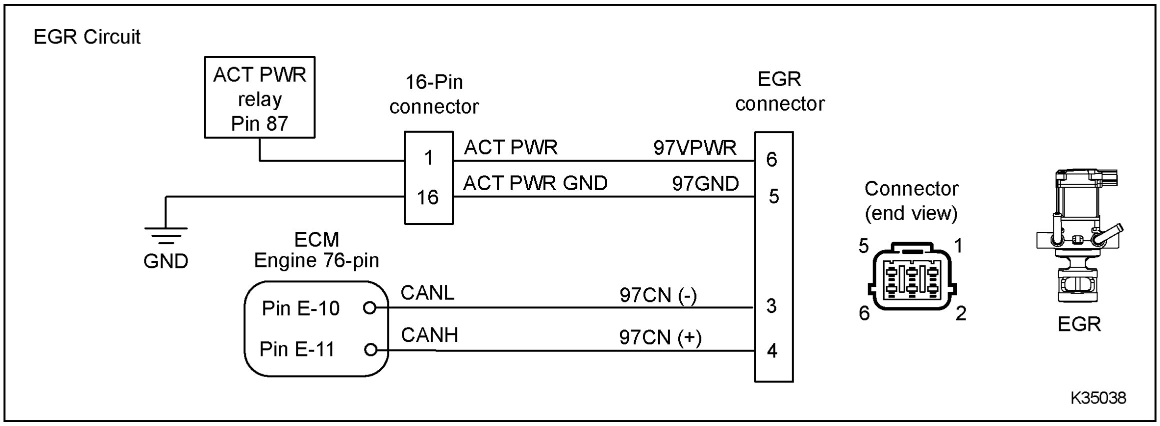


Figure 229 EGR circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Verify sensor voltage is within KOEO specification. See “Performance Specification” section.
3. Monitor sensor voltage. Verify an active DTC for the sensor.
   - If code is inactive, monitor the PID while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID will spike and the DTC 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.

Connector Voltage Check

Connect breakout harness between engine harness and EGR actuator. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
6 to GND	B+	If < B+, check ACT PWR circuit for OPEN or short to GND, or blown fuse. Do Harness Resistance Check (page 306).
5 to 6	B+	If < B+, check ACT PWR GND circuit for OPEN. Do Harness Resistance Check (page 306).
3 to GND	1 to 4 V	The sum of 3 to GND and 4 to GND should equal 4 to 5 V.
4 to GND	1 to 4 V	The sum of 4 to GND and 3 to GND should equal 4 to 5 V.

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and breakout harnesses to EGR actuator and ACT PWR relay. Leave ECM, EGR, and relay disconnected.

Test Point	Spec	Comment
3 to E-10	< 5 Ω	If > 5 Ω, check CANL for OPEN in circuit.
3 to GND	> 1 kΩ	If < 1 kΩ, check CANL for short to GND.
4 to E-11	< 5 Ω	If > 5 Ω, check CANH for OPEN in circuit.

Harness Resistance Check (cont.)

4 to GND	> 1 kΩ	If < 1 kΩ, check CANH for short to GND.
5 to GND	< 5 Ω	If > 5 Ω, check ACT PWR GND for OPEN in circuit. See truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for additional information.
6 to 87 (relay)	< 5 Ω	If > 5 Ω, check ACT PWR for OPEN in circuit.
		If < 5 Ω, and no voltage was detected on the connector voltage table, go to ACT PWR relay test.
6 to GND	> 1 kΩ	If < 1 kΩ, check ACT PWR for short to GND.
If measurements are in specification, replace the EGR valve.		

EGR Circuit Operation

The EGR actuator receives power at Pin 6, from the ACT PWR relay Pin 87. Ground for the EGR actuator is supplied at Pin 5, from battery ground. The ECM controls the EGR actuator through the CAN (private) circuits, CANH, ECM E-11 to EGR Pin 4, and CANL, ECM E-10 to EGR Pin 3.

CAN (private) Circuit Operation

The private Controller Area Network (CAN) provides a communication link between the ECM and a specific engine controller, the EGR actuator. The EGR actuator can be controlled through the private CAN network. The EGR can communicate failures back to the ECM through the private CAN network.

CAN (private) versus CAN (public)

The public CAN network is set up 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 set up to only communicate between the ECM and specific engine controls.

CAN Repair Information

The CAN 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.

EGT1 Sensor (Exhaust Gas Temperature 1)

DTC	SPN	FMI	Condition
1737	3241	4	EGT1 signal out-of-range LOW
1738	3241	3	EGT1 signal out-of-range HIGH
2675	3241	2	EGT1 temp not increasing with engine temp
2676	3241	1	EGT1 reading off compared to EGT2 and EGT3

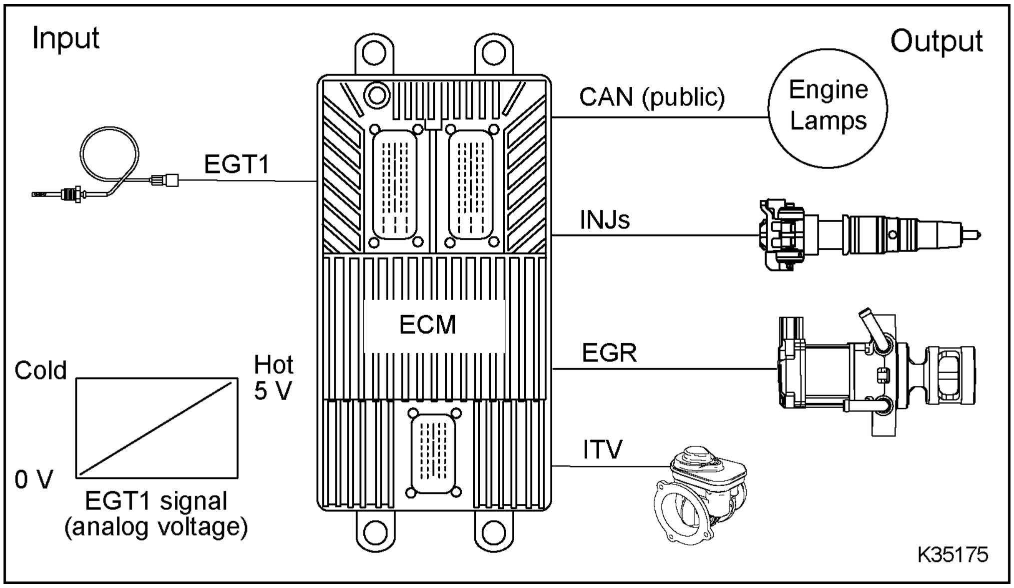


Figure 230 Function diagram for the EGT1 sensor

The function diagram for the EGT1 sensor includes the following:

- Exhaust Gas Temperature 1 (EGT1) sensor
- Electronic Control Module (ECM)
- Exhaust Gas Recirculation (EGR)
- Intake Throttle Valve (ITV)
- Fuel injector (INJ)
- Engine lamp (amber)
- Regeneration lamp

Function

The EGT1 sensor provides a feedback signal to the ECM indicating Diesel Oxidation Catalyst inlet temperature. Before and during a catalyst regeneration, the ECM will monitor this sensor along with the EGT2, EGT3, EGDP, EGRP and ITVP.

Sensor Location

The EGT1 sensor is the first exhaust temperature sensor installed down stream of the turbocharger and just before the Diesel Oxidation Catalyst.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- 3-Banana Plug Harness (page 425)
- Breakout Box (page 426)
- Exhaust Temperature Breakout Harness (page 430)
- Terminal Test Adapter Kit (page 432)

EGT1 Sensor End Diagnostics

DTC	Condition	Possible Causes
1737	EGT1 signal out-of-range LOW	• EGT1 signal circuit short to GND • Failed sensor
1738	EGT1 signal out-of-range HIGH	• EGT1 signal OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor
2675	EGT1 temp not increasing with engine temp	• EGT1 biased sensor or circuit • EGT sensor outside of exhaust system
2676	EGT1 reading off compared to EGT2 and EGT3	• EGT1 biased sensor or circuit • EGT sensor outside of exhaust system

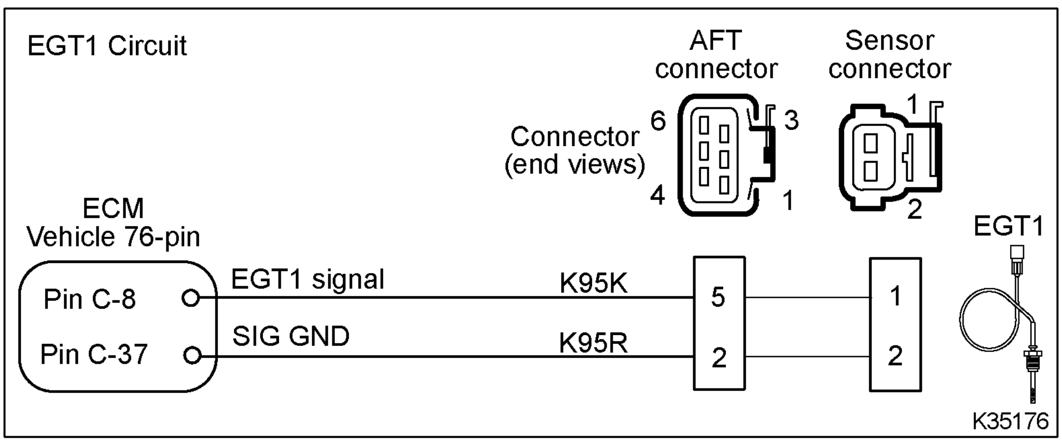


Figure 231 EGT1 circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Monitor sensor voltage. Verify an active DTC for the sensor.
   - If code is inactive, monitor the PID while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID will spike and the DTC 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 DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC	DTC 1738	If DTC 1737 is active, check EGT1 signal for short to GND. Do Harness Resistance Check (page 311).
EST - Check DTC Short 3-Banana plug harness across 1 and GND	DTC 1737	If DTC 1738 is active, check EGT1 signal for OPEN. Do Harness Resistance Check (page 311).
EST - Check DTC Short 3-Banana plug harness across 1 and 2	DTC 1737	If DTC 1738 is active, check SIG GND for OPEN. Do Harness Resistance Check (page 311).
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace sensor.		

EGT1 Pin-point Diagnostics

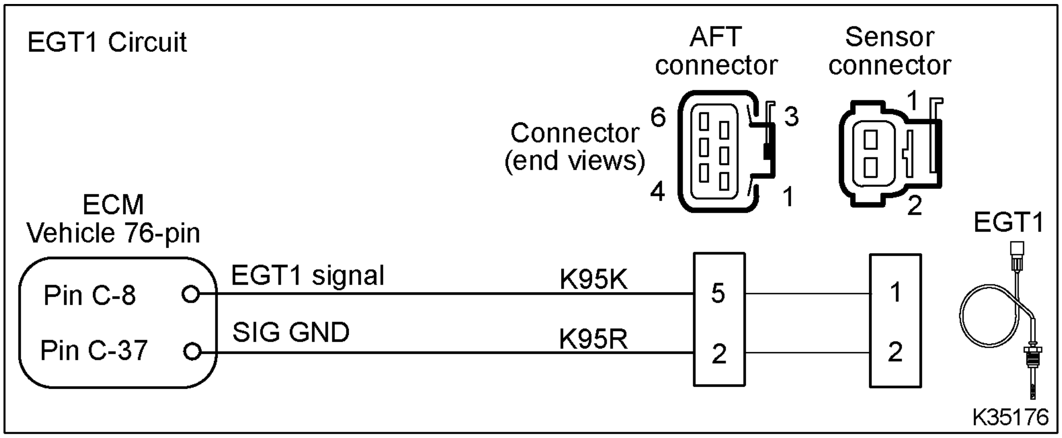


Figure 232 EGT1 circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
2 to GND	0 V	If > 0.25 V, check for short to PWR.
1 to GND	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 311).

Connector Resistance Checks to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	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 breakout box and exhaust temperature breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
2 to C-37	< 5 Ω	If > 5 Ω, check for OPEN circuit.
1 to C-8	< 5 Ω	If > 5 Ω, check for OPEN circuit.

EGT1 Circuit Operation

The EGT1 is a thermistor sensor that is supplied with a 5 V reference voltage at Pin 1 from ECM Pin C-8. The sensor is grounded at Pin 2 from ECM Pin C-37. As temperature increases, the resistance of the thermistor increases. This causes the signal voltage to increase.

EGT2 Sensor (Exhaust Gas Temperature 2)

DTC	SPN	FMI	Condition
1741	3242	4	EGT2 signal out-of-range LOW
1742	3242	3	EGT2 signal out-of-range HIGH
2673	3242	10	EGT2 not warming along with engine
2674	3242	2	EGT2 reading off compared to EGT1 and EGT3
2681	3241	1	EGT2 reading off compared to EGT1 and EGT3

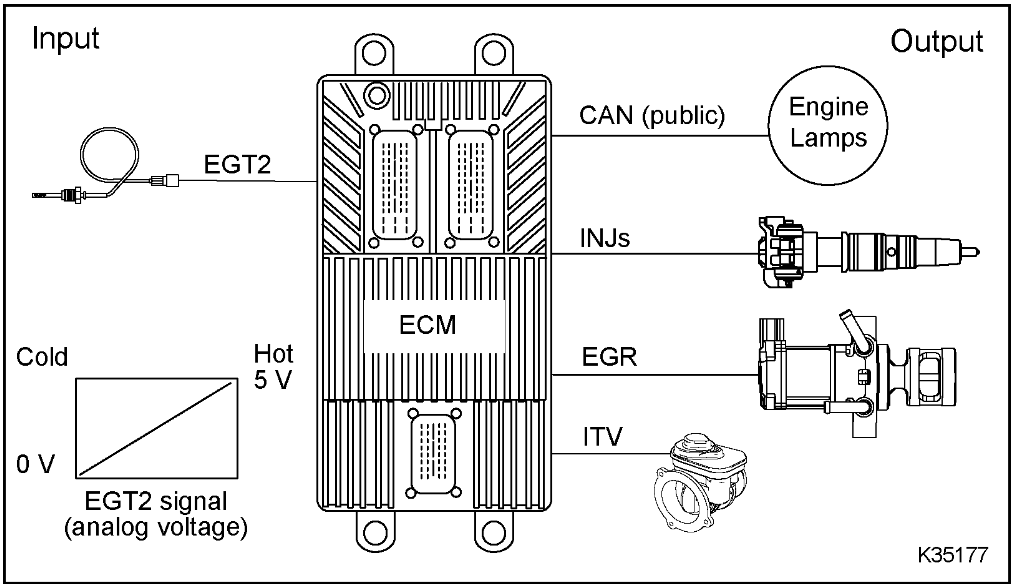


Figure 233 Function diagram for the EGT2 sensor

The function diagram for the EGT2 sensor includes the following:

- Exhaust Gas Temperature 2 (EGT2) sensor
- Electronic Control Module (ECM)
- Exhaust Gas Recirculation (EGR)
- Intake Throttle Valve (ITV)
- Fuel injector (INJ)
- Engine lamp (amber)
- Regeneration lamp

Function

The EGT2 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 EGT1, EGT3, EGDP, EGRP and ITVP.

Sensor Location

The EGT2 sensor is the second exhaust temperature sensor installed down stream of the turbocharger. It is located between the Diesel Oxidation Catalyst and the Diesel Particulate Filter.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- 3-Banana Plug Harness (page 425)
- Breakout Box (page 426)

- Exhaust Temperature Breakout Harness (page 430)
- Terminal Test Adapter Kit (page 432)

EGT2 Sensor End Diagnostics

DTC	Condition	Possible Causes
1741	EGT2 signal out-of-range LOW	• EGT2 signal circuit short to GND • Failed sensor
1742	EGT2 signal out-of-range HIGH	• EGT2 signal OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor
2673	EGT2 not warming along with engine	• EGT2 biased circuit or sensor • EGT2 sensor outside of exhaust system
2674	EGT2 reading off compared to EGT1 and EGT3	• EGT2 biased circuit or sensor
2681	EGT2 reading off compared to EGT1 and EGT3	• EGT2 sensor outside of exhaust system

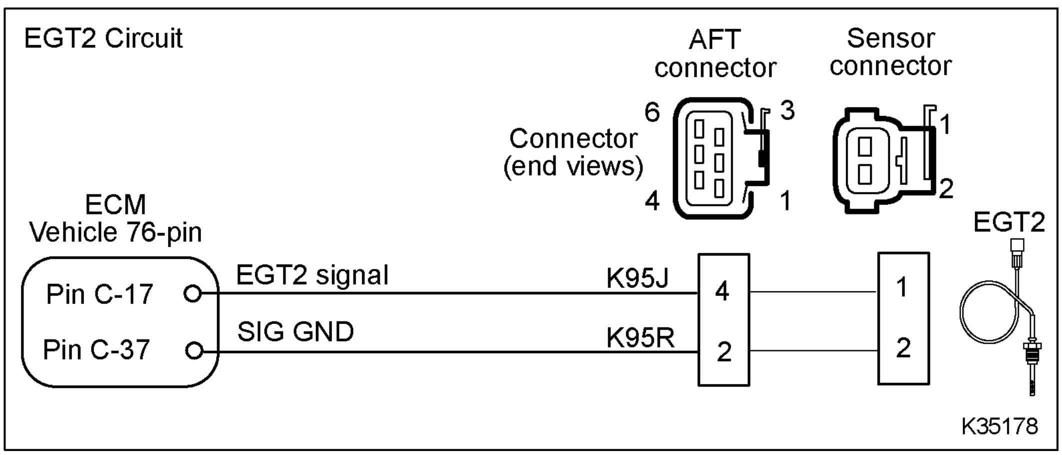


Figure 234 EGT2 circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Monitor sensor voltage. Verify an active DTC for the sensor.
   - If code is inactive, monitor the PID while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID will spike and the DTC 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 DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC	DTC 1742	If DTC 1741 is active, check EGT2 signal for short to GND. Do Harness Resistance Check (page 316).
EST - Check DTC Short 3-Banana plug harness across 1 and GND	DTC 1741	If DTC 1742 is active, check EGT2 signal for OPEN. Do Harness Resistance Check (page 316).
EST - Check DTC Short 3-Banana plug harness across 1 and 2	DTC 1741	If DTC 1742 is active, check SIG GND for OPEN. Do Harness Resistance Check (page 316).

If checks are within specification, connect sensor and clear DTCs. If active code remains, replace sensor.

EGT2 Pin-point Diagnostics

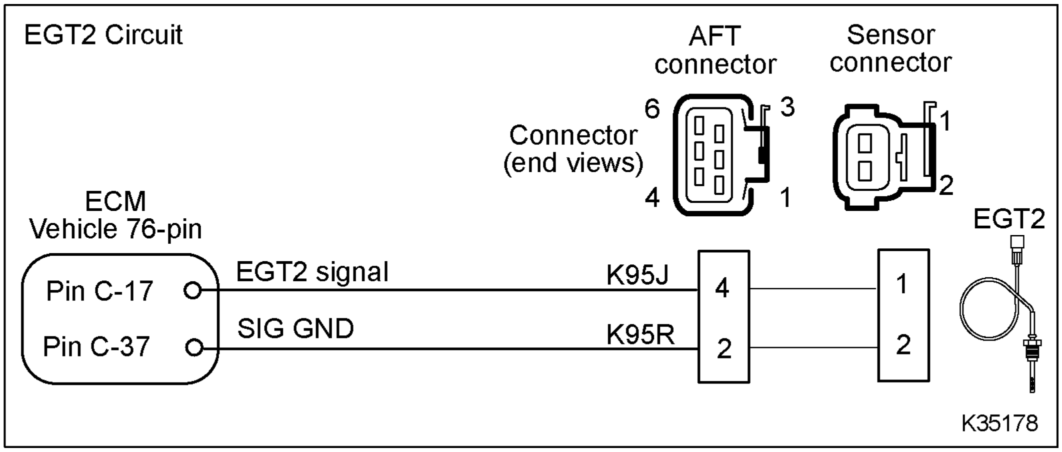


Figure 235 EGT2 circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
2 to GND	0 V	If > 0.25 V, check for short to PWR.
1 to GND	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 316).

Connector Resistance Checks to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	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 breakout box and breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
2 to C-37	< 5 Ω	If > 5 Ω, check for OPEN circuit.
1 to C-17	< 5 Ω	If > 5 Ω, check for OPEN circuit.

EGT2 Circuit Operation

The EGT2 is a thermistor sensor that is supplied with a 5 V reference voltage at Pin 1 from ECM Pin C-17. The sensor is grounded at Pin 2 from ECM Pin C-37. As temperature increases, the resistance of the thermistor decreases. This causes the signal voltage to increase.

EGT3 Sensor (Exhaust Gas Temperature 3)

DTC	SPN	FMI	Condition
1744	3245	4	EGT3 signal out-of-range LOW
1745	3245	3	EGT3 signal out-of-range HIGH
2677	3245	2	EGT3 not warming along with engine
2678	3245	1	EGT3 reading off compared to EGT1 and EGT2

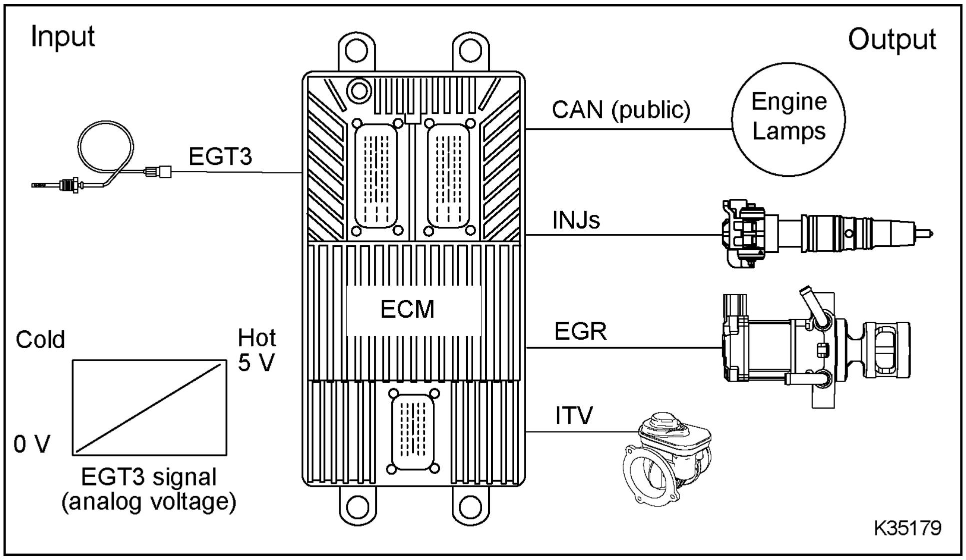


Figure 236 Function diagram for the EGT3 sensor

The function diagram for the EGT3 sensor includes the following:

- Exhaust Gas Temperature 3 (EGT3) sensor
- Electronic Control Module (ECM)
- Exhaust Gas Recirculation (EGR)
- Intake Throttle Valve (ITV)
- Fuel injector (INJ)
- Engine lamp (amber)
- Regeneration lamp

Function

The EGT3 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 EGT1, EGT2, EGDP, EGRP and ITVP.

Sensor Location

The EGT3 sensor is the third exhaust temperature sensor installed down stream of the turbocharger. It is located just after the Diesel Particulate Filter.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- 3-Banana Plug Harness (page 425)
- Breakout Box (page 426)
- Exhaust Temperature Breakout Harness (page 430)
- Terminal Test Adapter Kit (page 432)

EGT3 Sensor End Diagnostics

DTC	Condition	Possible Causes
1744	EGT3 signal out-of-range LOW	• EGT3 signal circuit short to GND • Failed sensor
1745	EGT3 signal out-of-range HIGH	• EGT3 signal OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor
2677	EGT3 not warming along with engine	• EGT3 biased circuit or sensor • EGT3 sensor outside of exhaust system
2678	EGT3 reading off compared to EGT1 and EGT2	• EGT3 biased circuit or sensor • EGT3 sensor outside of exhaust system

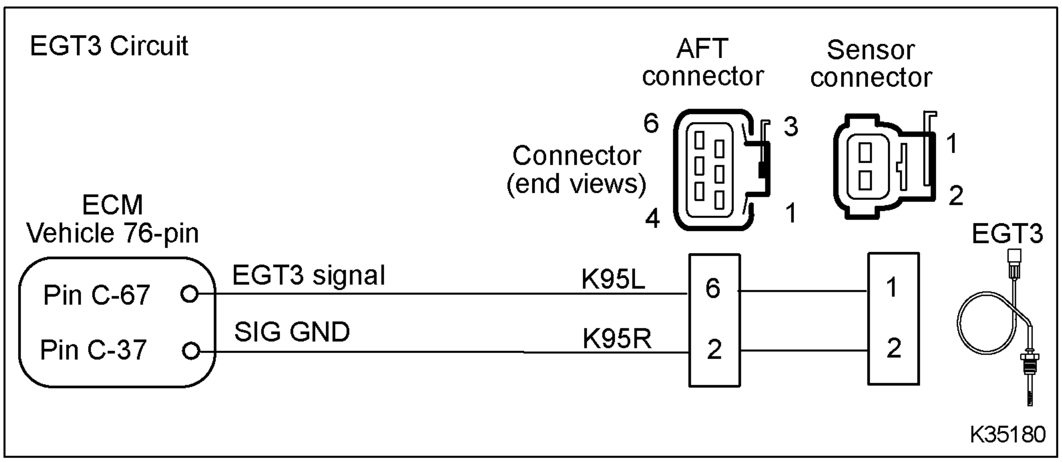


Figure 237 EGT3 circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Monitor sensor voltage. Verify an active DTC for the sensor.
   - If code is inactive, monitor the PID while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID will spike and the DTC 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 DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC	DTC 1745	If DTC 1744 is active, check EGT3 signal for short to GND. Do Harness Resistance Check (page 321).
EST - Check DTC Short 3-Banana plug harness across 1 and GND	DTC 1744	If DTC 1745 is active, check EGT3 signal for OPEN. Do Harness Resistance Check (page 321).
EST - Check DTC Short 3-Banana plug harness across 1 and 2	DTC 1744	If DTC 1745 is active, check SIG GND for OPEN. Do Harness Resistance Check (page 321).
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace sensor.		

EGT3 Pin-point Diagnostics

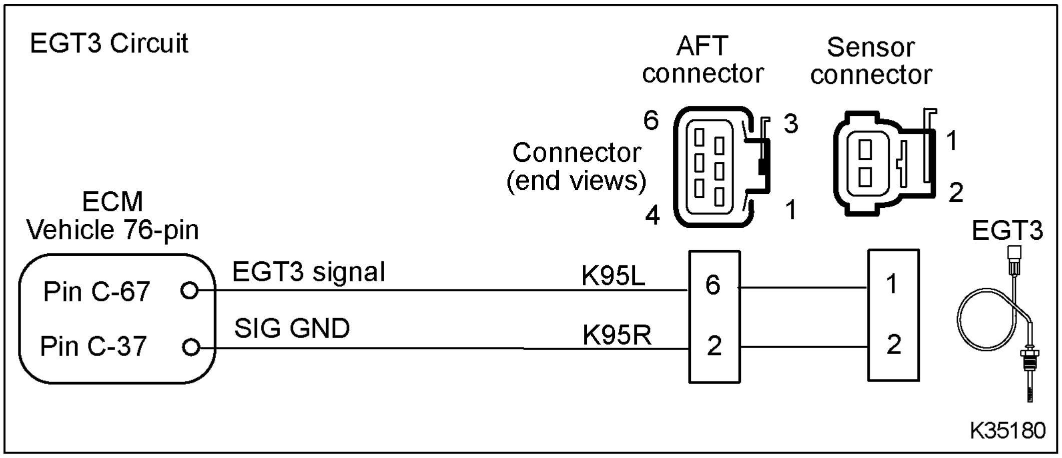


Figure 238 EGT3 circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
2 to GND	0 V	If > 0.25 V, check for short to PWR.
1 to GND	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 321).

Connector Resistance Checks to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	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 breakout box and breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
2 to C-37	< 5 Ω	If > 5 Ω, check for OPEN circuit.
1 to C-67	< 5 Ω	If > 5 Ω, check for OPEN circuit.

EGT3 Circuit Operation

The EGT3 is a thermistor sensor that is supplied with a 5 V reference voltage at Pin 1 from ECM Pin C-67. The sensor is grounded at Pin 2 from ECM Pin C-37. As temperature increases, the resistance of the thermistor increases. This causes the signal voltage to increase.

EOP Sensor (Engine Oil Pressure)

DTC	SPN	FMI	Condition
1211	100	4	EOP signal out-of-range LOW
1212	100	3	EOP signal out-of-range HIGH

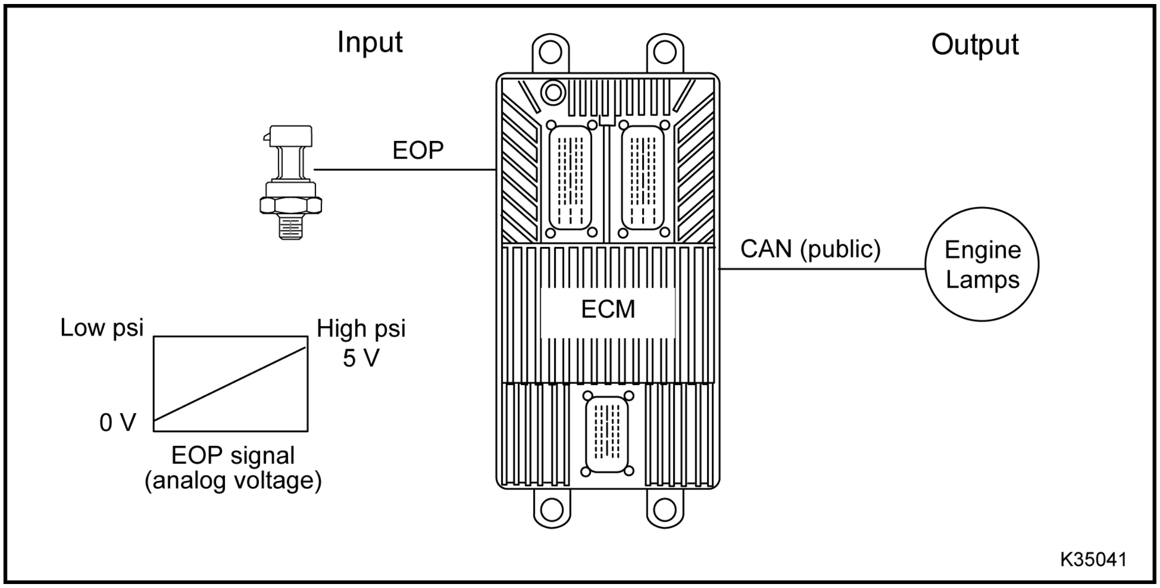


Figure 239 Function diagram for the EOP sensor

The function diagram for the EOP sensor includes the following:

- Engine Oil Pressure (EOP) sensor
- Electronic Control Module (ECM)
- Engine lamps (amber and red)

Function

The EOP sensor provides a feedback signal to the ECM indicating engine oil pressure. During engine operation, the ECM will monitor the EOP signal to determine if the oil pressure is satisfactory. If oil pressure is below desired pressure, the ECM will turn on the red engine lamp.

An optional feature, the Engine Warning and Protection System (EWPS), can be enabled to warn the engine operator and shut the engine down when a low engine oil pressure condition occurs.

Sensor Location

The EOP sensor is installed in the left side of the crankcase, below the left side of the fuel filter housing.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- 3-Banana Plug Harness (page 425)
- Breakout Box (page 426)
- Pressure Sensor Breakout Harness (page 431)
- Terminal Test Adapter Kit (page 432)

EOP Sensor End Diagnostics

DTC	Condition	Possible Causes
1211	EOP signal out-of-range LOW	• EOP signal circuit OPEN or short to GND • VREF circuit OPEN • Failed sensor
1212	EOP signal out-of-range HIGH	• EOP signal circuit short to PWR • Failed sensor

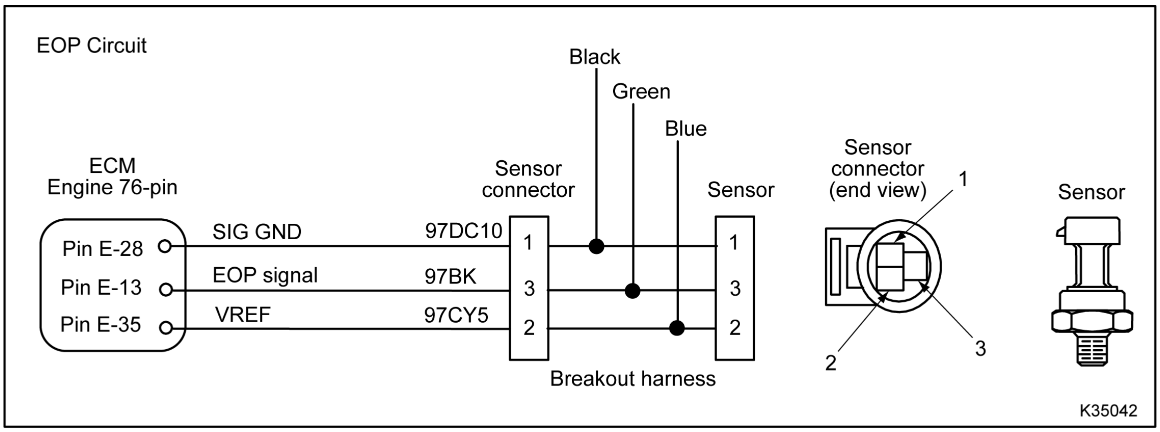


Figure 240 EOP circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Verify sensor voltage is within KOEO specification. See “Performance Specification” section.
3. Monitor sensor voltage. Verify an active DTC for the sensor.
   - If code is inactive, monitor the PID while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID will spike and the DTC 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.

Sensor Circuit Check

Connect sensor breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use EST to verify correct DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST – Check DTC	DTC 1211	If DTC 1212 is active, check EOP signal for short to PWR.
DMM – Measure volts 2 to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 327).
EST – Check DTC Short 500 breakout harness across 2 and 3	DTC 1212	If DTC 1211 is active, check EOP signal for OPEN. Do Harness Resistance Check (page 327).
DMM – Measure resistance 1 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 327).
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace sensor.		

EOP Pin-point Diagnostics

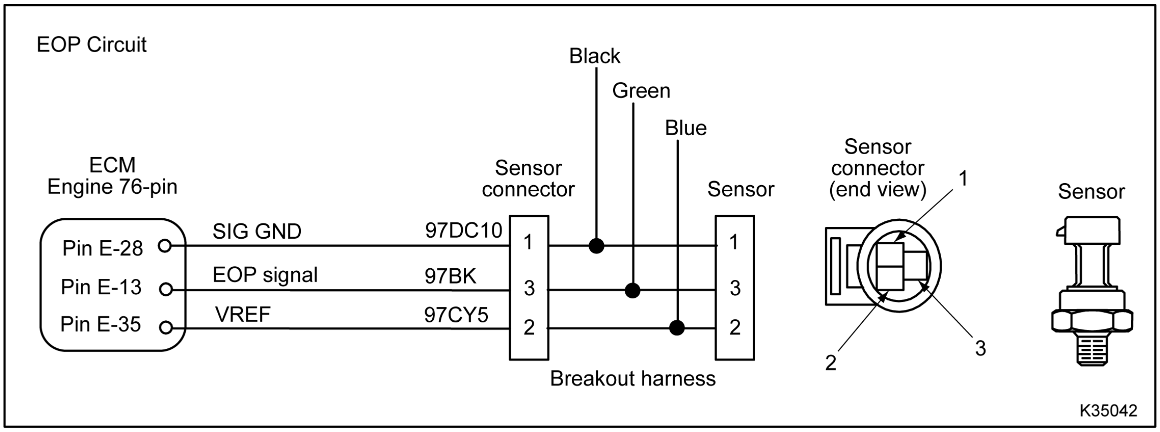


Figure 241 EOP circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	0 V	If > 0.25 V, check for short to PWR.
2 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 (page 327).
3 to GND	0 V	If > 0.25 V, check for short to PWR. Do Harness Resistance Check (page 327).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit.
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. Connect breakout box and sensor breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
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-13	< 5 Ω	If > 5 Ω, check EOP signal circuit for OPEN.

EOP Circuit Operation

The EOP sensor is a variable capacitance sensor that is supplied with a 5 V 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-13.

Fault Detection / Management

The ECM continuously monitors the control system. If the sensor signal is higher or lower than expected, the ECM will disable the EWPS, set a DTC, and turn on the warning lamp.

EOT Sensor (Engine Oil Temperature)

DTC	SPN	FMI	Condition
1299	175	10	EOT in-range fault
1311	175	4	EOT signal out-of-range LOW
1312	175	3	EOT signal out-of-range HIGH

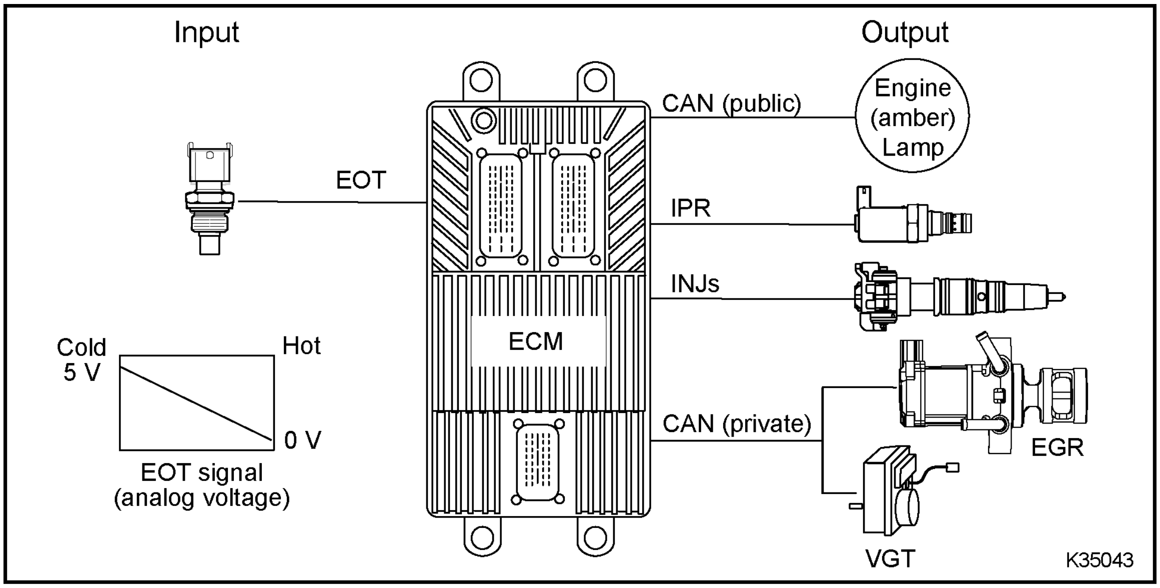


Figure 242 Function diagram for the EOT sensor

The function diagram for the EOT sensor includes the following:

- Engine Oil Temperature (EOT) sensor
- Electronic Control Module (ECM)
- Fuel injector (INJ)
- Exhaust Gas Recirculation Position (EGR)
- Variable Geometry Turbocharger (VGT)
- Injection Pressure Regulator (IPR)
- Engine lamp (amber)

Function

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 that adequate power and torque are available for all operating conditions.

Fast Idle Advance

Fast idle advance increases engine cold idle speed up to 750 rpm (normally 700 rpm) for faster warm-up to operating temperature. This is accomplished by the ECM monitoring the EOT sensor input and adjusting the fuel injector operation accordingly.

Low idle speed is increased proportionally when the engine oil temperature is between 15 °C (59 °F) at 700 rpm to below -10 °C (14 °F) at 750 rpm.

Sensor Location

The EOT sensor is located in the rear of the front cover, left of the high-pressure pump assembly.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- 3-Banana Plug Harness (page 425)
- Breakout Box (page 426)
- Temperature Sensor Breakout Harness (page 432)
- Terminal Test Adapter Kit (page 432)

EOT Sensor End Diagnostics

DTC	Condition	Possible Causes
1299	EOT in-range fault	Biased EOT circuit / sensor
1311	EOT signal out-of-range LOW	• EOT signal circuit short to GND • Failed sensor
1312	EOT signal out-of-range HIGH	• EOT signal OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor

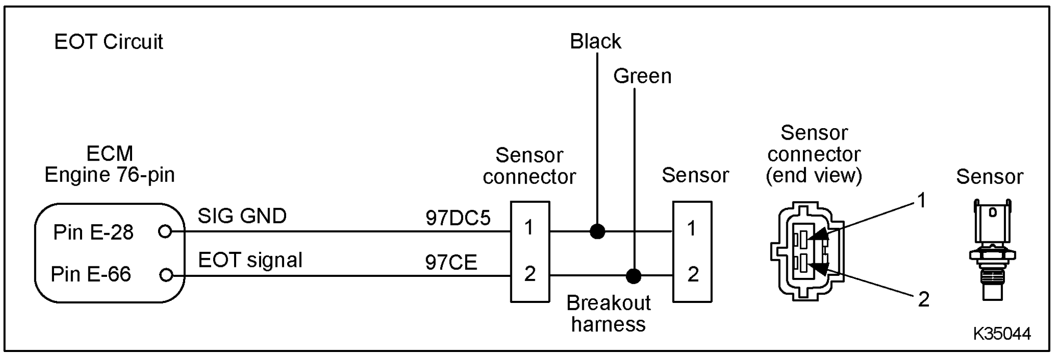


Figure 243 EOT circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Monitor sensor voltage. Verify an active DTC for the sensor.
   - If code is inactive, monitor the PID while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID will spike and the DTC 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 DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST – Check DTC	DTC 1312	If DTC 1311 is active, check EOT signal for short to GND. Do Harness Resistance Check (page 332).
EST – Check DTC Short 3-banana plug harness across 2 and GND	DTC 1311	If DTC 1312 is active, check EOT signal for OPEN. Do Harness Resistance Check (page 332).
EST – Check DTC Short 3-banana plug harness across 1 and 2	DTC 1311	If DTC 1312 is active, check SIG GND for OPEN. Do Harness Resistance Check (page 332).

If checks are within specification, connect sensor and clear DTCs. If active code remains, replace sensor.

EOT Pin-point Diagnostics

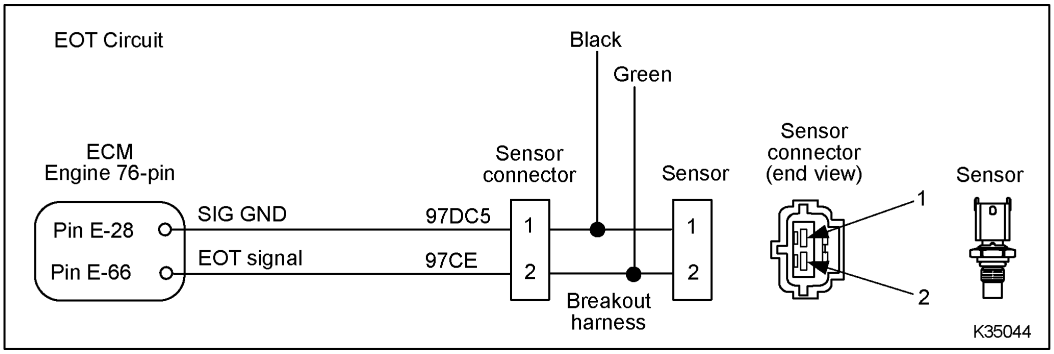


Figure 244 EOT circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	0 V	If > 0.25 V, check for short to PWR.
2 to GND	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 332).

Connector Resistance Checks to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

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	Spec	Comment
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.

EOT Circuit Operation

The EOT is a thermistor sensor that is supplied with a 5 V reference voltage at Pin 2 from ECM Pin E–66. The sensor is grounded at Pin 1 from ECM Pin E–28. As the temperature increases, the resistance of the thermistor decreases. This causes the signal voltage to decrease.

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 use a calibrated default value. The ECM will set a DTC, turn on the amber engine lamp, and run the engine in a default range of -20 °C (-4 °F) for starting and 100 °C (212 °F) for engine running conditions.

EWPS (Engine Warning and Protection System)

DTC	SPN	FMI	Condition
2313	100	1	EOP below warning level
2314	100	7	EOP below critical level
2315	190	0	Engine speed above warning level
2319	518	2	Torque limited to control engine overheat
2321	110	0	ECT above warning level
2322	110	7	ECT above critical level
2323	111	1	ECL below warning/critical level

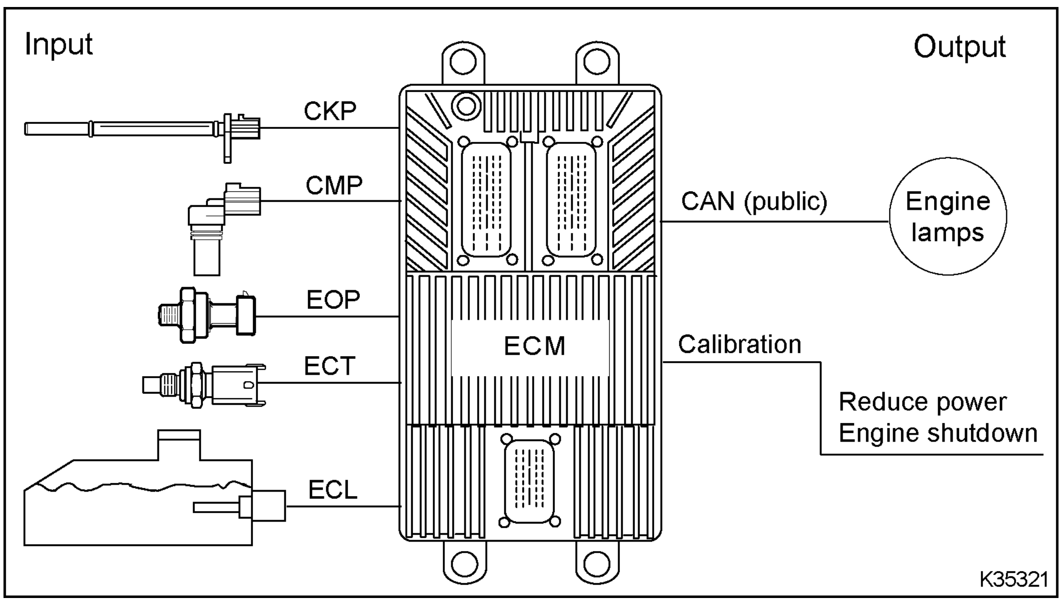


Figure 245 Function diagram for the EWPS

The function diagram for the EWPS includes the following:

- Electronic Control Module (ECM)
- Crankshaft Position (CKP) sensor
- Camshaft Position (CMP) sensor
- Engine Oil Pressure (EOP) switch
- Engine Coolant Temperature (ECT)
- Engine Coolant Level (ECL) sensor
- Engine lamp (red)
- Engine lamp (amber)

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 in which all engines are equipped. If one of these faults are detected, the ECM will illuminate the red OIL/WATER (OWL) lamp and set a corresponding DTC.

Standard Warning – No engine shut down available.

- RPM - Engine over-speed warning
- ECT - Engine over-heat warning

The following optional features to this base system provide added warning or protection.

2-way Warning – No engine shut down available.

- ECT - Engine over-heat warning
- EOP - Low engine oil pressure warning

3-way Warning – No engine shut down available.

- ECT - Engine over-heat warning
- EOP - Low engine oil pressure warning
- ECL - Low engine coolant level warning

3-way Protection – Engine shut down 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 OIL/WATER (OWL) lamp and set a DTC.

Critical – Temperature above specific threshold will shut down the engine and set a DTC.

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

ECT-WARNING – Specifies temperature threshold where the OIL/WATER lamp and warning buzzer will be turned on.

ECT-CRITICAL – Specifies temperature threshold where an engine shut down will be commanded.

PROT-ENG SPD1 – Specifies at what RPM a specified oil pressure (OIL-PRES-CRIT-SPD1) should be detected.

PROT-ENG SPD2 – Specifies at what RPM a specified oil pressure (OIL-PRES-CRIT-SPD2) should be detected.

PROT-ENG SPD3 – Specifies at what RPM a specified oil pressure (OIL-PRES-CRIT-SPD3) should be detected.

OIL-PRES-WARN-SPD1 – Specifies the minimum oil pressure with engine speed greater then (PROT-ENG-SPD1). Failure to meet set point will turn on the OIL/WATER lamp and warning buzzer.

OIL-PRES-WARN-SPD2 – Specifies the minimum oil pressure with engine speed greater then (PROT-ENG-SPD1) but less then (PROT-ENG-SPD2). Failure to meet set point will turn on the OIL/WATER lamp and warning buzzer.

OIL-PRES-WARN-SPD3 – Specifies the minimum oil pressure with engine speed greater then (PROT-ENG-SPD2) but less then (PROT-ENG-SPD3). Failure to meet set point will turn on the OIL/WATER lamp and warning buzzer.

OIL-PRES-CRIT-SPD1 – Specifies the minimum oil pressure with engine speed greater then (PROT-ENG-SPD1). Failure to meet set point will command an engine shut down.

OIL-PRES-CRIT-SPD2 – Specifies the minimum oil pressure with engine speed greater then (PROT-ENG-SPD1) but less then (PROT-ENG-SPD2). Failure to meet set point will command an engine shut down.

OIL-PRES-CRIT-SPD3 – Specifies the minimum oil pressure with engine speed greater then (PROT-ENG-SPD2) but less then (PROT-ENG-SPD3). Failure to meet set point will command an engine shut down.

DTC 2313
EWPS - EOP below Warning Level

- DTC 2313 is set by the ECM, when engine oil pressure is lower than expected while the engine is running. The specifications for the warning are:
  - 34 kPa (5 psi) @ 700 rpm
  - 69 kPa (10 psi) @ 1400 rpm
  - 138 kPa (20 psi) @ 2000 rpm
- For diagnostics, see Low Oil Pressure Diagnostics in the “Engine Symptoms Diagnostics (page 101)” section of this manual.
- DTC 2313 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 DTC 2313 is active, the red lamp is illuminated.

DTC 2314
EWPS - EOP below Critical Level

- DTC 2314 is set by the ECM, when the engine oil pressure drops below the critical level while the engine is running. The specifications are:
  - 14 kPa (2 psi) @ 700 rpm
  - 83 kPa (12 psi) @ 1400 rpm
  - 152 kPa (22 psi) @ 2000 rpm
- For diagnostics, see Low Oil Pressure in “Engine Symptoms Diagnostics” section of this manual.
- DTC 2314 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 DTC 2314 is active, the red lamp flashes and sounds an audible signal.

DTC 2315
Engine Speed above Warning Level

- DTC 2315 is set by the ECM when the engine rpm has exceeded 3900 rpm.
- DTC 2315 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 DTC 2315 is active the amber lamp is illuminated. The engine hours and miles of the last two over speed occurrences will be recorded in the engine event log.

DTC 2319
Torque limited to control engine overheat

- DTC 2319 is set by the ECM when the cooling system temperature exceeds 111 °C (232 °F). At this temperature the ECM will reduce the fuel delivered to the engine. When the temperature drops below 111 °C (232 °F) the DTC will become inactive and the engine will return to normal operation. The engine lamp is not illuminated.
- For each Celsius degree of temperature the fuel will be reduced by six percent. This will reduce the heat produced by the engine and the burden on the cooling system. The vehicle speed will also be reduced and allow the operator to downshift. This increases cooling system efficiency. As the temperature is reduced, the compensation level is reduced, until the temperature drops below 111 °C (232 °F) and normal operation is resumed.

DTC 2321
ECT above Warning level

- DTC 2321 is set by the ECM when the engine coolant temperature is above 113 °C (228 °F). The ECM illuminates the red lamp (OWL for CF). When the temperature drops below 113 °C (228 °F) the DTC will become inactive. For diagnostics, see Coolant Over-Temperature in the “Engine Symptoms Diagnostics” (page 101) section of this manual.
- For high altitude applications (103 kPa [15 psi] radiator cap), DTC 2321 is set by the ECM when the engine coolant temperature is above 116 °C (240 °F). When the temperature drops below 116 °C (240 °F) the DTC will become inactive.

DTC 2322
ECT above Critical level

- DTC 2322 is set by the ECM when the engine coolant temperature is above 116 °C (240 °F). The ECM illuminates the red lamp. When the temperature drops below 116 °C (240 °F) the DTC will become inactive. For diagnostics, see Coolant Over-Temperature in the “Engine Symptoms Diagnostics (page 101)” section of this manual.
- For high altitude applications (103 kPa [15 psi] radiator cap), DTC 2322 is set by the ECM when the engine coolant temperature is above 119 °C (246 °F). When the temperature drops below 119 °C (246 °F) the DTC will become inactive.

DTC 2323
ECL below Warning/Critical level

- DTC 2323 is set by the ECM when coolant is low. When the EWPS mode is 3-way protection and DTC 2323 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 thirty seconds. When the coolant has returned to correct levels, DTC 2323 will become active.

NOTE: If the coolant level is correct, do ECL Connector Voltage Test in this section. An ECL signal shorted to ground can cause DTC 2323.

IAH System (Inlet Air Heater)

DTC	SPN	FMI	Condition
None			

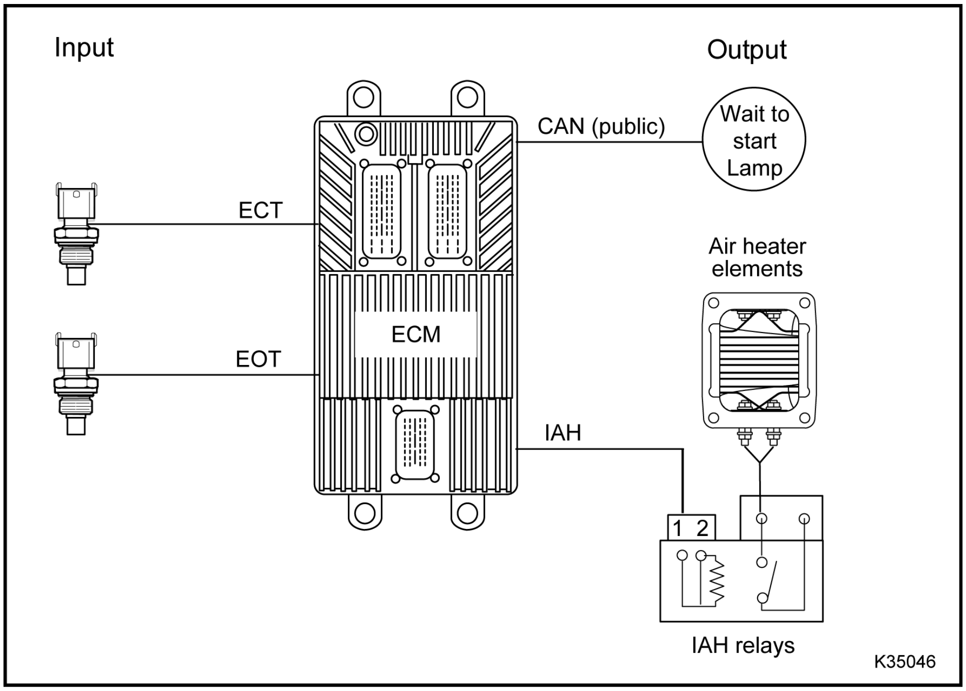


Figure 246 Function diagram for the IAH system

The function diagram for the IAH system includes the following:

- IAH relays
- IAH elements
- Electronic Control Module (ECM)
- Engine Coolant Temperature (ECT) sensor
- Engine Oil Temperature (EOT) sensor
- Wait to Start lamp (amber)

Function

The Inlet Air Heater (IAH) system warms the incoming air supply prior to cranking to aid cold engine starting and reduce white smoke during warm-up.

Component Location

The IAH is installed in the intake manifold behind the inlet throttle body. The IAH relays are installed on the left side of the engine on the ECM bracket.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- Amp Clamp (page 427)
- 16-pin Breakout Harness (page 425)
- Breakout Box (page 426)

IAH Pin-point Diagnostics

DTC	Condition	Possible Causes
None	Inactive IAH	• IAH relay control circuit OPEN or shorted to GND • IAH relay coil GND circuit OPEN • Failed relay(s)

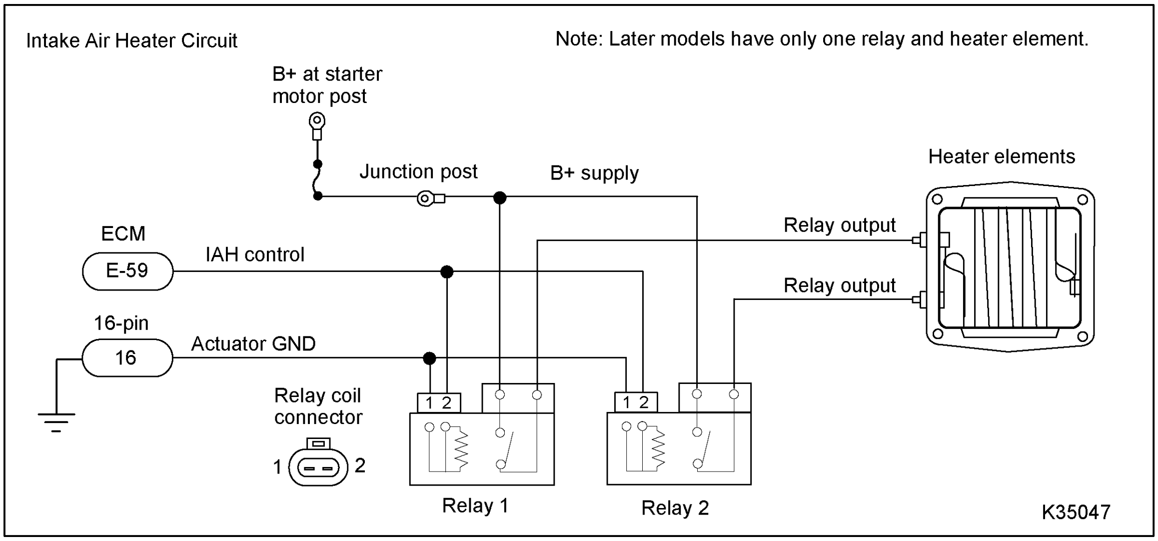


Figure 247 IAH circuit diagram

NOTE: For this procedure, run the KOEO Standard Test. Do not run the GPC/IAH test.

The KOEO Standard Test will enable the relays for two seconds every time the test is run. The GPC/IAH test only enables the relays twice for 45 seconds to prevent element overheating.

Voltage Check on Relay Switch – Output State Test

Turn ignition switch OFF. Use DMM to measure voltage on relay B+ side.

Test Point	Spec	Comment
Relay 1 B+ side to GND	B+	If < B+, check large power circuit to relay for OPEN, corroded terminal, or blown fuse link.
Relay 2 B+ side to GND	B+	If < B+, check large power 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 2 seconds during this test). Use DMM to measure voltage when relay is commanded on.		
Relay 1 Output side to GND	B+	If 0 V, do Voltage Check on Relay Coil – Output State Test .
Element to GND	B+	If < B+, check for corroded terminals on relay and element. Do Amperage Check .
Relay 2 Output side to GND	B+	If 0 V, do Voltage Check on Relay Coil – Output State Test .
Element to GND	B+	If < B+, check for corroded terminals on relay and element. Do Amperage Check .

Voltage Check on Relay Coil – Output State Test

Disconnect both relay connectors. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
Relay 1		
Pin 1 to GND	0 V	If > 0 V, check for OPEN or short to PWR.
Pin 2 to GND	2. 74 V	If < 2 V, check for OPEN or short to GND. Do Harness Resistance Check – Relay Coil (page 342).
Relay 2		
Pin 1 to GND	0 V	If > 0 V, check for OPEN or short to PWR.
Pin 2 to GND	2. 74 V	If < 2 V, check for OPEN or short to GND. Do Harness Resistance Check – Relay Coil (page 342).
Run KOEO Standard Test (IAH is commanded on for 2 seconds during this test). Use DMM to measure voltage when relay is commanded on.		

Voltage Check on Relay Coil – Output State Test (cont.)

Relay 1 Pin 2 to GND Pin 1 to 2	B+	If < B+, check actuator GND circuit for OPEN. Do Harness Resistance Check – Relay Coil (page 342).
Relay 2 Pin 2 to GND Pin 1 to 2	B+	If < B+, check IAH relay control circuit for OPEN or short to GND. Do Harness Resistance Check – Relay Coil (page 342).
If voltage checks at relay coil are okay, but voltage checks at relay switch failed, replace the relay.		

Amperage Draw Check

NOTE: Batteries must be fully charged before running this test.

Measure the amperage going to both elements, one at a time. Run Glow Plug / Air Intake Heater Output State test. Use a DMM with an amp probe. Set DMM to DCmV and zero amp clamp.

Test Point	Spec	Comment
Element 1	125 A ± 30 A (within 2 seconds)	If 0 A, do Voltage Check on Relay Switch – Output State Test If > 0 A, but below specification, check for corroded terminals on relay, element, and power source. Do Element Resistance Check .
Element 2	125 A ± 30 A (within 2 seconds)	If 0 A, do Voltage Check on Relay Switch – Output State Test If > 0 A, but below specification, check for corroded terminals on relay, element, and power source. Do Element Resistance Check .
If > 0 A, but below specification, and element and wiring check out okay, replace the relay.		

Element Resistance Check

Turn ignition switch to OFF. Use a DMM to measure resistance from heater element to engine GND.

Test Point	Spec	Comment
Element 1 to GND	< 0.5 Ω	If > 0.5 Ω, replace failed heater element.
Element 2 to GND	< 0.5 Ω	If > 0.5 Ω, replace failed heater element.

Harness Resistance Check – Relay Coil Circuits

Turn ignition to OFF. Connect breakout box. Leave ECM and relay(s) disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
Relay 1		
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.
Relay 2		
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	Spec	Comment
Relay 1 Output side to element	< 0.5 Ω	If > 0.5 Ω, check for OPEN circuit or corroded terminals.
Relay 2 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.

Relay 1 B+ side to battery positive post	< 0.5 Ω	If > 0.5 Ω, check for OPEN circuit or corroded terminals.
Relay 2 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 okay, but failed amperage test, replace the relay.

IAH Circuit Operation

The ECM controls the WAIT TO START lamp and IAH element based on ECT, EOT, and BAP (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 public CAN communication to the Electronic Gauge Cluster (EGC).

The ECM uses two relays to control the IAH elements (one relay per heating element). The ECM will energize the relays by supplying power from Pin E-59 to Pin 2 on each relay coil. The relay coils are grounded at Pin 1 through the 16-way connector Pin 16 from vehicle 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 relays are energized, power is supplied to the heating elements, which are grounded to the intake manifold.

Diagnostic Trouble Codes (DTCs)

There are no DTCs for IAH System.

IAT Sensor (Intake Air Temperature)

DTC	SPN	FMI	Condition
1154	171	4	IAT signal out-of-range LOW
1155	171	3	IAT signal out-of-range HIGH

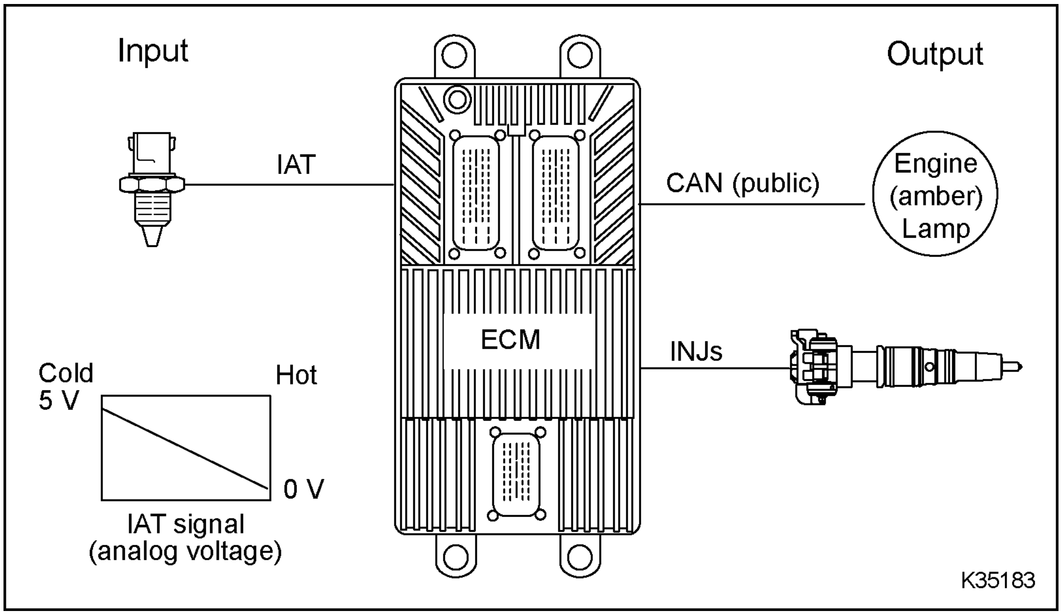


Figure 248 Function diagram for the IAT sensor

The function diagram for the IAT sensor includes the following:

- Intake Air Temperature (IAT) sensor
- Fuel injector (INJ)
- Electronic Control Module (ECM)
- Engine lamp (amber)

Function

The IAT sensor provides a feedback signal to the ECM indicating intake air temperature. The ECM monitors the IAT signal to control the timing and fuel rate for cold starting. The IAT is monitored while the engine is running to limit smoke and reduce exhaust emissions.

Sensor Location

The IAT sensor is installed in the air filter housing.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- 3-Banana Plug Harness (page 425)
- Breakout Box (page 426)
- Temperature Sensor Breakout Harness (page 432)
- Terminal Test Adapter Kit (page 432)

IAT Sensor End Diagnostics

DTC	Condition	Possible Causes
1154	IAT signal out-of-range LOW	• IAT signal circuit short to GND • Failed sensor
1155	IAT signal out-of-range HIGH	• IAT signal OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor

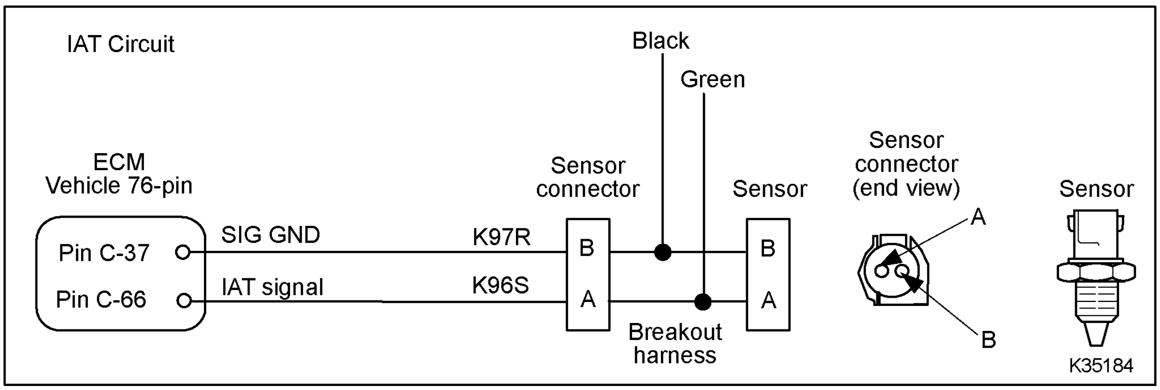


Figure 249 IAT circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Monitor sensor voltage. Verify an active DTC for the sensor.
   - If code is inactive, monitor the PID while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID will spike and the DTC 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 DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST - Check DTC	DTC 1155	If DTC 1154 is active, or < 4.5 V, check IAT signal for short to GND. Do Harness Resistance Check (page 347).
EST - Check PID	4.68 V	
EST - Check DTC Short 3-Banana plug harness across A and GND	DTC 1154	If DTC 1155 is active, check IAT signal for OPEN. Do Harness Resistance Check (page 347).
EST - Check DTC Short 3-Banana plug harness across A and B	DTC 1154	If DTC 1155 is active, check SIG GND for OPEN. Do Harness Resistance Check (page 347).

If checks are within specification, connect sensor and clear DTCs. If active code remains, replace sensor.

IAT Pin-point Diagnostics

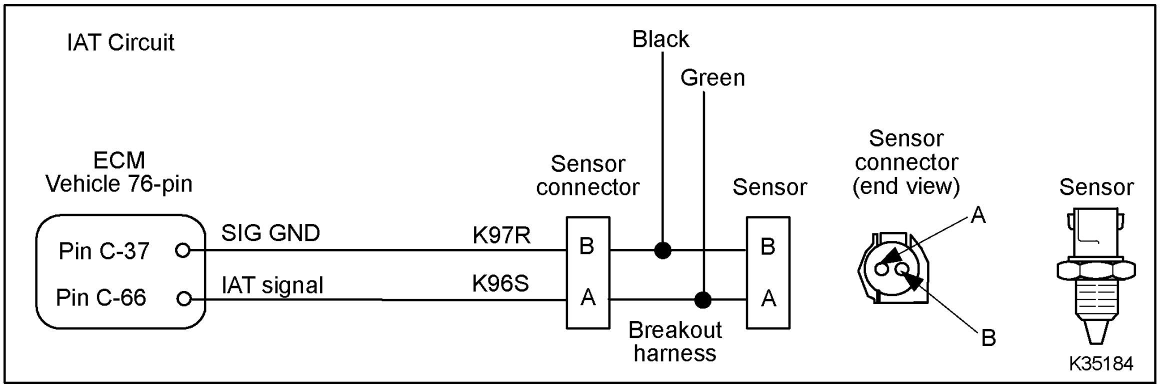


Figure 250 IAT circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
B to GND	0 V	If > 0.25 V, check for short to PWR.
A to GND	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 347).

Connector Resistance Checks to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
B to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit.
A to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
B to C-37	< 5 Ω	If > 5 Ω, check for OPEN circuit.
A to C-66	< 5 Ω	If > 5 Ω, check for OPEN circuit.

IAT Circuit Operation

The IAT is a thermistor sensor that is supplied with a 5 V reference voltage at Pin A from ECM Pin C-66. The sensor is grounded at Pin B from ECM Pin C-37.

As the temperature increases, the resistance of the thermistor decreases. This causes the signal voltage to decrease.

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 value. The ECM will set a DTC, turn on the amber engine lamp, and run the engine in a default range.

ICP Sensor (Injection Control Pressure)

DTC	SPN	FMI	Condition
1124	164	4	ICP signal out-of-range LOW
1125	164	3	ICP signal out-of-range HIGH
2332	164	13	ICP above KOEO spec

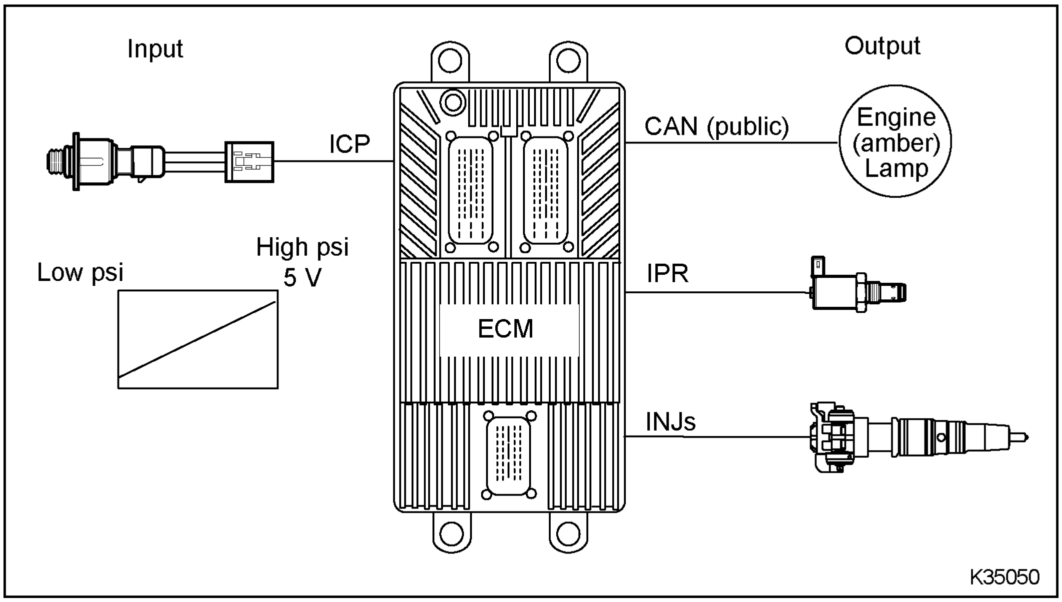


Figure 251 Function diagram for the ICP sensor

The function diagram for the ICP sensor includes the following:

- Injection Control Pressure (ICP) sensor
- Electronic Control Module (ECM)
- Fuel injector (INJ)
- Injection Pressure Regulator (IPR)
- Engine lamp (amber)

Function

The ICP sensor provides a feedback signal to the ECM indicating injection control pressure. The ECM monitors ICP as the engine is operating to modulate the IPR. This is a closed loop function in which the ECM continuously monitors and adjusts for ideal ICP determined by conditions such as load, speed, and temperature.

Sensor Location

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

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- 3-Banana Plug Harness (page 425)
- Breakout Harnesses
- Breakout Box (page 426)
- Terminal Test Adapter Kit (page 432)

ICP Sensor End Diagnostics

DTC	Condition	Possible Causes
1124	ICP signal out-of-range LOW	• ICP signal circuit short to GND • Failed sensor
1125	ICP signal out-of-range HIGH	• ICP signal circuit OPEN or short to PWR • SIG GND circuit OPEN • VREF circuit OPEN • Failed sensor
2332	ICP above KOEO spec	• ICP signal or SIG GND circuit OPEN • Biased circuit/sensor (ICPV above KOEO spec) • Failed sensor

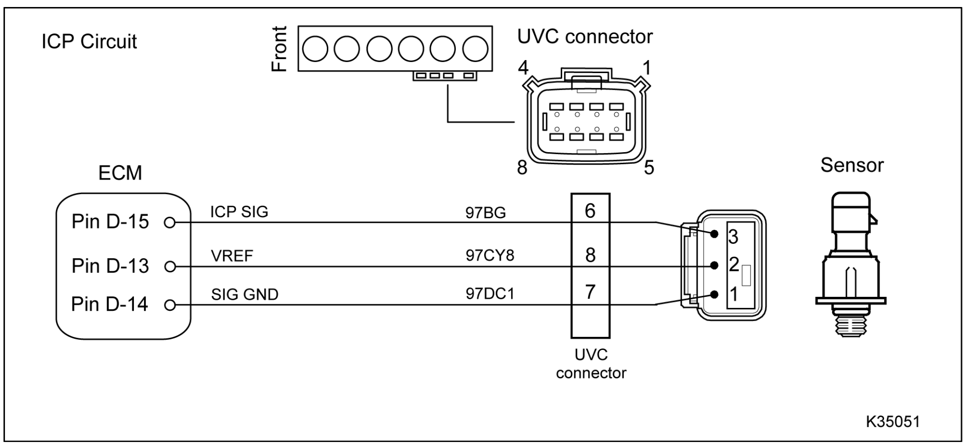


Figure 252 ICP circuit diagram

⚠ WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Verify sensor voltage is within KOEO specification. See “Performance Specification” section.
3. Monitor sensor voltage. Verify an active DTC for the sensor.
   - If code is inactive, monitor the PID while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID will spike and the DTC 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.

Sensor Circuit Check

Disconnect sensor connector from valve cover gasket (3rd to the rear). Turn ignition switch to ON. Use EST to verify correct DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST – Check DTC	DTC 1125	If DTC 1124 is active, check ICP signal for short to GND.
DMM – Measure resistance 7 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 353).
EST – Check DTC Short breakout harness across 6 and 7	DTC 1124	If DTC 1125 is active, check ICP signal for OPEN. Do Harness Resistance Check (page 353).
DMM – Measure volts 8 to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 353).

If checks are within specification, connect sensor and clear DTCs. If active code remains, check under valve cover harness for OPENs or shorts. If okay, replace sensor.

ICP Pin-point Diagnostics

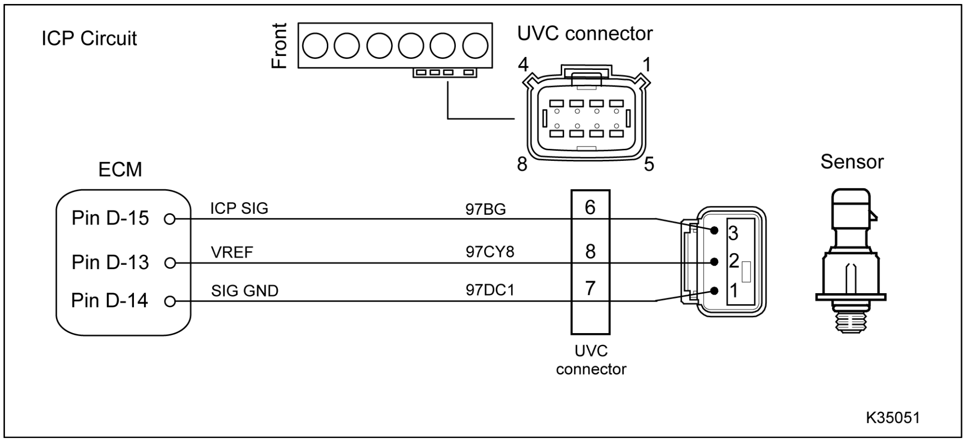


Figure 253 ICP circuit diagram

Connector Voltage Check

Disconnect sensor connector from valve cover gasket (3rd to the rear). Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
6 to GND	5 V	If < 4.5 V, check for short to GND.
7 to GND	0 V	If > 0.25 V, check for short to PWR.
8 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 (page 353).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect UVC breakout harness to engine harness. Leave valve cover gasket disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
6 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
7 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit.
8 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Under Valve Cover Resistance Check to Engine GND

Connect UVC breakout harness to valve cover gasket. Leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
6 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
7 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
8 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Harness Resistance Check

Turn ignition switch to OFF. Remove valve cover. Connect ECM breakout box to the 36-pin connector and ICP breakout harness to the UVC harness. Leave the ECM and ICP sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
D-14 to 1	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
D-14 to GND	> 1 kΩ	If < 1k Ω, check for short to GND.
D-15 to 3	< 5 Ω	If > 5 Ω, check FRP signal circuit for OPEN.
D-15 to GND	> 1 kΩ	If < 1k Ω, check for short to GND.
D-13 to 2	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN.
D-13 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

ICP Circuit Operation

The ICP sensor is a micro-strain gauge sensor that is supplied with a 5 V reference voltage at Pin 2 from ECM Pin D-13. The sensor is grounded at Pin 1 from ECM Pin D-14. The sensor returns a variable voltage signal from Pin 3 to ECM Pin D-15.

Fault Detection / Management

The ECM continuously monitors the signal of the ICP sensor to determine if the signal is within an expected range. The ECM disregards the sensor signal and uses a calibrated default value. The ECM will set a DTC, turn on the amber engine lamp, and run the engine in a default range.

ICP System (Injection Control Pressure)

DTC	SPN	FMI	Condition
2242	1442	2	ICP adaptation In-Range fault
2335	164	1	ICP unable to build pressure during crank
3333	8492	0	ICP above desired level
3334	8492	1	ICP below desired level
3373	164	15	ICP too high during test
3374	164	17	ICP unable to build during test

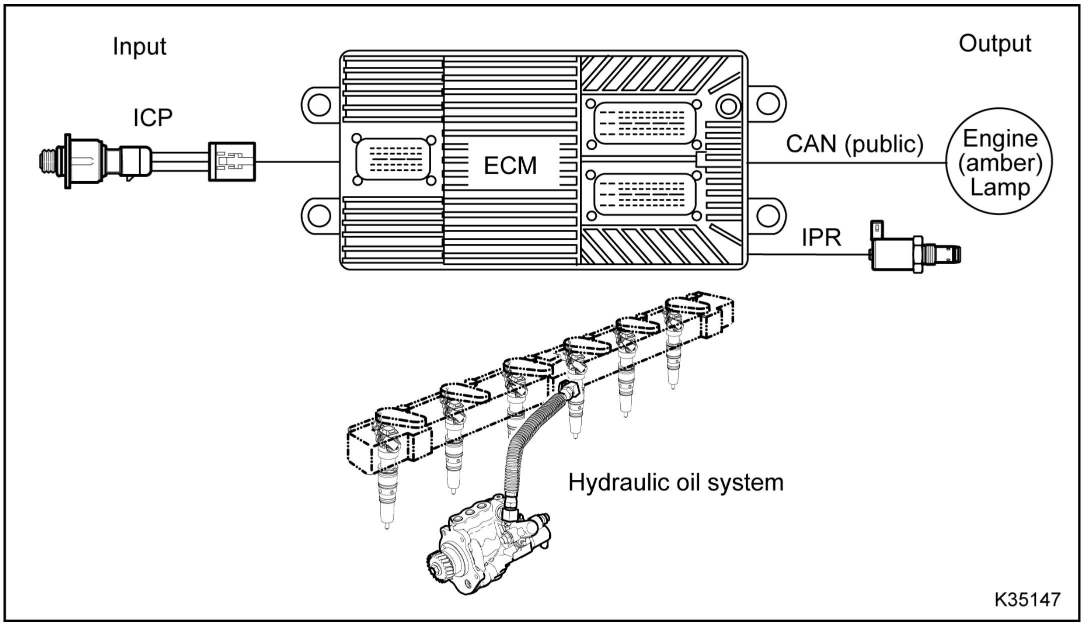


Figure 254 Function diagram for the ICP system

The ICP system includes the following:

- Hydraulic oil system
  - High-pressure hydraulic pump
  - High-pressure oil manifold
  - High-pressure oil hose
  - Fuel injectors (INJ)
- Injection Pressure Regulator (IPR) valve
- Injection Control Pressure (ICP) sensor
- Electronic Control Module (ECM)
- Engine lamp (amber)

Function

The ICP system is a mechanical hydraulic system, electronically controlled by the ECM. The ECM controls the IPR valve while monitoring the ICP sensor to provide the engine with the desired starting and operating pressures. The ICP system drives the high-pressure fuel spray through the injectors.

System Component Location

The IPR valve is located on the high-pressure pump assembly, which is mounted on the rear of the front cover (left side of engine). The high-pressure oil manifold is installed under the valve cover, directly over the injectors. The ICP sensor is installed on the high-pressure oil manifold.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)

ICP System Diagnostics

DTC	Condition	Possible Causes
2242	ICP adaptation In-Range fault	Injection control pressure command 10% higher then last learned command under same conditions. • Possible ICP system leak
2335	ICP unable to build during engine cranking	ICP below 3.5 MPa during engine crank • Low oil supply to high-pressure system • IPR circuit fault or failed valve • High-pressure oil pump failure
3333	ICP above desired level	ICP was above the desired pressure by 3% • Biased ICP sensor or circuit • Trapped air in system (if set after system was open) • Incorrect oil level • Aerated or contamination in engine oil IPR circuit fault or failed (sticking) valve
3334	ICP below desired level	ICP was below desired pressure by 3% • Biased ICP sensor or circuit • Incorrect oil level • Aerated or contamination in engine oil • IPR circuit fault or failed (sticking) valve • High-pressure oil pump failure
3373	ICP too high during test	ICP sensor above 8 MPa during first part of KOER Standard Test • Biased ICP sensor or circuit • Trapped air in system (if set after system was open) • Incorrect oil level • Aerated or contamination in engine oil • IPR circuit fault or failed (sticking)
3374	ICP unable to build during test	ICP sensor below 20 MPa during second part of KOER Standard Test • Biased ICP sensor or circuit • Incorrect oil level • Aerated or contamination in engine oil • IPR circuit fault or failed (sticking) valve • High-pressure oil pump failure

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.

DTC 2242 – ICP adaptation In-Range fault

DTC 3333 – ICP above desired level

DTC 3334 – ICP below desired level

DTC 3373 – ICP too high during test

DTC 3374 – ICP unable to build during test

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 DTCs. See ICP Sensor (page 349) in this section and check ICP KOEO specification.
4. Check for IPR DTC by running KOEO Standard test. See IPR (page 374) 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, 16-way, and 42-way connectors.
6. Check for aerated oil at high idle. See “Performance Diagnostics” (page 153) section in this manual.
7. Check the ICP system for leaks. See “Hard Start and No Start Diagnostics” section in this manual.

DTC 2335 – 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” section in this manual.
4. Check for other active or inactive ICP DTCs. See ICP Sensor (page 349) in this section of manual and check ICP KOEO specification.
5. Check for IPR DTC by running KOEO Standard test. See IPR (page 374) in this section of manual and check harness connection.
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, 16-way, and 42-way connectors.
7. Check the ICP system for leaks. See “Hard Start and No Start Diagnostics” section in this manual.

ICP System Operation

Mechanical Operation

Engine lube oil is supplied to the ICP reservoir that feeds the high-pressure pump. The IPR valve regulates the pressure by closing or opening the valve. The discharged oil passes through the injectors and drains to the oil sump. If equipped with optional Diamond Logic® engine brake, the oil can also drain through Brake Shut-off Valve (BSV).

Electrical Operation

The ICP system is a closed loop system. The ECM controls the IPR valve duty cycle while monitoring the ICP sensor. This provides the engine with the desired starting and operating pressure. When demand for ICP increases, the ECM will increase duty cycle to the IPR valve. When demand for ICP decreases, the ECM will decrease the duty cycle to the IPR valve.

When the ECM detects an error in the closed loop system, a DTC is set and the ECM will disregard the ICP signal and control the IPR valve from programmed default values. This is called open loop operation.

Fault Detection / Management

The Diagnostic Trouble Codes (DTCs) associated with this system may indicate an electrical or mechanical problem with the ICP system.

The ECM continuously monitors the ICP sensor to ensure the system constantly provides correct pressure. When feedback from the ICP sensor does not meet desired pressure, the ECM will set a DTC and illuminate the amber engine lamp. The ECM will disregard the ICP sensor signal and control the IPR valve from programmed default values until the system is diagnosed and repaired.

The ECM monitors the ICP during engine crank. If pressure does not build to the minimum starting pressure within a set time, a DTC will be set.

The KOER Standard test (EST with MasterDiagnostics® software) can be used to command the ECM to perform an engine running test on the ICP system. The ECM controls the IPR in a programmed sequence while monitoring the ICP sensor. If pressure set points do not match the expected testing range, a DTC will be set.

An electrical fault on the IPR can be detected by running the Output Circuit test during the KOEO Standard test. If a fault is detected, a DTC will be set.

Injector Circuits

DTC	SPN	FMI	Condition
4411-4416	8001-8006	6	Cyl (#) close coil: open circuit
4421-4426	8001-8006	5	Cyl (#) open coil: open circuit
4431-4436	8001-8006	4	Cyl (#) open coil: short circuit
4441-4446	8001-8006	3	Cyl (#) close coil: short circuit
4515	8151	5	Bank A injector open coil short
4516	8151	6	Bank A injector close coil short
4521	8152	5	Bank B injector open coil short
4522	8152	6	Bank B injector close coil short

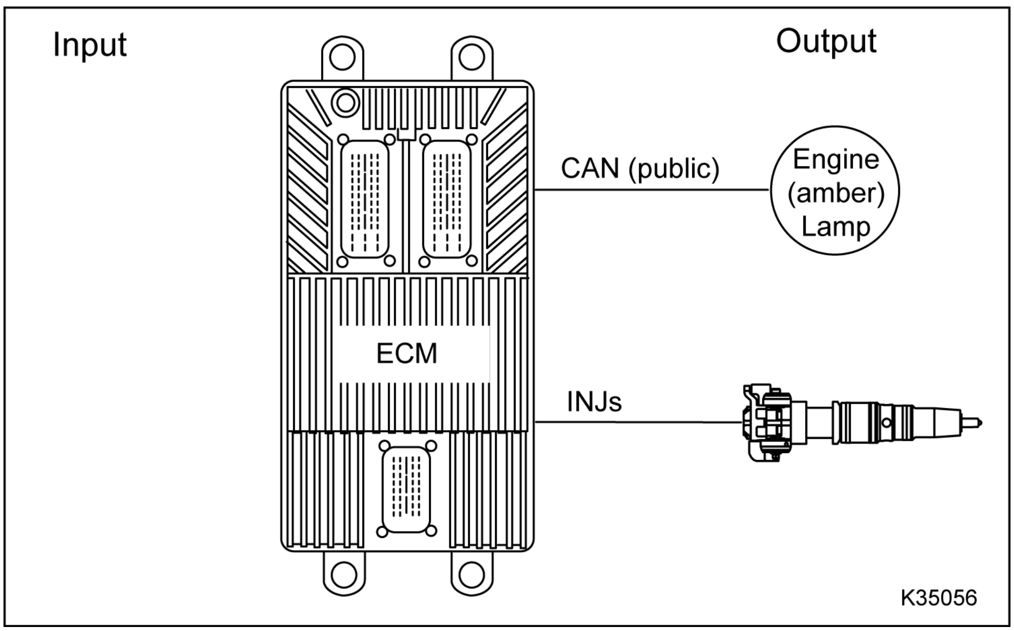


Figure 255 Function diagram for the INJ circuit

The function diagram for INJ circuit includes the following:

- Fuel injectors (INJ)
- Electronic Control Module (ECM)
- Engine lamp (amber)

Function

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 the amount of pressure at which the fuel is being sprayed.

Component Location

The injectors are installed in the cylinder head, under the valve cover and under the high-pressure oil rail.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)

- Terminal Test Adapter Kit (page 432)
- 8-pin Injector Harness (page 425)

Injector 1 Checks

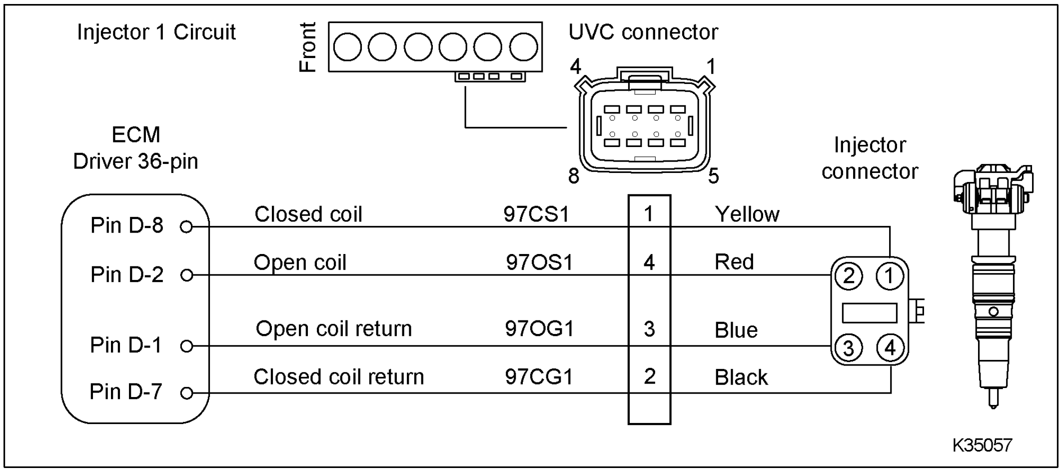


Figure 256 Injector 1 circuit diagram

Injector 1 – Resistance Checks Through Harness and Injector

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injector solenoids. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn the ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch OFF. Connect breakout box to the 36-pin ECM connector. Leave ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
D-1 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
D-2 to GND	> 1 kΩ	
D-7 to GND	> 1 kΩ	
D-8 to GND	> 1 kΩ	
D-1 to D-2	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
D-7 to D-8	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
D-1 to D-7	> 1 kΩ	If < 1 kΩ, check for cross-shorted circuits or injector coil for internal short.

Injector 1 - Injector Resistance Checks

Turn ignition switch OFF. Connect 8-pin UVC breakout harness to UVC connector. Use DMM to measure injector resistance.

Test Point	Spec	Comment
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	
1 to 2	1.0 Ω ± 0.5 Ω	If > 1.5 Ω, check for OPEN through injector.
3 to 4	1.0 Ω ± 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 OFF. Connect breakout box to ECM 36-pin connector. Leave ECM and UVC disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
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

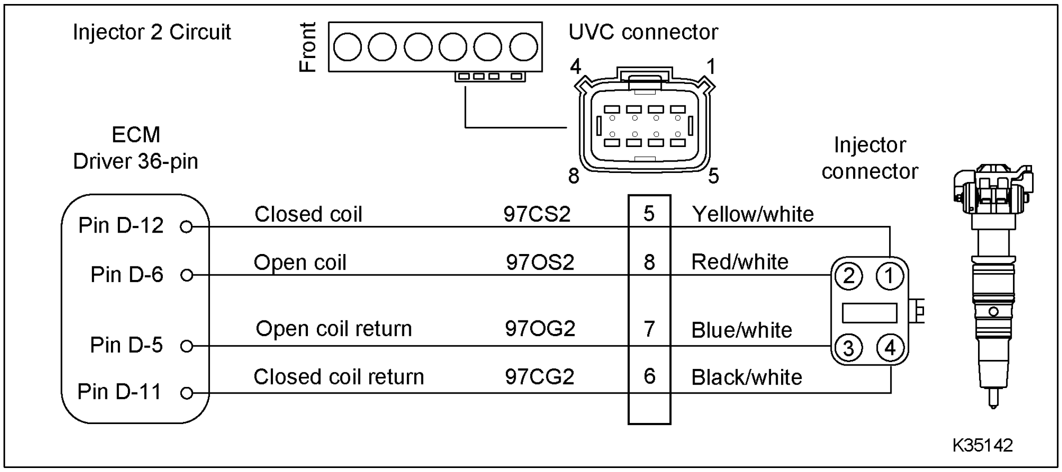


Figure 257 Injector 2 circuit diagram

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 avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn the ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch OFF. Connect injector breakout harness to the valve cover gasket. Use DMM to measure resistance.

Test Point	Spec	Comment
5 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
6 to GND	> 1 kΩ	
7 to GND	> 1 kΩ	
8 to GND	> 1 kΩ	

Injector 2 – Coil Resistance Check

Turn ignition switch OFF. Connect injector breakout harness to the valve cover gasket. Use DMM to measure resistance.

Test Point	Spec	Comment
5 to 6	0.5 Ω to 1.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
7 to 8	0.5 Ω 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 OFF. Connect breakout box and injector circuit breakout to engine harness. Leave ECM and UVC disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
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

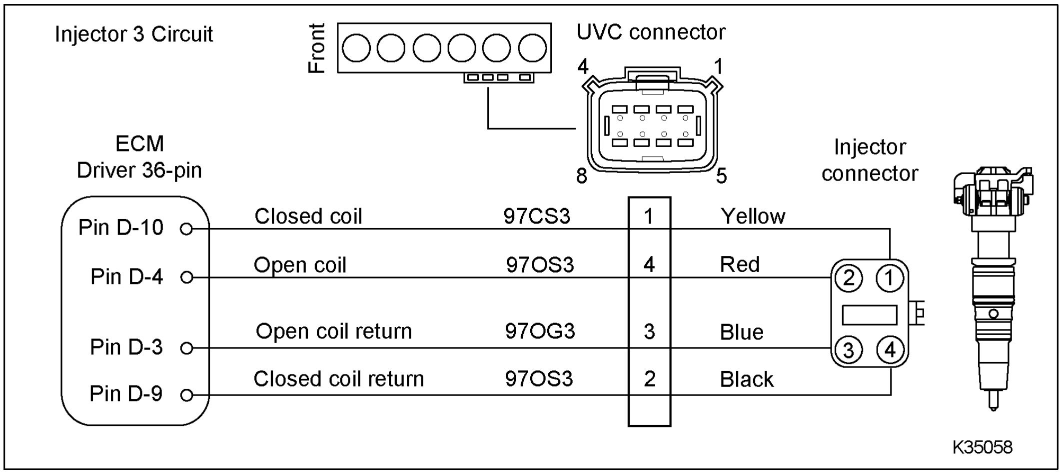


Figure 258 Injector 3 circuit diagram

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 avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn the ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch OFF. Connect injector breakout harness to the valve cover gasket. Use DMM to measure resistance.

Test Point	Spec	Comment
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 OFF. Connect injector breakout harness to the valve cover gasket. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to 2	0.5 Ω to 1.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
3 to 4	0.5 Ω 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 OFF. Connect breakout box and injector circuit breakout to engine harness. Leave ECM and UVC disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
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

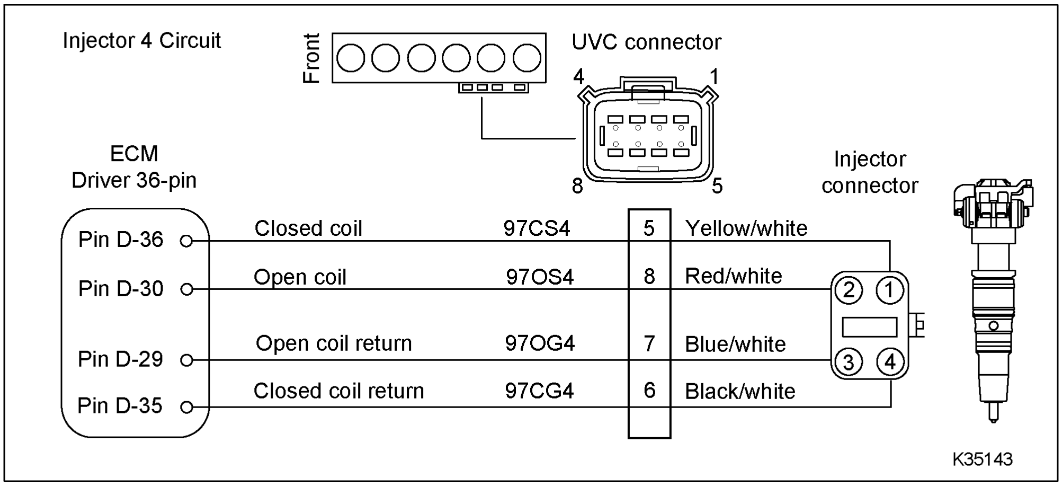


Figure 259 Injector 4 circuit diagram

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 avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn the ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch OFF. Connect injector breakout harness to the valve cover gasket. Use DMM to measure resistance.

Test Point	Spec	Comment
5 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
6 to GND	> 1 kΩ	
7 to GND	> 1 kΩ	
8 to GND	> 1 kΩ	

Injector 4 – Coil Resistance Check

Turn ignition switch OFF. Connect injector breakout harness to the valve cover gasket. Use DMM to measure resistance.

Test Point	Spec	Comment
5 to 6	0.5 Ω to 1.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
7 to 8	0.5 Ω 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 OFF. Connect breakout box and injector circuit breakout to engine harness. Leave ECM and UVC disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
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

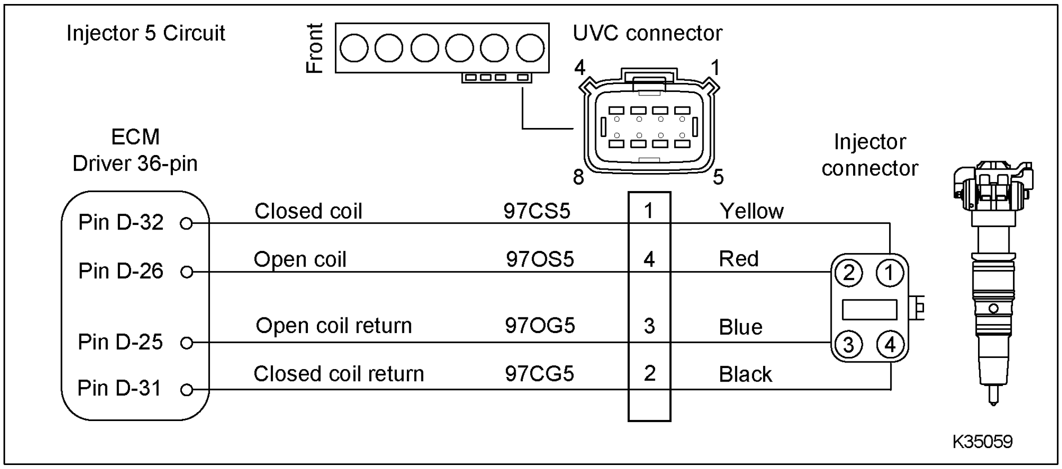


Figure 260 Injector 5 circuit diagram

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 avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn the ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch OFF. Connect injector breakout harness to the valve cover gasket. Use DMM to measure resistance.

Test Point	Spec	Comment
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 OFF. Connect injector breakout harness to the valve cover gasket. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to 2	0.5 Ω to 1.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
3 to 4	0.5 Ω 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 OFF. Connect breakout box and injector circuit breakout to engine harness. Leave ECM and UVC disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
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

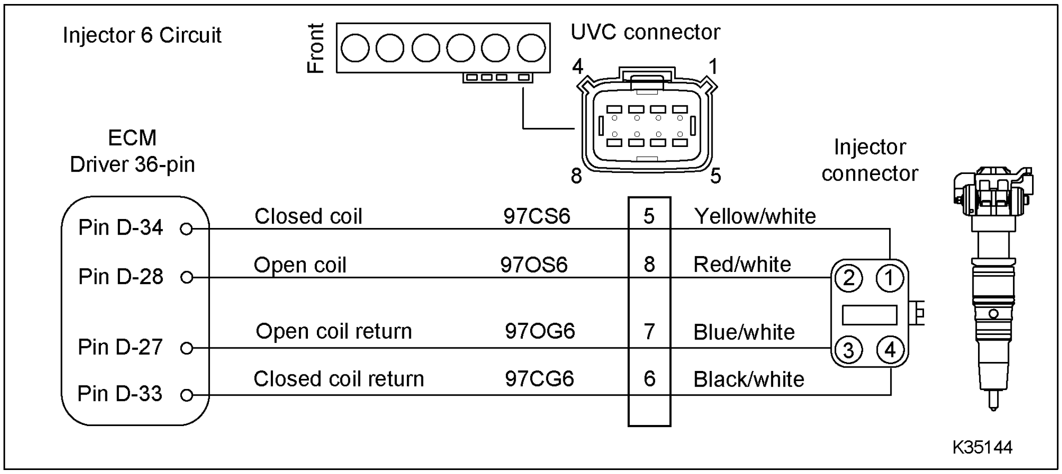


Figure 261 Injector 6 circuit diagram

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 avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn the ignition switch to OFF will cause a voltage spike and damage to electrical components.

Turn ignition switch OFF. Connect injector breakout harness to the valve cover gasket. Use DMM to measure resistance.

Test Point	Spec	Comment
5 to GND	> 1 kΩ	If < 1 kΩ, check circuit for short to GND or injector coil for internal short.
6 to GND	> 1 kΩ	
7 to GND	> 1 kΩ	
8 to GND	> 1 kΩ	

Injector 6 – Coil Resistance Check

Turn ignition switch OFF. Connect injector breakout harness to the valve cover gasket. Use DMM to measure resistance.

Test Point	Spec	Comment
5 to 6	0.5 Ω to 1.5 Ω	If > 1.5 Ω, check for OPEN circuit or OPEN injector coil.
7 to 8	0.5 Ω 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 OFF. Connect breakout box and injector circuit breakout to engine harness. Leave ECM and UVC disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
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 close coil. The ECM controlling circuits run from the 36-way driver connector, through the 8-way 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 V DC at 20 A. 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 A. When the current reaches 24 A, the ECM shuts off the high side driver. When the current drops to 16 A, 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 A. The time is compared to calibrated values and the ECM determines if a circuit or injector fault exists. Each injector has 6 failure modes and 3 DTCs. A failure can occur on the open or close coil circuit. When a fault is detected, a DTC 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.

IPR (Injection Pressure Regulator)

DTC	SPN	FMI	Condition
1276	8366	6	IPR short to B+ over-temperature
1277	8366	5	IPR short circuit

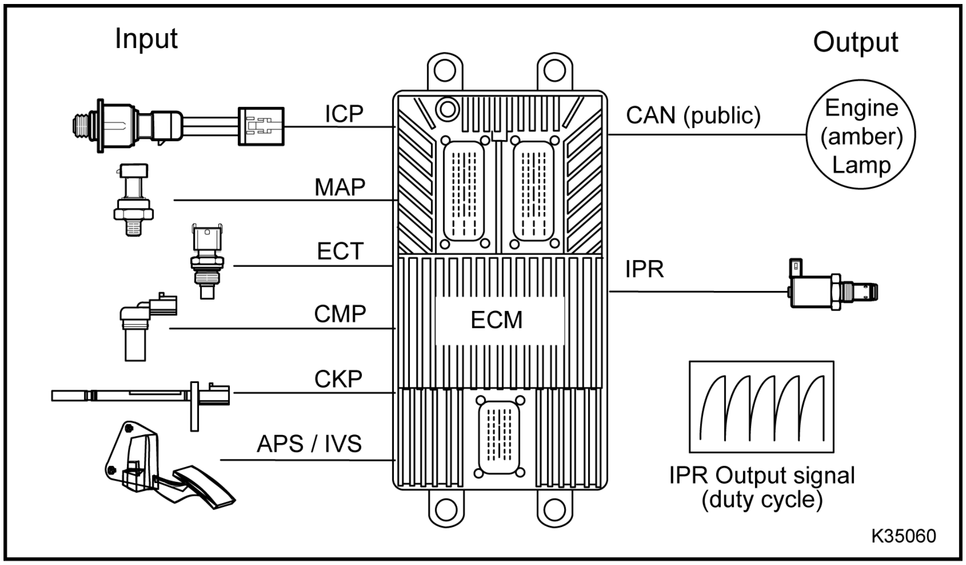


Figure 262 Function diagram for the IPR

The function diagram for the IPR includes the following:

- Injection Pressure Regulator (IPR)
- Engine Coolant Temperature (ECT) sensor
- Injection Control Pressure (ICP) sensor
- Manifold Absolute Pressure (MAP) sensor
- Camshaft Position (CMP) sensor
- Crankshaft Position (CKP) sensor
- Accelerator Position Sensor / Idle Validation Switch (APS/IVS) sensor
- Electronic Control Module (ECM)
- Engine lamp (amber)

Function

The IPR valve regulates oil pressure in the high-pressure injection control system that actuates the injectors. The ECM uses the ICP sensor to monitor system pressure and adjust the duty cycle to the valve to match engine requirements (starting, engine load, speed, and temperature).

IPR Location

The IPR is mounted in the body of the high-pressure pump.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- Breakout Box (page 426)
- Actuator Breakout Harness (page 426)
- Terminal Test Adapter Kit (page 432)

IPR Pin-point Diagnostics

DTC	Condition	Possible Causes
1276	IPR short to B+ over-temperature	• IPR control circuit shorted to PWR • Failed IPR valve
1277	IPR short circuit	• IPR control circuit shorted to GND • Failed IPR valve

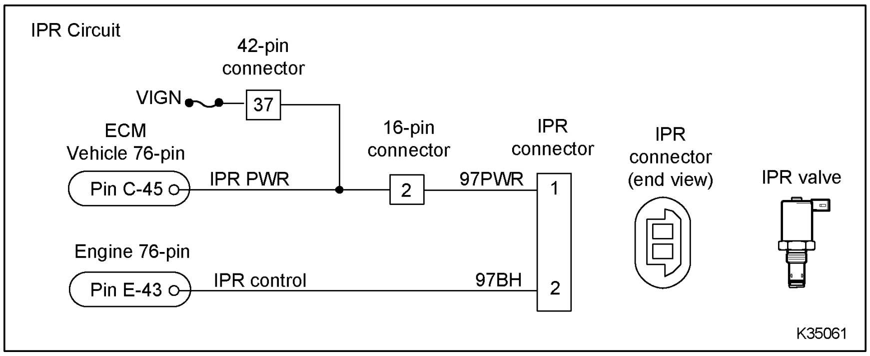


Figure 263 IPR circuit diagram

Connector Voltage Check

Connect breakout harness. Leave IPR valve disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
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 V, check IPR control circuit for short to PWR.

Operational Voltage Check – Output State Test

Connect breakout harness 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
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 V, check IPR control circuit for OPEN or failed IPR coil. Do Actuator and Harness Resistance check.

Actuator Resistance Check

Turn ignition switch to OFF. Connect breakout harness to IPR valve. Leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to 2	5.5 Ω ±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 breakout box, IPR, and 42-pin breakout harness. Leave ECM, IPR, and vehicle-side 42-pin connector disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
2 to E-43	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω, 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 < 1k Ω, check for short to PWR.

If all measurements are in specification, check VIGN circuit to 42-pin connector on the vehicle harness for OPEN.

IPR Circuit Operation

The IPR valve consists of a solenoid, poppet, and a spool valve assembly. The IPR valve is supplied with voltage at Pin 1 of the IPR connector through 16–pin connector (Pin 2) from VIGN. The control of the injection control system is gained by the ECM grounding Pin 2 of the IPR valve through Pin E-43 of the ECM.

Precise control is gained by varying the percentage of ON/OFF time of the IPR solenoid. A high duty cycle indicates a high amount of injection control pressure is being commanded. A low duty cycle indicates less pressure being commanded.

The ECM regulates ICP by controlling the ON/OFF time of the IPR solenoid. An increase or decrease in the ON/OFF time positions the poppet and spool valve inside the IPR and maintains pressure in the ICP system or vents pressure to the oil sump through the front cover.

NOTE: The engine may not operate with an IPR fault, depending on the mode of failure.

Fault Detection / Management

An open or short to ground in the ICP control circuit can be detected by an on demand output circuit check during KOEO Standard Test. If there is a circuit fault detected a Diagnostic Trouble Code (DTC) will be set.

IST System (Idle Shutdown Timer)

DTC	SPN	FMI	Condition
2324	593	14	Engine stopped by IST

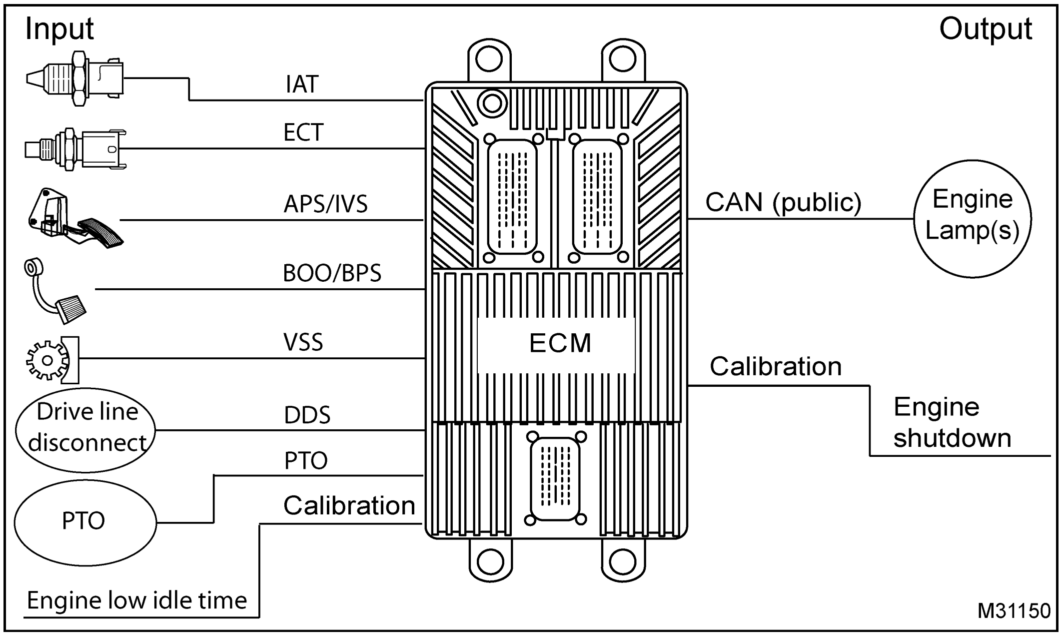


Figure 264 Function diagram for IST system

The IST function diagram includes the following:

- Electronic Control Module (ECM)
- Intake Air Temperature (IAT) sensor
- Engine Coolant Temperature (ECT) sensor
- Accelerator Position Sensor and Idle Validation Switch (APS/IVS)
- Brake ON/OFF (BOO) switch and Brake Pressure Switch (BPS)
- Driveline Disengagement Switch (DDS)
- Power Takeoff (PTO)
- Warning lamps

Function

The Idle Shutdown Timer (IST) allows the ECM to shut down the engine during extended engine idle times.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)

GOVERNMENT REGULATION: State and local regulations may limit engine idle time. The 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 for California ESS Compliant Engines

Beginning in 2008 MY, MaxxForce® engines certified for sale in the state of California (CA) will conform to mandatory California Air Resources Board (CARB) Engine Shutdown System (ESS) regulations. The prior function of the IST is available on CA ESS exempt and Federally certified engines (school buses, emergency, and military vehicles).

Engine idle duration is limited for ESS complaint engines as follows:

- When vehicle parking brake is set, the idle shutdown time is limited to the CARB requirement of 5 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. Adjusting this parameter reduces overall system shutdown time as follows:

- Adjusting parameter value between 5 and 15 minutes reduces idle shutdown time with the vehicle parking brake released. The default value of 5 minutes for the vehicle parking brake “set” condition remains unaffected.
- Adjusting parameter value between 2 and 5 minutes reduces idle time for both the vehicle parking brake ”released” and set” conditions.

While the Electronic Service Tool (EST) is installed, idle shutdown time is factory defaulted to 60 minutes and cannot be adjusted. If the IST is enabled, the Cold Ambient Protection (CAP) will not function.

NOTE: The CARB IST feature is factory programmed. Customers can not turn IST off for ESS compliant engines.

CARB 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 driveline 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 15.6 °C (60 °F)
- No active coolant temperature sensor diagnostic faults.
- No active intake air temperature sensor diagnostic faults.
- Engine is operating in run mode or in active diagnostic tool mode.
- Vehicle speed is less than 1.25 miles/hr.
- No active vehicle speed diagnostic faults.
- PTO Control is in OFF or Standby mode.
- Engine speed less than 750 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 (CAN message) (no transition detected from any pre-set state).

Engine Idle Shutdown Timer (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 idler timer. If the IST is enabled, the Cold Ambient Protection (CAP) will not function.

Federal IST Conditions

The following conditions must be true for the idle shutdown timer to activate. Any change to the “true” state of one or more of these conditions will reset or disable the IST.

Common Enable Conditions for All Federal IST Options

- Manual Diesel Particulate Filter (DPF) regeneration is inactive (not enabled).
- Steady driveline 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).
- PTO Remote mode disabled.
- Intake air temperature greater than 15.6 °C (60 °F) (MFG Default, Customer adjustable parameter).
- Intake air temperature lower than 44 °C (112 °F) (MFG Default, Customer adjustable parameter).
- Engine coolant temperature greater than 60 °C (140 °F).
- No active coolant temperature sensor diagnostic faults.
- No active intake air temperature sensor diagnostic faults.
- Engine is operating in run mode or in active diagnostic tool mode.
- Vehicle speed is less than 1.25 miles/hr.
- Steady parking brake state (CAN message). No transition detected from any pre-set state.

Additional operation enable conditions depending on selected Federal IST operation mode:

Federal IST Mode 1: PTO Operation Option Enable Conditions

- 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 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 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

The IST DTC does not indicate a system fault. DTC 2324 is set by the ECM when the engine has been shutdown due to exceeding the programmed idle time. The IST feature must be enabled for DTC 2324 to be displayed.

ITV (Intake Throttle Valve)

DTC	SPN	FMI	Condition
1287	3464	1	ITVL OCC self-test failed
1288	3464	0	ITVH OCC self-test failed
1292	7318	2	ITVP in-range fault
1293	7318	3	ITVP signal out-of-range HIGH
1294	7318	4	ITVP signal out-of-range LOW
1298	51	2	ITV operation fault - under V, over amp, over temp

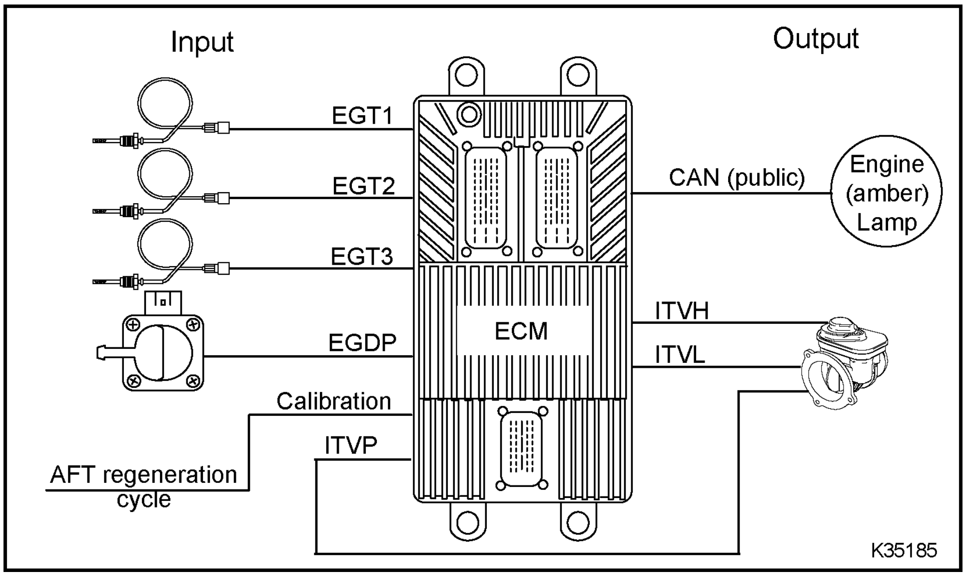


Figure 265 Function diagram for the ITV

The function diagram for the ITV includes the following:

- Intake Throttle Valve (ITV)
  - Intake Throttle Valve High (ITVH) circuit
  - Intake Throttle Valve Low (ITVL) circuit
  - Intake Throttle Valve Position (ITVP) sensor
- Electronic Control Module (ECM)
- Engine lamp (amber)
- Exhaust Gas Differential Pressure (EGDP) sensor
- Exhaust Gas Temperature 1 (EGT1) sensor
- Exhaust Gas Temperature 2 (EGT2) sensor
- Exhaust Gas Temperature 3 (EGT3) sensor

Function

The Intake Throttle Valve (ITV) is used to control air/fuel mixture during a regeneration process of the aftertreatment system. The ITV is also used to insure a smooth engine shut down by restricting air flow to the engine at shut down.

Component Location

The ITV is installed on the air intake between the air filter housing and EGR mixer.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- 3-Banana Plug Harness (page 425)
- Breakout Box (page 426)
- ITV Breakout Harness (page 430)
- Terminal Test Adapter Kit (page 432)

ITV Actuator End Diagnostics

DTC	Condition	Possible Causes
1287	ITVL OCC self-test failed	Valve is not opening as much as desired by 35% • ITV circuit fault • Failed valve
1288	ITVH OCC self-test failed	Valve is not closing as much as desired 35% • ITV circuit fault • Failed valve
1292	ITVP In-Range fault	ITV Position doesn't agree with the commanded position • ITV circuit fault • Failed valve
1293	ITVP signal out-of-range HIGH	• ITVP signal short to PWR
1294	ITVP signal out-of-range LOW	• ITVP signal OPEN or short to GND
1298	ITV operation fault - under V, over amp, over temp	• ITV circuit fault, Open or shorted • Failed valve

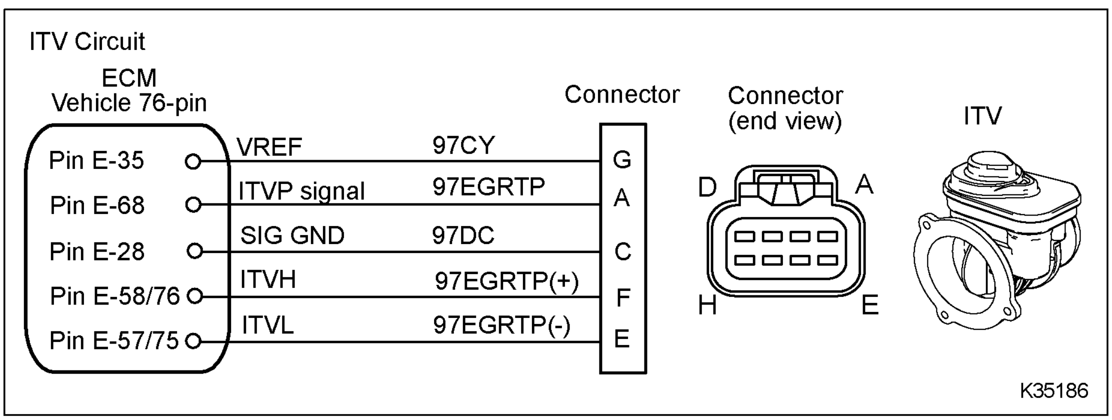


Figure 266 ITV actuator circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Verify sensor voltage is within KOEO specification. See “Performance Specification” section.
3. Monitor sensor voltage. Verify an active DTC for the sensor.
   - If code is inactive, monitor the PID while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID will spike and the DTC 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.

ITV Actuator Circuit Check

Connect breakout harness. Leave ITV disconnected. Turn ignition switch to ON. Use EST to monitor PID and DMM to measure voltage during Continuous Monitor test.

Test Point	Spec	Comments
EST - Check DTC	DTC 1294	If DTC 1293, check ITVP signal for short to PWR
DMM - Measure volts G to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 386).
EST - Check DTC Short breakout harness across A and G	DTC 1293	If DTC 1294, check ITVP signal for OPEN. Do Harness Resistance Check (page 386).
DMM - Measure resistance C to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 386).
DMM - Measure voltage E to GND	B+	If < B+, check ITVL for OPEN or short to GND. Do Harness Resistance Check (page 386).
DMM - Measure voltage F to GND	B+	If < B+, check ITVH for OPEN or short to GND. Do Harness Resistance Check (page 386).

ITV Actuator Pin-point Diagnostics

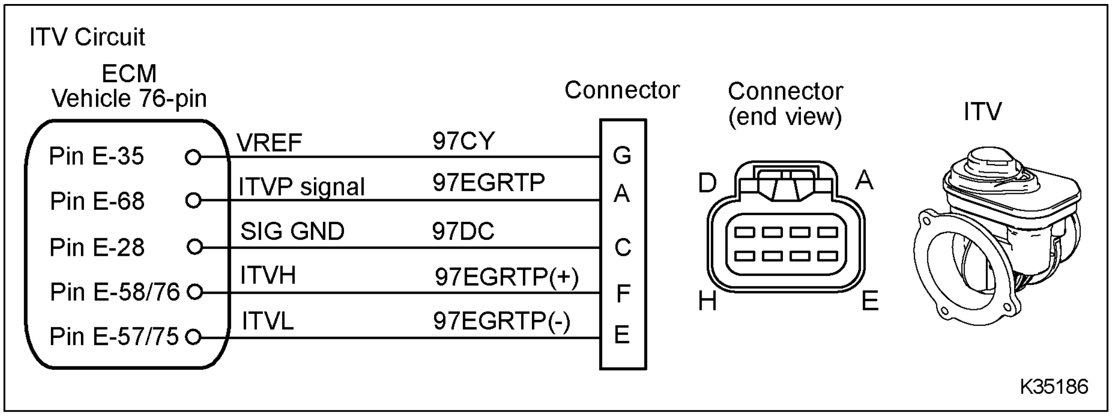


Figure 267 ITV actuator circuit diagram

Connector Voltage Check

Connect breakout harness. Leave actuator disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
C to GND	0 V	If > 0.25 V, check SIG GND for short to PWR.
G 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 (page 386).
A to GND	0 V	If > 0.25 V, check ITVP for short to PWR. Do Harness Resistance Check (page 386).
E to GND	B+	If < B+, check ITVL for OPEN or short to GND. Do Harness Resistance Check (page 386).
F to GND	B+	If < B+, check ITVH for OPEN or short to GND. Do Harness Resistance Check (page 386).
If checks are within specification, do Connector Resistance Check to GND (page 386).		

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect breakout harness. Leave actuator disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
A to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
C to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
F to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
G to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and actuator breakout harness. Leave ECM and actuator disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
A to E-68	< 5 Ω	If > 5 Ω, check ITVP signal circuit for OPEN
C to E-28	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN
E to E-57	< 5 Ω	If > 5 Ω, check ITVL circuit for OPEN
E to E-75	< 5 Ω	If > 5 Ω, check ITVL circuit for OPEN
F to E-58	< 5 Ω	If > 5 Ω, check ITVH circuit for OPEN
F to E-76	< 5 Ω	If > 5 Ω, check ITVH circuit for OPEN
G to E-35	< 5 Ω	If > 5 Ω, check VREF circuit for OPEN

ITV Actuator Circuit Operation

The ITV/ITVP is integrated into one component. ITV is the control valve actuator and ITVP is the valve position sensor.

ITVP sensor

The ITVP is a potentiometer sensor that is supplied with a 5 V reference voltage at Pin G from ECM Pin E-35. The sensor is grounded at Pin C from ECM Pin E-28. The sensor returns a variable voltage signal from Pin A to ECM Pin E-68.

ITV actuator

The ECM controls the ITV with a Pulse Width Modulation (PWM) signal through H-bridge circuitry.

Pulse Width Modulation - Voltage is supplied by a series of pulses. To control motor speed, it varies (modulates) the width of the pulses.

H-bridge is a bi-polar circuit. The ECM controls the ITV to close by driving the ITVH circuit high, this causes ITVL circuit to go low. The opposite occurs when the valve is commanded open.

Variable voltage is needed to move the valve. Very little voltage is needed to maintain its position.

Fault Detection / Management

The ECM will continuously monitor the ITVP sensor. If the sensor signal is higher or lower then expected, the ECM will set a DTC and turn on the amber engine lamp.

An open or short on the ITV controlling circuits can only be detected by on-demand output circuit check during KOEO Standard Test. If there is a circuit fault detected a DTC will set.

MAP Sensor (Manifold Absolute Pressure)

DTC	SPN	FMI	Condition
1121	102	3	MAP signal out-of-range HIGH
1122	102	4	MAP signal out-of-range LOW
1156	102	0	MAP signal in-range HIGH – MAP above baro at start
1157	102	1	MAP signal in-range LOW – MAP below baro at start

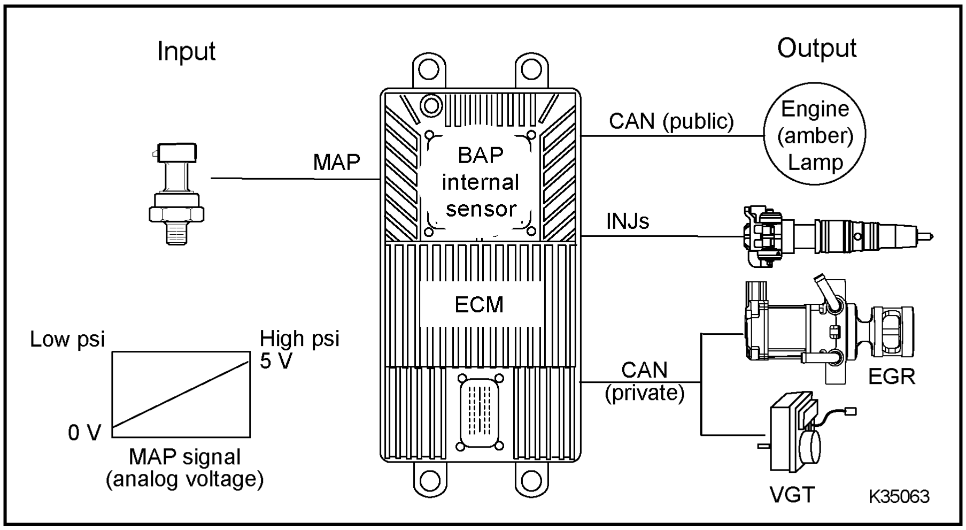


Figure 268 Function diagram for the MAP sensor

The function diagram for the MAP sensor includes the following:

- Manifold Absolute Pressure (MAP) sensor
- Electronic Control Module (ECM)
  - Barometric Absolute Pressure (BAP) internal sensor
- Exhaust Gas Recirculation (EGR)
- Variable Geometry Turbocharger (VGT)
- Fuel injector (INJ)
- Engine lamp (amber)

Function

The ECM uses the MAP sensor signal to assist in the calculation of the EGR and VGT duty percentage. The ECM monitors the MAP signal to determine intake manifold (boost) pressure. From this information the ECM can optimize control of fuel rate and injection timing for all engine operating conditions.

Sensor Location

The MAP sensor is installed in the intake manifold, left of the MAT sensor.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- 3-Banana Plug Harness (page 425)
- Breakout Box (page 426)
- Pressure Sensor Breakout Harness (page 431)
- Terminal Test Adapter Kit (page 432)

MAP Sensor End Diagnostics

DTC	Condition	Possible Causes
1121	MAP signal out-of-range HIGH	• MAP signal circuit short to PWR • Failed sensor
1122	MAP signal out-of-range LOW	• MAP signal circuit OPEN or short to GND • VREF circuit OPEN • Failed sensor
1156	MAP signal in-range HIGH – MAP above BARO at start	• SIG GND circuit OPEN • VREF circuit short to PWR • Biased circuit/sensor • Failed sensor
1157	MAP signal in-range LOW – MAP below BARO at start	• VREF circuit OPEN • Biased circuit/sensor • Failed sensor

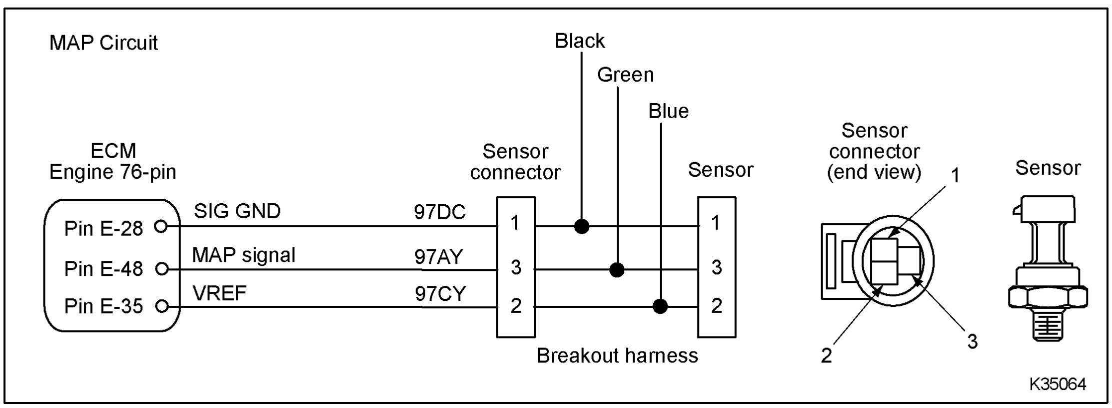


Figure 269 MAP circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Verify sensor voltage is within KOEO specifications. See “Performance Specifications” section.
3. Monitor sensor voltage. Verify an active DTC for the sensor.
   - If code is inactive, monitor the PID while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID will spike and the DTC 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.

Sensor Circuit Check

Connect sensor breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use EST to verify correct DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST – Check DTC	DTC 1122	If DTC 1121 is active, check MAP signal for short to PWR.
DMM – Measure volts 2 to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 390).
EST – Check DTC Short breakout harness across 2 and 3	DTC 1121	If DTC 1122 is active, check MAP signal for OPEN or short to GND. Do Harness Resistance Check (page 390).
DMM – Measure resistance 1 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN. Do Harness Resistance Check (page 390).

If checks are within specification, connect sensor and clear DTCs. If active code remains, replace sensor.

MAP Pin-point Diagnostics

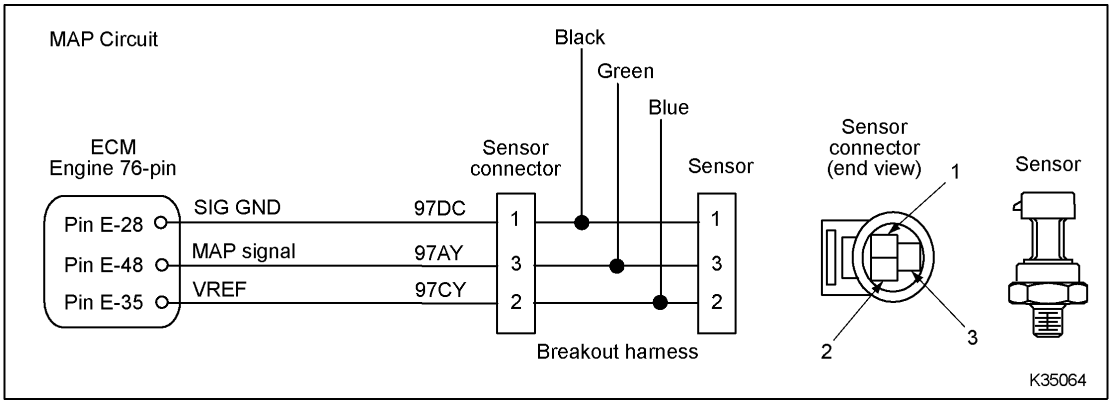


Figure 270 MAP circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	0 V	If > 0.25 V, check for short to PWR.
2 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 (page 390).
3 to GND	0 V	If > 0.25 V, check for short to PWR. Do Harness Resistance Check (page 390).

Connector Resistance Check to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
1 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit.
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. Connect breakout box and sensor breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
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 MAP signal circuit for OPEN.

MAP Circuit Operation

The MAP sensor is a variable capacitance sensor that is supplied with a 5 V 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-48.

Fault Detection / Management

The ECM monitors the BAP sensor as a baseline for zeroing the MAP and EBP signals.

The ECM continuously monitors the control system. If 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 DTC, turn on the amber engine lamp, run the engine in a default range, and disable the EWPS.

MAT Sensor (Manifold Air Temperature)

DTC	SPN	FMI	Condition
1161	105	4	MAT signal out-of-range LOW
1162	105	3	MAT signal out-of-range HIGH

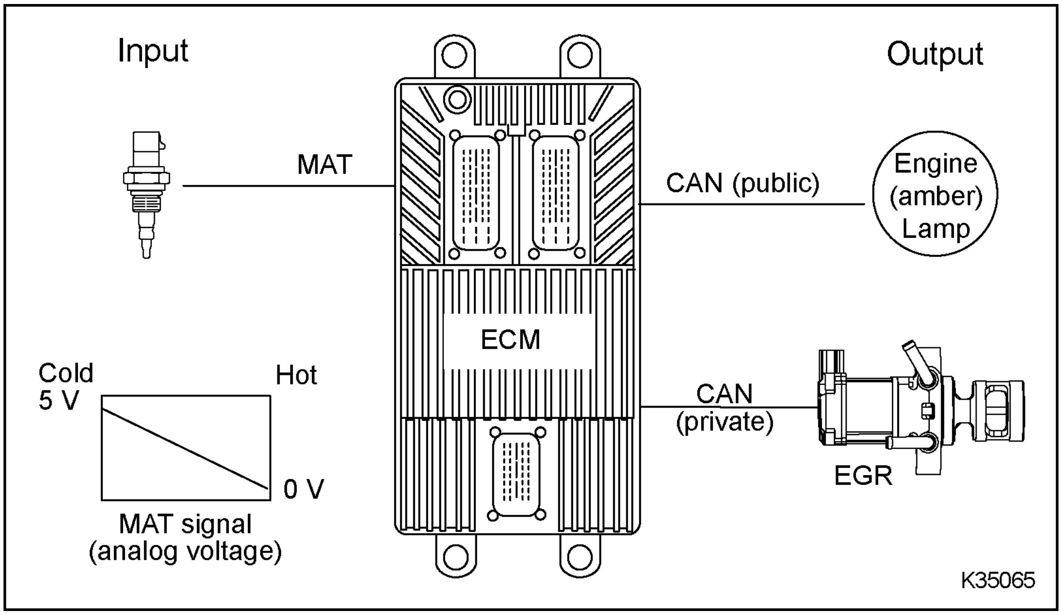


Figure 271 Function diagram for the MAT sensor

The function diagram for the MAT sensor includes the following:

- Manifold Air Temperature (MAT) sensor
- Exhaust Gas Recirculation (EGR)
- Electronic Control Module (ECM)
- Engine lamp (amber)

Function

The MAT sensor provides a feedback signal to the ECM indicating manifold air temperature. The ECM controls the EGR system based on the air temperature in the intake manifold. This aids in cold engine starting and warm-ups, and also reduces exhaust emissions.

Sensor Location

The MAT sensor is located in the intake manifold, next to the MAP sensor.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- 3-Banana Plug Harness (page 425)
- Breakout Box (page 426)
- MAT Sensor Breakout Harness (page 432)
- Terminal Test Adapter Kit (page 432)

MAT Sensor End Diagnostics

DTC	Condition	Possible Causes
1161	MAT signal out-of-range LOW	• MAT signal circuit short to GND • Failed sensor
1162	MAT signal out-of-range HIGH	• MAT signal OPEN or short to PWR • SIG GND circuit OPEN • Failed sensor

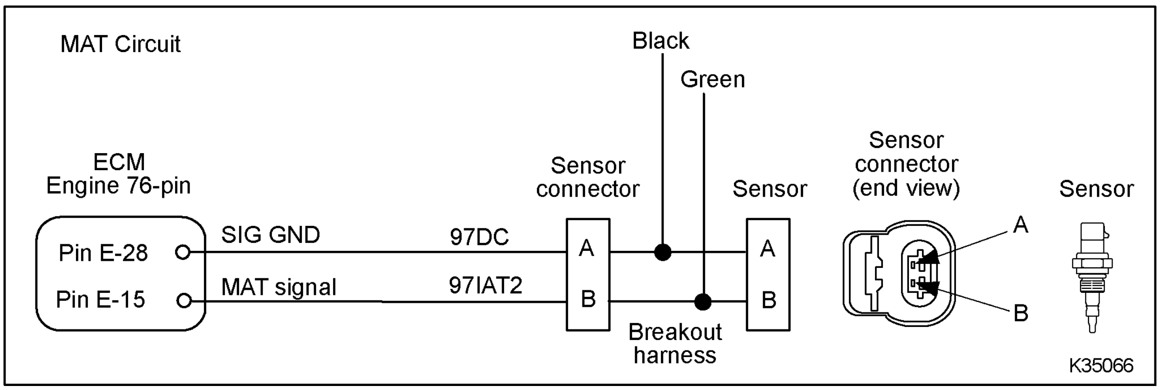


Figure 272 MAT circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the D_ContinuousMonitor.ssn.
2. Monitor sensor voltage. Verify an active DTC for the sensor.
    - If code is inactive, monitor the PID while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID will spike and the DTC 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 DTC goes active when corresponding fault is induced. Use DMM to measure circuits.

Test Point	Spec	Comments
EST – Check DTC	DTC 1162	If DTC 1161 is active, check MAT signal for short to GND. Do Harness Resistance Check (page 395).
EST – Check DTC Short 3-banana plug harness across B and GND	DTC 1161	If DTC 1162 is active, check MAT signal for OPEN. Do Harness Resistance Check (page 395).
EST – Check DTC Short 3-banana plug harness across A and B	DTC 1161	If DTC 1162 is active, check SIG GND for OPEN. Do Harness Resistance Check (page 395).

If checks are within specification, connect sensor and clear DTCs. If active code remains, replace sensor.

MAT Pin-point Diagnostics

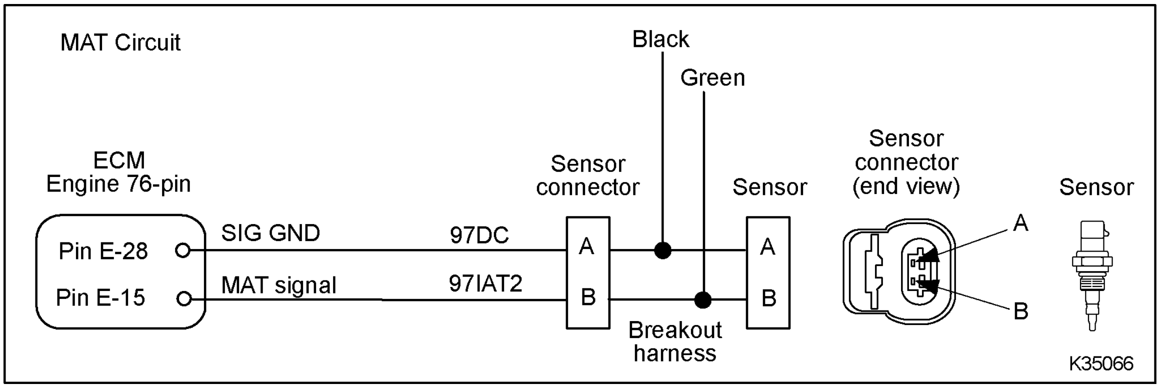


Figure 273 MAT circuit diagram

Connector Voltage Check

Connect breakout harness. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
A to GND	0 V	If > 0.25 V, check for short to PWR.
B to GND	4.6 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 395).

Connector Resistance Checks to GND

Turn ignition switch to OFF. Connect breakout harness. Leave sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
A to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit.
B to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and breakout harness. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
A to E-28	< 5 Ω	If > 5 Ω, check for OPEN circuit.
B to E-15	< 5 Ω	If > 5 Ω, check for OPEN circuit.

MAT Circuit Operation

The MAT is a thermistor sensor that is supplied with a 5 V reference voltage at Pin B from ECM Pin E–15. The sensor is grounded at Pin A from ECM Pin E–28.

As the temperature increases, the resistance of the thermistor decreases. This causes the signal voltage to decrease.

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 value. The ECM will set a DTC, turn on the amber engine lamp, and run the engine in a default range.

RSE (Radiator Shuttle Enable)

DTC	SPN	FMI	Condition
None			

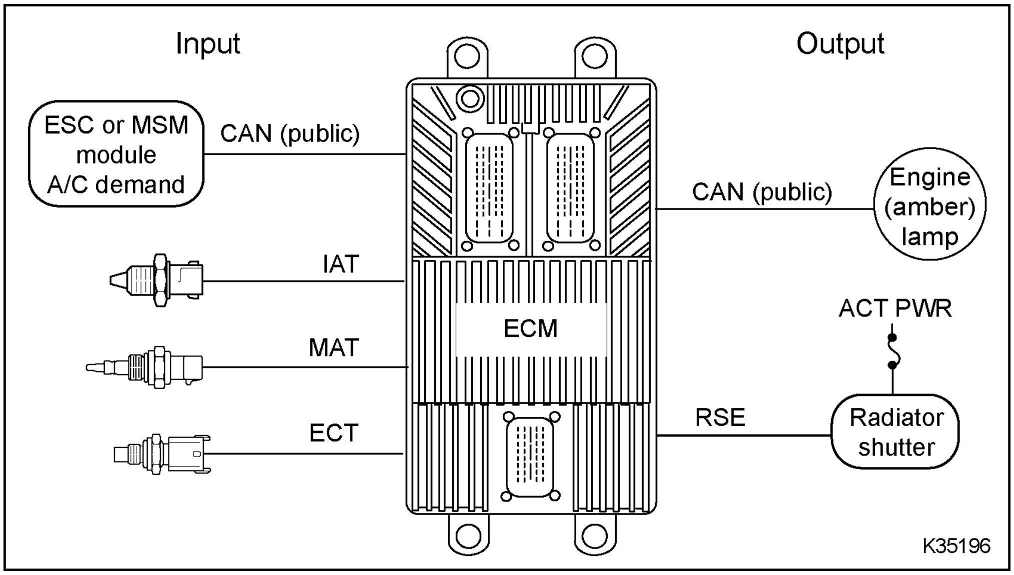


Figure 274 Function diagram for RSE

The function diagram for the RSE includes the following:

- Radiator Shuttle Enable (RSE)
- Electronic Control Module (ECM)
- Intake Air Temperature (IAT)
- Manifold Air Temperature (MAT)
- Engine Coolant Temperature (ECT)
- Engine lamp (amber)

Function

The Radiator Shutter Enable (RSE) feature provides the correct signal to open or close the radiator shutters (energize or de-energize the solenoid). 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.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- Terminal Test Adapter Kit (page 432)

RSE Circuit Diagnostics

DTC	Condition	Possible Causes
None	Inactive RSE	• RSE circuit OPEN or shorted to GND • ACT PWR circuit OPEN or shorted to GND, blown fuse • Failed relay • Failed RSE solenoid

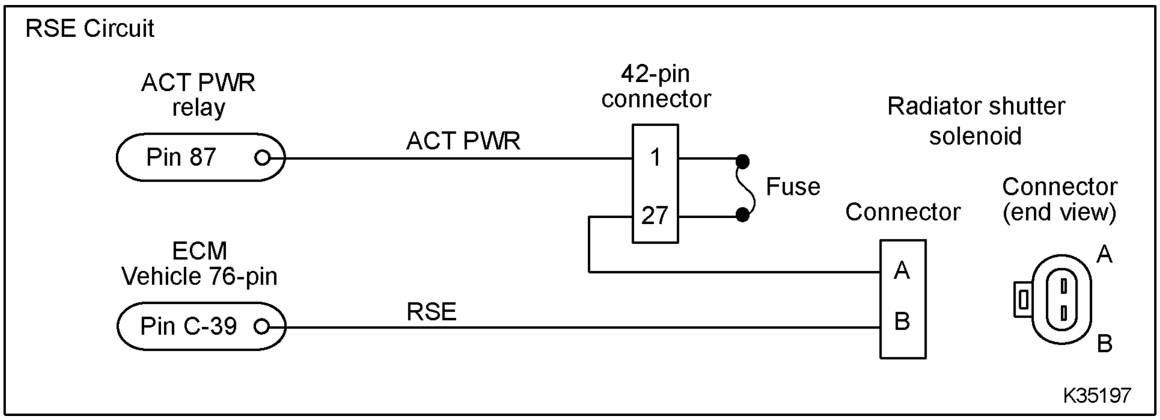


Figure 275 RSE circuit diagram

Voltage Check at RSE Connector - Output State Test

Disconnect radiator shuttle solenoid 2-pin connector. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
A to GND	B+	If < B+, check ACT PWR circuit for OPEN, blown fuse or failed relay
B to GND	0 V to 0.25 V	If > 0.25 V, check RSE circuit for short to PWR
Run Output State Test HIGH.		
B to B+	0 V to 0.25 V	If > 0.25 V, check RSE circuit for short to GND
Run Output State Test LOW.		
B to B+	B+	If < B+, check RSE circuit for OPEN or short to PWR. Do Harness Resistance Check (page 399)
A to B	B+	If < B+, check ACT PWR circuit for OPEN. Do Harness Resistance Check (page 399)

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box. Leave ECM and radiator shutter solenoid disconnected.

Test Point	Spec	Comment
C-39 to B	< 5 Ω	If > 5 Ω, check RSE for OPEN circuit
C-39 to GND	> 1 kΩ	If < 1 kΩ, check RSE circuit for short to GND
A to C-1, 3 and 5	< 5 Ω	If > 5 Ω, check ACT PWR for OPEN in circuit.
A to GND	> 1 kΩ	If < 1 kΩ, check ACT PWR for short to GND.

See truck *Chassis Electrical Circuit Diagram Manual* for fuse information.

RSE Circuit Operation

The control cylinder responds to air or hydraulic pressure from the shutter control valve, and actuates to hold the spring-loaded vanes closed. When pressure is relieved, the vanes open. The vanes open automatically when the vehicle is shut down.

The RSE solenoid is supplied ACT PWR at Pin A. The ECM Pin C-39 controls the solenoid by grounding Pin B.

The shutters will close when all of the following conditions exist:

- MAT is less than 37 °C (99 °F)
- IAT is less than 7 °C (45 °F)
- ECT is less than 80 °C (176 °F)
- No transmission retarder request is present
- No engine fan request is present

The shutters will open when any of the following conditions exist:

- MAT is greater than 60 °C (140 °F)
- IAT is greater than 12 °C (54 °F)
- Transmission retarder request is present
- Engine fan request is present
- ECT is greater than 87 °C (189 °F)

NOTE: ECT is customer programmable

The shutters will not close again until all closed conditions exist.

Fault Detection / Management

An open or short to ground in the RSE can be detected by the ECM during an on-demand engine standard test. The IAT, MAT, and ECT are continuously monitored. If a DTC is detected in the IAT, MAT, or ECT circuit, the RSE control is disabled and the radiator shutters remain open.

Diagnostic Trouble Codes (DTCs)

There are no DTCs for RSE.

Tachometer Output Circuit

DTC	SPN	FMI	Condition
			None

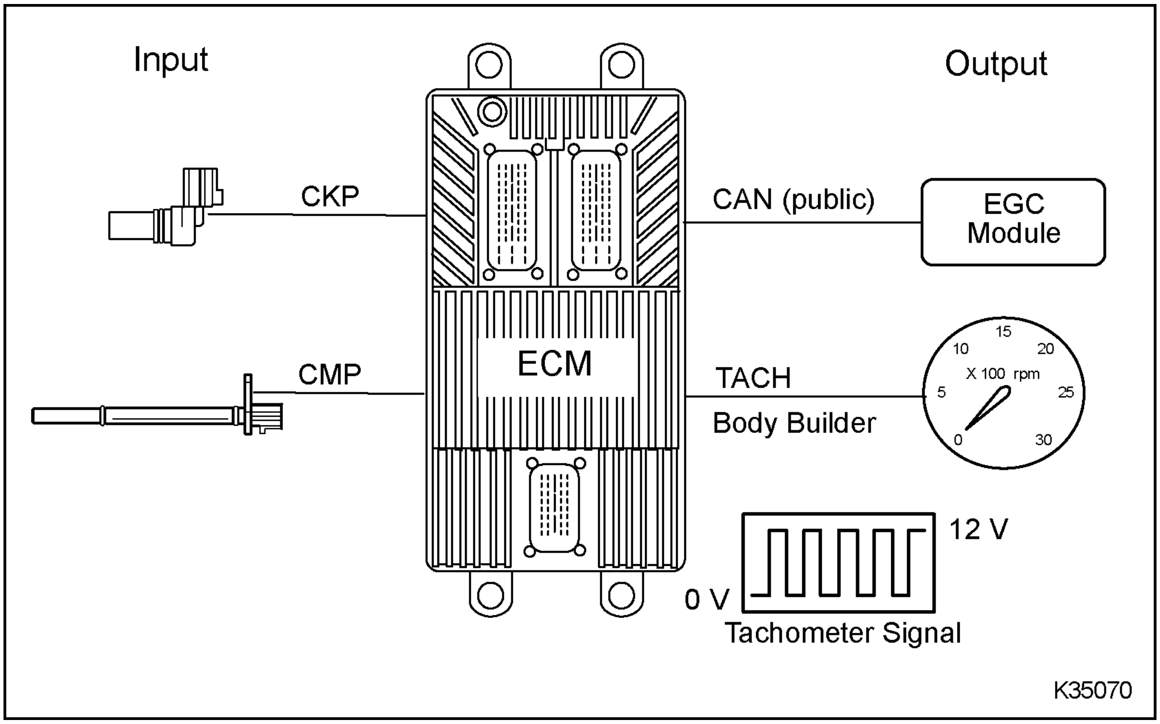


Figure 276 Function diagram for the tachometer output circuit

The function diagram for the tachometer output circuit includes the following:

- Remote tachometer
- Electronic Control Module (ECM)
- Electronic Gauge Cluster (EGC) Module
- Crankshaft Position (CKP) sensor
- Camshaft Position (CMP) sensor

The Tachometer signal is sent to the EGC through the public CAN network. The TACH signal is also supplied on one circuit to the body builder blunt cut-off circuits.

Tachometer Pin-point Diagnostics

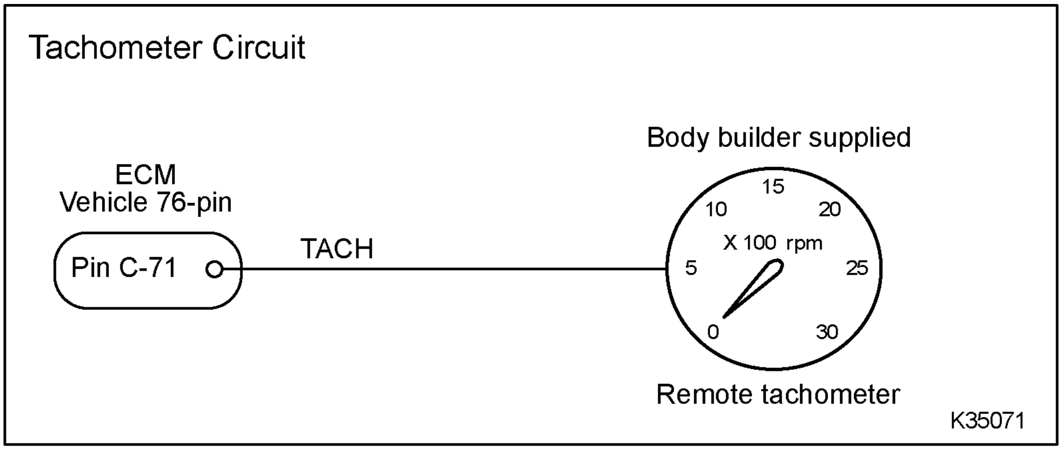


Figure 277 Tachometer circuit diagram

Circuit End Voltage Check

NOTE: If the tachometer is not working on the EGC, see truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide*.

Disconnect component from the body builder blunt cut off circuit. Turn ignition switch ON. Use DMM for measure voltage.

Test Point	Spec	Comment
TACH to GND	B+	If < B+, check for OPEN circuit
Start engine. Set DMM to Hz to measure engine speed signal.		
TACH to GND	Low idle = 140 Hz at 700 RPM High idle = 540 Hz at 2700 RPM	If no signal, do Harness Resistance Check (page 401).

Harness Resistance Check

Connect Breakout Box, leave ECM and TACH component disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
C-71 to TACH	< 5 Ω	If > 5 Ω , Check for OPEN circuit
C-71 to GND	> 1 kΩ	If < 1 kΩ, Check for short to GND

Tachometer Circuit Operation

The ECM receives a signal from the CMP sensor and calculates engine speed (rpm). The ECM provides an output for a remote tachometer with a 0 volts to 12 volts digital signal that indicates engine speed. The frequency sent by the ECM is 1/5th of the actual engine rpm (12 pulses per engine revolution).

Diagnostic Trouble Codes (DTCs)

DTCs are not available for communication between the ECM and the remote tachometer.

VGT (Variable Geometry Turbocharger) Actuator

DTC	SPN	FMI	Condition
1178	7316	0	VGT actuator temp above high limit
2174	8321	2	VGT communication fault
2175	8321	7	VGT performance fault
2176	8321	0	VGT commanded position over a threshold
2177	8321	1	VGT commanded position below a threshold
2549	8321	12	ECM not receiving VGT CAN messages
3345	7136	0	VGT control over duty
3347	7136	1	VGT control under duty

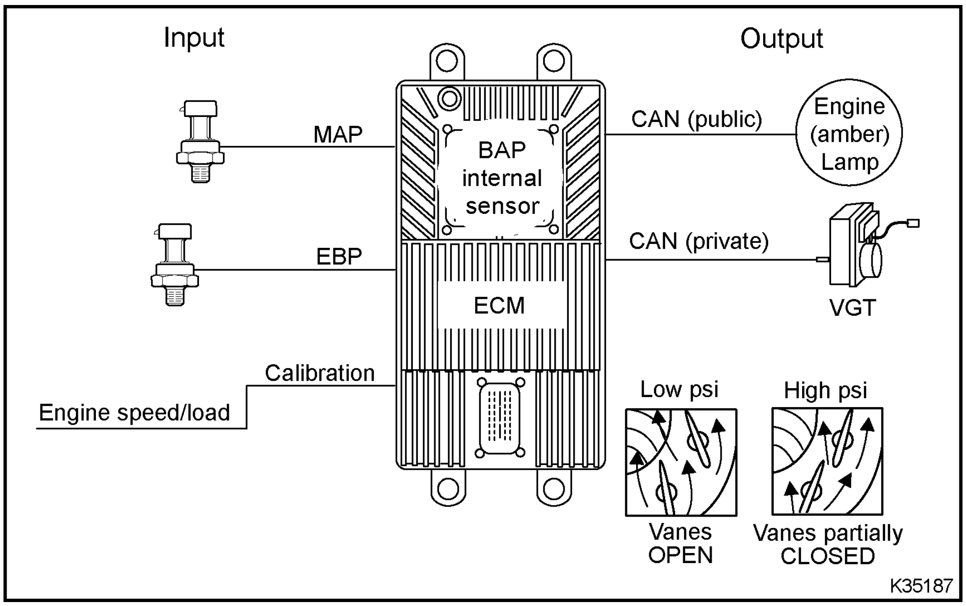


Figure 278 Function diagram for the VGT actuator

The function diagram for the VGT actuator includes the following:

- Variable Geometry Turbocharger (VGT) actuator
- Electronic Control Module (ECM)
  - Barometric Absolute Pressure (BAP) internal sensor
- Manifold Absolute Pressure (MAP) sensor
- Exhaust Back Pressure (EBP) sensor
- Engine lamp (amber)

Function

The Variable Geometry Turbocharger (VGT) is used for the following:

- Performance - The VGT provides faster turbo response and quicker acceleration with less lag.
- Emissions - The VGT controls the pressure difference between exhaust and inlet manifolds to ensure proper EGR operation.
- Engine Brake - The VGT increases the exhaust back pressure to increase engine braking.

Component Location

The VGT actuator is an electronic component mounted on the side of the turbocharger.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- Digital Multimeter (DMM) (page 428)
- 4-Pin Actuator Breakout Harness (page 425)
- Breakout Box (page 426)
- Terminal Test Adapter Kit (page 432)

VGT Actuator End Diagnostics

DTC	Condition	Possible Causes
1178	VGT actuator temp above high limit	ACT PWR circuit OPEN
2174	VGT communication fault	Battery GND circuit OPEN
2175	VGT performance fault	CANH circuit OPEN or shorted
2176	VGT commanded position over a threshold	CANL circuit OPEN or shorted
2177	VGT commanded position below a threshold	Sticky or stuck VGT linkage
2549	ECM not receiving VGT CAN messages	Failed VGT actuator
3345	VGT control over duty	
3347	VGT control under duty	

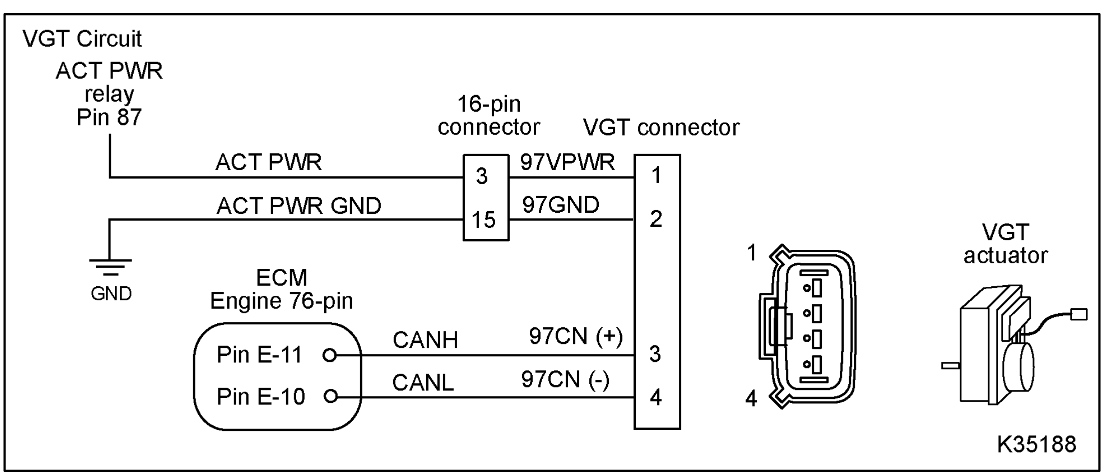


Figure 279 VGT actuator circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

NOTE: When the ignition switch is turned to ON, the VGT actuator will cycle the vanes closed and then back open before starting.

Determine if there is a mechanical or electrical problem. Visually inspect VGT vane linkage assembly for anything restricting movement. Try moving the VGT linkage by hand.

- If the linkage does not move freely through its full travel. Diagnosis turbocharger assembly, actuator, or electrical power or ground problem.
- If the linkage moves freely through its full travel. Do Connector Voltage Checks.

Connector Voltage Check

Connect breakout harness between engine harness and VGT actuator. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment
1 to GND	B+	If < B+, check ACT PWR circuit for OPEN or short to GND, or blown fuse. See Harness Resistance Check.
1 to 2	B+	If < B+, check GND circuit for OPEN. See Harness Resistance Check.
3 to GND	1 to 4 V	The sum of 3 to GND and 4 to GND should equal 4 to 5 V.
4 to GND	1 to 4 V	The sum of 4 to GND and 3 to GND should equal 4 to 5 V.

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and breakout harnesses to VGT and ACT PWR relay. Leave ECM, VGT, and relay disconnected.

Test Point	Spec	Comment
3 to E-11	< 5 Ω	If > 5 Ω, check CANH for OPEN in circuit.
3 to GND	> 1 kΩ	If < 1 kΩ, check CANH for short to GND.
4 to E-10	< 5 Ω	If > 5 Ω, check CANL for OPEN in circuit.
4 to GND	> 1 kΩ	If < 1 kΩ, check CANL for short to GND.
2 to GND	< 5 Ω	If > 5 Ω, check ACT PWR GND for OPEN in circuit.
1 to 87 (relay)	< 5 Ω	If > 5 Ω, check ACT PWR for OPEN in circuit.
		If < 5 Ω, but no voltage was detected in Connector Voltage Check, do ACT PWR Relay Test.
1 to GND	> 1 kΩ	If < 1 kΩ, check ACT PWR for short to GND.
If measurements are in specification, replace the VGT actuator.		

Operational Visual Inspection - Output State Test

Run KOEO Standard Test and Output State Test HIGH and LOW. Visually inspect actuator movement.

Test Point	Spec	Comment
Output State Test HIGH	OPEN	Run next test
Output State Test LOW	CLOSE	If VGT actuator does not cycle fully open and fully closed. Check for mechanical problem; sticking vanes or linkage

If the linkage moves freely and the circuit checks are okay, clear DTCs, and cycle the ignition switch.
If active code returns, replace the VGT actuator.

VGT Actuator Circuit Operation

The turbocharger has a set of movable vanes in the turbine housing, and they control boost by controlling exhaust turbine inlet pressure. At low engine speeds when exhaust flow is low, the vanes are partially closed. This increases the pressure of the exhaust pushing against the turbine blades, making the turbine spin faster and generating more boost. As engine speed increases, so does exhaust flow, so the vanes are opened to reduce turbine pressure and hold boost steady or reduce it as needed.

The ECM monitors the internal BAP sensor as a baseline for zeroing the MAP and EBP signals.

By monitoring the MAP and EBP sensors, the ECM can adjust turbine inlet pressure to control boost at any speed/load and to limit boost at full load. The ECM also controls the VGT actuator to ensure that there is always enough exhaust pressure for sufficient EGR flow. The default position of the VGT vanes are normally open.

The VGT actuator receives power at Pin 1, from the ACT PWR relay Pin 87. Ground for the VGT actuator is supplied at Pin 2, from battery ground. The ECM controls the VGT actuator through the CAN (private) circuits, CANH, ECM E-11 to VGT Pin 3, and CANL, ECM E-10 to VGT Pin 4.

CAN (private) Circuit Operation

The private Controller Area Network (CAN) provides a communication link between the ECM and a specific engine controller, in this case the VGT actuator. The VGT actuator can be controlled through the private CAN network. The VGT can communicate failures back to the ECM through the private CAN network.

CAN (private) versus CAN (public)

The public CAN network is set up 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 set up to only communicate between the ECM and specific engine controls.

CAN Repair Information

The CAN 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.

VREF (Reference Voltage)

DTC	SPN	FMI	Condition
5666	8339	4	VREF engine voltage below min
5667	8339	3	VREF engine voltage above max
5668	8340	4	VREF chassis voltage below min
5669	8340	3	VREF chassis voltage above max
5671	8341	4	VREF body voltage below min
5672	8341	3	VREF body voltage above max

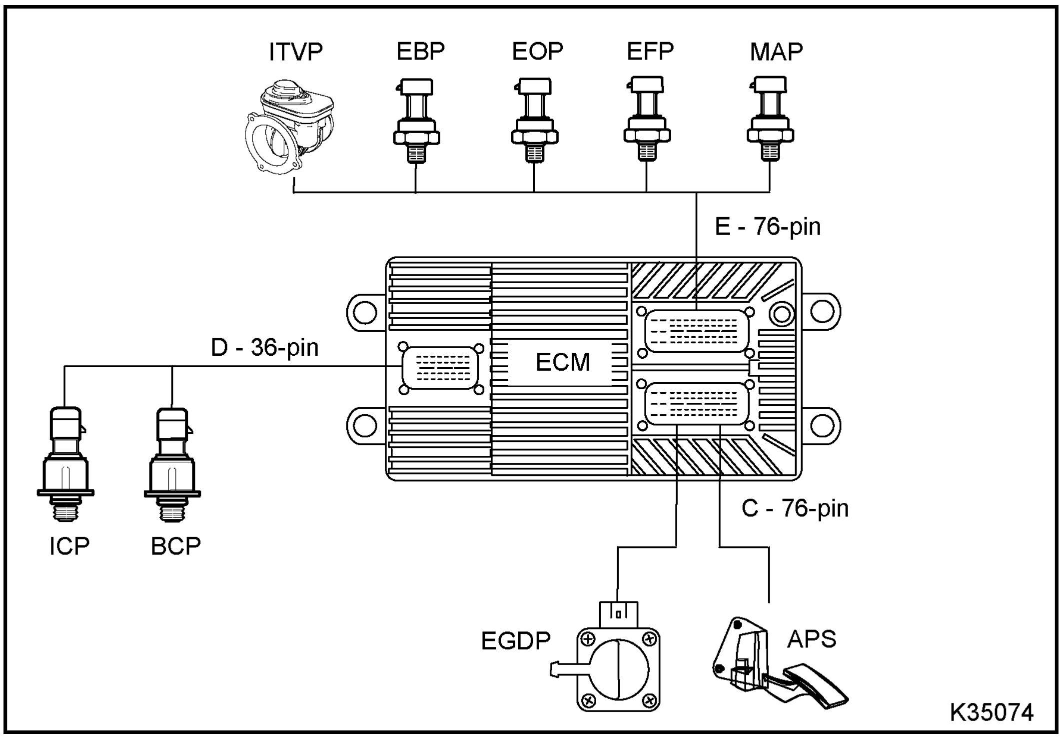


Figure 280 Function diagram for the VREF

The function diagram for the VREF includes the following:

- Electronic Control Module (ECM)
- Injection Control Pressure (ICP) sensor
- Brake Control Pressure (BCP) sensor (optional)
- Intake Throttle Valve Position (ITVP) sensor
- Exhaust Back Pressure (EBP) sensor
- Engine Oil Pressure (EOP) sensor
- Engine Fuel Pressure (EFP) sensor
- Manifold Absolute Pressure (MAP) sensor
- Exhaust Gas Differential Pressure (EDGP) sensor
- Accelerator Position Sensor (APS)

Function

The VREF circuit is a 5 volt reference point supplied by the ECM and provides power to all 3-wire sensors.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- DMM (page 428)
- Breakout Harness (page 431)
- Breakout Box (page 426)
- Terminal Test Adapter Kit (page 432)

VREF Pin-point Diagnostics

DTC	Condition	Possible Causes
5666	VREF engine voltage below min	• VREF circuit short to GND
5668	VREF chassis voltage below min	• Internally shorted sensor on VREF circuit
5671	VREF body voltage below min	
5667	VREF engine voltage above max	• VREF circuit short to PWR
5669	VREF chassis voltage above max	• Internally shorted sensor on VREF circuit
5672	VREF body voltage above max	

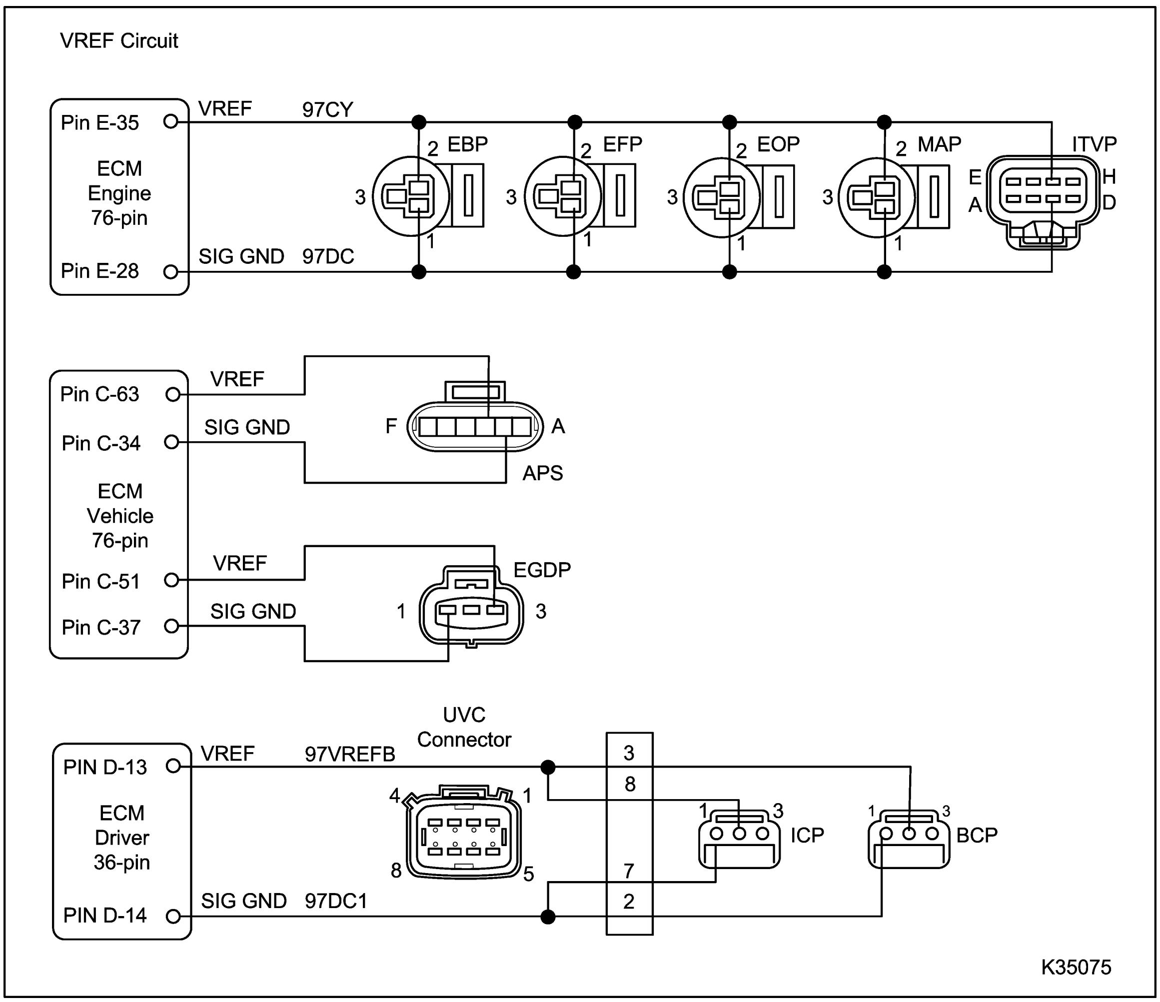


Figure 281 VREF circuit diagram

VREF Voltage Check

If multiple 3-wire sensor DTCs 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 an OPEN circuit between ECM and sensors.

Test Point	Spec	Comment
APS C to GND	5 V ± 0.5 V	See note.
EGDP 3 to GND	5 V ± 0.5 V	See note.
EBP 2 to GND	5 V ± 0.5 V	See note.
EFP 2 to GND	5 V ± 0.5 V	See note.
EOP 2 to GND	5 V ± 0.5 V	See note.
MAP 2 to GND	5 V ± 0.5 V	See note.
ITVP G to GND	5 V ± 0.5 V	See note.
BCP (option) 3 to GND	5 V ± 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 V ± 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.

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	Spec	Comment
APS C to GND	> 1 kΩ	See note.
EGDP 3 to GND	> 1 kΩ	See note.

Connector Resistance Check to GND (cont.)

EBP 2 to GND	> 1 kΩ	See note.
EFP 2 to GND	> 1 kΩ	See note.
EOP 2 to GND	> 1 kΩ	See note.
MAP 2 to GND	> 1 kΩ	See note.
ITVP G to GND	> 1 kΩ	See note.
BCP (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 breakout box and breakout harness. Leave ECM and all 3-wire sensors disconnected. Use DMM to measure resistance.

Sensor	Test Point	Spec	Comment
APS			
VREF	C to C-63	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	B to C–34		
EGDP			
VREF	3 to C-51	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	1 to C-37		
EBP			
VREF	2 to E-35	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	1 to E-28		
EFP			
VREF	2 to E-35	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	1 to E-28		
EOP			
VREF	2 to E-35	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	1 to E-28		
MAP			
VREF	2 to E-35	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	1 to E-28		
ITVP			
VREF	G to E-35	< 5 Ω	If > 5 Ω, check for OPEN circuit.
SIG GND	C to E-28		
BCP (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 APS and EGDP sensor circuit diagrams.

The ECM supplies VREF at Pin E–35 (engine connector), C–63 and C–51 (chassis connector), and D–14 (driver connector) when the ignition switch is on.

VREF provides power to all 3-wire sensors on the engine and the vehicle mounted APS/IVS. 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 DTC. When a VREF circuit is shorted to PWR or GND, a VREF DTC will be set.

NOTE: After removing connector, inspect for damaged pins, corrosion, or loose pins. Repair as required.

VSS (Vehicle Speed Sensor)

DTC	SPN	FMI	Condition
1141	84	4	VSS signal out-of-range LOW
1142	84	3	VSS signal out-of-range HIGH

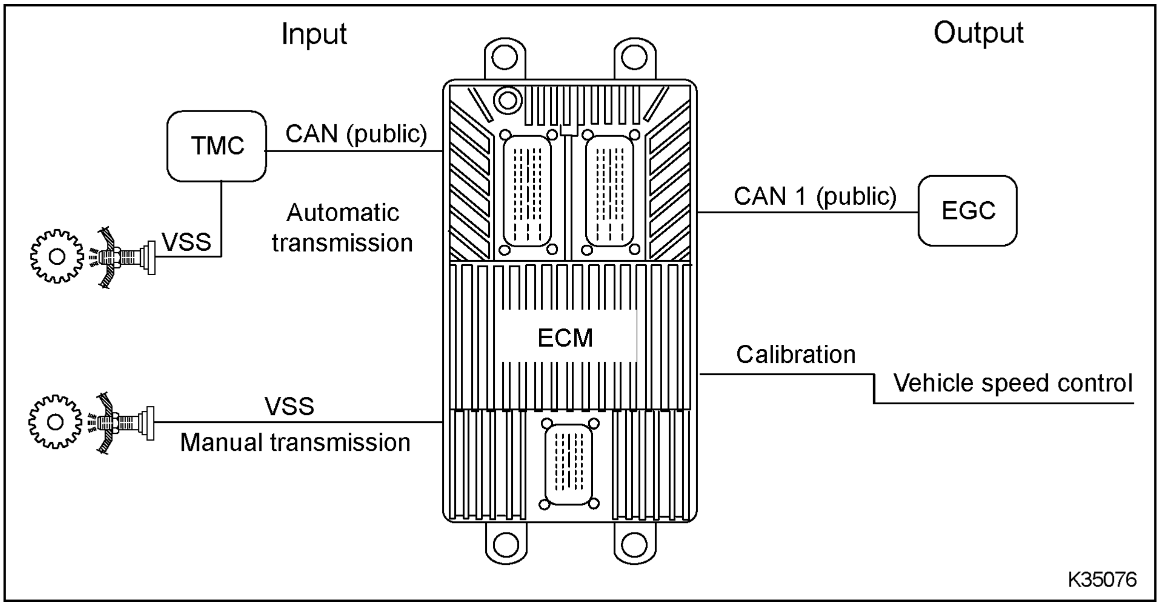


Figure 282 Function diagram for the VSS

The function diagram for the VSS includes the following:

- VSS
- Electronic Control Module (ECM)
- World Transmission Electronic Control (WTEC) ECM
- Cruise Control
- Power Takeoff
- Road Speed Limit

Function

The VSS is used by the ECM to monitor the vehicle's mph. The ECM uses this signal to control PTO, road speed limiting, and cruise control. Automatic transmissions will use this signal for shift scheduling.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)
- *Electrical System Troubleshooting Guide* (truck manual)
- Electrical Circuit Diagrams (truck manual)

VREF Pin-point Diagnostics

DTC	Condition	Possible Causes
1141	VSS signal Out-of-Range LOW	• VSS circuits short to GND • Failed VSS sensor
1142	VSS signal Out-of-Range HIGH	• VSS circuits OPEN short to PWR • Failed VSS sensor

VSS Pin-point Diagnostics (Manual Transmissions)

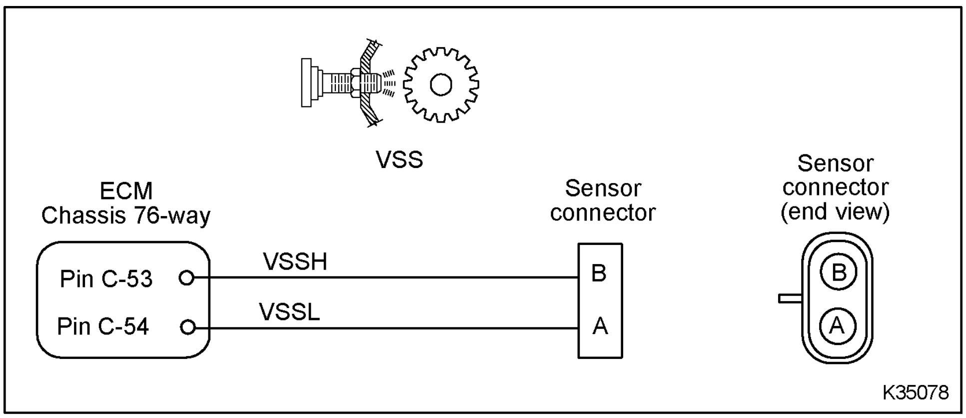


Figure 283 VSS circuit diagram (manual transmissions)

The VSS circuit requires the use of vehicle circuit diagrams. See truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for circuit numbers, connector and fuse locations.

Connector Voltage Check

Disconnect VSS. Turn ignition switch to ON. Use a DMM to measure voltage.

Test Point	Spec	Comment
B to gnd	2.5 V ± 0.5 V	If < 2 V, check for OPEN or short to GND.
A to gnd	2.5 V ± 0.5 V	If > 3 V, check for short to PWR.

Sensor Resistance Check

Disconnect VSS. Use a DMM to measure resistance through sensor.

Test Point	Spec	Comment
A to B	700 Ω ± 100 Ω	If not within specification, replace VSS.

Harness Resistance Check

Connect breakout box. Leave VSS and ECM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
C-53 to B	< 5 Ω	If > 5 Ω, check for OPEN circuit.
C-54 to A	< 5 Ω	If > 5 Ω, check for OPEN circuit.

VSS Pin-point Diagnostics (Allison Transmissions)

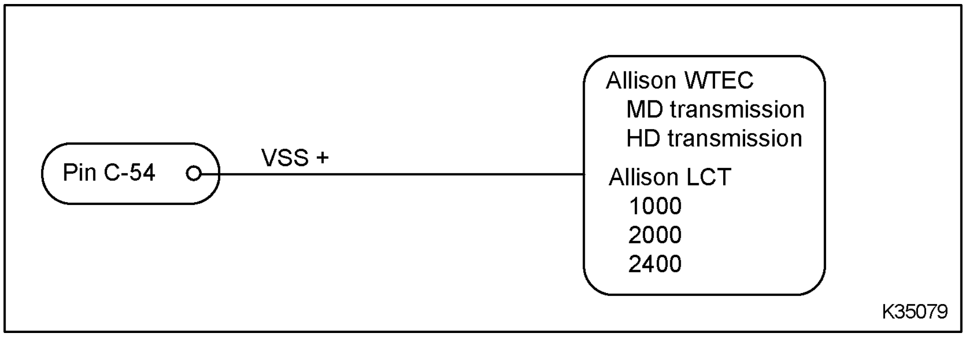


Figure 284 VSS circuit diagram (Allison transmissions)

The VSS circuit requires the use of vehicle circuit diagrams. See truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for circuit numbers, connector and fuse locations.

Resistance Check

Connect breakout box. Leave ECM and TCM disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
C-54 to TCM	< 5 Ω	If > 5 Ω, check for OPEN circuit.
C-54 to GND	> 1 kΩ	If < 1 kΩ, check for short to GND.
If within specification, see transmission diagnostics.		

Operational Check

Connect terminal probes between the VSO circuit and GND. Use DMM to measure Hz.

Test Point	Spec	Comment
Vehicle moving at 15 mph	125 Hz	If not with specification, check for circuit fault or failed sensor.
Vehicle moving at 25 mph	204 Hz	

VSS Circuit Operation (Manual and Allison Transmissions)

The VSS produces a pulsating AC voltage. The voltage level and number of pulses increase with vehicle speed.

Allison WTEC MD, HD, and 2000 series transmissions use an internal VSS that sends a signal to the transmission module. The transmission module processes the signal and sends a square wave signal to the engine ECM.

Fault Detection / Management

The ECM performs diagnostic checks on the VSS circuit when the engine is operating at 0 mph. The ECM transmits a voltage signal on the VSS circuit and determines if the return voltage is out of range high or low. When a fault condition is detected, the ECM disables the cruise control and power takeoff. If the road speed limiting option is enabled, the ECM will limit engine rpm for all gears.

NOTE: See truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for circuit numbers, connector and fuse locations. To diagnose Allison transmission VSS sensor problems, use Allison maintenance and diagnostic manuals.

WIF Sensor (Water In Fuel)

DTC	SPN	FMI	Condition
1253	97	3	WIF signal out-of-range LOW
1254	97	4	WIF signal out-of-range HIGH
1255	97	5	WIF signal open / circuit fault
2179	97	2	Water in fuel detected

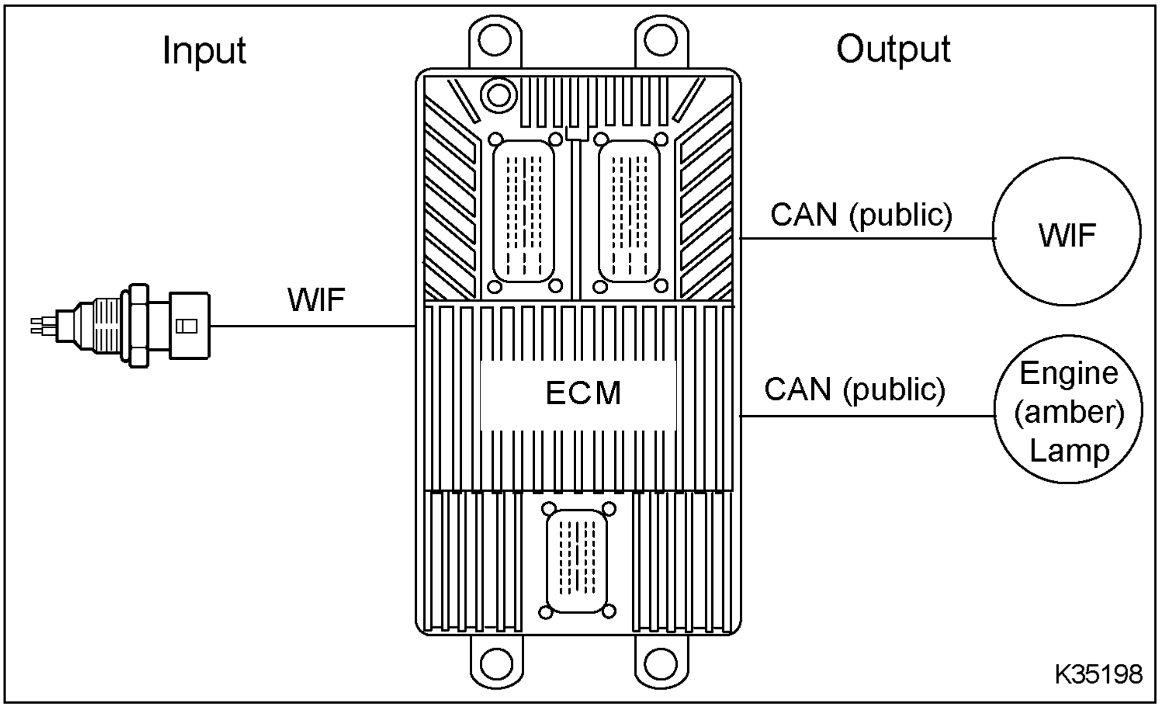


Figure 285 Function diagram for the WIF

The function diagram for the WIF includes the following:

- Water In Fuel (WIF) sensor
- Electronic Control Module (ECM)
- Engine lamp (amber)
- 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 DTC will set and the amber engine lamp will illuminate.

Sensor Location

The WIF sensor is located in the primary fuel filter housing.

Tools

- EST with MasterDiagnostics® software (page 429)
- EZ-Tech® interface cable (page 430)

WIF Pin-point Diagnostics

DTC	Condition	Possible Causes
1253	WIF signal out-of-range LOW	• WIF signal circuit short to GND • Failed sensor
1254	WIF signal out-of-range HIGH	• WIF signal circuit shorted to PWR • Failed sensor
1255	WIF signal open / circuit fault	• WIF signal circuit OPEN or short to PWR or GND • SIG GND circuit OPEN • Failed sensor
2179	Water in fuel detected	• Water detected in primary fuel filter housing

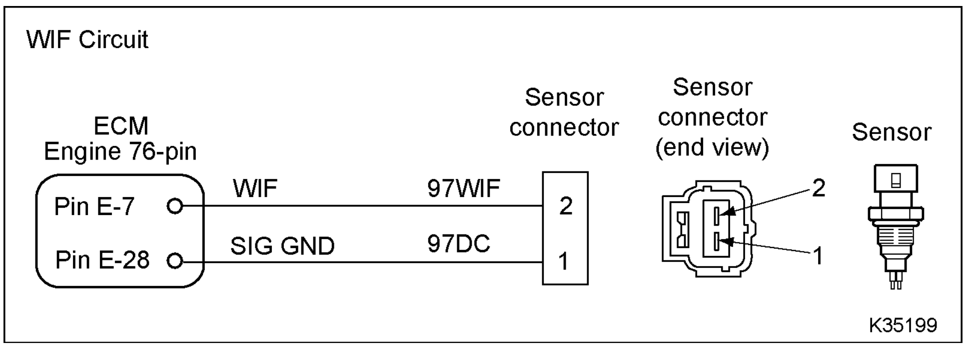


Figure 286 WIF circuit diagram

1. Drain a fuel sample from the water drain valve on the primary fuel filter housing. See Drain Water from Primary Fuel Filter in the "Engine Symptoms Diagnostics" section of this 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, open the D_SwitchMonitor.ssn

   NOTE: The WIF PID 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 PID while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the PID will change from No to Yes and the DTC 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.

Voltage Check

Disconnect WIF sensor connector. Turn ignition switch ON. Use DMM to measure voltage.

Test Point	Spec	Comments
1 to B+	B+	If < B+, check SIG GND circuit for OPEN
2 to GND	4.6 V	If > 5.5 V, check WIF circuit for short to PWR If < 4.0 V, check WIF circuit for short to GND

Connector Resistance Check to GND

Turn ignition switch to OFF. Disconnect harness from WIF sensor, Use DMM to measure resistance.

Test Point	Spec	Comments
1 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN circuit
2 to GND	> 1 kΩ	If < 1 kΩ, check WIF circuit for short to GND

Harness Resistance Check

Turn ignition switch to OFF. Connect breakout box and leave ECM and WIF sensor disconnected. Use DMM to measure resistance.

Test Point	Spec	Comments
1 to E-28	< 5 Ω	If > 5 Ω, check for OPEN circuit
2 to E-7	< 5 Ω	If > 5 Ω, check for OPEN circuit

WIF Circuit Operation

The WIF sensor is supplied with a 5 V reference voltage 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 V at normal state and below 4.0 V when water is detected.

Fault Detection/Management

The ECM continuously monitors the WIF sensor. If voltage drops below 4.0 V, DTC 2179 will set and the water in fuel lamp will be illuminated. Three other DTCs are set if there is a fault with the circuit or sensor.

Table of Contents

Electrical Tools

3-Banana Plug Harness

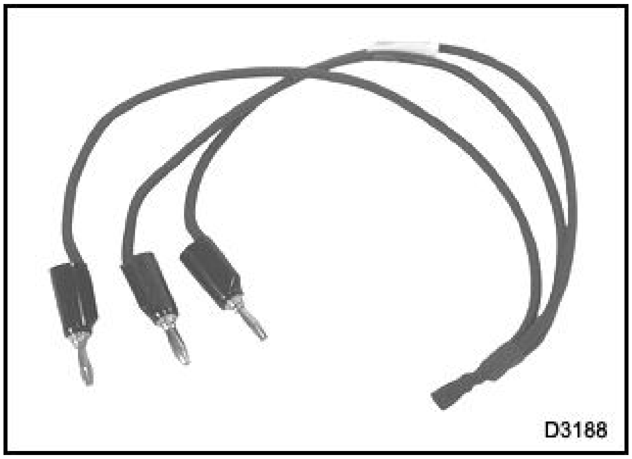


Figure 287 ZTSE4498

The 3-Banana Plug Harness is used for operational diagnostics of sensor circuits.

4-Pin Actuator Breakout Harness

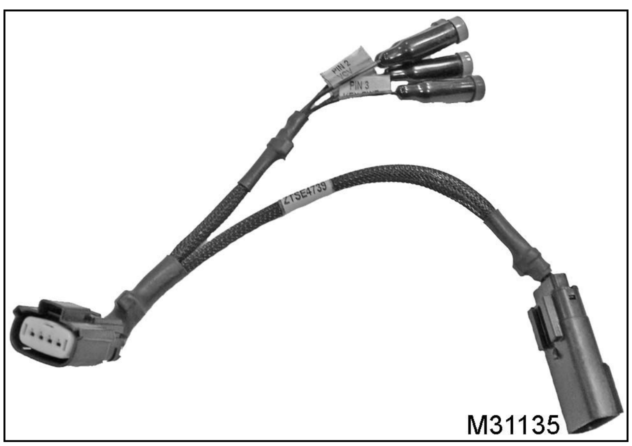


Figure 288 ZTSE4739

The 4-pin actuator breakout harness is used to measure voltage and resistance on circuits that go to the VGT actuator.

8-Pin Injector Harness

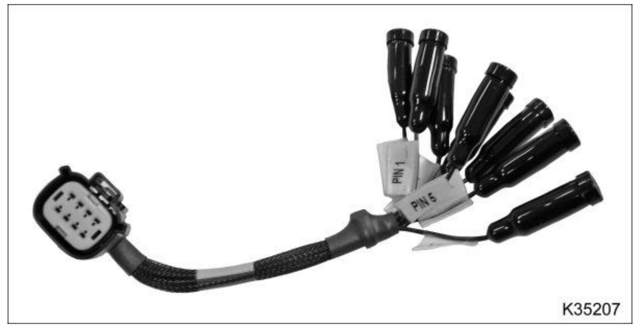


Figure 289 ZTSE4793

The 8-Pin UVC Breakout Harness is used to measure continuity of the UVC wiring and injector solenoids, ICP and BCP sensors, and BSV valve.

16-Pin Breakout Harness

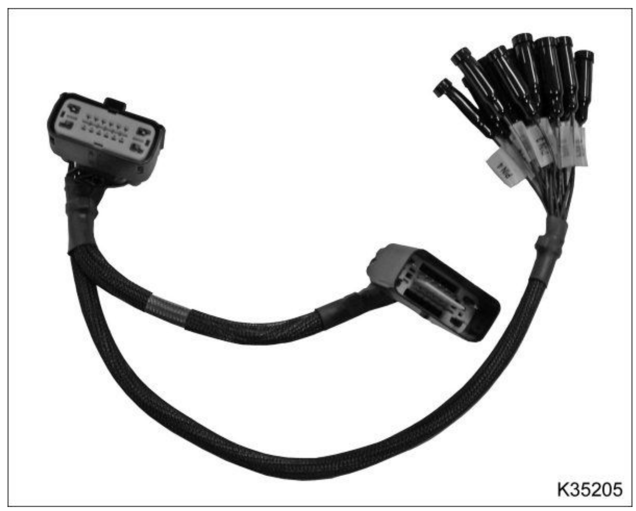


Figure 290 ZTSE4762

The 16-Pin Breakout Harness is used for circuit diagnostics for actuator power and ground (IPR, EGR, and VGT). Additional applications include the A/C clutch, alternator, and fuel heater.

180-Pin Breakout Box

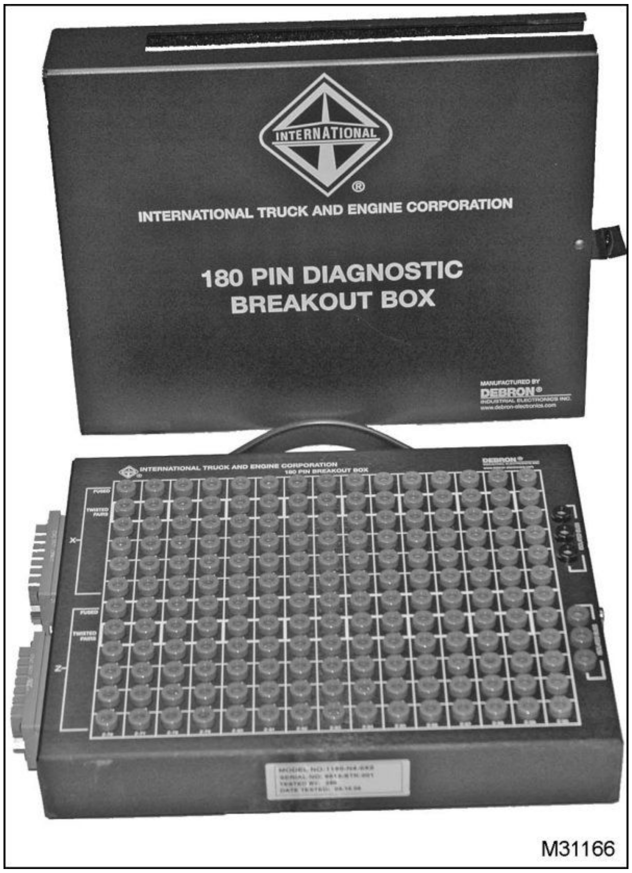


Figure 291 1180–N4–0X0

The 180-pin breakout box allows testing of the electronic control system components without disturbing connections or piercing wire insulation to access various signal voltages in the electronic control system.

This box is a universal type box that 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.

CAUTION: To prevent engine damage, do not use the Breakout Box to activate or control circuits. High current passing through the breakout box will burn out the internal circuitry. Use the Breakout Box for measurement only.

500 Ohm Resistor Harness

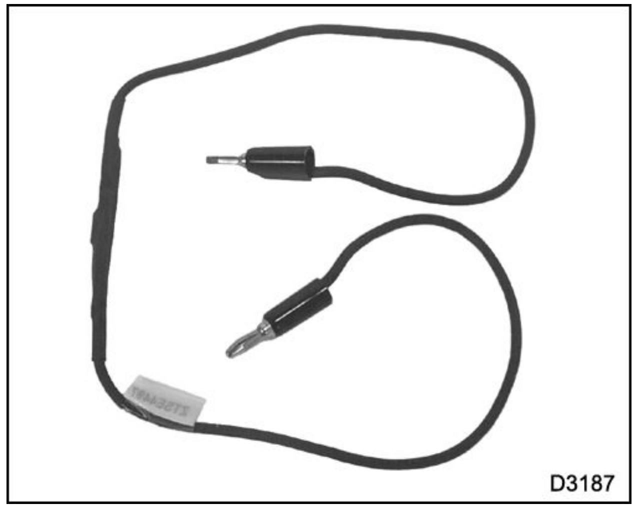


Figure 292 ZTSE4497

The 500 Ohm Resistor Harness is used for sensor end diagnostics of sensor circuits.

Actuator Breakout Harness (IPR)

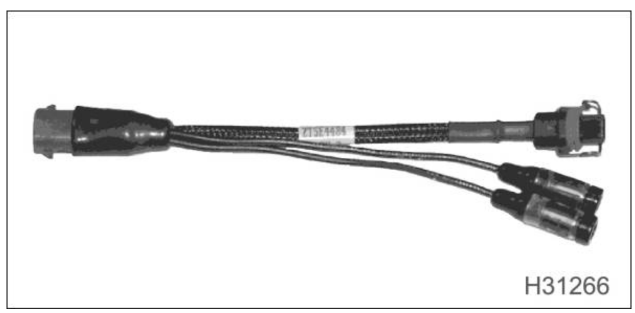


Figure 293 ZTSE4484

The Actuator Breakout Harness is used to measure the voltage and resistance on circuits that go to the IPR valve.

Amp Clamp

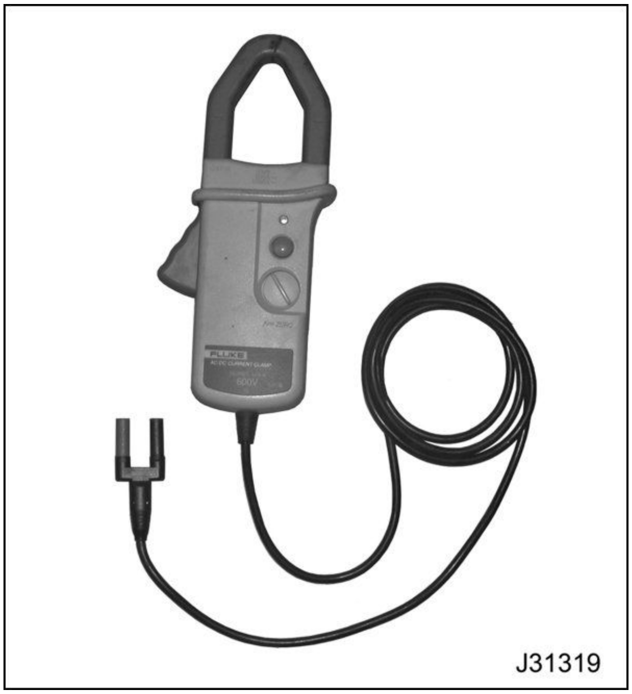


Figure 294 ZTSE4575

The Amp Clamp is used to measure amperage draw for the inlet air heater.

APS/IVS Sensor Breakout Harness

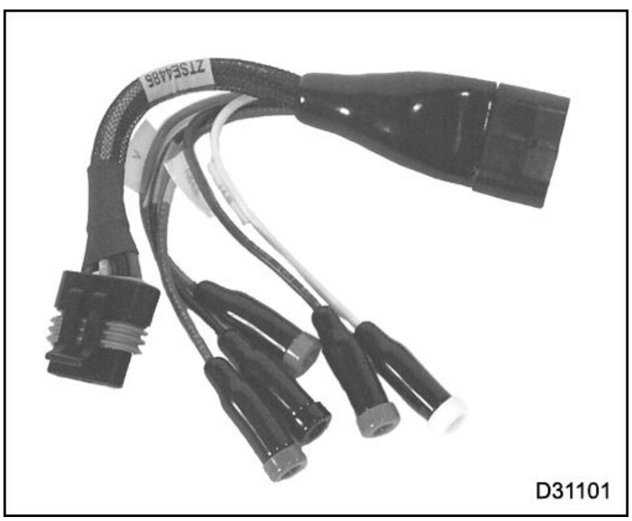


Figure 295 ZTSE4485

The APS/IVS Breakout Harness is used to measure voltage and resistance on circuits that go to the APS/IVS sensor.

Breakout Harnesses Kit

Figure 296 ZTSE4505

The Breakout Harness Kit contains the following breakout harnesses and test leads:

- 3-banana plug harness
- 12-pin breakout harness
- 500-ohm resistor harness
- Actuator breakout harness
- APS/IVS breakout harness
- EGR breakout harness
- IAT breakout harness
- Pressure sensor breakout harness
- Relay breakout harness
- Temperature sensor breakout harness (for IAT only)
- Temperature sensor breakout harness
- Glow plug test lead

Breakout Harnesses Kit

Figure 297 ZTSE4505E-UPD

The Breakout Harness Kit contains the following breakout harnesses and test leads:

- EGR Valve Breakout Harness (ZTSE4735)
- 4-Pin Actuator Breakout Harness (ZTSE4739)
- EGR Breakout Harness (ZTSE4758)
- Exhaust Temperature Breakout Harness (ZTSE4760)
- Exhaust Pressure Breakout Harness (ZTSE4761)
- 16-Pin Breakout Harness (ZTSE4762)
- FRP Breakout Harness (ZTSE4764)
- ITV Breakout Harness (ZTSE4765)
- MAT Breakout Harness (ZTSE4782)
- 8-Pin UVC Breakout Harness (ZTSE4793)
- 15-Pin UVC Breakout Harness (ZTSE4794)
- Glow Plug Breakout Harness (ZTSE4808)

Digital Multimeter (Fluke 88V)

Figure 298 ZTSE4357

The Fluke 88V Digital Multimeter (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 that the signal voltage measurement will not be affected by the voltmeter.

EGR Valve Breakout Harness

Figure 299 ZTSE4758

The EGR Breakout Harness is used to measure voltage and resistance on circuits that go to the EGR valve.

NOTE: Initial shipments of EGR breakout harness were labeled incorrectly.

The following graphic shows the breakout harness labeled correctly.

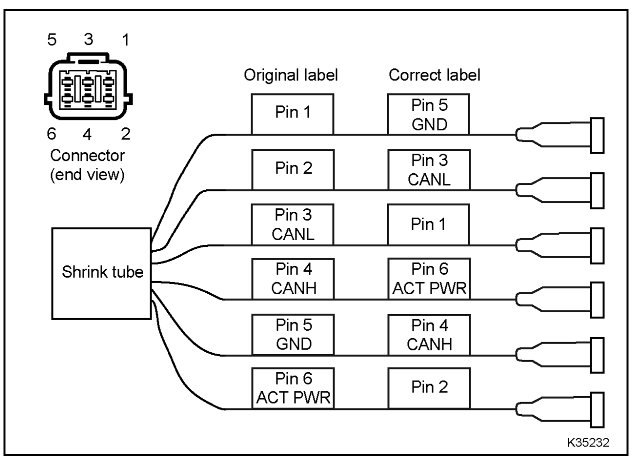


Figure 300 ZTSE4758A

EZ-Tech® Electronic Service Tool (EST)

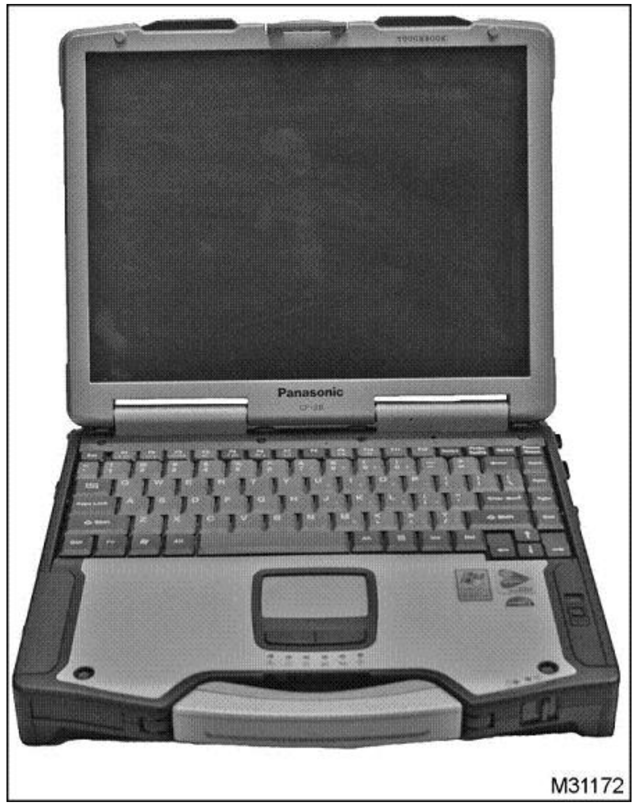


Figure 301 J-45067

The EST is used to run MasterDiagnostics® software for diagnosing and troubleshooting engine and vehicle problems.

The EZ-Tech® Interface Kit cables are included with the EST.

MasterDiagnostics® Software

MasterDiagnostics® 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.

Exhaust Pressure Breakout Harness

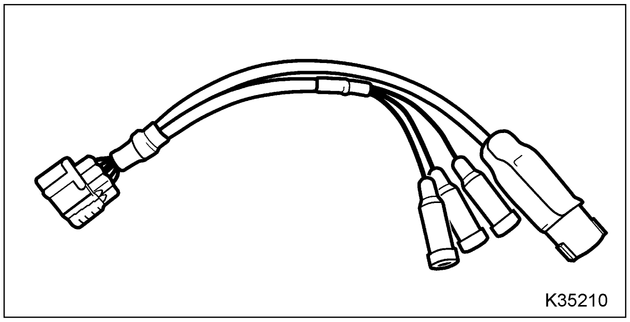


Figure 302 ZTSE4761

The exhaust pressure breakout harness is used to measure voltage and resistance on circuits that go to the Exhaust Gas Differential Pressure (EGDP) sensor.

Exhaust Temperature Breakout Harness

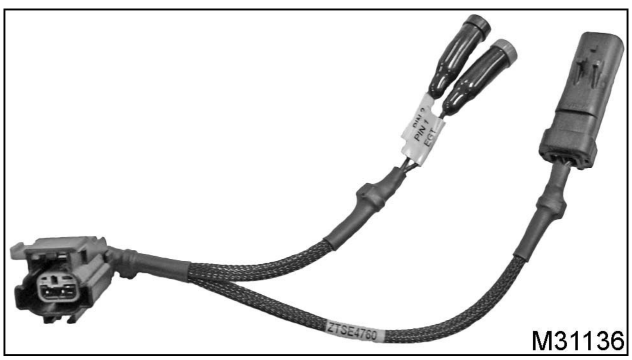


Figure 303 ZTSE4760

The exhaust temperature breakout harness is used to measure voltage and resistance on circuits that go to the Exhaust Gas Temperature (EGT) sensors.

EZ-Tech® Interface Kit

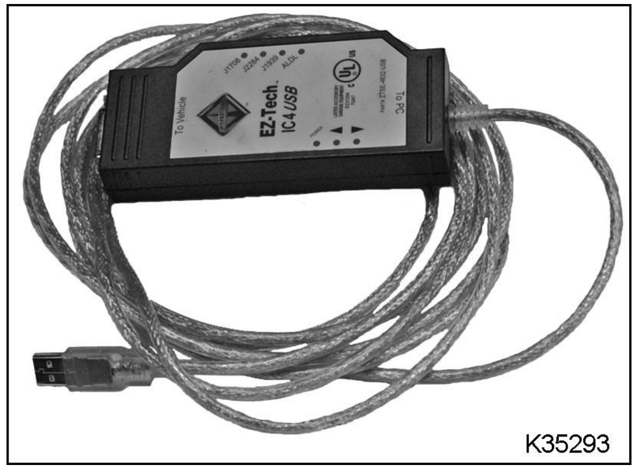


Figure 304 ZTSE4632–USB

These interface cables, included with the EZ-Tech®, connect the EST to Electronic Control Module (ECM).

ITV Breakout Harness

Figure 305 ZTSE4765

The ITV Breakout Harness is used to measure voltage and resistance on circuits that go to the ITV actuator and circuit.

MAT Breakout Harness

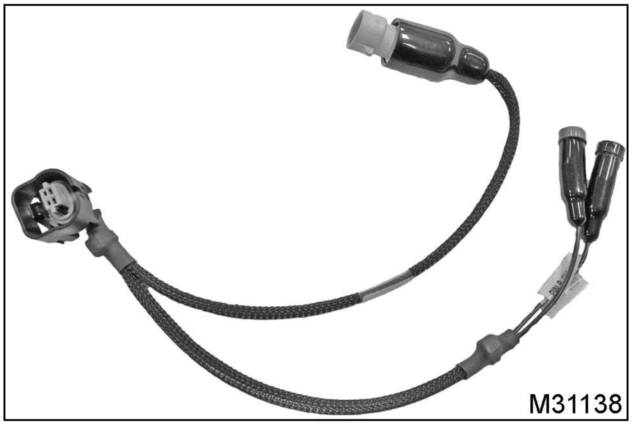


Figure 306 ZTSE4782

The MAT Breakout Harness is used to measure voltage and resistance on circuits that go to the MAT sensor.

Pressure Sensor Breakout Harness

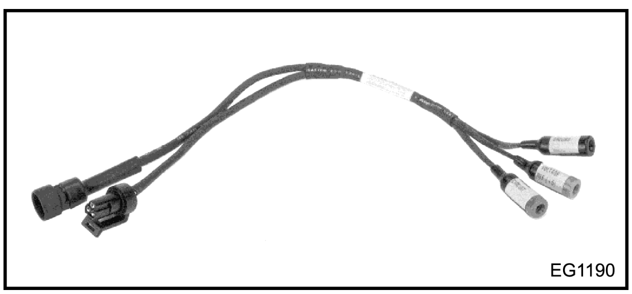


Figure 307 ZTSE4347

The Pressure Sensor Breakout Harness is used to measure voltage and resistance on circuits that go to the EBP, EFP, EOP, and MAP sensors.

Relay Breakout Harness

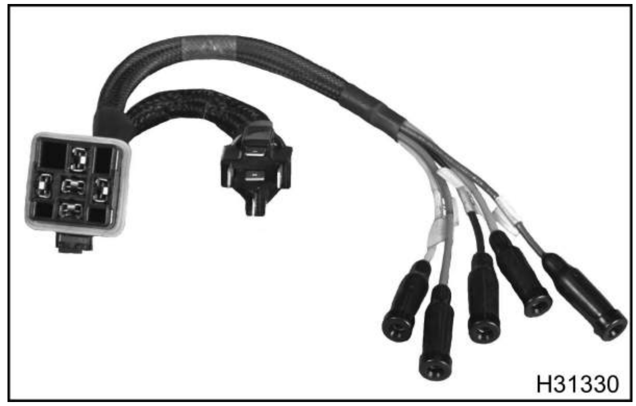


Figure 308 ZTSE4596

The Relay Breakout Harness is used to measure voltage and resistance on circuits that go to the EFAN and starter relays.

Relay Breakout Harness

Figure 309 ZTSE4674

The Relay Breakout Harness is used to measure voltage and resistance on circuits that go to the ECM and ACT PWR relays.

Temperature Sensor Breakout Harness

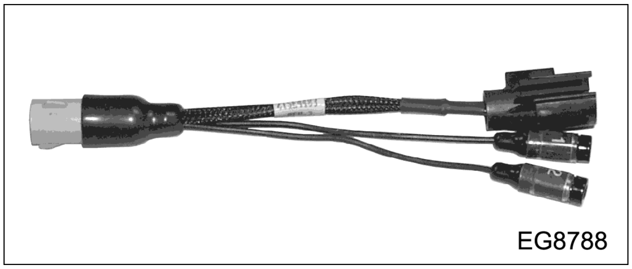


Figure 310 ZTSE4483

The Temperature Sensor Breakout Harness is used to measure voltage and resistance on circuits that go to the IAT sensor.

Temperature Sensor Breakout Harness

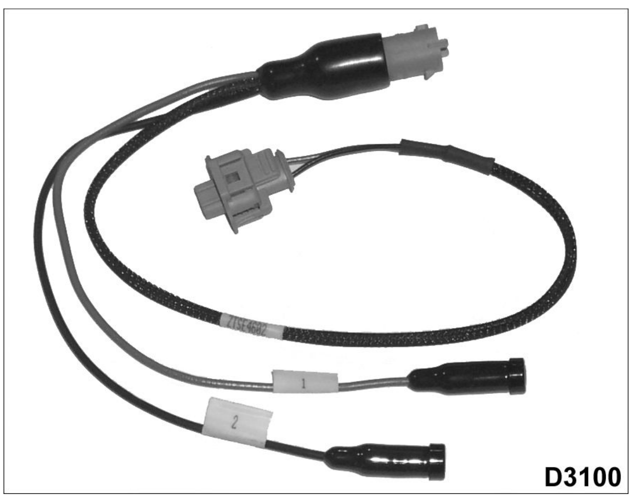


Figure 311 ZTSE4602

The Temperature Sensor Breakout Harness is used to measure voltage and resistance on circuits that go to the ECT, EFT, EOT, and MAT sensors.

Terminal Test Adapter Kit

Figure 312 ZTSE4435C

The Terminal Test Adapter Kit is used to access circuits in the connector harness and allows for the use of a 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.

Mechanical Tools

Charge Air Cooler Test Kit

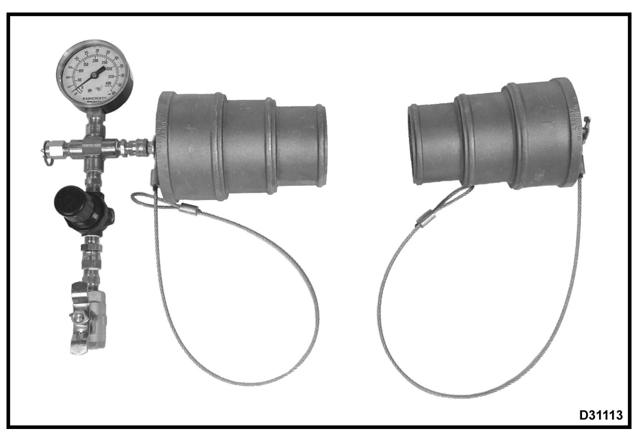


Figure 313 ZTSE4341

The Charge Air Cooler (CAC) Test Kit is used to pressurize the charge air cooler and piping to check for leaks.

Pressure Vacuum Module

Figure 314 Locally available

The Pressure Vacuum Module is used for pressure and vacuum measurements. A variety of pressure vacuum modules are available for purchase locally.

Crankcase Pressure Test Adapter

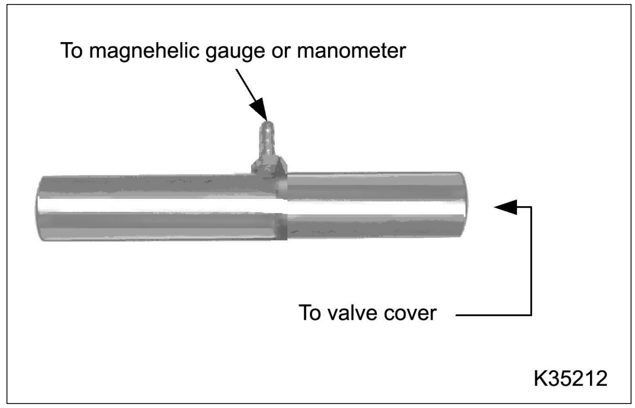


Figure 315 ZTSE4039 (0.406 in. diameter)

The Crankcase Pressure Test Adapter is used to measure combustion gas flow from the valve cover and may be used with the magnehelic gauge or slack tube manometer.

Pressure readings obtained with this adapter must be used as the main source of engine condition. Oil consumption trend data must also be used 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.

Fuel Inlet Restriction Adapter

Figure 316 ZTSE4817

The Fuel Inlet Restriction Adapter is used as a test port for measuring fuel restriction at the fuel strainer.

Fuel/Oil Pressure Test Coupler

Figure 317 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

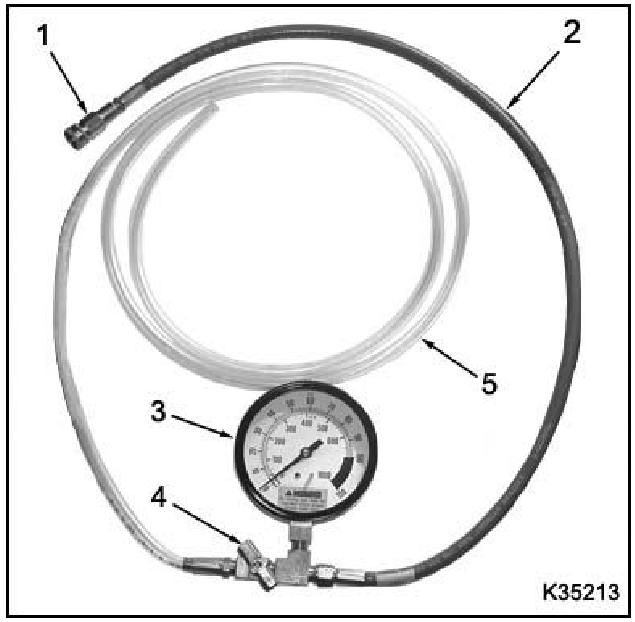


Figure 318 ZTSE4681

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 at the fuel rail.

Fuel Pressure Test Kit

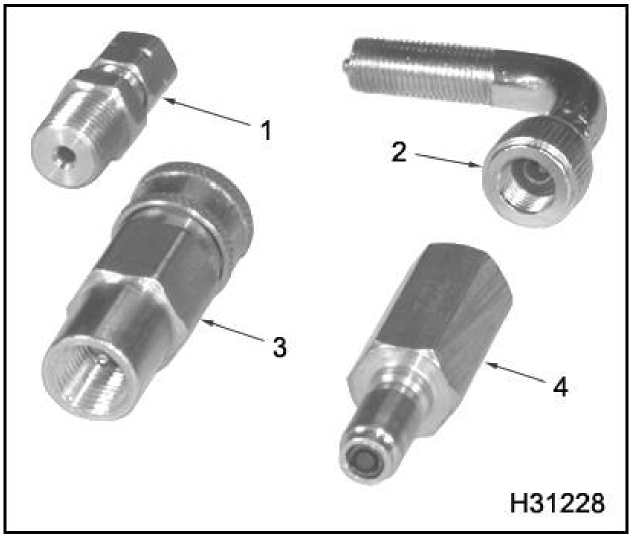


Figure 319 ZTSE4657

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 320 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.

Gauge Bar Tool

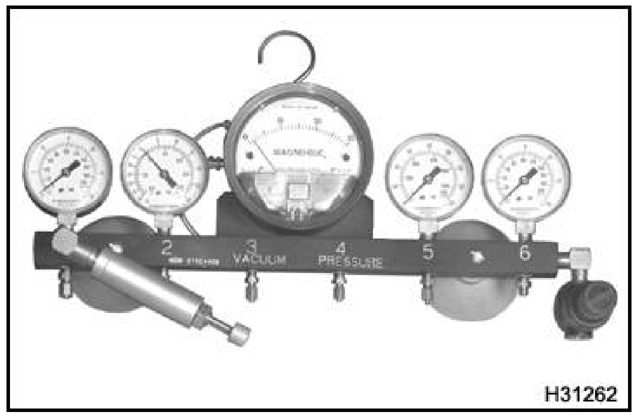


Figure 321 ZTSE4409

The Gauge Bar Tool is used to measure intake manifold (boost) pressure, fuel system inlet restriction, fuel pressure, oil pressure, air cleaner intake restriction, and crankcase pressure.

- 0 kPa to 200 kPa (0 psi to 30 psi) measures intake manifold pressure.
- 0-30 in Hg vacuum /0 kPa to 200 kPa (0 psi to 30 psi) compound gauge measures fuel system inlet restriction and intake manifold pressure.

  0-30 in H_2O /0 kPa to 7.5 kPa (0 psi to 1 psi) maximum pressure magnehelic gauge measures crankcase pressure and air inlet restriction.
- 60 kPa to 1100 kPa (0 psi to 160 psi) gauge may be used to check the fuel pressure and oil pressure.

ICP System Test Adapter

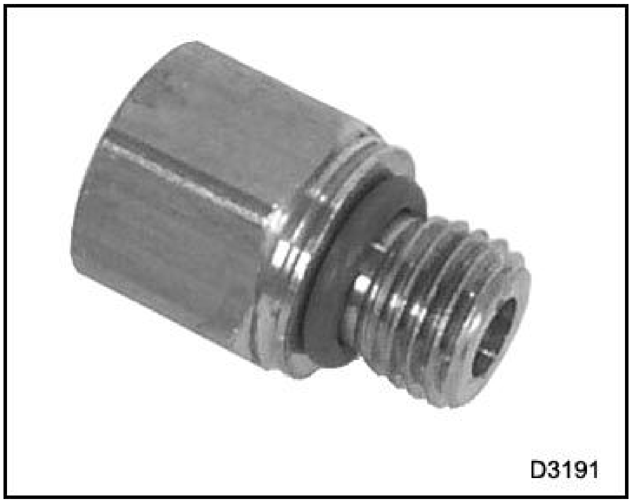


Figure 322 ZTSE4594

The Injection Control Pressure (ICP) System Test Adapter was first used to pressurize the ICP system for the International® VT 365 diesel engine to test ICP system integrity with the influence of the Injection Pressure Regulator (IPR) valve. This adapter is also used to take an oil sample or measure oil pressure at the Engine Oil Temperature (EOT) sensor port for the MaxxForce® DT, 9, and 10 diesel engine.

ICP Test Kit

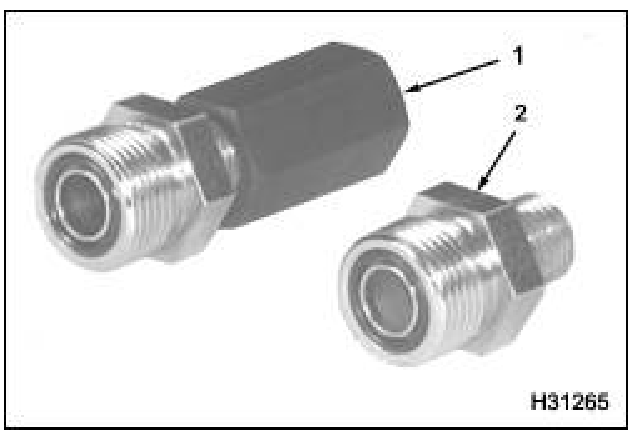


Figure 323 ZTSE4655

1. Fitting 13/16 - 16 NPT
2. ICP sensor adapter

The ICP Test Kit is used to check ICP system diagnostics. The ICP adapter is used with an ICP sensor and the VC 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

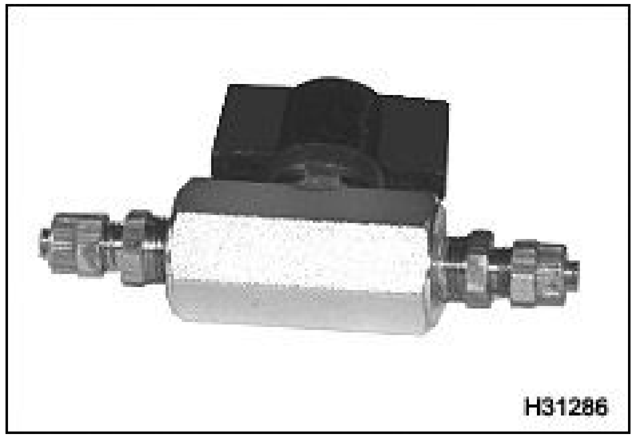


Figure 324 Part No. 221406

The Inline Shut-off Valve is used to make a test line assembly that connects to the ICP system test adapter 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 Test Adapter

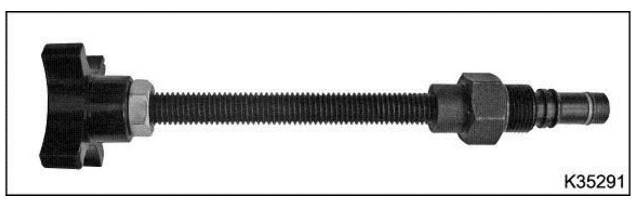


Figure 325 ZTSE4816

The IPR Test Adapter is used to check the high-pressure pump for inability to reach maximum injection control pressure.

Digital Manometer

Figure 326 Locally obtained

The Digital Manometer is used to measure low vacuum for intake restriction or low crankcase pressure. A variety of digital manometers are available for purchase locally.

Slack Tube Manometer

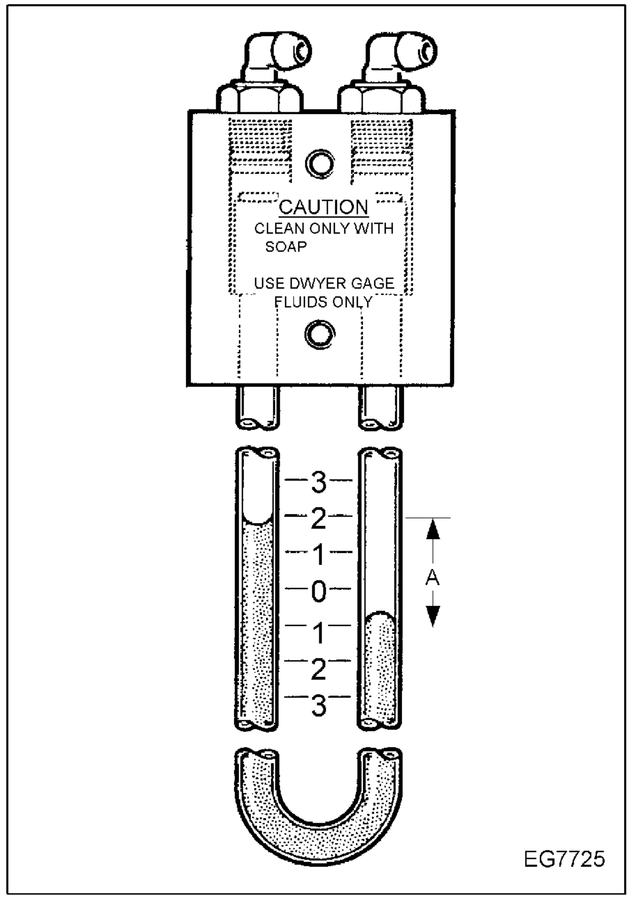


Figure 327 ZTSE2217A

The Slack Tube Manometer is a U-shaped tube with a scale mounted between the legs of the tube. When the portability of the gauge bar tool is not required, this manometer is used to measure low vacuum for intake restriction or low crankcase pressure.

Filling

Fill the manometer with water before checking pressure. Use only distilled water. Add some colored water vegetable dye so the scale can be read more easily. With both legs of the manometer open to the atmosphere, fill the tube until the top of the fluid column is near the zero mark on the scale. Shake the tube to eliminate any air bubbles.

Installing, Reading, and Cleaning

1. Support the manometer vertically. Make sure the fluid level is in line with the zero indicator on the graduated scale.
2. Connect one leg of the manometer to the source of the pressure or vacuum. Leave the other leg open to atmospheric pressure.
3. Start the engine and allow it to reach normal operating temperature. Then run the engine to high idle. The manometer can be read after 10 seconds.
4. Record the average position of the fluid level when it is above and below the zero indicator. Add the two figures together. The sum of the two is the total column of fluid (distance A). This represents the crankcase pressure in inches of water (in H_2O).

   At times, both columns of the manometer will not travel the same distance. This is no concern if the leg not connected to the pressure or vacuum source is open to the atmosphere.
5. Compare the manometer reading with engine specifications.
6. When the test is done, clean the tube thoroughly using soap and water. Avoid liquid soaps and solvents.

UV Leak Detection Kit

Figure 328 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 Pump and Gauge

Figure 329 ZTSE2499

The Vacuum Pump and Gauge is used to test the operation of the fuel pump.

Electronic Circuit Testing

Electrical Theory

Voltage

Voltage is electrical pressure or force that pushes current through a circuit. The pressure is measured in volts. The symbol V (for example, 12 V) is used in circuit diagrams to denote voltage. The letter E (Electromotive force) is also used for voltage. Voltage can be compared to the pressure necessary to push water through a metering valve.

Low voltage to a lamp will cause the lamp to glow dimly. This can be caused by low source voltage (discharged battery or low alternator output) or by high circuit resistance resulting from a poor connection. Resistance from a poor connection or poor ground is an additional load in the circuit. The additional load reduces voltage available to push current through the load device. Before making any meter measurements, review Ohm's Law.

Ohm's Law

Ohm's Law describes the relationship between current, voltage, and resistance in an electrical circuit. Ohm's Law also provides the basic formula for calculations.

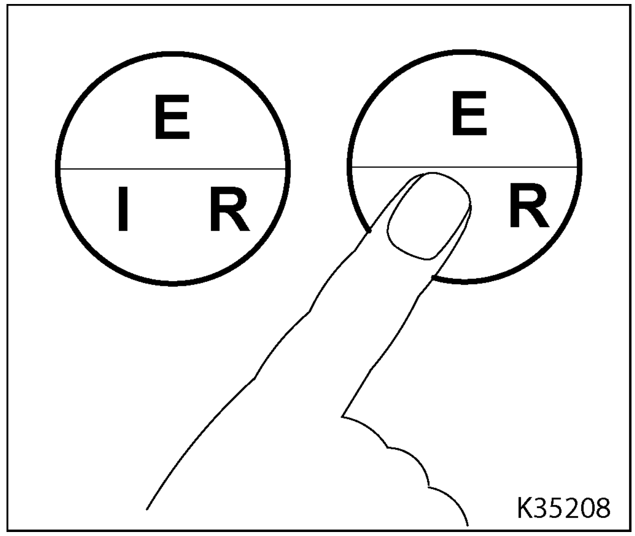


Figure 330 Ohm's Law

Memorize the formula in the circle. Cover the letter with a finger for the desired formula. For example, I is covered, the formula is I = E ÷ R.

If two values are known for a given circuit, the missing one can be found by substituting the values in amperes, volts, or ohms.

The three basic formulas for Ohm's Law are as follows:
I = Current (amperes)
E = Voltage (volts)
R = Resistance (ohms)

- I = E ÷ R

  This formula states that the current flow (I) in the circuit equals the voltage (E) applied to the circuit divided by the total resistance (R) in the circuit. This shows that an increase in voltage or a decrease in resistance increases the current flow.

- E = I × R

  This formula states that the voltage (E) applied to the circuit equals the current flow (I) in the circuit multiplied by the total resistance (R) in the circuit. The voltage drop is caused by resistance across a particular load device in a series of load devices.

- R = E ÷ I

  This formula states that the total resistance (R) in the circuit equals the voltage (E) applied to the circuit divided by the current flow (I) in the circuit. Resistance can be calculated for a specific current flow when a specific voltage is applied.

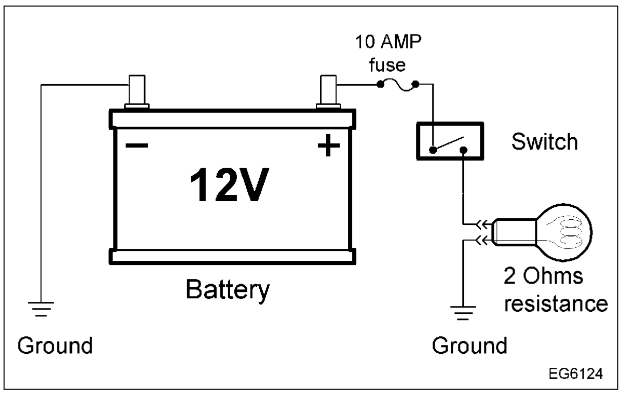


Figure 331 Simple electrical circuit

In a typical circuit, battery voltage is applied to a bulb through a 10 amp fuse and a switch. Closing the switch turns on the bulb.

To find the current flow, use the formula I = E ÷ R:

Fill in the numbers for the formula:

I = 12 V ÷ 2 ohms

I = 6 amps

The bulb in this circuit operates at 6 amps and is rated at 6 amps. With 12 volts applied, the bulb will glow at the rated output level (candlepower rating). However,

- If the voltage applied is low (low battery), the value of E is lower, current flow will be less, and the bulb will glow less brightly.
- If connections are loose or the switch is corroded, the circuit resistance will be greater (value of R will be larger), the current flow will be reduced, and the bulb will glow less brightly.

Voltage drops are important for the following reasons:

- High voltage drops indicate excessive resistance. For example, if a blower motor runs too slowly or a light glows too dimly, the circuit may have excessive resistance. Voltage drop readings can isolate problems in parts of a circuit (corroded or loose terminals, for example).
- Too low of a voltage drop indicates low resistance. For example, if a blower motor runs too fast, the problem could be low resistance in a resistor pack.
- Maximum allowable voltage drop under load is critical, especially for more than one high resistance problem. All voltage drops in a circuit are cumulative. Corroded terminals, loose connections, damaged wires or other similar conditions create undesirable voltage drops that decrease the voltage available across the key components in the circuit. Increased resistance will decrease current flow in the circuit, preventing other components from operating at peak efficiency. A small drop across wires (conductors), connectors, switches, etc., is normal because all conductors have some resistance, but the total should be less than 10% of the total voltage drop in the circuit.

Using the Digital Multimeter

The following electrical test equipment should be available for testing electronic circuits:

- Voltmeter
- Ohmmeter
- Ammeter
- Jumper wires
- Test lights

Test Meters

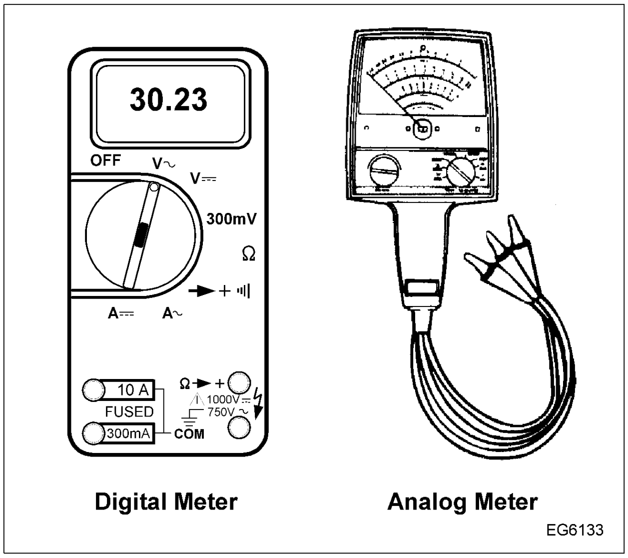


Figure 332 Typical Test Meters

Test meters come in a variety of models. Any working model will be adequate for simple tests. However, accurate readings are important. Make sure the test meter is of high quality. The Fluke 88 Digital Multimeter (DMM) is recommended because it has very little current and a high impedance (resistance) of 10 megaohms (10 MΩ).

CAUTION: To prevent engine damage, use a high impedance digital multimeter when troubleshooting an electronic circuit. Do not use a battery powered test light. Battery test lights can damage an electronic control circuit.

NOTE: Some devices in an electronic control system are not capable of carrying an appreciable amount of current. Therefore, test equipment must be designed to not damage any part the electronic control system. Do not use analog meters unless specified. Analog meters use too much current to test an electronic control system.

Jumper Wires

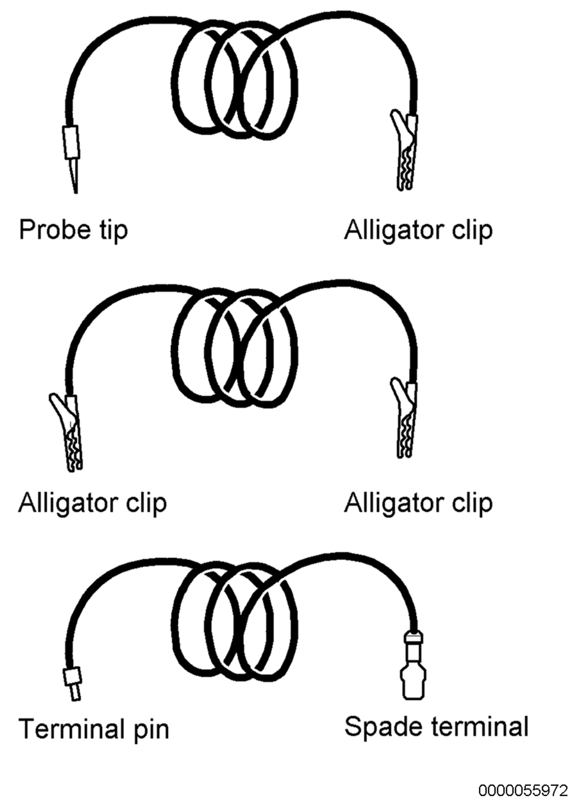


Figure 333 Jumper wires

Jumper wires allow a circuit to by-pass a suspected opening or break in a circuit. Use a jumper wire to check for open relay contacts, wire breaks and poor ground connections. Several jumper wires with different tips should be available.

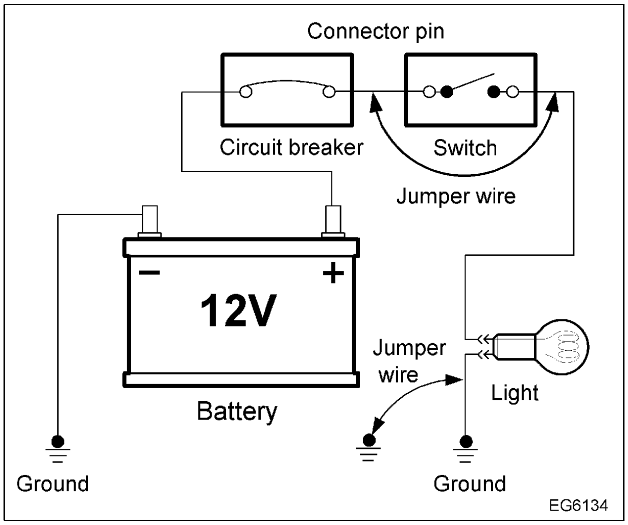


Figure 334 Troubleshooting with jumper wires

If the circuit works correctly with the jumper wire in place, but does not work when the jumper wire is removed, the circuit is open.

A circuit with no openings or breaks has continuity (uninterrupted current flow) and needs no further testing.

An opening in the ground circuit exists for the following:

- A switch is closed but the light does not illuminate.
- Jumping the switch does not illuminate the light.
- Jumping the light to the ground causes the light to illuminate.

Voltmeter

Use a voltmeter to answer the following questions:

- Does the circuit have voltage?
- What is the voltage reading?
- What is the voltage drop across a load device?

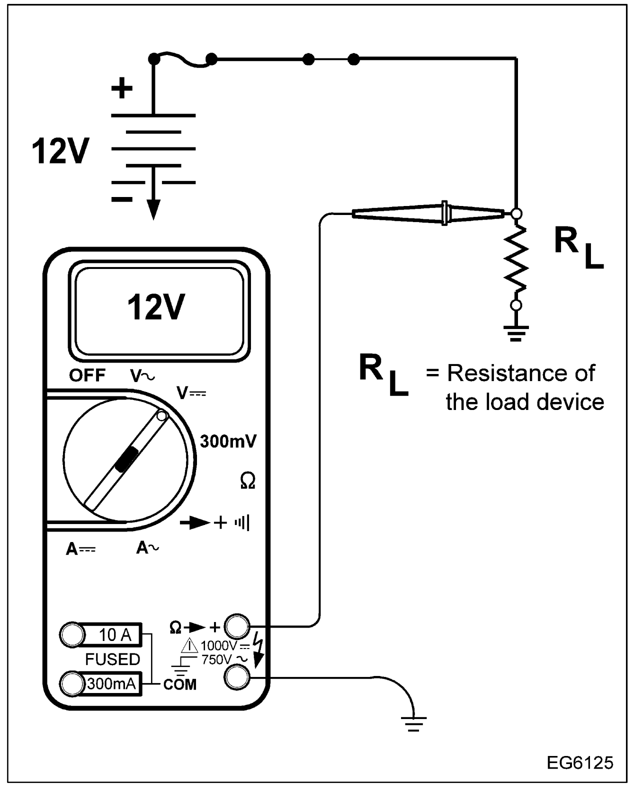


Figure 335 Checking power to a load device

To check for voltage to a load device, connect the positive meter lead to the input connection of the device (positive side) and connect the negative meter lead to a good vehicle ground.

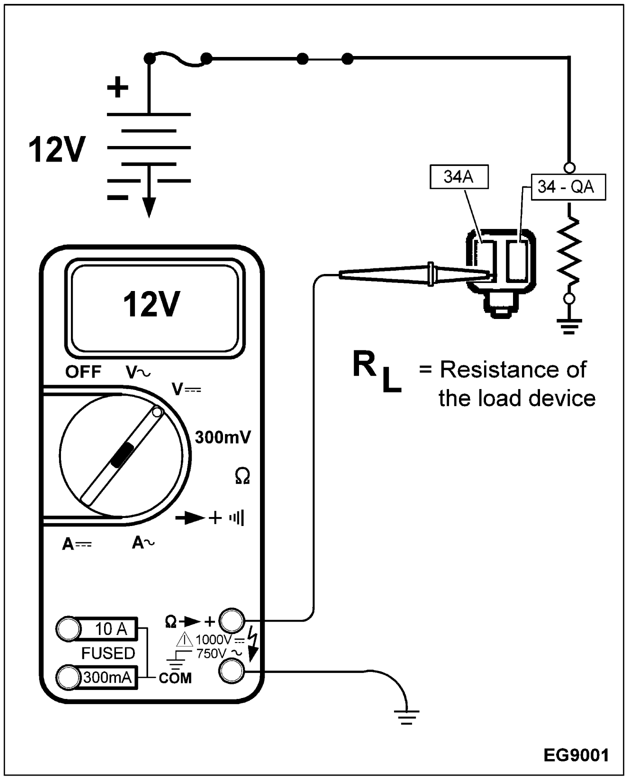


Figure 336 Checking power to a connector

Voltage to a device can also be measured by disconnecting the harness connector and using the correct tool in the Terminal Test Adapter Kit.

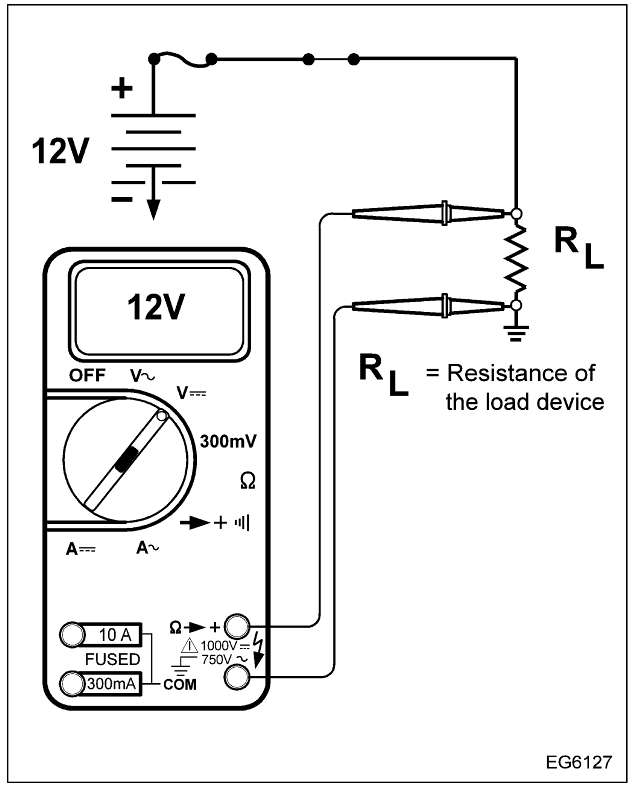


Figure 337 Checking voltage drop

To check the voltage drop across a load device, connect the positive lead of the voltmeter to the positive side of the device and the negative meter lead to the negative side of the device.

With the device operating, this will measure the voltage drop across the device. With only one device, all of the voltage should be dropped at the device. In any circuit, the voltage applied will equal the voltage dropped in the circuit. If this circuit only dropped 9 V across the load, it indicates the wires and connections dropped 3 V, indicating excessive circuit resistance.

Ammeter

An ammeter measures current flow (amperage) in a circuit. Amperes (or amps) are units of electron flow that indicate how many electrons are passing through the circuit. An amp is the unit of measurement for the current flow in the circuit.

Ohm's Law states that the current flow is equal to the circuit voltage divided by the total circuit resistance ($I = E \div R$). Therefore, increasing the voltage also increases the current flow. Any decrease in resistance will also increase the current flow.

At normal operating voltage, most circuits have a characteristic amount of current flow (current draw). Current draw can be measured with an ammeter. Valuable diagnostic information can be provided by referring to a specified current draw rating for a component (electrical device), measuring the current flow in the circuit, and then comparing the two measurements (the specified current draw versus the actual measurement).

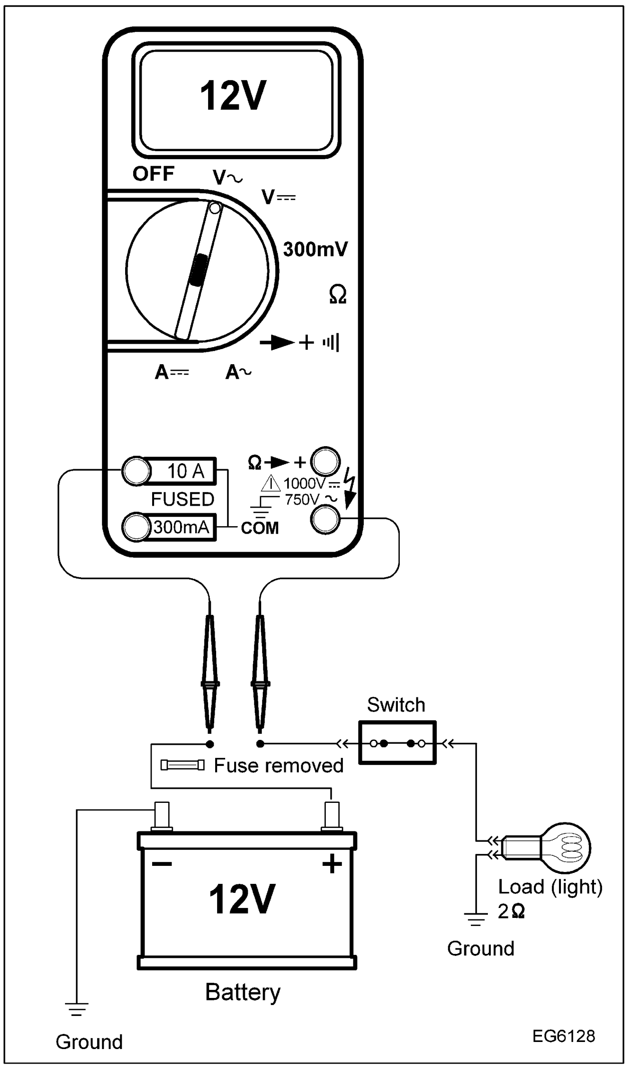


Figure 338 Installing the ammeter

An ammeter is connected in series with the load, switches, resistors, etc., so that all of the current flows through the meter. The ammeter measures current flow only when the circuit is powered up and operating. The DMM is fused to measure up to 10 amps using the 10 A connection point.

Before measuring current flow, determine approximately how many amps are in the circuit to correctly connect the ammeter. The estimate of current flow can easily be calculated. The resistance of the light bulb is 2 ohms. Applying Ohm's law, current flow will be 6 amps (6 amps = 12 V ÷ 2 ohms). If the fuse is removed and an ammeter is installed with the switch closed, 6 amps of current will be measured flowing in the circuit. Notice that the ammeter is installed in series so that all the current in the circuit flows through it.

WARNING: To prevent personal injury or death, turn power off before cutting, soldering, removing circuit components.

Excessive current draw means that more current is flowing in a circuit than the fuse and circuit were designed to handle. Excessive current draw will open fuses and circuit breakers, and will also quickly discharge batteries. An ammeter can diagnose these conditions.

Reduced current draw will cause a device (an electric window motor, for example) to operate poorly. Increased circuit resistance will cause lower current flow (often due to loose or corroded connections).

Ohmmeter

CAUTION: To prevent engine damage, turn power OFF before using the ohmmeter. Power from 12 V systems may damage the ohmmeter.

The ohmmeter measures resistance (ohms) in a circuit. Ohmmeters use a small battery to supply voltage and current flow through the circuit being tested. Based on Ohm's Law, the ohmmeter calculates resistance in the circuit by measuring the voltage of the meter battery and the amount of current flow in the circuit. Range selection and meter adjustment are not necessary with the DMM.

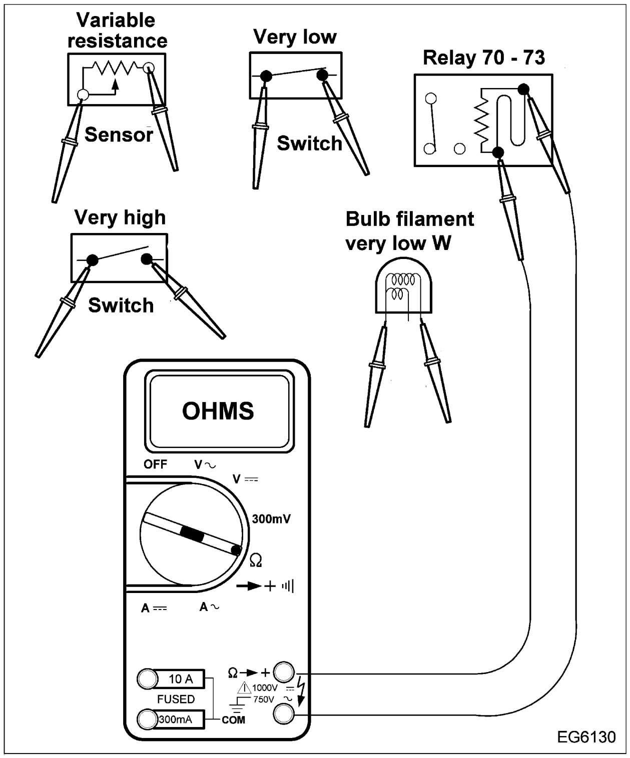


Figure 339 Measuring resistance

Resistance measurements are used to determine the resistance of a load or conductors, the value of resistors and the operation of variable resistors.

To measure the resistance of a component or a circuit, remove power from the circuit. Isolate the component or circuit from other components and circuits so that the meter current (from probe to probe) only flows through the selected component or circuit. When measuring the resistance of the load, most of the current flow from the meter will go through the indicator lamp because it has less resistance.

Remove one connector to the load. It is not always apparent when a component must be isolated, so it is a good practice to isolate a component or circuit by disconnecting one circuit. Place the ohmmeter leads across the component or circuit to display the resistance in ohms. When checking a sensor or variable resistor such as the fuel level gauge, heating the element or moving the arm should move the meter through a range of resistance that can be compared to a specification.

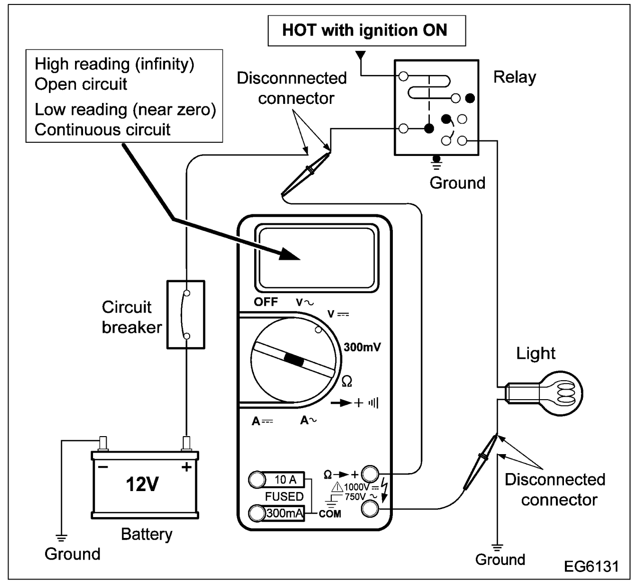


Figure 340 Checking for open circuits

Open electrical circuits can be diagnosed using an ohmmeter. Disconnect the power supply to the circuit and isolate the circuit from all other circuits. The circuit between the light and the ground is disconnected to prevent reading a circuit that may be shorted to ground ahead of the load device as a continuous circuit. Connect the ohmmeter to the open ends of the circuit. A high reading (infinity) indicates an open circuit. A reading near zero indicates a continuous circuit. With the Fluke 88 Digital Multimeter (DMM), an open circuit will read OL (over limit).

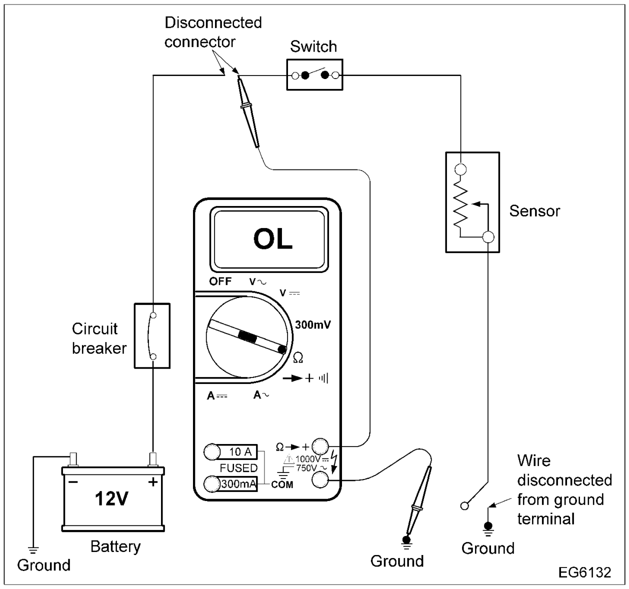


Figure 341 Checking for short circuits

Checks for short circuits are similar to checks for open circuits. Isolate the circuit from the power source and the ground point. Connect the ohmmeter between an isolated circuit and a good ground point to check the circuit for a short to ground. A short to ground will be indicated by a reading near zero. A circuit that is not shorted to ground will cause a high meter reading.

Measuring Duty Cycle with FLUKE 88

When measuring duty cycle, ensure that the large dial on the meter is pointing to volts DC, the DUTY button is set to the Duty Cycle function, and the trigger has a positive slope.

Use the following procedure to check duty cycle:

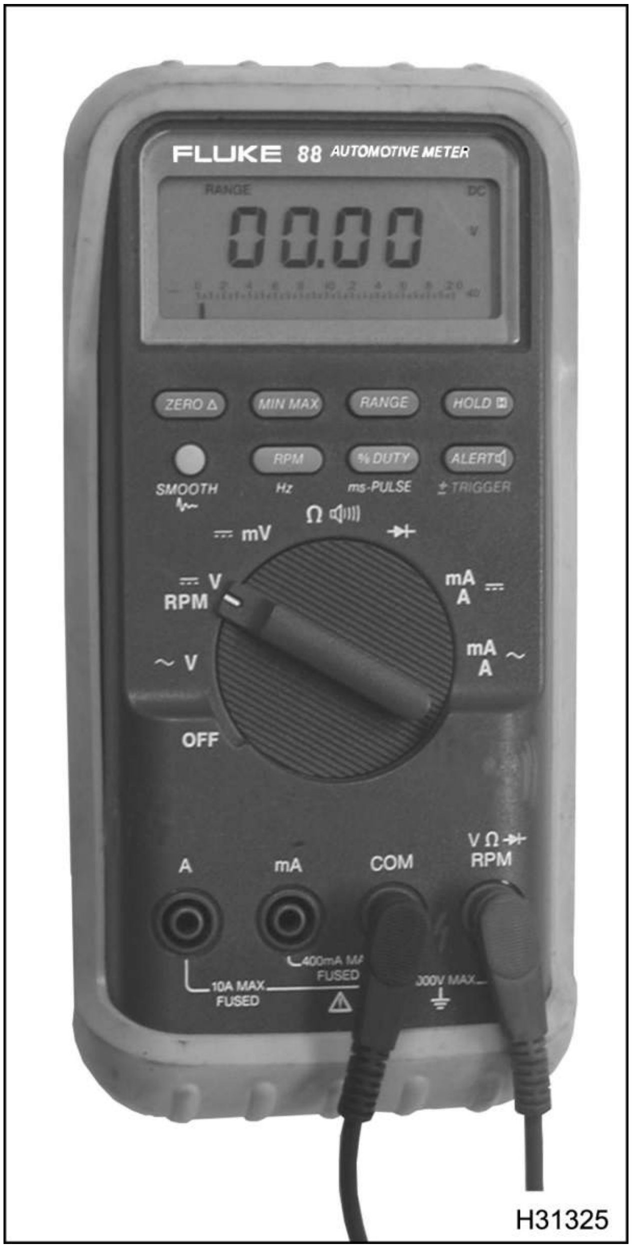


Figure 342 FLUKE 88 in volts dc mode

1. Turn the large dial on the meter to volts DC, indicated by V RPM.

Figure 343 FLUKE 88 with negative trigger slope in duty cycle mode

2. Press the % DUTY button to select duty cycle mode. The screen on the meter will show TRIG (with a _ under the TRIG) in the lower left hand corner of the screen. A percent sign will appear on the upper right hand corner of the screen.

Figure 344 FLUKE 88 in duty cycle mode with positive trigger slope

3. In duty cycle mode, press the ALERT button to change from negative to positive trigger slope. The slope is indicated by a plus or minus sign below TRIG in the lower left hand corner of the screen. A percent sign will appear on the upper right hand corner of the screen.
4. After the meter has been set to the correct settings, connect meter as indicated in Pin-Point Diagnostics.

Troubleshooting

1. Verify the problem.

   Operate the complete system and list all symptoms as follows:

   - Check the accuracy and completeness of the complaint.
   - Learn more that might give a clue to the nature and location of the problem.
   - Analyze what parts of the system are working.

2. See Section 7 in this manual or the correct chassis manual.

   Read the electrical operation for the problem circuit and review the circuit diagram. Understanding electrical operation and the circuit diagram can narrow the cause of the problem to one component or certain parts of the circuit.

3. Check the circuit diagram.

   Check the circuit diagram for possible clues to the problem. Location of specific components in the circuit will help identify the source of the problem.

   Circuit diagrams are designed to make it easy to identify common points in circuits. This helps to narrow the problem to a specific area. For example, if several circuits fail at the same time, check for a common power source or common ground connection (i.e., V_{REF}, signal ground, actuator power, actuator ground).

   If part of a circuit fails, check the connections between the part that works and the part that does not work. For example, if the low-beam headlights work, but both high-beam headlights and the high-beam indicator do not work, the power and ground paths must be good. Since the dimmer switch is the component that switches the power to the high-beam headlights, it is probably the cause of failure.

4. Determine the cause of the problem and follow diagnostic procedures in Section 7.
5. Make the repair.

   Repair the problem circuit as directed in the diagnostic tables

6. Verify that the repair is complete.

   Operate the system. Check that the repair has removed all symptoms and that the repair has not caused new symptoms.

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Abbreviations and Acronyms

Abbreviations and Acronyms

A or amp – Ampere
ABDC – After Bottom Dead Center
ABS – Antilock Brake System
AC – Alternating Current
A/C – Air Conditioner
ACC – Air Conditioner Control
ACCEL – Accelerate
ACD – Air Conditioner Demand
ACT PWR GND – Actuator Power Ground
AF – Air to Fuel ratio
AFT – Aftertreatment
AIT – Air Intake Temperature
Amb – Ambient
amp or A – Ampere
AMS – Air Management System
API – American Petroleum Institute
APS – Accelerator Position Sensor
APS/IVS – Accelerator Position Sensor / Idle Validation Switch
ASTM – American Society for Testing and Materials
ATA – American Trucking Association
ATDC – After Top Dead Center
AWG – American Wire Gauge

B+ or VBAT – Battery Voltage
BARO – Barometric Absolute Pressure
BBDC – Before Bottom Dead Center
BCP – Brake Control Pressure
BCS – Boost Control Solenoid
BDC – Bottom Dead Center
bhp – Brake Horsepower
BNO – Brake Normally Open
BOO – Brake On / Off
BPS – Brake Pressure Switch
BSV – Brake Shut-off Valve
BTDC – Before Top Dead Center
BTU – British Thermal Unit

C – Celsius
CAC – Charge Air Cooler
CAN – Controller Area Network
CAP – Cold Ambient Protection
CARB – California Air Resources Board
cc – Cubic centimeter
CCA – Cold Cranking Ampere
CID – Cubic Inch Displacement
cfm – Cubic feet per minute
cfs – Cubic feet per second
CKP – Crankshaft Position
CKPO – Crankshaft Position Out
cm – Centimeter
CMP – Camshaft Position
CMPO – Camshaft Position Out
CO – Carbon Monoxide
COO – Cruise On / Off switch
CPU – Central Processing Unit
CTC – Coolant Temperature Compensation
Cyl – Cylinder

DB – Decibel
DCA – Diesel Coolant Additive
DDI – Digital Direct Fuel Injection
DDS – Driveline Disengagement Switch
DLC – Data Link Connector
DME – Dimethyl Ether
DMM – Digital Multimeter
DOC – Diesel Oxidation Catalyst
DPF – Diesel Particulate Filter
DT – Diesel Turbocharged
DTC – Diagnostic Trouble Code
DTRM – Diesel Thermo Recirculation Module

EBP – Exhaust Back Pressure
EBPD – Exhaust Back Pressure Desired
ECI – Engine Crank inhibit
ECL – Engine Coolant Level
ECM – Electronic Control Module
ECM PWR – Electronic Control Module Power
ECT – Engine Coolant Temperature
EFP – Engine Fuel Pressure
EFRC – Engine Family Rating Code
EFT – Engine Fuel Temperature
EG – Ethylene Glycol
EGC – Electronic Gauge Cluster
EGDP – Exhaust Gas Differential Pressure
EGR – Exhaust Gas Recirculating
EGRH – Exhaust Gas Recirculation High control
EGRL – Exhaust Gas Recirculation Low control
EGRP – Exhaust Gas Recirculating Position
EGT1 – Exhaust Gas Temperature 1
EGT2 – Exhaust Gas Temperature 2
EGT3 – Exhaust Gas Temperature 3
EMI – Electromagnetic Interference
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
EWPS – Engine Warning Protection System

F – Fahrenheit
FCV – Fuel Coolant Valve
FEL – Family Emissions Limit
fhp – Friction horsepower
FMI – Failure Mode Indicator
FPC – Fuel Pump Control
FPCV – Fuel Pressure Control Valve
fpm – Feet per minute
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
HFCM – Horizontal Fuel Conditioning Module
Hg – Mercury
hp – Horsepower
HPFP – High-Pressure Fuel Pump
hr – Hour
Hyd – Hydraulic

IAT – Intake Air Temperature
IAHC – Inlet Air Heater Control
IAHD – Inlet Air Heater Diagnostic
IAHR – Inlet Air heater Relay
IC – Integrated Circuit
ICP – Injector Control Pressure
ID – Inside Diameter
IDM – Injector Drive Module
IGN – Ignition
ILO – Injector Leak Off
in – Inch
inHg – Inch of mercury
inH_2O – Inch of water
INJ – Injector
IPR – Injection Pressure Regulator
ISIS – International® Service Information System
IST – Idle Shutdown Timer
ITP – Internal Transfer Pump
ITV – Intake Throttle Valve
ITVH – Intake Throttle Valve High control
ITVL – Intake Throttle Valve Low control
ITVP – Intake Throttle Valve Position
IVS – Idle Validation Switch

JCT – Junction (electrical)

kg – Kilogram
km – Kilometer
km/h – Kilometers per hour
km/l – Kilometers per liter
KOEO – Key-On Engine-Off
KOER – Key-On Engine-Running
kPa – Kilopascal

L – Liter
L/h – Liters per hour
L/m – Liters per minute
L/s – Liters per second
lb – Pound
lbf – Pounds of force
lb/s – Pounds per second
lbf ft – Pounds of force per foot
lbf in – Pounds of force per inch
lbm – Pounds of mass
LSD – Low Sulfur Diesel

m – Meter
m/s – Meters per second
MAF – Mass Air Flow
MAG – Magnetic
MAP – Manifold Absolute Pressure
MAT – Manifold Air Temperature
mep – Mean effective pressure
mi – Mile
mm – Millimeter
mpg – Miles per gallon
mph – Miles per hour
MPR – Main Power Relay
MSDS – Material Safety Data Sheet
MSG – Micro Strain Gauge
MSM – Multiplex System Module
MY – Model Year

NC – Normally closed (electrical)
NETS – Navistar Electronics Technical Support
Nm – Newton meter
NO – Normally Open (electrical)
NO_x – Nitrogen Oxides

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
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
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 GRD – Signal Ground
S/N – Serial Number
SPN – Suspect Parameter Number
SW – Switch (electrical)
SYNC – Synchronization

TACH – Tachometer output signal
TBD – To Be Determined
TCAPE – Truck Computer Analysis of Performance and Economy
TDC – Top Dead Center
TCM – Transmission Control Module
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 Turbocharger
VIGN – Ignition Voltage
VIN – Vehicle Identification Number
VOP – Valve Opening Pressure
VRE – Vehicle Retarder Enable
VREF – Reference Voltage
VSO – Vehicle Speed Output
VSS – Vehicle Speed Sensor

WEL – Warn Engine Lamp
WIF – Water In Fuel
WTEC – World Transmission Electronically Controlled automatic transmissions (Allison)

XMSN – Transmission

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Terminology

Terms

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.

Aeration – The entrainment of air or combustion gas in coolant, lubricant, or fuel.

Aftercooler (Charge Air Cooler) – A heat exchanger mounted in the charge air path between the turbocharger and engine intake manifold. The aftercooler reduces the charge air temperature by transferring heat from the charge air to a cooling medium (usually air).

Ambient temperature – The environmental air temperature in which a unit is operating. In general, the temperature is measured in the shade (no solar radiation) and represents the air temperature for other engine cooling performance measurement purposes. Air entering the radiator may or may not be the same ambient due to possible heating from other sources or recirculation. (SAE J1004 SEP81)

Ampere (amp) – The standard unit for measuring the strength of an electrical current. The flow rate of a charge in a conductor or conducting medium of one coulomb per second. (SAE J1213 NOV82)

Analog – A continuously variable voltage.

Analog to digital converter (A/D) – A circuit in the ECM processing section that converts an analog signal (DC or AC) to a usable digital signal for the microprocessor.

American Trucking Association (ATA) Datalink – A serial datalink specified by the American Trucking Association and the SAE.

Boost pressure – 1. The pressure of the charge air leaving the turbocharger.

2. Inlet manifold pressure that is greater than atmospheric pressure. Obtained by turbocharging.

Bottom Dead Center (BDC) – The lowest position of the piston during the stroke.

Brake Horsepower (bhp) – The power output from an engine, not the indicated horsepower. The power output of an engine, sometimes-called flywheel horsepower is less than the indicated horsepower by the amount of friction horsepower consumed in the engine.

Brake Horsepower (bhp) net – Net brake horsepower is measured with all engine components. The power of an engine when configured as a fully equipped engine. (SAE J1349 JUN90)

Calibration – The data values used by the strategy to solve 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.

Catalyst – A substance that produces a chemical reaction without undergoing a chemical change itself.

Catalytic converter – An antipollution device in the exhaust system that contains a catalyst for chemically converting some pollutants in the exhaust gases (carbon monoxide, unburned hydrocarbons, and oxides of nitrogen) into harmless compounds.

Cavitation – A dynamic condition in a fluid system that forms gas-filled bubbles (cavities) in the fluid.

Cetane number – 1. The auto-ignition quality of diesel fuel.

2. A rating applied to diesel fuel similar to octane rating for gasoline.

3. A measure of how readily diesel fuel starts to burn (self-ignites) at high compression temperature.

Diesel fuel with a high cetane number self-ignites shortly after injection into the combustion chamber. Therefore, it has a short ignition delay time. Diesel fuel with a low cetane number resists self-ignition. Therefore, it has a longer ignition delay time.

Charge air – Dense, pressurized, heated air discharged from the turbocharger.

Charge Air Cooler (CAC) – See **Aftercooler**.

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 a sensor to provide feedback to the ECM. The ECM uses the sensor to continuously monitor variables and adjust 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.

Continuous Monitor Test – An ECM function that continuously monitors the inputs and outputs to ensure that readings are within set limits.

Coolant – A fluid used to transport heat from one point to another.

Coolant level switch – A switch sensor used to indicate low coolant level.

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 pressure – The force of air inside the crankcase against the crankcase housing.

Current – The flow of electrons passing through a conductor. Measured in amperes.

Damper – A device that reduces the amplitude of torsional vibration. (SAE J1479 JAN85)

Deaeration – The removal or purging of gases (air or combustion gas) entrained in coolant or lubricating oil.

Deaeration tank – A separate tank in the cooling 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) – Formerly called a Fault Code or Flash Code. A DTC is a three digit numeric code used for troubleshooting.

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.

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.

Duty cycle – A control signal that has a controlled on/off time measurement from 0 to 100%. Normally used to control solenoids.

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 rating – Engine rating includes **Rated hp** and **Rated rpm**.

Engine RUNNING tests – Tests done with the engine running.

Exhaust brake – A brake device using engine exhaust back pressure as a retarding medium.

Exhaust manifold – Exhaust gases flow through the exhaust manifold to the turbocharger exhaust inlet and are directed to the EGR cooler.

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 inlet restriction – A blockage, usually from contaminants, that prevents the flow of fluid through the fuel inlet line.

Fuel pressure – The force that the fuel exerts on the fuel system as it is pumped through the fuel system.

Fuel strainer – A pre-filter in the fuel system that keeps larger contaminants from entering the fuel system.

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.

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 – Generates a digital on/off signal that indicates speed and timing.

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**.

Hydrocarbons – Unburned or partially burned fuel molecules.

Idle speed –

- Low idle is minimum rpm at no load.
- High idle is maximum rpm at no load.

Intake manifold – A collection of tubes through which the fuel-air mixture flows from the fuel injector to the intake valves of the cylinders.

International NGV Tool Utilized for Next Generation Electronics (INTUNE) – The diagnostics software for chassis related components and systems.

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).

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 operating at or below maximum torque speed.

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.

MasterDiagnostics® (MD) – The diagnostics software for engine related components and systems.

Microprocessor – An integrated circuit in a microcomputer that controls information flow.

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 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 that the technician initiates using the EST and is run from a program in the processor.

Output Circuit Check (OCC) – An On demand test done during an Engine OFF self test to check the continuity of selected actuators.

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 is done. 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 Modulate (PWM) – The time that an actuator, such as an injector, remains energized.

Random Access Memory (RAM) – Computer memory that stores information. Information can be written to and read from RAM. Input information (current engine speed or temperature) can be stored in RAM to be compared to values stored in Read Only Memory (ROM). All memory in RAM is lost when the ignition switch is turned off.

Rated gross horsepower – Engine gross horsepower at rated speed as declared by the manufacturer. (SAE J1995 JUN90)

Rated horsepower – Maximum brake horsepower output of an engine as certified by the engine manufacturer. The power of an engine when configured as a basic engine. (SAE J1995 JUN90)

Rated net horsepower – Engine net horsepower at rated speed as declared by the manufacturer. (SAE J1349 JUN90)

Rated speed – The speed, as determined by the manufacturer, at which the engine is rated. (SAE J1995 JUN90)

Rated torque – Maximum torque produced by an engine as certified by the manufacturer.

Ratiometric Voltage – In a Micro Strain Gauge (MSG) sensor pressure to be measured exerts force on a pressure vessel that stretches and compresses to change resistance of strain gauges bonded to the surface of the pressure vessel. Internal sensor electronics convert the changes in resistance to a ratiometric voltage output.

Reference voltage (V_{REF}) – A 5 volt reference supplied by the ECM to operate the engine sensors.

Reserve capacity – Time in minutes that a fully charged battery can be discharged to 10.5 volts at 25 amperes.

Signal ground – The common ground wire to the ECM for the sensors.

Speed Control Command Switches (SCCS) – A set of switches used for cruise control, Power TakeOff (PTO), and remote hand throttle system.

Steady state condition – An engine operating at a constant speed and load and at stabilized temperatures and pressures. (SAE J215 JAN80)

Strategy – A plan or set of operating instructions that the microprocessor follows for a desired goal. Strategy is the computer program itself, including all equations and decision making logic. Strategy is always stored in ROM and cannot be changed during calibration.

Stroke – Stroke is the movement of the piston from Top Dead Center (TDC) to Bottom Dead Center (BDC).

Substrate – Material that supports the washcoating or catalytic materials.

System restriction (air) – The static pressure differential that occurs at a given air flow 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.

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) – Truck Computer Analysis of Performance and Economy is a computer program that simulates the performance and fuel economy of trucks.

Turbocharger – A turbine driven compressor mounted to the exhaust manifold. The turbocharger increases the pressure, temperature and density of intake air to charge air.

Variable capacitance sensor – A variable capacitance sensor is measures pressure. The pressure forces a ceramic material closer to a thin metal disc in the sensor, changing the capacitance of the sensor.

Vehicle Electronic System Programming System – The computer system used to program electronically controlled vehicles.

Vehicle Retarder Enable/Engage – Output from the ECM to a vehicle retarder.

Vehicle Speed Sensor (VSS) – Normally a magnetic pickup sensor mounted in the tailshaft housing of the transmission, used to indicate ground speed.

Viscosity – The internal resistance to the flow of any fluid.

Viscous fan – A fan drive that is activated when a thermostat, sensing high air temperature, forces fluid through a special coupling. The fluid activates the fan.

Volt (v) – A unit of electromotive force that will move a current of one ampere through a resistance of one Ohm.

Voltage – Electrical potential expressed in volts.

Voltage drop – Reduction in applied voltage from the current flowing through a circuit or portion of the circuit current multiplied by resistance.

Voltage ignition – Voltage supplied by the ignition switch when the key is ON.

Washcoat – A layer of alumina applied to the substrate in a monolith-type converter.

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All Ratings

Key-On Engine-Off

Barometric pressure at 620 ft above sea level	98 kPa (14 psi) / 4.0 V
Brake control pressure	0 MPa (0 psi) / 0.24 V
Engine oil pressure	0 kPa (0 psi) / 0.59 V
Exhaust back pressure	0 kPa (0 psi) / 0.73 V
Exhaust gas differential pressure	0 kPa (0 psi) / 0.70 V
Injection control pressure	0 MPa (0 psi) / 0.24 V
Manifold boost pressure (gauge)	0 kPa (0 psi) / 0.73 V
Accelerator position sensor (at idle)	0.65 V / 0 %
Accelerator position sensor (depressed to floor)	3.86 V / 100 %
Exhaust gas recirculation valve position	0 %
Intake throttle valve position	1.30 V / 5 %

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
Exhaust gas recirculation valve	0 %
Engine fuel pressure (min)	138 kPa (20 psi)

Low Idle, no load, stabilized engine operating temperature

Engine coolant temperature (at thermostat opening)	89 °C (192 °F) / 1.20 V
Engine oil temperature should not go -12 °C (10 °F) above engine coolant temperature.	
Manifold air temperature	71 °C (160 °F) / 1.60 V
Engine fuel pressure	275–515 kPa (40–80 psi)
Engine oil pressure (min with gauge)	270 kPa (39 psi) / 2.52 V

High Idle, no load, stabilized engine operating temperature

Engine fuel pressure	275–515 kPa (40–80 psi)
VGT control	44 %
VGT control OFF set	0.6 %
Crankcase pressure (max) using ZTSE4039	20 kPa (6 in Hg) @ high idle

Full load, rated speed on highway, stabilized engine operating temperature
(MaxxForce® DT at 2300 engine rpm and MaxxForce® 9 & 10 at 2000 engine rpm)

Air cleaner restriction (max)	6.2 kPa (25 in H_2O)
Engine fuel pressure	275–515 kPa (40–80 psi)
Fuel pump inlet restriction (max with gauge)	152 mm Hg (6 in Hg)
Water temperature differential across radiator (top to bottom)	6.7 °C to 8.4 °C (12 °F to 15 °F)

Component Specifications

Temperature Sensors (ECT, EOT, MAT)	
Temperature at -18 °C (0 °F)	4.65 V / 99 kΩ
Temperature at 0 °C (32 °F)	4.39 V / 93 kΩ
Temperature at 21 °C (70 °F)	3.78 V / 35 kΩ
Temperature at 65 °C (150 °F)	1.88 V / 6.26 kΩ
Temperature at 93 °C (200 °F)	1.02 V / 2.45 kΩ
Temperature Sensors (IAT)	
Temperature at -18 °C (0 °F)	4.25 V / 198 Ω
Temperature at 0 °C (32 °F)	3.86 V / 85 kΩ
Temperature at 21 °C (70 °F)	3.02 V / 34.5 kΩ
Temperature at 65 °C (150 °F)	1.16 V / 6.17 kΩ
Temperature Sensors (EGT1, EGT2, EGT3)	
Temperature at 21 °C (70 °F)	0.88 V / 111.8 Ω
Temperature at 65 °C (150 °F)	1 V / 146.6 Ω
Temperature at 93 °C (200 °F)	1.05 V / 266.1 Ω
Temperature at 204 °C (400 °F)	1.29 V / 347.1 Ω
Temperature at 482 °C (900 °F)	1.76 V / 536 Ω
Other Components	
CMP sensor	350 Ω ± 50 Ω
CKP sensor	900 Ω ± 100 Ω
Injection pressure regulator valve	5.5 Ω ± 0.5 Ω
Injector coil	1 Ω ± 0.5 Ω
Inlet air heater element	< 1 Ω

Inlet Air Heater

Amperage draw (dual grid heater)	125 amps on each grid within 2 seconds
Amperage draw (single grid heater)	125 amps within 2 seconds

Actuator Output State Test

Injection pressure regulator valve	Output state low: 0 % Output state high: 98 %
Exhaust gas recirculation valve	Output state low: 0 % Output state high: 90 %
VGT actuator	Output state low: 10 % Output state high: 90 %

Key-On Engine-Running VGT Test

VGT control	Output state low: 0 % Output state medium: 50 % Output state high: 80 %
VGT control OFF set	Output state low: 0.9 % Output state medium: 0 % Output state high: –6 %
Exhaust back pressure	Output state low: 6.9 kPa (1 psi) Output state medium: 27 kPa (4 psi) Output state high: 89 kPa (13 psi)
Manifold boost pressure	Output state low: 0 kPa (0 psi) Output state medium: 7 kPa (1 psi) Output state high: 28 kPa (4 psi)

MaxxForce® DT (7.6L)

210 hp @ 2600 rpm (12NSK)

MaxxForce® DT/210 hp @ 2600 rpm / 560 ft•lb @ 1400 rpm	
50 state 2008 Model Year (MY)	
Engine unit code	12NSK
Engine model	MaxxForce® DT/210
Engine Family Rating Code (EFRC)	1121
Injector part number, original equipment	1848718C92
Turbocharger part number	1850493C91
Injection timing	Nonadjustable
High idle speed - manual transmission	2700 rpm
High idle speed - automatic transmission	2700 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	4 kPa (0.6 psi) / 0.76 V
Exhaust back pressure	20 kPa (3 psi) / 0.90 V
Injection control pressure	5.9 MPa (850 psi) / 1 V
High Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	69 kPa (10 psi) / 1.26 V
Exhaust back pressure	124 kPa (18 psi) / 1.70 V
Injection control pressure	16 MPa (2340 psi) / 2.39 V
Torque converter stall (automatic transmission)	2600 rpm or greater @ 5 seconds or less
Full load, 2300 engine rpm, rated speed on highway, stabilized engine operating temperature	
Manifold boost pressure	144 kPa (21 psig) / 1.9 V
Exhaust back pressure	213 kPa (31 psig) / 2.4 V
Injection control pressure	31 MPa (4624 psi) / 4.5 V

225 hp @ 2600 rpm (12NSM)

MaxxForce® DT/225 hp @ 2600 rpm / 560 ft•lb @ 1400 rpm	
50 state 2008 Model Year (MY)	
Engine unit code	12NSM
Engine model	MaxxForce® DT/225
Engine Family Rating Code (EFRC)	1131
Injector part number, original equipment	1848718C92
Turbocharger part number	1850493C91
Injection timing	Nonadjustable
High idle speed - manual transmission	2700 rpm
High idle speed - automatic transmission	2700 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	4 kPa (0.6 psi) / 0.76 V
Exhaust back pressure	20 kPa (3 psi) / 0.90 V
Injection control pressure	5.9 MPa (850 psi) / 1 V
High Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	69 kPa (10 psi) / 1.26 V
Exhaust back pressure	124 kPa (18 psi) / 1.70 V
Injection control pressure	16 MPa (2320 psi) / 2.4 V
Torque converter stall (automatic transmission)	2600 rpm or greater @ 5 seconds or less
Full load, rated speed on highway, stabilized engine operating temperature	
Manifold boost pressure	144 kPa (21 psig) / 1.9 V
Exhaust back pressure	213 kPa (31 psig) / 2.4 V
Injection control pressure	31 MPa (4624 psi) / 4.5 V

225 hp @ 2600 rpm (12NSL)

MaxxForce® DT/225 hp @ 2600 rpm / 620 ft•lb @ 1400 rpm	
50 state 2008 Model Year (MY)	
Engine unit code	12NSL
Engine model	MaxxForce® DT/225
Engine Family Rating Code (EFRC)	1141
Injector part number, original equipment	1848718C92
Turbocharger part number	1850493C91
Injection timing	Nonadjustable
High idle speed - manual transmission	2700 rpm
High idle speed - automatic transmission	2700 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	4 kPa (0.6 psi) / 0.76 V
Exhaust back pressure	20 kPa (3 psi) / 0.90 V
Injection control pressure	5.9 MPa (850 psi) / 1 V
High Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	69 kPa (10 psi) / 1.26 V
Exhaust back pressure	124 kPa (18 psi) / 1.70 V
Injection control pressure	16 MPa (2340 psi) / 2.39 V
Torque converter stall (automatic transmission)	2600 rpm or greater @ 5 seconds or less
Full load, 2300 engine rpm, rated speed on highway, stabilized engine operating temperature	
Manifold boost pressure	144 kPa (21 psig) / 1.9 V
Exhaust back pressure	213 kPa (31 psig) / 2.4 V
Injection control pressure	31 MPa (4624 psi) / 4.5 V

230 hp @ 2400 rpm (12NSV)

MaxxForce® DT/230 hp @ 2600 rpm / 620 ft•lb @ 1400 rpm	
50 state 2008 Model Year (MY)	
Engine unit code	12NSV
Engine model	MaxxForce® DT/230
Engine Family Rating Code (EFRC)	1151
Injector part number, original equipment	1848718C92
Turbocharger part number	1850493C91
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	
Manifold boost pressure	4 kPa (0.6 psi) / 0.76 V
Exhaust back pressure	20 kPa (3 psi) / 0.90 V
Injection control pressure	5.9 MPa (850 psi) / 1 V
High Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	69 kPa (10 psi) / 1.26 V
Exhaust back pressure	124 kPa (18 psi) / 1.70 V
Injection control pressure	16 MPa (2340 psi) / 2.39 V
Torque converter stall (automatic transmission)	2600 rpm or greater @ 5 seconds or less
Full load, 2300 engine rpm, rated speed on highway, stabilized engine operating temperature	
Manifold boost pressure	144 kPa (21 psig) / 1.9 V
Exhaust back pressure	213 kPa (31 psig) / 2.4 V
Injection control pressure	31 MPa (4624 psi) / 4.5 V

245 hp @ 2600 rpm (12NSG)

MaxxForce® DT/245 hp @ 2600 rpm / 620 ft•lb @ 1400 rpm	
50 state 2008 Model Year (MY)	
Engine unit code	12NSG
Engine model	MaxxForce® DT/245
Engine Family Rating Code (EFRC)	2121
Injector part number, original equipment	1848718C92
Turbocharger part number	1850495C91
Injection timing	Nonadjustable
High idle speed - manual transmission	2700 rpm
High idle speed - automatic transmission	2700 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	13–34 kPa (2–5 psi)
Exhaust back pressure	41–82 kPa (6–12 psi)
Injection control pressure	6 MPa (870 psi) / 1.05 V
High Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	34–172 kPa (5–25 psi)
Exhaust back pressure	137–310 kPa (20–45 psi)
Injection control pressure	16 MPa (2320 psi) / 2.4 V
Torque converter stall (automatic transmission)	2600 rpm or greater @ 5 seconds or less
Full load, 2300 engine rpm, rated speed on highway, stabilized engine operating temperature	
Manifold boost pressure	173 kPa (25 psig) / 2.09 V
Exhaust back pressure	242 kPa (35 psig) / 2.64 V
Injection control pressure	32 MPa (4641 psi) / 4.6 V

255 hp @ 2600 rpm (12NSZ)

MaxxForce® DT/255 hp @ 2600 rpm / 660 ft•lb @ 1400 rpm	
50 state 2008 Model Year (MY)	
Engine unit code	12NSZ
Engine model	MaxxForce® DT/255
Engine Family Rating Code (EFRC)	2131
Injector part number, original equipment	1848718C92
Turbocharger part number	1850495C91
Injection timing	Nonadjustable
High idle speed - manual transmission	2700 rpm
High idle speed - automatic transmission	2700 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	13–34 kPa (2–5 psi)
Exhaust back pressure	41–82 kPa (6–12 psi)
Injection control pressure	6 MPa (870 psi) / 1.05 V
Torque converter stall (automatic transmission)	2600 rpm or greater @ 5 seconds or less
High Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	34–172 kPa (5–25 psi)
Exhaust back pressure	137–310 kPa (20–45 psi)
Injection control pressure	16 MPa (2320 psi) / 2.4 V
Full load, 2300 engine rpm, rated speed on highway, stabilized engine operating temperature	
Manifold boost pressure	174 kPa (25 psig) / 2.10 V
Exhaust back pressure	242 kPa (35 psig) / 2.64 V
Injection control pressure	32 MPa (4641 psi) / 4.6 V

260 hp @ 2400 rpm (12NTA)

MaxxForce® DT/260 hp @ 2400 rpm / 800 ft•lb @ 1400 rpm	
50 state 2008 Model Year (MY)	
Engine unit code	12NTA
Engine model	MaxxForce® DT/260
Engine Family Rating Code (EFRC)	2141
Injector part number, original equipment	1848718C92
Turbocharger part number	1850495C91
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	
Manifold boost pressure	13–34 kPa (2–5 psi)
Exhaust back pressure	41–82 kPa (6–12 psi)
Injection control pressure	6 MPa (870 psi) / 1.05 V
High Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	34–172 kPa (5–25 psi)
Exhaust back pressure	137–310 kPa (20–45 psi)
Injection control pressure	16 MPa (2320 psi) / 2.4 V
Torque converter stall (automatic transmission)	2600 rpm or greater @ 5 seconds or less
Full load, 2300 engine rpm, rated speed on highway, stabilized engine operating temperature	
Manifold boost pressure	174 kPa (25 psig) / 2.10 V
Exhaust back pressure	242 kPa (35 psig) / 2.64 V
Injection control pressure	32 MPa (4641 psi) / 4.6 V

285 hp @ 2400 rpm (12NTB)

MaxxForce® DT/285 hp @ 2400 rpm / 800 ft•lb @ 1400 rpm	
50 state 2008 Model Year (MY)	
Engine unit code	12NTB
Engine model	MaxxForce® DT/285
Engine Family Rating Code (EFRC)	2151
Injector part number, original equipment	1848718C92
Turbocharger part number	1850495C91
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	
Manifold boost pressure	13–34 kPa (2–5 psi)
Exhaust back pressure	41–82 kPa (6–12 psi)
Injection control pressure	6 MPa (870 psi) / 1.05 V
High Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	34–172 kPa (5–25 psi)
Exhaust back pressure	137–310 kPa (20–45 psi)
Injection control pressure	16 MPa (2320 psi) / 2.4 V
Torque converter stall (automatic transmission)	2600 rpm or greater @ 5 seconds or less
Full load, 2300 engine rpm, rated speed on highway, stabilized engine operating temperature	
Manifold boost pressure	174 kPa (25 psig) / 2.10 V
Exhaust back pressure	242 kPa (35 psig) / 2.64 V
Injection control pressure	32 MPa (4641 psi) / 4.6 V

300 hp @ 2400 rpm (12NSH)

MaxxForce® DT/300 hp @ 2400 rpm / 860 ft•lb @ 1400 rpm	
50 state 2008 Model Year (MY)	
Engine unit code	12NSH
Engine model	MaxxForce® DT/300
Engine Family Rating Code (EFRC)	2161
Injector part number, original equipment	1848718C92
Turbocharger part number	1850495C91
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	
Manifold boost pressure	13–34 kPa (2–5 psi)
Exhaust back pressure	41–82 kPa (6–12 psi)
Injection control pressure	6 MPa (870 psi) / 1.05 V
High Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	34–172 kPa (5–25 psi)
Exhaust back pressure	137–310 kPa (20–45 psi)
Injection control pressure	16 MPa (2320 psi) / 2.4 V
Torque converter stall (automatic transmission)	2600 rpm or greater @ 5 seconds or less
Full load, 2300 engine rpm, rated speed on highway, stabilized engine operating temperature	
Manifold boost pressure	174 kPa (25 psig) / 2.10 V
Exhaust back pressure	242 kPa (35 psig) / 2.64 V
Injection control pressure	32 MPa (4641 psi) / 4.6 V

300 hp @ 2400 rpm (12)

MaxxForce® DT/300 hp @ 2400 rpm / 660 ft•lb @ 1400 rpm	
50 state 2008 Model Year (MY)	
Engine unit code	12
Engine model	MaxxForce® DT/300
Engine Family Rating Code (EFRC)	2131
Injector part number, original equipment	1848718C92
Turbocharger part number	1850495C91
Injection timing	Nonadjustable
High idle speed - manual transmission	n/a
High idle speed - automatic transmission	2700 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	13–34 kPa (2–5 psi)
Exhaust back pressure	41–82 kPa (6–12 psi)
Injection control pressure	6 MPa (870 psi) / 1.05 V
High Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	34–172 kPa (5–25 psi)
Exhaust back pressure	137–310 kPa (20–45 psi)
Injection control pressure	16 MPa (2320 psi) / 2.4 V
Torque converter stall (automatic transmission)	2600 rpm or greater @ 5 seconds or less
Full load, rated speed on highway, stabilized engine operating temperature	
Manifold boost pressure	Rated speed: 206.5 kPa (30 psig) / 2.36 V
Exhaust back pressure	Rated speed: 305.1 kPa (44.26 psig) / 3.16 V
Injection control pressure	Rated speed: 32 MPa (4641 psi) / 4.6 V

MaxxForce® 9 (9.3L)

300 hp @ 2200 rpm (12NTC)

MaxxForce® 9/300 hp @ 2200 rpm / 800 ft•lb @ 1200 rpm	
50 state 2008 Model Year (MY)	
Engine unit code	12NTC
Engine model	MaxxForce® 9/300
Engine Family Rating Code (EFRC)	5121
Injector part number, original equipment	1848718C92
Turbocharger part number	1877446C91
Injection timing	Nonadjustable
High idle speed - manual transmission	2425 rpm
High idle speed - automatic transmission	2425 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	20 kPa (3 psi)
Exhaust back pressure	68 kPa (10 psi)
Injection control pressure	8 MPa (1160 psi) / 1.17 V
High Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	5–172 kPa (5–25 psi)
Exhaust back pressure	137–310 kPa (20–45 psi)
Injection control pressure	7–9 MPa (1015–1380 psi) / 1.1 – 1.5 V
Torque converter stall (automatic transmission)	2600 rpm or greater @ 5 seconds or less
Full load, 2000 engine rpm, rated speed on highway, stabilized engine operating temperature	
Manifold boost pressure	142 kPa (21 psig) / 1.85 V
Exhaust back pressure	227 kPa (33 psig) / 2.52 V

Injection control pressure	31.3 MPa (4540 psi) / 4.52 V

310 hp @ 2200 rpm (12NSJ)

MaxxForce® 9/310 hp @ 2200 rpm / 950 ft•lb @ 1200 rpm	
50 state 2008 Model Year (MY)	
Engine unit code	12NSJ
Engine model	MaxxForce® 9/310
Engine Family Rating Code (EFRC)	5131
Injector part number, original equipment	1848718C92
Turbocharger part number	1877446C91
Injection timing	Nonadjustable
High idle speed - manual transmission	2425 rpm
High idle speed - automatic transmission	2425 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	20 kPa (3 psi)
Exhaust back pressure	68 kPa (10 psi)
Injection control pressure	8 MPa (1160 psi) / 1.17 V
High Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	5–172 kPa (5–25 psi)
Exhaust back pressure	137–310 kPa (20–45 psi)
Injection control pressure	7–9 MPa (1015–1380 psi) / 1.1 – 1.5 V
Torque converter stall (automatic transmission)	2600 rpm or greater @ 5 seconds or less
Full load, 2000 engine rpm, rated speed on highway, stabilized engine operating temperature	
Manifold boost pressure	142 kPa (21 psig) / 1.85 V
Exhaust back pressure	237 kPa (34 psig) / 2.60 V
Injection control pressure	31.3 MPa (4540 psi) / 4.52 V

330 hp @ 2200 rpm (12NSX)

MaxxForce® 9/330 hp @ 2200 rpm / 950 ft•lb @ 1200 rpm	
50 state 2008 Model Year (MY)	
Engine unit code	12NSX
Engine model	MaxxForce® 9/330
Engine Family Rating Code (EFRC)	6121
Injector part number, original equipment	1848721C92
Turbocharger part number	1877446C91
Injection timing	Nonadjustable
High idle speed - manual transmission	2425 rpm
High idle speed - automatic transmission	2425 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	13–34 kPa (2–5 psi)
Exhaust back pressure	41–82 kPa (6–12 psi)
Injection control pressure	7 MPa (1015 psi) / 1.1 V
High Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	5–172 kPa (5–25 psi)
Exhaust back pressure	137–310 kPa (20–45 psi)
Injection control pressure	7–9 MPa (1015–1380 psi) / 1.1 – 1.5 V
Torque converter stall (automatic transmission)	2600 rpm or greater @ 5 seconds or less
Full load, 2000 engine rpm, rated speed on highway, stabilized engine operating temperature	
Manifold boost pressure	182 kPa (27 psig) / 2.16 V
Exhaust back pressure	213 kPa (31 psig) / 2.41 V
Injection control pressure	25.5 MPa (3700 psi) / 3.62 V

MaxxForce® 10 (9.3L)

310 hp @ 2100 rpm (12NST)

MaxxForce® 10/310 hp @ 2100 rpm / 1050 ft•lb @ 1200 rpm	
50 state 2008 Model Year (MY)	
Engine unit code	12NST
Engine model	MaxxForce® 10/310
Engine Family Rating Code (EFRC)	5141
Injector part number, original equipment	1848721C92
Turbocharger part number	1877446C91
Injection timing	Nonadjustable
High idle speed - manual transmission	2325 rpm
High idle speed - automatic transmission	2325 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	20 kPa (3 psi)
Exhaust back pressure	68 kPa (10 psi)
Injection control pressure	8 MPa (1160 psi) / 1.17 V
High Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	5–172 kPa (5–25 psi)
Exhaust back pressure	137–310 kPa (20–45 psi)
Injection control pressure	7–9 MPa (1015–1380 psi) / 1.1 – 1.5 V
Torque converter stall (automatic transmission)	2600 rpm or greater @ 5 seconds or less
Full load, 2000 engine rpm, rated speed on highway, stabilized engine operating temperature	
Manifold boost pressure	142 kPa (21 psig) / 1.85 V
Exhaust back pressure	242 kPa (35 psig) / 2.64 V

Injection control pressure	31.3 MPa (4540 psi) / 4.52 V

310 hp @ 2200 rpm (12NSU)

MaxxForce® 10/310 hp @ 2200 rpm / 1050 ft•lb @ 1200 rpm	
50 state 2008 Model Year (MY)	
Engine unit code	12NSU
Engine model	MaxxForce® 10/310
Engine Family Rating Code (EFRC)	5151
Injector part number, original equipment	1848721C92
Turbocharger part number	1877446C91
Injection timing	Nonadjustable
High idle speed - manual transmission	2425 rpm
High idle speed - automatic transmission	2425 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	20 kPa (3 psi)
Exhaust back pressure	68 kPa (10 psi)
Injection control pressure	8 MPa (1160 psi) / 1.17 V
High Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	5–172 kPa (5–25 psi)
Exhaust back pressure	137–310 kPa (20–45 psi)
Injection control pressure	7–9 MPa (1015–1380 psi) / 1.1 – 1.5 V
Torque converter stall (automatic transmission)	2600 rpm or greater @ 5 seconds or less
Full load, 2000 engine rpm, rated speed on highway, stabilized engine operating temperature	
Manifold boost pressure	142 kPa (21 psig) / 1.85 V
Exhaust back pressure	247 kPa (36 psig) / 2.68 V
Injection control pressure	31.3 MPa (4540 psi) / 4.52 V

330 hp @ 2100 rpm (12NSP)

MaxxForce® 10/330 hp @ 2100 rpm / 1150 ft•lb @ 1200 rpm	
50 state 2008 Model Year (MY)	
Engine unit code	12NSP
Engine model	MaxxForce® 10/330
Engine Family Rating Code (EFRC)	6131
Injector part number, original equipment	1848721C92
Turbocharger part number	1877446C91
Injection timing	Nonadjustable
High idle speed - manual transmission	2325 rpm
High idle speed - automatic transmission	2325 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	13–34 kPa (2–5 psi)
Exhaust back pressure	41–82 kPa (6–12 psi)
Injection control pressure	7 MPa (1015 psi) / 1.1 V
High Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	5–172 kPa (5–25 psi)
Exhaust back pressure	137–310 kPa (20–45 psi)
Injection control pressure	7–9 MPa (1015–1380 psi) / 1.1 – 1.5 V
Torque converter stall (automatic transmission)	2600 rpm or greater @ 5 seconds or less
Full load, 2000 engine rpm, rated speed on highway, stabilized engine operating temperature	
Manifold boost pressure	182 kPa (27 psig) / 2.16 V
Exhaust back pressure	215 kPa (31 psig) / 2.42 V
Injection control pressure	25.5 (3700 psi) / 3.6 V

330 hp @ 2200 rpm (12NSW)

MaxxForce® 10/330 hp @ 2200 rpm / 1150 ft•lb @ 1200 rpm	
50 state 2008 Model Year (MY)	
Engine unit code	12NSW
Engine model	MaxxForce® 10/330
Engine Family Rating Code (EFRC)	6141
Injector part number, original equipment	1848721C92
Turbocharger part number	1877446C91
Injection timing	Nonadjustable
High idle speed - manual transmission	2425 rpm
High idle speed - automatic transmission	2425 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	13–34 kPa (2–5 psi)
Exhaust back pressure	41–82 kPa (6–12 psi)
Injection control pressure	7 MPa (1015 psi) / 1.1 V
High Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	5–172 kPa (5–25 psi)
Exhaust back pressure	137–310 kPa (20–45 psi)
Injection control pressure	7–9 MPa (1015–1380 psi) / 1.1 – 1.5 V
Torque converter stall (automatic transmission)	2600 rpm or greater @ 5 seconds or less
Full load, 2000 engine rpm, rated speed on highway, stabilized engine operating temperature	
Manifold boost pressure	182 kPa (27 psig) / 2.16 V
Exhaust back pressure	215 kPa (31 psig) / 2.42 V
Injection control pressure	25.5 MPa (3700 psi) / 3.6 V

350 hp @ 2100 rpm (12NSN)

MaxxForce® 10/350 hp @ 2100 rpm / 1150 ft•lb @ 1200 rpm	
50 state 2008 Model Year (MY)	
Engine unit code	12NSN
Engine model	MaxxForce® 10/350
Engine Family Rating Code (EFRC)	6151
Injector part number, original equipment	1848721C92
Turbocharger part number	1877446C91
Injection timing	Nonadjustable
High idle speed - manual transmission	2325 rpm
High idle speed - automatic transmission	2325 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	13–34 kPa (2–5 psi)
Exhaust back pressure	41–82 kPa (6–12 psi)
Injection control pressure	7 MPa (1015 psi) / 1.1 V
High Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	5–172 kPa (5–25 psi)
Exhaust back pressure	137–310 kPa (20–45 psi)
Injection control pressure	7–9 MPa (1015–1380 psi) / 1.1 – 1.5 V
Torque converter stall (automatic transmission)	2600 rpm or greater @ 5 seconds or less
Full load, 2000 engine rpm, rated speed on highway, stabilized engine operating temperature	
Manifold boost pressure	182 kPa (27 psig) / 2.16 V
Exhaust back pressure	216 kPa (32 psig) / 2.43 V
Injection control pressure	25.5 MPa (3700 psi) / 3.6 V

350 hp @ 2200 rpm (12NSY)

MaxxForce® 10/350 hp @ 2200 rpm / 1150 ft•lb @ 1200 rpm	
50 state 2008 Model Year (MY)	
Engine unit code	12NSY
Engine model	MaxxForce® 10/350
Engine Family Rating Code (EFRC)	6161
Injector part number, original equipment	1848721C92
Turbocharger part number	1877446C91
Injection timing	Nonadjustable
High idle speed - manual transmission	2425 rpm
High idle speed - automatic transmission	2425 rpm
Low idle speed	700 rpm
Low Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	13–34 kPa (2–5 psi)
Exhaust back pressure	41–82 kPa (6–12 psi)
Injection control pressure	7 MPa (1015 psi) / 1.1 V
High Idle, no load, stabilized engine operating temperature	
Manifold boost pressure	5–172 kPa (5–25 psi)
Exhaust back pressure	137–310 kPa (20–45 psi)
Injection control pressure	7–9 MPa (1015–1380 psi) / 1.1 – 1.5 V
Torque converter stall (automatic transmission)	2600 rpm or greater @ 5 seconds or less
Full load, 2000 engine rpm, rated speed on highway, stabilized engine operating temperature	
Manifold boost pressure	182 kPa (27 psig) / 2.16 V
Exhaust back pressure (max)	218 kPa (32 psig) / 2.45 V
Injection control pressure	25.5 MPa (3700 psi) / 3.6 V

Table of Contents

Diagnostic Trouble Codes

DTC	SPN	FMI	Lamp	Circuit	Condition Description
1112	168	3	WEL	ECM PWR (page 271)	B+ out-of-range HIGH
1113	168	4	WEL	ECM PWR (page 271)	B+ out-of-range LOW
1114	110	4	WEL	ECT (page 282)	ECT signal out-of-range LOW
1115	110	3	WEL	ECT (page 282)	ECT signal out-of-range HIGH
1121	102	3	WEL	MAP (page 387)	MAP signal out-of-range HIGH
1122	102	4	WEL	MAP (page 387)	MAP signal out-of-range LOW
1124	164	4	MIL	ICP (page 349)	ICP signal out-of-range LOW
1125	164	3	MIL	ICP (page 349)	ICP signal out-of-range HIGH
1126	7139	4		BCP (page 232)	BCP signal out-of-range LOW
1127	7139	3		BCP (page 232)	BCP signal out-of-range HIGH
1131	91	4	WEL	APS/IVS (page 223)	APS signal out-of-range LOW
1132	91	3	WEL	APS/IVS (page 223)	APS signal out-of-range HIGH
1133	91	2	WEL	APS/IVS (page 223)	APS in-range fault
1134	91	7	WEL	APS/IVS (page 223)	APS and IVS disagree
1135	558	11	WEL	APS/IVS (page 223)	IVS signal fault
1136	94	4	WEL	EFP (page 292)	EFP signal out-of-range LOW
1137	94	3	WEL	EFP (page 292)	EFP signal out-of-range HIGH
1141	84	4	WEL	VSS (page 414)	VSS signal out-of-range LOW
1142	84	3	WEL	VSS (page 414)	VSS signal out-of-range HIGH
1143	8021	2	WEL	CMP (page 252)	CMP signal incorrect for CKP sync
1144	8021	8	WEL	CKP (page 249)	CKP signal noise detected
1146	8064	12	WEL	CKP (page 249)	CKP signal inactive
1147	8064	2	WEL	CKP (page 249)	CKP incorrect signal signature
1151	108	3	WEL	ECM SELF (page 276)	BAP signal out-of-range HIGH
1152	108	4	WEL	ECM SELF (page 276)	BAP signal out-of-range LOW
1154	171	4		IAT (page 344)	IAT signal out-of-range LOW
1155	171	3		IAT (page 344)	IAT signal out-of-range HIGH
1156	102	0	MIL*	MAP (page 387)	MAP signal in-range HIGH MAP above BARO at start
1157	102	1	MIL*	MAP (page 387)	MAP signal in-range LOW MAP below BARO at start
1161	105	4	WEL	MAT (page 392)	MAT signal out-of-range LOW

WEL – Warn Engine Lamp MIL – Malfunction Indicator Lamp OWL – Oil and Water Lamp

* Lamp is illuminated after second or third notification

DTC	SPN	FMI	Lamp	Circuit	Condition Description
1162	105	3	WEL	MAT (page 392)	MAT signal out-of-range HIGH
1178	7316	0	WEL	VGT (page 402)	VGT actuator temperature above high limit
1211	100	4	WEL	EOP (page 323)	EOP signal out-of-range LOW
1212	100	3	WEL	EOP (page 323)	EOP signal out-of-range HIGH
1213	8029	4		Truck	Remote throttle signal out-of-range LOW
1214	8029	3	WEL	Truck	Remote throttle signal out-of-range HIGH
1222	597	2	WEL	BOO/BPS (page 237)	Brake switch circuit fault
1236	111	2		ECL (page 268)	ECL in-range circuit fault
1253	97	3	WEL	WIF (page 419)	WIF signal out-of-range LOW
1254	97	4	WEL	WIF (page 419)	WIF signal out-of-range HIGH
1255	97	5	WEL	WIF (page 419)	WIF signal open circuit fault
1276	8366	6		IPR (page 374)	IPR short to B+, over temperature
1277	8366	5		IPR (page 374)	IPR short circuit
1287	3464	1	WEL*	ITV (page 381)	ITVL OCC self-test failed
1288	3464	0	WEL*	ITV (page 381)	ITVH OCC self-test failed
1292	7318	2	MIL	ITV (page 381)	ITVP in-range fault
1293	7318	3	MIL	ITV (page 381)	ITVP signal out-of-range HIGH
1294	7318	4	MIL	ITV (page 381)	ITVP signal out-of-range LOW
1298	51	2	MIL	ITV (page 381)	ITV operation fault – under V, over amp, over temp
1299	175	10	WEL*	EOT (page 328)	EOT in-range fault
1311	175	4	WEL	EOT (page 328)	EOT signal out-of-range LOW
1312	175	3	WEL	EOT (page 328)	EOT signal out-of-range HIGH
1362	412	0	WEL*	EGR (page 303)	EGR valve internal high circuit failure
1363	412	1	WEL*	EGR (page 303)	EGR valve internal low circuit failure
1396	7137	12	WEL	EGR (page 303)	EGRV initialization fault
1397	7137	4	MIL	EGR (page 303)	EGR position in-range fault
1398	8327	7	MIL	EGR (page 303)	EGR unable to achieve desired position
1729	3251	4	MIL	EGDP (page 297)	EGDP signal out-of-range LOW
1731	3251	3	MIL	EGDP (page 297)	EGDP signal out-of-range HIGH
1737	3241	4	MIL	EGT1 (page 308)	EGT1 signal out-of-range LOW
1738	3241	3	MIL	EGT1 (page 308)	EGT1 signal out-of-range HIGH
1741	3242	4	MIL	EGT2 (page 313)	EGT2 signal out-of-range LOW
1742	3242	3	MIL	EGT2 (page 313)	EGT2 signal out-of-range HIGH

WEL – Warn Engine Lamp MIL – Malfunction Indicator Lamp OWL – Oil and Water Lamp

* Lamp is illuminated after second or third notification

DTC	SPN	FMI	Lamp	Circuit	Condition Description
1744	3245	4	MIL	EGT3 (page 318)	EGT3 signal out-of-range LOW
1745	3245	3	MIL	EGT3 (page 318)	EGT3 signal out-of-range HIGH
2159	8365	7		BOO/BPS (page 237)	Brake applied while APS applied
2174	8321	2		VGT (page 402)	VGT communication fault
2175	8321	7	MIL	VGT (page 402)	VGT performance fault
2176	8321	0		VGT (page 402)	VGT commanded position over a threshold
2177	8321	1		VGT (page 402)	VGT commanded position below a threshold
2179	97	2		WIF (page 419)	Water in fuel detected
2232	8331	7		CAN public (page 243)	Resume normal speed control due to momentary CAN loss
2242	1442	2	MIL*	ICP SYS (page 354)	ICP adaptation in-range fault
2313	100	1	WEL	EWPS (page 334)	EOP below warning level
2314	100	7	OWL	EWPS (page 334)	EOP below critical level
2315	190	0		EWPS (page 334)	Engine speed above warning level
2319	518	2		EWPS (page 334)	Torque limited to control engine overheat
2321	110	0	OWL	EWPS (page 334)	ECT above warning level
2322	110	7		EWPS (page 334)	ECT above critical level
2323	111	1	OWL	EWPS (page 334)	ECL below warning/critical level
2324	593	14		IST (page 378)	Engine stopped by IST
2327	164	10		ICP SYS (page 354)	ICP abnormal rate of change
2332	164	13	MIL*	ICP (page 349)	ICP above KOEO spec
2335	164	1		ICP SYS (page 354)	ICP unable to build during engine cranking
2351	7129	1		AMS (page 218)	EBP below desired level
2352	7129	0		AMS (page 218)	EBP above desired level
2368	8146	7	WEL	EGR (page 303)	EGR valve communication fault
2369	1378	2			Engine oil service required
2371	94	0		EFP (page 292)	Fuel pressure above normal
2372	94	1		EFP (page 292)	Fuel pressure below normal
2388	2659	0	MIL*	AMS (page 218)	EGR flow excessive - possible leak to atmosphere
2389	2659	1	MIL*	AMS (page 218)	EGR flow insufficient - possible plugged system
2391	2791	11	MIL	EGR (page 303)	EGR valve internal circuit failure
2392	7138	6	MIL	EGR (page 303)	EGR duty cycle above limit
2393	7137	2	MIL	EGR (page 303)	EGR position sensor fault

WEL – Warn Engine Lamp MIL – Malfunction Indicator Lamp OWL – Oil and Water Lamp

* Lamp is illuminated after second or third notification

DTC	SPN	FMI	Lamp	Circuit	Condition Description
2394	8146	2	MIL	EGR (page 303)	EGR valve not receiving ECM CAN messages
2395	7317	3	WEL*	EGR (page 303)	EGRH OCC self-test failed
2396	7317	4	WEL*	EGR (page 303)	EGRL OCC self-test failed
2544	8329	7		CAN public(page 243)	ECM unable to send CAN messages
2545	8330	7		CAN public(page 243)	ECM not receiving body controller CAN messages
2546	7121	1		BCP (page 232)	BCP below desired
2547	7121	0		BCP (page 232)	BCP above desired
2549	8321	12	WEL	VGT (page 402)	ECM not receiving VGT CAN messages
2673	3242	10	MIL*	EGT2 (page 313)	EGT2 not warming along with engine
2674	3242	2	MIL*	EGT2 (page 313)	EGT2 reading off compared to EGT1 and EGT3
2675	3241	2	MIL*	EGT1 (page 308)	EGT1 temp not increasing with engine temp
2676	3241	1	MIL*	EGT1 (page 308)	EGT1 reading off compared to EGT2 and EGT3
2677	3245	2	MIL*	EGT3 (page 318)	EGT3 not warming along with engine
2678	3245	1	MIL*	EGT3 (page 318)	EGT3 reading off compared to EGT1 and EGT2
2681	3242	1	MIL*	EGT2 (page 313)	EGT2 reading off compared to EGT1 and EGT3
2687	8302	1	MIL	AFT SYS (page 209)	DPF, low flow resistance
2688	8302	0	MIL	AFT SYS (page 209)	DPF over temperature - possible filter damage
2699	3251	1	MIL	EGDP (page 297)	EGDP below desired level
2732	3251	2	MIL*	EGDP (page 297)	EGDP stuck in-range fault
2733	3251	10	MIL*	EGDP (page 297)	EGDP mismatch between key-on/off
2772	3524	0		AFT SYS(page 209)	Excessive time, a manual inhibit was set to prevent a DPF regeneration.
2782	8317	13		AFT SYS (page 209)	DPF servicing required
2783	8318	13		AFT SYS (page 209)	DPF load: above warning level
2784	8319	13	WEL	AFT SYS (page 209)	DPF load: above critical level 1 - engine de-rate
2785	8320	13	OWL	AFT SYS (page 209)	DPF load: above critical level 2 - further engine de-rate
3333	8492	0	MIL*	ICP SYS (page 354)	ICP above desired level
3334	8492	1	MIL*	ICP SYS (page 354)	ICP below desired level
3338	7129	17		AMS (page 218)	KOER STD - EBP unable to build during test
3339	7129	15		AMS (page 218)	KOER STD - EBP too high during test
3341	1209	4	MIL	EBP (page 258)	EBP signal out-of-range LOW
3342	1209	3	MIL	EBP (page 258)	EBP signal out-of-range HIGH

WEL – Warn Engine Lamp MIL – Malfunction Indicator Lamp OWL – Oil and Water Lamp

* Lamp is illuminated after second or third notification

DTC	SPN	FMI	Lamp	Circuit	Condition Description
3345	7136	0		VGT (page 402)	VGT control over duty
3346	1209	0		AMS (page 218)	AMT - EBP unable to build during EGR test
3347	7136	1		VGT (page 402)	VGT control under duty
3348	1209	1		AMS (page 218)	AMT - EBP too high during EGR test
3373	164	15	MIL*	ICP SYS (page 354)	ICP too high during test
3374	164	17	MIL*	ICP SYS (page 354)	ICP unable to build during test
3786	8326	2		AFT SYS (page 209)	DPF Test - test unsuccessful
4411	8001	6	WEL	INJ (page 360)	Cyl 1 close coil: open circuit
4412	8002	6	WEL	INJ (page 360)	Cyl 2 close coil: open circuit
4413	8003	6	WEL	INJ (page 360)	Cyl 3 close coil: open circuit
4414	8004	6	WEL	INJ (page 360)	Cyl 4 close coil: open circuit
4415	8005	6	WEL	INJ (page 360)	Cyl 5 close coil: open circuit
4416	8006	6	WEL	INJ (page 360)	Cyl 6 close coil: open circuit
4421	8001	5	WEL	INJ (page 360)	Cyl 1 open coil: open circuit
4422	8002	5	WEL	INJ (page 360)	Cyl 2 open coil: open circuit
4423	8003	5	WEL	INJ (page 360)	Cyl 3 open coil: open circuit
4424	8004	5	WEL	INJ (page 360)	Cyl 4 open coil: open circuit
4425	8005	5	WEL	INJ (page 360)	Cyl 5 open coil: open circuit
4426	8006	5	WEL	INJ (page 360)	Cyl 6 open coil: open circuit
4431	8001	4	WEL	INJ (page 360)	Cyl 1 open coil: short circuit
4432	8002	4	WEL	INJ (page 360)	Cyl 2 open coil: short circuit
4433	8003	4	WEL	INJ (page 360)	Cyl 3 open coil: short circuit
4434	8004	4	WEL	INJ (page 360)	Cyl 4 open coil: short circuit
4435	8005	4	WEL	INJ (page 360)	Cyl 5 open coil: short circuit
4436	8006	4	WEL	INJ (page 360)	Cyl 6 open coil: short circuit
4441	8001	3	WEL	INJ (page 360)	Cyl 1 close coil: short circuit
4442	8002	3	WEL	INJ (page 360)	Cyl 2 close coil: short circuit
4443	8003	3	WEL	INJ (page 360)	Cyl 3 close coil: short circuit
4444	8004	3	WEL	INJ (page 360)	Cyl 4 close coil: short circuit
4445	8005	3	WEL	INJ (page 360)	Cyl 5 close coil: short circuit
4446	8006	3	WEL	INJ (page 360)	Cyl 6 close coil: short circuit
4515	8151	5	WEL	INJ (page 360)	Bank A injector open coil short
4516	8151	6	WEL	INJ (page 360)	Bank A injector close coil short

WEL – Warn Engine Lamp MIL – Malfunction Indicator Lamp OWL – Oil and Water Lamp

* Lamp is illuminated after second or third notification

DTC	SPN	FMI	Lamp	Circuit	Condition Description
4521	8152	5	WEL	INJ (page 360)	Bank B injector open coil short
4522	8152	6	WEL	INJ (page 360)	Bank B injector close coil short
4551	8021	12	WEL	CMP (page 252)	CMP signal inactive
4552	8022	2		CMP (page 252)	CMP loss of sync
4553	8022	12	WEL	CKP (page 249)	CKP signal inactive
4554	8022	7	WEL	CKP (page 249)	CKP loss of sync
4555	8064	8	WEL	CKP (page 249)	CKP signal noise detected
4556	8022	8	WEL	CKP (page 249)	CKP period too short
4561	8001	1		CYL BAL (page 255)	Cyl 1 cyl balance below min limit
4562	8002	1		CYL BAL (page 255)	Cyl 2 cyl balance below min limit
4563	8003	1		CYL BAL (page 255)	Cyl 3 cyl balance below min limit
4564	8004	1		CYL BAL (page 255)	Cyl 4 cyl balance below min limit
4565	8005	1		CYL BAL (page 255)	Cyl 5 cyl balance below min limit
4566	8006	1		CYL BAL (page 255)	Cyl 6 cyl balance below min limit
4571	8001	0		CYL BAL (page 255)	Cyl 1 cyl balance max limit exceeded
4572	8002	0		CYL BAL (page 255)	Cyl 2 cyl balance max limit exceeded
4573	8003	0		CYL BAL (page 255)	Cyl 3 cyl balance max limit exceeded
4574	8004	0		CYL BAL (page 255)	Cyl 4 cyl balance max limit exceeded
4575	8005	0		CYL BAL (page 255)	Cyl 5 cyl balance max limit exceeded
4576	8006	0		CYL BAL (page 255)	Cyl 6 cyl balance max limit exceeded
4611	8021	13		CKP (page 249)	CKP signature one tooth off
4612	8021	7		CMP (page 252)	CMP to CKP incorrect reference
5382	1136	0		ECM SELF (page 276)	ECM error – over temperature
5618	8334	2		ECM SELF (page 276)	ECM error – SPI-BUS error 1
5619	8334	12		ECM SELF (page 276)	ECM error – SPI-BUS error 2
5627	8333	12		ECM SELF (page 276)	ECM error – Checksum program
5628	8333	2		ECM SELF (page 276)	ECM error – Checksum dataset
5632	8254	12		ECM SELF (page 276)	ECM error – RAM/CPU self-test fault
5633	8254	0		ECM SELF (page 276)	ECM error – CPU load above maximum
5634	8336	12		ECM SELF (page 276)	ECM error – MQPS daisy chain failure
5635	8337	12		ECM SELF (page 276)	ECM error – OCT daisy chain failure
5636	8338	12		ECM SELF (page 276)	ECM error – QPS daisy chain failure
5641	86	14	WEL	ECM SELF (page 276)	ECM error – CC monitoring

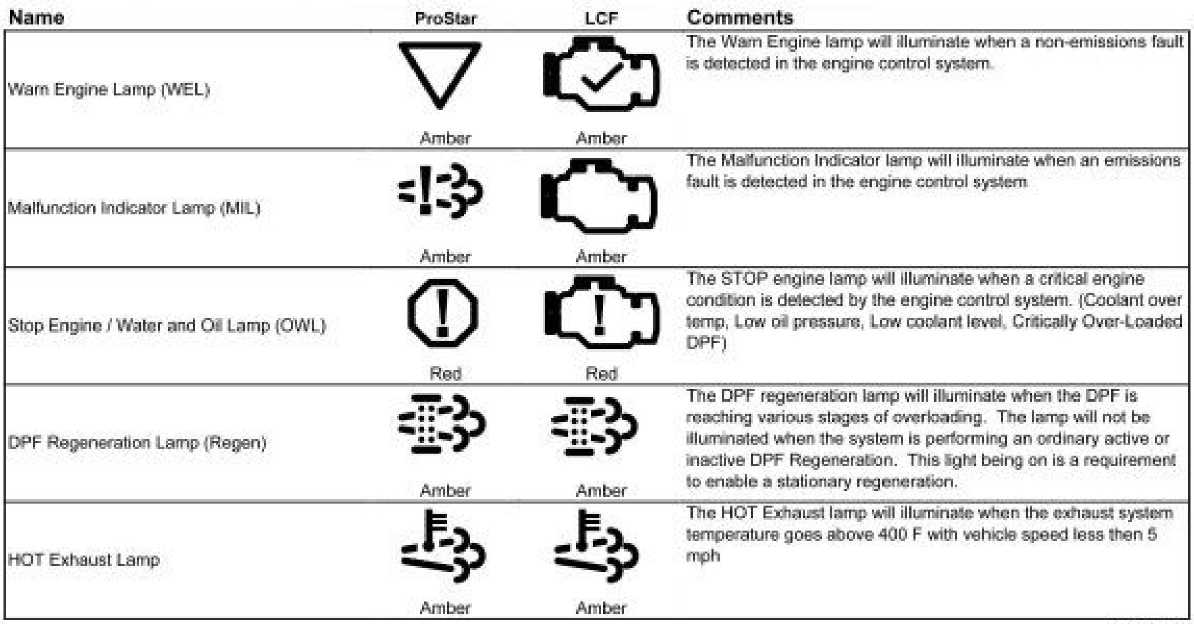
WEL – Warn Engine Lamp MIL – Malfunction Indicator Lamp OWL – Oil and Water Lamp

* Lamp is illuminated after second or third notification

DTC	SPN	FMI	Lamp	Circuit	Condition Description
5642	94	14	WEL	ECM SELF (page 276)	ECM error – Fuel cut off monitoring
5643	183	14	WEL	ECM SELF (page 276)	ECM error – Post Inj: monitoring error
5644	190	2	WEL	ECM SELF (page 276)	ECM error – Engine speed limitation
5645	7253	7		ECM SELF (page 276)	ECM error – EEPROM failure
5646	190	14	WEL	ECM SELF (page 276)	ECM error – Engine Speed: monitoring
5647	558	14	WEL	ECM SELF (page 276)	ECM error – PVS monitoring
5648	976	14	WEL	ECM SELF (page 276)	ECM error – PTO monitoring
5649	1136	14	WEL	ECM SELF (page 276)	ECM error – A/D conversion monitoring
5651	7132	14	WEL	ECM SELF (page 276)	ECM error – MFMA monitoring
5652	8240	14		ECM SELF (page 276)	ECM error – NVMY channel
5653	8300	14	WEL	ECM SELF (page 276)	ECM error – PPS monitoring
5654	8329	14	WEL	ECM SELF (page 276)	ECM error – CAN monitoring
5655	8332	14	WEL	ECM SELF (page 276)	ECM error – Service tool monitoring
5656	8335	14	WEL	ECM SELF (page 276)	ECM error – Processor monitoring
5666	8339	4	WEL	VREF (page 407)	VREF engine voltage below min
5667	8339	3	WEL	VREF (page 407)	VREF engine voltage above max
5668	8340	4	WEL	VREF (page 407)	VREF chassis voltage below min
5669	8340	3	WEL	VREF (page 407)	VREF chassis voltage above max
5671	8341	4	WEL	VREF (page 407)	VREF body voltage below min
5672	8341	3	WEL	VREF (page 407)	VREF body voltage above max

WEL – Warn Engine Lamp MIL – Malfunction Indicator Lamp OWL – Oil and Water Lamp

* Lamp is illuminated after second or third notification



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 345 Warning Lamps

Table of Contents

Description

Technical Service Information (TSI) letters are periodically published to inform service technicians of product enhancements and field service issues. File TSIs in this section for supplemental reference.