SERVICE MANUAL

DIAGNOSTIC/TROUBLESHOOTING MANUAL

EGES-240

July 2002

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FOREWORD

This diagnostic manual is part of a series of publications intended to assist service technicians in maintaining International® engines in accordance with the latest technical advancements.

Due to a commitment of continuous research and development, some procedures, specifications, and parts may be altered to improve International products and introduce technological advances.

Periodic revisions may be made to these publications and mailed automatically to "Revision Service" subscribers. The following literature, supporting International Diesel Engines, is available from:

International Truck and Engine Corporation
Printing and Distribution Services
61 Clark Road North
Battle Creek, MI 49015
616-968-4856

VT 365 Diesel Engine Service Literature

FORM NO* – DESCRIPTION

EGES-235 – *VT 365 Engine Service Manual*

EGES-240 – *VT 365 Engine Diagnostics Manual*

1171765R2 – *VT 365 Engine Operation and Maintenance Manual*

EGED-245 – VT 365 Hard Start and No Start Diagnostics Form

EGED-250 – VT 365 Performance Diagnostics Form

EGED-255 – VT 365 Electronic Control Systems Diagnostics Form

CGE-310 – Engine Diagnostic Trouble Codes

* - Publication with the latest revision will be furnished.

NOTE: A dash (-) and a numeral after the form number indicates the revision level.

SERVICE DIAGNOSIS

Service diagnosis is a systematic procedure of investigation to be followed in order to locate and correct an engine problem. The engine is first considered as a complete unit in its specific application and then the problem is localized to components or systems; intake, exhaust, cooling, lubrication or injection. Testing procedures will then help analyze the source of the problem.

PREREQUISITES FOR EFFECTIVE DIAGNOSIS:

- Knowledge of the principles of operation for both the engine and application systems
- Knowledge to perform and understand all procedures in the diagnostic and service publications
- Availability of and the ability to use gauges and diagnostic test equipment
- Availability of the most current information for the engine application

Although the cause of an engine failure may be apparent, very often the real cause is not found until a repeat failure occurs. This can be prevented if specific diagnostic action is taken before, during and after engine disassembly and during engine assembly.

It is also very important that specific diagnostic tests follow engine assembly before and after the engine is placed back into service.

Identification of the symptoms which lead to engine failure is the result of proper service diagnosis. Effective service diagnosis requires use of the following references:

- Engine Service Manual
- Hard Start and No Start Diagnostics
- Performance Diagnostics
- Electronic Control Systems Diagnostics
- Service Bulletins

NOTE: Metric values precede English values for test procedures and reference.

Examples: 96 kPa (14 psi), 20°C (68°F)

SAFETY INFORMATION

This manual provides general and specific service procedures and repair methods 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 can not be stated.

Departure from instructions in this manual or disregard of warnings and cautions can lead to injury or death, or both and damage to the engine or vehicle.

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

SAFETY TERMINOLOGY

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

Warning: Signals conditions, hazards, and unsafe practices that can cause injury or death.

Caution: Signals conditions and practices that can cause damage to the engine or vehicle.

Note: Signals a key point or procedure that must be followed for correct, efficient engine operation.

SAFETY INSTRUCTIONS

Vehicle

- Make sure the vehicle is in neutral, the parking brake is set, and the wheels are blocked before doing any work or diagnostic procedures on the engine or vehicle.

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 glasses and safety shoes (do not work in bare feet, sandals, or sneakers.)
- Wear correct work clothing.
- Do not wear rings, watches, or other jewelry.
- Restrain long hair.

Fire prevention

- Keep charged fire extinguishers close by.

NOTE: Three kinds of fire extinguishers are required:

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

Batteries

Batteries produce highly flammable gas during and after charging.

- Avoid leaning over batteries.
- Protect your eyes.
- Do not expose batteries to open flames or sparks.
- Do not smoke.
- Always disconnect the ground cable before working on the electrical system.

Compressed air

- Limit shop air pressure for blow gun to 207 kPa (30 psi).
- Use approve equipment.
- Do not direct air at body or clothing.
- Wear safety glasses or goggles.
- Use shielding to protect others in the work area.

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.
- Keep the funnel or nozzle of the hose in solid contact with the metal of the fuel tank inlet. Solid contact will prevent electrical sparks.
- 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.

Group 12

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ENGINE IDENTIFICATION

ENGINE SERIAL NUMBER

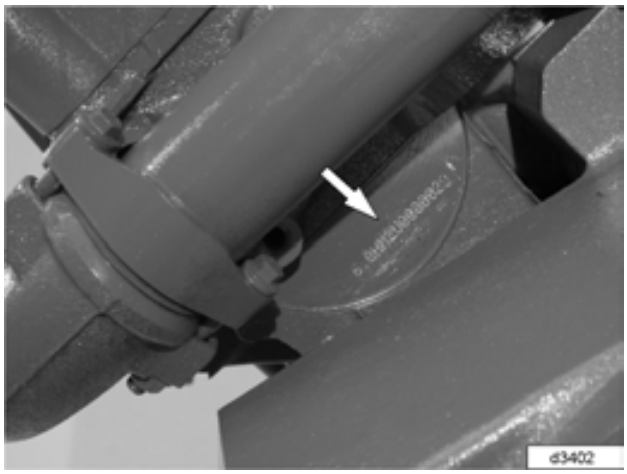

Figure 1 Engine serial number

The engine serial number is stamped on the crankcase pad on the rear left side of the crankcase below the cylinder head.

The engine serial number is also on an identification sticker on the valve cover.

Engine serial number examples

6.0HM2Y0000500

6.0HA2U0000508

Engine serial number codes

6.0 – Engine displacement
H – Diesel, turbocharged, Charge Air Cooled, and electronically controlled
M2 – Truck
A2 – Service
U – USA
Y – USA Huntsville
7 digit suffix – Engine serial number sequence

EMISSION LABELS

Two emission labels are issued for the International® VT 365 diesel engine

- Environmental Protection Agency (EPA) Emission Label
- U.S. Federal Family Emission Limits Label

Figure 2 Environmental Protection Agency (EPA) emission label (50 state)

The Environmental Protection Agency (EPA) Emission Label (shown above) or a Low Emission Vehicle (LEV) label (not shown) is on the right valve cover. Both labels have a similar design but different colors. Each engine will have one or the other, depending on engine application. Both EPA labels include the following:

- Advertised brake and horsepower ratings
- Engine model code
- Service applications
- Year the engine was certified to meet government EPA emission standards

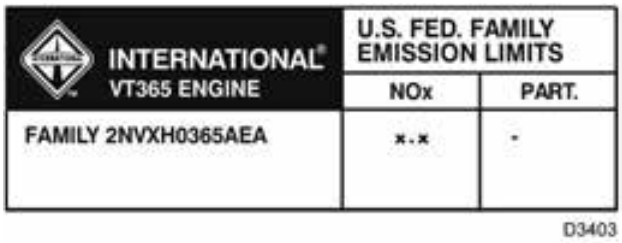

Figure 3 U.S. Federal Family Emission Limits label

Some engines may have the U.S. Federal Family Emission Limits Label on the right valve cover. This label identifies the engine family and emission limits established by the manufacturer and certified by the EPA.

Engine accessories

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

- Air compressor (for brake or suspension system)
- Air conditioning compressor
- Alternator
- Cooling fan clutch
- Electronic Variable Response Turbocharger (EVRT™)
- Power steering / fuel pump
- Starter motor

Labels or identification plates include information and specifications helpful to vehicle operators and technicians.

ENGINE DESCRIPTION

Table 1

International® VT 365 engine features and specifications

Engine	Diesel, 4 cycle
Configuration	4 OHV/1 Cam-in-Crankcase-V8
Displacement	365 cu. in (6.0L)
Bore and stroke	95 x 105 mm (3.74 x 4.134 in)
Compression ratio	18.0:1
Aspiration	Electronic Variable Response Turbocharger (EVRT™) and Charge Air Cooling (CAC)
Rated power @ rpm*	175 bhp @ 2600 rpm
Peak torque @ rpm*	460 lbf•ft @ 1400 rpm
Engine rotation, facing flywheel	Counterclockwise
Combustion system	Digital Direct Injection (DDI)
Total engine weight (auto with oil)	459 kg (1094 lb)
Cooling system capacity (engine only)	10.2 liters (10.8 qts)
Lube system capacity (including filter)	18 liters (19 qts)
Lube system capacity (dry)	21.8 liters (23 qts)
Firing order	1–2–7–3–4–5–6–8

*Base ratings are shown. See Appendix A.

Major features

Air Management System (AMS)

- Electronic Variable Response Turbocharger (EVRT™)
- Exhaust Gas Recirculation (EGR) system
- Chassis mounted Charge Air Cooling (CAC)

Digital Direct fuel Injection (DDI)

Two piece crankcase

One piece cylinder head with four valves per cylinder

Dual timing

Rear gear train

Closed crankcase ventilation

Oil cooler

The firing order is 1–2–7–3–4–5–6–8. When viewing the engine from the rear (flywheel end), the right side cylinders are numbered 1, 3, 5, and 7. Number one is the front position. The left side is numbered 2, 4, 6, and 8.

A two piece crankcase has been specially designed to withstand the loads of diesel operation. The lower crankcase has integral main bearing caps. Coolant and oil passages are cast and machined in the crankcase and front cover housing.

The crankshaft has five main bearings with fore and aft thrust controlled at the upper half of the number 4 main bearing. Two connecting rods are attached to each crankshaft journal. The piston pin moves freely inside the piston and rod. Piston pin retaining rings secure the piston pin within the piston.

One piece aluminum-alloy pistons are fitted with one keystone cut compression ring, one rectangular intermediate compression ring, and a two piece oil control ring. The combustion bowl (in the piston crown) is designed to reduce exhaust emissions.

The camshaft is supported by five insert bushings pressed into the crankcase. Two cam lobes, cam followers, push rods and valve bridges control four valves per cylinder. The camshaft is gear driven from the rear end of the crankshaft. A thrust flange is located between the camshaft gear and the crankcase. Camshaft thrust is controlled with the rear surface of the number 5 cam journal and the cam gear itself.

The hydraulic cam followers maintain zero valve lash and minimize engine noise. This eliminates periodic adjustment of valve lash. The hydraulic cam followers have rollers which provide excellent cam lobe and cam follower durability.

The lubrication system uses a crankshaft driven gerotor pump mounted on the front cover. The oil pressure regulator is built into the front cover and is accessible from outside the engine. Lube oil is routed through an oil cooler equipped with a pressure controlled bypass valve. Lube oil moves through passages in the crankcase to lubricate all internal components and to supply the piston cooling tubes and high pressure pump reservoir. The turbocharger and air compressor use external oil lines.

An Electronic Variable Response Turbocharger (EVRT™) is electronically controlled and hydraulically actuated. The EVRT™ is designed to provide boost control at low and high speeds for improved throttle response.

An exhaust gas recirculation valve allows water cooled exhaust gases to be fed into the inlet air stream to reduce exhaust emissions.

A closed crankcase breather system recirculates crankcase vapors back into the intake air system.

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

Engine operation is controlled by two engine mounted control modules:

- Electronic Control Module (ECM)
- Injector Drive Module (IDM)

The ECM receives signals from engine and chassis mounted sensors. The ECM controls engine operation with the following actuators:

- IPR
- EVRT™

- EGR
- Glow plug relay

The IDM controls fuel injector operation using data from the ECM.

ENGINE COMPONENT LOCATION

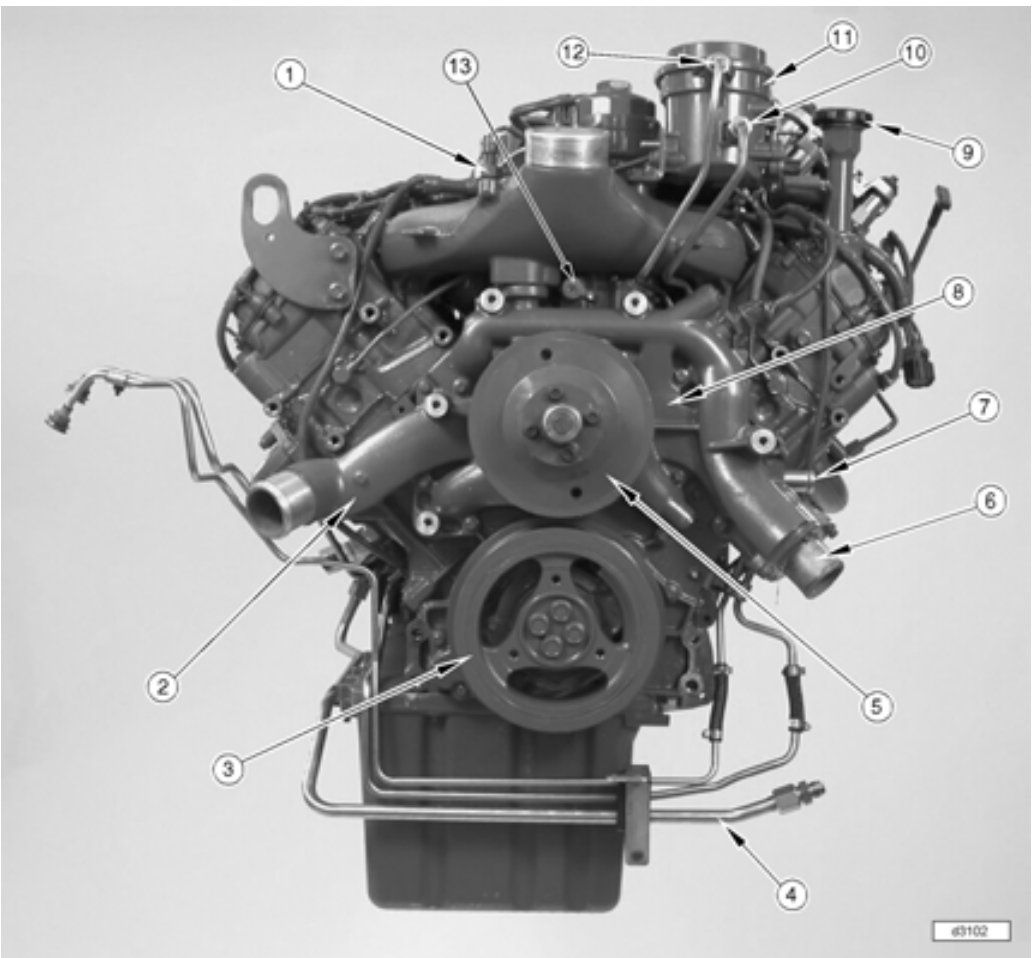

Figure 4 Component location — front

1. Manifold Absolute Pressure (MAP) sensor
2. Coolant inlet
3. Crankshaft vibration damper
4. Power steering line
5. Water pump pulley
6. Coolant outlet (thermostat)
7. Port for deaeration tank
8. Front cover housing
9. Lube oil fill
10. Fuel supply
11. Fuel filter housing
12. Fuel return / regulator
13. Lube oil pressure test port

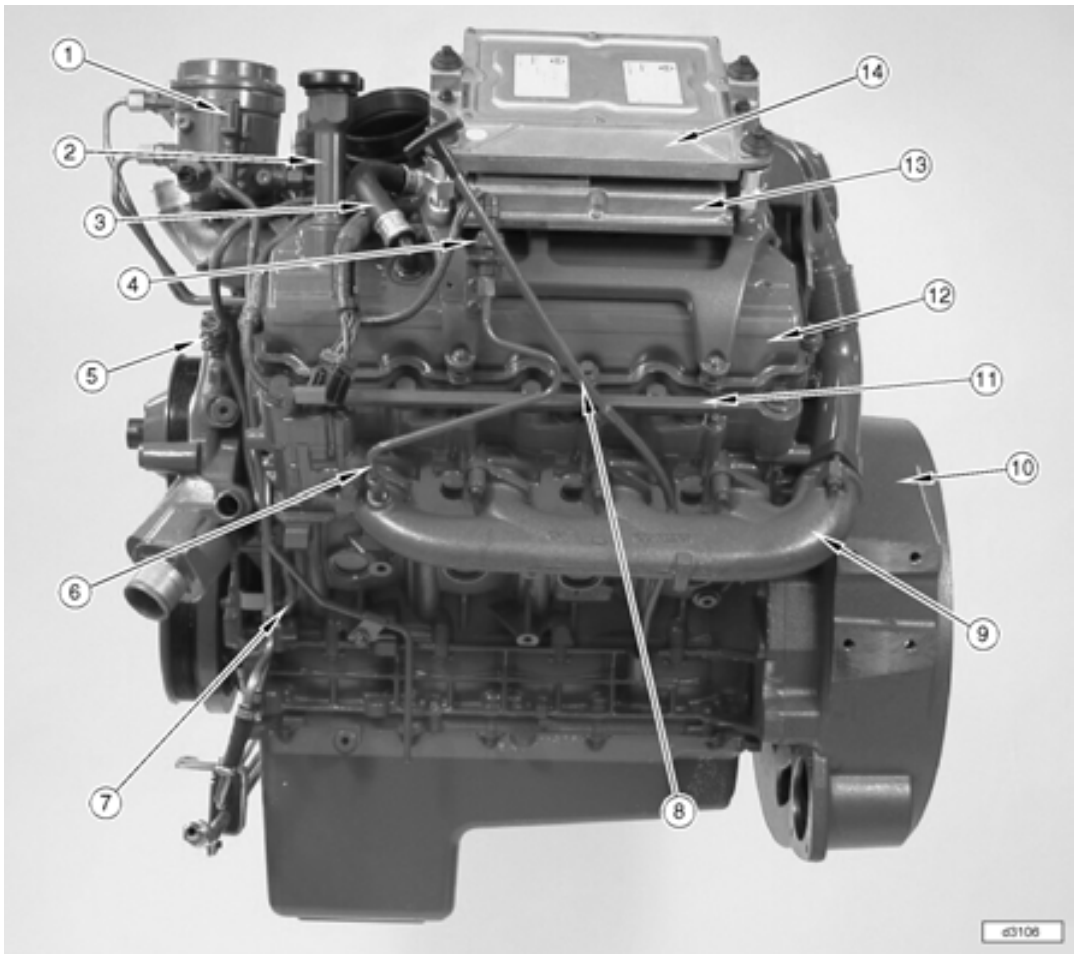

Figure 5 Component location — left

1. Fuel filter drain lever
2. Lube oil fill tube
3. Breather hose assembly with pitot tube
4. Exhaust Back Pressure (EBP) sensor
5. Engine Coolant Temperature (ECT) sensor
6. Exhaust back pressure piping
7. Camshaft Position (CMP) sensor
8. Oil level gauge and tube
9. Exhaust manifold
10. Rear cover
11. Glow plug harness rail
12. Valve cover
13. Injector Driver Module (IDM)
14. Electronic Control Module (ECM)

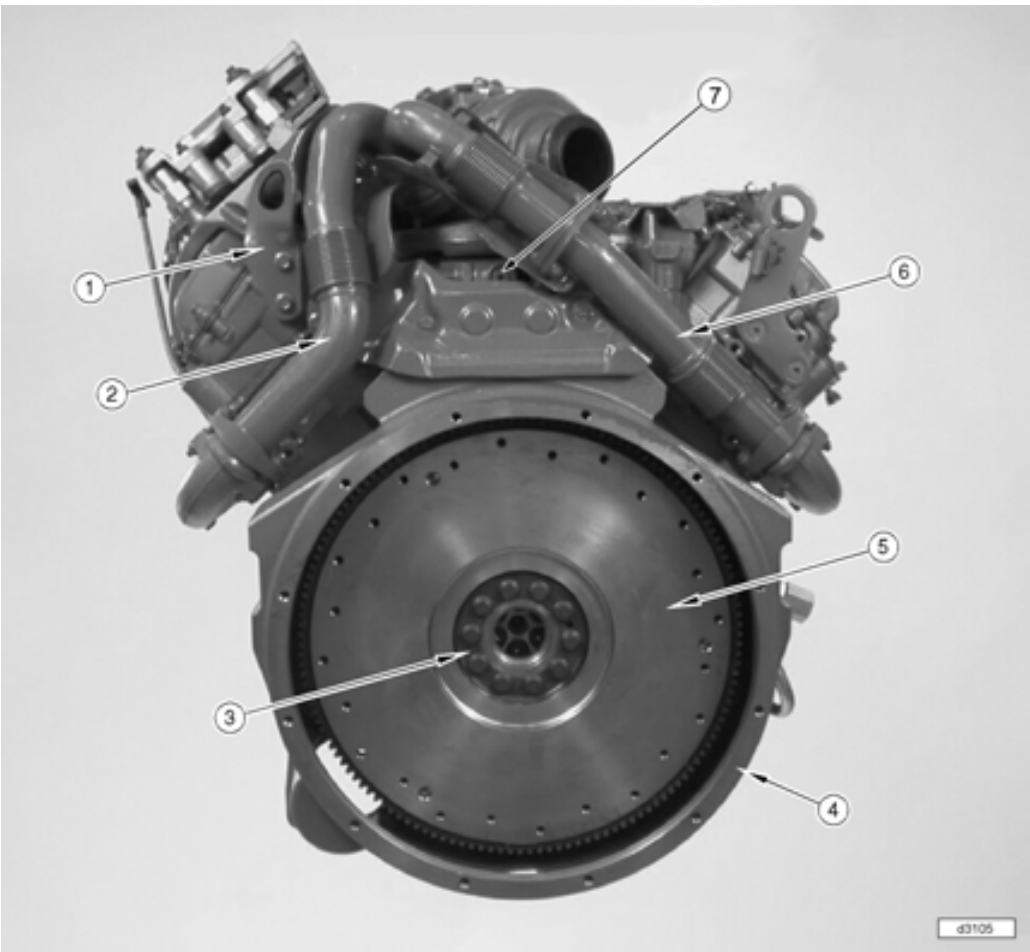

Figure 6 Component location — rear

1. Lifting eye (3)
2. Shielded tube exhaust assembly
3. Reinforcement ring
4. Rear cover
5. Flywheel (or flexplate)
6. Exhaust tube assembly, right
7. ICP system test port

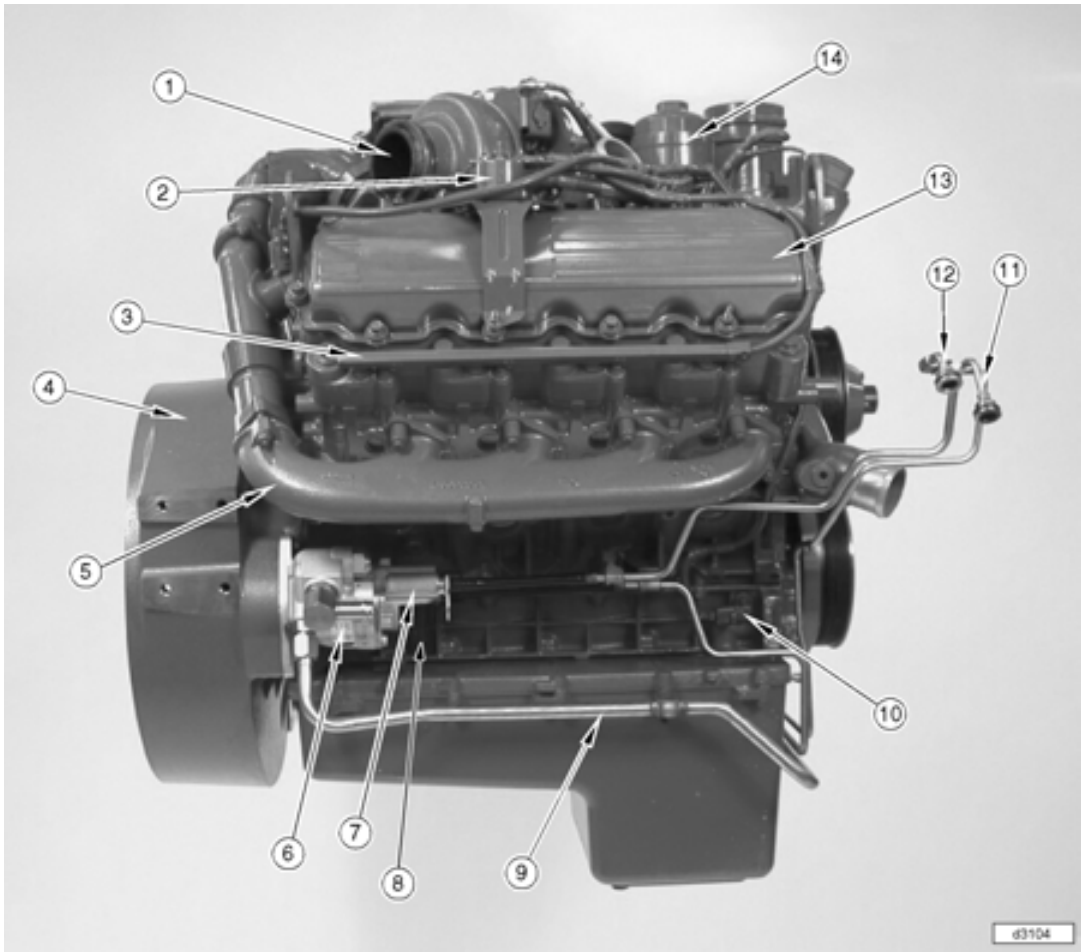

Figure 7 Component location — right

1. Turbocharger exhaust outlet
2. Glow plug relay
3. Glow plug harness rail
4. Rear cover
5. Exhaust manifold
6. Power steering pump
7. Fuel supply pump (transfer)
8. Fuel filter strainer
9. Power steering line
10. Crankshaft Position (CKP) sensor
11. Fuel return line
12. Fuel supply line
13. Valve cover
14. Oil filter housing

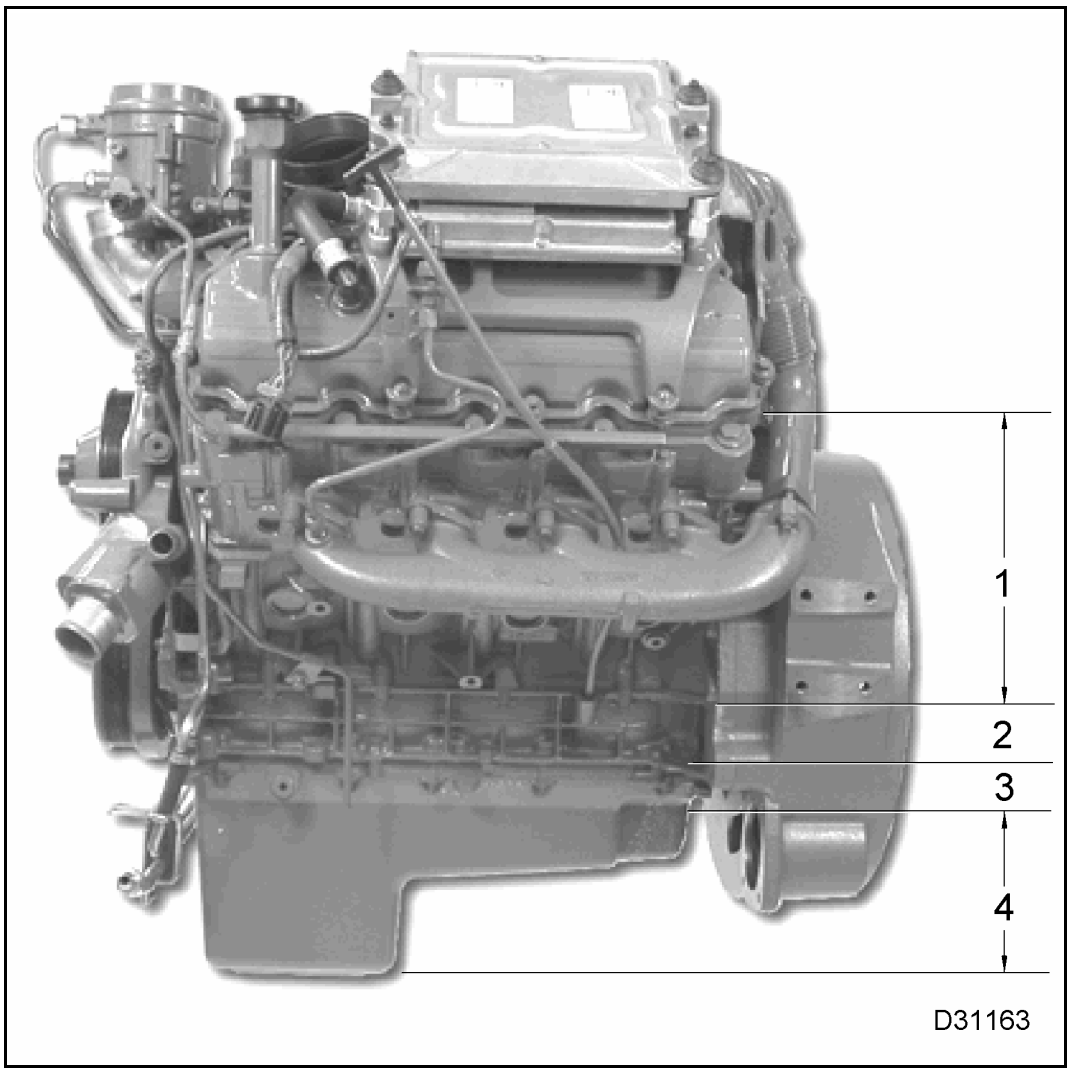

Figure 8 Crankcase and oil pan (upper and lower)

1. Upper crankcase
2. Lower crankcase
3. Upper oil pan
4. Lower oil pan

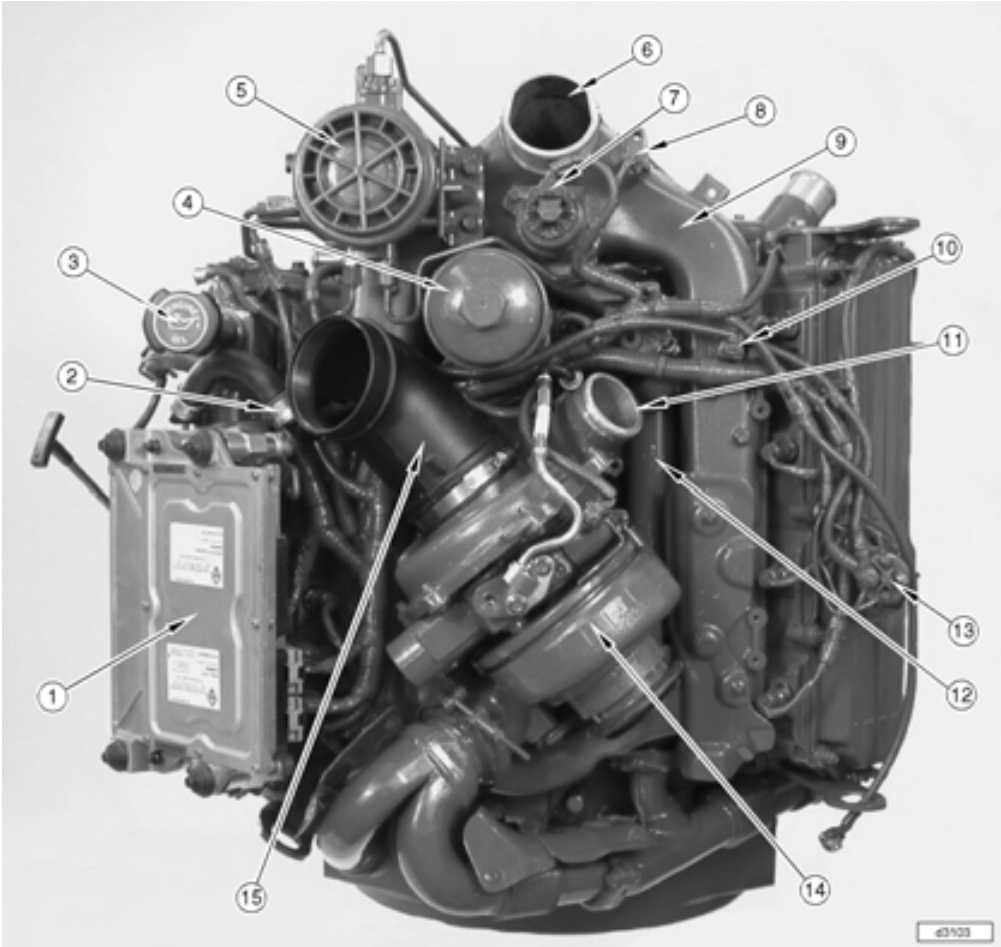

Figure 9 Component location — top

1. ECM/IDM assembly
2. Breather hose assembly with pitot tube
3. Lube oil fill
4. Oil filter housing
5. Fuel filter assembly
6. Intake manifold air inlet
7. Exhaust Gas Recirculation (EGR) valve
8. Manifold Absolute Pressure (MAP) sensor
9. Intake manifold
10. Manifold Air Temperature (MAT) sensor
11. Turbocharger air outlet (to CAC)
12. EGR cooler
13. Glow plug relay
14. EVRT™ turbocharger assembly
15. Air inlet duct

ENGINE SYSTEMS

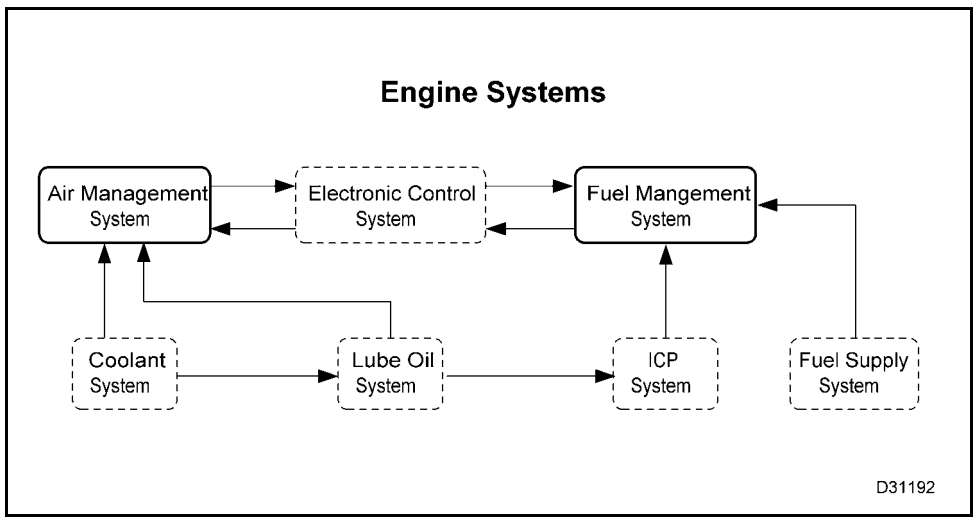

Figure 10

The primary engine systems are Air Management and Fuel Management which share some sub-systems or have a sub-system that contributes to their operation.

- The Electronic Control system controls the Air Management System and Fuel Management System.
- The Coolant System provides heat transfer for EGR gases and lubrication oil.
- The ICP system uses lube oil for hydraulic fluid to actuate the fuel injectors.
- The Fuel Supply System pressurizes fuel for transfer to the fuel injectors.
- The Lube Oil System provides lubrication and heat transfer to engine components.

AIR MANAGEMENT SYSTEM

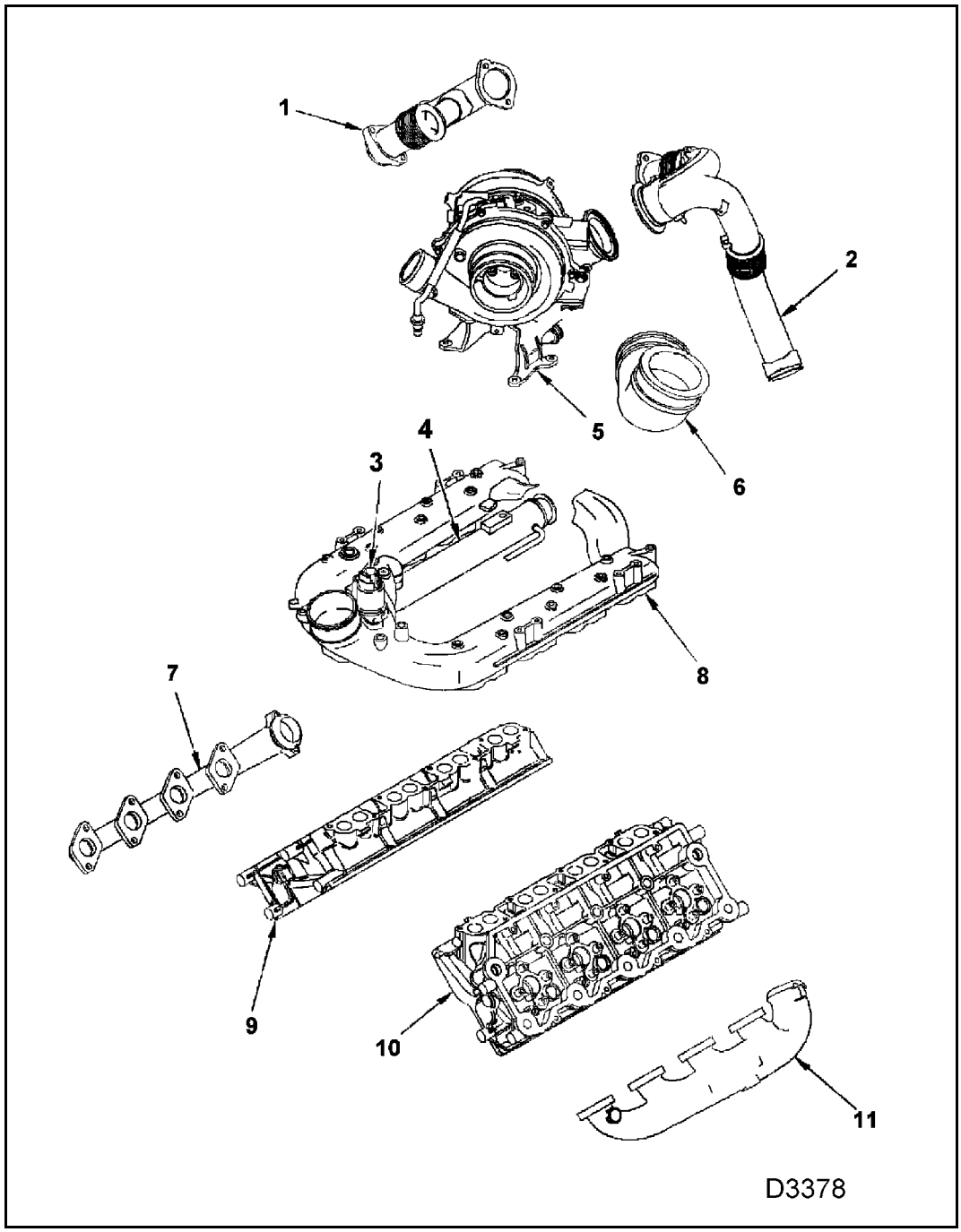

Figure 11 Air Management System (AMS)

1. Exhaust tube assembly, right
2. Shielded tube exhaust assembly
3. EGR valve
4. EGR cooler
5. EVRT™ turbocharger assembly with mounting bracket
6. Air inlet duct
7. Right exhaust manifold
8. Intake manifold
9. Right cylinder head
10. Left cylinder head
11. Left exhaust manifold

The Air Management system includes the following:

- Air filter assembly
- Closed crankcase breather
- Chassis mounted Charged Air Cooler (CAC)
- EVRT™ turbocharger
- Intake manifold
- Exhaust Gas Recirculation (EGR) system
- Exhaust system
- Catalytic converter– dependent on application
- Catalyzed Diesel Particulate Filter (CDPF) – dependent on application

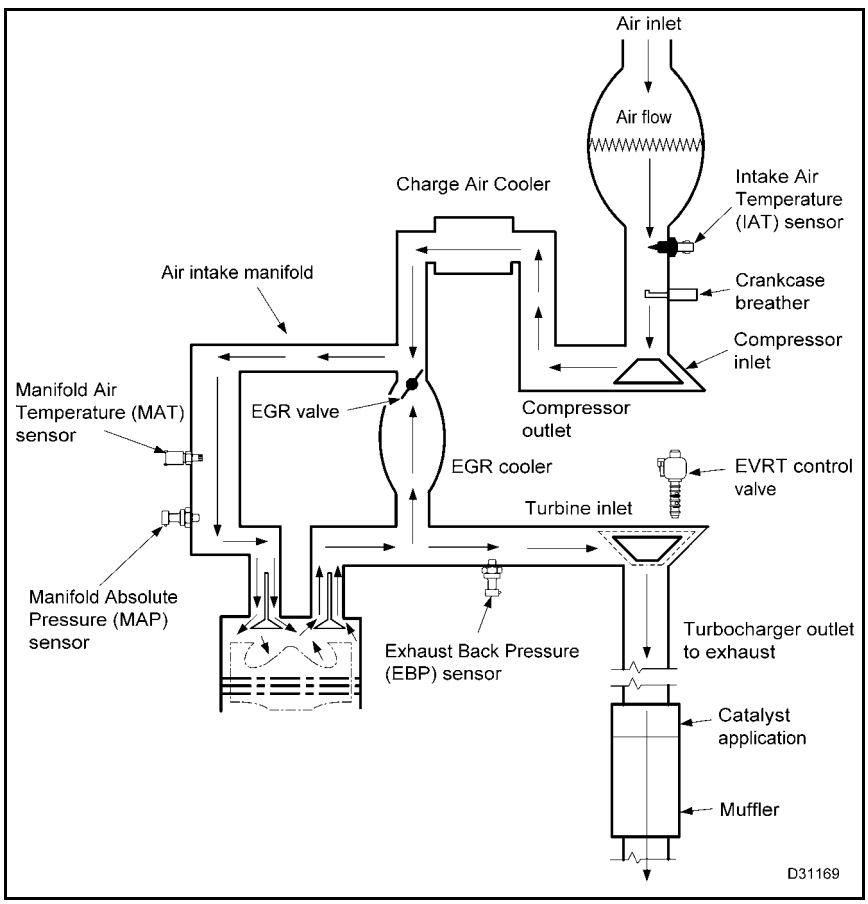

Figure 12 Air flow diagram

Air flow

Air enters and flows through the air filter assembly and mixes with air from crankcase ventilation. The turbocharger compresses the air mixture before it enters the Charge Air Cooler (CAC). Cooled compressed air flows from the CAC into the air intake manifold that directs air to the intake ports for each cylinder head.

After combustion, hot exhaust gas is forced through the exhaust manifolds to the EGR cooler and turbocharger.

- Some hot exhaust gas is cooled in the EGR cooler and flows through the EGR control valve back through the air intake manifold to mix with filtered air. This reduces nitrogen oxide (NOx) emissions and noise.
- The rest of the hot exhaust gas expands and flows to the turbocharger, spins the turbine wheel, and flows from the turbocharger outlet to the engine exhaust pipe.
- The turbocharger compressor wheel, on the same shaft as the turbine wheel, compresses the mixture of filtered air and air from crankcase ventilation.

The turbocharger responds directly to engine loads. During heavy load, an increased flow of exhaust gases turns the turbine wheel faster. This increased speed turns the compressor impeller faster and supplies more air or greater boost to the intake manifold. Conversely, when engine load is light, the flow of exhaust gases decreases and less air is pumped into the intake manifold.

The Electronic Variable Response Turbocharger (EVRT™) has been introduced to modify exhaust flow characteristics to be more efficient.

CHARGE AIR COOLER (CAC)

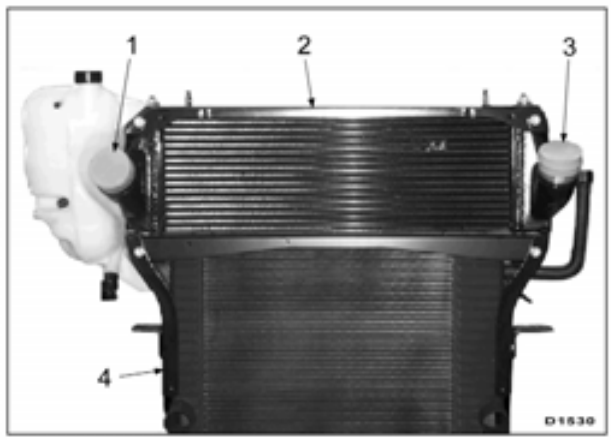

Figure 13 Charge Air Cooler

1. Air outlet
2. Charge Air Cooler
3. Air inlet
4. Radiator

The CAC cooler is on top of the radiator. Air from the turbocharger is pushed through a network of heat exchanger tubes before entering the air intake manifold. Outside air flowing over the tubes and fins cools the charged air. Charged air is cooler and denser than the uncooled air; cooler and denser air improves the fuel-to-air ratio during combustion, resulting in improved emission control and power output.

ELECTRONIC VARIABLE RESPONSE TURBOCHARGER (EVRT™)

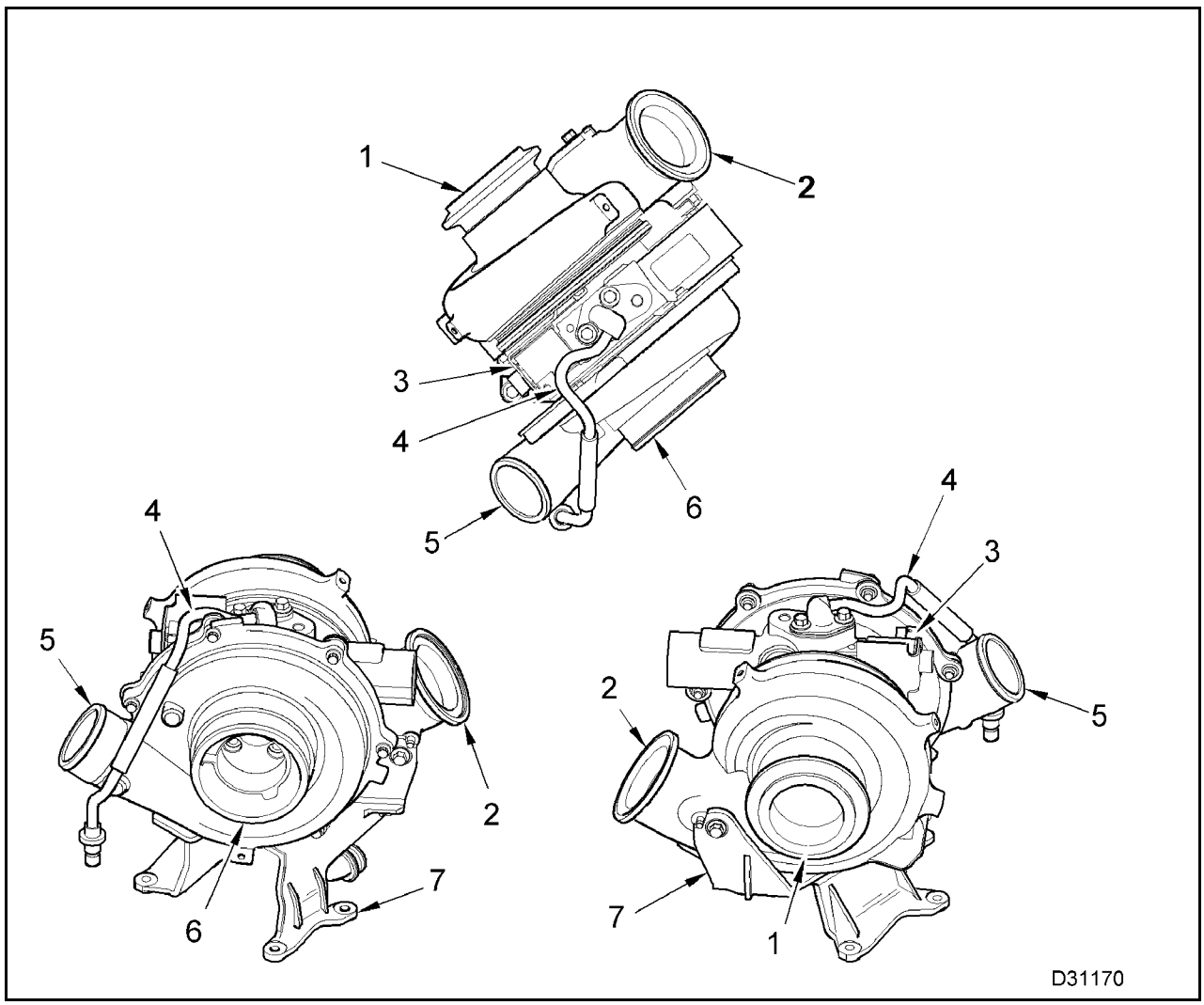

Figure 14 Electronic Variable Response Turbocharger (EVRT™)

1. Exhaust outlet
2. Exhaust inlet
3. EVRT™ control valve
4. Oil supply line
5. Compressor outlet
6. Air inlet
7. Turbocharger mounting bracket

The key feature of Electronic Variable Response Turbocharger (EVRT™) is actuated vanes in the turbine housing. The vanes modify flow characteristics of exhaust gases through the turbine housing. The benefit is the ability to control boost pressure needed to accommodate various engine speeds and load conditions. An additional benefit is lower emissions.

EVRT™ closed loop system

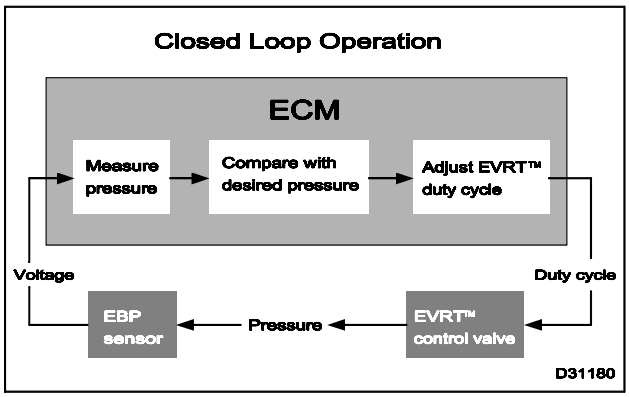

Figure 15 EVRT™ closed loop system

The EVRT™ is a closed loop system that uses the Exhaust Back Pressure (EBP) sensor to provide feedback to the ECM. The ECM uses the EBP sensor to continuously monitor EBP and adjust the duty cycle to the EVRT™ to match engine requirements.

EVRT™ control

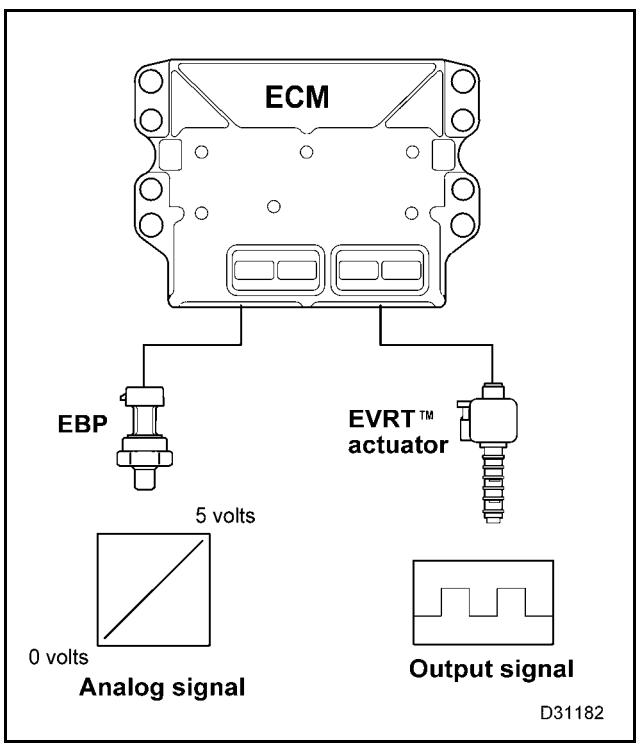

Figure 16 EVRT™ control

The solenoid receives a pulse width modulated signal from the ECM that indicates the on / off time that the control valve is energized. The control valve directs lube oil flow to both sides of the piston in the actuator housing. Directing oil to different sides of the piston increases or decreases exhaust back pressure.

Actuated vanes are mounted around the inside circumference of the turbine housing. A unison ring links all the vanes. When the unison ring moves, all vanes move to the same position. Unison ring movement occurs when either side of the actuator piston is pressurized by engine oil.

Exhaust gas flow can be regulated depending on required exhaust back pressure for engine speed and load.

NOTE: The EVRT™ is also called a Variable Geometry Turbocharger (VGT).

EXHAUST GAS RECIRCULATION (EGR) SYSTEM

The EGR system includes the following:

- EGR control valve
- EGR cooler
- Air intake manifold
- Exhaust tube assembly, right

The Exhaust Gas Recirculation (EGR) system reduces Nitrogen Oxide (NOx) emissions.

NO_x forms during a reaction between nitrogen and oxygen at high temperature during combustion. Combustion starts when fuel is injected into the cylinder before or slightly after the piston reaches top-dead-center.

EGR flow

Some exhaust from the right exhaust tube assembly flows into the EGR cooler. Exhaust from the EGR cooler flows into a passage in the air intake manifold that intersects with the EGR valve.

When EGR is commanded, the EGR control valve opens allowing cooled exhaust gases to enter the intake manifold to be mixed with filtered intake air then recycled through the combustion process. Cooling the exhaust gases increases the engine's tolerance for EGR.

EGR control valve

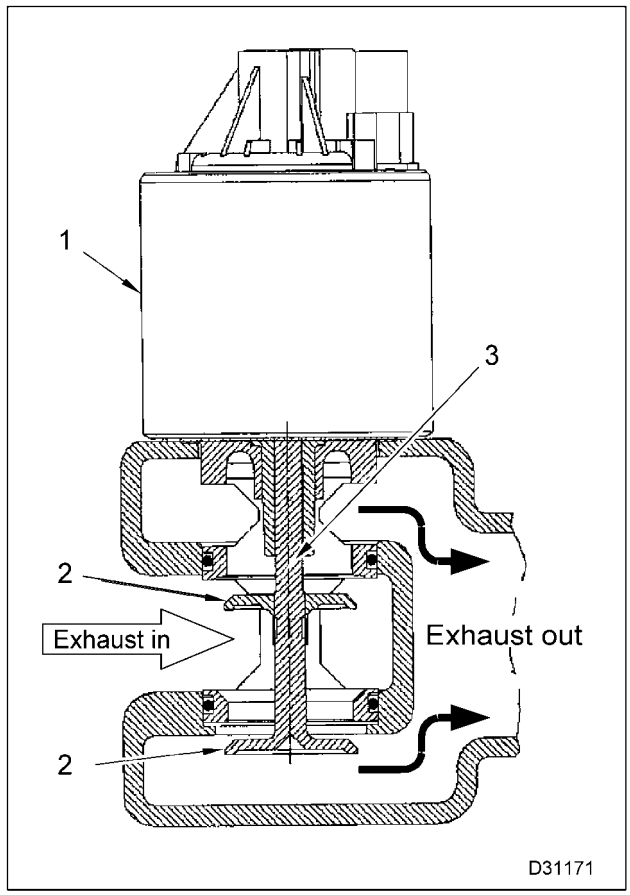

Figure 17 EGR control valve

1. Actuator coil
2. Valve heads (2)
3. Common shaft

The EGR valve uses a linear actuator to control the position of the flow-metering valve. The actuator pushes directly on the valve assembly. The valve assembly has two valve heads on a common shaft.

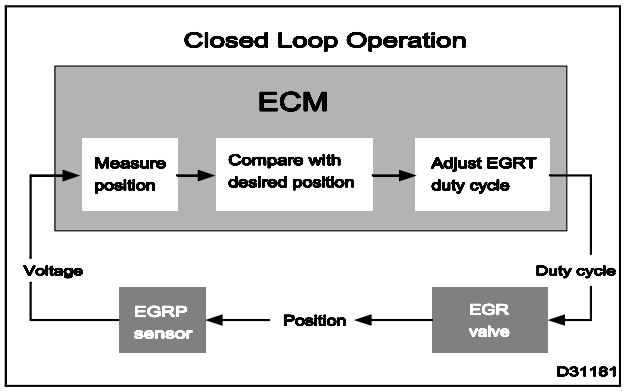

Figure 18 EGR closed loop operation

The actuator generates a magnetic force that acts directly on the valve. By changing the voltage input to the actuator coil, the available magnetic force is varied to change the valve position.

The actuator includes a built-in valve position sensor to provide the ECM with a feedback signal. The signal, based on a 5 volts (V_{REF}), is directly proportional to the valve opening. This output signal provides the information on the valve position relative to its seat.

The EGR is a closed loop system that uses the Exhaust Gas Recirculation Position sensor (EGRP) to provide feedback to the ECM. The ECM uses the EGRP sensor to continuously monitor EBP and adjust the duty cycle to the EGR control valve to match engine requirements.

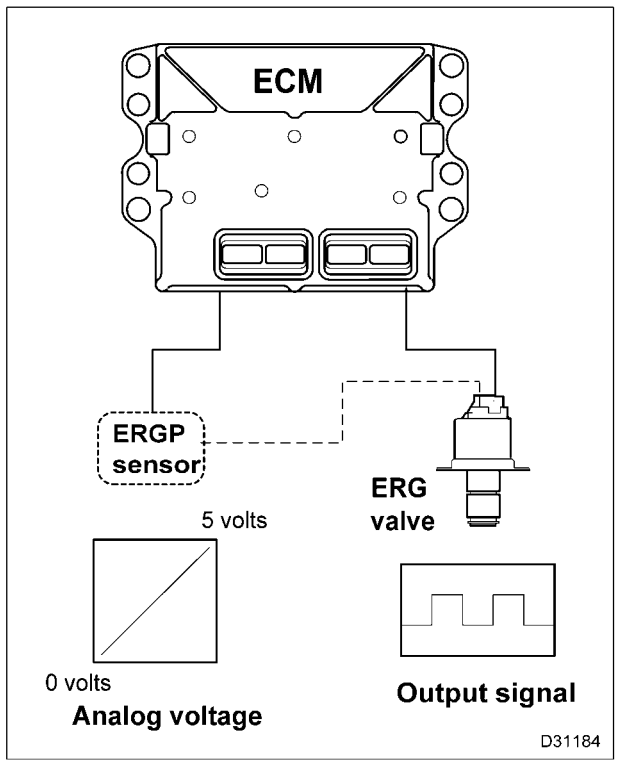

Figure 19 EGR control

The actuator coil receives a pulse width modulated signal from the ECM that indicates the on/off time that the control valve is energized

When actuated the valve shaft moves away from the actuator, unseating both valve heads at the same time. Exhaust enters the EGR valve between the two valve heads and exits through each valve head and seat interface.

EXHAUST SYSTEM

The exhaust system includes the following:

- Exhaust valves
- Exhaust manifolds
- Turbocharger
- Exhaust piping
- Muffler and catalytic converter – dependent on application
- Catalyzed Diesel Particulate Filter (CDPF) – dependent on application

The exhaust system removes exhaust gases from the engine. Exhaust gases exit from exhaust ports, through exhaust valves, and flow into the exhaust manifolds. Expanding exhaust gases are directed through the exhaust tubes. The right exhaust tube directs some exhaust gases into the Exhaust Gas Recirculation (EGR) cooler. Exhaust gases flowing into the turbocharger drive the turbine wheel. Exhaust gases exit the turbocharger and flow into the exhaust piping, through the muffler and catalytic converter or CDFP, depending on application, and out the discharge pipe to the atmosphere.

FUEL MANAGEMENT SYSTEM

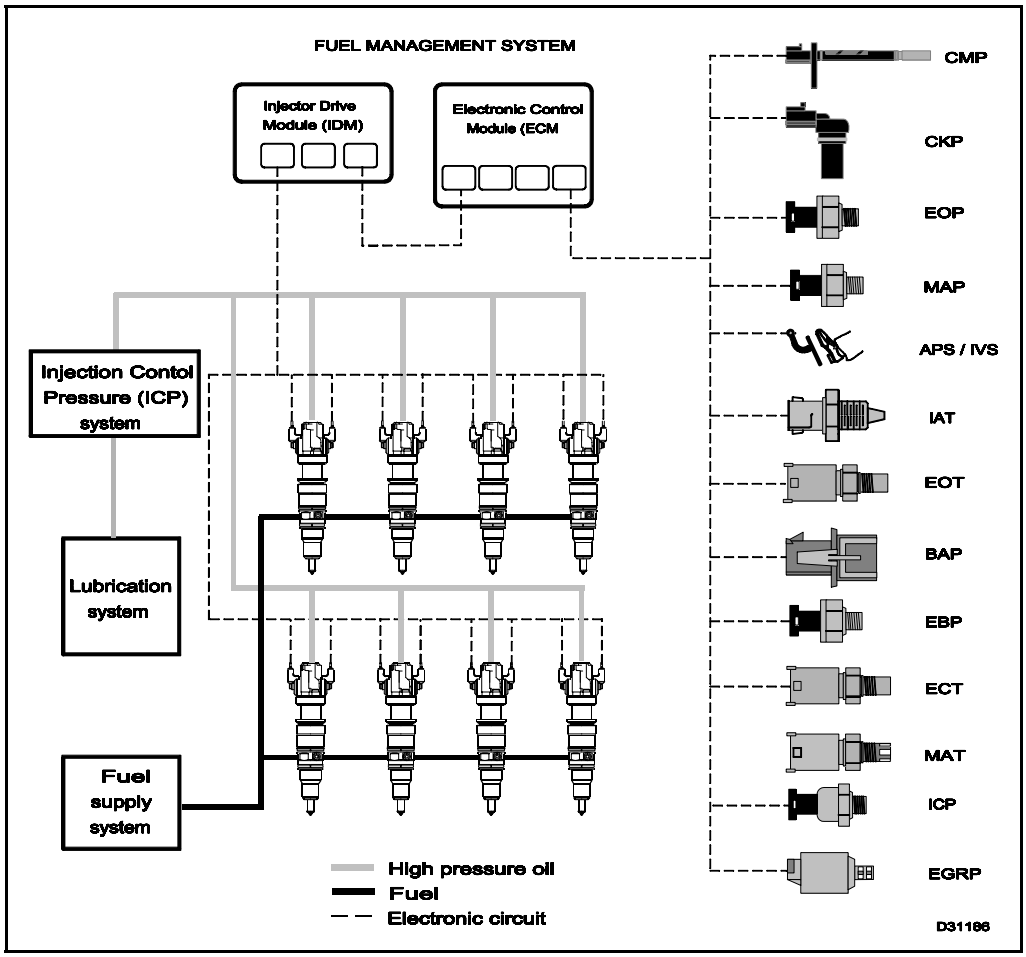

Figure 20

The fuel management system includes the following:

- Injection Control Pressure (ICP) system
- Fuel injectors
- Electronic control system
- Lubrication system
- Fuel supply system

INJECTION CONTROL PRESSURE (ICP) SYSTEM

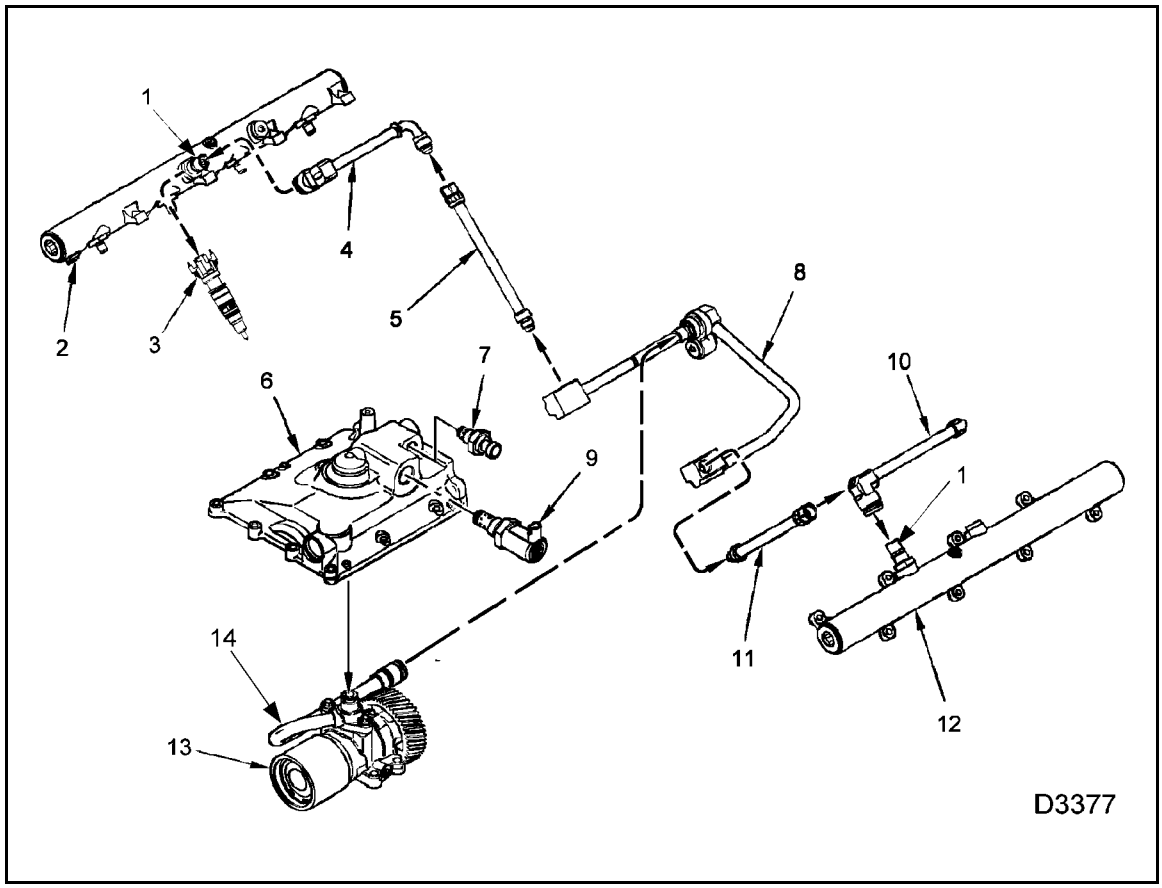

Figure 21 Injection Control Pressure (ICP) system

1. Oil rail fitting with check valve
2. High pressure oil rail (right)
3. Fuel injector
4. High pressure oil hose (right)
5. High pressure tube (crankcase to head, right)
6. High pressure oil pump cover
7. ICP sensor
8. High pressure tube assembly (rear branch)
9. IPR valve
10. High pressure oil hose (left)
11. High pressure tube (crankcase to head, left)
12. High pressure oil rail (left)
13. High pressure hydraulic pump assembly
14. Discharge tube

High pressure oil flow

Oil is drawn from the oil reservoir, filled by the engine lubrication system. The reservoir provides a constant supply of oil to a high pressure hydraulic pump inside the crankcase. The high pressure pump is a gear-driven swash-plate pump. The high pressure pump delivers high pressure oil through a discharge tube on the pump.

High pressure oil flows through the rear branch high pressure tube to each crankcase high pressure tube. Oil flows through a flexible hose attached to each high pressure tube to a check valve on the high pressure rail. The high pressure oil rail supplies high pressure oil to the top of each fuel injector.

Fuel injectors use high pressure oil when the OPEN coil is energized to pressurize and atomize the fuel into the combustion chamber. When injection is complete the CLOSED coil is energized to end injection. Oil leaves the hydraulic section of the injector near the top.

ICP Closed Loop System

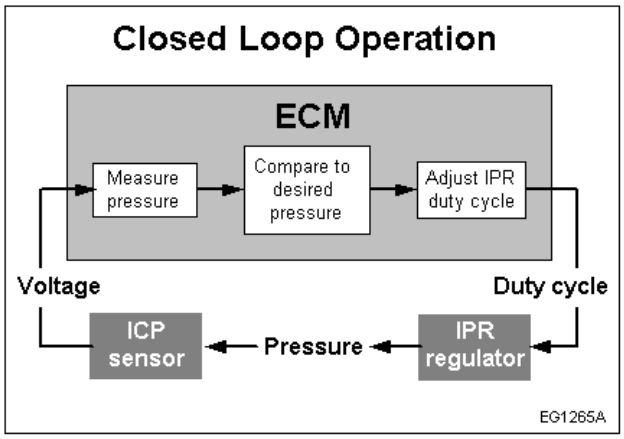

Figure 22 ICP closed loop system

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

ICP control

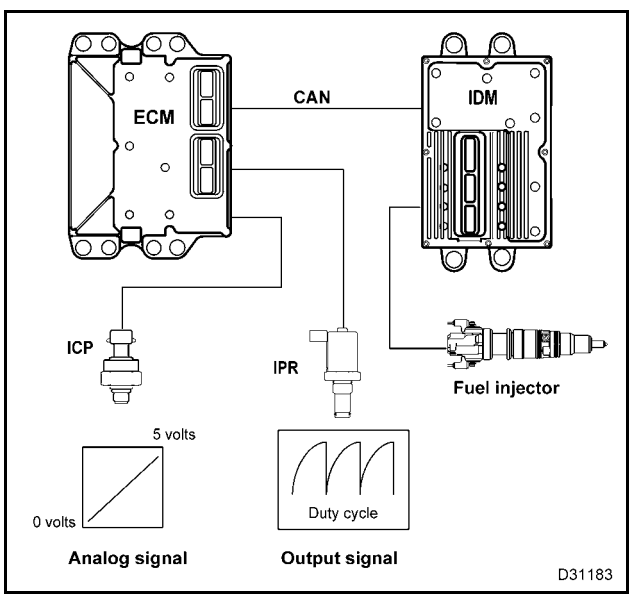

Figure 23 ICP control

ICP operation

The solenoid receives a pulse width modulated signal from the ECM that indicates the on/off time the control valve is energized. The pulse is modulated to control ICP pressure in the range of 3 to 20 MPa (500 to 3,000 psi).

The IPR valve is mounted in the high pressure pump cover. The IPR valve maintains the desired ICP by dumping excess oil out the bottom of the high pressure pump cover.

High pressure oil is routed to the IPR valve and ICP sensor through the discharge tube and passages in the high pressure pump cover.

As the demand for ICP increases, the ECM increases the pulse width to the IPR solenoid. When ICP demand decreases, the ECM decreases the (duty cycle) to the solenoid, allowing oil to flow from the drain orifice.

The ECM sets Diagnostic Trouble codes (DTCs), if the ICP electrical signal is out of range. DTCs are also set if an ICP signal corresponds to an out of range value for injection control pressure for a given operating condition.

The ECM will ignore ICP signals that are out of range. The IPR valve will operate from preprogrammed default values. This is called Open Loop.

FUEL INJECTORS

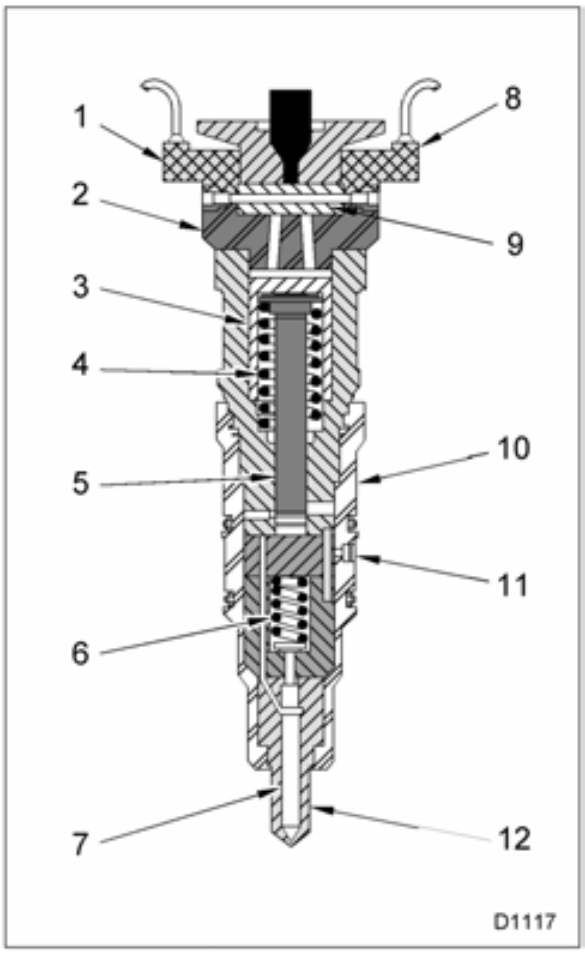

Figure 24 Fuel Injector

1. CLOSE coil
2. Control valve body
3. Intensifier piston
4. Piston return spring
5. Plunger
6. Valve opening pressure spring
7. Needle
8. OPEN coil
9. Spool valve (control valve)
10. Casenut
11. Fuel strainer (3)
12. Nozzle assembly

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 (micro second or millionth of a second). Each injector has a single four pin connector that passes through the rocker arm carrier

Injector coils and spool valve

An OPEN coil and a CLOSE coil on the injector move the spool 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 rail.
- When the spool valve is closed oil drains back to the crankcase.

Intensifier piston

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 force is also 7.1 times greater than ICP pressure on the plunger.

Plunger and barrel

Fuel pressure builds between the plunger and the barrel. When the intensifier piston pushes the plunger down, the plunger increases fuel pressure in the barrel 7.1 times greater than ICP. The plunger has tungsten carbide coating to reduce scuffing and poor performance.

Injector needle

The injector needle opens inward, off its seat when fuel pressure overcomes the Valve Opening Pressure (VOP) – approximately 21 MPa (3100 psi). Fuel is atomized at high pressure through the nozzle tip.

Fuel injector operation

The injection operation has three stages:

- Fill stage
- Main injection
- End of main injection

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 rail is dead headed at the spool valve.

Low pressure fuel fills the port below the plunger. The needle control spring holds the needle on its seat to prevent fuel from entering the combustion chamber.

Main injection (Step 1)

A pulse width current energizes the OPEN coil. Magnetic force moves the spool open. High pressure oil flows past the spool valve into the intensifier piston chamber. Oil pressure overcomes the force of the intensifier piston spring and the intensifier starts to move. An increase in fuel pressure under the plunger seats the fuel inlet check ball. Fuel pressure starts to build once the plunger passes the fuel spill port of the barrel. Force on the needle begins to build.

Main injection (Step 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 rail 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 – about 21 MPa (3100 psi) – the needle lifts of its seat and injection begins.

End of main injection (Step 1)

When the Injector Drive Module (IDM) determines that the correct injector On Time has been reached (meaning the correct amount of fuel has been delivered), the IDM sends 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 dead headed against the spool valve.

End of main injection (Step 2)

The pulse width controlled current to the CLOSE coil is shut off, but the spool valve remains closed. The intensifier piston and plunger return to their initial position. Oil above the intensifier piston flows past the spool valve through the exhaust ports. Fuel pressure decreases until the needle control spring forces the needle back onto its seat.

FUEL SUPPLY SYSTEM

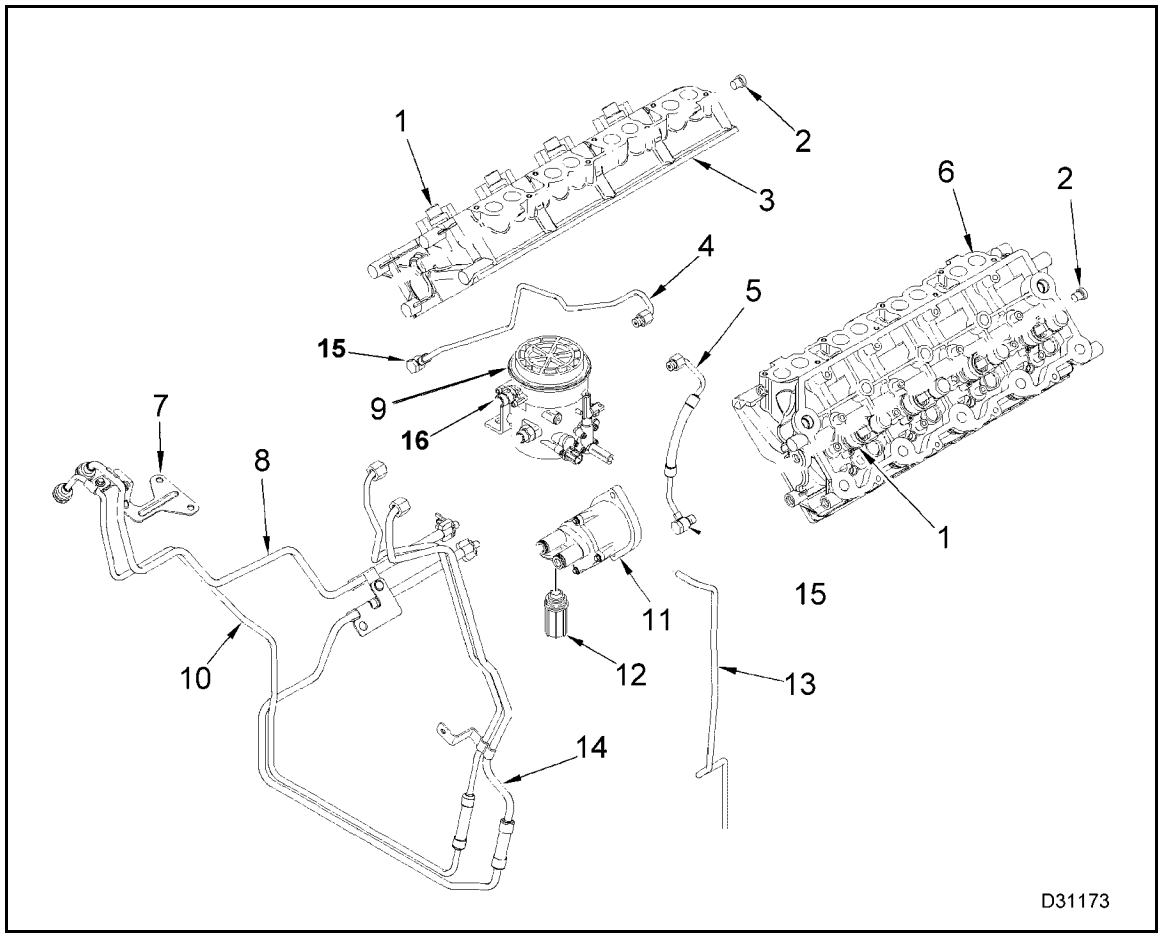

Figure 25 Fuel supply system

1. Fuel injector assembly (8)
2. Plug assembly, fuel rail (2)
3. Cylinder head (right)
4. Fuel supply line (right cylinder head)
5. Fuel supply line (left cylinder head)
6. Cylinder head (left)
7. Fuel tube mounting bracket
8. Fuel supply tube from tank
9. Fuel filter housing assembly
10. Fuel supply and return tube assembly
11. Fuel and power steering pump assembly (gear driven)
12. Fuel filter pre-strainer
13. Fuel filter water drain tube assembly
14. Fuel inlet tube
15. 12 mm banjo bolt with check valve (2)
16. Fuel filter regulator valve assembly

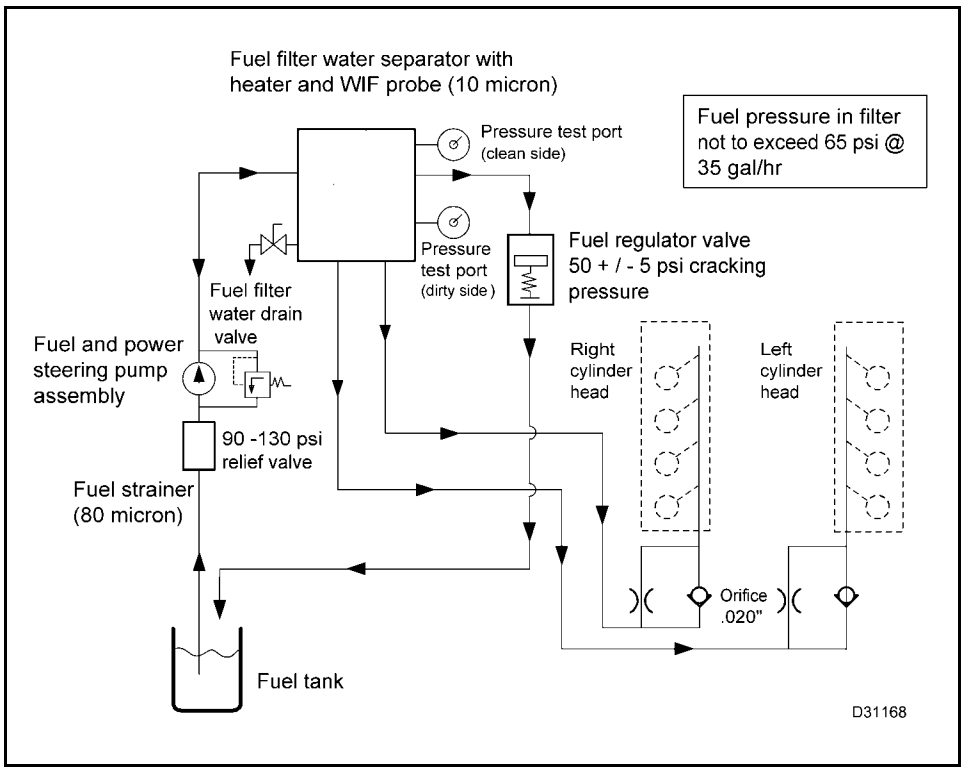

Figure 26 Fuel system schematic

The fuel supply system includes the following:

- Check valve banjo bolts
- Fuel tank(s)
- Fuel filter and housing
- Fuel supply lines
- Fuel passages in cylinder heads
- Fuel pressure regulator and fuel return lines
- Fuel supply pump (transfer)

FUEL FLOW

The fuel pump draws fuel from the fuel tank(s). Fuel passes through an 80 micron strainer on the pump. The fuel pump pressurizes and transfers fuel to the base of the fuel filter housing.

- The fuel filter housing regulates fuel pressure and relieves excessive pressure back to the fuel tank(s) through a fuel line connected to the top of the fuel filter housing. The fuel pressure regulator is calibrated to open at 345 kPa (50 psi) but at high rpm, low load pressure could reach more than 517 kPa (75 psi).
- The fuel is conditioned as it passes through a 10 micron filter to a standpipe in the center of the fuel filter housing.
- An optional electric heating element in the fuel filter housing warms the fuel to prevent waxing.
- A sensor in the base of the fuel housing detects water in the fuel. When enough water accumulates in the bottom of the housing, the sensor sends a signal to light the optional Water In Fuel (WIF) lamp on the instrument panel.
- A fuel drain valve on the housing is used to eliminate contaminants (usually water) from the fuel housing.
- Filtered fuel flows from the fuel filter housing to both cylinder heads through fuel lines.

Fuel flows past check valves through passages in the cylinder heads that intersect with the fuel injectors.

ENGINE LUBRICATION SYSTEM

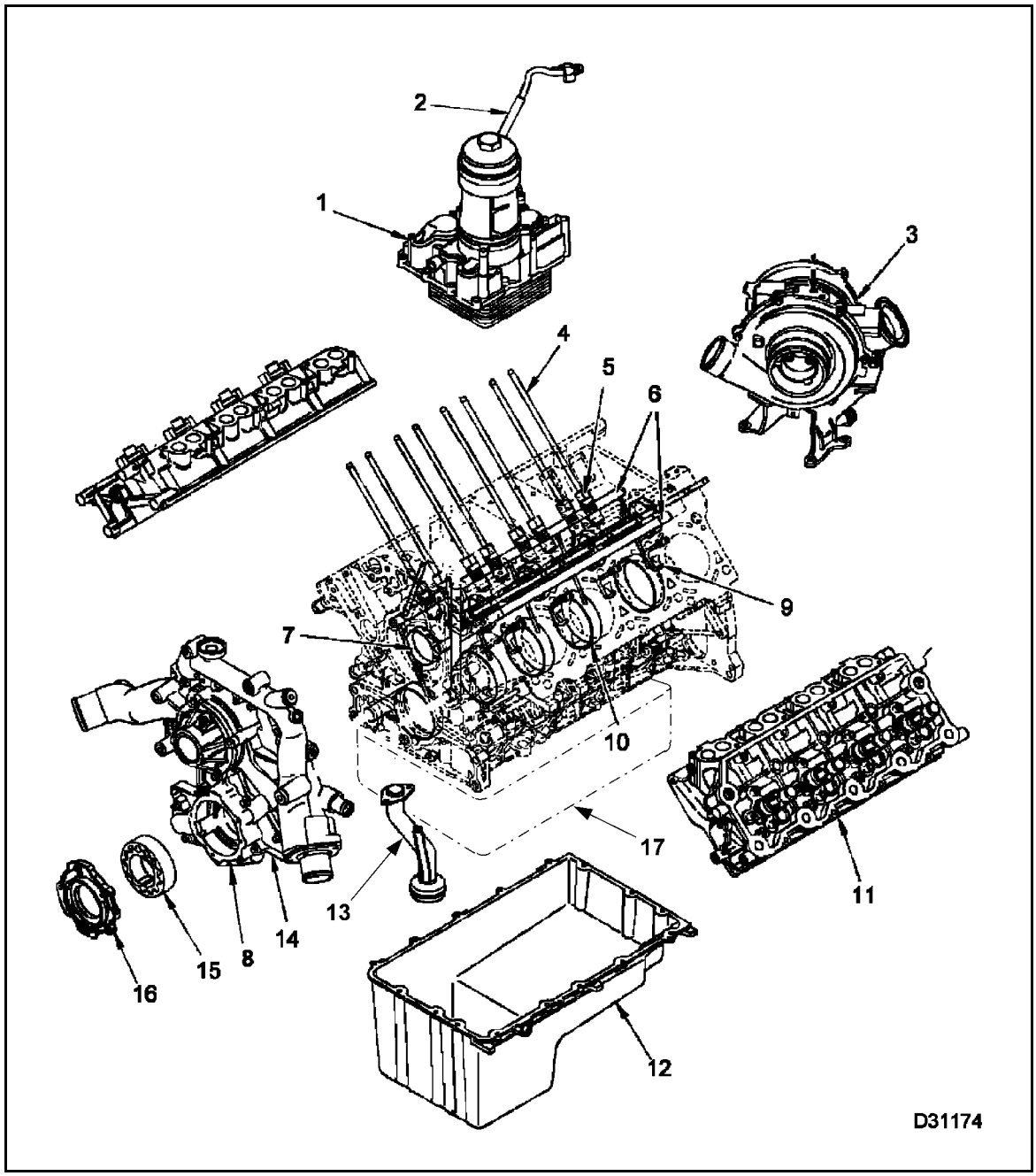

Figure 27 Lubrication system

1. Oil cooler cover with filter base
2. Turbocharger oil supply line
3. Turbocharger assembly
4. Push rod (16)
5. Valve lifter (16)
6. Main lube oil gallery (2)
7. Cam bushing (5)
8. Oil regulator valve
9. Piston cooling tube (8)
10. Main bearing insert (10)
11. Cylinder head (2)
12. Lower oil pan
13. Oil pick up tube
14. Front cover housing
15. Gerotor assembly
16. Gerotor housing cover
17. Upper oil pan

Oil Flow

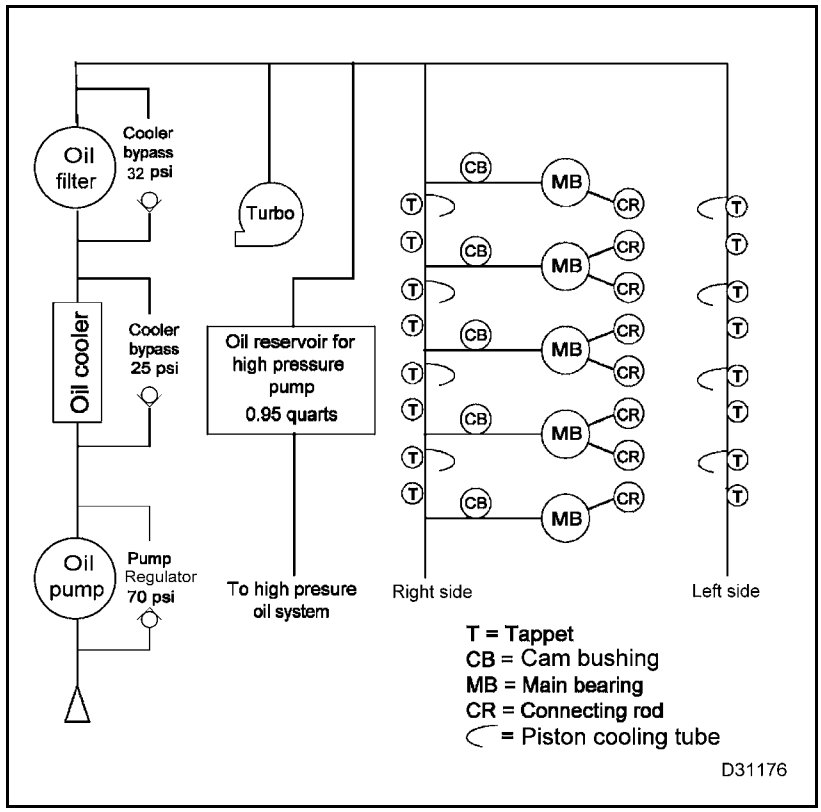

Figure 28 Lubrication System Schematic

The lubrication system is pressure regulated, cooled, and full flow filtered.

Oil is drawn from the oil pan through the pickup tube, upper oil pan, lower crankcase, and the front cover to the gerotor oil pump.

The gerotor oil pump includes the front cover assembly, gerotor assembly (inner and outer gears), and the gerotor housing cover. The crankshaft drives the inner rotor gear of the gerotor pump.

The gerotor pump pressurizes lube oil. Pressurized lube oil flows from the front cover through a passage in the lower crankcase. Lube oil from the lower crankcase flows through a passage in the upper crankcase to the oil cooler base. Passages in the oil cooler base direct lube oil and coolant.

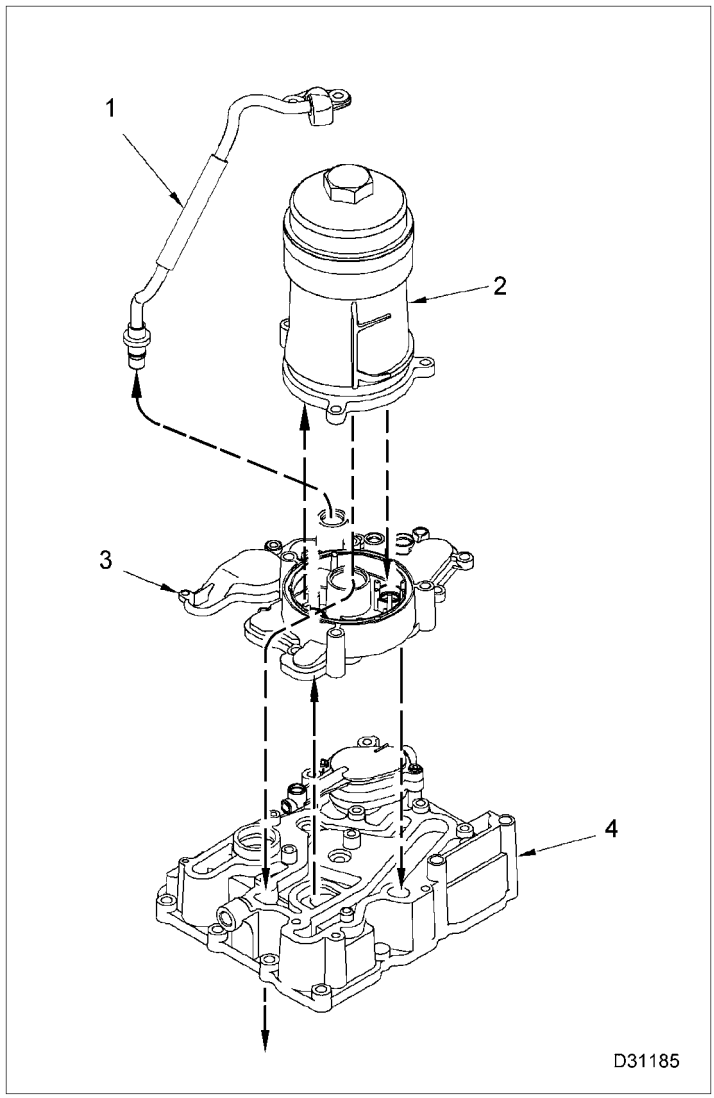

Figure 29 Oil cooler base and oil filter base

1. Turbocharger oil supply tube assembly
2. Oil filter housing
3. Oil filter base assembly
4. Oil cooler cover

Lube oil is routed from the front of the oil cooler cover to the back where it enters the oil cooler. Lube oil is cooled as it flows from the back of the oil cooler to the front into the oil filter housing.

- If the oil cooler is restricted, a bypass valve in the oil filter base will open and allow oil to bypass the oil cooler going directly to the oil filter housing.

Oil flows to the oil filter element. Oil passes through the outside of the element to the inside of the element, down the stand pipe, back into the oil filter base, and into the oil cooler base.

The oil filter base directs filtered oil in four ways:

- One passage supplies filtered oil to oil temperature sensor, oil pressure sensor, the oil supply tube for the EVRT™, and oil supply for the air compressor (optional).

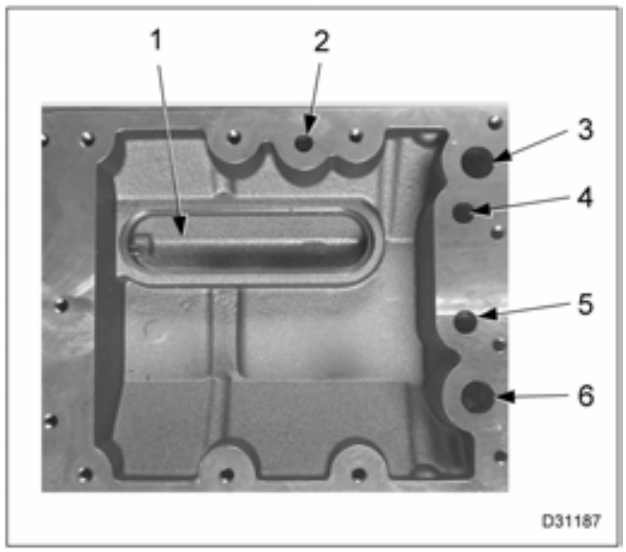

Figure 30 Oil reservoir in crankcase

1. Oil feed to high pressure pump
2. Oil filter drain to pan
3. Oil feed to oil cooler cover
4. Oil feed to left side of main lube oil gallery
5. Oil feed to right side of main lube oil gallery
6. Coolant feed to oil cooler

- A second passage supplies filtered oil to the reservoir in the crankcase for the high pressure pump and ICP system.

Two other passages supply filtered oil for the following:

Left side

- Main lube oil gallery
- Push rod and rocker arms
- Piston cooling tubes

Right Side

- Main lube oil gallery
- Push rod and rocker arms
- Piston cooling tubes
- Cam bushings
- Crankshaft main bearings
- Connecting rod bearings

When the oil filter is removed, oil flows from a drain valve in the oil filter base back to the oil pan.

COOLING SYSTEM

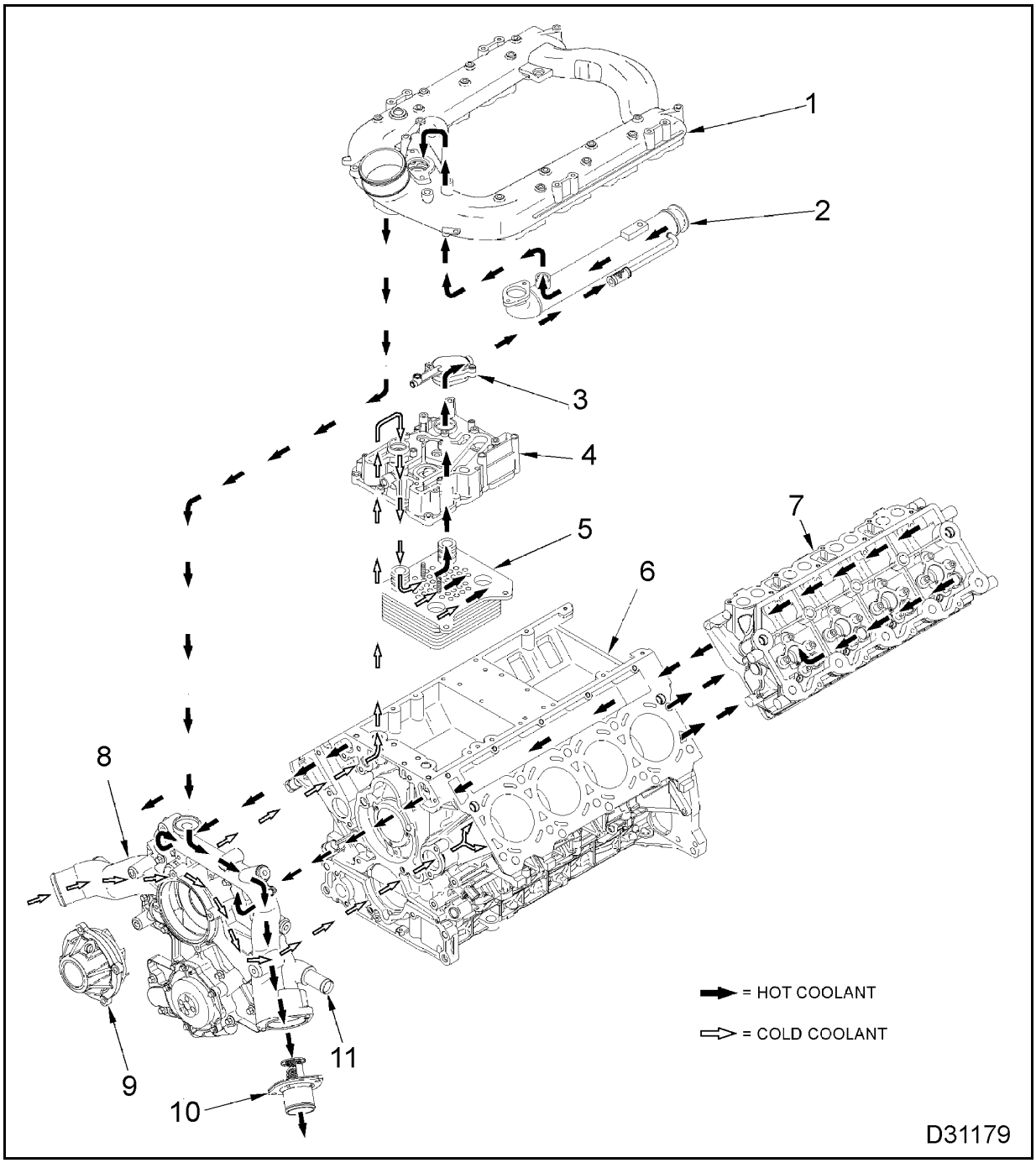

Figure 31 Engine coolant components

1. Intake manifold
2. EGR cooler
3. Coolant outlet cap
4. Oil cooler cover
5. Oil cooler (not serviced separately)
6. Crankcase
7. Cylinder head
8. Front cover housing
9. Water pump
10. Thermostat assembly
11. Coolant deaeration fitting (to deaeration tank)

The cooling system keeps the engine within a designated temperature range.

The centrifugal water pump (hub and impeller) is mounted in the pump housing of the front cover. The water pump has a built in reservoir to catch small amounts of coolant that may seep past the seal.

CAUTION: The water pump impeller may be damaged if dropped, or hit by a hard object.

Front cover housing flow

The water pump draws coolant from the radiator through inlet of the front cover housing. Coolant flows from the water pump through three passages in the front cover.

- Two passages (left and right) direct coolant into the crankcase (front to rear) to cool the cylinder walls and the cylinder heads.
- The third passage directs coolant through a passage in the crankcase to the oil cooler cover.

NOTE: If an oil cooler seal is damaged, weep holes in the oil filter base allow coolant to seep from the cooler cover.

Coolant returns to the water pump through three passages in the front cover.

- Two passages (left and right) from the crankcase direct coolant to the front cover.
- A third passage directs coolant from the intake manifold to the front cover.

Return coolant is directed to the thermostat in the front cover.

- If the thermostat is open, coolant flows to the radiator.
- If the thermostat is closed, coolant returns to the water pump through a bypass passage in the front cover, because the radiator outlet is blocked.

As the engine reaches operating temperatures, the thermostat opens and directs coolant to the radiator. This also restricts the bypass opening.

Crankcase and cylinder head flow

Coolant flows through passages in the front cover to the left and right sides of the crankcase. Coolant flows through the front of both sides of the crankcase, evenly distributing coolant around the cylinders, and exits the rear of the crankcase flowing up to the cylinder heads.

Coolant flows from the rear of the cylinder heads to the front of the cylinder heads, exits down a passage in the crankcase, and returns to the front cover.

Oil cooler and EGR cooler flow

The front cover directs coolant to a passage in the crankcase. Coolant flows from the crankcase to the front of the oil cooler cover. The oil cooler and the oil filter base direct coolant to the front of the oil cooler.

Coolant flows through the oil cooler from the front to rear and exits through the EGR cooler supply port.

Coolant flows from the rear of the EGR cooler to the front returning to the front cover though a passage in the intake manifold.

- The deaeration port is on top of the intake manifold.
- For engines equipped with an air compressor the deaeration point is at the air compressor and intake manifold.

NOTE: Earlier engines have a single line from the air compressor to the deaeration tank. Later engines have two lines. One from the intake and one from the air compressor that intersect one line to the deaeration tank.

ELECTRONIC CONTROL SYSTEM

ELECTRONIC CONTROL MODULE (ECM)

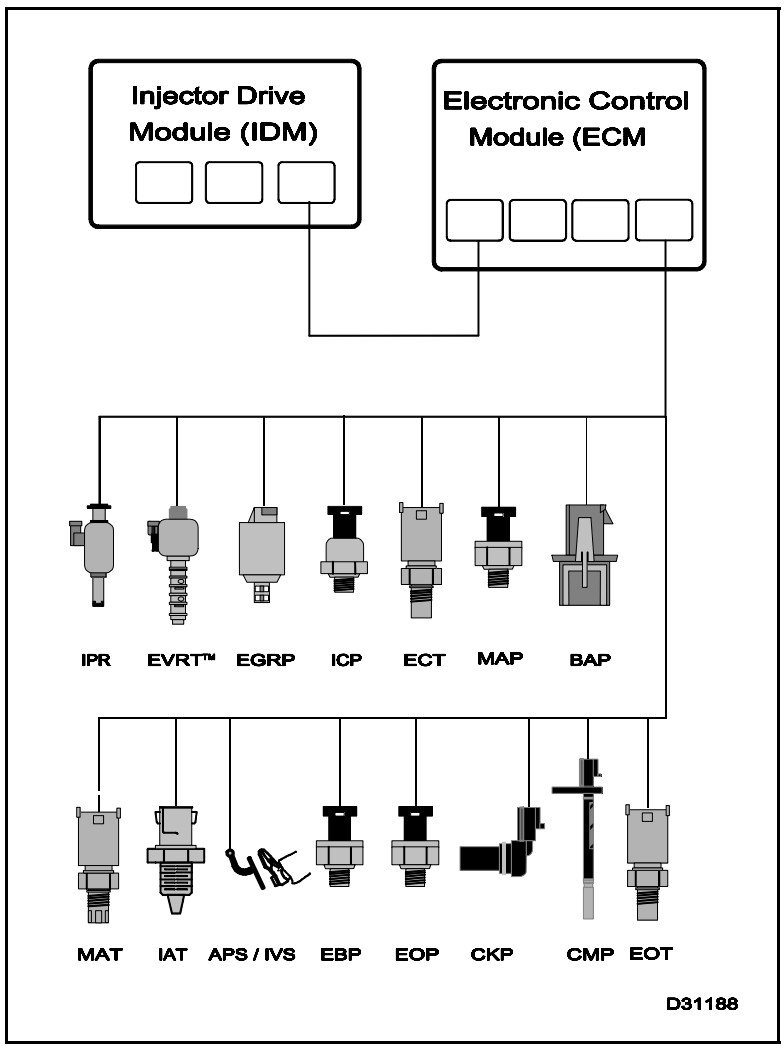

Figure 32

Operation and function

The Electronic Control Module (ECM) monitors and controls engine performance to ensure maximum performance and adherence to emissions standards. The ECM has four primary functions:

- Provides Reference Voltage (V_{REF})
- Conditions input signals
- Processes and stores control strategies
- Controls actuators

1. Reference voltage (V_{REF})

The ECM supplies a 5 volt V_{REF} signal to input sensors in the electronic control system. By comparing the 5 volt V_{REF} 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 two independent circuits for V_{REF}:

- V_{REF} A supplies 5 volts to engine sensors
- V_{REF} B supplies 5 volts to vehicle sensors

2. 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.

3. Microprocessor

The ECM internal 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 operating strategy for all engine operations.

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

- Foreground calculations are much 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 a slower rates. Engine temperature is an example.

Diagnostic Trouble Codes (DTCs) are generated 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 to achieve the 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 key OFF or when ECM power is interrupted. ROM information 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 conditions. Temporary information in RAM is lost when the ignition key is turned OFF or when ECM power is interrupted. RAM information includes the following:

- Engine temperature
- Engine rpm
- Accelerator pedal position

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

Actuators are controlled in three ways (determined by the kind of actuator):

- A duty cycle (percent time on/off)
- A controlled pulse width
- Switched on or off

ECM Control of Engine Operation

The ECM controls engine operation with the following:

- EVRT™ control valve
- EGR valve
- IPR valve
- Glow plug relay

Electronic Variable Response Turbocharger (EVRT™) control valve

The EVRT™ control valve is an actuator on top of the EVRT™. The EVRT™ control valve is a variable position valve that controls vane position in the turbine housing. The valve position is controlled by a switching voltage source in the ECM. The ground circuit is supplied directly from the battery ground at all times.

The actuator control is achieved by setting a pulse width modulated signal in response to engine speed, desired fuel quantity, boost or exhaust back pressure and altitude.

Exhaust Gas Recirculation (EGR) valve

The EGR valve controls the flow of exhaust gases into the intake manifold. The EGR valve has an actuator to control the valve position and a position sensor to provide a feedback signal to the ECM. The valve position is controlled by switching the ground circuit in the ECM. The voltage source is supplied by the ECM power relay. The actuator control is achieved by setting a pulse width modulated signal in response to engine speed, desired fuel quantity, boost or exhaust back pressure and altitude.

Injection Pressure Regulator (IPR)

The IPR valve controls pressure in the Injection Control Pressure (ICP) system. The IPR valve is a variable position valve controlled by the ECM. This regulated pressure actuates the fuel injectors. The valve position is controlled by switching the ground circuit in the ECM. The voltage source is supplied by the ignition switch.

Glow plug relay

The ECM activates the glow plug relay. The relay delivers V_{BAT} to the glow plugs for up to 120 seconds, depending on ambient temperature and altitude. The ground cicuit is supplied directly from the battery ground at all times. Relay is controlled by switching on a voltage source from the ECM.

INJECTION DRIVE MODULE (IDM)

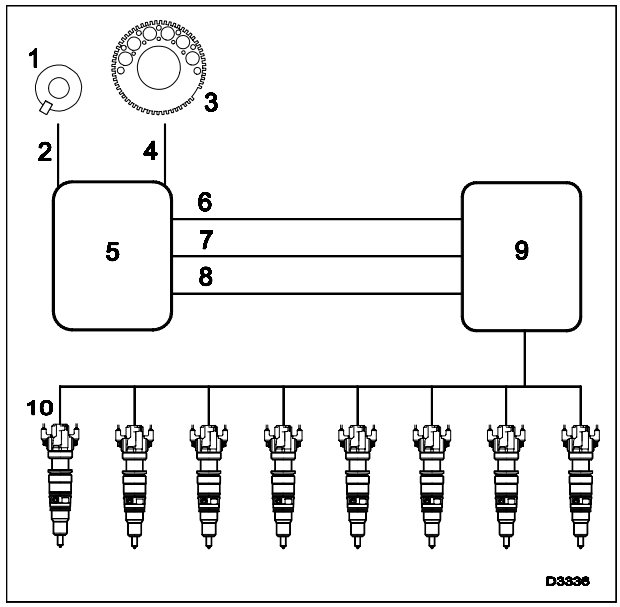

Figure 33 Injection Drive Module (IDM)

1. Camshaft with peg
2. Camshaft Position (CMP) signal
3. Crankshaft position sensor timing disk
4. Crankshaft Position (CKP) signal
5. Electronic Control Module (ECM)
6. Camshaft Position Output (CMPO) signal
7. Crankshaft Position Output (CKPO) signal
8. Controller Area Network (CAN 2) communication
9. Injection Drive Module (IDM)
10. Fuel injectors

The IDM has three functions:

- Electronic distributor for injectors
- Power source for injectors
- IDM and injector diagnostics

Electronic distributor for injectors

The IDM distributes current to the injectors. The IDM controls fueling to the engine by sending high voltage pluses to the OPEN and CLOSE coils of the injector. The IDM uses information from the ECM to determine the timing and quantity of fuel for each injector.

The ECM uses CMP and CKP input signals to calculate engine speed and position. The ECM conditions both input signals and supplies the IDM with CMP and CKP output signals. The IDM uses

CMP and CKP output signals to determine the correct sequence for injector firing.

The ECM sends information (fuel volume, EOT, and ICP) through the CAN 2 link to the IDM; the IDM uses this information to calculate the injection cycle.

Injector Power Source

The IDM creates a constant 48 volt (DC) supply to all injectors by making and breaking a 12 volt source across a coil in the IDM. The 48 volts created by the collapsed field is stored in capacitors until used by the injectors.

The IDM controls when the injector is turned on and how long the injector is active. The IDM first energizes the OPEN coil, then the CLOSE coil. The low side driver supplies a return circuit to the IDM for each injector coil (open and close). The high side driver controls the power supply to the injector. During each injection event, the low and high side drivers are switched on and off for each coil.

IDM and injector diagnostics

The IDM determines if an injector is drawing enough current. The IDM sends a fault to the ECM, indicating potential problems in the wiring harness or injector, and the ECM will set a DTC. The IDM also does self-diagnostic checks and sets a DTC to indicate failure of the IDM.

On demand tests can be done using the Electronic Service Tool (EST). The EST sends a request to the ECM, the ECM sends a request to the IDM to do a test. Some tests generate a DTC when a problem exists. Other tests require the technician to evaluate parameters, if a problem exists.

ENGINE AND VEHICLE SENSORS

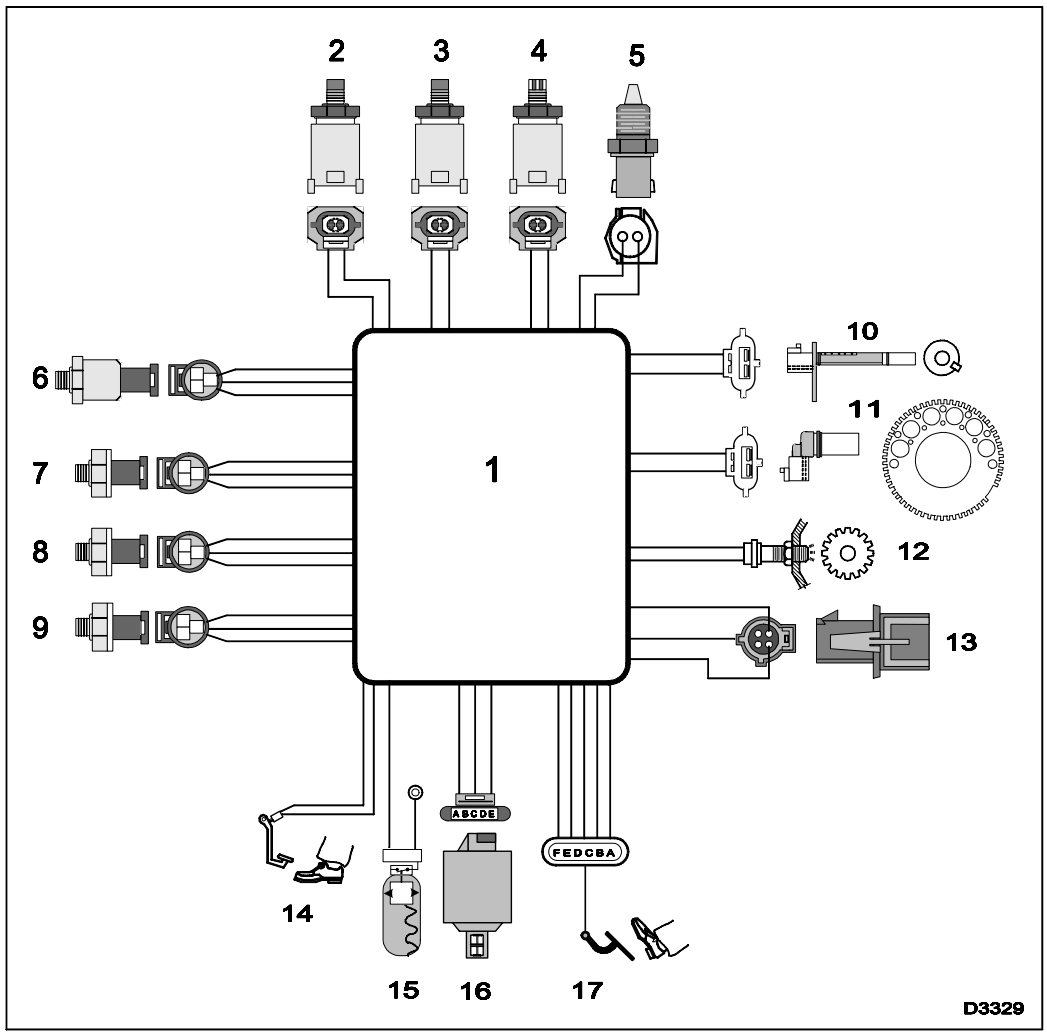

Figure 34 Engine and Vehicle Sensors

1. Electronic Control Module (ECM)
2. Engine Oil Temperature (EOT)
3. Engine Coolant Temperature (ECT)
4. Manifold Air Temperature (MAT)
5. Intake Air Temperature (IAT)
6. Injection Control Pressure (ICP)
7. Exhaust Back Pressure (EBP)
8. Engine Oil Pressure (EOP)
9. Manifold Absolute Pressure (MAP)
10. Camshaft Position (CMP)
11. Crankshaft Position (CKP)
12. Vehicle Speed Sensor (VSS)
13. Barometric Absolute Pressure (BAP)
14. Driveline Disengagement Switch (DDS)
15. Engine Coolant Level (ECL)
16. Exhaust Gas Recirculation valve Position (EGRP)
17. Accelerator Position Sensor (APS)

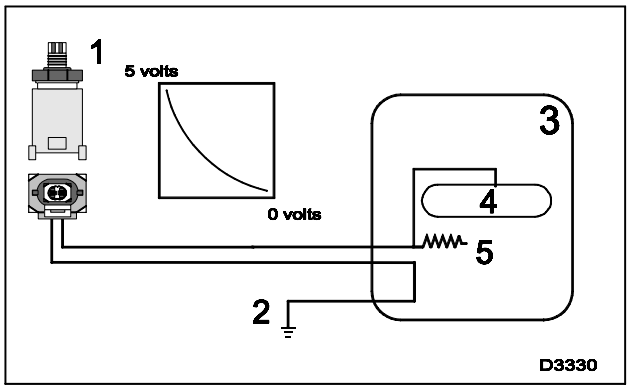

Figure 35 Thermistor

1. Temperature sensor
2. Ground
3. Electronic Control Module (ECM)
4. Microprocessor
5. Voltage Reference (Vref)

Thermistors

- ECT
- EOT
- IAT
- MAT

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

The top half of the voltage divider is the current limiting resistor that is internal to the ECM. A thermistor sensor has two electrical connectors, signal return and ground. The output of a thermistor sensor is a non-linear analog signal.

Engine Coolant Temperature (ECT)

The ECM monitors the ECT signal and uses this information for the instrument panel temperature gauge, coolant compensation, Engine Warning Protection System (EWPS), and glow plug operation. The ECT is a backup, if the EOT is out of range. The ECT sensor is installed in the left side of the front cover.

Engine Oil Temperature (EOT)

The ECM monitors the EOT signal to control fuel quantity and timing during the operating range of the engine. The EOT signal allows the ECM and IDM to compensate for differences in oil viscosity for temperature changes. This ensures that power and torque are available for all operating conditions. The EOT sensor is installed in the oil filter base.

Intake Air Temperature (IAT)

The ECM monitors the IAT signal to control timing and fuel rate during cold starts. The IAT sensor is chassis mounted on the air filter housing.

Manifold Air Temperature (MAT)

The ECM monitors the MAT signal for EGR operation. The MAT sensor is installed in the right side of the intake manifold.

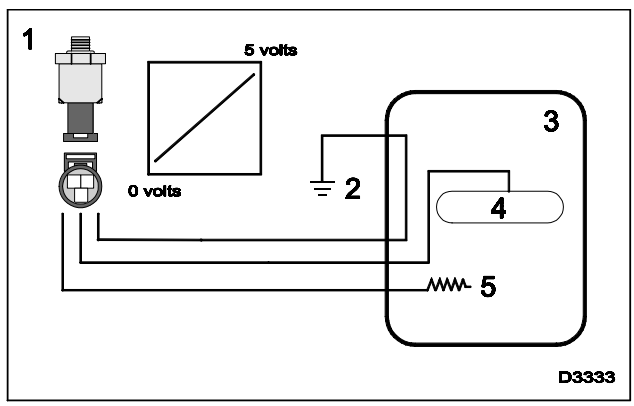

Figure 36 Variable capacitance sensor

1. Pressure sensor
2. Ground
3. Electronic Control Module (ECM)
4. Microprocessor
5. Voltage reference (Vref)

Variable capacitance sensors

- BAP
- EBP
- EOP
- ICP
- MAP

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 three wires:

- V_{REF}
- Signal return
- Signal ground

The sensor receives the V_{REF} and returns an analog signal voltage to the ECM. The ECM compares the voltage with preprogrammed 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.

Barometric Absolute Pressure (BAP)

The ECM monitors the BAP signal to determine altitude, adjust timing, fuel quantity, and glow plug operation. The BAP sensor is in the cab.

Engine Oil Pressure (EOP)

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 oil filter base.

Exhaust Back Pressure (EBP)

The ECM monitors EBP signal to determine exhaust back pressure. This sensor provides feedback to the ECM for closed loop control EVRT™. The EBP sensor is on a bracket on the left side of the engine just below the ECM.

Injection Control Pressure (ICP) sensor

The ECM monitors the ICP signal to determine the 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 ICP control. The ICP sensor is installed in the cover for high pressure oil pump.

Manifold Absolute Pressure (MAP)

The ECM monitors the MAP signal to determine intake manifold pressure (boost). This information is used to control fuel rate and injection timing. The MAP sensor is installed on the top front of the intake manifold.

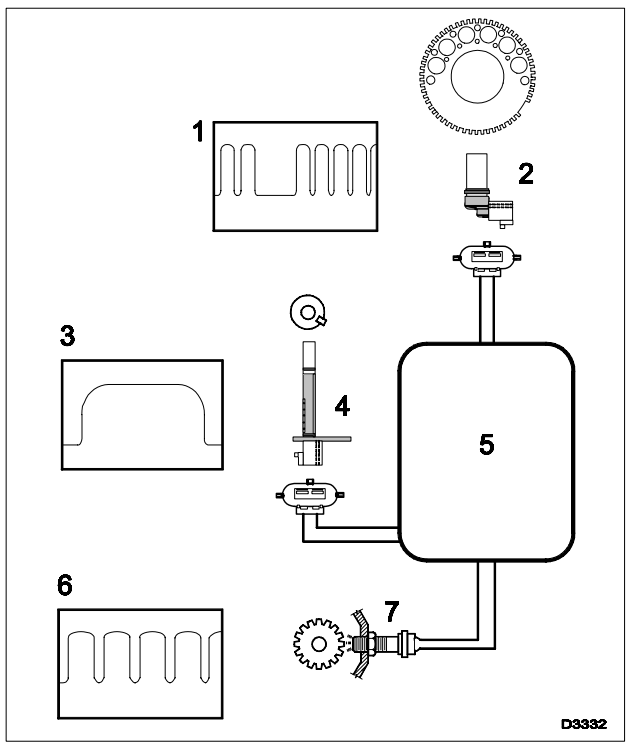

Figure 37 Magnetic pickups

1. Crankshaft Position (CKP) signal
2. Crankshaft Position (CKP) sensor
3. Camshaft position (CMP) signal
4. Camshaft position (CMP) sensor
5. Electronic Control Module (ECM)
6. Vehicle speed signal
7. Vehicle Speed Sensor (VSS)

Magnetic pickup sensors

- CKP
- CMP
- VSS

A magnetic pickup sensor generates an alternating frequency that indicates speed. Magnetic pickups have a two wire connection for signal and ground. This sensor has a permanent magnetic core surrounded by a wire coil. The signal frequency is generated by

the rotation of gear teeth that disturb the magnetic field.

Crankshaft Position (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. From the CKP signal frequency compared to the CMP signal frequency, the ECM can calculate engine rpm and timing requirements. The CKP is installed in the front right side of the lower crankcase.

Camshaft Position (CMP)

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 is installed in the front left side of the crankcase.

Vehicle Speed Sensor (VSS)

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

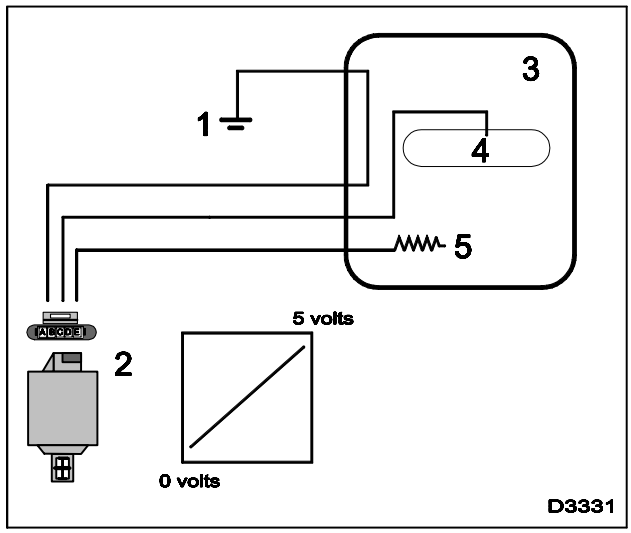

Figure 38 Potentiometer

1. Ground
2. Exhaust Gas Recirculation valve Position (EGRP) sensor
3. Electronic Control Module (ECM)
4. Microprocessor
5. Voltage reference (Vref)

Potentiometers

- APS
- EGRP

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.

Accelerator Position Sensor (APS)

The APS provides the ECM with a feedback signal (linear analog voltage) that indicates the operator's demand for power. The APS is mounted in the accelerator pedal. In the same application, a remote accelerator or throttle device can be used in addition to the accelerator pedal.

Exhaust Gas Recirculation valve Position (EGRP) sensor

The ECM monitors the EGRP sensor signal to determine the EGR valve position. EGRP sensor provides feedback to the ECM for closed loop control

of EGR. The EGRP sensor is part of the EGR valve, mounted on the top of the intake manifold.

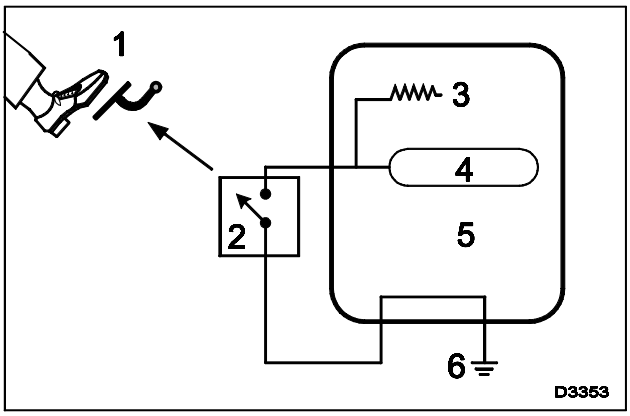

Figure 39 Switch

1. Accelerator pedal
2. Idle Validation Switch (IVS)
3. Voltage source with current limiting resistor
4. Microprocessor
5. ECM
6. Ground

Switches

- DDS
- ECL
- IVS

Switch sensors indicate position. They operate open or closed, allowing or preventing 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 closed, causing a zero voltage signal. Grounding switches are usually installed in series with a current limiting resistor.

Driveline Disengagement Switch (DDS)

The DDS determines if a vehicle is in gear. For manual transmissions, the clutch switch serves as the DDS. For automatic transmissions, the neutral switch functions as the DDS.

Engine Coolant Level (ECL)

The ECL switch is used in plastic deaeration tanks. When the magnetic switch is open, the tank is full.

The ECL lamp on the instrument panel signals the operator if engine coolant is low. ECL is part of the Engine Warning Protection System (EWPS)

Idle Validation Switch (IVS)

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

GLOW PLUG CONTROL SYSTEM

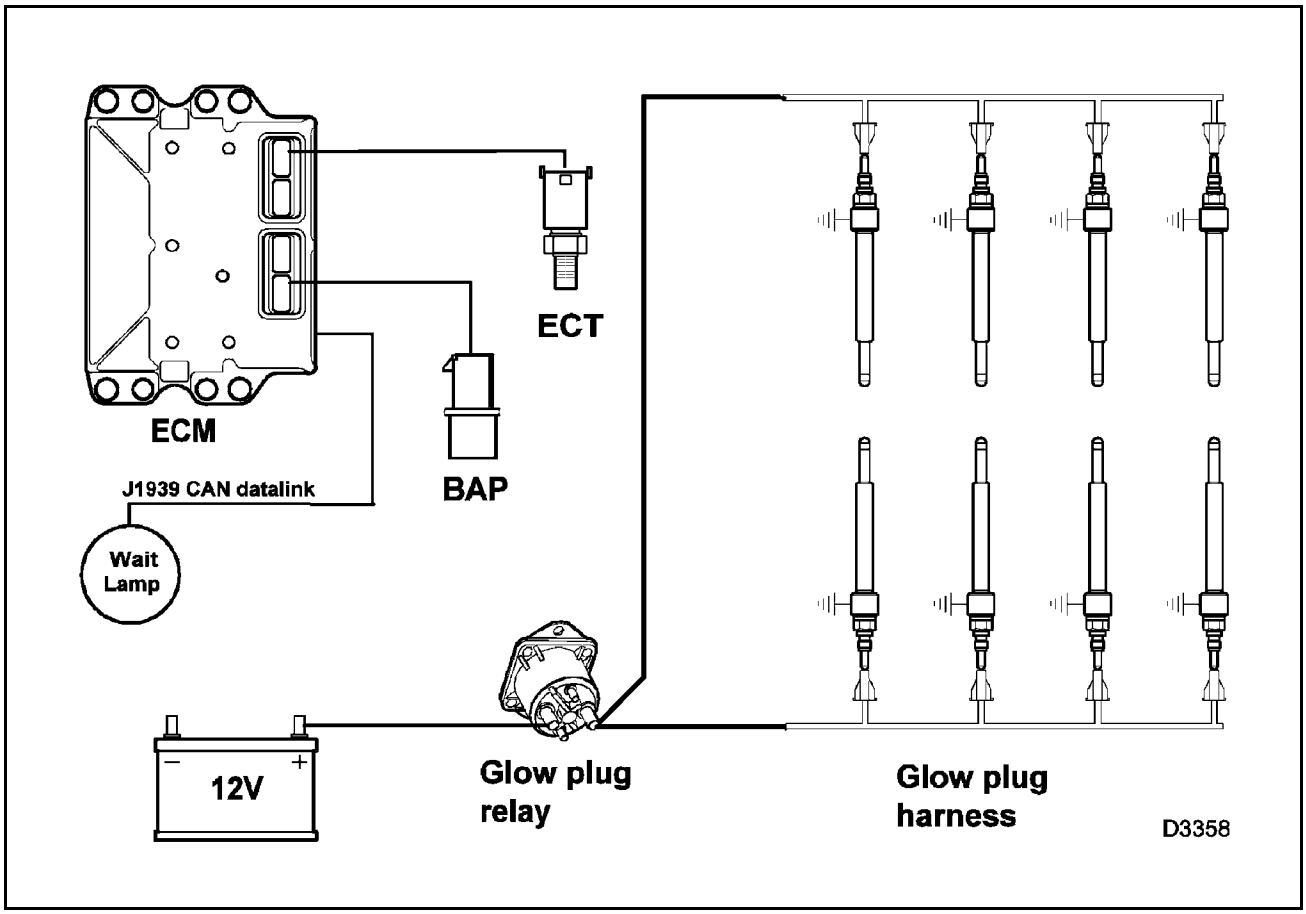

Figure 40 Glow plug control system

The glow plug control system warms the engine cylinders to aid cold engine starting and reduce exhaust emissions during warm-up.

The Electronic Control Module (ECM) is programmed to energize the glow plugs (through the glow plug relay) while monitoring certain programmed conditions for engine coolant temperature and atmospheric pressure.

The ECM monitors battery voltage and uses information from the Barometric Absolute Pressure (BAP) sensor and Engine Coolant Temperature (ECT) sensor to determine the amount of time that the WAIT TO START lamp is ON and the activation time of the glow plugs. The ECM controls the WAIT TO START lamp and the activation of the glow plugs separately. The glow plugs are self limiting and do not require cycling on and off. The glow plug relay will only cycle on and off repeatedly if system voltage is greater than 14.0 volts.

Glow plugs are activated for a longer time, if the engine is cold or the barometric pressure is low (high altitude).

The engine is ready to start when the WAIT TO START lamp is turned off by the ECM. The glow plugs can remain on up to 120 seconds while the engine is running to reduce exhaust emissions during engine warm-up.

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STANDARD FEATURES

ELECTRONIC GOVERNOR CONTROL

International® VT 365 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 the following functions:

- Transmission of engine parameter data
- Transmission and clearing of DTCs
- Diagnostics and trouble shooting
- Programming performance parameter values
- Programming engine and vehicle features
- Programming calibrations and strategies in the ECM and IDM

SERVICE DIAGNOSTICS

The Electronic Service Tool (EST) provides diagnostic information using the ATA datalink. The recommended EST is the EZ Tech™ with Master Diagnostics software.

Faults from sensors, actuators, electronic components, and engine systems are detected by the ECM and sent to the EST as Diagnostic Trouble Codes (DTCs). DTCs are necessary for correct diagnostic procedures.

EVENT LOGGING SYSTEM

The event logging system records engine operation above maximum rpm (overspeed), high coolant temperature, low coolant level, or low oil pressure. This information and readings for the odometer/hourmeter are stored in the ECM memory and can be read using the EST.

ELECTRONIC SPEEDOMETER AND TACHOMETER

The engine control system calibrates vehicle speed to 157,157 pulses per mile. The 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 cluster through the Drivetrain Datalink (CAN 1) and to the EST from the ATA datalink.

COLD IDLE ADVANCE

Cold idle advance increases engine cold idle speed (fast idle) up to 875 rpm (normally 700 rpm) for faster warm-up to operating temperature. This is accomplished by the ECM monitoring the ECT sensor input and adjusting the fuel injector operation accordingly.

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

COLD AMBIENT PROTECTION (CAP)

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

CAP maintains engine coolant temperature by increasing the engine rpm to a programmed value when the ambient air temperature is at or below 20°C (68°F) and the engine coolant temperature is below 70°C (158°F) while the engine has been idling with no load for more than 5 minutes.

CAP is standard on all trucks without an idle shutdown timer, with a clutch switch (manual transmissions) or a neutral safety switch (automatic transmissions).

COOLANT TEMPERATURE COMPENSATION (ENGINE OVER TEMPERATURE PROTECTION SYSTEM)

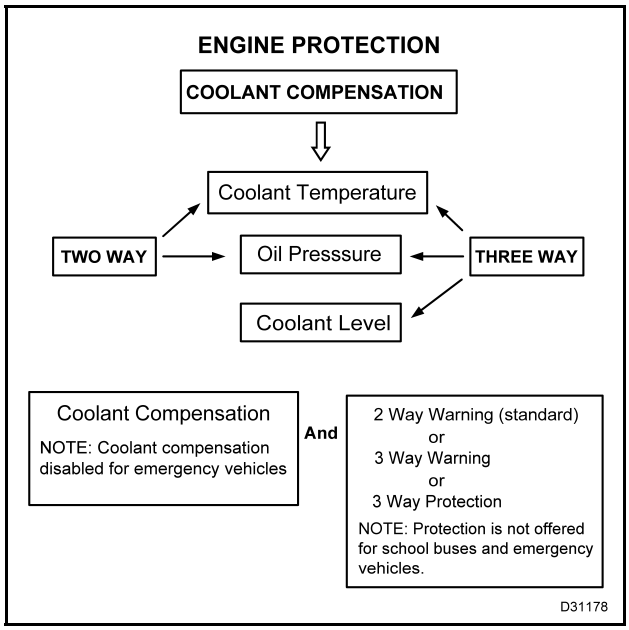

Figure 41 Coolant Temperature Compensation

Coolant Temperature Compensation reduces fuel delivery if Engine Coolant Temperature (ECT) is above cooling system specifications.

Before standard engine warning or optional warning/protection systems engage, the reduction in fuel delivery begins when ECT reaches approximately 107°C (224.6°F). A relatively rapid reduction of 15% will be achieved as ECT reaches approximately 109°C (229°F).

NOTE: Coolant Temperature Compensation may be disabled in emergency vehicles that require 100% power on demand.

GLOW PLUG ASSISTED START

Glow plug assisted start improves engine startability in cold weather. Glow plugs are controlled by the ECM, which monitors the engine temperature. An amber WAIT TO START lamp informs the operator when the engine is ready for cranking.

EXHAUST BACK PRESSURE ENGINE WARM-UP SYSTEM

When ambient and engine coolant temperatures are low, vanes in the Electronic Variable Response Turbocharger (EVRT™) restrict the exhaust flow. The increased engine load increases the amount of heat transferred to the cooling system. Heat transfer increases the amount of heat available to warm the vehicle interior. This feature is especially desirable in bus applications.

ENGINE CRANK INHIBIT (ECI)

ECI will not allow the starting motor to crank if the engine is running or the automatic transmission is in gear. ECI is an optional system for vehicles with manual transmissions.

CHANGE OIL INTERVAL MESSAGE

The change 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.

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing any diagnostic or service procedures on engine or vehicle.

Procedure

1. Set parking brake.
2. Turn the ignition key ON.

NOTE: Do step 3 and 4 within 10 seconds of key ON.

3. Press and release the CRUISE ON and RESUME/ACCEL switches at the same time (4 times within 6 seconds).

4. Press and hold both CRUISE ON and RESUME/ACCEL switches for 3 seconds.

5. Release both switches. The change oil interval message is reset.

OPTIONAL FEATURES

CRUISE CONTROL

The ECM will control engine speed to maintain a constant road speed with cruise control. Pressing the SET switch when the vehicle is at the desired speed with the CRUISE switch on activates the cruise control. Speed is increased or decreased by pressing ACCEL or CRUISE switches. The cruise control is deactivated by pressing the OFF switch, applying the brake pedal, clutch pedal, or on vehicles equipped with automatic transmissions, by placing the transmission in neutral.

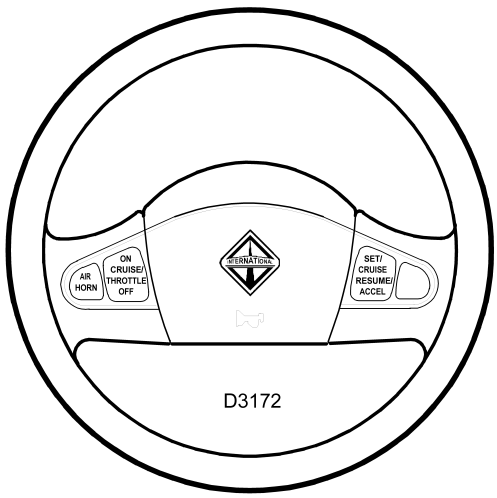

Figure 42 Switches for CRUISE ON and RESUME/ACCEL

ROAD SPEED LIMITING

Road speed limiting limits the speed to the maximum vehicle speed programmed by the customer.

BODY EQUIPMENT MANUFACTURER

Additional circuits and connector junction blocks are provided in the engine compartment on the left side of the cowl. These circuits include provisions for the following:

- Remote engine speed control
- Remote Power Takeoff (PTO) control commands
- Additional power and control circuits for after market added equipment

The standard electrical system provides breakout connections to the remote PTO.

ENGINE WARNING PROTECTION SYSTEM (EWPS)

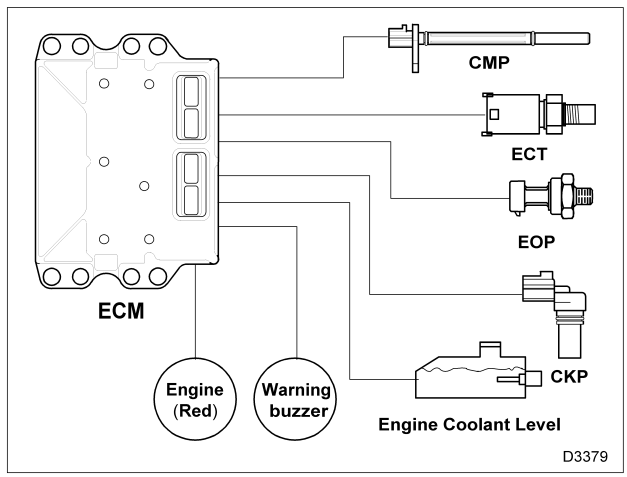

Figure 43 Engine Warning Protection System (EWPS)

The Engine Warning Protection System (EWPS) safeguards the engine from undesirable operating conditions to prevent engine damage and to prolong engine life. If any of the following conditions are detected, the Electronic Control Module (ECM) will illuminate the red ENGINE lamp and sound the warning buzzer:

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

When a critical engine condition is detected, the on-board electronics will shut the engine down if the protection feature has been enabled. The critical engine condition will be recorded by a logging feature that records the event in engine hours and odometer readings. After the engine has shutdown, the engine may be restarted for a thirty second run time.

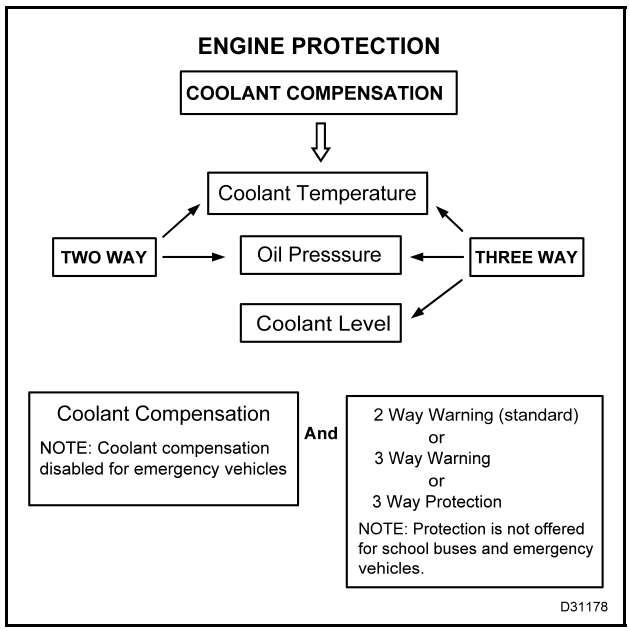

Figure 44 Engine protection

Coolant Temperature Compensation and Engine Warning Protection System (EWPS)

Coolant Temperature Compensation reduces fuel delivery if Engine Coolant Temperature (ECT) is above cooling system specifications.

The reduction in fuel delivery begins when ECT reaches approximately 107°C (224.6°F). A relatively rapid reduction of 15% will be achieved as the ECT reaches approximately 109°C (229°F).

The red ENGINE lamp will come on 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 121°C (250°F), if 3 way protection is disabled.

Fuel reduction is calibrated to a maximum of 40% 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.

IDLE SHUTDOWN TIMER (IST)

The Idle Shutdown Timer (IST) is an optional feature that allows the ECM to shutdown the engine when an extended idle condition occurs. The idle timer can be programmed for the customer to automatically shut the engine down for idle times that range from 2 to 120 minutes.

Before engine shutdown, the red ENGINE lamp will illuminate. The lamp will flash for 30 seconds to warn the operator the engine is approaching shutdown. Idle time is measured from last clutch or brake pedal transition. The engine must be out of gear for the IST to work.

Resets for Engine Shutdown Timer

- PTO is active
- Engine speed is not at idle speed (700 rpm)
- Vehicle movement or a Vehicle Speed Sensor (VSS) fault is detected
- Engine coolant operating temperature is below 60°C (140°F).
- Ambient air temperature is below 16°C (60°F) or above 44°C (110°F).
- Brake pedal movement or a brake switch fault is detected.
- Clutch pedal is depressed or a fault for the clutch pedal switch is detected (manual transmissions, if equipped with clutch switch).
- Shift selector is moved from neutral or park (automatic transmissions).

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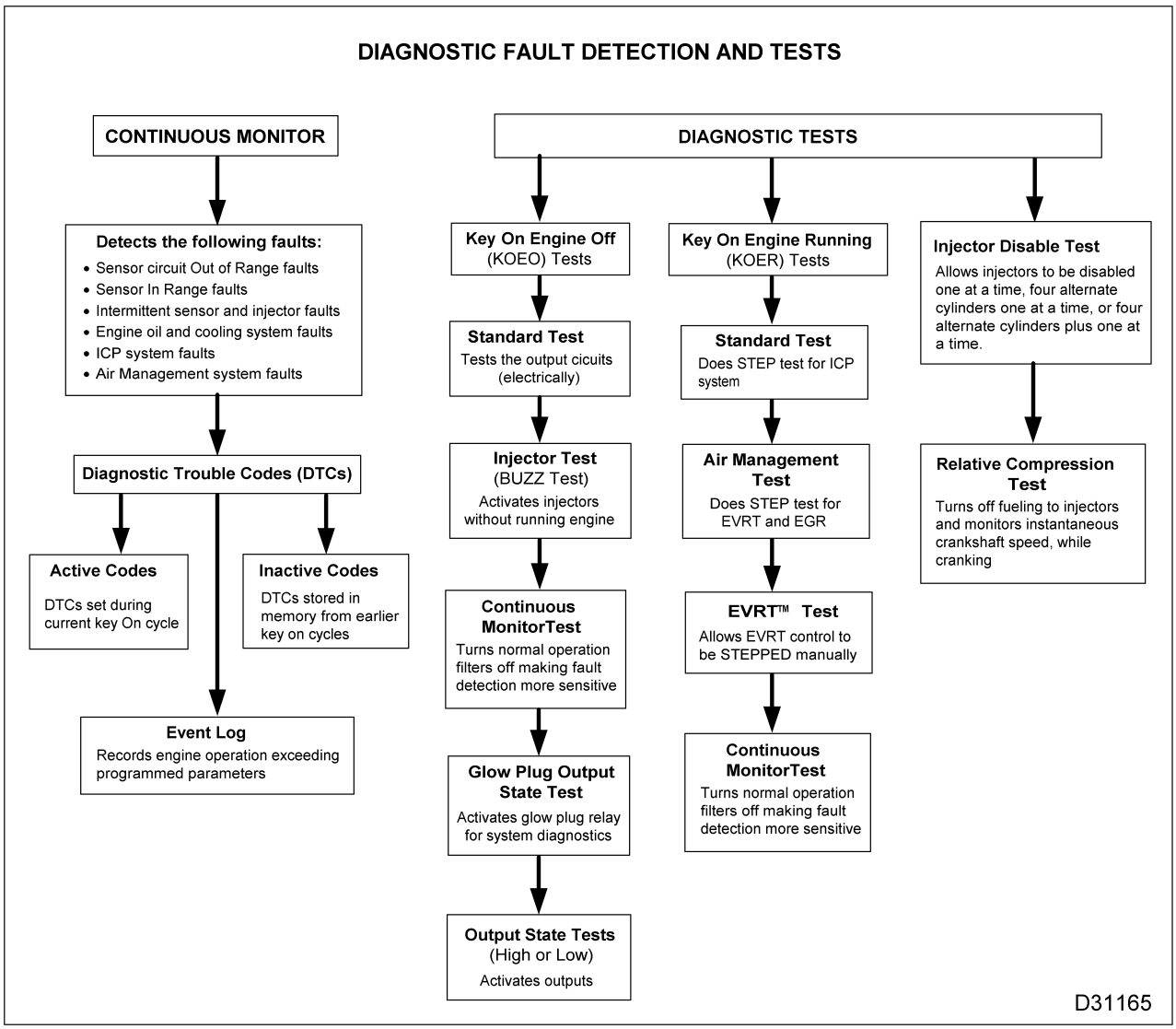

Figure 45

CONTINUOUS MONITOR

Continuous Monitor is (a series of continuous diagnostic tests) done by the Electronic Control Module (ECM) to detect failure modes (Out of Range, In Range, and System Faults). During Continuous Monitor the ignition key is on.

- **Out of Range High** (Voltage over normal operating range)
- **Out of Range Low** (Voltage under normal operating range)
- **In Range** (In normal operating range but not correct for conditions)
- **System Malfunction** (System is not operating according to conditions)

If an input signal is out of range, over or under normal operating range, the ECM records and sets a Diagnostic Trouble Code (DTC). The ECM monitors the operation of systems for in range conditions to determine if systems are working in a normal operational range; If the ECM detects that a system falls outside a predetermined range, it will record a fault and set a DTC.

Each DTC has a three digit number to identify the source of a malfunction measured or monitored electronically.

The ECM continuously monitors the Injection Control Pressure (ICP) system and the Air Management System (AMS) . If the ECM detects that a system falls outside a predetermined range, the ECM records a fault and sets a DTC.

A fault is a malfunction measured or monitored electronically. Faults are recorded as DTCs.

During normal engine operation, the ECM automatically performs several tests to detect faults. When a fault is detected, the ECM often runs a fault management strategy to allow continued, though sometimes degraded, vehicle operation.

ENGINE EVENTS

With the engine running, engine events are permanently recorded in the ECM; engine events can be retrieved with the Electronic Service Tool (EST).

Standard engine events

Standard engine events include excessive coolant temperature and engine rpm (overspeed).

Optional engine events

Optional engine events are monitored and recorded, if the engine is equipped with the optional Engine Warning Protection System (EWPS). Optional engine events recorded by the ECM include low coolant level and low oil pressure.

ENGINE EVENT HOURS/ODOMETER

The ECM records engine events in two ways, hours and odometer readings.

Examples

- Overheat Hour 1
- Overheat Hour 2
- Overheat Odometer 1
- Overheat Odometer 2

The ECM stores the two most recent events. Two events could happen in the same hour, and two events could happen in the same mile.

DIAGNOSTIC TROUBLE CODES

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing service bay diagnostics on engine or vehicle.

PROCEDURE USING EST

Accessing Diagnostic Trouble Codes (DTCs)

1. Turn ignition ON.

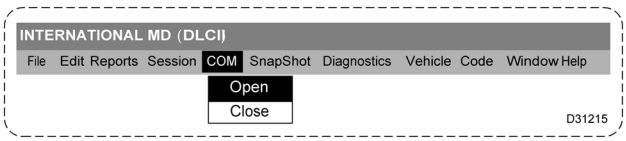

Figure 46

2. Select Com from the menu bar in the main window, then Open.

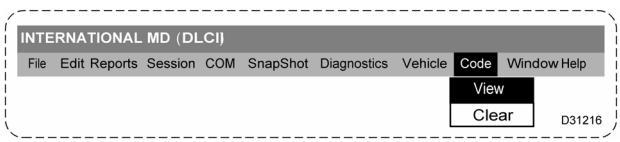

Figure 47 Menu bar Code/View

3. Select Code from the menu bar, then View for the Diagnostic Trouble Code window.

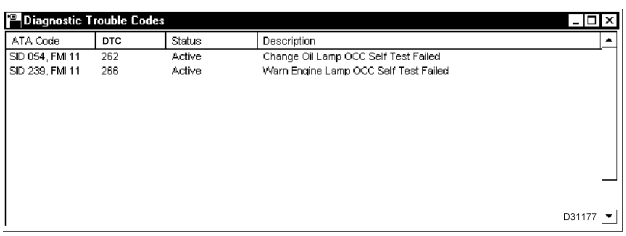

Figure 48 Diagnostic Trouble Code window

Reading DTCs

ATA code: Codes associated with a sub-system (SID), parameter (PID), and Failure Mode Indicator (FMI).

DTC: Diagnostics Trouble Codes.

Status: Indicates active, inactive, or active/inactive DTCs.

- **Active** : With the ignition key ON, active indicates a DTC for a condition currently in the system. When the key is turned off, an active DTC becomes inactive. (If a problem remains, the DTC will be active on the next key cycle.)
- **Inactive**: With the ignition key ON, inactive indicates a DTC for a condition no longer in the system. When the ignition key is turned off, inactive DTCs from previous ignition key on cycles are stored in the ECM memory.
- **Active/Inactive:** With the ignition key ON, active/inactive indicates a DTC for an intermittent condition currently in the system.

Description: Defines each DTC.

Clearing DTCs

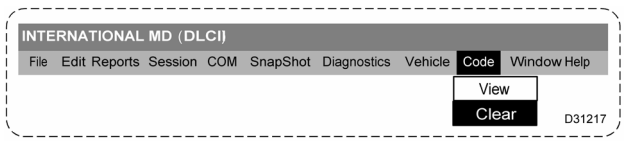

Figure 49 Menu bar Code/Clear

1. Select Code from the menu bar, then select Clear.

   NOTE: If unable to clear inactive DTCs, be sure Diagnostic Trouble Code window is active by clicking in the window area.

PROCEDURE USING SWITCHES FOR CRUISE ON AND RESUME/ACCEL

Accessing DTCs

Procedure

1. Set parking brake for the correct signal from the Electronic System Controller (ESC).

2. Turn the ignition switch ON. (Do not start the engine.)

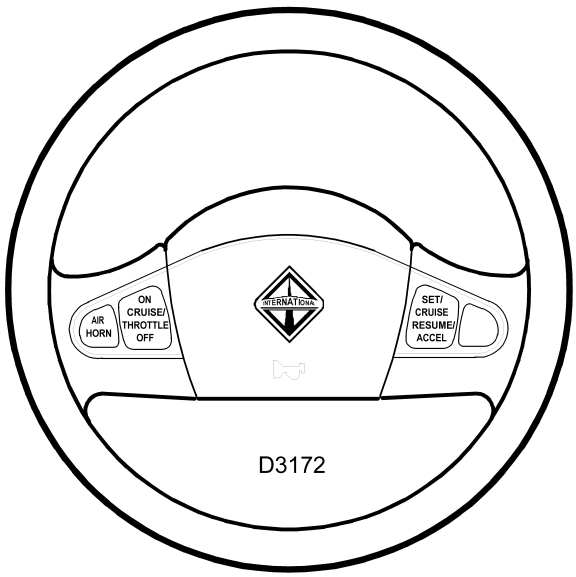

Figure 50 Switches for CRUISE ON and RESUME/ACCEL

3. Press and release the CRUISE ON and RESUME/ACCEL switches at the same time within 3 seconds of key ON.

   NOTE: There will be a 10 second delay from the time switches are pressed to the time DTCs are flashed.

Reading DTCs

1. The red ENGINE lamp will flash once to indicate the beginning of active DTCs.

2. The amber ENGINE lamp will flash repeatedly, signaling active DTCs.

   NOTE: All DTCs are three digits. Code 111 indicates that no errors were detected. See Appendix B in this manual or form CGE310 for DTCs.

3. Count the flashes of the amber ENGINE lamp in sequence. After each digit of the code a short pause will occur.

   - **Three amber flashes** and a pause indicate number 3.
   - **Two amber flashes**, a pause, **three amber flashes**, a pause, and **two amber flashes** and a pause indicate code 232.

4. For more than one DTC, the red ENGINE lamp will flash once indicating the beginning of another active DTC.

5. After all active DTCs have flashed, the red ENGINE lamp will flash twice to indicate the start of inactive DTCs. Count the flashes from the amber ENGINE lamp. If there is more than one inactive code, the red ENGINE lamp will flash once in between each DTC.

6. After all DTCs have been sent, the red ENGINE lamp will flash three times indicating end of DTC transmission.

7. To repeat DTC transmission, cylce the key and press and release the CRUISE ON and RESUME/ACCEL switches, at the same time, within 3 seconds of key ON. The ECM will resend stored DTCs.

Clearing DTCs

1. Set parking brake for the correct signal from the Electronic System Controller (ESC).

2. Turn ignition switch ON. (Do not start the engine.)

3. Press and hold the CRUISE ON and RESUME/ACCEL switches at the same time.

4. Press and release the accelerator pedal three times within 6 seconds of key ON.

5. Release the cruise control switches to clear the inactive DTCs.

DIAGNOSTIC TESTS

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing service bay diagnostics on engine or vehicle.

KEY ON ENGINE OFF TESTS

Standard Test

The Standard Test is done by the ECM. The technician runs this test, using the EST or the CRUISE ON and RESUME/ACCEL switches.

During the Standard Test, the ECM does an internal test of its processing components and memory.

The ECM automatically does an Output Circuit Check (OCC). By operating the ECM output circuits and measuring each individual 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 following circuits:

- Injection Pressure Regulator (IPR)
- Electronic Variable Response Turbocharger (EVRT™)
- Exhaust Gas Recirculation Valve (EGR)
- Glow Plug Control (GPC) relay
- Engine Fan (EFAN) – if programmed

The OCC evaluates the electrical condition of the circuits, not mechanical or hydraulic performance of the systems.

When the OCC is done, the Diagnostics Trouble Code window will display DTCs, if there are problems.

Procedure

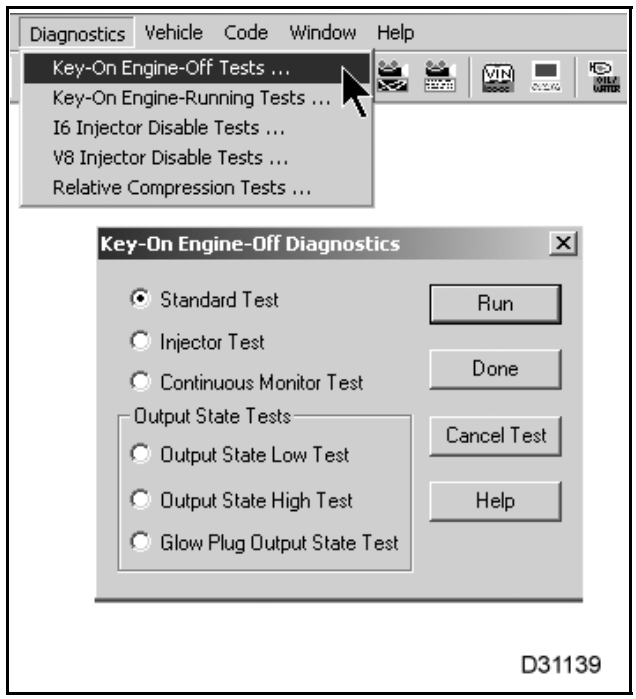

Figure 51 Standard Test

Standard Test using EST

1. Set parking brake for the correct signal from the Electronic System Controller (ESC).
2. Turn the ignition switch ON. (Do not start the engine.)
3. Select Diagnostics from the menu bar.
4. Select Key On Engine Off Tests from the drop down menu.
5. From the Key On Engine Off Diagnostics menu, select Standard Test and click Run to start the test.

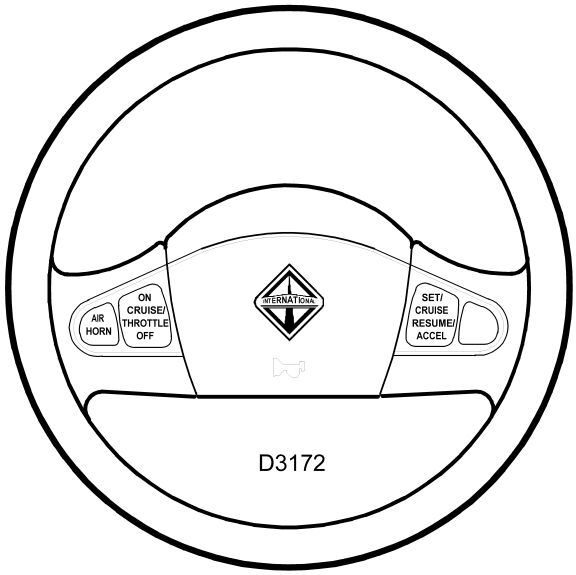

Figure 52 Switches for CRUISE ON and RESUME ACCELERATION

Standard Test using Cruise Switches

1. Set parking brake for the correct signal from the Electronic System Controller (ESC).

2. Turn the ignition switch ON. (Do not start the engine.)

3. Press and release the CRUISE ON and RESUME/ACCEL switches at the same time, twice within 3 seconds of key ON.

   - The ECM will begin the Output Circuit Check (OCC). If DTCs are detected, the ECM will flash the amber ENGINE lamp.

     When the OCC is done, the ECM will flash the red ENGINE and amber ENGINE to signal the DTCs.

NOTE: There will be a 10 second delay from the time switches are pressed to the time DTCs are flashed.

Injector Test

This test can only be done with the EST; Master Diagnostics software is required. The Standard Test must be done before doing the Injector Test.

The Injector Test diagnoses electrical problems in fuel delivery components.

NOTE: Before doing the Injector Test, DTCs should be accessed, noted and erased. This allows DTCs found to be displayed as Active DTCs.

During the test, the ECM actuates the injectors in numerical order (1 through 8), not in firing order. The ECM monitors the electrical circuit for each injector, evaluates the performance of the injectors coils, and checks the operation of the electrical circuit. If an electronic component in the fuel system fails the expected parameters, a DTC is set and transmitted to the EST.

NOTE: The technician can monitor injector operation by listening to the sound each injector produces as it is activated by the IDM; however, in Hard Start and No Start conditions, when oil may be very cold and thick, injectors may not be heard.

The Diagnostics Trouble Code window will display DTCs, if there are problems.

Procedure

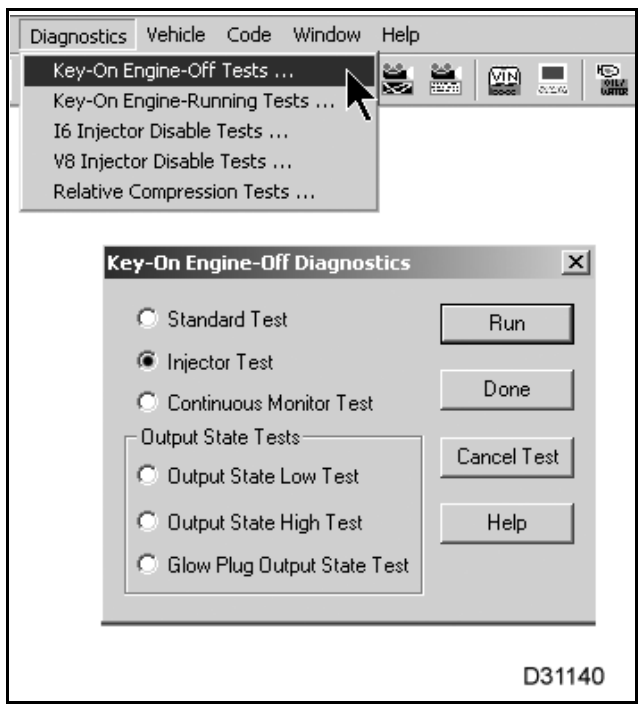

Figure 53 Injector Test

1. Select Diagnostics from the menu bar.

2. Select Key On Engine Off Tests from the drop down menu.

3. From the Key On Engine Off Diagnsotics menu, select Injector Test and click Run to start the test.

   NOTE: During this test, injector solenoids should click when actuated. If a series of clicks are not heard for each injector, one or more injectors are not activating.

Continuous Monitor Test

This test can only be done with the EST; Master Diagnostics software is required.

The Continuous Monitor Test troubleshoots intermittent connections at sensors and actuators. The engine can be off or running.

The EST monitors the following circuits:

- Accelerator Position Sensor (APS)
- Barometric Absolute Pressure (BAP)
- Engine Coolant Level (ECL)
- Engine Coolant Temperature (ECT)
- Engine Oil Pressure (EOP)
- Engine Oil Temperature (EOT)
- Exhaust Back Pressure (EBP)
- Exhaust Gas Recirculation valve Position (EGRP)
- Injection Control Pressure (ICP)
- Intake Air Temperature (IAT)
- Manifold Absolute Pressure (MAP)
- Manifold Air Temperature (MAT)
- Vehicle Speed Sensor (VSS)

Procedure

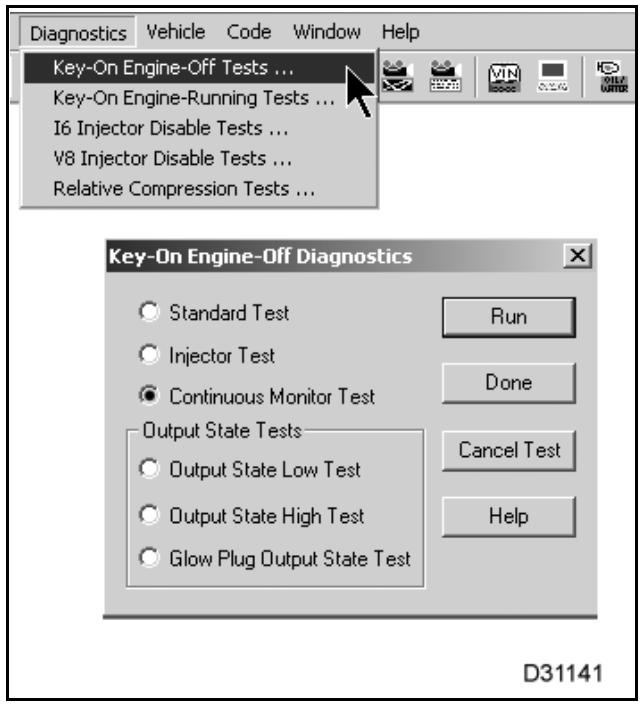

Figure 54 Continuous Monitor Test

1. Select Diagnostics from the menu bar.

2. Select Key On Engine Off Tests from the drop down menu.

3. From the Key On Engine Off Diagnostics menu, select Continuous Monitor Test, and click Run to start the test.

4. Wiggle connectors and wires at all suspected problem locations. If circuit continuity is interrupted, the EST will BEEP and display DTCs related to the condition.

Glow Plug Output State Test

This test can only be done with the EST; Master Diagnostics software is required.

The Glow Plug Output State Test allows the technician to determine if the Glow Plug System is operating correctly.

Selecting this test activates the Glow Plug relay for 120 seconds at a time; a DMM and current clamp are used

to measure on time and amperage draw off the glow plugs.

Procedure

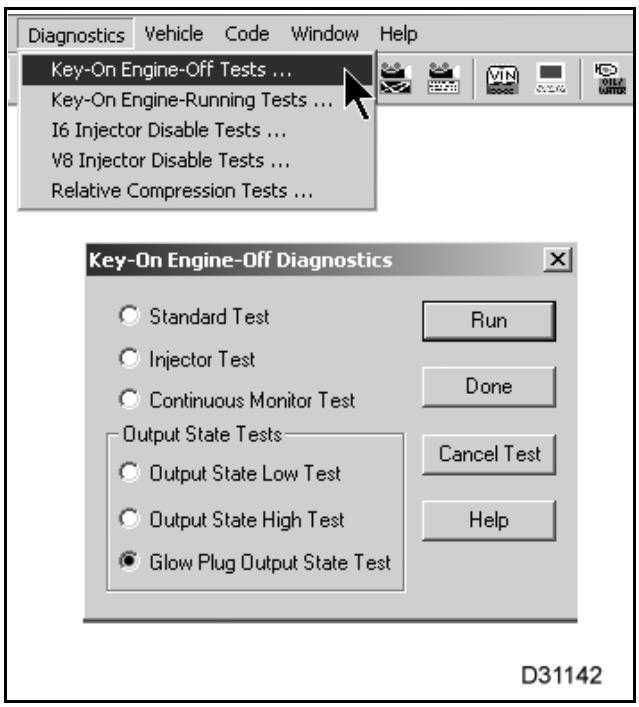

Figure 55 Glow Plug Output State Test

1. Select Diagnostics from the menu bar.

2. Select Key On Engine Off Tests from the drop down menu.

3. From the Key On Engine Off Diagnostics menu, select Glow Plug Output State Test, and click Run to start the test.

Output State Low Test

This test can only be done with the EST; Master Diagnostics software is required.

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 their low state. This actuates the output components controlled by the ECM, grounding the circuits.

During this 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:

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

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

- Engine Fan (EFAN) relay
- Exhaust Gas Recirculation valve Control (EGRC)
- Injection Pressure Regulator (IPR)

Procedure

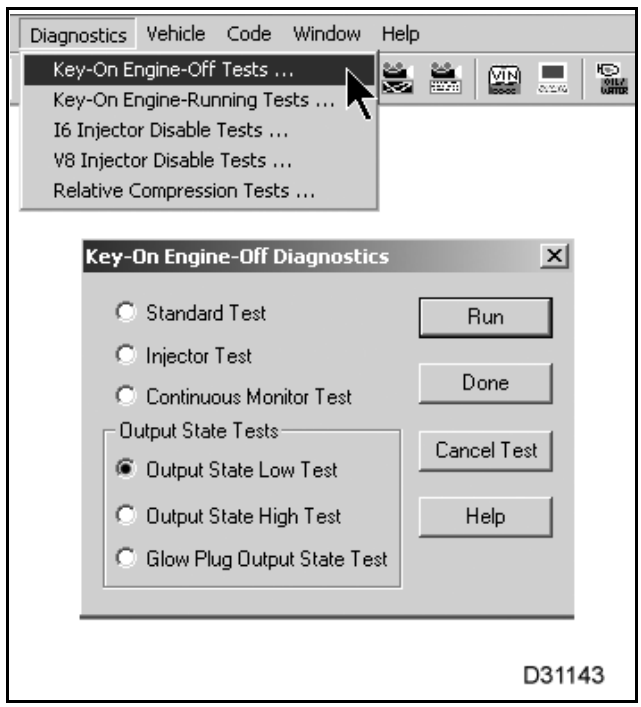

Figure 56 Output State Low Test

1. Select Diagnostics from the menu bar.

2. Select Key On Engine Off Tests from the drop down menu.

3. From the Key On Engine Off Diagnostics menu, select Output State Low Test, and click Run to start the test.

Output State High Test

This test can only be done with the EST; Master Diagnostics software is required.

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 their high state. This actuates the output components controlled by the ECM, energizing the control circuits.

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:

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

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

- Glow Plug Control (GPC) relay
- Variable Geometry Turbocharger (VGT)

Procedure

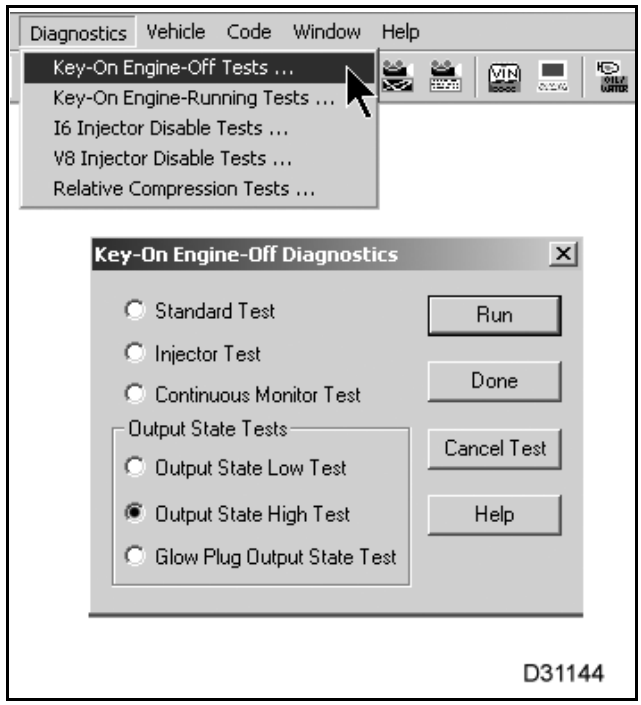

Figure 57 Output State High Test

1. Select Diagnostics from the menu bar.

2. Select Key On Engine Off Tests from the drop down menu.

3. From the Key On Engine Off Diagnostics menu, select Output State High Test, and click Run to start the test.

KEY ON ENGINE RUNNING TESTS

Standard Test

The Standard Test checks the operation of the Injection Control Pressure (ICP) system.

During the 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 test is done, the ECM returns the engine to the normal operating mode and transmits any DTCs set during the test.

Procedure

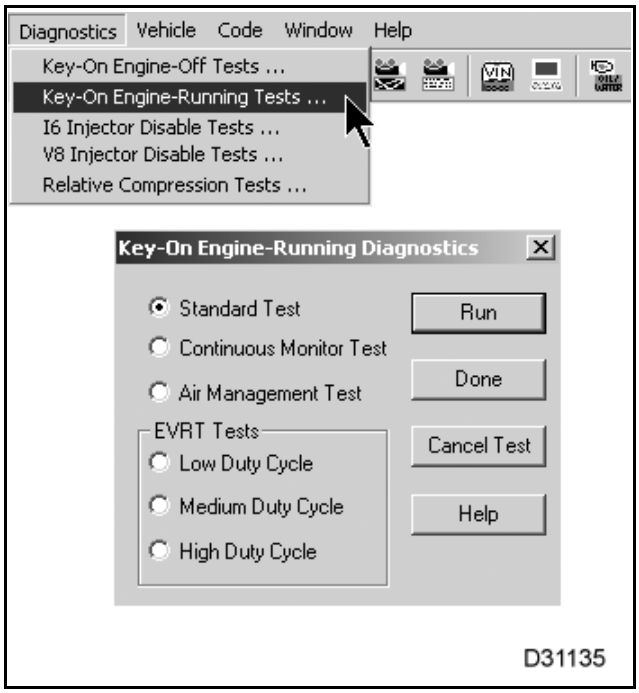

Figure 58 Standard Test

1. Select Diagnostics from the menu bar.

2. Select Key On Engine Running Tests from the drop down menu.

3. From the Key On Engine Off Diagnostics menu, select Standard Test, and click Run to start the test.

The ECM increases engine idle to a pre-determined value and commands the IPR valve to set ICP to rated speed pressure. If the performance of the ICP system is acceptable, the ECM will control the IPR valve and reduce the pressure in steps, while continuing to monitor the ICP system.

NOTE: Before doing this test, confirm the following conditions:

- **Problems causing Active DTCs were corrected, and active DTCs were cleared.**
- **Engine coolant temperature must be at least 70°C (158°F).**
- **Battery voltage must be higher than 12.5 volts.**
- **No signal from Vehicle Speed Sensor (VSS)**
- **Transmission in neutral**

When the test is done, the ECM restores normal engine operation, and the Diagnostics Trouble Code window will display DTCs, if there are problems.

Continuous Monitor Test

This test can only be done with the EST; Master Diagnostics software is required.

The Continuous Monitor Test troubleshoots intermittent connections at sensors and actuators. The engine can be off or running.

The EST monitors the following circuits:

- Accelerator Position Sensor (APS)
- Barometric Absolute Pressure (BAP)
- Engine Coolant Level (ECL)
- Engine Coolant Temperature (ECT)
- Engine Oil Pressure (EOP)
- Engine Oil Temperature (EOT)
- Exhaust Back Pressure (EBP)
- Exhaust Gas Recirculation valve Position (EGRP)
- Injection Control Pressure (ICP)
- Intake Air Temperature (IAT)
- Manifold Absolute Pressure (MAP)
- Manifold Air Temperature (MAT)
- Vehicle Speed Sensor (VSS)

Procedure

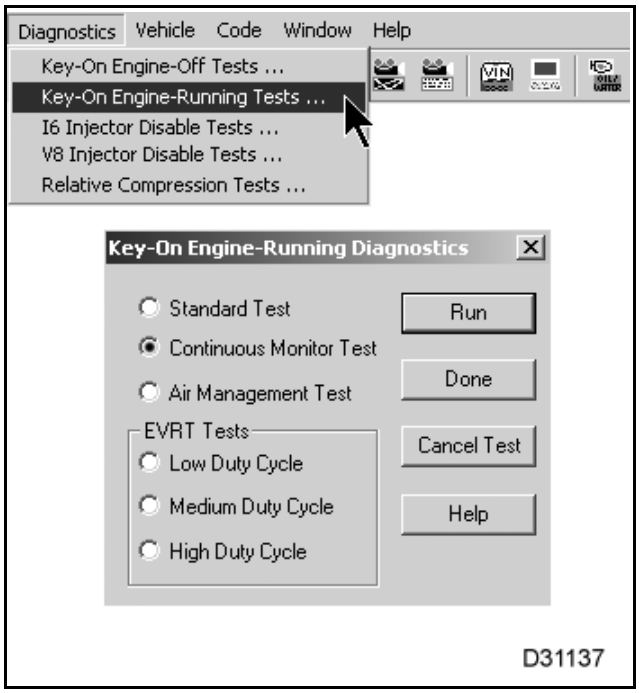

Figure 59 Continuous Monitor Test

1. Select Diagnostics from the menu bar.

2. Select Key On Engine Running Tests from the drop down menu.

3. From the Key On Engine Running Diagnostics menu, select Continuous Monitor Test, and click Run to start the test.

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

Be careful to avoid rotating parts (belts and fan) and hot engine surfaces.

4. Wiggle connectors and wires at all suspected problem locations. If circuit continuity is interrupted, the EST will beep and display DTCs related to the condition.

Air Management Test

This test can only be done with the EST; Master Diagnostics software is required. The Standard Test must be done before doing the Air Management Test.

The Air Management Test checks the operation of the Air management System and the following valves:

- Electronic Variable Response Turbocharger (EVRT™)Control Valve (also called VGT control valve)
- Exhaust Gas Recirculation Valve (EGR)

During the Air Management test, the ECM commands the EVRT™ (VGT control valve) and EGR actuators 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 exhaust back pressure sensor and compares those values to the expected values.

When the test is done, the ECM restores normal engine operation, and the Diagnostics Trouble Code window will display DTCs, if there are problems.

Procedure

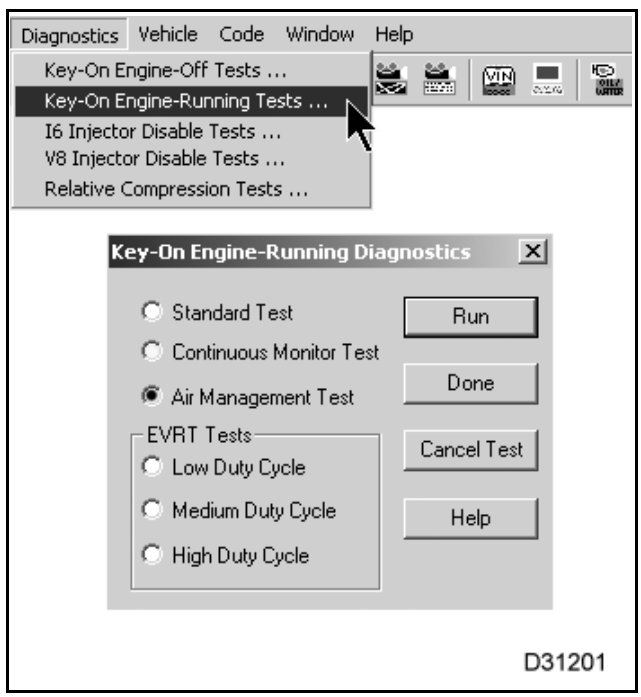

Figure 60 Air Management Test

1. Select Diagnostics from the menu bar.

2. Select Key On Engine Running Tests from the drop down menu.

3. From Key On Engine Running Diagnostics menu, select Air Management Test. and click Run to start the test.

The ECM increases engine idle speed, commands the VGT vanes to fully open, and allows EBP to stabilize. The ECM then measures and compares the pressures to expected values; pressures are expected to drop. If presssures do not meet expected values, a DTC is set and the test is cancelled.

The ECM then commands the VGT vanes to fully closed, while measuring and comparing the pressures to expected values; pressures are expected to increase. If pressures do not meet expected values, a DTC is set and the test is cancelled.

The ECM commands VGT vanes to fully open; pressures are expected to drop. If pressures do not meet expected values, a DTC is set and the test is cancelled.

If pressures are as expected, the test will continue and test EGR. The ECM commands VGT vanes to fully closed, while measuring and comparing the pressures to expected values; pressures are expected to increase. If pressures do not meet expected values, a DTC is set and the test is cancelled.

The ECM then commands the EGR to open and compares the EBP signal to expected values; pressure is expected to drop. If pressure does not meet expected values, a DTC is set and the test is cancelled.

The ECM then commands the EGR to close and compares EBP to expected values; pressure is expected to increase. If pressures do not meet expected values, a DTC is set and the engine will return to normal operating mode.

EVRT™ Test

This test can only be done with the EST; Master Diagnostics software is required. The Standard Test must be done before doing the EVRT™ Test.

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

NOTE: EVRT™ can be monitored by listening to exhaust sound, as duty is changed.

Procedure

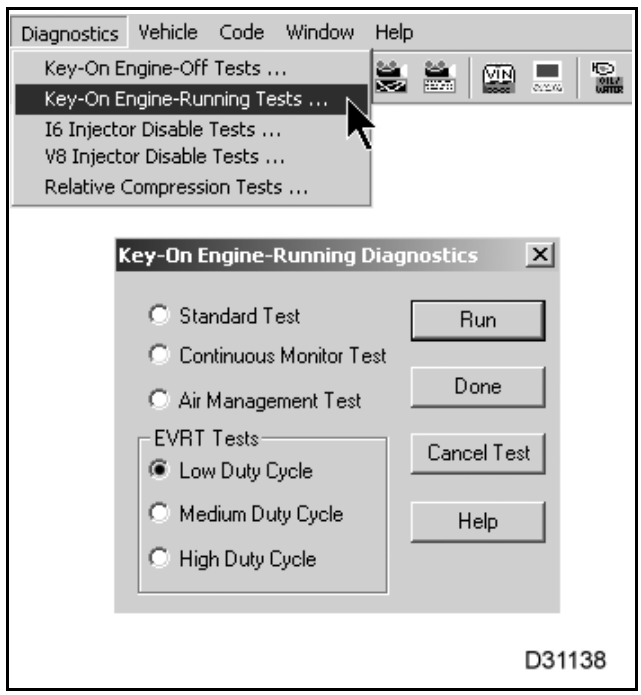

Figure 61 EVRT™ Tests

1. Select Diagnostics from the menu bar.

2. Select Key On Engine Running Tests from the drop down menu.

3. From Key On Engine Running Diagnostics menu, select the one of the following EVRT™ Tests, and click Run tostart the test.

   - Low duty
   - Medium duty
   - High duty

If the ECM does not receive a request from the EST, after about 2 minutes, the test will automatically end and the engine will return to normal operation.

INJECTOR DISABLE TESTS

The Injector Disable Tests allow the technician to shut off injectors to determine if a specific cylinder is contributing to engine performance. An injector can be shut off one at a time, four alternative cylinders at a time, or four alternative cylinders plus one.

Alternate cylinders are every other cylinder in firing order.

Firing order: 1–2–7–3–4–5–6–8

1–7–4–6

2–3–5–8

When all cylinders are active, the contribution of each cylinder is 12.5% of its overall effect to maintain governed speed. When four cylinders are shut off, contribution of each remaining cylinder is 25% of its overall effect to maintain governed speed. The technician should monitor fuel rate, and engine load.

These tests detect problems with injection and combustion events. These tests should be done in conjunction with the crankcase pressure test and the Relative Compression Test (RCT).

Procedure

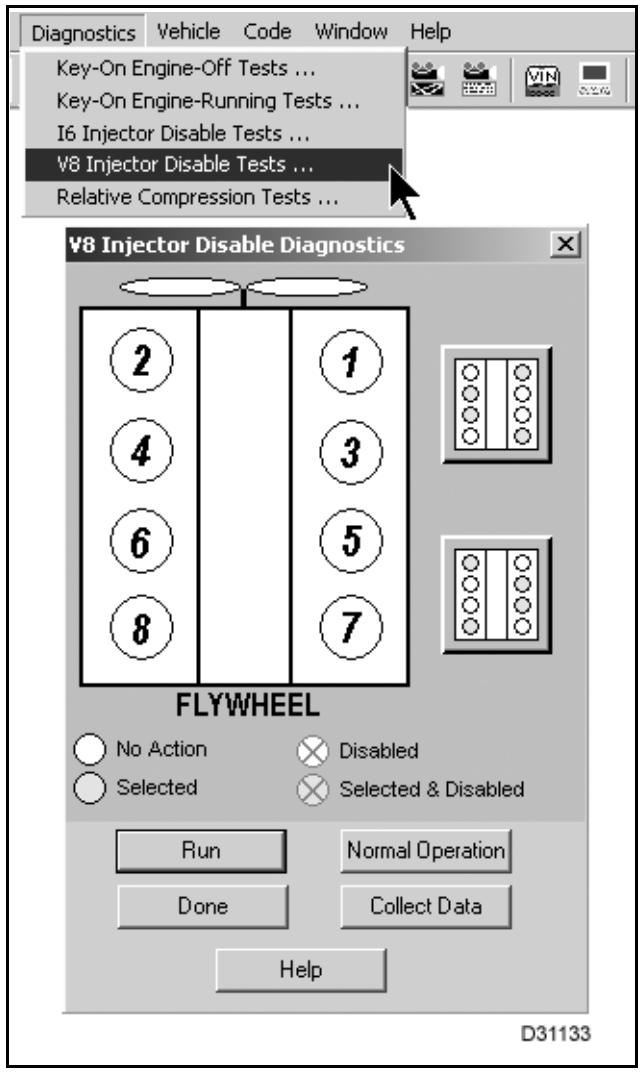

Figure 62 Injector Disable Tests

1. Select Diagnostics from the menu bar.

2. Select V8 Injector Disable Test from the drop down menu.

3. From the V8 Injector Disable Test menu, select cylinder to disable and click Run.

4. To return to normal operation, select and click Normal Operation.

RELATIVE COMPRESSION TEST

The relative compression test measures engine speed of each power cylinder at peak compression without fueling. This allows the technician to determine if a power cylinder is operating correctly by comparing the speed of each cylinder.

This test is used in conjunction with the Injector Disable Test to distinguish between an injector or mechanical problem.

Procedure

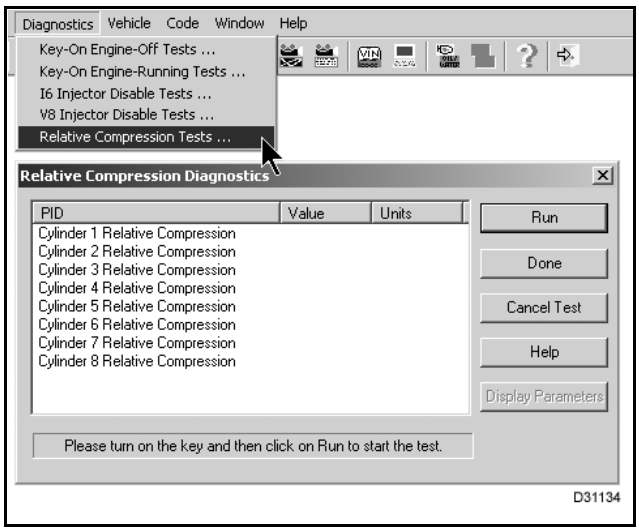

Figure 63 Relative Compression Tests

NOTE: Batteries must be fully charged before doing this test.

1. Select Diagnostics from the menu bar.
2. Select Relative Compression Test from the drop down menu.

Follow the messages at the bottom of the Relative Compression Diagnostics window.

3. Turn ignition key ON.
4. Click RUN.

> **WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following: Turn ignition key to crank the engine – within 5 seconds – after clicking RUN; if not done in 5 seconds, the EST will cancel the test, and the engine will start.**

5. Crank engine for 15 seconds or until another message instructs to stop cranking.
6. Interpret results.

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DESCRIPTION

Diagnostic test procedures help technicians find problems systematically and quickly to avoid unnecessary repairs. In this section, the concern is known and diagnostics are used to identify the cause of the complaint.

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing service bay diagnostics on engine or vehicle.

TEST PROCEDURES

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

COMBUSTION LEAKS TO COOLANT

Causes

- Injector sleeve failure
- Glow plug sleeve failure
- Head gasket failure
- Porous cylinder wall

Combustion leaks can be identified by combustion gas observed in engine coolant deaeration tank. The most probable cause of combustion gas leakage to the cooling system is past injector or glow plug sleeve in the cylinder head. A failed head gasket or porous cylinder wall is possible, but should not be suspected unless evidence of engine overheating or high engine mileage without proper coolant conditioning.

Combustion Leakage Test using Low Pressure

1. Plug in cylinder block heater to warm coolant.

WARNING: To avoid serious personal injury or possible death, use only the following procedure to remove the pressure type cap from the cooling system. Always allow the engine to cool first. Wrap a thick, heavy cloth around the cap. Loosen cap slowly; then pause a moment. This will avoid possible scalding by hot coolant or steam. Continue to turn cap to the left and remove.

2. Install radiator pressure tester with appropriate adapter.
3. Pressurize cooling system to 96 kPa (14 psi).
4. Remove glow plug harnesses and glow plugs for all cylinders.
5. Clean glow plug sleeves with cotton swabs.

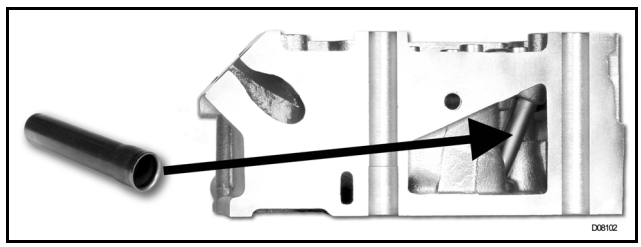

Figure 64 Cutaway of Cylinder Head Showing Glow Plug Sleeve

6. Verify that cooling system is still pressurized at 96 kPa (14 psi).
7. Bar engine over by hand and check for coolant flooding the top of piston and flowing out glow plug sleeve bore.
   - If leak is slight, pressure may have to be left on overnight and inspect cooling system for leakage in morning. Leave cylinder block heater plugged in.
   - If leak is found, go to step 8.
   - If no leakage is found, proceed to Combustion Leakage Test using High Pressure procedures.

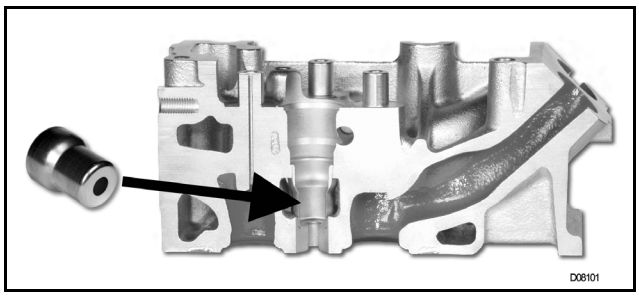

Figure 65 Cutaway of Cylinder Head Showing Injector Sleeve

8. Remove cylinder head from engine as described in the *Engine Service Manual*. Perform all inspections and pressure test cylinder head to verify leak path. Inspect cylinder head gasket for coolant leaks and verify crankcase and cylinder head surface flatness using a straight edge and feeler gauge.

    - It is recommended to replace both the injector and glow plug sleeves for a cylinder that shows combustion leakage.

9. If the injector and glow plug sleeves were replaced, retest the cylinder head with pressure test plate to verify repair.

10. Return coolant to operating level in the deaeration tank.

Combustion Leakage Test using High Pressure

1. Plug in cylinder block heater to warm coolant.

2. Remove glow plug harnesses and glow plugs for all cylinders.

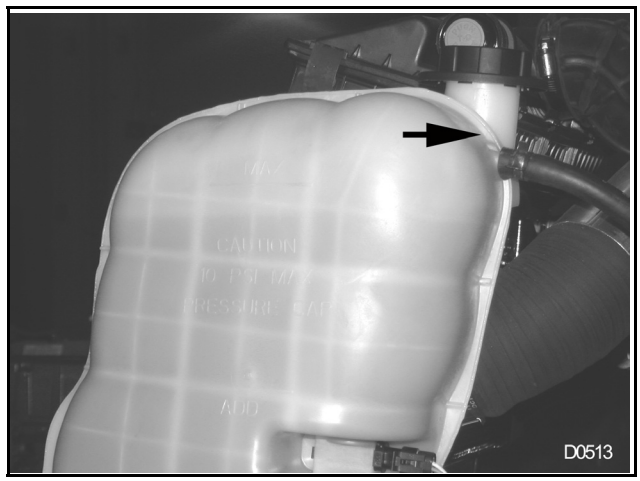

Figure 66 Deaeration Tank Fill Position

⚠ WARNING: To avoid serious personal injury or possible death, use only the following procedure to remove the pressure type cap from the cooling system. Always allow the engine to cool first. Wrap a thick, heavy cloth around the cap. Loosen cap slowly; then pause a moment. This will avoid possible scalding by hot coolant or steam. Continue to turn cap to the left and remove.

3. Remove cap (or radiator pressure tester) from deaeration tank and fill tank with coolant to a point above the deaeration inlet line to tank.

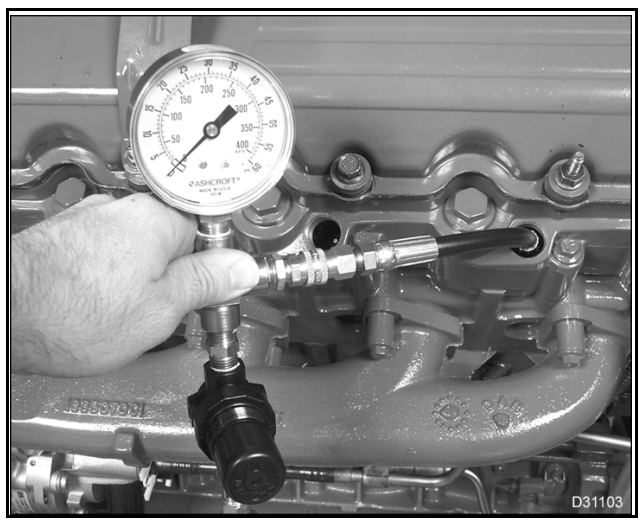

Figure 67 Compression Adapter Tool (ZTSE4506)

4. Install the compression adapter in the glow plug bore and adapt gauge end to accept shop air pressure 690–1100 kPa (100–160 psi).

   NOTE: Verify that O-ring is on compression adapter when installed and removed from glow plug bore.

> ⚠ **WARNING: To avoid serious personal injury, possible death, or damage to the engine, be aware that engine may rotate sharply when cylinder is pressurized.**

5. With shop air applied, bar engine over so that valves are shut on cylinder to be tested.

6. Observe deaeration tank for escaping air. If there is a leak in the pressurized cylinder, bubbles of air will be seen in the deaeration tank.

   NOTE: Pressurize each cylinder for a minimum of 3 minutes to ensure leaking air can arrive at deaeration tank

   - If leak is found, go to step 7.
   - If no leak is found, remove each cylinder head one at a time following the procedures described in the *Engine Service Manual*. Do all inspections and pressure test cylinder head to verify leak path. Inspect cylinder head gasket for coolant leaks and verify crankcase and cylinder head surface flatness using a straight edge and feeler gauge.
   - If cylinder head leak is found, repair as necessary and retest to confirm repair.
   - If no leak is found, inspect cylinder bores.

7. Remove cylinder head from engine as described in the *Engine Service Manual*. Perform all inspections and pressure test cylinder head to verify leak path. Inspect cylinder head gasket for coolant leaks and verify crankcase and cylinder head surface flatness using a straight edge and feeler gauge.

   - It is recommended to replace both the injector and glow plug sleeves for a cylinder that shows combustion leakage.

8. If the injector and glow plug sleeves were replaced, retest the cylinder head with pressure test plate to verify repair.

9. Return coolant to operating level in the deaeration tank.

COMBUSTION LEAKS TO FUEL

Causes

- Loose fuel injector hold down
- Missing/damaged copper injector gasket

Combustion leaks to fuel will exhibit one or more of the following characteristics:

- Engine stall during operation
- White to black smoke during cranking
- 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 using vacuum source procedure

Combustion Leak to Fuel Test Procedure

1. Verify operator complaint.

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle – comply with the following when draining fuel:

- **Do not smoke.**
- **Keep away from open flames and sparks.**

Figure 68 Fuel drain

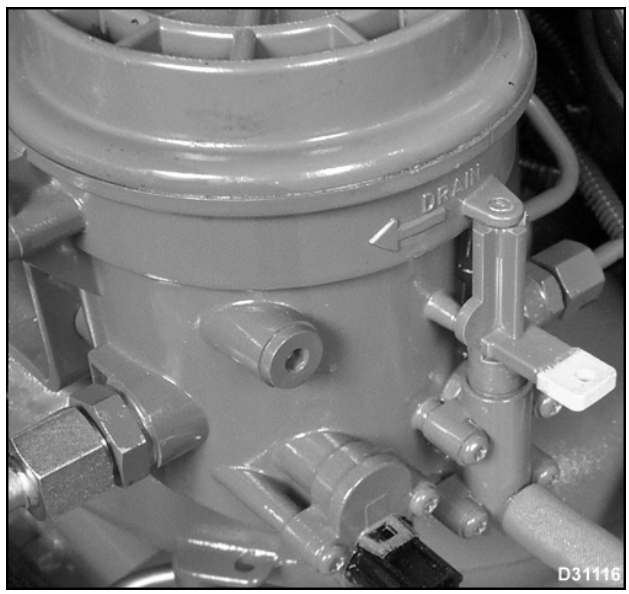

Figure 69 Open fuel drain valve

2. Drain fuel filter housing into container using drain valve. Leave drain open and container in place during test procedure.

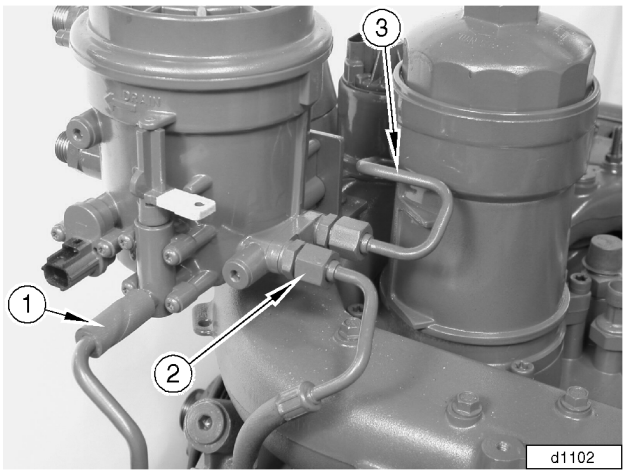

Figure 70 Fuel supply lines

1. Water drain tube assembly
2. Filter to left cylinder head tube assembly
3. Filter to right cylinder head tube assembly

3. Remove left and right fuel supply lines from fuel filter housing following the procedures in the *Engine Service Manual*.

⚠ WARNING: To avoid serious personal injury or possible death, be aware that engine may start causing fuel pump to supply fuel through supply lines to fuel filter housing.

4. Crank engine for 3 to 5 seconds while checking fuel supply lines for the following:
   - Fuel forced back through line(s) from combustion
   - Combustion gasses or smoke coming from line(s)
   - Audible sound of air/compression from line(s)
5. Remove valve cover following the procedures in the *Engine Service Manual* and inspect injectors on side of engine that is suspect of combustion in fuel. Repair as needed.

COOLANT IN LUBE OIL

Causes

- Glow plug sleeve failure
- Cylinder head cup plug failure
- Oil cooler bundle or O-ring failure
- Front cover gasket damage
- Front cover, cylinder head or crankcase porosity
- Cylinder head gasket leak
- Injector sleeve leak
- Accessory leak (water cooled air compressor)

Inspection Procedure for Lube Oil Contamination

1. Check coolant level and oil level gauge to verify oil contamination complaint.
    - The presence of coolant in the oil will generally give the oil a white milky 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.

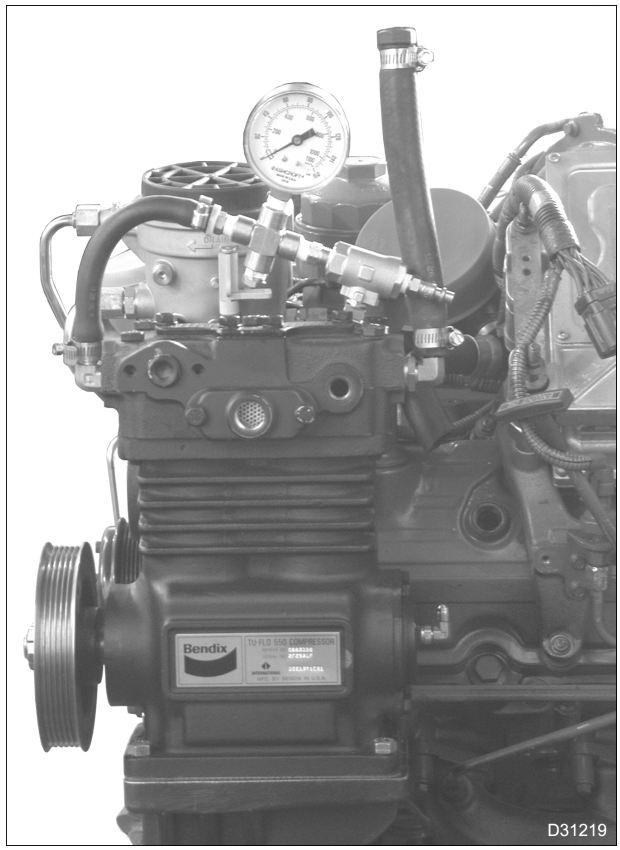

Figure 71 Air compressor isolated from engine for coolant leak test

3. If engine is equipped with an air compressor, isolate compressor from the engine and test for coolant leak.
    A. Remove the coolant inlet and outlet hoses for the air compressor cylinder head and remove the oil drain back line from the bottom of the air compressor mounting bracket.
    B. Fill air compressor coolant passage and hoses with coolant.
    C. Adapt air pressure fitting and regulator to one of the coolant hoses and block opposite hose.
    D. Pressurize air compressor coolant hoses to 96 kPa (14 psi).
    E. Inspect for coolant leakage from oil drain back line and listen for escaping air.

F. If leak is found, repair or replace air compressor. If no leak is found, proceed to next step.

4. Remove glow plug harnesses, glow plugs and valve covers. Drain engine oil and remove oil filter.

   • Leave oil drain plug out of pan and oil filter cap off.

5. Pressurize cooling system to 96 kPa (14 psi).

6. If coolant is leaking from oil pan, do the following.

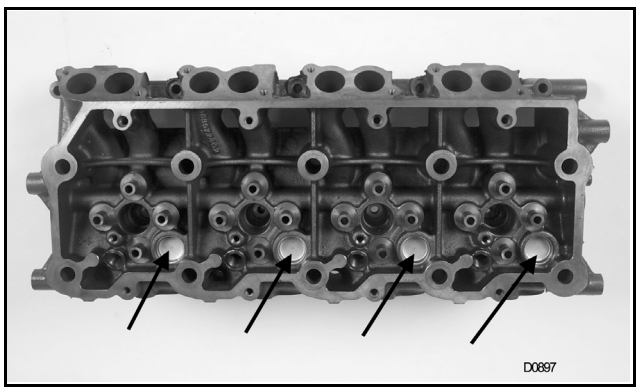

Figure 72 Cylinder Head Cup Plug Locations

A. Inspect entire cylinder head area for leaks at the cup plugs.

B. Inspect oil filter housing for coolant leaks from oil cooler.

C. If no leaks are found in above areas do step 9 to inspect for upper crankcase leakage.

D. If coolant system pressure is dropping and no coolant is leaking from oil pan, do step 7.

7. Bar engine over by hand and check for coolant flooding the top of piston and flowing out of the glow plug bore.

   • If leaks are found, do step 8.

   • If leaks are not found, do step 9.

8. Remove cylinder head from engine following the procedures in the *Engine Service Manual*. Perform all inspections and pressure test cylinder head to verify leak path. Inspect cylinder head gasket for damage at sealing areas which may have caused leak. Verify crankcase and cylinder head surface flatness using a straight edge and feeler gauge.

   • If glow plug or injector sleeve was replaced, retest cylinder head with pressure test plate to verify repair.

9. Remove upper and lower oil pans following the procedures in the *Engine Service Manual*.

10. Inspect for leakage in crankcase.

    • Verify 96 kPa (14 psi) pressure is maintained on radiator pressure tester.

    • If no leakage is found, do step 11.

11. Remove oil cooler and oil filter housing from the engine following the procedures in the *Engine Service Manual*.

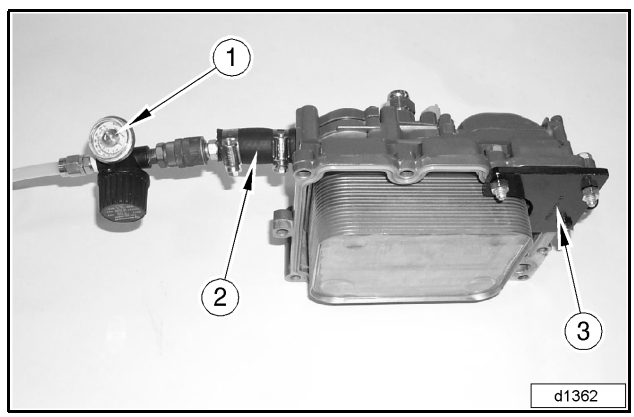

Figure 73 Oil Cooler

1. Air pressure regulator
2. Air adapter
3. Test plate

12. Do oil cooler pressure test following procedures in the *Engine Service Manual*.

    • If a leak is found, replace oil cooler assembly.

    • If no leak is found, do step 13.

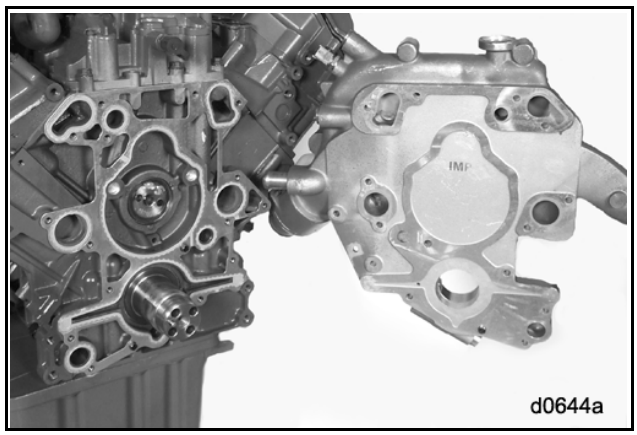

Figure 74 Front Cover Coolant Sealing Surfaces

13. Remove front cover and inspect gaskets and sealing surfaces following the procedures in the *Engine Service Manual*. Check front cover and crankcase with straight edge and feeler gauge.

14. Retest cooling system after any repair to confirm repair.

COOLANT LEAK TO EXHAUST

Causes

- Defective EGR cooler
- Porosity in cylinder head casting

Coolant Leak to Exhaust Test Procedure

1. Verify complaint of coolant leaking to exhaust.
    - Observation of coolant loss without engine overheating
    - Excessive white smoke from exhaust pipe on start up (hot or cold)
    - Check for coolant smell in exhaust
    - Check for coolant leaking from muffler
    - Severe case – engine hydraulic lock

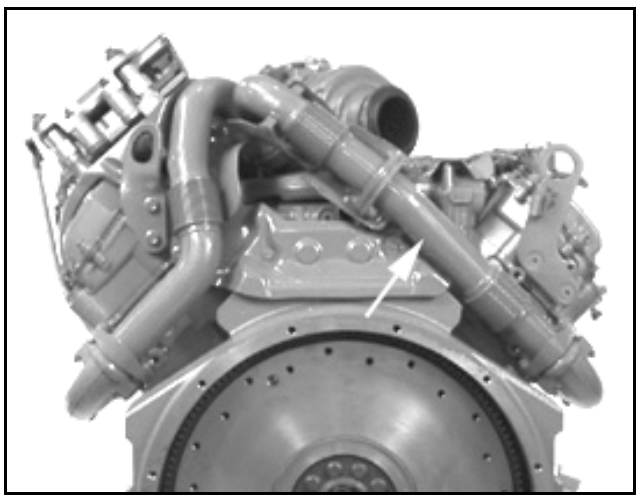

Figure 75 Turbocharger exhaust tubes

2. Remove turbocharger exhaust tube (lower) following the procedures in the *Engine Service Manual*.

> **WARNING: To avoid serious personal injury or possible death, use caution when removing turbocharger exhaust tube (lower) if coolant in tube could splash on technician or create slippery conditions.**

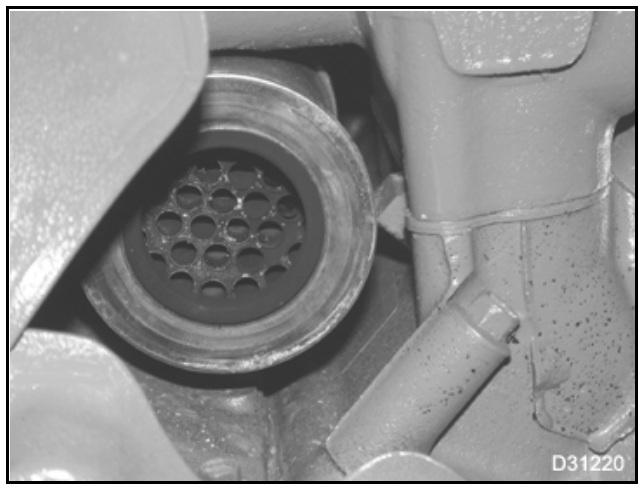

Figure 76 EGR cooler exhaust inlet

3. Check for presence of coolant in tube, right side exhaust manifold and EGR cooler exhaust inlet.

4. Plug in the cylinder block heater to warm coolant.

> **WARNING: To avoid serious personal injury or possible death, use only the following procedure to remove the pressure type cap from the cooling system. Always allow the engine to cool first. Wrap a thick, heavy cloth around the cap. Loosen cap slowly; then pause a moment. This will avoid possible scalding by hot coolant or steam. Continue to turn cap to the left and remove.**

5. Remove the radiator cap and pressurize cooling system to 96 kPa (14 psi) using the radiator pressure tester.

6. Check EGR cooler exhaust inlet for the presence of coolant.
    - If coolant is present, replace EGR cooler following the procedures in the *Engine Service Manual*.
    - If no leak is found, but pressure is dropping rapidly, inspect the exhaust manifolds for coolant. Repair as necessary following the procedures in the *Engine Service Manual*.
    - If no leak is found, continue with step 7.

7. Remove EGR valve and install Intake Manifold Pressure Test Plug (EGR) following the procedures in the *Engine Service Manual*.

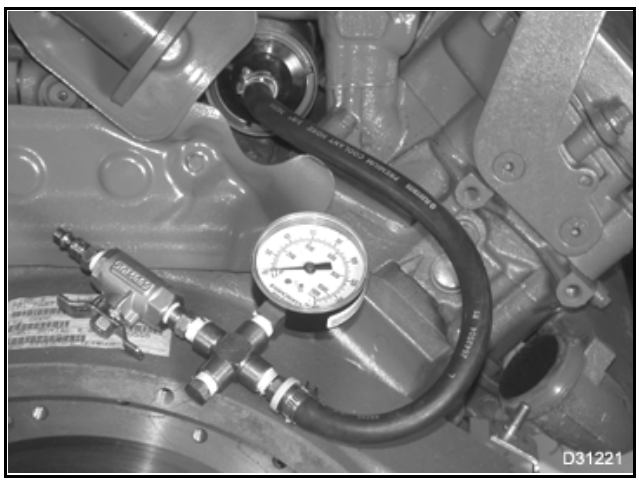

Figure 77 EGR test plate, air regulator, and air gauge installed

8. Install an air regulator onto EGR cooler pressure test plate and install onto EGR cooler exhaust inlet using original clamp. Follow the procedure in the *Engine Service Manual*.

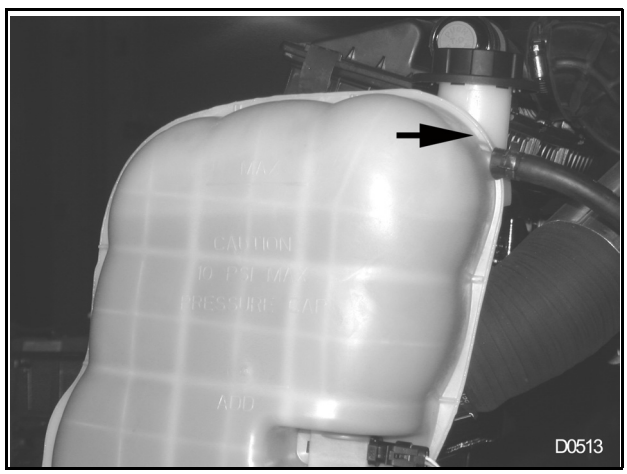

Figure 78 Deaeration tank fill position

9. Remove radiator pressure tester from coolant deaeration tank and fill tank with coolant to a point above the deaeration inlet line to tank. Leave radiator cap off.

10. Apply regulated air pressure of 172–414 kPa (25–60 psi) at the EGR cooler pressure test plate.

11. Observe coolant deaeration tank for air bubbles. Air pressure must be left on EGR cooler for a minimum of 5 minutes.

    - If air bubbles are observed in the tank, remove EGR cooler and retest following the procedures in the *Engine Service Manual* to verify EGR cooler is defective. Replace as needed.
    - If air bubbles are observed and EGR cooler passes additional testing, remove and pressure test the intake manifold following the procedures in the *Engine Service Manual*.
    - If no air bubbles are observed or EGR cooler and intake manifold have passed testing, contact Tech Services for further assistance.

COOLANT OVER-TEMPERATURE

Causes

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

Inspection for Coolant Over Temperature Conditions

1. Check coolant deaeration tank for correct fill level.

    - If coolant level is low, look for external leaks at radiator, engine and all coolant related hoses.

2. Inspect the condition of the following items: cooling fan blade, shroud, accessory drive belt, accessory drive belt tensioner, cooling fan drive clutch, and radiator.

    - If vehicle is new or recently repaired, verify the correct part number for any component related to the cooling system.
    - Verify that cooling fan blade, cooling fan drive clutch, and radiator are clean of debris and dirt build-up. Clean areas as required.

CAUTION: To avoid radiator damage, when using high pressure washer, be careful not to get wand to close to radiator fins.

3. Install Electronic Service Tool (EST) and check for active and inactive Diagnostic Trouble Codes (DTC) related to engine coolant over-temp conditions.

    - Using the EST, compare Engine Coolant Temperature (ECT), Engine Oil Temperature (EOT), Manifold Air Temperature (MAT), and Intake Air Temperature (IAT) with Key On Engine Off. All of the sensors should read within 1 Degree C (2 Degree F) of each other.

      NOTE: This is only accurate if done after a cold soak of at least 8 hours on the engine.

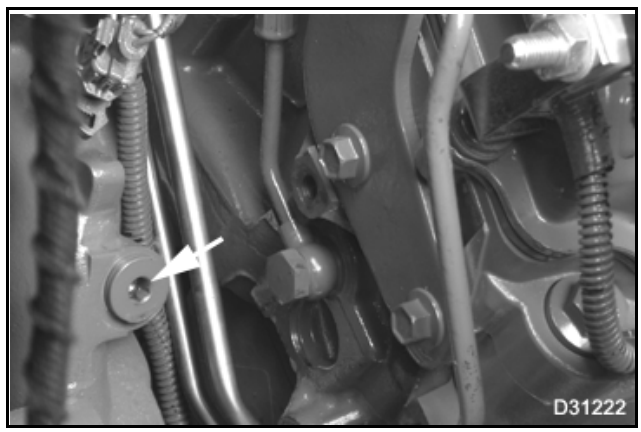

Figure 79 Coolant port in front cover

4. Install a manual gauge or thermocouple in the port of the front cover, operate the engine, and use the EST to monitor ECT.

    - If both the EST and mechanical gauge read near the same temperature +/- 3° C (+/- 5° F), do step 5.
    - If mechanical gauge and EST read values with a difference greater than +/- 3° C (+/- 5° F), do Electronic Control Systems Diagnostics for the ECT circuit found in Section 7 of this manual.

5. Run engine up to an operating temperature of at least 70° C (158° F). While monitoring ECT using

the EST, instrument panel coolant temperature gauge and the mechanical gauge. Attempt to duplicate the operator's concern of coolant over-temp.

- If instrument panel coolant temperature gauge reads a different temperature than the EST and mechanical gauge, refer to the *Electrical System Troubleshooting Guide* for the appropriate model and year of vehicle.
- If mechanical gauge and EST read values with a difference greater than +/- 3° C (+/- 5° F), do Electronic Control Systems Diagnostics for ECT circuit found in Section 7 of this manual.
- If concern cannot be duplicated, clean radiator fins (if not done previously). Flush the radiator fins with water on the cooling fan side of the radiator. **Do not continue further with diagnostics.**

CAUTION: To avoid radiator damage, when using high pressure washer, be careful not to get wand to close to radiator fins.

- If coolant over– temp is duplicated, do step 6.

WARNING: To avoid serious personal injury or possible death, use only the following procedure to remove the pressure type cap from the cooling system. Always allow the engine to cool first. Wrap a thick, heavy cloth around the cap. Loosen cap slowly; then pause a moment. This will avoid possible scalding by hot coolant or steam. Continue to turn cap to the left and remove.

6. 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, proceed to Combustion Leak to Coolant diagnostics in this section.
   - If pressure gauge reading is below pressure rating of system, do step 7.
7. Remove and inspect thermostat following the procedure in the *Engine Service Manual*. Check for opening temperature.
   - Replace as needed. Retest for condition after repair.
   - If thermostat passes test, do step 8.
8. Use vehicle diagnostics manual to review automatic transmission diagnostics.
9. If over-temp condition remains, remove radiator and have flow checked at radiator shop.
   - Retest engine for over-temp condition with repaired/replaced radiator.

ECM RESET/ IDM RESET (INTERMITTENT ENGINE STUMBLE)

- **Glow plug lamp cycles ON while engine running**
- **Glow plugs recycle while engine running**
- **Engine stumble and die**
- **Loss of accelerator pedal authority**
- **Miles driven are not logged if ECM reset occurs during current key cycle**

Causes

An Electronic Control Module (ECM) reset occurs when the ECM momentarily reboots or is turned OFF and ON while the engine is operating.

If a reset occurs, the engine will momentarily stumble and the ECM will go through a normal KEY ON cycle. This includes the following:

- Illuminate the WAIT TO START lamp
- Enable glow plugs
- Validate the accelerator pedal position

If the pedal is not at idle position when the reset occurs, a DTC is set and engine speed goes to low idle. The ECM will not allow accelerator pedal authority until the Accelerator Pedal Sensor (APS) is released.

An Injector Drive Module (IDM) reset will occur if power is lost to the circuits for IDM Logic or IDM Main Power while the engine is operating. If power is lost, the engine will miss and recover or stall. The APS will not be affected by this fault.

Momentary loss of power to the ECM or IDM may be caused by the following:

- Defective fuses
- Intermittent open at connectors
- Defective battery power feed harness
- Poor ground connection
- Defective power relay
- Shorted or open harness

Diagnostics for Engine Stumble

1. Using the EST, check for DTCs for both the engine and chassis modules.
   - If DTC 626 (unexpected reset fault) or 534 (IDM relay voltage low) are present as active or inactive codes, continue with step 4.
   - If any other engine DTCs are active, perform appropriate diagnostics and repairs before continuing with these procedures.
   - If any chassis DTCs are active when checking the Electronic System Controller (ESC), perform appropriate diagnostics and repairs before continuing.
2. Complete Test 3 (Fuel Pressure) on the Performance Diagnostics form or Section 6 of this manual.
3. Complete Test 4 (Fuel Inlet Restriction) on the Performance Diagnostics form or Section 6 of this manual.

See Section 7 in this manual, the *Chassis Electrical Circuit Diagram Manual and Electrical System Troubleshooting Guide* for the model and year of the vehicle when performing the following steps.

4. Check all ECM and IDM related fuses.
5. Check all Battery, V_{IGN} and ground connections for the ECM and IDM.
6. Monitor ECM powers and grounds with breakout box under operator complaint conditions.
7. Monitor IDM powers and grounds with 12 Pin Breakout Harness under operator complaint conditions.
8. If root cause has not been identified in previous steps, continue diagnosis by performing the remaining steps on the Performance Diagnostics form or Section 6 of this manual.

EXCESSIVE FUEL CONSUMPTION

Causes

Operator effects

- Inaccurate record keeping or tank filling
- Winter blend or No. 1 fuel
- High expectations

Application effects

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

Chassis effects

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

Engine effects

- Incorrect or defective thermostat
- Defective Electronic Variable Response Turbocharger (EVRT™) operation
- Oil aeration
- Fuel system leaks
- Base engine performance loss

Verifying Excessive Fuel Consumption Complaints

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

2. Loss of fuel economy is normal if winter blend fuel, kerosene or No. 1 diesel fuel is being used.

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

4. Do all tests on Performance Diagnostic form or in Section 6 of this manual. These tests will verify the operating condition of the following engine and chassis systems:

   - Intake system
   - Exhaust system
   - Fuel delivery and filtration
   - High pressure fuel system
   - Injector operation
   - EVRT™ turbocharger operation
   - Oil aeration
   - Base engine condition
   - Electronic control system condition

   If all tests are passed, the engine is operating normally.

FUEL IN COOLANT

Causes

- Leaking or cracked injector sleeve with injector O-ring failure
- Cracked or porous head casting in fuel rail area

Fuel in Coolant Leakage Test using High Pressure

1. Verify coolant contamination.
   - Check for diesel fuel odor in coolant.
   - Coolant may be discolored if diesel fuel is present.
2. Plug in the cylinder block heater to warm coolant.

⚠ WARNING: To avoid serious personal injury or possible death, use only the following procedure to remove the pressure type cap from the cooling system. Always allow the engine to cool first. Wrap a thick, heavy cloth around the cap. Loosen cap slowly; then pause a moment. This will avoid possible scalding by hot coolant or steam. Continue to turn cap to the left and remove.

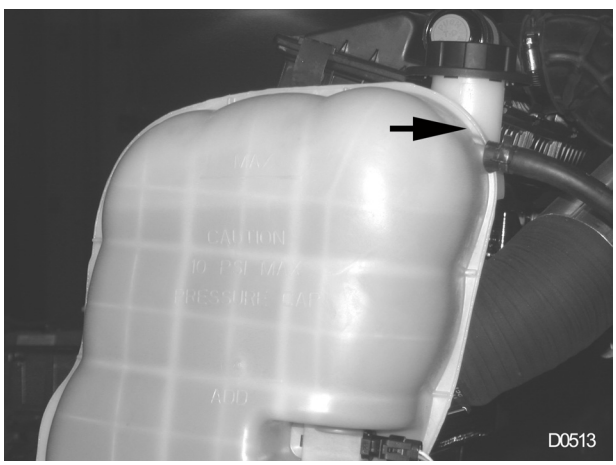

Figure 80 Deaeration Tank Fill Position

3. Remove cap from deaeration tank and fill with coolant to a level above the deaeration inlet line to tank.

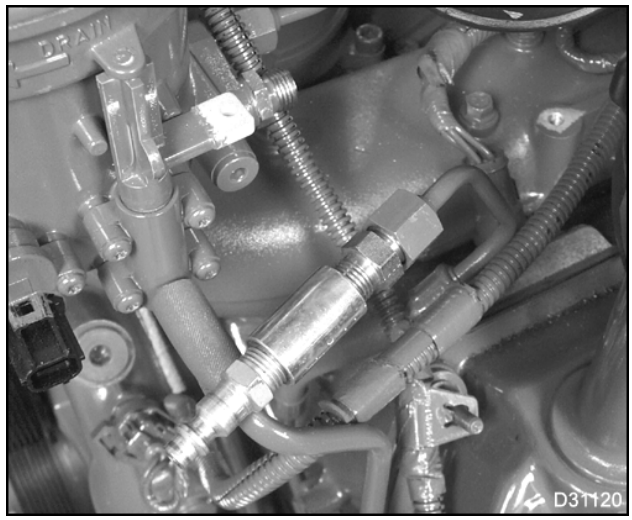

Figure 81 Pressurize Fuel System

4. Pressurize both fuel lines from the fuel filter header to cylinder heads to 550–690 kPa (80–100 psi) using the fuel line test adapter. Observe deaeration tank for air bubbles or loss of pressure at gauge.
   - If leak is found, remove cylinder head where leak was detected as described in the *Engine Service Manual*. Do all inspections and pressure test cylinder head to verify leak path. Replace or repair cylinder head, as necessary. If an injector sleeve was replaced, retest the cylinder head using the cylinder head pressure test plate.
   - If no leak is found, continue with Fuel in Coolant Leakage Test using Low Pressure.

Fuel in Coolant Leakage Test using Low Pressure

1. Verify coolant contamination.
   - Check for diesel fuel odor in coolant.
   - Coolant may be discolored if diesel fuel is present.
2. Plug in the cylinder block heater to warm coolant.

WARNING: To avoid serious personal injury or possible death, use only the following procedure to remove the pressure type cap from the cooling system. Always allow the engine to cool first. Wrap a thick, heavy cloth around the cap. Loosen cap slowly; then pause a moment. This will avoid possible scalding by hot coolant or steam. Continue to turn cap to the left and remove.

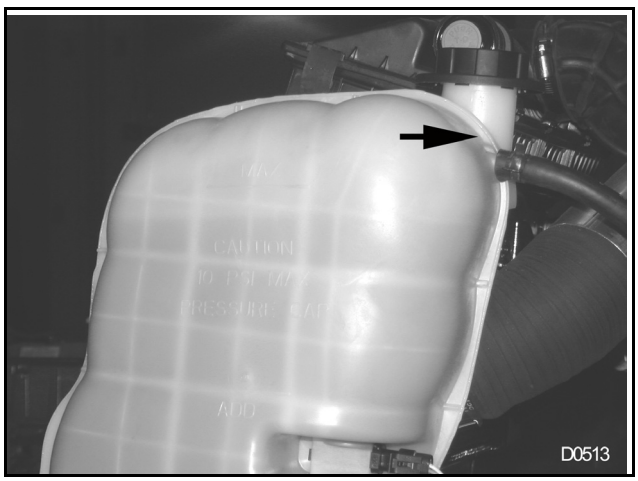

Figure 82 Deaeration Tank Fill Position

3. Remove cap from deaeration tank and fill with coolant to a level above the deaeration inlet line to tank.

4. Install radiator pressure tester at the coolant deaeration tank. Pressurize cooling system to 96 kPa (14 psi).

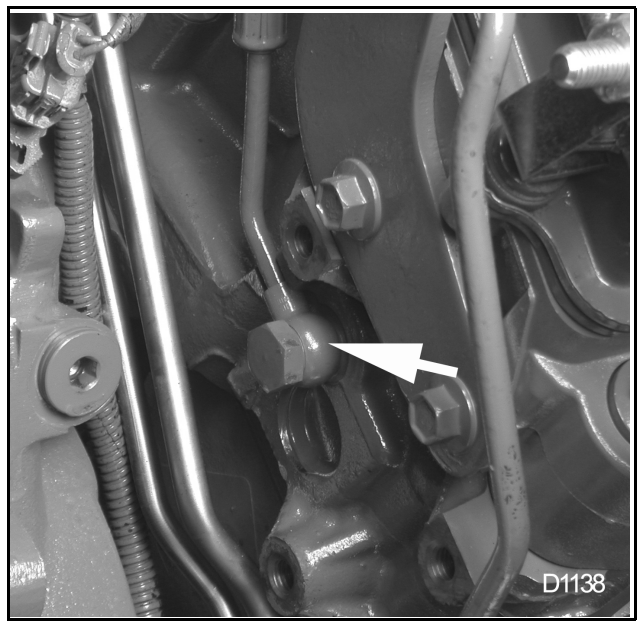

Figure 83 Fuel Line Banjo Fitting

5. Remove fuel line banjo fittings/check valves from front of cylinder heads as described in the *Engine Service Manual*.

6. Observe fuel rail bores at cylinder heads for air or coolant leaks.

   - If leak is found, remove valve cover and fuel injectors as described in the *Engine Service Manual*. Observe injector bores for leakage. Replace or repair cylinder head, as necessary. After repair, pressurize cooling system to confirm repair.
   - If no leak is found, remove each cylinder head one at a time following the procedures as described in the *Engine Service Manual*. Perform all inspections and pressure test cylinder head to check for leak paths.

FUEL IN LUBE OIL

Causes

- Leaking fuel injector or injector O-ring (A leaking injector sleeve or injector tip could cause contaminated engine oil, but would most likely be identified as a performance problem.)
- Porous cylinder head (most likely on low mileage vehicles)

Verifying Oil Dilution from Fuel System

1. Verify oil contamination. Oil contaminated with diesel fuel will have diesel fuel odor and will cause the oil level in engine to **grow**.

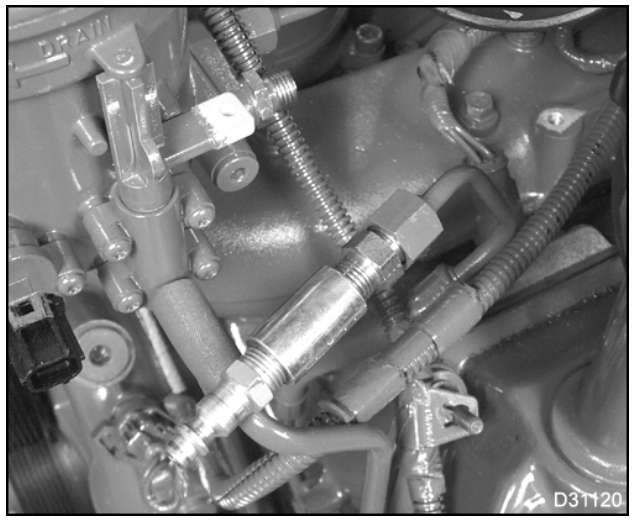

Figure 84 Pressurize Fuel System

2. Pressurize both fuel lines from the fuel filter header to the cylinder heads to 550–690 kPa (80–100 psi) using fuel line test adapter.

3. Once a loss of pressure or leak is determined, remove valve cover at suspected head and inspect for leak at injector areas.

LOW OIL PRESSURE

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
- Fuel in oil
- Stuck oil pressure regulator
- Scored/damaged oil pump
- Engine Oil Pressure (EOP) sensor biased
- Missing oil gallery plugs (front or rear)
- Broken, missing or loose piston cooling tube(s)
- Missing, damaged or worn bearing inserts or camshaft bushings
- Lifter missing (will also have performance problems)
- Aeration (cracked pickup tube, missing O-ring)

Low Oil Pressure Diagnostics

1. Verify oil level in engine by using oil level gauge while vehicle is parked on level ground. Check to see if oil is contaminated with fuel or coolant.
    - Engine oil level will vary depending on temperature of engine
    - If oil is contaminated, go to Fuel in Lube Oil or Coolant in Lube Oil test procedures located in this section.

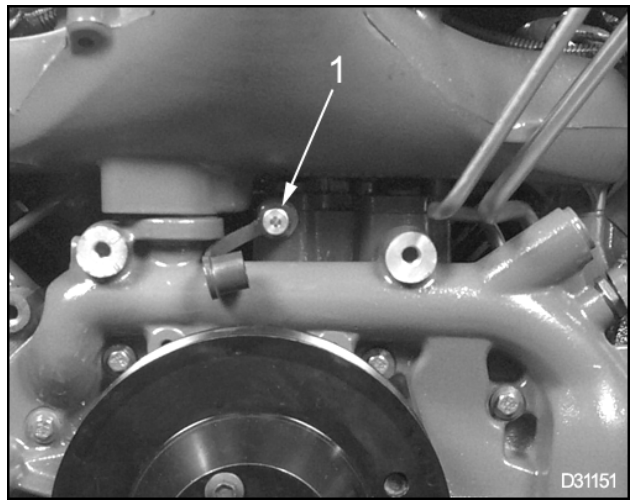

Figure 85 Lube Oil Pressure Test Port

1. Oil pressure test port

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following;

When routing test line , do not crimp the line, run the line too close to moving parts, or let the line touch hot engine surfaces.

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following;

When running the engine in the service bay, make sure the parking brake is set, the transmission is in neutral, and the wheels are blocked.

2. Verify oil pressure using a known good mechanical gauge installed at the lube oil pressure test port at the front of the engine. Measure pressure at both low and high idle no load. Engine must be at operating temperature.

- 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) perform Electronic Control Systems Diagnostics for the EOP circuit as described in Section 7 in 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.
- If oil pressure does not read within the specification listed in Appendix A in this Manual, continue to step 3.

3. Remove and inspect the lube oil pump as described in the *Engine Service Manual*.
   - Inspect the lube oil pump housing and cover for gouging or deep scratches.
   - Inspect the gerotor gears for excessive wear or damage.
   - If no excessive damage is found continue to step 4.

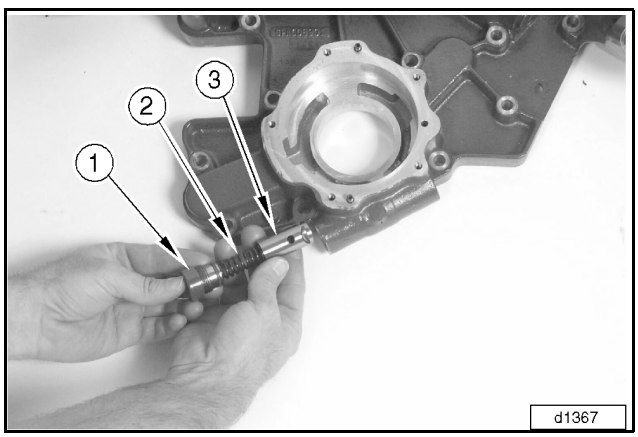

Figure 86 Oil Pressure Regulator Components

1. End cap and O-ring
2. Oil pressure regulator spring
3. Piston

4. Remove and inspect oil pressure regulator as described in the *Engine Service Manual*.
   - The oil pressure regulator piston should move freely in its bore in the front cover.
   - If oil pressure regulator is functional and passes visual inspection, reinstall regulator, gerotor gears, pump cover, and damper following the procedures in the *Engine Service Manual*. Retest following the Low Oil Pressure Diagnostics procedures in step 2. If oil pressure remains low, do step 5.

5. Drain oil from engine using a clean catch basin. Inspect oil drain plug magnet, drained oil and oil filter for foreign debris.
   - An oil sample should be taken to determine level of engine wear metals and contaminants in the oil.

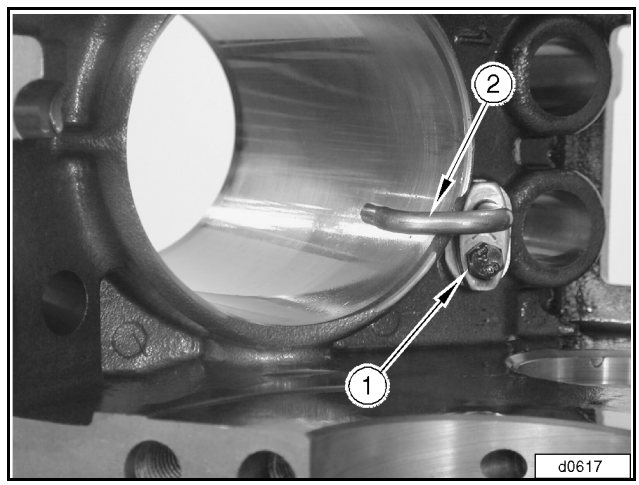

Figure 87 Piston Cooling Tube

1. Mounting bolt
2. Piston cooling tube

6. Remove both the upper and lower oil pans as described in the *Engine Service Manual*. Inspect for missing, loose or damaged oil pickup tube, O-ring, piston cooling tubes, bearing inserts, and cam bushings.

7. Reinstall oil filter cap without oil filter.

8. Connect fuel/oil pressure test coupler to a regulated shop air line.

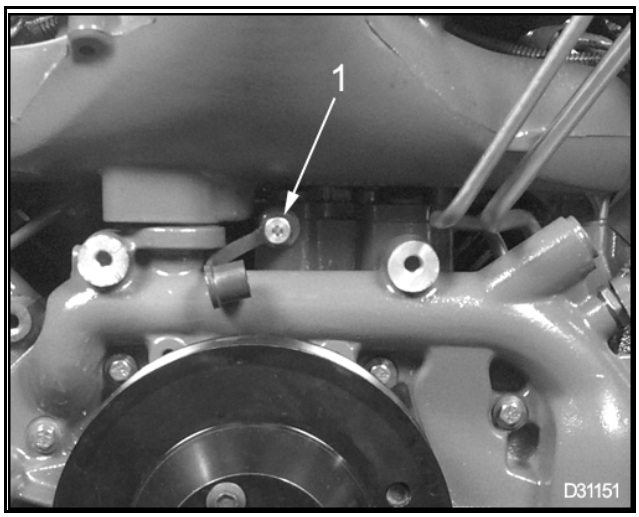

Figure 88 Lube Oil Pressure Test Port

1. Oil pressure test port

9. Connect to lube oil pressure test port and apply 345 kPa (50 psi).

10. Inspect for gross leaks.

    - If a major leak is observed from the front cover area, go to step 11.
    - If a major leak is observed from the rear cover area, go to step 13.
    - If a major leak is not observed, remove engine from vehicle. Disassemble engine and perform full inspection of all components following procedures in the *Engine Service Manual*.

11. Remove the front cover from the engine following procedures in the *Engine Service Manual* and complete inspection of the lube oil pump.

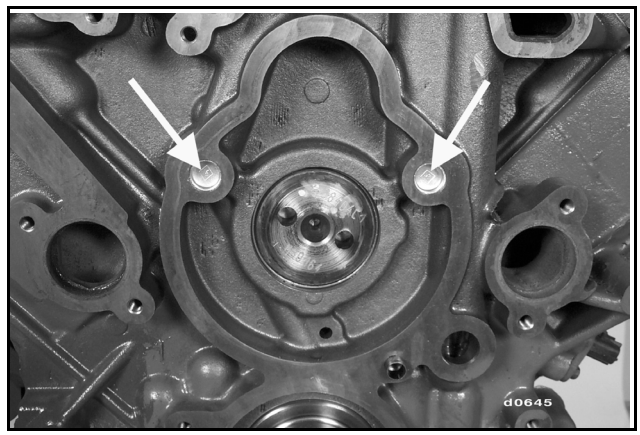

Figure 89 Main Oil Gallery Cup Plug Locations

12. With front cover removed from the engine, verify that the main oil gallery cup plugs are in position and not damaged.

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, the engine must be supported before removing rear cover or engine.

13. Remove engine from vehicle.

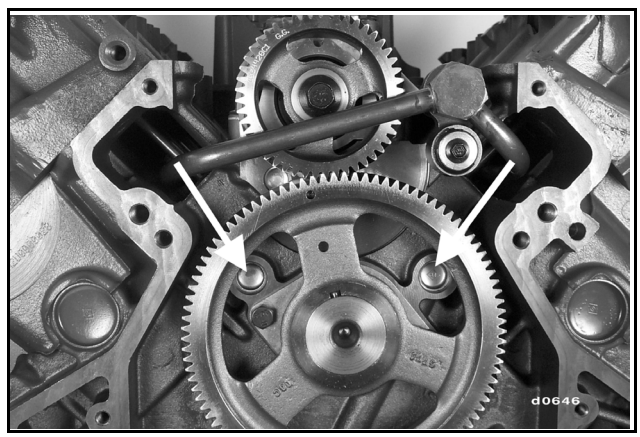

Figure 90 Rear Main Oil Gallery Cup Plug Locations

14. Remove the rear cover from the engine as described in the *Engine Service Manual*. Verify the rear main oil gallery cup plugs are in position and not damaged.

PRIMING THE FUEL SYSTEM

Priming without Vacuum Source

NOTE: If during diagnosis of concern, all three of the following issues are noted: fuel system will not prime, engine is exhibiting white to black smoke, and fuel pressure is pulsating, see Combustion Leaks to Fuel, in this Section.

In the event a run out of fuel condition occurs, observe the following instructions:

1. Add fuel to tank. If equipped with dual tanks, add fuel to passenger side tank. Check fuel level in operator side tank to verify transfer pump is operating properly.

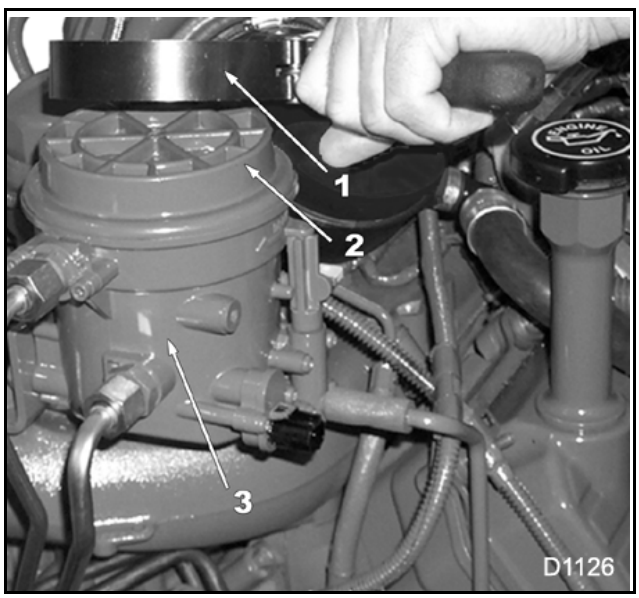

Figure 91 Removing fuel fiter cap

1. Band wrench
2. Fuel filter cap
3. Fuel filter assembly

2. Remove fuel filter cap using a band wrench. Leave filter in housing.

3. Fill fuel filter housing with diesel fuel up to the filter cap threads.

4. Replace fuel filter cap and tighten.

5. Engage starter for 30 seconds and allow starter to cool for 2 minutes.

   NOTE: Return key to RUN position only between starts to decrease load on batteries. This will prevent glow plugs from recycling.

   CAUTION: To avoid damage to starter, if engine fails to start within 30 seconds, release ignition switch and wait 2–3 minutes to allow starter motor to cool. Repeat above procedure.

6. Repeat step 5 until engine starts and runs on its own.

   - 3 to 5 cranking periods will be required to start vehicle. Additional cranking periods may be required if fuel filter is not primed.

NOTE: Bus applications with rear tank will require additional cranking periods because of increased distance from fuel tanks.

Priming with Vacuum Source

NOTE: If during diagnosis of concern, all three of the following issues are noted: fuel system will not prime, engine is exhibiting white to black smoke, and fuel pressure is pulsating, see Combustion Leaks to Fuel, in this Section.

1. Add fuel to tank. If equipped with dual tanks, add fuel to passenger side tank. Check fuel level in operator side tank to verify transfer pump is operating properly.

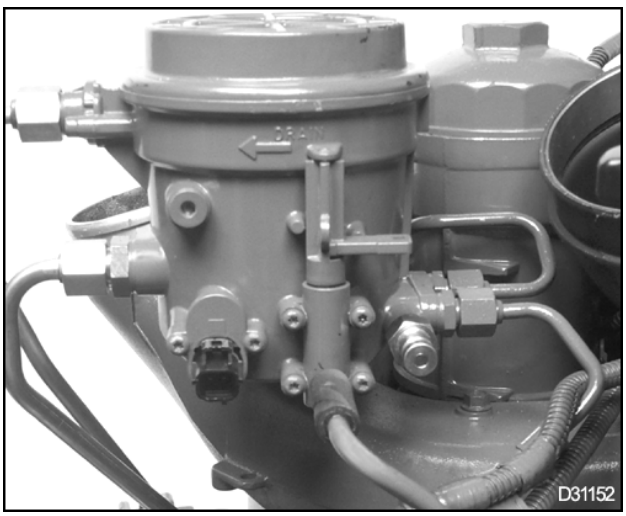

Figure 92 Fuel pressure test fitting

2. Install fuel pressure test fitting in unfiltered fuel test port.

3. Attach vacuum source to fuel/oil pressure test coupling and connect to fuel pressure test fitting.

4. Draw fuel from tank using vacuum source until level in fuel filter housing reaches fitting.

5. Disconnect vacuum source and fuel/oil pressure test coupler from fuel pressure test fitting.

6. Engage starter for 30 seconds and allow starter to cool for 2 minutes.

   NOTE: Return key to RUN position only between starts to decrease load on batteries. This will prevent glow plugs from recycling.

   CAUTION: To avoid damage to starter, if engine fails to start within 30 seconds, release ignition switch and wait 2–3 minutes to allow starter motor to cool. Repeat above procedure.

7. Repeat step 5 until engine starts and runs on its own.

   - 2 to 4 cranking periods will be required to start vehicle. Additional cranking periods may be required if fuel filter is not primed.

8. After engine has been started and is running smoothly, stop engine and remove fuel pressure test fitting and reinstall plug in filter housing.

ROUGH IDLE

Causes

- Engine oil (aerated, incorrect grade, low oil level, extended drain interval)
- Poor fuel quality
- Low fuel pressure
- Aerated fuel
- Electronic control system faults (ECM and IDM)
- Injection Control Pressure (ICP) system problems
- Fuel injectors not working properly
- Exhaust Gas Recirculation (EGR) valve stuck open
- Power cylinder problems
- Valve train problems
- Engine or flywheel balance problems
- Exhaust system to cab/chassis ground out
- Loose/worn engine mounts

Diagnostics for Verifying Rough Idle

1. Verify complaint. Confirm conditions when complaint is present.

   When does engine rough idle occur?

   - Hot – operating temperature
   - Cold
   - After high speed operation
   - Over entire engine speed range
   - Combination of the above conditions
   - Is there chassis vibration or any other conditions/observations present when engine idles rough.

2. Inspect exhaust system for contact with cab, frame or body of vehicle.

   Engine exhaust pipe contact with cab may transmit engine vibrations to cab, especially on acceleration or engine shifts. This condition may be incorrectly diagnosed as a rough idle complaint.

Complete the following tests on the Performance Diagnostic form. See Section 6 in this manual for specific details on each test.

3. Do Test 1 (Engine Oil) on Performance Diagnostics form. Check engine oil level. Verify correct oil grade for ambient temperature. See *Engine Operation and Maintenance Manual*, Engine Lubrication Requirements section. Confirm oil meets correct API specification for your model and year of engine.

4. Do Test 2 (Fuel) on Performance Diagnostics form. Verify quality and quantity of diesel fuel. Poor quality fuel or low cetane rating can cause white smoking, engine misfire, and low power. See *Engine Operation and Maintenance Manual*, Fuel Requirements section for your model and year of engine to determine minimum necessary fuel grade and cetane rating.

5. Do Test 3 (Fuel Pressure) on Performance Diagnostics form. Measure transfer pump pressure. Low fuel pressure will cause the engine to misfire and will cause a loss of power.

   - If fuel pressure is low, remove canister mounted on fuel pump and remove any debris on fuel inlet screen.

6. Do Test 4 (Fuel Inlet Restriction) on Performance Diagnostics form, using the fuel inlet restriction adapter.

   - Remove fuel pressure regulator from side of fuel filter housing and inspect valve and spring for damage. Inspect the rubber seat on the valve for tearing or swelling. Remove any foreign material found.

7. Do Test 5 (Diagnostic Trouble Codes) on Performance Diagnostics form. Intermittent sensor, injector or wiring harness faults can affect engine idle conditions. The ECM may have detected and recorded these conditions.

8. Do Test 6 (Key On Engine Off Standard Test) on Performance Diagnostics form. The KOEO Standard Test will verify electrical operation of all sensors and actuators.

9. Do Test 7 (Key On Engine Off Injector Test) on Performance Diagnostics form. This test will verify that the injectors are working electronically.

10. Do air in fuel and fuel return flow test. Install a clear line on the return fuel line and check to see if air bubbles are present while engine is running. An excessive amount of air indicates a suction side air leak or damaged injector gasket. These problems will cause rough idle and/or poor performance. If there is a question about what is excessive air, locate a good running vehicle and compare fuel flow.

11. Do Test 12 (Key On Engine Running Standard Test) on Performance Diagnostics form. This test will verify the functionality of the Injection Control Pressure (ICP) system. The engine must be at operating temperature 70°C (158°F) to do this test.

12. Do Test 16 (Injection Control Pressure) on Performance Diagnostics form. This test will confirm if the Injection Control Pressure (ICP) system is functioning properly and verify ICP stability.

13. Do Test 17 (Crankcase Pressure) on Performance Diagnostics form. This test will determine the condition of the power cylinders and base engine.

14. Do Test 18 (Injector Disable) on Performance Diagnostics form. The primary function of this test is to show the contributions of the individual power cylinders. The test will detect a weak cylinder which could be the result of an injector or base engine problem.

    - Test 18 is used in conjunction with Test 19 (Relative Compression) to distinguish between an injector or mechanical problem.

15. Do Test 19 (Relative Compression) on Performance Diagnostics form. This will verify base engine compression.

    - Test 19 is used in conjunction with Test 18 (Injector Disable) to distinguish between an injector or mechanical problem.

16. Inspect for engine and flywheel balance. Engine roughness at idle that gets worse with a no load acceleration may be caused by an out of balance condition.

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, support the vibration damper during mounting bolt removal. The damper can slide off the nose of the crankshaft very easily.

CAUTION: To prevent engine damage, you must always replace all four bolts when installing the vibration damper.

Do not use anti-seize compounds, grease, or any lubricants whatsoever. Lubricants have an adverse effect on torque results.

- Following the procedures in the *Engine Service Manual* remove the vibration damper and inspect the elastomer layer for cracks and misalignment. If no problem is found, reinstall vibration damper following the exact assembly procedures found in the *Engine Service Manual*. Verify that locating dowel at the end of the crankshaft is aligned with locating hole in the balancer for proper installation.
- Isolate the engine from transmission by removing the transmission, clutch and pressure plate or torque converter. Start the engine and evaluate for roughness. If the engine runs smooth, replace the torque converter or replace clutch and pressure plate.
- Following the procedures in the *Engine Service Manual*, remove the flywheel and verify proper orientation. If orientation is correct, replace or rebalance flywheel. When removing/installing the flywheel, ensure that the locating dowel is in the right place and that the flywheel is located properly on the dowel.

- Following the procedures in the *Engine Service Manual*, remove the lower and upper oil pan and inspect the crankshaft counterweights to ensure balance holes exist.

SMOKE

Black Smoke Diagnostics

Causes

- Air intake or exhaust restriction
- Turbocharger failure, turbocharger blade damage or turbocharger wheel stuck
- Loose injector
- Altitude (black smoke on hard acceleration or snap acceleration may be pronounced at higher elevations)
- Manifold Absolute Pressure (MAP) sensor defective

Procedures

1. If engine has fuel knock or there is evidence of fuel in the exhaust, remove exhaust manifolds and inspect for fuel in the exhaust ports. (Suspect loose injectors, missing or damaged O-ring and gasket on bottom of injector).

2. Inspect air inlet system and exhaust system for possible sources of restriction.

3. Visually inspect turbocharger for oil leakage or failure of blades. Some oil carryover is expected due to the closed crankcase ventilation system.

4. Do Test 9 (Intake Restriction) on Performance Diagnostics form or in Section 6 of this manual.

5. Do Test 11 (Exhaust Restriction) on Performance Diagnostics form or in Section 6 of this manual.

White Smoke Diagnostics

Causes

- Cold engine
- No glow plug operation
- Poor quality fuel
- EGR stuck open on startup
- Coolant leak to combustion from exhaust side
- Loose fuel injectors
- Defective fuel injectors
- Bent connecting rods
- Worn piston rings
- Low compression
- Coolant leaking into combustion chamber
- Intake manifold porosity

Procedures

1. In cold ambient temperatures, some white smoke is normal until the engine is up to operating temperature.

   - Ensure that engine is up to operating temperature 88°C (190°F) prior to verifying a white smoke complaint.
   - If the engine is unable to obtain operating temperature during a road test, verify thermostat opening temperature 88°C (190°F).

2. On a cold engine, the glow plug system may remain on for up to two minutes after the engine starts to assist in cold smoke cleanup. Do Tests 15A and 15B (Glow Plug System) on Hard Start and No Start Diagnostics form to verify glow plug operation.

3. Do Test 2 (Fuel) on Performance Diagnostics form. Verify quality and quantity of diesel fuel. Poor quality fuel or low cetane rating can cause white smoking, engine misfire and low power. See *Engine Operation and Maintenance Manual*, Fuel Requirements section for model and year of engine to determine minimum necessary fuel grade and cetane rating.

4. Do Test 10 (EGR Position) on Performance Diagnostics form, if operator complaint is white smoke on start-up only. Do test according to condition of operator complaint.

5. If there is coolant loss without engine overheating, check for coolant in exhaust.

   - If coolant is leaking from exhaust or can be smelled in the exhaust, refer to Coolant Leak to Exhaust diagnostics in this section.

6. If engine has fuel knock or evidence of fuel in exhaust, remove exhaust manifolds and inspect for fuel in the exhaust ports. (Suspect loose

injectors, missing or damaged O-ring and copper gasket on bottom of injector).

7. Inspect air induction system for evidence of water ingestion or evidence of unfiltered air entering the engine.

   - Water ingestion could have caused a hydraulic lock and bent connecting rods. If water ingestion is suspected, identify smoking cylinders by removing exhaust manifolds and running engine.
   - Unfiltered air entering the engine can cause excessive power cylinder wear and turbocharger compressor blade damage. If power cylinder wear is suspected, identify smoking cylinder(s) by removing exhaust manifolds and running engine.
   - If coolant is found in the intake manifold, refer to Coolant Leak to Exhaust diagnostics in this section.

8. Do compression test on cylinders that are white smoking using the compression test adapter. Inspect turbocharger for damage.

9. If engine is overheating with coolant loss, and cylinder head gasket, injector sleeve or glow plug sleeve is suspected for leaking, refer to Combustion Leaks to Coolant Test using High Pressure in this section.

Blue Smoke Diagnostics

Causes

- Excessive crankcase pressure
- Defective turbocharger
- Defective fuel injector
- Piston oil control ring stuck/damaged
- Leaking valve stem seals or worn valve guides

Procedures

1. Do oil consumption test on engine. Verify high oil consumption.

2. Do Test 17 (Crankcase Pressure) on Performance Diagnostics form or Section 6 of this manual.

   - If crankcase pressure is high and there is excessive oil consumption, investigate air compressor, turbocharger, and power cylinder components.
   - If crankcase pressure is normal and there is excessive oil consumption continue with next step.

3. Remove Charge Air Cooler (CAC) pipes and inspect CAC and intake system for excessive oil carryover.

   NOTE: Oil in the air induction system is normal, since the engine has a closed breather.

4. Inspect turbocharger for oil leak at both the compressor and turbine housings.

5. Remove exhaust manifolds and inspect exhaust ports for oil residue to pinpoint possible injector failure causing oil to mix with fuel injected into the power cylinder.

   - If crankcase pressure is normal and oil consumption is more than one quart per 500 miles, replace fuel injector in cylinder where oil residue is identified.

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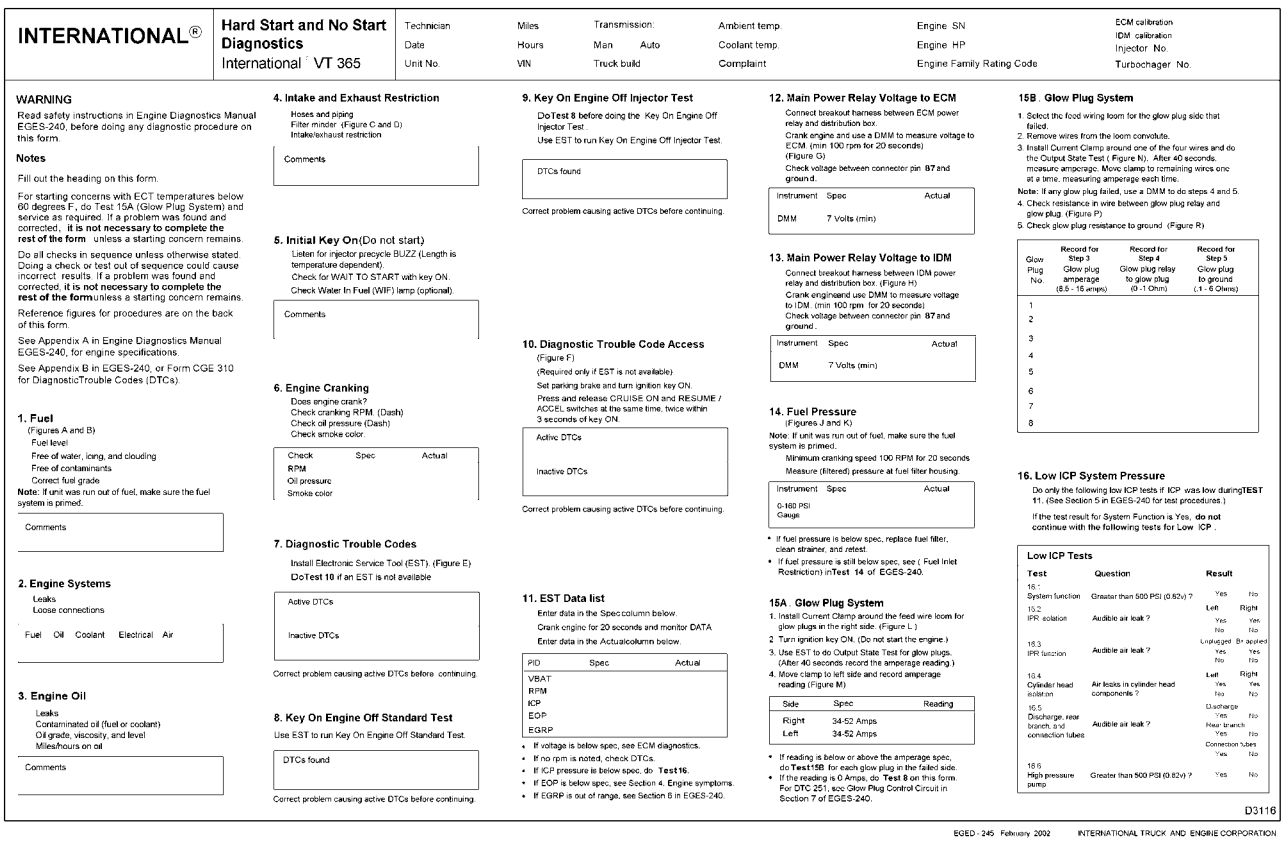
DESCRIPTION

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing service bay diagnostics on engine or vehicle.

Engine diagnostic forms provide customer satisfaction and assist technicians in troubleshooting International® VT 365 diesel engines. Diagnostic test procedures help technicians find problems systematically and quickly to avoid unnecessary repairs.



INTERNATIONAL®

Hard Start and No Start Diagnostics
International® VT 365

Technician | Miles | Transmission: | Ambient temp. | Engine SN | ECM calibration
Date | Hours | Man Auto | Coolant temp. | Engine HP | IDM calibration
Unit No. | VIN | Truck build | Complaint | Engine Family Rating Code | Injector No.
| | | | | | Turbocharger No.

WARNING
Read safety instructions in Engine Diagnostics Manual EGES-240, before doing any diagnostic procedure on this form.

Notes
Fill out the heading on this form.
For starting concerns with ECT temperatures below 60 degrees F, do Test 15A (Glow Plug System) and service as required. If a problem was found and corrected, **it is not necessary to complete the rest of the form** unless a starting concern remains.
Do all checks in sequence unless otherwise stated. Doing a check or test out of sequence could cause incorrect results. If a problem was found and corrected, **it is not necessary to complete the rest of the form** unless a starting concern remains.
Reference figures for procedures are on the back of this form.
See Appendix A in Engine Diagnostics Manual EGES-240, for engine specifications.
See Appendix B in EGES-240, or Form CGE 310 for DiagnosticTrouble Codes (DTCs).

1. Fuel
(Figures A and B)
Fuel level
Free of water, icing, and clouding
Free of contaminants
Correct fuel grade
Note: If unit was run out of fuel, make sure the fuel system is primed.
Comments

2. Engine Systems
Leaks
Loose connections
Fuel Oil Coolant Electrical Air

3. Engine Oil
Leaks
Contaminated oil (fuel or coolant)
Oil grade, viscosity, and level
Miles/hours on oil
Comments

4. Intake and Exhaust Restriction
Hoses and piping
Filter minder (Figure C and D)
Intake/exhaust restriction
Comments

5. Initial Key On (Do not start)
Listen for injector precycle BUZZ (Length is temperature dependent).
Check for WAIT TO START with key ON.
Check Water In Fuel (WIF) lamp (optional).
Comments

6. Engine Cranking
Does engine crank?
Check cranking RPM. (Dash)
Check oil pressure (Dash)
Check smoke color.

Check	Spec	Actual
RPM		
Oil pressure		
Smoke color		

7. Diagnostic Trouble Codes
Install Electronic Service Tool (EST). (Figure E)
Do **Test 10** if an EST is not available
Active DTCs
Inactive DTCs
Correct problem causing active DTCs before continuing.

8. Key On Engine Off Standard Test
Use EST to run Key On Engine Off Standard Test.
DTCs found
Correct problem causing active DTCs before continuing.

9. Key On Engine Off Injector Test
Do **Test 8** before doing the Key On Engine Off Injector Test.
Use EST to run Key On Engine Off Injector Test.
DTCs found
Correct problem causing active DTCs before continuing.

10. Diagnostic Trouble Code Access
(Figure F)
(Required only if EST is not available)
Set parking brake and turn ignition key ON.
Press and release CRUISE ON and RESUME / ACCEL switches at the same time, twice within 3 seconds of key ON.
Active DTCs
Inactive DTCs
Correct problem causing active DTCs before continuing.

11. EST Data list
Enter data in the Spec column below.
Crank engine for 20 seconds and monitor DATA.
Enter data in the Actual column below.

PID	Spec	Actual
VBAT		
RPM		
ICP		
EOP		
EGRP		

- If voltage is below spec, see ECM diagnostics.
- If no rpm is noted, check DTCs.
- If ICP pressure is below spec, do **Test 16**.
- If EOP is below spec, see Section 4, Engine symptoms.
- If EGRP is out of range, see Section 6 in EGES-240.

12. Main Power Relay Voltage to ECM
Connect breakout harness between ECM power relay and distribution box.
Crank engine and use a DMM to measure voltage to ECM. (min 100 rpm for 20 seconds) (Figure G)
Check voltage between connecter pin **87** and ground.

Instrument	Spec	Actual
DMM	7 Volts (min)	

13. Main Power Relay Voltage to IDM
Connect breakout harness between IDM power relay and distribution box. (Figure H)
Crank engine and use DMM to measure voltage to IDM. (min 100 rpm for 20 seconds)
Check voltage between connecter pin **87** and ground.

Instrument	Spec	Actual
DMM	7 Volts (min)	

14. Fuel Pressure
(Figures J and K)
Note: If unit was run out of fuel, make sure the fuel system is primed.
Minimum cranking speed 100 RPM for 20 seconds
Measure (filtered) pressure at fuel filter housing.

Instrument	Spec	Actual
0-160 PSI Gauge		

- If fuel pressure is below spec, replace fuel filter, clean strainer, and retest.
- If fuel pressure is still below spec, see (Fuel Inlet Restriction) in **Test 14** of EGES-240.

15A. Glow Plug System
1. Install Current Clamp around the feed wire loom for glow plugs in the right side. (Figure L.)
2. Turn ignition key ON. (Do not start the engine.)
3. Use EST to do Output State Test for glow plugs. (After 40 seconds record the amperage reading.)
4. Move clamp to left side and record amperage reading (Figure M)

Side	Spec	Reading
Right	34-52 Amps	
Left	34-52 Amps	

- If reading is below or above the amperage spec, do **Test 15B** for each glow plug in the failed side.
- If the reading is 0 Amps, do **Test 8** on this form. For DTC 251, see Glow Plug Control Circuit in Section 7 of EGES-240.

15B. Glow Plug System
1. Select the food wiring loom for the glow plug side that failed.
2. Remove wires from the loom convolute.
3. Install Current Clamp around one of the four wires and do the Output State Test (Figure N). After 40 seconds, measure amperage. Move clamp to remaining wires one at a time, measuring amperage each time.

Note: If any glow plug failed, use a DMM to do steps 4 and 5.
4. Check resistance in wire between glow plug relay and glow plug. (Figure P)
5. Check glow plug resistance to ground. (Figure R)

Glow Plug No.	Record for Step 3 Glow plug amperage (8.8 - 16 amps)	Record for Step 4 Glow plug relay to glow plug (0 - 1 Ohm)	Record for Step 5 Glow plug to ground (1 - 6 Ohms)
1			
2			
3			
4			
5			
6			
7			
8			

16. Low ICP System Pressure
Do only the following low ICP tests if ICP was low during **TEST 11**. (See Section 5 in EGES-240 for test procedures.)
If the test result for System Function is Yes, **do not continue with the following tests for Low ICP.**

Low ICP Tests

Test	Question	Result	
16.1 System function	Greater than 500 PSI (0.82v) ?	Yes	No
16.2 IPR isolation	Audible air leak ?	Left	Right
		Yes	Yes
		No	No
16.3 IPR function	Audible air leak ?	Unplugged	B+ applied
		Yes	Yes
		No	No
16.4 Cylinder head isolation	Air leaks in cylinder head components ?	Left	Right
		Yes	Yes
		No	No
16.5 Discharge, rear branch, and connection tubes	Audible air leak ?	Discharge	
		Yes	No
		Rear branch	
		Yes	No
		Connection tubes	
		Yes	No
16.6 High pressure pump	Greater than 500 PSI (0.82v) ?	Yes	No

D3116

EGED - 245 February 2002 INTERNATIONAL TRUCK AND ENGINE CORPORATION

Figure 93 Hard Start and No Start Diagnostics form EGED-245 (front side)

VEHICLE INFORMATION

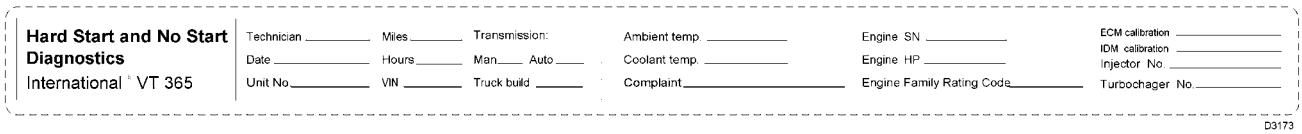


Figure 94

NOTE: Before starting diagnostic tests, fill out the heading for vehicle information on the front side of Hard Start and No Start form EGED-245.

- Technician and unit numbers are for reference only.
- Date, miles, and hours are for warranty claims.
- Engine Serial Number (ESN) and Vehicle Identification Number (VIN) are for ordering parts and referencing service information. The engine serial number is on a machined pad behind the left rear of block below the left cylinder head. The vehicle identification number is on the door jamb on the driver's side.
- Engine horsepower / emissions information and Engine Family Rating code (EFRC) help determine if the engine is the correct horsepower for the application and if the ECM is calibrated to the correct horsepower and emissions level. Information for engine horsepower and emissions is on the emission label on the right valve cover.
- Engine family rating codes and calibrations for the Electronic Control Module (ECM) and the Injector Drive Module (IDM) are found with the Electronic Service Tool (EST).
- Fill in the Turbocharger No. and Injector No. only if there is a suspected mismatch of components.

Hard Start and No Start Diagnostics form EGED-245 is available in 50 sheet pads from:

International® Truck and Engine Corporation
Printing, Procurement and Distribution
4956 Wayne Road
Battle Creek, Michigan 49015

OBTAINING VEHICLE INFORMATION

Figure 95 ATA connector

Figure 96 International ® EZ-Tech Interface cable

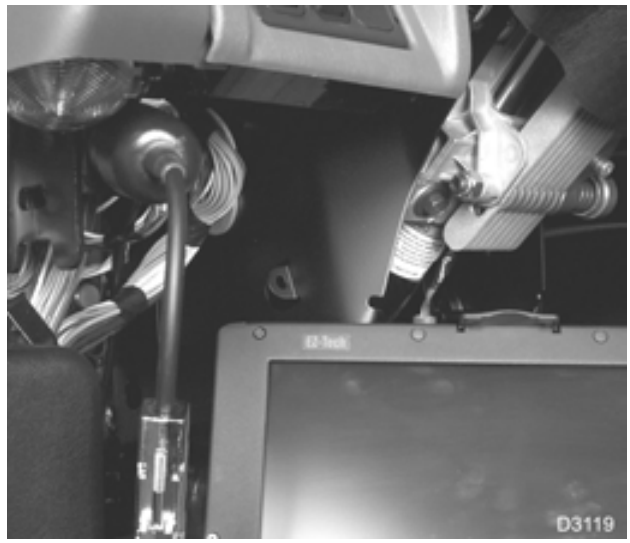


Figure 97 Installation of International® EZ-Tech Interface Cable

Procedure

1. Connect one end of the International® EZ-Tech Interface Cable to the EST and the other end to the ATA connector.

2. Boot up EST.

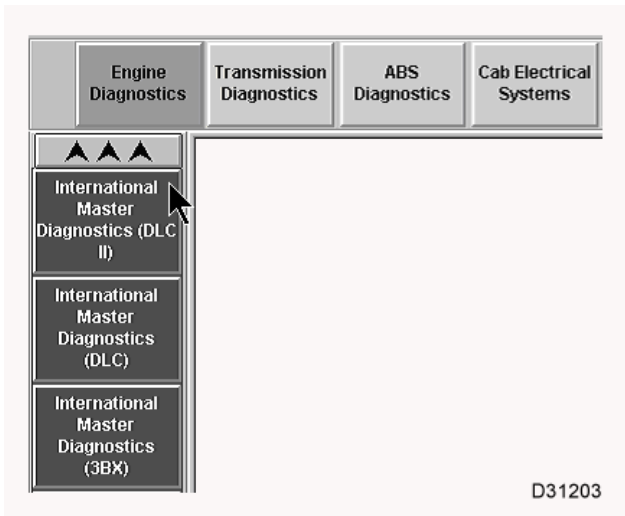


Figure 98 International® Launchpad

3. Select Vehicle Diagnostics, then International Master Diagnostics (DLC II).

4. Turn ignition ON.

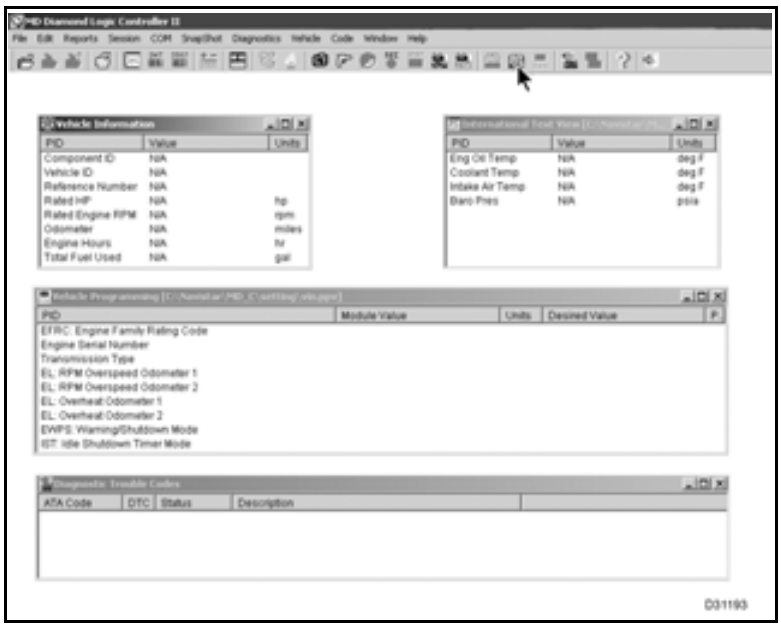


Figure 99 Open VIN session

5. Select VIN+ icon to open VIN session.

6. Using on screen information, fill out top of Hard Start and No Start Diagnostics form.

Table 2

Heading Information =	PID
Miles	Odometer
Hours	Engine hours
Transmission	Transmission Type
	Manual Non-Isochronous
	Manual Isochronous
	Allison AT/MT
	Allison MD
Ambient temp.	Intake Air Temp.
Coolant temp.	Coolant Temp
Engine SN	Engine Serial number
Engine HP	Rated HP
ECM calibration	Reference Number
	PRG2NR00
	(First group)
IDM calibration	Reference Number
	AFZ7AH02
	(Second group)

NOTE: Fill in the Turbocharger No. and Injector No. only if there is a suspected mismatch of components.

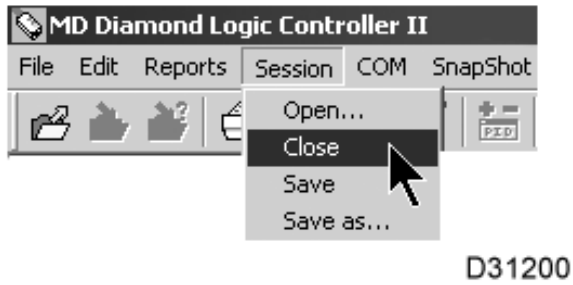


Figure 100 Close session

7. When finished filling out the top of the form, select session, then Close.

TEST PROCEDURES

FUEL

1. Fuel
(Figure A and B)
☐ Fuel level
☐ Free of water, icing, and clouding
☐ Free of contaminants
☐ Correct fuel grade
Note: If unit was run out of fuel, make sure the fuel system is primed.

Comments

D3155

Figure 101

Purpose

To check fuel level and quality for efficient engine operation

Tools

- Clear container (approximately 1 liter or 1 quart)

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle – comply with the following when taking fuel sample:

- **Do not smoke.**
- **Keep away from open flames and sparks.**

1. Take fuel sample from fuel tank. Fuel must be the correct grade, clean, and undiluted.

Figure 102 Fuel drain

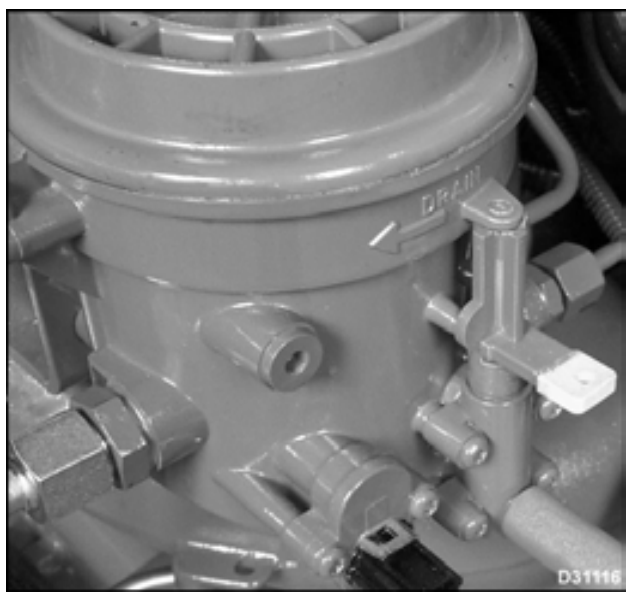


Figure 103 Open fuel drain valve

2. Route a hose from the fuel drain tube to a clear container and open the fuel drain valve.

   NOTE: Cold weather can cause fuel waxing in some grades of diesel fuel. Waxing will restrict or stop fuel flow through the fuel filter.

3. Check for gasoline or kerosene in the diesel fuel.

4. Check for sediment or water in the fuel sample.

NOTE: Some sediment or water could be found in the fuel sample, if the fuel filter was not serviced or drained for a long time. Take another sample to determine fuel quality.

NOTE: If unit was run out of fuel, make sure the fuel system was primed. See Section 4 in this manual for procedure.

NOTE: If all three of the following conditions are noted, see Combustion Leaks to Fuel in Section 4.

- **Fuel system will not prime**
- **White to black exhaust smoke**
- **Pulsating fuel pressure**

Possible Causes

- No fuel in tank.
- The in-line fuel valve (if equipped) could be shut off.
- Fuel supply line could be broken or crimped.
- The tank pickup tube could be clogged or cracked.
- Supplemental filters or water separators may be plugged or leaking allowing air to enter the fuel system.
- Water or contaminants in fuel tank.
- Ice in fuel lines.
- Debris in fuel tank
- Cloudy fuel indicates that fuel grade is unsuitable for cold temperatures.
- Fuel could be waxed or jelled. (usually Grade 2-D)

ENGINE SYSTEMS

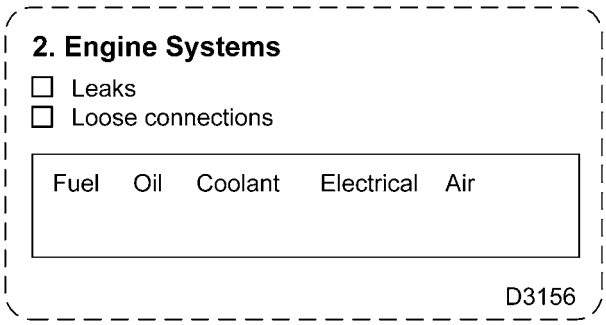


Figure 104

Purpose

To check engine systems for hard or no start conditions

Tools

- Inspection lamp

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

1. Inspect entire fuel system (including tank and lines) for leaks and damage.
2. Check entire engine for any oil leaks.
3. Inspect entire cooling system for leaks.
4. Check sensor, relay, and control module connections. All connections must be seated, in good condition, and free of damage or corrosion.

   NOTE: The engine will not start with the IPR valve, CMP sensor, or CKP sensor disconnected.
5. Inspect battery cable and fuse connections for corrosion. All connections must be seated, in good condition, and free of damage or corrosion.
6. Inspect engine wiring harness for correct routing and protection against rubbing or chaffing.
7. Check air induction system for leaks.

   NOTE: If leaks in the air induction system are suspected, continue with Step 8.
8. Inspect air cleaner housing for damage or distortion that could allow unfiltered air into the engine.
9. Inspect for end seal movement inside the housing. End seal movement is indicated if the seal contact area is polished. A polished contact area indicates that unfiltered air has passed by the filter element and into the engine.
10. Inspect air cleaner element for end cap dents, holes, damaged seals, and soot.
11. Inspect air intake hoses and clamps for tightness and positioning over sealing beads.
12. Inspect the chassis mounted charge air cooler and piping.

Possible Causes

- Loose or leaking fuel supply lines could cause fuel system to lose prime.
- Kinked or blocked fuel supply lines can restrict fuel flow.
- Massive or excessive fuel and oil leaks
- Coolant leaks could indicate serious engine damage.
- Damaged or incorrectly installed electronic connectors
- Blockage in the air induction system

ENGINE OIL

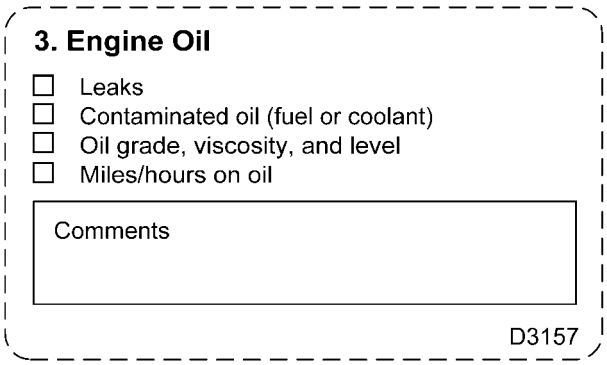


Figure 105

Purpose

To determine if crankcase oil level and oil quality are correct to ensure operation of the Injection Control Pressure (ICP) system

Tools

- None

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

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

   NOTE: Never check the oil level with the engine running or immediately after engine shutdown as an inaccurate reading will be obtained. Allow 15 minute drain down time.

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

3. Inspect oil for color and odor.
   - A milky white mix indicates coolant contamination.
   - Does oil have a diesel fuel odor?
4. Check engine service records for correct oil grade and viscosity for ambient operating temperatures. **Do not use 15W-40 oil below -6.7°C (20°F)**. Long oil drain intervals can increase oil viscosity; thicker oil will make engine cranking and starting more difficult below freezing temperatures. See Engine Lubrication Requirements in the *VT 365 Engine Operation and Maintenance Manual*. Confirm that oil meets correct API specifications.

Possible Causes

Low oil level

- Oil leak
- Oil consumption
- Incorrect servicing

High oil level

- Incorrect servicing
- Fuel in oil
- Coolant in oil
- Incorrect oil level gauge

Coolant in oil

- Cylinder head gasket leak
- Defective cup plug in cylinder head
- Injector sleeve leak
- Glow plug sleeve leak
- Front cover gasket leak
- Defective oil cooler bundle or O-ring
- Front cover, cylinder head, or crankcase porosity
- Accessory leak (water cooled air compressor)

Fuel in oil:

- Injector O-ring leak
- Cylinder head porosity

INTAKE AND EXHAUST RESTRICTION

4. Intake and Exhaust Restriction

- ☐ Hoses and piping
- ☐ Filter minder (Figure C and D)
- ☐ Intake/exhaust restriction

Comments

D3158

Figure 106

Purpose

To determine if intake or exhaust restriction is causing hard or no start conditions

NOTE: High intake or exhaust restriction can cause a large amount of black or blue smoke when starting the engine.

Tools

- None

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

Inspect the following parts for restriction, damage, or incorrect installation:

- Air cleaner inlet and ducting
- Air cleaner housing, filter element, and gaskets

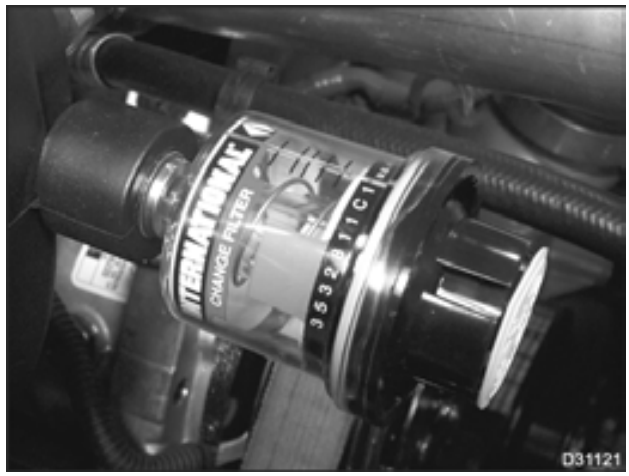


Figure 107 Low restriction

Figure 108 High restriction

NOTE: Intake restriction should be below 25 in H_2O. When the filter element reaches maximum allowable restriction, the yellow indicator will reach the top of window and automatically lock in this position.

- Exhaust pipes
- Chassis mounted CAC and piping

Possible Causes

- Snow, plastic bags, or other foreign material can restrict air flow in the air cleaner inlet. On engines recently repaired, rags or cap plugs may have been left in the intake system.
- Tailpipe or muffler may be damaged or collapsed.
- Restricted catalytic converter or Catalyzed Diesel Particulate Filter (CDPF) — if equipped

INITIAL KEY ON (DO NOT START)

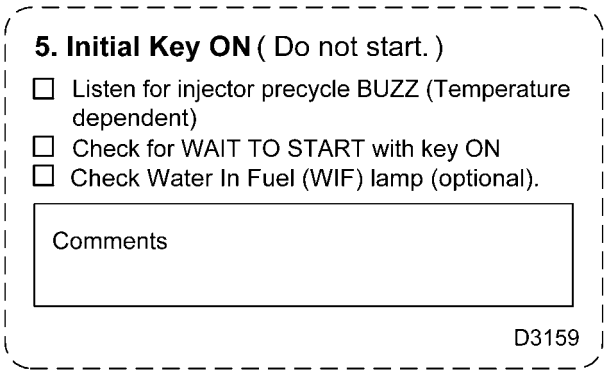


Figure 109

Purpose

To determine the following:

- Is the IDM powered up?
- Is the ECM powered up?
- Is water in the fuel?

Tools

- None

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

1. Turn ignition switch on. (Do not start the engine.)
2. Listen for injector precycle. [Do not mistake the sound of the instrument panel cycle self test or the Antilock Brake System (ABS) self check.] Shop noise can drown out the sound of injector precycle. Turn ignition key ON, pause, wait, and listen for injector precylce; if precycle is not heard, turn key OFF and repeat key ON, pause, wait, and listen several times to ensure hearing the injector precycle.
3. Monitor the WAIT TO START lamp.
4. Monitor the Water In Fuel (WIF) lamp (optional). (If the WIF lamp comes on check for water in the fuel filter housing.)

Possible Causes

No injection precycle

- No key power (v_{IGN})
- Defective IDM ground circuit
- No power from main power relay to IDM.
- CAN 2 link is not working.
- IDM failure

WAIT TO START lamp does not come on

- No key power (v_{IGN})
- Defective ECM ground circuit
- No power from main power relay to ECM
- CAN 1 link is not working (will not cause hard start no start).
- ECM failure
- Instrument panel lamp is out (will not cause hard start no start).

Water in fuel

- Water in fuel
- Electrical circuit failure

ENGINE CRANKING

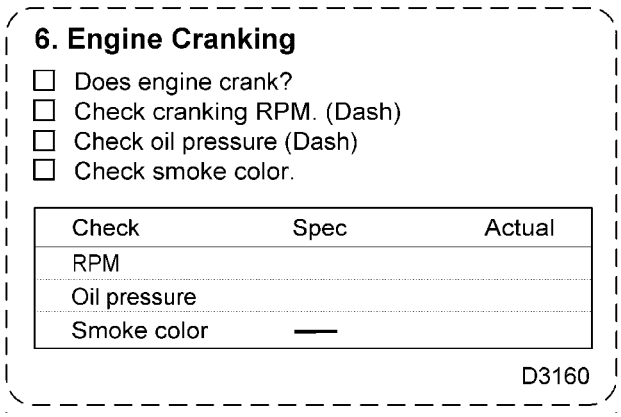


Figure 110

Purpose

To determine the following:

- Does the engine turn over?
- Does the instrument panel receive a signal from the ECM and is RPM sufficient?
- Is fuel getting into the cylinders?
- Is oil pressure sufficient?

Tools

- None

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

1. See Appendix A in this manual for specifications, and enter data in spec column for RPM and oil pressure on Hard Start and No Start Diagnostics form.

2. Turn ignition key to START.

   NOTE: If equipped, push optional push button to crank engine.

3. Check RPM (instrument panel) and record on diagnostics form.

4. Check oil pressure (instrument panel) and record on diagnostics form.

5. Check for exhaust smoke and record color on diagnostics form.

   NOTE: If smoke is seen, fuel is getting into the cylinders; the fuel supply system is working correctly.

   NOTE: If all three of the following conditions are noted, see Combustion Leaks to Fuel in Section 4.

   - **Fuel system will not prime**
   - **White to black exhaust smoke**
   - **Pulsating fuel pressure**

Possible Causes

Engine will not turn over

- Low or no battery power
- No key power (V_{IGN})
- Insufficient power to ECM
- Starting system failure
- Circuit fault for Engine Crank Inhibit (ECI)
- Cylinder hydraulic lock

Insufficient RPM

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

Insufficient oil pressure

- Oil gauge error on instrument panel
- Low oil level: oil leak, oil consumption, or incorrect servicing
- High oil level: incorrect servicing, fuel in oil, coolant in oil

- Incorrect oil viscosity
- Fuel in oil
- Stuck oil pressure regulator
- Scored or damaged oil pump
- Engine Oil Pressure (EOP) sensor biased
- Missing oil gallery plugs (front or rear)
- 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)

Excessive exhaust smoke with hard start no start concern

- Glow plug system problem
- Poor fuel quality
- Insufficient cylinder temperature
- Loose injector
- Low compression

DIAGNOSTIC TROUBLES CODES

7. Diagnostic Trouble Codes

☐ Install Electronic Service Tool (EST). (Figure E)

☐ Do **Test 10** if an EST is not available.

Active DTCs
Inactive DTCs

Correct problem causing active DTCs before continuing.

D3161

Figure 111

Purpose

To determine if the ECM has detected DTCs indicating conditions that could cause hard start or no start

Tools

- Electronic Service Tool (EST) with Master Diagnostics Software
- International® EZ-Tech Interface Cable

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

NOTE: Do Test 10 (Diagnostic Trouble Code Access), if an EST is not available.

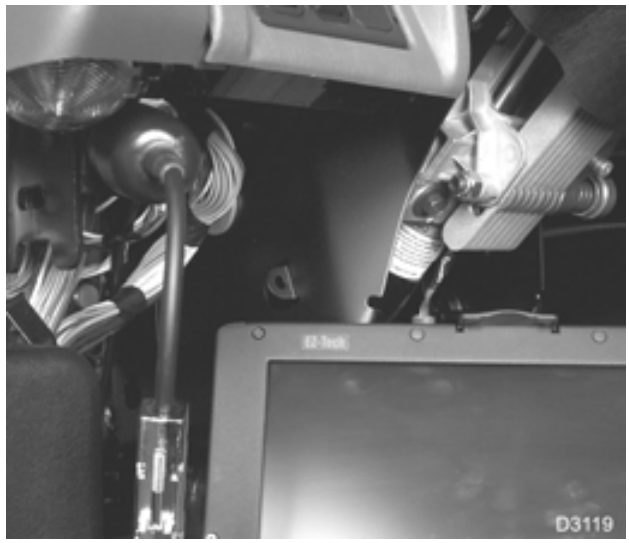


Figure 112 Installation of International® EZ–Tech Interface Cable

1. Turn ignition ON.

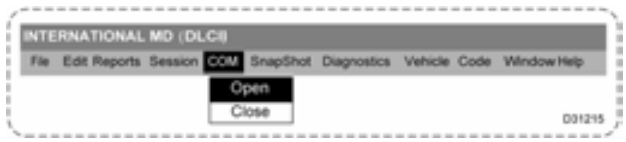


Figure 113 Menu bar Com/Open

2. Select COM from the menu bar, then Open.

Figure 114

3. Select Code from the menu bar, then View for the Diagnostic Trouble Code window.

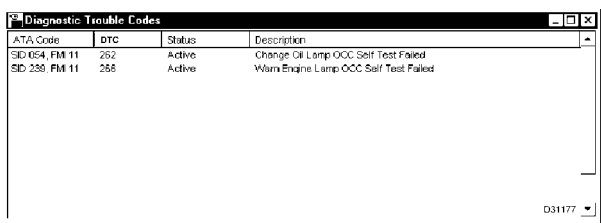


Figure 115 Diagnostics Trouble Code window

Reading DTCs

ATA code: Codes associated with a sub-system (SID), parameter (PID), and Failure Mode Indicator (FMI).

DTC: Diagnostic Trouble Codes.

Status: Indicates active, inactive, or active/inactive DTCs.

- **Active** : With the ignition key ON, active indicates a DTC for a condition currently in the system. When the key is turned off, an active DTC becomes inactive. (If a problem remains, the DTC will be active on the next key cycle.)
- **Inactive**: With the ignition key ON, inactive indicates a DTC for a condition no longer in the system. When the ignition key is turned off, inactive DTCs from previous key cycles are stored in the ECM memory.
- **Active/Inactive:** With the ignition key ON, active/inactive indicates a DTC for an intermittent condition currently in the system.

Description: Defines each DTC.

4. Record all DTCs on Hard Start and No Start Diagnostics form.

   See Appendix B in this manual for DTCs.

5. Correct problem causing active DTCs before continuing.

6. Clear DTCs.

Possible Causes

- Electronics failure
- Failure of the ICP sensor or ICP system
- Failure of the Air Management System

KEY ON ENGINE OFF STANDARD TEST

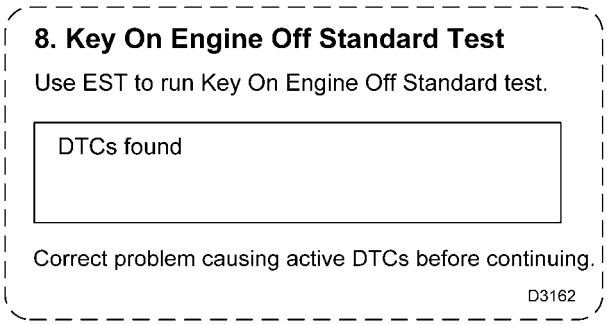


Figure 116

Purpose

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

Tools

- Electronic Service Tool (EST) with Master Diagnostics Software
- International® EZ-Tech Interface Cable

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

1. Set parking brake for the correct signal from the Electronic System Controller (ESC).
2. Turn ignition key to ON. (Do not start engine.)

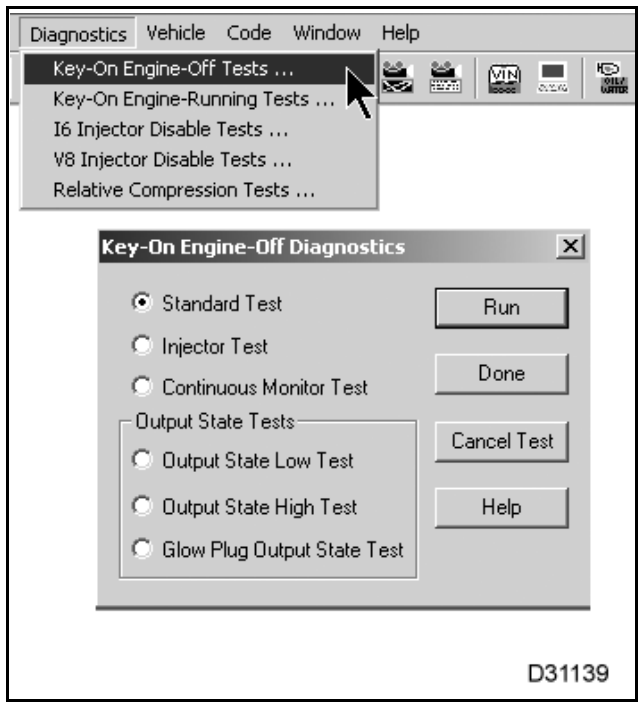


Figure 117 Key On Engine Off Standard Test

3. Select Diagnostics from the menu bar.
4. Select Key On Engine Off Tests from the drop down menu.
5. From the Key On Engine Off Diagnostics menu, select Standard Test and click Run to start the test.

   The ECM will complete an internal self-test and an Output Circuit Check (OCC). When the OCC is over, the diagnostic trouble code screen will show DTCs, if there is a problem.
6. Record all DTCs on Hard Start and No Start Diagnostics form.

   See Appendix B in this manual for DTCs.
7. Correct problem causing active DTCs.
8. Clear DTCs.

Possible Causes

- Defective electrical components or circuitry
- OCC fault for the IPR, glow plug relay, EGR valve, or EVRT™ control valve

KEY ON ENGINE OFF INJECTOR TEST

9. Key On Engine Off Injector Test

☐ Do **Test 8** before doing the Key On Engine Off Injector Test

☐ Use EST to run Key On Engine Off Injector test.

DTCs found

Correct problem causing active DTCs before continuing.

D3163

Figure 118

Purpose

To determine if fuel injectors are working (electronically) by energizing injectors in a programmed sequence. The ECM monitors this test and transmits DTCs, if injectors or injector circuits are not working correctly.

Tools

- Electronic Service Tool (EST) with Master Diagnostics Software
- International® EZ-Tech Interface Cable

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

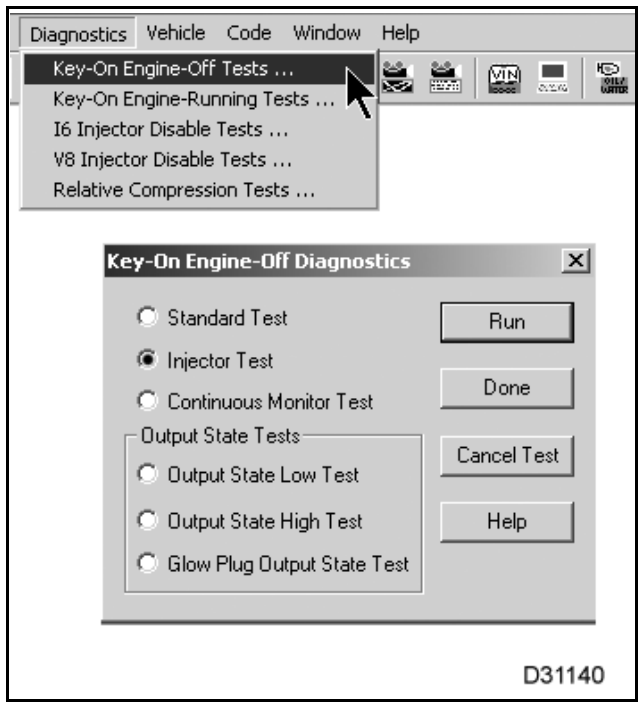


Figure 119 Key On Engine Off Injector Test

NOTE: Test 8 (Key On Engine Off Standard Test) must have been done before doing the Key On Engine Off Injector Test.

1. Select Diagnostics from the menu bar.
2. Select Key On Engine Off Tests from the drop down menu.
3. From the Key On Engine Off Diagnostics menu, select Injector Test and click Run to start the test.

   NOTE: During this test, injector solenoids should click when actuated. If a series of clicks are not heard for each injector, one or more injectors are not activating.

4. Record DTCs on Hard Start and No Start Diagnostics form.

   See Appendix B in this manual for DTCs.

5. Correct problem causing active DTCs.
6. Clear DTCs.

Possible Causes

- Injector wiring harness open or shorted
- Bad wiring harness connection on injector coil
- Open or shorted engine wiring harness to injectors
- Defective injector coil
- Defective IDM
- Defective ECM

DIAGNOSTIC TROUBLE CODE ACCESS

10. Diagnostic Trouble Code Access

(Figure F)

(Required only if EST is not available)

☐ Set parking brake and turn ignition key On.

☐ Press and release CRUISE ON and RESUME / ACCEL switches at the same time, twice within 3 seconds of key ON.

Active DTCs

Inactive DTCs

Correct problem causing active DTCs before continuing.

D3164

Figure 120

Purpose

To read Diagnostic Trouble Codes (DTCs) detected by the ECM, if the Electronic Service Tool (EST) is not available or if EST will not communicate with the ECM

Tools

- None

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

1. Set parking brake for the correct signal from the Electronic System Controller (ESC).

2. Turn ignition switch ON. (Do not start the engine.)

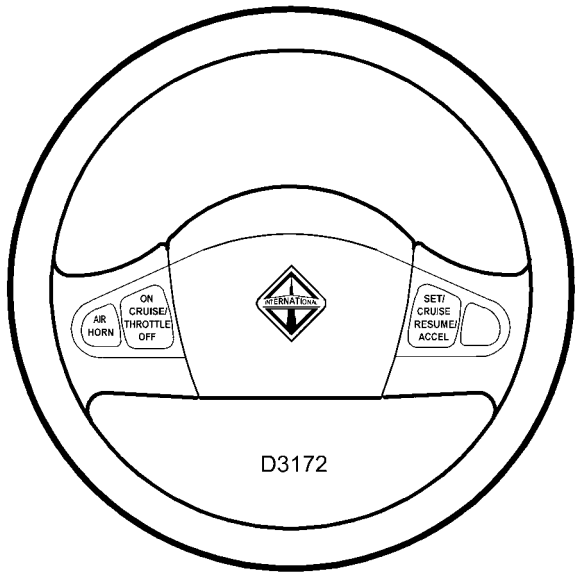


Figure 121 Switches for CRUISE ON and RESUME ACCELERATION

3. Press and release the CRUISE ON and RESUME/ACCEL switches, at the same time, twice within 3 seconds of key ON.

   - The ECM will begin the Output Circuit Check (OCC) (self test). If DTCs are detected, the ECM will flash the amber ENGINE lamp.
   - When the OCC is done, the ECM will flash the red ENGINE lamp and amber ENGINE lamp to signal the DTCs.

NOTE: There will be a 10 second delay from the time switches are pressed to the time DTCs are flashed.

Reading DTCs

1. The red ENGINE lamp will flash once to indicate the beginning of active DTCs.

2. The amber ENGINE lamp will flash repeatedly, signaling active DTCs.

   NOTE: All DTCs are three digits. Code 111 indicates that no errors were detected. See Appendix B in this manual for DTCs.

3. Count the flashes of the amber ENGINE lamp in sequence. After each digit of the code a short pause will occur.

- **Three amber flashes** and a pause indicate number 3.
- **Two amber flashes**, a pause, **three amber flashes**, a pause, and **two amber flashes** and a pause indicate code 232.

4. For more than one DTC, the red ENGINE lamp will flash once indicating the beginning of another active DTC.

5. After all active DTCs have flashed, the red ENGINE lamp will flash twice to indicate the start of inactive DTCs. Count the flashes from the amber ENGINE lamp. If there is more than one inactive code, the red ENGINE lamp will flash once in between each DTC.

6. After all DTCs have been sent, the red ENGINE lamp will flash three times indicating **end of DTC transmission**.

7. To repeat DTC transmission, cycle the key and press and release the CRUISE ON and RESUME/ACCEL switches at the same time, twice within 3 seconds of key ON. The ECM will resend stored DTCs.

Clearing Inactive DTCs

1. Set parking brake for the correct signal from the Electronic System Controller (ESC).

2. Turn ignition switch ON. (Do not start the engine.)

3. Press and hold the CRUISE ON and RESUME/ACCEL switches, at the same time.

4. Press and release the accelerator pedal three times within 6 seconds of key ON.

5. Release the cruise control buttons to clear the inactive DTCs.

Possible Causes

- Electronic component or circuit failures

EST DATA LIST

11. EST Data list

☐ Enter data in the Spec column below.

☐ Crank engine and monitor DATA for 20 seconds.

☐ Enter data in the Actual column below.

PID	Spec	Actual
VBAT		
RPM		
ICP		
EOP		
EGRP		

- If voltage is below spec, see ECM diagnostics.
- If no rpm is noted, check DTCs.
- If ICP pressure is below spec, do **Test16.**
- If EOP is below spec, see Section 4, Engine symptoms.
- If EGRP is out of range, see Section 6 in EGES-240.

D3165

Figure 122

Purpose

To determine if engine systems meet operating specifications to start engine

Monitoring Engine Systems using an EST

Tools

- Electronic Service Tool (EST) with Master Diagnostics Software
- International® EZ-Tech Interface Cable

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

NOTE: Batteries must be fully charged before doing test procedures.

NOTE: If an EST is not available, see alternate test procedures following this test.

1. See Appendix A in this manual for specifications, and record on Hard Start and No Start Diagnostics form.

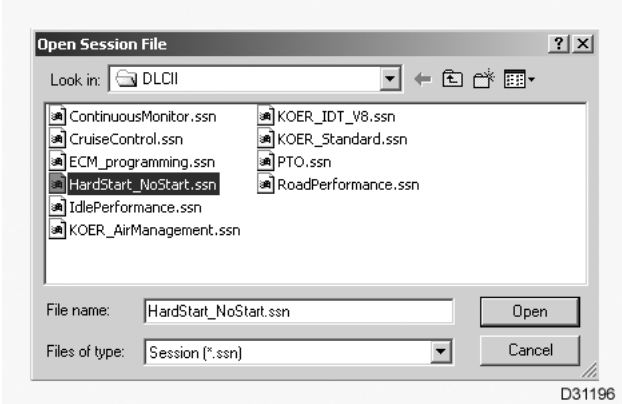


Figure 123 Hard Start No Start.ssn

2. Open Hard Start No Start.ssn to monitor engine operation.

3. Crank engine for 20 seconds and read EST to measure VBAT, RPM, ICP, EOP, and EGRP.

4. Record readings on diagnostics form.

   - Battery voltage must be 7 or more volts. If voltage to the Electronic Control Module (ECM) drops below 7 volts, the ECM will not remain powered up. If the ECM does not get power through the ECM relay, the engine will not start.
   - Engine cranking speed must generate the required Injection Control Pressure (ICP) to operate the fuel injectors and create required compression to ignite the fuel.
   - If the EST shows 0 RPM during engine cranking, the ECM may not be receiving a signal from the Crankshaft Position (CKP) sensor or Camshaft Position (CMP) sensor. The ECM will not send the fueling command to the IDM without a correct CKP or CMP signal. See CKP sensor and CMP sensor in Section 7.
   - If the EST indicates low or no ICP, do Test 16 (Low ICP System Pressure).
   - If oil pressure is low, the ICP system is not receiving enough oil.

- If EGR valve is open at startup it can disrupt the air fuel mixture enough to inhibit engine operation.

Possible Causes

Low battery voltage

- Defective batteries
- High resistance at battery cable connections or in wiring to the ECM
- Defective ECM power relay
- Blown in-line fuse (in battery box) that supplies voltage to the ECM
- Blown fuse in power distribution box

Low cranking RPM

- Electrical system malfunctions, incorrect oil, or long oil change intervals in cold ambient temperatures
- No RPM indication on the EST while cranking the engine: defective CKP sensor, CMP sensor, or circuit to the ECM. Recheck DTCs after cranking engine for 20 seconds.

Low ICP

- A leak in the high pressure oil system, a defective ICP sensor, or defective IPR valve
- Low oil level in the high pressure oil reservoir
- Defective high pressure oil pump or pump drive
- Defective IPR valve or electronic controls for the regulator

Low oil pressure

- Defective oil pressure regulator valve
- Defective gerotor oil pump
- Internal lube oil pressure leak

EGR valve

- Stuck or defective valve
- Defective position sensor

Monitoring Engine Systems using a Breakout Box

Tools

- Breakout box
- DMM

Procedure

NOTE: Make sure V_{IGN} is turned off.

1. Remove (X-1, X-2) and (X-3, X-4) connectors from ECM.

Figure 124 Breakout box installed

2. Install breakout box connectors (X-1, X-2) and (X-3, X-4) to ECM.

3. Install wiring harness connectors to breakout box headers (X-1, X-2) and (X-3, X-4).

Figure 125 Breakout Box

⚠ WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

When routing DMM leads, do not crimp the leads, run the leads too close to moving parts, or let the leads touch hot engine surfaces.

4. Connect DMM leads to breakout box

5. Crank the engine for 20 seconds and use DMM to measure values for the following:

V_{BAT} (DMM set to DC V)

- POS X3 – 3 to NEG X3 – 7 (V_{IGN} Pwr)
- POS X4 – 1 to NEG X3 – 6 (ECM Pwr)
- POS X4 – 2 to NEG X3 – 7 (ECM Pwr)

RPM (DMM set to DC mV Hz)

- POS X1 – 1 to NEG X3 – 7 (CKP)

RPM (DMM set to DC mV RPM²)

- POS X1 – 9 to NEG X3 – 7 (CMP)

ICP (DMM set to DC V)

- POS X1–20 to NEG X1– 6

EOP (DMM set to DC V)

- POS X2–7 to NEG X1–6

EGRP (DMM set to DC V)

- POS X2–9 to NEG X1–6

NOTE: See Appendix A and Section 7 for operational voltages and values.

Monitoring ICP using pressure sensor breakout harness

Tools

- Pressure sensor breakout harness
- DMM

1. Remove engine harness connector from ICP sensor.

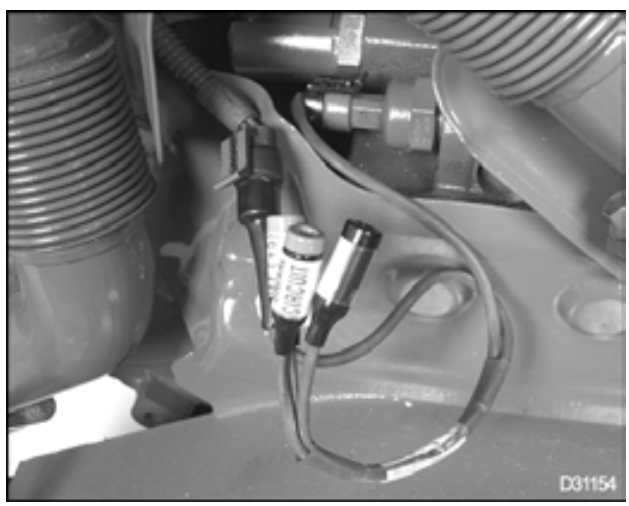


Figure 126 Pressure sensor breakout harness installed – ICP

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

When routing DMM leads, do not crimp the leads, run the leads too close to moving parts, or let the leads touch hot engine surfaces.

2. Connect pressure sensor breakout harness to engine harness and ICP sensor.

3. Use DMM to measure ICP while cranking engine for 20 seconds.

   - Connect POS to green (signal circuit) and NEG to black (signal ground).

   NOTE: See Appendix A and Section 7 for operational voltages and values.

Monitoring EGRP using EGR Breakout harness

Tools

- EGR breakout harness
- DMM

1. Remove engine harness connector from EGR valve.

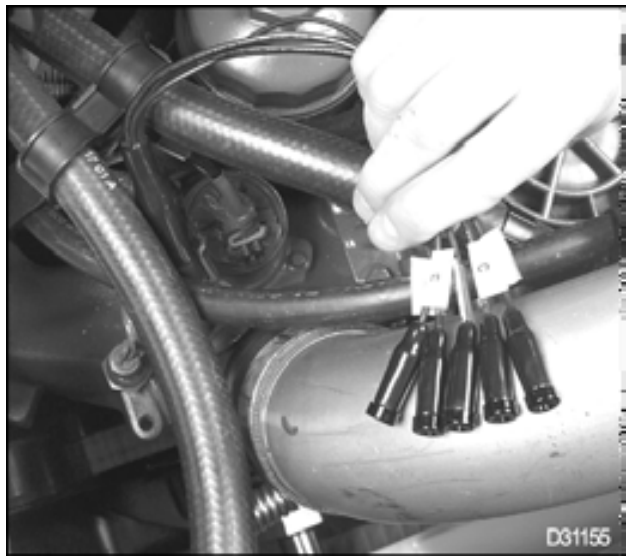


Figure 127 EGR breakout harness installed

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

When routing DMM leads, do not crimp the leads, run the leads too close to moving parts, or let the leads touch hot engine surfaces.

2. Connect EGR breakout harness to engine harness and EGR valve.

3. Use DMM to measure EGR position while cranking engine for 20 seconds.

   - Connect POS to green (signal circuit) and NEG to black (signal ground).

   NOTE: See Appendix A and Section 7 for operational voltages and values.

Monitoring EOP at Lube Oil Pressure Test Port

Tools

- Fuel/ oil pressure test coupler
- Gauge bar (0–60 psi gauge)

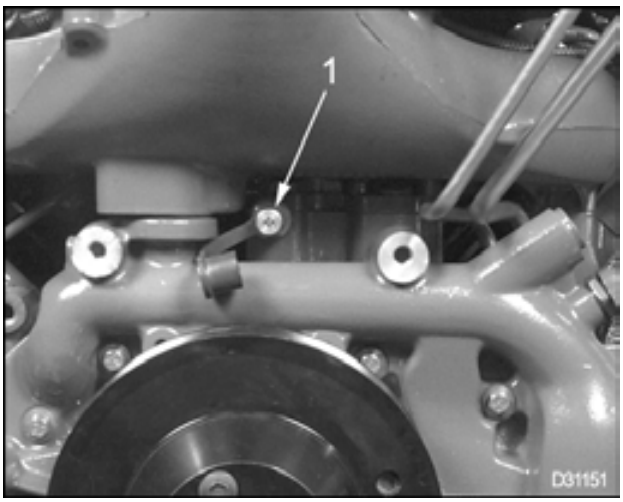


Figure 128 Lube oil pressure test port

1. Oil pressure test fitting

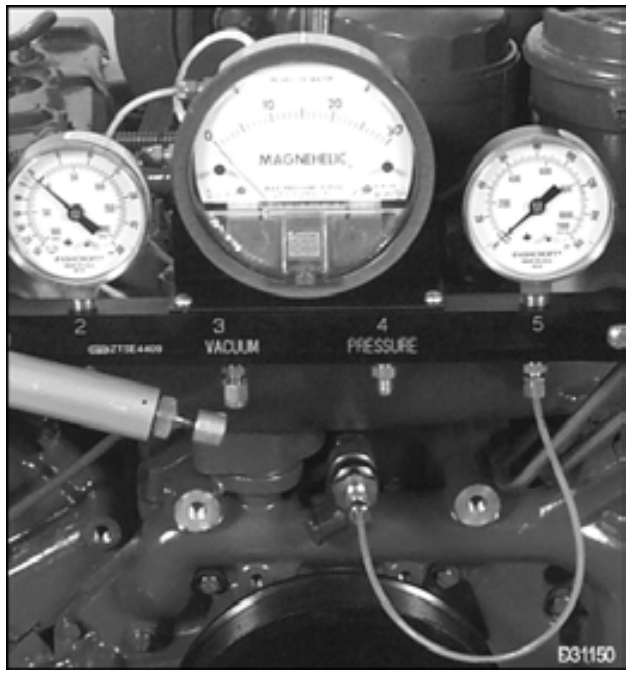


Figure 129 Measuring lube oil pressure

1. Connect fuel/oil pressure test coupler in line with gauge bar (0–60 psi gauge).

⚠ WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

When routing test line , do not crimp the line, run the line too close to moving parts, or let the line touch hot engine surfaces.

2. Connect coupling to test port.
3. Monitor EOP while cranking engine for 20 seconds.

MAIN POWER RELAY VOLTAGE TO ECM

12. Main Power Relay Voltage to ECM

- ☐ Connect breakout harness between ECM power relay and distribution box.
- ☐ Crank engine and use a DMM to measure voltage to ECM. (min 100 rpm for 20 seconds) (Figure G)
- ☐ Check voltage between connector pin **87** and **ground**.

Instrument	Spec	Actual
DMM	7 Volts (min)	

D3166

Figure 130

Purpose

To determine correct power supplied to operate the ECM. The ECM requires 7 volts minimum to operate

Tools

- Relay breakout harness
- DMM

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

NOTE: Batteries must be fully charged before doing the following procedures.

Voltage Measurement with Breakout harness at Main Power Relay

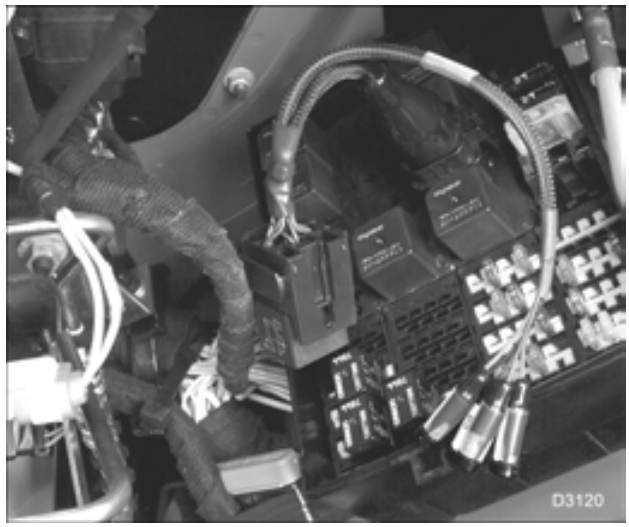


Figure 131 Relay breakout harness installed

1. Turn all accessories off.
2. Install relay breakout harness between ECM power relay and power distribution box.
3. Connect DMM POS to lead 87 and NEG to ground post on cowl.
4. Crank engine for 20 seconds and measure voltage.
5. Record the lowest voltage on Hard Start and No Start Diagnostics form .
    - If the voltage is below 7 volts, the ECM power relay may be resetting, resulting from low voltage and current from the batteries or problems in the ignition circuit or power feed circuits. See Electronic Control Module Power (ECM PWR) in Section 7.

Possible Causes

- Low battery voltage: defective batteries, high resistance at battery cable connections or in 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 power relay. The ECM power circuit fuse in battery box may be open, or the ECM power relay may be defective.

- V_{IGN} circuit problem
- Defective ECM

Voltage Measurement at ECM with Breakout Box

Tools

- Breakout box
- DMM

1. Turn off all accessories.

2. Remove 2 white connectors (X3 and X4) from ECM.

Figure 132 Breakout box installed

3. Install breakout box connectors (X3 and X4) to connections on ECM.

4. Connect chassis harness connectors to breakout box header (X3 and X4).

Figure 133 Breakout box

5. Connect leads of the DMM to the following test points on the breakout box:

   - POS X3 – 3 to NEG X3 – 7 (V_{IGN} Pwr)
   - POS X4 – 2 to NEG X3 – 7 (ECM Pwr)
   - POS X4 – 1 to NEG X3 – 7 (ECM Pwr)

6. Crank engine for 20 seconds and measure voltage.

7. Record the lowest voltage on Hard Start and No Start Diagnostics form .

   - If the voltage is below 7 volts, the ECM power relay may be resetting, resulting from low voltage and current from the batteries or problems in the ignition circuit or power feed circuits. See Electronic Control Module Power (ECM PWR) in Section 7.

MAIN POWER RELAY VOLTAGE TO IDM

13. Main Power Relay Voltage to IDM

- ☐ Connect breakout harness between IDM power relay and distribution box. (Figure H)
- ☐ Crank engine and use DMM to measure voltage to IDM. (min 100 rpm for 20 seconds.)
- ☐ Check voltage between connector pin **87** and **ground**.

Instrument	Spec	Actual
DMM	7 Volts (min)	

D3167

Figure 134

Purpose

To determine correct power supplied to operate the IDM. The IDM requires 7 volts minimum to operate

Tools

- Relay breakout harness
- DMM

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

NOTE: Batteries must be fully charged before doing the following procedures.

Voltage Measurement with Breakout Harness at Main Power Relay

Figure 135 Relay breakout harness installed

1. Turn all accessories off.
2. Install relay breakout harness between IDM power relay and power distribution box.
3. Connect DMM POS to lead 87 and NEG to ground post on cowl.
4. Crank engine for 20 seconds and measure voltage.
5. Record the lowest voltage on Hard Start and No Start Diagnostics form.
    - If the voltage is below 7 volts, the IDM power relay may be resetting, resulting from low voltage and current from the batteries or problems in the ignition circuit or power feed circuits. See Injector Drive Module Power (IDM PWR) in Section 7.

Possible Causes

- Low battery voltage: failed batteries, high resistance at battery cable connections or in wiring to the IDM
- Low or no battery voltage to the IDM: high resistance or an open power feed circuit to the IDM or IDM power relay. The IDM power circuit fuse in battery box may be open, or the IDM power relay may be defective.

- V_{IGN} circuit problem
- Defective IDM

Voltage Measurement at 12 Pin Connection with Breakout harness

Tools

- 12 way breakout harness
- DMM

1. Turn off all accessories.
2. Disconnect 12 Pin connector at IDM.

Figure 136 12 Pin breakout harness installed

3. Install 12 pin breakout harness between both connectors.
4. Connect leads of the DMM to each of the following test points:
   - POS 9 to NEG 8 (V_{IGN} and MPR)
   - POS 12 to NEG 1 (IDM Pwr-)
   - POS 6 to NEG 1 (IDM Pwr and Logic power)
5. Crank engine for 20 seconds and measure voltage.
6. Record the lowest voltage on Hard Start and No Start Diagnostics form .
   - If the voltage is below 7 volts, the IDM power relay may be resetting, resulting from low voltage and current from the batteries or problems in the ignition circuit power feed circuits. See Injector Drive Module Power (IDM PWR) in Section 7.

FUEL PRESSURE

14. Fuel Pressure
(Figures J and K)

Note: If unit was run out of fuel, make sure the fuel system is primed.

☐ Minimum cranking speed 100 rpm for 20 seconds

☐ Measure (filtered) pressure at fuel filter housing.

Instrument	Spec	Actual
0-160 PSI Gauge		

- If fuel pressure is below spec, replace fuel filter, clean strainer, and retest.
- If fuel pressure is still below spec, see (Fuel Inlet Restriction) in **Test 14**.

D3168

Figure 137

Purpose To check for correct fuel pressure

NOTE: If the fuel filter has a Water In Fuel (WIF) probe, ask the driver if the WIF lamp was on during vehicle operation.

NOTE: If unit was run out of fuel, make sure the fuel system was primed. See Section 4 in this manual for procedure.

NOTE: If all three of the following conditions are noted, see Combustion Leaks to Fuel in Section 4.

- **Fuel system will not prime**
- **White to black exhaust smoke**
- **Pulsating fuel pressure**

Tools

- Gauge bar (0–160 psi gauge)
- Fuel pressure test fitting
- Fuel/oil pressure test coupler

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

1. See Appendix A in this manual for specifications, and record on Hard Start and No Start Diagnostics form.

2. Remove plug from fuel filter housing (lower rear left).

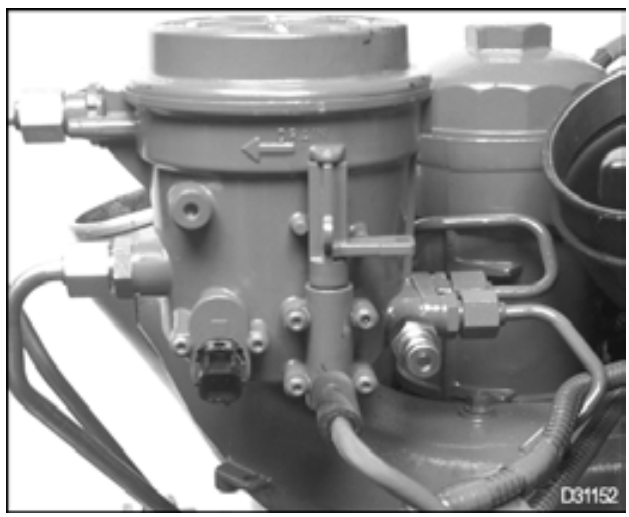


Figure 138 Fuel pressure test fitting installed

3. Install fuel pressure test fitting.

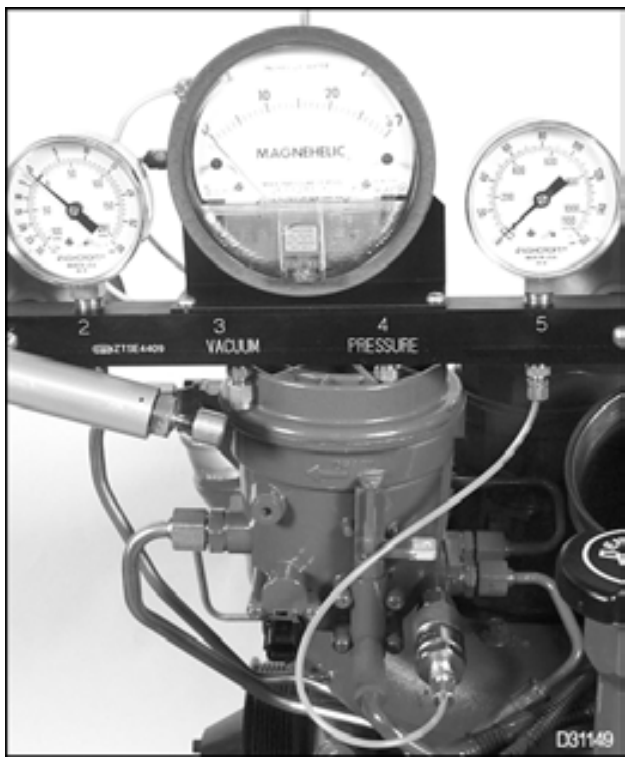


Figure 139 Measuring fuel pressure

4. Connect a line from fuel/oil pressure test coupler to the 0–160 psi gauge on gauge bar, then connect to test fitting.

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

When routing test line , do not crimp the line, run the line too close to moving parts, or let the line touch hot engine surfaces.

5. Crank engine for 20 seconds and measure fuel pressure.

6. Record readings on the diagnostics form.

   - If fuel pressure is low replace fuel filter, clean strainer, and retest.
   - If fuel pressure is still low, do the following Fuel Inlet Restriction test.

7. Remove fuel pressure test fitting and install plug.

Possible Causes

- Fuel tank empty
- Dirt or jelled fuel in the fuel filter will cause high restriction and low fuel pressure.
- A kinked or bent fuel supply line or a blocked pickup tube can cause high restriction and low fuel pressure.
- A loose fuel line on the suction side of the fuel system can ingest air into the system and cause low fuel pressure.
- Defective fuel regulator valve
- Debris in tank
- Internal fuel pump damage or damage to the drive gear

FUEL INLET RESTRICTION

Purpose

To check fuel inlet line for excessive restriction

Tools

- Gauge bar (0–30 in Hg vacuum gauge)
- Fuel inlet restriction adapter
- 30 mm combination wrench

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

1. See Appendix A in this manual for restriction specifications, and record on Hard Start and No Start Diagnostics form.

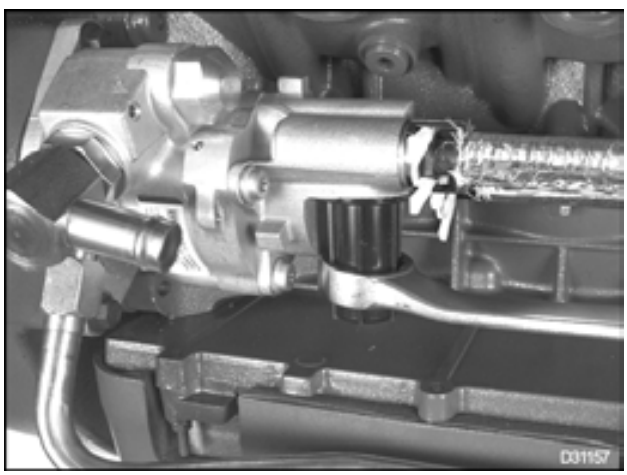


Figure 140 Removing fuel filter strainer

2. Remove fuel filter strainer.

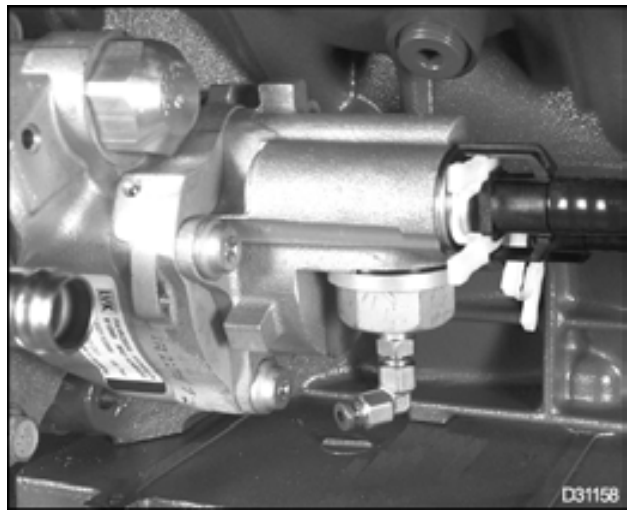


Figure 141 Fuel inlet restriction adapter installed

CAUTION: To prevent damage to threads, hand start adapter. Do not over tighten. (Both components are aluminum.)

3. Install fuel inlet restriction adapter.

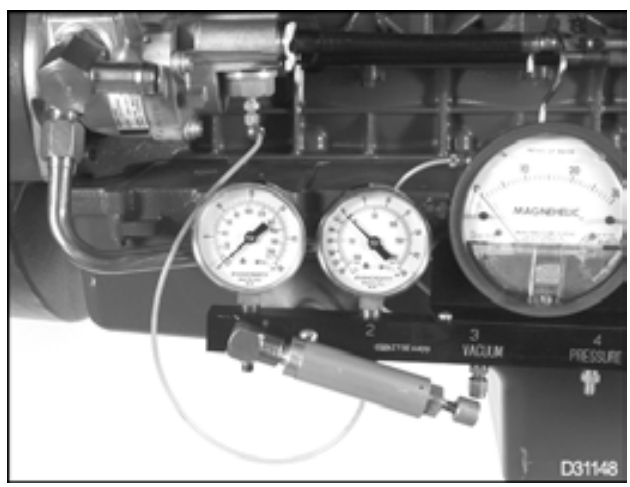


Figure 142 Measuring fuel inlet restriction

⚠ WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

When routing test line , do not crimp the line, run the line too close to moving parts, or let the line touch hot engine surfaces.

4. Connect a line from the adapter to the 0–30 in Hg vacuum gauge on gauge bar.

5. Crank engine for 20 seconds and measure restriction.

   - If restriction exceeds spec, find the restriction on the suction side of the fuel system and correct.
   - If fuel inlet restriction is in spec, continue with Step 5.

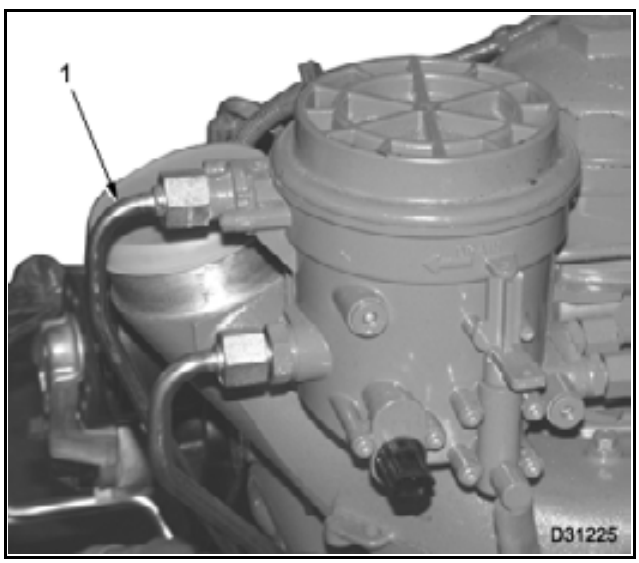


Figure 143 Removing fuel return line

1. Fuel return line

6. Remove fuel return line from the fuel regulator valve cap.

   NOTE: Use tape or a wire tie around the fuel line to prevent the nut from falling down.

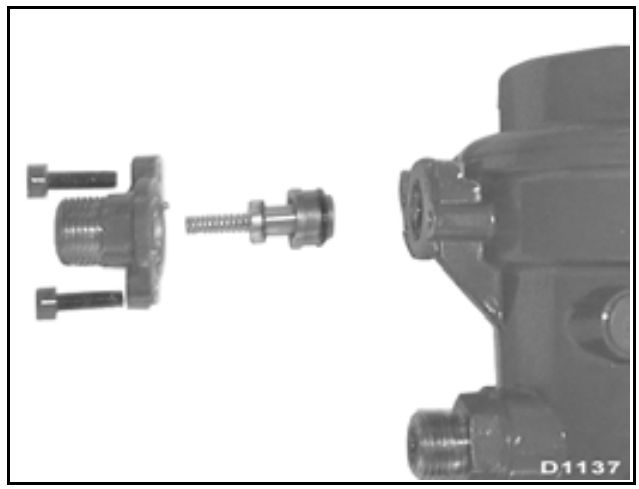


Figure 144 Removing regulator valve cap, spring, and valve

7. Remove fuel regulator valve cap.

8. Remove the fuel regulator spring and valve.

9. Inspect the regulator cavity in the filter housing for dirt or debris that could restrict fuel flow.

10. Check regulator seating surface (sleeve and O-ring) for damage.

11. If fuel regulator valve is not damaged, clean and reinstall regulator valve and retest fuel pressure.

12. If fuel pressure is still low, replace fuel regulator, and retest fuel pressure.

13. If fuel pressure is still low, replace fuel pump following the procedure in the *Engine Service Manual*.

14. Remove fuel test fitting and install plug.

Possible Causes

- Dirt or jelled fuel in the fuel filter will cause high restriction and low fuel pressure.
- A kinked or bent fuel supply line or a blocked pickup tube can cause high restriction and low fuel pressure.
- A loose fuel line on the suction side of the fuel system can ingest air into the system and cause low fuel pressure.
- Defective fuel regulator valve
- Internal fuel pump damage or damage to the drive gear

GLOW PLUG SYSTEM

15A. Glow Plug System

1. Install Current Clamp around the feed wire loom for glow plugs in the right side. (Figure L)
2. Turn ignition key ON. (Do not start the engine.)
3. Use EST to do Output State Test for glow plugs. (After 40 seconds record the amperage reading.)
4. Move clamp to left side and record amperage reading (Figure M).

Side	Spec	Reading
Right	34-52 Amps	
Left	34-52 Amps	

- If reading is below or above the amperage spec, do **Test15B** for each glow plug in the failed side.
- If the reading is 0 Amps, do **Test 8** on this form. For DTC 251, see Glow Plug Control Circuit in Section 7.

D3169

Figure 145

Purpose

To determine if the glow plug system is operating correctly to start the engine

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Current clamp
- DMM
- Glow plug test lead

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

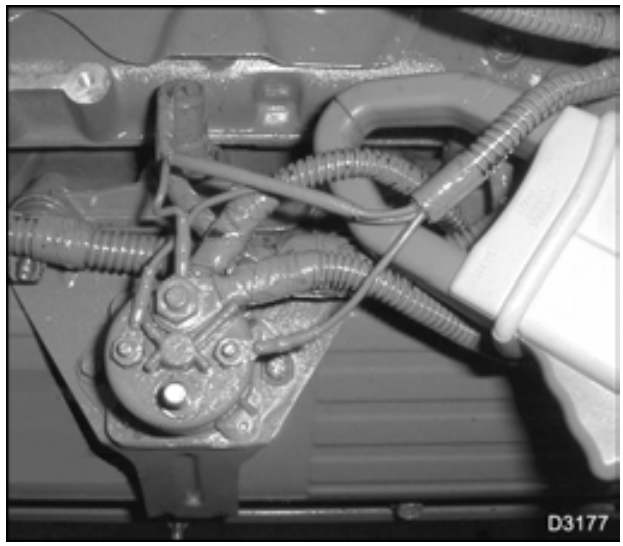


Figure 146 Current Clamp around feed wire loom for right side glow plugs

1. Install a Current Clamp around the feed wire loom for glow plugs in the right side.

2. Turn ignition key ON. (Do not start the engine.)

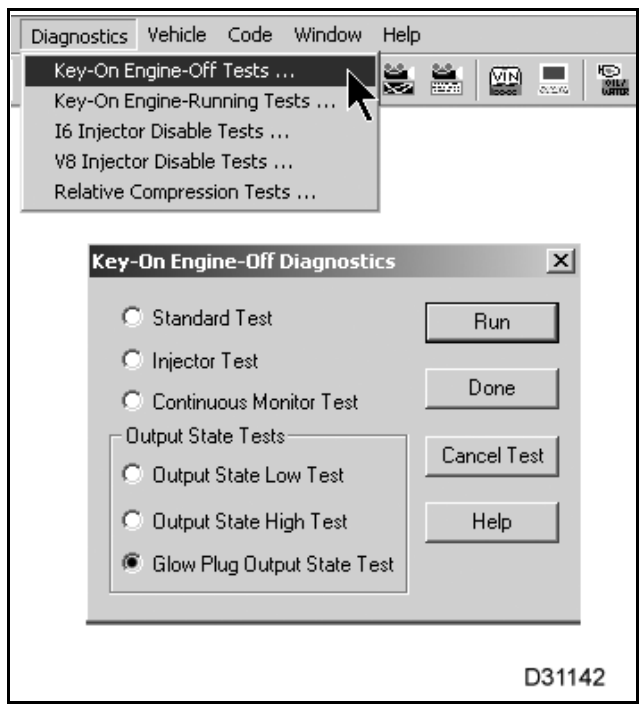


Figure 147 Glow Plug Output State Test

3. Select Diagnostics from the menu bar.

4. Select Key On Engine Off Tests from the drop down menu.

   NOTE: Test 8 (Key On Engine Off Standard Test) must have been done before doing the Glow Plug Output State Test.

5. From Key On Engine Off Diagnostics menu, select Glow Plug Output State Test and click run to start the test.

   After 40 seconds, record the amperage reading for the right side on Hard Start and No Start Diagnostics form.

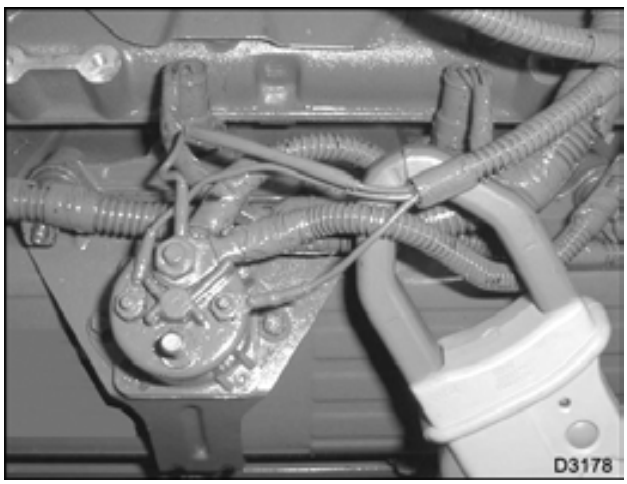


Figure 148 Current Clamp around feed wire loom for left side glow plugs

6. Install Current Clamp around the feed wire loom for glow plugs in the left side.

   - If not done within 120 seconds of starting Glow Plug Output State Test, repeat step 5 for left side glow plugs.
   - If a reading is below or above the amperage specification, do Test 15B (Glow Plug System Components).
   - If reading is 0 amps, do Test 8 (Key On Engine Off Standard Test). For DTC 251 see Glow Plug Control Circuits in Section 7.

GLOW PLUG SYSTEM (COMPONENTS)

15B. Glow Plug System(Components)

1. Select the feed wiring loom for the glow plug side that failed.
2. Remove wires from the loom convolute.
3. Install Current Clamp around one of the wires and do the Output State Test (Figure N). After 40 seconds, measure amperage for each glow plug one wire at a time.

Note: If any glow plug failed, use a DMM to do steps 4 and 5.

4. Check resistance in wire between glow plug relay and glow plug. (Figure P)
5. Check glow plug resistance to ground. (Figure R)

Glow Plug No.	Record for step 3 Glow plug amperage (8.5 - 16 amps)	Record for step 4 Glow plug relay to glow plug (0 -1 Ohm)	Record for step 5 Glow plug to ground (.1 - 6 Ohms)
1			
2			
3			
4			
5			
6			
7			
8			

D3170

Figure 149

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

1. Select the feed wiring loom for the glow plug side that failed.

2. Remove wires from the loom convolute.

3. Install Current Clamp around one of the four wires and do the Glow Plug Output StateTest.

   After 40 seconds, measure amperage. Move Current Clamp to remaining wires one at a time. measuring amperage each time.

   - If not done within 120 seconds of starting Glow Plug Output State Test, repeat Glow Plug Output State for the remaining glow plugs.

4. Record amperage on Hard Start and No Start Diagnostics form.

   - If any glow plug failed, use a DMM to do steps 5 through 8.

Figure 150 Resistance check between glow plug relay and glow plug

5. Check resistance of wire between the glow plug relay and glow plug.

6. Record resistance for each wire on diagnostics form.

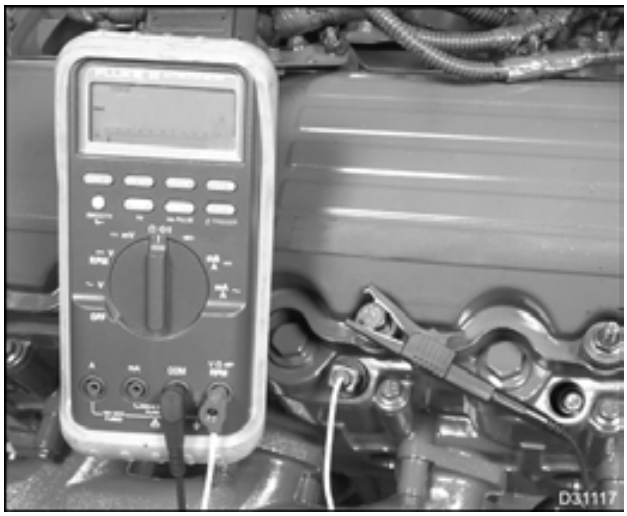


Figure 151 Glow plug resistance

7. Using glow plug test lead, check glow plug resistance to ground.

8. Record resistance for each suspect glow plug on dignostics form.

Possible Causes

- Defective wiring harness connection
- Poor ground connection
- Defective glow plug relay
- Defective glow plugs
- Defective ECM

LOW ICP SYSTEM PRESSURE

16. Low ICP System Pressure

Do only the following low ICP tests ifICP was low during **TEST 11**. (See Section 5 for test procedures.)

If the test result for System Function is Yes, **do not continue with the following tests for Low ICP**.

Low ICP Tests

Test	Question	Result
16.1 System function	Greater than 500 PSI (0.82v) ?	Yes No
16.2 IPR isolation	Audible air leak ?	Left Right Yes Yes No No
16.3 IPR function	Audible air leak ?	Unplugged B+ applied Yes Yes No No
16.4 Cylinder head isolation	Air leaks in cylinder head components ?	Left Right Yes Yes No No
16.5 Discharge, rear branch, and connection tubes	Audible air leak ?	Discharge Yes No Rear branch Yes No Connection tubes Yes No
16.6 High pressure pump	Greater than 500 PSI (0.82v) ?	Yes No

D3171

Figure 152

Purpose

To determine the cause of low ICP pressure that prevents engine starting

Tools

- Electronic Service Tool (EST) with Master Diagnostics
- International® EZ-Tech Interface Cable
- DMM
- Actuator breakout harness
- Pressure sensor breakout harness
- No. 6 leak test plug
- No. 10 leak test plug (2)
- IPR isolation adapter
- Test adapter for high pressure rail
- Test adapter for high pressure pump cover
- No. 6 release tool
- No. 8 and No. 10 release tool (combined)
- Shallow socket (12 point 19 mm) with extension
- Compressor air source 689 kPa (100 psi)

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedures

If there are no concerns with lube oil pressure, start Test 16.1 (System Function)

System Function (16.1)

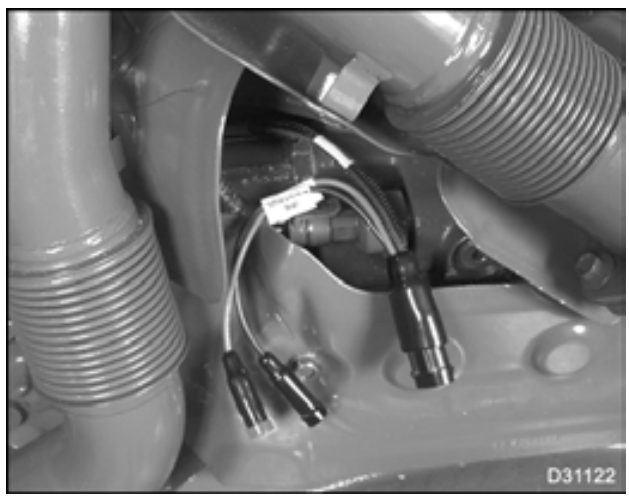


Figure 153 Actuator breakout harness installed to IPR

1. Install actuator breakout harness to IPR. (Do not connect engine harness.)

Figure 154 Ground to post on cowl

Figure 155 B+ on power distribution post

2. Apply ground and B+ volts to the IPR valve.

CAUTION: Do not leave the IPR valve energized longer than 120 seconds — this can damage the IPR valve.

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

While cranking the engine, the engine could start. Make sure the parking brake is set, the transmission is in neutral, and the wheels are blocked.

NOTE: If the engine starts, disconnect B+ or ground at the actuator breakout harness.

3. Crank the engine and monitor ICP using the EST or (DMM and pressure sensor breakout harness).

4. Record results (System Function) on Hard Start and No Start Diagnostics form.

   - If ICP increases above 3.45 MPa (500 psi) (.82v), the mechanical system is operating correctly for the engine to start. ICP can increase to 21.00 MPa (3,000 psi) (3.6v). **Do not continue with ICP system diagnostics.**
   - Check DTCs found during Test 8. (Make sure problems were corrected.)
   - For problems in the electrical circuit, see IPR Circuit Diagnostics in Section 7.
   - If 3.45 MPa kPa (500 psi) (.82v) can not be reached, continue with the following test IPR Isolation (16.2).

IPR Isolation (**16.2**)

1. Remove the oil fill cap from left valve cover to make it easier to hear leaks and prevent unintended pressurization of the crankcase.

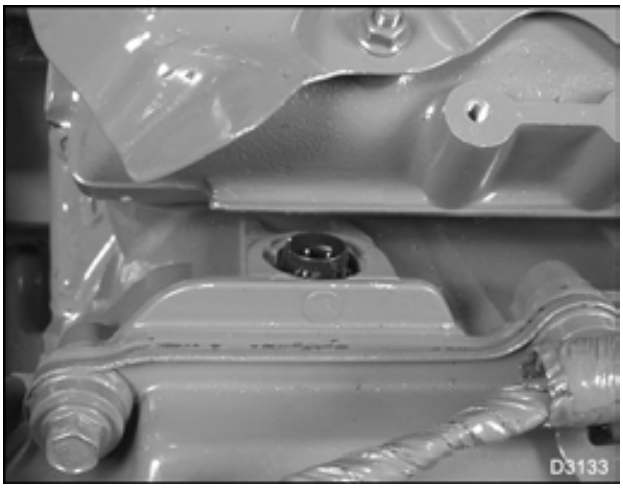


Figure 156 Fuel injection connector

2. Unplug connector for fuel injector 7.

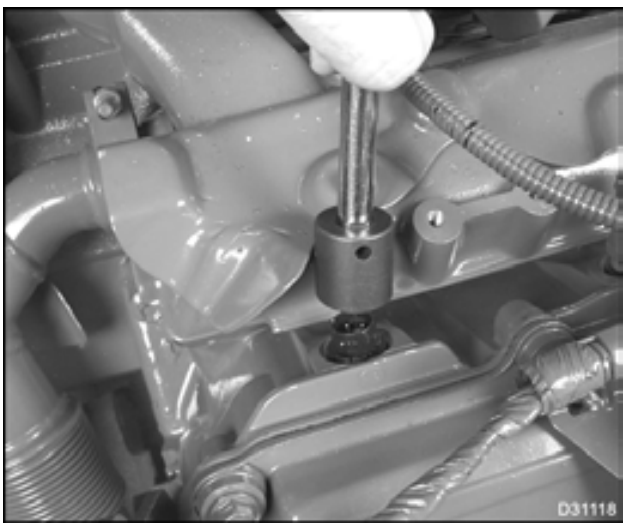


Figure 157 Releasing pass through connector

3. Use a shallow socket (12 point 19 mm) to release the pass through connector; push the pass through connector down (not too far) until the O-ring is almost completely out of the bore. (This makes it easier to hear leaks inside the right hand valve cover.)

4. Remove bolts from the high pressure heat shield. (Let heat shield rest on rear cover.)

5. Remove plug from rear of the high pressure pump cover.

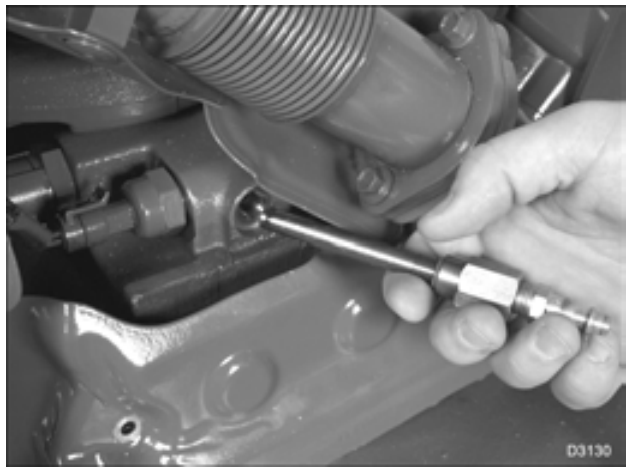


Figure 158 IPR isolation adapter

6. Install IPR isolation adapter, connect line for shop air, and apply 689 kPa (100 psi).

7. Listen for air leaks inside the left and right valve covers.

8. Record result on the diagnostics form.

   - If a leak is not heard in the left or right valve cover, remove IPR isolation adapter and continue with IPR function (16.3).

   NOTE: If a leak cannot be distinguished, remove the valve cover for right side first. (Both valve covers may have to be removed to complete the tests.)

   - If a leak is isolated in the left or right valve cover, see Step 9.

9. Remove isolation adapter from high pressure pump cover and install plug.

10. Install oil fill cap, reseat injector pass through connector, and connect No. 7 injector.

11. Reinstall heat shield

> **CAUTION: The heat shield is installed to prevent failure of the ICP sensor and the IPR.**

12. Continue with Cylinder Head Isolation (16.4) for the side that leaks air.

IPR Function (**16.3**)

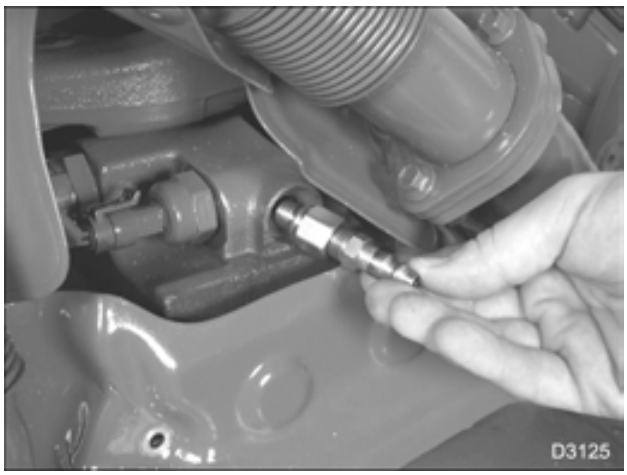


Figure 159 ICP system adapter

1. Install ICP system adapter .

2. Install IPR isolation adapter, connect line for shop air, apply 689 kPa (100 psi), and listen for leaks.

3. Record results on VTv365 Hard Start and No Start Diagnostics form.

   - A leak should be heard. Air should be passing through the IPR valve when the IPR valve is not energized.

4. Use actuator breakout harness to apply B+ and ground to the IPR valve.

5. Record results on the diagnostics form.

   - When the IPR valve is energized, the air leak should stop.
   - If the leak is still heard, replace the IPR valve following procedures in the *Engine Service Manual*, and repeat test for IPR Function.
   - If leak is not heard, continue with Step 6.

6. Remove actuator breakout harness and reconnect engine harness.

7. Remove ICP system adapter from high pressure pump cover and install plug.

8. Install oil fill cap, reseat injector pass through connector, and connect No. 7 injector.

9. Crank engine and monitor ICP, using EST or (DMM and pressure sensor breakout harness).

   - If engine does not start and engine pressure does not reach 3.45 MPa (500 psi), continue with test for High Pressure Pump (16.6).
   - If the engine starts, shut the engine down and install heat shield.

CAUTION: The heat shield is installed to prevent failure of the ICP sensor and the IPR.

Cylinder Head Isolation (**16.4**)

1. Remove valve cover for suspected side, following procedures in the *Engine Service Manual*.

   NOTE: If a leak cannot be distinguished, remove the valve cover for right side first. (Both valve covers may have to be removed to complete the tests.)

Figure 160 Releasing high pressure oil line from high pressure tube

2. Use No. 6 release tool to disconnect oil line from the connection tube.

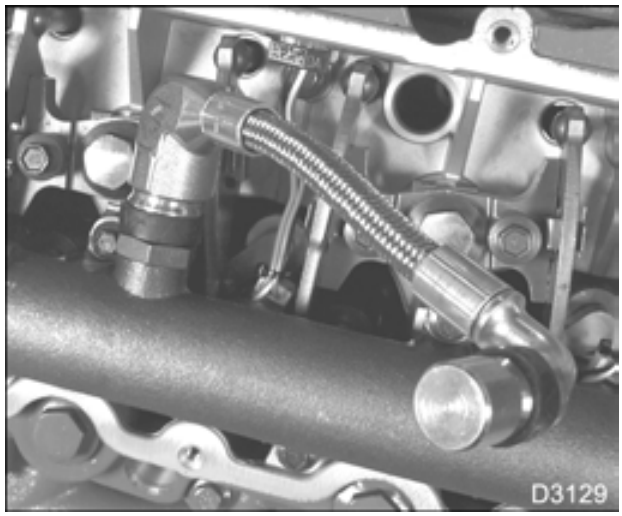


Figure 161 No. 6 leak test plug – installed

3. Install No. 6 leak test plug into the oil line.

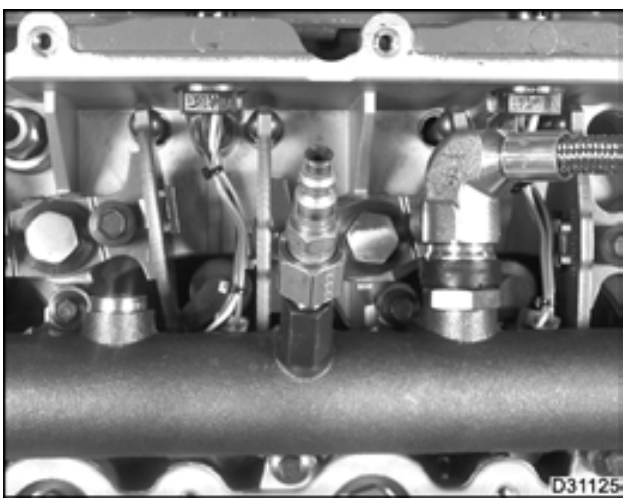


Figure 162 High pressure rail test adapter installed

4. Remove air bleed plug from the high pressure oil rail and install test adapter.

5. Connect shop air and apply 689 kPa (100 psi).

6. Check high pressure oil line, check fitting, high pressure oil rail, and fuel injectors for leaks.

7. Record results on Hard Start and No Start Diagnostics form.

   - If leaks were detected repair as needed.
   - If leaks were not detected for the suspect side, repeat procedure for the opposite side.
   - If leaks were not detected for both sides continue with Step 8.

8. Remove No. 6 leak test plug from high pressure line and reconnect line to connection tube.

9. Remove test adapter from oil rail and reinstall bleed screw.

10. Do the following test for Discharge, Rear branch, and Connection Tubes (16.5).

Discharge, Rear Branch , and Connection Tubes (16.5)

At this point both valve covers are removed.

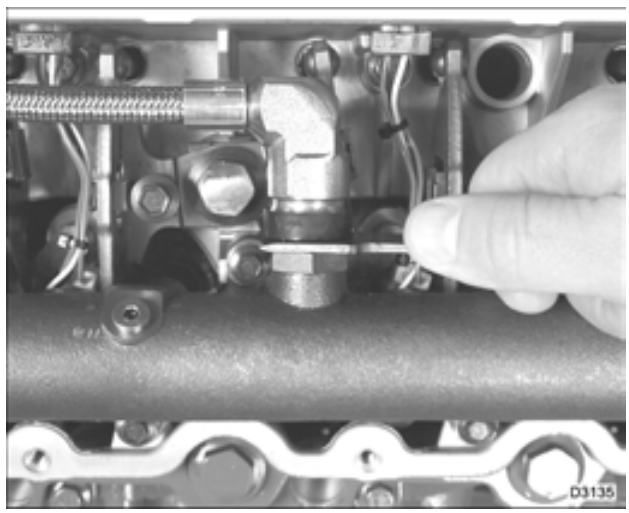


Figure 163 Releasing high pressure oil line from high pressure rail

1. Use No. 10 – No. 8 combination release tool to disconnect high pressure oil line from the high pressure rail on left and right sides.

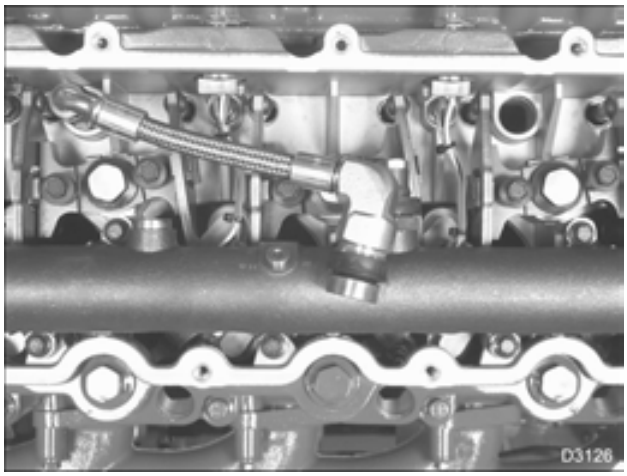


Figure 164 No. 10 leak test plug installed

2. Install No. 10 leak test plug in high pressure oil line for left and right sides.

3. Remove bolts from the high pressure heat shield. (Let heat shield rest on rear cover.)

4. Remove plug from rear of high pressure pump cover.

5. Install IPR isolation adapter, connector, and apply 689 kPa (100 psi) and listen for air leaks.

6. Record results on Hard Start and No Start Diagnostics form.

   - If a leak is heard continue with Step 7.
   - If an internal leak is not heard, check earlier test results.

Figure 165 Connection tube

7. Remove and check high pressure connection tubes for defects.

   - If connection tubes are good, reinstall the connection tubes, and connect high pressure oil lines.
   - If a connection tube is defective, replace the connection tube.

Figure 166 Under side of high pressure pump cover

8. Remove and check high pressure pump cover for defects in the discharge tube bore.

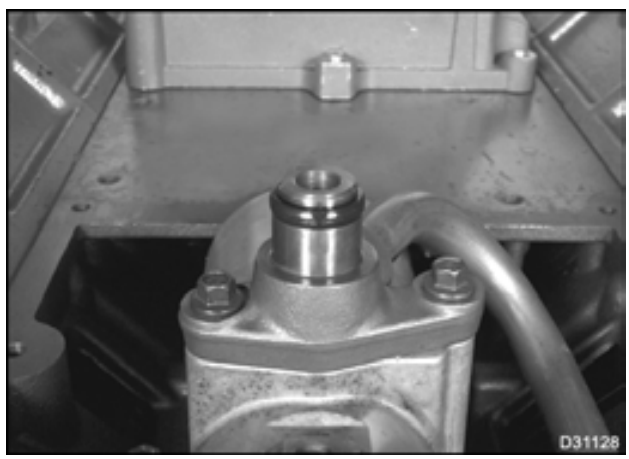


Figure 167 D-ring on high pressure pump discharge tube

9. Check D-ring on the high pressure discharge tube for damage.

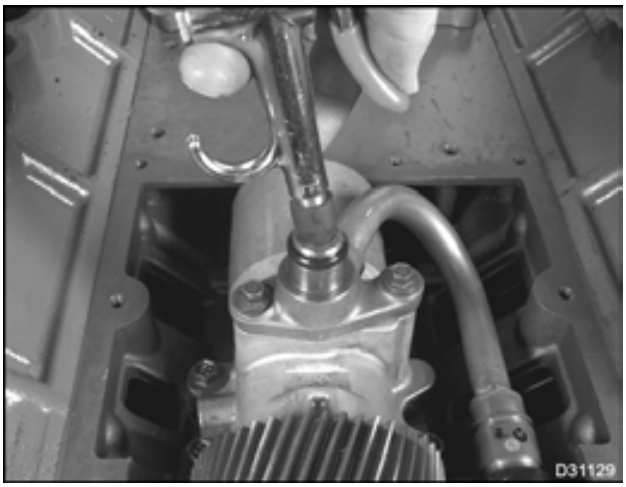


Figure 168 Applying shop air to high pressure discharge tube

10. Verify that No. 10 plugs are still in high pressure oil line.

11. Use rubber tipped blow gun to apply shop air into the discharge tube and listen for air leaks.)

    - While under pressure, inspect and check discharge tube and quick disconnect coupling on the rear branch tube.
    - If the origin of the leak is undetectable, the rear branch tube is leaking into the crankcase. (Replace the tube for the rear branch and retest.)
    - Before reassembling the engine, make sure the IPR isolation adapter is removed from the pump cover.

12. Remove isolation adapter from the high pressure pump cover, install plug, and install pump cover.

13. Install heat shield.

CAUTION: The heat shield is installed to prevent failure of the ICP sensor and the IPR.

High Pressure Pump (16.6)

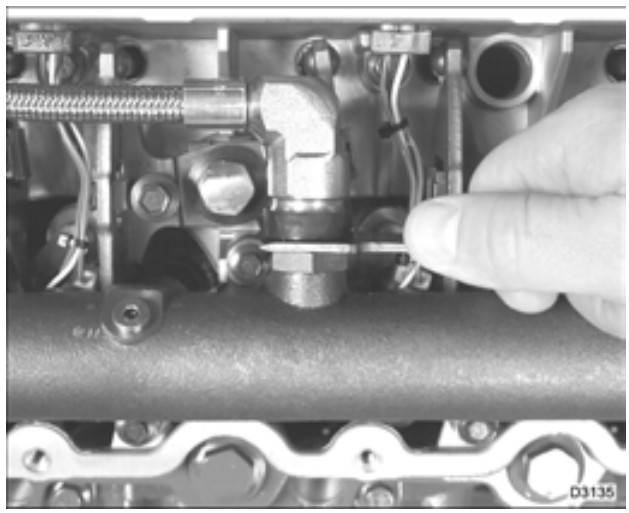


Figure 169 Releasing high pressure oil line from high pressure rail

1. Remove left and right valve covers following procedures in the *Engine Service Manual*.

2. Use No. 10 – No. 8 combination release tool to disconnect high pressure oil line from the high pressure rail on left and right sides.

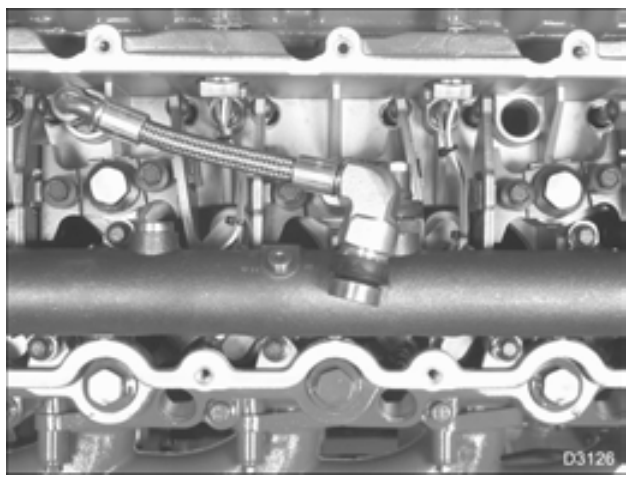


Figure 170 No. 10 leak test plug installed

3. Install No. 10 leak test plug in high pressure oil line for left and right sides.

CAUTION: Do not leave the IPR valve energized longer than 120 seconds — this can damage the IPR valve.

4. Use actuator breakout harness to apply B+ and ground to the IPR valve.

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

While cranking the engine, the engine could start. Make sure the parking brake is set, the transmission is in neutral, and the wheels are blocked.

NOTE: If the engine starts, disconnect B+ or ground at the actuator breakout harness.

5. Crank engine and monitor ICP, using EST or (DMM and pressure sensor breakout harness).

6. If 3.45 MPa (500 psi) (.82v) can not be reached and leaks are not detected, replace the high pressure pump following procedures in the *Engine Service Manual* and retest.

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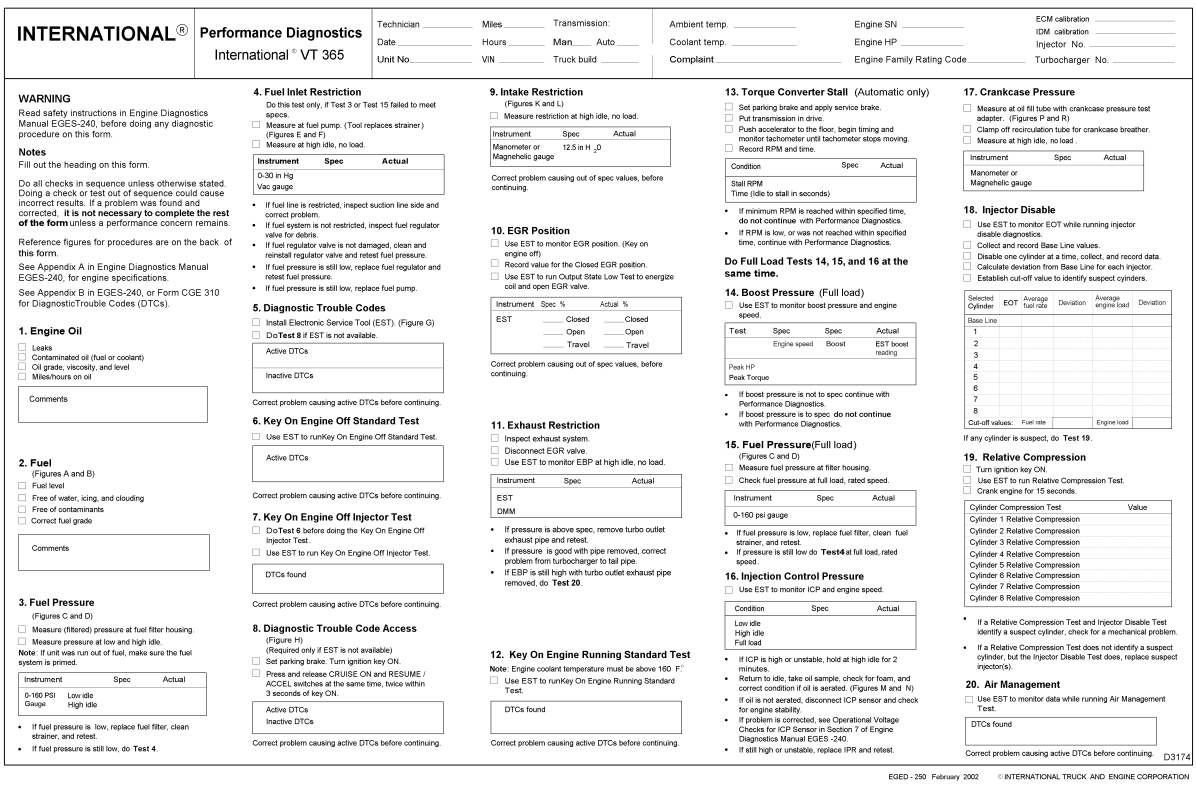
DESCRIPTION

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing service bay diagnostics on engine or vehicle.

Engine diagnostic forms provide customer satisfaction and assist technicians in troubleshooting International® VT 365 diesel engines. Diagnostic test procedures help technicians find problems systematically and quickly to avoid unnecessary repairs.



INTERNATIONAL®

Performance Diagnostics
International® VT 365

Technician _____ Miles _____ Transmission:
Date _____ Hours _____ Man____ Auto____
Unit No._____ VIN _____ Truck build _____

Ambient temp. _____ Engine SN _____
Coolant temp. _____ Engine HP _____
Complaint _____ Engine Family Rating Code _____

ECM calibration _____
IDM calibration _____
Injector No. _____
Turbocharger No. _____

WARNING
Read safety instructions in Engine Diagnostics Manual EGES-240, before doing any diagnostic procedure on this form.

Notes
Fill out the heading on this form.

Do all checks in sequence unless otherwise stated. Doing a check or test out of sequence could cause incorrect results. If a problem was found and corrected, **it is not necessary to complete the rest of the form** unless a performance concern remains.

Reference figures for procedures are on the back of this form.
See Appendix A in Engine Diagnostics Manual EGES-240, for engine specifications.
See Appendix B in EGES-240, or Form CGE 310 for DiagnosticTrouble Codes (DTCs).

1. Engine Oil
☐ Leaks
☐ Contaminated oil (fuel or coolant)
☐ Oil grade, viscosity, and level
☐ Miles/hours on oil
Comments

2. Fuel
(Figures A and B)
☐ Fuel level
☐ Free of water, icing, and clouding
☐ Free of contaminants
☐ Correct fuel grade
Comments

3. Fuel Pressure
(Figures C and D)
☐ Measure (filtered) pressure at fuel filter housing.
☐ Measure pressure at low and high idle.
Note: If unit was run out of fuel, make sure the fuel system is primed.

Instrument	Spec	Actual
0-160 PSI Gauge	Low idle High idle	

- If fuel pressure is low, replace fuel filter, clean strainer, and retest.
- If fuel pressure is still low, do **Test 4**.

4. Fuel Inlet Restriction
Do this test only, if Test 3 or Test 15 failed to meet specs.
☐ Measure at fuel pump. (Tool replaces strainer) (Figures E and F)
☐ Measure at high idle, no load.

Instrument	Spec	Actual
0-30 in Hg Vac gauge		

- If fuel line is restricted, inspect suction line side and correct problem.
- If fuel system is not restricted, inspect fuel regulator valve for debris.
- If fuel regulator valve is not damaged, clean and reinstall regulator valve and retest fuel pressure.
- If fuel pressure is still low, replace fuel regulator and retest fuel pressure.
- If fuel pressure is still low, replace fuel pump.

5. Diagnostic Trouble Codes
☐ Install Electronic Service Tool (EST). (Figure G)
☐ Do **Test 8** if EST is not available.
Active DTCs
Inactive DTCs
Correct problem causing active DTCs before continuing.

6. Key On Engine Off Standard Test
☐ Use EST to runKey On Engine Off Standard Test.
Active DTCs
Correct problem causing active DTCs before continuing.

7. Key On Engine Off Injector Test
☐ Do **Test 6** before doing the Key On Engine Off Injector Test.
☐ Use EST to run Key On Engine Off Injector Test.
DTCs found
Correct problem causing active DTCs before continuing.

8. Diagnostic Trouble Code Access
(Figure H)
(Required only if EST is not available)
☐ Set parking brake. Turn ignition key ON.
☐ Press and release CRUISE ON and RESUME / ACCEL switches at the same time, twice within 3 seconds of key ON.
Active DTCs
Inactive DTCs
Correct problem causing active DTCs before continuing.

9. Intake Restriction
(Figures K and L)
☐ Measure restriction at high idle, no load.

Instrument	Spec	Actual
Manometer or Magnehelic gauge	12.5 in H 0	

Correct problem causing out of spec values, before continuing.

10. EGR Position
☐ Use EST to monitor EGR position. (Key on engine off)
☐ Record value for the Closed EGR position.
☐ Use EST to run Output State Low Test to energize coil and open EGR valve.

Instrument	Spec %	Actual %
EST	____ Closed ____ Open ____ Travel	____Closed ____Open ____ Travel

Correct problem causing out of spec values, before continuing.

11. Exhaust Restriction
☐ Inspect exhaust system.
☐ Disconnect EGR valve.
☐ Use EST to monitor EBP at high idle, no load.

Instrument	Spec	Actual
EST DMM		

- If pressure is above spec, remove turbo outlet exhaust pipe and retest.
- If pressure is good with pipe removed, correct problem from turbocharger to tail pipe.
- If EBP is still high with turbo outlet exhaust pipe removed, do **Test 20**.

12. Key On Engine Running Standard Test
Note: Engine coolant temperature must be above 160 F.°
☐ Use EST to runKey On Engine Running Standard Test.
DTCs found
Correct problem causing active DTCs before continuing.

13. Torque Converter Stall (Automatic only)
☐ Set parking brake and apply service brake.
☐ Put transmission in drive.
☐ Push accelerator to the floor, begin timing and monitor tachometer until tachometer stops moving.
☐ Record RPM and time.

Condition	Spec	Actual
Stall RPM Time (Idle to stall in seconds)		

- If minimum RPM is reached within specified time, **do not continue** with Performance Diagnostics.
- If RPM is low, or was not reached within specified time, continue with Performance Diagnostics.

Do Full Load Tests 14, 15, and 16 at the same time.

14. Boost Pressure (Full load)
☐ Use EST to monitor boost pressure and engine speed.

Test	Spec	Spec	Actual
	Engine speed	Boost	EST boost reading
Peak HP Peak Torque			

- If boost pressure is not to spec continue with Performance Diagnostics.
- If boost pressure is to spec **do not continue** with Performance Diagnostics.

15. Fuel Pressure(Full load)
(Figures C and D)
☐ Measure fuel pressure at filter housing.
☐ Check fuel pressure at full load, rated speed.

Instrument	Spec	Actual
0-160 psi gauge		

- If fuel pressure is low, replace fuel filter, clean fuel strainer, and retest.
- If pressure is still low do **Test4** at full load, rated speed.

16. Injection Control Pressure
☐ Use EST to monitor ICP and engine speed.

Condition	Spec	Actual
Low idle High idle Full load		

- If ICP is high or unstable, hold at high idle for 2 minutes.
- Return to idle, take oil sample, check for foam, and correct condition if oil is aerated. (Figures **M** and N)
- If oil is not aerated, disconnect ICP sensor and check for engine stability.
- If problem is corrected, see Operational Voltage Checks for ICP Sensor in Section 7 of Engine Diagnostics Manual EGES -240.
- If still high or unstable, replace IPR and retest.

17. Crankcase Pressure
☐ Measure at oil fill tube with crankcase pressure test adapter. (Figures P and R)
☐ Clamp off recirculation tube for crankcase breather.
☐ Measure at high idle, no load .

Instrument	Spec	Actual
Manometer or Magnehelic gauge		

18. Injector Disable
☐ Use EST to monitor EOT while running injector disable diagnostics.
☐ Collect and record Base Line values.
☐ Disable one cylinder at a time, collect, and record data.
☐ Calculate deviation from Base Line for each injector.
☐ Establish cut-off value to identify suspect cylinders.

Selected Cylinder	EOT	Average fuel rate	Deviation	Average engine load	Deviation
Base Line					
1					
2					
3					
4					
5					
6					
7					
8					
Cut-off values:		Fuel rate		Engine load	

If any cylinder is suspect, do **Test 19**.

19. Relative Compression
☐ Turn ignition key ON.
☐ Use EST to run Relative Compression Test.
☐ Crank engine for 15 seconds.

Cylinder 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	
Cylinder 7 Relative Compression	
Cylinder 8 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(s).

20. Air Management
☐ Use EST to monitor data while running Air Management Test.
DTCs found
Correct problem causing active DTCs before continuing.

D3174

EGED - 250 February 2002 © INTERNATIONAL TRUCK AND ENGINE CORPORATION

Figure 171 Performance Diagnostics form EGED-250 (Front side)

VEHICLE INFORMATION

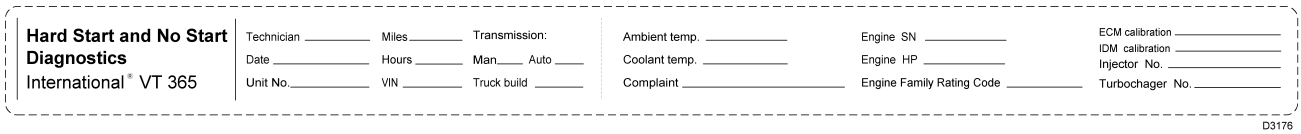


Figure 172

NOTE: Before starting diagnostic tests, fill out the heading for vehicle information on the front side of Performance Diagnostics form EGED-250.

- Technician and Unit numbers are for reference only
- Date, Miles, and Hours are for warranty claims
- Engine Serial Number (ESN) and Vehicle Identification Number (VIN) are for ordering parts and referencing service information. The engine serial number is on a machined pad behind the left rear of block below the left cylinder head. The Vehicle Identification Number is on the door jamb on the driver's side.
- Engine Horsepower / Emissions Information and Engine Family Rating Code (EFRC) helps determine if the engine is the correct horsepower for the application and if the ECM is calibrated to the correct horsepower and emissions level. Information for engine horsepower and emissions is on the emission label on the right side valve cover.
- Engine Family Rating Codes and calibrations for the Electronic Control Module (ECM) and the Injector Drive Module (IDM) are found with the Electronic Service Tool (EST).
- Fill in the Turbocharger No. and Injector No. only if there is a suspected mismatch of components.

Performance Diagnostics form EGED-250 is available in 50 sheet pads from:

International® Truck and Engine Corporation
Printing, Procurement and Distribution
4956 Wayne Road
Battle Creek, Michigan 49015

OBTAINING VEHICLE INFORMATION

Figure 173 ATA connector

Figure 174 International ® EZ-Tech Interface cable

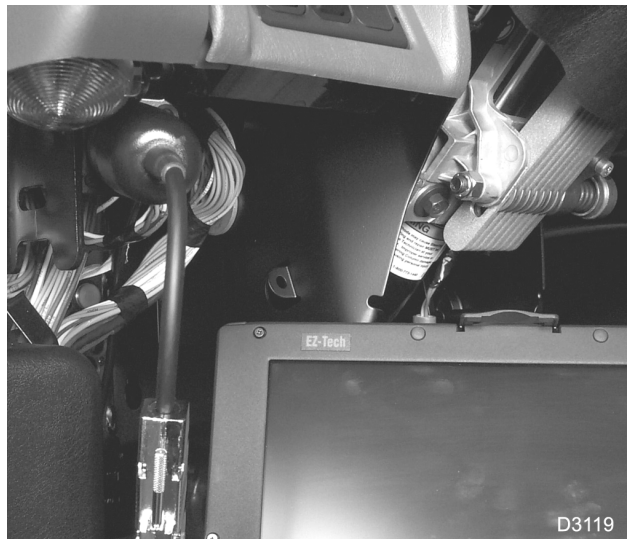


Figure 175 Installation of International® EZ-Tech Interface Cable

1. Connect one end of the International® EZ-Tech Interface Cable to the EST and the other end to the ATA connector.

2. Boot up EST.

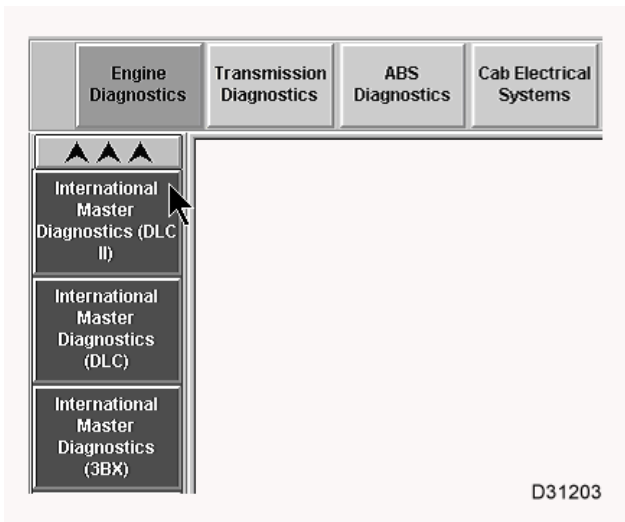


Figure 176 International® Launchpad

3. Select Vehicle Diagnostics, then International Master Diagnostics (DLC II).

4. Turn ignition ON.

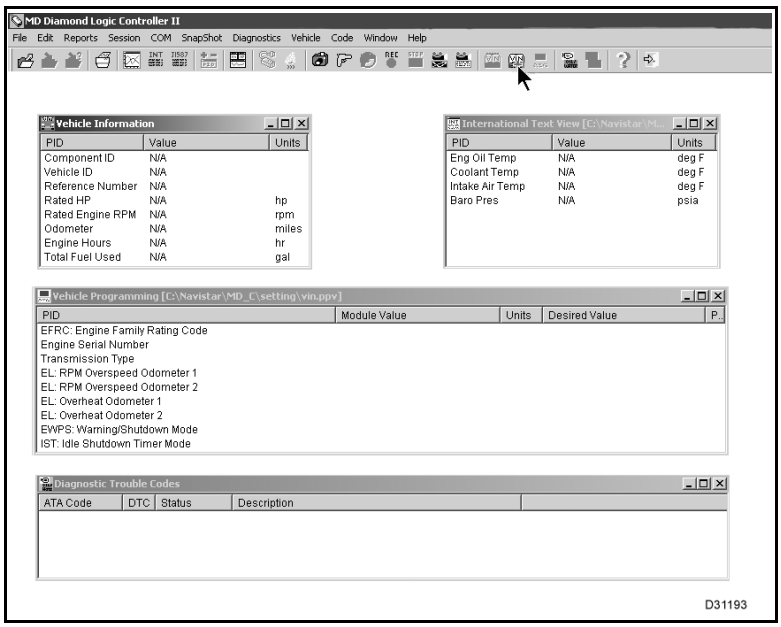


Figure 177 Open VIN session

5. Select VIN+ icon to open VIN session.

6. Using on screen information, fill out top of Hard Start and No Start Diagnostics form.

Table 3

Heading Information =	PID
Miles	Odometer
Hours	Engine hours
Transmission	Transmission Type
	Manual Non-Isochronous
	Manual Isochronous
	Allison AT/MT
	Allison MD
Ambient temp.	Intake Air Temp.
Coolant temp.	Coolant Temp
Engine SN	Engine Serial number
Engine HP	Rated HP
ECM calibration	Reference Number
	PRG2NR00
	(First group)
IDM calibration	Reference Number
	AFZ7AH02
	(Second group)

NOTE: Fill in the Turbocharger No. and Injector No. only if there is a suspected mismatch of components.

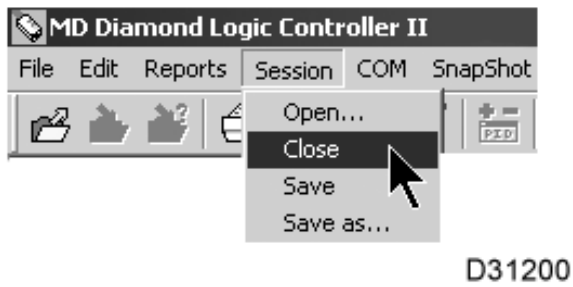


Figure 178 Close session

7. When finished filling out the top of the form, select session, then Close.

TEST PROCEDURES

ENGINE OIL

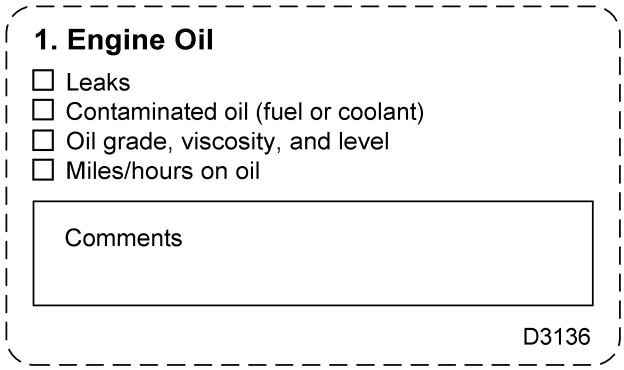


Figure 179

Purpose

To check engine oil level and quality and determine if oil pressure is correct for the injection control pressure system

Tools

- None

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

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

   NOTE: Never check the oil level with the engine running or immediately after engine shutdown as an inaccurate reading will be obtained. Allow 15 minute drain down time.

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

3. Inspect oil for color and odor.
   - A milky white mix indicates coolant contamination.
   - Does oil have a diesel fuel odor?
4. Check engine service records for correct oil grade and viscosity for ambient operating temperatures. **Do not use 15W-40 oil below -6.7°C (20°F)**. Long oil drain intervals can increase oil viscosity; thicker oil will make engine cranking and starting more difficult below freezing temperatures. See Engine Lubrication Requirements in the *Engine Operation and Maintenance Manual*. Confirm that oil meets correct API specifications.

Possible Causes

Low oil level

- Oil leak
- Oil consumption
- Incorrect servicing

High oil level

- Incorrect servicing
- Fuel in oil
- Incorrect oil level gauge
- Coolant in oil

Coolant in oil

- Cylinder head gasket leak
- Defective welch plug in cylinder head
- Injector sleeve leak
- Glow plug sleeve leak
- Front cover gasket leak
- Defective oil cooler bundle or O-ring
- Front cover, cylinder head, or crankcase porosity
- Accessory leak (water cooled air compressor)

Fuel in oil

- Injector O-ring leak
- Cylinder head porosity

FUEL

2. Fuel
(Figure A and B)
☐ Fuel level
☐ Free of water, icing, and clouding
☐ Free of contaminants
☐ Correct fuel grade

Comments

D3137

Figure 180

Purpose

To check fuel level and quality for efficient engine operation

Tools

- Clear container (approximately 1 Quart or 1 Liter)

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle – comply with the following when taking fuel sample:

- **Do not smoke.**
- **Keep away from open flames and sparks.**

1. Take fuel sample from fuel tank. Fuel must be the correct grade, clean, and undiluted.

Figure 181 Fuel drain

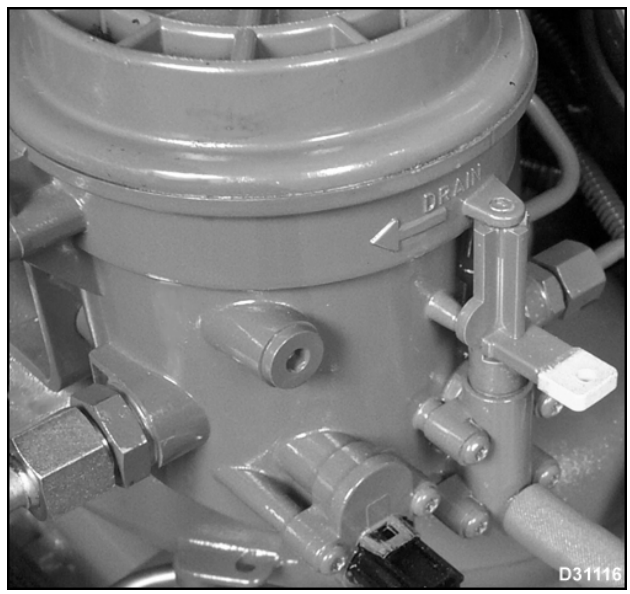


Figure 182 Open fuel drain valve

2. Run a hose from the fuel drain tube to a clear container and open the drain.

   NOTE: Cold weather can cause fuel waxing in some grades of diesel fuel. Waxing will restrict or stop fuel flow through the fuel filter.

3. Check for gasoline or kerosene in the diesel fuel.

4. Check for sediment or water in the fuel sample.

NOTE: Some sediment or water could be found in the fuel sample, if the fuel filter was not serviced or drained for a long time. Take another sample to determine fuel quality.

NOTE: If unit was run out of fuel, make sure the fuel system was primed. See Section 4 in this manual for procedure.

NOTE: If all three of the following conditions are noted, see Combustion Leaks to Fuel in Section 4.

- **Fuel system will not prime**
- **White to black exhaust smoke**
- **Pulsating fuel pressure**

Possible Causes

- No fuel in tank.
- The in-line fuel valve (if equipped) could be shut off.
- Fuel supply line could be broken or crimped.
- The tank pickup tube could be clogged or cracked.
- Supplemental filters or water separators may be plugged or leaking allowing air to enter the fuel system.
- Water or contaminants in fuel tank.
- Ice in fuel lines.
- Debris in fuel tank.
- Cloudy fuel indicates that fuel grade is unsuitable for cold temperatures.
- Fuel could be waxed or jelled. (usually Grade 2-D).

FUEL PRESSURE

3. Fuel Pressure
(Figure C and D)

☐ Measure (filtered) pressure at fuel filter housing.
☐ Measure pressure at low and high idle.

Note: If unit was run out of fuel, make sure the fuel system is primed.

Instrument	Spec	Actual
0-160 PSI Gauge	Low idle High idle	

If fuel pressure is low, replace fuel filter, clean strainer, and retest.

If fuel pressure is still low, do **Test 4**.

D3138

Figure 183

Purpose

To check for correct fuel pressure

NOTE: If the fuel filter has a Water In Fuel (WIF) probe, ask the operator if the WIF lamp was on during vehicle operation.

Tools

- Gauge bar (0–160 PSI gauge)
- Fuel pressure test fitting
- Fuel/oil pressure test coupler

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

1. See Appendix A in this manual for specifications, and record on Performance Diagnostics form.
2. Remove plug from fuel filter housing (lower rear left).

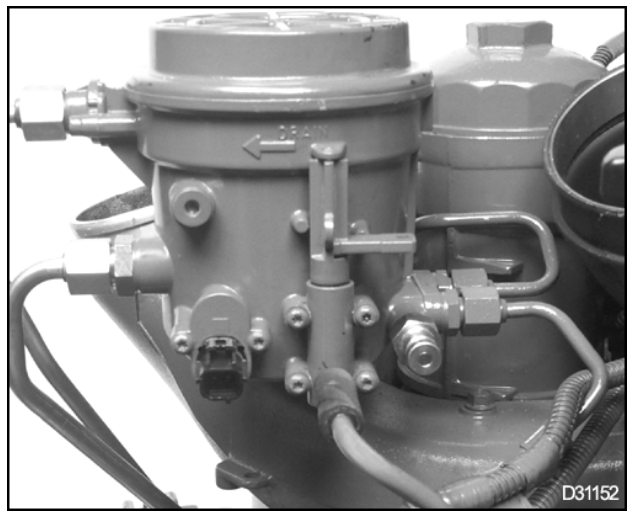


Figure 184 Fuel pressure test fitting installed

3. Install fuel pressure test fitting.

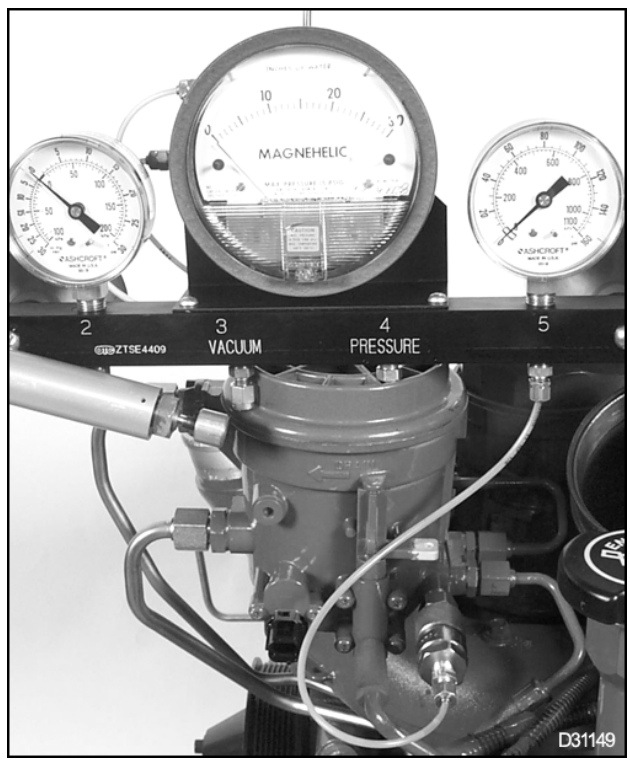


Figure 185 Measuring fuel pressure

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

When routing test line , do not crimp the line, run the line too close to moving parts, or let the line touch hot engine surfaces.

4. Connect a line from fuel/oil pressure test coupler to the 0–160 PSI gauge on gauge bar, then connect to test fitting.

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

When running the engine in the service bay, make sure the parking brake is set, the transmission is in neutral, and the wheels are blocked.

5. Measure minimum fuel pressure at low idle and high idle

6. Record readings on diagnostics form.
   - If fuel pressure is low replace fuel filter, clean strainer, and retest.
   - If fuel pressure is still low, do Test 4 (Fuel Inlet Restriction).

7. Remove fuel pressure test fitting and install plug.

Possible Causes

- Fuel tank empty
- Dirt or jelled fuel in the fuel filter will cause high restriction and low fuel pressure.
- A kinked or bent fuel supply line or a blocked pickup tube can cause high restriction and low fuel pressure.
- A loose fuel line on the suction side of the fuel system can ingest air into the system and cause low fuel pressure.
- Defective fuel regulator valve
- Debris in tank
- Internal fuel pump damage or damage to the drive gear

FUEL INLET RESTRICTION

4. Fuel Inlet Restriction

Do this test only, if Test 3 or Test 15 failed to meet specs.

☐ Measure at fuel pump. (Tool replaces strainer) (Figures E and F)

☐ Measure at high idle, no load.

Instrument	Spec	Actual
0-30 in Hg Vac gauge		

- If fuel line is restricted, inspect suction line side and correct problem.
- If fuel system is not restricted, inspect fuel regulator valve for debris.
- If fuel regulator valve is not damaged, clean and reinstall regulator valve and retest fuel pressure.
- If fuel pressure is still low, replace fuel regulator and retest fuel pressure.
- If fuel pressure is still low, replace fuel pump.

D3139

Figure 186

Purpose

To check fuel inlet line for excessive restriction

Tools

- Gauge Bar (0–30 in Hg vacuum gauge)
- Fuel inlet restriction adapter
- 30 mm combination wrench

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

1. See Appendix A in this manual for restriction specifications, and record on Performance Diagnostics form.

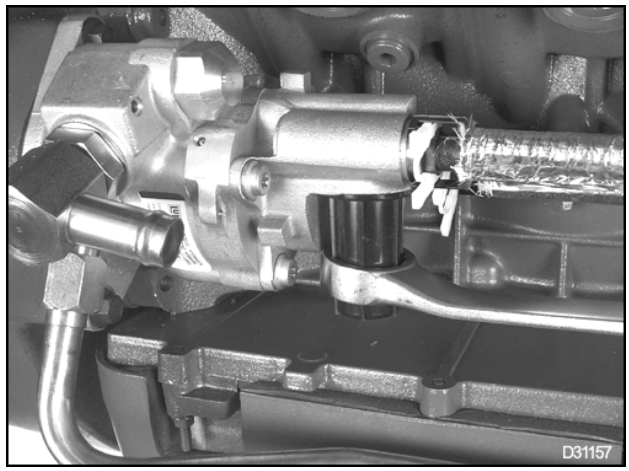


Figure 187

2. Remove fuel strainer.

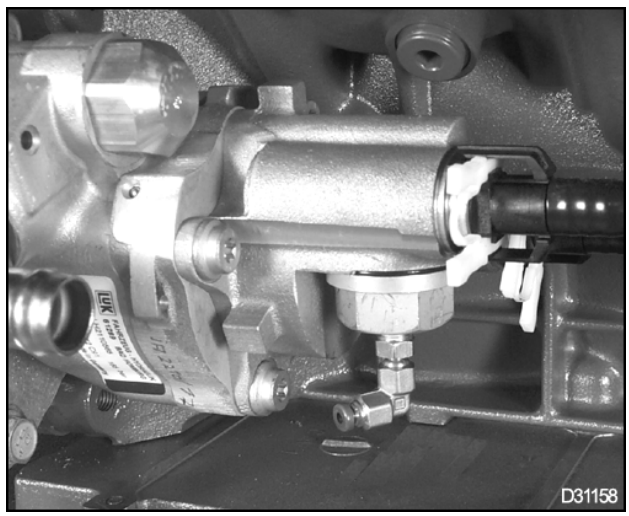


Figure 188 Fuel inlet restriction adapter installed

CAUTION: To prevent damage to threads, hand start adapter. Do not over tighten. (Both components are aluminum.)

3. Install fuel inlet restriction adapter.

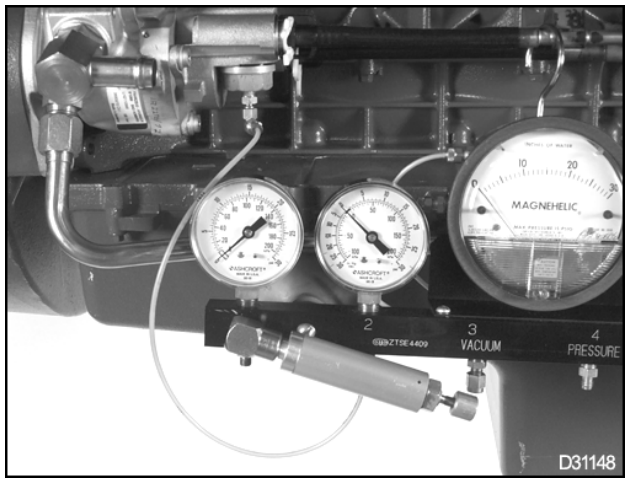


Figure 189 Measuring fuel inlet restriction

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

When routing test line , do not crimp the line, run the line too close to moving parts, or let the line touch hot engine surfaces.

4. Connect a line from the adapter to the 0–30 in Hg vacuum gauge on Gauge Bar.

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following;

When running the engine in the service bay, make sure the parking brake is set, the transmission is in neutral, and the wheels are blocked.

5. Measure restriction at high idle and record on diagnostics form.

   - If restriction exceeds spec, find the restriction on the suction side of the fuel system and correct.
   - If fuel inlet restriction is in spec, continue with Step 6.

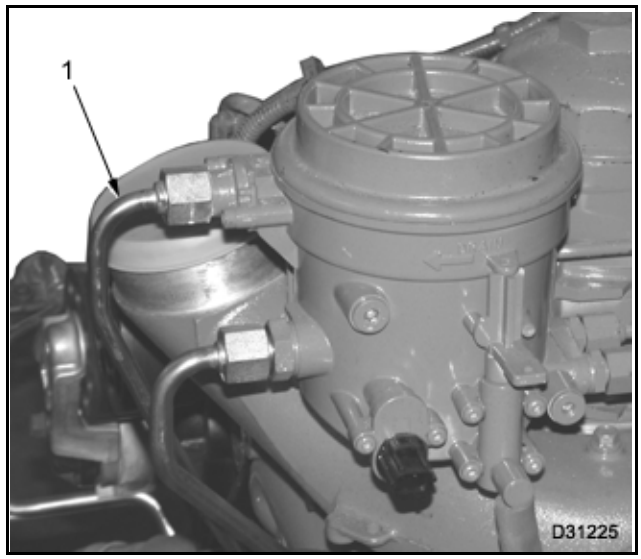


Figure 190 Removing fuel return line

1. Fuel return line

6. Remove fuel return line from the fuel regulator valve cap.

   NOTE: Use tape or a wire tie around the fuel line to prevent the nut from falling down.

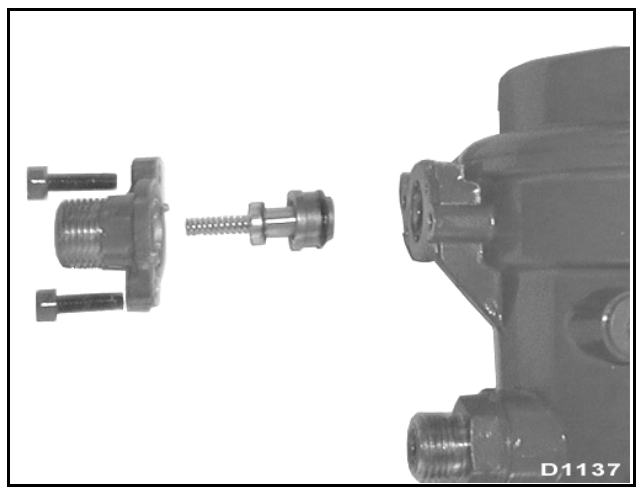


Figure 191 Fuel regulator valve

7. Remove fuel regulator valve cap.

8. Remove the fuel regulator spring and valve.

9. Inspect the regulator cavity in the filter housing for dirt or debris that could restrict fuel flow.

10. Check regulator seating surface (sleeve and O-ring) for damage.

11. If fuel regulator valve is not damaged, clean and reinstall regulator valve and retest fuel pressure.

12. If fuel pressure is still low, replace fuel regulator, and retest fuel pressure.

13. If fuel pressure is still low, replace fuel pump following procedure in the *Engine Service Manual*.

14. Remove fuel test fitting and install plug.

Possible Causes

- A kinked or bent fuel supply line or a blocked pickup tube can cause high restriction and low fuel pressure.
- A loose fuel line on the suction side of the fuel system can ingest air into the system and cause low fuel pressure.
- Defective or stuck fuel regulator valve
- Internal fuel pump damage or damage to the drive gear

DIAGNOSTIC TROUBLES CODES

5. Diagnostic Trouble Codes

☐ Install Electronic Service Tool (EST). (Figure G)

☐ Do **Test 8** if EST is not available.

Active DTCs
Inactive DTCs

Correct problem causing active DTCs before continuing.

D3140

Figure 192

Purpose

To determine if the ECM has detected DTCs indicating conditions that could cause poor performance

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

NOTE: Do Test 8 (Diagnostic Trouble Code Access), if an EST is not available.

Figure 193 Installation of International® EZ-Tech Interface Cable

1. Turn ignition ON.

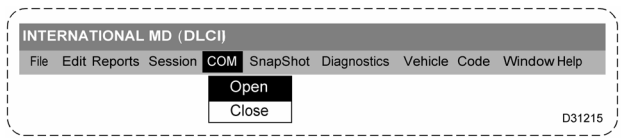


Figure 194 Menu bar Com/Open

2. Select COM from the menu bar, then Open.

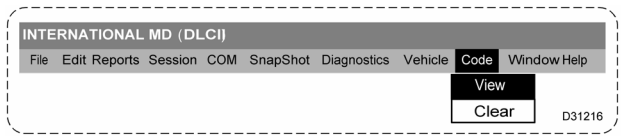


Figure 195 Menu bar Code/View

3. Select Code from the menu bar, then View for the Diagnostic Trouble Code window.

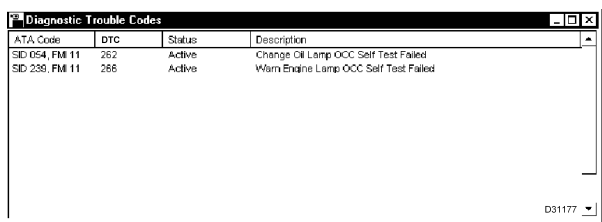


Figure 196 Diagnostics Trouble Code window

Reading DTCs

ATA code: Codes associated with a sub-system (SID), parameter (PID), and Failure Mode Indicator (FMI).

DTC: Diagnostic Trouble Codes.

Status: Indicates active, inactive, or active/inactive DTCs.

- **Active**: With the ignition key ON, active indicates a DTC for a condition currently in the system. When the key is turned off, an active DTC becomes inactive. (If a problem remains, the DTC will be active on the next key cycle.)
- **Inactive**: With the ignition key ON, inactive indicates a DTC for a condition no longer in the system. When the ignition key is turned off, inactive DTCs from previous key cycles are stored in the ECM memory.
- **Active/Inactive:** With the ignition key ON, active/inactive indicates a DTC for an intermittent condition currently in the system.

Description: Defines each DTC.

4. Record all DTCs on Performance Diagnostics form.

   See Appendix B in this manual for DTCs.

5. Correct problem causing active DTCs before continuing.

6. Clear DTCs.

Possible Causes

- Electronics failure
- Failure of the ICP sensor or ICP system
- Failure of the Air Management System

KEY ON ENGINE OFF STANDARD TEST

6. Key On Engine Off Standard Test

☐ Use EST to run Key On Engine Off Standard Test.

Active DTCs

Correct problem causing active DTCs before continuing.

D3141

Figure 197

Purpose

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

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

1. Set parking brake for the correct signal from the Electronic System Controller (ESC).
2. Turn ignition key ON. (Do not start the engine.)

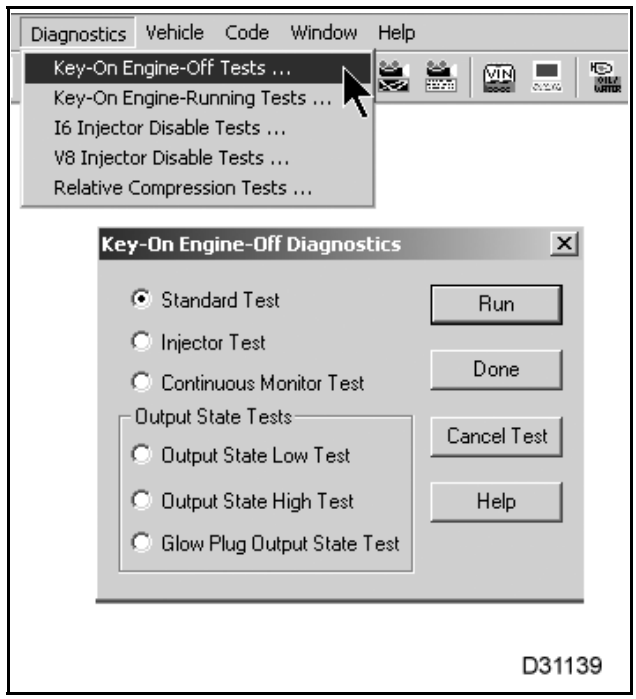


Figure 198 Key On Engine Off Standard Test

3. Select Diagnostics from the menu bar.
4. Select Key On Engine Off Tests from the drop down menu.
5. From the Key On Engine Off Diagnostics menu, select Standard Test and click Run to start the test.

   The ECM will complete an internal self-test and an Output Circuit Check (OCC). When the OCC is done, the Diagnostic Trouble Code screen will show DTCs, if there is a problem.
6. Record all DTCs on Performance Diagnostics form.

   See Appendix B in this manual for DTCs.
7. Correct problem causing active DTCs.
8. Clear DTCs.

Possible Causes

- Defective electrical components or circuitry.
- OCC fault for the IPR, glow plug relay, EGR valve, or EVRT™ control valve

KEY ON ENGINE OFF INJECTOR TEST

7. Key On Engine Off Injector Test

☐ Do **Test 6** before doing the Key On Engine Off Injector Test.

☐ Use EST to run Key On Engine Off Injector Test.

DTCs found

Correct problem causing active DTCs before continuing.

D3142

Figure 199

Purpose

To determine if the fuel injectors are working (electronically) by energizing the injectors in a programmed sequence. The ECM monitors this test and transmits DTCs, if injectors are not working correctly.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

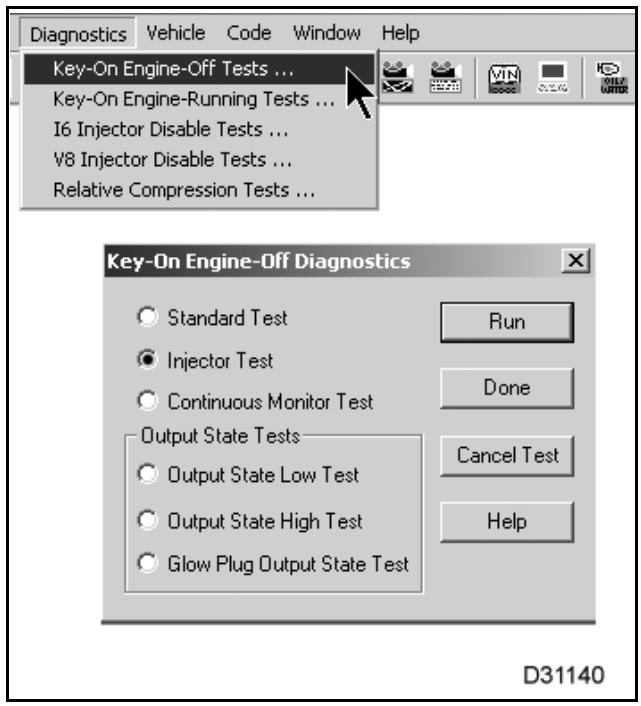


Figure 200 Key On Engine Off Injector Test

NOTE: Test 6 (Key On Engine Off Standard Test) must have been done before doing the Key On Engine Off Injector Test.

1. Select Diagnostics from the menu bar.
2. Select Key On Engine Off Test from the drop down menu.
3. From the Key On Engine Off Diagnostics menu, select Injector Test and click Run to start the test.

   NOTE: During this test, injector solenoids should click when actuated. If a series of clicks are not heard for each injector, one or more injectors are not activating.
4. Record DTCs on Performance Diagnostics form.

   See Appendix B in this manual for DTCs.
5. Correct problem causing active DTCs.
6. Clear DTCs.

Possible Causes

- Injector wiring harness open or shorted
- Bad wiring harness connection on injector coil
- Open or shorted engine wiring harness to injectors
- Defective injector coil
- Defective IDM
- Defective ECM

DIAGNOSTIC TROUBLE CODE ACCESS

8. Diagnostic Trouble Code Access
(Figure H)
(Required only if EST is not available)

☐ Set parking brake. Turn ignition key ON.

☐ Press and release CRUISE ON and RESUME / ACCEL switches at the same time, twice within 3 seconds of key ON.

Active DTCs
Inactive DTCs

Correct problem causing active DTCs before continuing.

D3143

Figure 201

Purpose

To read Diagnostic Trouble Codes (DTCs) detected by the ECM, if the Electronic Service Tool (EST) is not available or if EST will not communicate with the ECM

Tools

None

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

1. Set parking brake for the correct signal from the Electronic System Controller (ESC).

2. Turn ignition switch ON. (Do not start the engine.)

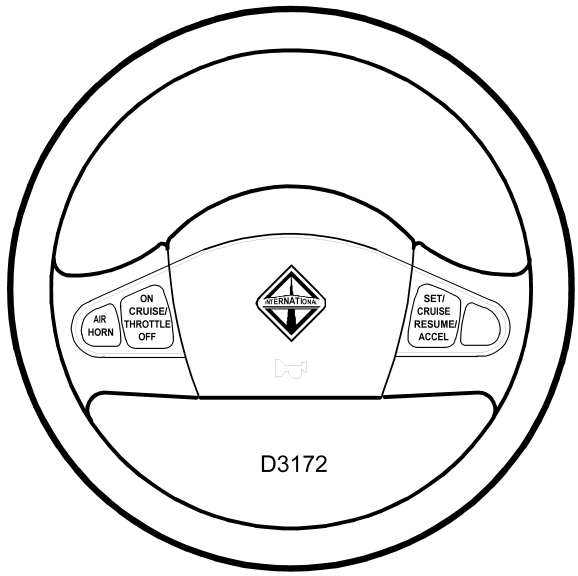


Figure 202 Switches for CRUISE ON and RESUME ACCELERATION

3. Press and release the CRUISE ON and RESUME/ACCEL switches, at the same time, twice within 3 seconds of key ON.

   - The ECM will begin the Output Circuit Check (OCC) (self test). If DTCs are detected, the ECM will flash the amber ENGINE lamp.

     When the OCC is done, the ECM will flash the red ENGINE lamp and amber ENGINE lamp to signal the DTCs.

NOTE: There will be a 10 second delay from the time switches are pressed to the time DTCs are flashed.

Reading DTCs

1. The red ENGINE lamp will flash once to indicate the beginning of active DTCs.

2. The amber ENGINE lamp will flash repeatedly, signaling active DTCs.

   NOTE: All DTCs are three digits. Code 111 indicates that no errors were detected. See Appendix B in this manual for DTCs.

3. Count the flashes of the amber ENGINE lamp in sequence. After each digit of the code a short pause will occur.

   - **Three amber flashes** and a pause indicate number 3.
   - **Two amber flashes**, a pause, **three amber flashes**, a pause, and **two amber flashes** and a pause indicate code 232.

4. For more than one DTC, the red ENGINE lamp will flash once indicating the beginning of another active DTC.

5. After all active DTCs have flashed, the red ENGINE lamp will flash twice to indicate the start of inactive DTCs. Count the flashes from the amber ENGINE lamp. If there is more than one inactive code, the red ENGINE lamp will flash once in between each DTC.

6. After all DTCs have been sent, the red ENGINE lamp will flash three times indicating **end of DTC transmission.**

7. To repeat DTC transmission, cycle the key and press and release the CRUISE ON and RESUME/ACCEL switches at the same time, twice within 3 seconds of key ON. The ECM will resend stored DTCs.

Clearing Inactive DTCs

1. Set parking brake for the correct signal from the Electronic System Controller (ESC).

2. Turn ignition switch ON. (Do not start the engine.)

3. Press and hold the CRUISE ON and RESUME/ACCEL switches, at the same time.

4. Press and release the accelerator pedal three times within 6 seconds of key ON.

5. Release the cruise control buttons to clear the inactive DTCs.

Possible Causes

- Electronic component or circuit failures

INTAKE RESTRICTION

9. Intake Restriction
(Figures K and L)

☐ Measure restriction at high idle, no load.

Instrument	Spec	Actual
Manometer or Magnehelic gauge	12.5 in H_2O	

Correct problem causing out of spec values, before continuing.

D3144

Figure 203

Purpose

To check for restriction in the air intake system likely to cause engine performance problems.

NOTE: High intake or exhaust restriction can cause a large amount of black or blue smoke.

Tools

- Gauge bar (magnehelic)
- Test line

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

1. Inspect the following parts for restriction, damage, or incorrect installation:
   - Air filter inlet and ducting
   - Hoses and clamps
   - Air filter housing, filter element, and gaskets
   - Chassis mounted CAC and piping
   - Air filter restriction indicator or gauge

Figure 204 Low restriction

Figure 205 High restriction

NOTE: Intake restriction should be below 25 in H_2O. When the filter element reaches maximum allowable restriction, the yellow indicator will reach the top of window and automatically lock in this position.

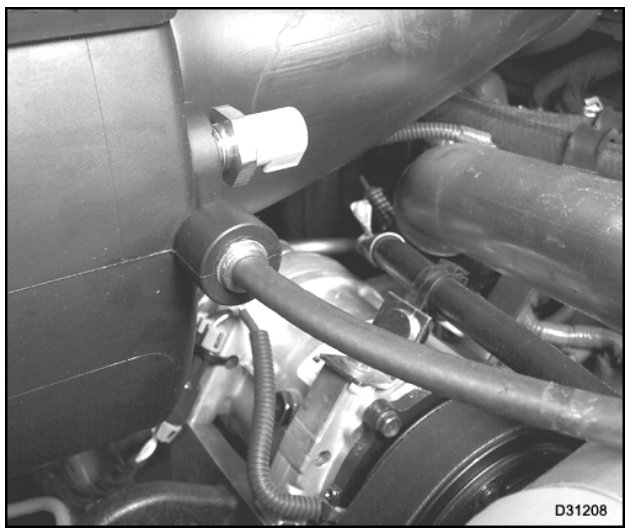


Figure 206 Air filter housing tap

2. Remove air intake restriction indicator or remove line to instrument panel restriction gauge from air filter housing.

3. Attach test line to tap for air filter housing.

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

When routing test line , do not crimp the line, run the line too close to moving parts, or let the line touch hot engine surfaces.

4. Connect line to magnehelic gauge or manometer.

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

When running the engine in the service bay, make sure the parking brake is set, the transmission is in neutral, and the wheels are blocked.

5. Run engine at high idle, no load.

6. Record reading on Performance Diagnostics form.

- If restriction is more than 3.13 kPa (12.5 in H_2O), replace air filter element.
- If restriction is more than 3.13 kPa (12.5 in H_2O), and a new filter is in place, check for obstructions in air inlet.
- If restriction is less than 3.13 kPa (12.5 in H_2O), continue with Performance Diagnostics.

NOTE: An equivalent test, using the instrument mounted restriction indicator, can only be done while operating the engine at full load and rated horsepower. The true maximum air cleaner restriction for this test is 6.22 kPa (25 in H_2O).

Possible Causes

- Snow in air cleaner inlet
- Ice in air cleaner inlet
- Plastic bags or other foreign material in air cleaner inlet
- Collapsed air filter
- On engines recently repaired, rags or cap plugs may have been left in the intake system.

EGR POSITION

10. EGR Position

- ☐ Use EST to monitor EGR position. (Key on engine off)
- ☐ Use EGR breakout harness and DMM to measure EGRP voltage.
- ☐ Record EST value for closed EGR position.
- ☐ Record voltage closed EGR position.
- ☐ Use EST to run Output State Low Test to energize coil and open EGR valve.
- ☐ Record EST value for open EGR position.
- ☐ Record voltage open EGR position.

Instrument	Spec % / v	Actual % / v
EST	____ % ____ v Closed	____ % ____ v Closed
	____ % ____ v Open	____ % ____ v Open
	____ % ____ v Travel	____ % ____ v Travel

Correct problem causing out of spec values, before continuing.

D3145

Figure 207

Purpose

- To check the EGR position when commanded close or open
- Is the EGR valve sticking or stuck?

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- EGR breakout harness
- DMM

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Monitoring EGR position using EST

1. See Appendix A in this manual for specifications, and record on Performance Diagnostics form.
2. Remove engine harness connector from EGR valve.

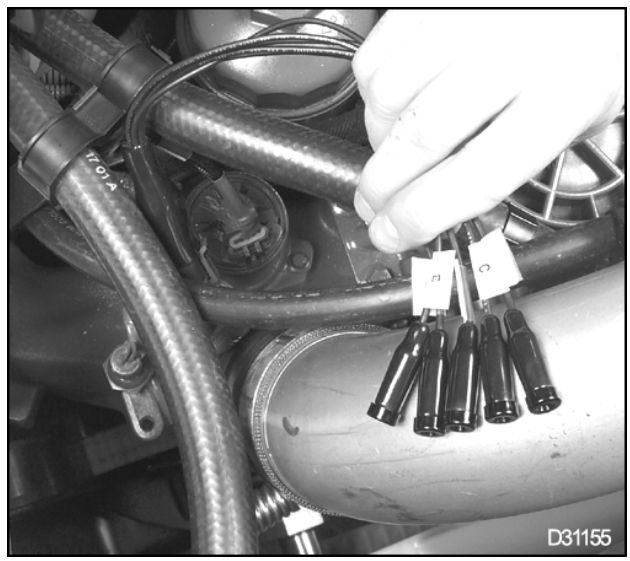


Figure 208 EGR breakout harness installed

⚠ WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

When routing DMM leads, do not crimp the leads, run the leads too close to moving parts, or let the leads touch hot engine surfaces.

3. Connect EGR breakout harness to engine harness and EGR valve.
4. Use DMM to measure EGR position voltage.
   - Connect POS to green (signal circuit) and NEG to black (signal ground).

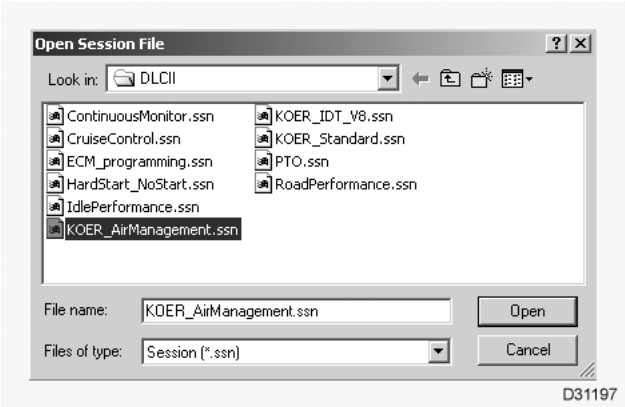


Figure 209 KOER Air Management.ssn

5. Open KOER Air Management.ssn to monitor EGR position.

6. Turn ignition key ON. (Do not start the engine.)

7. Record the value for the EGR (% closed) and voltage value (DMM) on diagnostics form.

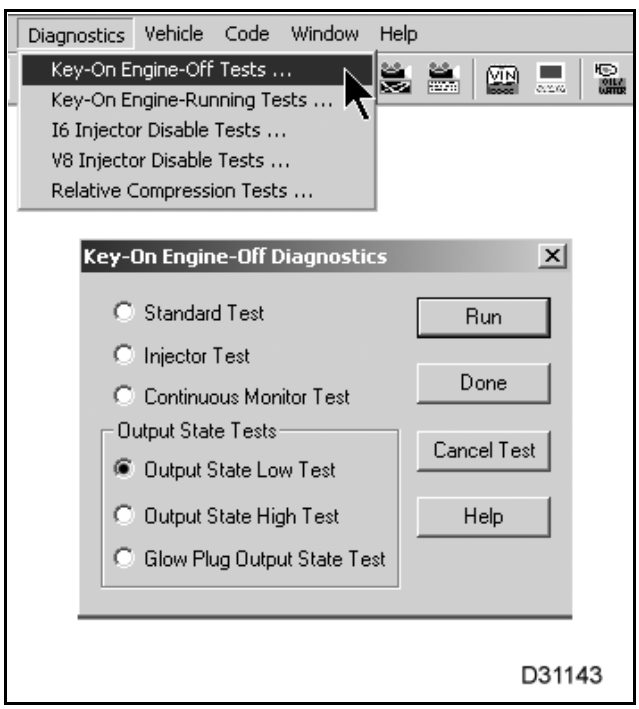


Figure 210 Output State Test Low

8. Select Diagnostics from menu bar.

9. Select Key On Engine Off Tests from drop down menu.

10. From the Key On Engine Off Diagnostics menu, select Output State Low Test, then Run to energize coil and open EGR valve.

11. Monitor EGRP % (open) and voltage value (DMM) and record on diagnostics form.

12. Click Cancel Test.

13. Subtract EGRP % (open) from EGRP % (closed) to get travel percent and record on diagnostics form.

14. Subtract (open) voltage from (closed) voltage and record diagnostics form.

    If both travel percent and voltage travel are below spec., replace EGR valve and retest.

NOTE: Initial ECM calibrations for DTC 365 and DTC 366 could become active during the test. Ignore and clear DTC 365 and DTC 366 when done.

Possible Causes

- Problem in EGR control circuit
- Defective EGR valve
- Defective ECM

EXHAUST RESTRICTION

11. Exhaust Restriction

☐ Inspect exhaust system.
☐ Disconnect EGR valve.
☐ Use EST to monitor EBP at high idle, no load.

Instrument	Spec	Actual
EST		
DMM		

- If pressure is above spec, remove turbo outlet exhaust pipe and retest.
- If pressure is good with pipe removed, correct problem from tubocharger to tail pipe.
- If EBP is still high with turbo outlet exhaust pipe removed, do **Test 20**.

D3146

Figure 211

Purpose

To check for restrictions in the exhaust system likely to cause engine performance problems

NOTE: High intake or exhaust restriction can cause a large amount of black or blue smoke.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Monitoring EBP using EST

1. See Appendix A in this manual for specifications, and record on Performance Diagnostics form.
2. Inspect the entire exhaust system for damage and restriction.
3. Disconnect the EGR valve.

NOTE: When the EGR valve is disconnected, the ECM will set a DTC for the EGR valve position out of range low (163). Ignore the DTC and clear after the test is complete. If EGR is plugged in during the test, results will be incorrect.

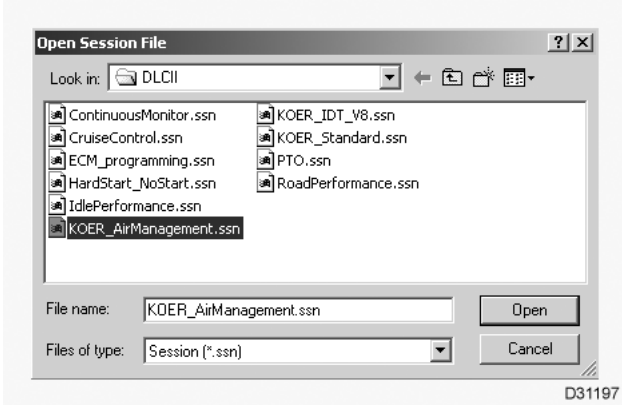


Figure 212 KOER Air Management.ssn

4. Open KOER Air Management.ssn to monitor EBP at high idle, no load.

⚠ WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

When running the engine in the service bay, make sure the parking brake is set, the transmission is in neutral, and the wheels are blocked.

5. Run engine at high idle, no load.
6. Record results on diagnostics form.
   - If restriction is to spec, reconnect EGR valve, clear DTCs, and continue with Performance Diagnostics.
   - If restriction is above spec, remove exhaust pipe from turbocharger outlet and retest.
   - If restriction is to spec with exhaust pipe removed, reconnect EGR valve, clear DTCs, and correct problem between turbocharger outlet and the tail pipe.

- If exhaust back pressure is still high with pipe removed from turbocharger outlet, reconnect EGR valve, clear DTCs, do Test 20 (Air Management).

Possible Causes

- Restricted exhaust pipe
- Collapsed exhaust pipe
- Damaged muffler
- Turbocharger malfunction
- Clogged catalytic converter

Monitoring EBP using pressure sensor breakout harness

Tools

- Pressure sensor breakout harness
- DMM

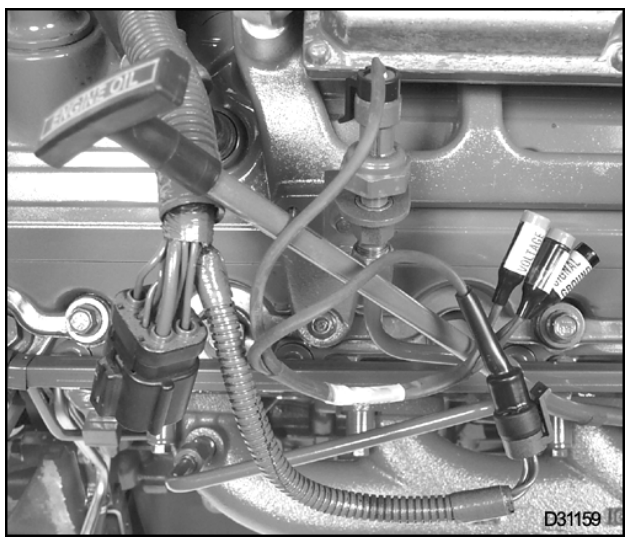


Figure 213 Pressure sensor breakout harness installed — EBP

1. Connect pressure sensor breakout harness to engine harness and EBP sensor.
2. Use DMM to measure EBP at high idle, no load.
   - Connect POS to green (signal circuit) and NEG to black (signal ground).

   NOTE: See Section 7 for operational voltages and values.

> **WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:**
>
> **When running the engine in the service bay, make sure the parking brake is set, the transmission is in neutral, and the wheels are blocked.**

3. Run engine at high idle, no load.
4. Record results on Performance Diagnostics form.
   - If restriction is to spec, reconnect EGR valve, clear DTCs, and continue with Performance Diagnostics.
   - If restriction is above spec, remove exhaust pipe from turbocharger outlet and retest.
   - If restriction is to spec with exhaust pipe removed, reconnect EGR valve, clear DTCs, and correct problem between turbocharger outlet and the tail pipe.
   - If exhaust back pressure is still high with pipe removed from turbocharger outlet, reconnect EGR valve, clear DTCs. A defective turbocharger is suspect. A service tool is needed to run Test 20 (Air Management).

KEY ON ENGINE RUNNING STANDARD TEST

12. Key On Engine Running Standard Test

Note: Engine coolant temperature must be above 160 °F

☐ Use EST to run Key On Engine Running Standard Test.

DTCs found

Correct problem causing active DTCs before continuing.

D3147

Figure 214

Purpose

To verify that the engine sensors and IPR are operating correctly within their specified operating ranges. The ECM will exercise the IPR and monitor sensor feedback signals. If a sensor or IPR problem exists, the ECM will transmit DTCs to the EST.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

1. Set parking brake.

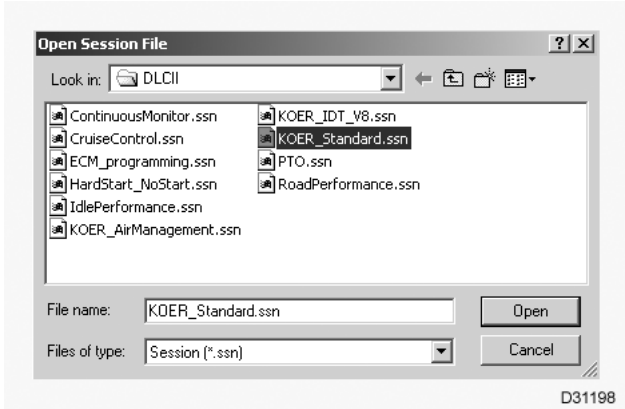


Figure 215 KOER Standard.ssn

2. Open KOER Standard.ssn to monitor engine operation.

⚠ WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

When running the engine in the service bay, make sure the parking brake is set, the transmission is in neutral, and the wheels are blocked.

3. Start and run engine to reach minimum operating temperature 70°C (158°F).

   NOTE: Engine coolant temperature must reach 70°C (158°F) minimum for the ECM to accurately test engine actuators and sensors. If engine coolant temperature is below self test range, the EST will display – Coolant temperature is out of range.

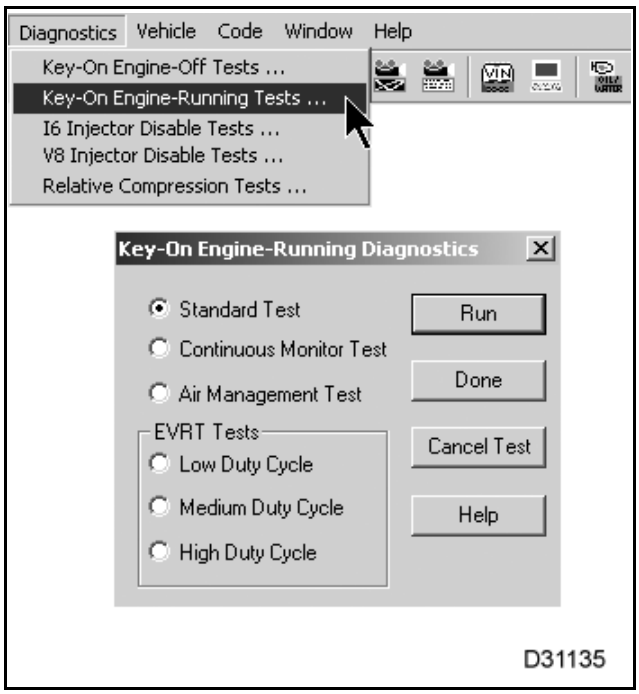


Figure 216 Key On Engine Running Standard Test

4. Select Diagnostics from menu bar.

5. Select Key On Engine Running Tests from the drop down menu.

6. From the Key On Engine Running Diagnostics Menu, select Standard Test and click Run to start the test.

7. The ECM will start the Key On Engine Running Standard Test and command the engine to accelerate to a predetermined engine RPM.

   During the 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 test is done, the ECM returns the engine to the normal operating mode and transmits any DTCs set during the test.

8. Record all DTCs on Performance Diagnostics form.

See Appendix B in this manual for DTCs.

9. Correct problems causing active DTCs.

10. Clear DTCs.

Possible Causes

- Oil leakage in high pressure Injection Control System
- Loose or corroded engine wiring harness for ICP
- Open or shorted wiring harness to ICP or IPR
- Defective ICP sensor
- Defective IPR valve
- Defective high pressure pump

TORQUE CONVERTER STALL

13. Torque Converter Stall (Automatic only)

- ☐ Set parking brake and apply service brake.
- ☐ Put transmission in drive.
- ☐ Push accelerator to the floor, begin timing and monitor tachometer until tachometer stops moving.
- ☐ Record RPM and time.

Condition	Spec	Actual
Stall RPM Time (Idle to stall in seconds)		

- If minimum RPM is reached within specified time, **do not continue** with Performance Diagnostics.
- If RPM is low, or was not reached within specified time, continue with Performance Diagnostics.

D3148

Figure 217

Purpose

To determine if the engine develops specified stall rpm within idle to stall time

Tools

None

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

⚠ WARNING: To prevent injury or possible death, make sure brakes are correctly adjusted and in good condition. This procedure should be done in an open lot.

CAUTION: Avoid damage to the drive train. Do not do this test for more than 10 seconds at a time or more than twice back to back. (If doing twice – wait 120 seconds between tests.)

1. See Appendix A in this manual for specifications, and record on Performance Diagnostics form.
2. Set parking brake and apply service brake.
3. Put transmission in drive.
4. Press accelerator pedal fully to the floor, monitor TACH, and begin timing until TACH stops moving.
5. Record stall RPM and idle to stall time on diagnostics form
   - If minimum RPM is reached in the specified time, **do not continue Performance Diagnostics.**
   - If RPM is low or not reached in the specified time, continue with Performance Diagnostic tests.

Possible Causes

- Restricted intake or exhaust
- Low fuel pressure
- Low ICP
- Control system faults
- Defective EGR valve
- Defective fuel injectors
- Defective turbocharger

BOOST PRESSURE

14. Boost Pressure (Full load)

☐ Use EST to monitor boost pressure and engine speed.

Test	Spec	Spec	Actual
	Engine speed	Boost	EST boost reading
Peak HP			
Peak Torque			

- If boost pressure is not to spec continue with Performance Diagnostics.
- If boost pressure is to spec **do not continue** with Performance Diagnostics.

D3149

Figure 218

Purpose

To determine if the engine develops sufficient boost pressure at the specified RPM

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Monitoring Boost Pressure using EST

NOTE: Do this test at full load along with Test 15 (Fuel Pressure) and 16 (Injection Control Pressure).

1. See Appendix A in this manual for specifications, and record on Performance Diagnostics form.

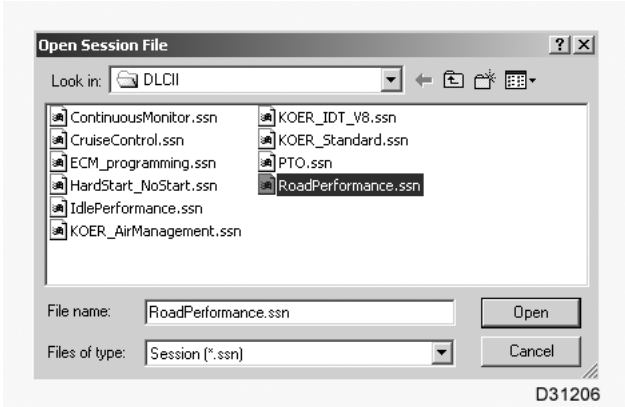


Figure 219 Road Performance. ssn

2. Open Road Performance.ssn to monitor engine operation.
3. Monitor boost pressure or MAP.
4. Drive vehicle and make sure engine operating temperature reaches 70°C (158°F).
5. Find a long, open stretch of road.
6. Select a suitable gear, press accelerator pedal fully to the floor, and accelerate to rated speed at 100% load.
7. Record EST boost pressure on diagnostics form.
   - If boost pressure is to spec, **do not continue Performance Diagnostics**.
   - If boost pressure is not to spec, continue with Performance Diagnostic tests.

Possible Causes

- Restricted intake or exhaust
- Low fuel pressure
- Low ICP
- Control system faults
- Defective EGR valve
- Defective fuel injectors
- Defective turbocharger

Monitoring Boost Pressure using Pressure Sensor Breakout Harness

Tools

- Pressure sensor breakout harness
- DMM

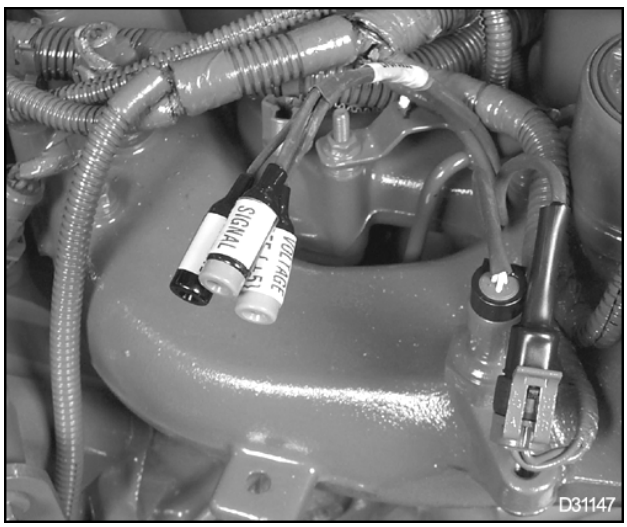


Figure 220 Pressure sensor breakout harness installed – MAP

1. Install pressure sensor breakout harness to MAP sensor and engine harness.

2. Use DMM to measure MAP at rated speed and full load.

   - Connect POS to green (signal circuit) and NEG to black (ground circuit).

   NOTE: See Section 7 for operational voltages and values.

⚠ WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

When routing DMM leads, do not crimp the leads, run the leads too close to moving parts, or let the leads touch hot engine surfaces. Secure the DMM and leads in the cab so as not to obstruct the operator.

3. Route DMM and leads into cab.

4. Monitor DMM voltage signal for MAP and record on Performance Diagnostics form.

5. Drive vehicle and make sure engine operating temperature reaches 70°C (158°F).

6. Find a long, open stretch of road.

7. Select a suitable gear, press accelerator pedal fully to the floor, and accelerate to rated speed at 100% load.

8. Record DMM voltage reading on diagnostics form.

   - If boost pressure is to spec, **do not continue Performance Diagnostics**.
   - If boost pressure is not to spec, continue with Performance Diagnostic tests.

FUEL PRESSURE (FULL LOAD)

15. Fuel Pressure (Full load)

(Figures C and D)

☐ Measure fuel pressure at filter housing.

☐ Check fuel pressure at full load, rated speed.

Instrument	Spec	Actual
0-160 psi gauge		

- If fuel pressure is low, replace fuel filter, clean fuel strainer, and retest.
- If pressure is still low do **Test 4** at full load, rated speed.

D3150

Figure 221

Purpose

To determine if the fuel system supplies the engine with the correct fuel quantity and pressure at full load conditions

Tools

- Gauge Bar (0–160 PSI gauge)
- Fuel pressure test fitting
- Fuel/oil pressure test coupler

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

NOTE: Do this test at full load along with Test 14 (Boost Pressure) and 16 (Injection Control Pressure).

1. See Appendix A in this manual for specifications, and record on Performance Diagnostics form.
2. Remove pipe plug from fuel filter housing (lower rear left).

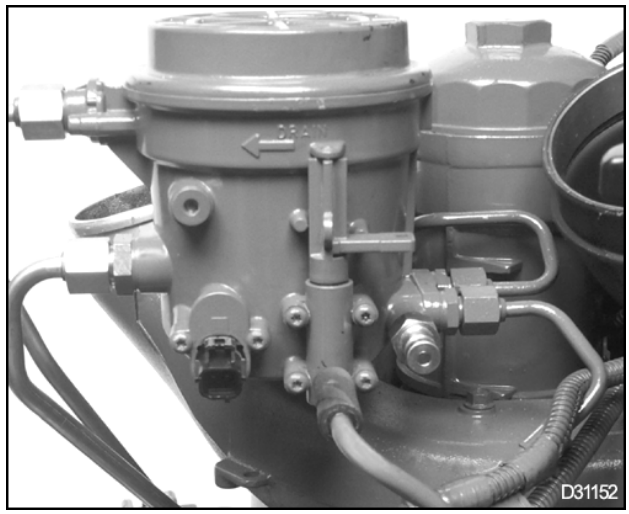


Figure 222 Fuel pressure test fitting installed

3. Install fuel pressure test fitting.

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

When routing test line, do not crimp the line, run the line too close to moving parts, or let the line touch hot engine surfaces. Secure the gauge bar and test line in the cab so as not to obstruct the operator.

4. Route test line from engine compartment to cab.
5. Connect a line from the fuel/oil pressure test coupler to the 0–160 psi gauge on gauge bar, then connect to test fitting.
6. Drive vehicle and make sure engine operating temperature reaches 70°C (158°F).
7. Find a long, open stretch of road.
8. Select a suitable gear, press accelerator pedal fully to the floor, and accelerate to rated speed at 100% load.
9. Record gauge reading on diagnostics form.

- If fuel pressure is low replace fuel filter, clean strainer, and retest.
- If fuel pressure is still low, do Test 4 (Fuel Inlet Restriction) at full load, rated speed.

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

When routing test line , do not crimp the line, run the line too close to moving parts, or let the line touch hot engine surfaces. Secure the gauge bar and test line in the cab so as not to obstruct the operator.

Possible Causes

- Dirt or jelled fuel in the fuel filter will cause high restriction and low fuel pressure.
- A kinked or bent fuel supply line or a blocked pickup tube can cause high restriction and low fuel pressure.
- A loose fuel line on the suction side of the fuel system can ingest air into the system and cause low fuel pressure.
- Defective fuel regulator valve
- Internal fuel pump damage or damage to the drive gear

INJECTION CONTROL PRESSURE

16. Injection Control Pressure

☐ Use EST to monitor ICP and engine speed.

Condition	Spec	Actual
Low idle		
High idle		
Full load		

- If ICP is high or unstable, hold at high idle for 2 minutes.
- Return to idle, take oil sample, check for foam, and correct condition if oil is aerated. (Figures M and N)
- If oil is not aerated, disconnect ICP sensor and check for engine stability.
- If problem is corrected, see Operational Voltage Checks for ICP Sensor in Section 7.
- If still high or unstable, replace IPR and retest.

D3151

Figure 223

Purpose

To determine if the ICP system is providing sufficient hydraulic pressure to operate the injectors.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Monitoring ICP using EST

NOTE: Do this test at full load along with Test 14 (Boost Pressure) and 15 (Fuel Pressure – Full Load).

⚠ WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

When running the engine in the service bay, make sure the parking brake is set, the transmission is in neutral, and the wheels are blocked.

1. See Appendix A in this manual for specifications, and record on Performance Diagnostics form.

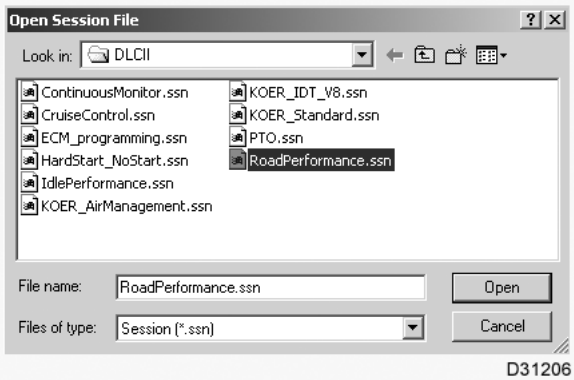


Figure 224 Road Performance.ssn

2. Open Road Performance.ssn, to monitor engine operation.
3. Monitor ICP.
4. Record ICP for low idle on diagnostics form.
5. Run engine at high idle, and record on diagnostics form.
   - If ICP is high or unstable for low or high idle conditions, do Step 6.
   - If ICP is in spec for high or low idle conditions, continue with Step 8.
6. Run engine at high idle for 2 minutes.

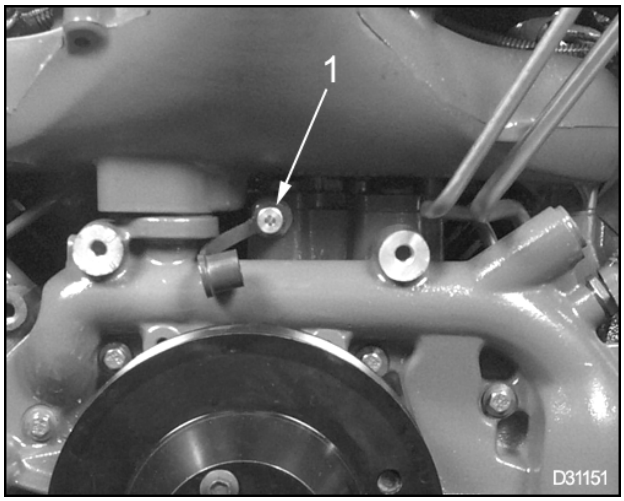


Figure 225 Lube oil pressure test port

1. Oil presure test fitting

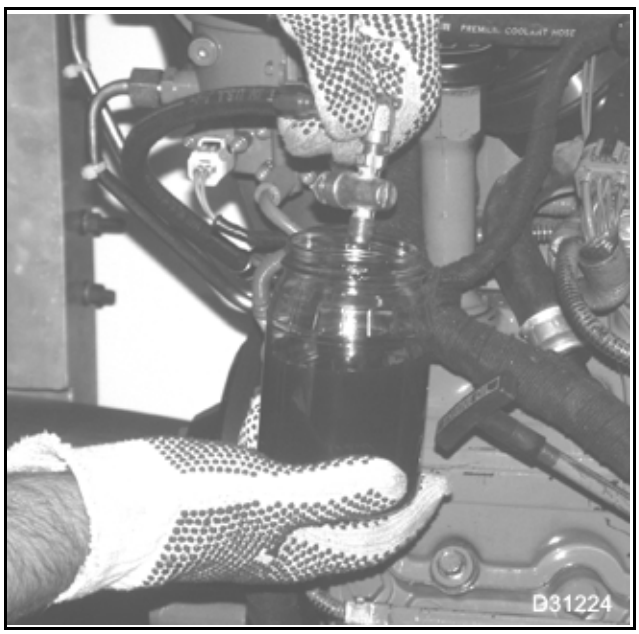


Figure 226 Taking oil sample

⚠ WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following when taking oil sample:

- **When routing oil line , do not run the line too close to moving parts.**
- **Do not let the line touch hot engine surfaces.**
- **Use caution not to burn hands.**

7. Return to low idle, take oil sample and check for foam.
   - If oil is aerated, foam build-up will be seen on top of the oil. Correct condition.
   - If oil is not aerated, disconnect ICP sensor and check for engine stability. If problem is corrected, see Operational Voltage Checks in Section 7.
   - If ICP is still high or unstable, replace IPR and retest.
8. Drive vehicle and make sure engine operating temperature reaches 70°C (158° F).
9. Find a long, open stretch of road.
10. Select a suitable gear, press accelerator pedal fully to the floor, and accelerate to rated speed at 100% load.
11. Record EST reading on diagnostics form.
    - If ICP is to spec, **do not continue**.
    - If ICP is not to spec, and oil is not aerated disconnect ICP sensor and retest. If problem is corrected, see Operational Voltage Checks in Section 7.
    - If ICP is still unstable, replace IPR following procedures in the *Engine Service Manual* and retest

Possible Causes

- Defective IPR valve,
- Defective high pressure pump,
- ICP system leakage
- The ECM commands the IPR valve to reduce ICP caused by low boost pressure, an incorrect feedback signal from APS, or an incorrect feedback signal from the ICP sensor.

Monitoring ICP using Pressure Sensor Breakout Harness

Tools

- Pressure sensor breakout harness
- DMM

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

When running the engine in the service bay, make sure the parking brake is set, the transmission is in neutral, and the wheels are blocked.

1. See Appendix A in this manual for specifications, and record on Performance Diagnostics form.
2. Remove engine harness connector from ICP sensor.

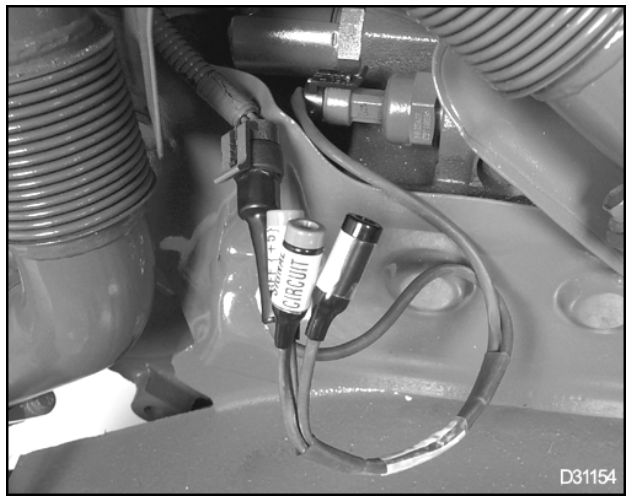


Figure 227 Pressure sensor breakout harness installed – ICP

3. Install pressure sensor breakout harness to ICP sensor and engine harness.
4. Use DMM to measure ICP at all conditions.
   - Connect POS to green (signal circuit) and NEG to black (ground circuit).

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

When routing DMM leads, do not crimp the leads, run the leads too close to moving parts, or let the leads touch hot engine surfaces. Secure the DMM and leads in the cab so as not to obstruct the operator.

5. Run DMM leads into cab.
6. Record ICP for low idle on diagnostics form.
7. Run engine for high idle and record on diagnostics form.
   - If ICP is high or unstable for low or high idle conditions, do Step 8.
   - If ICP is in spec for high or low idle conditions, continue with Step 10.

8. Run engine at high idle for 2 minutes.

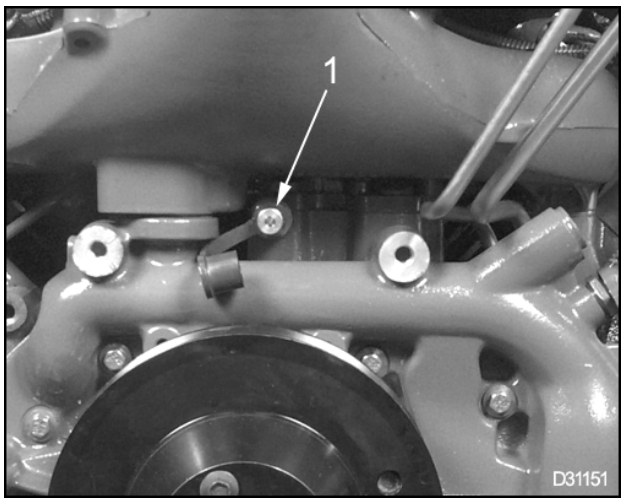


Figure 228

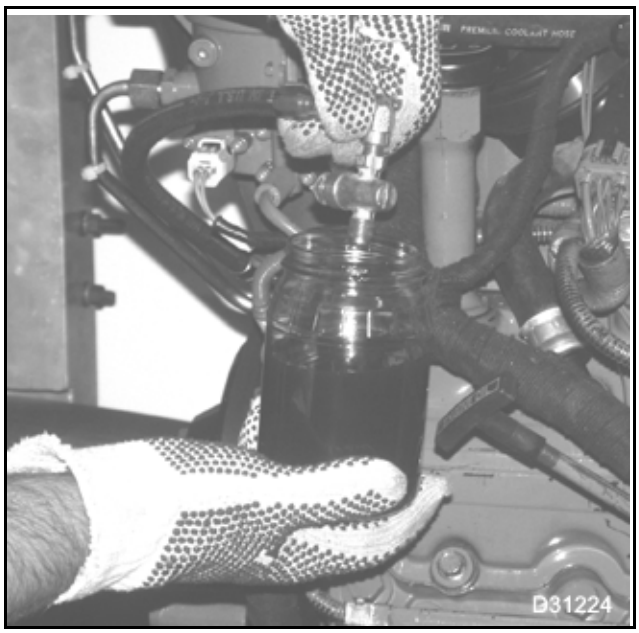


Figure 229 Taking oil sample

⚠ WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following when taking oil sample:

- **When routing oil line , do not run the line too close to moving parts.**
- **Do not let the line touch hot engine surfaces.**
- **Use caution not to burn hands.**

9. Return to low idle, take oil sample and check for foam.
   - If oil is aerated, foam build-up will be seen on top of the oil. Correct condition.
   - If oil is not aerated, disconnect ICP sensor and check for engine stability. If problem is corrected, see Operational Voltage Checks in Section 7.
   - If ICP is still high or unstable, replace IPR and retest.
10. Drive vehicle and make sure engine operating temperature reaches 70°C (158°F).
11. Find a long, open stretch of road.
12. Select a suitable gear, press accelerator pedal fully to the floor, and accelerate to rated speed at 100% load.
13. Record DMM voltage reading on diagnostics form.
    - If ICP is to spec, **do not continue**.
    - If ICP is not to spec, and oil is not aerated disconnect ICP sensor and retest. If problem is corrected, see Operational Voltage Checks in Section 7.
    - If ICP is still unstable, replace IPR following procedures in the *Engine Service Manual* and retest

CRANKCASE PRESSURE

17. Crankcase Pressure

- ☐ Measure at oil fill tube with crankcase pressure test adapter. (Figures P and R)
- ☐ Clamp off recirculation tube for crankcase breather.
- ☐ Measure at high idle, no load.

Instrument	Spec	Actual
Manometer or Magnehelic gauge		

D3152

Figure 230

Purpose

To measure the condition of the power cylinders

Tools

- Magnehelic gauge on gauge bar
- Crankcase pressure test adapter
- Heater hose pliers

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

1. See Appendix A in this manual for specifications, and record on Performance Diagnostics form.
2. Make sure the engine oil level is not above full mark and the oil level gauge is secured.
3. Make sure breather tube is secure in valve cover and air inlet duct.

Figure 231 Recirculation tube clamped closed

4. Clamp off recirculation tube with heater hose pliers.

Figure 232 Test line, crankcase breather tool, and gauge bar

5. Remove oil fill cap.
6. Install crankcase pressure test adapter to extended oil fill tube.

⚠ WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

When routing test line , do not crimp the line, run the line too close to moving parts, or let the line touch hot engine surfaces.

7. Connect a line from the crankcase pressure test adapter to the magnehelic gauge on the gauge bar or a water magnahelic gage.

⚠ WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

When running the engine in the service bay, make sure the parking brake is set, the transmission is in neutral, and the wheels are blocked.

8. Run engine to reach normal engine engine operating 70°C (158°F) before measuring crankcase pressure.

9. Run engine at high idle (no load) rpm. Allow the gauge reading to stabilize before taking the pressure reading.

10. Record crankcase pressure on diagnostics form.

    - If pressure is below spec, continue with Performance Diagnostics.
    - If pressure is above spec, continue with Step 11.

11. If engine has an air compressor, remove air comprerssor drive belt and retest.

    - If pressure is below spec, repair or replace air compressor.
    - If pressure is above spec, continue with Step 12.

12. Disconnect EVRT™ control valve and retest.

- If pressure is below spec, reconnect EVRT™ control valve, and retest doing Test 20 (Air Management) to see if crankcase pressure increases as turbocharger demand increases.
- If pressure fluxuates above and below spec, as EVRT™ is cycling, replace the turbocharger.
- If disconnecting or cycling the turbocharger does not bring pressure below spec, continue with step 13.

13. Do Test 19 (Relative Compression Test) to pin point suspect cylinders.

14. Do Test 18 (Injector Disable) to further pin point suspect cylinders.

15. Inspect air induction for dirt ingestion.

16. Measure compression with compression test adapter and gauge. Compare compression cylinder to cylinder.

Possible Causes

- Dirt in air induction system
- Badly worn or broken rings
- Cylinder bores badly worn or scored
- Leaking valve seals or worn valve guides
- A restricted orifice in crankcase breather tool
- Leaking intake manifold gasket
- Air compressor affecting crankcase pressure. Remove compressor discharge line to remove its influence.
- Defective turbocharger seals

INJECTOR DISABLE

18. Injector Disable

- ☐ Use EST to monitor EOT while running injector disable diagnostics.
- ☐ Collect and record Base Line values.
- ☐ Disable one cylinder at a time, collect, and record data.
- ☐ Calculate deviation from Base Line for each injector.
- ☐ Establish cut-off value to identify suspect cyinders.

Selected Cylinder	EOT	Average fuel rate	Deviation	Average engine load	Deviation
Base Line					
1					
2					
3					
4					
5					
6					
7					
8					
Cut-off values:		Fuel rate		Engine load	

If any cylinder is suspect, do **Test 19**.

D3153

Figure 233

Purpose

To determine the cause of rough engine idle

NOTE: This test is used in conjunction with Test 19 (Relative Compression) to distinguish between an injector problem or a mechanical problem.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

NOTE: Before doing this test, make sure Tests 1–17 were completed and the following conditions are maintained:

- **Maintain engine idle (during Steps 5 – 10).**
- **Keep EOT within 5° F (during Steps 5 – 10).**

Procedure

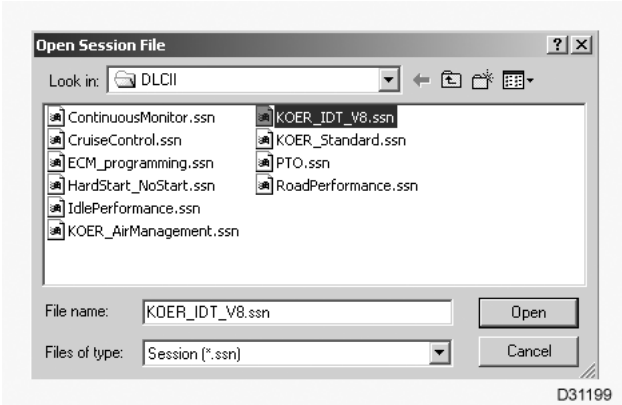


Figure 234 KOER IDT V8.ssn

1. Open KOER IDT V8.ssn. to monitor engine operation.

⚠ WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

When running the engine in the service bay, make sure the parking brake is set, the transmission is in neutral, and the wheels are blocked.

2. Start engine.

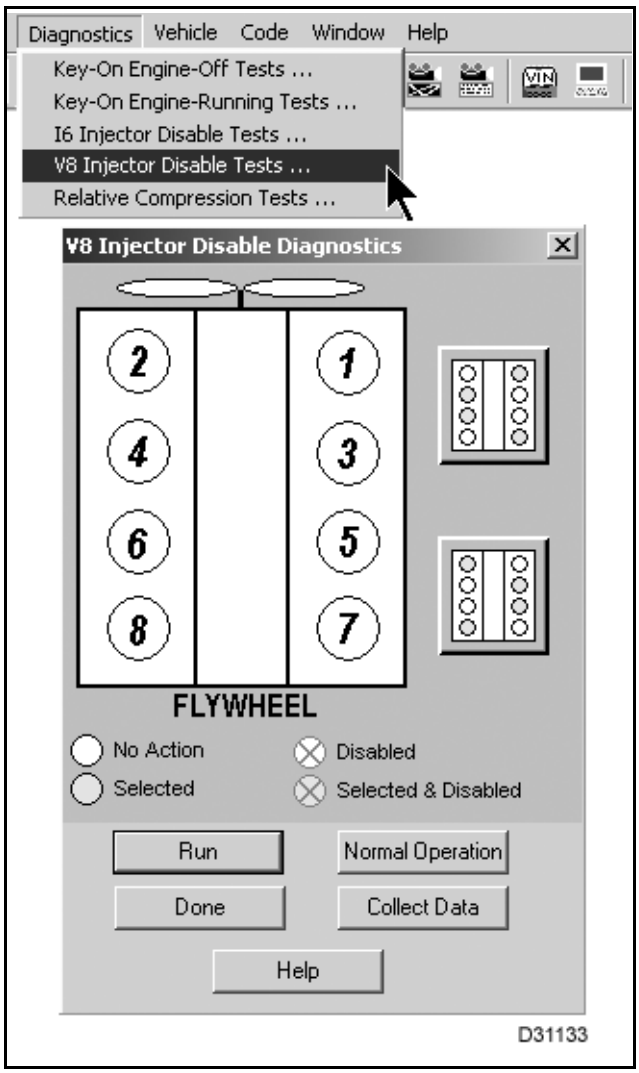


Figure 235 Injector Disable Test

3. Select Diagnostics from menu bar.

4. Select V8 Injector Disable Test.

5. Select Collect Data. (Base Line values will be shown.)

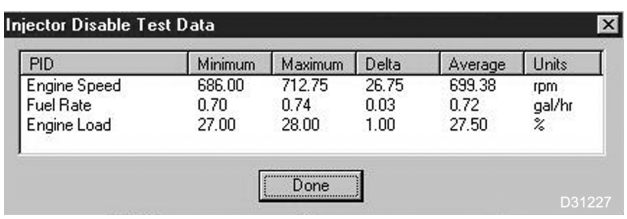


Figure 236 Injector Disable Test Data

6. Record Base Line values, EOT, average fuel rate, and average engine load on Performance Diagnostic form.

7. Select Cylinder 1 and click Run. (Injector 1 will be disabled.)

8. Click Collect Data.

9. Record EOT, average fuel rate, and average engine load on diagnostics form.

   NOTE: While running the engine listen for sound variations from cylinder to cylinder.

10. Repeat Steps 7 – 9 for each cylinder.

11. Subtract the base line for (average fuel rate) from the (average fuel rate) for each injector and record the difference (deviation).

12. Add deviations for all injectors and divide by 8. (Round to the nearest tenth — this is the cut off value.)

    Record cut off value on diagnostics form.

13. Subtract the base line for (average engine load) from the (average engine load) for each injector and record the difference (deviation).

14. Add deviations for all injectors and divide by 8. (Round to the nearest tenth — this is the cut off value.)

    Record cut off value on diagnostics form.

    - If deviation values for both average fuel rate and average engine load are less than the cut-off values for both fuel rate and engine load, the injector is suspect for weak cylinder contribution.
    - If only one deviation value is less than a cut-off value, do not suspect that cylinder.
    - If a suspect cylinder(s) is identified, do Test 19 (Relative Compression) to distinguish between an injector or mechanical problem.
    - If test 19 (Relative Compression) shows that cylinders are mechanically sound but the Injector Disable Test shows that one or more cylinders are bad, continue with Step 15.

15. Remove valve cover for suspect cylinder(s).

16. Start engine and run at idle.

17. Check oil coming out of spill spout of suspected injector(s). (Less oil coming out, compared with more oil coming out of the other injectors, means that less fuel is being delivered to the cylinder.)

    - If less oil is coming out of suspected injector(s), it is further confirmation of a bad injector.

18. Replace injector(s) following procedures in the *Engine Service Manual* and retest.

19. Test drive vehicle for 20 miles and check for rough idle.

20. If rough idle continues, do the Injector Disable Test again.

RELATIVE COMPRESSION

19. Relative Compression

- ☐ Turn ignition key ON.
- ☐ Use EST to run Relative Compression Test.
- ☐ Crank engine for 15 seconds.

Cylinder 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	
Cylinder 7 Relative Compression	
Cylinder 8 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(s).

D31146

Figure 237

Purpose

To check base engine condition

NOTE: Test 19 is used in conjunction with Test 18 (Injector Disable) to distinguish between an injector problem or a mechanical problem.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

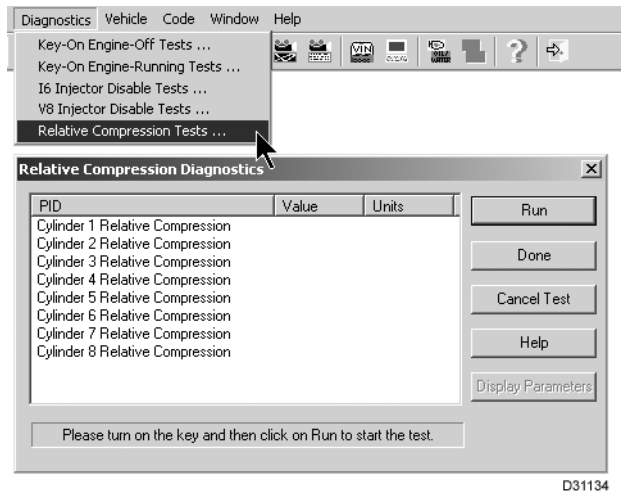


Figure 238 Relative Compression Test

NOTE: Batteries must be fully charged before doing this test.

1. Select Diagnostics from the menu bar.
2. Select Relative Compression Test from the drop down menu.
3. Follow the messages at the bottom of the window.
   - Turn ignition key ON.
   - Click run.

⚠ WARNING: Turn the ignition key to crank the engine – within 5 seconds – after clicking Run; if not done in 5 seconds, the EST will cancel the test, and the engine will start.

   - Crank engine for 15 seconds. (Another message may read Stop Cranking.)

4. Interpret results.

   - If a Relative Compression Test and Injector Disable Test identifies 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).

AIR MANAGEMENT

20. Air Management

☐ Use EST to monitor data while running Air Management Test.

DTCs found

Correct problem causing active DTCs before continuing.

D3154

Figure 239

Purpose

To determine if intake, exhaust, EVRT™, and EGR systems are working correctly

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

Procedure

⚠ WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

When running the engine in the service bay, make sure the parking brake is set, the transmission is in neutral, and the wheels are blocked.

NOTE: Test 12 (Key On Engine Running) must have been done before doing this test.

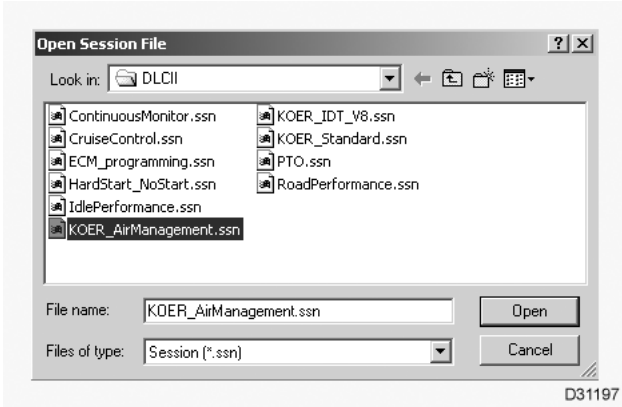


Figure 240 KOER Air Management.ssn

1. Open KOER Air Management.ssn to monitor engine operation.

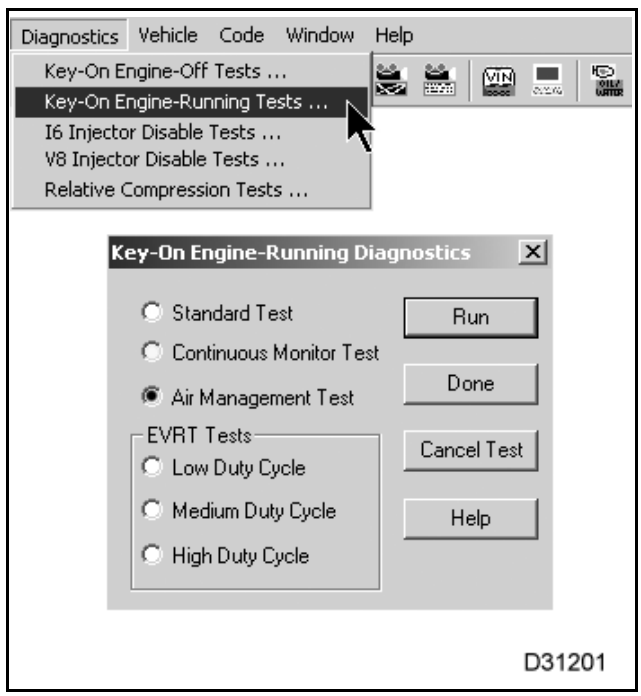


Figure 241 Air Management Test

2. Select Diagnostics from menu bar.

3. Select Key On Engine Running Tests from the drop down menu.

4. Select Air Management Test and click Run to start the test.

   The ECM will start the Air Management Test and command the engine to accelerate to a predetermined engine rpm. The ECM will monitor the effects of the EVRT™ and EGR valve movement using the EBP sensor.

   - If a problem is detected the ECM will cancel the test, set a DTC, and restore normal engine operation.

5. Record all DTCs on Performance Diagnostics form.

   See Appendix B in this manual for DTCs.

6. Correct problems causing active DTCs.

7. Clear DTCs.

Possible Causes

- Exhaust leaks
- Intake leaks
- Plugged EBP tube assembly
- Defective EGR valve
- Biased MAP or EBP sensor
- Defective EVRT™ control valve
- Defective turbocharger

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DESCRIPTION

This section includes the following diagnostic information:

- Electronic Control System Diagnostic form EGED 255
- Sensor and actuator locations
- Sensor and actuator tests
- Diagnostic procedures for sensors and actuators
- Pin point diagnostics
- Circuit diagnostics – Circuit diagnostics pertain to a specific ECM circuit and has the following structure:
  - Function diagram and text
  - Circuit diagram and diagnostic tests to diagnose Diagnostic Trouble Codes (DTCs) and verify circuit functions

DIAGNOSTIC FORM

ELECTRONIC CONTROL SYSTEM DIAGNOSTICS – EGED 255

Engine diagnostic forms assist technicians in troubleshooting International® VT 365 diesel engines. Diagnostic schematics and signal values help technicians find problems systematically and quickly to avoid unnecessary repairs.

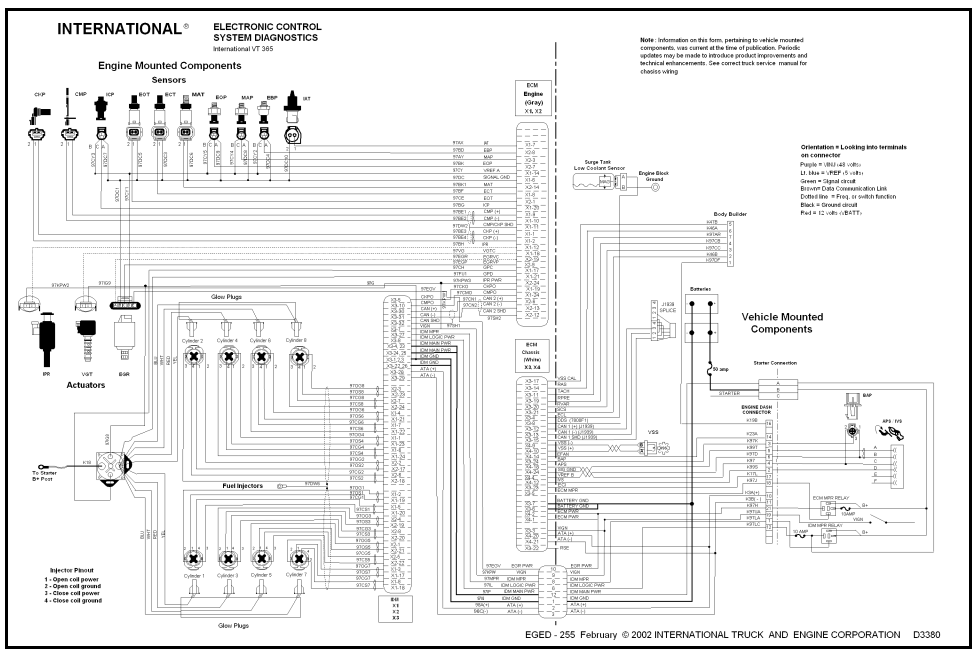

Figure 242 Electronic Control System Diagnostics form EGED-255 (front)

The front side of the Electronic Control System Diagnostics form EGED-255 consists of a circuit diagram for electrical components mounted on the engine and related vehicle circuits. For detailed description of vehicle circuits see Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations. The back side of the form consists of signal values for the engine circuits.

NOTE: All recorded signal values are with the breakout box installed on the ECM and harness.

Electronic Control System Diagnostic form EGED 255 is available in 50 sheet pads and can be ordered from:

International® Truck and Engine Corporation
Printing, Procurement and Distribution
4956 Wayne Road
Battle Creek, Michigan 49015

SENSOR AND ACTUATOR LOCATIONS

ENGINE MOUNTED COMPONENTS

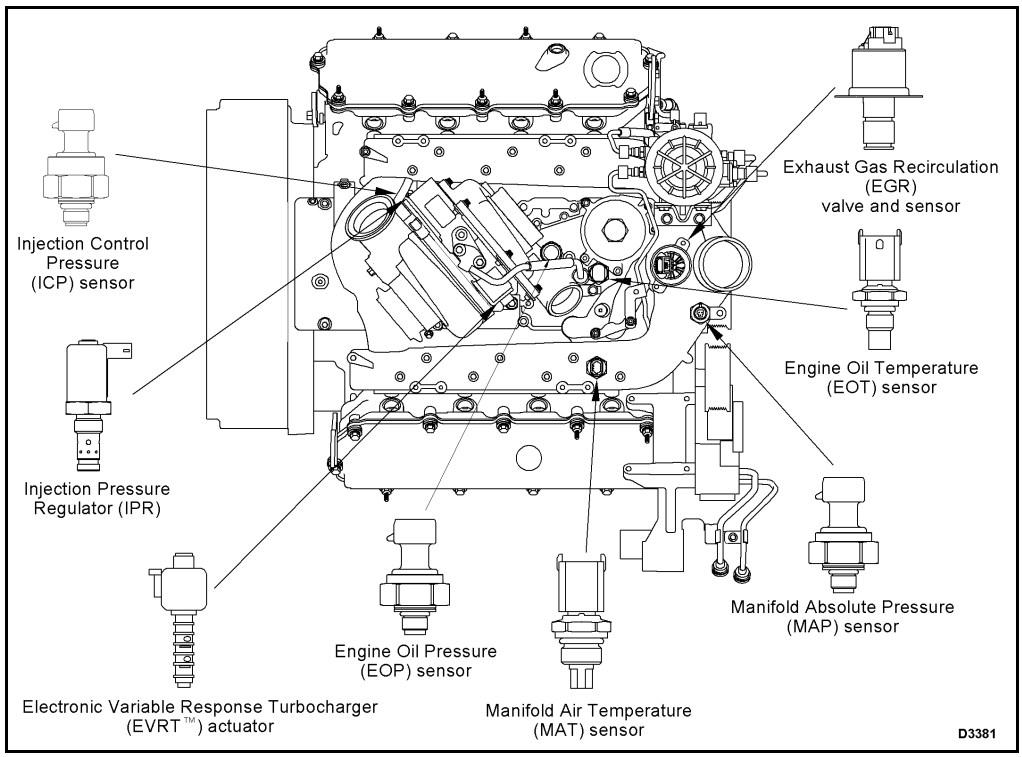

Figure 243 Top View

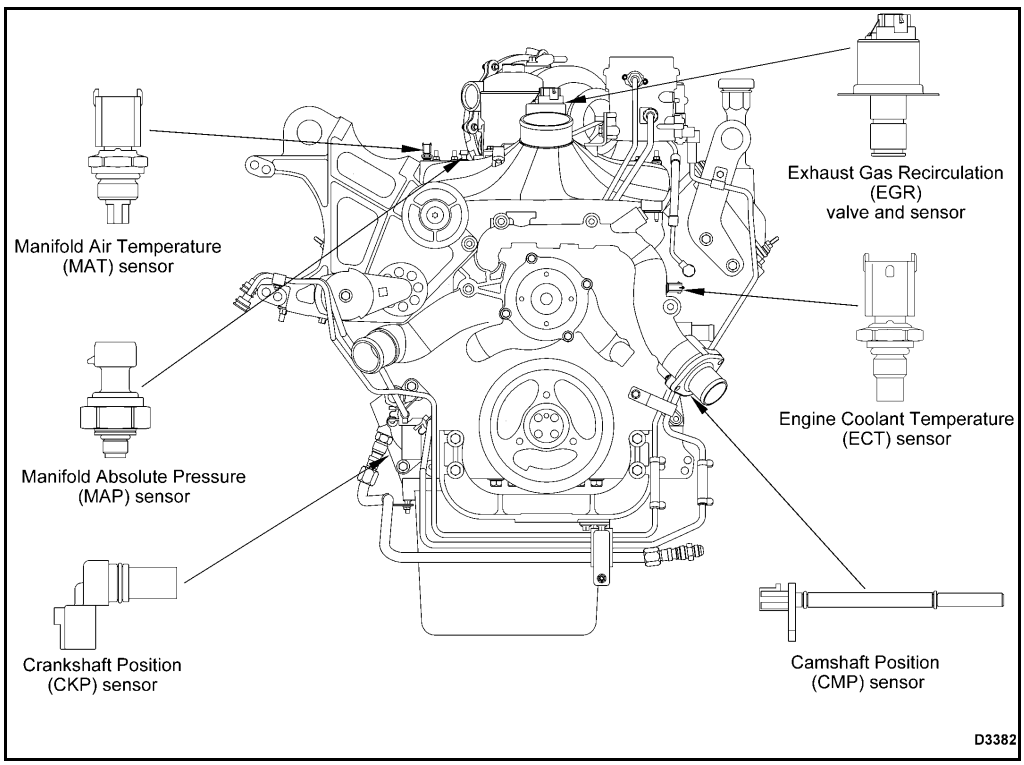

Figure 244 Front View

VEHICLE MOUNTED COMPONENTS

Figure 245 APS / IVS Sensor

The APS / IVS sensor is located above the accelerator pedal.

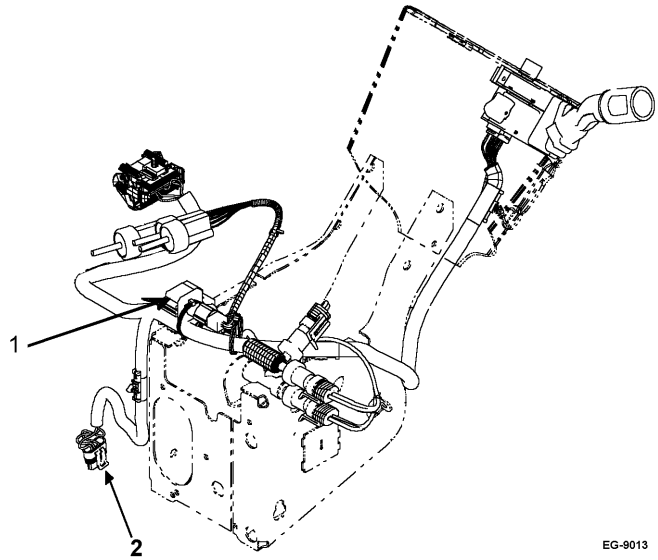

Figure 246

1. Barometric Absolute Pressure (BAP) sensor
2. Accelerator Pedal Position and Idle Validation Connector (APS / IVS)

The BAP sensor is located in the Driver Control Module (DCM) near the steering column.

DIAGNOSTIC PROCEDURES FOR SENSORS AND ACTUATORS

PIN GRIP INSPECTION

Figure 247 Pin Grip Test

1. Disconnect the harness connector from the sensor or actuator.

2. Inspect for corrosion, bent pins, spread terminals, or conditions that could cause a loose or intermittent connection.

3. Check the pin grip in the female terminal by inserting the correct tool from terminal test adapter kit .

V_{REF} TESTS USING MASTER DIAGNOSTICS

1. Plug the Electronic Service Tool (EST) tool into the American Trucking Association (ATA) datalink connector and start Master Diagnostics.

2. Disconnect sensor to be tested.

3. Install correct breakout harness to engine harness only.

4. Turn ignition key ON.

5. Monitor signal voltage with the EST using continuous monitor ssn. and initiating continuous monitor test (KOEO). Voltage should be near 0, unless the signal circuit is shorted or incorrectly wired to V_{REF}, B+, or other voltage sources. See Diagnostic table in Section 7 for the sensor being tested.

6. Use a Digital Multimeter (DMM) to verify V_{REF} at blue pin (V_{REF}) in breakout harness. (Voltage should be 5V ± 0.5)

   - Connect positive to blue and negative to chassis ground.
   - If voltage is greater than 5.5V, check V_{REF} for short to B+.
   - If voltage is less than 4.5V, check V_{REF} for open or short to ground.

7. Install 500 ohm harness between green (signal circuit), and blue (V_{REF}) pins of breakout harness. Monitor signal voltage with EST.

   - If voltage is less than 4.5V, check signal circuit for open or short to ground.

8. Use a DMM to check resistance from black pin (signal ground) of breakout harness to chassis ground.

   - If resistance is greater 5 ohm, check for open or high resistance between ECM and sensor connector.

9. Connect engine or chassis harness to sensor.

10. Use the EST to clear DTCs.

    - If an active DTC remains after checking test conditions, replace sensor.

TEMPERATURE SENSOR TESTS USING MASTER DIAGNOSTICS

1. Plug the Electronic Service Tool (EST) tool into the ATA connector and start Master Diagnostics.

2. Disconnect sensor to be tested.

3. Install correct breakout harness to engine harness only.

4. Turn ignition key ON.

5. Monitor signal voltage with the EST using continuous monitor ssn. and initiating continuous monitor test (KOEO) (voltage should be greater than 4.6V). See Diagnostic table in Section 7 for the sensor being tested.

   - If voltage is less than 4.6V, check signal circuit for short to ground.
   - If voltage is greater than 5.5V, check signal circuit for short to B+.

6. Install 3–Banana plug harness between green (signal circuit), and black (signal ground) pins of breakout harness.

   - If voltage is less than 0.127V, check ground circuit for open or high resistance.

7. Remove 3–Banana plug harness.

8. Connect engine or chassis harness to sensor.

9. Use the EST to clear DTCs.

   - If an active DTC remains after checking test conditions, replace sensor.

PIN POINT DIAGNOSTICS

CONNECTOR VOLTAGE CHECKS

Figure 248 Vref Check

Procedure

1. Turn ignition key ON.
2. Plug correct breakout harness into the harness connector.
3. Measure voltage at each pin with a DMM.
4. Compare sensor or actuator voltage readings with the expected voltages listed in Section 7 for circuits being tested.

   If a breakout harness is not available, use the correct tool from terminal test adapter kit. Do not directly probe the connector terminals with the DMM leads. For a circuit with an expected voltage, this test will verify circuit integrity.
5. Turn ignition OFF.

For circuits without an expected voltage, this test will determine if that circuit is shorted or miswired to V_{REF}, B+ or other voltage sources.

CONNECTOR CHECKS TO GROUND

Figure 249 Ground Resistance Check

Procedure

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.

1. Disconnect negative battery cable.
2. Use breakout harness to measure resistance from the lead of the harness to the negative battery cable.

   - Sensor signal ground circuits should measure less than 5 ohms.
   - V_{REF} and signal circuits should measure more than 1k ohms.
   - The control side of an actuator will measure more than 1k ohms, but the expected voltage for the other side of the actuator circuit will measure the voltage that the control side was switching, either power or ground.

- If the ECM is switching the ground circuit, the other side of the actuator circuit should measure more than 1k ohms from the connector terminal to battery ground.
- If the ECM is switching the power circuit, the other side of the actuator circuit should measure less than 5 ohms from the connector terminal to battery ground.

HARNESS RESISTANCE TESTS

CAUTION: To avoid engine damage, turn the ignition key to OFF before unplugging the connector or relay for the ECM and IDM. Failure to turn the key to OFF will cause a voltage spike and damage to electrical components.

1. Check harness resistance if a high resistance circuit or open circuit is suspected.
2. Connect breakout box to the ECM end of the harness only.
3. Measure resistance from breakout harness pin to the breakout box pin. Circuit wires should have a resistance of less than 5 ohms.

OPERATIONAL VOLTAGE CHECKS

Operational voltages checks determine In-range faults or intermittent connections.

To determine in-range faults and intermittent connections, monitor a suspected circuit and recreate conditions likely to cause the problem.

- Monitor signal voltage with the EST using continuous monitor ssn. and initiating continuous monitor test (KOEO). See Diagnostic table in Section 7 for the sensor being tested.
- Use a DMM and correct breakout harness or a DMM and breakout box. See Section 7 for circuits being tested.

CIRCUIT DIAGNOSTICS

ACCELERATOR PEDAL POSITION SENSOR AND IDLE VALIDATION SWITCH (APS/IVS)

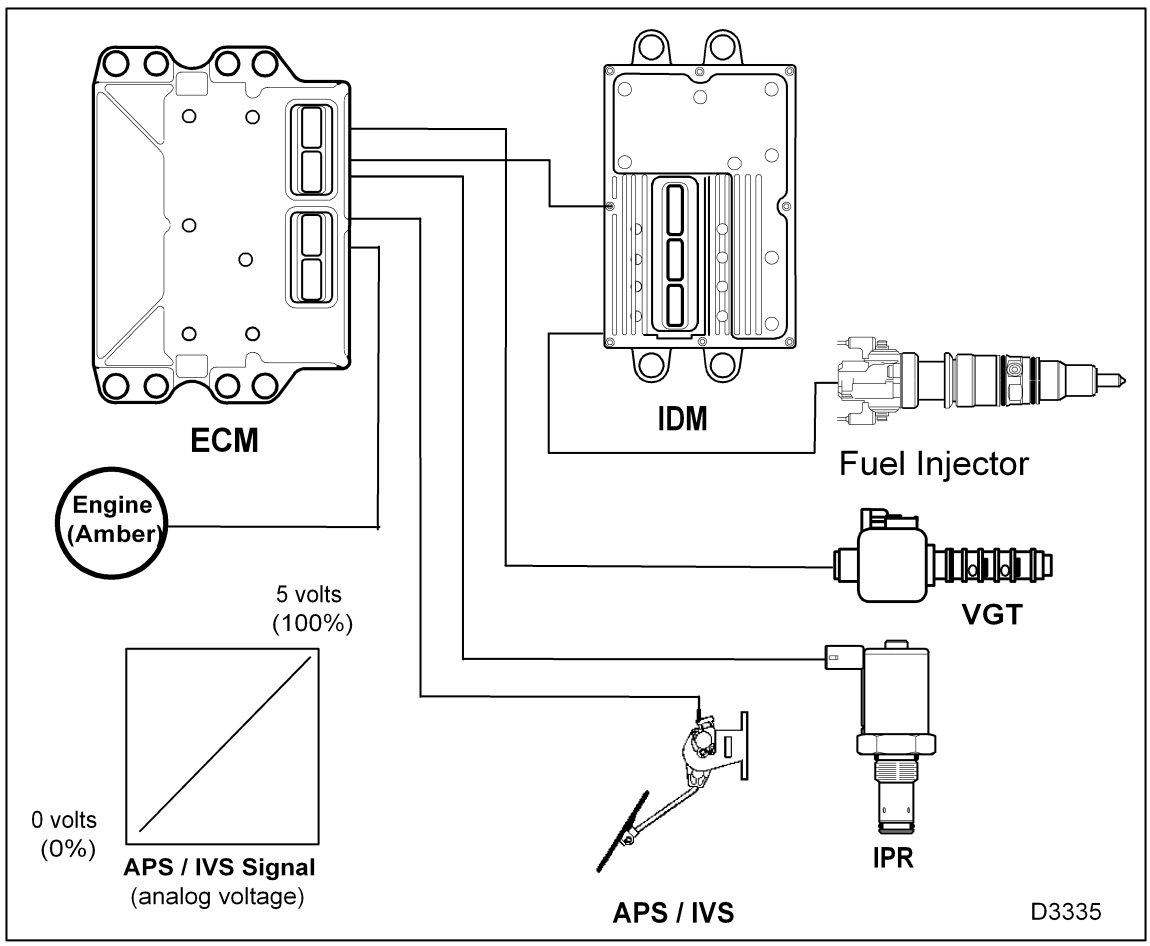

Figure 250 Function Diagram for the Accelerator Pedal Position Sensor and Idle Validation Switch (APS/IVS)

The Function Diagram for the APS/IVS includes the following:

- Accelerator Pedal Position Sensor and Idle Validation Switch (APS/IVS)
- Injection Control Pressure Regulator (IPR)
- Electronic Control Module (ECM)
- Variable Geometry Turbocharger (VGT) actuator
- Injection Driver Module (IDM)
- Fuel injector
- ENGINE lamp (amber)

Function

The APS/IVS sensor is a cab mounted potentiometer sensor. When the APS receives a 5V reference signal and a ground from the ECM, a linear analog voltage signal from the sensor will indicate the operator's demand for power. The IVS provides 0V or 12V to the ECM as redundant signal to verify the pedal idle position.

APS/IVS Circuit Operation

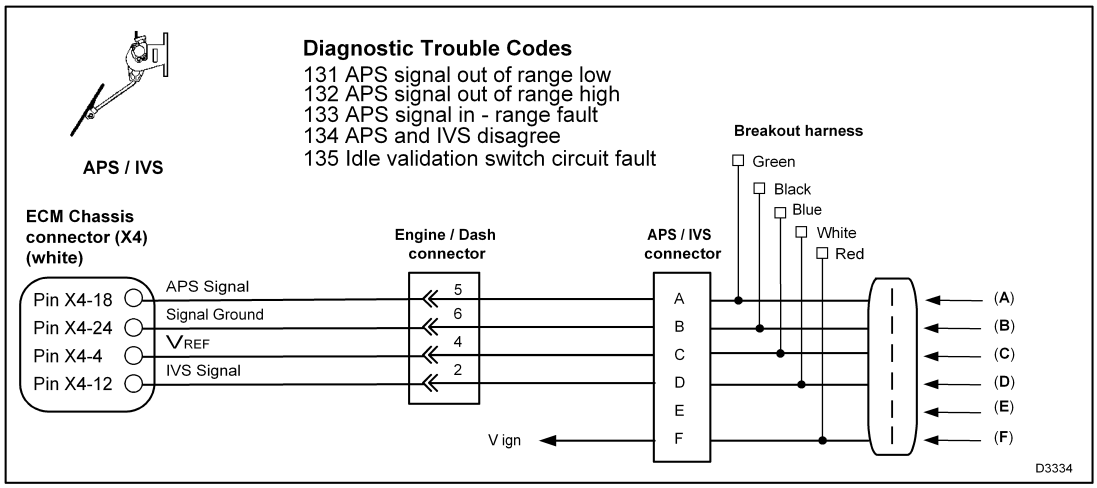

Figure 251 APS/IVS Circuit Diagram

The APS/IVS are integrated into one component and mounted on the pedal. The accelerator pedal assembly is serviceable to the extent that the APS/IVS switch can be replaced without replacing the complete assembly.

The ECM determines the accelerator pedal position by processing input signals from the APS and the IVS.

The accelerator pedal position is one of the controlling variables in the calculation of desired injection control pressure.

APS

The ECM sends a regulated 5V signal through the ECM chassis connector terminal X4–4 to APS connector terminal C. The APS then returns a variable voltage signal (depending on pedal position) from the APS connector terminal A to the ECM at terminal X4–18. The APS is grounded from connector terminal B to the ECM signal ground terminal X4–24.

APS Auto-Calibration

The ECM learns the lowest and highest pedal positions by reading and storing the minimum and maximum voltage levels from the APS. In this manner the ECM auto-calibrates the system to allow maximum pedal sensitivity. The ECM auto-calibrates as the key is on, but when the key is turned OFF, these values are lost. When the key is turned on again, this process starts over. When the pedal is disconnected (or a new one is installed), the pedal does not need to be calibrated. It simply auto-calibrates the new pedal assembly whenever the key is turned on again.

IVS

The ECM expects to receive one of two signals through the ECM chassis connector terminal X4–12 from APS/IVS connector terminal D:

- 0V when the pedal is at the idle position.
- B+ when the pedal is depressed

The IVS receives a 12V ignition voltage at terminal F from the ignition fuse in the power distribution box. When the pedal is not in the idle position (throttle applied), the IVS supplies a 12V signal to the ECM.

The ECM compares APS/IVS inputs to verify when the pedal is in the idle position. If the APS signal at terminal X4–18 indicates throttle is being applied, the ECM expects to see 12V at the IVS. If the APS signal indicates throttle is not applied, the ECM expects to see 0V at the IVS. The timing process is critical between the APS and IVS sensors. For this reason, it is very difficult to determine if the APS/IVS assembly is working correctly when using a Digital Multimeter (DMM).

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 the

signals are not what the ECM expects to see, DTCs will be set.

Any detected 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.

APS/IVS Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

NOTE: If multiple APS/IVS DTCs are present, verify the APS/IVS part number is correct for the specific vehicle model.

DTC 131
APS out of range low (ORL)

- DTC 131 is set if the ECM detects voltage less than 0.147V. Possible causes include a short to ground or an open in the APS signal circuit.
- DTC 131 can be set due to a short to ground or an open V_{REF} or signal circuits. If the condition causing DTC 131 is intermittent and the condition is no longer present, the code will become inactive and normal engine operation will resume.
- When DTC 131 is active the amber ENGINE lamp is illuminated.

DTC 132
APS out of range high (ORH)

- DTC 132 is set if the ECM detects a voltage greater than 4.55V then the ECM restricts engine speed to idle.
- DTC 132 can be set due to a short to V_{REF} or B+ in the APS signal circuit.
- When DTC 132 is active the amber ENGINE lamp is illuminated.

NOTE: The ECM monitors voltage on V_{REF} A and will adjust signal values for the sensors that use V_{REF} A for operation. If a sensor or circuit pulls V_{REF} lower than 5V, the ECM may set out of range high DTCs for the sensors that operate on V_{REF} B (APS, BAP, B+, and VSS).

DTC 133, 134 and 135
APS in-range fault

- The ECM checks the voltage output of the APS by comparing the APS signal with the IVS signal. APS and IVS signals can disagree in two cases:
  - The APS signal indicates the pedal is pressed down to accelerate, but the IVS signal indicates idle position.
  - The APS signal indicates the pedal has been released to allow the engine to return to idle, but the IVS signal indicates off-idle position of the pedal.

If the ECM detects either of the above conditions, the ECM attempts to isolate the source of conflict and set the appropriate DTC.

DTC 133
APS in-range fault

- If the IVS signal is changing and the APS signal is constant, the ECM assumes the APS is the conflict source and sets DTC 133. The engine rpm is restricted to idle.
- When DTC 133 is active the amber ENGINE lamp is illuminated.

DTC 134
APS/IVS disagree

- If neither the APS or IVS is changing, or both are changing, or the ECM cannot determine the DTC in specified time, DTC 134 is set and engine rpm is restricted to idle.
- When DTC 134 is active the amber ENGINE lamp is illuminated.

DTC 135
IVS circuit fault

- If the APS is changing but IVS is constant, the ECM assumes the IVS is the conflict source and sets DTC 135. In this case the ECM limits the APS signal to a lower value that provides less than full rpm, but does not limit engine rpm to idle.
- When DTC 135 is active the amber ENGINE lamp is illuminated.

DTC 133, 134, and 135 are caused by intermittent conditions. These DTCs remain active until the vehicle has been shutdown and restarted. They do not recover without cycling the key switch.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)
- Harness – 3-Banana and 500 ohm
- Breakout box
- APS/IVS breakout harness
- Terminal Test Adapter Kit

The APS/IVS circuit requires the use of vehicle circuit diagrams. See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.

APS/IVS Operational Diagnostics

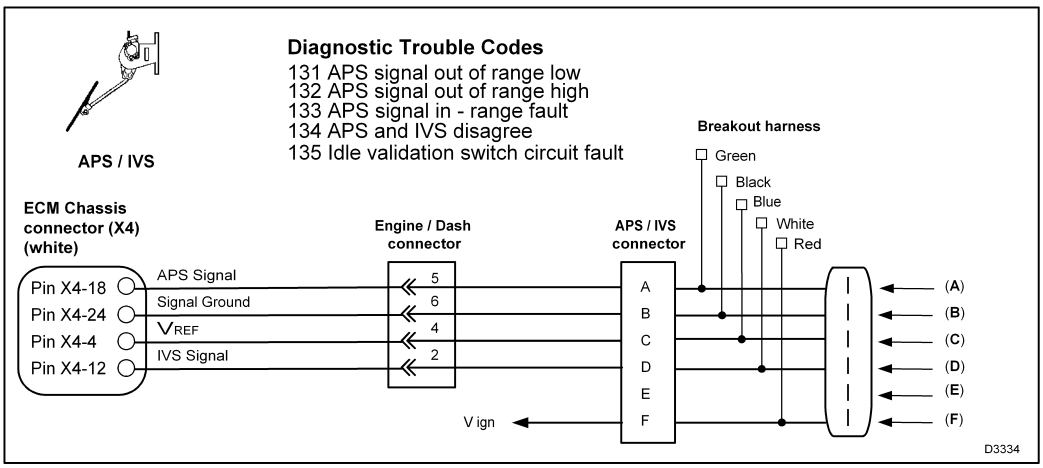

Figure 252 APS/IVS Circuit Diagram

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

Be careful to avoid rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the continuous monitor session. To monitor signal voltage, run Key ON Engine OFF continuous monitor test.
2. Monitor APS signal volts. Verify an active DTC for the APS/IVS circuit.
3. If code is active, complete step 5 and do circuit check for the APS/IVS sensor in table on the following page.
4. If code is inactive, wiggle connectors and wires at all suspected problem locations. If circuit continuity is interrupted, the EST will beep and display DTCs related to the condition.
5. Install APS breakout harness to engine harness only.

Table 4

Circuit Checks for APS Sensor (Use EST, DMM, breakout harness, and 500 ohm wire harness.)		
Test Condition	**Spec**	**Checks**
Sensor disconnected	0V	If voltage >0.147V, check signal circuit for short to V_{REF} or B+.
Measure voltage from BLUE PIN to ground with DMM	5V ±0.5	If voltage >5.5V, check V_{REF} for short to B+. If voltage is <4.5V, check V_{REF} for open or short to ground.
500 ohm harness installed between GREEN and BLUE pins of breakout harness.	5V	If voltage <4.55V, check signal circuit for open or short to ground. Remove negative battery cable. Measure resistance from PIN C to ground (spec >1kΩ) to check for short to ground. Use a breakout box to measure from PIN A to PIN X4–18 (spec <5Ω) to check for open in the harness.
Resistance from BLACK pin of breakout harness to chassis ground using DMM.	0V	If resistance is >5Ω, check for open or high resistance between ECM and sensor connector. Use a breakout box and measure resistance from between PIN B and PIN X4–24 (spec <5Ω).

6. Connect chassis harness to sensor. Use the EST to clear DTCs. If an active code remains after checking test conditions, inspect pedal assembly for excessive wear. If pedal assembly is in tact, replace the APS/IVS sensor.

APS/IVS Pin Point Diagnostics

Table 5

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.

Connector Voltage Checks (Disconnect sensor from harness and turn ignition key ON.)		
Test Point	**Spec**	**Comments**
A to gnd	<0.25V	Voltage >0.25V, signal is shorted to V_{REF} or B+
B to gnd	0V	Ground circuit, no voltage expected
C to gnd	5V ±0.05	Voltage >spec, wire shorted to B+; Voltage <spec, wire open or shorted to ground
D to gnd	0 – 0.25V	Voltage >0.25V, IVS signal wire shorted to V_{REF} or B+
F to gnd	B+	Voltage <10.5V check circuit for open or resistance – blown fuse
Connector Resistance Checks to Chassis Ground (Turn ignition key OFF. Disconnect sensor connector and negative battery cable.)		
A to gnd	>1kΩ	If <1kΩ, check for short to ground
B to gnd	<5Ω	If >5Ω, check for open signal ground
C to gnd	>500Ω	If <500Ω, check for short to ground
D to gnd	>1kΩ	If <1kΩ, check for short to ground
F to gnd	>1kΩ	If <1kΩ with fuse removed, check for short to ground
Harness Resistance Checks (Install breakout box on chassis harness only.)		
X4–18 to A	<5Ω	If >5Ω, check for APS signal wire open
X4–24 to B	<5Ω	If >5Ω, check for open signal ground
X4–4 to C	<5Ω	If >5Ω, check for open V_{REF} wire
X4–12 to D	<5Ω	If >5Ω, check for open IVS signal wire
Fuse to F	<5Ω	If >5Ω, check for open IVS power wire
NOTE: See truck Chassis Electrical Circuit Diagram manual for fuse location.		

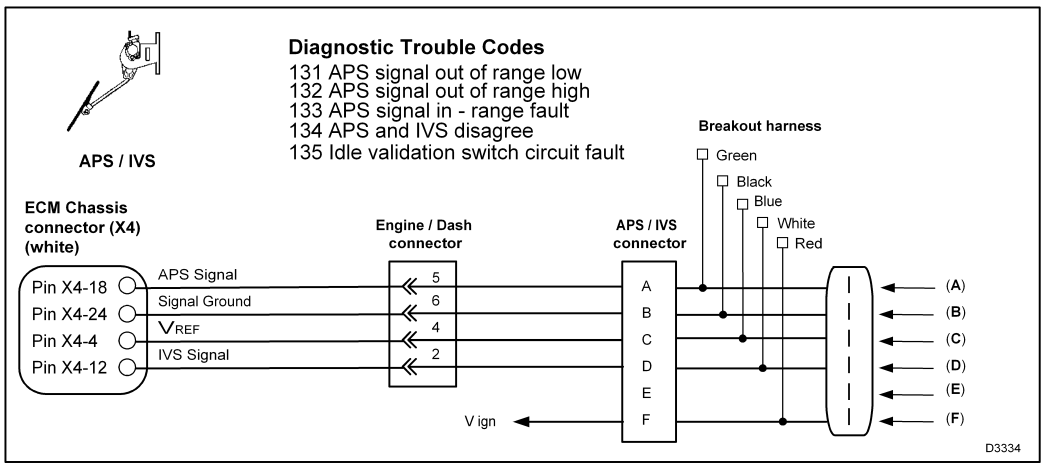

Figure 253 APS/IVS Circuit Diagram

Table 6

Operational Voltage Checks for APS/IVS Sensor (Check with breakout box installed to ECM and chassis harness. Inspect for bent pins or corrosion.)				
	APS test points: (+) X4–18 to (-) X4–24 or (+) green and (-) black		IVS test points: (+) X4–12 to (-) X4–24 or (+) green and (-) black	
Position	**Voltage**	**% APS**	**IVS Voltage**	**Comments**
Low idle	0.64 – 0.66V	0%	0V	IVS toggles just off idle
High idle	3.84 – 3.86V	98 – 102%	B+	
APS/IVS Diagnostic Trouble Code				
DTC 131 = APS signal voltage was <0.147V for more than 0.35 seconds.				
DTC 132 = APS signal voltage was >4.55V for more than 0.35 seconds.				
DTC 133 = APS signal in-range fault				
DTC 134 = APS and IVS disagree				
DTC 135 = Idle validation switch circuit fault – 50% APS only				

AIR MANAGEMENT SYSTEM (AMS)

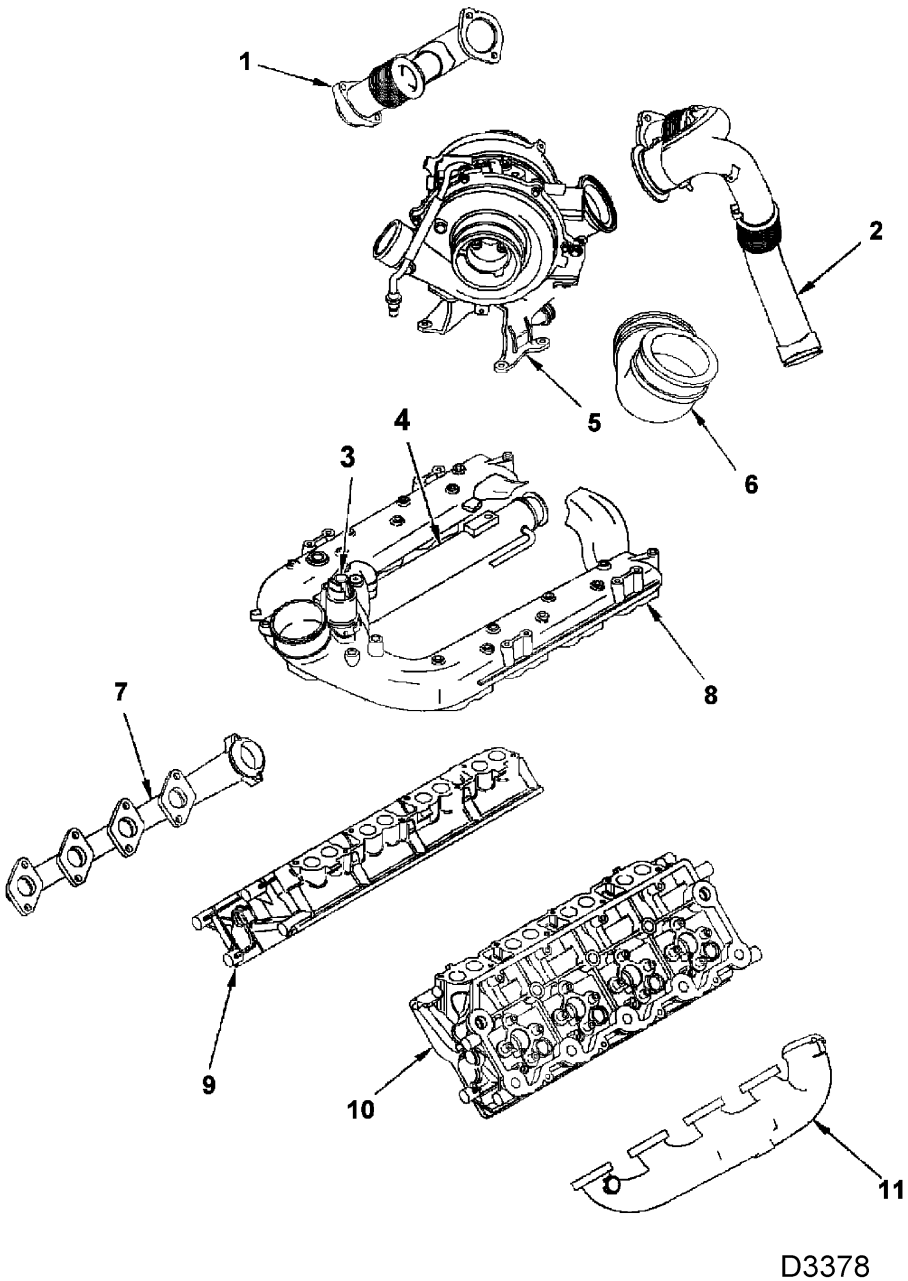

Figure 254 Function Diagram for the Air Management System (AMS)

1. Exhaust tube assembly, right
2. Shielded tube exhaust assembly
3. EGR valve
4. EGR cooler
5. EVRT™ turbocharger assembly with mounting bracket
6. Air inlet duct
7. Right exhaust manifold
8. Intake manifold
9. Right cylinder head
10. Left cylinder head
11. Left exhaust manifold

The Function Diagram for the AMS includes the following:

- Variable Geometry Turbocharger (VGT) System

- Exhaust Gas Recirculation (EGR)
- Exhaust system

AMS Operation

Function

The **Variable Geometry Turbocharger (VGT) system** controls internal actuated vanes to change the flow characteristics of the exhaust gas through the turbine, which causes a variation in the boost pressure produced by the turbocharger.

The VGT system is closed loop using the EBP sensor as the feedback. The vane position is adjusted to reach the desired exhaust back pressure. Vane position management is accomplished by changing the direction of engine oil flow in the VGT actuator. The ECM sends a pulse-width modulated signal to the VGT actuator causing the vanes to move. Varying the vane position changes the flow characteristics of the exhaust gas through the turbine housing and additionally results in a change of boost pressure.

The ECM calculates the appropriate desired exhaust back pressure in response to the changing engine speed, fuel desired, operator demand, engine operating temperatures, and altitude. The components involved with the control of the VGT include the following:

- Exhaust Back Pressure (EBP) sensor
- Engine Oil Temperature (EOT) sensor
- Exhaust Gas Recirculation Position (EGR) sensor
- Engine Coolant Temperature (ECT) sensor

The **Exhaust Gas Recirculation (EGR) system** controls the amount of exhaust gas being introduced to the engine intake manifold by modulating the EGR valve.

The EGR system is closed loop using the EGR valve Position (EGRP) sensor as the feedback. The EGRP is adjusted to reach the desired EGR valve position. The ECM sends a pulse-width modulated signal to the EGR valve actuator causing the EGR valve to move. The actual exhaust gas flow from the exhaust manifold to the intake manifold is regulated by calculating the pressure differential and the opening and closing of the EGR valve.

The EGR valve's fully closed position is calibrated each time the ECM is powered up to allow some compensation of carbon build up on the EGR valve.

When the engine operating temperatures and conditions are appropriate, the EGR valve will be exercised when the engine is shut down to reduce the chance of a stuck EGR valve.

The ECM calculates the appropriate desired EGR valve position in response to the changing engine speed, fuel desired, operator demand, engine operating temperatures, exhaust back pressure, boost pressure and altitude. Components involved with the control of the EGR include the following:

- Barometric Absolute Pressure (BAP) sensor
- Exhaust Back Pressure (EBP) sensor
- Manifold Air Temperature (MAT) sensor
- Manifold Air Pressure (MAP) sensor
- Accelerator Pedal Position Sensor (APS)
- Engine Coolant Temperature (ECT) sensor
- Engine Oil Temperature (EOT) sensor
- Electronic Variable Response Turbocharger (EVRT™) actuator

Fault Detection / Management

The ECM continuously monitors the Air Management System (AMS). When the ECM detects a fault in the any of the interdependent systems, the ECM will set a DTC and illuminate the amber ENGINE lamp.

The Electronic Variable Response Turbocharger (EVRT™) is continuously monitored by the ECM using the exhaust back pressure and the EVRT pulse-width modulated signal's duty cycle. A DTC is logged when the ECM determines that the duty cycle required to reach the desired boost or exhaust backpressure is greater or less than the ECM's pre-programmed expected values.

Service bay diagnostics for the EVRT are available and can be performed using the Electronic Service Tool (EST).

The Exhaust Gas Recirculation (EGR) system is continuously monitored by the ECM using the EGR valve position signal. When the EBP, MAP, MAT, EGRP, or BAP sensor has an out of range fault

(high or low), the EGR duty cycle will default to a pre-programmed value and close the valve.

Service bay diagnostics for the EGR are available and can be performed using the Electronic Service Tool (EST).

AMS Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

NOTE: Before proceeding make sure all sensor, injector and actuator electrical DTCs have been repaired. Follow the procedures outlined in Section 6 or Performance Diagnostics form.

Table 7

DTC 343 – Excessive exhaust backpressure	
DTC 343 is set by the ECM when the exhaust backpressure is greater than 260 kPa (37.7 psi).	
Possible Causes	**Comments**
EBP sensor bias high	Check sensor signal voltage in EBP circuit diagnostics.
EBP signal ground open	Check sensor signal voltage in EBP circuit diagnostics.
Exhaust restriction (muffler or catalytic converter)	Inspect exhaust – do performance diagnostics.
VGT valve or vanes stuck closed	Do performance diagnostics.
VGT Control Circuit short to B+	Do VGT circuit diagnostics.

Table 8

DTC 344 – Exhaust back pressure above spec with engine OFF	
DTC 344 is set by the ECM when the EBP is greater than 300 kPa (43.5 psi) when engine is off or being cranked.	
Possible Causes	**Comments**
EBP sensor bias high	Check sensor signal voltage in EBP circuit diagnostics.
EBP sensor or tube line plugged	Clean and retest (replace if needed)

Table 9

DTC 345 – Faults detected during VGT portion of AMS test	
DTC 345 is set by the ECM during the AMS test when the ECM measures the EBP and does not see the expected response in pressures.	
Possible Causes	**Comments**
Oil pressure and quality	Do performance diagnostics.
High intake restriction	Do performance diagnostics.
Intake / CAC system leak (pipes, loose clamps, hoses)	Do performance diagnostics.
Exhaust system leak	Do performance diagnostics.
MAP sensor bias	Check sensor signal voltage in MAP circuit diagnostics.
EBP sensor bias	Check sensor signal voltage in EBP circuit diagnostics.
EGR stuck open	Do performance diagnostics.
VGT valve or vanes sticking	Do performance diagnostics
EBP sensor or tube plugged	Clean and retest (replace if needed)
Power cylinder integrity	Do performance diagnostics.
VGT control circuit	Do KOEO standard test and VGT circuit diagnostics.

Table 10

DTC 346 – Faults detected during EGR portion of AMS test	
DTC 346 is set by the ECM during AMS test when the ECM measures EBP and EGRP and does not see the expected response in pressures versus position.	
Possible Causes	**Comments**
EGR valve stuck or sticking	Do performance diagnostics.
EGR valve position sensor bias	Check sensor signal voltage in EGR circuit diagnostics.
EBP sensor bias	Check sensor signal voltage in EBP circuit diagnostics.
EBP sensor or tube plugged	Clean and retest (replace if needed)
EGR control circuit	Do KOEO standard test and EGR circuit diagnostics.

Table 11

DTC 351 – Change in exhaust back pressure did not occur when expected	
DTC 351 is set by the ECM when less than 14.5 kPa (2.1 psi) is detected between Key ON and 2500 rpm.	
Possible Causes	**Comments**
EBP tube or sensor plugged	Clean and retest (replace if needed).
EBP sensor bias	Check sensor signal voltage in EBP circuit diagnostics.
EGR valve stuck open	Do performance diagnostics.
Exhaust system leak	Do performance diagnostics.

Table 12

DTC 353 – VGT control over duty cycle	
DTC 353 is set when the ECM overcompensates by increasing duty cycle to the VGT to achieve desired boost/backpressure.	
Possible Causes	**Comments**
Oil pressure and quality	Do performance diagnostics.
High intake restriction	Do performance diagnostics.
Intake / CAC system leak (pipes, loose clamps, hoses)	Do performance diagnostics.
Exhaust system leak	Do performance diagnostics.
BAP sensor bias low	Check sensor signal voltage in BAP circuit diagnostics.
MAP sensor bias low	Check sensor signal voltage in MAP circuit diagnostics.
EBP sensor bias low	Check sensor signal voltage in EBP circuit diagnostics.
ICP sensor bias high	Check sensor signal voltage in ICP circuit diagnostics.
Power cylinder integrity	Do performance diagnostics.
ICP system integrity	Do performance diagnostics.
Injector operation / part number	Check previous repairs. Do performance diagnostics.
EGR valve stuck open	Do performance diagnostics.
VGT valve or vanes sticking	Do performance diagnostics.
VGT control circuit open	Do KOEO standard test and VGT circuit diagnostics.

Table 13

DTC 354 – VGT control under duty cycle	
DTC 354 is set when the ECM overcompensates by decreasing duty cycle to the VGT to achieve the desired boost/backpressure.	
Possible Causes	**Comments**
Oil pressure and quality	Do performance diagnostics.
BAP sensor bias high	Check sensor signal voltage in BAP circuit diagnostics.
MAP sensor bias high	Check sensor signal voltage in MAP circuit diagnostics.
EBP sensor bias high	Check sensor signal voltage in EBP circuit diagnostics.
Open Exhaust (no muffler)	Inspect exhaust system.
ICP sensor bias low	Check sensor signal voltage in ICP circuit diagnostics.
ICP system integrity	Do performance diagnostics.
Injector operation / part number	Check previous repairs. Do performance diagnostics.
Exhaust restriction (muffler or catalytic converter)	Inspect exhaust – do performance diagnostics.

Table 14

DTC 355 – VGT overspeed	
DTC 355 is set when the ECM detects turbo over speed several times in a specific period of time (dependent on ECM calibration). Turbo speed is estimated by engine speed, boost pressure, and barometric pressure.	
Possible Causes	**Comments**
High intake restriction	Do performance diagnostics.
Intake / CAC system leak (pipes, loose clamps, hoses)	Do performance diagnostics.
Restricted CAC system	Do performance diagnostics.
VGT valve or vanes sticking	Do performance diagnostics.
Open exhaust (no muffler)	Inspect exhaust system
BAP sensor bias	Check sensor signal voltage in BAP circuit diagnostics.
MAP sensor bias high	Check sensor signal voltage in MAP circuit diagnostics.
EBP sensor bias low	Check sensor signal voltage in EBP circuit diagnostics.

Table 15

DTC 361 – VGT control input (MAP/EBP) above/below desired level	
DTC 361 is set when the ECM detects an in range error in the MAP/EBP signal.	
Possible Causes	**Comments**
High intake restriction	Do performance diagnostics.
Intake / CAC system leak (pipes, loose clamps, hoses)	Do performance diagnostics.
BAP sensor bias	Check sensor signal voltage in BAP circuit diagnostics.
MAP sensor bias	Check sensor signal voltage in MAP circuit diagnostics.
EBP sensor bias	Check sensor signal voltage in EBP circuit diagnostics.
ICP sensor bias	Check sensor signal voltage in ICP circuit diagnostics.
Power cylinder integrity	Do performance diagnostics.
ICP system integrity	Do performance diagnostics.
Injector operation / part number	Check previous repairs. Do performance diagnostics.
EGR valve stuck open	Do performance diagnostics.
VGT valve or vanes sticking	Do performance diagnostics.
VGT control circuit open	Do KOEO standard test and VGT circuit diagnostics.
Open Exhaust (no muffler)	Inspect exhaust system.
Exhaust restriction or leak (muffler or catalytic converter)	Inspect exhaust – do performance diagnostics.

Table 16

DTC 365 – EGR valve position above / below desired level	
DTC 365 is set when the actual EGR Valve Position does not match desired.	
Possible Causes	**Comments**
EGR valve stuck or sticking	Do performance diagnostics.
EGR valve position sensor bias	Check sensor signal voltage in EGR circuit diagnostics.
EBP sensor or tube plugged	Clean and retest (replace if needed)
EBP sensor bias	Check sensor signal voltage in EBP circuit diagnostics.
EGR control circuit	Do KOEO standard test and EGR circuit diagnostics.

Table 17

DTC 366 – EGR valve duty operating out of expected range	
DTC 366 is set when the ECM has overcompensated by increasing or decreasing EGR duty to achieve the desired EGRP.	
Possible Causes	**Comments**
EGR valve stuck	Do performance diagnostics.
EGR valve sluggish	Do performance diagnostics.
EGR valve position sensor error	Check sensor signal voltage in EGR circuit diagnostics.
Exhaust leak	Do performance diagnostics.
BAP sensor bias	Check sensor signal voltage in BAP circuit diagnostics.
EBP sensor bias	Check sensor signal voltage in EBP circuit diagnostics.
MAP sensor bias	Check sensor signal voltage in MAP circuit diagnostics.
EGR cooler restriction/leak	Do performance diagnostics.

Table 18

DTC 367 – Improper position signal when EGR valve is expected closed	
DTC 367 is set when the ECM detects the EGR Valve position is out of desired range during Key ON (signal voltage >2.5V).	
Possible Causes	**Comments**
EGR Valve stuck open	Do performance diagnostics.
EGR Valve position sensor bias high	Check sensor signal voltage in EGR circuit diagnostics.

AMERICAN TRUCKING ASSOCIATION (ATA) DATA LINK

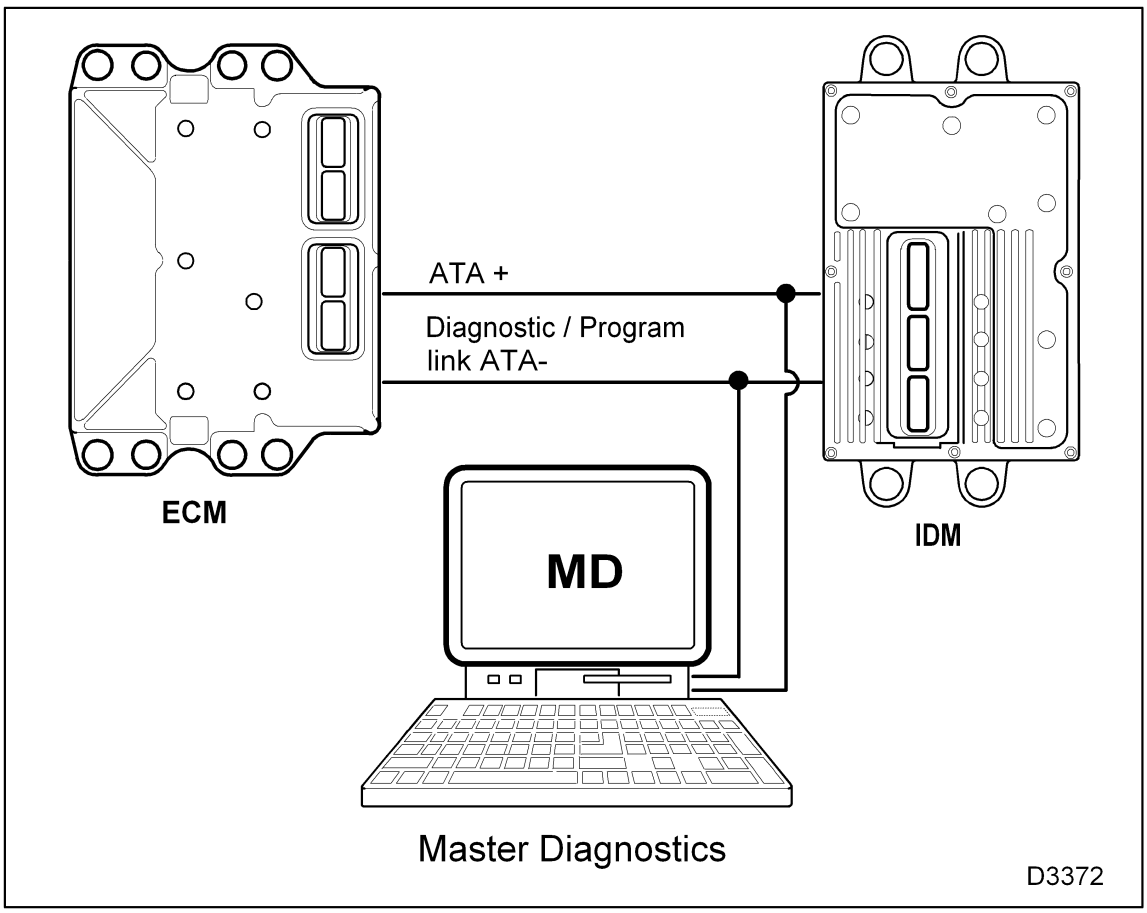

Figure 255 Function Diagram for the American Trucking Association (ATA) Data Link

The Function Diagram for the ATA data link includes the following:

- Electronic Service Tool (EST) with Master Diagnostics software
- Electronic Control Module (ECM)
- Injection Driver Module (IDM)

Function

The Data Communication Link signal is a 0 to 5V variable width square wave form signal that enables communication between the Master Diagnostic (MD) software and the ECM. The data communication link also allows for programming the IDM.

ATA Circuit Operation

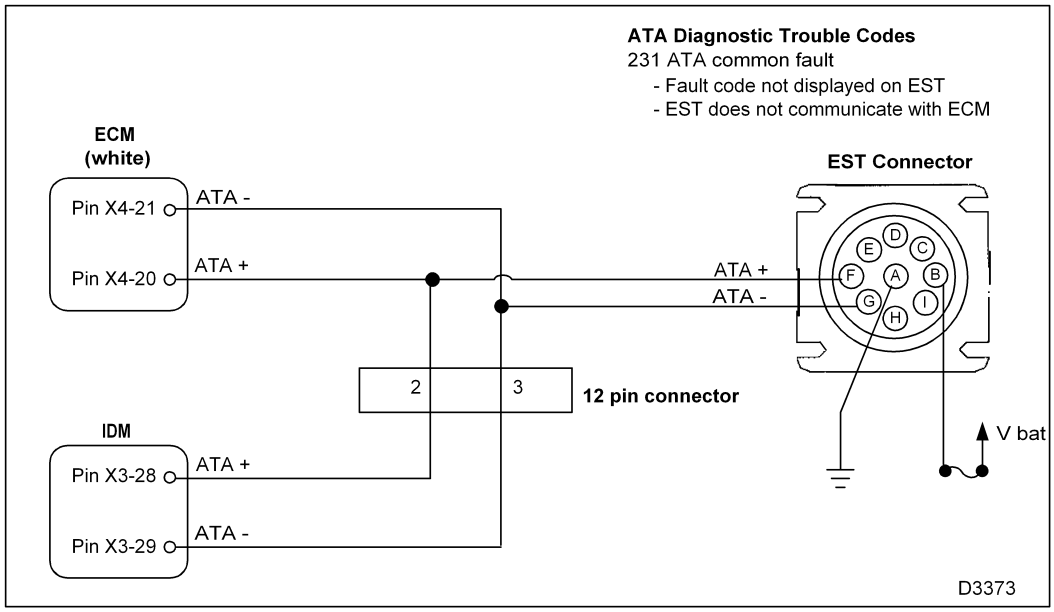

Figure 256 ATA Circuit Diagram

The ECM communicates with the EST and MD software through EST connector. The EST communicates with the ECM using the ATA datalink.

The IDM uses ATA only for programming.

The ATA circuit uses 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) and reversing the polarity of this circuit will disrupt communications.

ATA Data Link Connector

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 the following functions:

- Transmission of engine parameter data
- Transmission and clearing of DTCs
- Diagnostics and trouble shooting
- Programming performance parameter values
- Programming engine and vehicle features
- Programming calibrations and strategies in the ECM and IDM

Fault Detection / Management

The ECM continuously monitors the ATA datalink for an open, short or intermittent connection. If an active DTC occurs on the ATA datalink, the MD diagnostic software will not display correct data.

The IDM uses ATA for programming only. DTCs are not transmitted from the IDM through the ATA datatlink.

ATA Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

DTC 231
ATA data communication link error

- DTC 231 is set when the ECM can not access the ATA datalink. When this occurs, ATA data can not be retrieved using the EST. DTCs can only be retrieved using the cruise control feature.

- DTC 231 can be set when the any of the following conditions occur:
  - Defective ATA device (transmission controller or anti-lock brake controller) is connected to ATA bus and pulls signal to ground.
  - Number of ATA devices exceeds limit
  - Defective ECM
- When DTC 231 is active the amber ENGINE lamp is not illuminated.

NOTE: Vehicles equipped with the Allison WTEC transmission may display DTC 231 when attempting to program the ECM. The WTEC controller must be disconnected when programming the engine ECM.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)
- Breakout box
- Breakout harness

The ATA circuit requires the use of vehicle circuit diagrams. See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.

ATA Pin Point Diagnostics

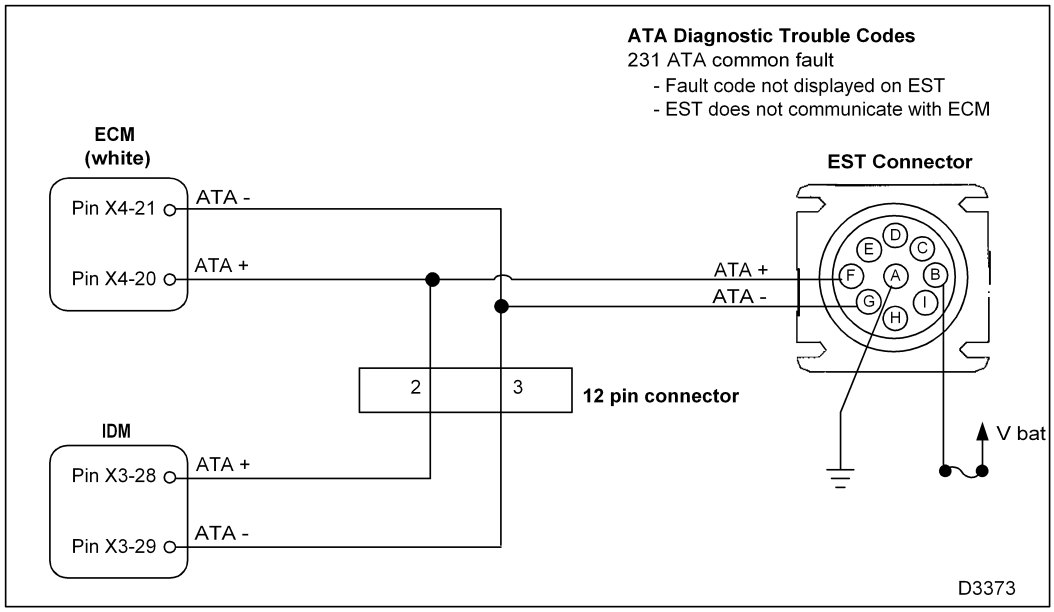

Figure 257 ATA Circuit Diagram

Table 19

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.

Connector at EST Voltage Checks (Key ON Engine OFF)			
Test Point	**Spec**	**Signal**	**Comments**
B to A	B+	Voltage	Should be voltage at B at all times. If no voltage is present, check ground and power circuits.
EST to Ground Voltage Checks (Turn ignition key OFF and disconnect negative battery cable.)			
F to gnd	>1kΩ	ATA +	If <1kΩ, check for short to ground through harness or internal within the ECM and IDM. Disconnect ECM and IDM and measure ground again. If short is still present, disconnect other devices connected to data communication link and retest. If short is still present, repair harness.
G to gnd	>1kΩ	ATA –	
B to gnd	>1kΩ	Power	With fuse removed, if<1kΩ, check for short to ground.
A to gnd	<5Ω	gnd	If >5Ω, check for an open circuit. The EST tool will not communicate.
EST and Dash Harness Resistance Checks (Turn ignition key OFF, disconnect negative battery cable, and install breakout box.)			
F to ECM X4–20	<5Ω	ATA +	Resistance from ECM chassis connector to EST connector.
G to ECM X4–21	<5Ω	ATA –	Resistance from ECM chassis connector to EST connector.
F to IDM X3–28	<5Ω	ATA +	Resistance from IDM connector to EST connector.
G to IDM X3–29	<5Ω	ATA –	Resistance from IDM connector to EST connector.
B to fuse	<5Ω	Power	Resistance from EST connector to power fuse. See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.
A to gnd	<5Ω	gnd	If >5Ω, check for an open circuit. Open circuit will prevent EST power up.
Diagnostic Trouble Code Description			
231 ATA data communication link error – ATA wiring or connector			

BAROMETRIC ABSOLUTE PRESSURE (BAP) SENSOR

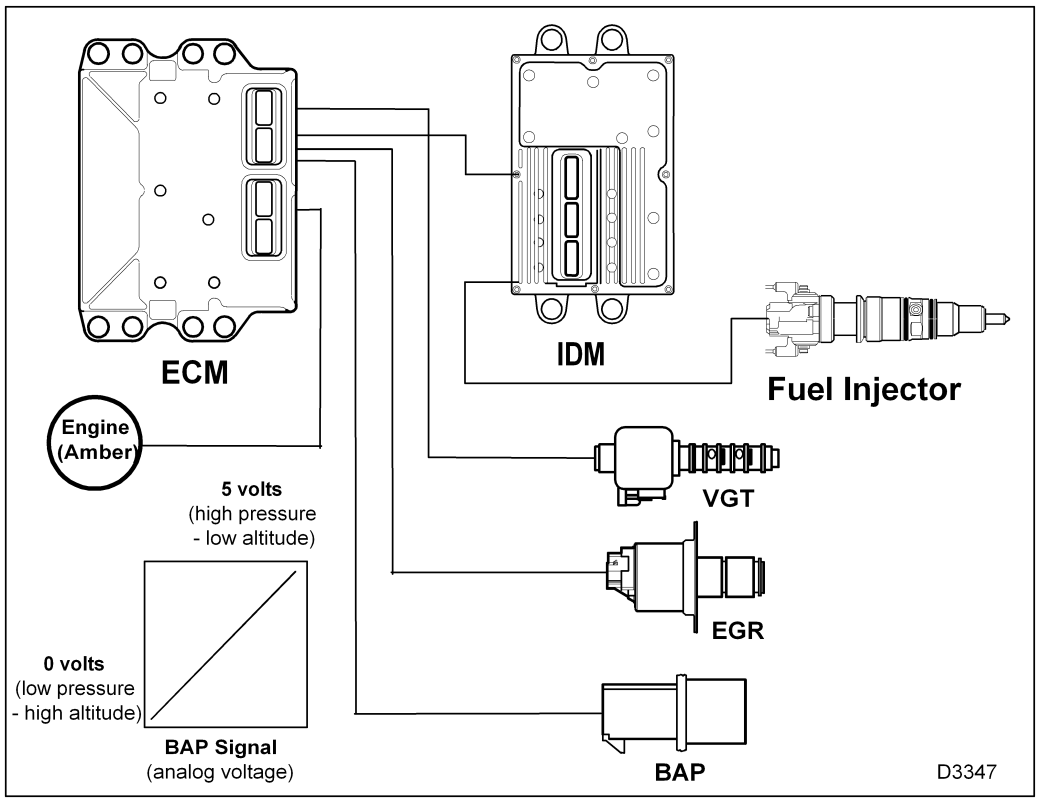

Figure 258 Function Diagram for the Barometric Absolute Pressure (BAP) Sensor

The Function Diagram for the BAP sensor includes the following:

- Barometric Absolute Pressure (BAP) sensor
- Electronic Control Module (ECM)
- Injection Driver Module (IDM)
- Fuel injector
- ENGINE lamp (amber)

Function

The BAP sensor is a cab mounted variable capacitance sensor. The ECM supplies a 5V reference signal which the BAP sensor uses to produce a linear analog voltage signal that indicates pressure.

The primary function of the BAP sensor is to provide a feedback signal to the ECM to adjust timing and fuel quantity. The ECM also uses the BAP signal to determine altitude to adjust glow plug on-time, control EGR and VGT.

BAP Circuit Operation

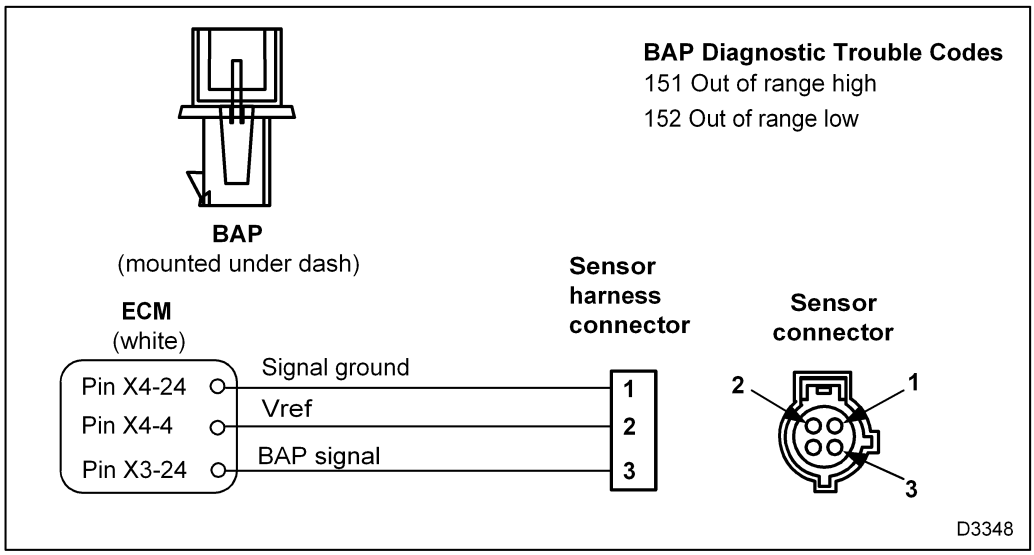

Figure 259 BAP Circuit Diagram

The BAP sensor is supplied with a 5V regulated signal voltage by the ECM from the ECM chassis connector terminal X4–4 to BAP connector terminal 2. The BAP sensor returns a variable voltage signal (representing atmospheric pressure) from BAP connector terminal 3 to ECM at terminal X3–24. The BAP sensor is grounded from the BAP connector terminal 1 to the ECM signal ground terminal X4–24.

Fault Detection / Management

When the ECM detects the BAP voltage signal out of range high or low, the ECM will ignore the BAP signal and use the Manifold Absolute Pressure (MAP) signal generated at low idle as an indication of barometric pressure. When a MAP fault is detected, the BAP signal will default to barometric pressure at sea level, 100.24 kPa (29.6 in Hg).

BAP Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

DTC 151
Out of range high

- DTC 151 is set when the BAP signal is greater than 4.95V for more than .5 second.
- DTC 151 can be set when the signal circuit is shorted to V_{REF} or B+. A defective BAP sensor can set DTC 151.
- When DTC 151 is active the amber ENGINE lamp is illuminated.

NOTE: The ECM monitors voltage on V_{REF} A and will adjust signal values for the sensors that use V_{REF} A for operation. If a sensor or circuit pulls V_{REF} lower than 5V, the ECM may set out of range high DTCs for the sensors that operate on V_{REF} B (APS, BAP, B+, and VSS).

DTC 152
Out of range low

- DTC 152 is set when the BAP signal is less than 1.0V for more than .5 second.
- DTC 152 can be set when the signal circuit is shorted to ground or open. If the V_{REF} is shorted to ground, DTC 152 can be set. A defective BAP sensor can set DTC 152.
- When DTC 152 is active the amber ENGINE lamp is illuminated.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)
- Breakout box

BAP Pin Point Diagnostics

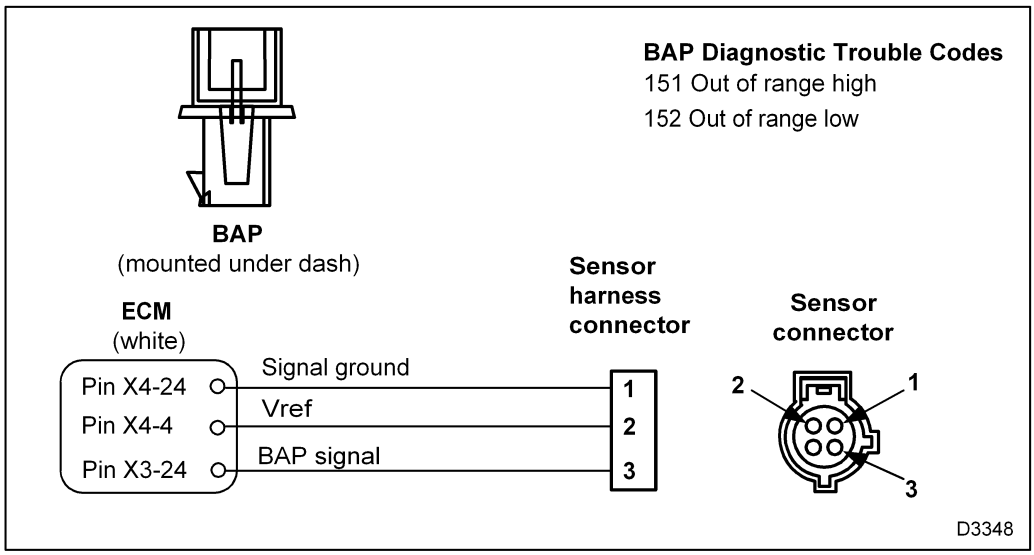

Figure 260 BAP Circuit Diagram

See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.

Table 20

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.

Connector Voltage Checks (Disconnect sensor from harness. Inspect for bent pins or corrosion. Turn ignition key ON.)

Test Point	Spec	Comments
1 to gnd	<0.25V	If >0.25V, check for high resistance or open in ground circuit.
2 to gnd	5V ± 0.5	If voltage is not to spec, V_{REF} circuit is shorted to gnd or open.
3 to gnd	<0.25V	If voltage >spec, wire is shorted to V_{REF} or B+
Connector Resistance Checks to Chassis Ground (Turn ignition key OFF. Disconnect negative battery cable and sensor connector.)		
1 to gnd	<5Ω	If >5Ω, check for open signal ground
2 to gnd	>1kΩ	If <1kΩ, check for V_{REF} short to ground
3 to gnd	>1kΩ	If <1kΩ, check for signal short to ground
Harness Resistance Checks (Install breakout box on chassis harness only.)		
X4-24 to 1	<5Ω	If >5Ω, check for open signal ground
X4–4 to 2	<5Ω	If >5Ω, check for open V_{REF}
X3–24 to 3	<5Ω	If >5Ω, check for open signal circuit

Table 21

Operational Voltage Checks for BAP Sensor (Check with breakout box installed to ECM and chassis harness.)

Test Point	Voltage	kPa (in Hg)	Comments
X3–24 to X4–24	4.89V	105 kPa (31.0905 in Hg)	High atmospheric pressure.
X3–24 to X4–24	4.60V	100 kPa (29.61 in Hg)	Normal atmospheric pressure at sea level.
X3–24 to X4–24	2.60V	60 kPa (17.766 in Hg)	Normal atmospheric pressure at 10,000 feet.
BAP Diagnostic Trouble Code			
DTC 151 = Signal voltage was >4.95V for more than 0.5 seconds			
DTC 152 = Signal voltage was < 1.0V for more than 0.5 seconds			

BRAKE SWITCH CIRCUIT

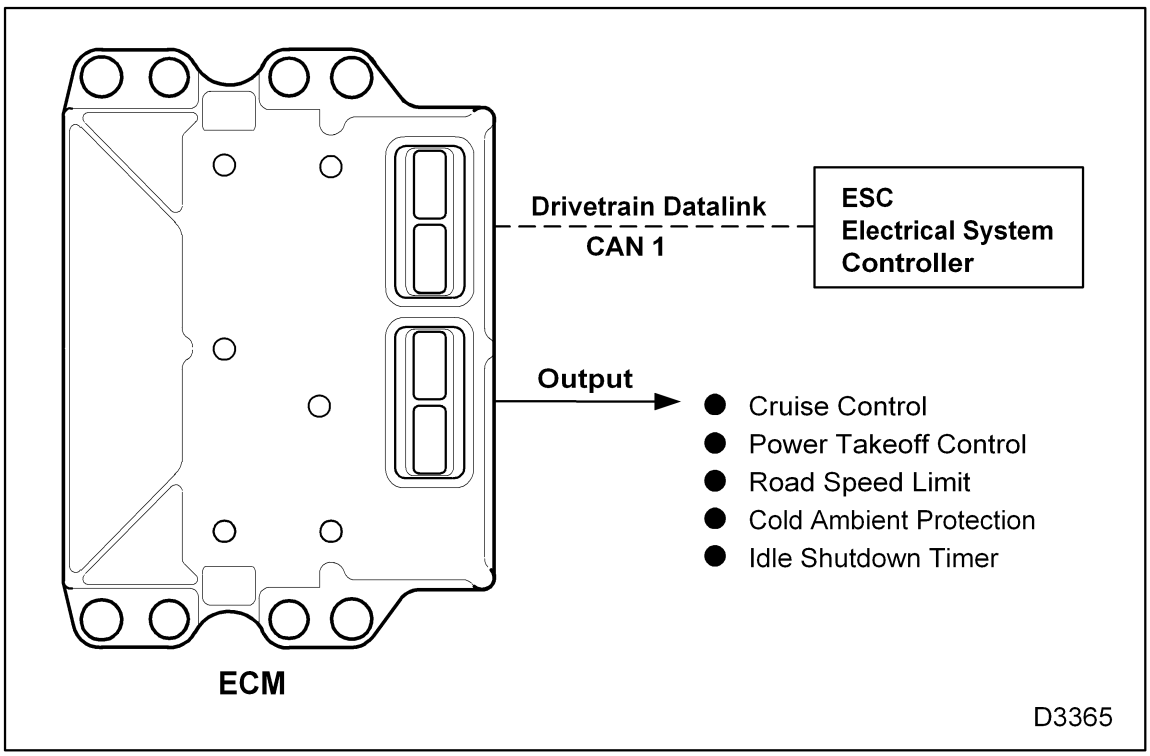

Figure 261 Function Diagram for the Brake Switch

Brake Switch Operation

The service brake circuit signals the ECM when the brakes are applied. The information is used to disengage the Cruise control and Power Takeoff (PTO) function. The brake signal will interrupt the Cold Ambient Protection (CAP) feature and will reset the time interval for the Idle Shutdown Timer (IST) feature.

CAMSHAFT POSITION (CMP) SENSOR

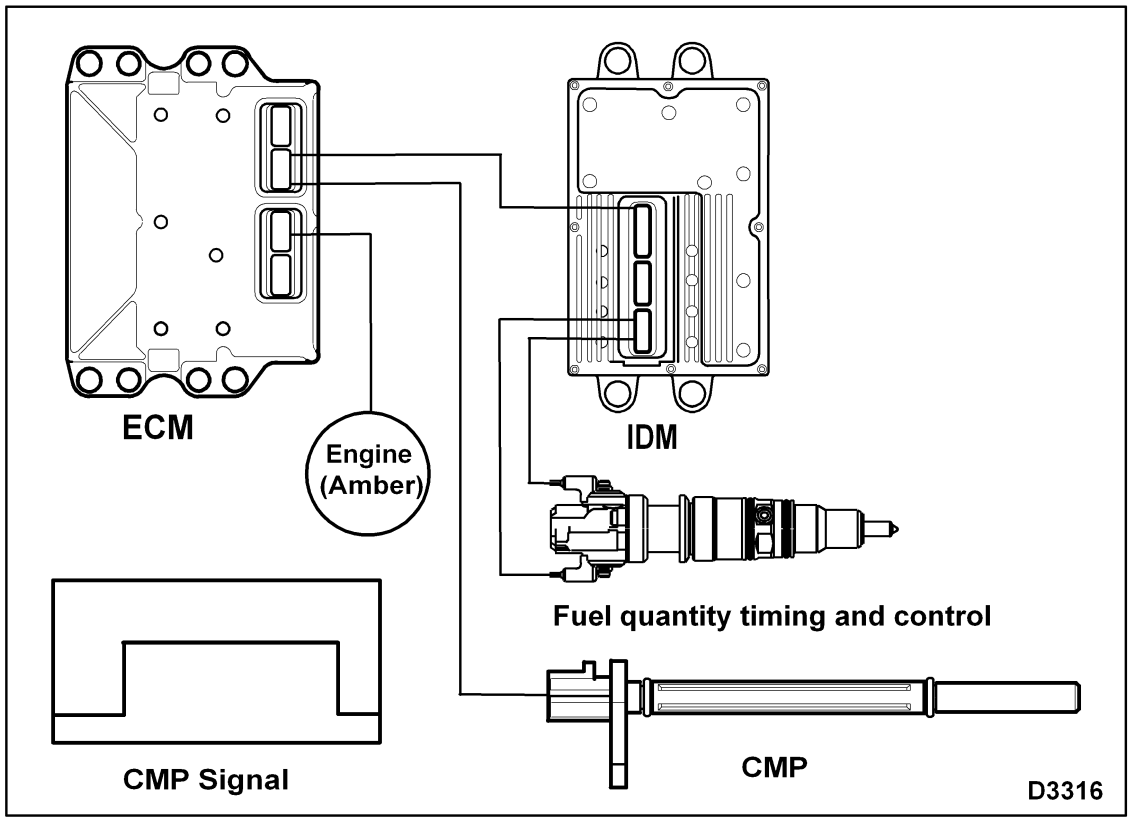

Figure 262 Function Diagram for the Camshaft Position (CMP) Sensor

The Function Diagram for the CMP sensor includes the following:

- Camshaft Position (CMP) sensor
- Electronic Control Module (ECM)
- Injector Drive Module (IDM)
- Fuel Injector
- ENGINE lamp (amber)

The camshaft position signal source is a magnetic pickup sensor mounted on the left front side of the engine crankcase. The sensor identifies the position of the cam by locating a peg on the cam. The peg will pass the sensor once per camshaft revolution and produce a single pulse correspondingly.

Camshaft speed is calculated from the frequency of the CMP sensor signal. Diagnostic information on the CMP input signal is obtained by performing accuracy checks on signal levels, frequency, and duty cycle with software strategies.

CMP Circuit Operation

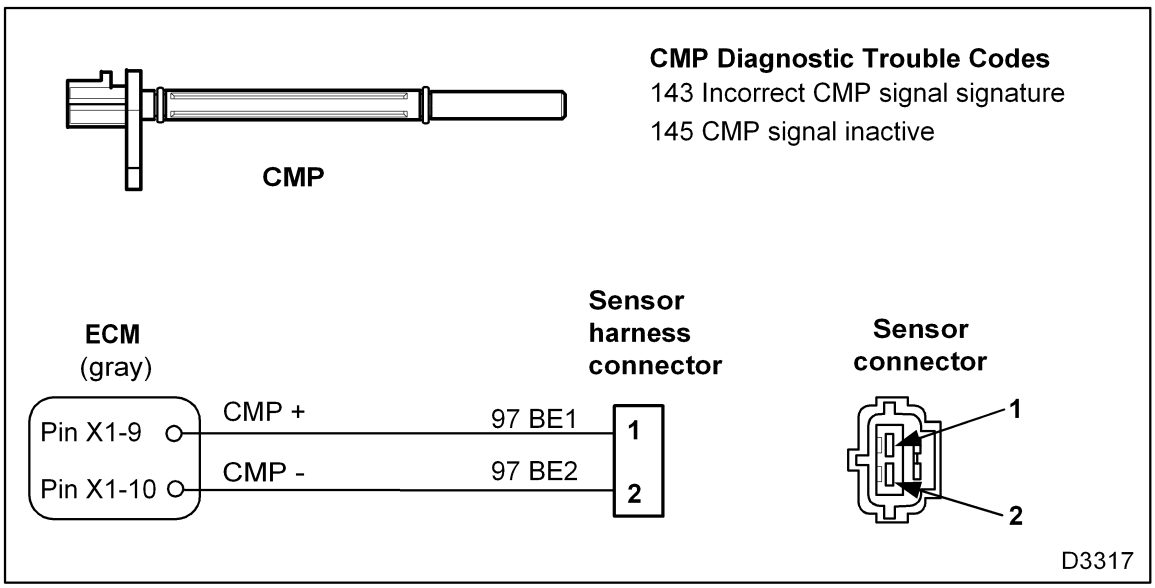

Figure 263 CMP Circuit Diagram

The ECM needs the CKP and CMP signal to calculate engine speed and position. The CMP creates a signal that the ECM uses to indicate a particular side. The CMP contains a permanent magnet which creates a magnetic field. The signal is created when the camshaft peg rotates past the sensor breaking the magnetic field. The ECM terminals for the CMP sensor are CMP positive X1-9 and CMP negative X1-10.

NOTE: Engine will not operate without CMP signal.

Fault Detection / Management

An inactive CMP signal during cranking is detectable by the ECM. During engine cranking the ECM monitors the CKP signal and Injection Control Pressure (ICP) to verify the engine 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. When the level is sufficient to effect engine operation a corresponding DTC will be set. An inactive CMP signal will cause a no start condition.

CMP Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

DTC 143
Incorrect CMP signal signature

- DTC 143 is set by the ECM when the CMP transition occurs at the wrong CKP location.
- DTC 143 can be set due to a mistimed camshaft to crankshaft, electrical noise in the CMP circuit, or a defective CMP sensor.

DTC 145
CMP signal inactive

- DTC 145 is set by the ECM when the CMP signal is inactive, the CKP signal is active, and the ICP has increased.
- DTC 145 can be set due to an open short to ground or open voltage source in the CMP circuit. A defective sensor can cause DTC 145 to be set.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)
- Breakout box

CMP Pin Point Diagnostics

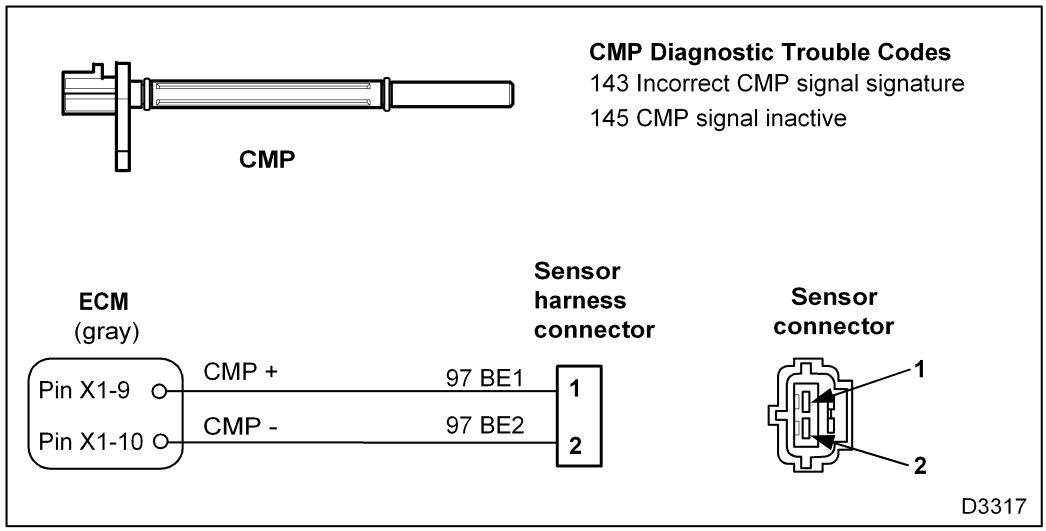

Figure 264

Table 22

Sensor and Circuit Resistance Check (Check with breakout box installed on engine harness only and CMP sensor connected. Inspect for bent pins or corrosion.)		
Test Point	**Spec**	**Comments**
X1–9 to X1–10	800-1kΩ	Resistance through sensor and complete circuit
X1–9 to gnd	>1kΩ	If <1kΩ, check for harness or sensor shorted to ground.
X1–10 to gnd	>1kΩ	If <1kΩ, check for harness or sensor shorted to ground.
Harness Resistance Check (Check with breakout box installed on engine harness only. Check from ECM to sensor harness connector.)		
X1–9 to 1	<5Ω	If >5Ω, check for open circuit.
X1–10 to 2	<5Ω	If >5Ω, check for open circuit.

Table 23

Operational Checks for CMP Sensor (Check with breakout box installed to ECM and engine harness.)				
Test Point	**Engine Cranking**	**Low Idle**	**High Idle**	**Comments**
X1–9 to X1–6	130–225 rpm²@ 130–225 rpm	700 rpm²@ 700 rpm	2950 rpm² @ 2950 rpm	Set DMM to DCmV-rpm²
Diagnostic Trouble Code Description				
DTC 143 = Incorrect CMP signal signature				
DTC 145 = CMP signal inactive				

CONTROLLER AREA NETWORK (CAN) COMMUNICATIONS

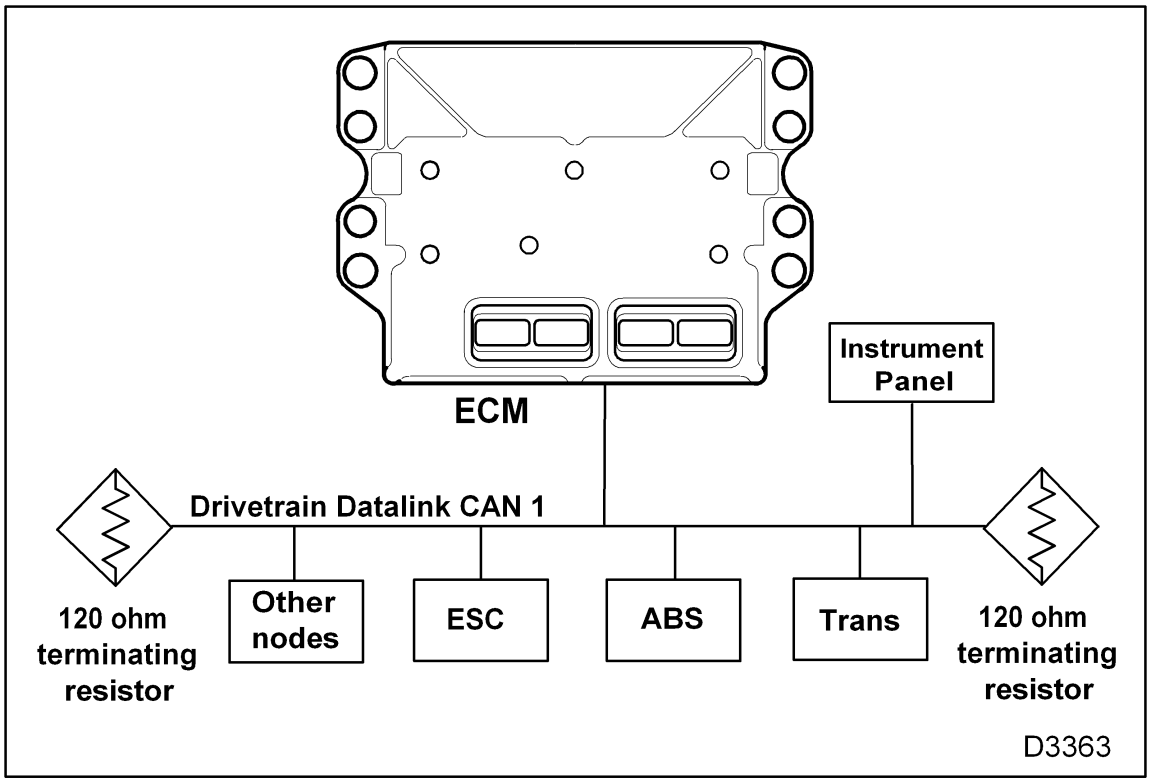

Figure 265 Function Diagram for the Controller Area Network (CAN)

The Function Diagram for the CAN includes the following:

- Electronic Control Module (ECM)
- Drivetrain Datalink (CAN 1)
- Terminating resistors – 120 ohm
- ENGINE lamp (amber)

Function

The Drivetrain Datalink is a Society of Automotive Engineers (SAE) term referring to one of the datalinks common to all trucks. The Drivetrain Datalink is the communication link for the Electronic Control Module (ECM), Electronic System Controller (ESC), and the instrument panel. The Drivetrain Datalink is also used for power train communication and control.

The engine controller transmits component information across the Drivetrain Datalink to the instrument panel. The following instrument panel components are in constant communication with the Drivetrain Datalink:

- Oil pressure gauge
- Engine oil temperature gauge
- Tachometer
- Speedometer
- Odometer / hourmeter
- Coolant temperature gauge
- Coolant level lamp
- Engine red lamp
- Engine amber lamp
- Change oil message
- Cruise / PTO control
- Wait to Start lamp

The ECM and ESC use the Drivetrain Datalink to provide the instrument panel with status information on the following features.

- Cruise control ON/OFF
- Cruise control Set / Cruise
- Cruise control resume / accelerate
- Cruise control clutch
- Brake pedal
- AC demand
- Self-test input
- Remote Accelerator Pedal (RPS)
- In-Cab PTO / Throttle switch

Fault Detection / Management

There are no engine DTCs for CAN 1 communications.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)

NOTE: See truck Chassis Electrical Circuit Diagram and Electrical System Troubleshooting Guide.

CAN Pin Point Diagnostics

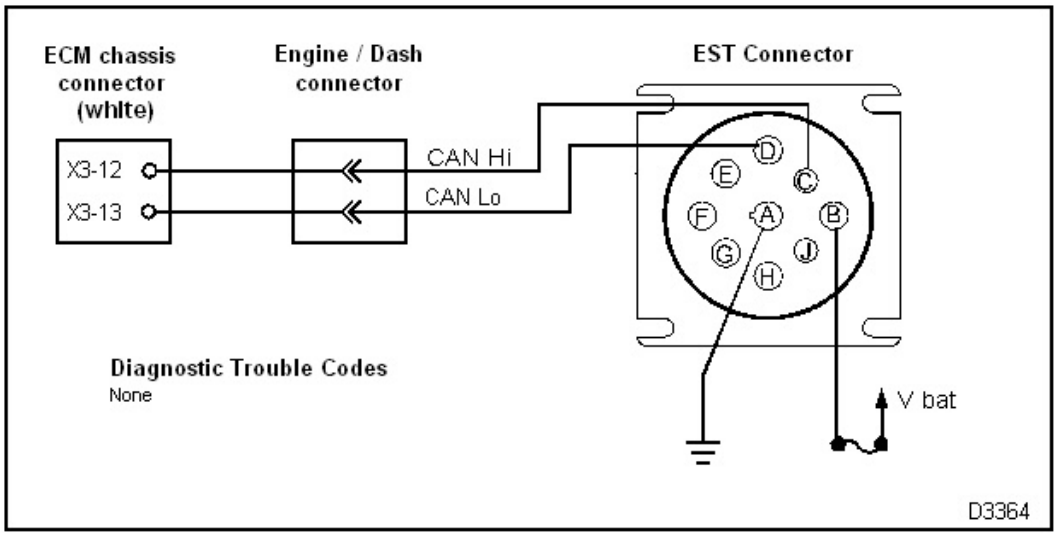

Figure 266 CAN Communication Circuit Diagram

Table 24

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.

Voltage Checks (Check at EST connector with Key ON Engine OFF.)

Test Point	Spec	Signal	Comments
B to A	B+	Power	Should be B+ power at B all times. If no power, check ground and power circuits. See truck Chassis Electrical Circuit Diagram manual.
C to A	C+	Power	Should be between 2-7V.
Resistance Checks (Turn ignition key OFF. Check at EST connector with negative battery cable disconnected.)			
C to A	>1MΩ	CAN+	If <1MΩ, a short between CAN+ and ground exists. Disconnect ECM X3 and check again. If short is no longer present, replace ECM. If short exists, harness or other node component defective.
D to A	>1MΩ	CAN-	If <1MΩ, a short between CAN – and ground exists. Disconnect ECM X3 and check again. If short is no longer present, replace ECM. If short still exists, harness or other node component defective.
C to D	60Ω	CAN	The datalink has two terminating resistors in parallel of 120Ω each. If >70Ω, check for missing terminating resister or open in the CAN+ or CAN – wires. If <50Ω, check for extra terminating resistor. If <5Ω, check for short between CAN+ and CAN –.

CRANKSHAFT POSITION (CKP) SENSOR

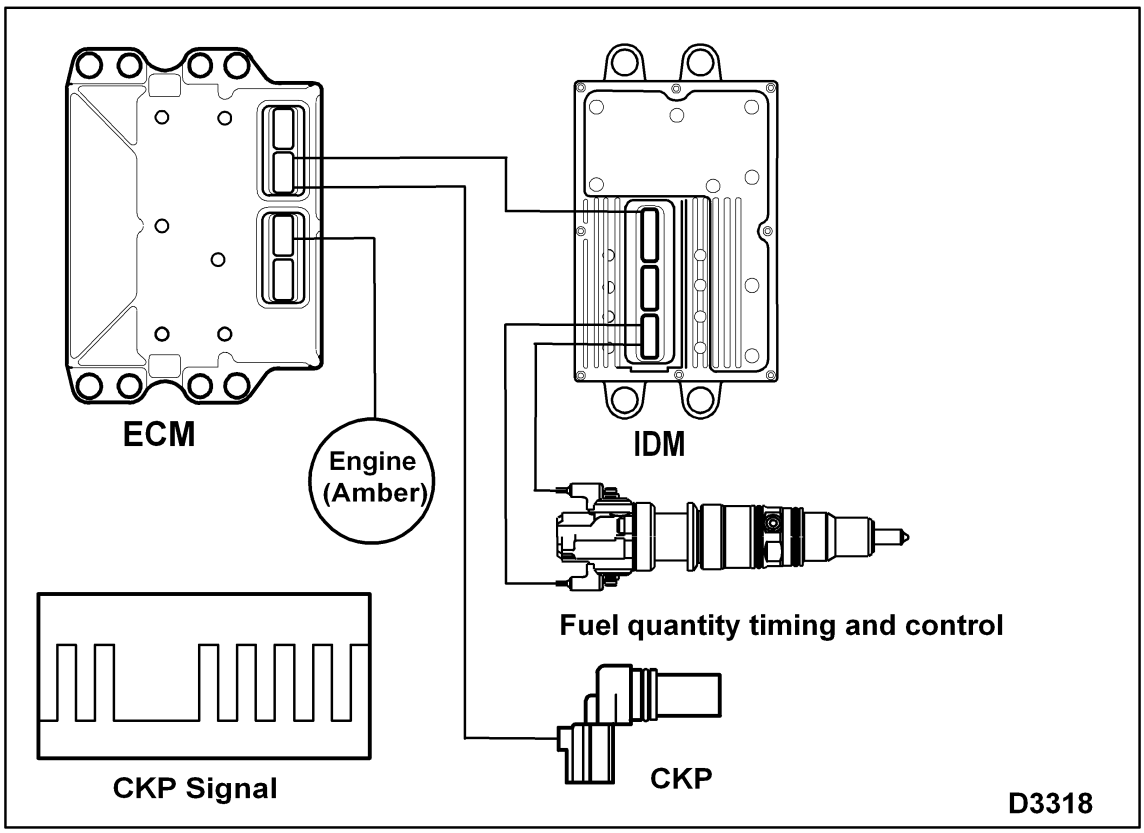

Figure 267 Function Diagram for the Crankshaft Position (CKP) Sensor

The Function Diagram for the CKP sensor includes the following:

- Crankshaft Position (CKP) sensor
- Electronic Control Module (ECM)
- Injector Driver Module (IDM)
- Fuel injector
- ENGINE lamp (amber)

Function

The crankshaft position signal source is a magnetic pickup sensor mounted in the right front side of the engine crankcase. 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.

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 compared to the CMP signal frequency, the ECM can calculate engine rpm and timing requirements. Diagnostic information on the CKP input signal is obtained by performing accuracy checks on frequency, and duty cycle with software strategies.

CKP Circuit Operation

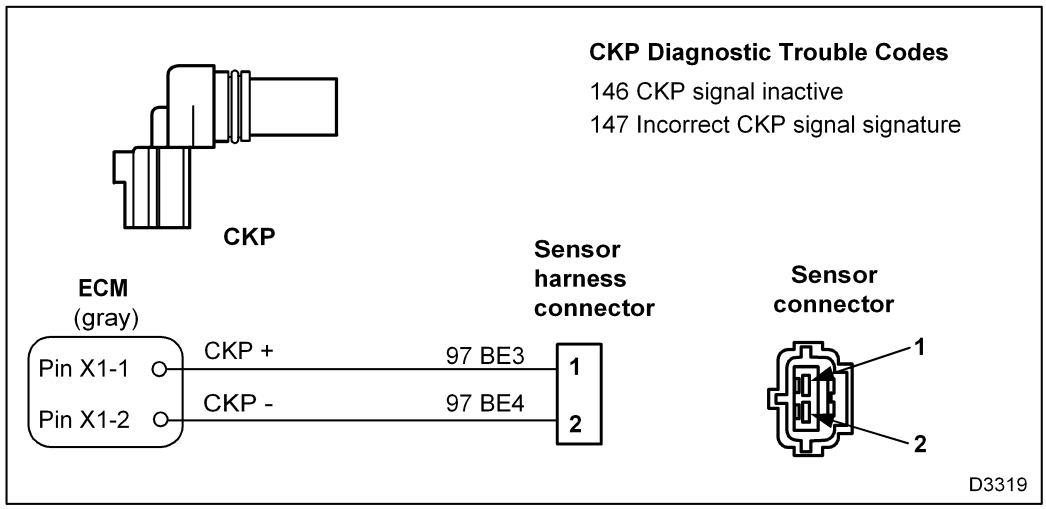

Figure 268 CKP Circuit Diagram

The ECM uses the CKP and CMP signal to calculate engine speed and position. The CKP creates a signal used by the ECM to indicate cylinder identification in a particular side. The CKP 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 terminals for the CKP sensor are CKP negative X1-2 and CKP positive X1-1.

NOTE: Engine will not operate without CKP signal. If rpm appears on EST, check ECM / IDM communication circuit in this section.

Fault / Detection Management

An inactive CKP signal during cranking is detectable by the ECM. During engine cranking the ECM monitors the CMP signal and Injection Control Pressure 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.

CKP Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

DTC 146
CKP sensor inactive

- DTC 146 is set by the ECM when no CKP signal is detected while the CMP signal is active and ICP has increased.
- DTC 146 can be set due to an open short to ground or voltage source in the CKP circuit. A defective CKP sensor can also set DTC 146.

DTC 147
Incorrect CKP signal signature

- DTC 147 is set by the ECM when the CKP signal has too few or many transitions per engine rotation.
- DTC 147 can be set due to an electrical noise in the CKP circuit or a defective CKP sensor.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)
- Breakout box

CKP Pin Point Diagnostics

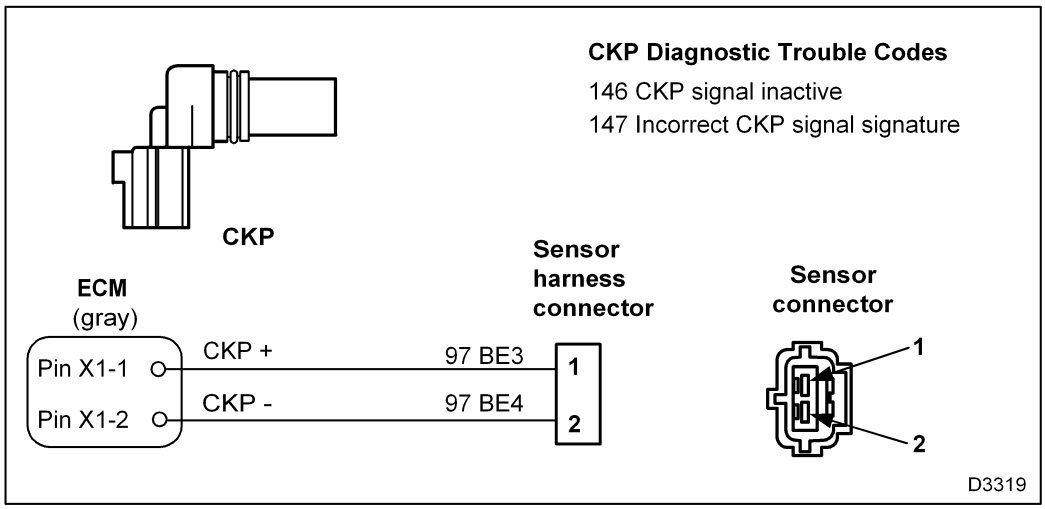

Figure 269

Table 25

Sensor Continuity Checks (Turn ignition key OFF. Check with breakout box installed on engine harness only and CKP sensor connected.)		
Test Point	**Spec**	**Comments**
X1–2 to X1–1	300–400Ω	Resistance through complete harness and sensor circuit.
Harness Resistance Checks (Check with sensor and negative battery cable disconnected. Install breakout box on engine harness only. Inspect for bent pins or corrosion.)		
X1–2 to 2	<5Ω	If >5Ω, check for open circuit.
X1–1 to 1	<5Ω	If >5Ω, check for open circuit.
X1–2 to gnd	>1kΩ	If <1kΩ, check for short to ground.
X1–1 to gnd	>1kΩ	If <1kΩ, check for short to ground.

Table 26

Operation Checks for CKP Sensor (Check with breakout box installed to ECM and engine harness.)				
Test Point	**Engine Cranking**	**Low Idle**	**High Idle**	**Comments**
CKP X1–1 to gnd X1–6	130–225 Hz @ 130–225 rpm	650–700 Hz @ 700 rpm	2.80k-3.00 Hz @ 2950 rpm	Set DMM to DCmV-Hz
Diagnostic Trouble Code Description				
DTC 146 = CKP signal inactive (CMP signal active and ICP increased)				
DTC 147 = Incorrect CKP signal signature				

CYLINDER BALANCE

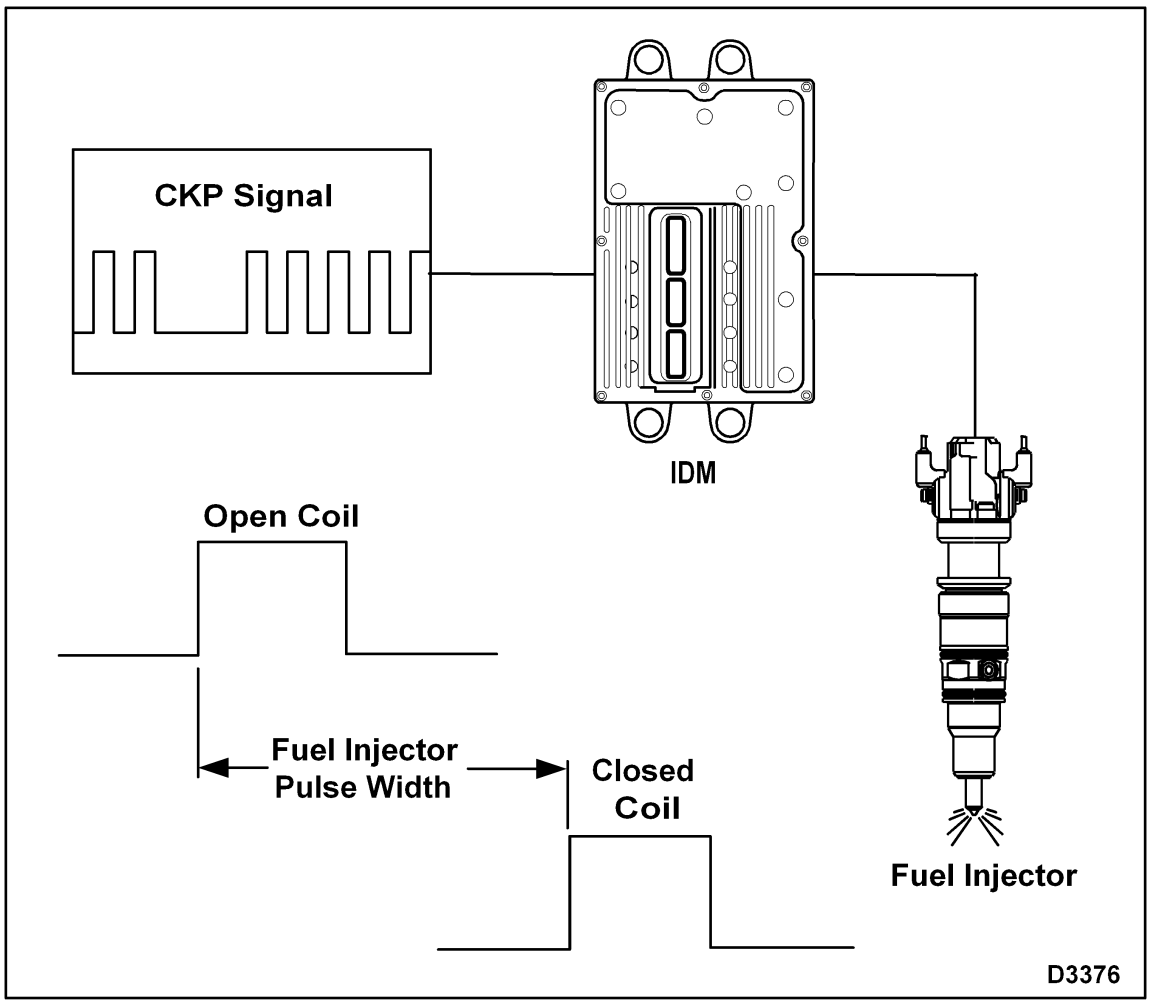

Figure 270 Cylinder Balance Function

Cylinder Balance Operation

Many factors can influence the combustion process in a power cylinder and thereby affect the production of torque or horsepower from that cylinder. These factors include piston and cylinder geometry, injector performance, and rail pressure. Variations in any of these factors can lead to unevenness in torque and horsepower from one cylinder to the next. Power cylinder unevenness can result in increased engine noise and vibration, especially at low idle conditions. This is also referred to as rough idle.

The IDM utilizes a Cylinder Balance control strategy in an attempt to even the power contribution of the cylinders, particularly at low idle conditions. This strategy incorporates information from the crankshaft position system. The IDM uses the instantaneous engine speed near Top Dead Center (TDC) for each cylinder as an indication of that cylinder's power contribution. The IDM 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 IDM 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.

Fault Detection / Management

While the engine is running, the IDM is constantly monitoring the crankshaft position system and can determine if the engine requires to be balanced. A DTC for Cylinder Balance will be set if the IDM is unable to balance the engine.

If a DTC for Cylinder Balance is set active, the IDM will turn off the Cylinder Balance strategy until the next key on cycle.

If a DTC for injector circuit is set active, the IDM will turn off the Cylinder Balance strategy. When the DTC changes to inactive the Cylinder Balance control will reset to on.

CYL BAL Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

DTC 571–578
Cylinder balance limit exceeded

- DTC 571–578 is set by the ECM when the IDM is unable to adjust fuel quantity to compensate for rough idle.

When DTCs are set for Cylinder Balance all Performance Diagnostics (section 6) should be performed.

ELECTRONIC CONTROL MODULE POWER (ECM PWR)

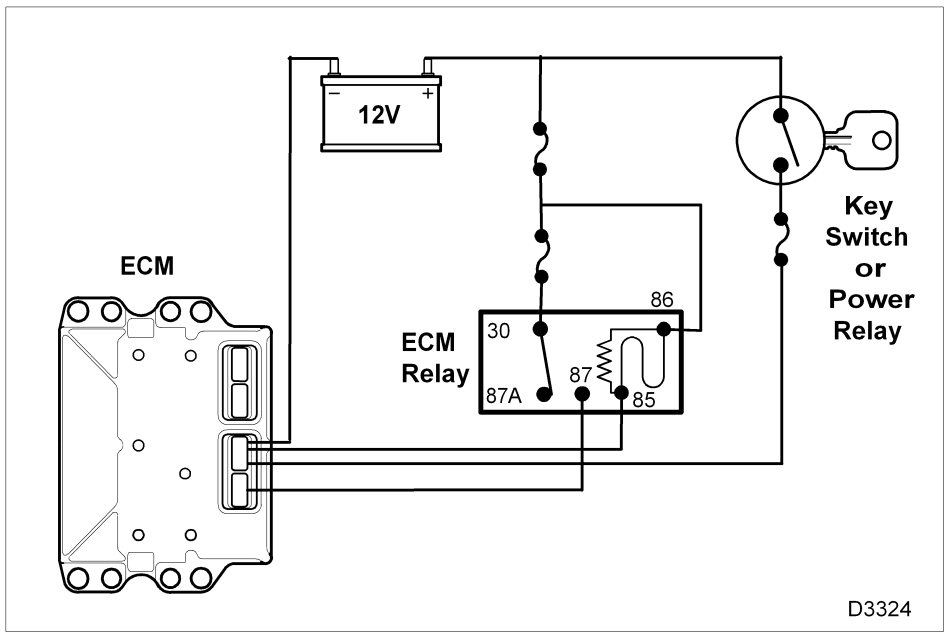

Figure 271 Function Diagram for the Electronic Control Module Power (ECM PWR)

The Function Diagram for ECM PWR includes the following:

- Electronic Control Module (ECM)
- Battery
- Electronic Control Module relay
- Ignition switch or power relay
- Fuses

Function

The Electronic Control Module (ECM) requires a 12V power source to function correctly. The operating power is received directly from the vehicle batteries through the ECM relay contacts each time the ignition key switch is turned ON.

Turning the ignition key switch ON causes the ECM to provide an internal ground to the coil side of the ECM relay. This causes the relay to close its contacts and provide the ECM with the power necessary to perform its various functions.

ECM PWR Circuit Operation

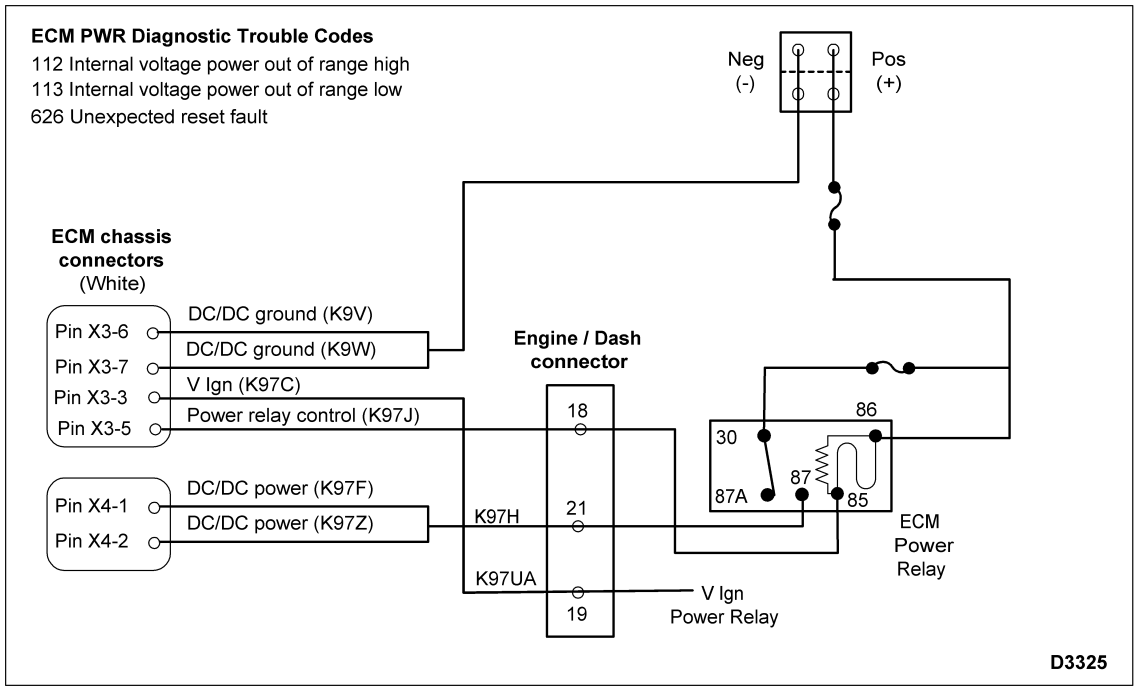

Figure 272 ECM PWR Circuit Diagram

The ECM is grounded directly to the battery negative terminal through ECM terminals X3-6 and X3-7.

The ECM receives V_{IGN} power at terminal X3-3. The power signals the ECM to provide a ground path to switch the ECM power relay from terminal X3-5 to 85. Switching the ECM relay provides power directly from the battery positive terminal through 2 fuses and relay contacts 30 and 87 to terminals X4-1 and X4-2. See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.

Fault Detection / Management

The ECM internally monitors battery voltage. When the ECM continuously receives less than 7V or more than 23V a Diagnostic Trouble Code (DTC) will be set.

ECM PWR Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

DTC 112
Internal voltage power out of range high

- DTC 112 is set when the ECM detects an alternator output greater than 23V at pin X3–3 for more than 0.5 sec.
- DTC 112 can be set when jump starting the engine and additional voltage is introduced. Incorrect external battery connections can cause the voltage increase.
- If the condition causing DTC 112 is intermittent, the code will change from active to inactive status. DTC 112 will not cause the amber ENGINE lamp to turn on.

DTC 113
Internal voltage power out of range low

- DTC 113 is set when the ECM detects less than 7.0V at pin X3–3 for more than 0.5 sec.
- DTC 113 can be set by a defective alternator or ECM power relay, discharged batteries, or increased resistance in the battery feed circuits.
- If the condition causing DTC 113 is intermittent, the code will change from active to inactive status. DTC 113 will not cause the amber ENGINE lamp to turn on.

NOTE: The ECM monitors voltage on V_{REF} A and will adjust signal values for the sensors that use V_{REF} A for operation. If a sensor or circuit pulls V_{REF} lower than 5V, the ECM may set out of range high DTCs for the sensors that operate on V_{REF} B (APS, BAP, B+, and VSS).

DTC 626
Unexpected reset fault

- DTC 626 is set when power is interrupted to the ECM. Loose or dirty connections at battery or ground cables can cause the ECM to power down.
- After circuit becomes intact, the ECM will reboot. Erratic engine performance can occur. Turning engine ignition key OFF and then ON will cause the code to change from active to inactive status.
- When DTC 626 is active, monitor the voltage at ECM pins X4–1 and X4–2. Examine for intermittent connections in the power feed wiring. The EST can be used to indicate DTCs and display the V_{IGN} voltage measured by the ECM to pin X3–3.
- DTC 626 will not turn the amber ENGINE lamp on.

When DTC 112 or 113 is active, see truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)
- Relay Breakout harness
- Breakout box
- Terminal Test Adapter Kit

ECM PWR Pin Point Diagnostics

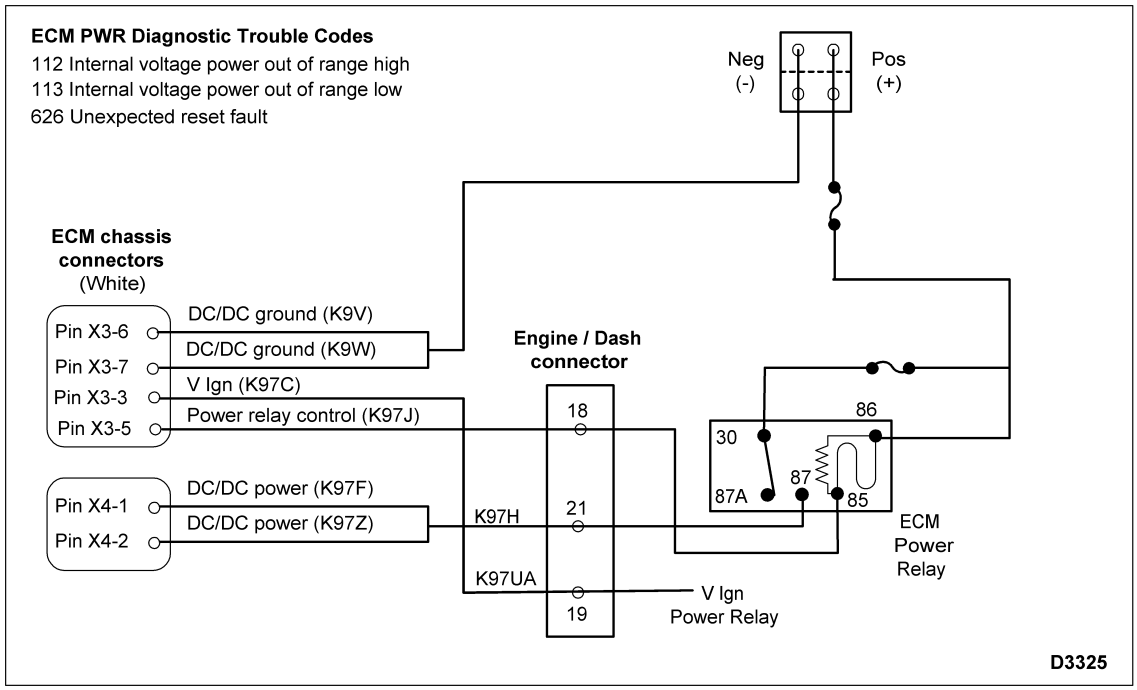

Figure 273 ECM PWR Circuit Diagram

The ECM PWR circuit requires the use of vehicle circuit diagrams. See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.

Table 27

CAUTION: To avoid engine damage, turn the ignition key to OFF before unplugging the connector or relay for the ECM. Failure to turn the key to OFF will cause a voltage spike and damage to electrical components.

Key ON Engine OFF – Voltage Checks at ECM Power Relay Socket (Follow tests in order. Check with ECM relay and breakout harness installed, ignition Key ON Engine OFF. Inspect for bent pins or corrosion.)

Test Point	Spec	Comments
86 to gnd	12V ±1.5	Continuous voltage. If no voltage, check power circuits from batteries through fuse. If fuse is blown, check for short to ground. If fuse is good, check for open between PIN 30 and B+. See truck Chassis Electrical Circuit Diagram manual for relay and fuse locations.
30 to gnd	12V ± 1.5	Continuous voltage. If no voltage, check fuses. If fuse is blown, check for short to ground. If fuse is good, check for open between PIN 30 and B+. See truck Chassis Electrical Circuit Diagram manual for fuse and relay locations.
85 to gnd	0.06 to 2V	If >2V is present, check for open circuit between PIN X3–5 to PIN 85 on relay or V_{IGN} circuit. See truck Chassis Electrical Circuit Diagram manual for relay and fuse locations.
87 to gnd	12V ±1.5	Continuous voltage. If no voltage, replace relay.

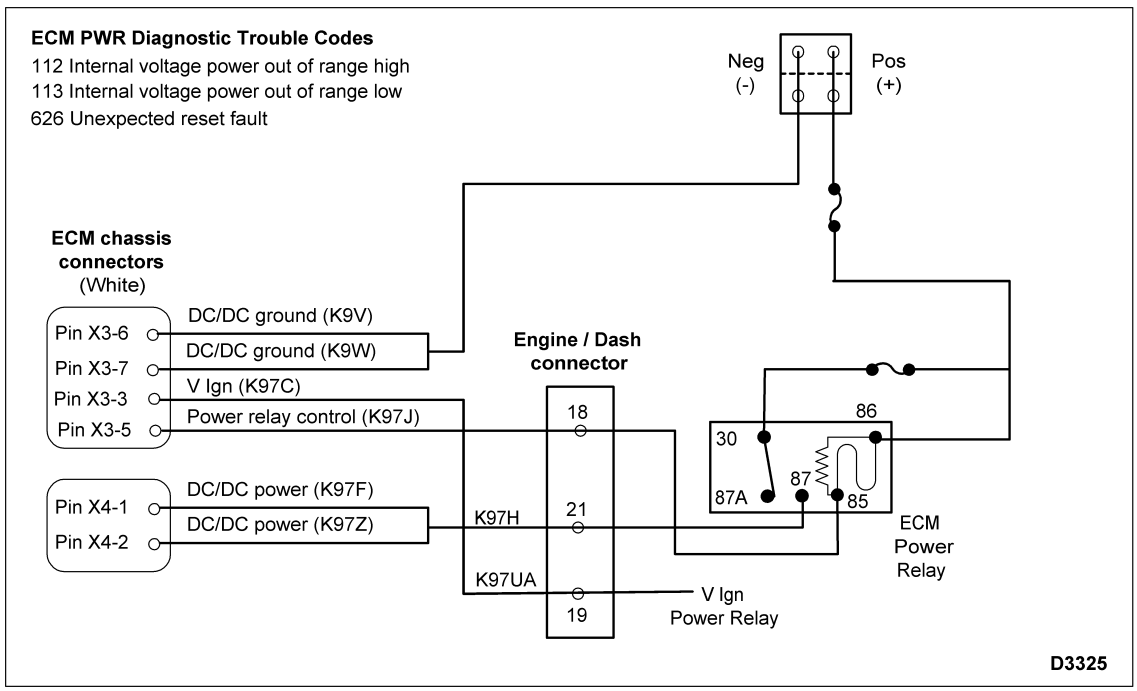

Figure 274 ECM PWR Circuit Diagram

Table 28

CAUTION: To avoid engine damage, turn the ignition key to OFF before unplugging the connector or relay for the ECM. Failure to turn the key to OFF will cause a voltage spike and damage to electrical components.

Key ON Engine OFF – Voltage Checks at ECM (Follow tests in order. Check with breakout box installed between chassis harness and ECM. Inspect for bent pins and corrosion.)

Test Point	Spec	Comments
X3–3 to gnd	12V ±1.5	Power from ignition switch to ECM. If no voltage, see truck Chassis Electrical Circuit Diagram manual for relay and fuse locations.
X3–6 to gnd	0V	Ground – voltage reading indicates poor ground to battery. If voltage is present check for open or high resistance between battery (–) and ECM pins.
X3–7 to gnd	0V	Ground – voltage reading indicates poor ground to battery. If voltage is present check for open or high resistance between battery (–) and ECM pins.
X3–5 to gnd	0.06–2V	ECM grounds relay through internal transistor. If >2V is present, replace ECM.
X4–1 to gnd	12V ±1.5	Power from relay to ECM. If no voltage, check for open between X4–1 and 87 on ECM relay. See truck Chassis Electrical Circuit Diagram manual for relay and fuse locations.
X4–2 to gnd	12V ±1.5	Power from relay to ECM. If no voltage, check for open between X4–2 and 87 on ECM relay. See truck Chassis Electrical Circuit Diagram manual for relay and fuse locations.

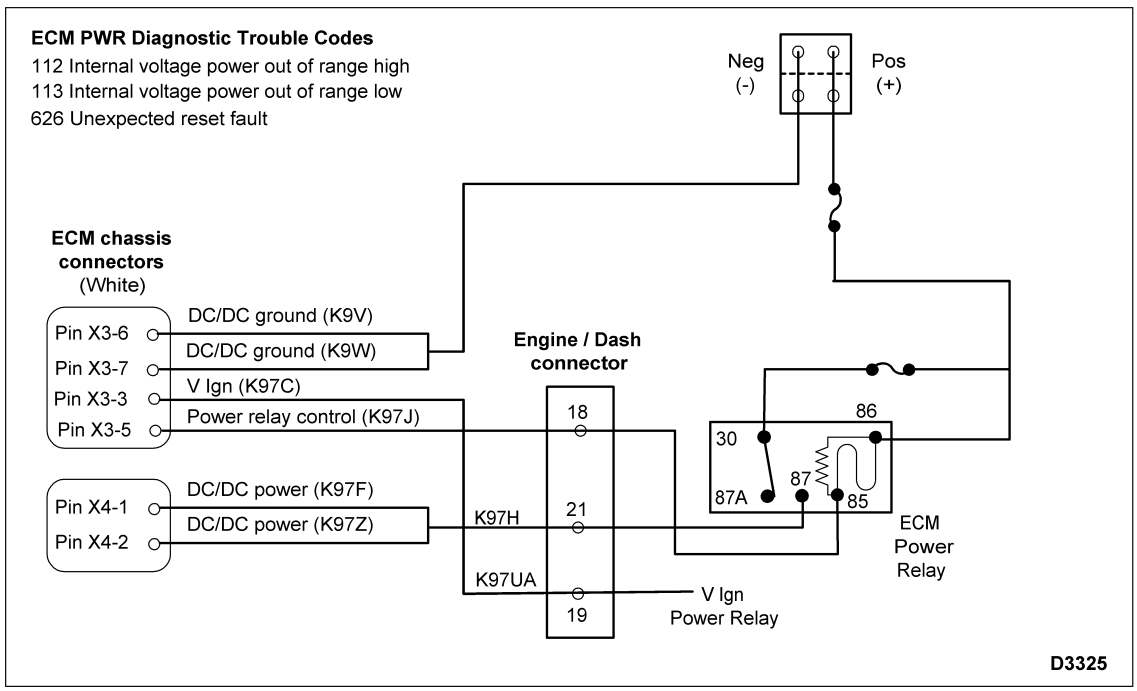

Figure 275 ECM PWR Circuit Diagram

Table 29

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.

CAUTION: To avoid engine damage, turn the ignition key to OFF before unplugging the connector or relay for the ECM. Failure to turn the key to OFF will cause a voltage spike and damage to electrical components.

Harness Resistance Checks (Check with Key OFF. Disconnect negative battery cable. Inspect for bent pins or corrosion. Install relay breakout harness and breakout box to X3 and X4 chassis harness only.)

Test Point	Spec	Comments
X3–5 to 85 (ECM relay)	<5Ω	If >5Ω, check connections for open between ECM and relay. See truck Chassis Electrical Circuit Diagram manual for relay and fuse locations.
X4–1 to 87 (ECM relay)	<5Ω	If >5Ω, check connections for open between ECM and relay. See truck Chassis Electrical Circuit Diagram manual for relay and fuse locations.
X4–2 to 87 (ECM relay)	<5Ω	If >5Ω, check connections for open between ECM and relay. See truck Chassis Electrical Circuit Diagram manual for relay and fuse locations.
30 (ECM relay) to B+ cable	<5Ω	If >5Ω, check connections for open between relay and positive battery cable. Check fuses. See truck Chassis Electrical Circuit Diagram manual for relay and fuse locations.
86 (ECM relay) to B+ cable	<5Ω	If >5Ω, check connections for open between relay and positive battery cable. Check fuse. See truck Chassis Electrical Circuit Diagram manual for relay and fuse locations.
X3–6 to neg bat cable	<5Ω	If >5Ω, check connections to battery ground. See truck Chassis Electrical Circuit Diagram manual for relay and fuse locations.
X3–7 to neg bat cable	<5Ω	If >5Ω, check connections to battery ground. See truck Chassis Electrical Circuit Diagram manual for relay and fuse locations.
X3–3 to V_{IGN} (power relay)	<5Ω	If >5Ω, check connections or open between ECM and V_{IGN} power relay. See truck Chassis Electrical Circuit Diagram manual for relay and fuse locations.

ECM PWR Diagnostic Trouble Code
DTC 112 = Internal voltage power out of range high >23V
DTC 113 = Internal voltage power out of range low <7V
DTC 626 = Unexpected reset fault

ELECTRONIC CONTROL MODULE (ECM) SELF DIAGNOSTICS

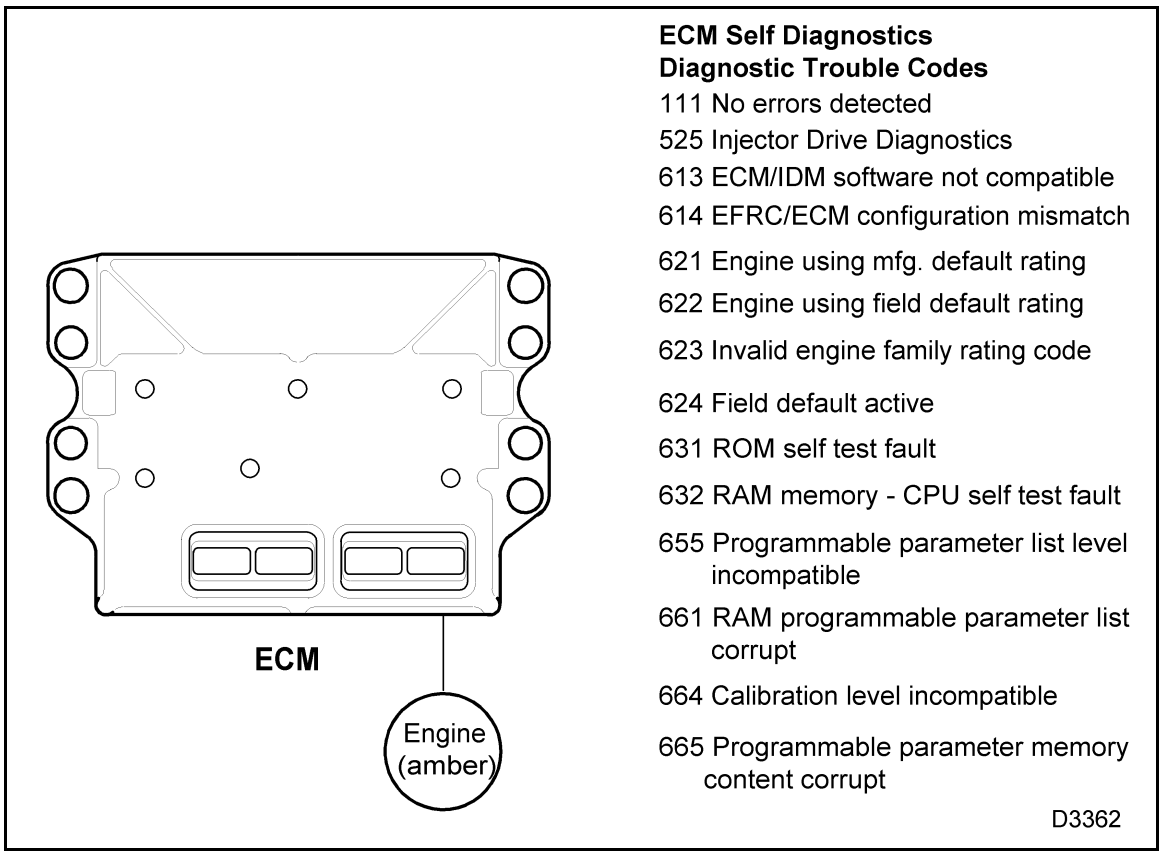

Figure 276 Electronic Control Module (ECM)

The ECM monitors and controls the engine operation and performance. The ECM also performs the following functions:

- Enables Power Takeoff and cruise control
- Communicates engine and vehicle information to instrument cluster
- Enables electronically controlled transmission (for vehicles with feature)
- Enables diagnostic programming tools

Fault Detection / Management

The ECM automatically performs diagnostic self-checks. The ECM self tests include memory, programming, and internal power supply checks. The ECM will detect internal Diagnostic Trouble Codes (DTCs), depending on the severity of the problem, and provide DTC management strategies to permit limited engine and vehicle operation.

When DTCs 613, 614, 621, 622, and 623 are set by the ECM, the amber ENGINE lamp will be illuminated.

ECM Self Diagnostic Trouble Codes (DTCs)

Table 30

DTC 111 – No errors detected	
Condition	No DTC conditions detected
Note:	Can only determine if ECM has detected continuous DTCs detected during an Output Circuit Check. DTCs generated during an On-Demand Test such as KOER Standard test can only be accessed by an EST.
DTC 613 – ECM / IDM software incompatible	
Condition	ECM / IDM software is incompatible
Symptoms:	Possible no start – low power
Possible Causes:	Field replacement ECM or IDM mismatch
Actions:	Replace with correct ECM or IDM
DTC 614 – ECM Memory / Programming Diagnostics	
Condition	EFRC / ECM configuration mismatch
Symptoms:	Possible hard start / no start or low power condition
Possible Causes:	Wrong Engine Family Rating Code (EFRC) selected for the ECM strategy programmed in the module.
Actions:	Check EFRC and verify that it matches the ECM strategy level. Reprogram the ECM or change the EFRC as required.
DTC 621 – Engine using mfg. default rating	
Condition	Manufacturing Defaults Selected.
Symptoms:	Very low power (25 hp).
Possible Causes:	Programmable parameters for the ECM were never programmed in module. (Usually occurs in new vehicle or new module).
Actions:	Program ECM.
DTC 622 –Engine using field default rating	
Condition	Engine using Field Default Rating.
Symptoms:	Low power (lowest rating in engine class) and vehicle features not working.
Possible Causes:	Programmable parameters for the ECM incorrectly programmed in module.
Actions:	Program ECM.
DTC 623 – Invalid engine family rating code	
Condition	Invalid EFRC
Symptoms:	Possible hard start and no start or low power condition.
Possible Causes:	Wrong EFRC selected for the ECM strategy programmed in the module.
Actions:	Check the EFRC and verify that it matches the ECM strategy level. Reprogram the ECM or change the EFRC as necessary.

DTC 624 – Field default active	
Condition	Field Defaults Active.
Symptoms:	Low power (lowest rating in engine class) and vehicle features not functioning.
Possible Causes:	Programmable parameters for the ECM incorrectly programmed in module.
Actions:	Program ECM
DTC 631 – Read Only Memory (ROM) self test fault	
Condition	ROM Self Test fault
Symptoms:	No Start.
Possible Causes:	Internal ECM problem.
Actions:	Replace the ECM.
DTC 632 – Random Access Memory (RAM) - Central Processing Unit (CPU) self test fault	
Condition	RAM Memory - CPU Self Test fault.
Symptoms:	No Start.
Possible Causes:	Internal ECM problem.
Actions:	Replace the ECM.
DTC 655 – Programmable parameter list level incompatible	
Condition	Programmable Parameter List Level Incompatible.
Symptoms:	No start or run in field defaults.
Possible Causes:	Programming problem or internal ECM problem.
Actions:	Program ECM
DTC 661 – RAM programmable parameter list corrupt	
Condition	RAM Programmable Parameter List Corrupt.
Symptoms:	No start or run in field defaults.
Possible Causes:	Internal ECM problem.
Actions:	Replace the ECM.
DTC 664 – Calibration level incompatible	
Condition	Calibration Level Incompatible.
Symptoms:	No start or run in field defaults.
Possible Causes:	Programmable problem or internal ECM problem.
Actions:	Program ECM
DTC 665 – Programmable parameter memory content corrupt	
Condition	Programmable Parameter Memory Content Corrupt.
Symptoms:	No start or run in field defaults.
Possible Causes:	Internal ECM problem.
Actions:	Replace the ECM.

ELECTRONIC CONTROL MODULE (ECM) / INJECTOR DRIVER MODULE (IDM) COMMUNICATIONS

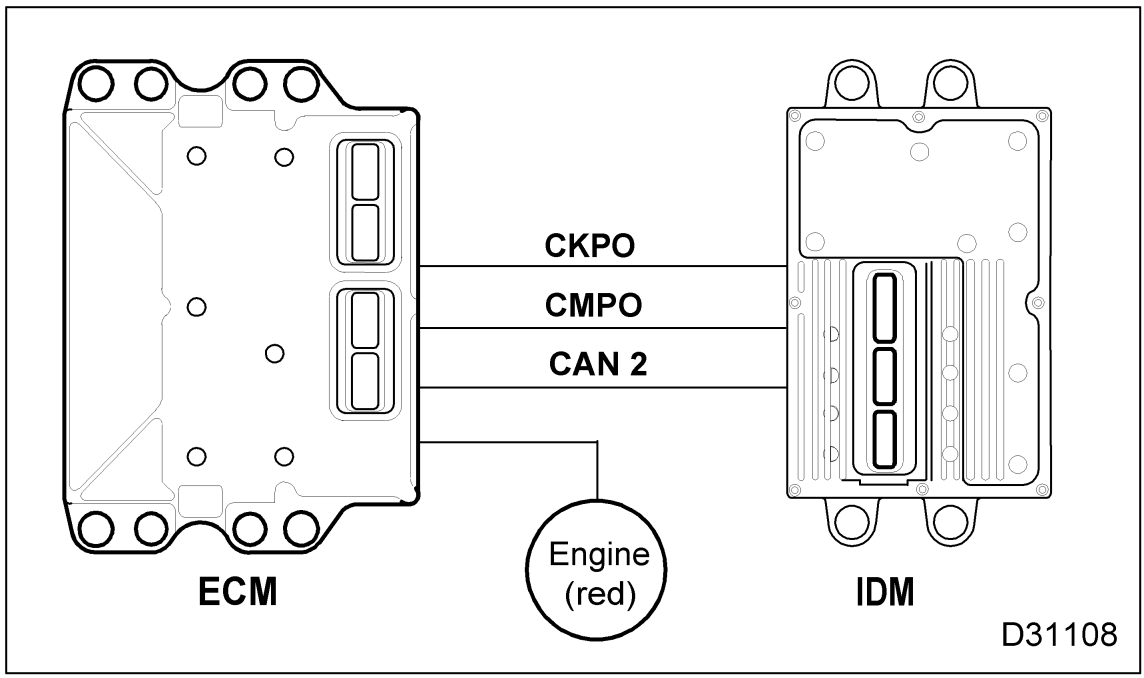

Figure 277 Function Diagram for the ECM / IDM Communication system

The Function Diagram for the ECM / IDM communication system includes the following:

- Electronic Control Module (ECM)
- Injector Driver Module (IDM)
- Crankshaft Position Output (CKPO) signal
- Camshaft Position Output (CMPO) signal
- Controller Area Network (CAN 2) link

Function

The Electronic Control Module (ECM) provides two output channels to aid the Injector Driver Module (IDM) with engine speed and position signals. The Crankshaft Position Output (CKPO) and Camshaft Position Output (CMPO) channels are in phase with the CKP and CMP signals received by the ECM.

The ECM and IDM are in continuous communication. The CKPO and CMPO convert the CKP and CMP signals into switching controls that interface with the IDM.

The Controller Area Network (CAN 2) link is a bi-directional communication line between the ECM and IDM. Both controllers use the link to send operating strategies, sensor information, diagnostic demands, and Diagnostic Trouble Codes (DTCs).

NOTE: The engine will not operate without the CAN 2, CKPO, or CMPO signal.

ECM / IDM Circuit Operation

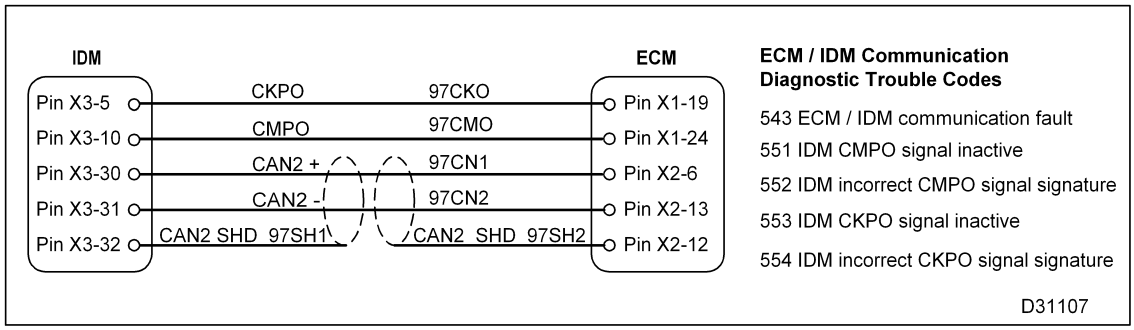

Figure 278 ECM / IDM Circuit Diagram

The ECM / IDM communication link consists of a series of interdependent signals that include the Crankshaft Position Output (CKPO), Camshaft Position Output (CMPO), and the Controller Area Network (CAN 2) link.

The CKPO signal is a 0 to 12V signal that communicates from the ECM to the IDM the position of the crankshaft. The signal is used by the IDM to synchronize the injector firing sequence and is calculated from the signal generated from the CKP sensor. The ECM generates the CKPO signal by pulling down (switching to ground) a 12V communication circuit in the IDM.

The CMPO signal is a 0 to 12V signal that communicates from the ECM to the IDM the position of the camshaft. The signal is used by the IDM to synchronize the injector firing sequence and is calculated from the signal generated from the CMP sensor. The ECM generates the CMPO signal by pulling down (switching to ground) a 12V communication circuit in the IDM.

CAN 2 is a J1939 high speed private communication link between the ECM and IDM. The ECM receives messages that include injector coil status, IDM calibration level, CMPO and CKPO DTCs, injector DTCs, IDM DTCs, and injector test results from the IDM. The IDM receives injector diagnostic commands, operation strategies, modes and conditions from the ECM.

NOTE: CAN 2 is used only as communication between the ECM and IDM. There is no relation to the CAN 1 link that is used for communication with various processors on a vehicle.

Fault Detection / Management

The ECM continuously monitors the IDM. When the ECM fails to receive required continuous communication from the IDM, the ECM will set a DTC.

ECM / IDM Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

DTC 543
ECM / IDM communication fault

- DTC 543 is set by the ECM when the ECM is not communicating with the IDM.
- DTC 543 can be set when CAN 2 J1939 between ECM and IDM is shorted to ground, V_{REF}, or battery or the current is open. If IDM power is low, DTC 543 can be set.
- When DTC 543 is active the amber ENGINE lamp is illuminated.

DTC 551
IDM / CMPO signal inactive

- DTC 551 is set by the ECM when no CMPO signal is present while the CKPO is active. DTC 551 can also be set when no CMPO/CKPO is present while the ECM reports it is in the run mode.
- DTC 551 can be set when the CMPO is open, or shorted to ground or shorted to a voltage source. If Logic power is low, DTC 551 can be set.

DTC 552
IDM incorrect CMPO signal signature

- DTC 552 is set when the CMPO transition occurs at the wrong CKPO tooth.
- DTC 552 can be set due to a camshaft incorrectly timed to crankshaft or an electrical noise creating a miscount on CMP location.

DTC 553
IDM / CKPO signal inactive

- DTC 553 is set by the ECM when no CKPO signal is present while the CMPO is active. DTC 552 can also be set when no CMPO/CKPO is present while the ECM reports it is in the run mode.
- DTC 553 can be set when CKPO is open, shorted to ground, or shorted to a voltage source. DTC 553 can also be set If logic power is low.

DTC 554
IDM incorrect CKPO signal signature

- DTC 554 is set by the ECM when CKPO signal has too few or too many transitions per engine rotation.
- DTC 554 can be set due to an electrical noise or a defective CKP sensor.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)
- Breakout box
- Terminal Test Adapter Kit

ECM / IDM Pin Point Diagnostics

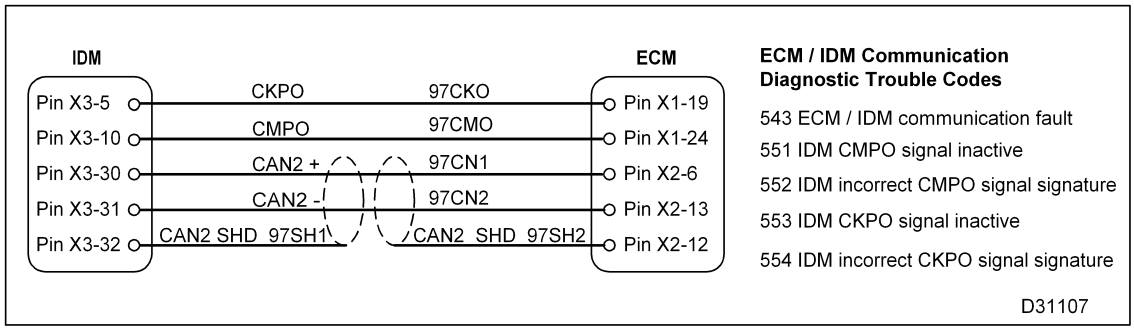

Figure 279 ECM / IDM Circuit Diagram

Table 31

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.

CAUTION: To avoid engine damage, turn the ignition key to OFF before unplugging the connector or relay for the ECM and IDM. Failure to turn the key to OFF will cause a voltage spike and damage to electrical components.

IDM Connector Voltage Checks to Chassis Ground (Check with breakout box on ECM engine harness connector X1 and X2 only. Turn ignition key ON and engine OFF. Do not connect breakout box to ECM. Inspect for bent pins or corrosion.)

Test Point	Spec	Comments
X2–6 to gnd	1–4V	Digital signal. If no voltage check for open or short to ground.
X2–13 to gnd	1–4V	Digital signal. If no voltage check for open or short to ground.
X1–19 to gnd	11–12V	If <11–12V, check for open or short to ground. Check IDM power relay.
X1–24 to gnd	11–12V	If <11–12V, check for open or short to ground. Check IDM power relay.
X2–12 to gnd	0V	Ground, no voltage expected

Resistance Checks to Chassis Ground (Check with breakout box on engine harness only at ECM connector X1 and X2. Turn ignition key OFF. Disconnect negative battery cable.)

X1–19 to gnd	>1kΩ	If <1kΩ, check for short to ground or internal IDM problem. Test with IDM connector X3 disconnected. If problem remains, repair or replace harness. If disconnect of X3 corrected problem, replace IDM.
X1–24 to gnd	>1kΩ	
X2–6 to gnd	>1kΩ	
X2–13 to gnd	>1kΩ	
X2–12 to gnd	<10Ω	If >10Ω, check for open in harness

Harness Resistance Checks (Check with breakout box on ECM harness only at ECM connector X1 and X2. IDM checked at harness connector X3 using terminal test pins. IDM terminals are numbered on the mating end of the connector.)

NOTE: Test points are from ECM to IDM.

ECM X1–19 to IDM X3–5	<5Ω	If >5Ω, check for open in harness
ECM X1–24 to IDM X3–10	<5Ω	If >5Ω, check for open in harness
ECM X2–6 to IDM X3–30	<5Ω	If >5Ω, check for open in harness
ECM X2–13 to IDM X3–31	<5Ω	If >5Ω, check for open in harness
ECM X2–12 to IDM X3–32	<5Ω	If >5Ω, check for open in harness

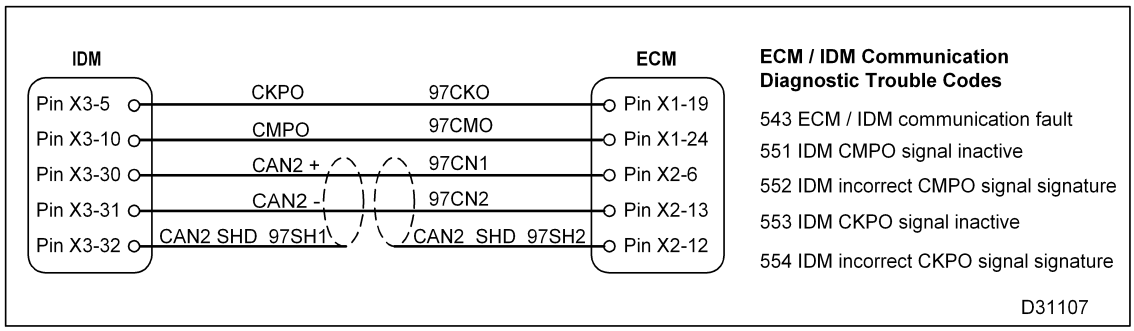

Figure 280 ECM / IDM Circuit Diagram

Table 32

Operational Checks for CMPO and CKPO (Check with breakout box installed to ECM and engine harness.)				
Test Point	**Engine Cranking**	**Low Idle**	**High Idle**	**Comments**
X1–24 to X1–6	130–225 rpm[2] @ 130–225 rpm	700 rpm[2] @ 700 rpm	2950 rpm [2] @ 2950 rpm	Set DMM to DC-rpm[2]
X1–19 to X1–6	130–225 Hz @ 130–225 rpm	700 Hz @ 700 rpm	2.95 Hz @ 2950 rpm	Set DMM to DC-Hz
Diagnostic Trouble Code Description				
DTC 543 = ECM / IDM communication fault				
DTC 551 = IDM CMPO signal inactive				
DTC 552 = IDM incorrect CMPO signal signature				
DTC 553 = IDM CKPO signal inactive				
DTC 554 = IDM incorrect CKPO signal signature				

ENGINE COOLANT LEVEL (ECL) SENSOR

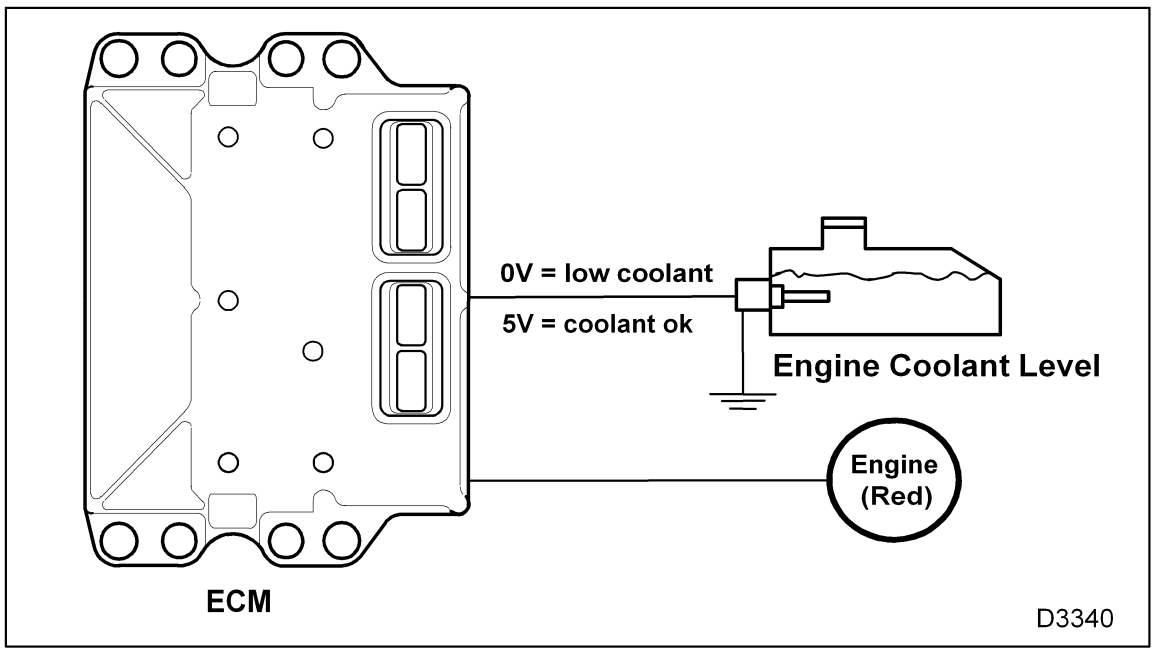

Figure 281 Function Diagram for the Engine Coolant Level (ECL) System

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.

The ECL system includes the Electronic Control Module (ECM) and the engine coolant tank with a coolant level sensor. The ECL sensor is in the deaeration tank on the radiator.

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. The feature can not be enabled if the ECM was not factory programmed for 3-way protection.

ECL Circuit Operation

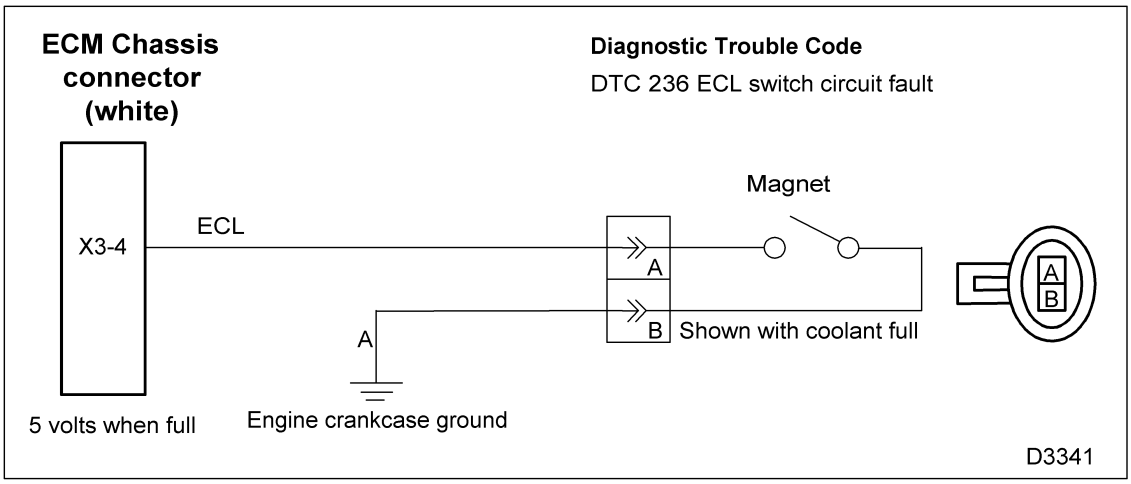

Figure 282 ECL Circuit Diagram

The coolant level sensor 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 5V signal at ECM pin X3–4. When the level is low, the switch will close and ECM pin X3–4 will be 0V.

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, DTC 236 will be set.

ECL Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

DTC 236
ECL switch circuit DTC

- DTC 236 is set when the ECM detects an in-range voltage more than 3.4V or less than 4.3V at ECM PIN X3–4 for more than 2.0 seconds.
- DTC 236 can be set when a high resistance connection or intermittent short to ground in the circuit exists.
- DTC 236 will not cause the red ENGINE lamp to illuminate. If the condition is intermittent, the DTC will be logged as inactive.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)
- Breakout box

ECL Pin Point Diagnostics

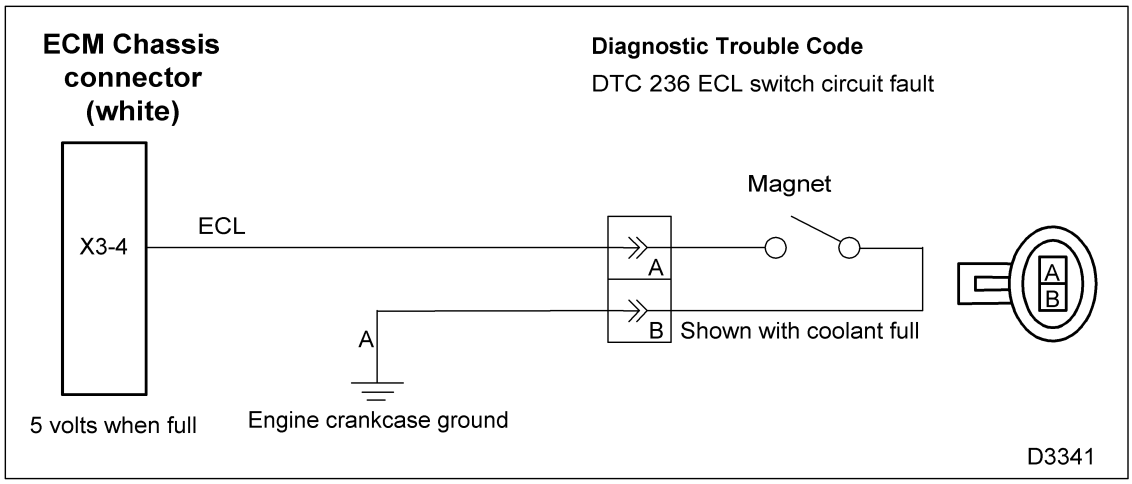

Figure 283 ECL System Circuit Diagram

The ECL circuit may require the use of vehicle circuit diagrams. See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.

Table 33

Coolant Level Sensor Connector (Disconnect sensor from harness and turn ignition key ON. Test with coolant level full.) **Note:**After removing connector, inspect for damaged pins, corrosion, or loose terminals. Repair as required.		
Test Point	**Spec**	**Comments**
A to gnd	5V ±0.5	If voltage <5V, check for open signal circuit or defective ECM.
B to gnd	0V	If voltage >0V, check for signal circuit shorted to another circuit
Sensor Resistance Checks (Disconnect sensor connector and measure across sensor)		
A to B	>1kΩ	If <1kΩ, check for low coolant, defective sensor, or shorted sensor harness.
Harness Resistance Checks (Turn ignition key OFF. Install breakout box on chassis harness only. Disconnect sensor.)		
B to gnd	<5Ω	If >5Ω, check for open ground wire
X3-4 to A	<5Ω	If >5Ω, check for open signal wire (breakout box installed)
Operational Voltage Checks (Check with breakout box installed and sensor connected. Turn ignition key ON.)		
X3-4 to X3-7	5V	Voltage >4.3V with tank full. Voltage <3.4V with tank empty (use breakout box)
ECL Diagnostic Trouble Code		
DTC 236 = Signal voltage was >3.4V or <4.3V more than 2.0 seconds.		

ENGINE COOLANT TEMPERATURE (ECT) SENSOR

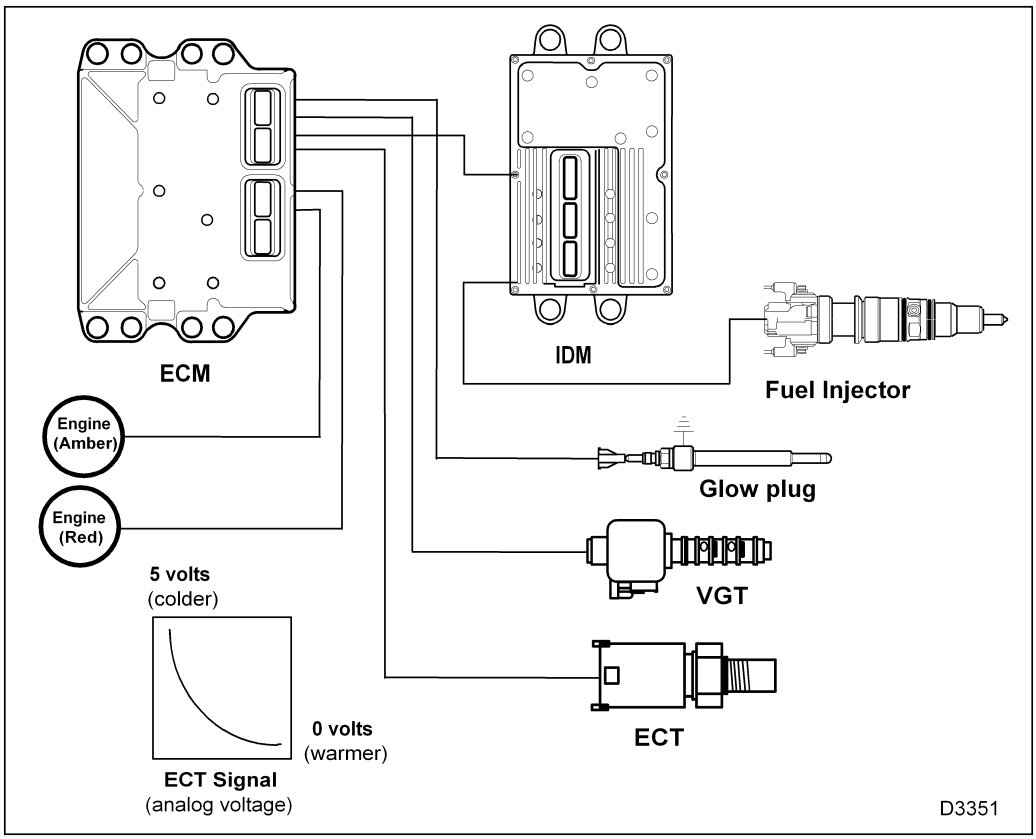

Figure 284 Function Diagram for the Engine Coolant Temperature (ECT) Sensor

The Function Diagram for the ECT sensor includes the following:

- Engine Coolant Temperature (ECT) sensor
- Electronic Control Module (ECM)
- Injector Drive Module (IDM)
- Fuel injector
- Glow plugs
- Variable Geometry Turbocharger (VGT) actuator
- ENGINE lamp (amber and red)

Function

The ECT sensor is a thermistor sensor located on the left side of the front cover. The ECM supplies a 5V reference signal which the ECT sensor uses to produce an analog voltage that indicates temperature.

The ECT sensor changes resistance when exposed to different temperatures. When the temperature of the coolant decreases, the resistance of the thermistor increases and the voltage signal increases. As the temperature of the coolant increases, the resistance of the thermistor decreases and the voltage signal decreases.

The ECT sensor provides a feedback signal to the ECM indicating engine coolant temperature. The ECM monitors the ECT signal to control the following features:

- EWPS
- CAP
- IST
- Cold idle advance
- Coolant compensation
- Glowplug operation

During engine operation, if the ECM recognizes that the ECT signal is lower or higher than the expected value it will set a DTC.

Coolant Temperature Compensation

Coolant Temperature Compensation reduces fuel delivery if Engine Coolant Temperature (ECT) is above cooling system specifications.

The reduction in fuel delivery begins when ECT reaches approximately 107°C (224.6°F). A relatively rapid reduction of 15% will be achieved as the ECT reaches approximately 109°C (229°F).

The red ENGINE lamp will come on 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 121°C (250°F), if 3 way protection is disabled.

Fuel reduction is calibrated to a maximum of 40% 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.

Cold Idle Advance

Cold idle advance increases engine cold idle speed (fast idle) up to 875 rpm (normally 700 rpm) for faster warm-up to operating temperature. This is accomplished by the ECM monitoring the ECT sensor input and adjusting the fuel injector operation accordingly.

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

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.

ECT Circuit Operation

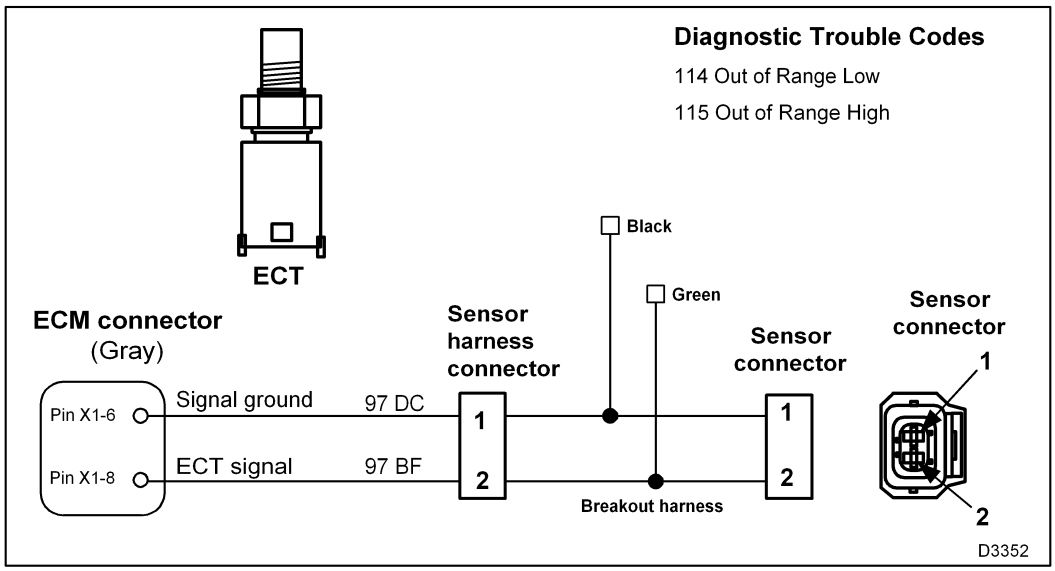

Figure 285 ECT Circuit Diagram

The ECT sensor is supplied with a 5V reference voltage at terminal 2 from ECM terminal X1–8. The sensor is grounded at terminal 1 through the signal ground terminal at the ECM terminal X1–6. When the coolant temperature increases or decreases, the sensor changes resistance and provides the coolant temperature signal voltage at the ECM. The signal voltage is read by the ECM to determine the temperature of the coolant.

Fault Detection / Management

The ECM continuously monitors the signal of the ECT sensor to determine if the signal is within an expected range. If the ECM detects an out of range high or low, the ECM will ignore the ECT signal and assume an engine coolant temperature of -34°C (-29°F) for starting and 82°C (180°F) for engine running conditions. When this occurs, the EWPS, CAP, IST, cold idle advance, and coolant compensation features are disabled.

ECT Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

DTC 114
Out of range low

- DTC 114 set by the ECM when the ECT signal is less than 0.127V for more than 0.35 second.
- DTC 114 can set due to a short to ground in the signal circuit or a defective sensor.
- When DTC 114 is active the amber ENGINE lamp is illuminated.

DTC 115
Out of range high

- DTC 115 set by the ECM when the ECT signal is more than 4.6V for more than 0.35 second.
- DTC 115 can set due to an open signal or ground circuit, a short to a voltage source, or a defective sensor.
- When DTC 115 is active the amber ENGINE lamp is illuminated.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)
- Harness – 3-Banana plug and 500 ohm
- Breakout box and harness
- Terminal Test Adapter Kit

ECT Operational Diagnostics

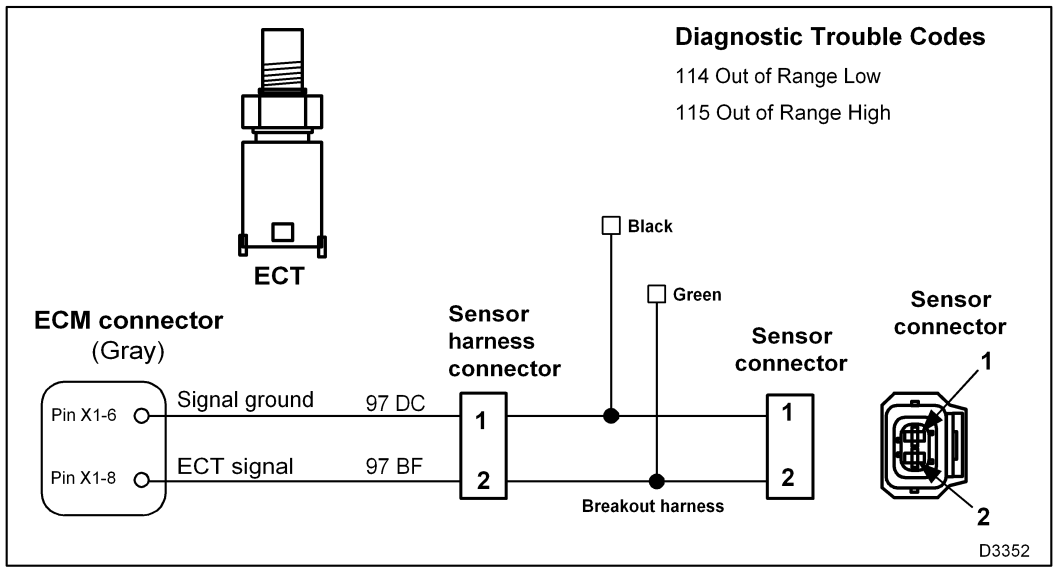

Figure 286 ECT Circuit Diagram

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

Be careful to avoid rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the continuous monitor session. To monitor signal voltage, run Key ON Engine OFF Continuous Monitor Test.

2. Monitor ECT signal volts. Verify an active DTC for the ECT circuit.

3. If code is active, complete step 5 and do circuit check for the ECT sensor in table on the following page.

4. If code is inactive, wiggle connectors and wires at all suspected problem locations. If circuit continuity is interrupted, the EST will beep and display DTCs related to the condition.

5. Install temperature sensor breakout harness to engine harness only.

NOTE: After removing connector, inspect for damaged pins, corrosion, or loose terminals. Repair as required.

Table 34

Circuit Checks for ECT Sensor (Use EST, breakout harness, and wire harnesses – 3-Banana plug and 500 ohm.)

Test Condition	Spec	Checks
Sensor disconnected	>4.6V	If voltage < 4.6V, check signal circuit for short to ground.
3–Banana plug harness installed between GREEN and BLACK pins of breakout harness.	0V	If voltage is >0.127V, check ground and signal circuit for open or high resistance. Use a breakout box and measure resistance from PIN 1 to PIN X1–6 and from PIN 2 to X1–8 (spec <5Ω).
500 ohm harness installed between GREEN and BLACK pins of breakout harness.	<1.0V	If voltage >1.0V, check signal circuit for short to V_{REF}, B+, or another sensor's signal voltage.

6. Connect engine harness to sensor. Use the EST to clear DTCs. If an active code remains after checking test conditions, replace the ECT sensor.

ECT Pin Point Diagnostics

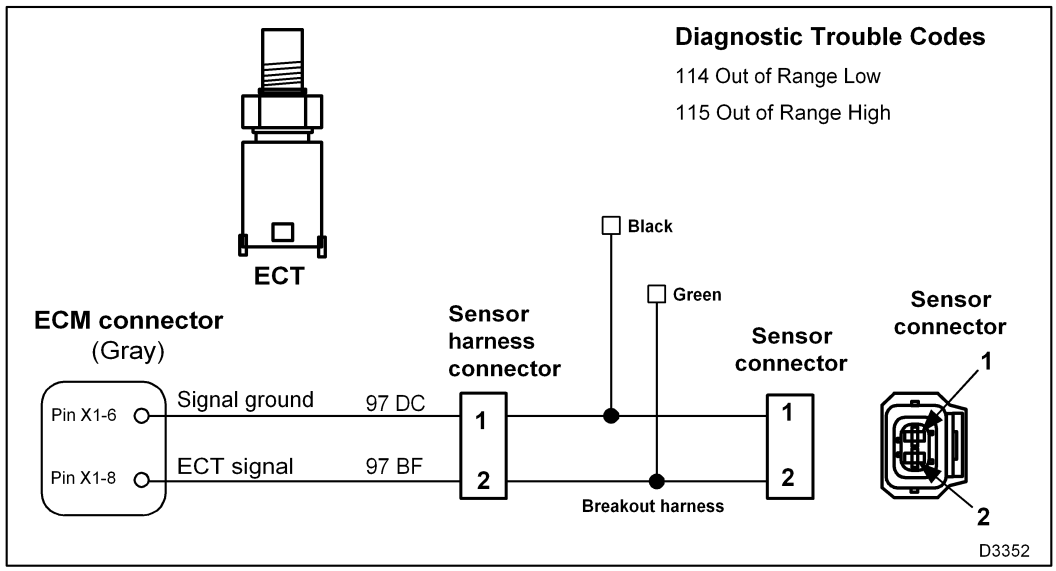

Figure 287 ECT Circuit Diagram

Table 35

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.

Connector Voltage Checks (Disconnect sensor from harness and turn ignition key ON.)

Test Point	Spec	Comments
2 to gnd	4.6–5.0V	Pull up voltage, if no voltage or low, circuit is open, has high resistance, or short to ground
1 to gnd	0–0.25V	Voltage >0.25V, wire shorted to V_{REF} or B+.
Connector Resistance Checks to Chassis Ground (Turn ignition key OFF. Disconnect negative battery cable and sensor connector.)		
1 to gnd	<5Ω	If >5Ω, check for open ground circuit
2 to gnd	>1kΩ	If <1kΩ, check for shorted signal to ground
Harness Resistance Checks (Install breakout box on engine harness only.)		
X1–6 to 1	<5Ω	If >5Ω, check for open ground wire
X1–8 to 2	<5Ω	If >5Ω, check for open signal wire

Table 36

Operational Voltage Checks for ECT Sensor (Check with breakout box installed to ECM and engine harness.)			
Test Point	**Coolant Temp °C (°F)**	**Resistance**	**Voltage**
X1–8 to X1–6	108°C (228°F)	1.605kΩ	0.37V
X1–8 to X1–6	87.7°C (190°F)	3kΩ	0.65V
X1–8 to X1–6	0°C (32°F)	94.1kΩ	3.86V
X1–8 to X1–6	–17.7°C (0°F)	210kΩ	4.25V
ECT Diagnostic Trouble Code			
DTC 114 = Signal voltage was <0.127V for more than 0.35 second.			
DTC 115 = Signal voltage was >4.6V for more than 0.35 second.			
DTC 316 = See Engine Warning and Protection System (EWPS)			
DTC 321 = See Engine Warning and Protection System (EWPS)			
DTC 322 = See Engine Warning and Protection System (EWPS)			
DTC 325 = See Engine Warning and Protection System (EWPS)			

ENGINE CRANK INHIBIT (ECI) SYSTEM

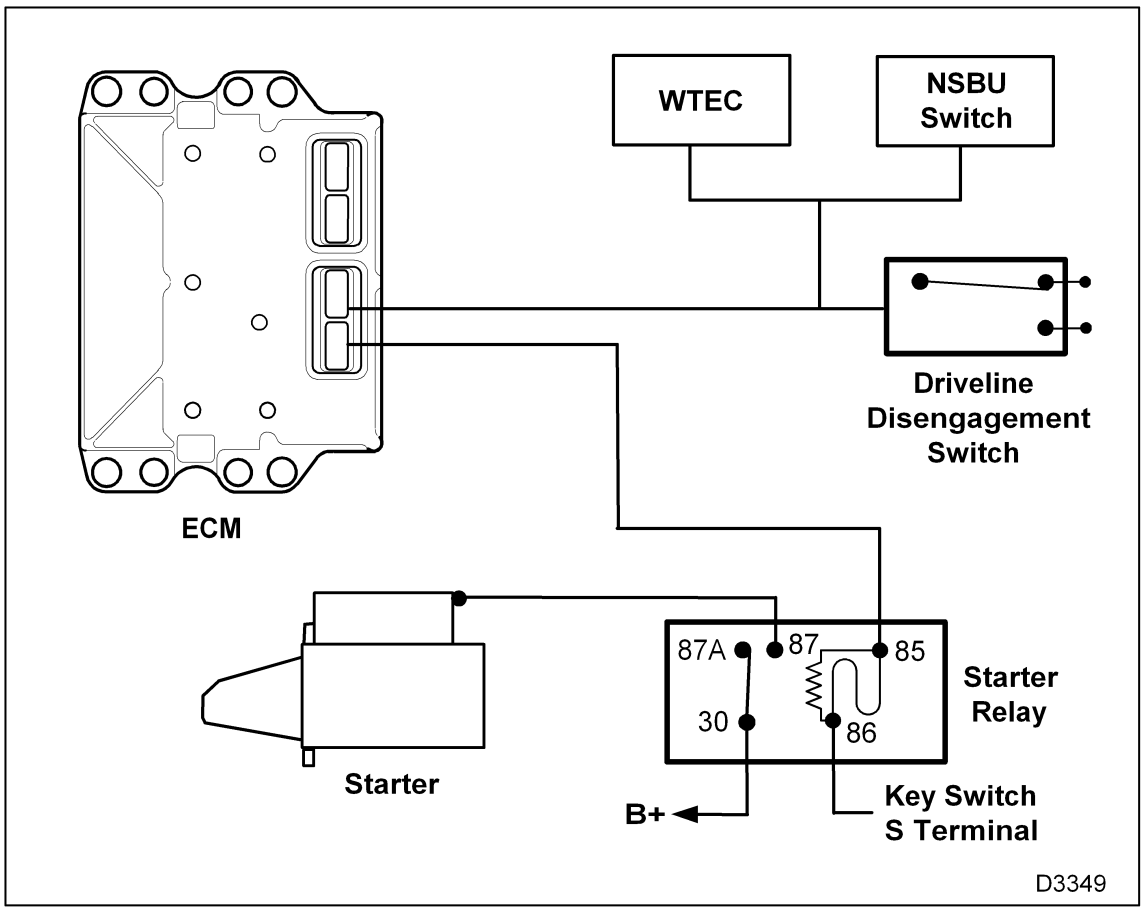

Figure 288 Function Diagram for Engine Crank Inhibit (ECI) System

The Function Diagram for the ECI system consists of the following.

- Electronic Control Module (ECM)
- Starter
- Starter relay
- World Transmission Electronically Controlled (WTEC)
- Neutral Start Backup Switch (NSBU)
- Driveline Disengagement Switch (DDS)

Function

The Engine Crank Inhibit (ECI) is a function of the ECM to control the operation of the cranking motor. The ECM prevents engagement of the cranking motor when the engine is running. This prevents damage to the starter pinion and ring gear. The transmission neutral safety switch or clutch switch prevents engagement of the cranking motor when the transmission is in gear or when the clutch pedal is not depressed.

The engine starter relay controls battery voltage to the crank motor solenoid. The starter relay can also be controlled by an optional over crank thermocouple.

Operation

The ECM controls the starting system. The clutch switch or transmission neutral switch provide input to the ECM. Both switches prevent the cranking motor from being engaged unless the transmission is in neutral or the clutch is depressed.

Start Relay

The engine starter relay controls voltage to the starter motor. Turning the ignition key to start position supplies current to energize the relay at terminal 86. If the engine is not running and the driveline is not engaged, the ECM terminal X3–23 will enable the relay by suppling a ground circuit to terminal 85 of the relay. When the relay is closed, current passes through the relay to the terminals on the cranking motor solenoid.

Before troubleshooting, inspect circuit connectors for loose or damaged terminals or wires. Wires and connections must be free of damage or corrosion. When connectors corrode, a white residue will be present and must be removed. Make sure the batteries are fully charged. To ensure accurate readings, check battery cables and grounds for clean and tight connections.

Clutch Switch

Manual transmissions use the clutch switch to supply a signal to the ECM indicating that the driveline is disengaged. A 12V signal on the Driveline Disengagement Switch (DDS) circuit indicates that the clutch is disengaged. A 0V 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 12V signal on the DDS circuit indicating that the transmission is out of gear. A 0V 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 ECU controls 12V to pin 86 of the starter relay. Pin X3–8 of the ECM receives 12V from the WTEC Auto Neutral relay when the transmission is shifted to neutral or auto neutral. Without the additional relay, the DDS input (pin X3–8) allows cranking in auto neutral.

Electronic Control Module (ECM)

When the ECM recognizes that the engine is not running and the driveline is not engaged, the ECM will ground terminal X3–23. 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 terminal X3–23. This prevents the ECI relay from closing and the starter motor from engaging.

Fault Detection / Management

When the on demand Engine ON standard test is run, an open or short to ground can be detected on the coil side of the ECI relay.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)
- Breakout box
- Harness – 3-Banana plug and 500 ohm
- Relay breakout harness

ECI Circuit Diagnostics

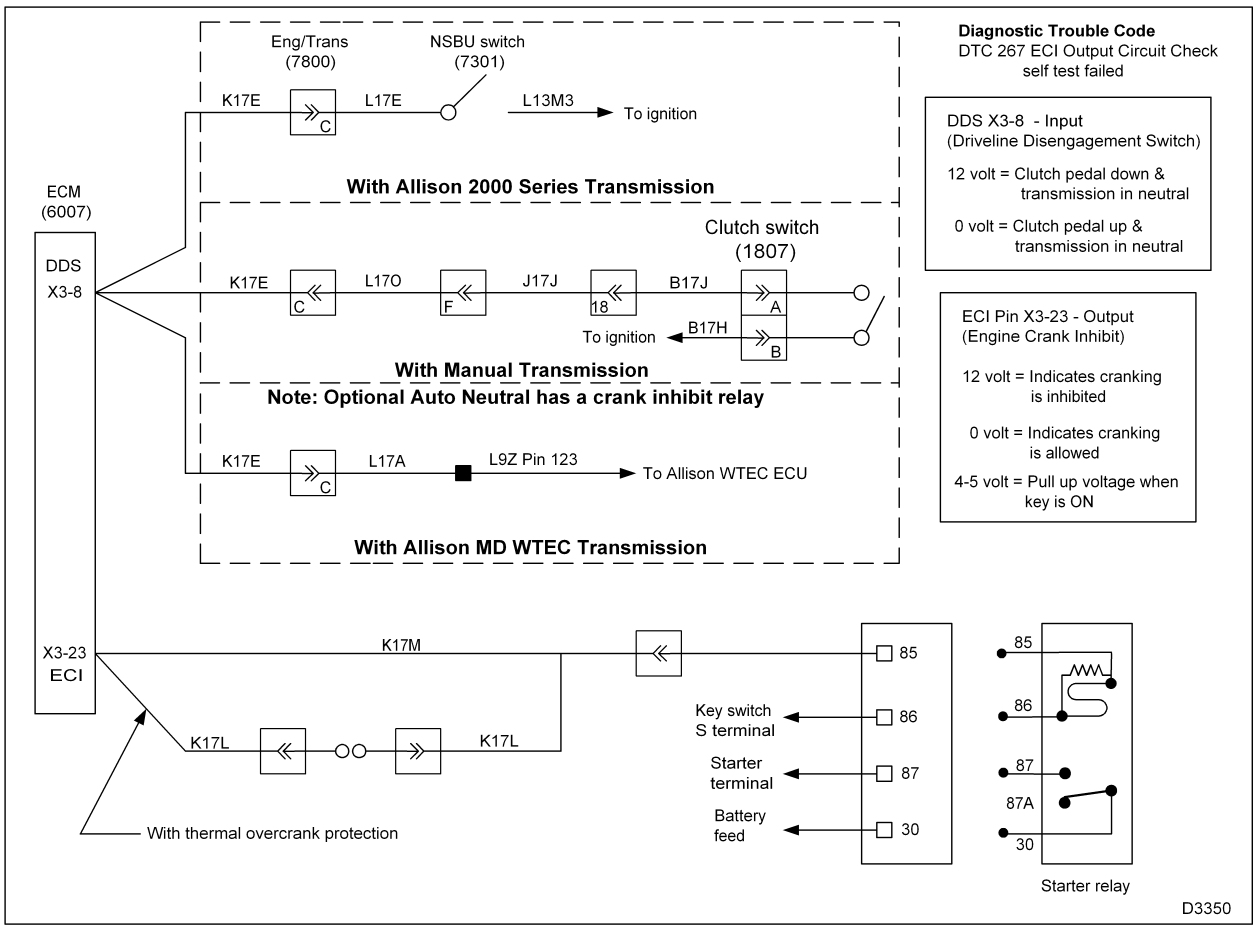

Figure 289 ECI Circuit Diagram

The ECI circuit requires the use of vehicle circuit diagrams. See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.

Table 37

ECI Relay Voltage Checks (Turn ignition key ON. Check with ECI relay removed.)		
Test Point	**Spec**	**Comments**
86 to gnd	12V ±1.5	Check with relay unplugged and starter switch (key or button) engaged. If no voltage present, troubleshoot ignition crank circuit.
30 to gnd	12V ± 1.5	If no voltage is present, troubleshoot battery wiring.
85 to gnd	4 to 5V	ECM will pull circuit up to 4V to 5V with key ON and go to 0V when the clutch is depressed or transmission is in neutral.

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

When running the engine in the service bay, make sure the parking brake is set, the transmission is in neutral, and the wheels are blocked.

ECI Circuit Test – With the transmission out of gear and the clutch depressed with wheels safely blocked, insert a harness between socket pins 86 and 87 of the starter relay. If the engine cranks when the start switch is engaged, check for failed ECI relay or problems with the ECM or ECM wiring harness.

Table 38

ECI Chassis Circuit Checks (Check with ECI relay installed and breakout box connected.)		
Test Point	**Spec**	**Comments**
X3–8 to X3–7	0V or 12V	Manual Trans – 12V with clutch pedal down, 0V clutch pedal up. Auto Trans – 12V with trans in neutral, 0V trans in gear.
X3–23 to X3–7	12V ± 1.5	If no voltage is present, troubleshoot battery wiring.
	0–0.6V	At crank with clutch down or auto trans in neutral, if ECM PIN X3–8 is at 12V and PIN X3–23 is not at 0–0.6V, check ECM programming. Cranking allowed. See truck Electrical System Troubleshooting Guide
	4–5V	Pull up voltage from ECM with Key ON Engine OFF or Running: trans in gear or clutch up.
ECI Diagnostic Trouble Code		
DTC 267 ECI Output Circuit Check self test failed		

ENGINE FAN CONTROL (EFAN)

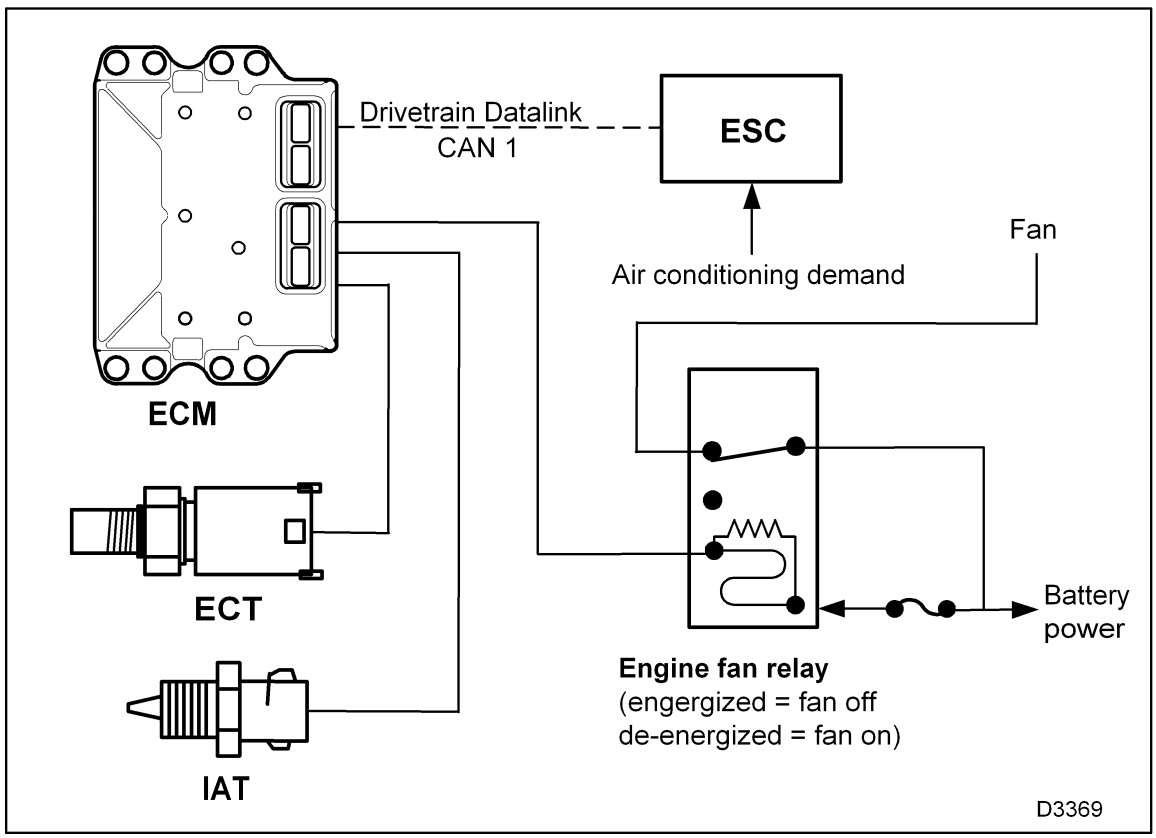

Figure 290 Function Diagram for Engine Fan Control (EFAN)

The Function Diagram for EFAN includes the following:

- Electronic Control Module (ECM)
- Engine Coolant Temperature (ECT) sensor
- Intake Air Temperature (IAT) sensor
- Electronic System Controller (ESC)
- Engine fan relay

Function

The EFAN control provides ON/OFF control of the engine cooling system fan. The ECM can be programmed to set and monitor limits for engine coolant temperature, intake air temperature, engine mode selection (operating or diagnostic).

EFAN is accessible with the EST. Fan on and off temperature can be programmed by technician, but the mode of operation must be done by Tech Services.

The purpose of the Engine Fan Control is to provide the correct logic to determine when the Fan should be turned on or off by energizing/de-energizing the fan drive relay. The purpose of the engine fan is to allow a higher air flow for heat exchange between the radiator and the ambient air when needed.

Engine Fan Control: This parameter indicates to the on-board electronics whether or not the truck has the electronic engine fan control feature.

AC Fan Activation: This feature will allow fan activation though the ECM when requested through the ESC during AC operation.

Disable: Feature is turned off at all times.

Fan On Temperature: This parameter indicates the coolant temperature that the fan will be electronically activated.

Fan Off Temperature: This parameter indicates the coolant temperature that the fan will be electronically deactivated.

EFAN Circuit Operation

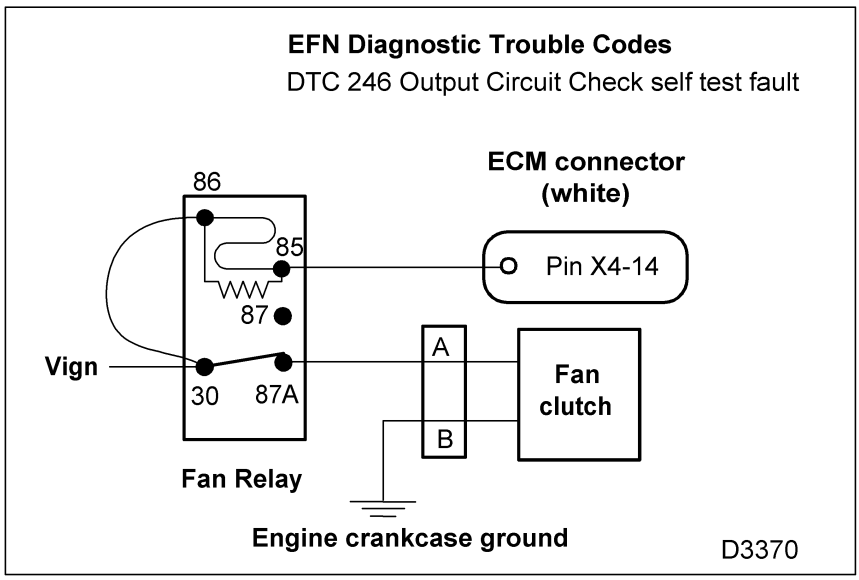

Figure 291 EFAN Circuit Diagram

With the ignition key on, power is supplied to terminals 30 and 86 on the engine fan relay. Terminal X4-14 on the ECM is used to either apply or remove the ground circuit from the fan relay coil side terminal 85. When the fan needs to be energized (turned on), terminal X4-14 is set high (12 volts) and the ground circuit to the coil side of the relay is interrupted causing the relay to unlatch, sending power supply from terminal 30 to 87A on the relay to the fan clutch. When the fan needs to be de-energized (turned off), terminal X4-14 is set low (grounded internal to the ECM) and the ground circuit to the coil side of the relay is complete causing the relay to latch, interrupting the power supply to the fan clutch.

NOTE: The circuit shown is with the fan engaged / on and the relay de-energized / off.

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 monitored continuously. If a DTC is detected in the IAT or ECT, the EFAN control is disabled and the engine fan is on all the time.

NOTE: Before diagnosing, check that ECM is programmed correctly. Verify vehicle / application has an electronic fan.

EFAN Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

DTC 246
OCC self test fault

- DTC 246 is set by the ECM only during the Key ON Engine OFF Standard test. During this test the ECM performs an output circuit test that momentarily enables the EFAN solenoid and measures the voltage drop across the relay

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)
- Relay breakout harness

EFAN Pin Point Diagnostics

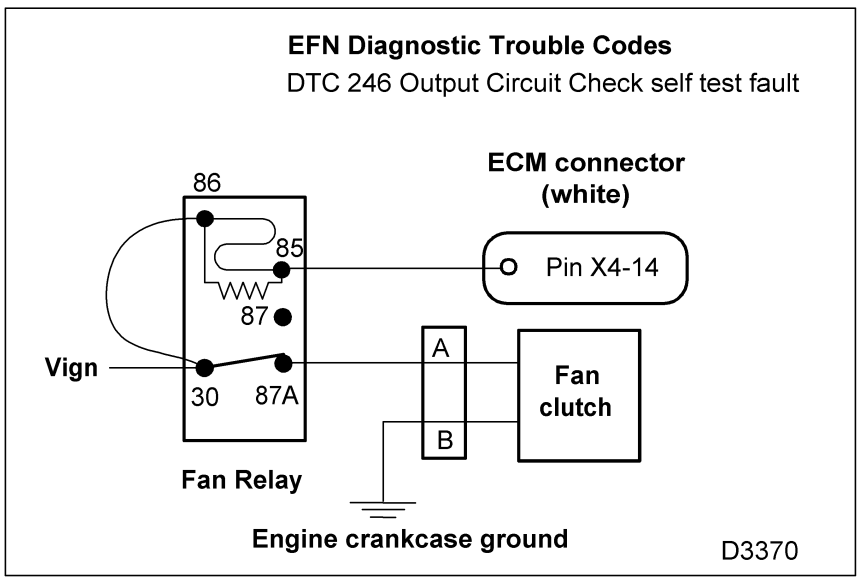

Figure 292 EFAN Circuit Diagram

The EFAN circuit requires the use of vehicle circuit diagrams. See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.

Table 39

Fan Clutch Voltage / Resistance Checks (Disconnect fan clutch. Key ON Engine OFF.)		
Test Point	**Spec**	**Comments**
A to gnd	B+	Do Output State Test High. If B+ is present, the EFAN circuit is functioning. If no voltage is present, the relay is not on. Check for an open in circuit to solenoid or improperly programmed ECM.
A to gnd	0V	Do Output State Test Low. If voltage is present, check for short to voltage source or actuator circuit shorted to ground.
B to gnd	<5Ω	Key OFF resistance to ground. If >5Ω, check for open or loose connection to ground at engine crankcase.
Voltage Checks at Fan Relay Connector (Check with relay removed and key ON.)		
30 to gnd	B+	V_{IGN} power to relay. If no voltage is present, see truck Chassis Electrical Circuit Diagram manual.
86 to gnd	B+	
85 to gnd	0V	ECM control (no voltage expected)
87A to gnd	0V	Power to EFAN (no voltage expected with relay disconnected)
Voltage Checks at ECM X4 (Check with breakout box installed to ECM and chassis harness, relay installed, and key ON.)		
X4–14 to gnd	0V	Fan off – Do Output State Test Low
X4–14 to gnd	B+	Fan on – Do Output State Test High
Harness Resistance Checks (Turn ignition key OFF. Disconnect fan. Check with breakout box installed on chassis harness only.)		
X4–14 to 85	<5Ω	If >5Ω, check for harness open between ECM and relay terminal.
87A to A (fan)	<5Ω	If >5Ω, check for harness open between relay terminal and A (fan).
30 to Fuse	<5Ω	If >5Ω, check for harness open between fuse and relay terminal. See truck Chassis Electrical Circuit Diagram manual for fuse information.
30 to 86	<5Ω	If >5Ω, check for harness open at relay terminal.

ENGINE OIL PRESSURE (EOP) SENSOR

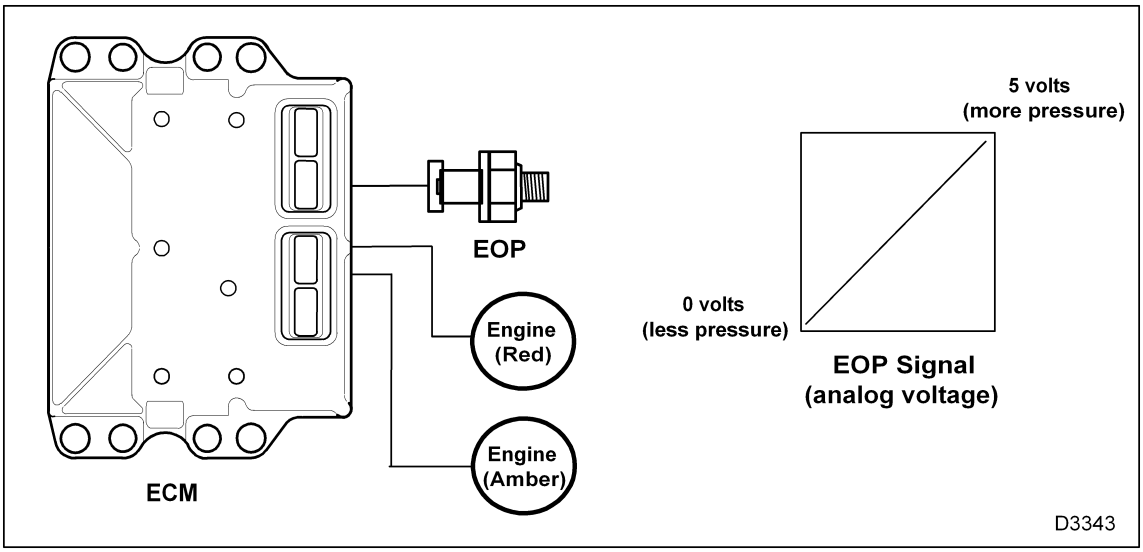

Figure 293 Function Diagram for the Engine Oil Pressure (EOP) Sensor

The Function Diagram for the EOP sensor includes the following:

- Engine Oil Pressure (EOP) sensor
- Electronic Control Module (ECM)
- ENGINE lamp (amber and red)

Function

The Engine Oil Pressure (EOP) sensor is a variable capacitance sensor on the oil filter base on the top of the engine. The ECM supplies a 5V reference signal which the EOP sensor uses to produce a linear analog voltage that indicates oil pressure.

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.

EOP Circuit Operation

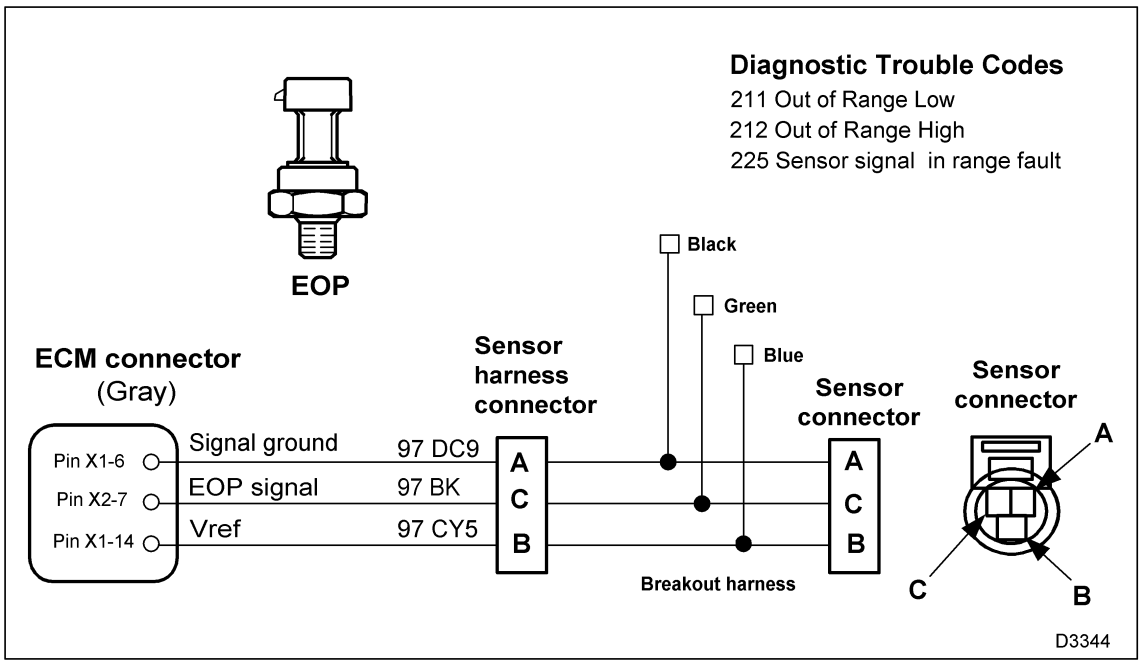

Figure 294 EOP Circuit Diagram

The EOP sensor is supplied with a 5V reference voltage at terminal B from ECM terminal X1–14. The EOP sensor is also supplied with a ground at terminal A from X1–6. The EOP sensor sends a signal from terminal C of the sensor to ECM terminal X2–7.

Fault Detection / Management

When the EOP signal voltage is detected out of range high or low, the ECM will cause the engine to ignore the EOP signal and disable the Engine Warning and Protection System (EWPS).

EOP Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

DTC 211
Out of range low

- DTC 211 is set by the ECM when the EOP signal is less than 0.039V for more than 0.35 second.
- DTC 211 can be set due to an open or short to ground on the signal circuit, a defective sensor or an open V_{REF} circuit or V_{REF} short to ground.
- When DTC 211 is active the amber ENGINE lamp is illuminated.

DTC 212
Out of range high

- DTC 212 is set by the ECM when the EOP signal is greater than 4.9V for more than 0.35 second.
- DTC 212 can be set due to an open signal ground circuit, short to a voltage source on the ICP signal circuit, or a defective sensor.
- When DTC 212 is active the amber ENGINE lamp is illuminated.

DTC 225
Sensor signal in range fault

- DTC 225 is set by the ECM when the EOP signal voltage is higher than expected with the key ON and the engine OFF.
- DTC 225 can be set due to a biased circuit or a defective EOP sensor.
- When DTC 225 is active the amber ENGINE lamp is illuminated.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)
- Harness – 3-Banana plug and 500 ohm
- Breakout box
- Breakout harness
- Terminal Test Adapter Kit

EOP Operational Diagnostics

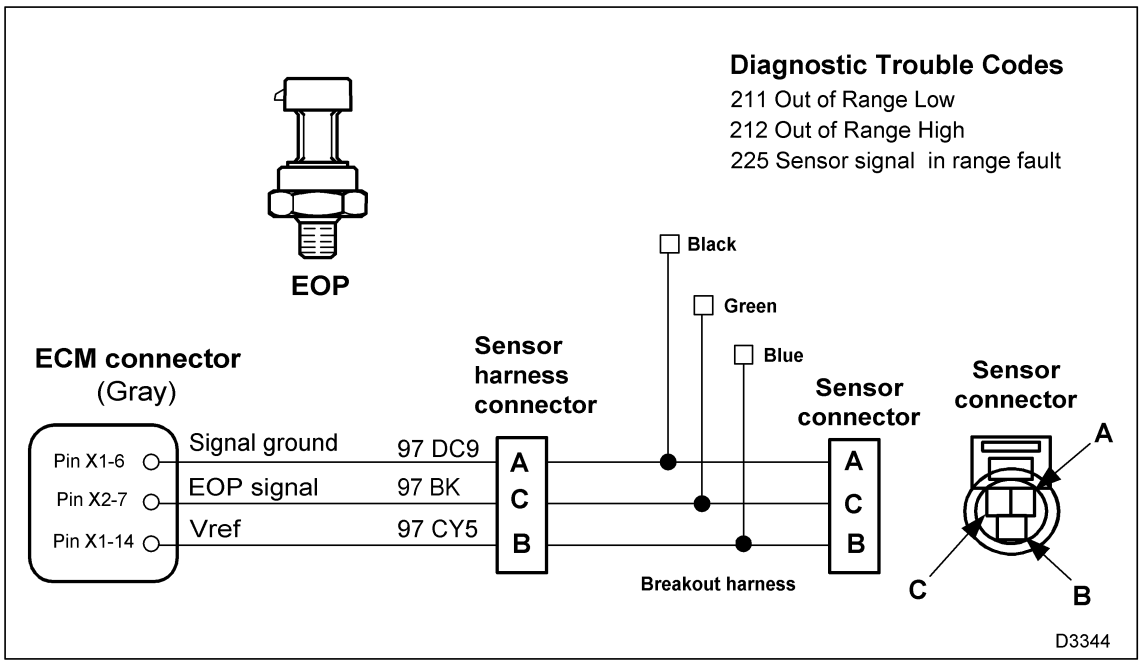

Figure 295 EOP Circuit Diagram

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

Be careful to avoid rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the continuous monitor session. To monitor signal voltage, run Key ON Engine OFF Continuous Monitor Test.

2. Monitor EOP signal volts. Verify an active DTC for the EOP circuit.

3. If code is active, complete step 5 and do circuit check for the EOP sensor in table on the following page.

4. If code is inactive, wiggle connectors and wires at all suspected problem locations. If circuit continuity is interrupted, the EST will beep and display DTCs related to the condition.

5. Install pressure sensor breakout harness to engine harness only.

NOTE: After removing connector, inspect for damaged pins, corrosion, or loose terminals. Repair as required.

Table 40

Circuit Checks for EOP Sensor (Use EST, DMM, breakout harness, and 500 ohm wire harness.)		
Test Condition	**Spec**	**Checks**
Sensor disconnected	0V	If voltage >0.039V, check signal circuit for short to V_{REF} or B+.
Measure voltage from BLUE pin to ground with DMM	5V ±0.5	If voltage >5.5V, check V_{REF} for short to B+. If voltage is <4.5V, check V_{REF} circuit for open or short to ground.
500 ohm harness installed between GREEN and BLUE pins of breakout harness.	5V	If voltage <4.9V, check signal circuit for open or short to ground. Remove negative battery cable. Measure resistance from PIN C to ground (spec >1kΩ) to check for short to ground. Use a breakout box from PIN C to PIN X2–7 (spec <5Ω) to check for open in the harness.
Resistance from BLACK pin of breakout harness to chassis ground using DMM.	<5Ω	If resistance is >5Ω, check for open or high resistance between ECM and sensor connector. Use a breakout box and measure resistance from between PIN A and PIN X1–6 (spec <5Ω).

6. Connect engine harness to sensor. Use the EST to clear DTCs. If an active code remains after checking test conditions, replace the EOP sensor.

EOP Pin Point Diagnostics

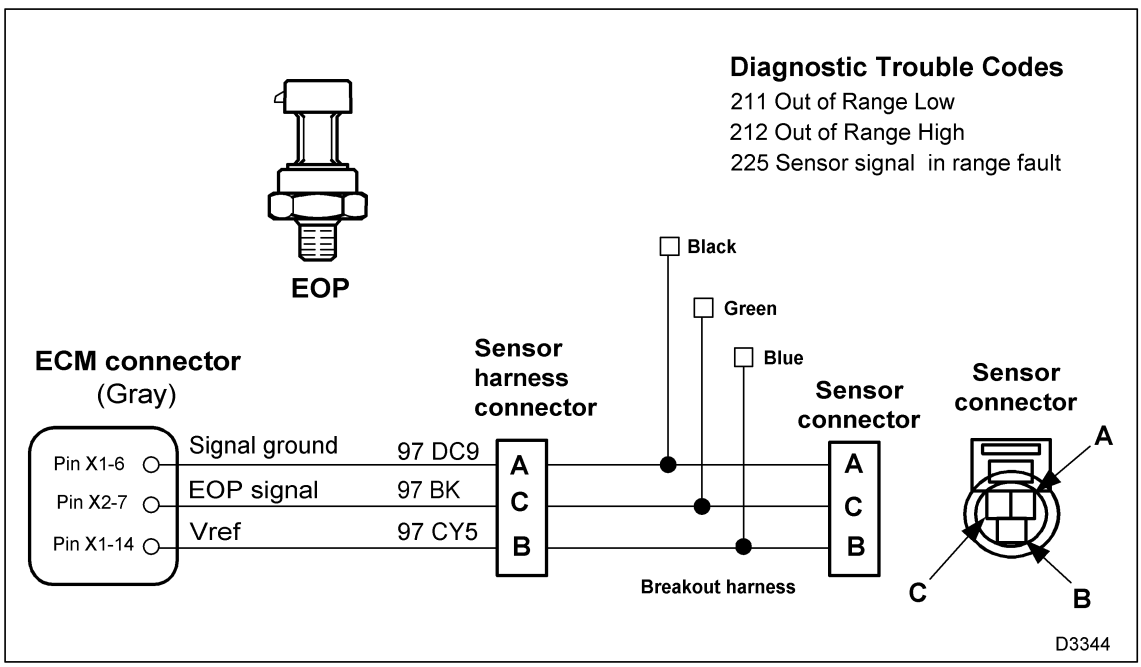

Figure 296 EOP Circuit Diagram

Table 41

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.

Connector Voltage Checks (Disconnect sensor from harness and turn ignition key ON.)		
Test Point	**Spec**	**Comments**
A to gnd	0V	Signal ground (no voltage expected) if voltage is present, check for short to B+ or V_{REF}.
B to gnd	5V ±0.5	If voltage is not to spec, V_{REF} is open or shorted to ground.
C to gnd	<0.25	If voltage >0.25V, signal ground wire is shorted to V_{REF} or B+.
Connector Resistance Checks to Chassis Ground (Turn ignition key OFF. Disconnect negative battery cable and sensor connector.)		
A to gnd	<5Ω	If >5Ω, check for open circuit
B to gnd	>500Ω	If <500Ω, check for short to ground
C to gnd	>1kΩ	If <1kΩ, check for short to ground
Harness Resistance Checks (Install breakout box on engine harness only.)		
X1–6 to A	<5Ω	If >5Ω, check for open ground wire
X1–14 to B	<5Ω	If >5Ω, check for open V_{REF} wire
X2–7 to C	<5Ω	If >5Ω, check for open signal wire

Table 42

EOP Operational Voltage Checks (Check with breakout box installed to the ECM and engine harness.)			
Test Point	**Volt**	**kPa (psi)**	**Comments**
X2–7 to X1–6	0.89V	34 (5)	Pressure will vary with engine speed and temperature.
X2–7 to X1–6	1.15V	69 (10)	
X2–7 to X1–6	2.40V	241 (35)	
X2–7 to X1–6	3.61V	414 (60)	
EOP Diagnostic Trouble Code			
DTC 211 = Signal voltage was <0.039V for more than 0.35 second			
DTC 212 = Signal voltage was >4.9V for more than 0.35 second			
DTC 225 = Engine oil pressure was >15 psi with Key ON Engine OFF			
DTC 313 = See Engine Warning and Protection System (EWPS)			
DTC 314 = See Engine Warning and Protection System (EWPS)			

ENGINE OIL TEMPERATURE (EOT) SENSOR

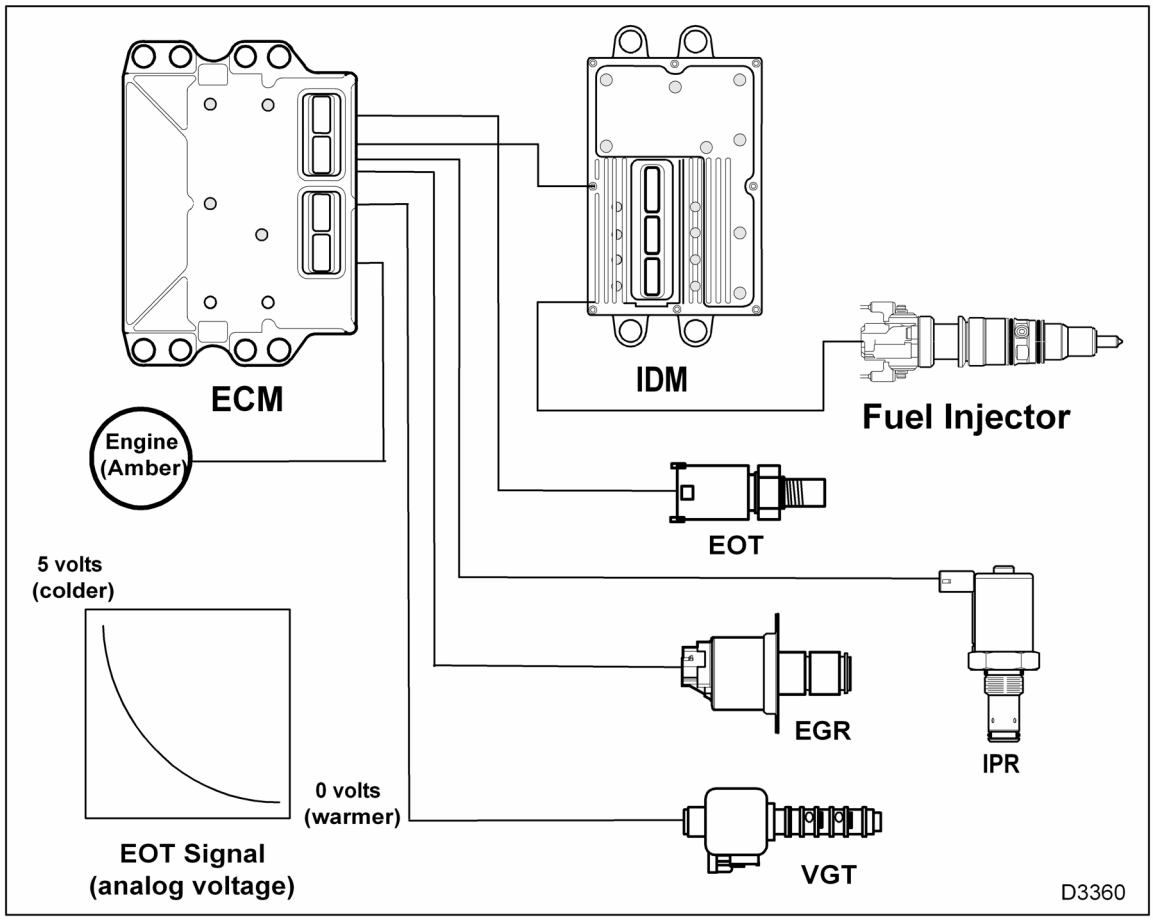

Figure 297 Function Diagram for the Engine Oil Temperature (EOT) Sensor

The Function Diagram for the EOT sensor includes the following:

- Engine Oil Temperature (EOT) sensor
- Electronic Control Module (ECM)
- Injection Driver Module (IDM)
- Fuel injector
- Exhaust Gas Recirculation (EGR) sensor
- Variable Geometry Turbocharger (VGT) actuator
- Injection Pressure Regulator (IPR)
- ENGINE lamp (amber)

Function

The EOT sensor is a thermistor sensor located on top of the engine in the oil filter base. The ECM supplies a 5V reference signal which the EOT sensor uses to produce an analog voltage that indicates temperature. The EOT changes resistance when exposed to different temperatures. When oil temperature decreases, the resistance of the thermistor increases. This causes the signal voltage to increase. When oil temperature increases, the resistance of the thermistor decreases. This causes the signal voltage to decrease.

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. During engine operation, if the ECM recognizes that the EOT signal is lower or higher than the expected value it will set a DTC.

EOT Circuit Operation

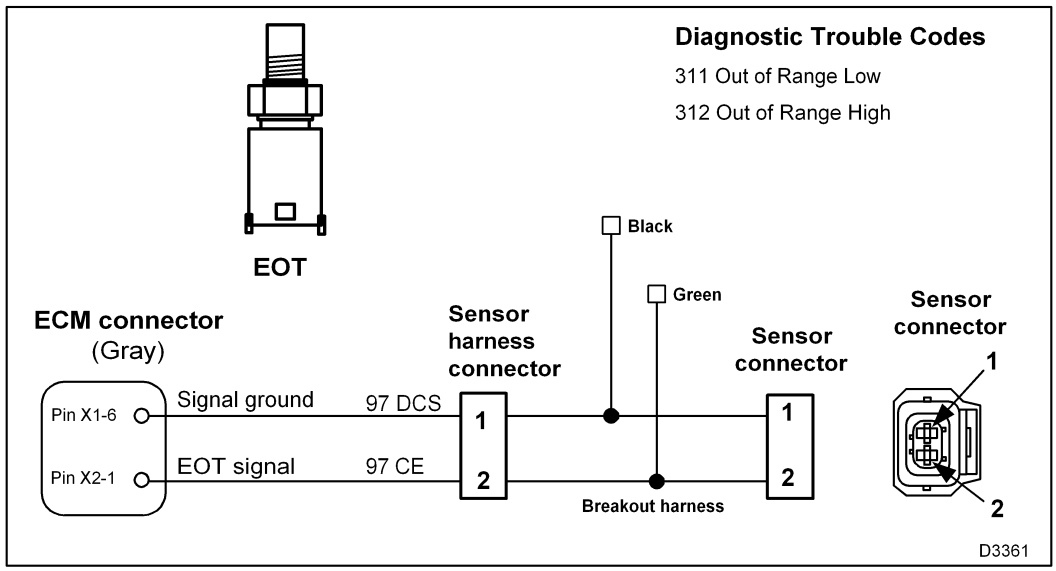

Figure 298 EOT Circuit Diagram

The EOT sensor is supplied with a 5V reference voltage at terminal 2 from ECM terminal X2–1. The sensor is grounded at terminal 1 through the signal ground terminal at the ECM terminal X1–6. When the oil temperature increases or decreases, the sensor changes resistance and provides the oil temperature signal voltage at the ECM. The signal voltage is read by the ECM to determine the temperature of the oil.

Fault Detection / Management

The ECM continuously monitors the signal of the EOT sensor to determine if the signal is within an expected range. If the ECM detects an out of range high or low, the ECM will ignore the EOT signal and assume an engine oil temperature of -20°C (–4°F) for starting and 100°C (212°F) for engine running conditions.

EOT Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

DTC 311
Out of range low

- DTC 311 is set by the ECM when the EOT signal is less than 0.2V for more than 0.35 second.
- DTC 311 can be set due to a sensor signal wire short to ground or a defective EOT sensor.
- When DTC 311 is active the amber ENGINE lamp is illuminated.

DTC 312
Out of range high

- DTC 312 is set by the ECM when the EOT signal is greater than 4.8V for more than 0.35 second.
- DTC 312 can be set due to a signal or ground circuit open, a short to a voltage source, or a defective EOT sensor.
- When DTC 312 is active the amber ENGINE lamp is illuminated.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)
- Harness – 3-Banana plug and 500 ohm
- Breakout box
- Breakout harness
- Terminal Test Adapter Kit

EOT Operational Diagnostics

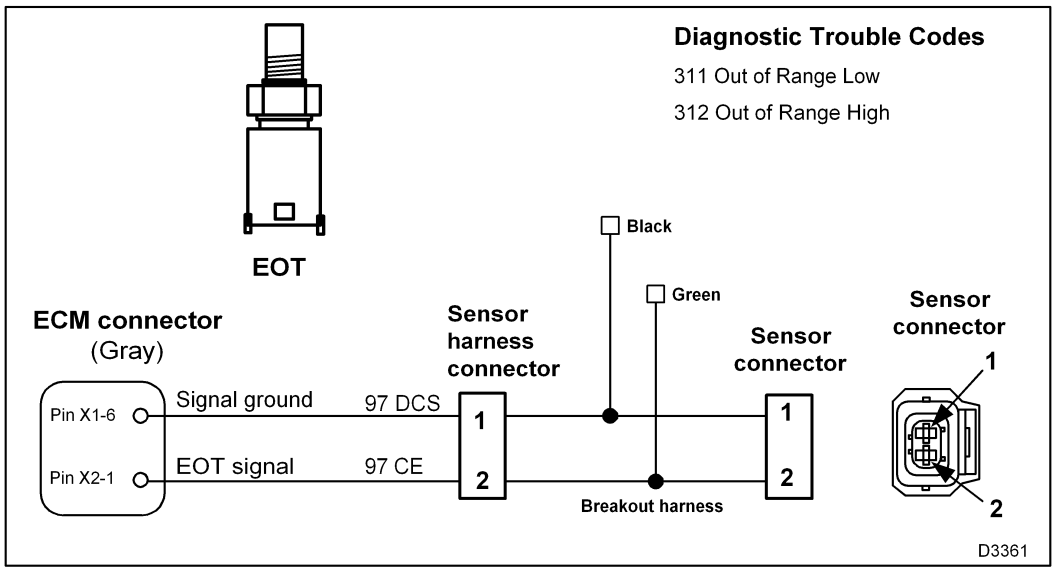

Figure 299 EOT Circuit Diagram

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

Be careful to avoid rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the continuous monitor session. To monitor signal voltage, run Key ON Engine OFF continuous monitor test.

2. Monitor EOT signal volts. Verify an active DTC for the EOT circuit.

3. If code is active, complete step 5 and do circuit check for the EOT sensor in table on the following page.

4. If code is inactive, wiggle connectors and wires at all suspected problem locations. If circuit continuity is interrupted, the EST will beep and display DTCs related to the condition.

5. Install temperature sensor breakout harness to engine harness only.

NOTE: After removing connector, inspect for damaged pins, corrosion, or loose terminals. Repair as required.

Table 43

Circuit Checks for EOT Sensor (Use EST, breakout harness, and wire harnesses – 3-Banana plug and 500 ohm.)

Test Condition	Spec	Checks
Sensor disconnected	>4.78V	If voltage <4.78V, check signal circuit for short to ground.
3–Banana plug harness installed between GREEN and BLACK pins of breakout harness.	0V	If voltage is >0.2V, check ground and signal circuit for open or high resistance. Use a breakout box and measure resistance from PIN 1 to PIN X1–6 and from PIN 2 to X2–1 (spec <5Ω).
500 ohm harness installed between GREEN and BLACK pins of breakout harness.	<1.0V	If voltage >1.0V, check signal circuit for short to V_{REF}, B+, or another sensor's signal voltage.

6. Connect engine harness to sensor. Use the EST to clear DTCs. If an active code remains after checking test conditions, replace the EOT sensor.

EOT Pin Point Diagnostics

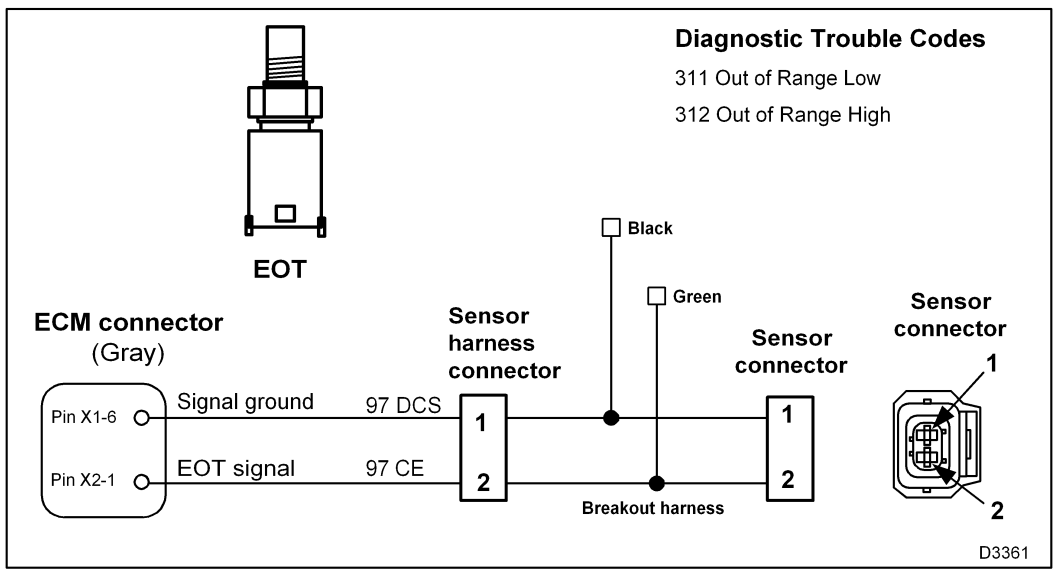

Figure 300 EOT Circuit Diagram

Table 44

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.

Connector Voltage Checks (Disconnect sensor from harness and turn ignition key ON.)		
Test Point	**Spec**	**Comments**
2 to gnd	4.8–5.0V	Pull up voltage, if low or no voltage, circuit has open, high resistance, or short to ground.
1 to gnd	0–0.25V	If >0.25V, signal ground wire is shorted to V_{REF} or B+.
Connector Resistance Checks to Chassis Ground (Turn ignition key OFF. Disconnect negative battery cable and sensor connector.)		
1 to gnd	<5Ω	If >5Ω, check for open ground circuit
2 to gnd	>1kΩ	If <1kΩ, check for signal short to ground
Harness Resistance Checks (Install breakout box on engine harness only.)		
X1–6 to 1	<5Ω	If >5Ω, check for open ground wire
X2–1 to 2	<5Ω	If >5Ω, check for open signal wire

Table 45

Operational Voltage Checks for EOT Sensor (Check with breakout box installed to the ECM and engine harness.)			
Test Point	**Temp °C (°F)**	**Resistance**	**Volts**
X2–1 to X1–6	0°C (32°F)	91.1kΩ	4.348V
X2–1 to X1–6	20°C (68°F)	35.5kΩ	3.782V
X2–1 to X1–6	100°C (212°F)	2.0k Ω	0.819V
EOT Diagnostic Trouble Code			
DTC 311 = Signal voltage was <0.2V for more than 0.35 second			
DTC 312 = Signal voltage was >4.78V for more than 0.35 second			

ENGINE WARNING AND PROTECTION SYSTEM (EWPS)

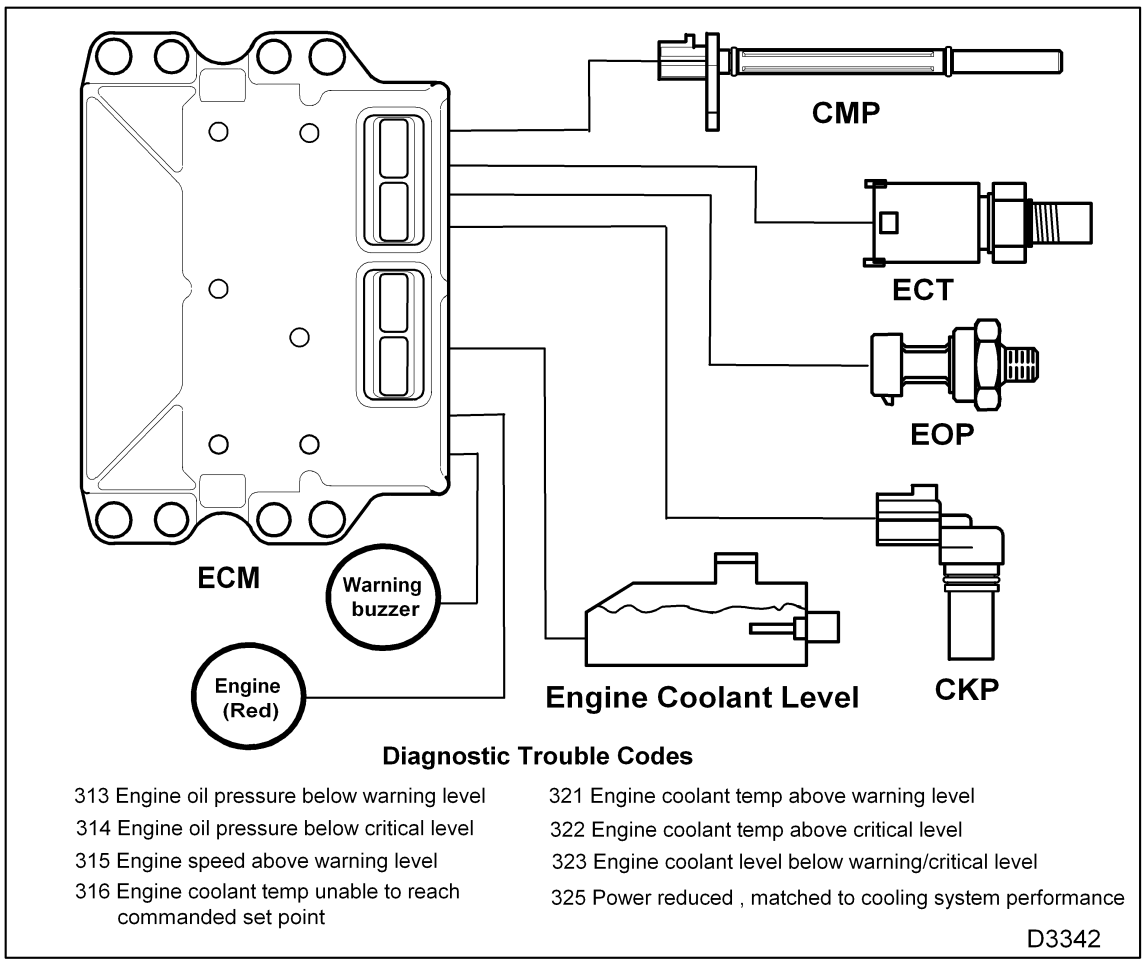

Figure 301 Function Diagram for the Engine Warning Protection System (EWPS)

Function

The Engine Warning Protection System (EWPS) safeguards the engine from undesirable operating conditions to prevent engine damage and to prolong engine life. When a warning condition is detected, the on-board electronics will illuminate the red ENGINE lamp.

When a critical engine condition is detected, the on-board electronics will shut the engine down if the protection feature has been enabled. The critical engine condition will be recorded by a logging feature that records the event in engine hours and odometer readings. After the engine has shutdown, the engine may be restarted for a thirty second run time.

There are four options of EWPS:

- Standard
- 2–way warning
- 3–way warning
- 3–way protection

EWPS Operational Diagnostics

The EWPS includes the following features:

EWPS mode – This parameter indicates to the on-board electronics the desired mode of operation for the engine warning and protection feature.

Standard warning (rpm, ECT) – Engine overspeed and overheat are provided as the default operating mode. No engine shutdown is available.

2–way warning (rpm, ECT, EOP) – Engine overspeed, overheat, and low oil pressure are monitored in the engine warning operating mode. No engine shutdown is available.

3–way warning (rpm, ECT, EOP, ECL) – Engine overspeed, overheat, low oil pressure, and low coolant level are monitored in the engine warning operating mode. No engine shutdown is available.

3-way Protection (rpm, ECT, EOP, ECL) – Engine overspeed, overheat, low oil pressure, and low coolant level are monitored in the engine protection operating mode. Engine shutdown is available when a critical engine condition is detected. Critical engine conditions include overheat, low oil pressure and low coolant level.

ECT Warning Temperature – This parameter indicates when an engine overheat condition warrants the red ENGINE lamp to be illuminated and the warning buzzer to be activated.

ECT Critical Temperature – This parameter indicates when an engine overheat condition warrants an engine shutdown. The event logging feature will log when this event has occurred in both engine hours and odometer readings.

EOP RPM Boundary 1 – This parameter indicates the rpm range that engine oil pressure level 1 is used for the loss of engine oil pressure detection.

EOP RPM Boundary 2 – This parameter indicates the rpm range that engine oil pressure level 2 is used for the loss of engine oil pressure detection.

EOP RPM Boundary 3 – This parameter indicates the rpm range that engine oil pressure level 3 is used for the loss of engine oil pressure detection.

EOP Warning Level 1 – This parameter indicates when a loss of engine oil pressure warrants the red ENGINE lamp to be illuminated and the warning buzzer to be activated.

EOP Warning Level 2 – This parameter indicates when a loss of engine oil pressure condition warrants the red ENGINE lamp to be illuminated and the warning buzzer to be activated.

EOP Warning Level 3 – This parameter indicates when a loss of engine oil pressure condition warrants the red ENGINE lamp to be illuminated and the warning buzzer to be activated.

EOP Critical Level 1 – This parameter indicates when a loss of engine oil pressure condition warrants an engine shutdown. The event logging feature will log when this event has occurred in both engine hours and odometer readings.

EOP Critical Level 2 – This parameter indicates when a loss of engine oil pressure condition warrants an engine shutdown. The event logging feature will log when this event has occurred in both engine hours and odometer readings.

EOP Critical Level 3 – This parameter indicates when a loss of engine oil pressure condition warrants an engine shutdown. The event logging feature will log when this event has occurred in both engine hours and odometer readings.

EWPS Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

DTC 323
Engine coolant below warning/critical level

- DTC 323 is set by the ECM when coolant is low. When the EWPS mode is 3-way protection and DTC 323 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 323 will become inactive.

NOTE: If coolant level is correct, see Electronic Diagnostics for ECL. An ECL signal shorted to ground can cause DTC 323.

DTC 321
Above warning level

- DTC 321 is set by the ECM when the engine coolant temperature is above 109°C (228°F). The ECM illuminates the red ENGINE lamp and sounds the audible alarm. When the temperature drops below 109°C (228°F) the DTC will become inactive. See section 4 for diagnostics.

DTC 322
Engine coolant temperature above critical level

- DTC 322 is set by the ECM when the engine coolant temperature is above 112.5°C (234.5°F). The ECM illuminates the red ENGINE lamp and sounds the audible alarm. When the temperature drops below 112.5°C (234.5°F) the DTC will become inactive. See section 4 for diagnostics.

DTC 325
Power reduced, matched to cooling system performance

- DTC 325 is set by the ECM when the cooling system temperature exceeds 107°C (225°C). At this temperature the ECM will reduce the fuel delivered to the engine. . When the temperature drops below 107°C (225°C) the DTC will become inactive and the engine will return to normal operation.

  For each Celsius degree of temperature the fuel will be reduced 6%. This reduces the heat produced by the engine and reduces the burden on the cooling system. The vehicle speed will also be reduced and allow the operator to downshift and increase the efficiency of the cooling system. As the temperature is reduced the compensation level is reduced until the temperature drops below 107°C (225°C) and normal operation is resumed.

DTC 316
CAP fault – unable to warm engine

NOTE: DTC 316 only indicates the engine has not been able to reach operating temperature. It does not indicate an electronic fault.

- DTC 316 is set if the engine does not reach operating temperature. DTC 316 will only be set with engines that have Cold Ambient Protection (CAP) strategy enabled. DTC 316 is set after the engine has run for more than 120 minutes and has not exceeded the following specifications for engine coolant temperature. DTC 316 can be cleared with the Electronic Service Tool.
  - Manual transmission 65° C (149° F)
  - Automatic transmission 60° C (140° F)
- DTC 316 can be set due to any of the following conditions:
  - Extended idle time
  - Cold ambient temperatures (may require use of winter front)
  - Thermostat stuck in open position
  - Incorrectly plumbed cooling system (thermostat bypassed)
  - Auxiliary heater cores cooling off engine (school bus application)
  - Fan clutch locked on

DTC 313
Engine oil pressure below warning level

- DTC 313 is set by the ECM when the oil pressure has dropped below the warning level. The specification for the warning level is:
  - 34kPa (5.0 psi) @ 700 rpm
  - 69 kPa (10.0 psi) @ 1400 rpm
  - 138 kPa (20.0 psi) @ 2000 rpm

  The ECM illuminates the red ENGINE lamp and sounds an audible alarm. See section 4 for diagnostics.
- DTC 313 can be set due to a defective sensor sending an incorrect signal. To confirm this, compare actual oil pressure to the reading on the data list of the EST. Low oil pressure due to defective mechanical components will also set DTC 313.

DTC 314
Engine oil pressure below critical level

- DTC 314 is set by the ECM when the oil pressure has dropped below the critical level. The specification for the critical level is:
  - 14kPa (2.0 psi) @ 700 rpm
  - 34 kPa (5.0 psi) @ 1400 rpm
  - 152 kPa (12.0 psi) @ 2000 rpm

  The ECM flashes the red ENGINE lamp and sounds an audible alarm. See section 4 for diagnostics.
- DTC 314 can be set due to a defective sensor sending an incorrect signal. To confirm this, compare actual oil pressure to the reading on the data list of the EST. Low oil pressure due to defective mechanical components will also set DTC 313.

DTC 315
Engine speed above warning level

- DTC 315 is set by the ECM when the engine rpm has exceeded 3350 rpm.
- DTC 315 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 315 is active the amber ENGINE lamp is illuminated. The engine hours and miles of the last two over speed occurrences will be recorded in the Engine Event Log.

EXHAUST BACK PRESSURE (EBP) SENSOR

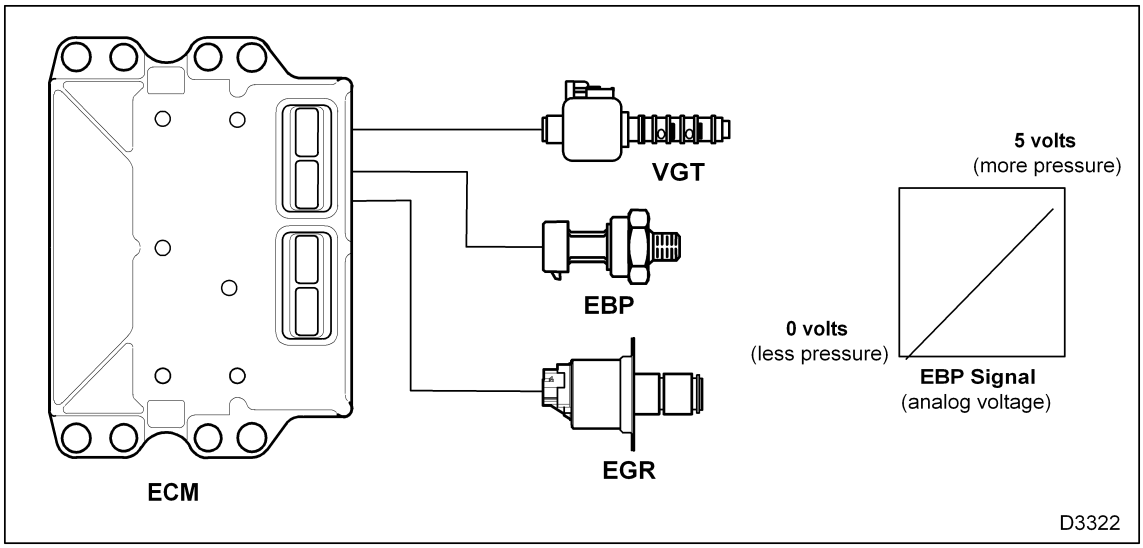

Figure 302 Function Diagram for the Exhaust Back Pressure (EBP) Sensor

The Function Diagram for the EBP sensor includes the following:

- Exhaust Back Pressure (EBP) sensor
- Electronic Control Module (ECM)
- Variable Geometry Turbocharger (VGT) actuator
- Exhaust Gas Recirculation (EGR) actuator

Function

The Exhaust Back Pressure (EBP) sensor is a variable capacitance sensor mounted to a bracket on the left side valve cover. The ECM supplies a 5V regulated signal which the EBP sensor uses to produce a linear analog voltage that indicates pressure. The EBP measures exhaust back pressure so that the ECM can control the VGT and EGR system.

EBP Circuit Operation

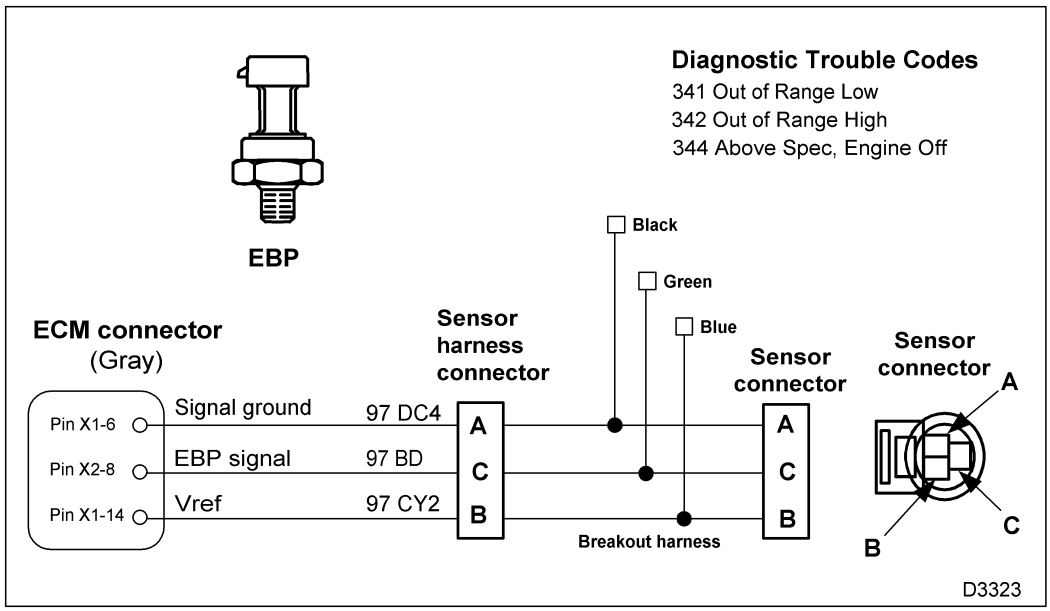

Figure 303 EBP Circuit Diagram

The EBP sensor is supplied with a 5V reference voltage at terminal B from ECM terminal X1–14. The EBP sensor is also supplied with a ground circuit at terminal A from ECM terminal X1–6. The EBP sensor sends a signal from terminal C of the sensor to ECM terminal X2–8.

Fault Detection / Management

When the EBP signal voltage is detected out of range high or low, the ECM will cause the engine to ignore the EBP signal. The EGR valve will close and the ECM will rely on the VGT pre-programmed values.

EBP Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

DTC 341
Out of range low

- DTC 341 is set by the ECM when the EBP signal is less than 0.039V for more than 0.5 second.
- DTC 341 can be set due to an open or short to ground on the signal circuit, a defective sensor or an open V_{REF} circuit or V_{REF} short to ground.
- When DTC 341 is active the amber ENGINE lamp is illuminated.

DTC 342
Out of range high

- DTC 342 is set by the ECM when the EBP signal is more than 4.9V for more than 0.5 second.
- DTC 342 can be set due to an open signal ground circuit, short to a voltage source on the EBP signal circuit, or a defective sensor.
- When DTC 342 is active the amber ENGINE lamp is illuminated.

DTC 344
Above spec, engine off

- DTC 344 is set by the ECM when the exhaust back pressure is greater than 130 kPa (19 psi) with the Key ON Engine OFF.
- DTC 344 can be set due to a plugged EBP sensor or a restriction in the tube leading to the sensor. To check for this condition, remove the sensor and tube and inspect for carbon deposits.
- When DTC 344 is active the amber ENGINE lamp is illuminated.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)
- Harness – 3-Banana plug and 500 ohm
- Breakout box
- Breakout harness
- Terminal Test Adapter Kit

EBP Operational Diagnostics

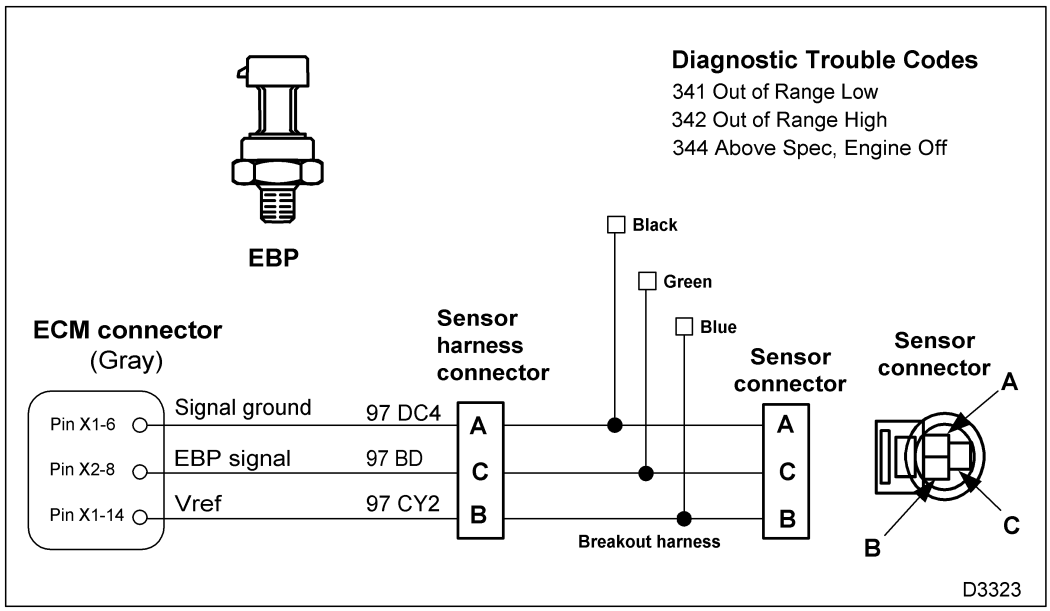

Figure 304 EBP Circuit Diagram

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

Be careful to avoid rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the continuous monitor session. To monitor signal voltage, run Key ON Engine OFF continuous monitor test.

2. Monitor EBP signal volts. Verify an active DTC for the EBP circuit.

3. If code is active, complete step 5 and do circuit check for the EBP sensor in table on the following page.

4. If code is inactive, wiggle connectors and wires at all suspected problem locations. If circuit continuity is interrupted, the EST will beep and display DTCs related to the condition.

5. Install pressure sensor breakout harness to engine harness only.

NOTE: After removing connector, inspect for damaged pins, corrosion, or loose terminals. Repair as required.

Table 46

Circuit Checks for EBP Sensor (Use EST, DMM, breakout harness, and 500 ohm wire harness.)		
Test Condition	**Spec**	**Checks**
Sensor disconnected	0V	If voltage >0.039V, check signal circuit for short to V_{REF} or B+.
Measure voltage from BLUE PIN to ground with DMM	5V ±0.5	If voltage >5.5V, check V_{REF} for short to B+. If voltage is <4.5V, check V_{REF} circuit for open or short to ground.
500 ohm harness installed between GREEN and BLUE pins of breakout harness.	5V	If voltage <4.9V, check signal circuit for open or short to ground. Remove negative battery cable. Measure resistance from PIN C to ground (spec >1kΩ) to check for short to ground. Use a breakout box from PIN C to PIN X2–8 (spec <5Ω) to check for open in the harness.
Resistance from BLACK pin of breakout harness to chassis ground using DMM.	<5Ω	If resistance is >5Ω, check for open or high resistance between ECM and sensor connector. Use a breakout box and measure resistance from between PIN A and PIN X1–6 (spec <5Ω).

6. Connect engine harness to sensor. Use the EST to clear DTCs. If an active code remains after checking test conditions, replace the EBP sensor.

EBP Pin Point Diagnostics

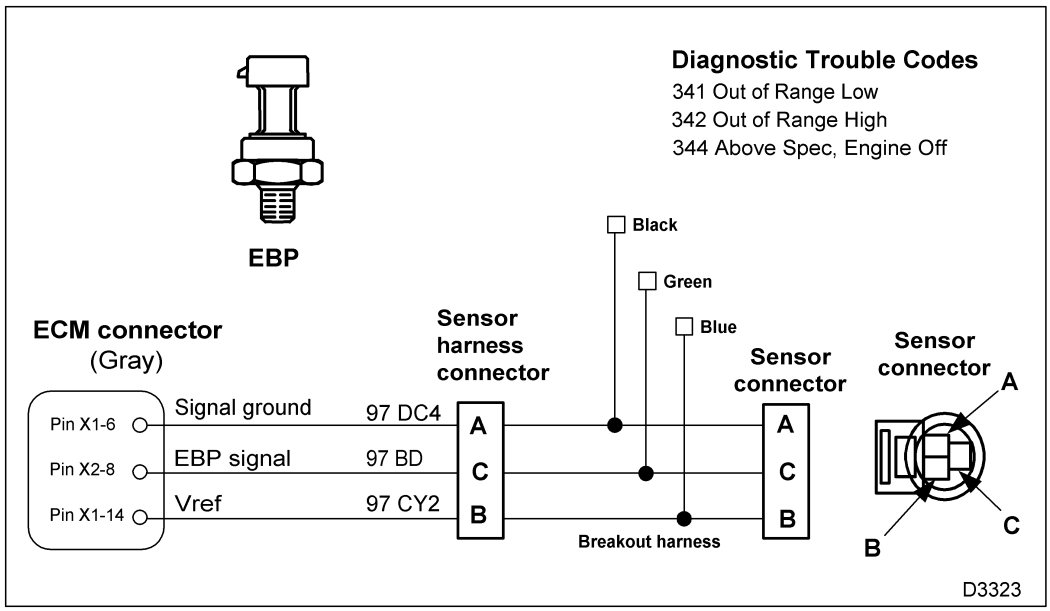

Figure 305 EBP Circuit Diagram

Table 47

> **WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.**

Connector Voltage Checks (Disconnect sensor from harness and turn ignition key ON.)

Test Point	Spec	Comments
A to gnd	0V	Signal ground (no voltage expected) If voltage is present, check for short to B+ or V_{REF}.
B to gnd	5V ±0.5	If voltage is not to spec, V_{REF} is open or shorted to ground.
C to gnd	<0.25V	If voltage >0.25V, signal wire is shorted to V_{REF} or B+.
Connector Resistance Checks to Chassis Ground (Turn ignition key OFF. Disconnect negative battery cable and sensor connector.)		
A to gnd	<5Ω	If >5Ω, check for open circuit.
B to gnd	>500Ω	If <500Ω, check for short to ground.
C to gnd	>1kΩ	If <1kΩ, check for short to ground.
Harness Resistance Checks (Install breakout box on engine harness only.)		
X1–6 to A	<5Ω	If >5Ω, check for open ground wire.
X1–14 to B	<5Ω	If >5Ω, check for open V_{REF} wire.
X2–8 to C	<5Ω	If >5Ω, check for open signal wire.

Table 48

EBP Operational Voltage Checks (Check with breakout box installed to the ECM and engine harness.)		
Test Point	**Volt**	**kPa (psi)**
X2–8 to X1–6	.8–1.0V	0 (0)
X2–8 to X1–6	1.73V	55 (8)
X2–8 to X1–6	2.72V	124 (18)
EBP Diagnostic Trouble Code		
DTC 341 = Signal voltage was <0.039V for more than 0.5 second		
DTC 342 = Signal voltage was >4.9V for more than 0.5 second		
DTC 344 = Exhaust back pressure was >19 psi with Key ON Engine OFF		

EXHAUST GAS RECIRCULATION (EGR) ACTUATOR

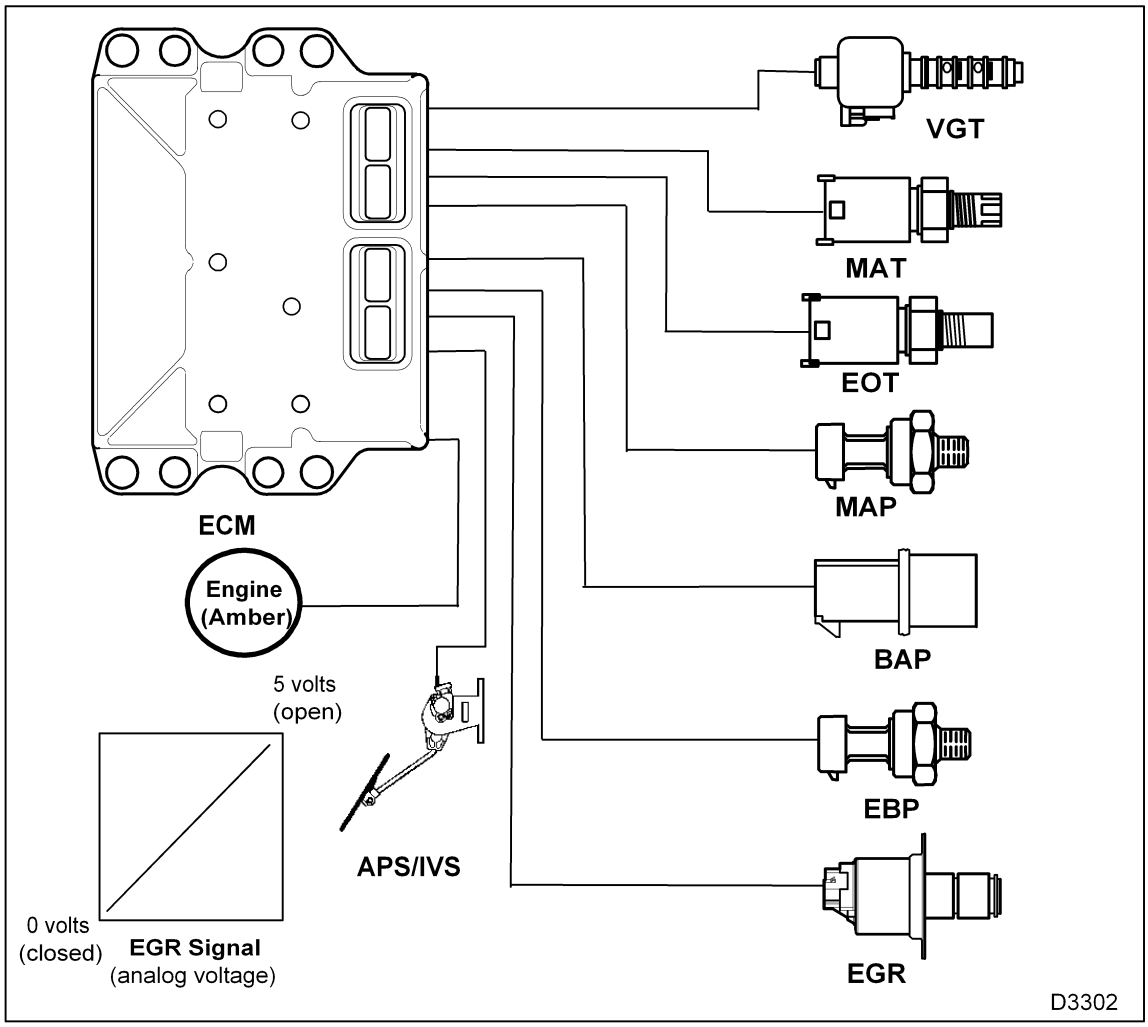

Figure 306 Function Diagram for the Exhaust Gas Recirculation (EGR) Actuator

The Function Diagram for the EGR actuator includes the following:

- Electronic Control Module (ECM)
- Exhaust Gas Recirculation (EGR) actuator
- Exhaust Gas Recirculation Position (EGRP) sensor

Function

The EGR actuator consists of two components, a valve with actuator (solenoid) and a position sensor to monitor valve movement. The EGR is at the front of the engine on top of the intake manifold.

The EGR actuator is a variable position valve that controls the amount of exhaust that enters the intake system. The EGR valve is controlled by the ECM using a pulse width modulated signal. The system is closed loop using the EGRP as input. Other inputs that are used to calculate the desired position of the EGR valve include BAP, EBP, MAT, VGT control, MAP, APS, and EOT.

The EGRP sensor is a potentiometer sensor. When the EGRP receives a 5V reference signal and a ground from the ECM, a linear analog voltage signal from the sensor will indicate position of the EGR valve.

EGR Circuit Operation

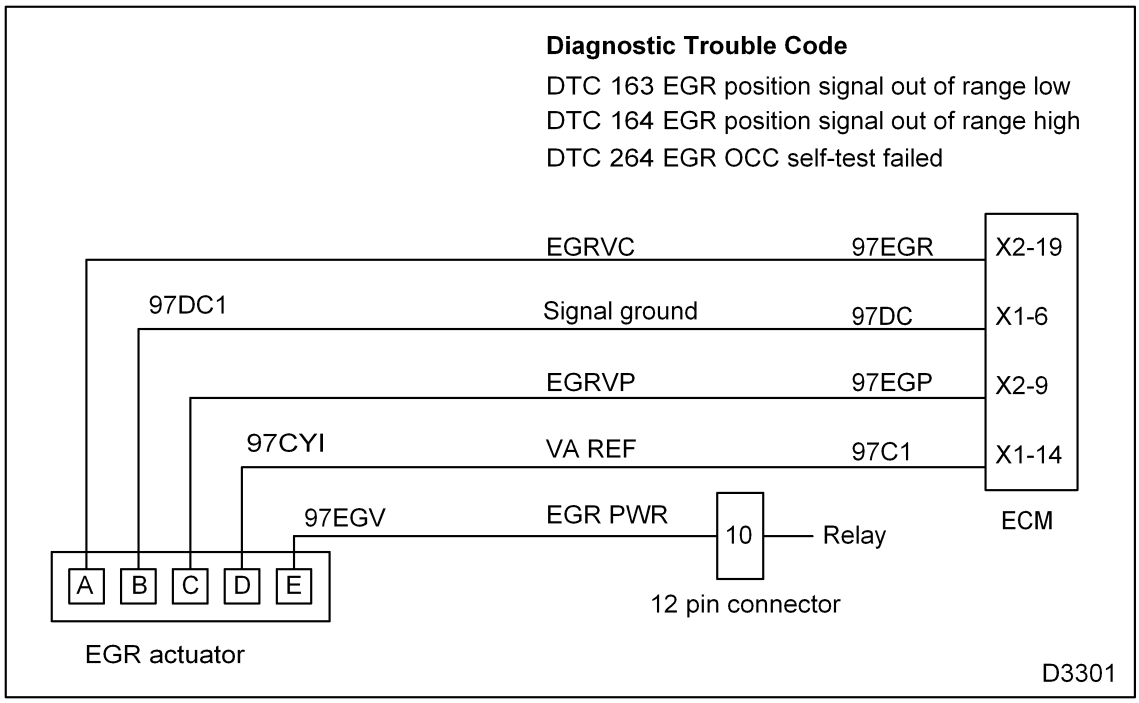

Figure 307 EGR Circuit Diagram

The EGR actuator receives 12V to terminal E from ECM power relay. The ECM controls the EGR through terminal A by grounding terminal X2-19 with a pulse width modulated signal. Precise control is gained by varying the percentage of ON/OFF time of the EGR coil. A high duty cycle indicates more force on the valve to open . A low duty cycle indicates less force on the valve to open.

The EGRP is supplied a 5 volt reference at terminal D from ECM terminal X1-14. The EGRP sensor is also supplied at terminal B from ECM terminal X1-6. The EGRP sensor sends a signal from terminal C of the sensor to ECM terminal to X2–9.

Fault Detection / Management

An open or short to ground in the EGR control circuit can be detected by an on demand output circuit check during KOEO Standard test. If there is a circuit fault detected a DTC will be set.

When the EGRP signal voltage is detected out of range high or low, the ECM will cause the engine to ignore the EGRP signal and the EGR valve will close and the amber ENGINE lamp will be illuminated.

The EGRP sensor is calibrated to zero position each time the key is cycled to allow compensation if carbon deposits develop on the valve. If the deposits get so heavy that the position is out of range to zero, a DTC will be set, the valve will close, and the amber ENGINE lamp will be illuminated.

The EGR actuator can also be tested for a stuck or sticking valve by performing an Output State Low Test while monitoring EGRP percentage. See Performance Diagnostic Section 6 for additional information.

EGR Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

DTC 163
EGRP signal out of range low

- DTC 163 is set by the ECM the EGRP voltage is less than 0.3V for more than 0.35 second.
- DTC 163 can be set due to an open or short to ground on the signal circuit, a defective sensor or an open V_{REF} circuit or V_{REF} short to ground.

- When DTC 163 is active the amber ENGINE lamp is illuminated.

DTC 164
EGRP signal out of range high

- DTC 164 is set by the ECM when the EGRP voltage is greater than 4.5V for more than 0.35 second.
- DTC 164 can be set due to an open or short to ground on the signal circuit, a defective sensor or an open V_{REF} circuit or V_{REF} short to ground.
- When DTC 164 is active the amber ENGINE lamp is illuminated.

DTC 264
EGR OCC self test failed

- DTC 264 is set by the ECM when the OCC test fails after the Key ON Engine OFF Standard test has been run.
- DTC 264 can be set due to open or shorts to ground, short to voltage source in the EGR control circuit, or a defective coil.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)
- Harness – 3-Banana and 500 ohm
- Breakout harness
- Breakout box
- Terminal Test Adapter Kit

EGR Operational Diagnostics

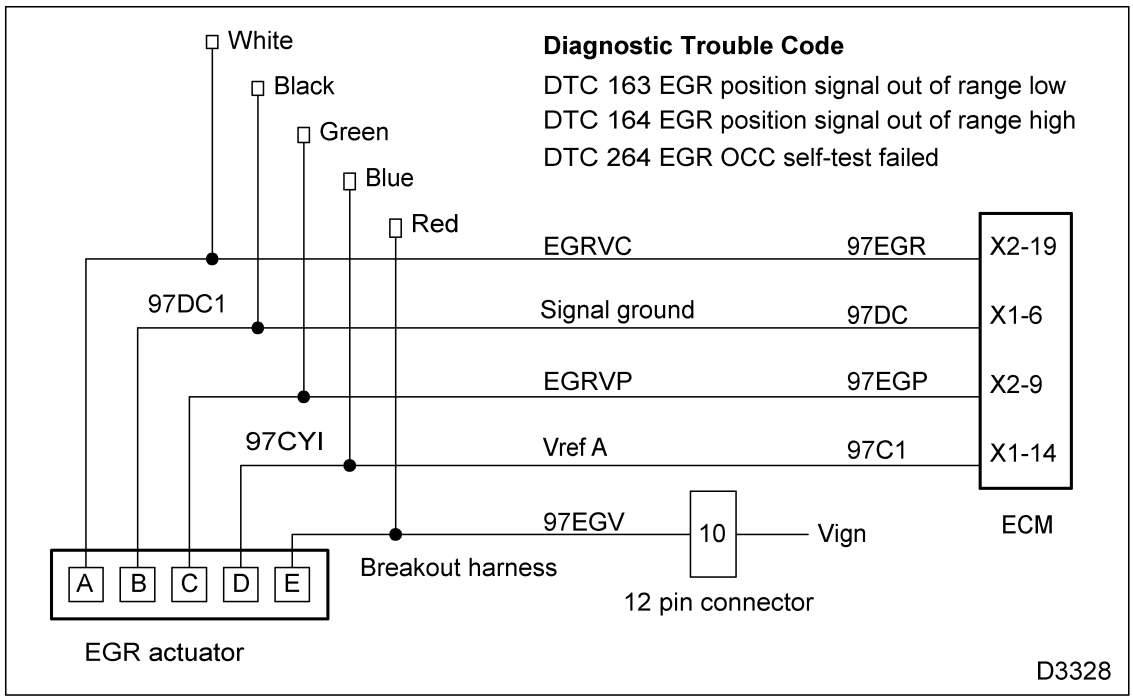

Figure 308 EGR Circuit Diagram with Breakout harness

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

Be careful to avoid rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the continuous monitor session. To monitor signal voltage, run Key ON Engine OFF continuous monitor test.

2. Monitor EGR signal volts. Verify an active DTC for the EGR circuit.

3. If code is active, complete step 5 and do circuit check for the EGR sensor in table on the following page.

4. If code is inactive, wiggle connectors and wires at all suspected problem locations. If circuit continuity is interrupted, the EST will beep and display DTCs related to the condition.

5. Install EGR breakout harness to engine harness only.

NOTE: After removing connector, inspect for damaged pins, corrosion, or loose terminals. Repair as required.

Table 49

Circuit Checks for EGR Sensor (Use EST, DMM, breakout harness, and 500 ohm wire harness.)		
Test Condition	**Spec**	**Checks**
Sensor disconnected	0V	If voltage >0.039V, check signal circuit for short to V_{REF} or B+.
Voltage from PIN D to ground with DMM.	5V ±0.5	If voltage >5.5V, check V_{REF} for short to B+. If voltage is <4.5V, check V_{REF} for open or short to ground. Remove the negative battery cable. Use breakout box and measure resistance from PIN D to X1–14 (spec <5Ω) to check for a short to ground or open in the harness.
500 ohm harness installed between GREEN and BLUE wires of breakout harness.	5V	If voltage <4.55V, check signal circuit for open or short to ground. Remove negative battery cable. Measure resistance from PIN C to ground (spec >1kΩ) to check for short to ground. Use a breakout box from PIN C to PIN X2–9 (spec <5Ω) to check for open in the harness.
Resistance from BLACK wire of breakout harness to chassis ground using DMM.	<5Ω	If resistance is >5Ω, check for open or high resistance between ECM and sensor connector. Use a breakout box and measure resistance from between PIN B and PIN X1–6 (spec <5Ω).

6. Connect engine harness to sensor. Use the EST to clear DTCs. If an active code remains after checking test conditions, replace the EGR valve.

EGR Pin Point Diagnostics

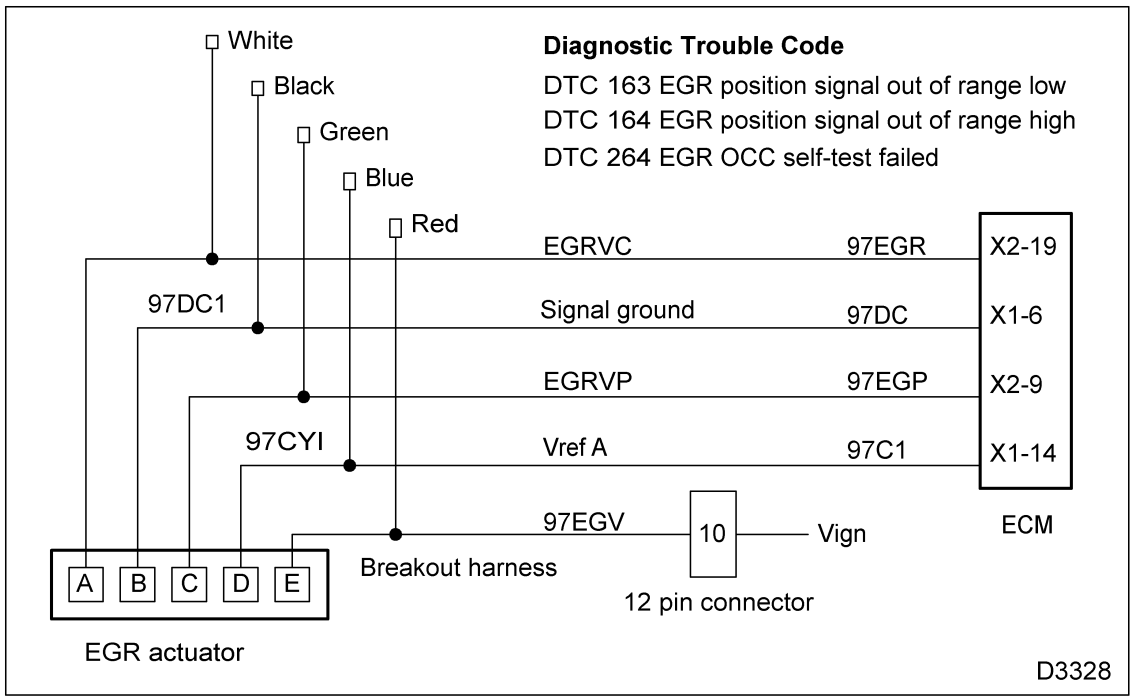

Figure 309 EGR Circuit Diagram with Breakout harness

Table 50

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.

Connector Voltage Checks (Disconnect sensor from harness and turn ignition key ON.)

Test Point	Spec	Comments
A to gnd	2.0 to 10V	If not in spec, check for control circuit shorted to B+ or ground
B to gnd	0V	Signal ground (no voltage expected). If voltage is present, check for short to B+ or V_{REF}
C to gnd	<0.25V	If >2.5V, signal circuit is shorted to V_{REF} or B+.
D to gnd	5V ±0.5	If voltage not to spec, V_{REF} circuit is shorted to gnd or B+
E to gnd	B+	EGR power from V_{IGN}. If no voltage, check from EGR to voltage source. See truck Chassis Electrical Circuit Diagram manual.

Resistance Checks to Chassis Ground (Install EGR breakout harness on engine harness only.)		
A to gnd	>1kΩ	If <1kΩ, control circuit short to ground.
B to gnd	<5Ω	If >5Ω, signal ground has open or high resistance.
C to gnd	>1kΩ	If <1kΩ, EGRP signal short to ground.
D to gnd	>500Ω	If <500Ω, V_{REF} short to ground.
E to gnd	>1kΩ	If <1kΩ, short to ground exists. See truck Chassis Electrical Circuit Diagram manual.
Harness Resistance Checks at EGR Valve Harness to Breakout Box ECM (Turn ignition key OFF. Install breakout box and EGR breakout harness on engine harness only.)		
A to X2–19	<5Ω	If >5Ω, ground wire open.
B to X1–6	<5Ω	If >5Ω, V_{REF} wire open.
C to X2–9	<5Ω	If >5Ω, EGRP signal wire open.
D to X1–14	<5Ω	If >5Ω, V_{REF} wire open.
E to power relay	<5Ω	If >5Ω, open circuit to power relay.
EGR Operational Voltage Checks (Check with breakout box installed to ECM and engine harness.Turn ignition key ON and engine OFF.)		
X2–9 to X1–6	0.6 – 1.2V	
EGR Diagnostic Trouble Codes (DTCs)		
DTC 163 = Signal voltage was <0.3V for more than 0.35 second		
DTC 164 = Signal voltage was >4.2V for more than 0.35 second		
DTC 264 = EGR OCC self test failed		

GLOW PLUG CONTROL (GPC) CIRCUIT

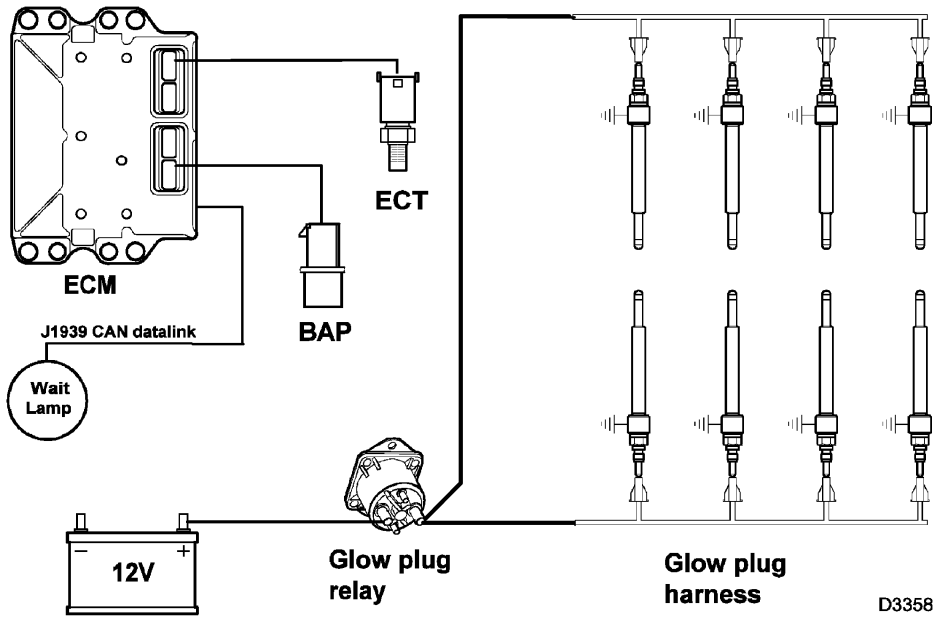

Figure 310 Function Diagram for the Glow Plug Control (GPC) Function

The Function Diagram for the Glow Plug Control system includes the following:

- Glow plugs
- Glow plug relay
- Electronic Control Module (ECM)
- Engine Coolant Temperature sensor (ECT)
- Barometric Absolute Pressure sensor (BAP)
- Battery

Function

The glow plug control system warms the engine cylinders to aid cold engine starting and reduce exhaust emissions during warm-up.

The Electronic Control Module (ECM) is programmed to energize the glow plugs (through the glow plug relay) while monitoring certain programmed conditions for engine coolant temperature and atmospheric pressure.

The ECM monitors battery voltage and uses information from the Barometric Absolute Pressure (BAP) sensor and Engine Coolant Temperature (ECT) sensor to determine the amount of time that the WAIT TO START lamp is ON and the activation time of the glow plugs. The ECM controls the WAIT TO START lamp and the activation of the glow plugs separately. The glow plug WAIT TO START lamp indicates when the glow plugs have been on long enough to start the engine. The on time normally varies between 2 to 10 seconds. The glow plugs are self limiting and do not require cycling on and off. The glow plug relay will only cycle on and off repeatedly if system voltage is greater than 14.0 volts.

Glow plugs are activated for a longer time, if the engine is cold or the barometric pressure is low (high altitude).

The engine is ready to start when the WAIT TO START lamp is turned off by the ECM. The glow plugs can remain on up to 120 seconds while the engine is running to reduce exhaust emissions during engine warm-up.

NOTE: The WAIT TO START lamp on time is independent from the glow plug relay on time.

GPC Circuit Operation

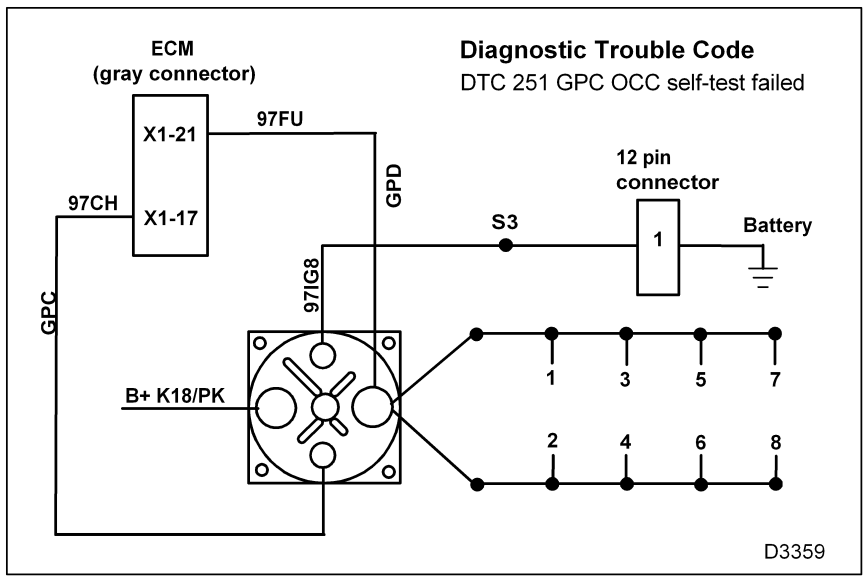

Figure 311 Glow Plug Control (GPC) Circuit Diagram

The glow plug control system operation on time is dependent upon the ECT, BAP, and battery voltage. The glow plug relay is activated by power supplied by the ECM through terminal X1–17 to circuit 97CH. The coil of the glow plug relay is grounded through circuit 97IG8, the 12 pin connector and to the battery negative terminal. Power is supplied to the switch side of the glow plug relay from the starter motor. When the relay coil is energized, power is supplied to the glow plugs which are grounded through the cylinder head.

The Wait to Start lamp time is transmitted over the CAN 1 datalink. See truck Chassis Electrical Circuit Diagram manual.

Fault Detection / Management

An open or short to ground in the glow plug relay circuit can be detected by an on demand Output Circuit Check (OCC) performed during the Key ON Engine OFF (KOEO) Standard tests. When a circuit fault is detected, a DTC will be set. Glow plug and glow plug harness problems can not be detected by the ECM.

Glow Plug Control Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

DTC 251
GPC Output Circuit Check self-test failed.

- DTC 251 is set by the ECM when the OCC test has failed after the KOEO Standard test has been run.
- DTC 251 can be set for an open or shorted GPC signal circuit, an open feed circuit, or an open glow plug relay coil.

Tools

- Digital Multimeter (DMM)
- Breakout box
- 12 pin breakout harness

NOTE: The GPC circuit requires the use of vehicle circuit diagrams. See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.

GPC Pin Point Diagnostics

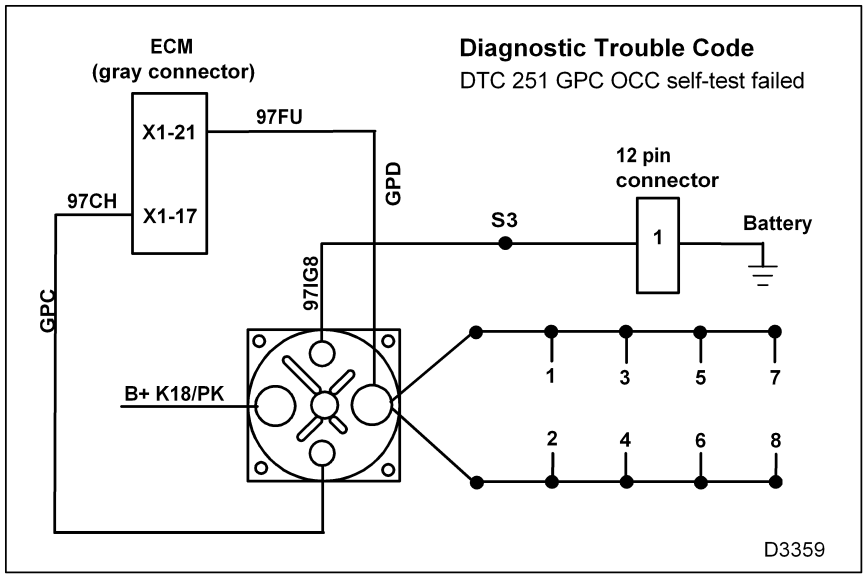

Figure 312 Glow Plug Control (GPC) Circuit Diagram

Table 51

Glow Plug Relay Voltage Checks		
Test Point	**Spec**	**Comments**
Relay feed to gnd	B+	Relay switch power, B+ should be present at all times (terminal with single 6 gauge wire). Check connection at starter or fusible links if no voltage is present.
Glow Plug feed to gnd	B+	Glow plug feed voltage should be present 0 to 120 seconds after key is cycled on (temperature dependent). (large terminal with 3 wires)
97CH to gnd	B+ or 0V	Glow Plug Control ECM commands relay ON = B+, OFF=0V
97IG8 to gnd	0V	GPC relay grounded from batteries. If voltage is present, check for open circuit.
Harness Resistance Checks (Check with specific connections disconnected and Key OFF.)		
97IG8 to gnd	<5Ω	If >5Ω, check for open circuit between relay and gnd.
97IG8 to PIN 1 on 12 pin breakout harness	<5Ω	If>5Ω, check for open from relay to 12 pin connector.
97CH to gnd	>1kΩ	If <1kΩ, check for short to ground from relay to X1–17
97CH at relay to X1–17	<5Ω	If >5Ω, check for open circuit between relay and ECM

For glow plug and harness diagnostics, see Section 5 in the manual.

NOTE: Circuit 97FU1 is for future diagnostics and is not used at this time.

IDLE SHUTDOWN TIMER (IST) SYSTEM

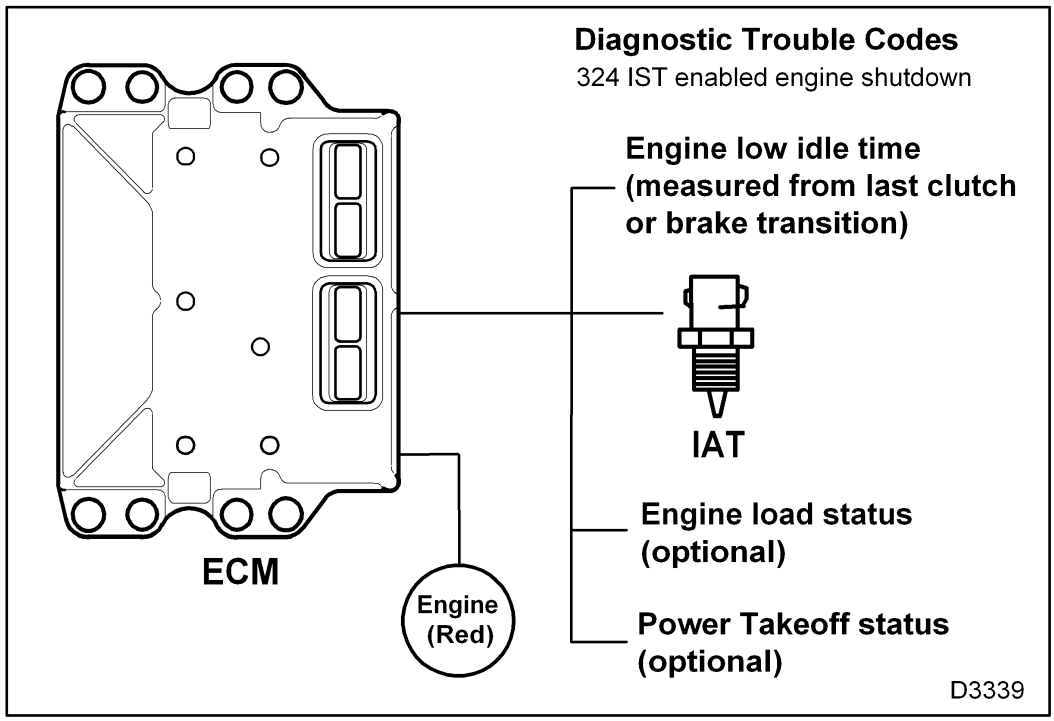

Figure 313 Function Diagram for the Idle Shutdown Timer (IST) System

IST Operation

The Idle Shutdown Timer (IST) is an optional feature that allows the ECM to shutdown the engine when an extended idle condition occurs. The idle timer can be programmed for the customer to automatically shut the engine down for idle times that range from 2 to 120 minutes.

Before engine shutdown, the red ENGINE lamp will illuminate. The lamp will flash for 30 seconds to warn the operator the engine is approaching shutdown. Idle time is measured from last clutch or brake pedal transition. The engine must be out of gear for the IST to work.

The IST feature can be programmed to operate at specific ambient air temperatures, allowing engine operation in cold or hot weather. Power Takeoff (PTO) applications can be programmed to disable the IST feature for load levels or when PTO features are active.

The resets for the Engine Shutdown Timer include:

- PTO is active
- Engine speed is not at idle speed (700 rpm)
- Vehicle movement or a Vehicle Speed Sensor (VSS) fault is detected
- Engine coolant operating temperature is below 60°C (140°F).
- Ambient air temperature is below 16°C (60°F) or above 44°C (110°F).
- Brake pedal movement or a brake switch fault is detected.
- Clutch pedal is depressed or a fault for the clutch pedal switch is detected (manual transmissions, if equipped with clutch switch).
- Shift selector is moved from neutral or park (automatic transmissions).

The IST feature provides several advantages when enabled. Reduced emissions, fuel consumption, and engine wear are all direct results from the IST strategy.

There are four states of the IST electronic operation.

- **Idle shutdown timer** – indicates to the on-board electronics that the vehicle has the feature.
  - OFF – feature is turned off at all times.
  - PTO available – feature allows prolonged engine idle shutdown when engine is in low idle and PTO is disabled.
  - No engine load – feature allows prolonged engine idle shutdown when engine is in low idle / no load condition.
  - Tamper proof – feature prohibits operator over-ride.
- **Idle shutdown time** – indicates the programmed value of engine idle time before engine will shutdown.
- **Maximum ambient intake air temperature** – indicates maximum value of ambient intake air temperature programmed to shutdown engine. This feature prevents engine shutdown due to air conditioner usage.
- **Minimum ambient intake air temperature** – indicates minimum value of ambient intake air temperature programmed to shutdown engine. This feature prevents engine shutdown due to cold ambient temperature.

Fault Detection / Management

The IST feature is internal to the ECM. The subsystems that contribute to the IST strategy have their own fault codes. The fault code for the IST is not a system diagnostic trouble code. The IST fault code is only set to indicate that the IST has been activated and the engine has shutdown.

IST Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

DTC 324
IST enabled engine shutdown

- DTC 324 is set by the ECM when the engine has been shutdown due to exceeding the programmed idle time criteria. The IST feature must be enabled for DTC 324 to be displayed.

NOTE: DTC 324 does not indicate any system or circuit DTCs. Diagnostic checks are not required for DTC 324.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable

INJECTION CONTROL PRESSURE (ICP) SENSOR

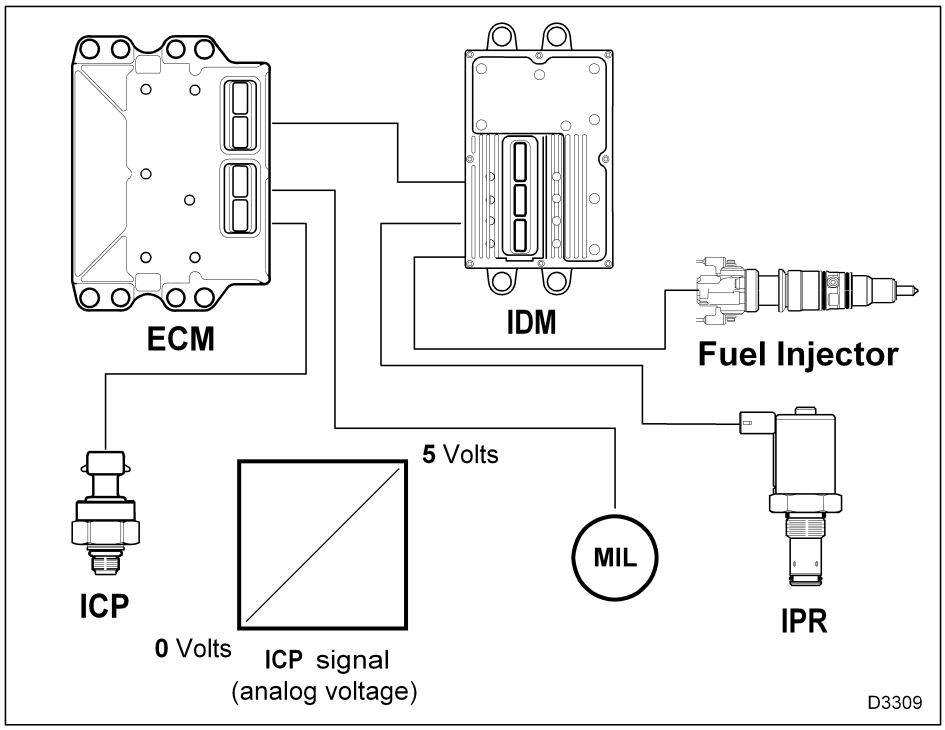

Figure 314 Function Diagram for the Injection Control Pressure (ICP) Sensor

The Function Diagram for the ICP sensor includes the following:

- Injection Control Pressure (ICP) sensor
- Electronic Control Module (ECM)
- Injector Drive Module (IDM)
- Fuel injector
- Injection Pressure Regulator (IPR)
- ENGINE lamp (amber)

Function

The ICP sensor is a variable capacitance sensor located at the top rear of the engine in the high pressure pump cover. The ECM supplies a 5V reference signal which the ICP sensor uses to produce a linear analog voltage that indicates pressure.

The primary function of the ICP sensor is to provide a feedback signal to the ECM indicating ICP. The ECM monitors ICP as the engine is operating to modulate the IPR. This is a closed loop function which means the ECM continuously monitors and adjusts for ideal ICP determined by conditions such as load, speed, and temperature.

The ECM monitors the ICP signal to determine if the performance of the hydraulic system is satisfactory. During engine operation, if the ECM recognizes that the ICP signal is lower or higher than the value that the IPR is trying to achieve the ECM will set a DTC and illuminate the amber ENGINE lamp.

The ICP signal from the ECM is one of the signals the IDM uses to command the correct injector timing.

ICP Circuit Operation

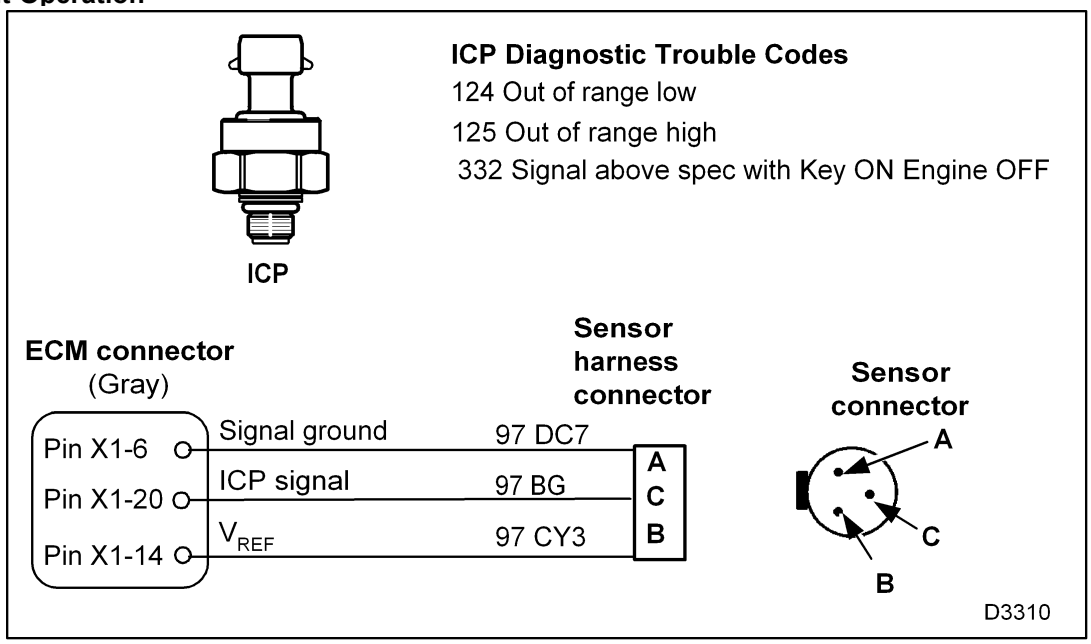

Figure 315 ICP Circuit Diagram

The ICP sensor is supplied with a 5V reference voltage at terminal B from ECM terminal X1–14. The ICP sensor is also supplied with a ground circuit at terminal A from ECM terminal X1–6. The ICP sensor sends a signal from terminal C of the sensor to ECM terminal X1–20.

Fault Detection / Management

The ECM continuously monitors the signal of the ICP sensor to determine if the signal is within an expected range. If the ECM detects a higher or lower voltage than expected, the ECM will set a DTC, illuminate the amber ENGINE lamp, ignore the ICP sensor signal, and use a preset value based on engine operating conditions.

ICP Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

DTC 124
ICP signal out of range low

- DTC 124 is set by the ECM if signal voltage is less than 0.039V for more than 0.1 second.
- DTC 124 can be set due to an open or short to ground on the signal circuit, a defective sensor or an open V_{REF} circuit or V_{REF} short to ground.
- When DTC 124 is active the amber ENGINE lamp is illuminated.

DTC 125
ICP signal out of range high

- DTC 125 is set by the ECM if the signal voltage is greater than 4.9V for more than 0.1 second.
- DTC 125 can be set due to an open signal ground circuit, short to a voltage source on the ICP signal circuit, or a defective sensor.
- When DTC 125 is active the amber ENGINE lamp is illuminated.

DTC 332
ICP above specification with engine off

- DTC 332 is set by the ECM, if the voltage signal from the ICP sensor is higher than expected with the Key ON Engine OFF. If the ECM sets DTC 332, the ECM will ignore the ICP signal and operate the IPR with fixed values based on engine operating conditions.
- DTC 332 can be caused by a defective sensor, a biased circuit, or momentary loss of the CMP/CKP signal.
- When DTC 332 is active the amber ENGINE lamp is illuminated.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)
- Harness – 3-Banana and 500 ohm
- Breakout harness
- Breakout box
- Terminal Test Adapter Kit

ICP Operational Diagnostics

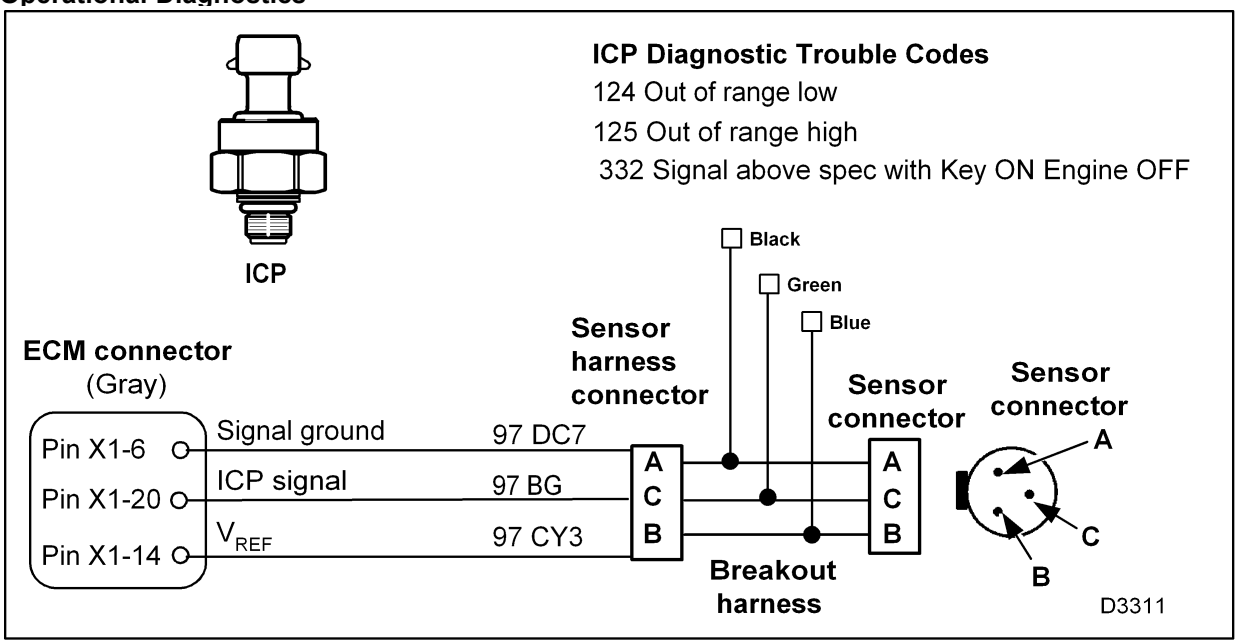

Figure 316 ICP Circuit Diagram with Breakout harness

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

Be careful to avoid rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the continuous monitor session. To monitor signal voltage, run Key ON Engine OFF continuous monitor test.

2. Monitor ICP signal volts. Verify an active DTC for the ICP circuit.

3. If code is active, complete step 5 and do circuit check for the ICP sensor in table on the following page.

4. If code is inactive, wiggle connectors and wires at all suspected problem locations. If circuit continuity is interrupted, the EST will beep and display DTCs related to the condition.

5. Install pressure sensor breakout harness to engine harness only.

NOTE: After removing connector, inspect for damaged pins, corrosion, or loose terminals. Repair as required.

Table 52

Circuit Checks for ICP Sensor (Use EST, DMM, breakout harness, and 500 ohm wire harness.)		
Test Condition	**Spec**	**Checks**
Sensor disconnected	0V	If voltage >0.039V, check signal circuit for short to V_{REF} or B+.
Voltage from BLUE Pin to ground with DMM	5V ±0.5	If voltage >5.5V, check V_{REF} for short to B+. If voltage is <4.5V, check V_{REF} for open or short to ground.
500 ohm harness installed between GREEN and BLUE pins of breakout harness.	5V	If voltage <4.9V, check signal circuit for open or short to ground. Remove negative battery cable. Measure resistance from PIN C to ground (spec >1kΩ) to check for short to ground. Use a breakout box from PIN C to PIN X1–20 (spec <5Ω) to check for open in the harness.
Resistance from BLACK pin of breakout harness to chassis ground using DMM.	<5Ω	If resistance is >5Ω, check for open or high resistance between ECM and sensor connector. Use a breakout box and measure resistance from between PIN A and PIN X1–6 (spec <5Ω).

6. Connect engine harness to sensor. Use the EST to clear DTCs. If an active code remains after checking test conditions, replace the ICP sensor.

ICP Pin Point Diagnostics

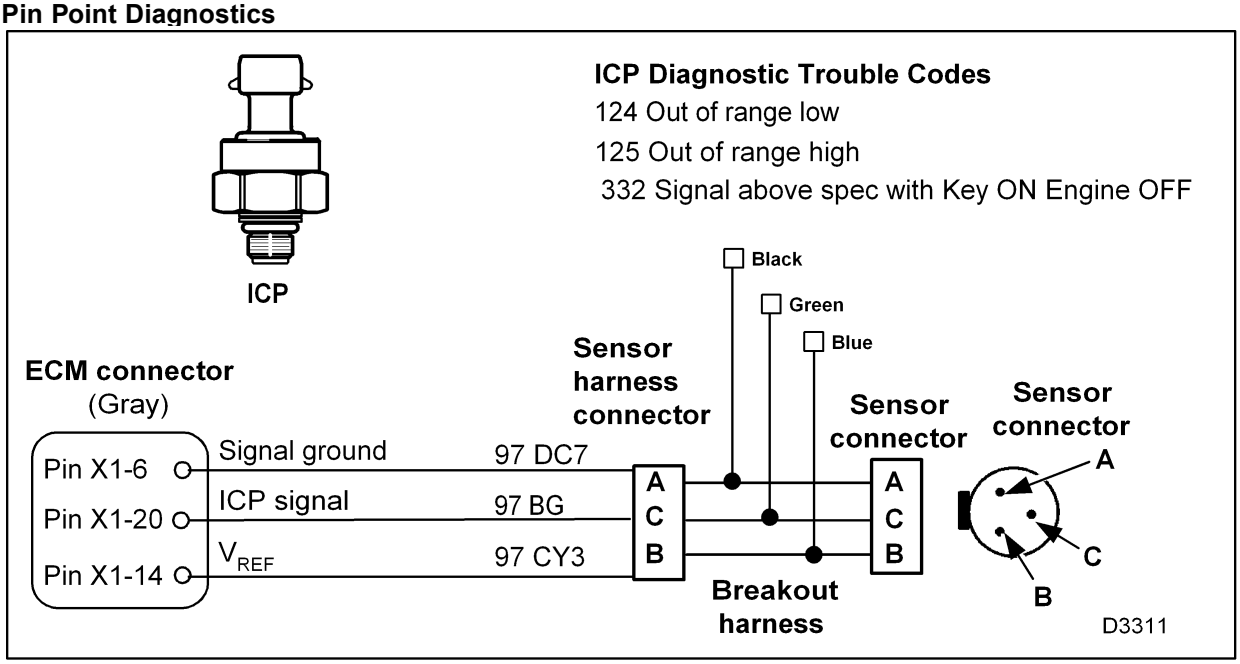

Figure 317 ICP Circuit Diagram with Breakout harness

Table 53

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.

Connector Voltage Checks (Disconnect sensor from harness and turn ignition key ON.)

Test Point	Spec	Comments
A to gnd	0V	Signal ground (No voltage expected). If voltage is present, check for short to B+ or V_{REF}.
B to gnd	5V ± 0.5	If voltage is not to spec, V_{REF} circuit is shorted to gnd or B+
C to gnd	<0.25V	If voltage >0.25V, wire is shorted to V_{REF} or B+
Connector Resistance Checks to Chassis Ground (Turn ignition key OFF. Disconnect negative battery cable and sensor.)		
A to gnd	<5Ω	If >5Ω, check for open circuit
B to gnd	>500Ω	If <500Ω, check for short to ground
C to gnd	>1kΩ	If <1kΩ, check for short to ground
Harness Resistance Checks (Install breakout box on engine harness only.)		
X1–6 to A	<5Ω	If >5Ω, check for open ground wire
X1–14 to B	<5Ω	If >5Ω, check for open V_{REF} wire
X1–20 to C	<5Ω	If >5Ω, check for open signal wire

Table 54

Operational Voltage Checks for ICP Sensor (Check with breakout box installed to ECM and engine harness.)			
Test Point	**EST voltage readings: Signal to ground**	**Spec**	**Checks**
X1–20 to X1–6	0.15V to 0.3V	0 psi (0 kPa)	Atmospheric pressure with Key ON Engine OFF
X1–20 to X1–6	See performance specs	See performance specs	Minimum at engine cranking speed
X1–20 to X1–6	See performance specs	See performance specs	Low idle, no load
X1–20 to X1–6	See performance specs	See performance specs	High idle, no load
X1–20 to X1–6	See performance specs	See performance specs	Rated speed, full load
ICP Diagnostic Trouble Code			
DTC 124 = Signal voltage was <0.39V for more than 0.1 second			
DTC 125 = Signal voltage was >4.9V for more than 0.1 second			
DTC 332 = Signal voltage was >1.625V, ignition Key ON Engine OFF 7.99 kPa (1160 psi)			

INJECTION CONTROL PRESSURE (ICP) SYSTEM

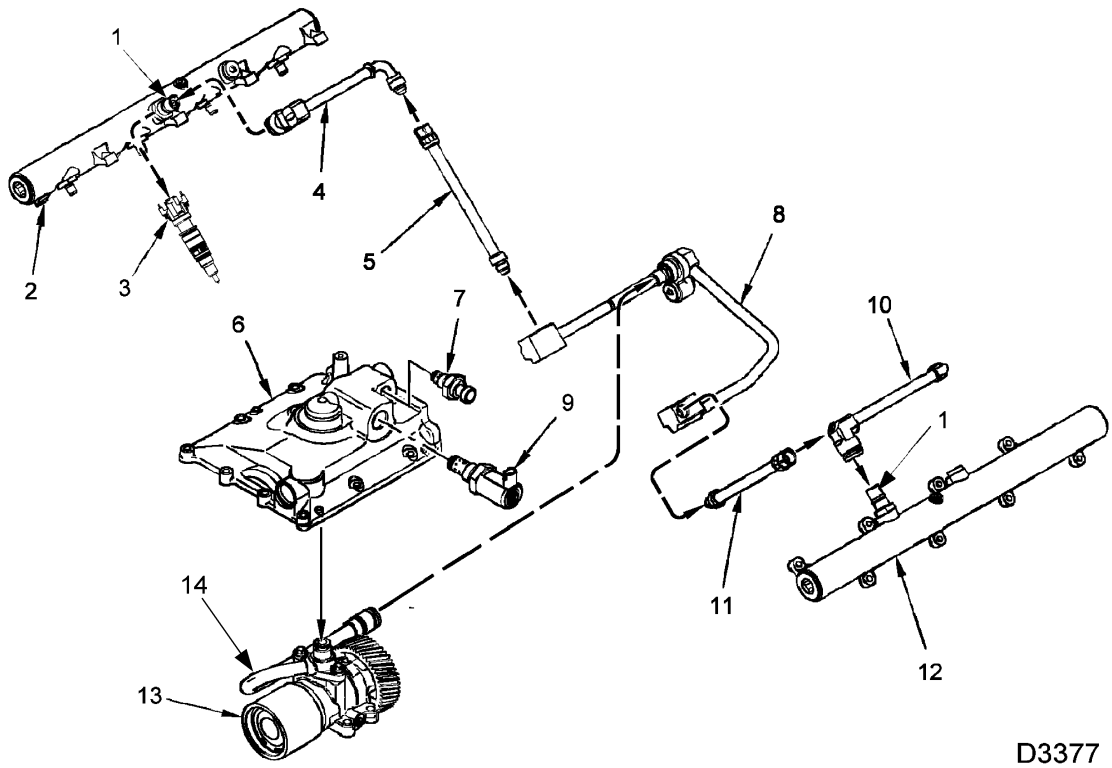

Figure 318 Function Diagram for the Injection Control Pressure (ICP) System

1. Oil rail fitting with check valve
2. High pressure oil rail (right)
3. Fuel injector
4. High pressure oil hose (right)
5. High pressure tube (crankcase to head, right)
6. High pressure oil pump cover
7. ICP sensor
8. High pressure tube assembly (rear branch)
9. IPR Valve
10. High pressure oil hose (left)
11. High pressure tube (crankcase to head, left)
12. High pressure oil rail (left)
13. High pressure oil pump with discharge tube

The ICP system consists of the following sub-systems and components:

- Electronic Control Module (ECM)
- Injectors
- Injection Pressure Regulator (IPR)
- Injection Control Pressure (ICP) sensor
- Engine lubrication system
- High pressure pump reservoir
- Reservoir screen
- Crankcase passage
- High pressure hydraulic pump
- Pump cover
- Discharge line
- Rear branch line
- High pressure oil hoses
- High pressure connector tubes
- High pressure oil rails
- Associated wiring

Function

The function of the injection control pressure system is to develop, maintain, and control the high pressure injection control pressure to provide the force to actuate the injectors and provide fuel to the engine.

ICP System Operation

Fault Detection / Management

The Diagnostic Trouble Codes associated with this system may indicate an electrical or electronic control system failure, but **will most likely indicate a mechanical or hydraulic problem with the injection control pressure system.**

The ECM continuously monitors the ICP in the system to assure the control system is providing the proper control pressure at all times. If the oil pressure feedback provided by the ICP sensor does not meet the ECM's desired values, the ECM will set a DTC, illuminate the amber engine lamp and control the operation of the ICP system by calculating the correct oil pressure for all engine operating conditions until the system is diagnosed and repaired.

The ECM monitors the injection control pressure developed while the engine is cranking. When pressure does not develop in an expected time frame, the ECM will set a Diagnostic Trouble Code (DTC). The DTC will aid in identifying and diagnosing the hard start and no start condition.

The Electronic Service Tool (EST) 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 and evaluates system performance. When the test concludes, if a performance issue has been detected, the ECM will set a DTC for that system condition.

When an ICP fault is detected, the ECM will default to open loop of IPR control and the EST will display N/A on ICP data. ICP desired will indicate default pressure.

ICP System Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

NOTE: Repair all injector, sensor, and actuator DTCs before doing ICP diagnostic checks and tests.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)

Table 55

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle, when performing ICP system checks and tests – comply with the following:

- **Read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.**
- **When running the engine in the service bay, make sure the parking brake is set, the transmission is in neutral, and the wheels are blocked.**
- **Be careful to avoid rotating parts (belts and fan) and hot engine surfaces.**

Table 56

DTC 331 – ICP system above working system range
DTC 331 is set by the ECM when the injection control pressure is above normal working range of 25 MPa (3675 psi). DTC 331 can be an indicator of a problem in the mechanical injection control pressure system, wiring, or ICP sensor. When DTC 331 is active, the ECM will ignore feedback from the ICP sensor and control the IPR valve from programmed default values. The amber ENGINE lamp will be illuminated when DTC 331 is active. Possible causes for DTC 331 include the following: • Debris in engine • Incorrect grade of oil • Defective, stuck or plugged inlet on the IPR valve • IPR control wire shorted to ground • ICP sensor or circuit causing signal to be biased high

Checks and Tests	Comments
Check oil level and quality.	Check oil level and for contamination, debris, and correct API classification.
Do the KOEO Standard test.	Test will verify IPR valve circuit continuity. See Section 6 – Performance Diagnostics.
Do the ICP operational voltage checks.	See ICP circuit diagnostics.
Do Performance Diagnostics – Section 6	See KOER Standard test and Injection Control Pressure test.

Table 57

DTC 333 – ICP above / below desired level

DTC 333 indicates an injection control system response time fault and may be set during normal engine operation through the continuous monitor function or during the Engine Running Standard Test.

DTC 333 is set by the ECM when the measured pressure does not match the pressure expected by the ECM. DTC 333 will be set if the measured value is less than or greater than 2.5 MPa (362 psi) of desired injection control pressure for a period greater than 7 seconds.

When DTC 333 is active, the ECM will ignore feedback from the ICP sensor and control the IPR valve from programmed default values. The amber ENGINE lamp will be illuminated when DTC 333 is active.

Possible causes for DTC 333 include the following:

- Low oil level in crankcase
- Contaminated engine oil
- Debris in engine oil
- Aerated engine oil
- Trapped air in the ICP system (particularly after an injector or high pressure pump replacement)
- Intermittent IPR valve wiring connection. Spread IPR harness terminals at valve, poorly crimped terminals, or pulled back pins.
- Defective or stuck injection pressure regulator
- Leaks in ICP system
- Problem with ICP sensor or sensor circuit, incorrect sensor, system biased high or low
- Defective high pressure hydraulic pump

Checks and Tests	Comments
Check repair history – Determine if trapped air caused by ICP system disassembly.	If ICP system was serviced, vehicle should be operated 20 miles to validate system performance
Check oil level and quality.	Check oil level, API classification. Inspect for debris. If contamination is suspected, check oil filter element.
Check active and inactive DTCs.	Repair any ICP sensor codes. See ICP circuit diagnostics.
Do KOEO Standard test.	Test will verify IPR circuit continuity. See Section 6 – Performance Diagnostic.
Do KOER Standard test.	Test will verify major ICP system failure. See Section 6 – Performance Diagnostics.
Do KOER continuous monitor test (intermittent DTC detected).	When running test, wiggle wires on ICP sensor, IPR valve, and all pass through connectors while engine is running.
Do ICP pressure test.	Verify if oil is aerated at high idle. See Section 6 – Performance Diagnostics.
Test ICP system for leaks.	See Section 5 – Hard Start and No Start Diagnostics.

Table 58

DTC 334 – ICP unable to reach set point, poor performance

DTC 334 indicates an injection control system response time fault and may be set during normal engine operation through the continuous monitor function or during the Engine Running Standard Test.

DTC 334 compares measured ICP to desired ICP and looks for a large pressure difference of 9 MPa (1300 psi) for a period of 3 seconds.

When DTC 334 is active, the ECM ignores the ICP sensor and controls the IPR valve operation from programmed default values.

Possible causes for DTC 334 include the following:

- Low oil level in crankcase
- Contaminated engine oil
- Debris in engine oil
- Aerated engine oil
- Trapped air in the ICP system (particularly after an injector or high pressure pump replacement)
- Intermittent IPR valve wiring connection. Spread IPR harness terminals at valve, poorly crimped terminals, or pulled back pins.
- Defective or stuck injection pressure regulator
- Leaks in ICP system
- Problem with ICP sensor or sensor circuit, incorrect sensor, system biased high or low
- Defective high pressure hydraulic pump

Checks and Tests	Comments
Check repair history – Determine if trapped air caused by ICP system disassembly.	If ICP system was serviced, vehicle should be operated 20 miles to validate system performance
Check oil level and quality.	Check oil level, API classification. Inspect for debris. If contamination is suspected, check oil filter element.
Check active and inactive DTCs.	Repair any ICP sensor codes. See ICP circuit diagnostics.
Do KOEO Standard test.	Test will verify IPR circuit continuity. See Section 6 – performance diagnostics.
Do KOER Standard test.	Test will verify major ICP system failure. See Section 6 – Performance Diagnostics.
Do KOER continuous monitor test (intermittent DTC detected).	When running test, wiggle wires on ICP sensor, IPR valve, and all pass through connectors while engine is running.
Do ICP pressure test.	Verify if oil is aerated at high idle. See Section 6 – Performance Diagnostics.
Test ICP system for leaks.	See Section 5 – Hard Start and No Start Diagnostics (Low ICP System Pressure).

Table 59

DTC 335 – ICP unable to build pressure when cranking	
DTC 335 is set after the ECM detects 8 to 10 seconds of engine cranking with less than 5 MPa (725 psi) of ICP. Engine cranking speed must be greater than 130 rpm before diagnostic trouble code detection can begin. Engine cranking time varies with engine temperature. Possible causes for DTC 335 include the following: • Low oil level in crankcase • No lube oil pressure or lube oil delivery (reservoir empty or not filling) • Trapped air in the ICP system (particularly after an injector or high pressure pump replacement) • Leaks in ICP system • Defective or stuck injection pressure regulator • Loose high pressure hydraulic pump gear • Defective high pressure hydraulic pump	
Checks and Tests	**Comments**
Visual inspection	Verify ICP sensor and IPR wiring is connected. Check for oil leaks. Verify if system has been recently serviced (air entrapment). If ICP system was serviced, vehicle should be operated 20 miles to validate system performance.
Check oil level and pressure.	Inspect engine oil for debris. Verify lube oil pressure and delivery during engine cranking. Verify delivery by collecting oil from lube oil pressure tap. See Section 5 – Hard Start and No Start Diagnostics.
Check active and inactive DTCs.	Repair any ICP, CKP, or CMP sensor codes first. See ICP, CKP, and CMP circuit diagnostics.
Do KOEO Standard test.	Test will verify IPR valve circuit continuity. See Section 5 – Hard Start and No Start Diagnostics.
Do KOER continuous monitor test.	When engine is running, enable test, wiggle wires on ICP sensor, IPR valve, and all pass through connectors. If DTC is set, or engine dies, check codes and inspect wires at connection point.
Do ICP pressure test.	Test will verify if oil is aerated at high idle. See Section 6 – performance diagnostics.
Test ICP system for leaks.	See Section 5 – Hard Start and No Start Diagnostics (Low ICP System Pressure).

INJECTOR DRIVE CIRCUITS (INJ)

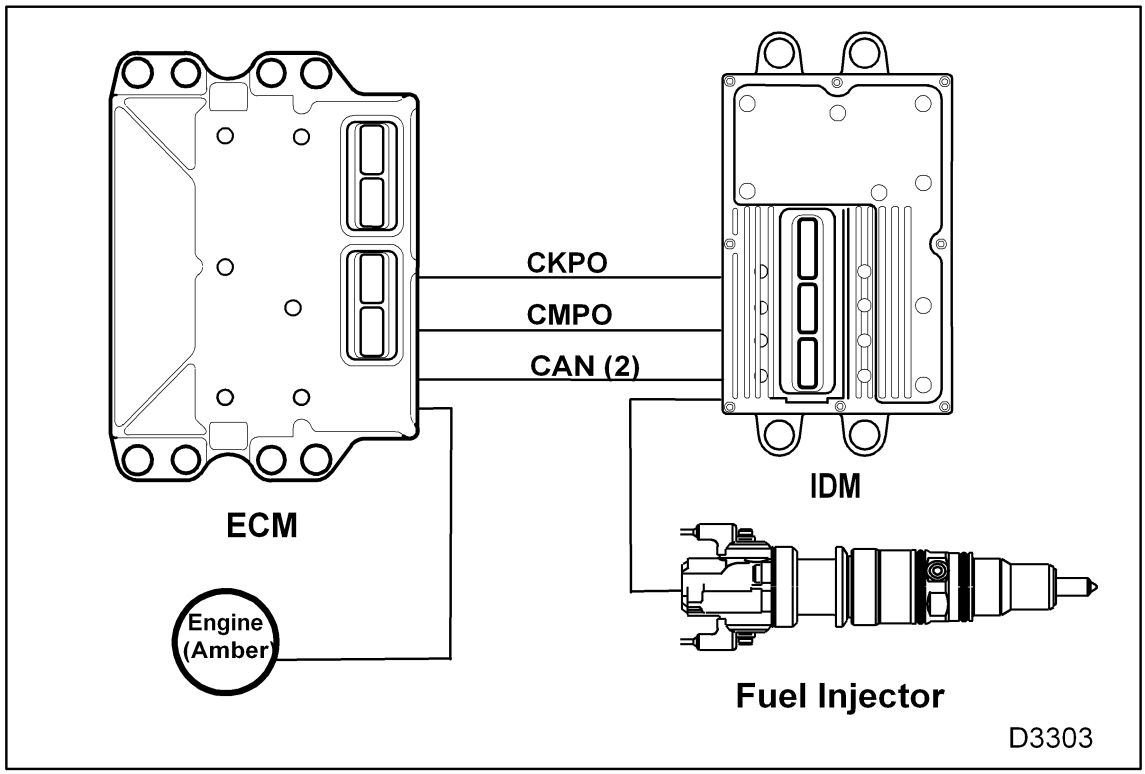

Figure 319 Function Diagram for the Injector Drive (INJ)

The Function Diagram for INJ includes the following:

- Injectors
- Electronic Control Module (ECM)
- Injector Driver Module (IDM)
- Controller Area Network (CAN 1) link
- Camshaft Position Output (CMPO) signal
- Crankshaft Position Output (CKPO) signal

Function

The IDM is used to control the injectors. The IDM receives CMPO and CKPO signals and fueling information via CAN from the ECM. The IDM calculates injection timing and injector actuation time based on the fuel quantity requested for any engine operation condition.

INJ Circuit Operation

When a coil needs to be energized the IDM turns on both the high and low side driver.

High Side Drive Outputs

The IDM regulates the current at a average of 20 amps. When the current reaches 24 amps the IDM shuts of the high side driver. When the current drops to 16 amps the IDM turns on the high side driver.

Low Side Drive Returns

The injector solenoids are grounded through the low side return circuits. The ECM monitors 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 internal to the ECM.

Fault Detection / Management

When the engine is running, the IDM can detect individual injector coil open and shorts to ground or battery. A Key ON Engine OFF Injector Test allows

the operator to enable all injector coils when the engine is off to verify circuit operation. When the IDM detects a fault, DTCs are transmitted over the CAN 2 line between the ECM and IDM.

The IDM transmits a high and low side drive output to the injectors. The high side output supplies the injectors with a power supply of 48V DC at 20 amps. The low side output supplies a return circuit to each injector coil.

The injectors are under the right and left valve covers. Each injector has a close and open coil. The IDM continuously monitors the amount of time (rising time) taken by each coil to draw 20 amps. The time is compared to calibrated values and the IDM 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 short to ground condition is detected on an injector (low or high side), the IDM discontinues power to the shorted injector, enables the amber ENGINE lamp, and operates the engine on the remaining cylinders.

INJ Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp. The last digit in the injector DTC corresponds to the cylinder where a fault has been detected.

DTC 421-428
High side to low side open

- DTC 421–428 is set by the ECM when the rising time is too long on open or close coil. DTC 421–428 usually indicates a harness or coil is open.

DTC 431-438
High shorted to low side

- DTC 431–438 is set by the ECM when the rising time to 20 amps is short, but not zero on the open or close coil. DTC 431–438 usually indicates an internally shorted coil.

DTC 451-458
High or low side short to ground or V_{BATT}

- DTC 451–458 is set by the ECM when the rising time to 20 amps is zero on the open or close coil. DTC 451–458 usually indicates the harness or coil is shorted to ground.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)
- Terminal Test Adapter Kit

INJ Pin Point Diagnostics

WARNING: To avoid serious personal injury or possible death, do not perform voltage checks with the engine running. Injector solenoid operating voltage of 48V DC @ 20 amps is present on injector circuits.

CAUTION: To avoid engine damage, turn the ignition key to OFF before unplugging the connector or relay for the IDM. Failure to turn the key to OFF will cause a voltage spike and damage to electrical components.

Before doing injector diagnostic testing:

1. Turn ignition key OFF.

2. Disconnect IDM connectors (X1 and X2).

All tests are checked at harness end. Terminal numbers are marked on all connector mating ends. After checking resistance through injector coils and resistance to chassis ground, if tests are in spec and DTC is active, replace the injector.

NOTE: Only diagnose injectors with active DTCs.

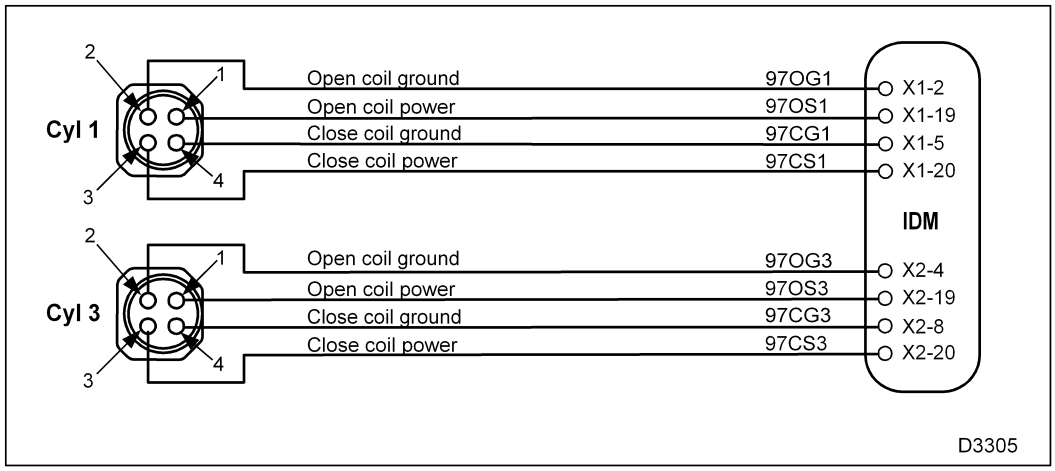

Figure 320 Cylinder 1 and 3 Circuit Diagram

Table 60

Injector Cylinder 1		
Test Point	**Spec**	**Comments**
X1–2 to X1–19	0.7–1.5Ω	If >1.5Ω, check for open or high resistance between IDM and injector, or open injector coil
X1–2 to gnd, X1–19 to gnd	>1kΩ	If <1kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If >1kΩ, the short is in the injector.
X1–5 to X1–20	0.7–1.5Ω	If >1.5Ω, check for open or high resistance between IDM and injector, or open injector coil.
X1–5 to gnd, X1–20 to gnd	>1kΩ	If <1kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If >1kΩ, the short is in the injector.

Table 61

Injector Cylinder 3		
Test Point	**Spec**	**Comments**
X2–4 to X2–19	0.7–1.5Ω	If >1.5Ω, check for open or high resistance between IDM and injector, or open injector coil
X2–4 to gnd, X2–19 to gnd	>1kΩ	If <1kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If >1kΩ, the short is in the injector.
X2–8 to X2–20	0.7–1.5Ω	If >1.5Ω, check for open or high resistance between IDM and injector, or open injector coil
X2–8 to gnd, X2–20 to gnd	>1kΩ	If <1kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If >1kΩ, the short is in the injector.

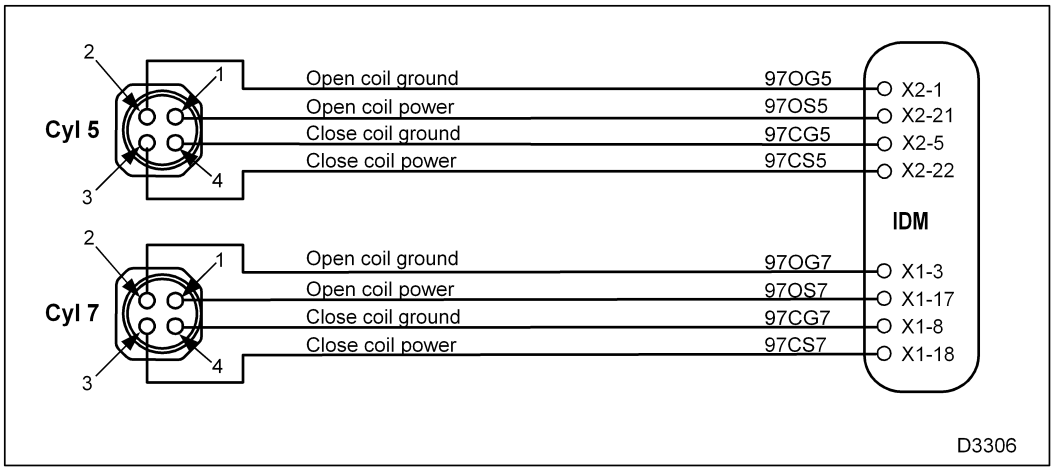

Figure 321 Cylinder 5 and 7 Circuit Diagram

Table 62

Injector Cylinder 5		
Test Point	**Spec**	**Comments**
X2–1 to X2–21	0.7–1.5Ω	If >1.5Ω, check for open or high resistance between IDM and injector, or open injector coil
X2–1 to gnd, X2–21 to gnd	>1kΩ	If <1kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If >1kΩ, the short is in the injector.
X2–5 to X2–22	0.7–1.5Ω	If >1.5Ω, check for open or high resistance between IDM and injector, or open injector coil
X2–5 to gnd, X2–22 to gnd	>1kΩ	If <1kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If >1kΩ, the short is in the injector.

Table 63

Injector Cylinder 7		
Test Point	**Spec**	**Comments**
X1–3 to X1–17	0.7–1.5Ω	If >1.5Ω, check for open or high resistance between IDM and injector, or open injector coil
X1–3 to gnd, X1–17 to gnd	>1kΩ	If <1kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If >1kΩ, the short is in the injector.
X1–8 to X1–18	0.7–1.5Ω	If >1.5Ω, check for open or high resistance between IDM and injector, or open injector coil
X1–8 to gnd, X1–18 to gnd	>1kΩ	If <1kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If >1kΩ, the short is in the injector.

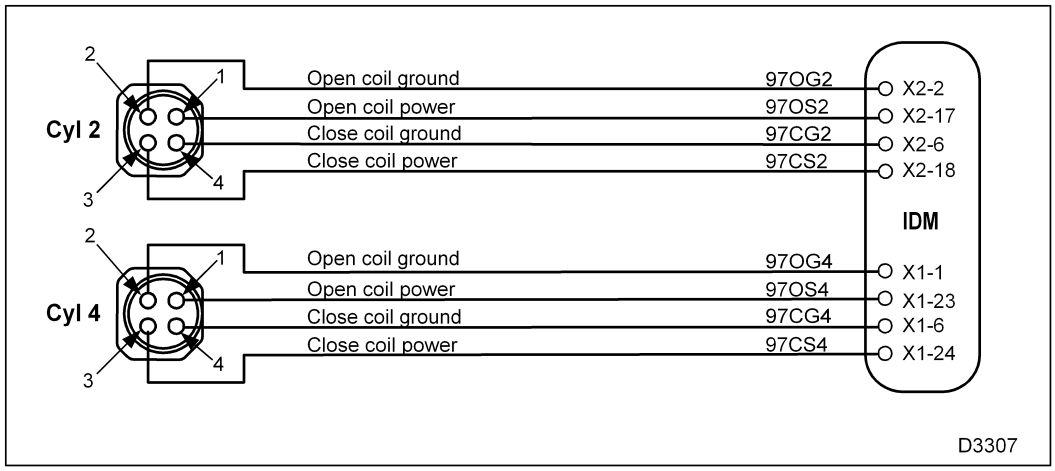

Figure 322 Cylinder 2 and 4 Circuit Diagram

Table 64

Injector Cylinder 2		
Test Point	**Spec**	**Comments**
X2–6 to X2–18	0.7–1.5Ω	If >1.5Ω, check for open or high resistance between IDM and injector, or open injector coil
X2–6 to gnd, X2–18 to gnd	>1kΩ	If <1kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If >1kΩ, the short is in the injector.
X2–2 to X2–17	0.7–1.5Ω	If >1.5Ω, check for open or high resistance between IDM and injector, or open injector coil
X2–2 to gnd, X2–17 to gnd	>1kΩ	If <1kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If >1kΩ, the short is in the injector.

Table 65

Injector Cylinder 4		
Test Point	**Spec**	**Comments**
X1–6 to X1–24	0.7–1.5Ω	If >1.5Ω, check for open or high resistance between IDM and injector, or open injector coil
X1–6 to gnd, X1–24 to gnd	>1kΩ	If <1kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If >1kΩ, the short is in the injector.
X1–1 to X1–23	0.7–1.5Ω	If >1.5Ω, check for open or high resistance between IDM and injector, or open injector coil
X1–1 to gnd, X1–23 to gnd	>1kΩ	If <1kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If >1kΩ, the short is in the injector.

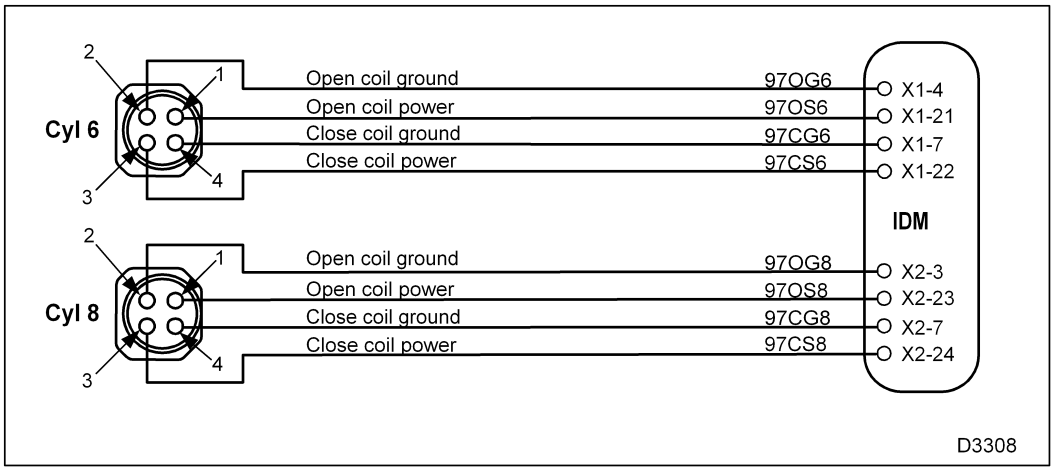

Figure 323 Cylinder 6 and 8 Circuit Diagram

Table 66

Injector Cylinder 6		
Test Point	**Spec**	**Comments**
X1–7 to X1–22	0.7–1.5Ω	If >1.5Ω, check for open or high resistance between IDM and injector, or open injector coil
X1–7 to gnd, X1–22 to gnd	>1k Ω	If <1kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If >1kΩ, the short is in the injector.
X1–4 to X1–21	0.7–1.5Ω	If >1.5Ω, check for open or high resistance between IDM and injector, or open injector coil
X1–4 to gnd, X1–21 to gnd	>1kΩ	If <1kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If >1kΩ, the short is in the injector.

Table 67

Injector Cylinder 8		
Test Point	**Spec**	**Comments**
X2–7 to X2–24	0.7–1.5Ω	If >1.5Ω, check for open or high resistance between IDM and injector, or open injector coil
X2–7 to gnd, X2–24 to gnd	>1kΩ	If <1kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If >1kΩ, the short is in the injector.
X2–3 to X2–23	0.7–1.5Ω	If >1.5Ω, check for open or high resistance between IDM and injector, or open injector coil
X2–3 to gnd, X2–23 to gnd	>1kΩ	If <1kΩ, check for short to ground in harness or injector coil. Disconnect injector and retest. If >1kΩ, the short is in the injector.

INJECTION DRIVER MODULE POWER (IDM PWR)

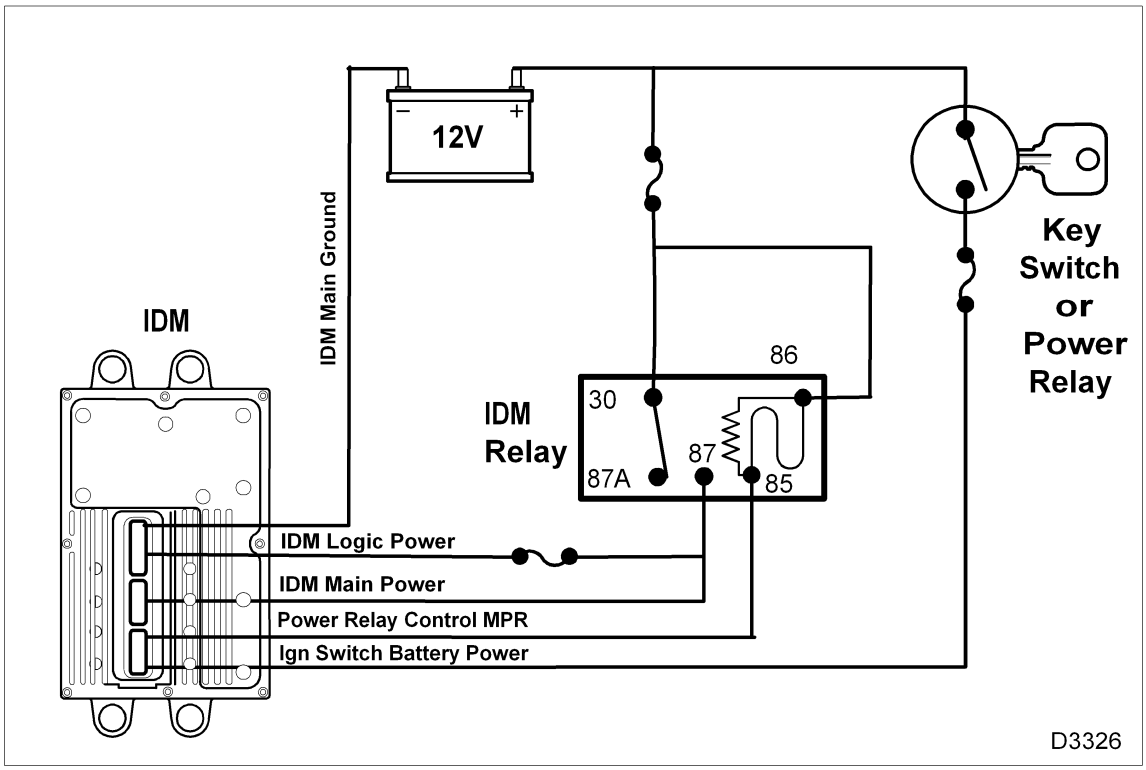

Figure 324 Function Diagram for the Injection Driver Module Power Supply (IDM PWR)

The function Diagram for the IDM PWR includes the following:

- Injection Driver Module (IDM)
- Injection Driver Module relay
- Battery
- Ignition switch
- Fuses

Function

The Injector Drive Module (IDM) requires a 12V power source. The IDM receives power from the vehicle batteries though the IDM relay contacts each time the ignition key switch is turned ON. As the ignition is turned ON, the IDM provides an internal ground to the coil side of the IDM relay. This closes the relay contacts and provides the IDM with necessary power.

IDM PWR Circuit Operation

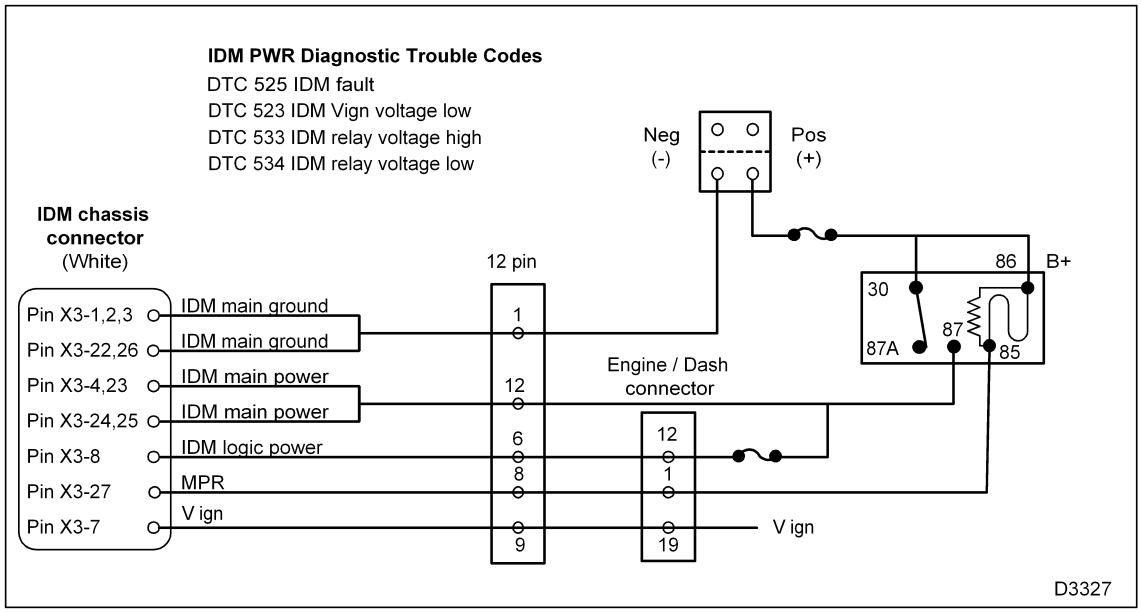

Figure 325 IDM PWR Circuit Diagram

The IDM is grounded directly to the battery negative terminal through IDM terminals X3-1, X3-2, X3-3, X3-22 and X3-26.

The IDM receives V_{IGN} power at terminal X3-7. The power signals the IDM to provide a ground path to switch the IDM power relay from terminal X3-27 to 85. Switching the IDM relay provides power directly from the battery positive terminal through a fuse and relay contacts 30 and 87 to terminals X3-4, X3-23, X3-24 and X3-25. Power is also supplied to terminal X3-8 for IDM logic and is protected with a fuse. See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.

Fault Detection / Management

The IDM internally monitors battery voltage. When the IDM continuously receives less than 7V or more than 16V a Diagnostic Trouble Code (DTC) will be set.

IDM PWR Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

DTC 525
IDM fault

- DTC 525 is set by the ECM when there is an internal IDM failure. When DTC 525 is set, replace the IDM.
- When DTC 525 is active the amber ENGINE lamp is illuminated.

DTC 523
IDM V_{IGN} voltage low

- DTC 523 is set by the ECM when the voltage from V_{IGN} is below 7V.
- DTC 523 can be set due to poor connections between the IDM terminal X3-7 and the V_{IGN}.

DTC 533
IDM relay voltage high

- DTC 533 is set by the ECM when the voltage from the IDM power relay exceeds 16V.
- DTC 533 can be set due to an alternator voltage output of 16V or more. DTC 533 can also be set when jump starting the engine or incorrect external battery connections exist.

DTC 534
IDM relay voltage low

- DTC 534 is set by the ECM when the voltage from the IDM power relay is less than 7V.
- DTC 534 can be set due to a defective alternator, IDM power relay, discharged batteries or increased resistance in the battery feed circuits.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)
- 12 pin breakout harness
- Breakout box
- Terminal Test Adapter Kit
- Relay breakout harness

IDM PWR Pin Point Diagnostics

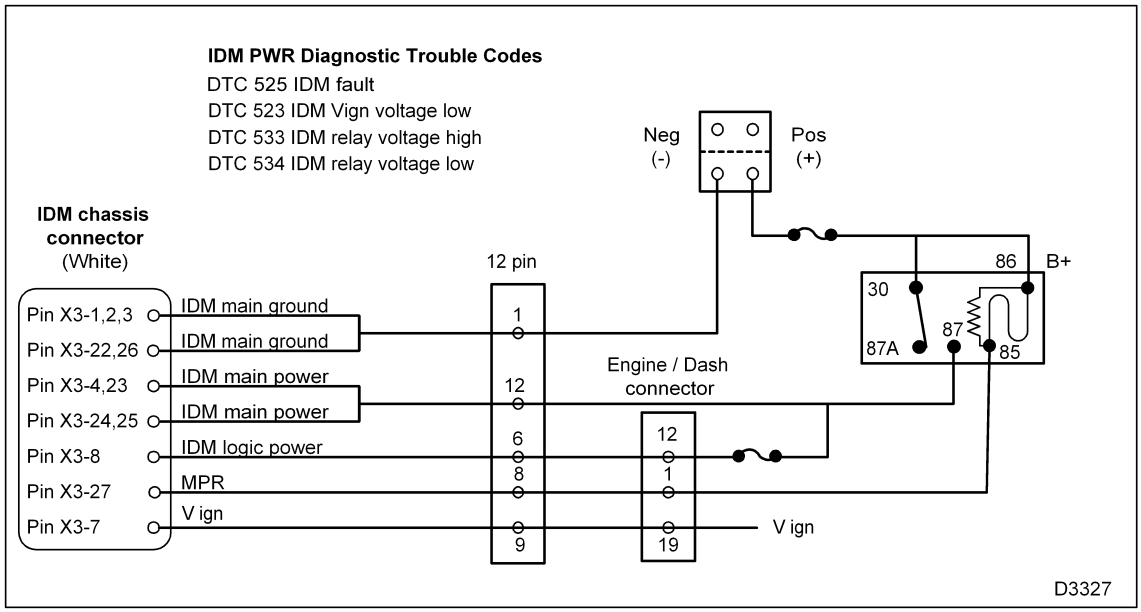

Figure 326 IDM PWR Circuit Diagram

The IDM PWR circuit requires the use of vehicle circuit diagrams. See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.

Table 68

CAUTION: To avoid engine damage, turn the ignition key to OFF before unplugging the connector relay for the IDM. Failure to turn the key to OFF will cause a voltage spike and damage to electrical components.

Key ON Engine OFF – Voltage Checks at IDM Power Relay Socket (Follow tests in order. Check with IDM relay and breakout harness installed, ignition Key ON Engine OFF. If all tests are in spec, proceed to 12 pin voltage checks.)

Test Point	Spec	Comments
86 to gnd	12V ±1.5	Continuous voltage. If no voltage, check power circuits from battery or fuse. If fuse is blown, check for short to ground. If fuse is good, check for open between PIN 86 and B+. See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.
30 to gnd	12V ± 1.5	Continuous voltage. If no voltage, check power circuits from battery or fuse. If fuse is blown, check for short to ground. If fuse is good, check for open between PIN 30 and B+. See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.
85 to gnd	0.06–2V	If >2V, check for open circuit between IDM PIN X3-27 to PIN 85 on relay or V_{IGN} circuit – continue with 12 pin voltage checks.
87 to gnd	12V ±1.5	Continuous voltage. If no voltage, replace relay.

12–pin Breakout Harness

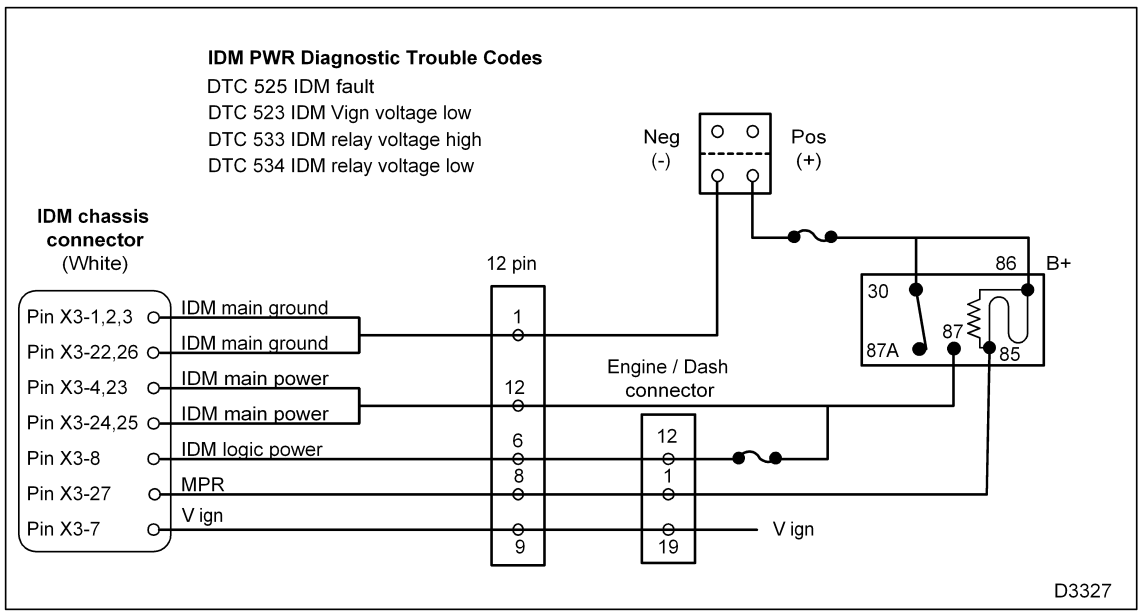

Figure 327 IDM PWR Circuit Diagram

Table 69

CAUTION: To avoid engine damage, turn the ignition key to OFF before unplugging the connector or relay for the IDM. Failure to turn the key to OFF will cause a voltage spike and damage to electrical components.

Key ON Engine OFF – Voltage Checks at 12 pin Connector (Check with breakout harness installed at 12 pin connector, IDM relay installed, and Key ON Engine OFF. Follow tests in order. Inspect for bent pins or corrosion.)

Test Point	Spec	Comments
9 to gnd	12V	Power from ignition switch to IDM. If no voltage, see truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.
8 to gnd	0.06–2V	IDM MPR – 12 pin connector. If >2V, check for open circuit between IDM PIN X3–27 to PIN 8.
12 to gnd	12V	IDM power from relay PIN 87. If no voltage, check from PIN 12 to PIN 87 on relay for open or short to ground.
6 to gnd	12V	IDM logic power from relay PIN 87 with fuse. If fuse is blown, check for short to ground. If fuse is good, check for open circuit between fuse to PIN 6. See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.
1 to gnd	0V	Ground – voltage reading indicates poor ground to battery. If voltage is present check for open or high resistance between battery (–) and IDM pins.

Table 70

CAUTION: To avoid engine damage, turn the ignition key to OFF before unplugging the connector or relay for the IDM. Failure to turn the key to OFF will cause a voltage spike and damage to electrical components.

Key ON Engine OFF – Voltage Checks at IDM (Check with IDM power relay installed. Disconnect IDM X3 connector. Ground terminal X3–27 using test pin and harness to activate relay and check at harness connector. Inspect for bent pins or corrosion.)

Test Point	Spec	Comments
X3–7 to gnd	12V ±1.5	Power from ignition switch to IDM. If no voltage, see truck Chassis Electrical Circuit Diagram manual.
X3–1 to gnd	0V	Ground – voltage reading indicates poor ground to battery. See truck Chassis Electrical Circuit Diagram manual.
X3–2 to gnd	0V	Ground – voltage reading indicates poor ground to battery. See truck Chassis Electrical Circuit Diagram manual.
X3–3 to gnd	0V	Ground – voltage reading indicates poor ground to battery. See truck Chassis Electrical Circuit Diagram manual.
X3–22 to gnd	0V	Ground – voltage reading indicates poor ground to battery. See truck Chassis Electrical Circuit Diagram manual.
X3–26 to gnd	0V	Ground – voltage reading indicates poor ground to battery. See truck Chassis Electrical Circuit Diagram manual.
X3–27 to gnd	0V	IDM grounds relay through internal transistor. Expect 0V with X3–27 grounded. If voltage is present, check test pin and jumper.
X3–8 to gnd	12V ±1.5	Power from relay to IDM. If no voltage, check fuses. If a fuse is blown, check for short to ground. If fuses are good, check for open circuit between 87 and X3–8. See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.
X3–4 to gnd	12V ±1.5	Power from relay to IDM. If no voltage, check for open between PIN X3–4 and 87 on IDM relay. See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.
X3–23 to gnd	12V ±1.5	Power from relay to IDM. If no voltage, check for open between PIN X3–23 and 87 on IDM relay. See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.
X3– 24 to gnd	12V ±1.5	Power from relay to IDM. If no voltage, check for open between PIN X3–24 and 87 on IDM relay. See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.
X3–25 to gnd	12V ±1.5	Power from relay to IDM. If no voltage, check for open between PIN X3–25 and 87 on IDM relay. See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.

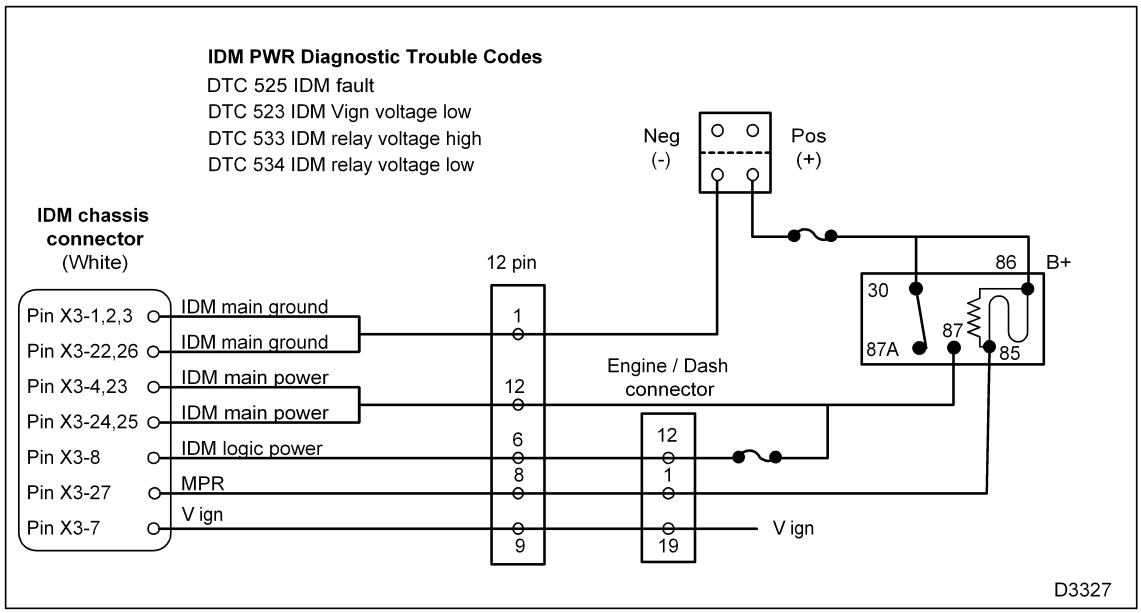

Figure 328 IDM PWR Circuit Diagram

Table 71

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.

CAUTION: To avoid engine damage, turn the ignition key to OFF before unplugging the connector relay for the IDM. Failure to turn the key to OFF will cause a voltage spike and damage to electrical components.

Harness Resistance Checks (Check with key OFF. Disconnect negative battery cable and IDM X3 harness. IDM harness connector end is numbered at mating end.)

Test Point (IDM to Neg bat cable)	**Spec**	**Comments**
X3–1 to neg bat cable	<5Ω	If >5Ω, check connection to battery ground. See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.
X3–2 to neg bat cable	<5Ω	
X3–3 to neg bat cable	<5Ω	
X3–22 to neg bat cable	<5Ω	
X3–26 to neg bat cable	<5Ω	
Test Point (IDM to IDM relay)	**Spec**	**Comments**
X3–4 to 87	<5Ω	If >5Ω, check connection from IDM to relay. See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.
X3–23 to 87	<5Ω	
X3–24 to 87	<5Ω	
X3–25 to 87	<5Ω	
X3–8 to 87	<5Ω	If >5Ω, check connection from IDM through fuse to relay.
X3–27 to 85	<5Ω	If >5Ω, check connection from IDM to relay.
X3–7 to V_{IGN}	<5Ω	If >5Ω, see truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations. Check connections in circuit.
IDM PWR Diagnostic Trouble Code		
DTC 525 = IDM fault		
DTC 523 = IDM V_{IGN} voltage low		
DTC 533 = IDM relay voltage high		
DTC 534 = IDM relay voltage low		

INJECTION PRESSURE REGULATOR (IPR)

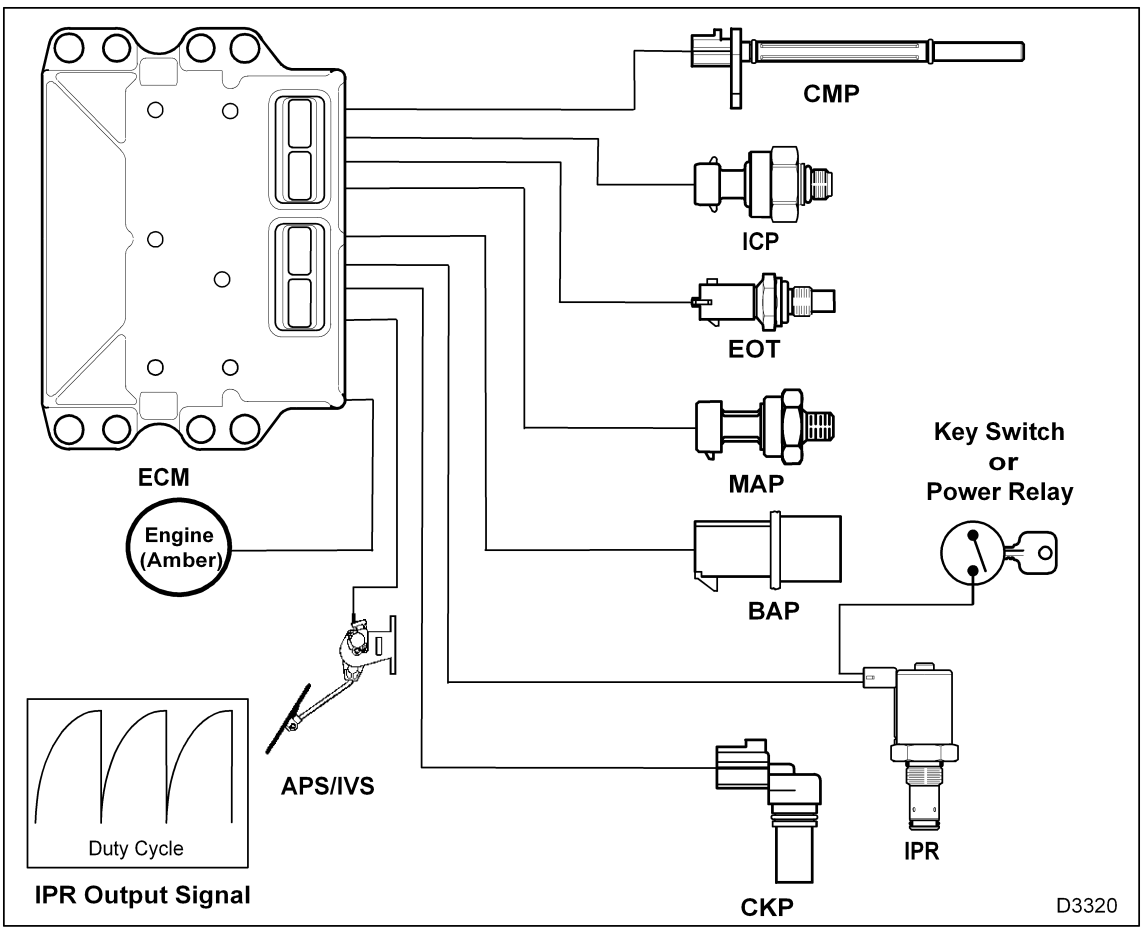

Figure 329 Function Diagram for the Injector Pressure Regulator (IPR)

The Function Diagram for the IPR includes the following:

- Injection Pressure Regulator (IPR)
- Engine Oil Temperature (EOT) sensor
- Injection Control Pressure (ICP) sensor
- Manifold Absolute Pressure (MAP) sensor
- Barometric Pressure (BAP) sensor
- Camshaft Position (CMP) sensor
- Crankshaft Position (CKP) sensor
- Accelerator Position / Idle Validation (APS/IVS) sensor
- Electronic Control Module (ECM)

Function

The IPR valve controls oil pressure in the high pressure injection control system that actuates the injectors. The IPR valve consists of a solenoid, poppet, and a spool valve assembly. The IPR is mounted on the top rear of engine in the high pressure oil pump cover. 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 via the rear cover.

NOTE: The engine may not operate with an IPR fault, depending on the mode of failure.

IPR Circuit Operation

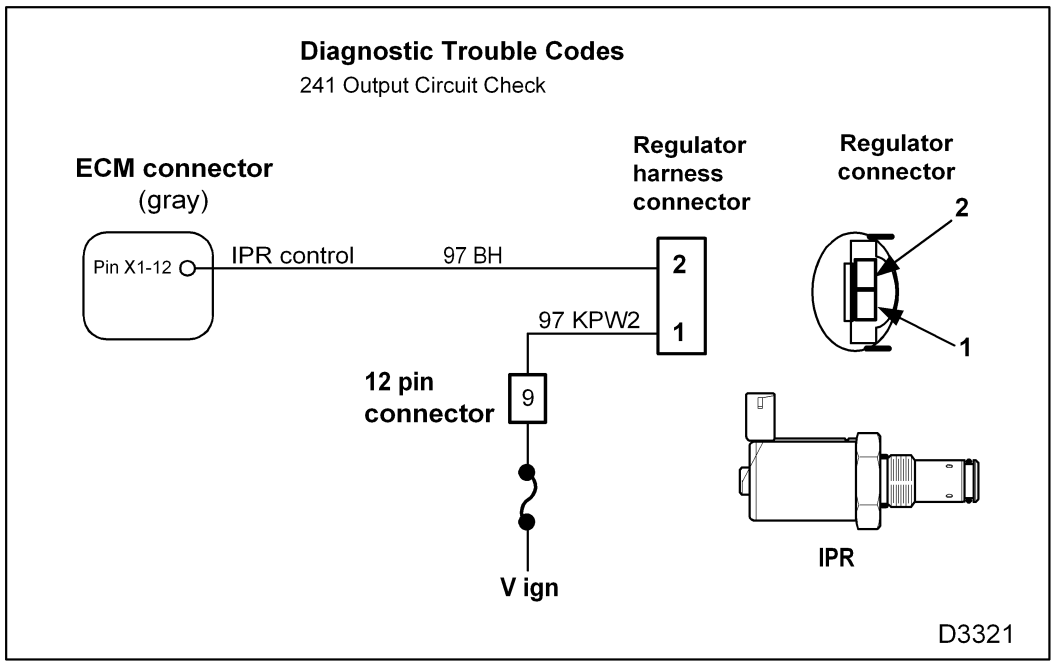

Figure 330 IPR Circuit Diagram

The IPR valve is supplied with voltage from V_{IGN} at terminal 1 of the IPR connector. The control of the injection control system is gained by the ECM grounding terminal 2 of the IPR valve through PIN X1-12 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.

Fault Detection / Management

An open or short to ground in the EGR control circuit can be detected by an on demand output circuit check during KOEO Standard tests. If there is a circuit fault detected a DTC will be set. When the engine is running, the ECM can detect if the injection control pressure is equal to the desired pressure. When the measured injection control pressure does not compare to the desired pressure, the ECM will ignore the measured ICP signal and controls the engine with the desired value.

IPR Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

DTC 241
Output Circuit Check (OCC)

- DTC 241 is set by the ECM when the OCC test has failed after the KOEO Standard test has been run.
- DTC 241 can be set when a poor connection to the IPR solenoid or defective IPR coil exists.
- When DTC 241 is active the engine will not run and the amber ENGINE lamp will not be illuminated.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)
- Breakout box
- Breakout harness
- Terminal Test Adapter Kit

The IPR circuit requires the use of vehicle circuit diagrams. See truck Chassis Electrical Circuit

Diagram manual for circuit numbers, connector and fuse locations.

IPR Pin Point Diagnostics

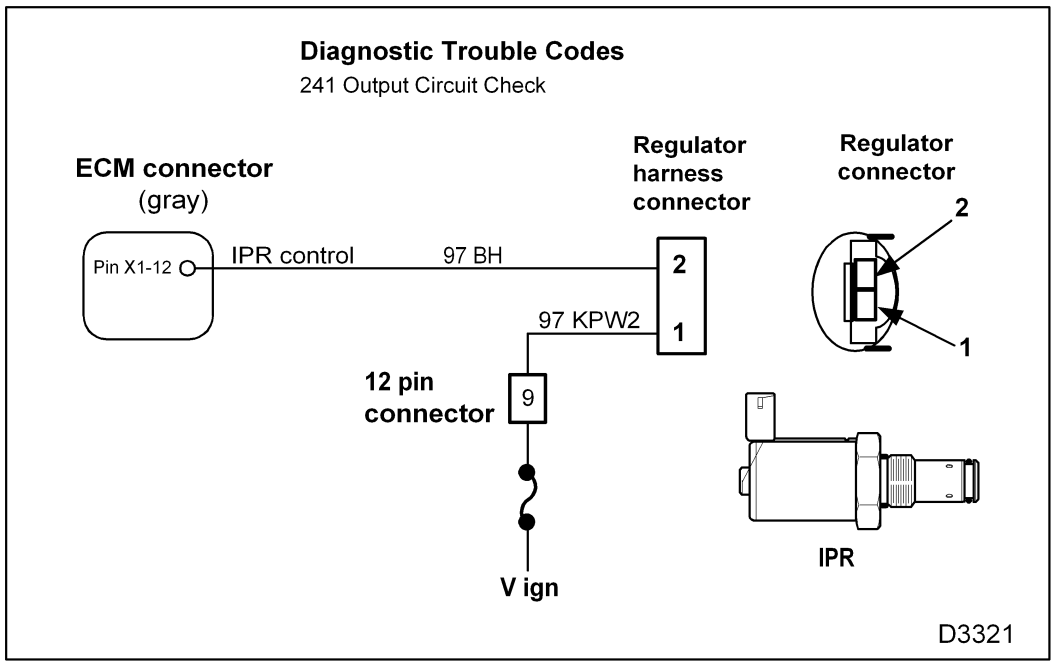

Figure 331 IPR Circuit Diagram

Table 72

IPR Voltage Checks (Check with regulator connector disconnected, breakout harness installed, and ignition Key ON.)		
Test Point	**Spec**	**Comments**
1 to gnd	B+	IPR power from V_{IGN} – If no voltage, check from fuse to IPR connector. See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.
2 to gnd	0– 0.25V	If >0.25V, control wire is shorted to V_{REF} or B+.
Connector Resistance Checks to Chassis Ground (Check with IPR connector disconnected, ignition key OFF, and negative battery cable disconnected.)		
1 to gnd	>1kΩ	Resistance to chassis ground. If <1kΩ, check for short to ground in circuit (check with fuse removed)
2 to gnd	>1kΩ	If <1kΩ, check for short to ground
Harness Resistance Checks (Install breakout box on engine harness only. Check with fuse removed.)		
X1–12 to fuse	5–20Ω	Resistance through entire IPR circuit including regulator, check with harness connected to IPR
Fuse to 1	<5Ω	If >5Ω IPR power is open
X1–12 to 2	<5Ω	If >5Ω IPR control wire is open
IPR Diagnostic Trouble Code		
DTC 241 = Output Circuit Check detected during Standard Test, indicates high or low resistance in circuit.		

INTAKE AIR TEMPERATURE (IAT) SENSOR

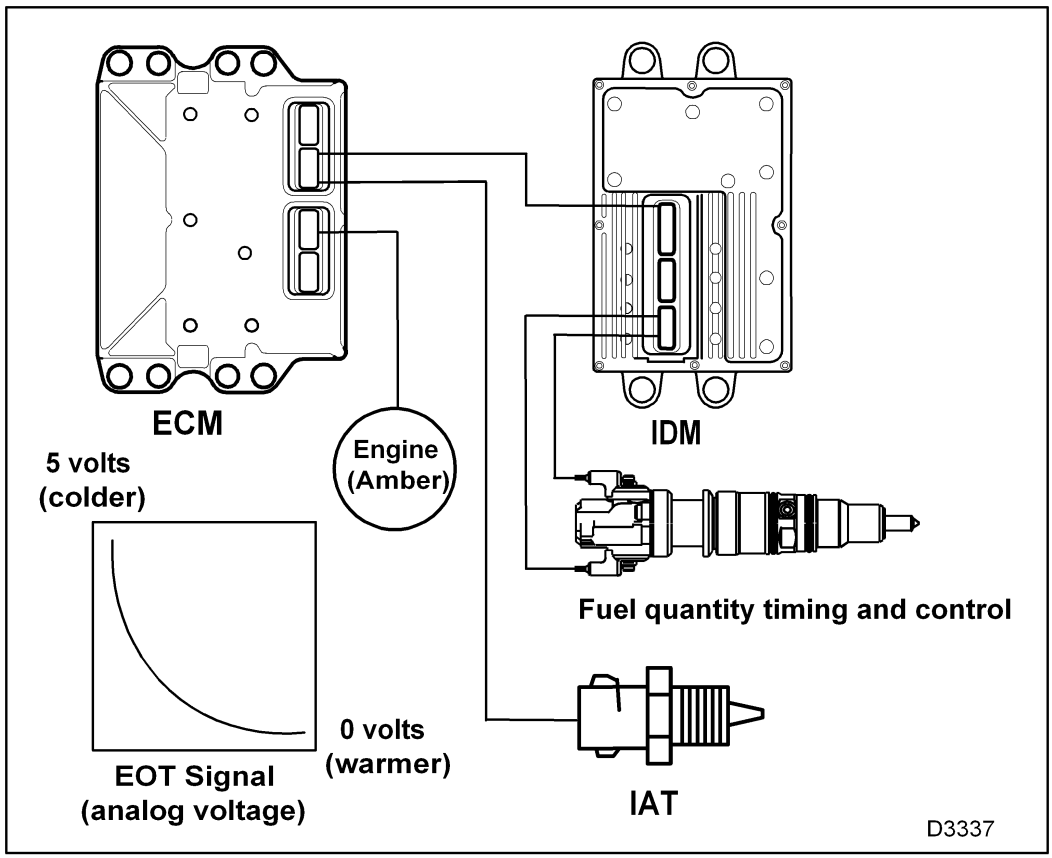

Figure 332 Function Diagram for the Intake Air Temperature (IAT) Sensor

The Function Diagram for the IAT sensor includes the following:

- Intake Air Temperature (IAT) sensor
- Electronic Control Module (ECM)
- Fuel injector
- ENGINE lamp (amber)

Function

The Intake Air Temperature (IAT) sensor is a thermistor sensor located on the air filter housing. The ECM supplies a 5V reference signal which the IAT uses to produce an analog voltage that indicates the intake air temperature. The IAT changes resistance when exposed to different temperatures. When air temperature decreases, the resistance of the thermistor increases. This causes the signal voltage to increase. When air temperature increases, the resistance of the thermistor decreases. This causes the signal voltage to decrease.

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 continuous monitoring by the IAT sensor limits smoke emissions.

IAT Circuit Operation

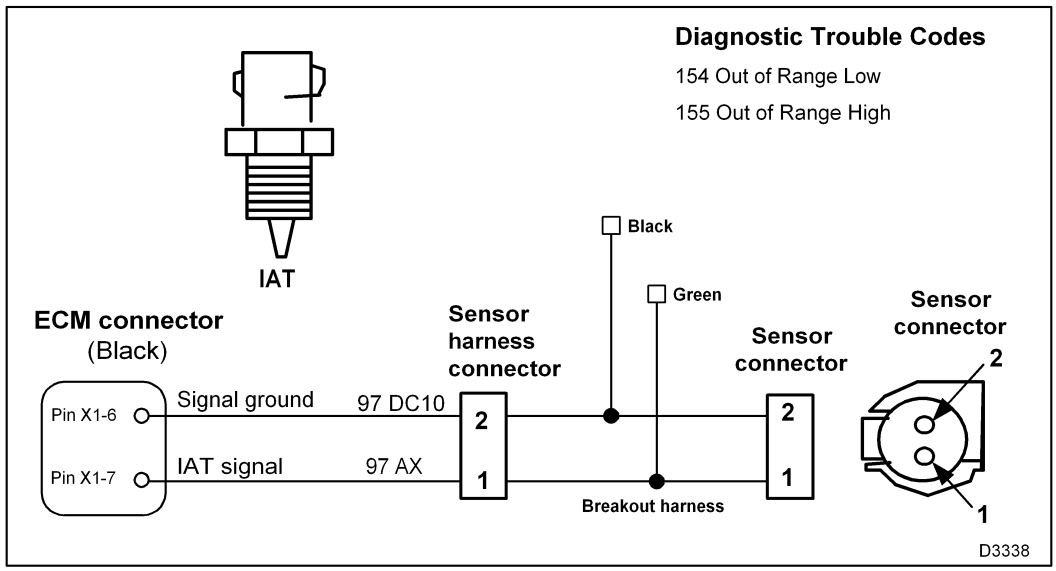

Figure 333 IAT Circuit Diagram

The IAT sensor is supplied with a 5V reference signal at terminal 1 from ECM terminal X1–7. A return circuit (ground) is supplied at terminal 2 from ECM terminal X1–6. As the air temperature increases or decreases, the sensor changes resistance and provides the air temperature signal voltage at the ECM. The signal voltage is read by the ECM to determine the intake air temperature.

Fault Detection / Management

When the ECM detects an IAT signal out of range high or low, the ECM will ignore the IAT signal and assume an ambient temperature of 25°C (77°F).

IAT Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp on the vehicle dash.

DTC 154
IAT signal out of range low

- DTC 154 is set by the ECM if signal voltage is less than 0.127V for more than 0.35 second. When DTC 154 is active, the ECM will default to 25°C (77°F) for starting.
- DTC 154 can be set due to a short to ground in the signal circuit or a defective IAT sensor.
- When DTC 154 is active, the amber ENGINE lamp is illuminated.

DTC 155
IAT signal out of range high

- DTC 155 is set by the ECM if signal voltage is more than 4.6V for more than 0.35 second. When DTC 155 is active, the ECM will default to a value of 25°C (77°F) for starting.
- DTC 155 can set due to an open signal or ground circuit, a short to a voltage source, or a defective sensor.
- When DTC 155 is active, the amber ENGINE lamp is illuminated.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)
- Harness – 3–banana plug and 500 ohm
- Breakout harness
- Breakout box
- Terminal Test Adapter Kit

IAT Operational Diagnostics

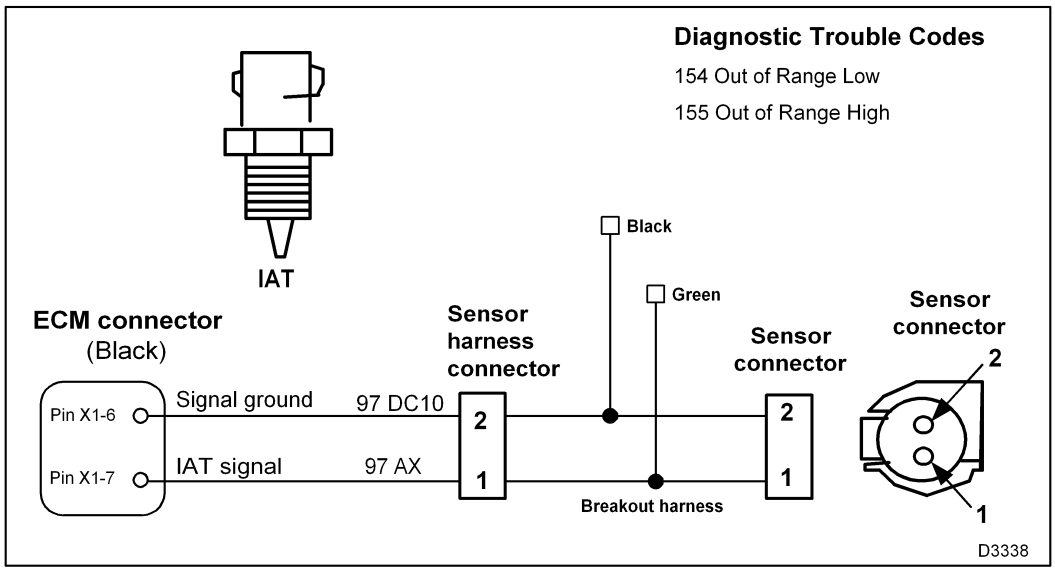

Figure 334 IAT Circuit Diagram

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

Be careful to avoid rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the continuous monitor session. To monitor signal voltage, run Key ON Engine OFF continuous monitor test.

2. Monitor IAT signal volts. Verify an active DTC for the IAT circuit.

3. If code is active, complete step 5 and do circuit check for the IAT sensor in table on the following page.

4. If code is inactive, wiggle connectors and wires at all suspected problem locations. If circuit continuity is interrupted, the EST will beep and display DTCs related to the condition.

5. Install temperature sensor breakout harness to engine harness only.

NOTE: After removing connector, inspect for damaged pins, corrosion, or loose terminals. Repair as required.

Table 73

Circuit Checks for IAT Sensor (Use EST, breakout harness, and wire harnesses – 3-Banana plug and 500 ohm.)

Test Condition	Spec	Checks
Sensor disconnected	>4.6V	If voltage <4.6V, check signal circuit for short to ground.
3–Banana plug harness installed between GREEN and BLACK pins of breakout harness.	0V	If voltage is >0.127V, check ground and signal circuit for open or high resistance. Use a breakout box and measure resistance from PIN 2 to PIN X1–6 and from PIN 1 to X1–7 (spec <5Ω).
500 ohm harness installed between GREEN and BLACK pins of breakout harness.	<1.0V	If voltage >1.0V, check signal circuit for short to V_{REF}, B+, or another sensor's signal voltage.

6. Connect engine harness to sensor. Use the EST to clear DTCs. If an active code remains after checking test conditions, replace the IAT sensor.

IAT Pin Point Diagnostics

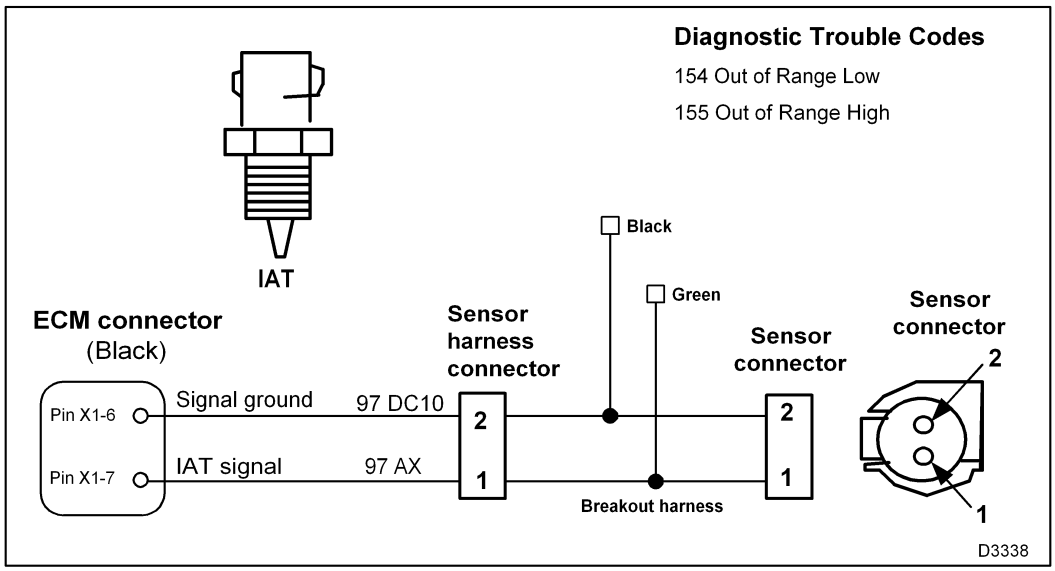

Figure 335 IAT Circuit Diagram

Table 74

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.

Connector Voltage Checks (Disconnect sensor from harness and turn ignition key ON.)

Test Point	Spec	Comments
2 to gnd	0–0.25V	Signal ground (No voltage expected). If >0.25V, signal wire is shorted to V_{REF} or B+.
1 to gnd	4.6–5.0V	Pull up voltage, if no voltage, circuit has open, high resistance, or short to ground.
Connector Resistance Checks to Chassis Ground (Turn ignition key OFF. Disconnect sensor connector and negative battery cable.)		
2 to gnd	<5Ω	If >5Ω, check for open ground circuit
1 to gnd	>1kΩ	If <1kΩ, check for signal circuit short to ground
Harness Resistance Checks (Install breakout box on engine harness only.)		
X1–6 to 2	<5Ω	If >5Ω, check for open ground wire
X1–7 to 1	<5Ω	If>5Ω, check for open signal wire open

Table 75

Operational Voltage Checks for IAT Sensor (Check with breakout box installed to the ECM and engine harness.)			
Test Point	**Temp °C (°F)**	**Resistance**	**Volts @ Resistance**
X1–6 to X1–7	0°C (32°F)	91.1kΩ	3.846V
X1–6 to X1–7	20°C (68°F)	35.5kΩ	3.041V
X1–6 to X1–7	100°C (212°F)	2.0kΩ	0.446V
IAT Diagnostic Trouble Code			
DTC 154 = Signal voltage was <0.127V for more than 0.2 seconds			
DTC 155 = Signal voltage was >4.6V for more than 0.2 seconds			

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR

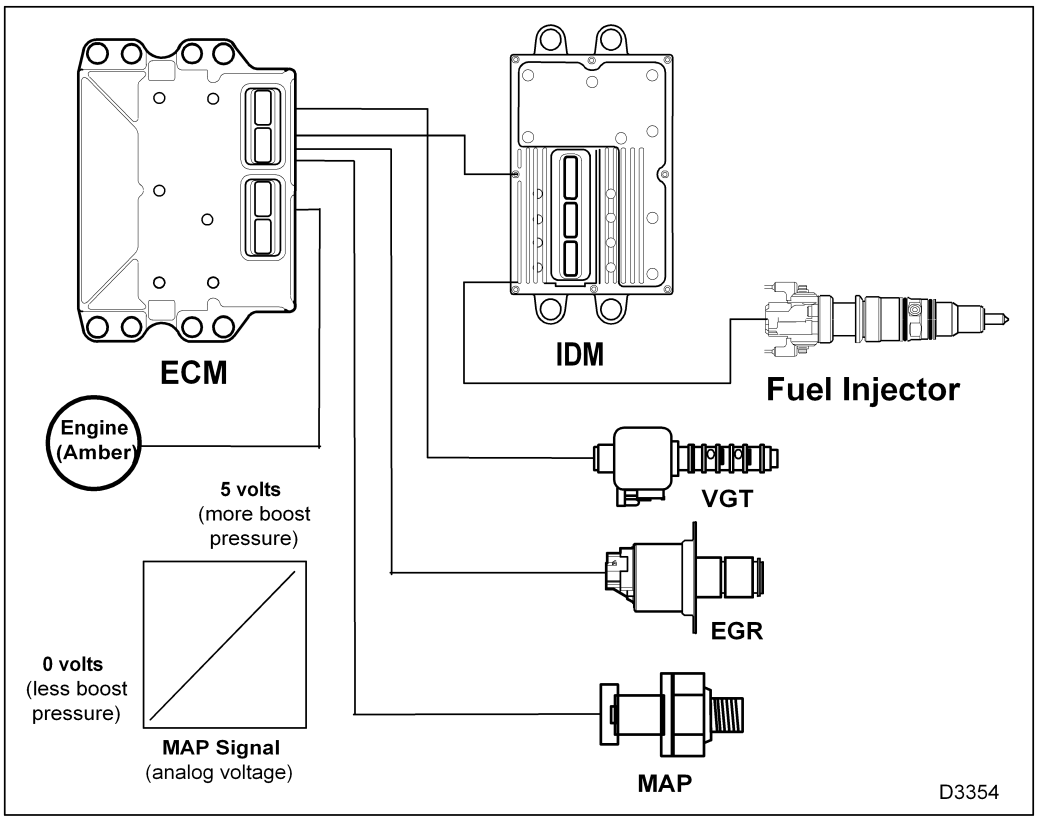

Figure 336 Function Diagram for the Manifold Absolute Pressure (MAP) Sensor

The Function Diagram for the MAP sensor includes the following:

- Manifold Absolute Pressure (MAP) sensor
- Electronic Control Module (ECM)
- Exhaust Gas Recirculation (EGR) actuator
- Variable Geometry Turbocharger (VGT) actuator
- Fuel injector
- ENGINE lamp (amber)

Function

The MAP sensor is a variable capacitance sensor on the top of the intake manifold at the front of the engine. The ECM supplies a 5V reference signal which the MAP sensor uses to produce a linear analog voltage that indicates pressure. The ECM uses the MAP sensor signal to assist in the calculation of the EGR and VGT duty percentage. The ECM measures 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.

MAP Circuit Operation

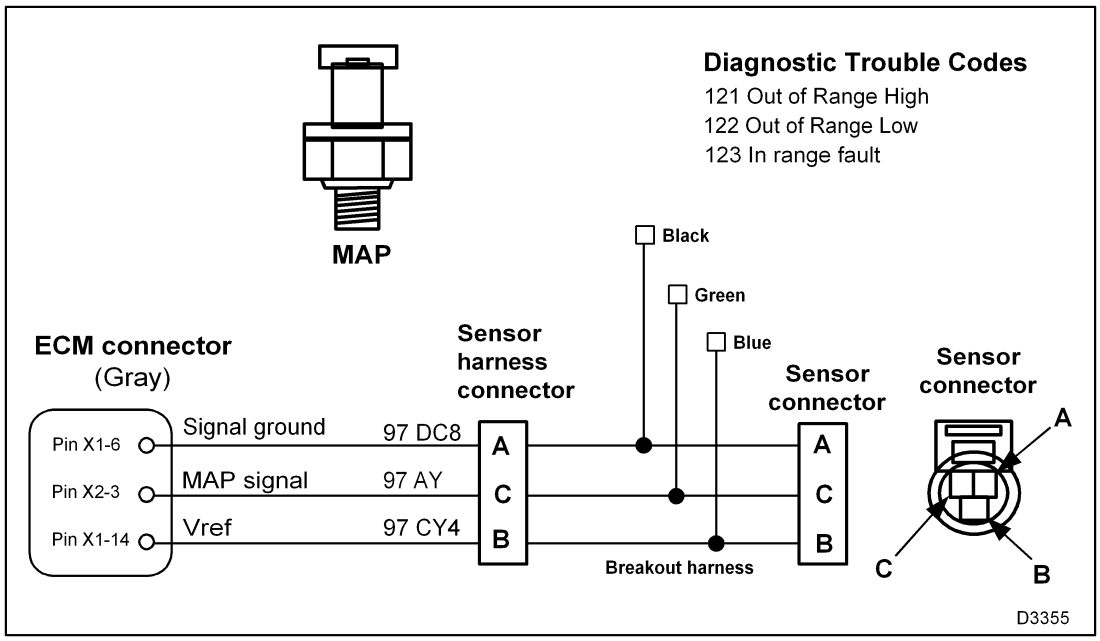

Figure 337 MAP Circuit Diagram

The MAP sensor is supplied with a 5V reference voltage at terminal B from ECM terminal X1–14. The MAP sensor is also supplied with a return circuit (ground) at terminal A from ECM terminal X1–6. The MAP sensor sends a signal from terminal C of the sensor to ECM terminal X2–3.

Fault Detection / Management

The ECM will ignore the MAP signal when the signal is detected to be out of range or an incorrect value is read. The engine will continue to operate based on estimated values.

MAP Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

DTC 121
Out of range high

- DTC 121 is set by the ECM when the MAP signal is greater than 4.9V for more than 0.4 second.
- DTC 121 can be set due to a sensor signal wire short to V_{REF} or B+ or a defective MAP sensor
- When DTC 121 is active the amber ENGINE lamp is illuminated.

DTC 122
Out of range low

- DTC 122 is set by ECM when the MAP signal is less than 0.039V for more than 0.4 second.
- DTC 122 can be set due to a sensor signal circuit open or shorted to ground or a defective MAP sensor. DTC 122 can also be set due to an extremely restricted CAC/intake system.
- When DTC 122 is active the amber ENGINE lamp is illuminated.

DTC 123
In range fault

- DTC 123 is set by ECM when the MAP signal is greater than 120 kPa (2 psi) absolute at low idle.
- DTC 123 can be set due to a restricted or plugged sensor inlet, V_{REF} shorted to a voltage source higher than 5.5V, or a defective MAP sensor.
- When DTC 123 is active the amber ENGINE lamp is illuminated.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)
- Harness – 3-Banana plug and 500 ohm
- Breakout box
- Breakout harness
- Terminal Test Adapter Kit

MAP Operational Diagnostics

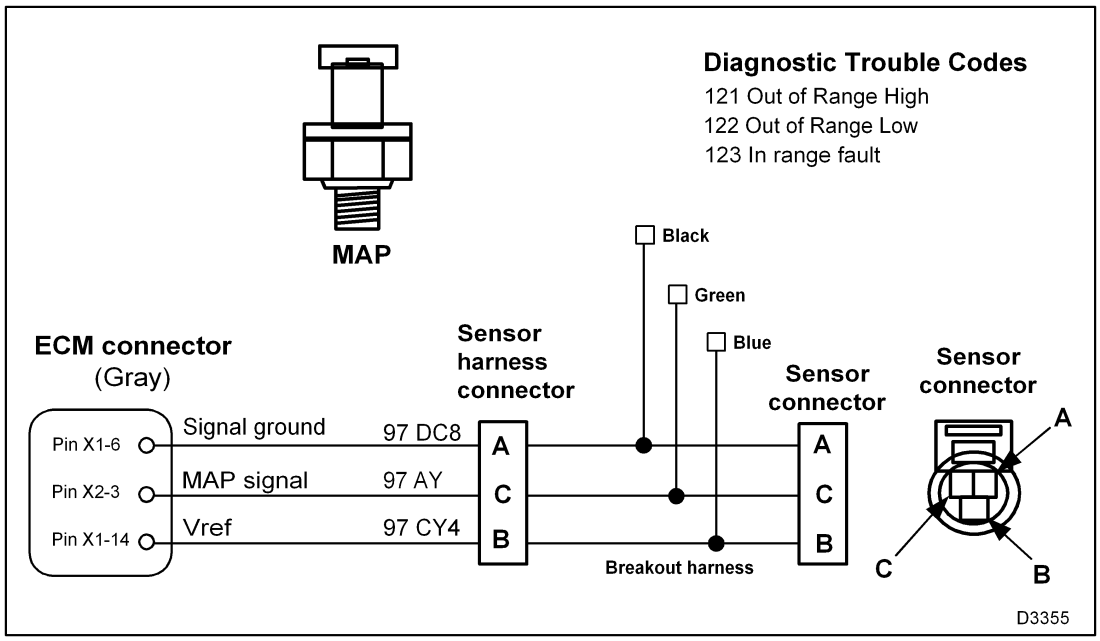

Figure 338 MAP Circuit Diagram

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

Be careful to avoid rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the continuous monitor session. To monitor signal voltage, run Key ON Engine OFF continuous monitor test.

2. Monitor MAP signal volts. Verify an active DTC for the MAP circuit.

3. If code is active, complete step 5 and do circuit check for the MAP sensor in table on the following page

4. If code is inactive, wiggle connectors and wires at all suspected problem locations. If circuit continuity is interrupted, the EST will beep and display DTCs related to the condition.

5. Install pressure sensor breakout harness to engine harness only.

NOTE: After removing connector, inspect for damaged pins, corrosion, or loose terminals. Repair as required.

Table 76

Circuit Checks for MAP Sensor (Use EST, DMM, breakout harness, and 500 ohm wire harness.)		
Test Condition	**Spec**	**Checks**
Sensor disconnected	0V	If voltage >0.039V, check signal circuit for short to V_{REF} or B+.
Voltage from BLUE pin to ground with DMM	5V ±0.5	If voltage >5.5V, check V_{REF} for short to B+. If voltage is <4.5V, check V_{REF} for open or short to ground.
500 ohm harness installed between GREEN and BLUE pins of breakout harness.	5V	If voltage <4.9V, check signal circuit for open or short to ground. Remove negative battery cable. Measure resistance from PIN C to ground (spec >1kΩ) to check for short to ground. Use a breakout box from PIN C to PIN X2–8 (spec <5Ω) to check for open in the harness.
Resistance from BLACK pin of breakout harness to chassis ground using DMM.	<5Ω	If resistance is >5Ω, check for open or high resistance between ECM and sensor connector. Use a breakout box and measure resistance from between PIN A and PIN X1–6 (spec <5Ω).

6. Connect engine harness to sensor. Use the EST to clear DTCs. If an active code remains after checking test conditions, replace the MAP sensor.

MAP Pin Point Diagnostics

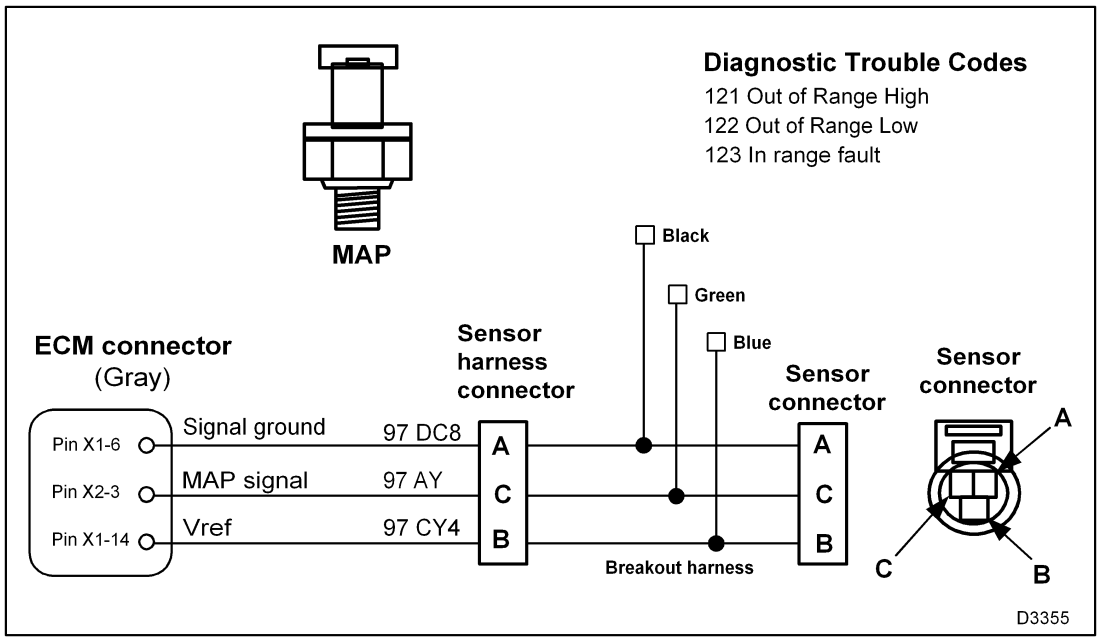

Figure 339 MAP Circuit Diagram

Table 77

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.

Connector Voltage Checks (Disconnect sensor from harness and turn ignition key ON.)		
Test Point	**Spec**	**Comments**
A to gnd	0–0.25V	If >0.25V, check ground circuit for open or high resistance, check signal ground for short to V_{REF} or B+.
B to gnd	5V ± 0.5	If voltage is not to spec, V_{REF} circuit is shorted to ground or B+.
C to gnd	0–0.25V	If >0.25V, signal ground is shorted to V_{REF} or B+.
Connector Resistance Checks to Chassis Ground (Turn ignition key OFF. Disconnect negative battery cable and sensor connector.)		
A to gnd	<5Ω	If >5Ω, check for open circuit
B to gnd	>500Ω	If <500Ω, check for short to ground
C to gnd	>1kΩ	If <1kΩ, check for short to ground
Harness Resistance Checks (Install breakout box on engine harness only.)		
X1–6 to A	<5Ω	If >5Ω, check for open ground wire
X1–14 to B	<5Ω	If >5Ω, check for open V_{REF} wire
X2–3 to C	<5Ω	If >5Ω, check for open signal wire

Table 78

Operational Voltage Checks for MAP Sensor (Check with breakout box installed to the ECM and engine harness.)			
Test Point	**EST voltage readings: Signal to ground**	**Spec**	**Checks**
X2–3 to X1–6	0.039V	N/A	Out of range low limit
X2–3 to X1–6	0.92V	0 psi	Voltage with Key ON Engine OFF. Atmospheric pressure dependent on altitude and BAP pressure.
X2–3 to X1–6	1.73V	8 psi	
X2–3 to X1–6	2.72V	18 psi	
X2–3 to X1–6	See performance specs	See performance specs	Rated speed, full load
MAP Diagnostic Trouble Code			
DTC 121 = Signal voltage was >4.9V for more than 0.4 second			
DTC 122 = Signal voltage was <0.039V for more than 0.4 second			
DTC 123 = Detected boost signal voltage was >2.0 psi at low idle.			

MANIFOLD AIR TEMPERATURE (MAT) SENSOR

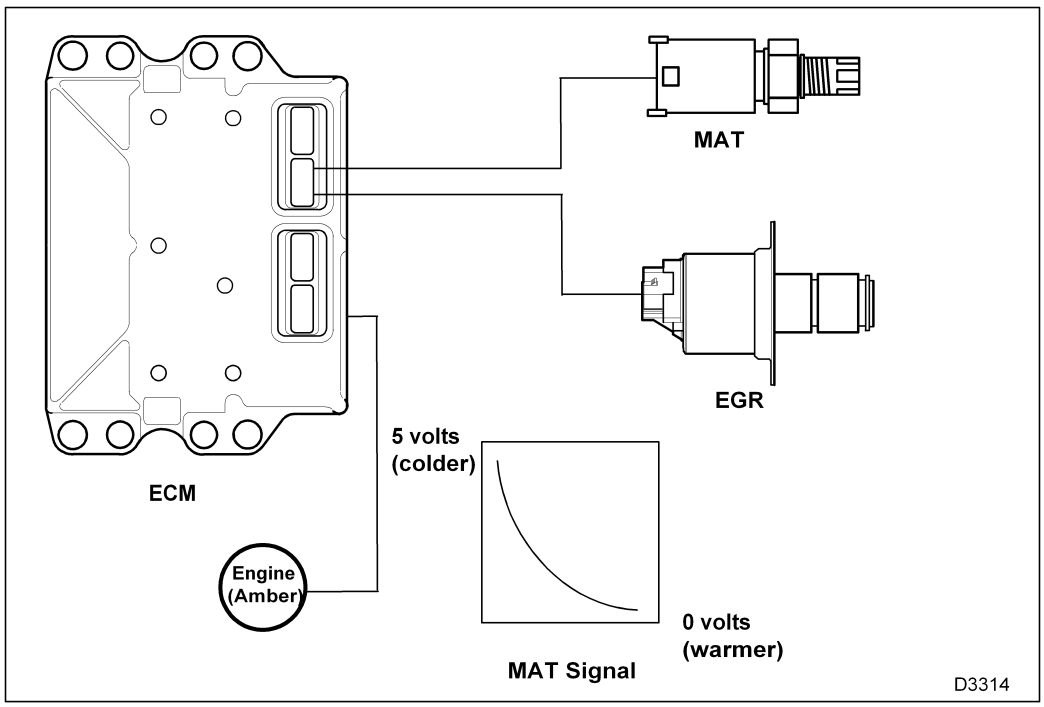

Figure 340 Function Diagram for the Manifold Air Temperature (MAT) Sensor

The Function Diagram for the MAT sensor includes the following:

- Manifold Air Temperature (MAT) sensor
- Exhaust Gas Recirculation (EGR) actuator
- Electronic Control Module (ECM)
- ENGINE lamp (amber)

Function

The MAT sensor is a thermistor sensor on the top of the intake manifold in the right front of the engine. The ECM supplies a 5V reference signal that the MAT sensor uses to produce an analog voltage that indicates temperature. The MAT changes resistance when exposed to different temperatures. When air temperature decreases, the resistance of the thermistor increases. This causes the signal voltage to increase. When air temperature increases, the resistance of the thermistor decreases. This causes the signal voltage to decrease.

The MAT sensor provides a feedback signal to the ECM indicating manifold air temperature. The ECM monitors the MAT signal to determine if the temperature is satisfactory. During engine operation, if the ECM recognizes that the MAT signal is lower or higher than the expected value it will set a DTC.

MAT Circuit Operation

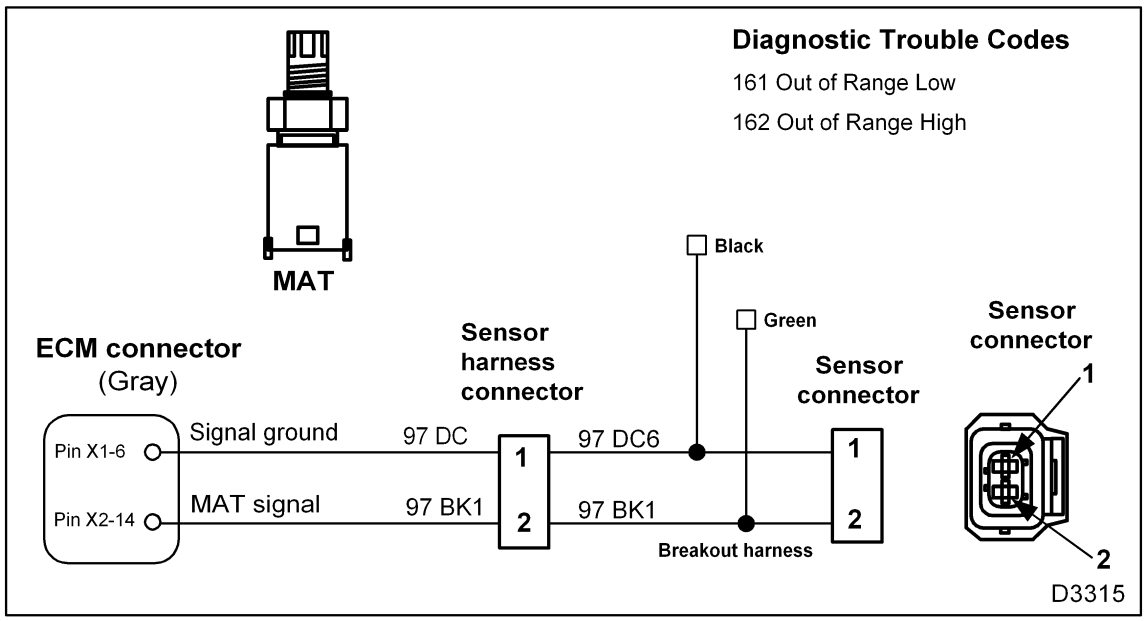

Figure 341 MAT Circuit Diagram

The MAT sensor is supplied with a 5V reference voltage at terminal 2 from ECM terminal X2–14. The sensor is grounded at terminal 1 through the signal ground terminal at the ECM terminal X1–6. When the air temperature increases or decreases, the sensor changes resistance and provides the air temperature signal voltage at the ECM. The signal voltage is read by the ECM to determine the temperature of the air.

Fault Detection / Management

The ECM continuously monitors the signal of the MAT sensor to determine if the signal is within an expected range. If the ECM detects the signal voltage is higher or lower than expected, the ECM will set a DTC.

MAT Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

DTC 161
Out of range low

- DTC 161 is set by the ECM when the signal voltage is less than 0.098V for more than 0.35 second.
- DTC 161 can be set due to a short to ground in the signal circuit or a defective sensor.
- When DTC 161 is active the amber ENGINE lamp is illuminated.

DTC 162
Out of range high

- DTC 162 is set by ECM when the signal voltage is greater than 4.58V for more than 0.35 second.
- DTC 162 can be set due to an open signal or ground circuit , short to a voltage source, or a defective sensor.
- When DTC 162 is active the amber ENGINE lamp is illuminated.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)
- Harness – 3-Banana plug and 500 ohm
- Breakout box
- Breakout harness

MAT Operational Diagnostics

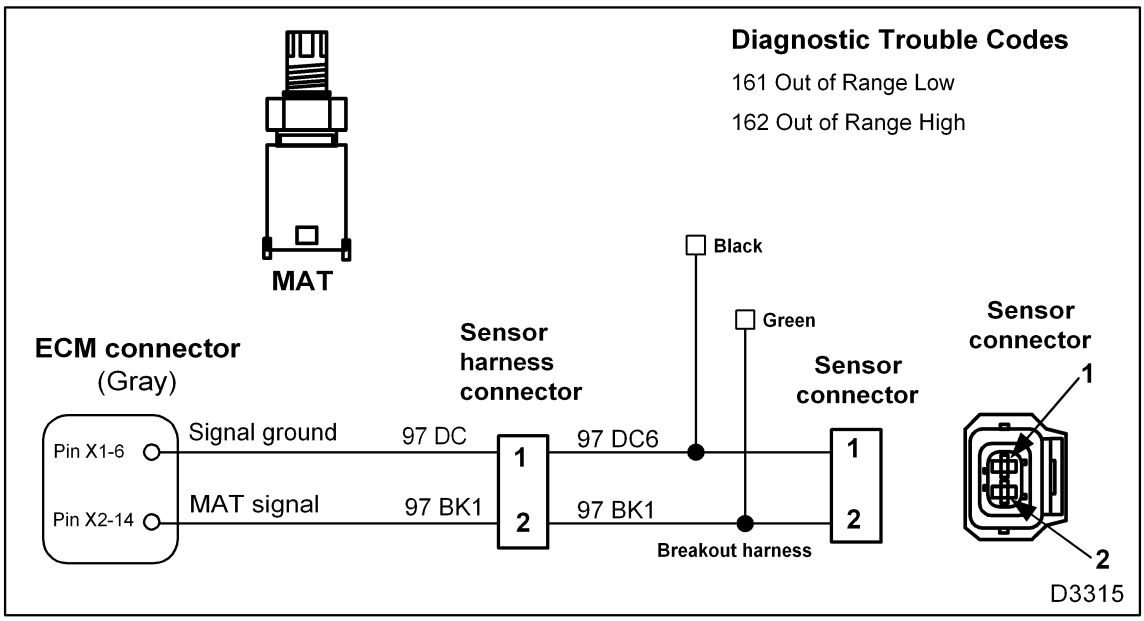

Figure 342 MAT Circuit Diagram

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle – comply with the following:

Be careful to avoid rotating parts (belts and fan) and hot engine surfaces.

1. Using EST, open the continuous monitor session. To monitor signal voltage, run Key ON Engine OFF continuous monitor test.

2. Monitor MAT signal volts. Verify an active DTC for the MAT circuit.

3. If code is active, complete step 5 and do circuit check for the MAT sensor in table on the following page.

4. If code is inactive, wiggle connectors and wires at all suspected problem locations. If circuit continuity is interrupted, the EST will beep and display DTCs related to the condition.

5. Install temperature sensor breakout harness to engine harness only.

NOTE: After removing connector, inspect for damaged pins, corrosion, or loose terminals. Repair as required.

Table 79

Circuit Checks for MAT Sensor (Use EST, breakout harness, and wire harnesses – 3-Banana plug and 500 ohm.)

Test Condition	Spec	Checks
Sensor disconnected	>4.6V	If voltage <4.6V, check signal circuit for short to ground.
3–Banana plug harness installed between GREEN and BLACK pins of breakout harness.	0V	If voltage is >0.127V, check ground and signal circuit for open or high resistance. Use a breakout box and measure resistance from PIN 1 to PIN X1–6 and from PIN 2 to X2–14 (spec <5Ω).
500 ohm harness installed between GREEN and BLACK pins of breakout harness.	<1.0V	If voltage >1.0V, check signal circuit for short to V_{REF}, B+, or another sensor's signal voltage.

6. Connect engine harness to sensor. Use the EST to clear DTCs. If an active code remains after checking test conditions, replace the MAT sensor.

MAT Pin Point Diagnostics

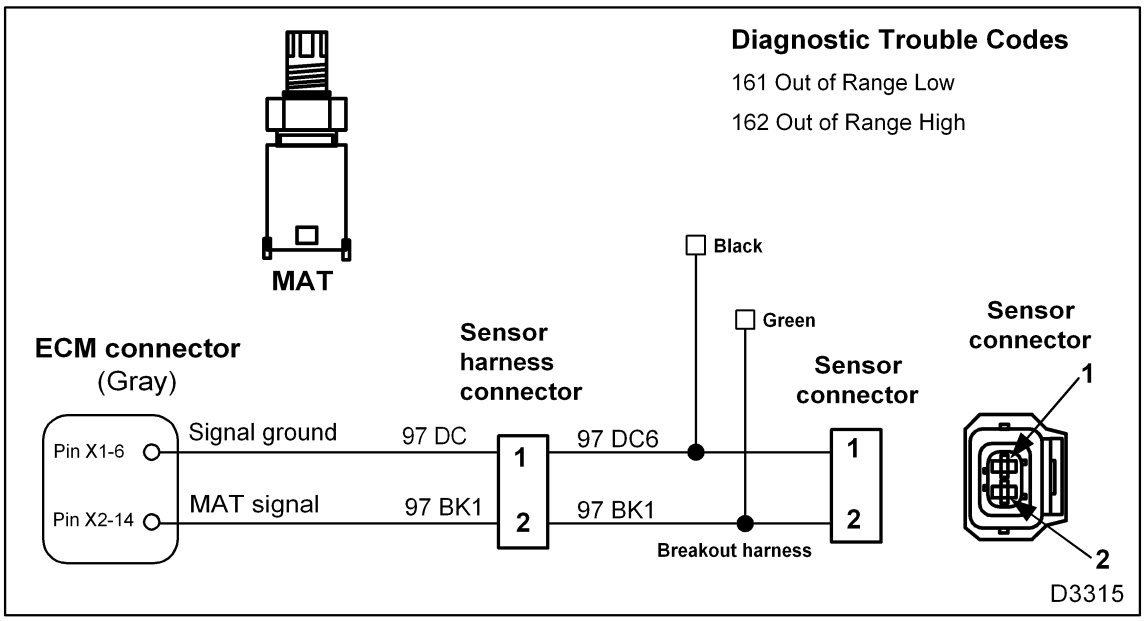

Figure 343 MAT Circuit Diagram

Table 80

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.

Connector Voltage Checks (Disconnect sensor from harness and turn ignition key ON.)

Test Point	Spec	Comments
1 to gnd	0–0.25V	If >0.25V, signal wire is shorted to V_{REF} or battery
2 to gnd	4.6–5V	Pull up voltage, if no voltage, circuit has open or high resistance or short to ground
Connector Resistance Checks to Chassis Ground (Turn ignition key OFF. Disconnect sensor connector and negative battery cable).		
1 to gnd	<5Ω	If >5Ω, check for open circuit
2 to gnd	>1kΩ	If <1kΩ, check for shorted signal to ground
Harness Resistance Checks (Install breakout box on engine harness only)		
X1–6 to 1	<5Ω	If >5Ω, check for open ground wire
X2–14 to 2	<5Ω	If >5Ω, check for open signal wire

Table 81

Operational Voltage Checks for MAT Sensor (Check with breakout box installed to the ECM and engine harness.)			
Test Point	**Temp °C (°F)**	**Resistance**	**Volts @ Resistance**
X2–14 to X1–6	0°C (32°F)	95.8kΩ	3.87V
X2–14 to X1–6	15°C (59°F)	46.8kΩ	3.31V
X2–14 to X1–6	40°C (104°F)	16.1kΩ	2.15V
X2–14 to X1–6	100°C (212°F)	2.08kΩ	0.47V
MAT Diagnostic Trouble Code			
DTC 161 = Signal voltage was <0.098V for more than 1.0 second			
DTC 162 = Signal voltage was >4.58V for more than 1.0 second			

REFERENCE VOLTAGE (V_{REF})

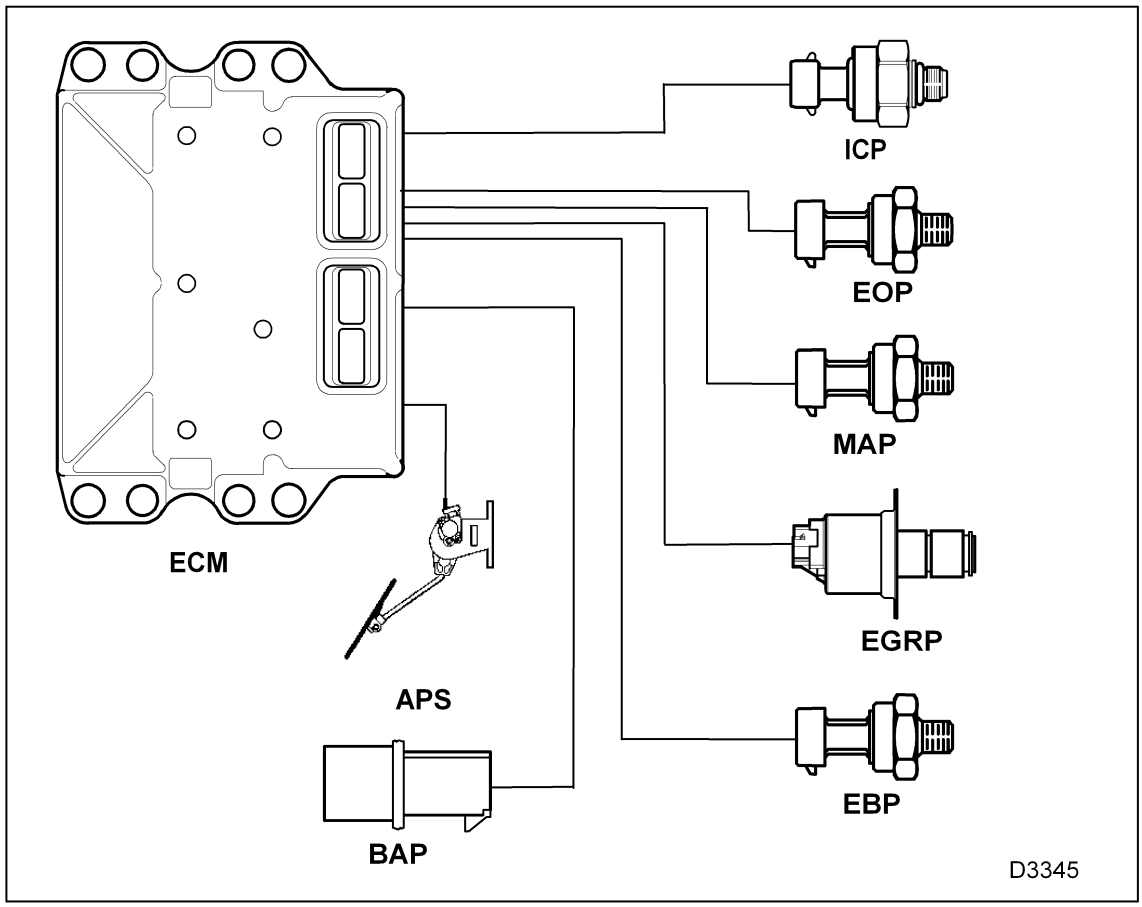

Figure 344 Function Diagram for the Reference Voltage (Vref)

The Function Diagram for the V_{REF} includes the following:

- Manifold Absolute Pressure (MAP) sensor
- Exhaust Gas Recirculation Position (EGRP) sensor
- Injection Control Pressure (ICP) sensor
- Barometric Atmospheric Pressure (BAP) sensor
- Engine Oil Pressure (EOP) sensor
- Accelerator Position Sensor (APS)
- Exhaust Back Pressure (EBP) sensor
- Electronic Control Module (ECM)

Function

The ECM contains a regulated 5V DC voltage reference source to power engine and vehicle sensors. The sensor signals are compared to the V_{REF} to determine actual sensor output signal values. These values are processed by the ECM for engine operation.

The system has two V_{REF} circuits:

- V_{REF} A for engine sensors
- V_{REF} B for chassis sensors

NOTE: See truck Chassis Electrical Circuit Diagram manual for APS and BAP sensor circuit diagrams.

V_{REF} Circuit Operation

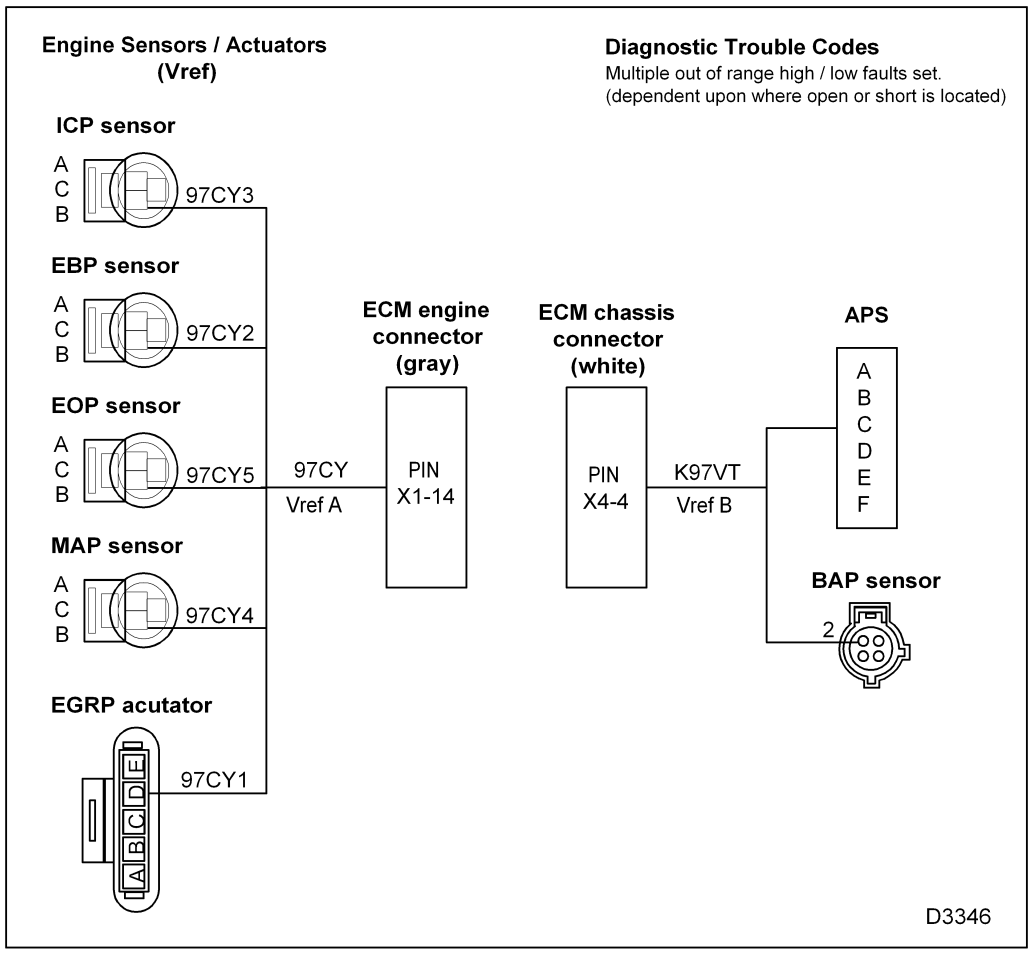

Figure 345 V_{REF} Circuit Diagram

The ECM supplies V_{REF} when the ignition key is on at terminals X1–14 (engine connector) and X4–4 (chassis connector).

Fault Detection / Management

There are no DTCs for V_{REF}. When a V_{REF} circuit fault occurs in a sensor, the ECM may set an out of range high or low code. Multiple high or low codes are indicators of a V_{REF} or signal ground fault condition. When a V_{REF} signal is shorted to ground, shorted to ground occurs, the ECM will reset and cause a stumble.

When the ECM sets multiple sensor DTCs, the V_{REF} circuit is open or shorted, or the signal ground circuit is open. To determine if the V_{REF} circuits are the cause, complete the pin point diagnostics check.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)
- Breakout harnesses
- Breakout box
- Terminal Test Adapter Kit

NOTE: After removing connector, inspect for damaged pins, corrosion, or loose terminals. Repair as required.

V_{REF} Pin Point Diagnostics

Table 82

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.

NOTE: The ECM monitors voltage on V_{REF} A and will adjust signal values for the sensors that use V_{REF} A for operation. If a sensor or circuit pulls V_{REF} lower than 5V, the ECM may set out of range high DTCs for the sensors that operate on V_{REF} B (APS, BAP, B+, and VSS).

Voltage Reference Connector Checks (If multiple DTCs are set, remove harness connections and measure V_{REF} at suspected sensor circuits.)

Sensor	Test Points	Spec	Comments
EBP	B to gnd	5V ±0.5	Check V_{REF} at each sensor. To isolate area of short or open circuit, identify sensors without V_{REF} and sensors that share a common V_{REF}. If disconnecting a sensor causes V_{REF} to be present in the circuit that had no previous V_{REF}, it is likely that the disconnected sensor had shorted V_{REF} to ground.
MAP	B to gnd	5V ±0.5	
ICP	B to gnd	5V ±0.5	
APS	C to gnd	5V ±0.5	
BAP	B to gnd	5V ±0.5	
EGRP	D to gnd	5V ±0.5	

Connector Checks to Chassis Ground (Turn ignition key OFF. Disconnect sensors and negative battery cable.)

EBP	B to gnd	>500Ω	If resistance is< spec, check for short to ground. If a short to ground condition exists, remove all sensor connectors that are connected to V_{REF} and ECM. Inspect to determine if short is in sensor, ECM, or wiring harness. Spec is >1kΩ with all common sensors disconnected from harness.
MAP	B to gnd	>500Ω	
ICP	B to gnd	>500Ω	
APS	C to gnd	>1kΩ	
BAP	B to gnd	>1kΩ	
EGRP	D to gnd	>500Ω	

Harness Resistance Checks (Turn ignition key OFF and all accessories. Disconnect sensors and install breakout box on engine harness only.)

EBP	B to X1–14	<5Ω	Measure resistance with DMM from sensor connector to ECM 24 pin connectors. If resistance is >5Ω, check for high resistance or an open in the V_{REF} supply circuit.
MAP	B to X1–14	<5Ω	
ICP	B to X1–14	<5Ω	
APS	C to X4–4	<5Ω	
BAP	B to X4–4	<5Ω	
EGRP	D to X1–14	<5Ω	

SPEED CONTROL COMMAND SWITCHES (SCCS)

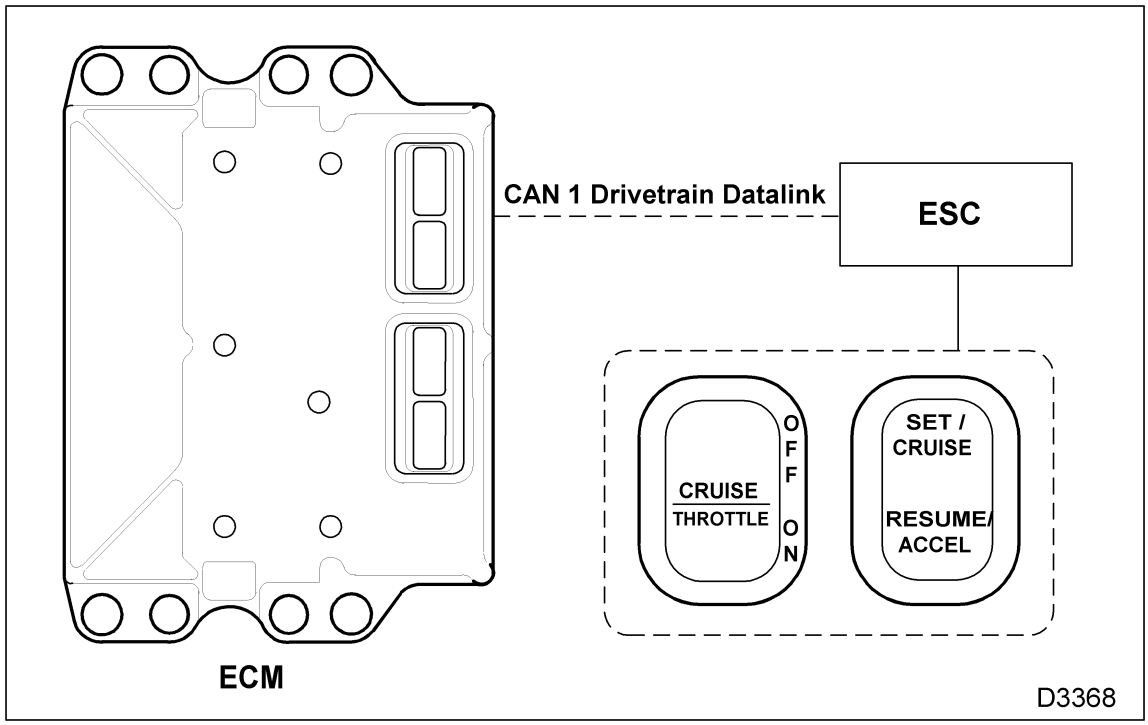

Figure 346 Function Diagram for the Speed Control Command Switch (SCCS)

The Function Diagram for the SCCS includes the following:

- Electronic System Controller (ESC)
- Electronic Control Module (ECM)
- Steering wheel cruise control switches

Cruise Control

The ECM will control engine speed to maintain a constant road speed with cruise control. Pressing the set switch when the vehicle is at the desired speed with the CRUISE switch in the on position activates the cruise control. Speed is increased or decreased by pressing ACCEL/CRUISE switches. The cruise control is deactivated by pressing the off switch, applying the brake pedal, clutch pedal, or on vehicles equipped with automatic transmissions, by placing the transmission in neutral.

Power Takeoff (PTO) Control

Engine speed can be controlled by the SCCS switches if the PTO option has been programmed into the ECM and the vehicle is stationary. Variable as well as preset speeds are available depending on ECM programming. The PTO function is turned on by pressing the cruise switch on. Pressing the SET/CRUISE or RESUME/ACCEL switches will increase or decrease engine speed depending on PTO programming.

SCCS Circuit Operation

Cruise control allows the ECM to control the engines power delivery to maintain a constant vehicle speed. The speed set point is determined by the operator and the cruise high and low set points are programmed in the ECM. The minimum engine speed that the cruise control can be engaged is programmed in the ECM.

Cruise control features are enabled as follows:

Table 83

Cruise ON/OFF button:	ON enables and OFF disables the cruise control functions.
SET / CRUISE:	If the cruise is enabled but a speed is not set, pressing the SET/CRUISE switch will select the current vehicle speed as the set speed. If the cruise is enabled and a speed is set, pressing the SET/CRUISE switch will cause the vehicle speed to decrease.
RESUME / ACCEL:	If the cruise is enabled, but has been deactivated by applying the brake or clutch, pressing the RESUME/ACCEL switch will cause the vehicle speed to resume to the last set speed. If the cruise is enabled and active, pressing the RESUME/ACCEL switch will cause the vehicle speed to accelerate.

In-Cab PTO

In-Cab PTO has three different modes of operation. These modes are selected by programming the ECM In-Cab PTO Mode. These modes are:

- In-Cab Preset
- In-Cab Variable
- In-Cab Mobile

In-Cab Preset

In-Cab Preset is selected by programming the ECM programmable parameters for In-Cab Mode to In-Cab Preset. This allows the operator to select one of two programmed values for engine speed. To operate, press the ON/OFF switch to the ON position. Then press either the SET/CRUISE or RESUME/ACCEL switch. This will cause the engine speed to run at the value programmed into PTO Set Speed.

Pressing the off switch, brake pedal, clutch pedal, placing the automatic transmission in gear, or a signal from the VSS (unless programmed for Mobile operation), will deactivate the PTO speed control. PTO speed control will not be functional if the VSS signal is in fault.

In-Cab Variable

In-Cab Variable is selected by programming the ECM Programmable Parameters for In-Cab Mode to In-Cab Variable. This option allows the operator to set the engine speed to a desired value. The control module will then maintain this speed over varying load conditions up to the engines rated power in the selected speed range.

To enable, press the ON/OFF switch to the ON position. Speed may be adjusted two ways. First the operator may adjust the engine speed with the accelerator and then press the SET/CRUISE switch. Second, the operator may press the RESUME/ACCEL to increase engine speed incrementally or press the SET/CRUISE switch to decrease the engine speed.

Engine set speed will be limited to the value programmed in the ECM for Maximum PTO speed.

Pressing the OFF switch, brake pedal, clutch pedal, placing the automatic transmission in gear, or a signal from the VSS, (unless programmed for Mobile operation), will deactivate the PTO speed control. PTO speed control will not be functional if the VSS signal is in fault.

In-Cab Mobile

In-Cab Mobile is selected by programming the ECM programmable parameters for the In-Cab mode to In-Cab Mobile. This allows the operator to use the engine speed control the same as In-Cab Variable, however, in this mode the vehicle can be moving while the mode is active. See In-Cab Variable for more details. The maximum speed of the vehicle is programmable up to 20 m.p.h. This mode is the same as In-Cab Variable, however, a speed signal will not disable the speed control until the programmed maximum speed is exceeded.

Remote PTO

Remote PTO can be enabled by two means, Remote Preset and Remote Variable. Operation of the speed control depends on which signal is enabled.

Remote Preset

When in the preset mode, the set switch will cause the engine to run at the programmed set speed. The RESUME/ACCEL switch will allow the engine to run at the programmed resume speed.

With the remote preset enabled, the speed is adjusted as with In-Cab preset. See In-Cab preset for more details.

Turning the ON/OFF switch OFF, depressing the brake pedal, clutch pedal, placing the automatic transmission in gear, or a signal from the VSS will deactivate the PTO speed control. However, the programmed option of PTO Operation Disable will prevent the clutch and brake signals from interrupting the PTO speed control, as well as cause the APS to be inoperative. PTO speed control will not be functional if the VSS signal is in fault.

Remote Variable

Enabling the remote variable signal allows for the engine speed to be adjusted to the desired level. Pressing the RESUME / ACCEL switch will cause the engine speed to increase, pressing the SET/CRUISE switch will cause the engine speed to decrease.

With remote variable enabled the speed is adjusted as with In-Cab Variable.

Opening the switch to pin X3–20, pressing the ON/OFF switch to OFF, depressing the brake or clutch pedal or placing the automatic transmission in gear, or a signal from the VSS will deactivate the PTO speed control. However the programmed option of PTO Operation Disable will prevent the clutch and brake signals from interrupting the PTO speed control, as well as cause the APS to be inoperative. PTO speed control will not be functional if the VSS signal is in fault.

PTO Speed Ramp Rate

The rate at which the speed of the engine will change will depend on load conditions and on a programmed value called PTO speed ramp rate. A higher value will cause the engine to change speed more quickly.

Tools

- Electronic Service Tool (EST) with INTUNE and Master Diagnostics software
- International® EZ-Tech Interface Cable
- International® J1939 Interface Cable
- Electrical System Troubleshooting Guide (truck manual)
- Electrical Circuit Diagrams (truck manual)

Fault Detection / Management

The ECM does not monitor the SCCS system for faults. There are no Diagnostic Trouble Codes (DTCs) for this system.

Diagnostics

If the engine does not respond to the cruise control switches, use INTUNE to monitor cruise switch input to the ESC. If the switch state does not change when the cruise controls are pressed, diagnose the cruise switch circuits using the Electrical System Troubleshooting Guide.

If the ESC is receiving the cruise switch input, use Master Diagnostics to view the cruise switch state. If the switch state does not change as the switch is pressed, verify communication exists between the ECM and the ESC (does the ECM respond to other ESC inputs). If the switch state does change, verify that other conditions do not exist that would stop or delay the reaction to the input. Examples include:

- rpm below minimum
- rpm above maximum
- Road speed below minimum / Road speed above maximum
- Brake pedal depressed
- Clutch / driveline disengaged

The EST can be used to monitor the status of the PTO controls. Comparing the data list reading to actual operation will indicate if the controls are operating correctly. Using the menu option of programmable parameters the programming can be verified to be sure the ECM is programmed correctly for the application. Also the data list can be used to monitor the parameters that cause interruption of PTO speed control.

TACHOMETER OUTPUT CIRCUIT

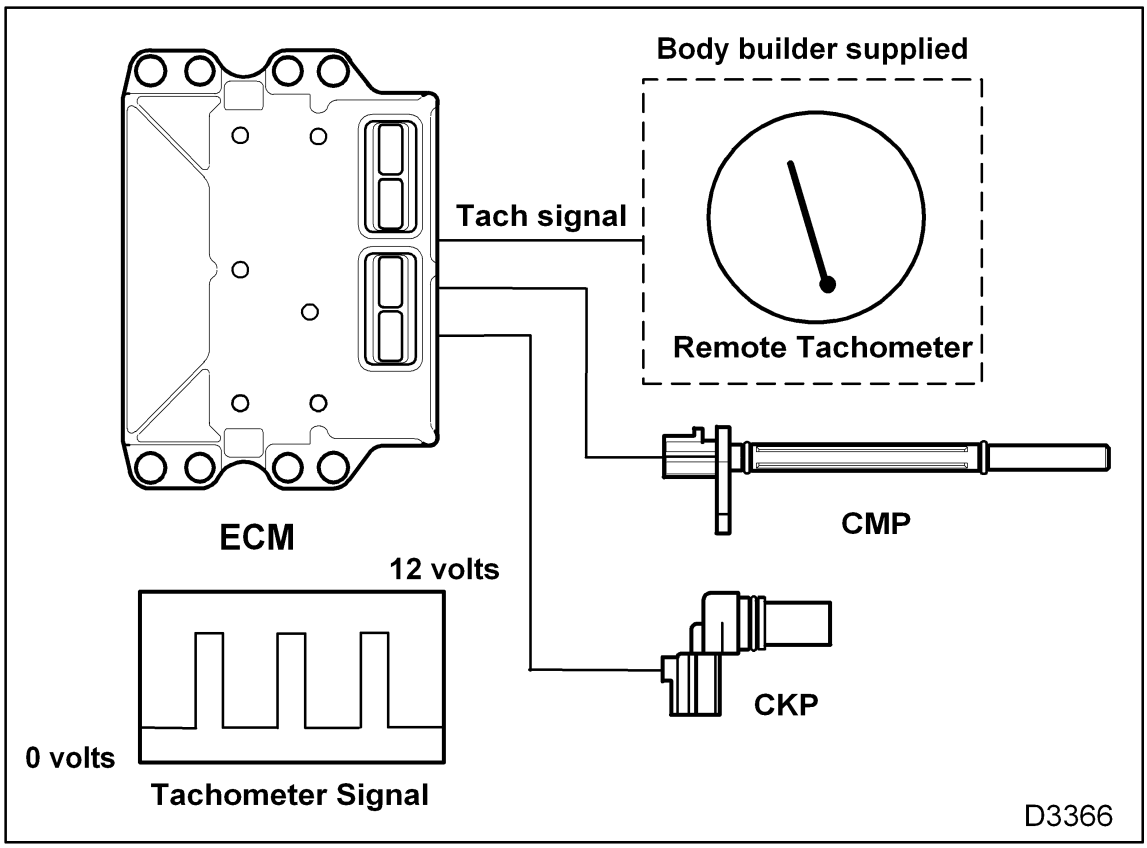

Figure 347 Function Diagram for the Tachometer Output Circuit

The Function Diagram for the Tachometer output circuit consists of the following:

- Remote tachometer
- Electronic Control Module (ECM)
- Camshaft Position (CMP) sensor
- Crankshaft Position (CKP) sensor

The ECM provides an output for a remote tachometer with a 0–12V digital signal that indicates engine speed. The frequency sent by the ECM is 1/5th of the actual engine rpm (12 pulse / rev = rpm / 5).

NOTE: Initial production ECMs send a frequency of 1 pulse / 2 revs = CMPO.

Tachometer Input Signal

The ECM receives a signal from the CMP sensor and calculates engine speed (rpm). The ECM sends the calculated engine speed as a digital buffered TACH signal from the ECM connector to the owner installed tachometer.

Tachometer Diagnostic Trouble Codes (DTCs)

DTCs are not available for communication between the ECM and the remote tachometer.

Tachometer Pin Point Diagnostics

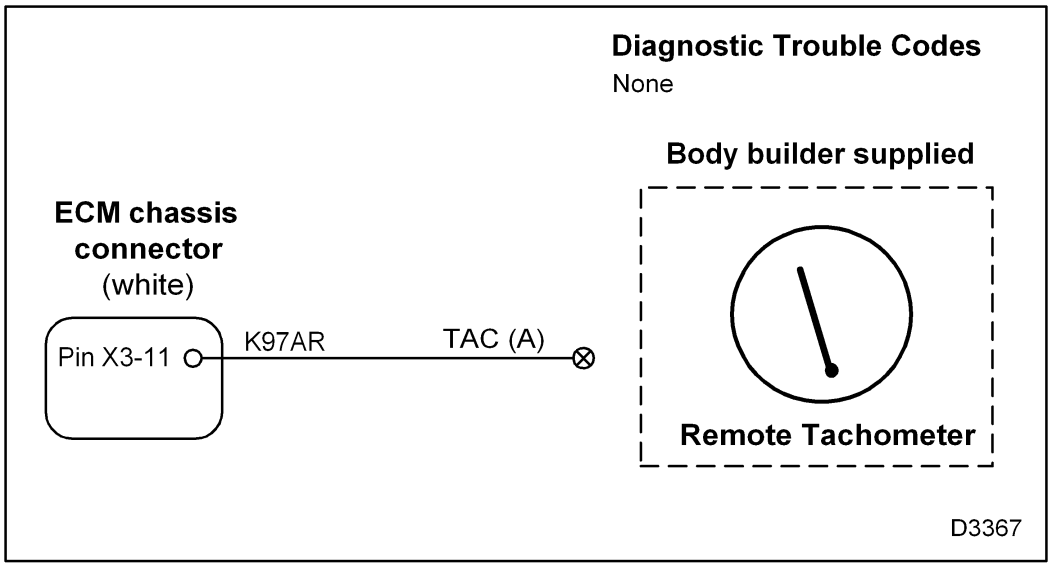

Figure 348 Tachometer Circuit Diagram

Table 84

Key ON Engine OFF Voltage Checks at ECM (Check with breakout box installed and Key ON Engine OFF.)			
Test Point	**Spec**	**Signal**	**Comments**
X3–11 to X3–7	12V ±1.5	TACH A	The signal is pulled up by the ECM with the Key ON Engine OFF.
Connector Checks to Ground at ECM (Check with breakout box installed and key OFF.)			
X3–11 to X3–7	>1kΩ	TACH A	If <1kΩ, check for short to ground either through the harness or internal ECM. Disconnect the ECM from the breakout box and measure to ground again. If short is still present, repair harness.
Harness Resistance Checks (Check with breakout box installed and key OFF.)			
X3–11 to tach	<5Ω	TACH	Resistance from ECM connector to TACH input – Optional owner / operator tach.
Key ON Engine Running Signal Checks – TACH (Check with breakout box installed.)			
X3–11 to X3–7	140–700 Hz		Tach signal from the ECM is a frequency that is engine rpm ÷5.

NOTE: The instrument cluster tachometer does not use these outputs. See truck Electrical System Troubleshooting Guide.

VARIABLE GEOMETRY TURBOCHARGER (VGT) ACTUATOR

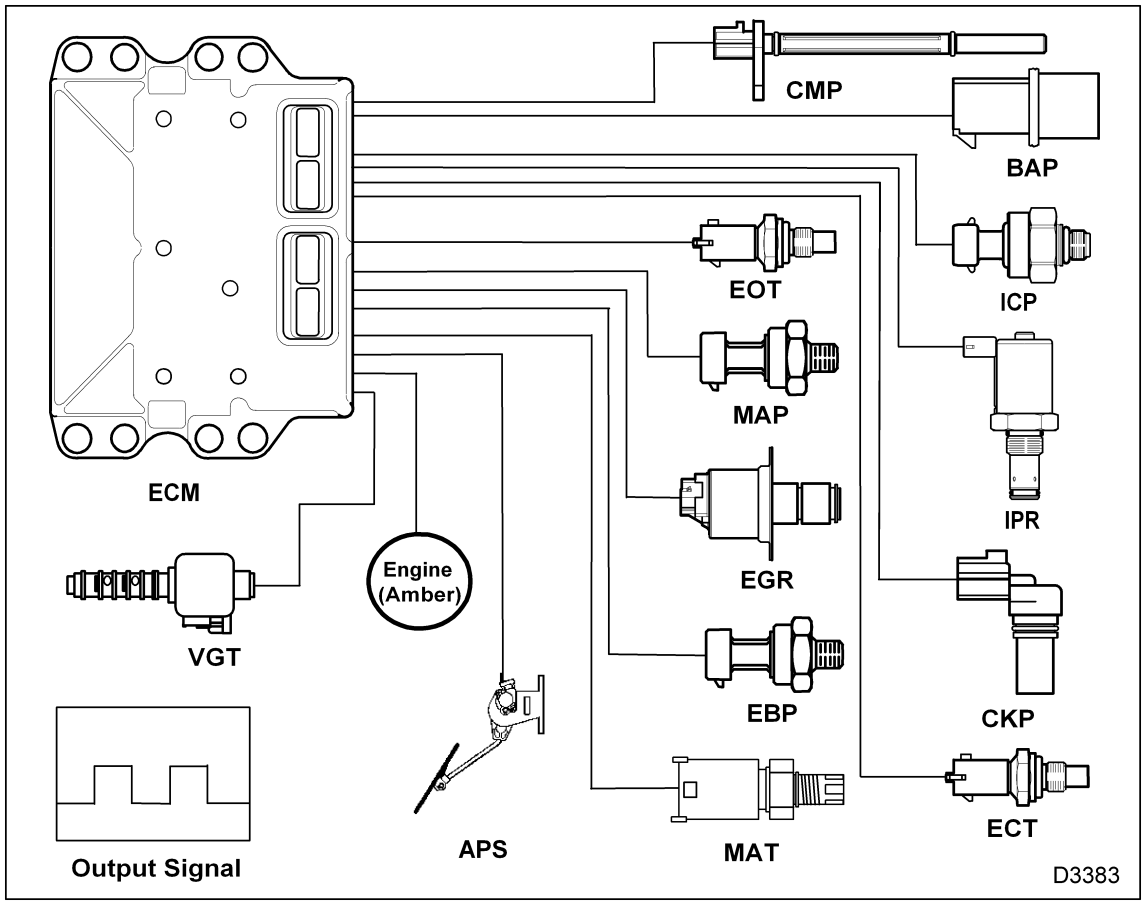

Figure 349 Function Diagram for the Variable Geometry Turbocharger (VGT) Actuator

The Function Diagram for the Variable Geometry Turbocharger actuator includes the following:

- Variable Geometry Turbocharger (VGT) actuator
- Electronic Control Module (ECM)
- Accelerator Pedal Position sensor and Idle Validation Switch (APS/IVS)
- Barometric Absolute Pressure (BAP) sensor
- Camshaft Position (CMP) sensor
- Crankshaft Position (CKP) sensor
- Engine Coolant Temperature (ECT) sensor
- Engine Gas Recirculation (EGR) sensor
- Engine Oil Temperature (EOT) sensor
- Exhaust Back Pressure (EBP) sensor
- Injection Control Pressure (ICP) sensor
- Injection Control Pressure Regulator (IPR)
- Manifold Absolute Pressure (MAP) sensor
- Manifold Air Temperature (MAT) sensor

Function

The Variable Geometry Turbocharger (VGT) actuator is a variable position valve that controls vane position in the turbine housing. The VGT actuator is located on top of the turbocharger. The valve position is controlled by switching a voltage source inside the ECM. The ground circuit is supplied directly from the battery ground at all times.

The actuator control is achieved by setting a pulse width modulated signal in response to engine speed, desired fuel quantity, boost or exhaust back pressure and altitude.

VGT Circuit Operation

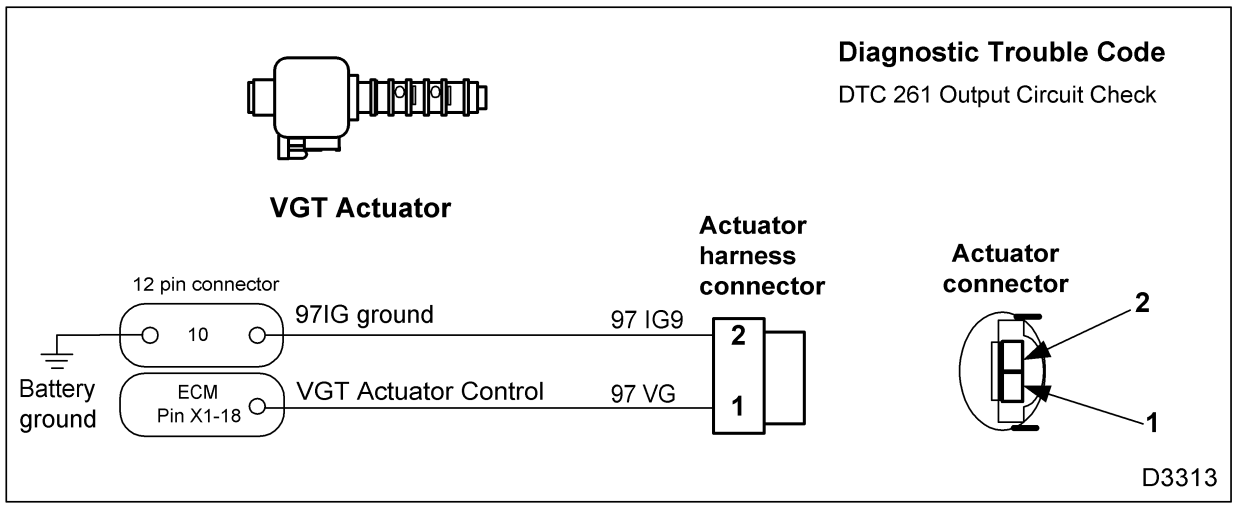

Figure 350 VGT Circuit Diagram

The VGT actuator receives ground at terminal 2 directly from the battery ground terminal. The ECM controls the VGT by sending a pulse width modulated signal from terminal X1–18 to terminal 1 on the VGT actuator. Precise control is gained by varying the percentage of ON/OFF time of the VGT solenoid. A high duty cycle indicates a high amount of exhaust back pressure is being commanded. A low duty cycle indicates less pressure being commanded.

Fault Detection / Management

An open or short to ground in the VGT control circuit can be detected by an on demand output circuit check during KOEO Standard tests. If there is a circuit fault detected a DTC will be set. When the engine is running, the ECM can detect if the exhaust back pressure is equal to the desired pressure. When the measured exhaust back pressure does not compare to the desired pressure, the ECM will ignore the measured EBP signal and controls the engine with the desired value.

VGT Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

DTC 261
Output Circuit Check

- DTC 261 is set by the ECM when the OCC test has failed after the KOEO Standard test has been run.
- DTC 261 can be set when a poor connection to the VGT solenoid or defective VGT coil exists.

Tools

- Electronic Service Tool (EST) with Master Diagnostics software
- International® EZ-Tech Interface Cable
- Digital Multimeter (DMM)
- Breakout harness
- Breakout box
- Terminal Test Adapter Kit
- 12–pin breakout harness

VGT Pin Point Diagnostics

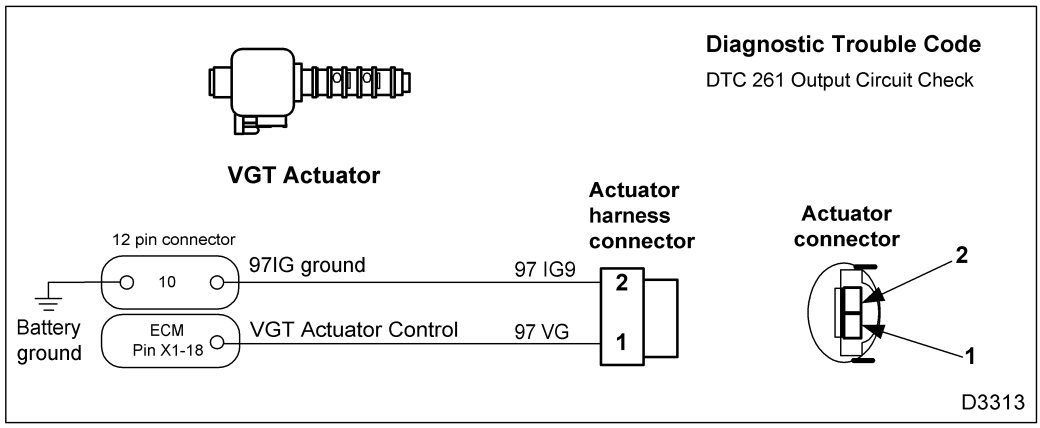

Figure 351 VGT Circuit Diagram

Table 85

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.

NOTE: See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.

Actuator Circuit Resistance Checks (Turn ignition key OFF. Disconnect negative battery cable. Check with breakout box installed in X1 ECM engine harness only.)

X1–18 to gnd	3–7Ω	Resistance through entire VGT circuit including actuator coil. Check with actuator connector connected.

Harness Checks (Turn ignition key OFF. Disconnect negative battery cable. Check with breakout box installed in X1 ECM engine harness only. Install 12-pin breakout harness to chassis and engine harness. Install actuator harness to engine harness only.)

Test Point	Spec	Comments
X1–18 to 1	<5Ω	If >5Ω, check for open VGT control wire.
2 to gnd	<5Ω	If >5Ω, check for open VGT ground circuit.
2 to 10 (12 pin)	<5Ω	If >5Ω, check for open between actuator connector PIN 2 to PIN 10 on 12 pin breakout harness.
10 (12 pin) to gnd	<5Ω	If >5Ω, check for open between 10 on 12 pin and chassis ground.
1 to gnd	>1kΩ	If <1kΩ, check for short to ground in circuit between actuator connector and ECM PIN X1–18.

VGT Diagnostic Trouble Code

DTC 261 = VGT actuator OCC test fail

VEHICLE SPEED SENSOR (VSS)

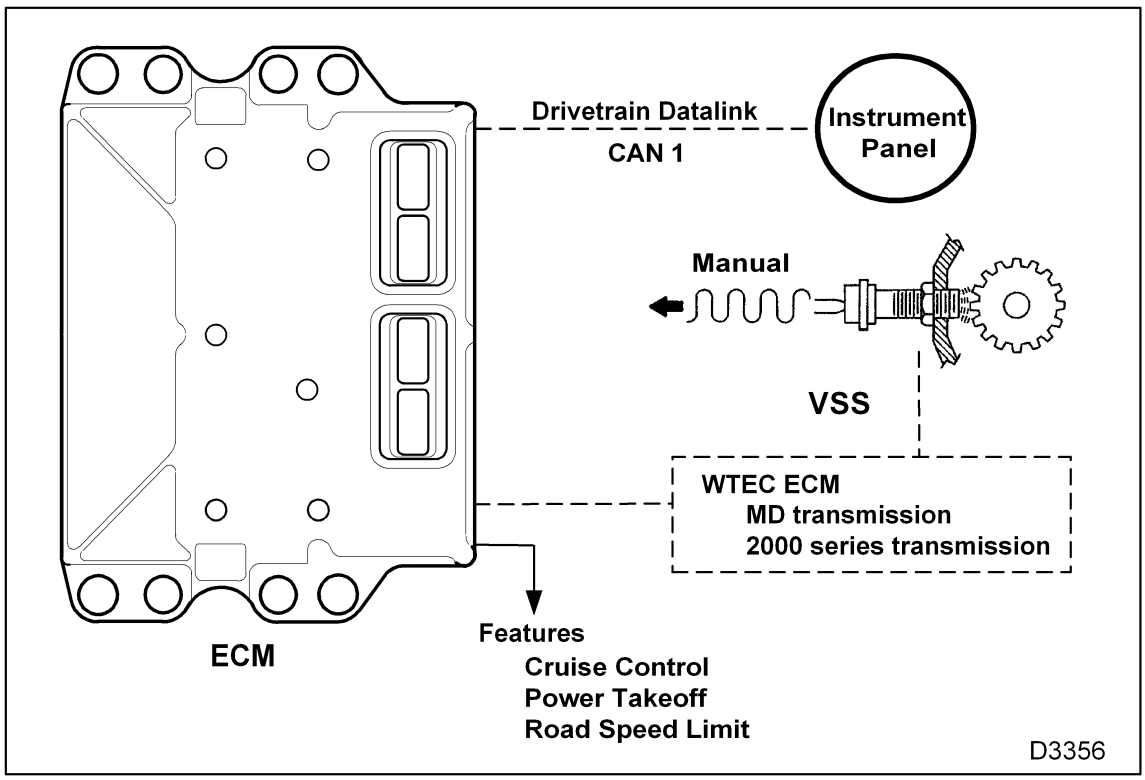

Figure 352 Function Diagram for the Vehicle Speed Sensor (VSS)

The Function Diagram for the VSS includes the following:

- Vehicle Speed Sensor (VSS)
- Electronic Control Module (ECM)
- World Transmission Electronic Control (WTEC) ECM
- Cruise Control, Power Takeoff, Road Speed Limit

Function

The Vehicle Speed Sensor (VSS) is a magnetic pick-up sensor located in the transmission. The VSS reads the rotation of a 16 toothed gear and produces a sine wave signal. The ECM processes the sine wave signal to calculate vehicle speed. The Drivetrain Datalink (CAN 1) transmits the calculated speed to the speedometer. The calculated speed also assists in control strategies that include Cruise Control, Power Takeoff, and Road Speed Limiting.

Allison WTEC MD 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.

VSS Circuit Operation

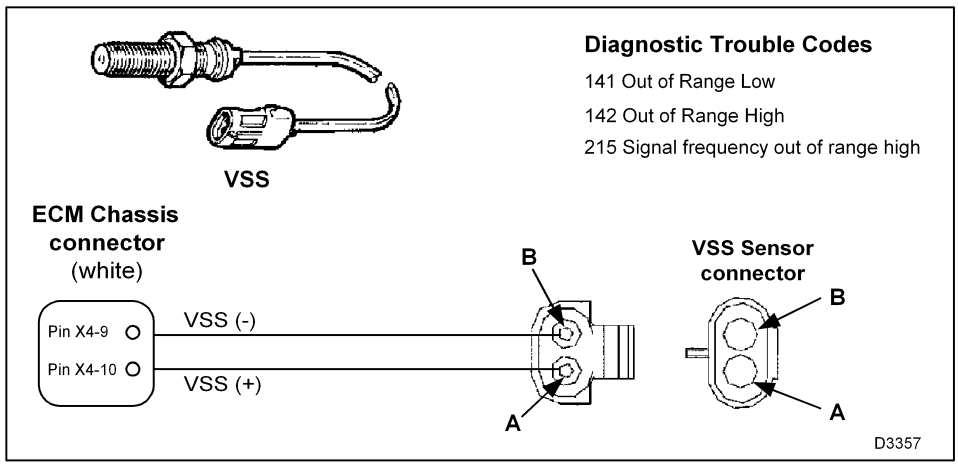

Figure 353 VSS Circuit Diagram

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.

The ECM will not set DTCs for VSS circuit failure for vehicles equipped with Allison MD (WTEC) and 2000 series transmissions. Vehicles equipped with MD transmissions only diagnose the communication circuit (CAN 1) between the engine and transmission module.

NOTE: See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations. To diagnose MD VSS sensor problems, see truck Electrical System Troubleshooting Guide and Allison WTEC maintenance and diagnostic manual.

VSS Diagnostic Trouble Codes (DTCs)

DTCs are read using the Electronic Service Tool (EST) or by counting the flashes from the amber and red ENGINE lamp.

DTC 141
Out of Range Low

- DTC 141 is set by the ECM when an out of range low condition is detected in the VSS circuit.
- When DTC 141 is active the amber ENGINE lamp is not illuminated.

DTC 142
Out of Range High

- DTC 142 is set by the ECM when an out of range high condition is detected in the VSS circuit.
- When DTC 142 is active the amber ENGINE lamp is not illuminated.

NOTE: The ECM monitors voltage on V_{REF} A and will adjust signal values for the sensors that use V_{REF} A for operation. If a sensor or circuit pulls V_{REF} lower than 5V, the ECM may set out of range high DTCs for the sensors that operate on V_{REF} B (APS, BAP, B+, and VSS).

DTC 215
Signal Frequency Out of Range High

- DTC 215 is set by the ECM when the ECM detects a VSS signal greater than 4365 Hz.

Tools

- Electronic Service Tool (EST) with INTUNE and Master Diagnostics software
- International® EZ-Tech Interface Cable
- International® J1939 Interface Cable
- Electrical System Troubleshooting Guide (truck manual)
- Electrical Circuit Diagrams (truck manual)

VSS Pin Point Diagnostics

The VSS circuit requires the use of vehicle circuit diagrams. See truck Chassis Electrical Circuit Diagram manual for circuit numbers, connector and fuse locations.

Table 86

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, always disconnect main negative battery cable first. Always connect the main negative battery cable last.

Connector Voltage Checks (Disconnect sensor from harness and turn ignition key ON.)

Test Point	Spec	Comments
B to gnd	2–3V	ECM pull up voltage when sensor disconnected. If no voltage present, check for open or short to ground.
A to gnd	2–3V	

Sensor Continuity Checks (Check with sensor disconnected and ignition key OFF.)

Test Point	Spec	Comments
B to gnd	>1kΩ	If <1kΩ, check for short to ground
A to gnd	>1kΩ	If <1kΩ, check for short to ground
B to A	600–800Ω	Manual transmission (measure resistance through sensor)
B to A	Ref Allison Manual	MD Automatic Transmission (electronically controlled)

Harness Resistance Checks (Turn ignition key OFF. Disconnect negative battery cable and sensor. Install breakout box on chassis harness only.)

X4–9 to B	<5Ω	If >5Ω, check for open circuit.
X4–10 to A	<5Ω	If >5Ω, check for open circuit.
X4–9 to gnd	>1kΩ	If <1kΩ, check for short to ground.
X4–10 to gnd	>1kΩ	If <1kΩ, check for short to ground.
X4–10 to X4–9	>2V AC	If <2V AC, check sensor adjustment or replace defective sensor.

VSS Diagnostic Trouble Code

DTC 141 = ECM detected low voltage across VSS circuit for >0.5 seconds

DTC 142 = ECM detected high voltage across VSS circuit for >0.5 seconds

DTC 215 = ECM detected VSS frequency signal >4.365 kHz

NOTE: If circuit checks are within spec and condition remains, see transmission manual for sensor inspection and adjustment.

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TOOLS AND ACCESSORIES

EZ-TECH™ ELECTRONIC SERVICE TOOL (EST)

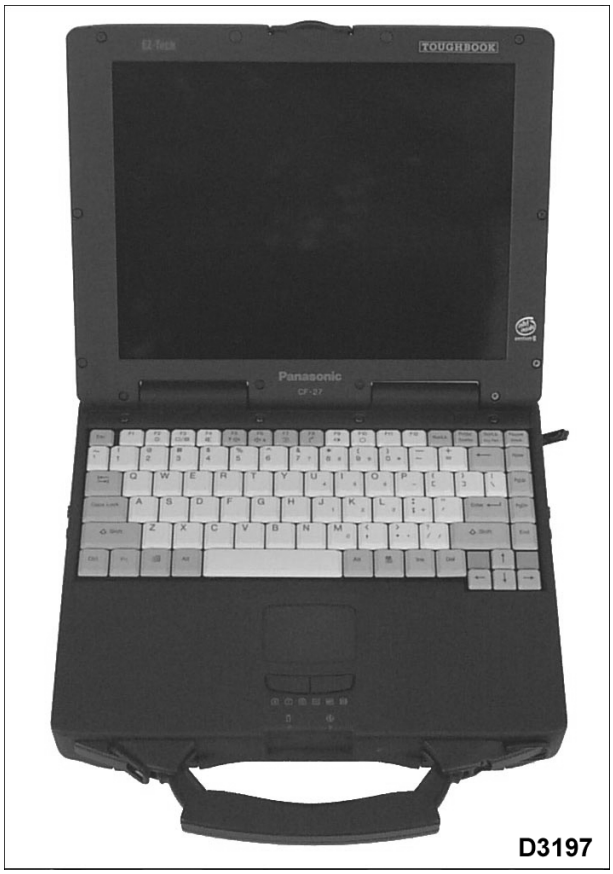

Figure 354 J-45067

The Electronic Service Tool (EST) is used to run Master Diagnostics (MD) software for diagnosing and troubleshooting engine and vehicle problems.

EZ-TECH™ INTERFACE KIT

Figure 355 ZTSE4444B

These cables, which come with the EZ-Tech, are used to connect the EST to communicate with the Electronic Control Module (ECM).

MASTER DIAGNOSTICS SOFTWARE (MD32)

International® Master Diagnostics software, when loaded to an EST or laptop computer, is used to check the performance of various engine systems, diagnose engine problems, and keep a troubleshooting history for an engine.

DIGITAL MULTIMETER (FLUKE 88™)

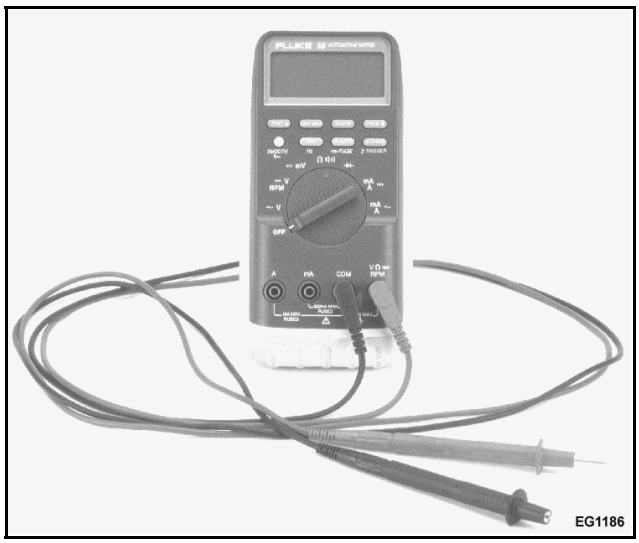

Figure 356 ZTSE4357

The Fluke 88™ 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.

96–PIN BREAKOUT BOX — DLC II

Figure 357 ZTSE4582

The 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.

CAUTION: The breakout box is used for measurement only, not to activate or control circuits. High current levels passing through the breakout box will burn out the internal circuitry.

BREAKOUT HARNESS KIT

Figure 358 ZTSE4505A

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
- Temperature sensor breakout harness
- Glow plug test lead

3–BANANA PLUG HARNESS

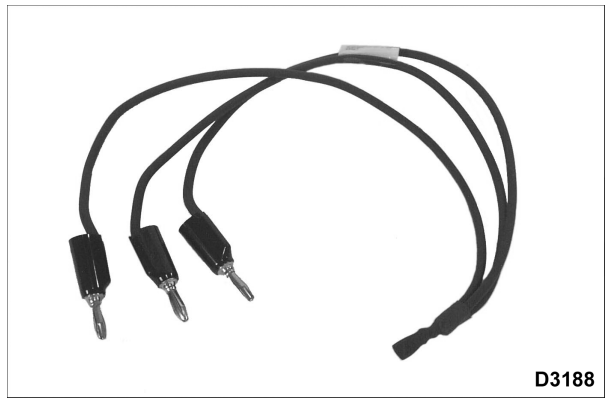

Figure 359 ZTSE4498

The 3–Banana Plug Harness is used for operational diagnostics of sensor circuits.

12–PIN BREAKOUT HARNESS

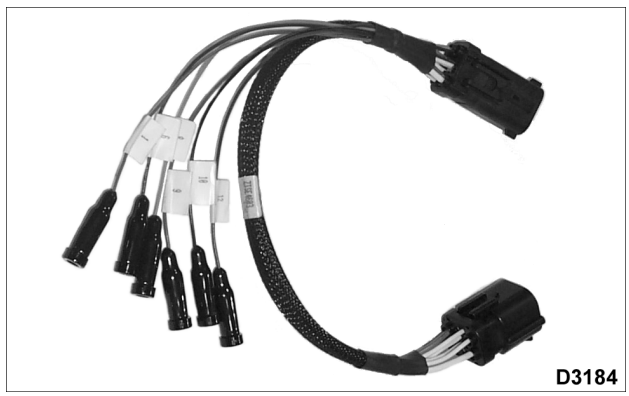

Figure 360 ZTSE4603

The 12–Pin Breakout Harness is used for circuit diagnostics for the Injector Drive Module (IDM) powers and grounds and for the Exhaust Gas Recirculation (EGR) power.

500 OHM RESISTOR HARNESS

Figure 361 ZTSE4497

The 500 ohm harness is used for operational diagnostics of sensor circuits.

ACTUATOR BREAKOUT HARNESS (IPR/VGT)

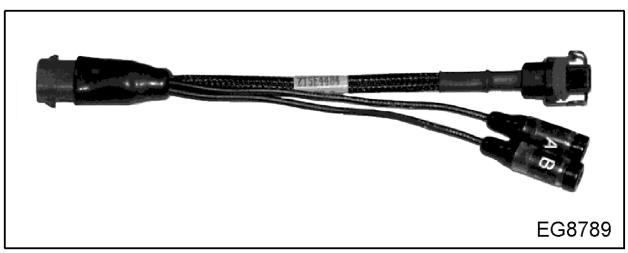

Figure 362 ZTSE4484

The actuator breakout harness is used to measure the voltage supplied to the Injection Pressure Regulator (IPR) and Variable Geometry Turbocharger (VGT) actuators.

For electrical circuit diagnostics, install the breakout harness between the electrical harness and the valve. For Injection Control Pressure (ICP) system diagnostics, plug the breakout harness into the IPR valve only.

APS/IVS SENSOR BREAKOUT HARNESS

Figure 363 ZTSE4485

The Accelerator Pedal Position Sensor (APS) / Idle Validation Switch (IVS) harness is used to measure V_{REF}, APS signal, signal ground, IVS signal, and IVS power at the APS/IVS sensor.

EGR BREAKOUT HARNESS

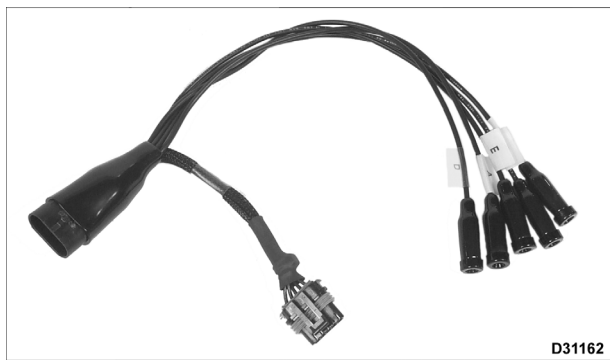

Figure 364 ZTSE4595

The EGR breakout harness is used to access the V_{REF}, sensor ground and signal voltage circuits for the EGR position sensor. This breakout harness can also be used to access the supply voltage to the EGR valve.

PRESSURE SENSOR BREAKOUT HARNESS

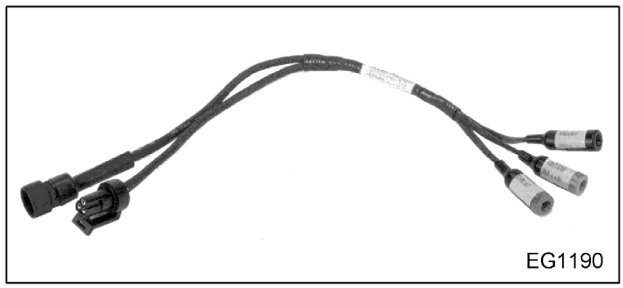

Figure 365 ZTSE4347

The pressure sensor breakout harness is used to access the V_{REF}, signal ground and signal voltage circuits for the following sensors:

- Injector Control Pressure (ICP)
- Manifold Absolute Pressure (MAP)
- Exhaust Back Pressure (EBP)
- Engine Oil Pressure (EOP)

RELAY BREAKOUT HARNESS

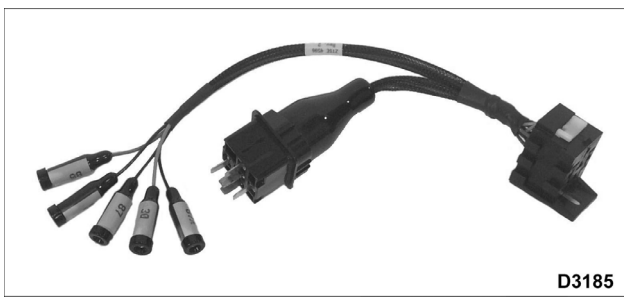

Figure 366 ZTSE4596

The relay breakout harness is used to measure power supplied from the IDM relay or from the ECM relay to check the operation of the relay in the circuit.

TEMPERATURE SENSOR BREAKOUT HARNESS

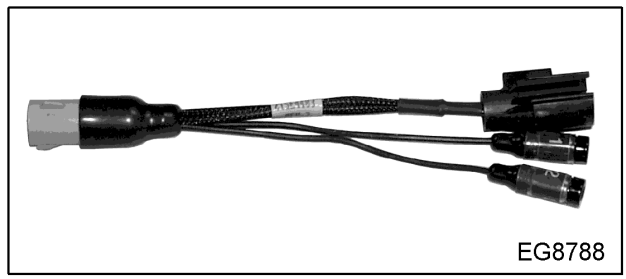

Figure 367 ZTSE4483

The temperature sensor breakout harness enables the technician to quickly connect a voltmeter and read voltage signals for the Intake Air Temperature (IAT) sensor.

TEMPERATURE SENSOR BREAKOUT HARNESS

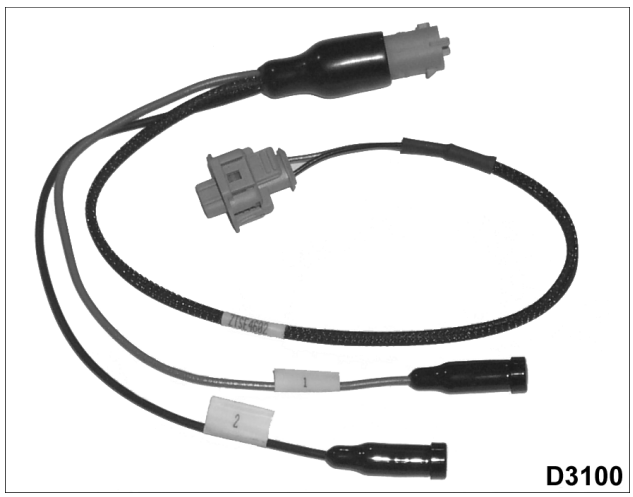

Figure 368 ZTSE4602

The temperature sensor breakout harness enables the technician to quickly connect a voltmeter and read voltage signals for the following sensors:

- Engine Coolant Temperature (ECT)
- Engine Oil Temperature (EOT)
- Manifold Absolute Temperature (MAT)

GLOW PLUG TEST LEAD

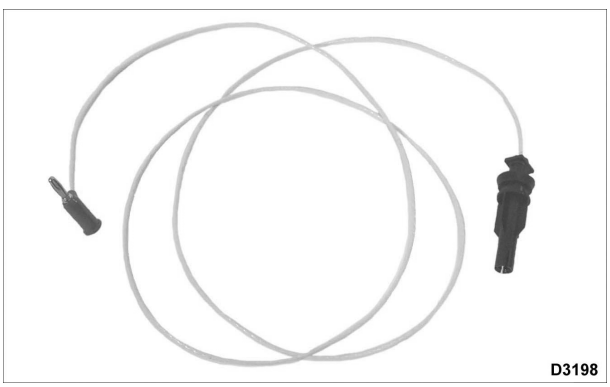

Figure 369 ZTSE4568

The glow plug test lead is used to measure the resistance of the glow plug to ground.

TERMINAL TEST ADAPTER KIT

Figure 370 ZTSE4435A

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.

GAUGE BAR TOOL

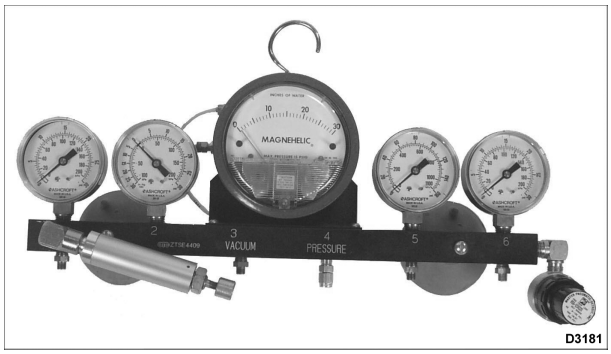

Figure 371 ZTSE4409

The gauge bar tool is used to measure intake manifold (boost) pressure, fuel pressure, air cleaner intake restriction, fuel restriction, and crankcase pressure.

- 0-200 kPa (0-30 psi) gauge No. 1 may be used to measure the intake manifold (boost) pressure.
- Compound gauge No. 2 — 0-30 in Hg vacuum gauge/0-200 kPa (0-30 psi) gauge — may be used to measure the fuel system inlet restriction, fuel pressure or intake manifold (boost) pressure.
- The 0-30 in H_2O (0-1.5 psi maximum pressure) magnehelic gauge may be used to measure the air cleaner restriction or crankcase pressure.

  When using the magnehelic gauge, plug the test line into the correct port. Use the VACUUM port (No. 3) to read air cleaner restriction. Use the PRESSURE port (No. 4) to read crankcase pressure.

- 0-200 kPa (0-30 psi) gauge No. 5 may be used to check the fuel pressure.
- 0-1100 kPa (0-160 psi) gauge No. 6 with a built in regulator may be used to check the movement of a waste gate actuator.

Operating Instructions

Connect test lines between the gauge ports on the gauge bar and the test points shown on the rear side of the Hard Start and No Start Diagnostic form or the Performance Diagnostic form.

SLACK TUBE MANOMETER

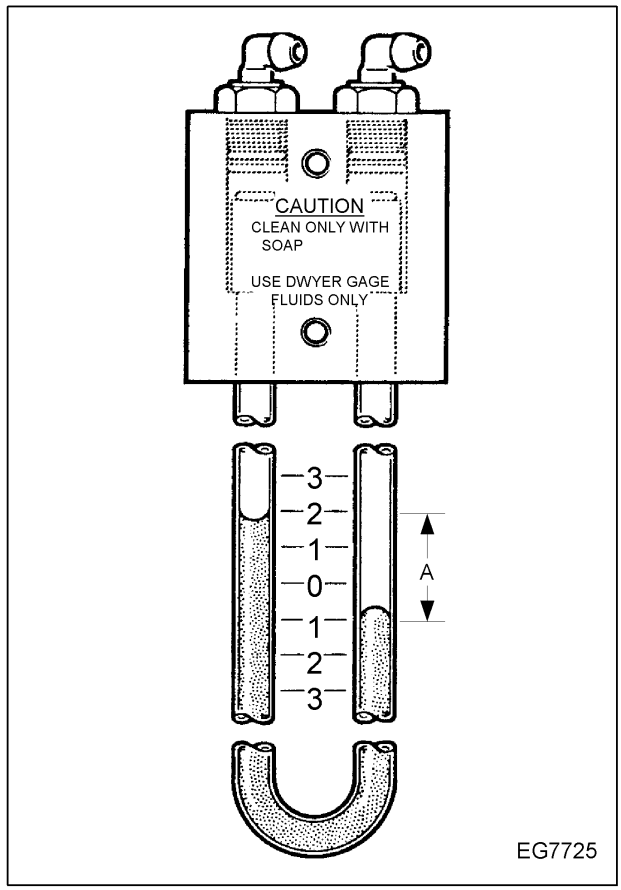

Figure 372 Dwyer™ No. 1211–48

The manometer is a U-shaped tube with a scale mounted between the legs of the U. When the portability of the gauge bar tool is not required, this manometer is used to measure either low pressure or vacuum (intake restriction, crankcase pressure or exhaust back pressure).

Filling

The manometer must be filled with water before checking any pressure. Use only drinking water without additives. 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.

NOTE: Never fill the manometer with an antifreeze solution, soda pop, tonic, etc. The increase in density causes false readings.

Installing, Reading and Cleaning

1. Support the manometer in a vertical position. 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. The other leg is left 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 observed after approximately 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 of no concern as long as the leg that is not connected to the pressure or vacuum source is open to the atmosphere.

5. Compare the manometer reading with engine specifications.

6. When test is finished, clean the tube thoroughly using a little pure soap and water. Avoid liquid soaps and solvents.

FUEL/OIL PRESSURE TEST COUPLER

Figure 373 ZTSE4526

The fuel/oil pressure test coupler is used with the fuel pressure test fitting for an easy connection to measure fuel pressure.

The coupler can be used with the engine oil pressure test port for an easy connection to measure engine oil pressure or take an oil sample.

FUEL PRESSURE TEST FITTING

Figure 374 ZTSE4542

The fuel pressure test fitting is used to measure fuel pressure. Install it in the fuel filter housing.

FUEL LINE TEST ADAPTER

Figure 375 ZTSE4607

The fuel line test adapter is used to pressurize the fuel supply to the cylinder head to check for leaks.

FUEL INLET RESTRICTION ADADPTER

Figure 376 ZTSE4583

The fuel inlet restriction adapter is used to measure the fuel inlet restriction. Install it in place of the fuel strainer.

ICP PRESSURE TEST TOOL

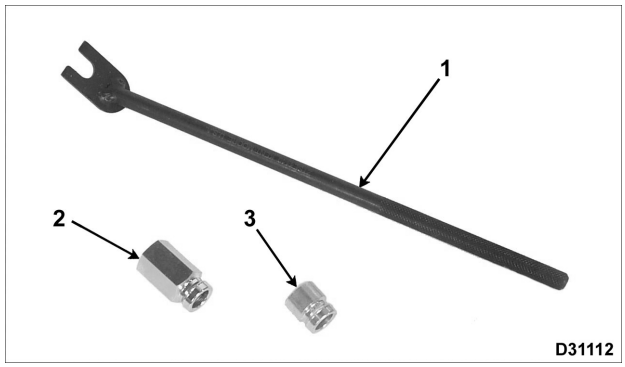

Figure 377 ZTSE4454

1. No. 6 Quick release tool (ZTSE4449)
2. ICP sensor adapter No. 6 (ZTSE4450)
3. ICP leak test Plug No. 6 (ZTSE4451)

The Injection Control Pressure Kit is used for ICP system diagnostics for International® T444E and VT 365 diesel engines.

The quick release tool is used to disconnect the high pressure oil line at the connector tube. The plug is used to block off the high pressure oil lines to check for system leaks.

QUICK RELEASE TOOL

Figure 378 ZTSE4581

The No. 8 end of the release tool is used to disconnect the oil supply line from the oil filter base to the turbocharger.

The No. 10 end of the release tool is used to disconnect the high pressure oil line at the high pressure oil rail.

IPR ISOLATION ADAPTER

Figure 379 ZTSE4605

The IPR isolation adapter is used to pressurize the ICP system to test the system's integrity without the influence of the IPR valve. Install the adapter into the back of the high pressure pump cover to block off the high pressure oil flow (control) to the IPR valve. If IPR valve leaks, replace the IPR valve.

ICP SYSTEM TEST ADAPTER

Figure 380 ZTSE4594

The ICP system test adapter is used to pressurize the ICP system to test the system's integrity with the influence of the IPR valve. Install the adapter into the back of the high pressure pump cover.

HIGH PRESSURE RAIL TEST ADAPTER

Figure 381 ZTSE4584

The high pressure rail test adapter is used to pressurize the high pressure oil rail and fuel injectors for ICP system diagnostics.

ICP LEAK TEST PLUGS (NO. 10)

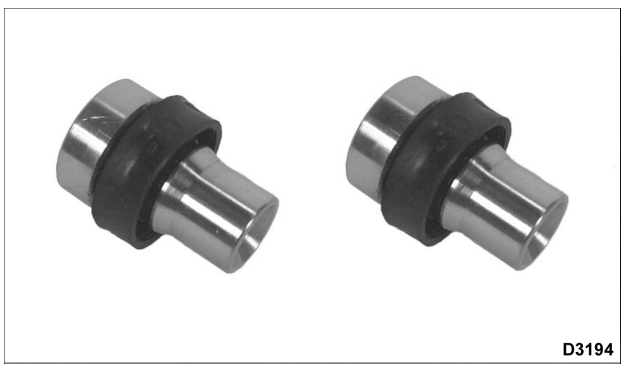

Figure 382 ZTSE4576

The ICP leak test plugs are used to block off high pressure lines during ICP system diagnostics to isolate leakage.

CRANKCASE PRESSURE TEST ADAPTER

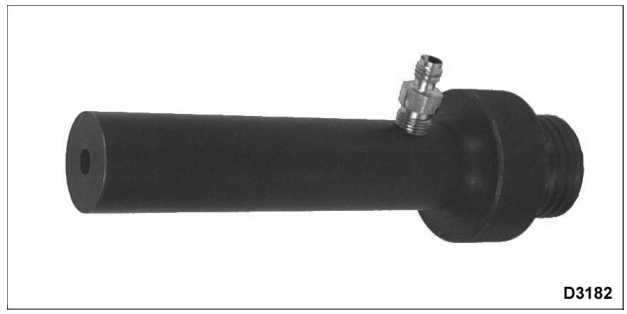

Figure 383 ZTSE4510

The crankcase pressure test adapter is used to measure combustion gas flow out of the engine breather. It may be used with the 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.

CYLINDER COMPRESSION GAUGE

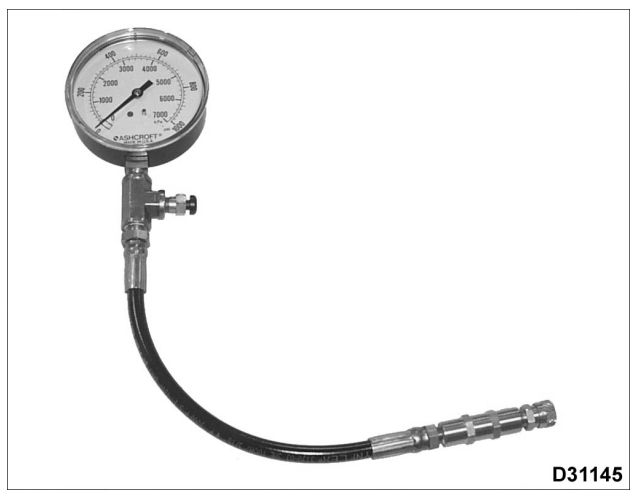

Figure 384 ZTSE2482A

The compression gauge is used to measure cylinder pressure (compression).

COMPRESSION TEST ADAPTER

Figure 385 ZTSE4506

The compression test adapter is used with a compression gauge to measure the cylinder pressure (compression). Install it in place of the glow plug.

CHARGE AIR COOLER TEST KIT

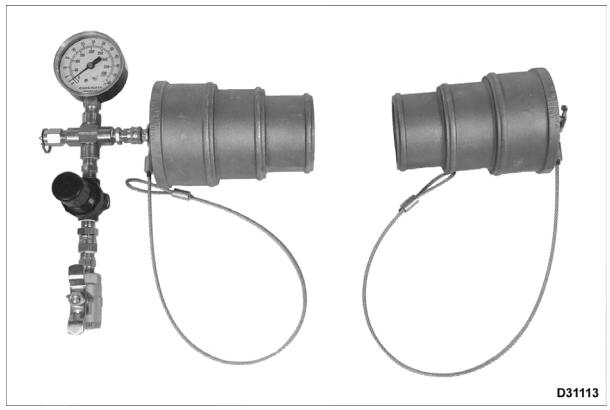

Figure 386 ZTSE4341

The Charge Air Cooler (CAC) test kit is used to pressurize the charge air cooler and piping to check for leaks.

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, 12V) 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.

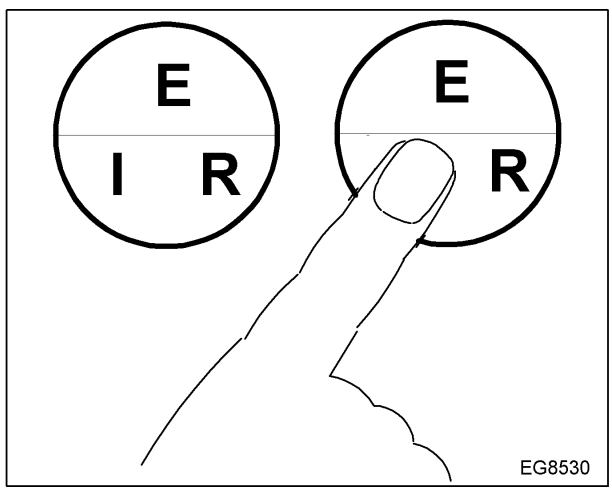

Figure 387 Ohm's Law

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.

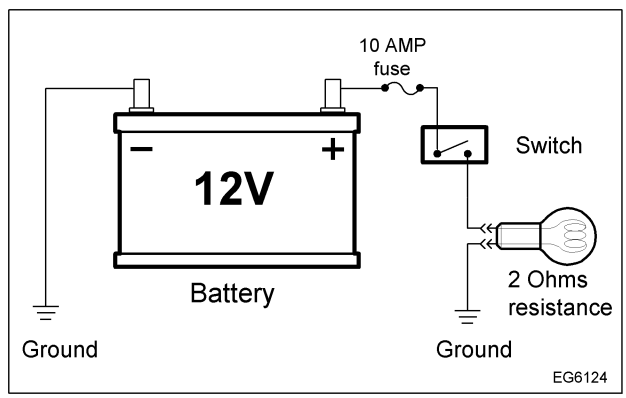

Figure 388 Simple Electrical Circuit

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 = 12V ÷ 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

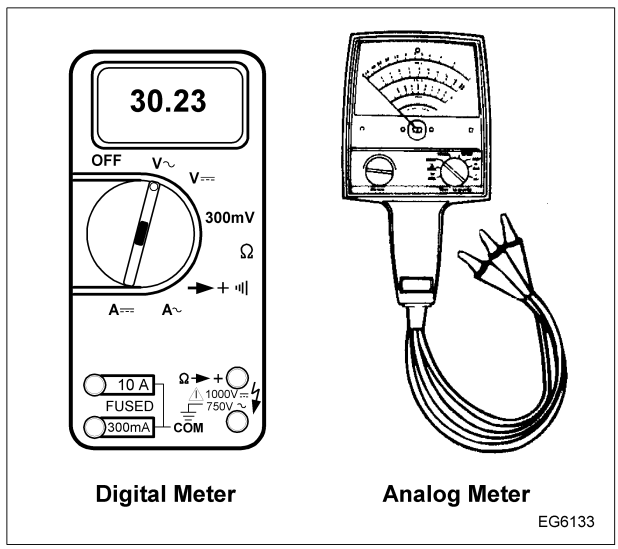

Figure 389 Typical Test Meters

All 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 is recommended because it has very little current and a high impedance (resistance) of 10 megaohms (10 MΩ).

CAUTION: Use only high impedance digital multimeters when troubleshooting an electronic circuit. Do not use any kind of 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

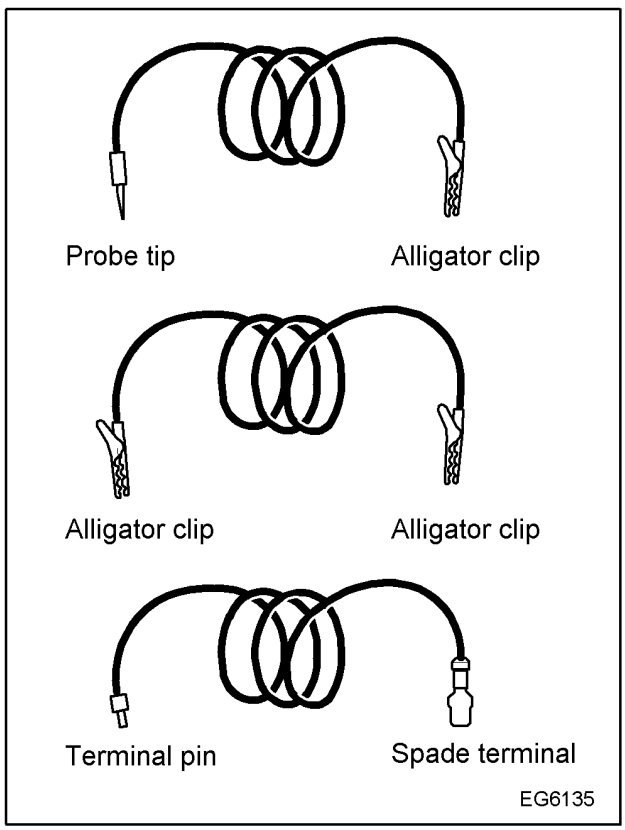

Figure 390 Jumper Wires

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.

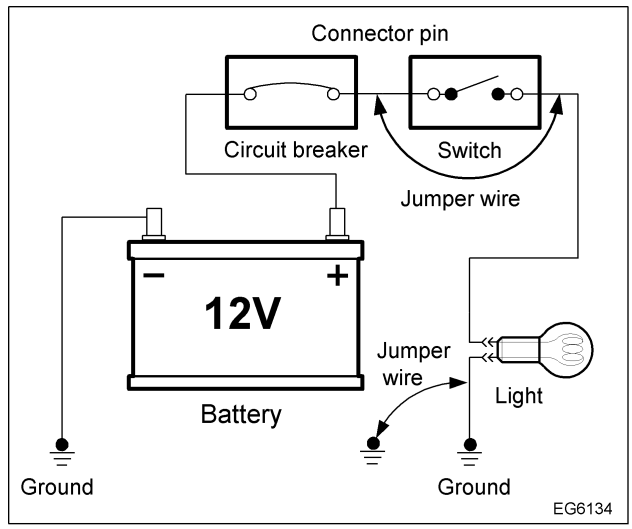

Figure 391 Troubleshooting with Jumper Wires

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?

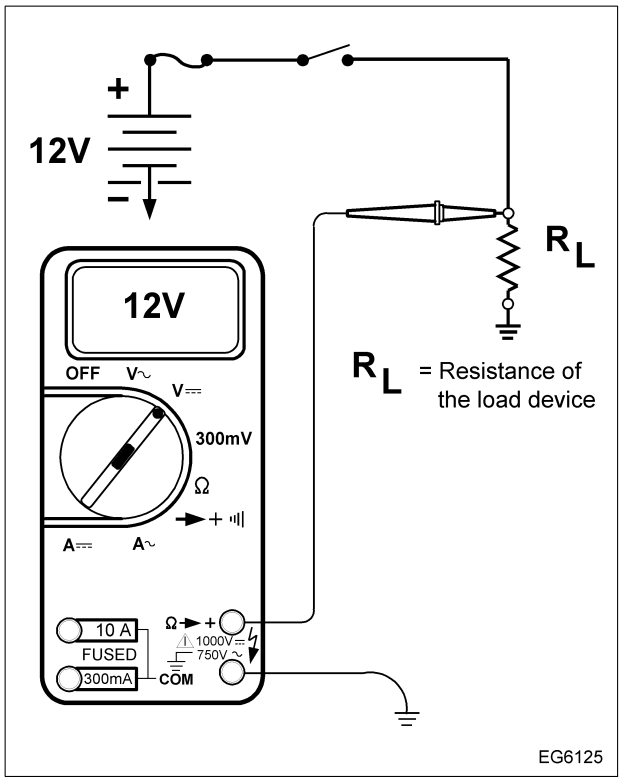

Figure 392 Checking Power to a Load Device

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.

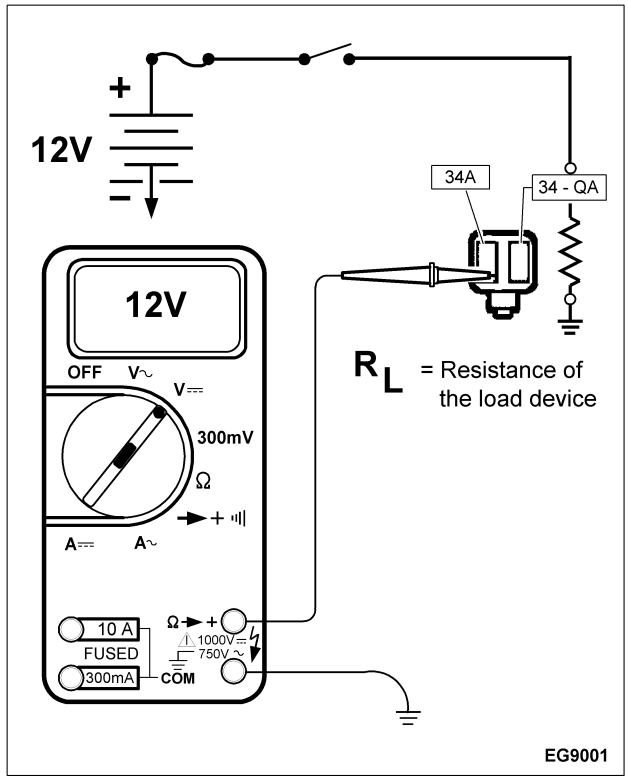

Figure 393 Checking Power to a Connector

Voltage to a device can also be measured by disconnecting the harness connector and using the correct tool in the Terminal Test Adapter Kit.

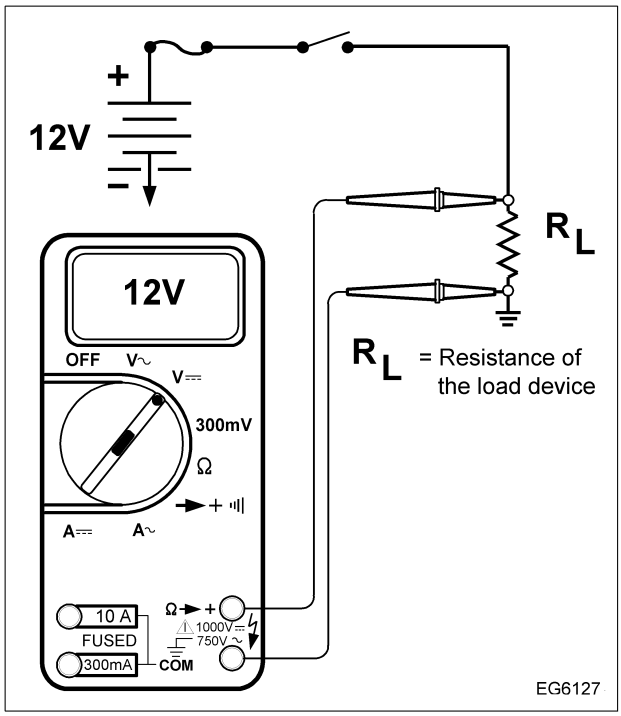

Figure 394 Checking Voltage Drop

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 9V across the load, it indicates the wires and connections dropped 3V, 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 ÷ 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 rating vs. the actual measurement).

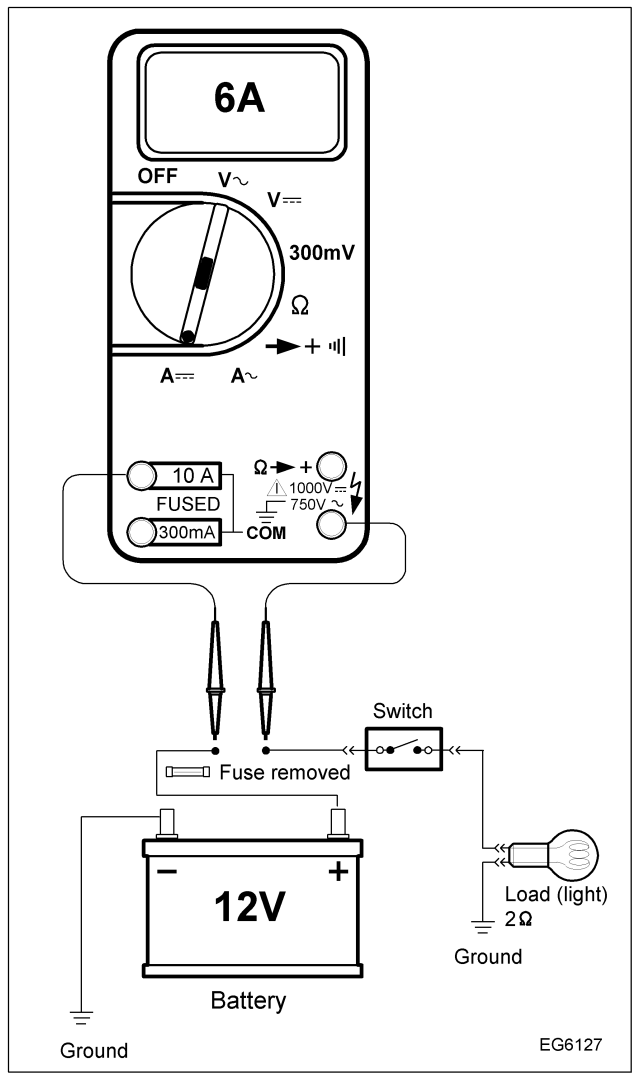

Figure 395 Installing the Ammeter

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 10A 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 = 12V ÷ 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 avoid serious personal injury or possible death, always make sure the power is off before cutting, soldering, removing circuit components or before inserting the digital multimeter for current measurements. Even small amounts of current can be dangerous.

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 damage to the test meter, only use the ohmmeter on circuits when the power is OFF. Power from 12-volt systems may damage the meter.

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. With the DMM, range selection and meter adjustment are not necessary.

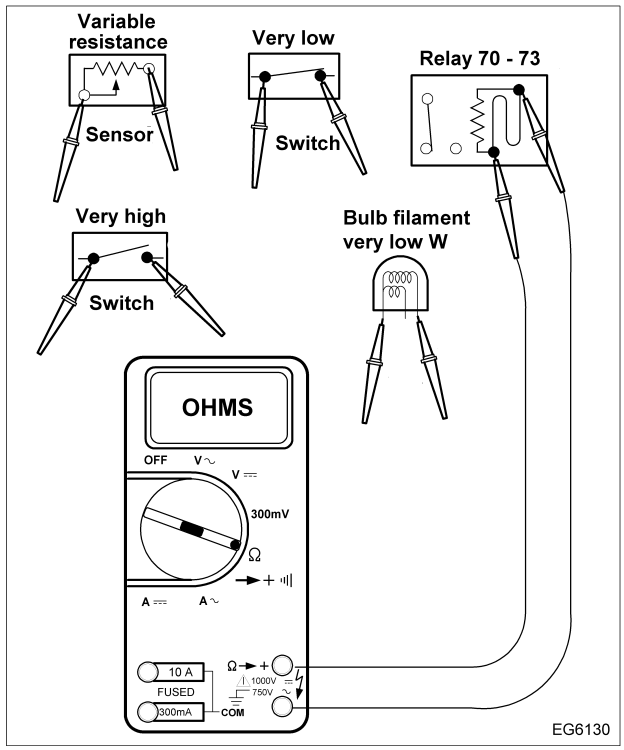

Figure 396 Measuring Resistance

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.

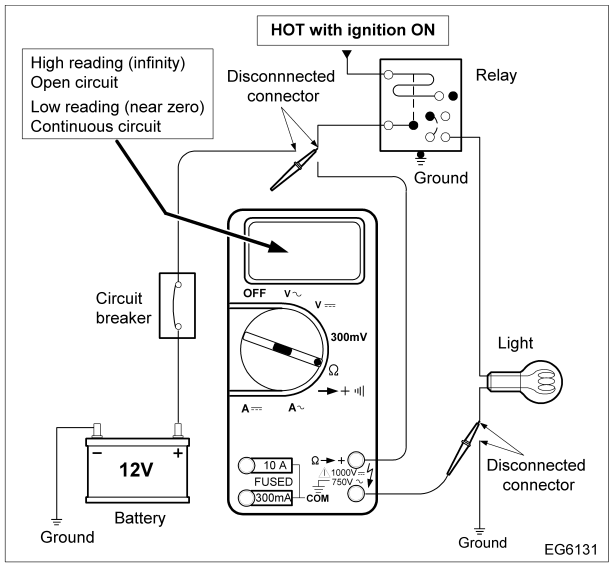

Figure 397 Checking for Open Circuits

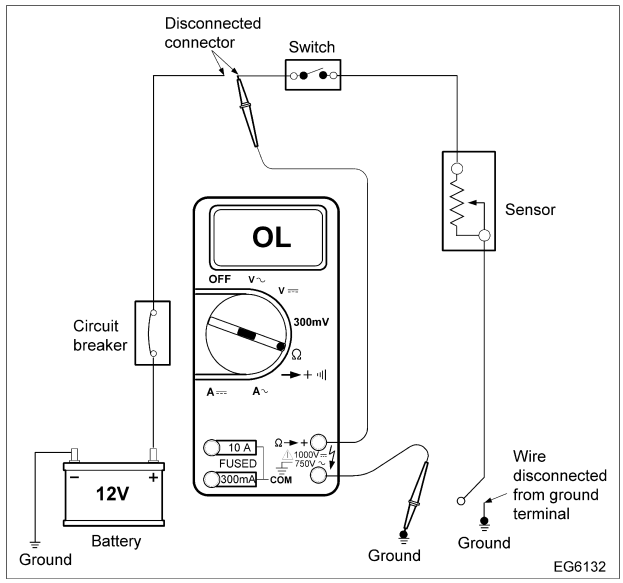

Figure 398 Checking for Short Circuits

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, an open circuit will read OL (over limit).

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.

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.

   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 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.

USING MASTER DIAGNOSTICS (MD 32)

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing service bay diagnostics on engine or vehicle.

STARTING MASTER DIAGNOSTICS FROM THE WINDOWS DESKTOP

1. Connect the EST or laptop computer to the EZ-Tech Interface. (See Tools and Accessories.)

Figure 399 International® Truck Interface (ZTSE4444A)

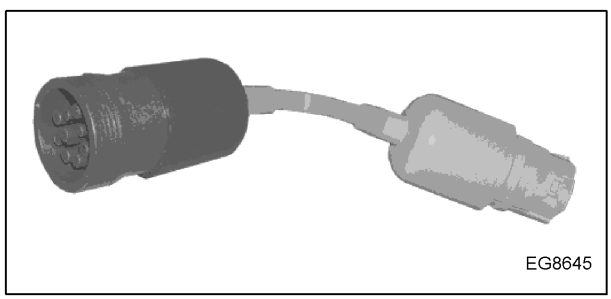

Figure 400 ATA 9–Pin to 6–Pin Adapter (ZTSE4467)

NOTE: If the EZ-Tech Interface is not available, the previous International® Truck Interface cable and ATA 9–pin to 6–pin adapter can be used.

2. Boot up the EST or laptop computer with Master Diagnostics software.

3. Double click on the desktop icon (Vehicle Diagnostics).

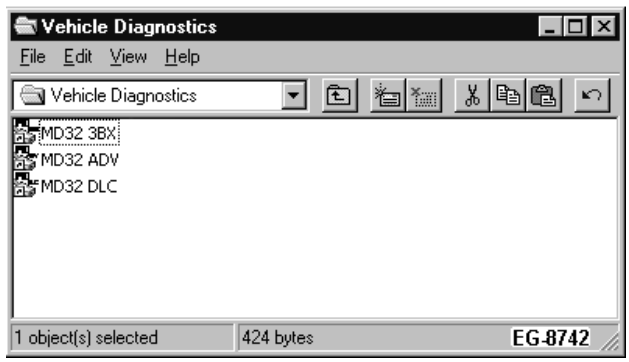

Figure 401 Vehicle Diagnostics Open Window

4. The Vehicle Diagnostics window will be displayed. Depending on the vehicle, Master Diagnostics can be opened for engines using a 3 box engine controller, for those that use the single box Diamond Logic™ controller (DLC) or for those that use the 2 box Diamond Logic Control (DLCII).

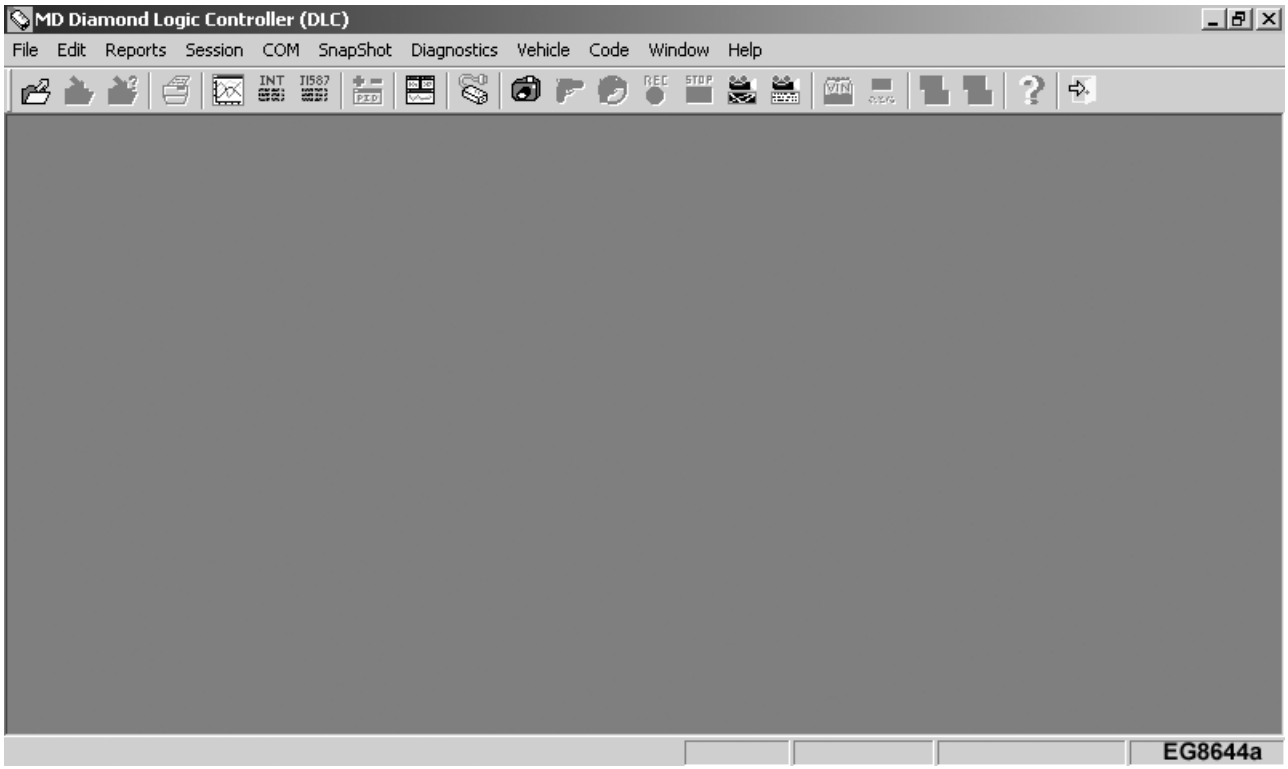

Figure 402 Main Window

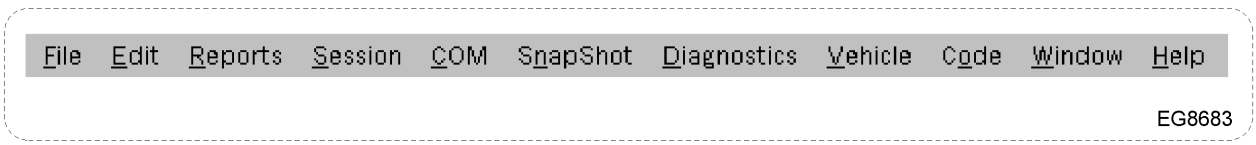

Figure 403 Drop-Down Menu Bar

After starting the Master Diagnostics software, the computer should display the main window .

There is a menu bar just below the window's title bar. All available software features can be accessed by these drop-down menus .

Figure 404 Tool Bar Icons

The tool bar menu provides quick and easy access to features of this software.

1. **File→ Open:** Opens a graphical or text display file, snapshot setup (*.trg), or programmable parameter display file (*.ppv). This option allows the user to recall and view previously saved configurations. Three display formats are available: *.ntv (a text display for International engines), *.jtv (a text display for generic J1587 ATA data link engines), *.pgv (a graphical display).
2. **File→ Save:** Saves the configuration of the highlighted window.
3. **File→ Save As:** Saves the configuration of the highlighted window and prompts the user for a file name.
4. **File→ Print:** Prints the highlighted window to the printer or a file. Not all windows may be printed.
5. **File→ New:** Opens a new graphical display window.
6. **File→ New:** Opens a new International® text display window.
7. **File→ New:** Opens a new J1587 ATA text display window.
8. **Edit→ Add/Delete/Edit:** Adds, deletes or edits parameters from the highlighted window.
9. **Session→ Open:** Retrieves a previously setup Master Diagnostics sessions.
10. **COM→ Open:** Begins the ATA communications via the EST COM port.
11. **Sniffer→ Open:** Opens and displays all active Message ID (MID) addresses on the ATA datalink. This provides a quick view of available electronic modules.
12. **Snapshot→ Setup:** Sets up the snapshot recording options: the trigger source, pre-trigger recording time, post-trigger recording time, which parameters to record, how often to sample data, etc.
13. **Snapshot→ Arm:** Arms the trigger for the snapshot.
14. **Snapshot→ Disarm:** Disarms the trigger for the snapshot.
15. **Snapshot→ Start:** Manually starts the snapshot recording. The F2 key has the same function.
16. **Snapshot→ Stop:** Manually stops the snapshot recording. The F3 key has the same function.
17. **Snapshot→ Replay:** Replays a snapshot recording file in a graphical format.
18. **Snapshot→ Replay:** Replays a snapshot recording file in a text format.
19. **Vehicle→ View Information→ Basic:** Opens the vehicle information window.
20. **Vehicle→ View Information→ Basic +:** Opens vehicle information, programming, DTC, and temperature windows.
21. **Vehicle→ Program:** Opens an electronic engine controller module programming window.
22. **Code→ View:** Opens the trouble code window.
23. **Code→ Clear:** Clears the trouble codes contained in the ECM.
24. **Help→ Contents:** Opens Master Diagnostics software help.
25. **File→ Exit:** Exits and terminates the Master Diagnostics program.

OPENING A COM PORT

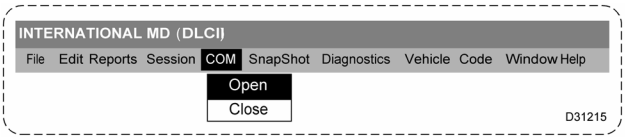

Figure 405

1. Before using the software, the settings must be configured. Click COM on the drop-down menu bar and select Open.

2. Select COM 1 or COM 2 to open the ATA bus. This allows a link between the ECM to Master Diagnostics.

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing service bay diagnostics on engine or vehicle.

3. Turn ignition key ON to complete the link. Data will flow to Master Diagnostics.

TEXT WINDOW AND ADDING PARAMETER IDENTIFIERS (PID)

To monitor engine parameter data in text format, first create a text window.

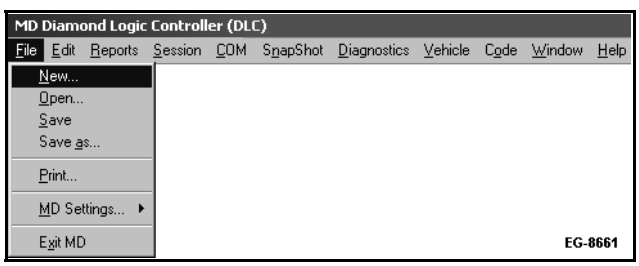

Figure 406

1. Select File and then New on the menu bar to open the Select a File Type dialog box.

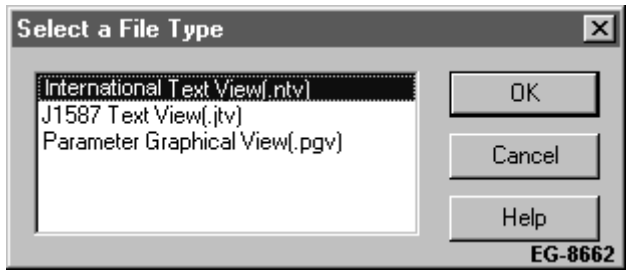

Figure 407

2. Select International Text View (.ntv) and click on OK.

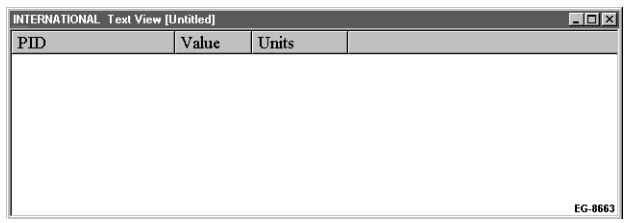

Figure 408

An empty Text View display window will appear. Text view windows have three columns: PID, Value, and Units. The PID column shows the PID description or acronym. The Value column shows the current data value. The Units column shows the display value units (English or metric).

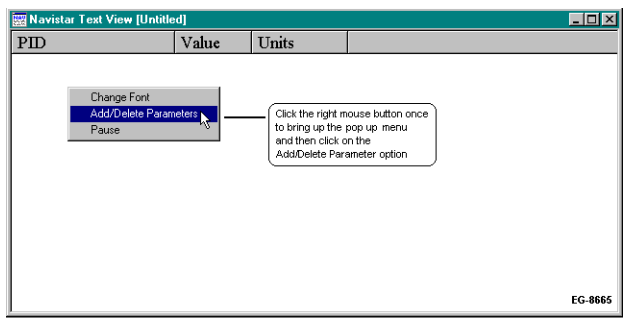

Figure 409

3. To add parameters to this window, right click in the window, then select Add/Delete Parameters on the pop-up menu.

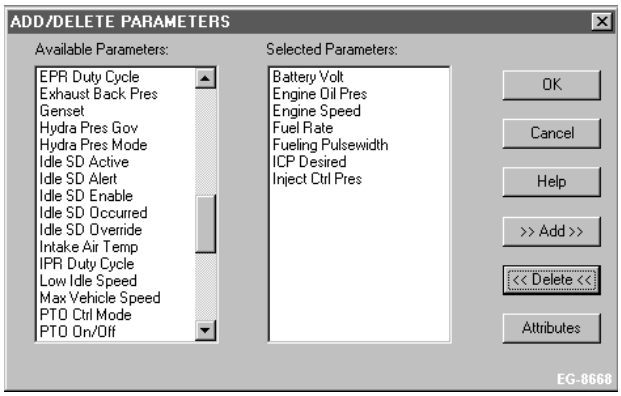

Figure 410

4. To add parameters to the Selected Parameter list box, double click on a parameter or click on all of the desired parameters in the Available Parameter list box. Then click the >>ADD>>.

The order in which PIDs are displayed in the Text View window is dependent on when a parameter is added to the Selected Parameter list. For example, a double click on the Fuel Rate first and then Fueling Pulse Width, then Fuel Rate will be displayed on top of Fueling Pulse Width in the Text View window. Use the vertical scroll bar to view additional parameters in the Available Parameters list box.

Double clicking a parameter in the Selected Parameter list will remove it from the Text View window.

To recall the original settings, click on the Defaults button to restore the attributes to the factory defaults.

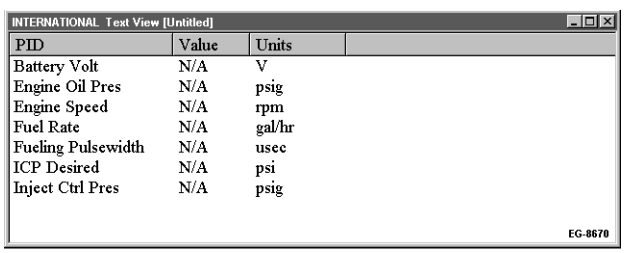

Figure 411

5. When done adding or deleting parameters and modifying the attributes, click the OK button in the ADD/DELETE PARAMETERS dialog box. The text window will display the selected parameters.

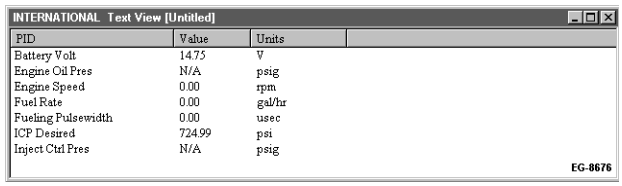

Figure 412

This Text View window is configured and ready to be used. Opening the COM port at this time will allow the data to be displayed. The resulting window illustrates some parameter values (static data w/engine off).

By clicking on Units, the units of all the displayed parameters can be toggled between metric or English.

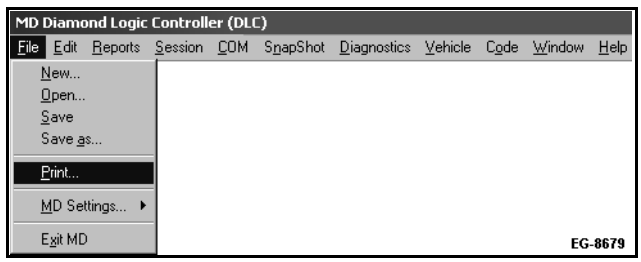

Figure 413

6. To print the information in these Text View windows, select File and then Print on the menu bar.

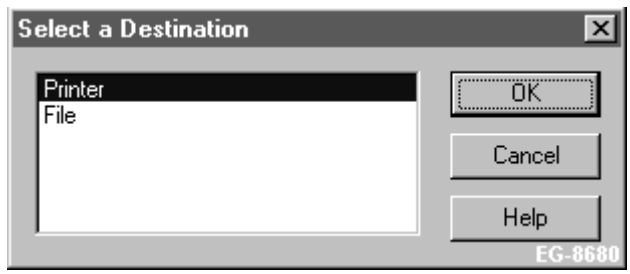

Figure 414

The printout can be sent to the printer or to a file.

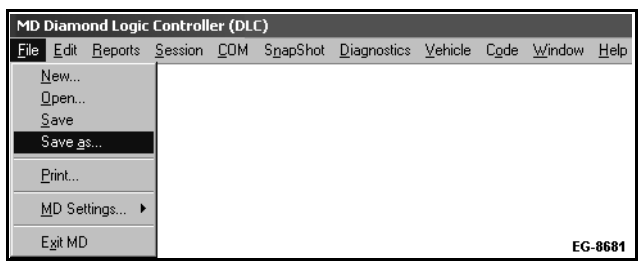

Figure 415

7. The configuration of these Text Views may be saved for later retrieval; the list of displayed parameters, font size, and type information is saved. The actual parameter data is not part of the configuration. Click File on the menu bar and then click Save As.

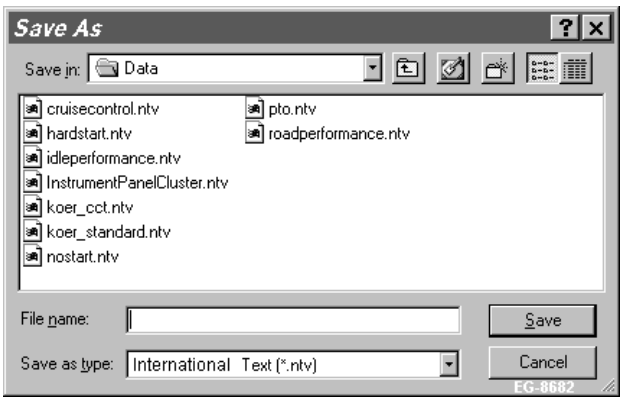

Figure 416

The Save As file dialog box will appear. Type a file name inside the File name edit box and click Save button.

GRAPHIC WINDOW AND ADDING PARAMETER IDENTIFIERS (PID)

To monitor the engine parameter data in graphical format, first create a graphical window. This is done similarly to the creation of a Text View window.

1. Select File and then New (See Figure 406) on the menu bar to open the Select a File Type dialog box.

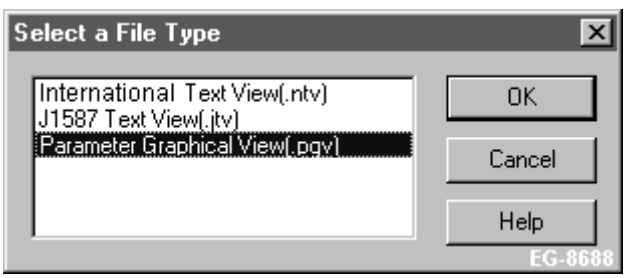

Figure 417

2. Select Parameter Graphical View (.pgv) and click OK.

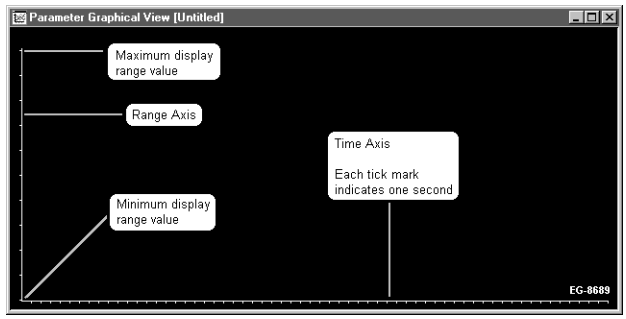

Figure 418

A generic graphical display window will appear. It will not have any parameters in it . It will display the time axis and the range axis.

3. Beginning with Step 3 in the section Text View and Adding Parameter Identifiers (PID), the procedure to add or delete parameters is the same.

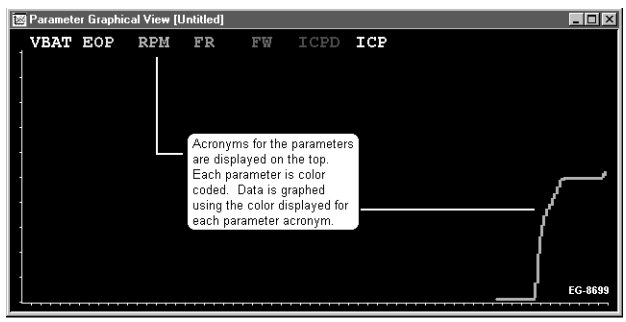

Figure 419

The Graphical View will now display the selected parameters using their acronyms. Master Diagnostics preselects different colors for each parameter in the order they are added to the window.

Use a Text View window to find the full description for these parameters (See Figure 412).

OPENING A SESSION FILE

The session menu allows a previously setup session to be opened. International® has setup several diagnostic sessions. The desktop workspace will have all the needed Text View windows, trouble code windows, ATA bus, etc., already configured for use.

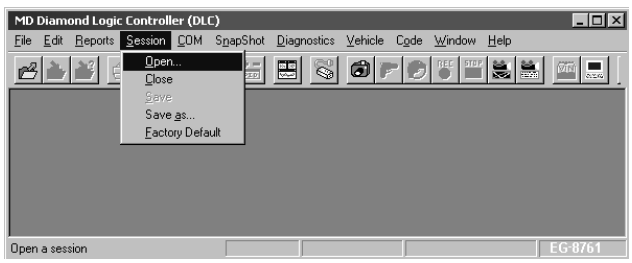

Figure 420

1. Select Session and then Open from the drop down menu bar.

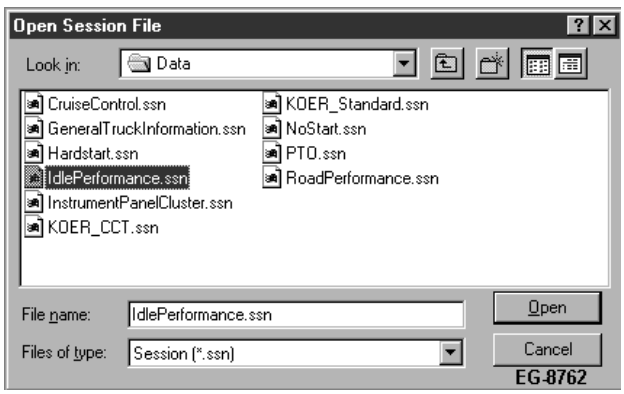

Figure 421

2. The Open Session File dialog box will appear. Click on one of the preconfigured sessions to highlight it, then select Open.

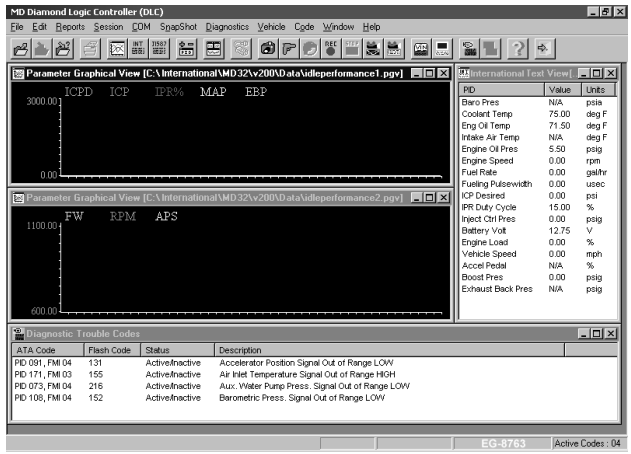

Figure 422

The session will automatically be brought up. These windows are placed in an organized manner.

A session can be set up and saved. See the Master Diagnostics (MD) Software User's Manual for detailed instructions.

DISPLAYING SENSOR VOLTAGES

1. Open session file Continuous Monitor.
2. Select Diagnostic drop down menu.
3. Select Continuous Monitor Test.

DIAGNOSTIC TESTING

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing service bay diagnostics on engine or vehicle.

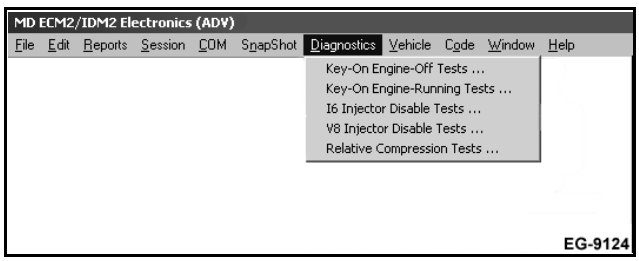

Figure 423

1. Select Diagnostics from the menu bar. These on-demand diagnostic tests may only be invoked by the drop-down menu.

- Key On Engine Off Tests
- Key On Engine Running Tests
- I6 Disable Injector Tests
- V8 Disable Injector Tests
- Relative Compression Tests

NOTE: The example is for the DLCII Master Diagnostics. The 3 box system and DLC offer only the first two options from the list.

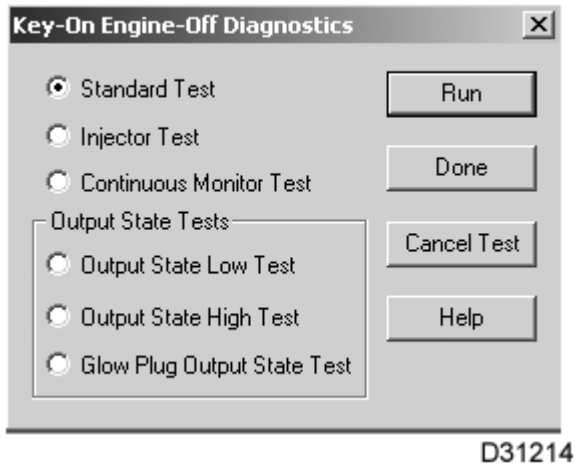

Figure 424

2. After selecting the desired category of tests from the drop-down menu, a dialog box will appear to chose the specific tests to run.

See Section 3 Diagnostic Software Operation as to when to do these tests and how to interpret the results.

The ECM determines whether the requested on-demand diagnostic test can be executed. Master Diagnostics will provide a warning message as to the reason why the ECM did not execute the test. See the Master Diagnostic User's Manual for detailed instructions.

CHECK AND CLEAR DIAGNOSTIC TROUBLE CODES (DTCS)

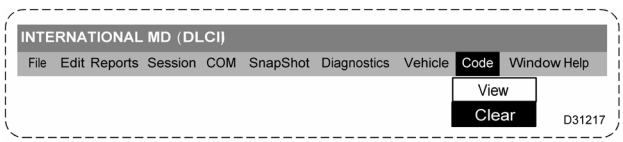

Figure 425

1. Select Code on the menu bar, then the View option.

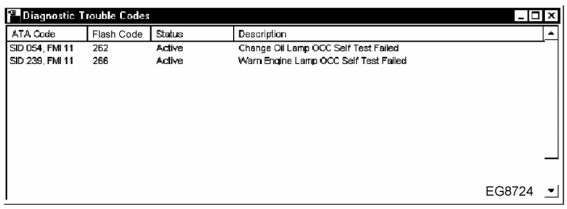

Figure 426

If the ECM has detected any DTCs, they will be displayed automatically. DTCs detected on the current (ignition) Key-ON cycle will be displayed as active. Only DTCs detected on previous key cycles will be displayed as inactive. An up/down scroll bar will automatically appear whenever there are too many codes to be displayed in the window. Slide the scroll bar up or down to view any remaining codes.

2. To learn more about a DTC, double click on any of the parameters listed in the ATA Code column of the DTC window. This will launch Help and display further details associated with a specific DTC. See the topic EST Help.

3. To clear codes, select Code then Clear from the drop-down menu bar.

VIEW ACCUMULATORS (VEHICLE INFORMATION)

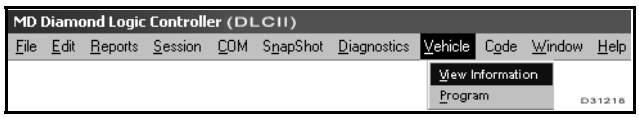

Figure 427

Select Vehicle and then View Information on the menu bar.

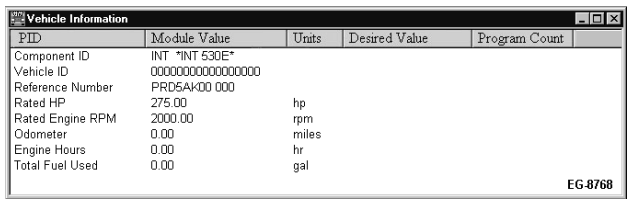

Figure 428

The Vehicle Information will appear.

PROGRAMMABLE PARAMETERS, CHANGE/VIEW

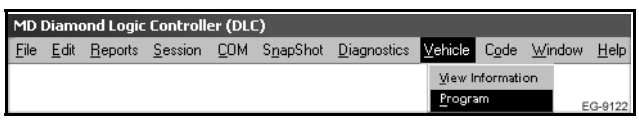

Figure 429

1. Select Vehicle, then Program, from the drop-down menu bar. A generic Vehicle Programming window will appear.

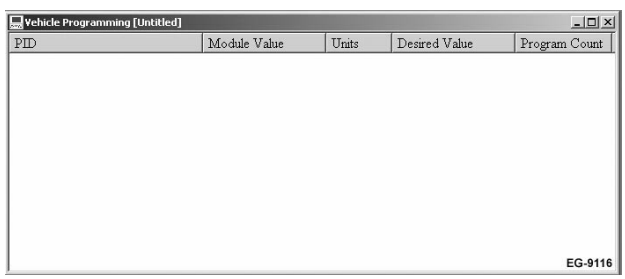

Figure 430

2. Add programmable parameters to this window by selecting Edit from the drop down menu bar and then Add/Delete/Edit Parameters.

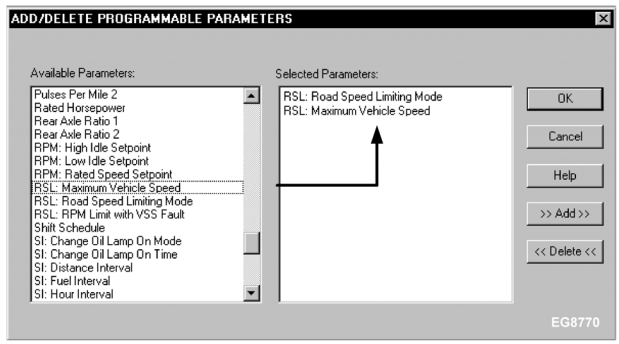

Figure 431

3. Double clicking on a parameter from the Selected Parameters list box will remove it from the Vehicle Programming view window.

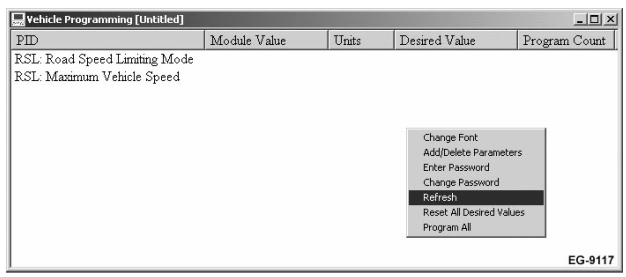

Figure 432

4. Placing the mouse pointer within the Vehicle Programming window and right clicking will bring up the advanced features.

5. Click the advanced features Refresh option.

   The current value information being supplied by the ECM will be displayed to the desired parameters. A password must be entered to modify any parameters.

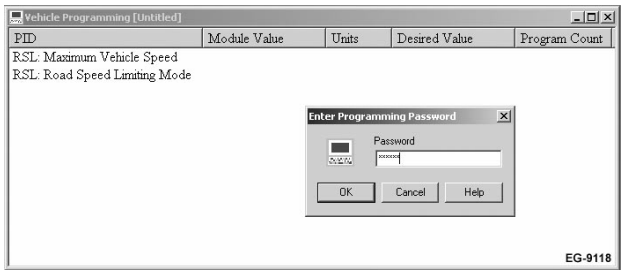

Figure 433

6. Placing the mouse pointer within the Vehicle Programming window and right clicking will bring up the advanced features. Click on the Enter Password option. This allows a password to be entered and retained for use. The password must be between 4 and 8 alphanumeric characters.

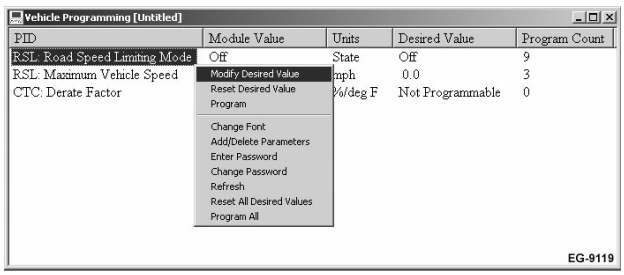

Figure 434

The following screens illustrate the two Edit Parameter displays that normally appear after right clicking on the desired parameter. They differ on what can be changed. All parameters that can be toggled ON / OFF or changed within a numerical range will display — The parameter was programmed successfully — after clicking OK.

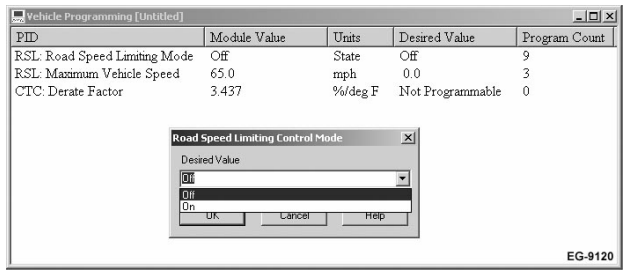

Figure 435

This is an example of a parameter value that can only be turned ON or OFF. After a selection, click OK.

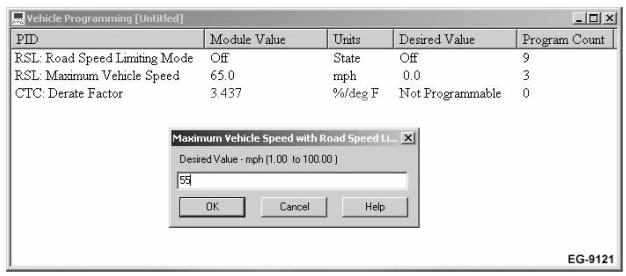

Figure 436

For those parameters that require numeric entries, enter the appropriate value in the New Value box . The value must be within the required range. Click OK when complete.

Depending on the application, some parameters such as Coolant Temperature Compensation (CTC) and Derate Factor can not be changed. These are read only parameters and provide no means for modification.

7. To verify that the parameter was changed, right click to bring up the advanced features. Click the Refresh option. MD will request all the programmable parameter information from the ECM.

SNAPSHOT- RECORD AND REPLAY

Recording a Snapshot

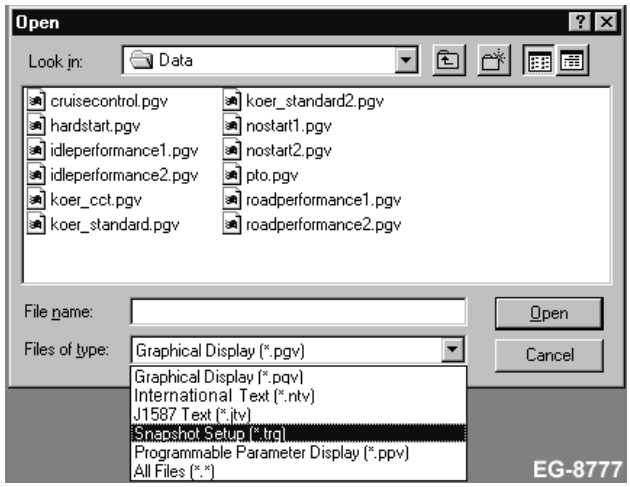

Figure 437

To open an existing snapshot setup, select File from the drop-down menu, then Open. Select the (*.trg) extension in the Files of type box within the Open dialog box, then select the appropriate file from the various list.

Replaying a Snapshot with Graphical Windows

The replay feature will only playback recorded files created by Master Diagnostics software. The replay feature allows two different displays: graphical and text.

Select Snapshot then Replay and finally Graphical.

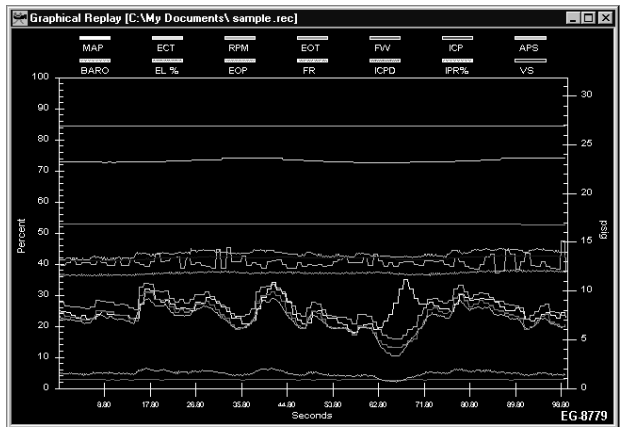

Figure 438 Replaying a Snapshot with Graphical Window

The Open Snap Shot Recording File dialog box will appear. Click on a desired filename, then click Open. The Graphical Replay window opens. To modify this window for viewing data, see the Master Diagnostics (MD) Software User's Manual.

Replaying a Snapshot with Text Windows

Select SnapShot, from the drop down menu bar then Replay and finally Text.

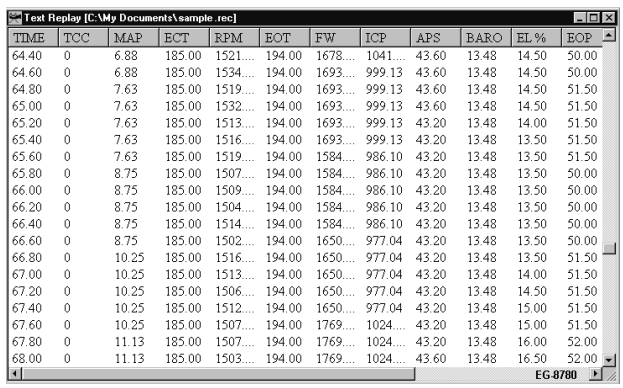

Figure 439 Replaying a Snapshot with Text Window

The Open Snap Shot Recording Filedialog box appears. Click on a filename to select it and then click Open. The Text Replay window opens.

EST HELP

This software release of Master Diagnostics has an extensive set of documentation loaded into the electronic help file. This section describes the organization and the layout of Help file.

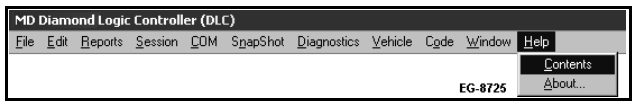

Figure 440

Select Help and then Contents.

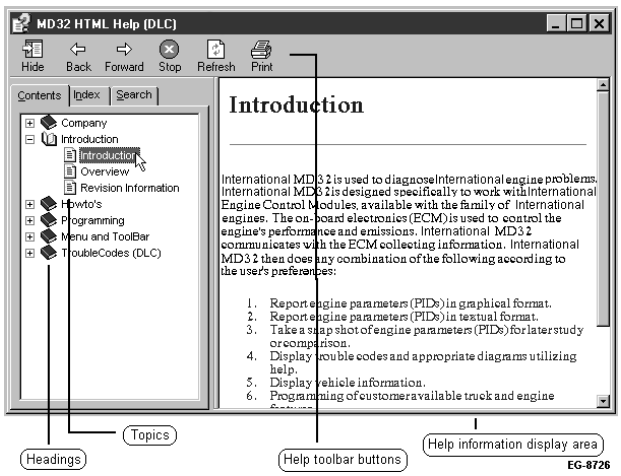

Figure 441

The Help section will appear.

The Help file is arranged under the following headings: Company, Introduction, How to's, Programming, Menus Toolbar, and DTCs.

The Introduction topic contains the software revision information. This topic documents the changes to software releases. Click Revision Information. It will display the software revision contained in this release.

The How to's topic describes the features of this software's usage, access, and examples. Double clicking on the heading labeled How to's will display more help functions.

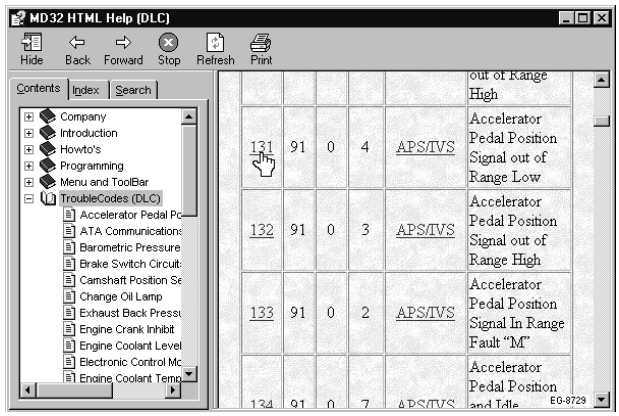

Figure 442

The Trouble Codes (DLCII) topic contains service procedures and technical information on International engines. Placing the pointer over a DTC number or the circuit index causes the pointer to change from the shape of an arrow to the shape of a hand, indicating that these topics are hot linked.

Example: Double clicking on the DTC brings up a detailed description of possible causes. This is normally displayed when double clicking the DTC in the DTC window (See Figure 426).

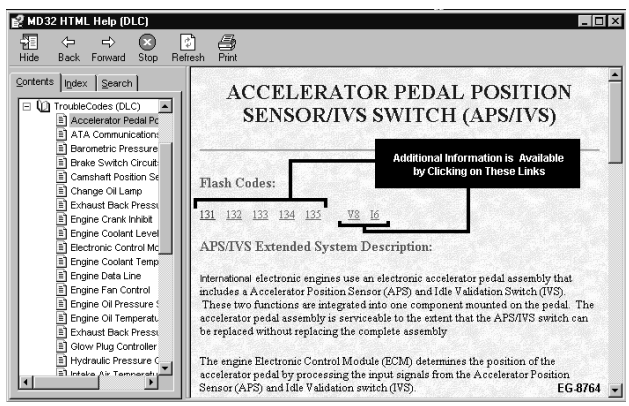

Figure 443

Clicking on a hot link in the circuit index will bring up a detailed description of the circuit involved with this DTC as well as others. The circuit index is also organized under topics corresponding to their related DTCs. Related circuit diagrams can be reviewed by clicking on the appropriate engine family hot link (V-8 or I-6).

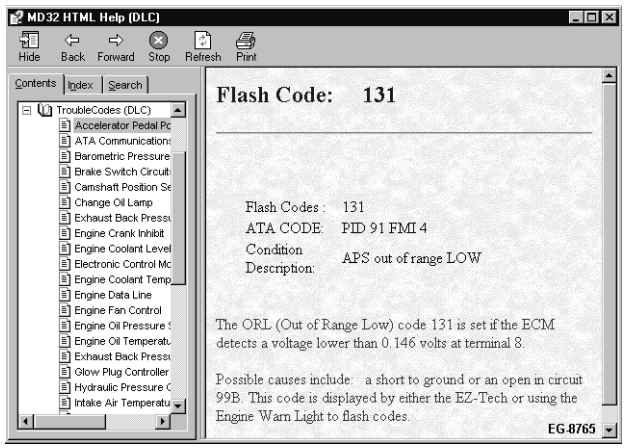

Figure 444

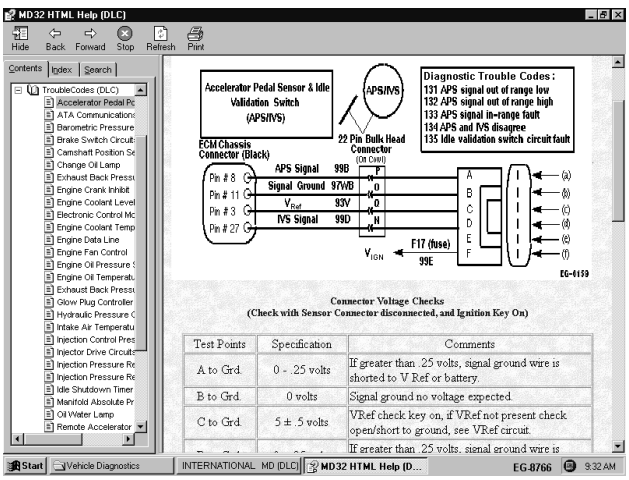

Figure 445

Example: Clicking on DTC 131 brings up a window detailing more information about DTC 131. Clicking on the I-6 hot link opens up an electrical diagram and voltage/resistance checks for harnesses and connectors.

Click on the Index tab. This displays all EST HELP topic indexes. Double clicking on an index item causes the help information to be displayed.

Click on the Search tab. A search with EST HELP is done by using specific words or phrases. The advanced search feature provides conditional searches. Type in the words or phrases in the search box and click on the List Topics button. Select the topic, then click on the Display button to display the help information.

Check the *Master Diagnostic Software User's Manual* for questions and additional information.

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Abbreviations and Acronyms.....433

ABBREVIATIONS AND ACRONYMS

AAT – Ambient Air Temperature
ABDC – After Bottom Dead Center
ABS – Antilock Brake System
AC – Alternating Current
ACCEL – Accelerate
AF – Air to Fuel ratio
AIT – Air Intake Temperature
Amb – Ambient
Amp – Ampere
AMS – Air Management System
API – American Petroleum Institute
APS – Accelerator Position Sensor
ASTM – American Society for Testing and Materials
ATA – American Trucking Association
ATDC – After Top Dead Center
AWG – American Wire Gauge
AWHP – Available Wheel Horsepower

BAP – Barometric Absolute Pressure
Bar – Barometric
BBDC – Before Bottom Dead Center
BDC – Bottom Dead Center
bhp – Brake horsepower
BK – Black (electrical wire color)
BNO – Brake Normally Open
BTDC – Before Top Dead Center
BTU – British Thermal Unit

C – Celsius
CAC – Charge Air Cooler/Cooling
CAN – Controller Area Network
CAN 1 – Controller Area Network (public)
CAN 2 – Controller Area Network (private)
CAP – Cold Ambient Protection
CARB – California Air Resources Board
cc – Cubic centimeter
CCA – Cold Cranking Ampere
CDPF – Catalyzed Diesel Particulate Filter
CG – Center of Gravity
CID – Cubic Inch Displacement
cfm – Cubic feet per minute
cfs – Cubic feet per second
CKP – Crankshaft Position
CLS – Coolant Level Switch
cm – Centimeter
CMP – Camshaft Position
CO – Carbon Monoxide
CTC – Coolant Temperature Compensation

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
DTC – Diagnostic Trouble Code

EBP – Exhaust Back Pressure
EBPD – Exhaust Back Pressure Device
ECI – Engine Crank Inhibit
ECM – Electronic Control Module
ECT – Engine Coolant Temperature
EFRC – Engine Family Rating Code
EG – Ethylene Glycol
EGR – Exhaust Gas Recirculating
EGRP – Exhaust Gas Recirculating Position
EMI – Electromagnetic Interference
EOP – Engine Oil Pressure
EOT – Engine Oil Temperature
EPA – Environmental Protection Agency
EPACT – Energy Policy ACT
EPR – Engine Pressure Regulator
ESC – Electronic System Controller
ESN – Engine Serial Number
EST – Electronic Service Tool
EVRT™ – Electronic Variable Response Turbocharger
EWPS – Engine Warning Protection System

F – Fahrenheit
fhp – Friction horsepower
fpm – Feet per minute
fps – Feet per second
ft – Feet

G – Ground (electrical) or Acceleration of Gravity
gal – Gallon
gal/h – Gallons per hour
gal/min – Gallons per minute
gal/s – Gallons per second
GY – Gray (electrical wire color)
GCW – Gross Combined Weight
gph – Gallons per hour
gpm – Gallons per minute
GVW – Gross Vehicle Weight

H_2O – Water
HC – Hydrocarbons
Hg – Mercury
hp – Horsepower
hr – Hour
Hyd – Hydraulic

IAT – Intake Air Temperature
ICP – Injector Control Pressure
ID – Inside Diameter
IDM – Injector Drive Module
IGN – Ignition
Imep – Indicated mean effective pressure
in – Inch
inHg – Inch of mercury
inH_2O – Inch of water
INJ – Injector drive
IPR – Injection Pressure Regulator
ISIS – International® Service Information System
IVS – Idle Validation Switch

JCT – Junction (electrical)

kg – Kilogram
km – Kilometer
km/h – Kilometer per hour
km/l – Kilometer per liter
KOEO – Key ON Engine OFF
KOER – Key ON Engine RUNNING
kPa – Kilopascal
kW – Kilowatt

L – Liter
L/h – Liters per hour
L/m – Liters per minute
L/s – Liters per second
lb – Pound
lb/s – Pounds per second
lbf – Pounds of force
lbf•ft – Pounds of force per foot
lbf•in – Pounds of force per inch
lbm – Pounds of mass

m – Meter
m/s – Meters per second
Mag – Magnetic
MAP – Manifold Absolute Pressure
MAT – Manifold Absolute Temperature
MD – Master Diagnostics
mep – Mean effective pressure
mi – Mile
mm – Millimeter
mpg – Miles per gallon
mph – Miles per hour

N – Newton
NC – Normally Closed (electrical)
NETS – Navistar Electronics Technical Support
N•m – Newton meter
NO – Normally Open (electrical)
NO – Nitrogen Oxide
NO_x – Nitrogen Oxides

OAT – Organic Acid Technology
OCC – Output Circuit Check
OCP – Overcrank Protection
OD – Outside Diameter
OL – Over Limit
ORB – O-ring Boss
OSHA – Occupational Safety and Hazard Administration
OWL – Oil/Water Light (alarm)

PG – Propylene Glycol
PID – Parameter Identifier
PK – Pink (electrical wire color)
PM – Particulate matter
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

qt – Quart

RAM – Random Access Memory
REPTO – Rear Engine Power TakeOff
rev – Revolution
RFI – Radio Frequency Interference
rpm – Revolutions per minute
RTV – Room Temperature Vulcanized

SAE – Society of Automotive Engineers
SCA – Supplemental Cooling Additive
SCCS – Speed Control Command Switches
SID – Sub-System Identifier
SIG GRD – Signal Ground
SLBOCLE – Scuffing Load Ball On Cylinder Lubricity Evaluator
SI – International System of Units (modern version of metric measuring system)
S/N – Serial Number
SO_2 – Sulfur Dioxide
SW – Switch (electrical)
SYNC – Synchronization

T – Temperature
Ta – Ambient air temperature (also AAT)
Tb – Temperature of water from engine outlet
TACH – Tachometer output signal

TBD – To Be Determined/Defined
TCAPE – Truck Computer Analysis of Performance and Economy
TDC – Top Dead Center
TERM – Terminal (electrical)
TTS – Transmission Tailshaft Speed

UK – United Kingdom
UVC – Under Valve Cover

V – Volt
V_{BAT} – Battery Voltage
V_{IGN} – Ignition Voltage
V_{REF} – Reference Voltage
V_{REF} A – Reference Voltage (engine)
V_{REF} B – Reference Voltage (chassis)
VEPS – Vehicle Electronics Programming System
VGT – Variable Geometry Turbocharger
VIN – Vehicle Identification Number
VOP – Valve Opening Pressure
VRE – Vehicle Retarder Enable
VT – Violet (electrical wire color)

WH – White (electrical wire color)
WIF – Water In Fuel
WTEC – World Transmission Electronically Controlled automatic transmissions (Allison)

XMSN – Transmission

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Terminology.....**439**

TERMINOLOGY

Accelerator Pedal Position Sensor (APS) – A potentiometer sensor that indicates the position of the throttle pedal.

Accessory work – The work per cycle required to drive engine accessories (normally, only those essential to engine operation).

Actuator – A device that performs work in response to an input signal.

Aeration – The entrainment of gas (air or combustion gas) in the coolant or lubricant.

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.

Barometric Absolute Pressure (BAP) sensor – A variable capacitance sensor which, when supplied with a 5 volt reference signal from the ECM, produces a linear analog voltage signal indicating atmospheric pressure.

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.

Camshaft Position (CMP) sensor – A Hall effect sensor indicates engine speed and camshaft position. Speed is indicated by the number of vanes counted per revolution of the camshaft. Camshaft position is indicated by a single narrow vane that indicates cylinder position 1.

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 (autoignites) at high compression temperature.

Diesel fuel with a high cetane number autoignites shortly after injection into the combustion chamber. Therefore, it has a short ignition delay time. Diesel fuel with a low cetane number resists autoignition. 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.

Controller Area Network (CAN) – This is a J1939 high speed communication link. **CAN 1** is a public drive train data link between the vehicle modules and ECM. **CAN 2** is a private link between the ECM and IDM.

Coolant – A fluid used to transport heat from one point to another.

Coolant level switch – A switch sensor used to indicate low coolant level.

Cooling system capacity (volume) – The amount of coolant that completely fills a cooling system to its designated cold level mark. (SAE J1004 SEP81)

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.

Driveline Disengagement Switch (DDS) – A switch that indicates when the driveline is disengaged from 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.

Drivetrain data link (CAN 1) J1939 – The primary communication link for the ECM, ESC, and instrument cluster.

Duty cycle – A control signal that has a controlled on/off time measurement from 0 to 100%. Normally used to control solenoids.

Elastomer – An elastic, rubber-like substance such as natural or synthetic rubber material. (SAE J111 MAR85)

Electronic Control Module (ECM) – An electronic microprocessor that monitors and controls engine performance, exhaust emissions, and vehicle system performance (cruise control, transmission control, starter engagement, etc). The ECM provides diagnostic information for engine and vehicle systems and can be programmed at different levels for engine protection, warning,. and shutdown.

Electronic Service Tool (EST) – A computer diagnostic and programming tool for the ECM and ESC. The hardware is typically a laptop computer or notebook computer. The diagnostic and programming software includes International Master Diagnostics, ISIS on-line documentation, and NETS for factory programming.

Electronic System Controller (ESC) – An electronic module that provides multiple analog and switched input interfaces to monitor vehicle functions through solid state switches, relay driver outputs, and serial data communication.

Electronic Variable Response Turbocharger (EVRT™) – Contains actuated vanes in the turbine housing that modify the flow characteristics of exhaust gases through the turbine housing. The net benefit is the ability to provide the appropriate boost pressure for various engine speeds and load conditions. The EVRT™ lowers emissions and improves fuel economy.

Engine Control Module (ECM) power relay – An ECM controlled relay that supplies power to the ECM.

Engine Coolant Temperature (ECT) sensor – A thermistor sensor that senses engine coolant temperature.

Engine Crank Inhibit (ECI) circuit – The ECM output that controls the ECI relay to control the operation of the starter motor.

Engine Family Rating Code (EFRC) – A readable code in the calibration list of the EST that identifies engine horsepower and emission calibrations.

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 RUNNING tests – Tests done with the engine running.

Engine Oil Pressure (EOP) sensor – A variable capacitance sensor that senses engine oil pressure.

Engine Oil Temperature (EOT) sensor – A thermistor sensor that senses engine oil temperature.

Exhaust brake – A brake device using engine exhaust back pressure as a retarding medium.

Exhaust Gas Recirculation (EGR) cooler – Allows heat to dissipate from the exhaust gases. Exhaust gases remain in the cooler or continue flowing through the system. The flow of exhaust gases through the cooler is regulated by the EGR valve.

Exhaust Gas Recirculation (EGR) valve – Regulates the flow of exhaust gases by varying the open and closed positions of the valve. When the valve is fully closed, exhaust gases remain in the cooler. When the valve is partially or fully open, the exhaust gases continue to flow through a connecting port in the intake manifold.

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 add 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 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 the minimum engine speed. High idle is the maximum governed engine speed at no load.

Idle Validation Switch (IVS) – An On/Off switch that senses when the accelerator pedal is in the idle position.

Injector Driver Module (IDM) power relay – An IDM controlled relay that supplies power to the IDM.

Indicated horsepower – The theoretical power transmitted to the pistons by gas in the cylinders.

Injection Control Pressure (ICP) – High lube oil pressure generated by a high pressure pump/pressure regulator used to hydraulically actuate the fuel injectors.

Injection Pressure Regulator (IPR) – A Pulse Width Modulated (PWM) regulator valve, controlled by the ECM, that regulates injection control pressure.

Injection Control Pressure (ICP) sensor – A variable capacitance sensor that senses injection control pressure.

Intake Air Temperature (IAT) sensor – A thermistor sensor that senses intake air temperature.

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.

Manifold Absolute Pressure (MAP) – Intake air manifold pressure (boost pressure).

Manifold Absolute Pressure (MAP) sensor – A variable capacitance sensor that senses low oil pressure.

Manometer – A double-leg liquid-column gauge, or a single inclined gauge, used to measure the difference between two fluid pressures. Typically, a manometer records in inches of water.

Master Diagnostics (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.

Output State Check (OSC) – An On demand test that forces the processor to activate actuators (High or Low) for additional diagnostics.

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.

Potentiometer – An electro-mechanical device (variable voltage divider) that senses the position of a mechanical component. Mechanical motion connected to the wiper causes it to move along the resistance material in a rotary fashion. The voltage on the wiper changes at each point along the resistance material and is proportional to the amount of mechanical movement. Potentiometers have three connections: V_{REF}, signal out (wiper), and ground.

Power – Power is a measure of the rate at which work is done. See and compare with **Torque**.

Power TakeOff (PTO) – Accessory output, usually from the transmission, used to power a hydraulic pump for a special auxiliary feature (garbage packing, lift equipment, etc).

Pulse Width Modulation (PWM) – 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.

Read Only Memory (ROM) – Computer memory that stores permanent information for calibration tables and operating strategies. Permanently stored Information in ROM cannot be changed or lost by turning the engine off or when ECM power is interrupted.

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.

Sulfur dioxide (SO_2) – Sulfur dioxide is caused by oxidation of sulfur contained in fuel.

Switch sensors – Switch sensors create a digital signal by opening or closing a switch. The on or off signal can indicate position (clutch switch), level (coolant level switch), or pressure (oil pressure switch). A switch sensor normally has two connectors: signal return (grd) and the signal. A switch sensor is usually a low speed digital signal input.

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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175 hp @ 2600 rpm 449

195 hp @ 2600 rpm.....452

215 hp @ 2600 rpm 455

175 HP @ 2600 RPM

Table 87

VT 365/175 hp @ 2600 rpm (460 ft·lbf torque @ 1400 rpm)	
50 state 2002 Model Year (MY)	
Engine unit code 12NPB	
International® VT 365 diesel engine specifications	
Engine model	International® VT 365/175
Engine rating	175 bhp @ 2600 rpm
Engine Family Rating Code (EFRC)	2111
Injector part number, original equipment	1843108C91
Turbocharger part number	1837985C91
Turbine A/R ratio	0.90
Injection timing	Nonadjustable
High idle speed — manual transmission	2950 rpm
High idle speed — automatic transmission	2950 rpm
Low idle speed	700 rpm
Engine cranking	
Minimum battery voltage	9.0V
Minimum cranking rpm	100 rpm
Minimum ICP pressure / voltage	2.5 MPa (365 psi) 0.65V
Minimum oil pressure	34.5 kPa (5 psi)
EGRP starting	0% (0.6-1.2V)
Minimum fuel pressure	206.8 kPa (30 psi)
EGR position	
Closed	0% (0.6-1.2V)
Open	90-100% (4.0-4.52V)
Minimum travel – greater than or equal to % and V	90% and 3.2V

Data taken at low idle, no load, stabilized operating temperature	
Injection Control Pressure/voltage	4.25 ± 0.3 MPa (616 ± 44 psi) 0.93V
Fuel pressure, min.	276 kPa (40 psi)
Exhaust Back Pressure (sensor), max.	30 kPa (4.5 psi)
Oil pressure, min.	69 kPa (10 psi)
Data taken at high idle, no load, stabilized operating temperature	
Air cleaner restriction, max.	3.11 kPa (12.5 in H_2O)
Injection Control Pressure/voltage	11.5 ± 1.0 MPa (1668 ± 150 psi) 2.11V
Fuel pressure, min.	345 kPa (50 psi)
Fuel inlet restriction, max.	20.0 kPa (6 in Hg vacuum)
Exhaust Back Pressure (sensor), max.	121 kPa (17.5 psi)
Oil pressure, min.	276 kPa (40 psi)
Crankcase pressure using restrictor tool ZTSE4510, max.	1.99 kPa (8.0 in H_2O)
Data taken at full load, rated speed on chassis dynamometer or highway, stabilized operating temperature	
Air cleaner restriction, max.	6.22 kPa (25 in H_2O)
Injection Control Pressure/voltage	18.0 ± 1.0 MPa (2611 ± 150 psi) 3.17V
Fuel pressure, min.	345 kPa (50 psi)
Oil pressure, min.	276 kPa (40 psi)
Intake manifold pressure (full load, rated speed)	98.6 ± 10.3 kPa (14.3 ± 1.5 psi) 0.88 ± 0.15V @ 2600 rpm
Intake manifold pressure (full load, peak torque)	82.7 ± 10.3 kPa (12.0 ± 1.5 psi) 0.65 ± 0.15V @ 1400 rpm
Exhaust Back Pressure (sensor), max.	221 kPa (32 psi)
Exhaust back pressure (after turbocharger), max.	16.9 kPa (68 in H_2O) @ 2600 rpm
Data taken after engine reaches stabilized operating temperature	
Torque converter stall (rpm / time)	2000 rpm or greater / 5 sec or less
Lube oil temperature (oil gallery), max.	121°C (250°F)

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 26.7°C (80°F) or above.

Water temperature differential across radiator	2–5°C (6–12°F)

Thermostat specifications	
Type	Balanced pressure, wax pellet
Minimum recommended coolant operating temperature	70°C (158°F)
Start-to-open temperature, 0.38 mm (0.015 in) stroke	87–91°C (188–196°F)
Full-open temperature, 8 mm (0.315 in) stroke	104°C (219°F)

Diesel fuel specifications (max. sulfur content of 0.05%)	
Minimum fuel requirements	45 cetane
Expected temperature	**Preferred fuel grade**
Above -7°C (20°F)	Grade No. 2–D
Below -7°C (20°F)	Grade No. 1–D

NOTE: If grade No. 1–D is not available, use a winterized or climatized Grade No. 2–D fuel. This is made by blending Grade No. 1–D with No. 2–D fuel to match the temperature conditions in your area.

Lubrication specifications	
Oil quality	API category CH-4

NOTE: API is currently reviewing for licensing a new diesel oil category to be designated as CI-4. When CI-4 oil becomes available, it will be the preferred oil for use in all International® engines.

Oil viscosity	15w-40 preferred

195 HP @ 2600 RPM

Table 88

VT 365/195 hp @ 2600 rpm (520 ft·lbf torque @ 1400 rpm)	
50 state 2002 Model Year (MY)	
Engine unit code 12NPC	
International® VT 365 diesel engine specifications	
Engine model	International® VT 365/195
Engine rating	195 bhp @ 2600 rpm
Engine Family Rating Code (EFRC)	2121
Injector part number, original equipment	1843108C91
Turbocharger part number	1837985C91
Turbine A/R ratio	0.90
Injection timing	Nonadjustable
High idle speed — manual transmission	2950 rpm
High idle speed — automatic transmission	2950 rpm
Low idle speed	700 rpm
Engine cranking	
Minimum battery voltage	9.0V
Minimum cranking rpm	100 rpm
Minimum ICP pressure / voltage	2.5 MPa (365 psi) 0.65V
Minimum oil pressure	34.5 kPa (5 psi)
EGRP starting	0% (0.6–1.2V)
Minimum fuel pressure	206.8kPa (30 psi)
EGR position	
Closed	0% (0.6-1.2V)
Open	90-100% (4.0-4.52V)
Minimum travel – greater than or equal to % and V	90% and 3.2V

Data taken at low idle, no load, stabilized operating temperature	
Injection Control Pressure/voltage	4.25 ± 0.3 MPa (616 ± 44 psi) 0.93V
Fuel pressure, min.	276 kPa (40 psi)
Exhaust Back Pressure (sensor), max.	30 kPa (4.5 psi)
Oil pressure, min.	69 kPa (10 psi)
Data taken at high idle, no load, stabilized operating temperature	
Air cleaner restriction (high idle, no load), max.	3.11 kPa (12.5 in H_2O)
Injection Control Pressure/voltage	11.5 ± 1.0 MPa (1668 ± 150 psi) 2.11V
Fuel pressure, min.	345 kPa (50 psi)
Fuel inlet restriction, max.	20 kPa (6 in Hg vacuum)
Exhaust Back Pressure (sensor), max.	121 kPa (17.5 psi)
Oil pressure, min.	276 kPa (40 psi)
Crankcase pressure using restrictor tool ZTSE4510, max.	1.99 kPa (8.0 in H_2O)
Data taken at full load, rated speed on chassis dynamometer or highway, stabilized operating temperature	
Air cleaner restriction (full load, rated speed), max.	6.2 kPa (25 in H_2O)
Injection Control Pressure/voltage	18.0 ± 1.0 MPa (2611 ± 150 psi) 3.17V
Fuel pressure, min.	345 kPa (50 psi)
Oil pressure, min.	276 kPa (40 psi)
Intake manifold pressure (full load, rated speed)	110.3 ± 10.3 kPa (16.0 ± 1.5 psi) 1.05 ± 0.15V @ 2600 rpm
Intake manifold pressure (full load, peak torque)	100 ± 10.3 kPa (14.5 ± 1.5 psi) 0.90 ± 0.15V @ 1400 rpm
Exhaust Back Pressure (sensor), max	221 kPa (32 psi)
Exhaust back pressure (after turbocharger), max.	16.9 kPa (68 in H_2O) @ 2600 rpm
Data taken after engine reaches stabilized operating temperature	
Torque converter stall (rpm / time)	2000 rpm or greater / 5 sec or less
Lube oil temperature (oil gallery), max.	121°C (250°F)

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 26.7°C (80°F) or above	
Water temperature differential across radiator	2–5°C (6–12°F)
Thermostat specifications	
Type	Balanced pressure, wax pellet
Minimum recommended coolant operating temperature	70°C (158°F)
Start-to-open temperature, 0.38 mm (0.015 in) stroke	87–91°C (188–196°F)
Full-open temperature, 8 mm (0.315 in) stroke	104°C (219°F)
Diesel fuel specifications (max. sulfur content of 0.05%)	
Minimum fuel requirements	45 cetane
Expected temperature	**Preferred fuel grade**
Above -7°C (20°F)	Grade No. 2–D
Below -7°C (20°F)	Grade No. 1–D
NOTE: If grade No. 1–D is not available, use a winterized or climatized Grade No. 2–D fuel. This is made by blending Grade No. 1–D with No. 2–D fuel to match the temperature conditions in your area.	
Lubrication specifications	
Oil quality	API category CH-4
NOTE: API is currently reviewing for licensing a new diesel oil category to be designated as CI-4. When CI-4 oil becomes available, it will be the preferred oil for use in all International® engines.	
Oil viscosity	15w-40 preferred

215 HP @ 2600 RPM

Table 89

VT 365/215 hp @ 2600 rpm (540 ft·lbf torque @ 1400 rpm)	
50 state 2002 Model Year (MY)	
Engine unit code 12NPD	
International® VT 365 diesel engine specifications	
Engine model	International® VT 365/215
Engine rating	215 bhp @ 2600 rpm
Engine Family Rating Code (EFRC)	2141
Injector part number, original equipment	1843108C91
Turbocharger part number	1837985C91
Turbine A/R ratio	0.90
Injection timing	Nonadjustable
High Idle Speed — manual transmission	2950 rpm
High idle speed — automatic transmission	2950 rpm
Low idle speed	700 rpm
Engine cranking	
Minimum battery voltage	9.0V
Minimum cranking rpm	100 rpm
Minimum ICP / voltage	2.5 MPa (365 psi) 0.65V
Minimum oil pressure	34.5 kPa (5 psi)
EGRP starting	0% (0.6–1.2V)
Minimum fuel pressure	206.8 kPa (30 psi)
EGR position	
Closed	0% (0.6–1.2V)
Open	90-100% (4.0-4.52V)
Minimum travel – greater than or equal to % and V	90% and 3.2V

Data taken at low idle, no load, stabilized operating temperature	
Injection Control Pressure/voltage	4.25 ± 0.3 MPa (616 ± 44 psi) 0.93V
Fuel pressure, min.	276 kPa (40 psi)
Exhaust Back Pressure (sensor), max.	30 kPa (4.5 psi)
Oil pressure, min.	69 kPa (10 psi)
Data taken at high idle, no load, stabilized operating temperature	
Air cleaner restriction, max.	3.11 kPa (12.5 in H_2O)
Injection Control Pressure/voltage	11.5 ± 1.0 MPa (1668 ± 150 psi) 2.11V
Fuel Pressure, Min.	345 kPa (50 psi)
Fuel inlet restriction, max.	20 kPa (6 in Hg Vacuum)
Exhaust Back Pressure (sensor), max.	121 kPa (17.5 psi)
Oil pressure, min.	276 kPa (40 psi)
Crankcase pressure using restrictor tool ZTSE4510, max.	1.99 kPa (8.0 in H_2O)
Data taken at full load, rated speed on chassis dynamometer or highway, stabilized operating temperature	
Air cleaner restriction, max.	6.2 kPa (25 in H_2O)
Injection Control Pressure/voltage	19.0 ± 1.0 MPa (2765 ± 150 psi) 3.34V
Fuel pressure, min.	345 kPa (50 psi)
Oil pressure, min.	276 kPa (40 psi)
Intake manifold pressure (full load, rated speed)	120.7 ± 10.3 kPa (17.5 ± 1.5 psi) 1.20 ± 0.15V @ 2600 rpm
Intake manifold pressure (full load, peak torque)	107 ± 10.3 kPa (15.5 ± 1.5 psi) 1.00 ± 0.15V @ 1400 rpm
Exhaust Back Pressure (sensor), max.	221 kPa (32 psi)
Exhaust back pressure (after turbocharger), max.	16.9 kPa (68 in H_2O) @ 2600 rpm
Data taken after engine reaches stabilized operating temperature	
Torque converter stall (rpm / time)	2000 rpm or greater / 5 sec or less
Lube oil temperature (oil gallery), max.	121°C (250°F)

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 26.7°C (80°F) or above	
Water temperature differential across radiator	2–5°C (6–12°F)
Thermostat specifications	
Type	Balanced pressure, wax pellet
Minimum recommended coolant operating temperature	70°C (158°F)
Start-to-open temperature, 0.38 mm (0.015 in) stroke	87–91°C (188–196°F)
Full-open temperature, 8 mm (0.315 in) stroke	104°C (219°F)
Diesel fuel specifications (max. sulfur content of 0.05%)	
Minimum fuel requirements	45 cetane
Expected temperature	**Preferred fuel grade**
Above -7°C (20°F)	Grade No. 2–D
Below -7°C (20°F)	Grade No. 1–D
NOTE: If grade No. 1–D is not available, use a winterized or climatized Grade No. 2–D fuel. This is made by blending Grade No. 1–D with No. 2–D fuel to match the temperature conditions in your area.	
Lubrication specifications	
Oil quality	API category CH-4
NOTE: API is currently reviewing for licensing a new diesel oil category to be designated as CI-4. When CI-4 oil becomes available, it will be the preferred oil for use in all International® engines.	
Oil viscosity	15w-40 preferred

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DIAGNOSTIC TROUBLE CODE INDEX

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DTC	PID	SID	FMI	SEC. 7 PAGE NO.	CIRCUIT	CONDITION DESCRIPTION
*Indicates amber ENGINE lamp on when a Diagnostic Trouble Code(DTC) is set.						
** Indicates red ENGINE lamp on if the Engine Warning Protection System (EWPS) is enabled and a DTC is set.						
✓ See chassis circuit diagrams and *Engine Diagnostics Manual* for more information						
111				page 267	ECM	No errors detected - flash code only
112✓	168	0	3	page 258	ECM PWR	Electrical system voltage B+ out of range high
113✓	168	0	4	page 258	ECM PWR	Electrical system voltage B+ out of range low
114*	110	0	4	page 280	ECT	Engine Coolant Temperature signal out of range low
115*	110	0	3	page 280	ECT	Engine Coolant Temperature signal out of range high
121*	102	0	3	page 367	MAP	Intake Manifold Absolute Pressure signal out of range high
122*	102	0	4	page 367	MAP	Intake Manifold Absolute Pressure signal out of range low
123*	102	0	2	page 367	MAP	Intake Manifold Absolute Pressure signal in range fault
124*	164	0	4	page 329	ICP	Injection Control Pressure signal out of range low
125*	164	0	3		ICP	Injection Control Pressure signal out of range high
131*✓	91	0	4	page 220	APS/IVS	APS signal out of range low
132*✓	91	0	3	page 220	APS/IVS	APS signal out of range high
133*✓	91	0	2	page 220	APS/IVS	APS signal in range DTC
134*✓	91	0	7	page 221	APS/IVS	APS signal and IVS disagree
135*✓	0	230	11	page 221	APS/IVS	Idle Validation Switch circuit fault
141✓	84	0	4	page 392	VSS	Vehicle Speed Sensor signal out of range low
142✓	84	0	3	page 392	VSS	Vehicle Speed Sensor signal out of range high
143	0	21	2	page 246	CMP	Incorrect CMP signal signature
145	0	21	12	page 246	CMP	CMP signal inactive
146	0	64	12	page 253	CKP	CKP signal inactive
147	0	64	2	page 253	CKP	Incorrect CKP signal signature
151*✓	108	0	3	page 240	BAP	Barometric Absolute Pressure signal out of range high

152*✓	108	0	4	page 240	BAP	Barometric Absolute Pressure signal out of range low
154	171	0	4	page 361	IAT	Inlet Air temperature signal out of range low
155	171	0	3	page 361	IAT	Inlet Air temperature signal out of range high
161*	105	0	4	page 375	MAT	Manifold Air Temperature Signal out of range low
162*	105	0	3	page 375	MAT	Manifold Air Temperature Signal out of range high
163*	27	0	4	page 317	EGR	Exhaust Gas Recirculation Valve Position Signal out of range low
164*	27	0	3	page 318	EGR	Exhaust Gas Recirculation Valve Position Signal out of range high
211*	100	0	4	page 295	EOP	Engine Oil Pressure signal out of range low
212*	100	0	3	page 295	EOP	Engine Oil Pressure signal out of range high
215✓	84	0	8	page 392	VSS	Vehicle Speed Sensor signal frequency out of range high
225	100	0	0	page 295	EOP	EOP sensor signal in range fault
231✓	0	250	2	page 235	ATA	ATA data communication link error
236✓	111	0	2	page 276	ECL	ECL switch circuit fault
241✓	0	42	11	page 357	IPR	Injection Control Pressure regulator OCC self test failed
246✓	0	56	11	page 291	EFAN	Engine Fan - OCC self test fault
251✓	0	38	11	page 324	GPC	Glow Plug Control OCC self test failed
256✓	0	55	11		RSE	Radiator Shutter Enable OCC fault
261✓	0	27	11	page 389	VGT	Variable Geometry Turbo control OCC self test failed
264✓	27	0	11	page 318	EGR	Exhaust Gas Recirculation OCC self test failed
267✓	0	39	11	page 288	ECI	Engine Crank Inhibit OCC self test failed
311*	175	0	4	page 301	EOT	Engine Oil Temperature signal out of range low
312*	175	0	3	page 301	EOT	Engine Oil Temperature signal out of range high
313	100	0	1	page 307	EWPS**	Engine Oil Pressure below warning level
314	100	0	7	page 308	EWPS**	Engine Oil Pressure below critical level
315*	190	0	0	page 308	EWPS	Engine speed above warning level
316	110	0	1	page 307	EWPS	Engine Coolant Temperature unable to reach commanded set point
321	110	0	0	page 307	EWPS**	Engine Coolant Temperature above warning level
322	110	0	7	page 307	EWPS**	Engine Coolant Temperature above critical level

323	111	0	1	page 306	EWPS**	Engine Coolant Level below warning/critical level
324	71	0	14	page 327	IST**	Idle Shutdown Timer enabled engine shutdown
325	110	0	14	page 307	EWPS	Power reduced, matched to cooling system performance
331*	164	0	0	page 337	ICP sys	Injection Control Pressure above system working range
332*	164	0	13	page 330	ICP	Injection Control Pressure above spec. with engine not running
333*	164	0	10	page 338	ICP sys	Injection Control Pressure above/below desired level
334	164	0	7	page 339	ICP sys	ICP unable to achieve setpoint in time (poor performance)
335	164	0	1	page 340	ICP sys	ICP unable to build pressure during cranking
341*	0	34	4	page 310	EBP	Exhaust Back Pressure signal out of range low
342*	0	34	3	page 310	EBP	Exhaust Back Pressure signal out of range high
343*	0	34	0	page 228	AMS	Excessive exhaust back pressure (gauge)
344*	0	34	13	page 310	EBP	Exhaust back pressure above spec. when engine off
345	0	27	2	page 229	AMS	Faults detected during VGT portion of the AMS Test
346	27	0	2	page 229	AMS	Faults detected during EGR portion of the AMS Test
351	0	34	7	page 230	AMS	Change in exhaust back pressure did not occur when expected
353	0	27	5	page 230	AMS	Variable Geometry Turbo control over duty cycle
354	0	27	6	page 231	AMS	Variable Geometry Turbo control under duty cycle
355	103	0	0	page 231	AMS	Variable Geometry Turbo overspeed
361	0	27	10	page 232	AMS	VGT control input (MAP/EBP) above/below desired level
365*	27	0	10	page 232	AMS	EGR Valve Position above/below desired level
366*	27	0	8	page 233	AMS	EGR valve operating outside of the expected range
367*	27	0	0	page 233	AMS	Incorrect position signal when EGR valve is expected closed
421-428	0	1-8	5	page 342	INJ	High side to low side open (cylinder number indicated)
431-438	0	1-8	4	page 342	INJ	High side shorted to low side (cylinder number indicated)

451-458	0	1-8	6	page 342	INJ	High side short to ground or V_{BAT} (cylinder number indicated)
523✓	0	233	4	page 348	IDM	IDM V_{IGN} voltage low
525*	0	254	6	page 348	IDM	IDM fault
533✓	0	221	3	page 348	IDM	IDM relay voltage high
534✓	0	221	4	page 349	IDM	IDM relay voltage low
543*	0	155	7	page 270	ECM/IDM	ECM/IDM communications fault
551	0	22	12	page 270	ECM/IDM	IDM/CMPO signal inactive
552	0	22	2	page 271	ECM/IDM	IDM incorrect CMPO signal signature
553	0	22	11	page 271	ECM/IDM	IDM CKPO signal inactive
554	0	22	8	page 271	ECM/IDM	IDM incorrect CKPO signal signature
571-578*	0	1–8	5	page 256	CYL BAL	Cylinder Balance limit exceeded
613*	0	252	1	page 267	ECM	ECM/IDM software not compatible
614*	0	252	13	page 267	ECM	EFRC/ECM configuration mismatch
621*	0	253	1	page 267	ECM	Engine using mfg. default rating
622*	0	253	0	page 267	ECM	Engine using field default rating
623*	0	253	13	page 267	ECM	Invalid Engine Family Rating Code (EFRC)
624	0	240	14	page 268	ECM	Field default active
626✓	0	254	8	page 259	ECM PWR	Unexpected reset fault
631	0	240	2	page 268	ECM	Read Only Memory (ROM) self test fault
632	0	254	12	page 268	ECM	Random Access Memory (RAM) - CPU self test fault
655	0	240	13	page 268	ECM	Programmable parameter list level incompatible
661	0	240	11	page 268	ECM	RAM programmable parameter list corrupt
664	0	253	14	page 268	ECM	Calibration level incompatible
665	0	252	14	page 268	ECM	Programmable parameter memory content corrupt

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DESCRIPTION

Technical Service Information (TSI) letters are periodically published to inform service technicians of product enhancements and field service issues. File TSIs in this section for supplemental reference.

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