DIAGNOSTIC/TROUBLESHOOTING MANUAL

International® MaxxForce® 7

DIESEL ENGINE

2007 through 2009 Model Years

EGES-350-2

Printed in the United States of America

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Foreword

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

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

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

International® MaxxForce® 7 Series Service Literature

Number*	Description
EGES-345	International® MaxxForce® 7 *Engine Service Manual*
EGES-350-1	International® MaxxForce® 7 *Diagnostics Manual*
1171941R3	International® MaxxForce® 7 *Operation and Maintenance Manual*
EGED-365	International® MaxxForce® 7 Electronic Control Systems Form
EGED-355-1	International® MaxxForce® 7 Diagnostic Form

* - Publication with the latest revision will be furnished.

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

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

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

Service Diagnosis

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

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

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

Prerequisites for Effective Diagnosis

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

Technical Service Literature required for Effective Diagnosis

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

Safety Information

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

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

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

Safety Terminology

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

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

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

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

Safety Instructions

Work Area

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

Safety Equipment

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

Protective Measures

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

Vehicle

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

Engine

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

Fire Prevention

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

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

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

Batteries

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

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

Compressed Air

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

Tools

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

Fluids Under Pressure

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

Fuel

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

Removal of Tools, Parts, and Equipment

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

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Engine Identification

Engine Serial Number

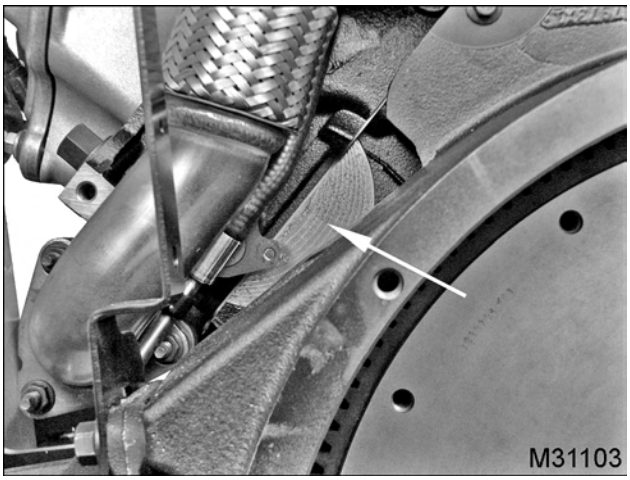


Figure 1 Engine serial number

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

Engine Serial Number Example

6.4HM2YXXXXXXX

6.4 – Engine displacement (liters)
H – Diesel, turbocharged, air intercooled and electronically controlled
M2 – Motor truck
Y – United States, Huntsville
7 digit suffix – Sequence number

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

The U.S. Environmental Protection Agency (EPA) exhaust emission label is on top of the rear of the right valve cover, under the EBP sensor mounting bracket. The label includes the following:

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

Engine Accessories

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

- Air compressor
- Air conditioning compressor
- Alternator
- Cooling fan clutch
- Power steering pump
- Starter motor
- Variable Geometry Turbocharger (VGT)

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

Engine Description

International® MaxxForce® 7 Features and Specifications

Engine configuration	4 stroke, V8 diesel
Displacement	6.4 liters (389 in^3)
Bore (sleeve diameter)	98.2 mm (3.87 in.)
Stroke	105 mm (4.134 in.)
Compression ratio	17.5:1
Aspiration	Variable Geometry Turbocharger (VGT) and Charge Air Cooled (CAC)
Rated power @ rpm	230 hp @ 2300 rpm[1]
Peak torque @ rpm	620 ft·lbs @ 1500 rpm[1]
Engine rotation (facing flywheel)	Counterclockwise
Combustion system	Direct injection, turbocharged
Fuel system	Direct injection common rail
Cooling system capacity (engine only)	10.23 liters (10.8 quarts US)
Lube system capacity (including filter)	17 liters (18 quarts US)
Lube system capacity (overhaul only, with filter)	18.9 liters (19 quarts US)
Firing order	1-2-7-3-4-5-6-8

[1] Initial rating at the time of manual printing, ratings are subject to change for various application. See EPA emission label for the exact rating for a particular engine.

Standard Features

The International® MaxxForce® 7 is a V8 engine with a displacement of 6.4 liters (389 cubic inches).

The electronic governor controls the engine's rpm within a safe and stable operating range for ideal performance. Low idle governor prevents the engine rpm from dropping below a stable speed to prevent stalling when various loads are demanded on the engine. High idle governor prevents the engine rpm from going above a safe speed that would cause internal damage to the engine.

The cylinder heads have four valves per cylinder. Each fuel injector is centrally located between the four valves and directs fuel over the piston bowl for improved performance and reduced emissions.

The camshaft is supported by four bushings pressed into the crankcase. The camshaft is crankshaft driven and thrust is controlled by a plate mounted behind the fourth cam journal.

The overhead valve train includes hydraulic roller cam followers, push rods, rocker arms, and valve bridges to open the dual intake and exhaust valves.

The crankcase is comprised of two major matching components. The upper crankcase half houses the cylinders, main bearing saddles, with oil and coolant passages either cast or machined. The lower crankcase consists of a structural plate with the main bearing caps machined into it for improved load retention and alignment.

The crankshaft is supported by five main bearings with fore and aft thrust controlled at the upper half of the second main bearing. Two connecting rods are attached to each crankshaft rod journal and are offset to minimize vibration. Piston pins are free floating, allowing the pins free lateral movement within the connecting rod as well as the piston. Piston pins are held in place with retaining rings.

One piece aluminum-alloy pistons are fitted with one keystone ring, one rectangular intermediate compression ring, and a two piece oil control ring. The combustion bowl is located in the piston crown to reduce emissions. All pistons are mated to fractured cap joint connecting rods.

The Crankshaft Position (CKP) sensor and Camshaft Position (CMP) sensor are used by the Electronic Control Module (ECM) to calculate rpm, fuel timing, fuel quantity, and duration of fuel injection.

The Exhaust Gas Recirculating (EGR) system includes an EGR valve and an intake throttle valve. The EGR valve is mounted in an EGR mixer elbow that is part of the EGR valve elbow housing. The intake throttle valve is mounted on the other side of the EGR valve elbow housing in the air stream from the CAC.

A gerotor lube oil pump is mounted in the front cover and is driven by the crankshaft. Pressurized oil is supplied to engine components. All MaxxForce® 7 engines use an engine oil cooler and engine oil filter.

A closed crankcase breather system draws crankcase vapors through a breather element. The breather element removes oil from the vapor and sends the vapor to the air intake and returns the oil to the crankcase.

The low-pressure fuel pump draws fuel from the fuel tank(s) through the primary fuel filter. The primary fuel filter assembly includes a Water in Fuel (WIF) sensor and an optional fuel heater. Water and solids are separated from the fuel and the water is collected in the water separator bowl. The instrument panel WIF lamp is illuminated when water needs to be drained. A drain valve in the water separator bowl drains water out. Fuel is discharged to the secondary fuel filter. The secondary fuel filter assembly is pressure regulated and incorporates an air bleed orifice allowing air to be automatically purged if it has been introduced to the system.

The high-pressure fuel system includes a High-pressure Fuel Pump (HPFP), high-pressure common rails, and fuel injectors. The ECM electronically controls the injectors allowing multiple injections and more precise fuel delivery to improve combustion, emissions, and cold start performance.

A hand operated primer pump is mounted on the right valve cover. The manual priming pump draws fuel from the fuel tank(s) through the primary filter after filter replacement or when system has run out of fuel. This primes the fuel system to minimize the amount of air injected into the system on initial startup.

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

The Exhaust Gas Recirculating (EGR) system circulates cooled exhaust into the intake air stream

in the intake manifold. This cools the combustion process and reduces the formation of NO_X engine emissions.

Diamond Logic® engine control is a single electronic control unit that monitors and controls the engine and chassis components.

The glow plug relay controls the eight glow plugs, one for each cylinder. The glow plugs warm the cylinders during start-up.

Optional Features

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

A coolant heater is available to raise the temperature of the coolant surrounding the cylinders for improved performance during cold weather startups.

A fuel heater is available to warm the supply fuel in the primary fuel filter. Warmed supply fuel prevents waxing, and improves performance and fuel economy during cold weather start-up.

Chassis Mounted Features

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

The Aftertreatment System processes engine exhaust so that it meets emissions requirements at the tailpipe.

- The oxidation catalyst burns oxygen and hydrocarbons in the exhaust stream.
- The DPF captures and burns particulates in the exhaust stream.

Engine Component Locations

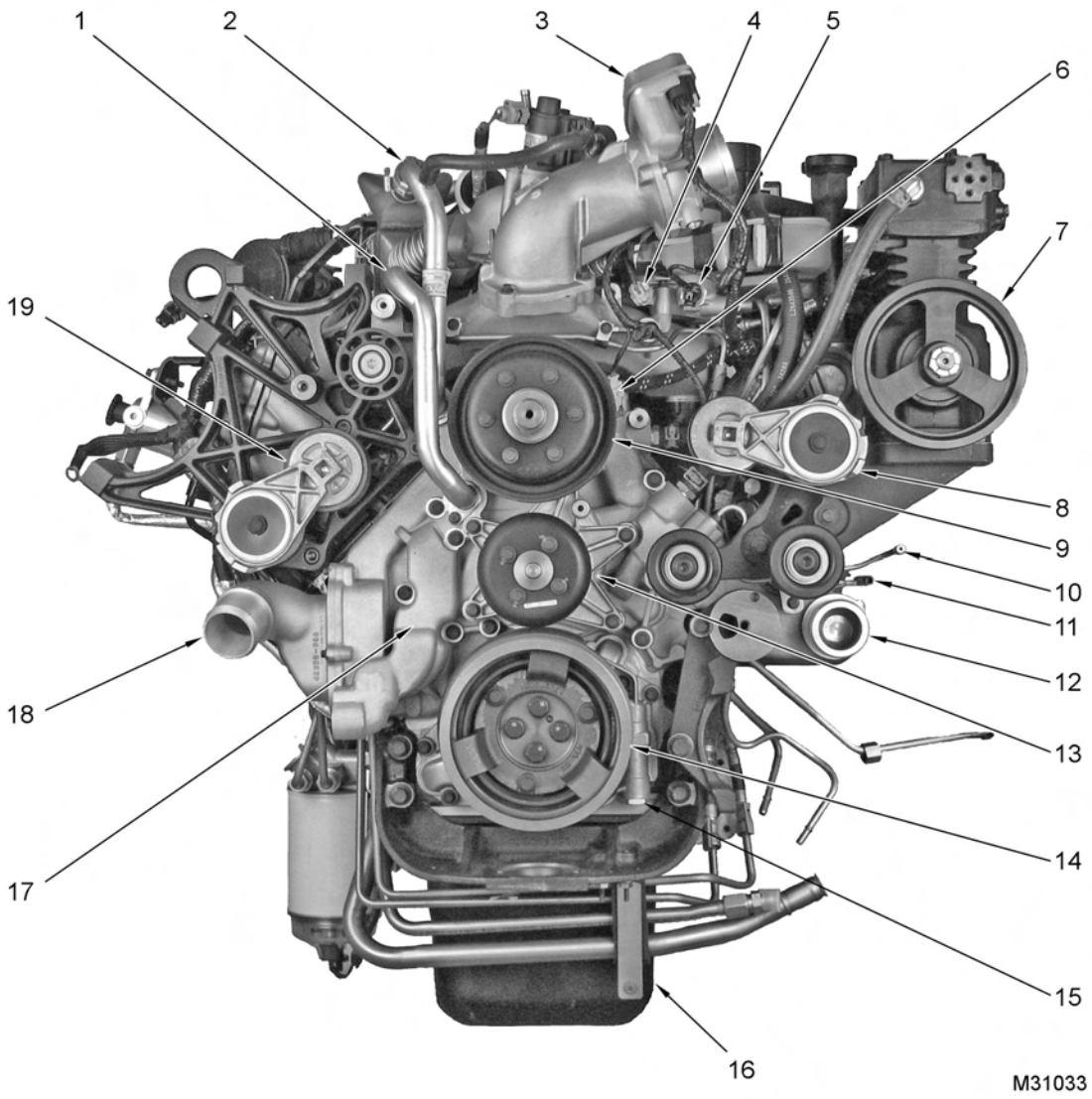


Figure 3 Front

1. EGR coolant supply tube (cooler)
2. EGR coolant return tube (cooler)
3. Intake throttle housing assembly (ITV)
4. Engine Fuel Temperature (EFT) sensor
5. Engine Fuel Pressure (EFP) sensor
6. Engine Coolant Temperature (ECT) sensor
7. Air compressor pulley
8. Air compressor belt tensioner
9. Fan pulley
10. Coolant to secondary radiator
11. Coolant to fuel cooler
12. Coolant inlet
13. Water pump pulley
14. Vibration damper/engine oil pump
15. Oil pressure regulator
16. Lower oil pan
17. Front crankcase cover
18. Thermostat housing (coolant outlet)
19. Belt tensioner

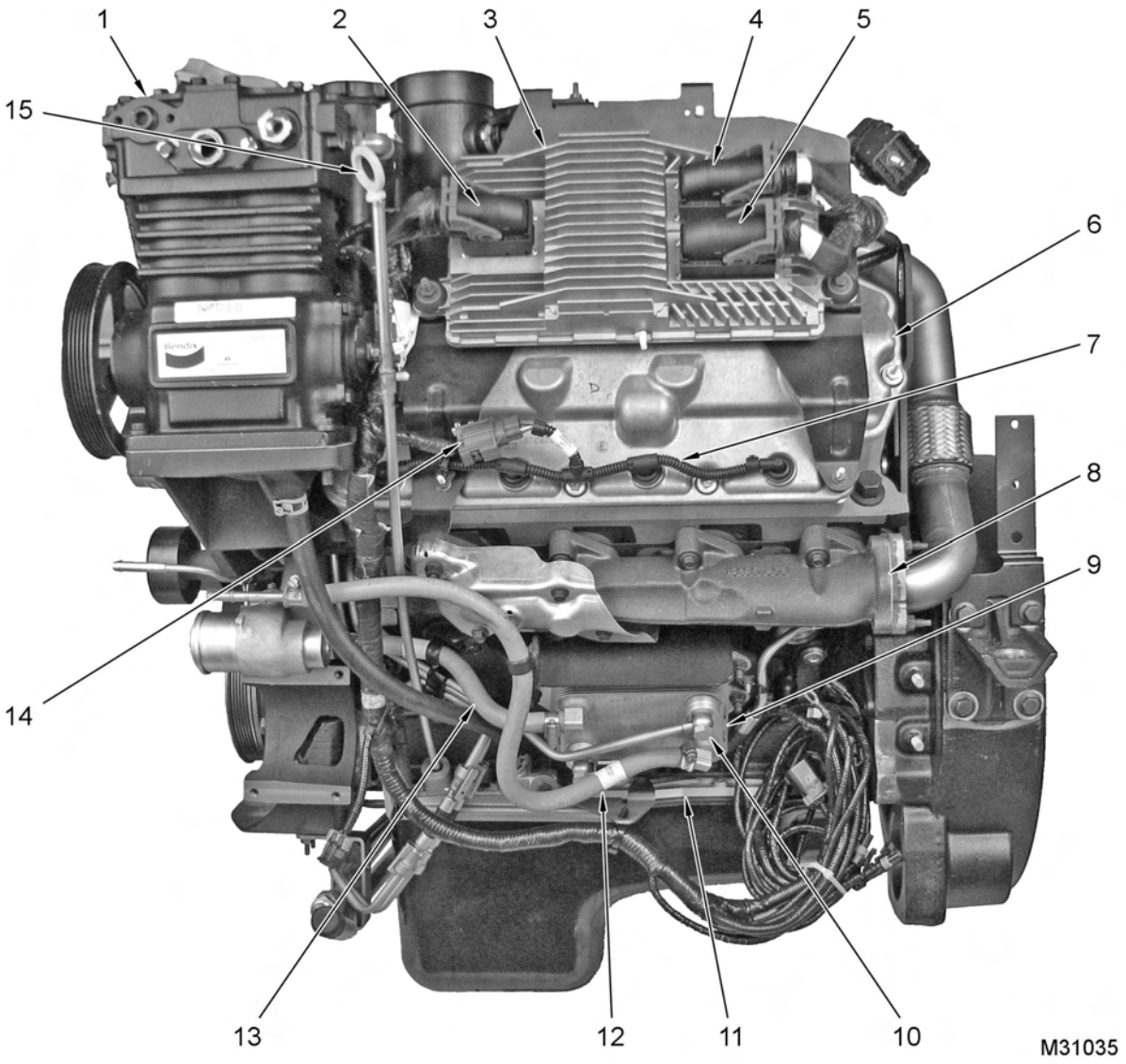


Figure 4 Left

1. Air compressor
2. Injector harness
3. Electronic Control Module (ECM)
4. Engine 76-pin harness
5. Vehicle 76-pin harness
6. Valve cover (left)
7. Glow plug harness assembly (left)
8. Exhaust manifold (left)
9. Fuel cooler assembly
10. Fuel cooler to filter tube assembly (secondary fuel filter)
11. Upper oil pan
12. Coolant-in hose (Coolant supply to fuel cooler)
13. Coolant-out from fuel cooler hose
14. Glow plug harness assembly connector (left)
15. Oil level gauge tube assembly

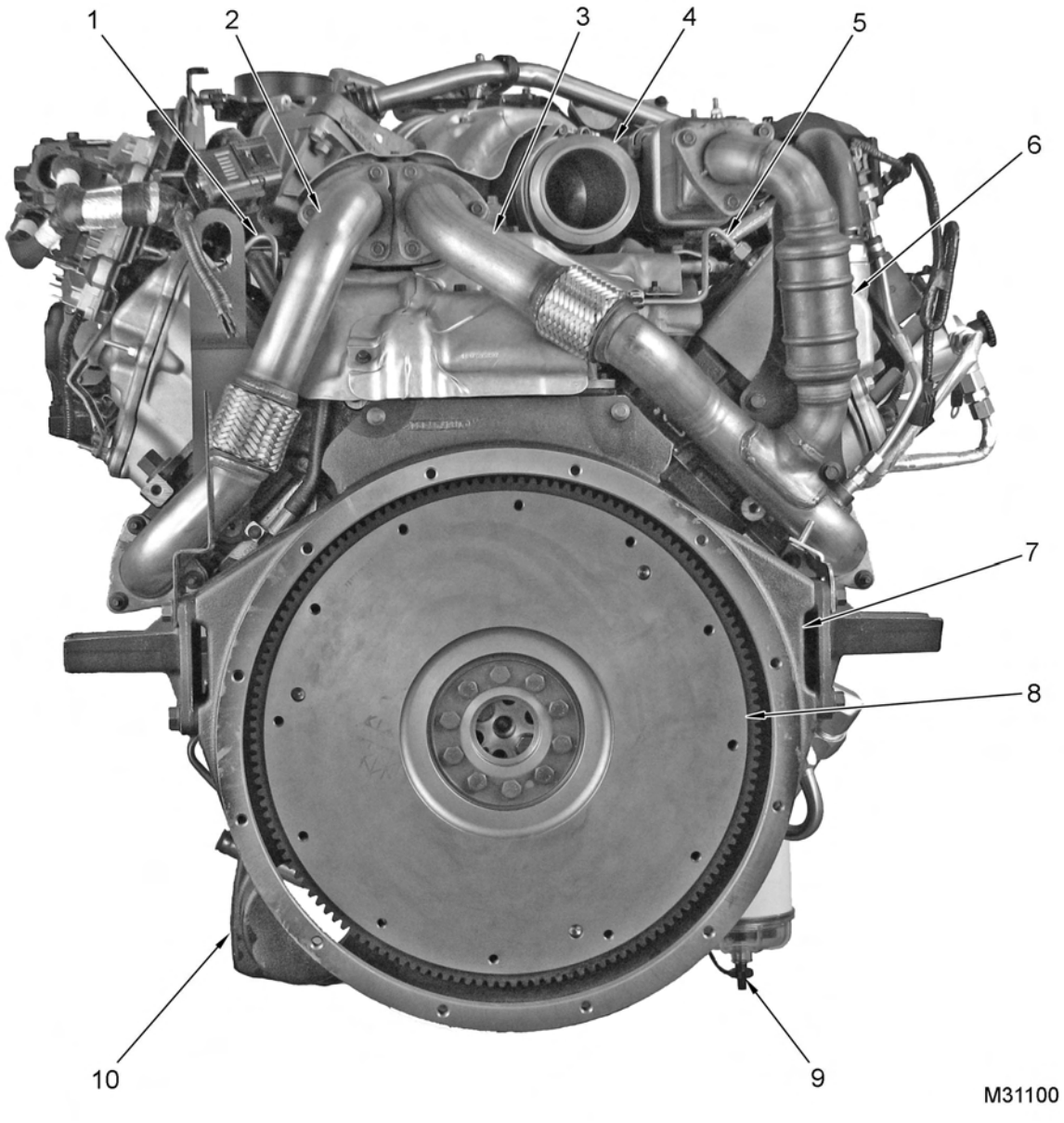


Figure 5 Rear

1. Pump left tube assembly (high-pressure fuel to left fuel rail)
2. Left exhaust tube assembly
3. Right exhaust tube assembly
4. Exhaust outlet
5. Pump right tube assembly (high-pressure fuel to right fuel rail)
6. EGR cooler Diesel Oxidation Catalyst (DOC)
7. Crankcase rear cover
8. Flywheel assembly
9. Fuel drain valve (water and sediment drain for fuel filter)
10. Starter mount (rear cover)

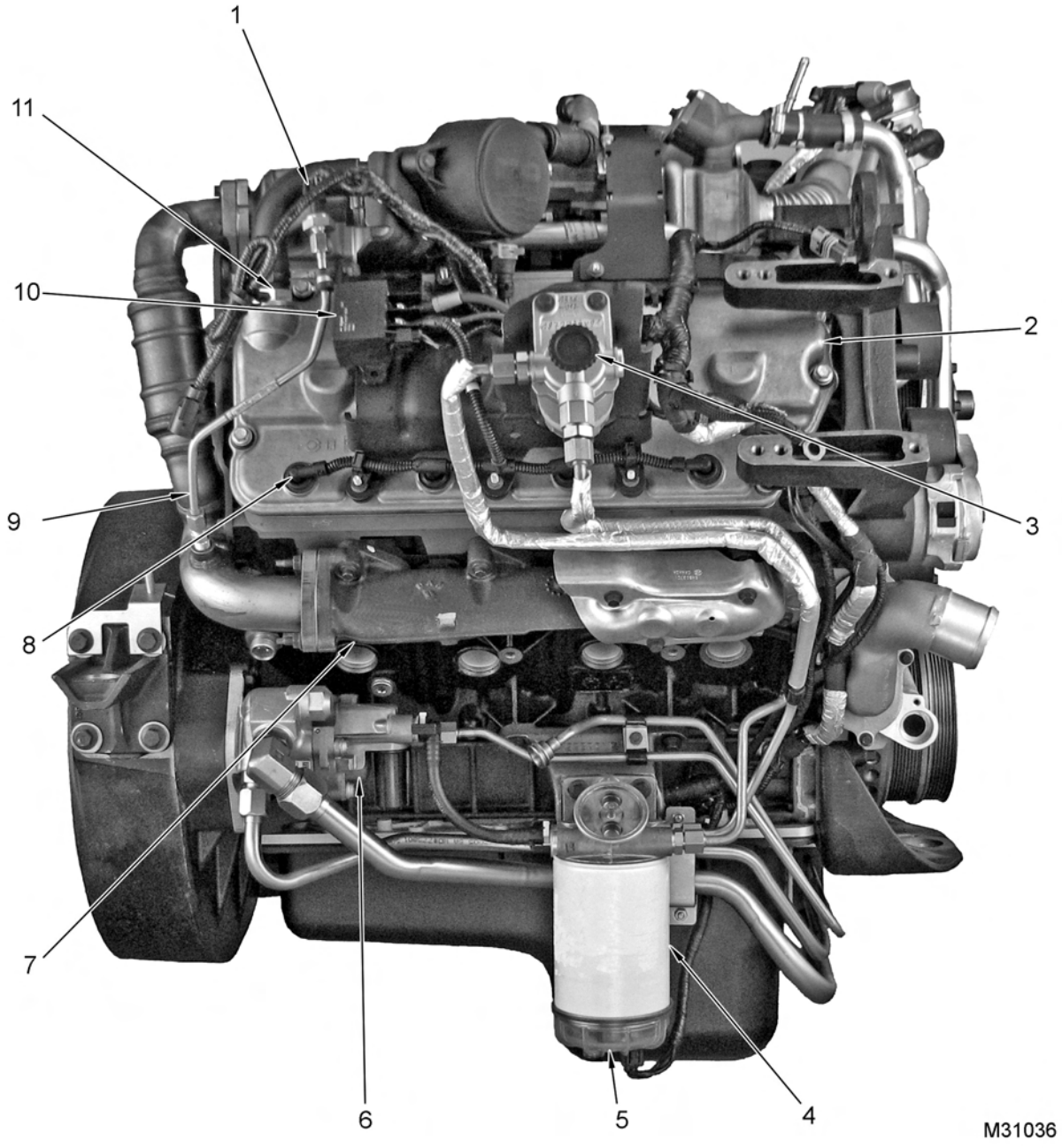


Figure 6 Right

1. Exhaust Back Pressure (EBP) sensor
2. Valve cover (right)
3. Fuel primer pump assembly
4. Primary fuel filter assembly
5. Bowl assembly with fuel heater/probe
6. Fuel Restriction Test Cap
7. Gear driven fuel pump assembly (low-pressure fuel pump)
8. Exhaust manifold (right)
9. Glow plug harness assembly (right)
10. EBP tube
11. Glow plug relay
12. Breather inlet adapter (crankcase vent)

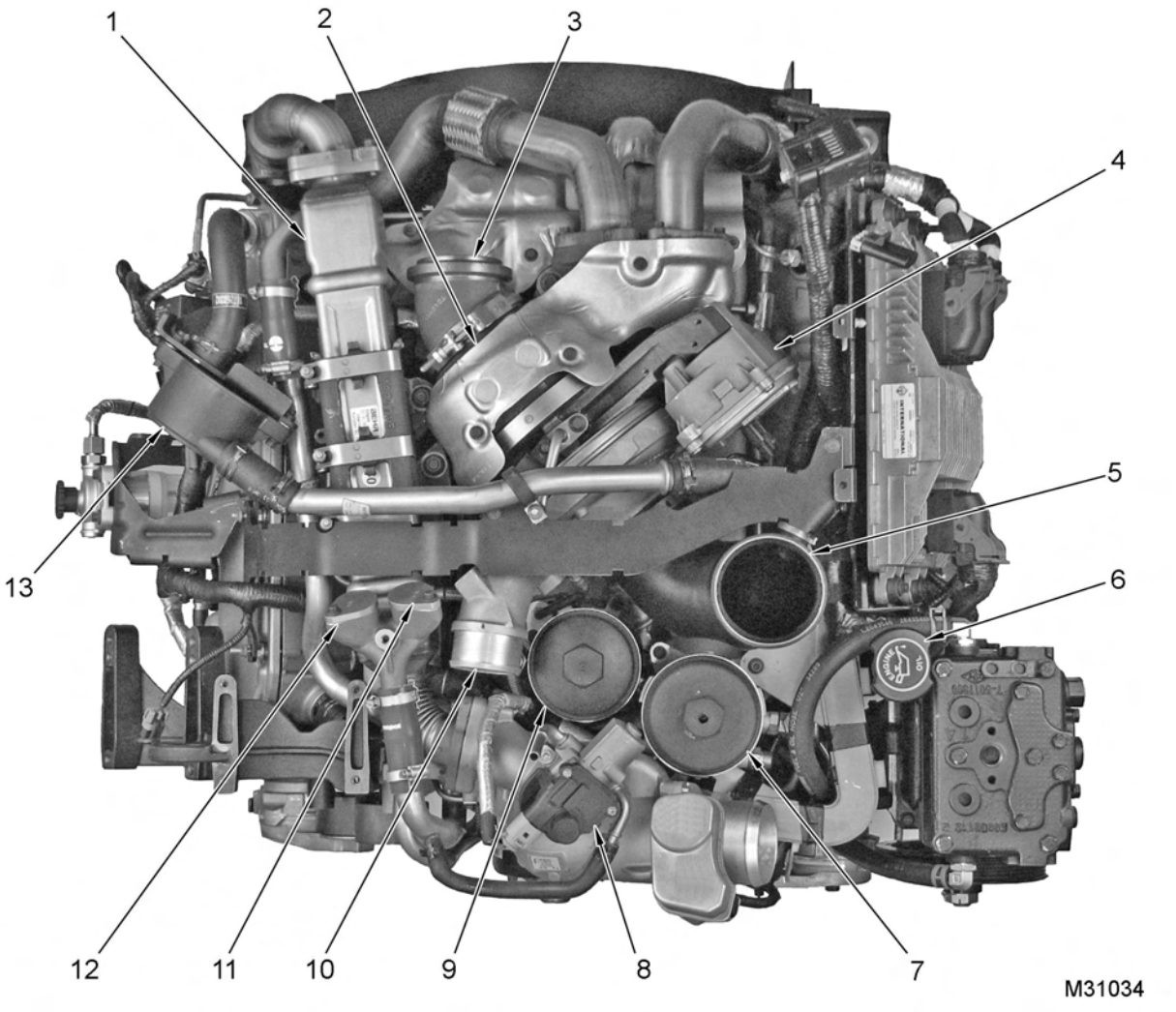


Figure 7 Top

1. Exhaust Gas Recirculating (EGR) cooler
2. Turbocharger assembly
3. Exhaust outlet (Turbocharger)
4. VGT actuator
5. Turbocharger air inlet duct
6. Oil fill cap
7. Secondary fuel filter assembly
8. EGR valve assembly
9. Oil filter
10. Turbocharger air outlet
11. Coolant to chassis heater
12. Coolant to chassis heater (dual for bus applications)
13. Breather assembly (crankcase pressure)

Air Management System

Air Management Components and Air Flow

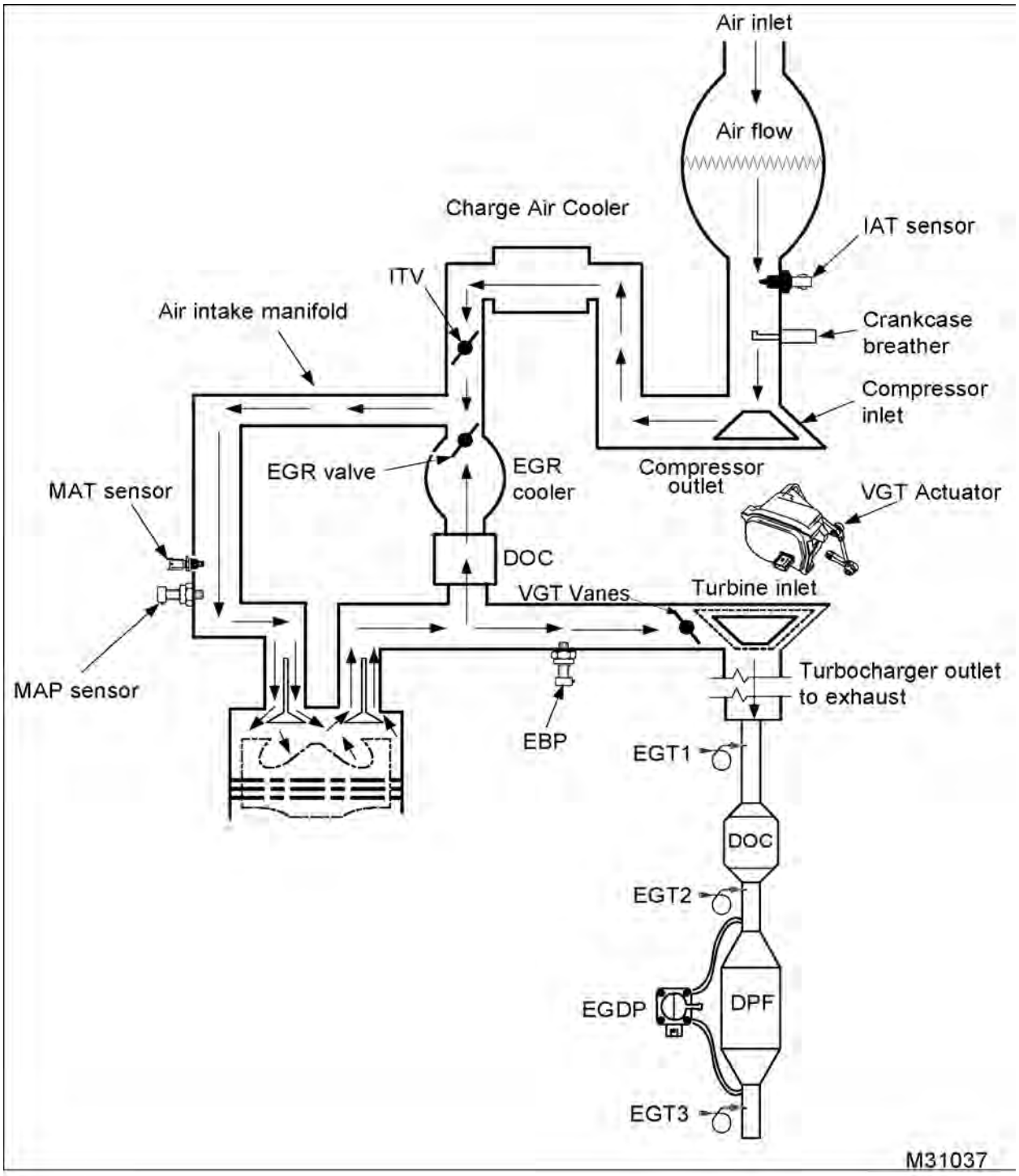


Figure 8 Air Management System (AMS)

The Air Management System (AMS) includes the following:

- Air filter assembly
- Intake Air Temperature (IAT) sensor
- Variable Geometry Turbocharger (VGT) assembly
- Charge Air Cooler (CAC)
- Intake Throttle Valve (ITV)
- Manifold Air Temperature (MAT) sensor
- Manifold Absolute Pressure (MAP) sensor
- Intake manifold
- Intake valves
- Exhaust Gas Recirculating (EGR) system (EGR valve, EGR cooler, and EGR cooler DOC)
- Exhaust valves
- Exhaust manifolds
- Exhaust Back Pressure (EBP) sensor
- Exhaust tubes
- Diesel Oxidation Catalyst (DOC)
- Diesel Particulate Filter (DPF)

Air Flow

Air flows through the air filter assembly and enters the Variable Geometry Turbocharger (VGT). The compressor in the VGT increases the pressure, temperature, and density of the intake air before it enters the Charge Air Cooler (CAC). Cooled compressed air flows from the CAC into the EGR valve elbow housing.

If the EGR control valve is open, exhaust gas will mix with filtered intake air and flow into the intake manifold. If the EGR control valve is closed, only filtered air will flow into the intake manifold.

After combustion, exhaust gas is forced through the exhaust manifold to the EGR cooler and VGT. Some exhaust gas is cooled in the EGR cooler and flows through the EGR valve to the EGR valve elbow housing. When exhaust gas mixes with filtered air and fuel during the combustion process, this cools the combustion process and reduces the formation of NO_X engine emissions. The rest of the exhaust gas flows to the VGT when it spins and expands through the turbine wheel, varying boost pressure. The VGT compressor wheel is on the same shaft as the turbine wheel and compresses the mixture of filtered air.

The VGT responds directly to engine loads. During heavy load, increased temperature of exhaust 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 temperature of exhaust decreases and less air is directed into the intake manifold.

Charge Air Cooler (CAC)

The CAC is mounted on top of the radiator. Air from the turbocharger passes through a network of heat exchanger tubes before entering the EGR valve elbow housing. Outside air flowing over the CAC cools the charged air. Charged air is cooler and denser than the air that is not cooled and improves the fuel-to-air ratio during combustion. This results in improved emission control and power output.

Variable Geometry Turbocharger (VGT) Assembly

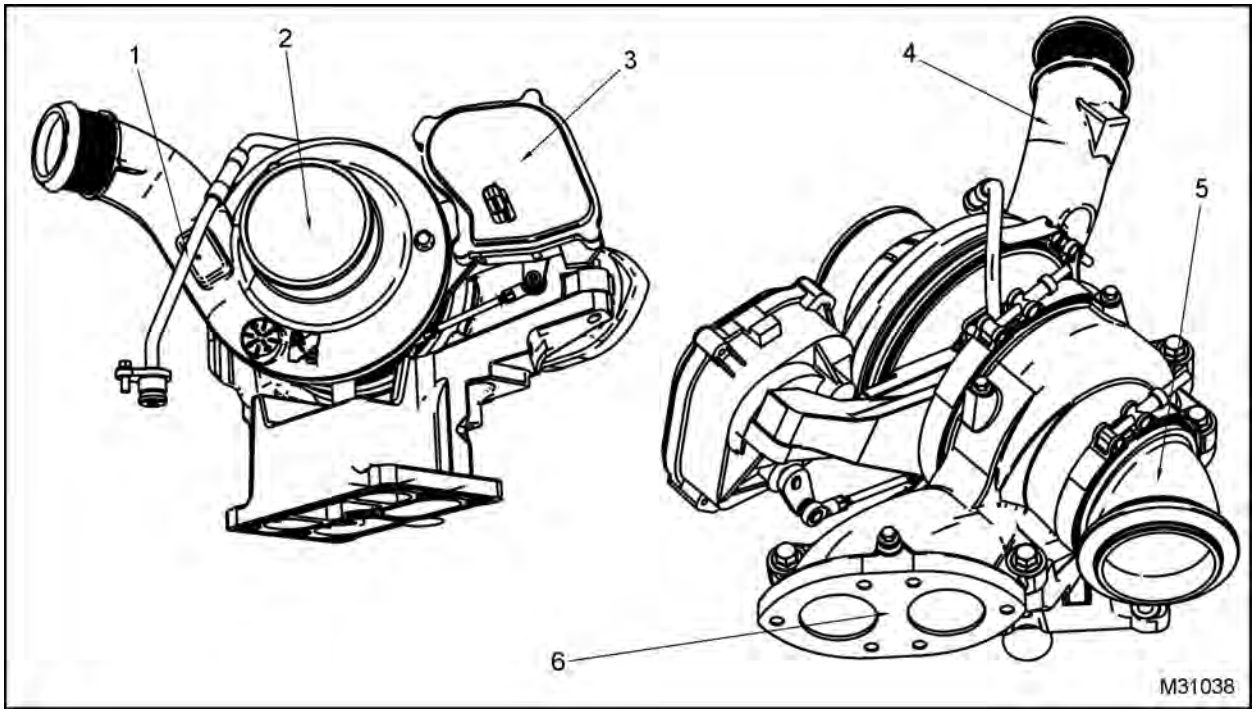


Figure 9 Turbocharger

1. Turbocharger oil supply tube
2. Air inlet
3. VGT actuator
4. Compressor outlet
5. Exhaust outlet
6. Exhaust inlet

The VGT has actuated vanes in its turbine housing. The vanes modify flow characteristics of exhaust gases through the turbine housing. The benefit is the ability to control boost pressure for various engine speeds and load conditions. An additional benefit is lower emissions.

The VGT 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 VGT to match engine requirements.

VGT closed loop system

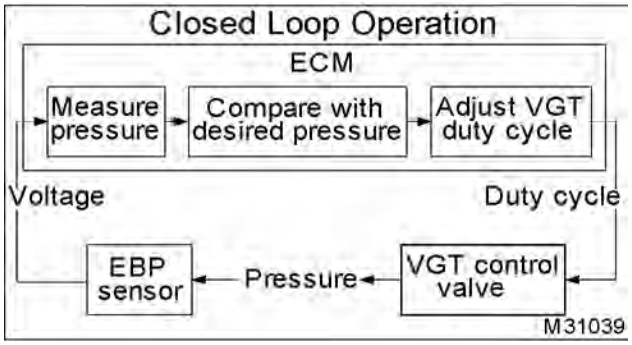


Figure 10 VGT closed loop system

VGT control

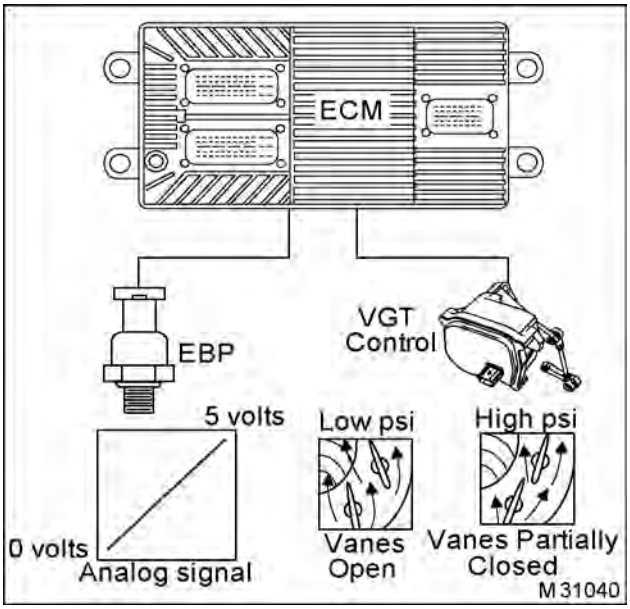


Figure 11 VGT control

Actuator vanes are mounted around the inside circumference of the turbine housing. An adjusting ring links all the vanes. When the adjusting ring moves, all vanes move to the same position. The adjusting ring is connected to the VGT actuator through a vane operating lever. The actuator receives a signal from the ECM. The actuator moves the valve operating lever that moves the unison ring based on the increase or decrease of the exhaust back pressure.

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

Exhaust Gas Recirculating (EGR) System

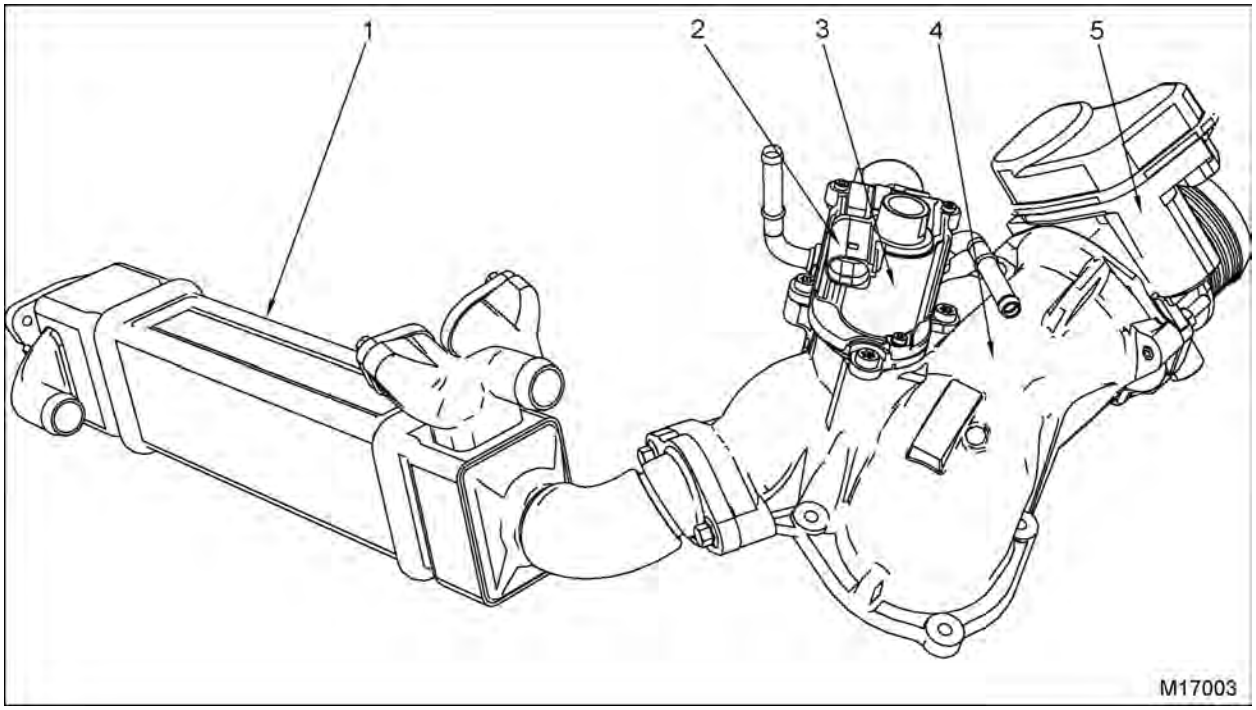


Figure 12 EGR system

1. EGR cooler
2. EGR valve connector
3. EGR valve assembly
4. EGR valve elbow housing
5. Intake throttle housing assembly (ITV)

The EGR system includes the following:

- Exhaust tube assembly
- EGR cooler
- EGR valve assembly
- EGR valve control
- EGR valve elbow housing
- ITV assembly

The EGR system reduces Nitrogen Oxide (NO_X) emissions. The EGR system is also used to adjust the fuel to air ratio for regeneration.

NO_X gas forms during a reaction between nitrogen and oxygen at the high temperatures of combustion. By mixing exhaust gasses with the inlet air peak combustion temperature is reduced thus reducing the formation of NO_X emissions.

EGR Flow

Some exhaust from the exhaust tube assembly flows through a Diesel Oxidation Catalyst (DOC) into the EGR cooler. Exhaust from the EGR cooler flows into the EGR valve elbow housing, through the EGR valve, and into the intake manifold.

When EGR is required, the EGR valve opens, allowing cooled exhaust gases to enter the intake manifold to be mixed with filtered intake air. The exhaust gases are then recycled through the combustion process.

EGR Valve

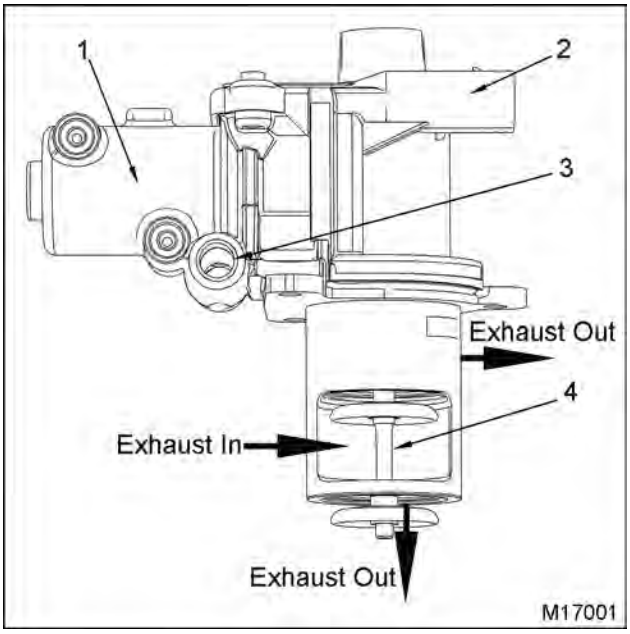


Figure 13 EGR valve

1. DC motor
2. Connector
3. Coolant return
4. Poppet valve assembly

The EGR valve uses a DC motor to control the position of the valve assembly. The motor drives the poppet valve assembly at the same time it drives the position sensor. The poppet valve assembly has two valve heads (poppets) on a common shaft.

Exhaust flow enters the EGR valve elbow housing and enters the EGR valve. Exhaust flows through the two valve poppets into the intake mixer where it mixes with incoming air from the air inlet throttle valve. The mixed air goes into the intake manifold and cylinders.

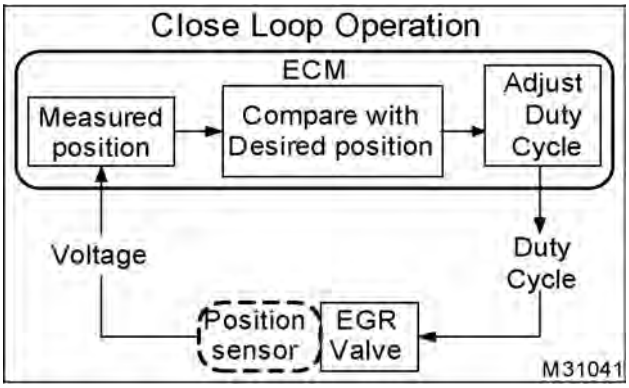


Figure 14 EGR closed loop operation

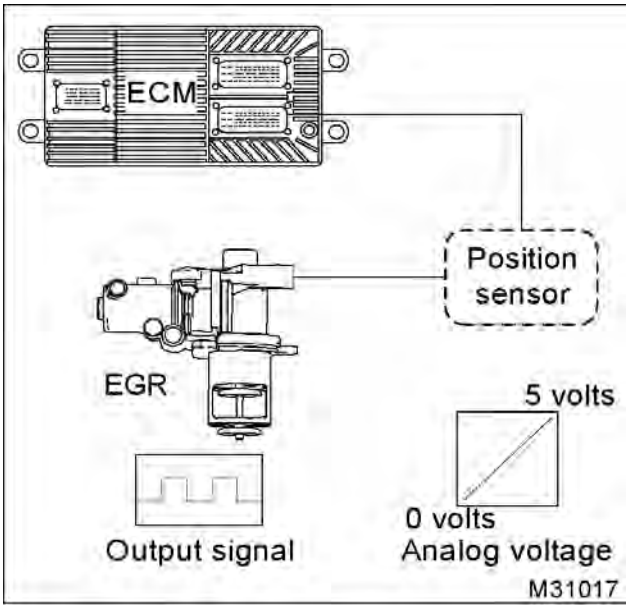


Figure 15 EGR control

The EGR valve consists of two major components; a valve body and an actuator motor. The valve has a Hall effect position sensor to monitor valve movement. The EGR valve is located at the front of the engine in the EGR valve elbow housing.

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

Intake Throttle Valve (ITV)

The ECM monitors the aftertreatment system. The ECM controls the intake throttle valve during aftertreatment regeneration and purge.

The ITV is controlled to restricts intake air flow. Restricted air flow will increase exhaust temperature.

Aftertreatment (AFT) System

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

AFT Control System

The control system performs the following functions:

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

Sensors

Sensors produce a representative electronic signal based on temperature and pressure. It is used by the control system to regulate the after treatment function.

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

Diesel Oxidation Catalyst (DOC)

The DOC does the following:

- Oxidizes hydrocarbons and carbon monoxide (CO) in exhaust stream
- Provides heat for exhaust system warm-up
- Aids in system temperature management for the DPF
- Oxidizes NO into NO_2 for passive DPF regeneration

Diesel Particulate Filter (DPF)

The DPF does the following:

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

AFT Conditions and Responses

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

Fuel System

Fuel System Components

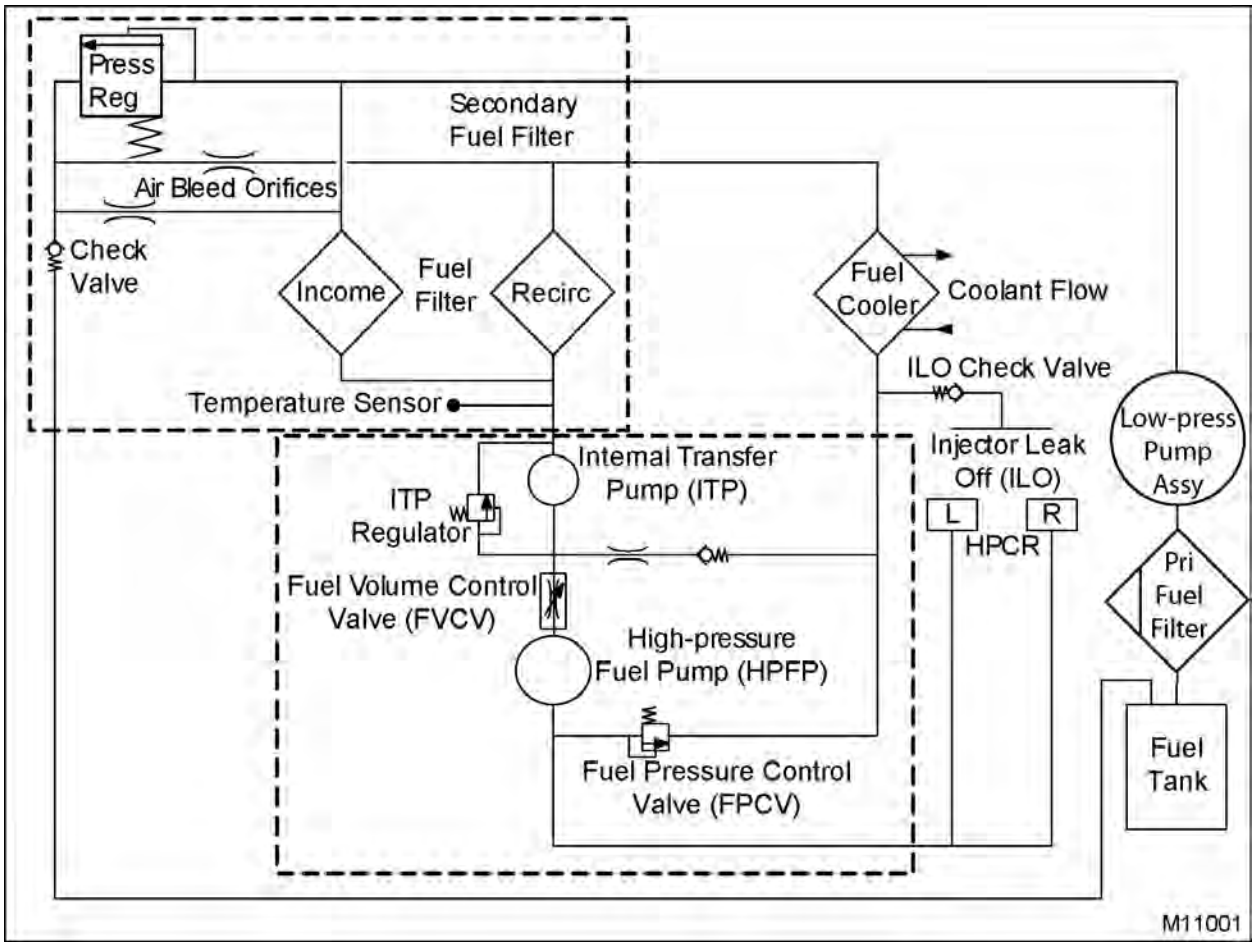


Figure 16 Fuel system schematic

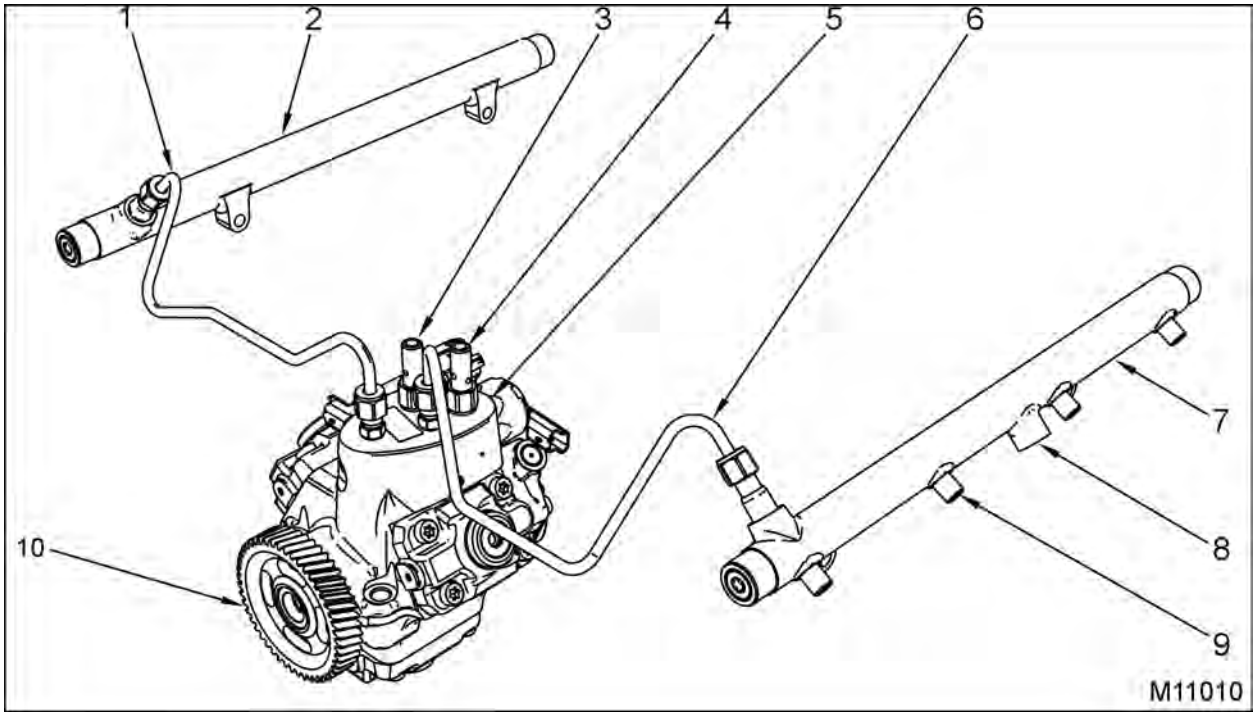


Figure 17 High-pressure fuel system

1. Pump left tube assembly (pump-to-rail)
2. Left rail assembly
3. Pump return tube connection (pump-to-cooler)
4. Filter to pump tube connection (pump-to-secondary fuel filter)
5. High-pressure Fuel Pump (HPFP) assembly
6. Pump right tube assembly (pump-to-rail)
7. Right rail assembly
8. Fuel Rail Pressure (FRP) sensor port
9. Fuel rail to injector fuel tube ports (4 for each rail)
10. HPFP gear

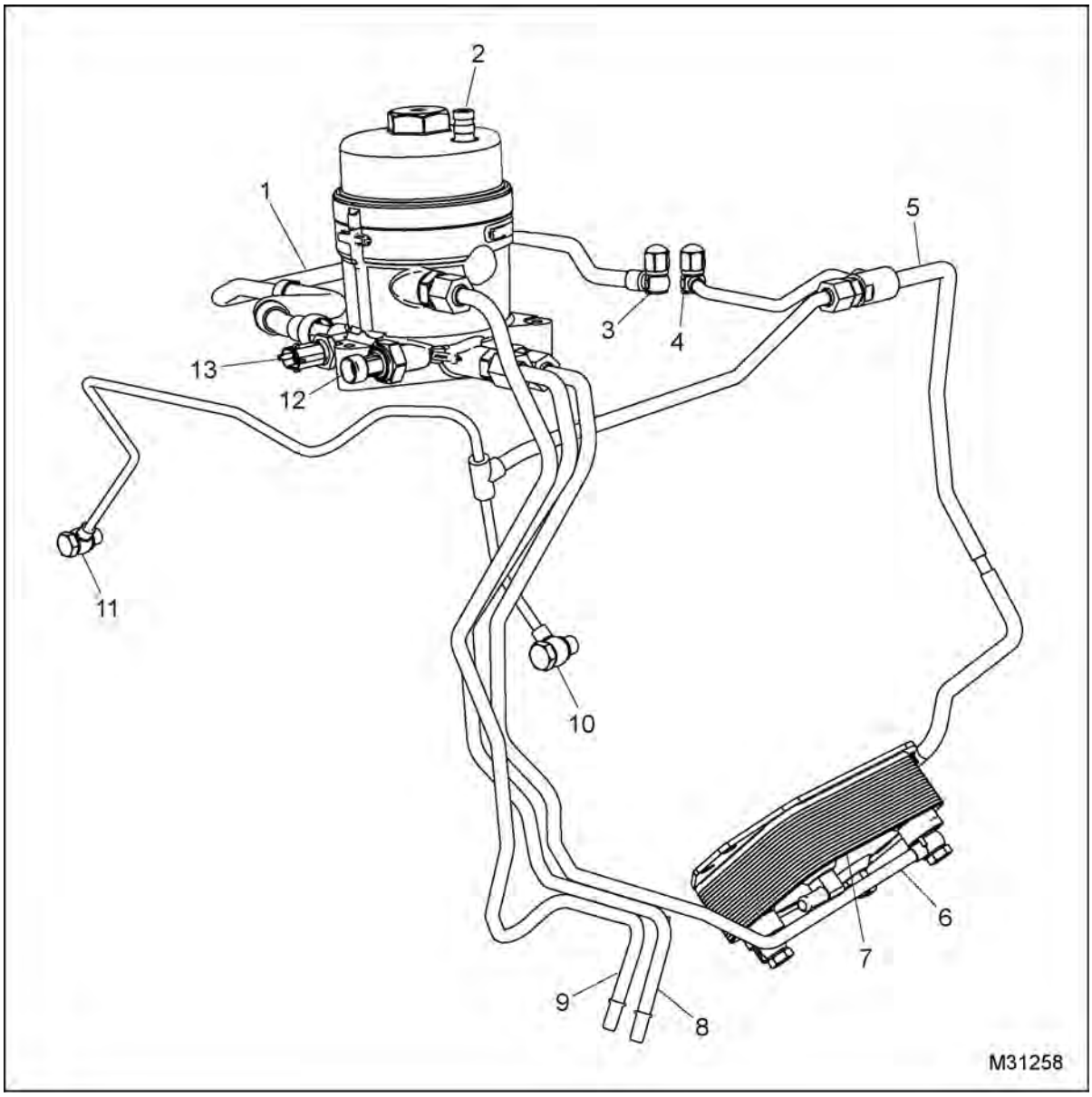


Figure 18 Low-pressure fuel system

1. Filter to pump tube assembly (high-pressure pump-to-secondary fuel filter)
2. Fuel pressure diagnostic port (dirty side)
3. Filter to pump tube assembly M12 banjo fitting
4. High-pressure pump to cooler tube assembly M12 banjo fitting
5. High-pressure pump to cooler tube assembly
6. Fuel cooler to filter tube assembly (cooler-to-secondary fuel filter)
7. Fuel cooler assembly
8. Fuel return to tank tube assembly (secondary fuel filter-to-fuel tank)
9. Fuel supply to filter tube (low-pressure fuel pump-to-secondary fuel filter)
10. Left injector return tube assembly 1/4 inch banjo fitting
11. Right injector return tube assembly 1/4 inch banjo fitting
12. Engine Fuel Pressure (EFP) sensor (optional)
13. Engine Fuel Temperature (EFT) sensor

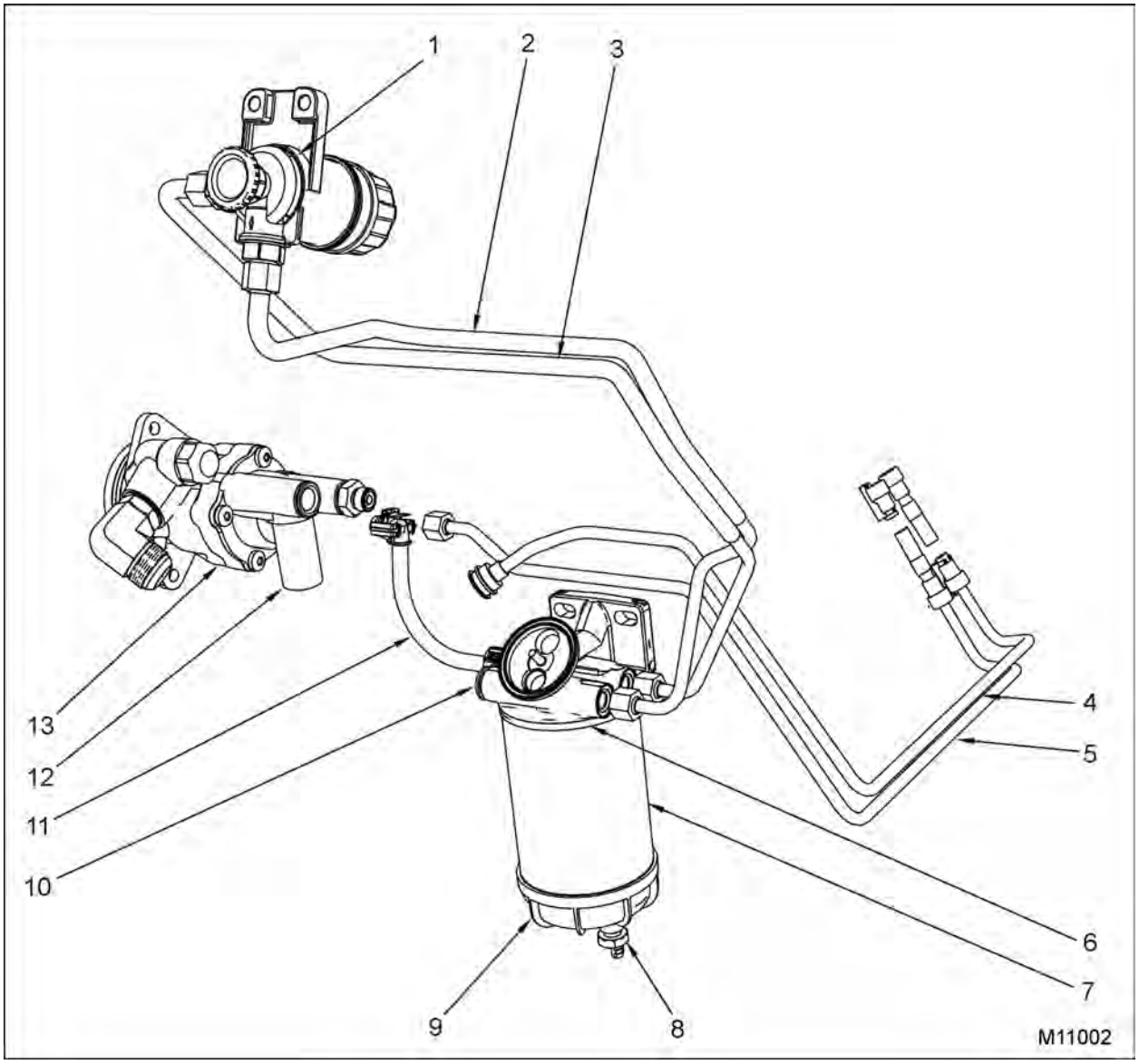


Figure 19 Low-pressure fuel supply system

1. Fuel primer pump assembly
2. Fuel supply tube assembly
3. Fuel return from primer tube assembly
4. Fuel return tube assembly (secondary fuel filter-to-fuel tank)
5. Fuel supply tube assembly (low-pressure fuel pump-to-secondary fuel filter)
6. Fuel filter primary header
7. Primary filter element assembly
8. Fuel drain valve (water and sediment drain for fuel filter)
9. Bowl assembly with fuel heater/probe (optional)
10. Fuel from tank
11. Primary filter to pump tube assembly
12. Fuel Restriction Test Cap
13. Gear driven fuel pump assembly (low-pressure fuel pump)

The fuel system includes the following:

- Low-pressure fuel system
  - Low-pressure fuel pump assembly
  - Primary fuel filter assembly
  - Secondary fuel filter assembly
  - Fuel cooler assembly
  - Fuel primer pump assembly
- High-pressure fuel system
  - High-pressure Fuel Pump (HPFP) assembly
  - High-pressure fuel rails assemblies (left and right)
  - Fuel injector assemblies (8)

Low-pressure Fuel System

Low-pressure fuel pump

The low-pressure fuel pump draws fuel from the fuel tank(s) through the primary fuel filter and supplies fuel to the secondary fuel filter. It is mounted on the right side of the flywheel housing and driven through idler gears by the crankshaft.

Primary fuel filter assembly

The primary filter removes water and filters fuel from the fuel tank(s). It is mounted in front of the low-pressure fuel pump.

Fuel primer pump

The manual priming pump draws fuel from the fuel tank(s) through the primary filter after filter replacement or when system has run out of fuel. This primes the fuel system to minimize the amount of air injected into the system on initial startup.

Secondary fuel filter assembly

The secondary fuel filter assembly is a two stage filter with an internal pressure regulator mounted adjacent to the oil filter.

An internal pressure relief valve maintains a constant pressure throughout the low-pressure system.

A five micron first stage filter filters fuel from the low-pressure fuel pump. The first stage filter has an internal drilled air bleed orifice to automatically remove air from the fuel. The filtered fuel is mixed with the cooled fuel from the fuel cooler and is directed to a four micron secondary filter. Pressure is maintained by an internal pressure regulator.

Fuel is additionally filtered in the second stage filter and is directed to the high-pressure fuel pump. This second stage filter also has an internal drilled air bleed orifice to automatically remove air from the fuel.

Fuel from the pressure regulator and both air bleed orifices return to the fuel tank(s) through a check valve that maintains constant back pressure in the bleed header.

The secondary fuel filter assembly has a temperature sensor mounted in the supply line to the HPFP.

Fuel cooler

The fuel from the fuel injectors and the HPFP flows through the fuel cooler where it is cooled by the secondary radiator. Cooled fuel is then directed to the secondary fuel filter assembly.

High-pressure Fuel System

High-pressure Fuel Pump (HPFP) assembly

The HPFP is a three piston volumetric pump that supplies fuel at high pressure to both the fuel rails. The HPFP is mounted in the rear valley on top of the engine and driven by the camshaft.

Internal Transfer Pump (ITP)

The ITP is part of the HPFP assembly and driven off the same shaft as the HPFP assembly. The ITP supplies fuel at a slightly higher pressure and flow to the Fuel Volume Control Valve (FVCV). Cooling flow for the ITP is provided by routing fuel back to the suction side of the transfer pump. The discharge of the ITP has an orifice and check valve that also provides additional cooling for the ITP by routing flow to the fuel cooler.

Fuel Volume Control Valve (FVCV)

The FVCV regulates the volume of flow sent to the HPFP. The FVCV is located in the HPFP assembly and controlled by the FRP via the ECM. The FVCV puts the necessary quantity of fuel under pressure to the HPFP.

FVCV control depends on engine speed, injector quantity, fuel temperature, and the number of injections per cycle.

Fuel Pressure Control Valve (FPCV)

The FPCV controls the fuel pressure to the fuel rails. The FPCV is located in the HPFP assembly and is controlled by the FRP via the ECM. FPCV control depends on fuel pressure and fuel temperature.

Fuel Rail Pressure (FRP) sensor

The FRP monitors the fuel pressure in the fuel rails and sends a signal to the ECM. It is located in the right fuel rail. The FRP sensor harness is routed through the right Under Valve Cover (UVC) harness along with the fuel injector connections.

High-pressure Piezo Common Rail (HPCR) System

The HPFP pumps fuel through separate tubes to each fuel rail. Each fuel rail has four fuel tubes, one for each injector, that maintain constant pressure from the high-pressure pump to each injector.

The injectors operate in five cycles; two pre-injection cycles, a main-injection cycle, a post-injection cycle, and a late post-injection cycle. The pre-injection cycles and post-injection cycle reduce combustion noise, mechanical load, and exhaust emissions. The main-injection cycle injects and atomizes fuel in the combustion chambers for combustion. The late post-injection cycle adds fuel to the exhaust to regenerate the aftertreatment system.

Each injector has an actuator that opens or closes the injector nozzle. Charging the actuator opens the nozzle. The nozzle is closed by discharging the actuator. The ECM charges and discharges each actuator by energizing the appropriate high side or low side output. The low side output supplies a return circuit for each actuator.

Fault Detection/Management

The ECM can detect if the output is shorted to ground/battery detection, the output is open, or if the injector is shorted.

Return Fuel System

The return fuel system moves unused fuel from the fuel injectors to the fuel cooler. Excess fuel out of the FVCV and the FPCV mix with fuel from the fuel injectors on the way to the fuel cooler.

Engine Lubrication System

Lubrication System Components and Oil Flow

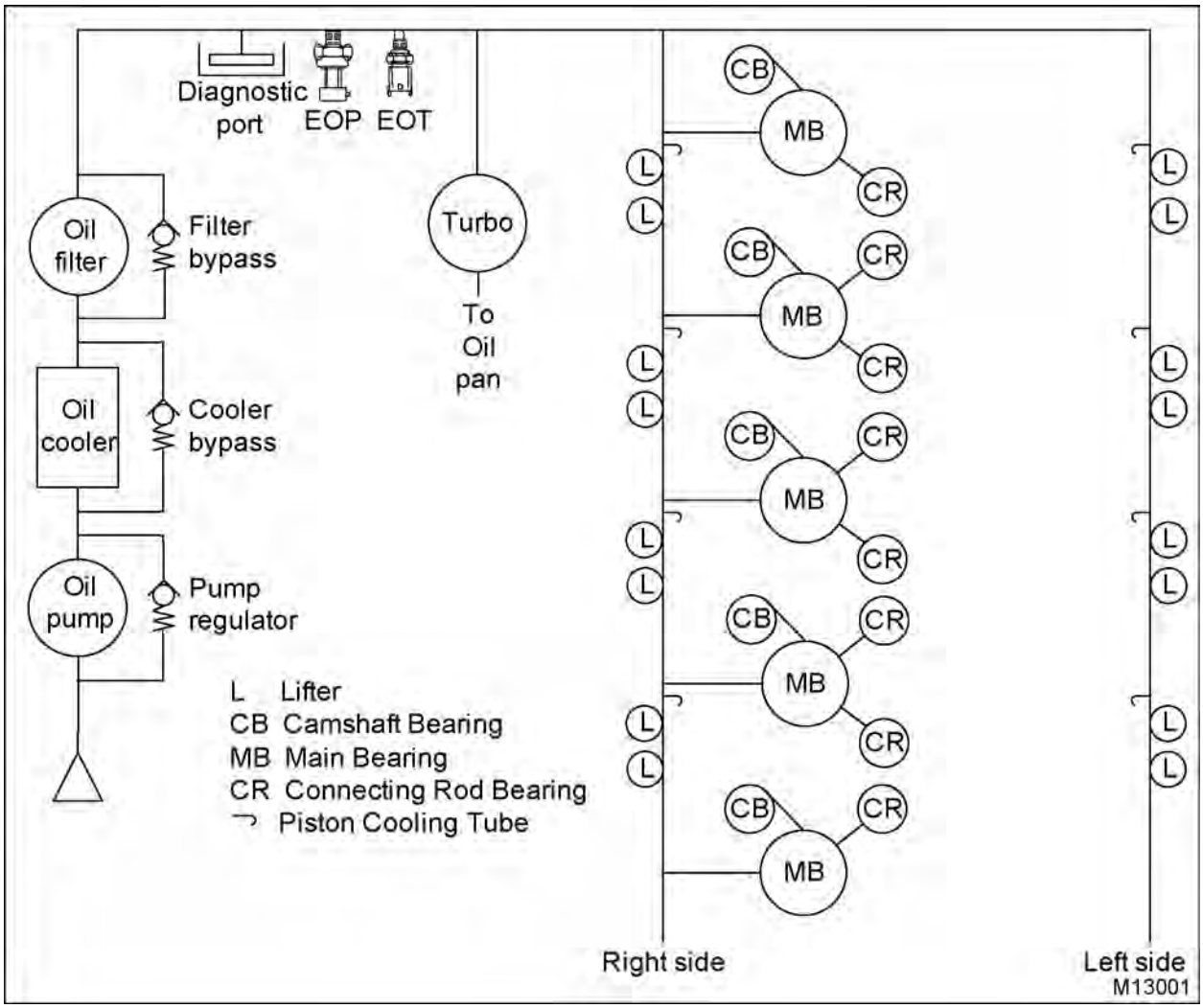


Figure 20 Lubricating system schematic

Oil Flow

The lubrication system includes:

- Oil pan assemblies
- Gerotor oil pump
- Front crankcase cover
- Oil pressure regulator valve
- Crankcase assembly
- Oil cooler cover assembly
- Oil filter base assembly
- Engine Oil Pressure (EOP) sensor
- Engine Oil Temperature (EOT) sensor
- Piston cooling tube
- Lifters
- Push rods

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

A gerotor oil pump draws oil from the oil pan through an oil pickup tube. Oil then flows through passages in the lower crankcase, front cover, and in the oil pump housing to the gerotor oil pump.

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

Oil pressure is maintained by the pressure regulating valve assembly. The pressure regulating valve in the discharge oil flow relieves excess oil pressure back to the suction side of the gerotor oil pump.

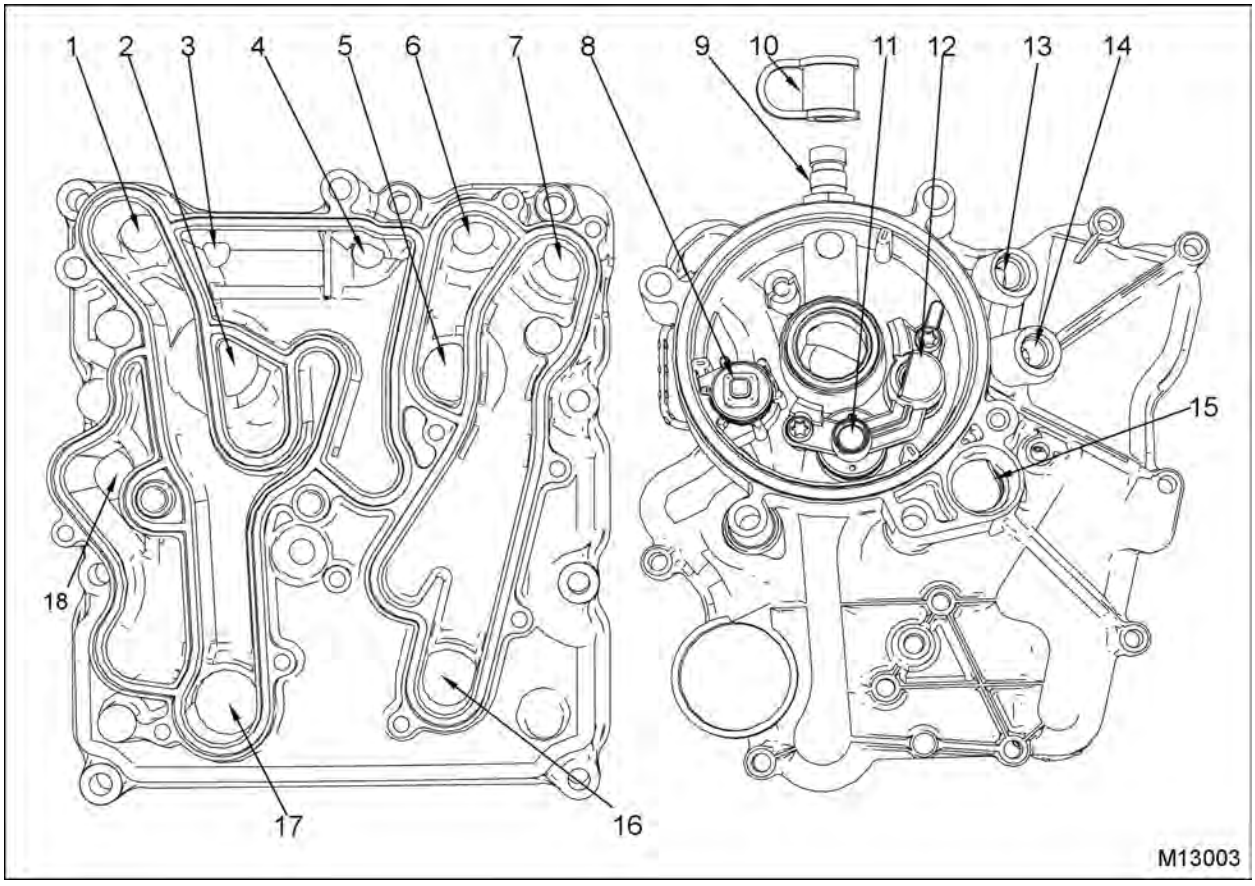


Figure 21 Oil cooler cover and oil filter base location details

1. Unfiltered oil flow from pump
2. Oil cooler outlet (oil)
3. Filtered oil to crankcase galleries and other components
4. Filtered oil to crankcase galleries and other components
5. Coolant inlet to oil cooler
6. Coolant inlet from water pump
7. Coolant outlet to cooling system
8. Oil drain valve assembly
9. Diagnostic coupling assembly
10. Diagnostic coupling dust cap
11. Filter inlet check valve
12. Oil cooler bypass valve
13. Engine Oil Temperature (EOT) sensor port
14. Engine Oil Pressure (EOP) sensor port
15. Turbocharger oil supply port
16. Coolant outlet from oil cooler
17. Oil cooler inlet (oil)
18. Oil drain to sump

Pressurized oil from the pump flows through passages in the oil pump housing and upper crankcase to the oil cooler cover. Oil flows through plates in the cooler, is cooled, and then flows back to the oil cooler cover.

If the oil cooler is restricted, a bypass valve in the oil filter base opens, oil bypasses the oil cooler, and flows to the oil filter base.

Oil flows through the oil filter base to the oil filter element. If the oil filter element is restricted, a bypass valve in the oil filter return line opens. Oil bypasses the oil filter element and flows to the oil filter base. Both bypass valves ensure full flow of oil to the engine if the filter or cooler is restricted. The oil filter base directs filtered oil to the oil supply tube to lubricate the turbocharger, EOP sensor, EOT sensor, diagnostic port, and oil cooler cover. Lubricating oil from the turbocharger drains back to the oil pan. When the oil filter is removed, oil flows through a drain valve in the oil filter base back to the oil pan.

Cooling System

Cooling System Components and Flow

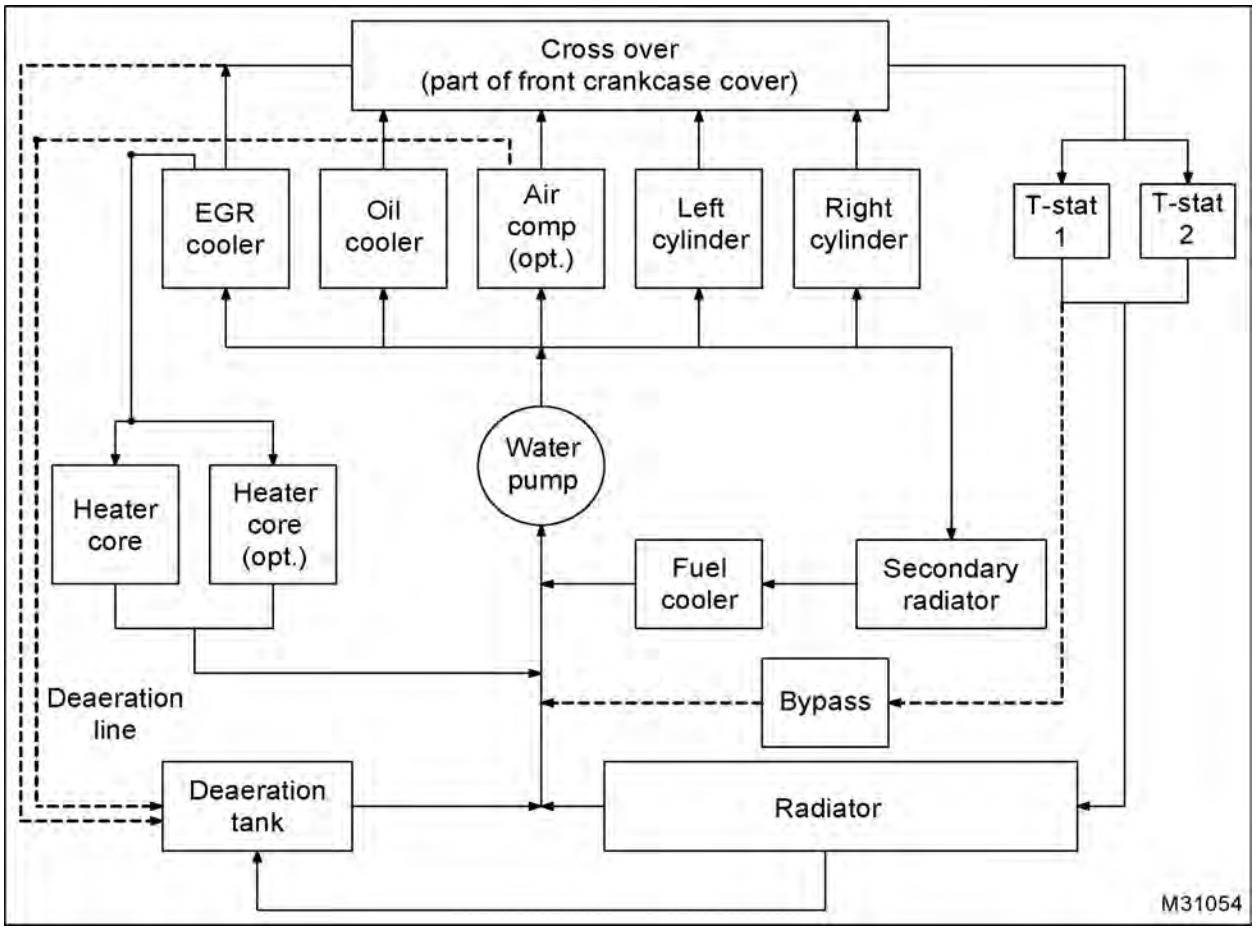


Figure 22 Cooling system schematic

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

Water Pump

The centrifugal water pump is mounted in the front crankcase cover. The water pump has a built in reservoir to catch small amounts of coolant that may seep past the seal. Water pump rotation is counter-clockwise when viewed from the front of the engine.

If the dual thermostats are shut, coolant is circulated through an internal bypass in one of the thermostats.

The surge tank keeps the system full with a line to the suction of the water pump.

Front Crankcase Cover Flow

Pressurized coolant from the water pump flows through the coolant supply housing in the front cover. Flow is directed through passages in the crankcase and ports in the front cover to support cooling system requirements.

- Two passages (left and right) direct coolant through the crankcase (front to rear) to cool the cylinder walls (combustion chamber) and then directed at the rear of the crankcase up to the cylinder heads.
- A passage directs coolant from the front cover and through the crankcase to the oil cooler to cool lubricating oil.

- A port in the front cover directs coolant through tubing to the EGR cooler to cool the exhaust gasses.
- A port in the front cover directs coolant through tubing to the brake air compressor.
- A port in the front cover directs coolant through a secondary radiator to the fuel cooler, to cool unused fuel from the injectors.

Hot coolant return flow is directed through passages in the crankcase and ports in the front cover to the coolant return cross over housing.

- Two passages (left and right) through the crankcase return coolant from the cylinder heads.
- A passage through the crankcase returns coolant from the oil cooler.
- A port in the coolant return cross over housing returns coolant through tubing from the brake air compressor.
- A port in the coolant return cross over housing returns coolant through tubing from the EGR cooler.
- A port in the coolant return cross over housing returns coolant through tubing from the fuel cooler.

The coolant return housing has one temperature sensor point.

The EGR cooler supplies coolant to the heater core for cab heating.

The coolant return cross over housing directs coolant to the dual thermostat housing.

Thermostats

Two thermostats are located in the thermostat housing. If the coolant temperature is above the thermostat opening temperature, coolant flows to the radiator to be cooled. If the coolant temperature is below the opening temperature for both thermostats, both thermostats are closed. Coolant returns back to the water pump through a bypass on one of the thermostats. As the coolant temperature increases, the first thermostat starts to open and flow starts through the radiator. As coolant temperature continues to increase, the first thermostat will fully open. The second thermostat will then start to open, increasing flow to the radiator until both thermostats are fully open.

Deaeration Tank

The radiator and the coolant system are kept full and pressurized by the deaeration tank. As coolant in the radiator heats up and expands, the level in the deaeration tank goes up and pressure increases. The deaeration tank also removes air from the cooling system.

Radiator Shutters

Closing the radiator shutters will keep the engine warm during cold weather operation. This provides faster warm up of the passenger cab and faster windshield defrosting.

Fuel Coolant Valve (FCV)

The FCV is used to redirect coolant through the fuel cooler. The ECM uses the Engine Fuel Temperature (EFT) sensor to monitor fuel temperature and controls the FCV to maintain the desired fuel temperature. The valve opens automatically allowing coolant to pass through the cooler. The ECM controls this valve in cold weather to warm the fuel and also prevents the temperature from getting too hot.

Electronic Control System

Electronic Control System Components

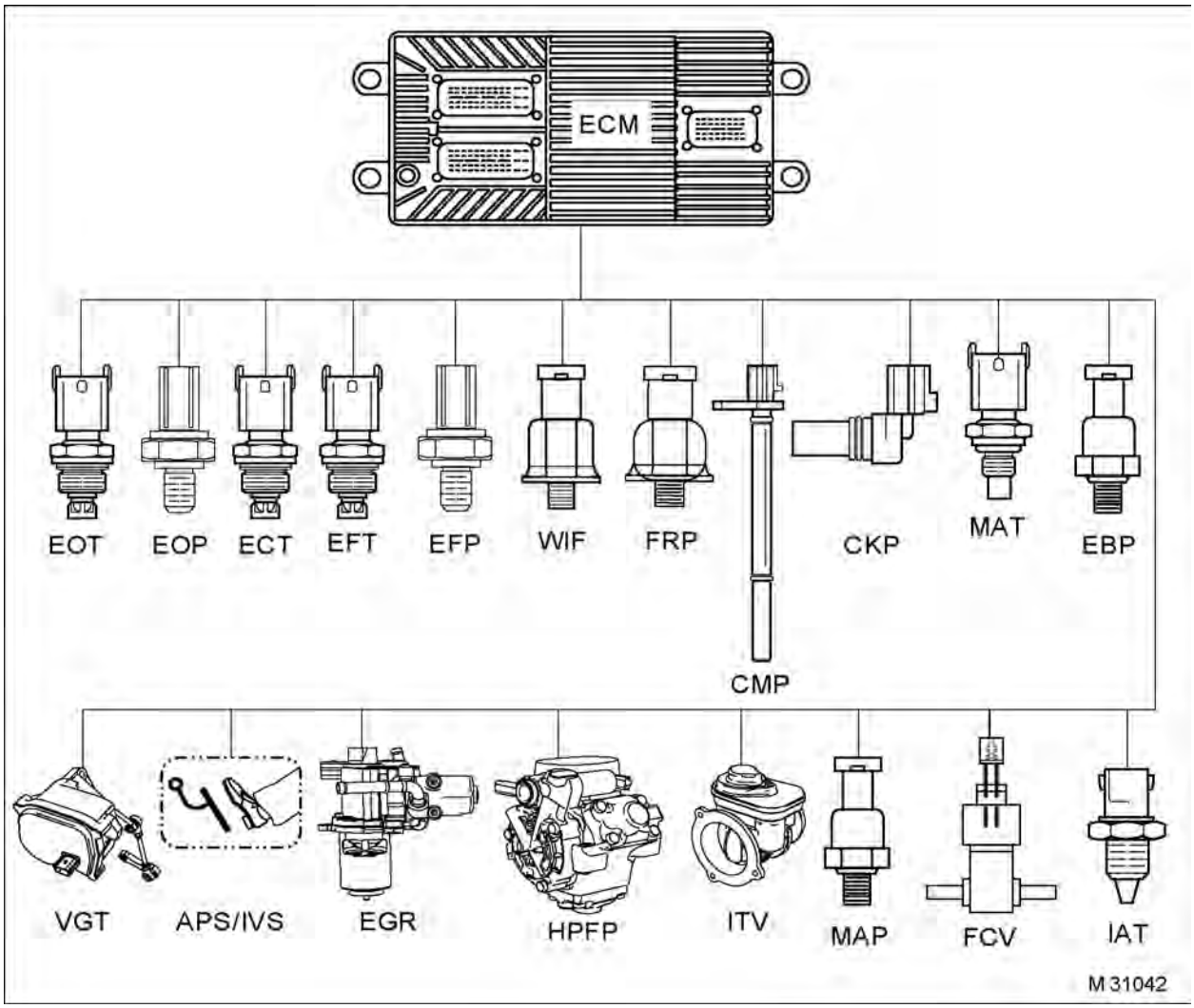


Figure 23 Electronic Control System

Operation and Function

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

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

Reference Voltage (VREF)

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

The ECM supplies three independent circuits for VREF:

- VREF supplies 5 volts to engine sensors

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

Signal Conditioner

The signal conditioner in the internal microprocessor converts analog signals to digital signals, squares up sine wave signals, or amplifies low intensity signals to a level that the ECM microprocessor can process.

Microprocessor

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

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

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

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

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

Microprocessor memory

The ECM microprocessor includes Flash Memory and Random Access Memory (RAM).

Flash Memory

Flash memory is a non-volatile form of memory that is electrically erasable and re-programmable. ROM (Read only memory) was used when the program (control strategy and calibration) was built into the physical silicon or was burnt in with a one time programming. In ROM, the program is fixed and to change it you physically have to change the hardware. With Flash memory, you can keep reprogramming it. Flash memory is used to update vehicles in the field (over public CAN) with new calibrations, software bug fixes, or new features.

Flash memory includes the following:

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

RAM

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

- Engine temperature
- Engine rpm
- Accelerator pedal position

Actuator Control

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

Actuators are controlled in three ways, determined by the kind of actuator.

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

Actuators

The ECM controls engine operation with the following:

- EGR valve and control
- VGT control
- Intake throttle control and throttle position
- Glow plug relay

H-bridge Circuit

The EGR valve and ITV actuator motors are operated by an H-bridge (by-polar) circuit in each valve assembly.

An H-bridge circuit operates like putting a power source on one side of a motor and hooking the other side of the motor to a ground. This turns the motor. By shifting the leads on the motor it will turn in the opposite direction.

To control the motor in both forward and reverse with a processor, you will need an H-Bridge. Relays configured in this fashion make an H-Bridge. The "high side drivers" are the relays that control the positive voltage to the motor. This is called sourcing current. The "low side drivers" are the relays that control the negative voltage to sink current to the motor. "Sinking current" is the term for connecting the circuit to the negative side of the power supply, which is usually ground.

Exhaust Gas Recirculating (EGR) Valve and Control

The EGR valve controls the flow of exhaust gases to the intake manifold. The EGR valve is integrated with an EGRP sensor.

The ECM controls the EGR valve with a Pulse Width Modulation (PWM) signal through H-bridge circuitry.

The ECM controls motor speed using PWM. The EGR is closed by driving the Exhaust Gas Recirculating High (EGRH) circuit high. When driving the EGRH high, this causes Exhaust Gas Recirculating Low (EGRL) circuit to go low.

Variable voltage is needed to move the valve and minimal voltage is needed to maintain its position.

Intake Throttle Valve (ITV) Actuator and Position Sensor

The ITV is used to control air/fuel mixture during a regeneration process of the aftertreatment system. The ITV is also used to insure a smooth engine shut down by restricting air flow to the engine at shut down.

The ECM controls the ITV with a Pulse Width Modulation (PWM) signal through H-bridge circuitry.

The ECM controls motor speed using PWM. The ITV is close by driving the Intake Throttle Valve High (ITVH) circuit high. When driving the ITVH high, this causes Intake Throttle Valve Low (ITVL) circuit to go low.

Variable voltage is needed to move the valve and minimal voltage is needed to maintain its position.

Glow Plug Relay

The ECM activates the glow plug relay. The relay delivers VBAT to the glow plugs for up to 60 seconds in one key cycle, depending on engine coolant temperature and altitude. The ground circuit is supplied directly from the battery ground at all times. Relay is controlled by switching on a voltage source from the ECM.

Engine and Vehicle Sensors

Thermistor Sensors

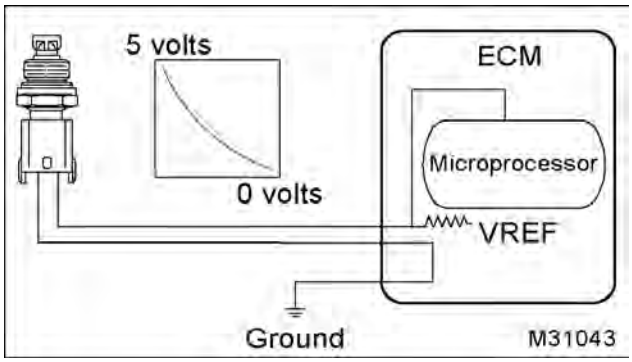


Figure 24 Thermistor sensors

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

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

Thermistor Sensors

- Engine Coolant Temperature (ECT) Sensor
- Engine Oil Temperature (EOT) Sensor

- Engine Fuel Temperature (EFT) Sensor
- Manifold Air Temperature (MAT) Sensor
- Intake Air Temperature (IAT) Sensor

NOTE: For specific information and location see applicable sensor in the “Electronic Control Systems Diagnostics” section of EGES-350-1 *MaxxForce® 7 Engine Diagnostics Manual*.

Variable Capacitance Sensors

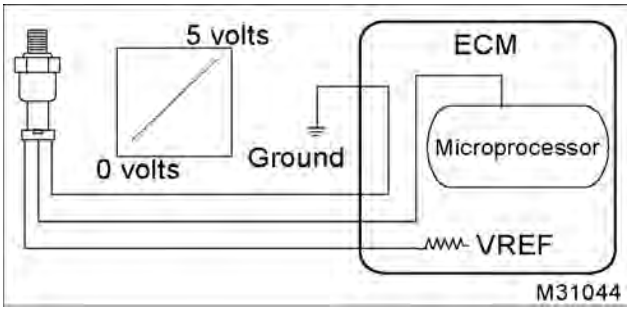


Figure 25 Variable capacitance sensors

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:

- VREF
- Signal
- Signal return (ground) (SIG GND)

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

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

Variable Capacitance Sensors

- Exhaust Back Pressure (EBP) Sensor
- Manifold Absolute Pressure (MAP) Sensor
- Engine Oil Pressure (EOP) Sensor
- Engine Fuel Pressure (EFP) Sensor

NOTE: For specific information and location see applicable sensor in the “Electronic Control Systems Diagnostics” section of EGES-350-1 *MaxxForce® 7 Engine Diagnostics Manual*.

Micro Strain Gauge (MSG) Sensor

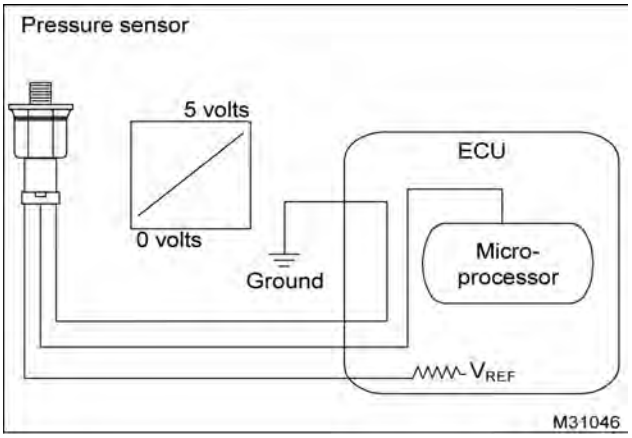


Figure 26 MSG sensor

A Micro Strain Gauge (MSG) sensor measures pressure. Pressure to be measured exerts force on a pressure vessel that stretches and compresses to change resistance of strain gauges bonded to the surface of the pressure vessel. Internal sensor electronics convert the changes in resistance to a ratiometric voltage output.

The sensor is connected to the ECM by three wires:

- VREF
- Signal
- Signal return (ground) (SIG GND)

The sensor is powered by VREF received from the ECM and is grounded through the ECM to a common sensor ground.

MSG Sensors

- Fuel Rail Pressure (FRP) sensor

NOTE: For specific information and location see applicable sensor in the “Electronic Control Systems Diagnostics” section of EGES-350-1 *MaxxForce® 7 Engine Diagnostics Manual*.

Magnetic Pickup Sensors

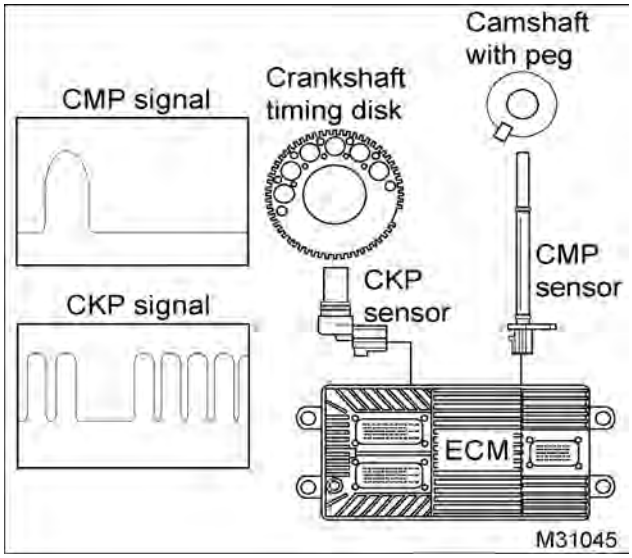


Figure 27 Magnetic pickup sensors

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.

Magnetic Pickup Sensors

- Crankshaft Position (CKP) Sensor
- Camshaft Position (CMP) Sensor

NOTE: For specific information and location see applicable sensor in the “Electronic Control Systems Diagnostics” section of EGES-350-1 *MaxxForce® 7 Engine Diagnostics Manual*.

Potentiometer

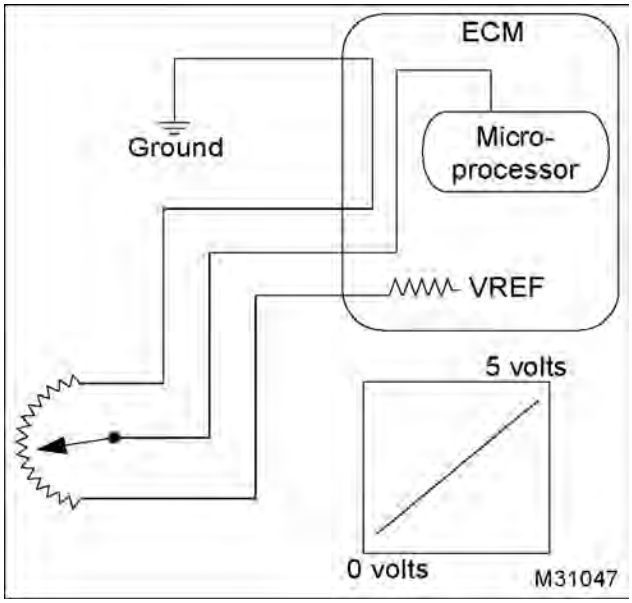


Figure 28 Potentiometer

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

Potentiometer

- Accelerator Position Sensor (APS)

NOTE: For specific information and location see applicable sensor in the “Electronic Control Systems Diagnostics” section of EGES-350-1 *MaxxForce® 7 Engine Diagnostics Manual*.

Switches

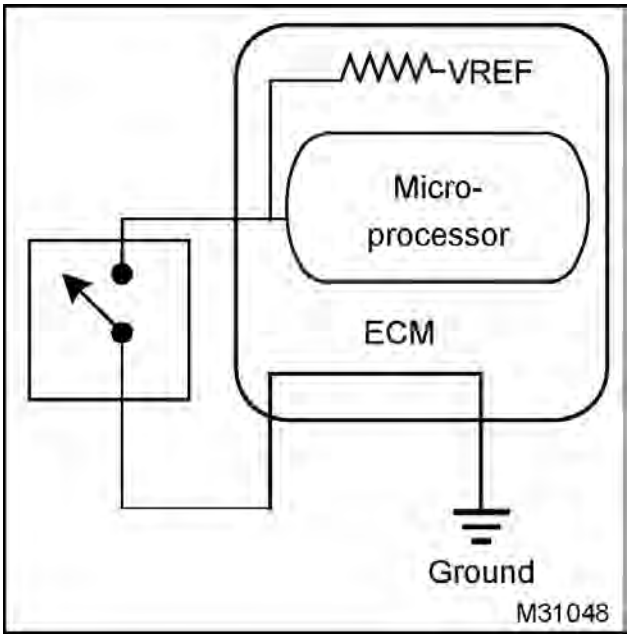


Figure 29 Switch

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

Switches

- Engine Coolant Level (ECL) Switch

NOTE: For specific information and location see applicable sensor in the “Electronic Control Systems Diagnostics” section of EGES-350-1 *MaxxForce® 7 Engine Diagnostics Manual*.

Glow Plug Control System

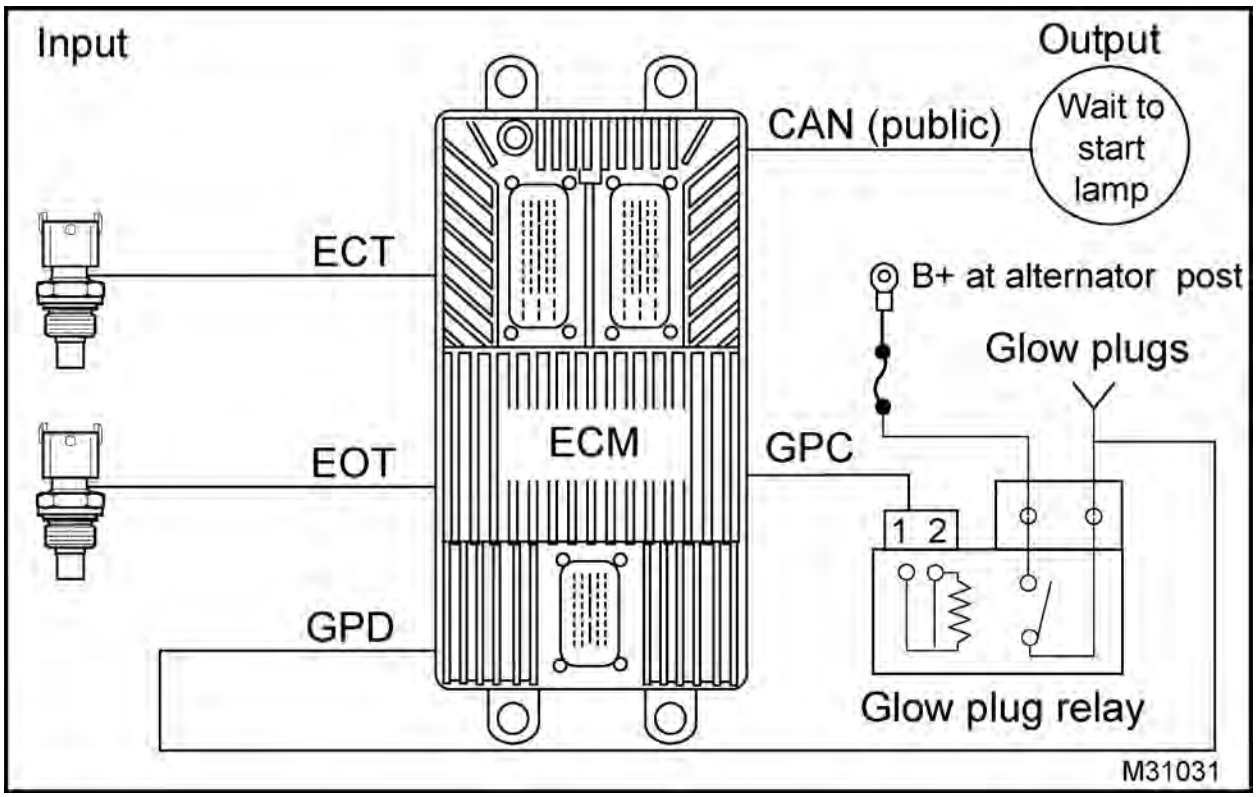


Figure 30 Glow plug control system

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

The ECM energizes the glow plug relay while monitoring programmed conditions for engine coolant temperature and atmospheric pressure.

The ECM controls the wait to start lamp and glow plugs based on ECT and EOT. The wait to start lamp (0 to 10 seconds) ON-time is independent from the glow plugs (0 to 60 seconds in one key cycle) ON-time.

The ECM controls the wait to start lamp through public CAN communication to the electronic gauge cluster.

The power is supplied to the switch side of the relay from the starter motor through a fusible link. When the relay is energized, power is supplied to the glow plugs, which are grounded through the cylinder heads.

Table of Contents

Standard Features

Electronic Governor Control

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

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

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

American Trucking Association (ATA) Datalink

Vehicles are equipped with an ATA datalink for communications between the Electronic Control Module (ECM), ATA Electronic Gauge Cluster (EGC) and the Electronic Service Tool (EST).

For additional information, see ATA Datalink (page 189) in “Electronic Control Systems Diagnostics” section in this manual.

Electronic Service Tool (EST) Interface

Vehicles are equipped with the EST interface for communication between the Electronic Control Module (ECM) and the EST.

CAN is a J1939 serial bus system, also known as the Drivetrain Datalink. The public Controller Area Network (CAN) provides a communication link between all connecting modules by sending and receiving messages.

The EST with MasterDiagnostics® software communicates with the ECM through the EST interface . The EST, through the public CAN, is able to retrieve Diagnostic Trouble Codes (DTCs), run diagnostic tests, and view Parameter Identifiers (PIDs) from all inputs and outputs of the ECM.

CAN public supports the follow functions:

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

Service Diagnostics

The Electronic Service Tool (EST) communicates with the control system through the public CAN network. The EST allows the user to retrieve and clear fault codes, run special diagnostic tests and monitor control system sensors and actuators, update control system software, and adjust special features.

Event Logging System

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

Electronic Speedometer and Tachometer

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

The tachometer signal is generated by the ECM by computing signals for the Camshaft Position (CMP) sensor and Crankshaft Position (CKP) sensor. Calculations for each sensor are sent to the instrument panel through the Drivetrain Datalink (CAN 1) and to the EST through the ATA datalink.

Fast Idle Advance

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

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

Cold Ambient Protection (CAP)

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

CAP maintains engine coolant temperature by increasing the engine rpm to a programmed value

when the ambient air temperature is at or below 0 °C (32 °F) and the engine coolant temperature is below 75 °C (167 °F) while the engine has been idling with no load for more than 5 minutes.

CAP is standard on trucks with a neutral safety switch. CAP is also standard on trucks without an Idle Shutdown Timer (IST).

Aftertreatment System

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

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

Engine Crank Inhibit (ECI)

The ECI prevents starter engagement when the engine is running or when the transmission is in gear.

Optional Features

Road Speed Limiting (RSL)

RSL limits the speed to the maximum vehicle speed programmed by the customer.

Service Interval

Service interval warns the operator of the need to change the engine oil and oil filter.

See Reset Service Interval Message in “Diagnostic Software Operation” section of this manual.

Cruise Control

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

Radiator Shutter Enable (RSE)

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

Engine Fan

The engine fan allows higher air flow through the radiator when the A/C is on or when the coolant or inlet air temperatures goes above a set temperature.

Engine Warning Protection System (EWPS)

The Engine Warning Protection System (EWPS) warns the operator of engine conditions that can damage the engine. EWPS has two modes of operation: warning mode (standard) and protection mode (optional).

Warning mode (standard)

- The warning mode is the standard calibration for EWPS.
- The warning mode monitors engine rpm, Engine Coolant Temperature (ECT), Engine Oil Pressure (EOP), and Engine Coolant Level (ECL) (optional).
- When a condition meets or exceeds a programmed warning limit, the red engine lamp will illuminate and an alarm will sound.
- The engine will not shut down.

Protection mode (optional)

- The protection mode is an optional calibration that can be added to the EWPS by the dealer, if requested by the customer.
- The protection mode monitors critical engine conditions: ECT, ECL, and EOP.
- When a condition meets or exceeds a programmed (warning critical) limit, the red engine lamp will flash and an alarm will sound.

- The engine will shut down, after 30 seconds of operation past critical threshold values for coolant temperature, coolant level or oil pressure. The operator has 30 seconds to safely pull the vehicle off the road. If the critical engine condition remains, the ECM allows the engine to be restarted and run for 30 second periods.

NOTE: The protection mode is not offered on school buses or emergency vehicles.

Idle Shutdown Timer (IST)

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

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

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

- Amber flashing idle shutdown indicator for multiplex electrical systems (MaxxForce® 7).
- Red flashing indicator with audible alarm for non-multiplex electrical systems.

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

IST for California ESS Compliant Engines

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

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

- When vehicle parking brake is set, the idle shutdown time is limited to the California Air Resources Board (CARB) requirement of 5 minutes.
- When vehicle parking brake is released, the idle shutdown time is limited to the CARB requirement of 15 minutes.

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

Engine Idle Shutdown Timer (Federal–Optional)

Idle time can be programmed from 5 to 120 minutes. While the EST is installed, the IST function will be active with the programmed shutdown time in effect. Parking brake transitions reset the idle timer in all 2008 engines. If the IST is enabled, the Cold Ambient Protection (CAP) will not function.

For additional information, see IST (Idle Shutdown Timer) (page 337) in “Electronic Control Systems Diagnostics” section of this manual.

Table of Contents

MasterDiagnostics® Software

Open Application

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

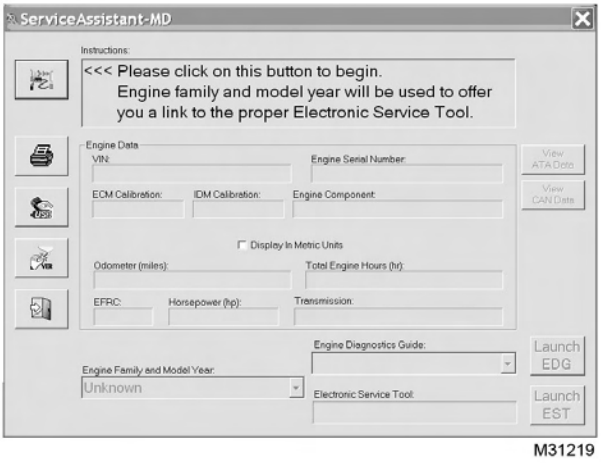


Figure 31 Diagnostic window

NOTE: If the EST does not communicate with the vehicle, refer to the IC4 Interface Device Self Test (page 50).

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

Choose COM Device

1. Select COM.

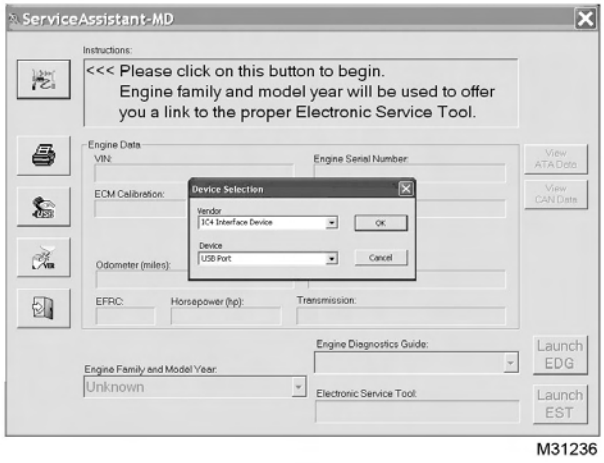


Figure 32 Diagnostic COM selection

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

Retrieve Engine Information

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

Open Diagnostic Form

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

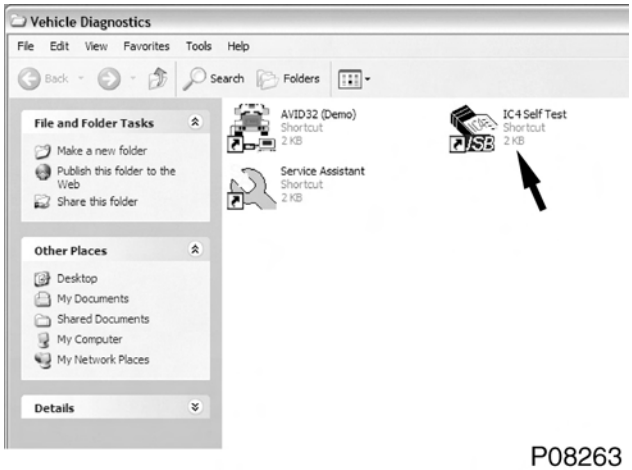
Open MasterDiagnostics® Software

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

Electronic Service Tool (EST) Communication Diagnostics

IC4 Interface Device Self Test

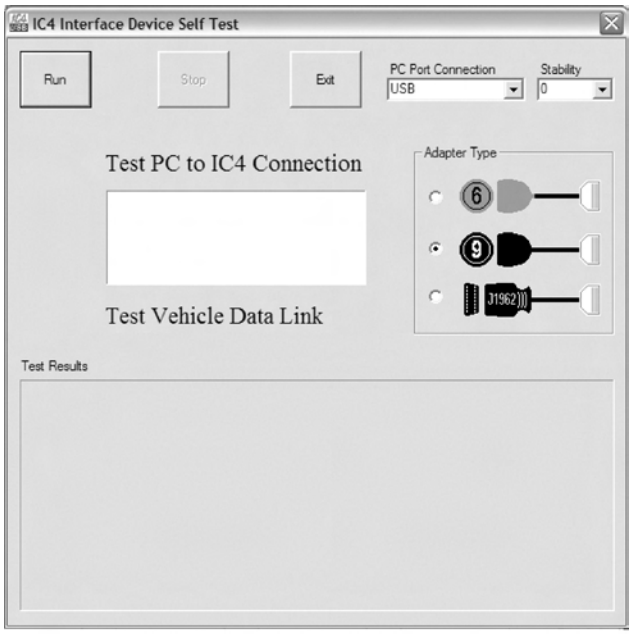
1. Connect the interface cable to the diagnostic connector and the EST.
2. Turn ignition switch to ON. Do not start the engine.



P08263

Figure 33 Vehicle diagnostics folder

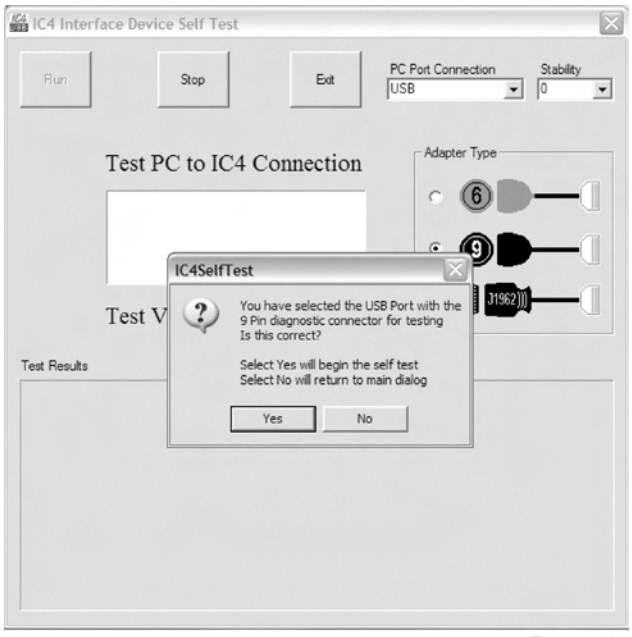
3. From the EST desktop open the Vehicle Diagnostics folder.
4. Double-click the IC4 Self Test icon.



P08242

Figure 34 Self Test Run command

5. Select Run button.



P08243

Figure 35 Connector confirmation

6. Verify the correct interface connector is selected.

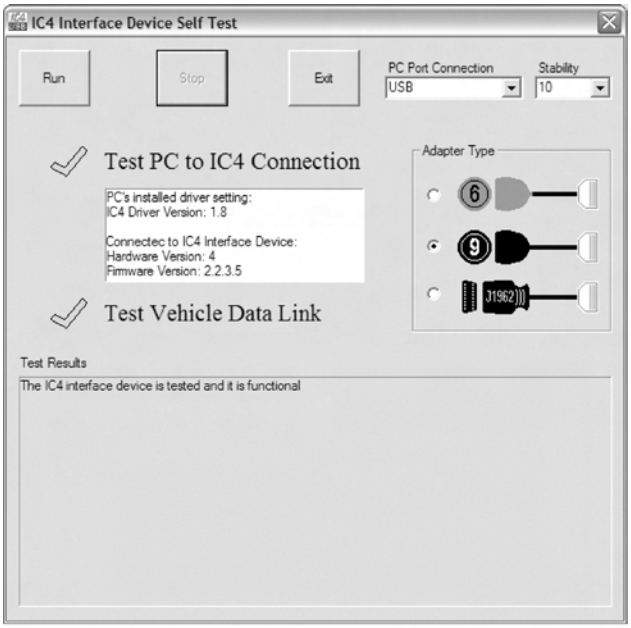


Figure 36 Test result

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

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

Communications (COM)

Open Communications

Figure 37 COM open

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

Figure 38 COM open confirmation

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

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

Close Communications

Figure 39 COM close

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

Diagnostic Trouble Codes (DTCs)

Reading DTCs with EST

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

Figure 40 Viewing DTCs

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

Clearing DTCs

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

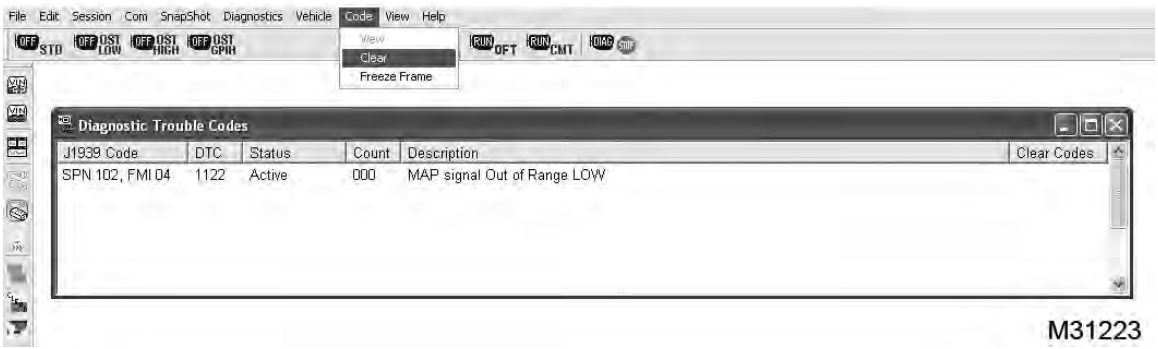


Figure 41 Clearing DTCs

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

Session Files

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

Opening Session File

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

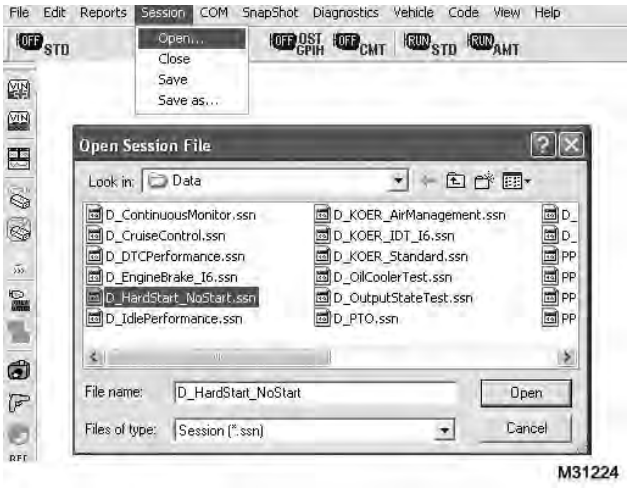


Figure 42 Open session file

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

Adding and Deleting Session Parameter Identifiers (PIDs)

1. Open desired session file.

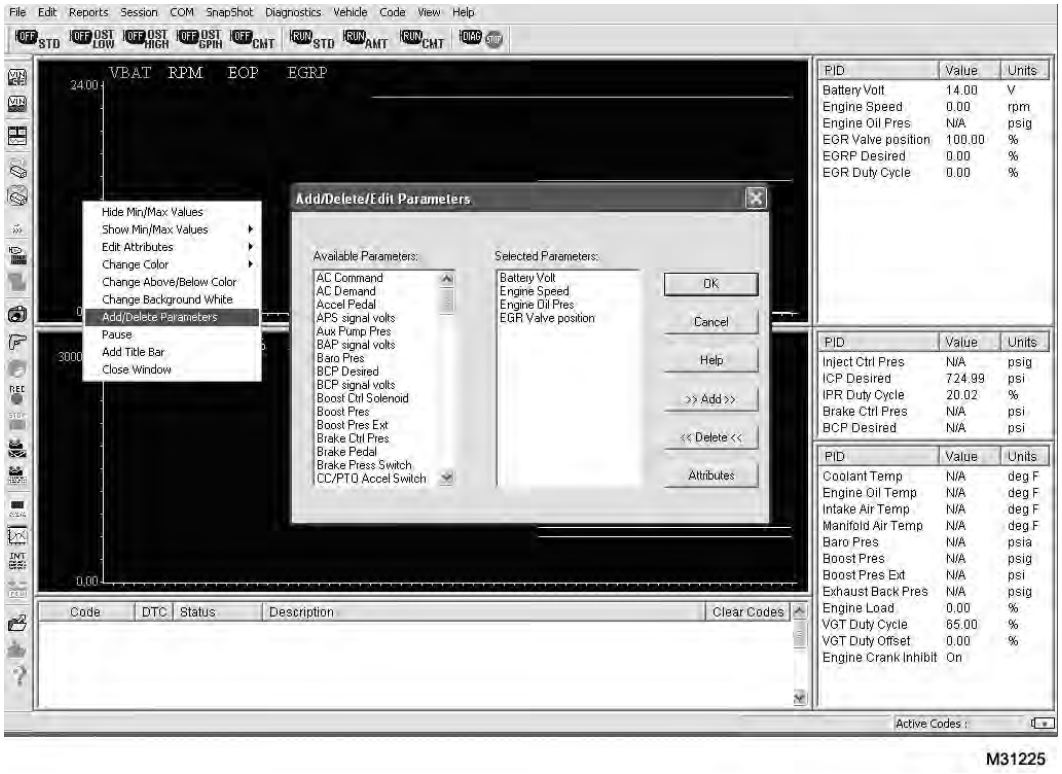


Figure 43 Add/Delete/Edit PIDs

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

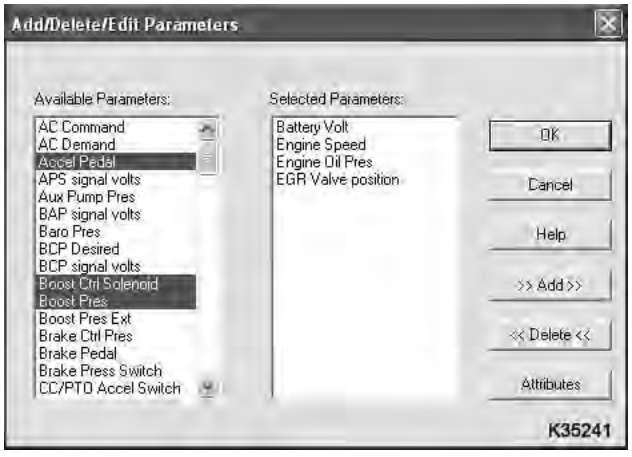


Figure 44 Selecting additional PIDS

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

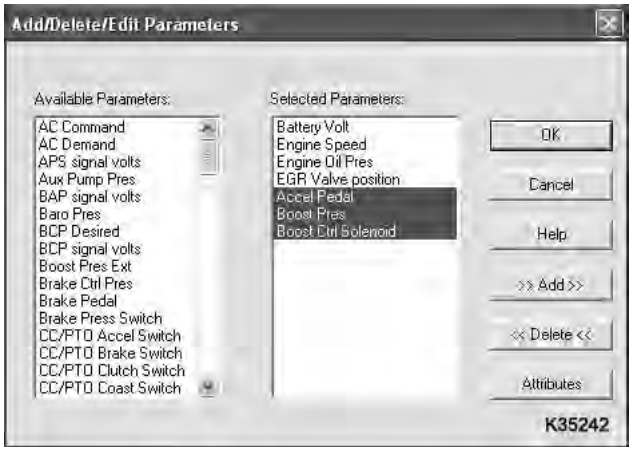


Figure 45 Additional PIDS added to session

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

8. Select OK to return to the session file.

Closing Session File

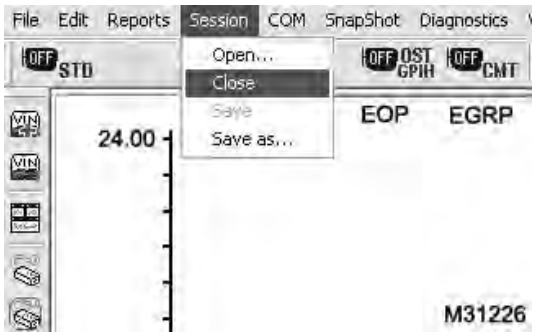


Figure 46 Closing session file

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

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

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

VIN+ Session

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

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

Figure 47 Select VIN+ icon

3. Select the VIN+ icon.

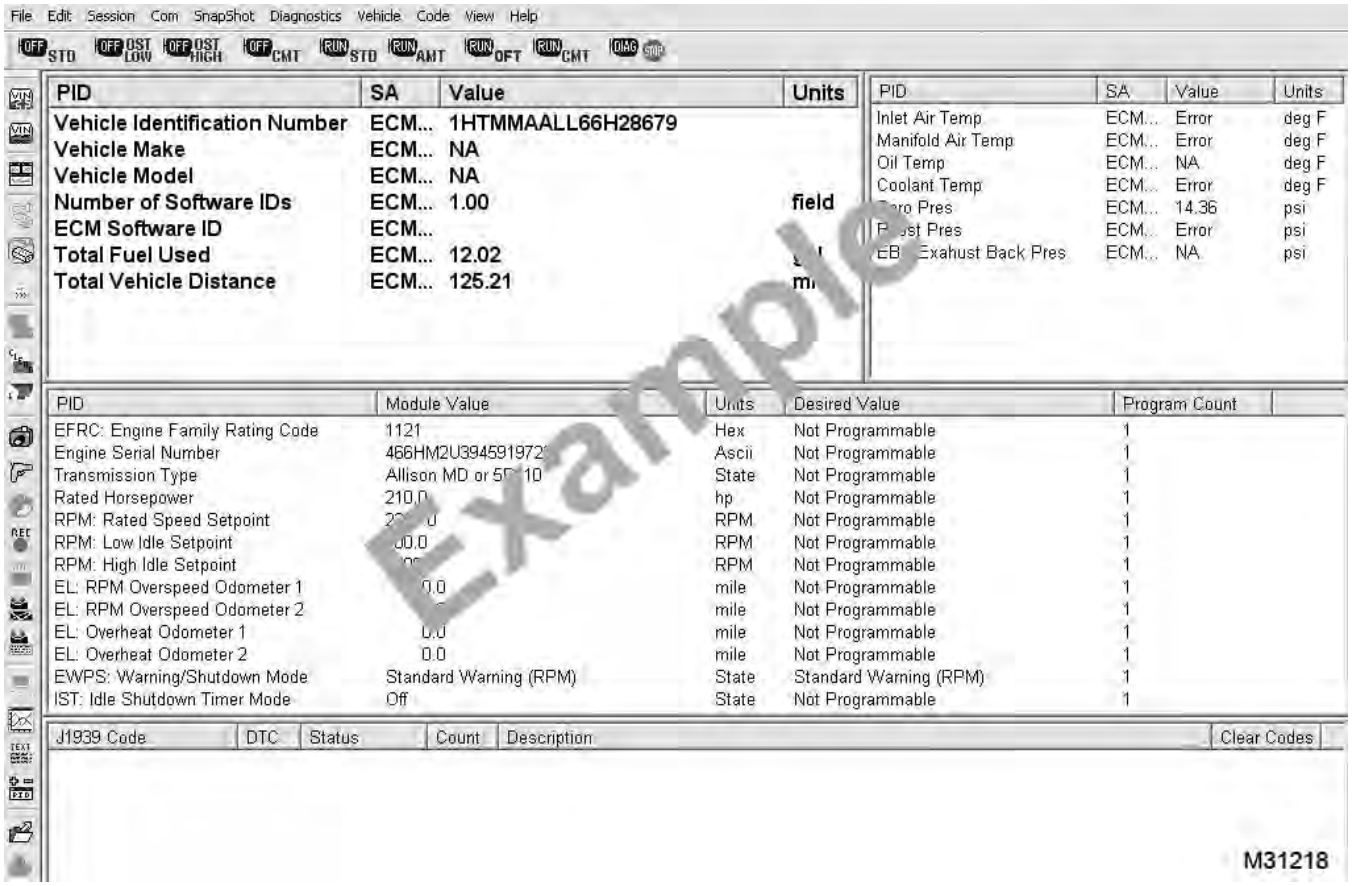


Figure 48 VIN+ session (example)

4. The VIN+ session is displayed on screen.

Snapshots

Opening Specific Snapshots

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

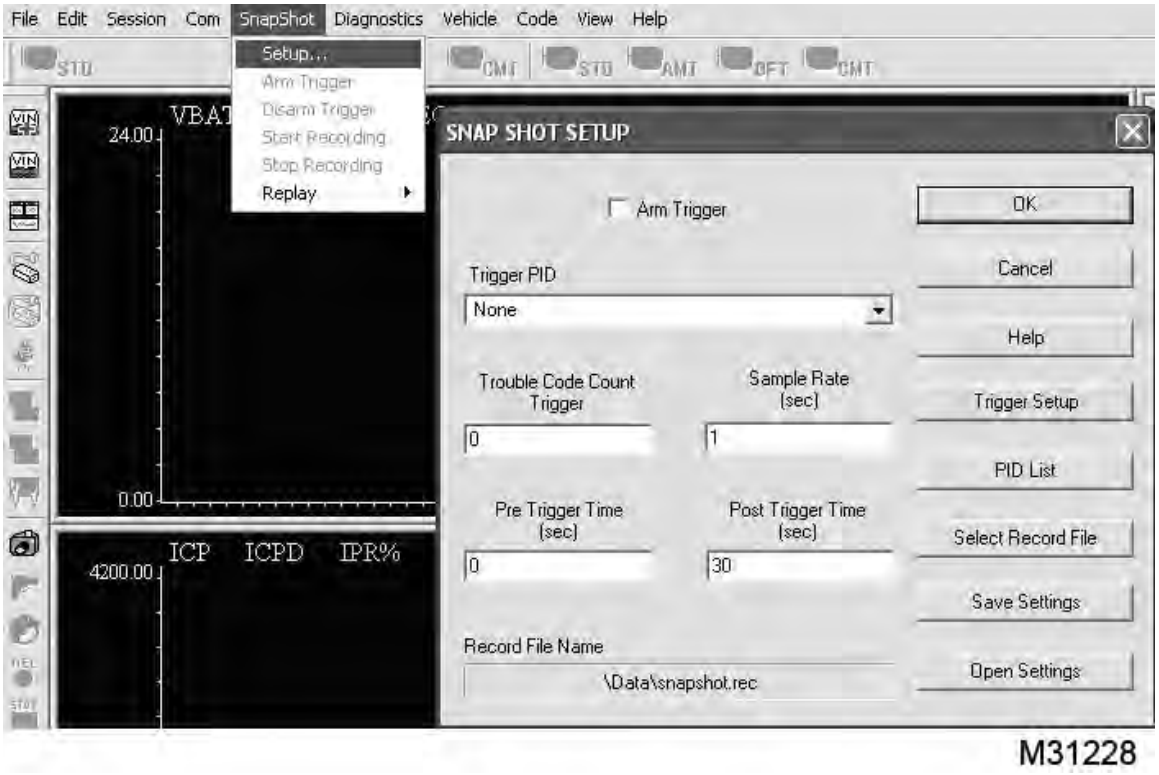


Figure 49 Opening specific snapshot

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

Opening Basic Snapshots

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

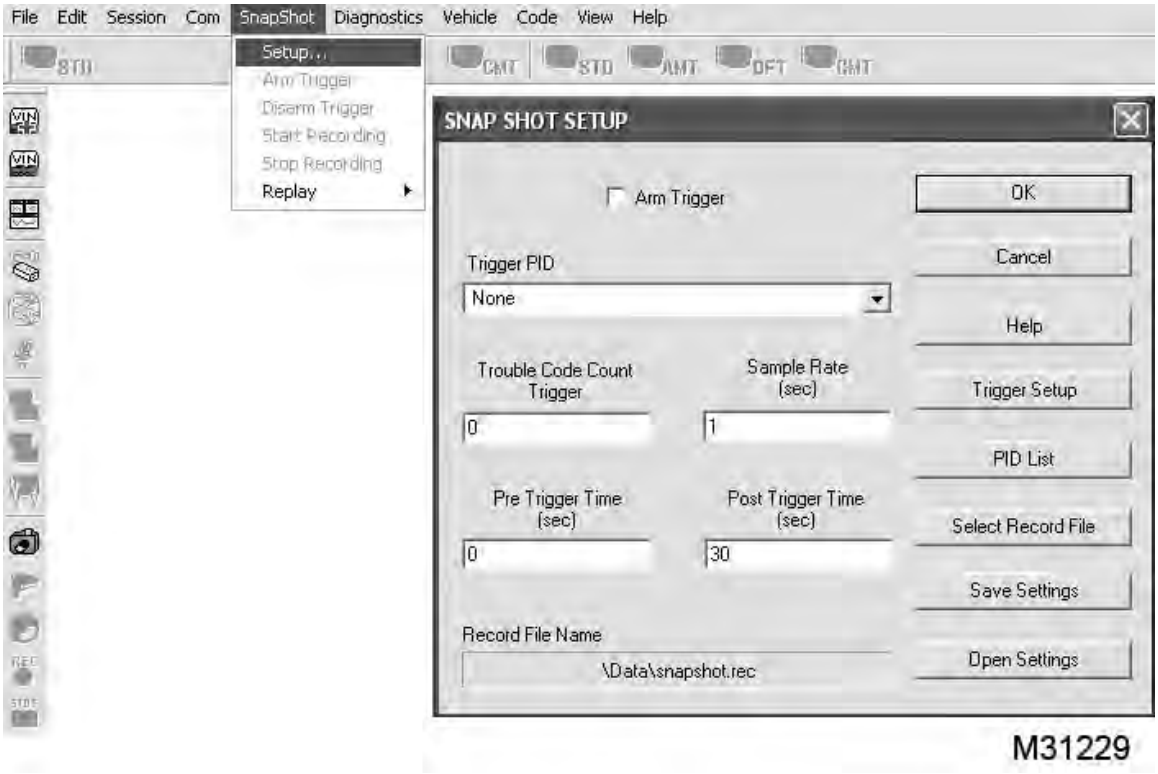


Figure 50 Opening basic snapshot

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

Snapshot Set-Up

Snapshot Trigger using Active DTCs

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

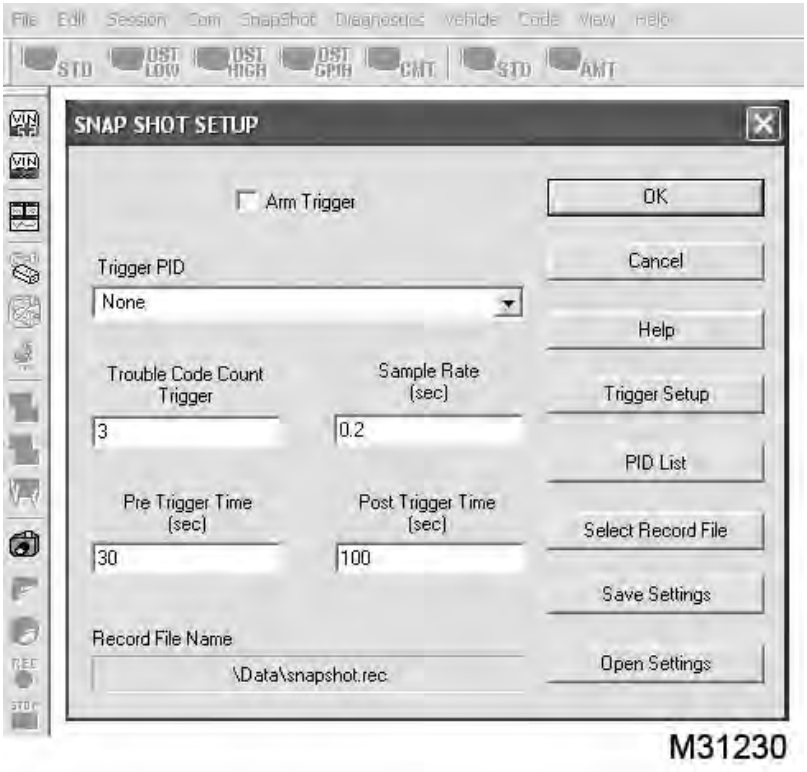


Figure 51 Snapshot for active DTC trigger

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

Figure 52 Arm trigger box

Snapshot Trigger using Parameter Identifier (PID)

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

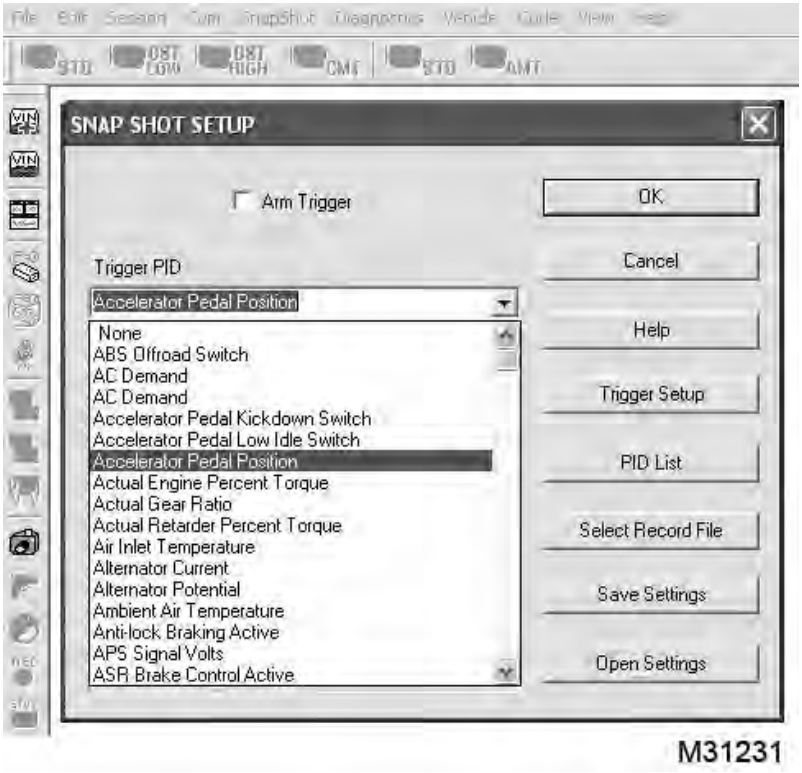


Figure 53 Selecting PID trigger

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

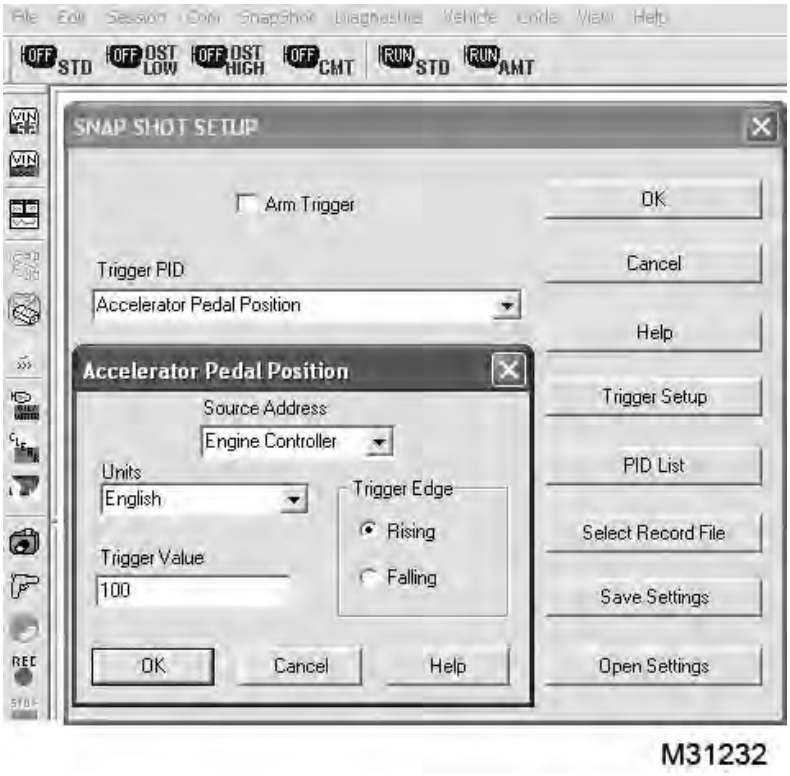


Figure 54 PID trigger set-up

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

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

Figure 55 Arm trigger box

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

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

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

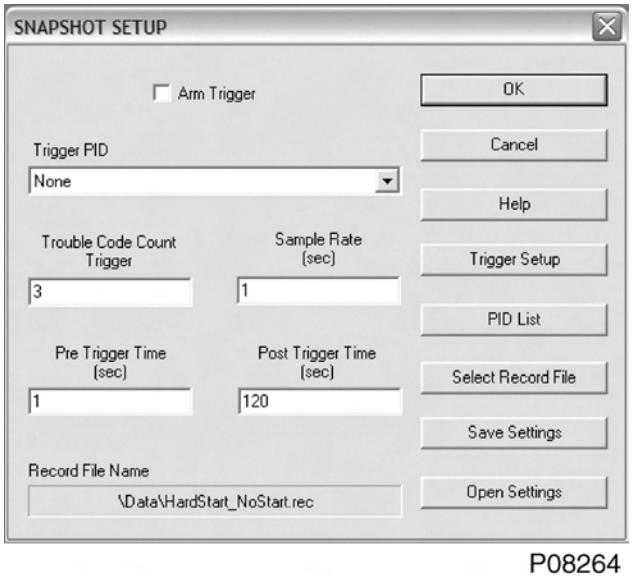


Figure 56 Adjusting snapshot times

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

   Sample Rate adjusts the interval for each recording.

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

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

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

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

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

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

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

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

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

Snapshot PID List

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

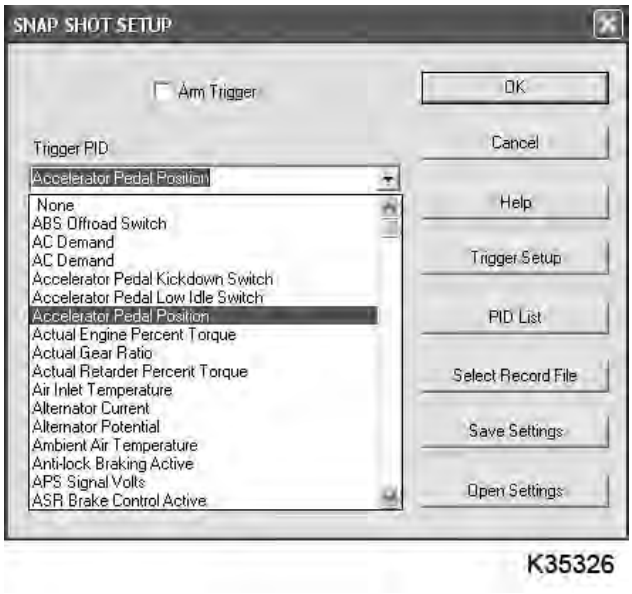


Figure 57 Selecting PIDs to record

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

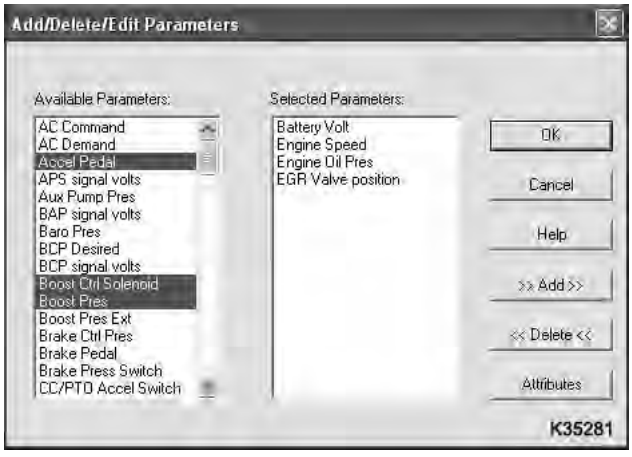


Figure 58 Selecting additional PIDS for snapshot

2. Select additional PIDs in the left column.
3. Select the ADD button to move the selected PIDs to the right column.

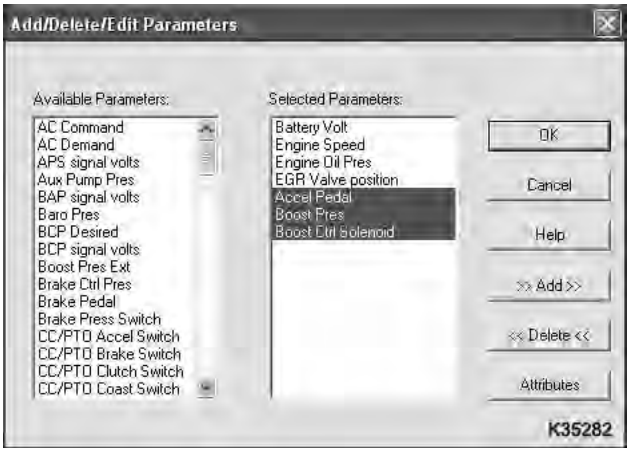


Figure 59 Additional PIDS added to snapshot

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

Rename REC Files

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

Figure 60 Naming REC file

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

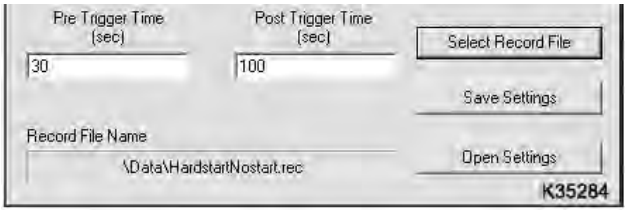


Figure 61 Verify REC file name

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

Manual Trigger Snapshots

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

Figure 62 Recording active

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

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

6. Select snapshot STOP button on the side toolbar.

   The recording status will change to inactive.

Figure 63 Recording not active

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

Replay Snapshot Graphic

1. Open MasterDiagnostics®.

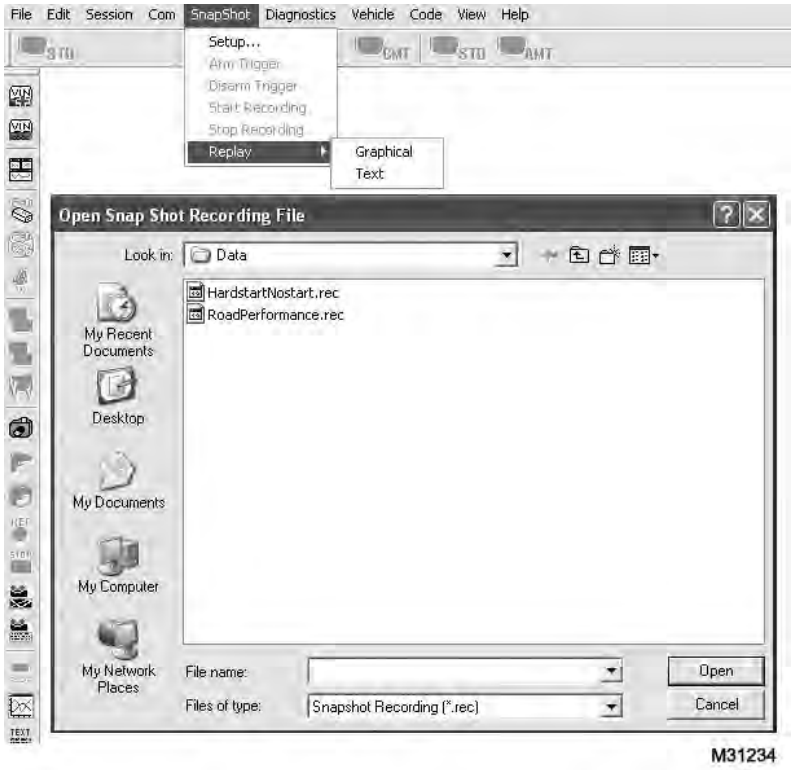


Figure 64 Replaying REC file

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

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

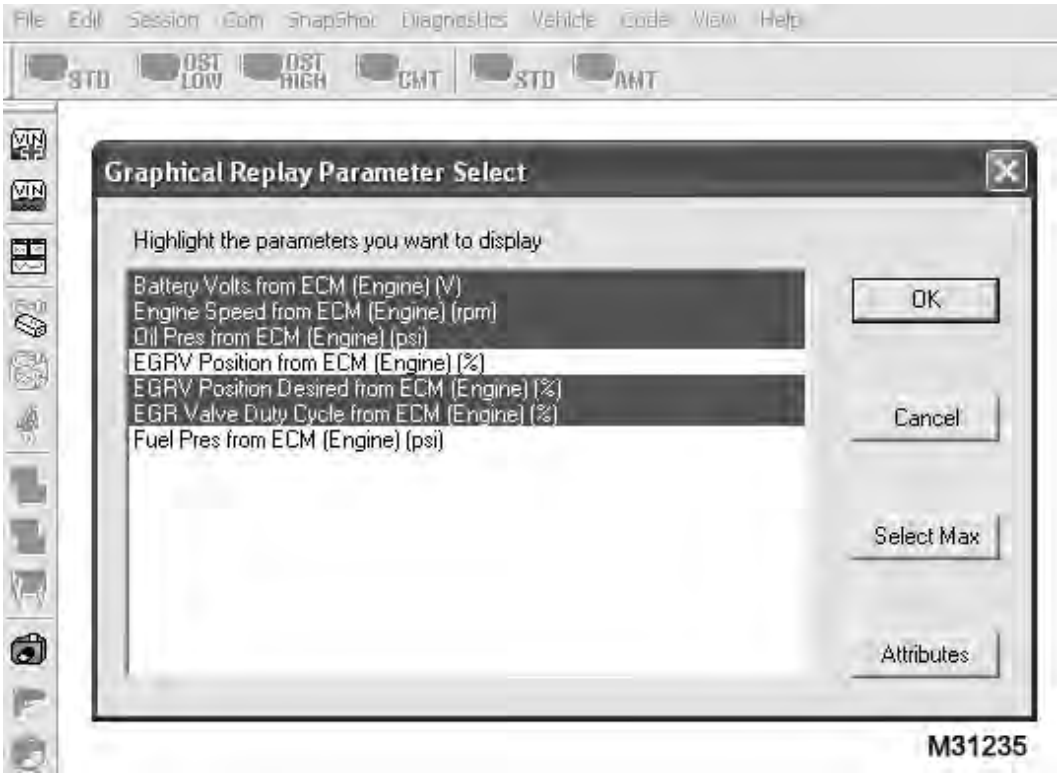


Figure 65 Selecting PIDs to replay

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

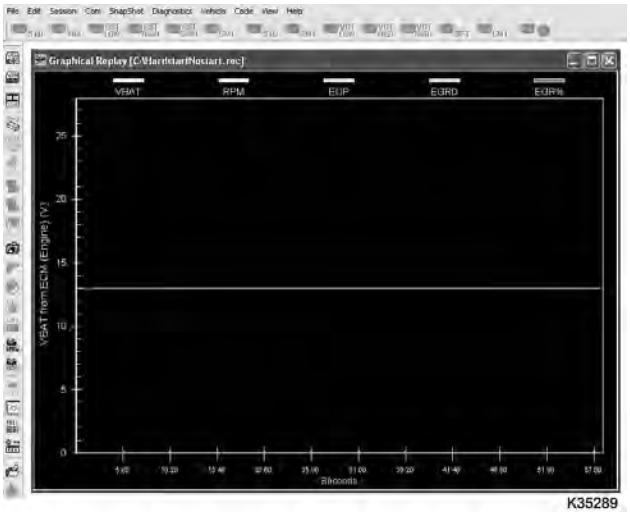


Figure 66 REC file graph view

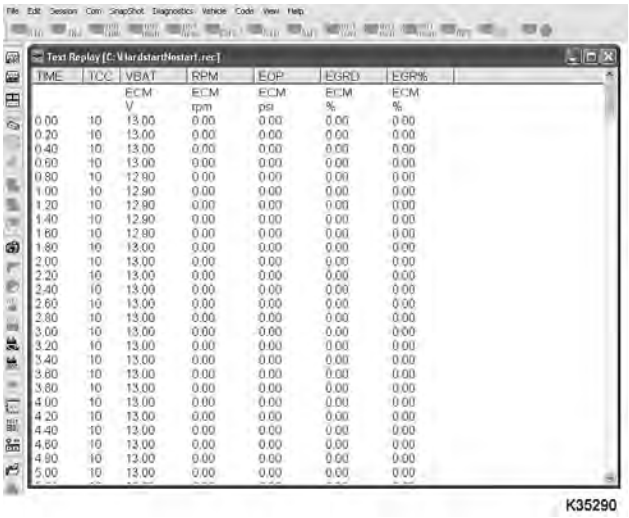


Figure 67 REC file text view

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

Diagnostic Tests

Key-On Engine-Off Tests

Standard Test

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

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

The ECM cycles the following actuators:

- FVCV
- EFAN relay
- RSE
- GPC
- FPCV
- ITV
- VGT
- EGR valve

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

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

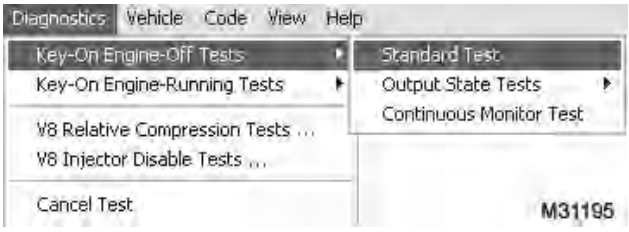


Figure 68 Standard test menu

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

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

Output State Low Test

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

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

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

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

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

- FVCV
- FPCV
- EFAN relay
- VGT
- RSE
- EGR valve
- GPC

1. Turn ignition switch to the ON.

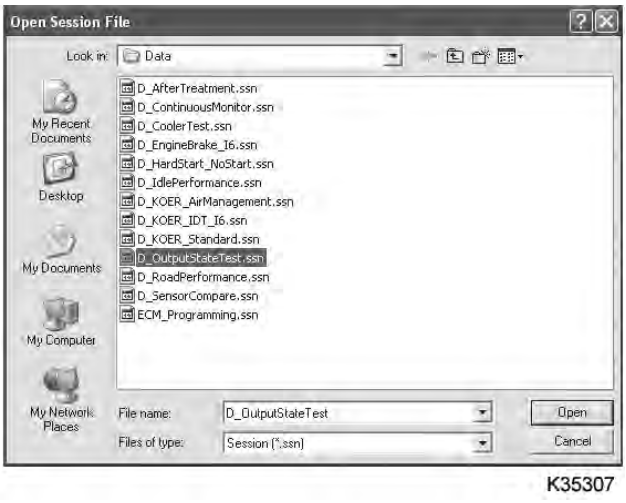


Figure 69 Output state test session

2. Open session and select D_OutputStateTest session from menu.

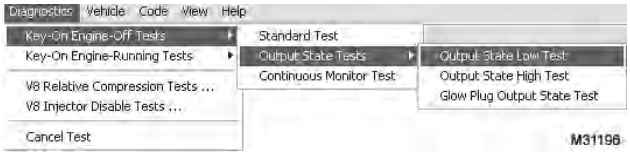


Figure 70 Output state low test menu

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

Output State High Test

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

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

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

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

The VGT actuator is activated when toggled high during the test.

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

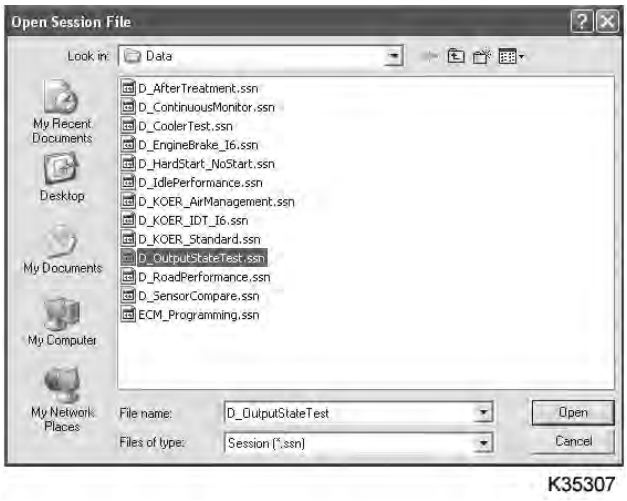


Figure 71 Output state test session

2. Open session and select D_OutputStateTest session from menu.

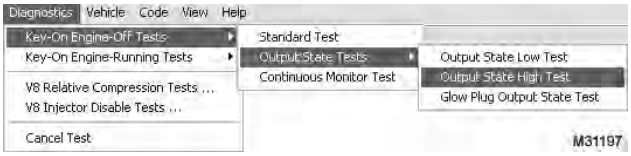


Figure 72 Output state high test menu

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

Glow Plug Output State Test

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.

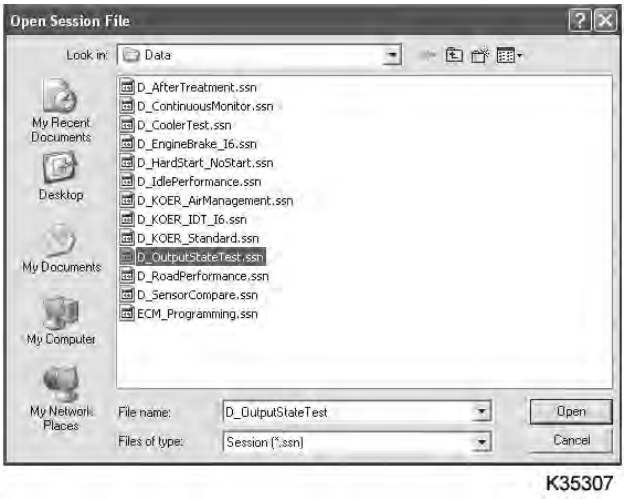


Figure 73 Output state test session

1. Open session and select D_OutputStateTest session from menu.

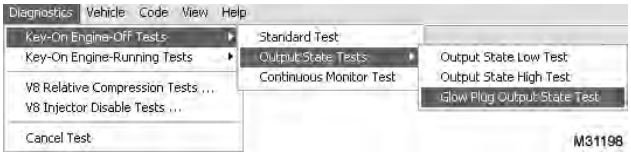


Figure 74 Glow plug output state test menu

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

Key-On Engine-Running Tests

Standard Test

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

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

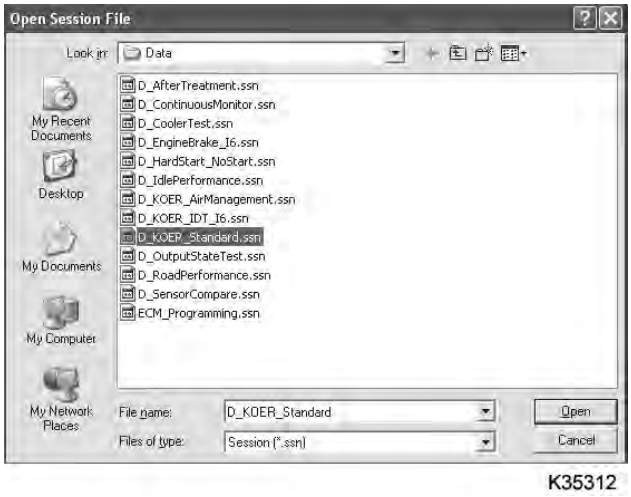


Figure 75 KOER standard session menu

1. Open session and select D_KOER_Standard session from menu.

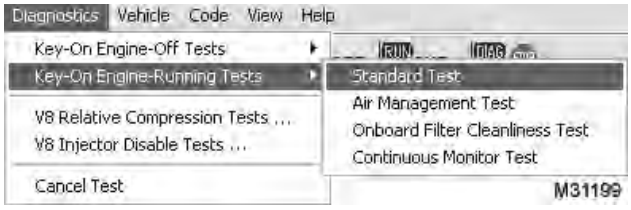


Figure 76 Standard test menu

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

Engine Aftertreatment Test

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

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

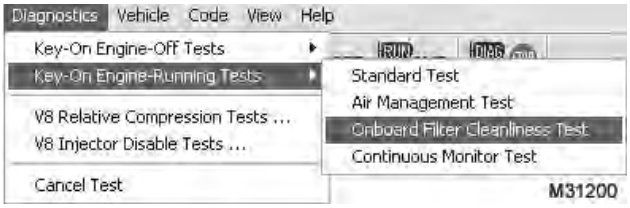


Figure 77 Engine aftertreatment test menu

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

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

   The ECM will monitor the effects of the regeneration system by using feedback signals from the temperature and pressure sensors.
4. Follow the on-screen instructions.
5. To cancel test, select Diagnostics from menu bar, then Cancel Test.

Air Management Test

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

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

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

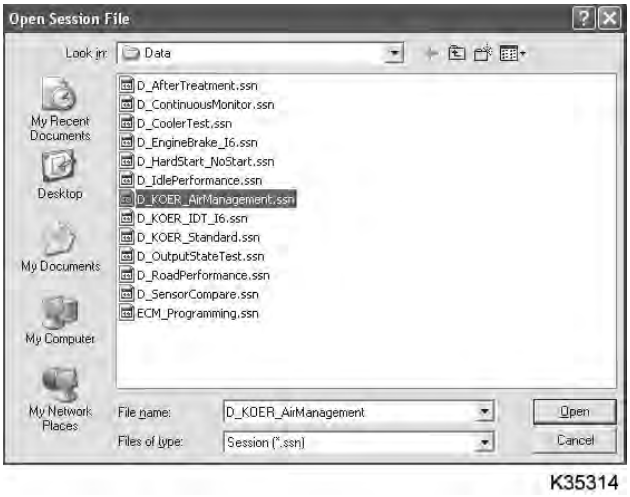


Figure 78 Air management session

1. Open session and select D_KOER_AirManagement session from menu.

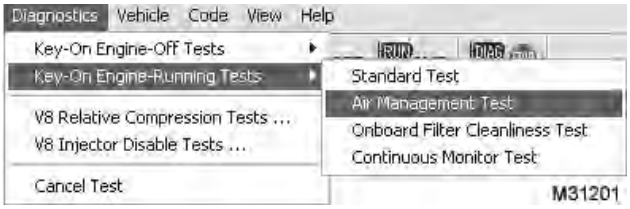


Figure 79 Air management menu

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

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

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

Continuous Monitoring – Troubleshooting Intermittent Connections

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

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

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

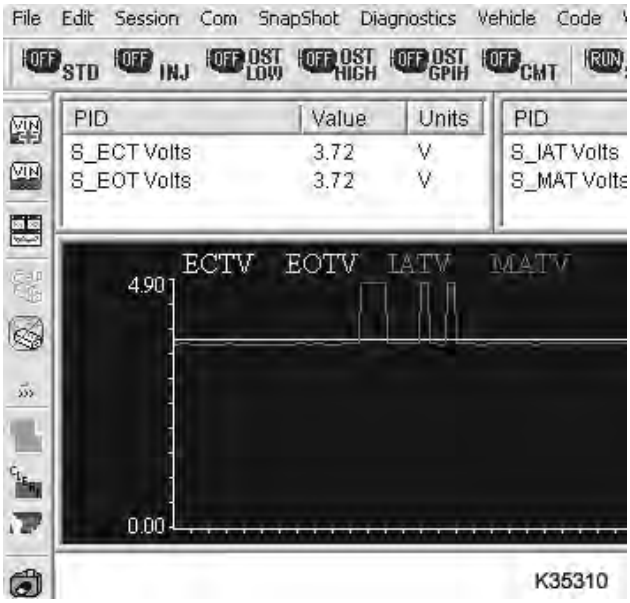


Figure 80 Continuous monitoring

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

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

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

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

Injector Disable Test

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

NOTE: The EOT indicator will change from red to green when engine temperature reaches acceptable temperature.

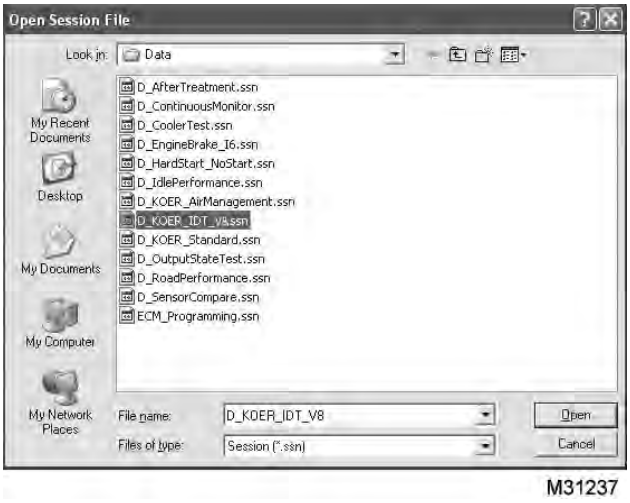


Figure 81 Injector disable session

1. Open session and select D_IDT_V8 session from menu.

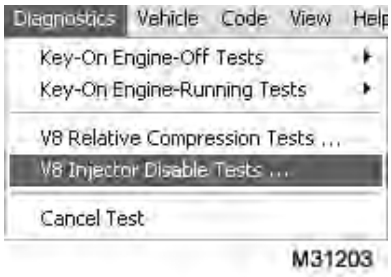


Figure 82 Injector disable test menu

2. Select Diagnostics from menu bar and V8 Injector Disable Test from drop down menu.

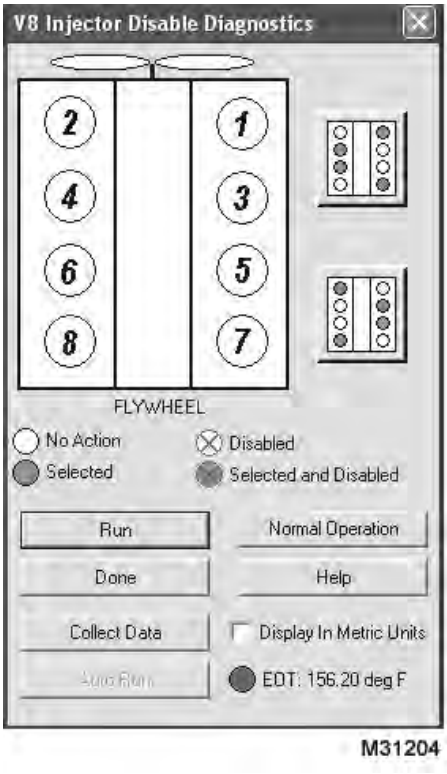


Figure 83 Injector disable test

3. Select cylinder number and select Run. The selected injector will be disabled and engine noise should change.

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

4. Select Normal Operation. The selected injector will be enabled and engine noise should return to previous state of operation.

   If a change is not heard or felt, increase engine to 1000 rpm and evaluate injector again.

5. Repeat steps 3 and 4 for the remaining cylinders.

6. To cancel test, select Diagnostics from menu bar, then Cancel Test.

Relative Compression

Do not use this test to diagnose a cylinder balance problem. Currently it is unreliable to detect low compression cylinders.

See “Performance Diagnostics” section for Manual Compression test using a Cylinder Compression Gauge and Compression Test Adapter.

Reset Engine Change Oil Message

Reset Message with EST

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

General Information

Installed MasterDiagnostics® Version

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

Approved Interface Cable

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

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

Table of Contents

Coolant System

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

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

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

WARNING: To prevent personal injury or death, allow engine to cool before working with components.

Air Compressor Leak Test

1. Drain coolant from the system.

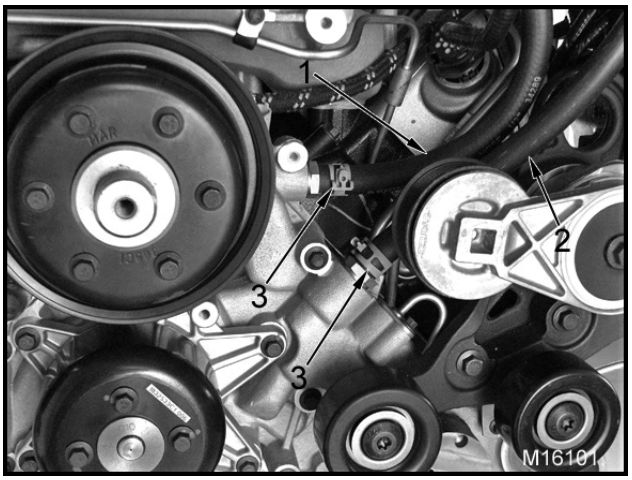


Figure 84 Air compressor coolant hoses

1. Coolant return hose
2. Coolant supply hose
3. Hose clamp (2)

2. Remove two hose clamps and disconnect the coolant supply and return hoses for the air compressor from the crankcase.
3. Fill air compressor coolant passage and hoses with coolant.

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

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

4. Adapt air pressure fitting and regulator to one of the coolant hoses and block opposite hose.
5. Pressurize air compressor coolant hoses to 96 kPa (14 psi).
   - If a leak is noticed, repair or replace the air compressor.
   - If coolant is not leaking, see Front Cover Inspection (page 86) in this section.
6. Test the cooling system again after any repair to validate the repair.

Combustion Leaks to Coolant

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

Symptom

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

Possible Causes

- Improper service
- Failed injector sleeve
- Failed air compressor
- Failed head gasket
- Failed (Exhaust Gas Recirculation) EGR cooler
- Failed glow plug sleeves
- Porous cylinder wall

The likely cause of combustion gas leakage to the cooling system is an EGR failure. However, this should not be considered unless there is evidence of engine overheating or high engine mileage without proper coolant conditioning.

Tools

- Radiator Pressure Testing Kit
- Plastic surge cap adapter
- EGR Cooler Test Plates
- Cylinder Head Test Plate
- Radiator Pressure Testing Kit
- Compression Test Adapter
- Cylinder block heater

Combustion Leak Test (Low-pressure)

1. If the engine equipped with an air compressor, verify that the excess coolant comes from a combustion leak and not the air compressor.
2. Plug in the cylinder block heater, if available, to warm coolant.
   - If the engine is equipped with an air compressor, go to the next step.
   - If the engine is not equipped with an air compressor, go to step 4.
3. Close off both supply and return coolant hoses for the air compressor using hose pinch-off pliers. Run the engine to test the coolant system for combustion leakage.
   - If coolant continues overflowing from the deaeration tank, go to the next step.
   - If coolant stops overflowing from deaeration tank, repair or replace the air compressor, see Air Compressor Leak Test (page 81) in this section.

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

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

4. Install Radiator Pressure Testing Kit with appropriate adapter on the deaeration tank.
5. Pressurize the cooling system to 96 kPa (14 psi).
6. Remove glow plug harnesses and glow plugs for all cylinders.
7. Clean glow plug sleeves with cotton swabs.
8. Verify that the cooling system is still pressurized at 96 kPa (14 psi).

WARNING: To prevent personal injury or death, be aware that crankshaft may rotate suddenly when a cylinder is pressurized.

9. 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. If installed, leave cylinder block heater plugged in.

- If leak is found, go to the next step.
- If no leakage is found, go to Combustion Leakage Test (High-pressure) (page 83) in this section.

NOTE: It is not necessary to remove the cylinder heads to remove and replace the injector and glow plug sleeves.

10. 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.

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

11. If the injector and glow plug sleeves were replaced, retest the cylinder head with Cylinder Head Test Plate to verify repair.
12. Reinstall cylinder head on the engine as described in the *Engine Service Manual*.
13. Fill the deaeration tank, with coolant, to the FULL mark.

Combustion Leakage Test (High-pressure)

1. Plug in cylinder block heater, if available, to warm engine coolant.
2. Remove glow plug harnesses and glow plugs for all cylinders, follow procedures in the *Engine Service Manual*.

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

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

3. Fill deaeration tank, with coolant, to the FULL mark.
4. Install the Compression Test Adapter in the glow plug bore and adapter gauge end to accept shop air pressure 690 to 1100 kPa (100 to 160 psi).

   NOTE: Verify that the O-ring is on the Compression Test Adapter when it is installed and removed from glow plug bore.

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

WARNING: To prevent personal injury or death, be aware that crankshaft may rotate suddenly when a cylinder is pressurized.

5. Bar engine over so that valves are shut on cylinder to be tested. Apply shop air for a minimum of three minutes to ensure leaking air can arrive at deaeration tank.
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.
7. Release air pressure, bar engine over so the next set of valves are shut on cylinder to be tested. Repeat steps 4 through 6 until all cylinders have been tested.
8. Unplug coolant heater.
9. If a leak is found, go to the next step.

   If no leak is found, remove one cylinder head from the engine following the procedures in the *Engine Service Manual*. Check that the cylinder head is within specifications by doing all inspections and the cylinder head pressure test. Inspect cylinder head gasket for coolant leaks and verify crankcase and cylinder head surface flatness using a straight edge and feeler gauge. Inspect crankcase and cylinder bores. If leak is not found, remove second cylinder head and do all inspections and the cylinder head pressure test.

10. Remove leaking cylinder head from engine following the procedures in the *Engine Service Manual*. Do all inspections and cylinder head pressure test 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. Inspect crankcase and cylinder bores.

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

11. If the injector and glow plug sleeves were replaced, retest the cylinder head with the Cylinder Head Pressure Test Plate to verify repair.
12. Reinstall cylinder head on engine as described in the *Engine Service Manual*.
13. Fill deaeration tank, with coolant, to the FULL mark.

Coolant Leak to Exhaust/Intake

Symptoms

- Coolant residue at exhaust manifold flanges
- Engine overheating
- Coolant smell in exhaust
- Coolant leaking from exhaust
- Severe case - engine hydraulic lock

Possible Causes

- Failed EGR cooler
- Injector cup and gasket leak
- Intake side of cylinder head cup plugs leaking
- Porosity in cylinder head castings
- Blown or leaking cylinder head gasket

Tools

- Radiator Pressure Testing Kit
- Plastic surge cap adapter
- EGR Cooler Pressure Test Plate (ZTSE4707)
- Cylinder block heater

EGR Cooler Inspection

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

WARNING: To prevent personal injury or death, carefully remove turbocharger exhaust tubing. Coolant in tubing could splash out and create slippery conditions.

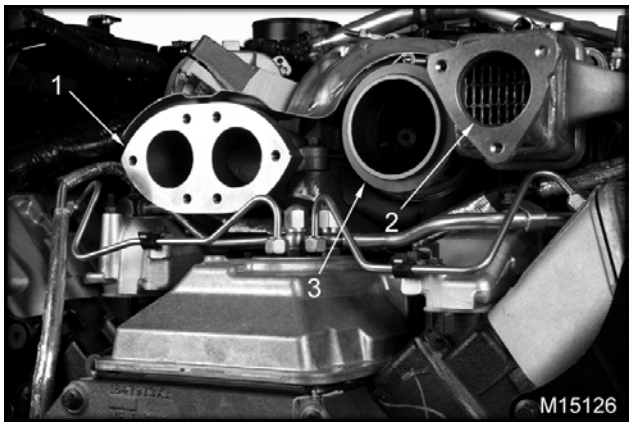


Figure 85 Exhaust ports

1. Turbocharger inlet ports
2. EGR cooler inlet port
3. Turbocharger exhaust outlet

1. Remove turbocharger to exhaust tubing and the inlet tube to EGR cooler following the procedures in the *Engine Service Manual*.
2. Check for presence of coolant in tubing, exhaust manifolds and EGR cooler exhaust inlet.
3. Plug in the cylinder block heater, if available, to warm coolant.

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

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

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

4. Install Radiator Pressure Testing Kit with the appropriate adapter.
5. Pressurize cooling system to 96 kPa (14 psi).
6. Check EGR cooler exhaust inlet for 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 the next step.
7. Drain coolant from the system.
8. Remove and pressure test the EGR cooler following the procedure in the *Engine Service Manual*.
   - If a leak is noticed, replace the EGR cooler.
   - If a leak is not noticed, install the EGR cooler following the procedure in the *Engine Service Manual*.
9. Fill cooling system.
10. Pressurize cooling system to 96 kPa (14 psi).
11. Remove valve covers and inspect cylinder head for cracks, porosity, and leaking cup plugs.

Coolant in Lube Oil

Symptom

Crankcase lube oil contaminated with coolant will generally cause the oil to thicken and turn gray. The crankcase may also be overfilled.

Possible Causes

- Glow plug sleeve leak
- Coolant leak past EGR O-rings
- Accessory leak (water cooled air compressor)
- Injector sleeve leak
- Cylinder head cup plug failure
- Cylinder head gasket leak
- Oil filter base assembly and oil cooler bundle failure
- Front cover gasket damage
- Front cover, cylinder head, or crankcase porosity

Tools

- Radiator Pressure Testing Kit
- Plastic surge cap adapter
- Cylinder block heater

Lube Oil Contamination

1. Check coolant level and oil level gauge to verify oil contamination complaint.
   - Coolant in the oil will generally cause the oil to thicken and turn gray black.
   - If coolant in the oil can not be verified, an oil sample can be taken for analysis.
2. Plug in cylinder block heater, if available, to warm coolant.
3. If engine is equipped with an air compressor, isolate compressor from the engine and test for coolant leak. See Combustion Leak Test (Low-pressure) (page 82) in this section.
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.

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

5. Pressurize cooling system to 96 kPa (14 psi).
6. If coolant system pressure is dropping and no coolant is leaking from oil pan, do the next step. If coolant is leaking into oil pan, inspect the following:

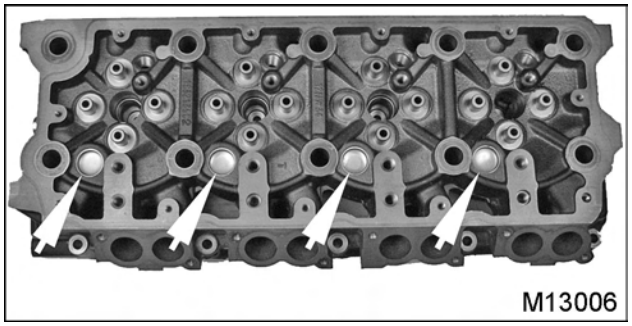


Figure 86 Cylinder Head Cup Plugs

- Inspect entire cylinder head area for leaks at the cup plugs.
- If no leaks are found in above areas, go to step 9, and inspect for upper crankcase leakage.

WARNING: To prevent personal injury or death, be aware that crankshaft may rotate suddenly when a cylinder is pressurized.

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, continue with Cylinder Head Leak Test, step 5 (page 87).
   - If leaks are not found, continue with step 8.
8. Remove upper and lower oil pans following the procedures in the *Engine Service Manual*.

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

9. Inspect for leakage in crankcase.
   - Verify 96 kPa (14 psi) pressure is maintained on radiator pressure tester.
   - If no leakage is found, do the next step.

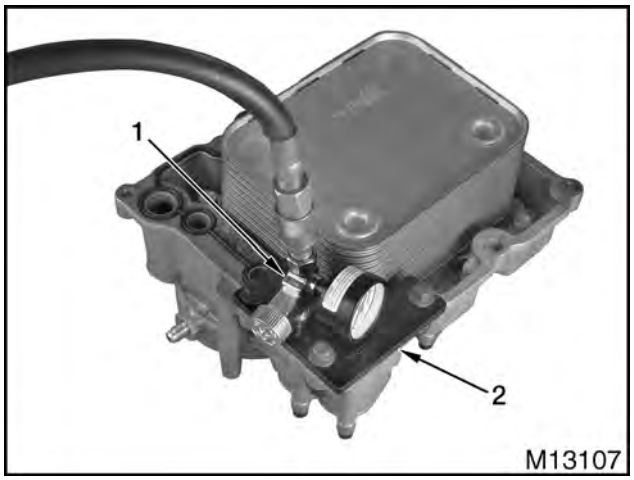


Figure 87 Oil cooler cover assembly pressure test

1. Air pressure regulator
2. Oil Cooler Pressure Test Plate (ZTSE4730)

10. Remove and test the oil cooler and oil filter housing following the procedures in the *Engine Service Manual*.
    - If a leak is found, replace oil cooler assembly.
    - If no leak is found, see Front Cover Inspection (page 86) in this section.

Front Cover Inspection

1. Remove front cover and inspect gaskets and sealing surfaces following the procedure in the *Engine Service Manual*.
2. Reinstall front cover following the procedure in the *Engine Service Manual*.
3. Test the cooling system again after any repair to validate the repair.

Cylinder Head Leak Test

WARNING: To prevent personal injury or death, comply with the following:

- Read all safety instructions in the “Safety Information” section of this manual.
- When draining fuel, store diesel fuel properly in an approved container designed for and clearly marked DIESEL FUEL.
- Do not smoke.
- Keep vehicle away from open flames and sparks.

1. Remove valve covers following the procedure in the *Engine Service Manual*.
2. Plug in cylinder head heater, if available, to warm coolant.

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

3. Pressurize the cooling system to 96 kPa (14 psi)
4. Inspect both cylinder heads for cracks or leaks at the cup plugs.
    - If leaking, repair or replace cracked or leaking component.
    - If not leaking, do the next step.
5. Drain coolant from system.
6. Remove one cylinder head from engine following the procedures in the *Engine Service Manual*.
7. Inspect and pressure test cylinder head following procedures in the *Engine Service Manual*.

- Inspect cylinder head gasket for damage at sealing points. Verify crankcase and cylinder head surfaces flatness using a straightedge and feeler gauge. Replace cylinder head gasket and head bolts. Repair or replace cylinder head if necessary.
- If glow plug or injector sleeve was replaced, retest cylinder head with pressure test plate to verify repair.
- Inspect cylinder head for cracks in the coolant passages. Repair or replace.

8. Inspect crankcase top deck coolant passages and cylinders for cracks following procedures in the *Engine Service Manual*.
9. If no leak is found, repeat steps 6 through 7 for the second cylinder head.
10. Pressure test cooling system to confirm repair.
11. Fill cooling system.

Coolant Over-Temperature

Symptom

When the coolant temperature is above 107 °C (224 °F), Diagnostic Trouble Code (DTC) 2319 will set and the Electronic Control Module (ECM) will command less fueling. A torque loss will occur.

When the coolant temperature is above 109 °C (228 °F), the red ENGINE lamp will be illuminated and DTC 2321 will set.

When the coolant temperature is above 112 °C (234 °F), the red ENGINE lamp will flash, an audible alarm will sound, and DTC 2322 will set. If the vehicle has the warning protection feature enabled, the engine will shutdown after 30 seconds.

Possible Causes

- Low engine coolant level
- Coolant leaks
- Internal or external radiator blockage or wrong radiator
- Water pump failure
- One or both coolant thermostats missing or stuck (closed)
- Slipping cooling fan drive clutch
- Cooling fan blade assembly wrong or damaged
- Broken/worn accessory drive belt
- Accessory belt tensioner failure
- Instrument panel gauge error
- Engine Coolant Temperature (ECT) sensor biased

- Chassis effects, transmission, or aftermarket equipment

Tools

- Radiator Pressure Testing Kit
- Plastic surge cap adapter
- EST with International® Engines MasterDiagnostics® Software
- EZ-Tech® Interface Kit
- Digital Multimeter (DMM)

Coolant Over-Temperature Diagnostics and Repair

1. Check coolant deaeration tank is filled to the FULL mark.

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

2. Inspect the condition of the following items: cooling fan, 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 the cooling fan, cooling fan drive clutch, and radiator are clean of debris and dirt build-up. Clean areas as required.

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

3. Connect Electronic Service Tool (EST) and check for active and inactive Diagnostic Trouble Codes (DTC) related to engine coolant over-temp conditions. Compare Engine Coolant Temperature (ECT), Engine Oil Temperature (EOT), Manifold Air Temperature (MAT), and Intake Air Temperature (IAT) with Key-On Engine-Off. After a cold soak of at least eight hours, all temperature sensors should read within 2 °C (5 °F) of each other.

4. Run engine up to an operating temperature of at least 70 °C (158 °F). Monitor ECT using the EST.

5. Attempt to duplicate the operator's concern of coolant over-temperature.

   - 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.
   - If coolant over-temperature is duplicated, continue with the next step.

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

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

6. Install the Radiator Pressure Test Kit on the deaeration tank and run engine at elevated idle. Monitor the pressure in the system using the tester gauge.

   - If pressure is higher than the pressure rating of the cooling system cap, continue with Combustion Leaks to Coolant (page 82) in this section.
   - If pressure gauge reading is below pressure rating of system, continue with step 7.

7. Remove and inspect thermostats following the procedure in the *Engine Service Manual*. Check for correct opening temperature on both thermostats.

   - Replace as needed. Retest for condition after repair.
   - If both thermostats pass test, continue to next step.

8. Use vehicle diagnostics manual to review automatic transmission diagnostics.

9. If over-temperature condition remains, remove radiator and have it flow tested and cleaned or

replaced. Retest engine for over-temperature condition with repaired or new radiator.

Temperature Sensor Validation Test

1. Connect EST and check for active and inactive DTCs related to engine coolant over-temp conditions.
   - Repair problems relating to coolant over-temp DTCs before continuing.
   - If no DTCs exist, do next step.
2. Using the EST, compare ECT, EOT, and MAT with Key-On Engine-Off. After a cold soak of at least 8 hours, all temperature sensors should read within 2° C (5° F) of each other.
3. Install a manual gauge or DMM with a thermocouple in the EGR cooler inlet port, operate the engine, and use the EST to monitor ECT.
4. Run engine up to an operating temperature of at least 70° C (158° F). While monitoring ECT using the EST, instrument panel coolant temperature gauge and the mechanical or electrical 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 test gauge, refer to the *Electrical System Troubleshooting Guide* for the appropriate model and year of vehicle.
   - If test gauge and EST read values with a difference greater than ± 3° C (± 5° F), do ECT Sensor (Engine Coolant Temperature) - Operational Voltage Check in the in the "Electronic Control Systems Diagnostics" section of this manual.
   - If the gauge is reading correctly and the engine is running over-temperature, go to Cooling System Operating Pressure Test (page 89) in this section.

Cooling System Operating Pressure Test

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

Install the Radiator Pressure Testing Kit on the deaeration tank and run engine at elevated idle. Monitor system pressure using the tester gauge. See if pressure rises above normal value of deaeration tank cap.

- If pressure is higher than the pressure rating of the cooling system cap, go to Combustion Leaks to Coolant (page 82) in this section.
- If pressure gauge reading is below pressure rating of system, replace the thermostats.

Engine Inspection

Symptom

Excessive low power on takeoff or intermittent low power from drive cycle to drive cycle

Possible Causes

Low Power

- Electrical power or ground issue
- Inoperative turbocharger assembly or failed turbocharger actuator
- Aerated fuel
- ECM or electronic control system faults
- Poor fuel quality
- Low supply pressure fuel pressure below specification
- High-pressure fuel pressure below specification
- Fuel injectors not working properly
- Inoperative Intake Throttle Valve (ITV)
- Power cylinders problem
- Valve train problems
- Failed Charge Air Cooler(s) (CAC)
- Failed extension tube(s)
- Aftertreatment (AFT) system issues
- Plugged Diesel Particulate Filter (DPF)

Rough Idle

- Poor fuel quality
- Low supply fuel pressure below specification
- High-pressure fuel pressure below specification

- Aerated fuel
- Electronic control system faults
- Plugged DPF
- Plugged Diesel Oxidation Catalyst (DOC)
- 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 contact
- Loose or worn engine mounts

Tools

- Digital Multimeter (DMM)
- 4-Pin Actuator Breakout Harness
- EST with International® Engines MasterDiagnostics® Software

Low Power (Turbocharger Assembly and Actuator)

For low power issues, perform the tests in the “Performance Diagnostics ” section of this manual.

Rough Idle

1. Confirm conditions when rough idle complaint is present. When does rough idle occur?
   - Hot - operating temperature
   - Cold
   - After high speed operation
   - Over entire engine speed range
   - Combination of the above conditions
   - Is chassis vibration or any other conditions or observations present when engine idles rough.
2. Inspect exhaust system for contact with frame or body of vehicle. Exhaust pipe contact with cab or frame may transmit engine vibrations and noise to cab.

Complete the following performance diagnostic tests in the “Performance Diagnostics” section of this manual.

3. Engine Oil. Check engine oil level. See *Engine Operation and Maintenance Manual*, for proper oil grade at specific temperatures. Confirm oil meets correct API specification for model and year of engine. Make sure engine is not overfilled.
4. Fuel. Verify quality and quantity of diesel fuel, fuel aeration, and fuel pressure. Poor quality fuel or low cetane rating can cause 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.
5. KOEO Standard Test. The KOEO Standard test will verify electrical operation of actuators.
6. Diagnostic Trouble Codes and ECM Calibration. Intermittent sensor, injector, or wiring harness faults can affect engine idle conditions. The ECM may have detected and recorded these conditions.
7. KOER Standard Test.
8. Air Management. The test will verify EGR valve, turbocharger actuator, and ITV movement.
9. Crankcase Pressure.
10. Fuel Rail Pressure. This test will verify the functionality of the fuel rail system. The engine must be at operating temperature 70 °C (158 °F) to do this test.

Engine and Flexplate Balance Inspection

Inspect engine and drivetrain balance. Rough idle that gets worse with no-load acceleration may be caused by an out of balance engine, flexplate, or torque converter. Remove the accessory drive belt to isolate accessories during balance testing.

Inspect vibration damper for cracks and misalignment.

Inspect flexplate for cracks, damage and verify proper orientation. When removing or installing the flexplate, ensure the locating dowel is in the right place and the flexplate is located properly on the dowel.

Inspect the primary balancer shaft to ensure it tis properly installed.

Isolate the engine from transmission by removing the transmission and torque converter. Start the engine and evaluate imbalance. if the engine runs smooth, diagnose the torque converter and transmission, see applicable vehicle *Service Manual*.

Electrical System

ECM Reset (Intermittent Engine Stumble)

Symptom

An Electronic Control Module (ECM) reset occurs when the ECM momentarily reboots or is turned OFF and ON while the engine is operating. Symptoms of this include the following:

- Wait to start lamp cycles ON while engine running
- Glow plugs recycle while engine running
- Engine stumbles and may die
- Loss of accelerator pedal authority
- Miles driven are not logged if ECM reset occurs during current key cycle

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
- 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.

Possible Causes

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

- Poor (intermittent OPEN or high resistance) ground connection
- Poor battery power feed harness connection
- Poor fuse connection
- Intermittent open at connectors
- Poor power relay connection
- Poor module connection, corrosion, or water

Diagnostics for Engine Stumble

1. Do Fuel in the “Performance Diagnostics” section of this manual.

See the “Electronic Control Systems Diagnostics” section of this manual or the application specific truck *Circuit Diagram Manual* and *Service Manual* when performing the following steps.

2. Check all ECM related fuses.
3. Check all Battery, VIGN and ground connections for the ECM.
4. Monitor ECM powers and grounds with breakout box under operator complaint conditions.
5. Monitor injector powers and grounds with breakout harness under operator complaint conditions.
6. If root cause has not been identified in previous steps, continue diagnosis by doing the remaining tests in “Performance Diagnostics” section of this manual.

Fuel System

WARNING: To prevent personal injury or death, do not smoke or park vehicle near open flames or sparks.

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

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

Priming the Fuel System

See the *Engine Operation and Maintenance Manual*, “Section 4 - Engine Operation”, Priming the Fuel System for the correct procedure.

Excessive Fuel Consumption

Symptom

Engine is using more fuel than previously required to perform the same task.

Possible Causes

Operator effects

- Inaccurate record keeping or tank filling
- Winter blend or No. 1 fuel
- Unrealistic 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, or air pressure

Chassis effects

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

Engine effects

- Incorrect or inoperative thermostat(s)
- Failed turbocharger control system
- Fuel system performance loss
- Fuel system leaks
- Base engine performance loss

Verifying Excessive Fuel Consumption Complaints

1. Review operator and fueling records.
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 Truck Computer Analysis of Performance and Economy (TCAPE) report.
4. Do all tests on Performance Diagnostic form or in “Performance Diagnostics” section 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
   - VGT operation
   - Base engine condition
   - Electronic control system condition

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

Fuel in Coolant

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

Symptom

Coolant contaminated with diesel fuel will have a diesel fuel odor.

Possible Causes

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

Fuel in Coolant Leakage Test (Low-pressure)

1. Remove both fuel lines at the fuel cooler.

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

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

2. Remove radiator cap.
3. Verify coolant contamination.
    - Check for diesel fuel odor in coolant.
    - Coolant may be discolored if diesel fuel is present.
4. Fill deaeration tank with coolant to the FULL mark.
5. Plug in the cylinder block heater, if available, to warm coolant.

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

6. Install Radiator Pressure Testing Kit with appropriate adapter on the deaeration tank. Pressurize cooling system to 96 kPa (14 psi).
7. Inspect the fuel cooler for any coolant coming from the fuel side. If the cooler is leaking, replace the cooler and retest.
8. If the fuel cooler is not leaking, remove fuel injector return line banjo fittings and check valves on front of cylinder heads following the procedures in the *Engine Service Manual*.
9. Inspect the fuel injector return line bores at cylinder heads for coolant leaks.
    - If leak is found, remove valve cover and fuel injectors from the suspect cylinder head, following procedures in the *Engine Service Manual*. Observe injector sleeves for leakage. 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 Coolant Leakage Test (High-pressure)

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

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

1. Verify coolant contamination.
    - Check for diesel fuel odor in coolant.
    - Coolant may be discolored if diesel fuel is present.
2. Fill deaeration tank with coolant to the FULL mark.
3. Plug in the cylinder block heater, if available, to warm coolant.

NOTE: When removing the cylinder head injector return line banjo bolts, fuel may leak out. Put in a suitable container to collect this leakage. Collect and dispose of this fuel according to local regulations.

4. Remove the left and right cylinder head injector return line banjo bolts, following the procedures in the *Engine Service Manual*.

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

5. Individually pressurize both fuel injector return lines from the cylinder heads to 550 to 690 kPa (80 to 100 psi) using the Fuel Line Test Adapter.

Observe deaeration tank for air bubbles or loss of pressure at gauge.

- If leak is found, do all inspections and test cylinder heads to verify leak path. Repair cylinder head, as necessary.
- If no leak is found, continue with Fuel in Coolant Leakage Test (Low-pressure) (page 92) in this section.

Fuel In Lube Oil

Symptom

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

Possible Causes

Leaking fuel under the valve cover

- High-pressure fuel pump
- Fuel rail pressure sensor
- Excessive DPF regenerations
- Fuel rail to fuel injector supply lines
- Fuel injector(s)
- 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

Tools

- One gallon of clean diesel fuel
- Indicator dye mix (2 oz.)
- UV Leak Detection Kit (black light)

Verifying Fuel Dilution from Oil System

1. Verify oil contamination. Perform a white paper test.

NOTE: The black light requires warm-up time. Turn on the black light.

2. Perform a fuel leakage test.

NOTE: Only use indicator dye approved for use with diesel fuel.

   a. Verify that there is no dye existing in the oil before starting the dye test.

   b. Supply the engine with an alternate supply of clean diesel fuel with the manufacturers recommendations for the amount of dye per gallon to be added.

   c. Remove the left and right glow plug harnesses from both cylinder head valve covers.

   d. Turn ignition switch to ON, run the engine at high idle until dye is seen through a glow plug hole using the UV leak detection kit, or a maximum of five minutes. Turn ignition switch to OFF.

   e. If dye was visible through a glow plug hole, remove the valve cover of the suspect cylinder head and inspect all internal fuel connections for leaks.

   f. If no dye was visible through any glow plug hole, remove both valve covers and check all internal fuel connections for leaks.

3. If no leaks are found under both valve covers, contact Technical Services for further assistance.

Fuel to Exhaust

Symptom

Fuel leaking into the exhaust results in a wet exhaust system and possibly damage the Diesel Particulate Filter (DPF).

Possible Causes

- Fuel injector leaking
- Internal engine damage

Do High-pressure Fuel System Leak Test (page 100), in this section.

Air or Combustion Leaks to Fuel

Possible Causes

- Compression leak past compression gasket to fuel return

- Loose fuel injector hold down
- Missing or damaged stainless steel injector gasket
- Combustion leaks to fuel will exhibit one or more of these characteristics:
  - Engine stall during operation
  - Rough running engine
  - Extended engine crank time (hard start)
  - FRP pressure slow to build while cranking
  - Exhaust smell coming from the fuel tank(s)
  - Excessive fuel pressure in the low-pressure fuel system while cranking
  - Pulsating fuel pressure (low-pressure fuel system) during crank or engine running at idle.
  - No start

Air or Combustion Leak to Fuel Test

Inspect cylinder head for air or combustion leaks by removing the injector return line and attaching a test adapter to monitor air from the test adapter. Air in the fuel from the test adapter is an indication of air leaks from the cylinder head that is still attached.

1. Verify operator complaint.

WARNING: To prevent personal injury or death, do not smoke or park vehicle near open flames or sparks when draining fuel. Store diesel fuel properly in an approved container designed for and clearly marked DIESEL FUEL.

2. Place a suitable container under the secondary fuel filter housing to catch draining fuel.
3. Disconnect one of the injector return lines from each cylinder head.

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

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

4. Turn ignition switch to ON, start or crank engine for 20 seconds. Inspect for air or combustion leaks in the fuel. Turn ignition switch to OFF.
   - Combustion gasses or smoke coming from sample line
   - Fuel forced back through lines from combustion
   - Audible sound of air/compression from sample line
5. Install the return line (temporarily) at the front of the cylinder using the existing copper gaskets and the banjo bolt. Remove the other injector return line. Install the fuel pressure test adapter on the banjo fitting using the existing copper gaskets and the banjo bolt.
6. Repeat steps 2 through 6 for the other injector return line from the other cylinder head.
7. If diagnostic tests confirm an air or combustion leak to the fuel supply, remove the glow plug harness on the suspected side following the procedures in the *Engine Service Manual*. Inspect for indications of leaks from the injector hold down clamps, injector crush gaskets, and the injector nipple. Repair if necessary and retest.
8. After air or combustions leaks to fuel have been repaired and retested, remove both return line banjo fittings, re-install the return line banjo fittings with new copper gasket, following the procedures in the *Engine Service Manual*.

Low Fuel Pressure and Aeration

Symptom

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

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

- Difficulty priming fuel system

Possible Causes

- Leaks in fuel supply to fuel pump
- Loose fuel injector hold down
- Missing/damaged stainless steel injector gasket
- Suction side leak or cracked line

See Fuel Pressure and Aerated Fuel in the “Performance Diagnostics” section of this manual.

Water In Fuel (WIF) Lamp

Possible Causes

- Water or ice in fuel supply system or damaged connection
- Corrosion on connector, sensor, or cover plate assembly
- Failed ECM
- Failed WIF sensor

Tools

- Clean drain pan, flat with a wide opening

Drain Water from Primary Fuel Filter

1. If the WIF lamp is on or fuel system contamination is suspected, continue with next step.
2. Put a clean flat drain pan under the primary filter.

WARNING: To prevent personal injury or death, do not smoke or park vehicle near open flames or sparks when draining fuel. Store diesel fuel properly in an approved container designed for and clearly marked DIESEL FUEL.

3. Drain the water separator following the procedures in the *Engine Service Manual*.
4. Check fuel in drain pan for contamination. Dispose of the contents in the drain pan properly in accordance with local requirements.
    - Excessive water or contaminants may indicate that the tank and fuel system need to be flushed and cleaned.
    - The fuel should be clear, not cloudy. Cloudy fuel indicates that the fuel is not a suitable grade for cold temperatures.
    - The fuel should not be dyed red or blue, these colors indicate off-highway fuel.
    - Fuel should not be waxing or gelling. Waxing or gelling cold weather can clog the fuel filters and the fuel pump and cause restrictions in the fuel or low fuel pressure.
5. Turn ignition switch to ON, determine if WIF lamp is off.
    - If the WIF lamp is off, the procedure is complete, do not continue.
    - If the WIF lamp is on, continue with the next step.

NOTE: If the WIF indicator stays on after the water has been drained, the WIF sensor or the WIF sensor connector may be corroded, the condition should be corrected and retested.

6. Check the WIF sensor connector, do WIF sensor (Water In Fuel) (page 380) in the “Electronic Control Systems Diagnostics” section of this manual.
7. Turn ignition switch to ON, determine if WIF lamp is off.
    - If the WIF lamp is off, the procedure is complete, do not continue.
    - If the WIF lamp is on, replace the primary fuel filter.

Priming the Fuel System

WARNING: To prevent personal injury or death, make sure that the engine has cooled before priming the fuel system.

WARNING: To prevent personal injury or death, stay clear of moving parts. The engine may start if fuel is in the system.

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

CAUTION: To prevent possible engine damage, do not manually actuate either the Fuel Pressure Control Valve (FPCV) or Fuel Pressure Control Valve (FVCV) on the high-pressure pump to build rail pressure in the event of a no start condition.

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

NOTE: If the fuel system will not prime during diagnosis, the engine will exhibit pulsating fuel pressure. See “Air or Combustion Leaks to Fuel” (page 94) in this section.

Priming - Low-pressure Fuel System

Perform this procedure whenever the following actions occur:

- Fuel tank is drained or runs dry
- The primary fuel filter is removed or replaced
- Any fuel connection between the fuel tank and the secondary fuel filter is broken
- The secondary fuel filter is removed or replaced
- The high-pressure fuel system is serviced

1. Make sure all fuel system connections are secure and the proper fuel filters are installed.
2. Make sure the battery is fully charged or install a battery charger.
3. Prime the suction side of the low-pressure fuel system:
   a. Tighten the primary fuel filter components that were removed (canister filter element, seals, or bowl) to specified torque values. See the *Engine Service Manual* for special torque values.
   b. Unscrew the piston knob on the manual fuel priming pump and start pumping until the fuel pressure builds up on the delivery side of the primer pump. The pressure build up will be indicated by higher pumping force on the manual priming pump.
   c. Fully screw the piston knob back in when priming is completed.

CAUTION: To prevent damage to the starter, if engine fails to start within 30 seconds, release ignition switch and wait 2 to 3 minutes to allow starter motor to cool.

4. Engage starter for 10 seconds and allow starter to cool for two minutes.

WARNING: To prevent personal injury or death, when routing test line, do not crimp line, run line too close to moving parts, or let line touch hot engine. Secure the gauge and test line to not obstruct vehicle operation.

5. If the engine does not fire during the first 2 cranking attempts, connect a pressure gauge to the test connection on the secondary fuel filter. Monitor the pressure gauge during the third cranking attempt.
   a. If pressure does not build up on the pressure gauge during the third crank attempt, unscrew the primary filter cap and separate the filter element from the filter cap.
   b. With the filter element completely inserted in the filter over the standpipe.

      NOTE: The filter element must be fully seated on the standpipe.

   c. Slowly pour fuel in the housing until full.

      CAUTION: To prevent engine damage, tighten fuel cap on fuel filter assembly. The engine will not run, if the fuel filter element is not installed. The fuel filter element is required to open the valve in the center stand pipe, allowing fuel to flow into the filter.

   d. Install the cap on the primary fuel filter, tighten to special torque. See the *Engine Service Manual* for the special torque value.
   e. Prime fuel system or repeat step 3.
6. Engage starter for 10 seconds and allow starter to cool for two minutes, monitor the pressure gauge on the secondary fuel filter. If the engine does not start and there is no increase in pressure at the gauge on the secondary filter, then repeat steps 3 and 4.
7. If the engine does not fire after five crank events, de-energize the Fuel Pressure Control Valve (FPCV) and Fuel Volume Control Valve (FVCV) in the high-pressure pump.

NOTE: De-energizing the FVCV closes the valve and controls the valve at the lower limit of 6.7% Pulse Width Modulate (PWM) signal. De-energizing the FPCV opens the valve to maximum and controls the valve at the lower limit of the PWM signal (~0). (This allows all the fuel delivered by the internal transfer pump to go to the high-pressure pump and allows for a minimum high-pressure pump outlet pressure making refilling easy.)

CAUTION: To prevent engine damage, use extreme care, the engine may start with a de-energized FVCV, a minimum fuel quantity entering the high-pressure pump, and rail pressure still very low.

8. Engage starter for 20 seconds to purge any trapped air from the high-pressure pump. Allow starter to cool for two minutes.
9. Energize the FPCV and the FVCV. Engage starter for 30 seconds and allow starter to cool for two minutes. If the engine does not fire, contact Technical Services.

Priming - High-pressure Fuel System

CAUTION: To prevent possible engine damage, high pressure lines from the high-pressure pump to the fuel rails must be replaced whenever they are disconnected from the rails or the high-pressure pump. High pressure fuel lines should never be reused.

NOTE: This procedure applies only when the high-pressure pump is removed or replaced, or the high pressure lines from the high-pressure pump to the fuel rails are disconnected.

NOTE: It is not necessary to re-prime the high-pressure fuel system after removal or replacement of injectors, fuel rail, rail to injector lines, or FRP sensor.

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

1. After reinstalling the high-pressure pump, when installing the two high-pressure pump to fuel rail lines, do not tighten the connections at the fuel rails. Install suitable catch under the loose connections.
2. Ensure low-pressure fuel system is primed with fuel.

   NOTE: If replacing the engine secondary fuel filter, complete this step after priming the high-pressure fuel system.
3. Engage starter for 20 seconds and allow starter to cool for two minutes. Continue to crank the engine in 20 second intervals until solid fuel (no air) is present at both connections.
4. Tighten both pump to fuel rail compression fittings to special torque. See the applicable torque chart in the *Engine Service Manual*.
5. After tightening both pump to fuel rail compression fittings, the engine is ready to start. If the engine does not fire within 30 seconds, repeat the low-pressure fuel system priming procedure.

Priming with Vacuum Source

NOTE: If the fuel system will not prime during diagnosis, the engine will exhibit pulsating fuel pressure in the low-pressure fuel system. See Air or Combustion Leaks to Fuel (page 94) 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 correctly.
2. Install fuel pressure test fitting on unfiltered fuel test port on the secondary fuel filter.
3. Attach vacuum source to fuel pressure test coupling and connect to fuel pressure test fitting on the secondary fuel filter.
4. Draw fuel from tank using vacuum source until level in secondary fuel filter housing reaches fitting.
5. Disconnect vacuum source and fuel pressure test coupler from fuel pressure test fitting.

CAUTION: To prevent damage to the starter, if engine fails to start within 30 seconds, release ignition switch and wait 2 to 3 minutes to allow starter motor to cool.

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

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

7. Repeat step 6 until engine starts and runs on its own.
   - Three to five 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.

Low Fuel Rail Pressure

Symptom

Low fuel rail pressure results from an engine hard start or no start condition.

Possible Causes

- Fuel Rail Pressure (FRP) sensor or circuit
- Fuel Pressure Control Valve (FPCV) or circuit
- Fuel Volume Control Valve (FVCV) or circuit
- Electronic Control Module (ECM)
- High-pressure fuel line leaks (internal or external fuel lines)
- High-Pressure Fuel Pump (HPFP)
- Fuel injectors
- Insufficient low pressure fuel pressure
- Plugged fuel filter
- Aerated fuel
- Cracked or leaking fuel lines

Tools

- EST with MasterDiagnostics® Software
- IC4 USB Interface Cable
- Digital Multimeter (DMM)
- CMP, CKP, and FPCV Breakout Harness
- 180-Pin Breakout Box

Test FRP Sensor

Figure 88 ECM connected to breakout box

1. ECM
2. ECM connectors
3. Breakout box connectors

NOTE: Verify adequate fuel supply pressure.

1. Connect the 180-Pin Breakout Box between the ECM and the driver 36-Pin Connector.

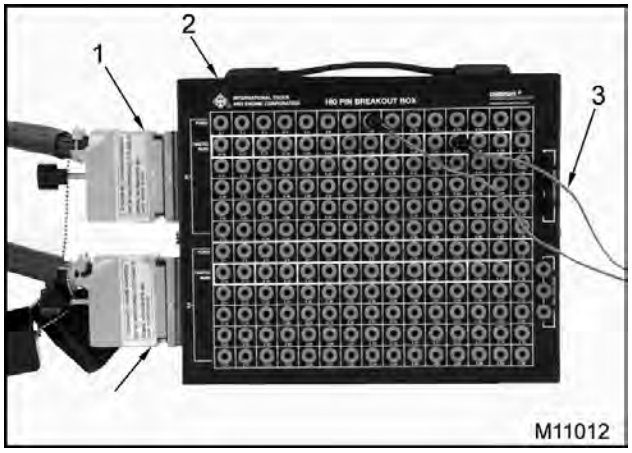


Figure 89 Breakout box connections

1. 36 - Pin Connector
2. 180 - Pin Breakout Box
3. Jumper cable

2. Jump ECM Pin E-8 to E-27, this shorts the FRP signal to SIG GND.

   NOTE: Verifies the sensor is not biased and puts the engine in Limp-Home mode.

3. Turn ignition switch to ON, attempt to start the engine.
   - If the engine starts, the FRP sensor circuit is at fault. See FRP Sensor (Fuel Rail Pressure) in the “Electronic Control Systems Diagnostics” section of this manual.
   - If the engine does not start, verify FVCV and FPCV are operating correctly. See Check FVCV and FPCV Coil Resistance (page 100) in this section.

Check FVCV and FPCV Coil Resistance

NOTE: Verify FVCV and FPCV connections are in place.

1. Connect the relay breakout harness between the ECM relay and the chassis harness.
2. Measure resistance from ECM relay Pin 87 to FPCV Pin E-22 and FVCV Pin E-61.
3. The resistance for both is 3 ± 0.5 ohms.
   - If the resistance is out of specification, see FPCV (Fuel Pressure Control Valve) and FVCV (Fuel Volume Control Valve) in the “Electronic Control Systems Diagnostics” section of this manual.
   - If the resistance is in specification, verify that the ECM is controlling the HPFP. See HPFP Duty Cycle Control in this section.

HPFP Duty Cycle Control

NOTE: Measuring the duty cycle of the HPFP, verifies that the ECM is controlling the pump.

1. Connect the positive lead of the DMM to a battery positive connection. Connect the negative lead to ECM Pin E-22 and E-61 on the breakout box.
2. Set the DMM meter to voltage, press the duty cycle button, and press the trigger button to make sure the DMM is set to positive trigger.
3. On the breakout box, short the FRP sensor to ground, jump ECM Pin E-8 to E-27.
4. Turn ignition switch to ON, crank the engine. Measure the duty cycle, should be approximately 30% duty cycle positive trigger value for both valves.
   - If the duty cycle is out of specification, see FPCV (Fuel Pressure Control Valve) and FVCV (Fuel Volume Control Valve) in the “Electronic Control Systems Diagnostics” section of this manual.
   - If the duty cycle is in specification, measure the pump output.

High-pressure Fuel System Leak Test

CAUTION: To prevent engine damage, when high-pressure fuel line connections are broken, the fuel line must be replaced.

NOTE: When removing the pump tube assemblies, fuel may leak out. Put in a suitable catch or container to collect this leakage. Collect and dispose of this fuel according to local regulations.

1. Connect the 180-Pin Breakout Box between the ECM and the driver 36-Pin Connector.

Figure 90 High-pressure Fuel Block-off Cap

2. Disconnect the high-pressure fuel supply line to right fuel rail at the pump connection. Install a High-pressure Fuel Block-off Cap.

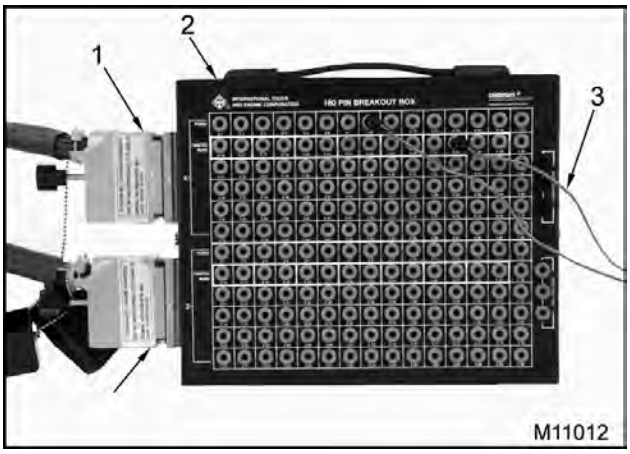


Figure 91 Breakout box connections

1. 36 - Pin Connector
2. 180 - Pin Breakout Box
3. Jumper cable

3. On the breakout box, short the FRP sensor to ground, jump ECM Pin E-8 to E-27.
4. Turn ignition switch to ON, attempt to start the engine.
   - If the engine starts, the right fuel rail has a fuel leak. Go to step 14.
   - If the engine does not start, go to the next step.
5. Remove High-pressure Fuel Block-off Cap. Temporarily install high-pressure fuel line to right fuel rail.
6. Disconnect the high-pressure fuel supply line to left fuel rail at the pump connection. Install a High-pressure Fuel Block-off Cap.
7. On the breakout box, short the FRP sensor to ground, jump ECM Pin E-8 to E-27.
8. Turn ignition switch to ON, attempt to start the engine.
   - If the engine starts, the left fuel rail has a fuel leak. Go to step 14.
   - If the engine does not start, go to the next step.
9. Disconnect the high-pressure fuel supply line to right fuel rail at the pump connection. Install a High-pressure Fuel Block-off Cap.

Figure 92 FRP sensor adapter with spare FRP sensor installed

10. Set up to measure the deadhead pressure of the HPFP.
    a. Remove High-pressure Fuel Block-off Cap. Temporarily install high-pressure fuel supply line to left fuel rail line to the pump.
    b. Disconnect the high-pressure fuel supply line to left fuel rail at the fuel rail connection.
    c. Connect the FRP sensor adapter to the high-pressure fuel supply line to left fuel rail at the fuel supply line connection. Install a spare FRP sensor in the adapter.
    d. Disconnect the MAP sensor harness.
    e. Connect the pressure sensor breakout harness between the spare FRP sensor and the MAP sensor harness. Connect the DMM to the Pressure Sensor Breakout Harness to measure the voltage.
11. On the breakout box, short the FRP sensor to ground, jump ECM Pin E-8 to E-27.
12. Turn ignition switch to ON, attempt to start the engine.
    - If the voltage is low, replace the HPFP and retest.
    - If the voltage is in specification, go to the next step.
13. Remove the spare FRP sensor and sensor adapter. Temporarily install both high-pressure fuel supply lines to both fuel rails.
14. Set up to measure fuel injector leakage.
    a. Remove the valve cover for the suspect side of the engine.
    b. Starting with the rear fuel injector, disconnect the injector fuel supply line from the fuel rail.
    c. Install a High-pressure Fuel Block-off Cap on the fuel rail.
15. On the breakout box, short the FRP sensor to ground, jump ECM Pin E-8 to E-27.
16. Turn ignition switch to ON, attempt to start the engine.
    - If the engine starts, replace the isolated jumper tube, retest the effected fuel rail.
    - If the engine does not start, redo step 14 for the next injector while leaving the exiting block-off cap in place.

Lubrication System

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

WARNING: To prevent personal injury or death, when routing test line, do not crimp line, run line too close to moving parts, or let line touch hot engine. Secure the gauge and test line to not obstruct vehicle operation.

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

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

Low Oil Pressure

Possible Causes

- Low oil level: oil leak, oil consumption or incorrect servicing
- High oil level: incorrect servicing, fuel in oil, or coolant in oil
- Stuck oil pressure regulator
- Scored or damaged oil pump
- Engine Oil Pressure (EOP) sensor biased
- Missing oil gallery cup 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)

Tools

- Fuel / Oil Pressure Test Coupler

Low Oil Pressure Diagnostics

1. Verify oil level in engine 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 (page 94) or Coolant in Lube Oil (page 85) in this section.
2. Connect fitting on test line with Fuel/Oil Pressure Test Coupler to a 0 to 1723 kPa (0 to 250 psi) gauge.
3. Connect Fuel/Oil Pressure Test Coupler to diagnostic coupling assembly.
4. Start the engine and measure oil pressure at both low and high idle, under no load conditions. Engine must be at normal operating temperature.
   - If oil pressure reads within specification listed in Appendix A: MaxxForce® 7 Performance Specifications and the instrument panel indicator indicated low pressure, perform EOP Sensor (Engine Oil Pressure) diagnostics in the “Electronic Control Systems Diagnostics” section of this manual. Repair or replace the oil pressure indicator as required.
   - If oil pressure does not read within the specification, continue with the next step.
5. 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 following the procedures in the *Engine Service Manual*. Redo this procedure starting with step 4. If oil pressure remains low, continue with the next step.
6. Remove and inspect the lube oil pump following the procedure 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 with the next step.
7. Drain oil from engine using a clean drain pan. 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.
8. Remove both the upper and lower oil pans following the procedure in the *Engine Service Manual*. Inspect for missing, loose, or damaged oil pickup tube, O-ring, piston cooling tubes, bearing inserts, and cam bushings.

CAUTION: To prevent damage to the engine, verify the oil filter is intact. Running the engine with a failed oil filter could cause rapid deterioration of the engine due to dirty oil.

9. Reinstall the oil filter, the oil filter cap, the oil pump, and oil pump cover.

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

10. Connect regulated shop air line to the oil filter diagnostic coupling assembly.
11. Slowly apply air pressure in 34.5 kPa (5 psi) increments to 345 kPa (50 psi).
12. Inspect for gross leaks internally.
    - If a major leak is observed from the front cover area, continue with the next step.
    - If a major leak is observed from the rear cover area, continue with step 15.
    - 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*.
13. Remove the front cover from the engine following procedures in the *Engine Service Manual* and complete inspection of the lube oil pump.

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

WARNING: To prevent personal injury or death, support engine (if in chassis) before removing rear cover or flywheel.

15. 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.

Table of Contents

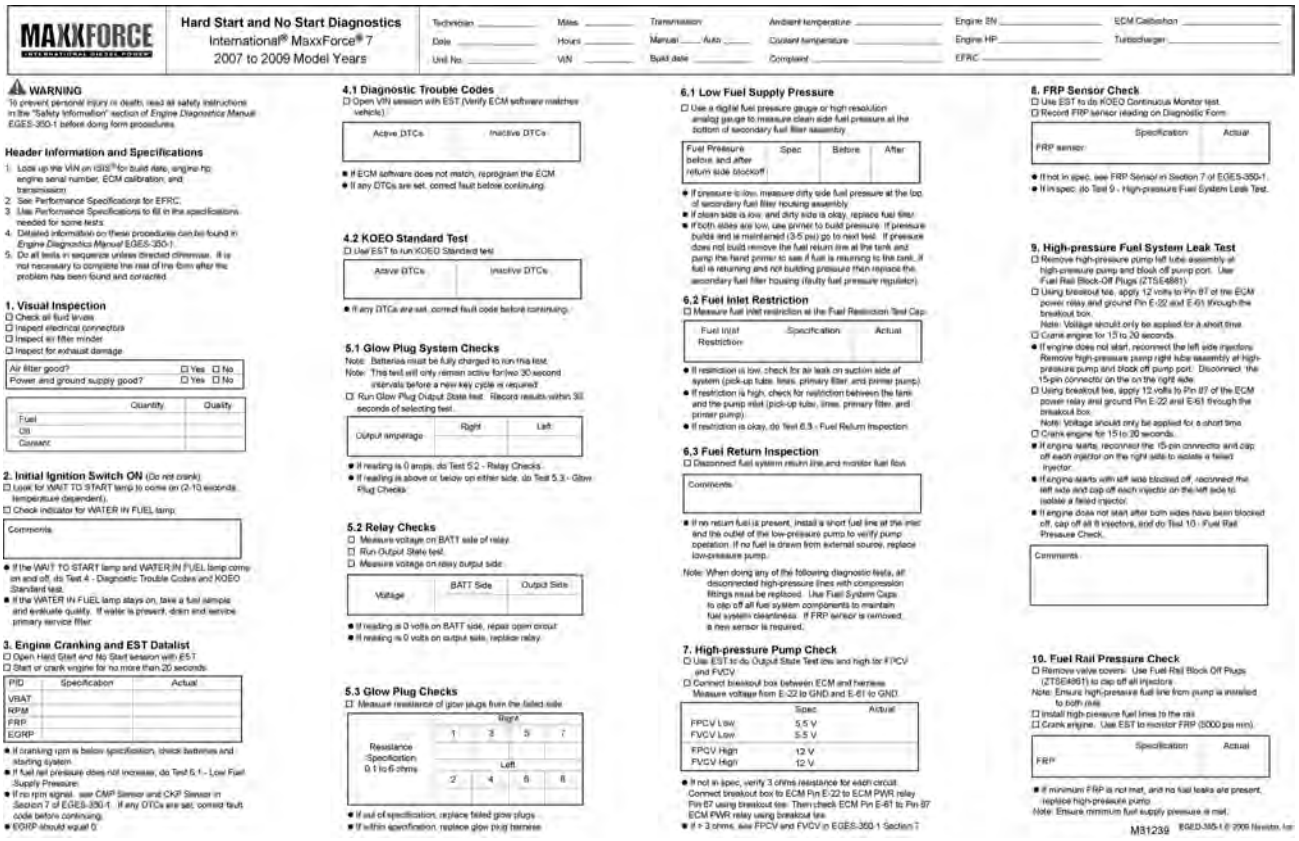
Diagnostic Form

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

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

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

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


MAXXFORCE

Hard Start and No Start Diagnostics
International® MaxxForce® 7
2007 to 2009 Model Years

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

WARNING
To prevent personal injury or death, read all safety instructions in the "Safety Information" section of Engine Diagnostics Manual EGES-350-1 before doing form procedures.

Header Information and Specifications
1. Look up the VIN on ISIS® for build date, engine hp, engine serial number, ECM calibration, and transmission.
2. See Performance Specifications for EPA/C.
3. Use Performance Specifications to fill in the specifications needed for some tests.
4. Detailed information on these procedures can be found in Engine Diagnostics Manual EGES-350-1.
5. Do all tests in sequence unless directed otherwise. It is not necessary to complete the rest of the form after the problem has been found and corrected.

1. Visual Inspection
☐ Check all fluid levels
☐ Inspect electrical connectors
☐ Inspect air filter minder
☐ Inspect for exhaust damage

Air filter good?	☐ Yes ☐ No
Power and ground supply good?	☐ Yes ☐ No

	Quantity	Quality
Fuel		
Oil		
Coolant		

2. Initial Ignition Switch ON (Do not crank)
☐ Look for WAIT TO START lamp to come on (2-10 seconds temperature dependent).
☐ Check indicator for WATER IN FUEL lamp.

Comments:

- If the WAIT TO START lamp and WATER IN FUEL lamp come on and off, do Test 4 - Diagnostic Trouble Codes and KOEO Standard test.
- If the WATER IN FUEL lamp stays on, take a fuel sample and evaluate quality. If water is present, drain and service primary service filter.

3. Engine Cranking and EST Datalist
☐ Open Hard Start and No Start session with EST.
☐ Start or crank engine for no more than 20 seconds.

PID	Specification	Actual
VBAT		
RPM		
FRP		
EGRP		

- If cranking rpm is below specification, check batteries and starting system.
- If fuel rail pressure does not increase, do Test 6.1 - Low Fuel Supply Pressure.
- If no rpm signal, see CMP Sensor and CKP Sensor in Section 7 of EGES-350-1. If any DTCs are set, correct fault code before continuing.
- EGRP should equal 0.

4.1 Diagnostic Trouble Codes
☐ Open VIN session with EST (Verify ECM software matches vehicle.)

Active DTCs	Inactive DTCs

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

4.2 KOEO Standard Test
☐ Use EST to run KOEO Standard test.

Active DTCs	Inactive DTCs

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

5.1 Glow Plug System Checks
Note: Batteries must be fully charged to run this test.
Note: This test will only remain active for two 30 second intervals before a new key cycle is required.
☐ Run Glow Plug Output State test. Record results within 30 seconds of selecting test.

	Right	Left
Output amperage		

- If reading is 0 amps, do Test 5.2 - Relay Checks.
- If reading is above or below on either side, do Test 5.3 - Glow Plug Checks.

5.2 Relay Checks
☐ Measure voltage on BATT side of relay.
☐ Run Output State test.
☐ Measure voltage on relay output side.

Voltage	BATT Side	Output Side

- If reading is 0 volts on BATT side, repair open circuit.
- If reading is 0 volts on output side, replace relay.

5.3 Glow Plug Checks
☐ Measure resistance of glow plugs from the failed side.

Resistance Specification: 0.1 to 6 ohms	Right			
	1	3	5	7
	Left			
	2	4	6	8

- If out of specification, replace failed glow plugs.
- If within specification, replace glow plug harness.

6.1 Low Fuel Supply Pressure
☐ Use a digital fuel pressure gauge or high resolution analog gauge to measure clean side fuel pressure at the bottom of secondary fuel filter assembly.

Fuel Pressure	Spec	Before	After
before and after return side blockoff			

- If pressure is low, measure dirty side fuel pressure at the top of secondary fuel filter housing assembly.
- If clean side is low, and dirty side is okay, replace fuel filter.
- If both sides are low, use primer to build pressure. If pressure builds and is maintained (3-5 psi) go to next test. If pressure does not build remove the fuel return line at the tank and pump the hand primer to see if fuel is returning to the tank. If fuel is returning and not building pressure then replace the secondary fuel filter housing (faulty fuel pressure regulator).

6.2 Fuel Inlet Restriction
☐ Measure fuel inlet restriction at the Fuel Restriction Test Cap.

Fuel Inlet Restriction:	Specification:	Actual

- If restriction is low, check for air leak on suction side of system (pick-up tube, lines, primary filter, and primer pump).
- If restriction is high, check for restriction between the tank and the pump inlet (pick-up tube, lines, primary filter, and primer pump).
- If restriction is okay, do Test 6.3 - Fuel Return Inspection.

6.3 Fuel Return Inspection
☐ Disconnect fuel system return line and monitor fuel flow.

Comments:

- If no return fuel is present, install a short fuel line at the inlet and the outlet of the low-pressure pump to verify pump operation. If no fuel is drawn from external source, replace low-pressure pump.

Note: When doing any of the following diagnostic tests, all disconnected high-pressure lines with compression fittings must be replaced. Use Fuel System Caps to cap off all fuel system components to maintain fuel system cleanliness. If FRP sensor is removed, a new sensor is required.

7. High-pressure Pump Check
☐ Use EST to do Output State Test low and high for FPCV and FVCV.
☐ Connect breakout box between ECM and harness. Measure voltage from E-22 to GND and E-61 to GND.

	Spec	Actual
FPCV Low	5.5 V	
FVCV Low	5.5 V	
FPCV High	12 V	
FVCV High	12 V	

- If not in spec, verify 3 ohms resistance for each circuit. Connect breakout box to ECM Pin E-22 to ECM PWR relay Pin 87 using breakout tee. Then check ECM Pin E-61 to Pin 87 ECM PWR relay using breakout tee.
- If > 3 ohms, see FPCV and FVCV in EGES-350-1 Section 7.

8. FRP Sensor Check
☐ Use EST to do KOEO Continuous Monitor test.
☐ Record FRP sensor reading on Diagnostic Form.

	Specification	Actual
FRP sensor		

- If not in spec, see FRP Sensor in Section 7 of EGES-350-1.
- If in spec, do Test 9 - High-pressure Fuel System Leak Test.

9. High-pressure Fuel System Leak Test
☐ Remove high-pressure pump left tube assembly at high-pressure pump and block off pump port. Use Fuel Rail Block-Off Plugs (ZTSE4961).
☐ Using breakout tee, apply 12 volts to Pin 87 of the ECM power relay and ground Pin E-22 and E-61 through the breakout box.
Note: Voltage should only be applied for a short time.
☐ Crank engine for 15 to 20 seconds.
- If engine does not start, reconnect the left side injectors. Remove high-pressure pump right tube assembly at high-pressure pump and block off pump port. Disconnect the 15-pin connector on the on the right side.

☐ Using breakout tee, apply 12 volts to Pin 87 of the ECM power relay and ground Pin E-22 and E-61 through the breakout box.
Note: Voltage should only be applied for a short time.
☐ Crank engine for 15 to 20 seconds.
- If engine starts, reconnect the 15-pin connector and cap off each injector on the right side to isolate a failed injector.
- If engine starts with left side blocked off, reconnect the left side and cap off each injector on the left side to isolate a failed injector.
- If engine does not start after both sides have been blocked off, cap off all 8 injectors, and do Test 10 - Fuel Rail Pressure Check.

Comments:

10. Fuel Rail Pressure Check
☐ Remove valve covers. Use Fuel Rail Block Off Plugs (ZTSE4961) to cap off all injectors.
Note: Ensure high-pressure fuel line from pump is installed to both rails.
☐ Install high-pressure fuel lines to the rail.
☐ Crank engine. Use EST to monitor FRP (5000 psi min).

	Specification	Actual
FRP		

- If minimum FRP is not met, and no fuel leaks are present, replace high-pressure pump.

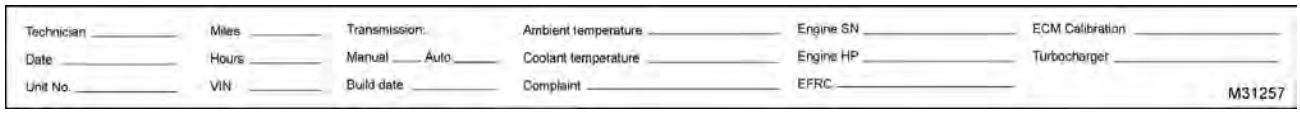
Note: Ensure minimum fuel supply pressure is met.

M31239 EGED-355-1 © 2009 Navistar, Inc.

Figure 93 Diagnostic Form EGED-355-1 (Hard Start and No Start)

Diagnostic Forms are available in 50 sheet pads. To order technical service literature, contact your International dealer.

Header Information



Enter Header Information

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

Enter Vehicle Information

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

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

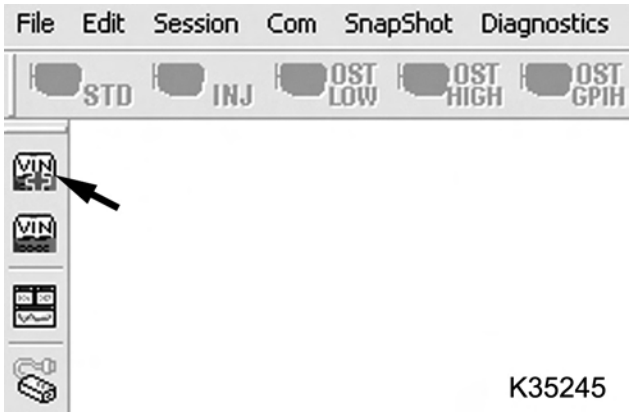
Enter Performance Specification Information

11. See "Performance Specifications" appendix in this manual or Technical Service Information (TSI) bulletin to obtain the following header information:

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

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

Verify ECM Calibration with Vehicle Specifications



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

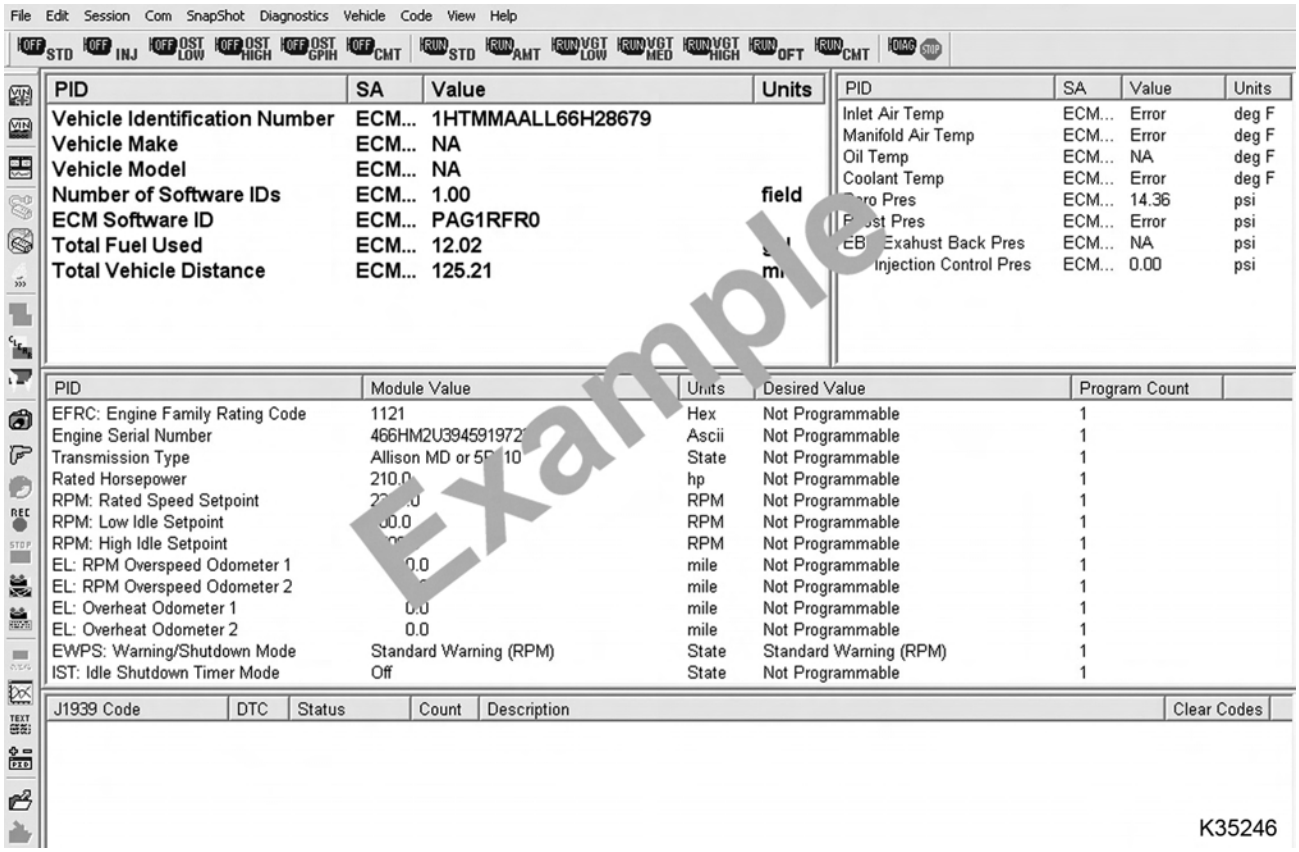


Figure 96 VIN+ session (example)

13. Verify the following match vehicle specification:
    - VIN
    - ECM calibration (ECM Software ID)
    - Rated hp
    - EFRC
    - Transmission
    - Engine SN

      Note: The engine serial number is located on the rear of the crankcase, below the left cylinder head.

14. Enter the following information:
    - Odometer (miles) (Total Vehicle Distance)
    - Engine hours
    - Intake Air Temperature
    - Coolant temperature

Test Procedures

1. Visual Inspection

Purpose

Check fluid levels, look for intake and exhaust restrictions, and electrical system problems.

Tools

- Inspection lamp
- Flash light

Engine Oil

1. Park vehicle on level ground. Turn engine off. Wait 15 minutes for oil level to stabilize.
2. Use oil level gauge (dip stick) to verify engine oil level. Record results on Diagnostic Form.
   - If oil level is below specification, inspect for leaks, oil consumption, or improper servicing.
   - If oil level is above specification, inspect for fuel dilution, coolant contamination, or improper servicing.

Fuel Level

1. Park vehicle on level ground. Turn engine off.
2. Use dash gauge to check fuel level. Inspect fuel tank fill ports to verify.

   Record results on Diagnostic Form.
   - If fuel tank is empty, put the correct grade of diesel fuel in the fuel tank.
   - If fuel level is low or below dash gauge reading, inspect for leaks, or fuel gauge problems.
   - If fuel level is above empty, and no tank contamination is evident, no repair is required.

Engine Coolant Level

1. Park vehicle on level ground.

   NOTE: Turn engine off. Wait 15 minutes or more for engine to cool.
2. Check coolant level on surge tank level window. Record results on Diagnostic Form.
   - If coolant level is low, inspect for leaks, coolant in the oil, coolant in the exhaust, improper servicing, or problems causing engine overheating.
   - If coolant level is at full level, and no tank contamination or leaks are evident, no repair is required.

Electrical System

1. Inspect batteries and electrical system (engine and vehicle) for loose or disconnected connections, corroded terminals, or broken and damaged wires.
2. Repair electrical problems as required.

Exhaust System

1. Inspect exhaust system (engine and vehicle) for restrictions, damage, and leaks.
2. Repair exhaust system problems as required.

Intake Air System and Charge Air Cooler (CAC)

1. Inspect CAC system, including intercooler and all intake piping and ducts for leaks and damage.

   Inspect the following parts for restriction, damage or incorrect installation:
   - Air inlet hoses and ducts
   - Air filter housing, filter element, and gaskets
   - CAC and piping
   - Air filter inlet and duct - look inside duct and remove any restrictions.

Figure 97 Air filter restriction gauge

2. Check the air filter restriction gauge.
3. Inspect all CAC and intake air connections and clamps.
4. If a CAC or intake air system problem is found, repair as required.

2. Initial Ignition Switch ON (Do Not Crank)

Purpose

To determine the following:

- Is the Electronic Control Module (ECM) powered up?
- Is there water in the fuel?

Tools

None

Procedure

1. Turn ignition switch to ON. Do not start engine. Check for the following:
   - WAIT TO START lamp
   - WATER IN FUEL lamp
2. If the WAIT TO START lamp and WATER IN FUEL lamp come on and off, do Test 4– Diagnostic Trouble Codes and KOEO Standard Test.
3. If the WATER IN FUEL lamp stays on, take a fuel sample and evaluate quality. If water is present, drain and service primary service filter.

Possible Causes

WAIT TO START lamp does not illuminate

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

WATER IN FUEL lamp illuminates

- Water in fuel
- Electrical circuit failure

3. Engine Cranking and EST Datalist

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

Purpose

To determine if engine systems meet operating specifications to start engine

Monitoring Engine Systems using an EST

Tools

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

Procedure

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

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

NOTE: Batteries must be fully charged before doing the following steps.

1. See "Performance Specifications" – Appendix A for specifications and record on Diagnostic Form.

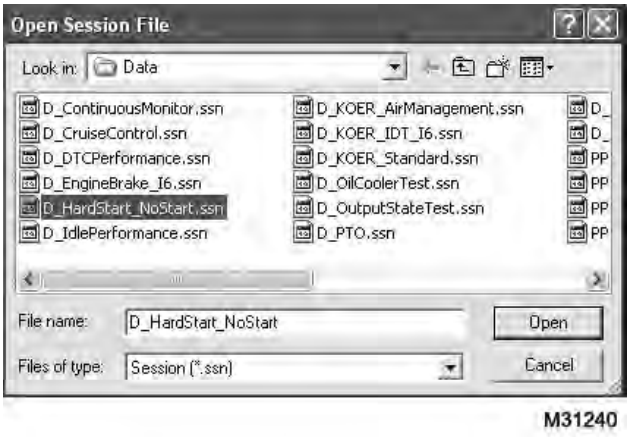


Figure 98 D_HardStart_ NoStart.ssn

2. Open D_HardStart_NoStart.ssn to monitor engine operation.
3. Turn the ignition switch to ON. Do not start engine.
4. Crank engine for no more than 20 seconds. Use EST to read VBAT, RPM, FRP, and EGRP.
5. Record readings on Diagnostic Form.
   - If cranking rpm is below specification, check batteries and starting system.
   - If fuel rail pressure does not increase, do Test 6.1 – Low Fuel Supply Pressure.
   - If no rpm signal is present, see "CKP Sensor" and "CMP Sensor" in *Electronic Control Systems Diagnostics* section of this manual.
   - EGRP should equal 0.

Possible Causes

Low battery voltage

- Failed batteries
- High-resistance at battery cable connections or in wiring to the ECM
- Failed ECM main power relay

Low cranking rpm

- Electrical system malfunctions, low batteries, starter failure, or incorrect oil
- No rpm indication on the EST while cranking the engine
  - — Failed CKP sensor
  - — Failed CMP sensor
  - — Failed circuit to ECM

Low Fuel Rail Pressure

- Failed FRP sensor
- Failed high-pressure pump
- Low fuel supply pressure
- Aerated fuel

Monitoring FRP using a Breakout Harness

NOTE: This is an alternate procedure to be used if an EST is not available.

Tools

- Pressure Sensor Breakout Harness
- Digital Multimeter (DMM)

Procedure

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

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

1. See "Performance Specifications" – Appendix A for specifications and record on Diagnostic Form.

Figure 99 15-pin UVC connector

2. Disconnect the engine harness from the 15-pin UVC connector.

3. Connect 15-Pin UVC Breakout Harness to the UVC connector and engine harness.

4. Use DMM to measure FRP sensor voltage.

- Connect POS to Pin E-8 and NEG to Pin E-27

2. Start or crank engine for no more than 20 seconds.

3. Measure signal voltage and cranking rpm. See "Performance Specifications" – Appendix A for specifications.
   - If in specification, continue to next test.
   - If not in specification, do Test 6.1 - Low Fuel Supply Pressure.

Possible Causes

- Failed FRP sensor
- Failed high-pressure pump
- Low supply fuel pressure
- High-pressure leaks
- Aerated fuel

4. Diagnostic Trouble Codes and KOEO Standard Test

4.1 Diagnostic Trouble Codes

Purpose

- To determine if the ECM has detected DTCs indicating conditions that could cause engine problems

Tools

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

1. Turn the ignition switch ON, engine OFF.
2. Using the EST with MasterDiagnostics® software, open the VIN+ session. Select the VIN+ icon.
3. Record calibration level on Diagnostic Form header.
    - Verify ECM software matches vehicle. If ECM software does not match, reprogram the ECM.

Checking for DTCs

DTC: Diagnostic Trouble Code

Status: Indicates active or inactive DTCs

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

Description: Defines each DTC

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

4.2 KOEO Standard Test

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

Purpose

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

Possible Causes

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

Tools

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

Procedure

1. Turn ignition switch to ON. Do not start engine
2. Open COM device.
3. Select KOEO Tests. Select Standard Test from the drop down menu.
4. Follow the on-screen instructions.
5. Record DTCs on the Diagnostic Form.
6. If DTCs are detected, correct problems causing DTCs. See “Appendix B: Diagnostic Trouble Code (DTC) Index.”
7. Clear DTCs.
8. Run the KOEO Standard Test again.

5. Glow Plug System

Purpose

To determine if the glow plug system is operating correctly to start the engine

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- DMM
- Glow Plug Sensor Harness
- Current clamp

5.1 Glow Plug System Checks

Procedure

NOTE: Batteries need to be fully charged for this test.

1. Turn ignition switch to ON, engine OFF.

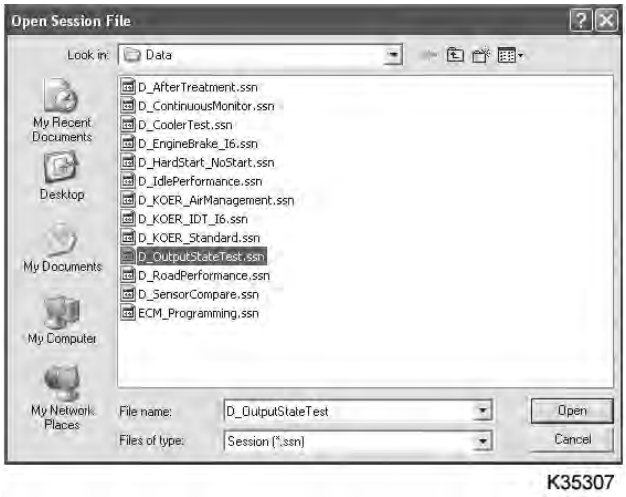


Figure 100 Output state test session

2. Open session and select D_OutputStateTest session from menu.

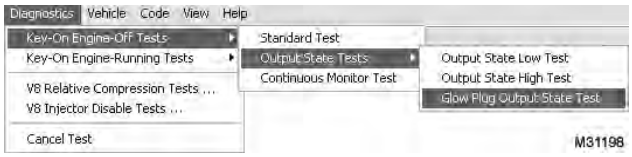


Figure 101 Glow plug output state test menu

3. Select Key-On Engine-Off Tests. From the drop down menu, select Output State Tests, then select Glow Plug Output State Test.

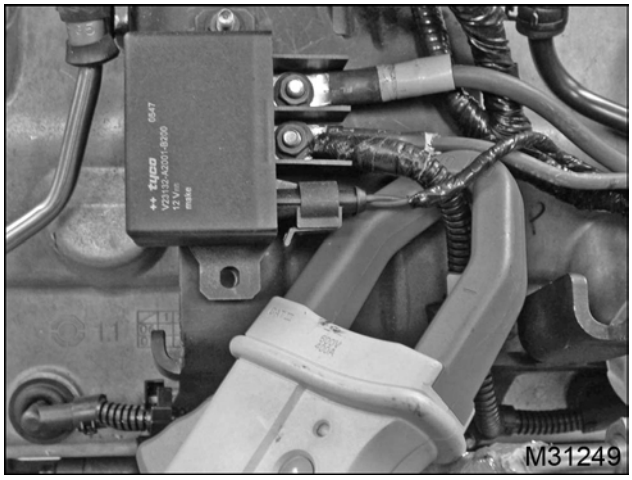


Figure 102 Current clamp around right side glow plug loom

4. Connect current clamp to right side glow plug loom.
5. Select Run. Record results within 30 seconds of selecting Glow Plug Output State Test.

   NOTE: This test will remain active for two 30 second intervals before a new key cycle is required.

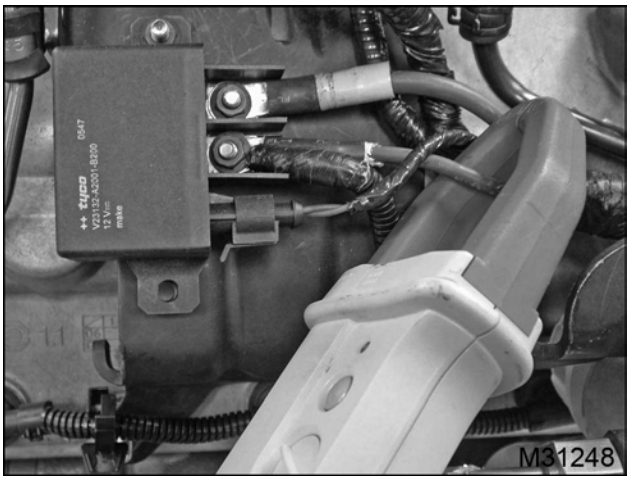


Figure 103 Current clamp around left side glow plug loom

6. Move current clamp to the left side loom. Select Run. Record results within 30 seconds of selecting Glow Plug Output State Test.

- If amperage was 0 for both sides, do Test 5.2 – Relay Checks.
- If amperage is above or below specification, do Test 5.3 – Glow Plug Checks.
- If amperage is within specification, the glow plugs are operating without fault. Continue to next test.

5.2 Relay Checks

Procedure

1. Turn ignition switch to OFF.

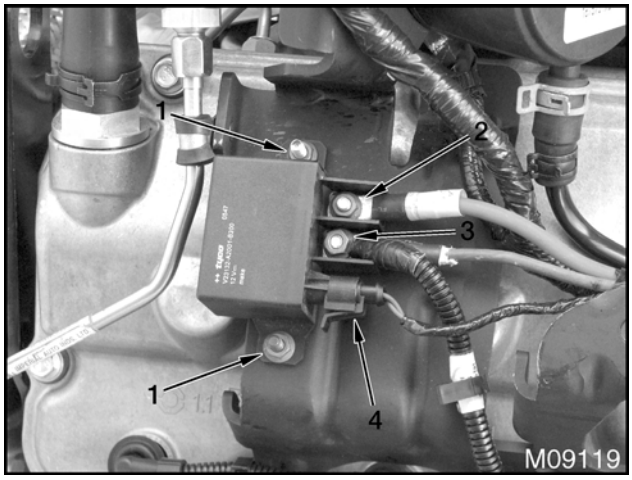


Figure 104 Glow plug relay

1. Glow plug relay nuts
2. Battery (+) cable nut
3. Glow plug harness nut
4. Glow plug relay control connector

2. Connect DMM between GND and B+ feed on glow plug relay.
3. Record results on the Diagnostic Form.
   - If B+ is present, go to next step.
   - If B+ is not present, repair open power feed to relay.
4. Connect DMM between GND and switching side of relay (other large post on relay).

NOTE: Key-on can only be done twice. Cranking engine will reset key-on capability.

5. Turn ignition switch to ON, engine OFF.

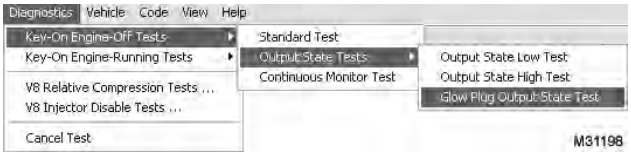


Figure 105 Glow plug output state test

6. Run Glow Plug Output State test.
7. Record results on Diagnostic Form.
   - If B+ is present, do Glow Plug Checks.
   - If B+ is not present, replace glow plug relay.

5.3 Glow Plug Checks

Procedure

1. Turn ignition switch to OFF.
2. Disconnect the harness from glow plugs on the side of concern.
3. Install Glow Plug Sensor Harness.
4. Use a DMM to measure resistance between glow plug and engine GND.
5. Record results on Diagnostic Form.
   - If any glow plug is below specification, replace glow plug or plugs.
   - If all glow plugs are within specification, replace the glow plug harness.

6. Fuel System

6.1 Low Fuel Supply Pressure

Purpose

To check for incorrect fuel pressure

Tools

- Digital fuel pressure gauge or high resolution analog gauge

Procedure

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

1. Use a digital fuel pressure gauge or high resolution analog gauge to measure clean side fuel pressure at the bottom of the secondary fuel filter assembly.

- If pressure is low, measure dirty side fuel pressure at the top of secondary fuel filter assembly.
- If clean side pressure is low, and dirty side is okay, replace fuel filter.
- If both sides are low, use primer pump to build pressure. If pressure builds and is maintained (3-5 psi) continue to next test. If pressure does not build, suspect the pressure regulator. Remove the fuel return line at the tank and pump the hand primer to see if fuel is returning to the tank, if fuel is returning and not building pressure then replace the secondary fuel filter housing which contains the pressure regulator (not serviceable).

6.2 Fuel Inlet Restriction

Purpose

To check for fuel supply system restriction

NOTE: This test is only valid if engine will start and achieve high idle.

Tools

- Gauge Bar Tool (0–30 in Hg vacuum gauge)
- Fuel Inlet Restriction Adapter

Procedure

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

1. See "Performance Specifications" – Appendix A for restriction specifications. Record on Diagnostic Form.
2. Remove Fuel Restriction Test Cap.

   NOTE: The MaxxForce® 7 does not use a fuel strainer.

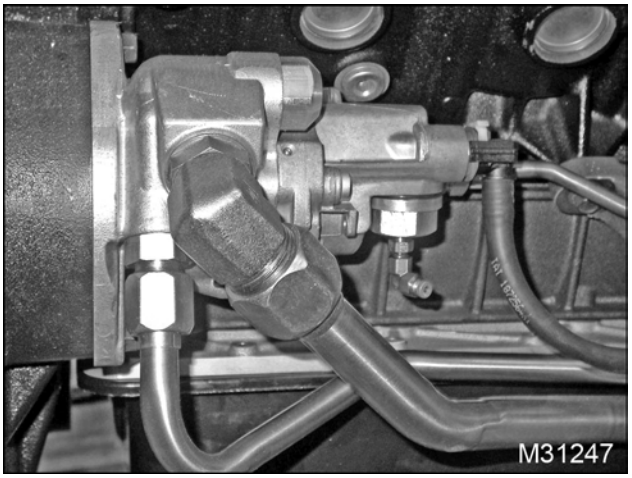


Figure 106 Fuel inlet restriction adapter installed

3. Install fuel inlet restriction adapter.

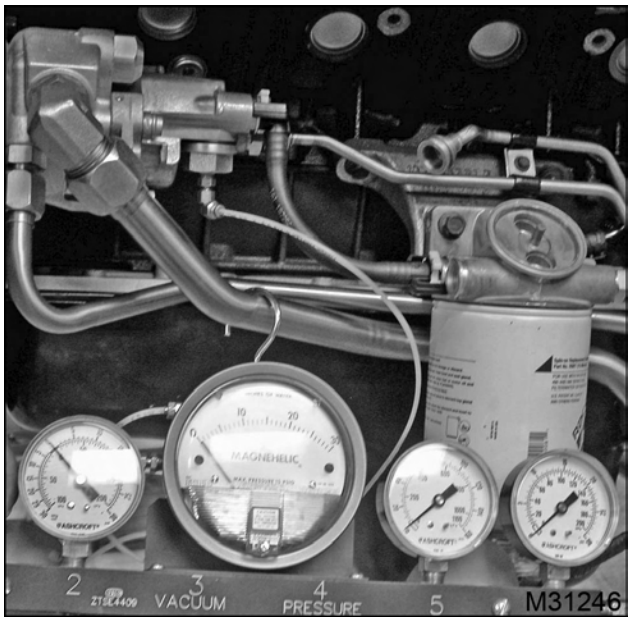


Figure 107 Measuring fuel inlet restriction

4. Connect a line from the adapter to the 0–30 in Hg vacuum gauge on gauge bar.

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

5. If "Hard Start" then start and run engine at high idle. If "No start" crank engine to measure restriction. Record results on the Diagnostic Form.
   - If restriction is low, check for air leak on the suction side of the system.
   - If restriction is high, check for restriction between the tank and the pump inlet (pick-up tube, lines, primary filter, and primer pump).
   - If restriction is okay, do Test 6.3 - Fuel Return Inspection.

Possible Causes (High and Low Restriction)

- Dirt or jelled fuel in the fuel filter
- Kinked or bent fuel supply line or a blocked fuel pickup tube
- Loose fuel line on the suction side of the fuel system
- Failed fuel regulator valve (located in secondary fuel filter housing)
- Failed fuel pump

6.3 Fuel Return Inspection

Purpose

To check fuel return function

Tools

- Short fuel line

Procedure

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

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

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

Install a short fuel line at both the inlet and the outlet sides of the low-pressure pump to verify pump operation.

- If fuel is not drawn from external source, replace the low-pressure pump.
- If return fuel is not present, continue to the next step.

7. High-pressure Pump Check

Purpose

To check for high-pressure pump function

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- Breakout Box
- Relay Breakout Harness

NOTE: All disconnected high-pressure lines with compression fittings must be replaced. Use fuel system caps to cap off all fuel system components to maintain fuel system cleanliness. If the FRP sensor is removed, a new sensor is required.

FPCV and FVCV Output State Test Low

Procedure

1. Turn ignition switch to ON.
2. Connect breakout box between ECM and harness. Measure voltage from E-22 to GND and E-61 to GND.
3. Open session and select D_OutputStateTest session from menu.

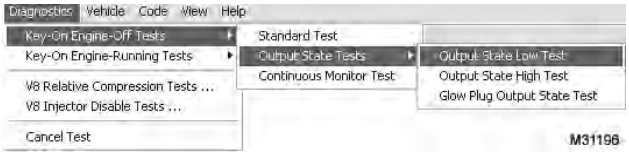


Figure 108 Output state low test menu

4. Select Diagnostics from the menu bar.
5. Select Key-On Engine-Off Tests. From the drop down menu, select Output State Tests, then select Output State Low Test.
6. Monitor the FPCV and FVCV voltage. Record results on Diagnostic Form.
   - If not in specification, verify 3 ohms resistance. Use Relay Breakout Harness to connect breakout box to ECM Pin E-22 to ECM PWR relay Pin 87. Then check ECM Pin 61 to Pin 87 ECM PWR relay using Relay Breakout Harness.
   - If > 3 ohms, see FPCV and FVCV in “Electronic Control Systems Diagnostics” section of this manual for wiring troubleshooting.

FPCV and FVCV Output State Test High

Procedure

1. Turn ignition switch to ON.
2. Connect breakout box between ECM and harness. Measure voltage from E-22 to GND and E-61 to GND.
3. Open session and select D_OutputStateTest session from menu.

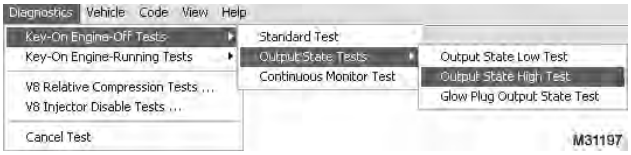


Figure 109 Output state high test menu

4. Select Diagnostics from the menu bar.
5. Select Key-On Engine-Off Tests. From the drop down menu, select Output State Tests, then select Output State High Test.
6. Monitor the FPCV and FVCV voltage. Record results on Diagnostic Form.
   - If not in specification, verify 3 ohms resistance. Use Relay Breakout Harness to connect breakout box to ECM Pin E-22 to ECM PWR relay Pin 87. Then check ECM Pin 61 to Pin 87 ECM PWR relay using Relay Breakout Harness.
   - If > 3 ohms, see FPCV and FVCV in “Electronic Control Systems Diagnostics” section of this manual for wiring troubleshooting.

8. FRP Sensor Check

Purpose

To check for FRP sensor malfunction while running KOEO Continuous Monitor test

Tools

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

NOTE: All disconnected high-pressure lines with compression fittings must be replaced. Use fuel system caps to cap off all fuel system components to maintain fuel system cleanliness. If the FRP sensor is removed, a new sensor is required.

Procedure

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

1. Turn ignition switch to ON. Do not start engine.
2. Open the Sensor Compare session.
3. Use the EST to monitor the FRP sensor signal voltage. Record results on Diagnostic Form.
   - If not in specification, see FRP Sensor in "Electronic Control Systems Diagnostics" section of this manual.
   - If in specification, do Test 9 – High-pressure Fuel System Leak Test.

9. High-pressure Fuel System Leak Test

Purpose

To check high-pressure fuel pump and injectors for inability to reach required fuel rail pressure

Tools

- Breakout Box
- Fuel Rail Block-Off Plugs

Procedure

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

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

NOTE: All disconnected high-pressure lines with compression fittings must be replaced. Use fuel system caps to cap off all fuel system components to maintain fuel system cleanliness. If the FRP sensor is removed, a new sensor is required.

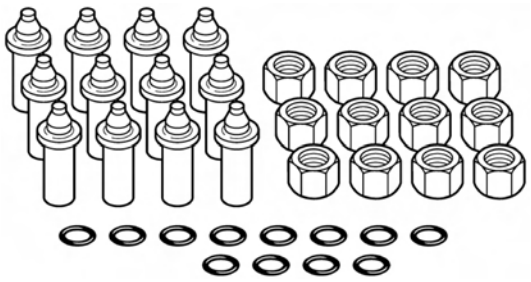


Figure 110 Fuel rail block-off plugs

1. Remove high-pressure pump left tube assembly at high-pressure pump and block off pump port. Use Fuel Rail Block-Off Plugs.
2. Using breakout tee, apply 12 volts to Pin 87 of the ECM power relay and ground Pin E-22 and E-61 through the breakout box.

   NOTE: Voltage should only be applied for a short time.
3. Crank engine for 15 to 20 seconds.
   - If engine does not start, reconnect the left side injectors. Remove high-pressure pump right tube assembly at high-pressure pump and block off pump port.

     Disconnect the 15-pin connector on the right side.
4. Using breakout tee, apply 12 volts to Pin 87 of the ECM power relay and ground Pin E-22 and E-61 through the breakout box.

   NOTE: Voltage should only be applied for a short time.
5. Crank engine for 15 to 20 seconds.
   - If engine starts, reconnect the 15-pin connector and cap off each injector on the right side to isolate a failed injector.
   - If engine starts with left bank blocked off, reconnect the left side and cap off each injector on the left side to isolate a failed injector.
   - If engine does not start after each side has been blocked off individually, cap off all 8 injectors and do Test 10 – Fuel Rail Pressure Check.

Possible Causes

- Failed high-pressure fuel pump
- Failed injector
- High pressure leak
- Low fuel supply fuel pressure

10. Fuel Rail Pressure Check

Purpose

To check for minimum fuel rail pressure

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Fuel Rail Block Off Plugs

Procedure

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

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

NOTE: All disconnected high-pressure lines with compression fittings must be replaced. Use fuel system caps to cap off all fuel system components to maintain fuel system cleanliness. If the FRP sensor is removed, a new sensor is required.

NOTE: Ensure minimum fuel supply pressure is met.

1. See "Performance Specifications" – Appendix A for specifications and record on Diagnostic Form.
2. Remove engine valve cover following the procedure in *Engine Service Manual*.

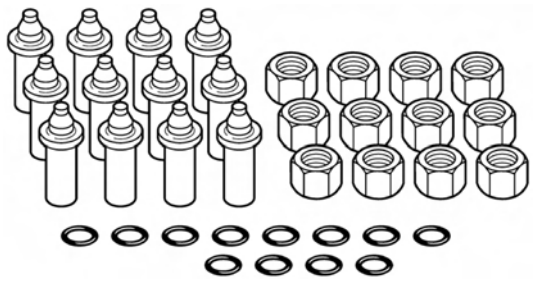


Figure 111 Fuel rail block-off plugs

3. Cap off all injectors using Fuel Rail Block-Off Plugs.

NOTE: Ensure high-pressure fuel line from pump is installed to both rails.

4. Install high-pressure fuel line to the fuel rail.
5. Crank engine for 15 to 20 seconds.
6. Monitor the FRP sensor voltage using the EST. Record results on Diagnostic Form.
   - If minimum fuel rail pressure is not met, and no fuel leaks are present, replace high-pressure fuel pump.

Possible Causes

- Failed high-pressure fuel pump

Table of Contents

Diagnostic Form

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

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

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

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

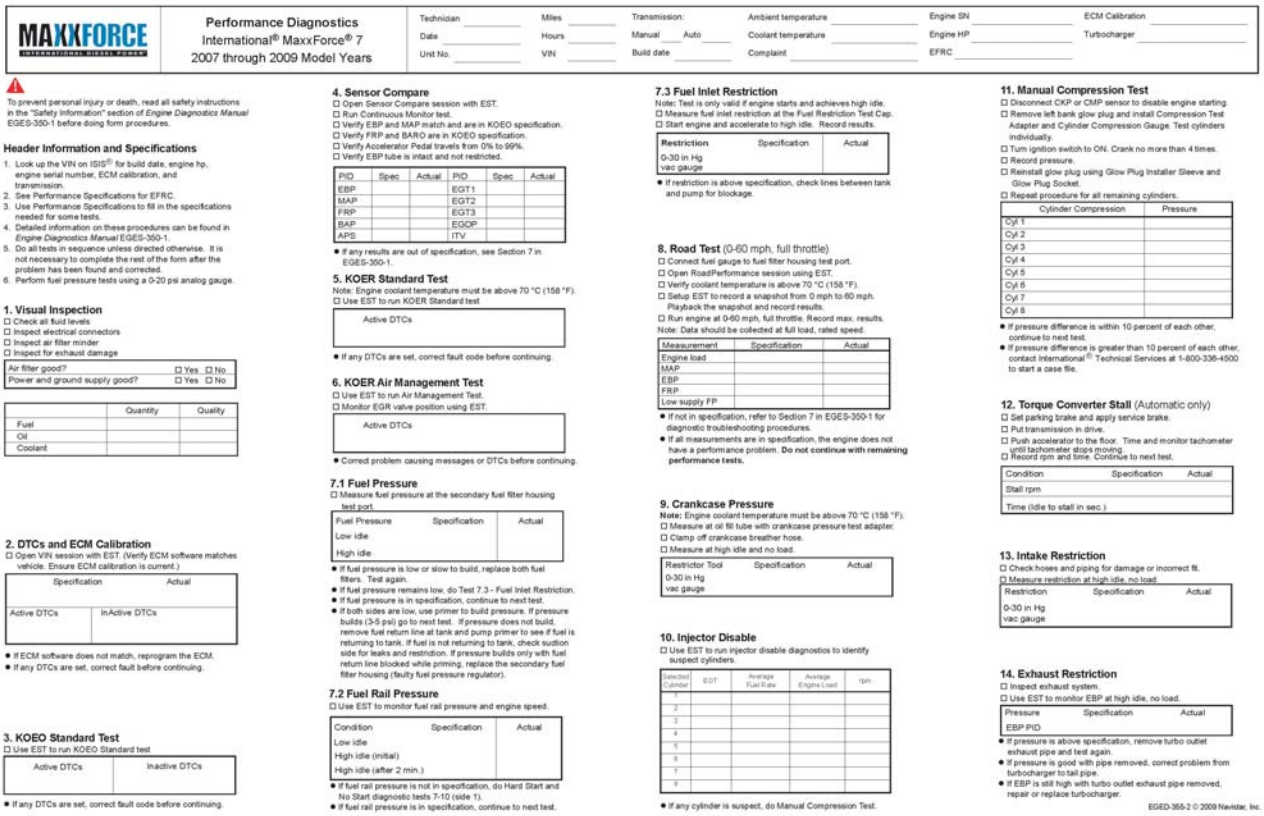
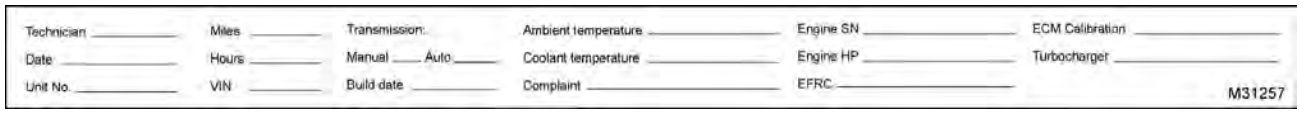


Figure 112 Diagnostic Form EGED-355-2 (Performance Diagnostics)

Diagnostic Forms are available in 50 sheet pads. To order technical service literature, contact your International dealer.

Header Information



Enter Header Information

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

Enter Vehicle Information

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

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

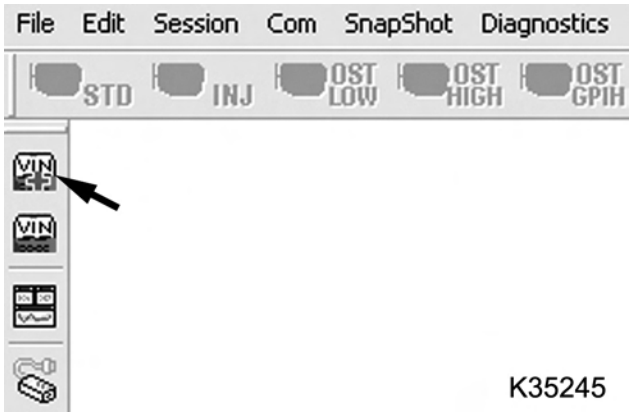
Enter Performance Specification Information

11. See "Performance Specifications" appendix in this manual or Technical Service Information (TSI) bulletin to obtain the following header information:

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

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

Verify ECM Calibration with Vehicle Specifications



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

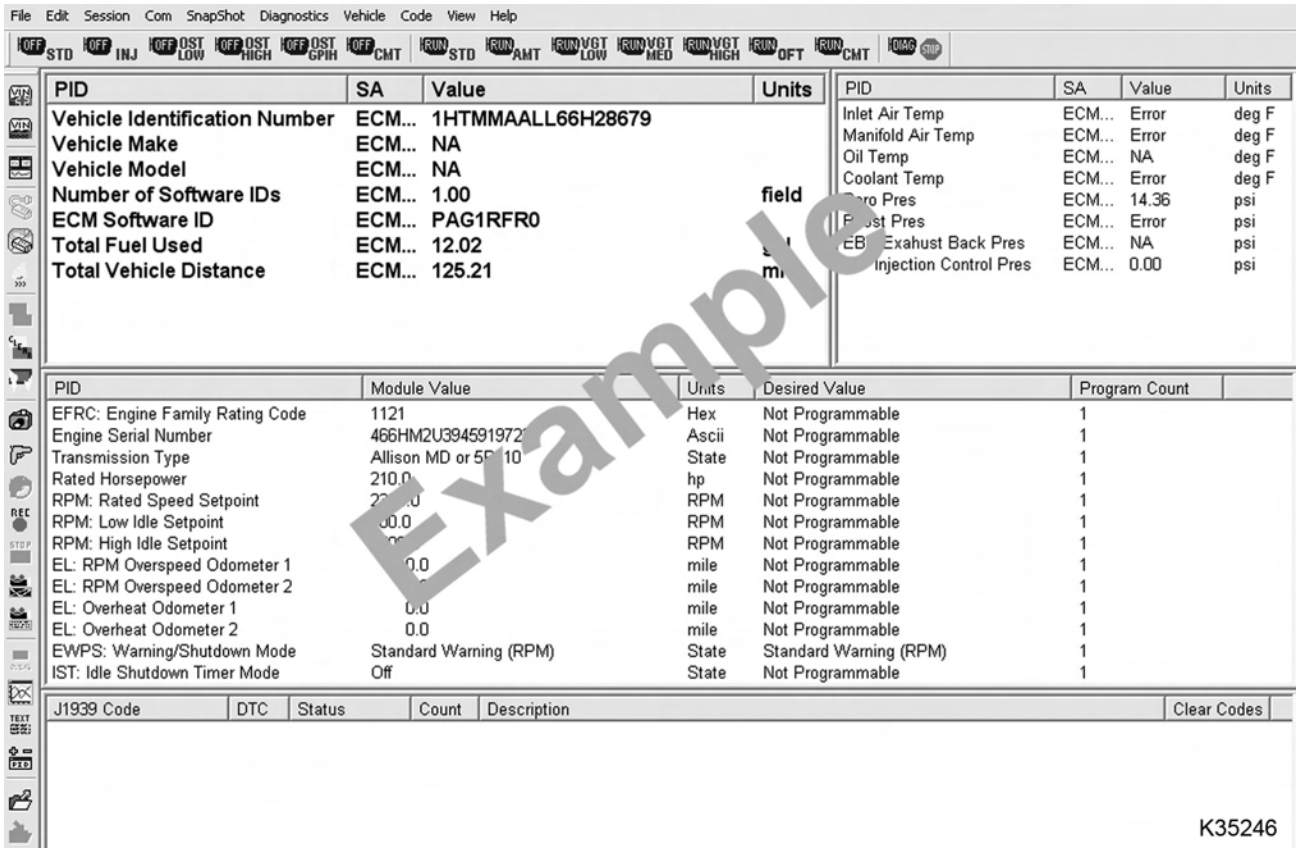


Figure 115 VIN+ session (example)

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

      Note: The engine serial number is located on the rear of the crankcase, below the left cylinder head.
    - Transmission
14. Enter the following information:
    - Odometer (miles) (Total Vehicle Distance)
    - Engine hours
    - Intake Air Temperature
    - Coolant temperature

Test Procedures

1. Visual Inspection

Purpose

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

Tools

- Inspection lamp

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

Fuel Level

1. Park vehicle on level ground.

   NOTE: Engine should not be running.

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

Engine Oil

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

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

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

Engine Coolant Level

1. Park vehicle on level ground.

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

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

Electrical System

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

Exhaust System

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

Intake Air System and Charge Air Cooler (CAC)

1. Inspect CAC system, including intercooler and all intake piping and ducts for leaks and damage.

   Inspect the following parts for restriction, damage or incorrect installation:
   - Air inlet hoses and ducts
   - Air filter housing, filter element, and gaskets

- CAC and piping
- Air filter inlet and duct - look inside duct and remove any restrictions.

Figure 116 Air filter restriction gauge

2. Check the air filter restriction gauge.
3. Inspect all CAC and intake air connections and clamps.
4. If a CAC or intake air system problem is found, repair as required.

2. DTCs and ECM Calibration

Purpose

- To verify the ECM calibration matches the vehicle
- To determine if the ECM has detected DTCs indicating conditions that could cause engine problems

Tools

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

Checking ECM Calibration

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

Checking for DTCs

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

DTC: Diagnostic Trouble Code

Status: Indicates active or inactive DTCs

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

Description: Defines each DTC

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

3. KOEO Standard Test

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

Purpose

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

Tools

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

Procedure

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

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

Possible Causes

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

4. Sensor Compare

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

Purpose

To check for sensor malfunction while running KOEO Continuous Monitor test

Tools

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

Procedure

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

1. Turn ignition switch to ON. Do not start engine.
2. Open COM device.
3. Open SensorCompare session
4. Select Key-On Engine-Off Tests and Continuous Monitor Test from the drop down menu.
5. Check KOEO sensor values.
6. Record results on Diagnostic Form.
7. Verify if sensor values are normal.
    - If out of specification, see “Electronic Control Systems Diagnostics” section of this manual for the applicable sensor out of specification.
    - If sensors are in specification, no repair is required. Continue to next test.

Possible Causes

- Failed sensor circuits.
- Biased or damaged sensor

5. KOER Standard Test

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

Purpose

To inspect for engine sensors malfunctions within specified operating ranges

Tools

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

Procedure

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

1. Open session and select D_KOER_Standard session from menu.
2. Start engine and run until minimum engine coolant temperature of 70 °C (158 °F) is reached.
3. Select Key-On Engine-Running Tests and Standard Test from the drop down menu.
4. Follow the on-screen instructions.
   - The ECM will start the KOER Standard Test by commanding the rpm to rise to a predetermined level.
   - When the test is finished, the ECM will return the rpm to low idle.
5. Record DTCs on Diagnostic Form. See “Diagnostic Trouble Codes” appendix in this manual for DTCs.
   - If no DTCs are detected, no repair is required.
   - If DTCs are detected, correct the problems causing DTCs.
6. Clear DTCs.
7. Run the KOER Standard Test again.

Possible Causes

- Sensor and actuator circuit problems
- Failed engine sensors or actuators

6. KOER Air Management Test

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

Purpose

To check for intake, exhaust, VGT, and EGR system malfunctions

Tools

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

Procedure

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

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

1. Open session and select D_KOER_AirManagement session from menu.
2. Turn ignition switch to ON and start engine.
3. Select Key-On Engine-Running test. From the drop down menu, select Air Management test.

   The ECM will start the air management test. The engine is commanded to accelerate to a predetermined rpm. The ECM will monitor the effects of the VGT and EGR system by using feedback signals from the EBP sensor.

   - If no problem is detected, the test will run to completion and resume low idle rpm.
   - If a problem is detected, the ECM will cancel the test, set a DTC, and resume low idle rpm.
4. Record results on Diagnostic Form.
   - If no problems are detected, no repair is required.
   - If a problem is detected, see VGT Actuator in Section 7 of this manual.

Possible Causes

- Intake/exhaust leak or restriction
- Blocked EBP tube assembly
- EBP/MAP sensor biased or damaged
- Failed EGR control valve
- Failed VGT actuator or turbocharger

7. Fuel System

7.1 Fuel Pressure

Purpose

To verify adequate fuel pressure

NOTE: This test is only valid if engine will start.

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Gauge Bar Tool (0–30 in Hg vacuum gauge)
- Analog or digital pressure gauge

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

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

1. See "Performance Specifications" – Appendix A for specifications and record on Diagnostic Form.

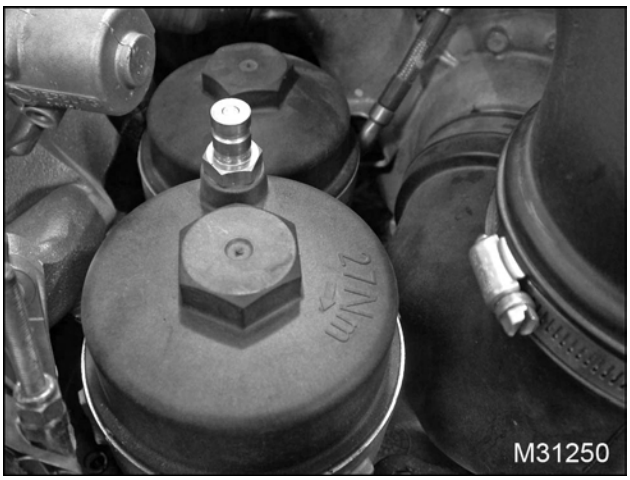


Figure 117 Secondary fuel filter test port (top)

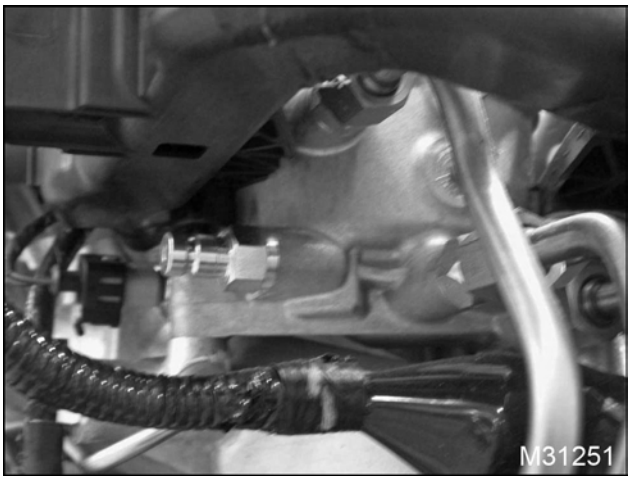


Figure 118 Secondary fuel filter test port (bottom)

2. Measure fuel pressure at the secondary fuel filter housing test port. Record results on Diagnostic Form.

   NOTE: Analog or digital pressure gauge is required for measuring low pressure side.

3. Compare the low and high idle fuel pressure readings.

   - If fuel pressure is low or slow to build, replace both fuel filters. Test again.
   - If both sides are low use primer pump to build pressure. If pressure builds and is maintained (3-5 psi) continue to the next test. If pressure does not build go to Low Fuel Supply Pressure (page 119) for further diagnostics.
   - If fuel pressure remains low, do Test 7.3 – Fuel Inlet Restriction.

     NOTE: This test is only valid if engine will start and achieve high idle.

   - If fuel pressure is in specification, continue to the next test.

7.2 Fuel Rail Pressure

Purpose

To determine if the high-pressure fuel system is providing enough fuel pressure to operate injectors

Tools

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

Monitoring Fuel Rail Pressure with EST

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

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

1. See "Performance Specifications" – Appendix A for specifications and record on Diagnostic Form.
2. Open D_RoadPerformance.ssn to monitor engine operation.
3. Turn ignition switch to ON. Do not start engine.
4. Monitor the fuel rail pressure using the EST.
   - If pressure is not in specification, the FRP sensor or circuitry is suspect.
   - If pressure is in specification, continue with the next step.
5. Start engine and run at low idle and monitor fuel rail pressure. Record results on Diagnostic Form.
6. Run engine at high idle and monitor fuel rail pressure. Continue to run the engine at high idle for 2 minutes and monitor fuel rail pressure. Record results on Diagnostic Form.
7. Compare the low and high idle fuel rail pressure readings.
   - If fuel rail pressure is not in specification, see "Hard Start and No Start" section in this manual and do Tests 7 through 10.
   - If fuel rail pressure is in specification, do Test 8 – Road Test.

Possible Causes

- Fuel rail system leakage (fuel lines, etc.)
- Failed high-pressure pump
- Failed injector
- Biased sensors
- Low or no low-side fuel pressure

Monitoring Fuel Rail Pressure without EST

NOTE: Do this procedure if an EST is not available. This is an alternative method.

Tools

- Breakout box
- Digital Multimeter (DMM)
- FRP Sensor Breakout Harness
- 15-Pin UVC Breakout Harness

Procedure

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

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

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

1. See "Performance Specifications" – Appendix A for specifications and record on Diagnostic Form.

Figure 119 15-pin UVC connector

2. Disconnect the engine harness from the 15-pin UVC connector.

3. Connect 15-Pin UVC Breakout Harness to the UVC connector and engine harness.

4. Use DMM to measure FRP sensor voltage.

- Connect POS to Pin E-8 and NEG to Pin E-27

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

6. Measure the FRP sensor voltage. Record on Diagnostic Form.

- If voltage is not in specification, the FRP sensor or circuitry is suspect.
- If voltage is in specification, continue with the next step.

7. Start engine and run at low idle and monitor fuel rail pressure voltage. Record results on Diagnostic Form.

8. Run engine at high idle and monitor fuel rail pressure voltage. Continue to run the engine at high idle for 2 minutes and monitor fuel rail pressure voltage. Record results on Diagnostic Form.

9. Compare the low and high idle fuel rail pressure readings voltage.

- If fuel rail pressure voltage is not in specification, see “Hard Start and No Start” section in this manual and do Tests 7 through 10.
- If fuel rail pressure is in specification, do Test 8 – Road Test.

Possible Causes

- Fuel rail system leakage (fuel lines, etc.)
- Failed high-pressure pump
- Failed injector
- Biased sensors
- Low or no low-side fuel pressure
- Faulty harness

7.3 Fuel Inlet Restriction

Purpose

To check for fuel supply system restriction

NOTE: This test is only valid if engine will start and achieve high idle.

Tools

- Gauge Bar Tool (0–30 in Hg vacuum gauge)
- Fuel Inlet Restriction Adapter

Procedure

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

1. See “Performance Specifications” – Appendix A for restriction specifications. Record on Diagnostic Form.
2. Remove Fuel Restriction Test Cap.

   NOTE: The MaxxForce® 7 does not use a fuel strainer.

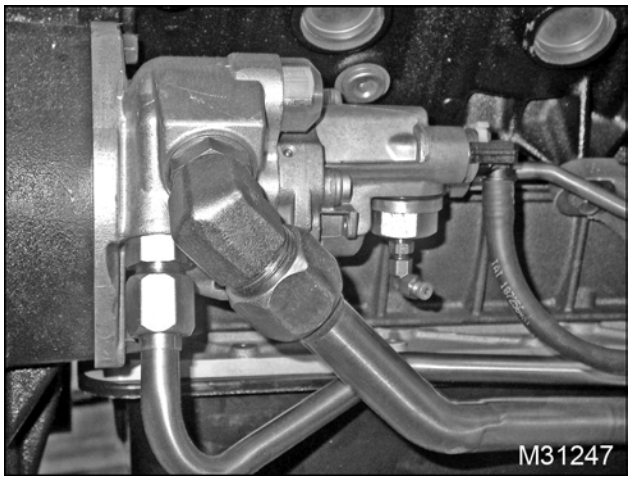


Figure 120 Fuel inlet restriction adapter installed

3. Install fuel inlet restriction adapter.

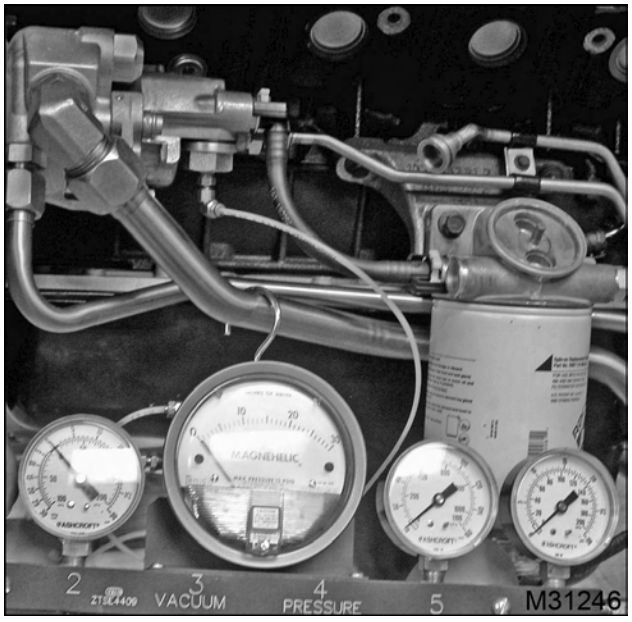


Figure 121 Measuring fuel inlet restriction

4. Connect a line from the adapter to the 0–30 in Hg vacuum gauge on gauge bar.

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

5. Start and run engine at high idle. Measure restriction.
6. Record results on Diagnostic Form.
   - If restriction is above specification, check suction line and pick-up tube between fuel tank and pump for blockage.
   - If there is no restriction or pressure, inspect for suction side leaks.

Possible Causes (High and Low Restriction)

- Dirt or jelled fuel in the fuel filter
- Kinked or bent fuel supply line or a blocked fuel pickup tube
- Loose fuel line on the suction side of the fuel system
- Failed fuel regulator valve (located in secondary fuel filter housing)
- Failed fuel pump

8. Road Test (0–60 mph, full throttle)

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

Purpose

To check for unacceptable engine performance at 0–60 mph, full throttle by means of maximum boost and minimum fuel pressure

Tools

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

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

1. Open Road Performance session.
2. Start engine and run until minimum engine coolant temperature of 70 °C (158 °F) is reached.
3. Set the Road Performance snapshot to record at 0.2 second interval for the following PIDs:
   - Engine load (EL %)
   - ERPM
   - Boost pressure (MAP)
   - Exhaust back pressure (EBP)
   - VGT offset
   - Fuel rail pressure
   - VGT duty cycle
   - Vehicle speed
4. Find an open stretch of road. Start snapshot recording. When driving conditions are safe, select a suitable gear and accelerate from 0–60 mph at uninterrupted full throttle.
5. When road test is complete, stop snapshot recording.
6. Save snapshot for review and future reference.
7. Replay snapshot in graphic or text view to review results for EL %, MAP, EBP, FRP, ERPM, VGT offset, VGT duty cycle, and vehicle speed.
   - Pay close attention to rated hp and peak TQ rpm.
   - EL % should be near 100 percent.
8. Record results on Diagnostic Form.
   - If results are in specification, no repair is required.
   - If results are out of specification, correct problems. Test again to validate repairs.

Unacceptable Boost Possible Causes

- Boost leaks
- Restricted intake or exhaust
- Control system faults
- Biased BAP, EBP, or MAP sensors
- Power cylinder condition
- Low fuel pressure
- Failed EGR valve
- Failed turbocharger
- Failed fuel injectors
- Plugged DPF
- Plugged DOC

Unacceptable Fuel Rail Pressure Possible Causes

- FRP circuit fault
- Failed fuel pump
- Failed high-pressure fuel pump
- Failed fuel injectors
- High-pressure fuel line leaks
- Biased FRP sensor

Unacceptable Fuel Pressure Possible Causes

- Fuel filter blockage
- Incorrect fuel grade for cold climate
- Debris, water, or ice in fuel system
- Oil, gasoline, or kerosene present in fuel system
- Excessive leak on high-pressure fuel side
- Fuel supply line leak, damage, or blockage
- Air leak in suction side fuel line or filter assembly
- Failed fuel regulator valve (located in secondary fuel filter housing)
- Failed fuel pump

9. Crankcase Pressure

Purpose

To measure the condition of the power cylinders

Tools

- Gauge Bar Tool
- Crankcase Pressure Test Adapter
- Heater hose pliers

Procedure

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

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

1. See "Performance Specifications" – Appendix A for specifications and record on Diagnostic Form.
2. Ensure the engine oil level is not above full mark and the oil level gauge is secured.

Figure 122 Recirculation tube clamped closed

3. Clamp off recirculation tube with heater hose pliers.

Figure 123 Test line, crankcase breather tool, and gauge bar

4. Remove oil fill cap.
5. Install crankcase pressure test adapter to extended oil fill tube.
6. Connect a line from the crankcase pressure test adapter to the magnehelic gauge on the gauge bar.
7. Run engine to reach normal engine operating 70 °C (158 °F) before measuring crankcase pressure.
8. Run engine at high idle (no load) rpm. Allow the gauge reading to stabilize before taking the pressure reading.
9. Record crankcase pressure on Diagnostic Form.
   - If pressure is below specification, continue with Performance Diagnostics.
   - If pressure is above specification, continue to next step.
10. If engine has an air compressor, remove air compressor drive belt and test again.
    - If pressure is below specification, repair or replace air compressor.
    - If pressure is above specification, continue to next step.

11. Disconnect VGT control valve connector and test again.

- If pressure is below specification, reconnect VGT control valve. Do Test 6 – KOER Air Management to see if crankcase pressure increases as turbocharger demand increases.
- If pressure fluctuates above and below specification, as VGT is cycling, replace the turbocharger.
- If disconnecting or cycling the turbocharger does not bring pressure below specification, go to next step.

12. Inspect air induction for dirt ingestion.

13. 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
- Leaking intake manifold gasket
- Failed turbocharger seals

10. Injector Disable

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

Purpose

To determine the cause of rough engine idle

NOTE: The Injector Disable test is used in conjunction with a Manual Compression Test to distinguish between an injector problem or a mechanical problem.

Tools

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

Procedure

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

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

NOTE: Before doing this test, all preceding tests must be completed.

1. Open session and select D_IDT_V8 session from menu.
2. Turn ignition switch to ON.
3. Select Diagnostics from menu bar and V8 Injector Disable Test from drop down menu.
4. Start and warm up the engine.

   NOTE: The EOT indicator will change from red to green when engine temperature reaches acceptable temperature.
5. Select cylinder number and select Run. The selected injector will be disabled and engine noise should change.
6. Record results on Diagnostic Form.

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

7. Select Normal Operation. Injector will be enabled and engine noise should return to previous state of operation.

   If a change is not heard or felt, increase engine to 1000 rpm and evaluate injector again.
8. Repeat steps 5 and 7 for the remaining cylinders.

   NOTE: Listen for tone changes from cylinder to cylinder.

   - If test does not identify a suspect cylinder, do Manual Compression Test in this section.
   - If test identifies a suspect cylinder, do Manual Compression Test. Do not attempt to repair injectors without completing Injector Disable and Manual Compression Test first.

Possible Causes

- Open or short injector wiring
- Failed injector
- Failed ECM
- Power cylinder issue

11. Manual Compression Test

Purpose

To measure the condition of the power cylinders

Tools

- Cylinder Compression Gauge
- Compression Test Adapter
- Glow Plug Installer Sleeve
- Glow Plug Socket

Procedure

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

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

WARNING: To prevent personal injury or death, ensure engine starting capability is disabled before doing Compression Test procedures.

1. Disconnect CMP or CKP sensor connector to disable engine starting.

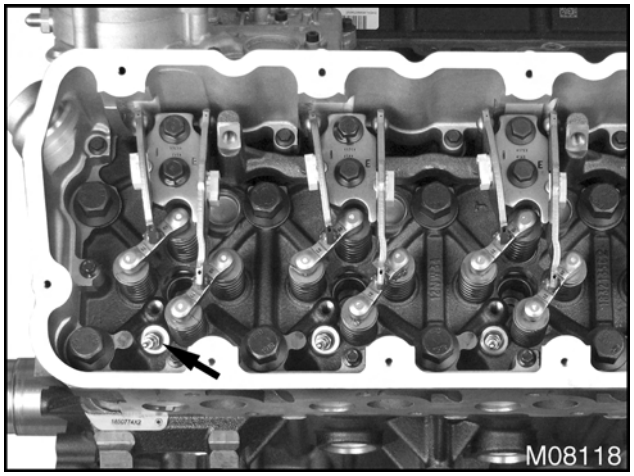


Figure 124 Glow plugs (typical)

2. Remove glow plug from cylinder 2 following the procedure in *Engine Service Manual*. It is not necessary to remove the valve covers.

   NOTE: Left bank cylinders include 2, 4, 6, and 8. Right bank cylinders include 1, 3, 5, and 7.

3. Inspect Compression Test Adapter O-ring. Ensure O-ring is intact and seated correctly.

Figure 125 Installing Compression Test Adapter

4. Install and hand tighten Compression Test Adapter.

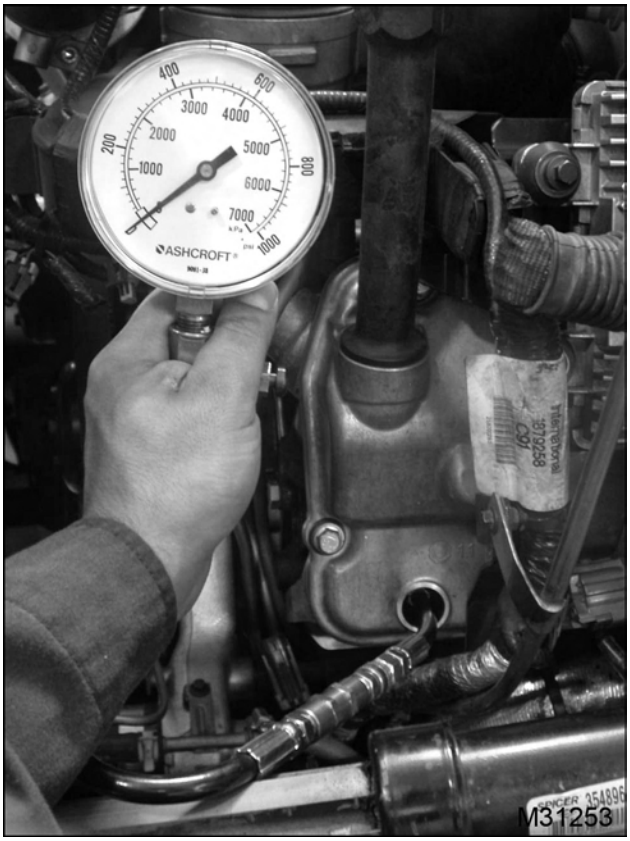


Figure 126 Cylinder Compression Gauge installed

5. Connect Cylinder Compression Gauge to adapter.
6. Turn ignition switch to ON. Crank engine for no more than 4 revolutions.

   NOTE: If more than 4 revolutions occur, bleed air from Cylinder Compression Gauge. Repeat cranking procedure.
7. Record pressure on Diagnostic Form.
8. Bleed pressure from gauge, then disconnect Cylinder Compression Gauge from adapter. Remove Compression Test Adapter.

Figure 127 Installing glow plug

9. Reinstall glow plug using Glow Plug Installer Sleeve and Glow Plug Socket. Follow the procedure in *Engine Service Manual*.
10. Repeat Steps 2 through 9 for all remaining individual glow plugs.
    - If pressure difference is within 10 percent of each other, continue to the next step.
    - If pressure difference is greater than 10 percent of each other, contact International® Technical Services at 1-800-336-4500 to start a case file.

Possible Causes

- Loose fuel injector
- Valve train damage
- Power cylinder damage

12. Torque Converter Stall (Automatic only)

Purpose

To check for engine inability to meet specified stall rpm within specified time

Tools

- None

Procedure

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

WARNING: To prevent personal injury or death, make sure brakes are correctly adjusted and in good condition. Ensure parking brake is set before doing the Torque Converter Stall Test. This test should be done in an open lot.

CAUTION: To prevent drive train damage, do not do this test for more than 10 seconds at a time or more than twice back to back. If doing twice – wait 2 minutes between tests.

1. Turn ignition switch to ON. Start the engine.
2. Set parking brake and apply service brake.
3. Put transmission in drive.
4. Press accelerator pedal to the floor. Begin timing until TACH stops moving.
5. Record stall rpm and time to reach stall rpm on Diagnostic Form.
   - If no problems are found, no action is required.
   - If stall rpm is below specification, or stall time is above specification, continue to next test.

Possible Causes

- Intake or exhaust restriction
- Boost or exhaust system leak
- Biased engine sensors
- Low supply fuel pressure
- EGR control valve issue
- Turbocharger issue
- Fuel injector issue
- Power cylinder issue

13. Intake Restriction

Purpose

To check for restrictions causing hard start or no start conditions

Tools

- None

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

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

1. Inspect Charge Air Cooler (CAC) system, including intercooler and all intake piping and ducts for leaks and damage.

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

   - Air inlet hoses and ducts
   - Air filter housing, filter element, and gaskets
   - CAC and piping
   - Air filter inlet and duct - look inside duct and remove any restrictions.
2. Inspect all CAC and intake air connections and clamps.
3. If a CAC or intake air system problem is found, repair as required.
4. See "Performance Specifications" for air cleaner restriction specification.

Figure 128 Air filter restriction gauge

5. Locate the air filter restriction gauge or install a Gauge Bar Tool to the air filter housing.
6. Start engine and run at high idle.
7. Record intake restriction on Diagnostic Form.
8. If restriction is detected, repair as required. Test again to validate repair.

14. Exhaust Restriction

Purpose

To check for exhaust system restrictions

Tools

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

Procedure

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

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

1. Turn ignition switch to ON.
2. Open COM device.
3. Open KOER_AirManagement session.
4. Unplug EGR valve harness to EGR connection during the test. Ignore the DTC that will be set.
5. Start the engine and run at high idle, no load.
6. Record exhaust back pressure on Diagnostic Form.
   - If exhaust back pressure is in specification, reconnect EGR valve and clear DTCs. No repair is required.
   - If exhaust back pressure is above specification, continue to next step.

WARNING: To prevent personal injury or death, allow engine to cool before working with components.

7. Remove exhaust pipe from turbocharger outlet and test again.
   - If exhaust back pressure is in specification, reconnect EGR valve, clear DTCs, and repair issue between turbocharger outlet and tailpipe.
   - If exhaust back pressure is above specification, reconnect exhaust pipe, reconnect EGR valve, clear DTCs, and repair issue with VGT.

Possible Causes

- Damaged or biased EBP sensor
- Restricted or collapsed exhaust piping
- Restricted or damaged exhaust components
- VGT issue or turbocharger CAC hoses and connections