DIAGNOSTIC/TROUBLESHOOTING MANUAL

EGES-420-2

December 2009

Read all safety instructions in the "Safety Information" section of this manual before doing any procedures.
Follow all warnings, cautions, and notes.

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Foreword

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

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

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

Technical Service Literature

1171898R5	International® MaxxForce® 11 and 13 *Engine Operation and Maintenance Manual*
EGES-415-1	International® MaxxForce® 11 and 13 *Engine Service Manual*
EGES-420-2	International® MaxxForce® 11 and 13 *Engine Diagnostic manual*
EGED-425	International® MaxxForce® 11 and 13 *Engine Performance Form*
EGED-430-2	International® MaxxForce® 11 and 13 *Engine Wiring Diagram*
EGED-435	International® MaxxForce® 11 and 13 *Signal Values* (available on ISIS® only)

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

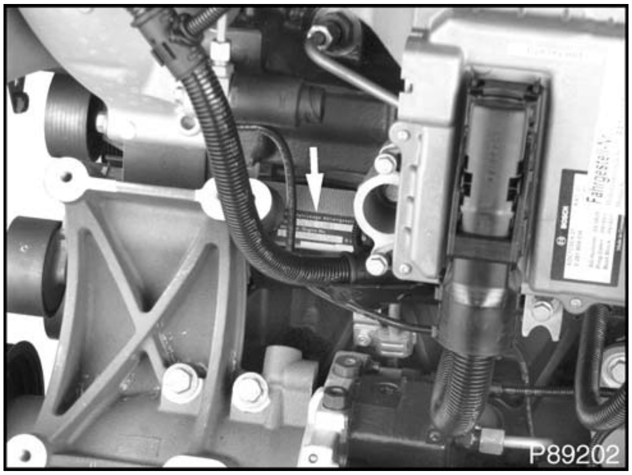


Figure 1 Engine serial number

The engine serial number is located on the upper left side of the crankcase below the cylinder head.

Engine Serial Number Examples

International® MaxxForce® 11: 105HM2DXXXXXXX

International® MaxxForce® 13: 124HM2DXXXXXXX

International® MaxxForce® 11: 105HM2YXXXXXXX

International® MaxxForce® 13: 124HM2YXXXXXXX

Engine Serial Number Codes

105 – Engine displacement
124 – Engine displacement
H – Diesel, turbocharged, Charge Air Cooler (CAC) and electronically controlled
M2 – Motor truck
D – Germany
Y – United States, Huntsville
7 digit suffix – Engine serial number sequence

Engine Emission Label

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

The U.S. Environmental Protection Agency (EPA) exhaust emission label is on top of the valve cover (front left side). The EPA label typically includes the following:

- Model year
- Engine family, model, and displacement
- Advertised brake horsepower and torque rating
- Emission family and control systems
- Valve lash specifications
- Engine serial number
- EPA, EURO, and reserved fields for specific applications

Engine Accessory Labels and Identification Plates

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

- Air compressor

- Air conditioning compressor
- Alternator
- Aftertreatment Control Module (ACM)
- Cooling fan clutch
- Engine Control Module (ECM)
- Engine Interface Module (EIM)
- High pressure pump
- Power steering pump
- Starter motor
- Turbochargers

Engine Description

International® MaxxForce® 11 and 13 Diesel Engines	
Engine Configuration	4 stroke, inline six cylinder diesel
Advertised brake horsepower @ rpm	
• MaxxForce® 11	See EPA exhaust emission label
• MaxxForce ® 13	See EPA exhaust emission label
Peak torque @ rpm	
• MaxxForce® 11	See EPA exhaust emission label
• MaxxForce® 13	See EPA exhaust emission label
Displacement	
• MaxxForce® 11	10.5 L (641 in^3)
• MaxxForce® 13	12.4 L (758 in^3)
Compression ratio	17.0:1
Stroke	
• MaxxForce® 11	155 mm (6.10 in)
• MaxxForce® 13	166 mm (6.54 in)
Bore (sleeve diameter)	
• MaxxForce® 11	120 mm (4.72 in)
• MaxxForce® 13	126 mm (4.96 in)
Total engine weight (dry weight without trim or accessories)	
• MaxxForce® 11	1018 kg (2244 lbs)
• MaxxForce® 13	1018 kg (2244 lbs)
Firing order	1-5-3-6-2-4
Engine rotation direction (facing flywheel)	Counterclockwise

Aspiration	Dual turbocharged and charge air cooled
Combustion system	Direct injection turbocharged
Fuel system	High pressure common rail
Lube system capacity (including filter)	40 L (42 qts)
Lube system capacity (overhaul only, with filter)	44 L (46 qts)
Engine oil pressure at operating temperature with SAE 15W-40 oil	
• Low idle	138 - 172 kPa (20 - 25 psi)
• High idle	448 - 586 kPa (65 - 85 psi)
Idle speed (no load)	600 rpm
Thermostat operating temperature	83 °C - 91 °C (181 °F - 196 °F)

Standard Features

The International® MaxxForce® 11 and 13 diesel engines are designed for increased durability, reliability, and ease of maintenance.

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

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

The MaxxForce® 11 engines use aluminum pistons, and the MaxxForce® 13 engines use one piece steel pistons. All pistons use an offset piston axis and centered combustion bowls. Crown markings show correct piston orientation in the crankcase.

The one piece crankcase can withstand high pressure loads during operation. The crankcase uses replaceable wet cylinder liners that are sealed by dual crevice seals.

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

A gerotor lube oil pump is mounted behind the front cover and is driven by the crankshaft. Pressurized oil is supplied to engine components. All International® MaxxForce® 11 and 13 engines use an engine oil cooler and a cartridge-style engine oil filter element.

The distributor case serves as the mounting bracket for the refrigerant compressor. The pad mounting design of the alternator and refrigerant compressor brackets provide easy removal and improved durability.

The low pressure fuel supply pump draws fuel from the fuel tank through the fuel strainer element, and pumps it through the fuel filter housing assembly. The fuel filter housing assembly includes the filter element, fuel pressure sensor, and drain valve. Conditioned fuel is then pumped through the high pressure fuel pump towards the fuel injectors.

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

The International® MaxxForce® 11 and 13 engines use dual turbochargers with an air-to-liquid Charge Air Cooler (CAC) after each stage.

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

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

An open crankcase breather system uses an engine mounted oil separator to return oil to the crankcase and vent the crankcase gasses to the atmosphere.

Optional Features

The engine retarder is available as an option for all engine displacements. The engine retarder is a compression release system that provides additional vehicle braking performance. The operator can control the engine retarder for different operating conditions.

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

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

The coolant heater warms the engine coolant surrounding the cylinders. Warmed engine coolant increases fuel economy and aids start-up in cold weather conditions.

Chassis Mounted Features

The aftertreatment system, part of the larger exhaust system, processes engine exhaust so that it meets tailpipe emission requirements.

- The Diesel Oxidation Catalyst (DOC) oxidizes hydrocarbons and carbon monoxide, provides heat for exhaust system warmup, aids in temperature management for the DPF, and oxidizes NO into NO_2 for passive DPF regeneration.
- The Diesel Particulate Filter (DPF) temporarily stores carbon-based particulates, oxidizes stored particulates, stores non-combustible ash, and provides required exhaust back pressure drop for engine performance.

Engine Component Locations

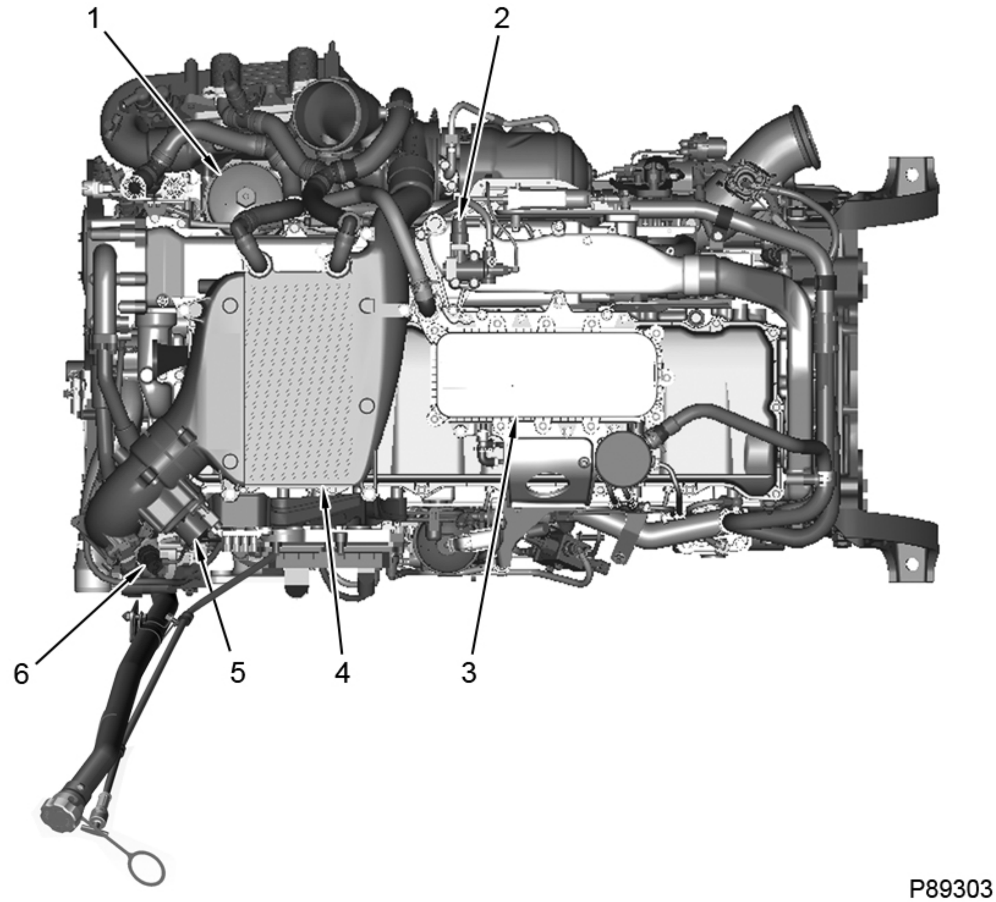


Figure 3 Component location – top

1. Oil module
2. Exhaust Gas Recirculation (EGR) control valve
3. Service breather assembly
4. High-pressure Charge Air Cooler (HPCAC)
5. Intake Throttle Valve (ITV)
6. Glow plug

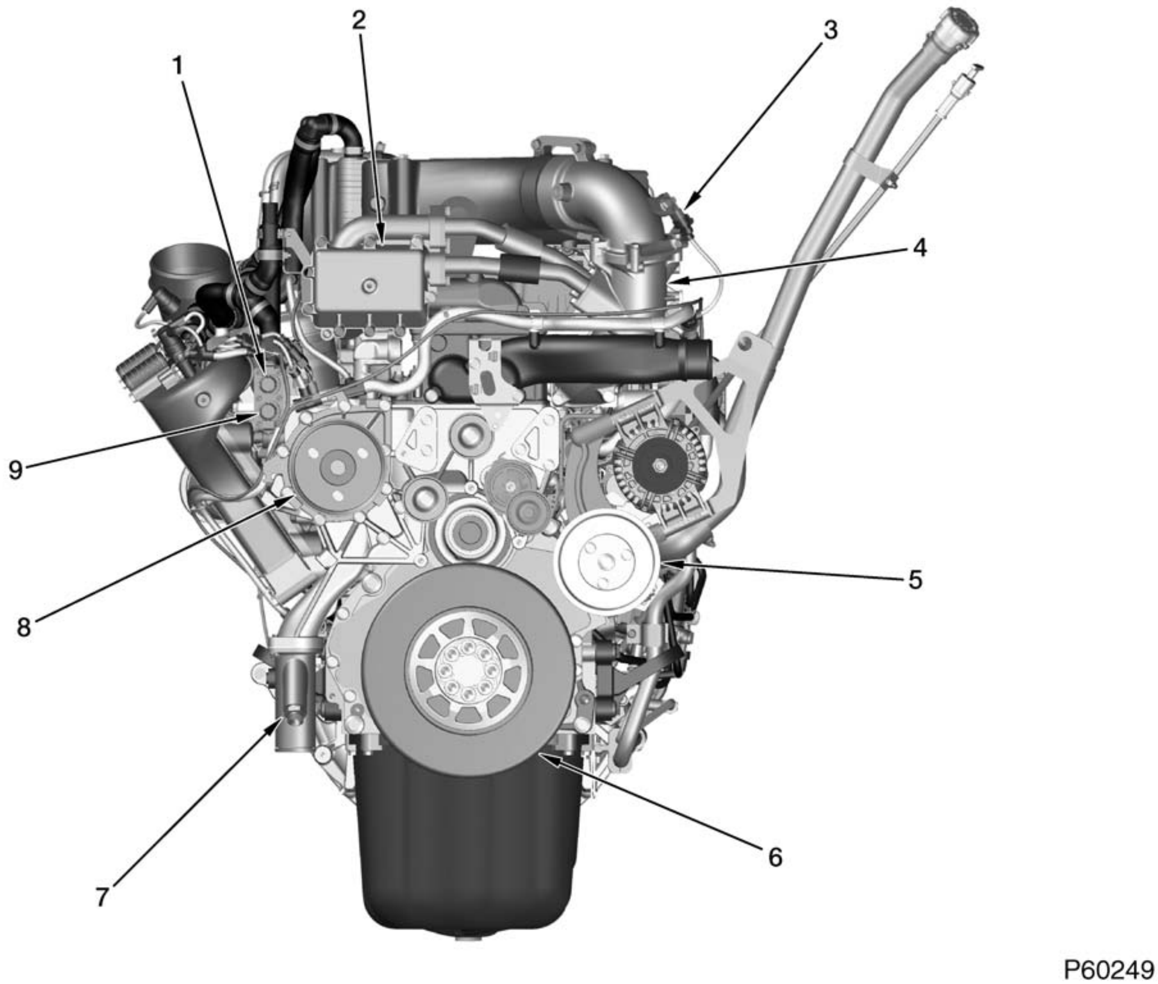


Figure 4 Component location – front

1. Coolant Mixer Valve (CMV)
2. Exhaust Gas Recirculation (EGR) module
3. Manifold Absolute Pressure/ Intake Air Temperature 2 (MAP/IAT2) sensor
4. Air inlet duct
5. Pulley (drive housing)
6. Vibration damper
7. Coolant heater (if equipped)
8. Pulley (water pump)
9. Coolant Flow Valve (CFV)

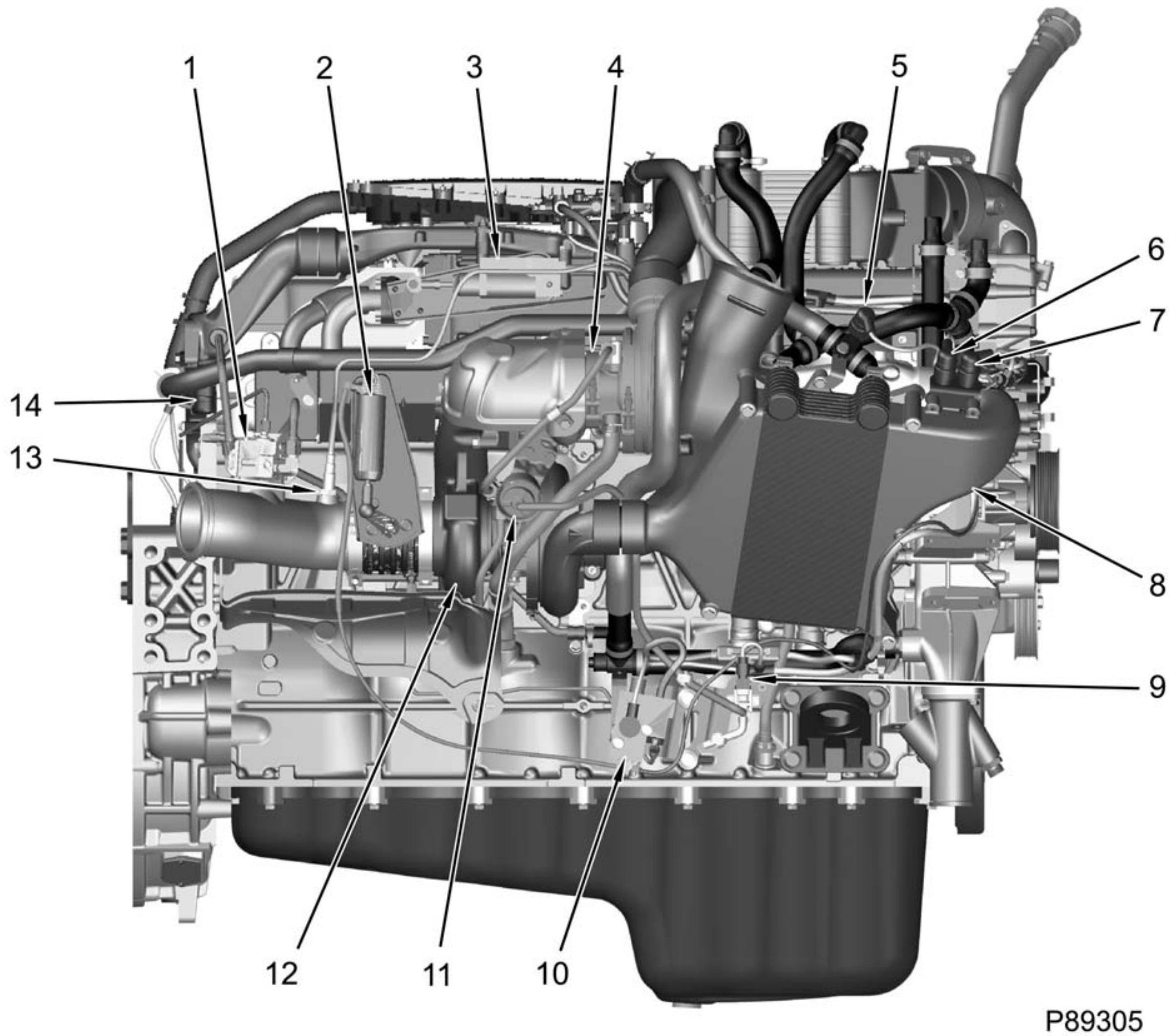


Figure 5 Component location – right

1. Aftertreatment Fuel Injector (AFI)
2. Exhaust manifold with butterfly
3. Exhaust Gas Recirculation (EGR) module
4. High-pressure turbocharger
5. Engine Coolant Temperature 2 (ECT2) sensor
6. Engine Oil Temperature (EOT) sensor adapter line
7. Engine Oil Pressure (EOP) sensor adapter line
8. Low-pressure Charge Air Cooler (LPCAC)
9. Boost Control Solenoid (BCS) valve
10. Retarder control
11. Boost control actuator
12. Low-pressure turbocharger
13. Exhaust Lambda Sensor (ELS)
14. Engine Coolant Temperature (ECT) sensor

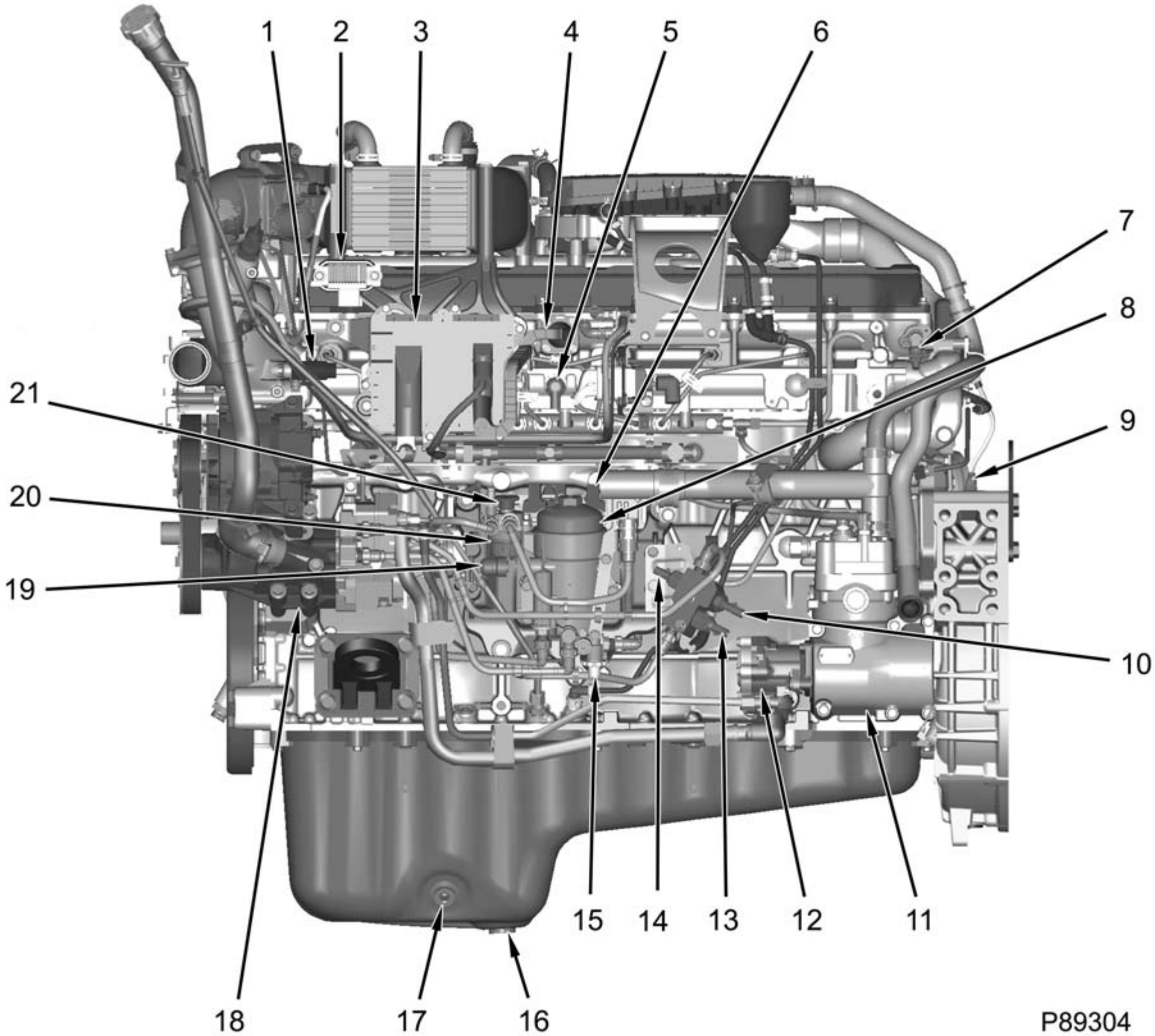


Figure 6 Component location – left

1. Cold Start Solenoid (CSS) valve
2. Cold Start Relay (CSR)
3. Engine Control Module (ECM)
4. Injector harness
5. Manifold Air Temperature (MAT) sensor
6. Engine Interface Module (EIM)
7. Camshaft Position (CMP) sensor
8. Fuel filter housing assembly
9. Crankshaft Position (CKP) sensor
10. Aftertreatment Fuel Pressure (AFP) sensor
11. Air compressor
12. Power steering pump
13. Aftertreatment Fuel Supply (AFS) valve
14. Aftertreatment Fuel Drain (AFD) valve
15. Water drain valve (from fuel filter)
16. Oil drain plug
17. Oil preheater (optional)
18. High-pressure pump
19. Engine Fuel Pressure (EFP) sensor
20. Fuel strainer cover
21. Fuel primer pump assembly

Air Management System (AMS)

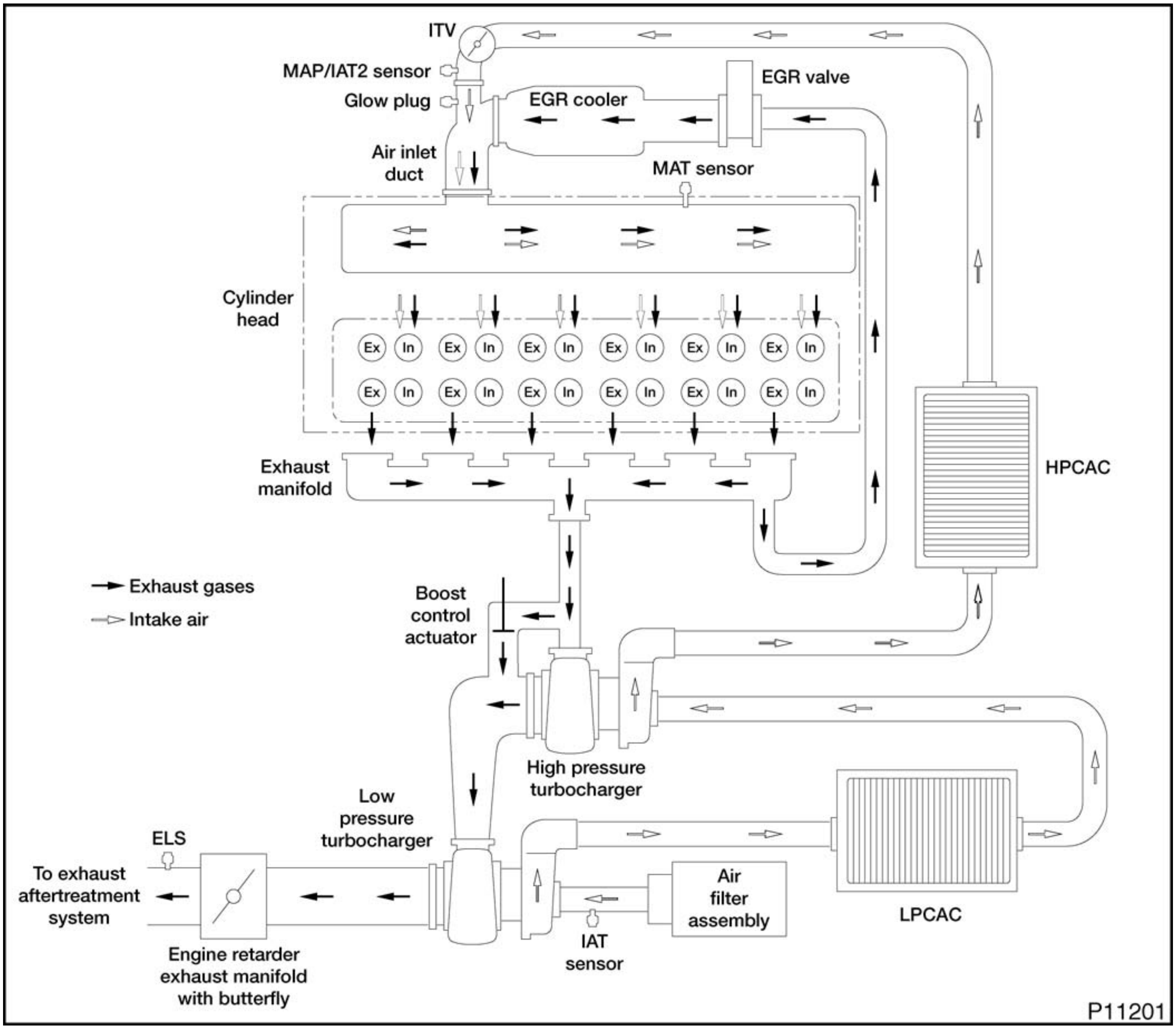


Figure 7 Air Management System (AMS)

The AMS includes the following:

- Air filter assembly
- Low pressure turbocharger
- Low Pressure Charge Air Cooler (LPCAC)
- High pressure turbocharger
- High Pressure Charge Air Cooler (HPCAC)
- Intake Throttle Valve (ITV)
- Air inlet duct
- Cold start assist
- Exhaust and intake valves
- Exhaust Gas Recirculation (EGR)
- Exhaust system
- Engine retarder exhaust manifold with butterfly
- Diesel Particulate Filter (DPF) – aftertreatment

Air Flow

Air flows through the air filter assembly and enters the low pressure turbocharger. The low pressure turbocharger increases the pressure, temperature, and density of the intake air before it enters the LPCAC. Cooled compressed air flows from the LPCAC into the high pressure turbocharger. The high pressure turbocharger increases the intake air pressure up to 345 kPa (50 psi). The hot compressed air flows into the HPCAC where it is cooled, and then through the Intake Throttle Valve (ITV) and air inlet duct.

If the EGR control valve is open, exhaust gas passes through the EGR system into air inlet duct where it is mixed with the filtered intake air. This mixture flows through the air inlet duct into the intake manifold and cylinder head. The intake manifold is an integral part of the cylinder head casting.

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

During cold weather, the cold start assist system rapidly heats the intake air by injecting and igniting small quantities of fuel into the air inlet duct.

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

The engine retarder exhaust manifold contains a butterfly valve that is actuated by an external actuator. When the engine retarder control is applied, the butterfly valve restricts flow and increases exhaust backpressure. The increased backpressure actuates the engine retarder. When the butterfly valve is opened, the backpressure is released and the exhaust valves return to normal operation.

The exhaust gases flow from the engine retarder exhaust manifold through the vehicle aftertreatment system, to the exhaust tail pipe.

Air Management Components

Turbochargers

The International® MaxxForce® 11 and 13 engines are equipped with an electronically controlled two stage turbocharger system. This system provides high levels of charge air pressure to improve the engine performance and to help reduce emissions. Because of its ability to generate very high charge air pressure levels, and to avoid Charge Air Cooler (CAC) overloading conditions, the system is fitted with a spring loaded boost control valve. The boost control valve is actuated by compressed air regulated to 296 kPa (43 psi). The compressed air flow to the boost control actuator is controlled by an electronically controlled Boost Control Solenoid (BCS) valve based on the Pulse Width Modulated (PWM) signal supplied by the Engine Control Module (ECM). The high and low pressure turbochargers are installed as an assembly on the exhaust manifold, on right side of engine.

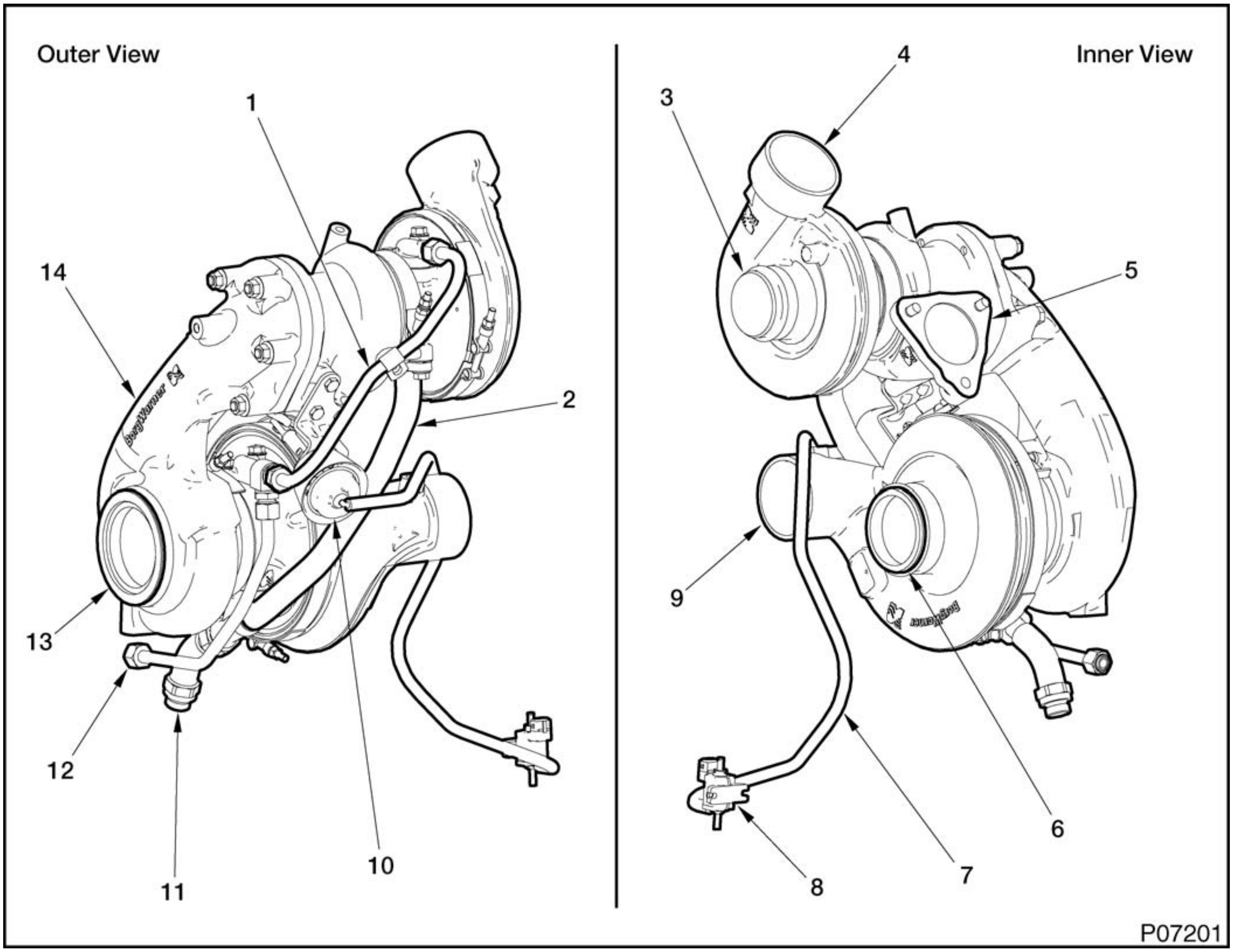


Figure 8 Low and high pressure turbocharger components

1. High pressure turbocharger oil pressure pipe
2. High pressure turbocharger oil return pipe
3. High pressure compressor inlet
4. High pressure compressor outlet
5. High pressure turbine inlet
6. Low pressure compressor inlet
7. Boost control actuator control hose
8. Boost Control Solenoid (BCS) valve
9. Low pressure compressor outlet
10. Boost control actuator
11. Low pressure turbocharger oil return pipe
12. Low pressure turbocharger oil pressure pipe
13. Low pressure turbine outlet
14. High pressure turbine outlet to low pressure turbine inlet tube

The low and high pressure turbochargers are installed inline on the right side of the engine. The high pressure turbocharger is connected directly to the exhaust manifold through the high pressure turbine inlet. The high pressure turbocharger is equipped with a boost control actuator that regulates the turbocharger boost by controlling the amount of exhaust gases that pass through the high pressure turbine. When the boost demand is low, the boost control actuator opens, allowing part of the exhaust gas flow to bypass the high pressure turbine. Cooled compressed air from the Low Pressure Charge Air Cooler (LPCAC) enters the high pressure compressor, where it is further compressed and directed into the High Pressure Charge Air Cooler (HPCAC).

The low pressure turbocharger is installed directly to the output of the high pressure turbine. The exhaust gases enter the low pressure turbocharger through the low pressure turbine inlet and exit through the low pressure turbine outlet. Fresh air from the air filter enters the low pressure compressor where it is compressed and directed into the LPCAC.

Low Pressure Charge Air Cooler (LPCAC)

The LPCAC is installed between the low pressure and the high pressure turbochargers. The LPCAC air inlet is connected to the low pressure compressor outlet and uses engine coolant to regulate the charge air temperature. The LPCAC air outlet is connected to the turbine inlet on the high pressure turbocharger.

High Pressure Charge Air Cooler (HPCAC)

The HPCAC is installed between the high pressure turbocharger and the Intake Throttle Valve (ITV). The HPCAC air inlet is connected to the high pressure compressor outlet and uses engine coolant to regulate the charge air temperature. The HPCAC air outlet is connected directly to the ITV body.

Boost Control Solenoid (BCS) Valve

The BCS valve controls the boost control actuator position by regulating the compressed air based on a Pulse Width Modulated (PWM) signal received from the Engine Control Module (ECM).

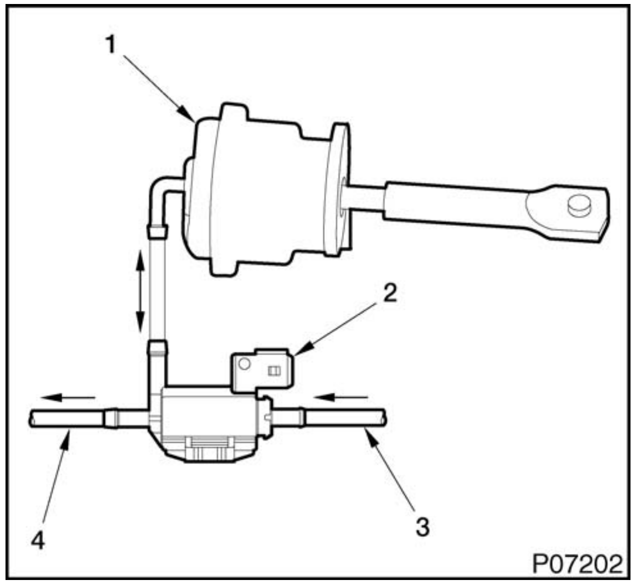


Figure 9 BCS valve operation

1. Boost control actuator
2. BCS valve
3. Compressed regulated air supply
4. Vent to atmosphere

With no PWM signal, the BCS valve is open and air is supplied to the boost control actuator maintaining it in the open position. When an increase in the charge air pressure is required, the ECM supplies PWM voltage to close the BCS valve. The limit values of the PWM signal are between approximately 9%, corresponding to a fully opened BCS valve, and 100%, corresponding to a closed BCS valve. When the BCS valve closes it interrupts the air supply to the boost control actuator and at the same time relieves the air pressure from the boost control actuator by allowing it to vent to the atmosphere. The boost control actuator then closes, resulting in increased charge air pressure.

Exhaust Gas Recirculation (EGR) System

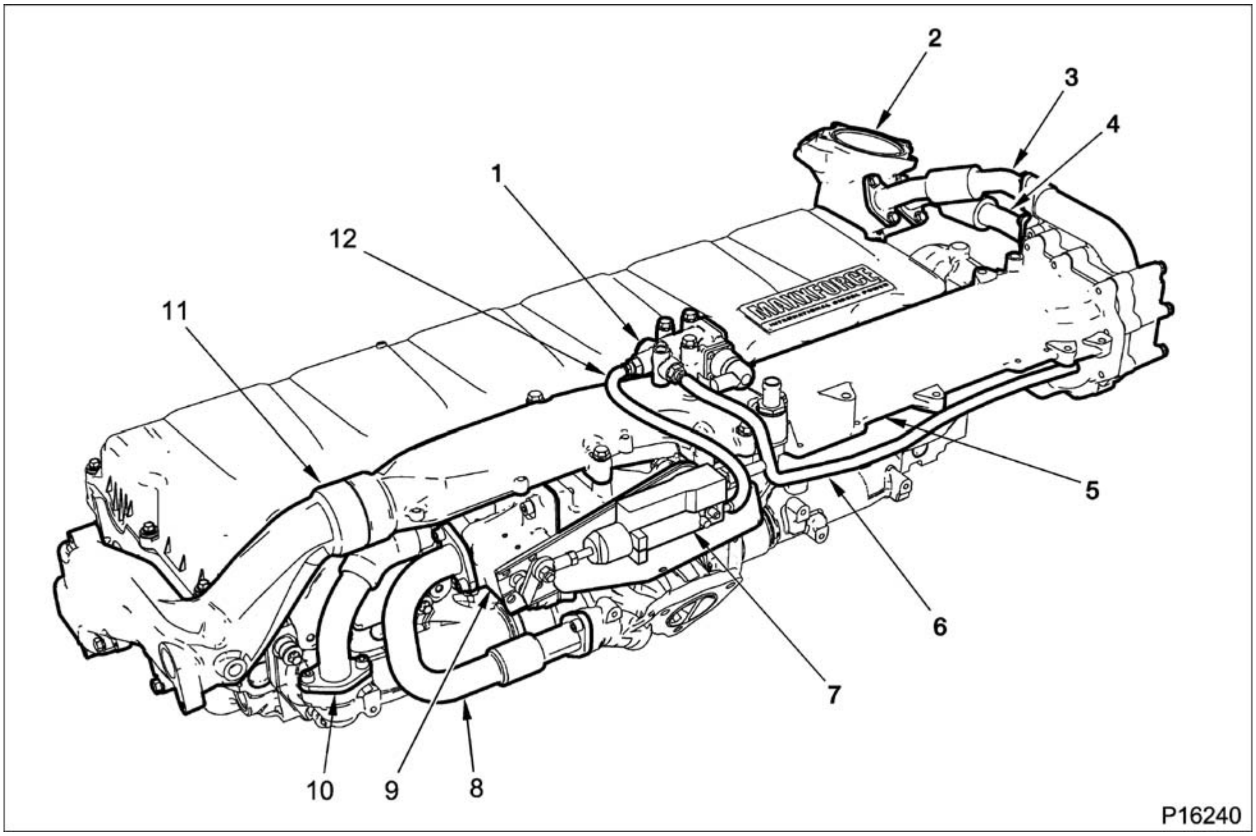


Figure 10 EGR system

1. EGR control valve
2. Air inlet duct
3. Front inner EGR tube
4. Front outer EGR tube
5. EGR module
6. Air supply line assembly
7. EGR throttle valve actuator
8. Rear outer EGR tube
9. EGR throttle valve
10. Rear inner EGR tube
11. Coolant elbow
12. EGR control valve - EGR cooler module air line assembly

EGR System Overview

The EGR system reduces Nitrogen Oxides (NO_x) engine emissions by introducing cooled exhaust gas into the air inlet duct. NO_x forms during a reaction between nitrogen and oxygen at high temperatures during combustion. An Exhaust Lambda Sensor (ELS) located in the exhaust pipe, monitors the oxygen content in the exhaust gas and provides input to the Engine Control Module (ECM) to control the EGR throttle valve.

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

- Charge air temperatures is below 10 °C (50 °F)
- Charge air temperature exceeds 70 °C (158 °F)
- Engine coolant temperature exceeds 95 °C (203 °F)
- During engine retarder control operation
- Acceleration/high engine load

EGR Flow

Exhaust gas from the exhaust manifold flows through the rear EGR tubes to EGR throttle valve. When the EGR is activated, the EGR throttle valve opens and allows exhaust gas to enter the EGR module for cooling. Cooled exhaust gas flows through the front EGR tubes into the air inlet duct where it is mixed with filtered intake air.

EGR Control

The EGR system consists of an EGR module, EGR control valve, and Exhaust Lambda Sensor (ELS). The EGR module contains an EGR throttle valve which consists of an air actuator cylinder, mounting bracket, and valve. Within the air actuator cylinder is an Exhaust Gas Recirculation Position (EGRP) sensor.

The EGR throttle valve is installed at the rear of the EGR module on the right side of engine valve cover and limits the exhaust gas flow into the EGR cooler.

The EGR actuator cylinder uses compressed air controlled by the EGR control valve to move and hold position of an exhaust gas flapper valve internal to the EGR module. The EGRP sensor located inside the actuator cylinder, monitors and provides an EGR valve position signal to the ECM.

The EGR control valve is connected to the truck compressed air system and regulates the air supply to the EGR throttle valve based on the Pulse Width Modulated (PWM) signal from the ECM.

The ELS is installed in the exhaust pipe in front of the aftertreatment fuel injector. The ELS has a heater element that heats the sensor to its normal operating temperature of 780 °C (1436 °F). During initial engine warm-up the ELS heater element is activated only after the engine coolant reaches 40 °C (104 °F) and the exhaust gas temperature exceeds 100 °C (212 °F) for more than 30 seconds.

EGR Open Loop System

During the engine warm-up period and before the ELS reaches its normal operating temperature, the EGR system operates in open loop. In open loop, the EGR system is controlled by the ECM based on the charge air temperature, engine coolant temperature, engine speed, and load conditions. The EGR actuator provides feedback to the ECM on current valve position through the EGRP sensor.

EGR Closed Loop System

After the ELS reaches its operating temperature, the EGR system switches to closed loop operation. In closed loop, the EGR system is controlled by the ECM based on the ELS readings.

Aftertreatment (AFT) System

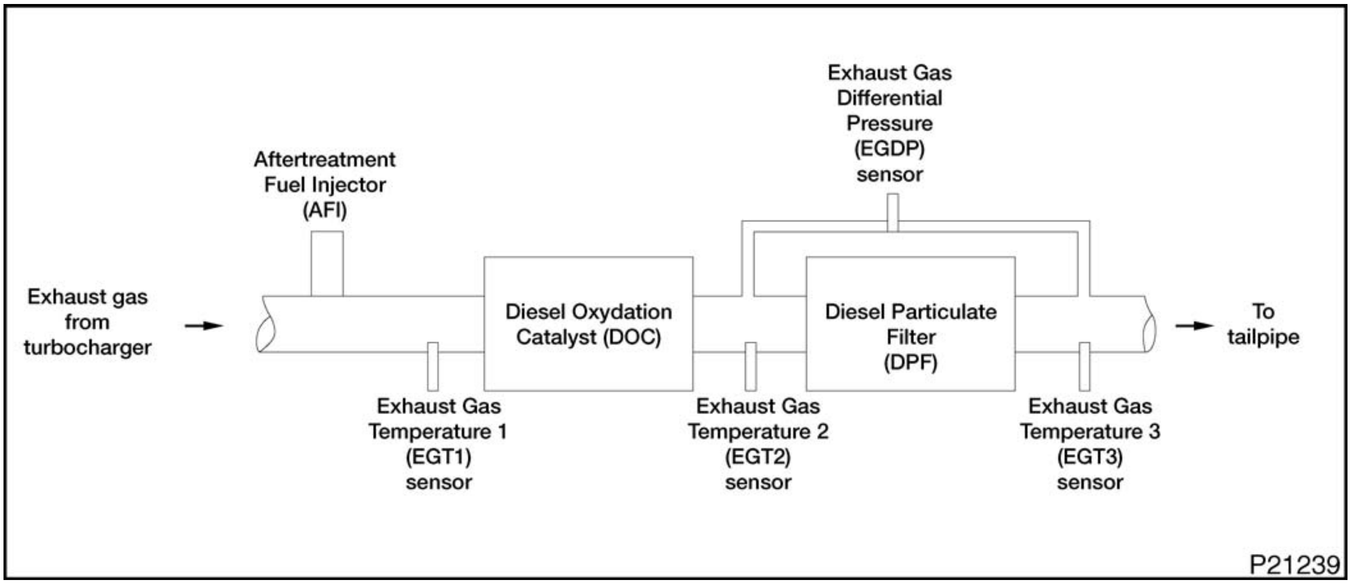


Figure 11 AFT system overview

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.

The AFT system performs the following functions:

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

Aftertreatment Fuel Injection

The aftertreatment system injects fuel into the exhaust gas to increase the temperature necessary for DPF regeneration. Control of the aftertreatment fuel injection is done by the Aftertreatment Control Module (ACM). The ACM receives data from the aftertreatment sensors directly and determines when regeneration is required.

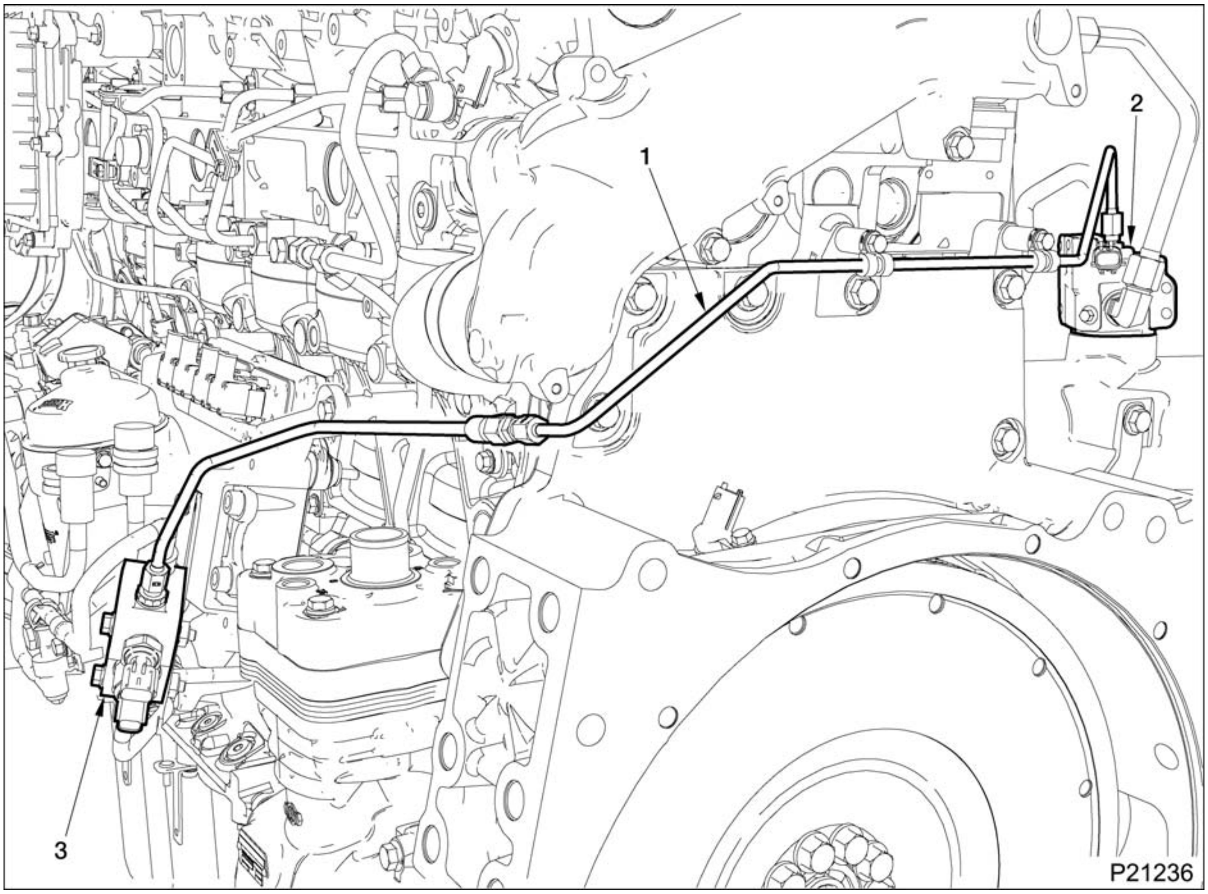


Figure 12 Aftertreatment fuel injection components

1. Fuel supply assembly
2. Aftertreatment Fuel Injector (AFI)
3. Hydrocarbon (HC) cut-off valve

Hydrocarbon (HC) Cut-off Valve

The HC cut-off valve is installed on the left side of the engine in front of the air compressor. The HC cut-off valve is connected to the clean side of the low pressure fuel system as well as to the fuel return line, and controls the fuel flow to the AFI.

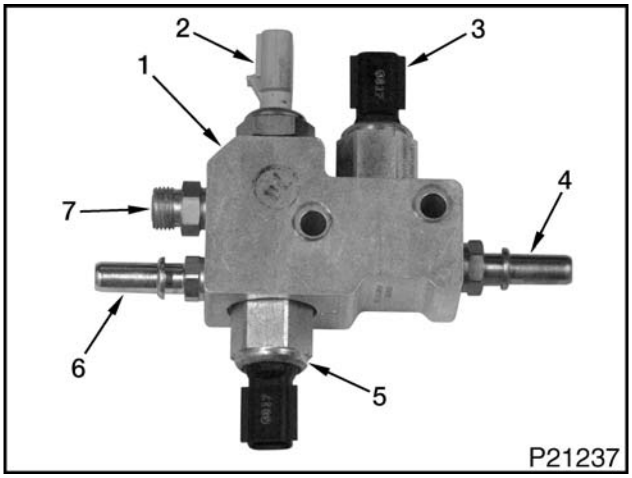


Figure 13 HC cut-off valve

1. HC cut-off valve
2. Aftertreatment Fuel Pressure (AFP) sensor
3. Aftertreatment Fuel Supply (AFS) valve
4. Fuel supply from fuel filter housing assembly
5. Aftertreatment Fuel Drain (AFD) valve
6. Fuel return to tank
7. Fuel supply to AFI

The AFS valve controls the fuel supply to the AFI when regeneration is required. The AFS valve is controlled by the ACM.

The AFP sensor monitors the fuel pressure in the aftertreatment fuel system and provides a signal to the ACM.

The AFD valve is used to relieve the pressure from the aftertreatment fuel system. A fuel overpressure can occur due to fuel thermal expansion inside the AFI fuel supply line. When the fuel pressure increases, the ACM commands the AFD to open and relieve the fuel pressure into the fuel return to tank line.

Aftertreatment Fuel Injector (AFI)

The AFI is located on the right side of the engine and is installed on the turbo exhaust pipe after the Exhaust Lambda Sensor (ELS).

Pressurized fuel is supplied to the AFI from the HC cut-off valve through the fuel supply assembly. When the conditions required for regeneration are met, the ACM sends a voltage to the AFI solenoid valve to open and inject fuel into the turbo exhaust pipe.

To protect the AFI internal components, continuous engine coolant flow through the AFI is maintained by external coolant supply and return lines.

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 non-combustible ash

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

Aftertreatment System Conditions and Responses

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

Fuel Management System

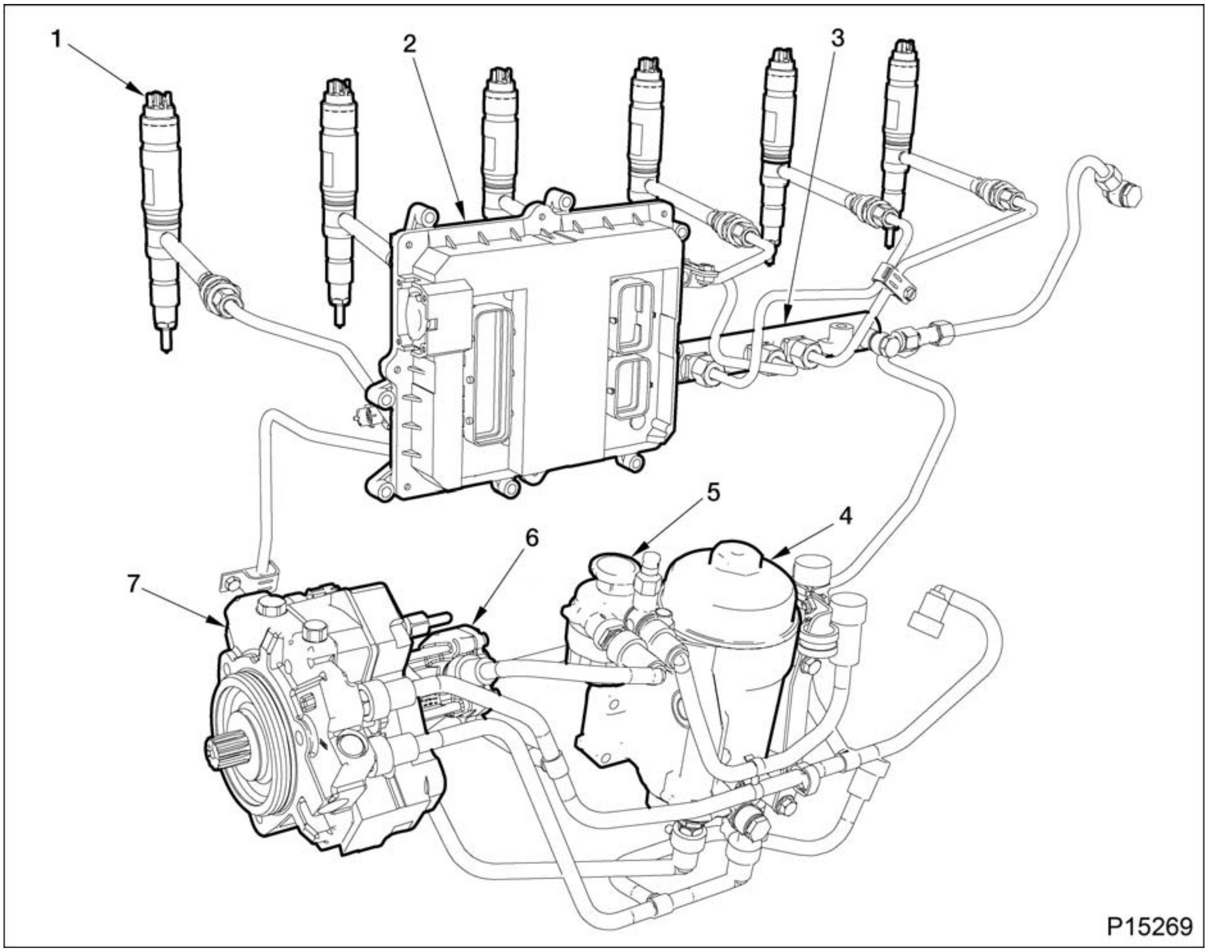


Figure 14 Fuel system

1. Injector (6)
2. Engine Control Module (ECM)
3. Pressure pipe rail
4. Fuel filter housing assembly
5. Fuel primer pump assembly
6. Low pressure fuel pump
7. High pressure pump

The International® MaxxForce® 11 and 13 engines are equipped with a high pressure common rail injection system. The common rail fuel injection system provides fuel under constant high pressure to the fuel injectors for optimal fuel atomization in the combustion chamber.

Fuel is pumped from the tank and through a fuel strainer element by a low pressure fuel pump mounted on the left side of engine. Fuel flows from the low pressure fuel pump through a main fuel filter housing assembly before being supplied to a high pressure pump. The high pressure pump supplies high pressure fuel to a pressure pipe rail, which feeds the injectors through individual tubes. The low pressure fuel pump and the high pressure pump are assembled as one gear driven unit.

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

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

Low Pressure Fuel System

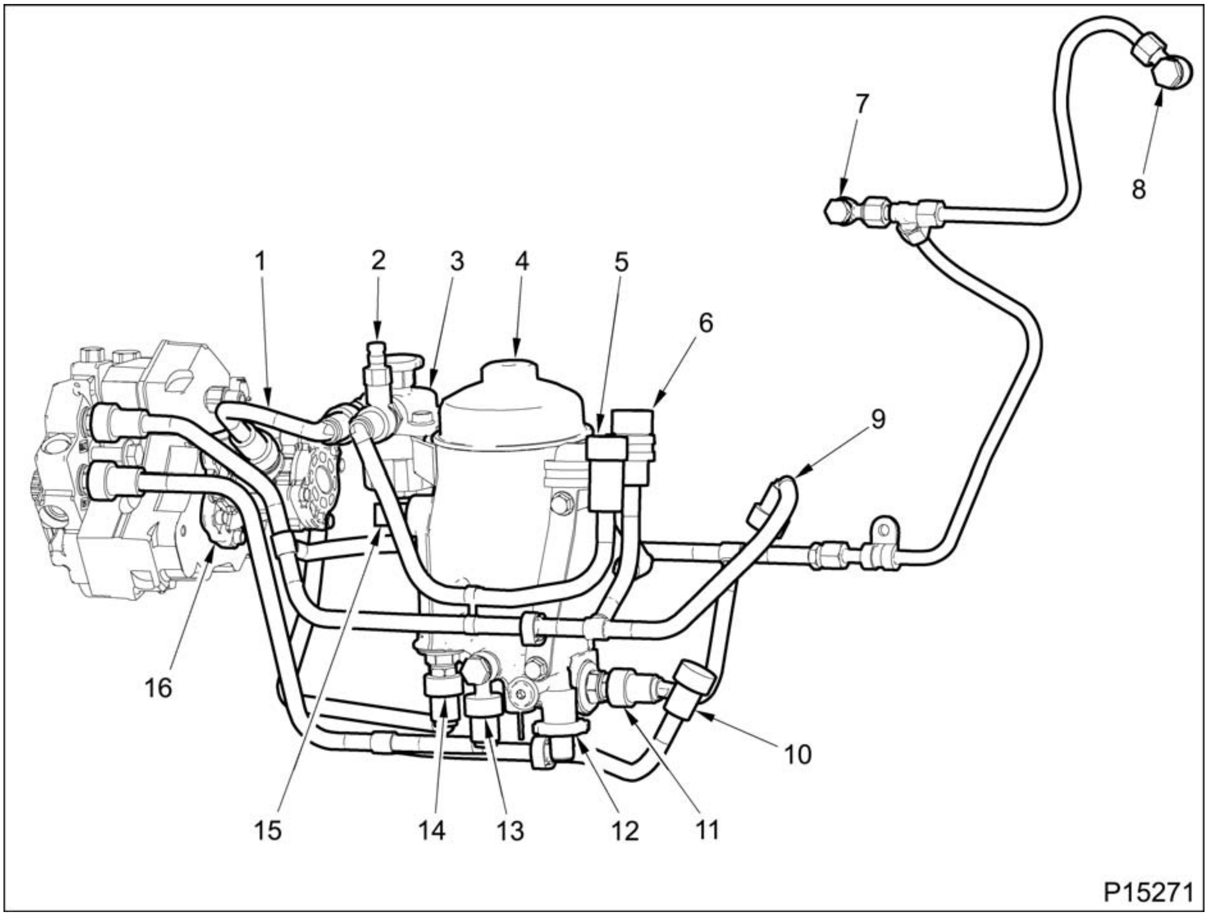


Figure 15 Low pressure fuel system

1. Preliminary filter feed fuel line
2. Quick disconnect valve
3. Fuel primer pump assembly
4. Fuel filter housing assembly
5. Fuel supply from tank connector
6. Fuel return to tank connector
7. Rail pressure relief valve return
8. Injector fuel return
9. Fuel return line
10. Filter T-connector fuel line
11. Return from fuel filter connection
12. Water drain valve
13. Fuel supply to high pressure pump connection
14. Fuel supply to fuel filter connection
15. Engine Fuel Pressure (EFP) sensor
16. Low pressure fuel pump (part of high pressure pump)

The low pressure fuel system pumps fuel from the tank through the fuel strainer element and separator filter element, then to the high pressure fuel system, cold start assist system, and aftertreatment system. The low pressure fuel system consists of fuel lines, fuel primer pump assembly, low pressure fuel pump, fuel filter housing assembly, and fuel pressure sensor.

Fuel Primer Pump Assembly

The fuel is drawn from the tank through the fuel primer pump assembly and into the low pressure fuel pump. The fuel primer pump assembly has an integrated fuel strainer element that can be washed. The fuel primer pump assembly is manually operated and is used to prime the low pressure fuel system anytime the system is emptied.

Low Pressure Fuel Pump

Fuel is drawn from the fuel primer pump assembly into the low pressure fuel pump. The low pressure fuel pump is flanged to and is driven by the high pressure pump. The low pressure fuel pump supplies fuel to the fuel filter housing assembly at pressures varying between 496 kPa (72 psi) at idle, and 896 kPa (130 psi) at rated speed. The low pressure fuel pump is equipped with an internal pressure regulator that relieves the fuel pressure internally if the pressure exceeds 896 kPa (130 psi).

Fuel Filter Housing Assembly

The fuel filter housing assembly is located on the left side of the engine and has a disposable filter element. An Engine Fuel Pressure (EFP) sensor is installed on the front side of the fuel filter housing assembly and it measures fuel pressure between the low pressure fuel pump and the filter element. The fuel filter housing assembly also has a drain valve that allows water and dirt to be drained periodically and during filter element replacement. An additional function of the fuel filter housing assembly is fuel system self-deaeration. The air separated from fuel is pushed back into the fuel tanks through the return line.

The fuel filter housing assembly is equipped with two additional ports to provide filtered fuel to the aftertreatment system and to the cold start assist system. An orifice regulator is integrated into the fuel filter housing assembly and regulates the fuel pressure for the cold start assist system to 55 kPa (8 psi).

High Pressure Fuel System

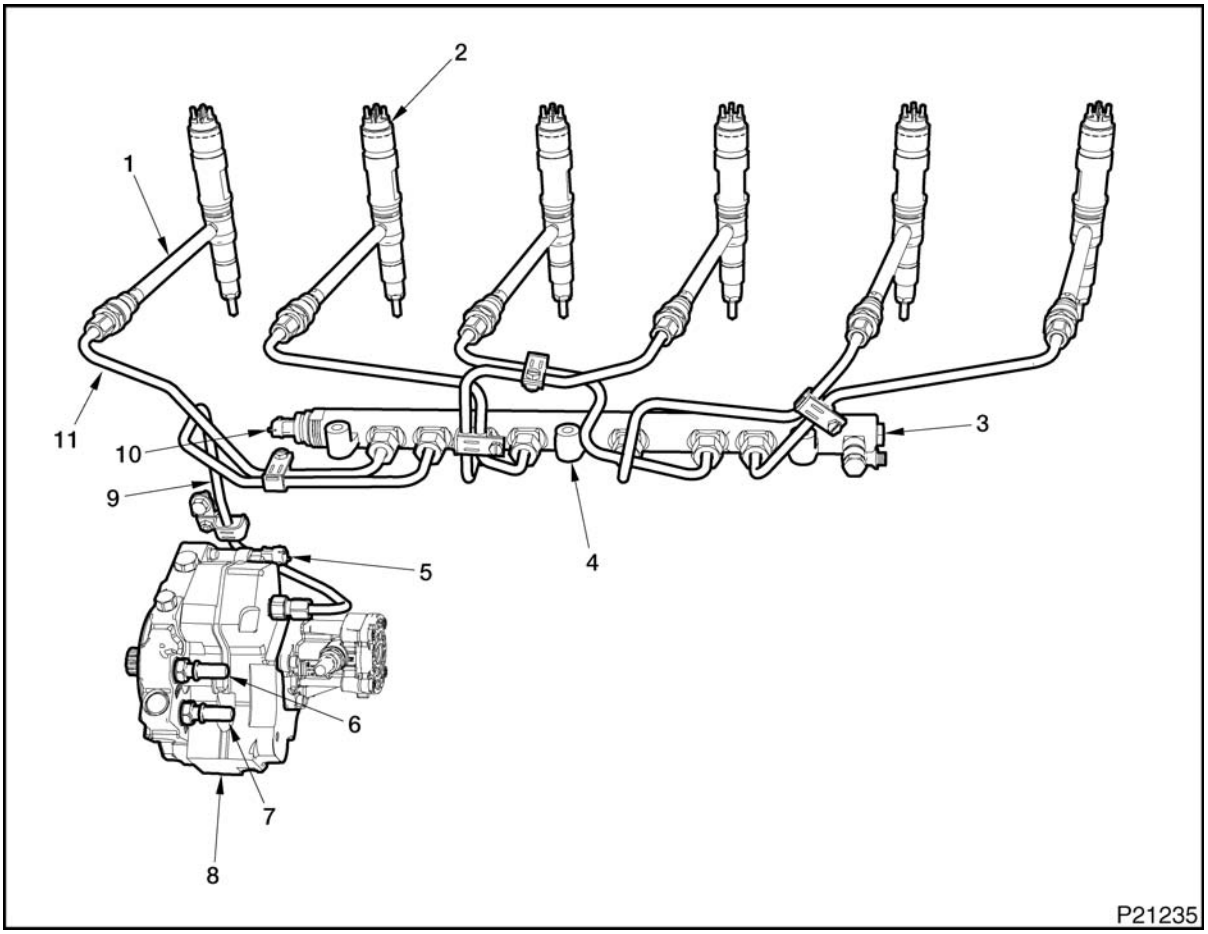


Figure 16 High pressure fuel system

1. Pressure pipe (6)
2. Injector (6)
3. Rail pressure relief valve
4. Pressure pipe rail
5. Fuel Pressure Control Valve (FPCV) (part of high pressure pump)
6. Fuel return from high pressure pump threaded union
7. Fuel supply to high pressure pump threaded union
8. High pressure pump
9. Pressure line
10. Fuel Rail Pressure (FRP) sensor
11. Injection line (6)

Pressurization and injection are separate in the common rail injection system. The optimal injection pressure is generated by the high pressure pump at any engine speed. High pressure fuel quantity from high pressure pump is controlled by a proportional valve. The injection timing and quantity are calculated in the Engine Control Module (ECM) and implemented by solenoid valve controlled injectors. The use of solenoid valve controlled injectors allows three injections per cycle.

The first injection is used to reduce combustion noise and emissions by introducing a small amount of fuel into the cylinder, preventing a rapid rise in cylinder pressure when combustion begins. The first injection occurs only during idling and in partial load mode. The second injection is the main injection. This injection allows high temperatures to be maintained during combustion, but not long enough to allow generation of large soot amounts. The third injection is done during the power stroke to maximize cylinder temperature and reduce engine soot generation.

The high pressure fuel system consists of high pressure pump with integrated Fuel Pressure Control Valve (FPCV), pressure pipe rail, fuel high pressure fuel lines, injectors, FRP sensor, and pressure relief valve.

High Pressure Pump

The high pressure pump supplies the necessary quantity of high pressure fuel for all operating engine modes. The high pressure pump is gear driven and is fuel lubricated. Fuel from the low pressure fuel pump is forced through the fuel filter housing assembly and into the high pressure pump. The flow of fuel to the suction chamber of the high pressure pump is controlled by the FPCV in order to control the high pressure fuel output.

Fuel Pressure Control Valve (FPCV)

The FPCV is a variable position actuator installed on the suction side of the high pressure pump and controls the output fuel pressure. The ECM sends a Pulse Width Modulated (PWM) signal to control the FPCV. A 100% duty cycle PWM signal corresponds to zero fuel pressure delivery, while a 0% duty cycle PWM corresponds to maximum fuel pressure delivery.

Pressure Pipe Rail

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

Fuel Rail Pressure (FRP) Sensor

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

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

Pressure Relief Valve

The pressure relief valve maintains the fuel pressure inside the pressure pipe rail below 179,000 kPa (26,000 psi). If the high pressure pump fuel output exceeds 179,000 kPa (26,000 psi), the pressure relief valve opens and allows fuel to flow into the fuel return line. With the pressure relief valve open, the fuel pressure in the pressure pipe rail drops to approximately 80,000 kPa (11,600 psi).

Injector

The International® MaxxForce® 11 and 13 engines are equipped with electronically controlled injectors. During engine operation, injectors are supplied at all times with high pressure fuel, and the injector solenoid valves open up to three times per cycle. The injectors are positioned vertically in the center of the cylinder head and are held in place by brackets. The seal between the injectors and the combustion chamber consists of a copper washer on the tip of each injector.

Engine Lubrication System

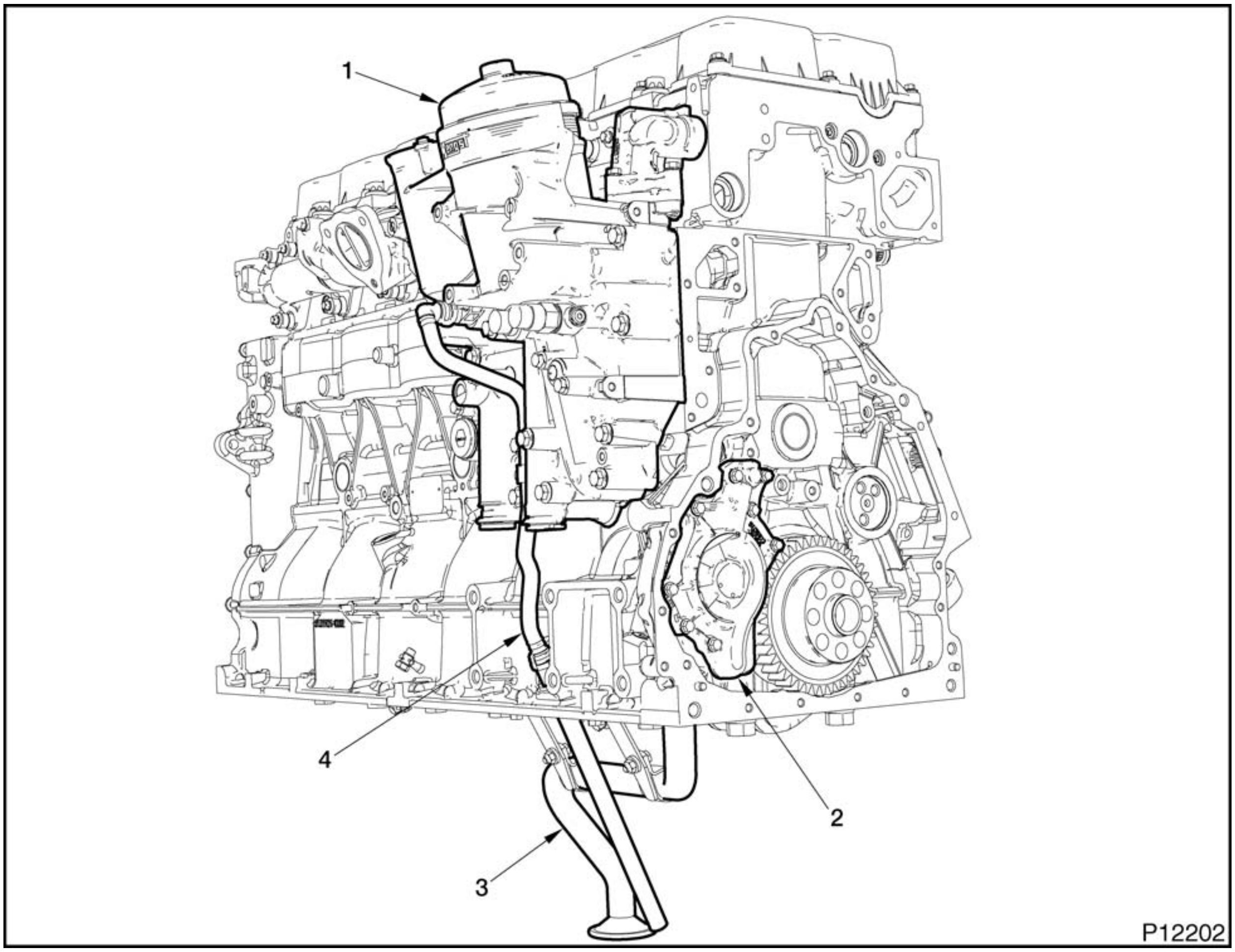


Figure 17 Oil system overview (typical)

1. Oil module
2. Oil pump
3. Oil suction line
4. Oil return tube

Engine oil pressure is generated by a gerotor oil pump located inside the front cover and is driven off of the crankshaft gear. The oil module is located on the right side of the engine and houses the oil filter element, the oil cooler assembly, and the oil pressure regulator. Pressurized filtered oil passes between the oil filter element and cylinder head through an external flange elbow. Oil drains back into the oil module through a separate passage in the external flange elbow, and into the crankcase from an opening at the rear of the cylinder head.

Oil Flow and Components

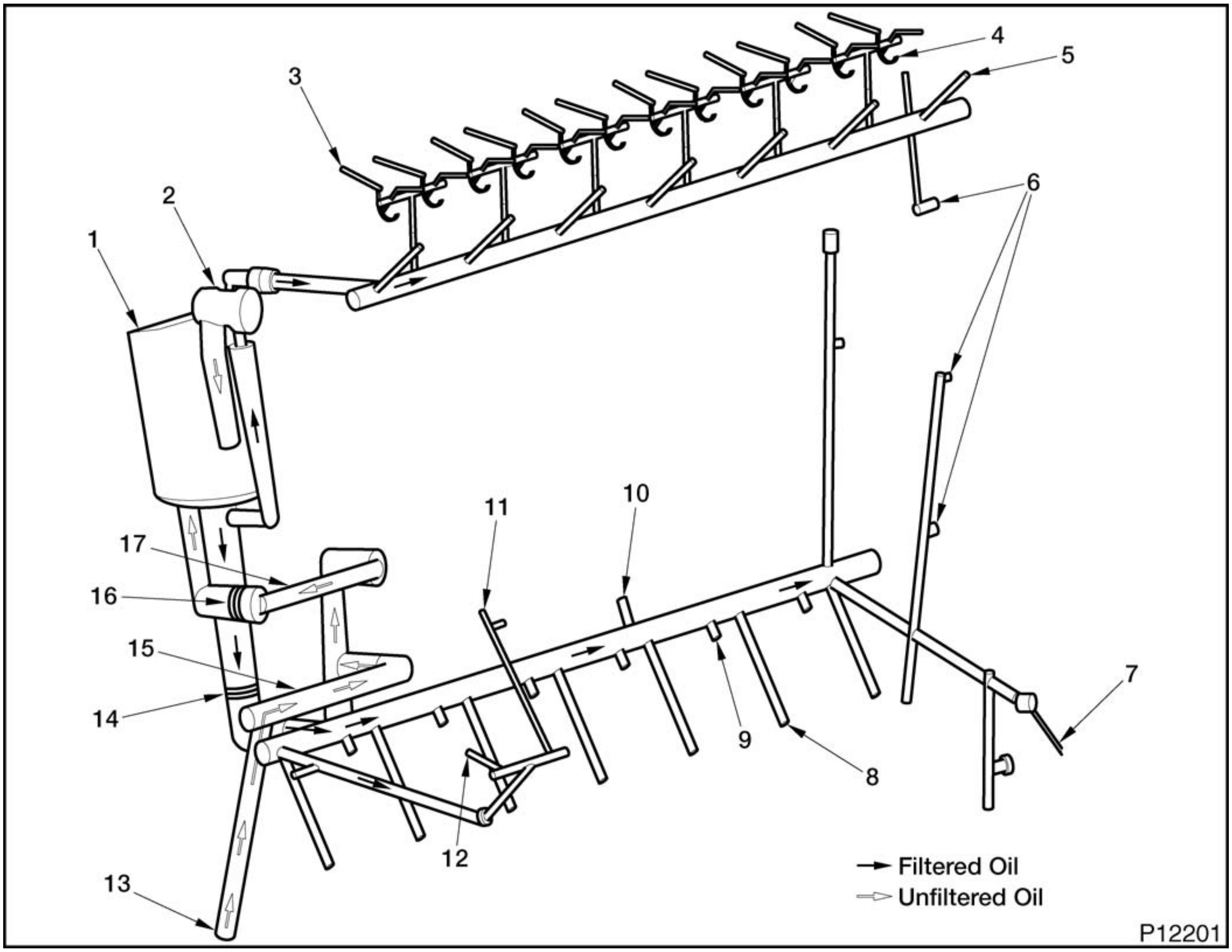


Figure 18 Oil flow

1. Oil filter element
2. Oil return from cylinder head
3. Oil supply to exhaust valve bridge
4. Oil supply to rocker gear
5. Oil supply to camshaft bearings
6. Oil supply to intermediate gears
7. Oil supply to air compressor
8. Oil supply to crankshaft main bearings
9. Oil supply to piston oil sprayer nozzles
10. Oil supply to turbochargers
11. Oil supply to drive housing
12. Oil supply to front cover
13. Oil pump output
14. Oil pressure relief valve
15. Oil supply to oil module
16. Oil return shutoff valve
17. Oil cooler

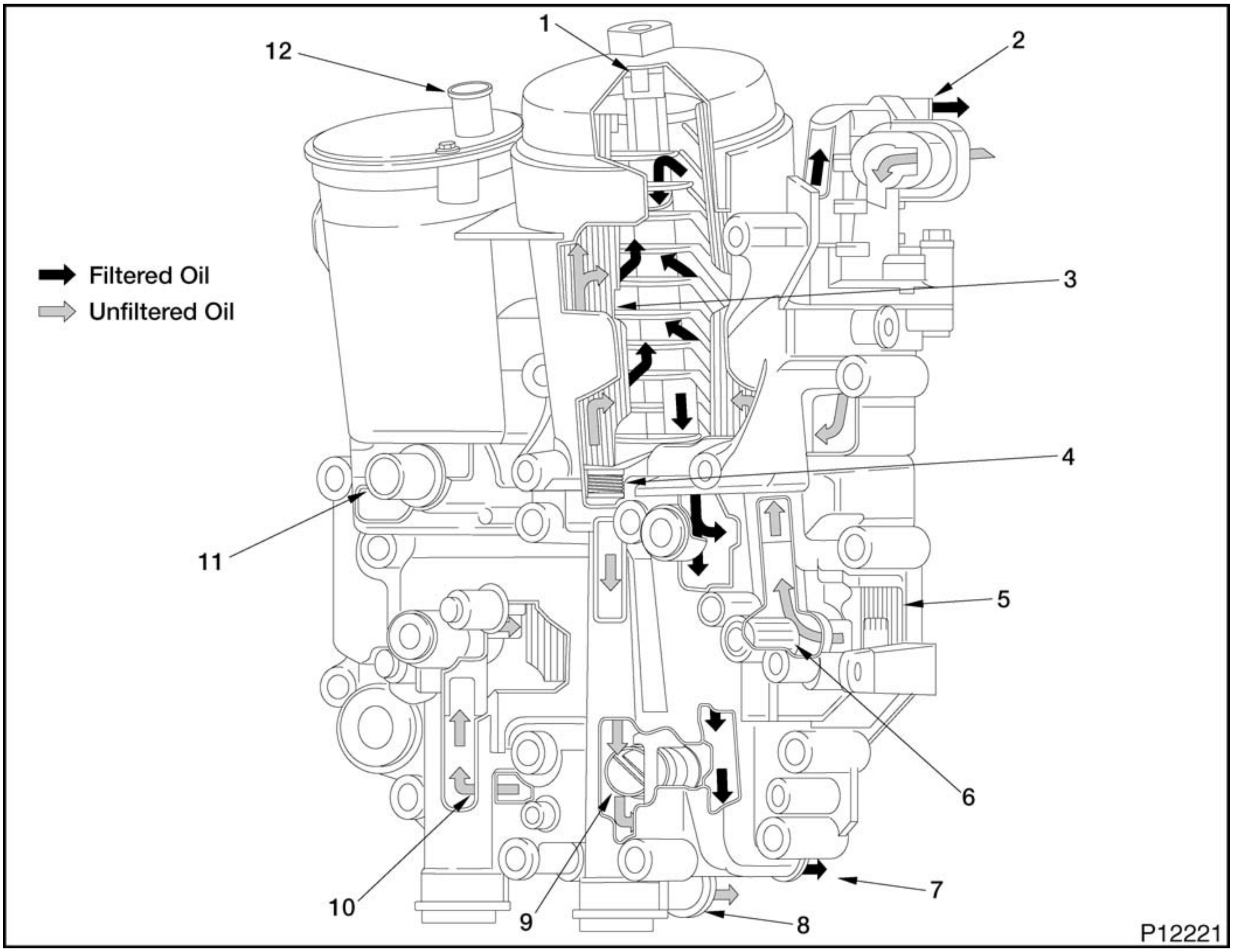


Figure 19 Oil module flow

1. Oil filter bypass valve (part of oil module)
2. Oil supply to cylinder head
3. Oil filter element
4. Service oil drain valve
5. Oil cooler
6. Oil return shutoff valve
7. Oil supply to crankcase
8. Oil return to crankcase
9. Oil pressure relief valve
10. Oil supply from oil pump
11. Crankcase breather oil return connection
12. Oil module to crankcase breather connection

Unfiltered oil is drawn from the oil pan through the pickup tube and front cover passage by the crankshaft driven gerotor pump. The pressurized oil is moved through a vertical crankcase passage and into the oil module.

Inside the oil module, unfiltered oil flows through plates in the oil cooler heat exchanger. Engine coolant flows around the plates to cool the surrounding oil. An oil return shutoff valve installed at the exit from the oil cooler prevents the oil from draining through the oil pump and back into the oil pan when the engine is stopped. If the oil pressure coming out of the oil pump is too high, a pressure relief valve allows the excess oil to return through the crankcase and into the oil pan before entering the oil cooler.

Oil that exits the oil cooler flows through a return shutoff valve that prevents the oil from draining back into the oil pan. From the return shutoff valve, oil enters the oil filter element and flows from the outside to the inside of the filter element to remove debris.

When the filter is restricted, an oil filter bypass valve opens and allows oil to bypass the filter so engine lubrication is maintained. If the oil pressure inside the oil filter element is too high, an oil pressure relief valve, located at the bottom of the oil filter element housing, allows the excess oil to return to the oil pan.

After passing through the oil filter element, the oil flow is directed to the cylinder head and the crankcase.

Clean oil enters cylinder head through an external flange elbow connected directly to the oil module. Inside the cylinder head, oil flows through passages to lubricate the camshaft bearings, rocker arms, exhaust valve bridges, and cylinder intermediate gear.

Clean oil enters the crankcase directly from the oil module to lubricate the crankshaft, high pressure pump, air compressor, intermediate gears, and turbochargers. The crankshaft has cross-drillings that direct oil to the connecting rods.

Oil sprayer nozzles continuously direct cooled oil to the bottom of the piston crowns.

The turbochargers are lubricated with filtered oil from an external supply tube that connects the main oil gallery from the crankcase to the center housing of each turbocharger. Oil drains back to the oil pan through the low and high pressure turbocharger oil return pipes connected to the crankcase.

A service oil drain valve, located at the bottom of the filter element cavity, opens automatically when the filter element is lifted for replacement, and allows the oil from the oil filter element cavity to drain into the oil pan.

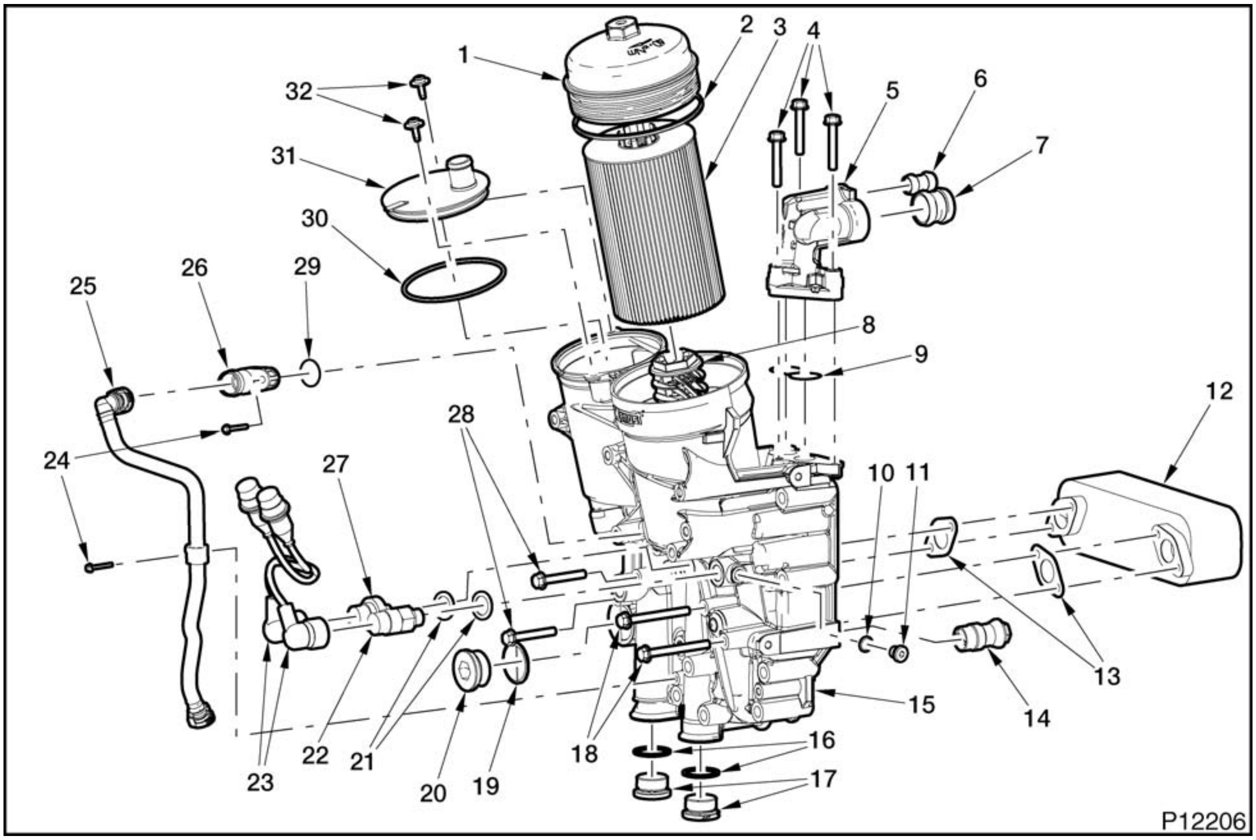


Figure 20 Oil module

1. Oil filter cover
2. O-ring seal
3. Oil filter element
4. M8 x 50 hex bolt (3)
5. Flange elbow
6. DMR20/DN14 extension tube
7. DMR37/DN29 extension tube
8. Oil filter bypass valve (part of oil module)
9. Gasket for flange elbow
10. Seal
11. M10 x 1.0 plug
12. Oil cooler
13. Oil cooler gaskets
14. Oil pressure relief valve
15. Oil module
16. Plug seal (2)
17. M33 x 2 plug (2)
18. M8 x 80 hex bolt (2)
19. Plug seal
20. M38 x 1.5 plug
21. BS-16.7 x 24.0 O-ring seal
22. Engine Oil Pressure (EOP) sensor
23. Adapter lines (electrical connections)
24. M6 x 18 hex bolt (2)
25. Oil return tube
26. Straight fitting
27. Engine Oil Temperature (EOT) sensor
28. M8 x 55 hex bolt (2)
29. O-ring seal
30. O-ring seal
31. Breather cup
32. M6 bolt with washer (2)

The oil module contains a canister style filter, the oil cooler, the EOP and EOT sensors, a pressure relief valve, an oil filter bypass valve, and an oil return shutoff valve. The oil module housing also collects, and then directs crankcase emissions to the breather system through the breather cup at the top of the oil module housing. The oil that separates from the crankcase emissions before it reaches the breather system is drained back into the oil pan through the oil return tube.

Engine Cooling System

Cooling System Components

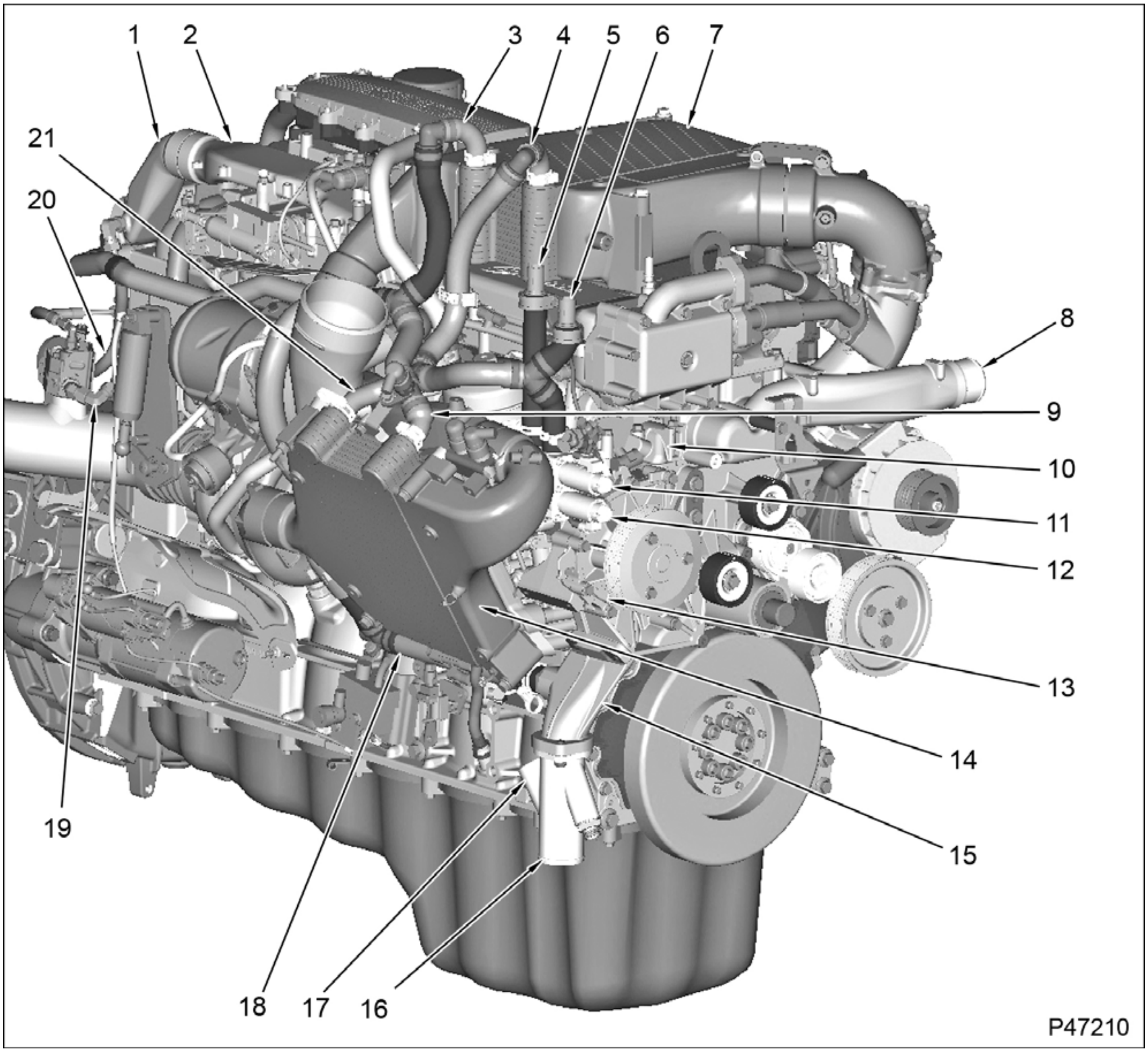


Figure 21 Cooling system components

1. Coolant elbow (middle)
2. Coolant elbow (upper)
3. High-pressure Charge Air Cooler (HPCAC) return coolant pipe
4. HPCAC supply coolant pipe
5. Low Temperature Radiator (LTR) coolant supply pipe
6. Coolant return from LTR
7. HPCAC
8. Coolant elbow (supply to radiator)
9. LPCAC return coolant pipe
10. Thermostat housing assembly
11. Coolant Mixer Valve (CMV)
12. Coolant Flow Valve (CFV)
13. Water pump
14. LPCAC
15. Distributor case
16. Coolant elbow (return from radiator)
17. Surge tank line connector
18. Charge Air Cooler (CAC) return coolant pipe
19. AFI coolant return line
20. Aftertreatment Fuel Injector (AFI) coolant supply line
21. Low Pressure Charge Air Cooler (LPCAC) supply coolant pipe

Cooling System Flow

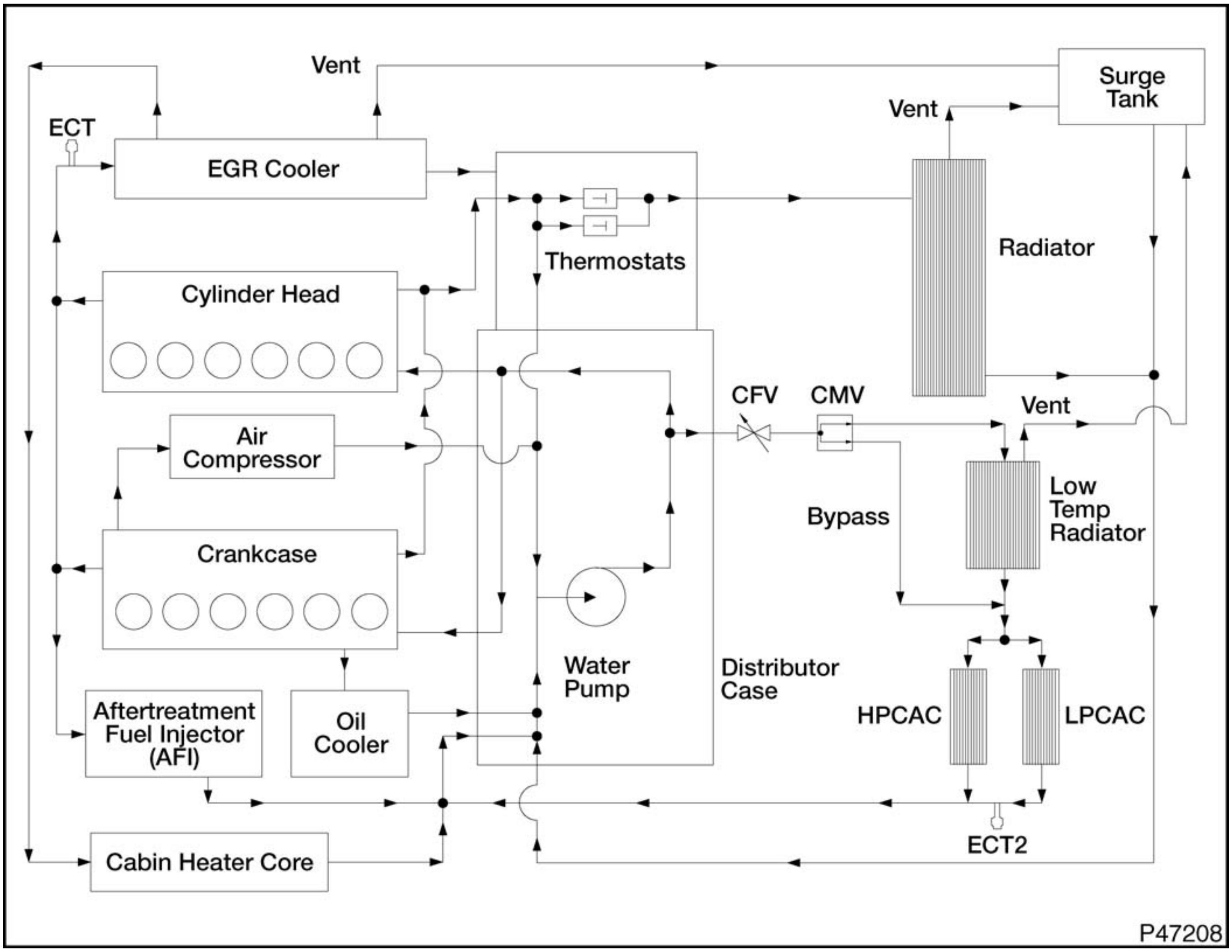


Figure 22 Cooling system flow

The water pump is located on the distributor case and draws coolant from the radiator through the coolant inlet at the lower right side of the distributor case.

The International® MaxxForce® 11 and 13 engines have no coolant passages between the crankcase and cylinder head through the cylinder head gasket. This design eliminates the possibility of coolant leaks at the cylinder head gasket. Coolant in and out of the crankcase and cylinder head is directed through external passages. Coolant flows through the crankcase and cylinder head from front to rear. This coolant flows around the cylinder liners and combustion chambers to absorb heat from combustion.

Coolant exiting the crankcase and cylinder head at the rear of the engine is directed through an external coolant elbow to the Exhaust Gas Recirculation (EGR) module. Coolant passes between the EGR cooler plates, travels parallel to the exhaust flow, and exits into the distributor case. A deaeration port on the top of the EGR module directs coolant and trapped air towards the coolant surge tank.

Coolant from the pump also flows through the HPCAC and the LPCAC to regulate the charge air temperature. Flow through the charge air coolers is controlled by the Coolant Mixer Valve (CMV) and Coolant Flow Valve (CFV). Depending on the coolant temperature, CMV sends coolant through the Charge Air Coolers (CACs), or indirectly to the CACs, after going through the Low Temperature Radiator (LTR) located in front of the main coolant radiator. When the charge air temperature is too low, CMV bypasses the LTR and directs all the coolant through the CACs. When the charge air temperature increases, CMV directs a percentage of the coolant to the LTR before it enters the CACs to cool the charge air. If the engine coolant temperature is too high, CMV sends all of the coolant flow through the LTR and through the CACs to help cool the engine faster.

Both coolant valves are controlled by the Engine Control Module (ECM) based on signals from the Engine Coolant Temperature (ECT) sensor, ECT2 sensor, and the Manifold Air Pressure/Intake Air Temperature 2 (MAP/IAT2) sensors.

Coolant flow to the radiator is controlled by two thermostats. When the thermostats are closed, coolant flowing out of the EGR cooler is directed through a bypass port inside the front cover into the water pump. When the thermostats are open the bypass port is blocked, and coolant is directed from the engine into the radiator.

Coolant passes through the radiator and is cooled by air flowing through the radiator from ram air and operation of the coolant fan. The coolant returns to the engine through the inlet elbow.

The air compressor is cooled with coolant supplied by a hose from the left side of the crankcase. Coolant passes through the air compressor cylinder head and returns through a passage inside the crankcase to the distributor case.

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

Thermostat Operation

The International® MaxxForce® 11 and 13 engines are fitted with two thermostats in a common housing to ensure sufficient coolant flow in all operating conditions. The thermostats are located at the top of the distributor case.

The thermostat housing assembly has two outlets. One directs coolant to the radiator when the engine is at operating temperature. The second outlet directs coolant to the water pump until the engine reaches operating temperature. The thermostats begin to open at 83 °C (181 °F) and are fully open at 91 °C (196 °F).

When engine coolant is below the 83 °C (181 °F) the thermostats are closed, blocking coolant flow to the radiator. Coolant is forced to flow through a bypass port back to the water pump.

When coolant temperature reaches the opening temperature of 83 °C (181 °F) the thermostats open allowing some coolant to flow to the radiator. When coolant temperature exceeds 91 °C (196 °F), the lower seat blocks the bypass port directing full coolant flow to the radiator.

Coolant Control Valve (CCV) operation

The CCV is installed on the upper right side of the distributor housing and controls the coolant flow to the CACs.

The CCV has two separate solenoid actuated valves; CMV, and CFV. The CMV and the CFV are part of the CCV assembly and cannot be serviced separately. The CMV and CFV solenoids are controlled by two separate Pulse Width Modulated (PWM) signals from the ECM. The PWM signal duty cycles vary between 0% and 100% depending on the coolant and charge air temperature.

CFV

The CFV is installed on the lower side of CCV and controls the amount of coolant flow through the LPCAC and HPCAC. If the engine coolant temperature is too low, the CFV closes to reduce the coolant flow through the CACs.

CMV

The CMV is installed on the upper side of CCV and controls the coolant flow through the LTR. When the temperature of the charge air and coolant coming out of the CACs is low, the CMV directs the coolant through a LTR bypass directly into the CACs. This helps the engine reach its normal operating temperature faster. If the temperature of the charge air and coolant coming out of the CACs is high, the CMV directs the coolant flow through the LTR. This prevents an overheating of the charge air cooler which can result in failure of the CACs.

Engine Retarder System

The engine retarder system is optional equipment for all engine displacements. The engine retarder system uses exhaust back pressure and engine oil pressure to improve the engine braking power by holding the exhaust valves slightly open during the cylinder compression and power strokes.

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

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

Engine Retarder Control System Components

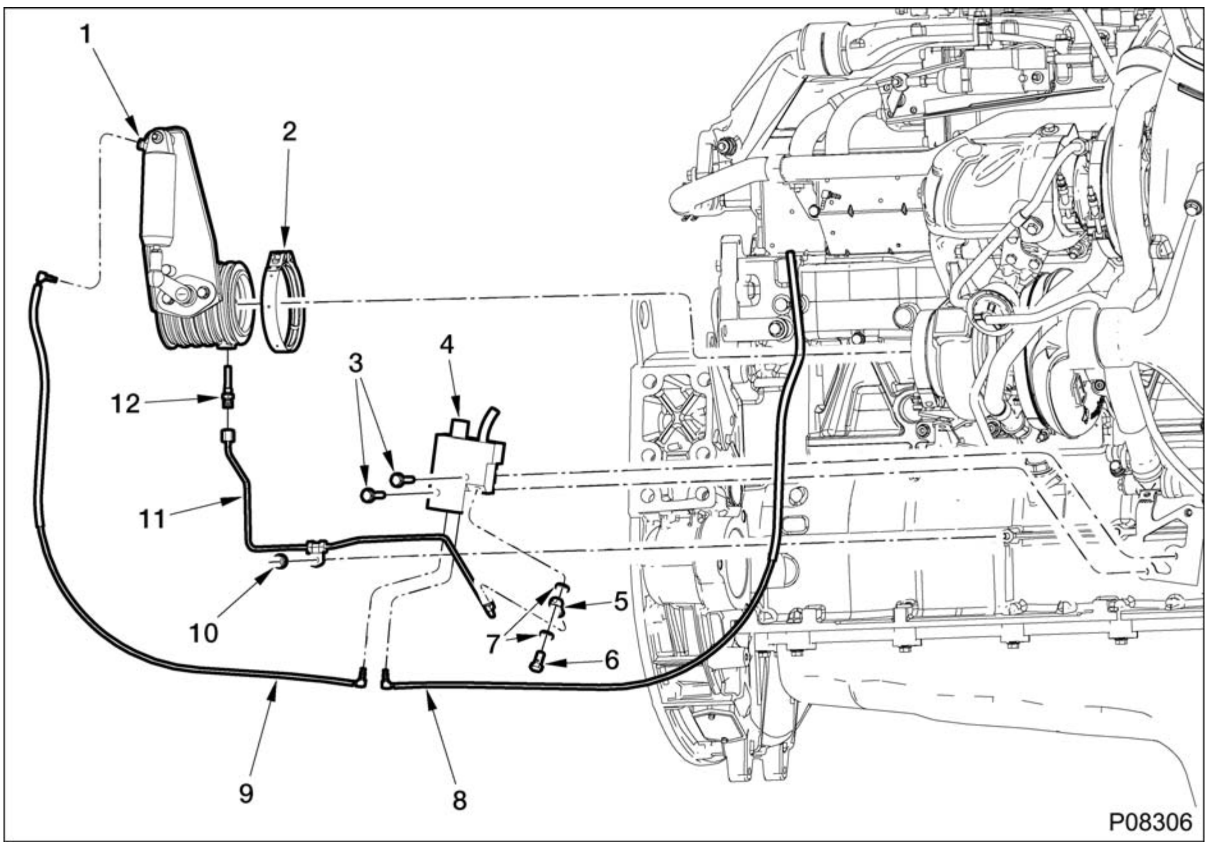


Figure 23 Engine retarder control system – external components

1. Exhaust manifold with butterfly
2. DMR 114 profiled clamp
3. M8 x 55 hex bolt (2)
4. Retarder control
5. Ring union
6. Size 6 hollow screw
7. 10 x 1.35 seal (2)
8. Air supply line assembly
9. Pressure air line
10. M8 x 16 x 20 stud bolt
11. Pressure line
12. Straight union

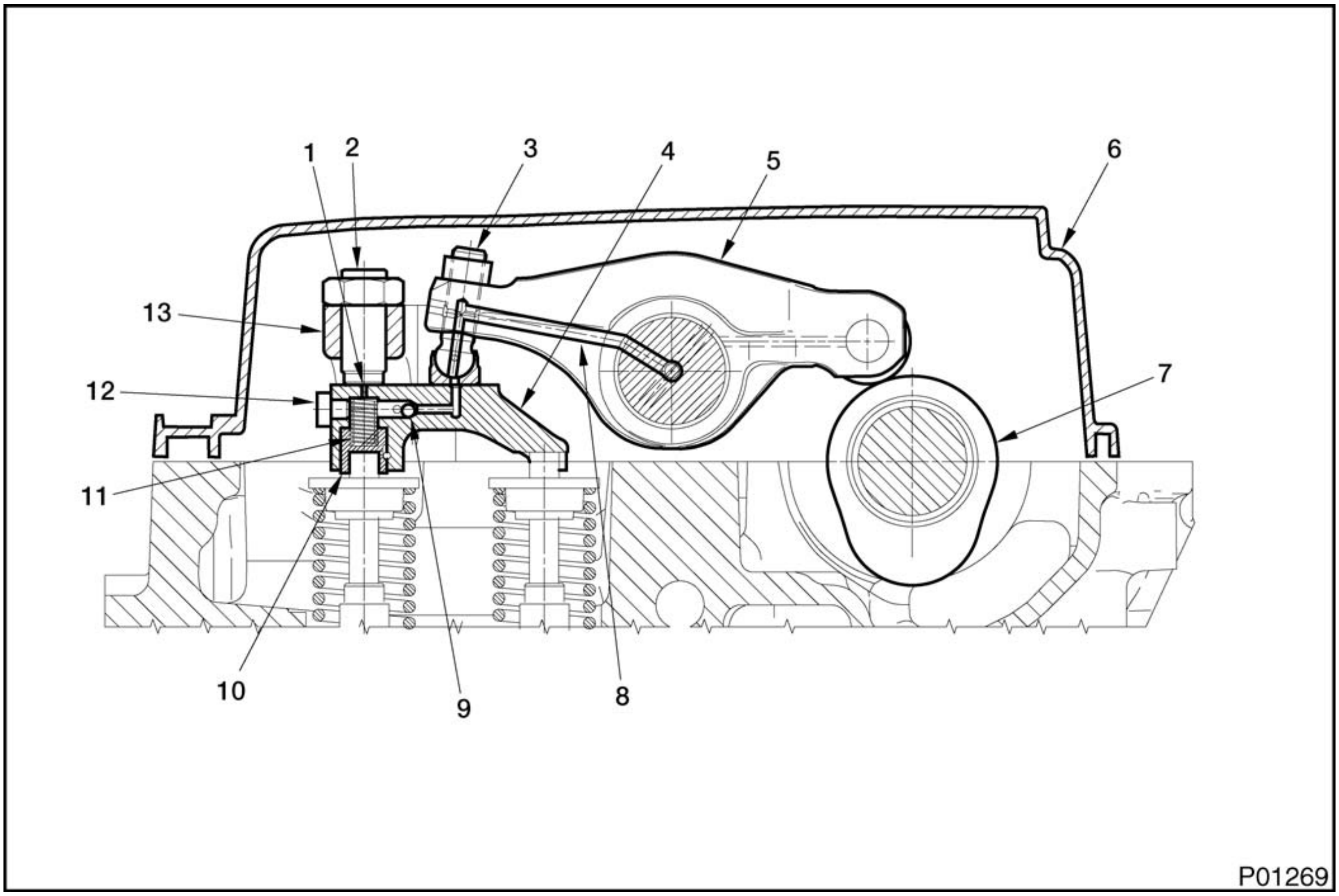


Figure 24 Engine retarder control system – internal components

1. Valve bridge orifice
2. Engine retarder adjusting screw
3. Exhaust valve lash adjusting screw
4. Exhaust valve bridge
5. Rocker arm
6. Valve cover
7. Camshaft
8. Oil passage
9. Check valve
10. Engine retarder piston
11. Spring
12. Plug
13. Counterpiece

Retarder Control

The retarder control is a proportional valve that controls the compressed air supply to the butterfly valve actuator located in the exhaust manifold. Compressed air is supplied to the retarder control from the truck air system.

The retarder control has an integrated exhaust back pressure sensor that is connected to the retarder exhaust manifold through a pressure line. The retarder control monitors the exhaust back pressure and automatically adjusts the butterfly valve position to achieve optimum exhaust back pressure for maximum engine retarder efficiency.

The retarder control is installed on the lower right side of the engine.

Engine Retarder Exhaust Manifold

The engine retarder exhaust manifold is located in the exhaust system on the right side of the engine, immediately after the low pressure turbocharger. A butterfly valve inside the engine retarder exhaust manifold is open and closed by an external air controlled actuator. Compressed air to the actuator is provided through the retarder control.

Engine Retarder Counterpiece and Exhaust Valve Bridge

The engine retarder control system uses engine oil pressure to hold the exhaust valves slightly open during engine retarding. Pressurized engine oil is supplied through the rocker arms to the engine retarder piston located inside the exhaust valve bridge. A spring located inside the valve bridge ensures that the valve bridge and the exhaust rocker arm are in contact at all times during engine operation, to ensure continuous oil supply to the engine retarder piston. The spring height is taken into consideration when the valve lash is adjusted, and requires the technician to fully compress the spring before setting the exhaust valves lash. The spring also pushes the engine retarder piston onto the exhaust valve stem. The counterpiece has a retarder lash adjusting screw that blocks the orifice located on the valve bridge. When the rocker arm pushes the valve bridge to open the exhaust valves, the orifice allows the release of oil pressure inside the valve bridge.

Engine Retarder System Operation

When the engine retarder is operated, the engine retarder butterfly valve in the exhaust system is closed and exhaust back pressure builds up in the cylinder head exhaust ports. The increased exhaust back pressure forces the exhaust valves to open slightly during retarder operation. As the exhaust valve opens slightly, a spring pushes the engine retarder piston inside the exhaust valve bridge forcing it to follow the exhaust valve stem. As the engine retarder piston is pushed down, the engine oil supplied through the rocker arm passage fills the space behind the engine retarder piston. A check valve inside the exhaust valve bridge and an orifice blocked by the engine retarder adjusting screw prevent the oil from backing up, causing a hydraulic lock behind the engine retarder piston. The locked engine retarder piston holds the exhaust valve slightly open until the next exhaust stroke. At the beginning of the exhaust stroke, the camshaft lobe pushes the rocker arm onto the exhaust valve bridge opening the exhaust valves completely. As the valve bridge is pushed down by the rocker arm, the orifice located in the valve bridge above the engine retarder piston opens and bleeds off the oil that caused the hydraulic lock inside the valve bridge. At the end of the exhaust stroke, the exhaust valve closes completely and, if the engine retarder is still activated, the cycle repeats on all power cylinders.

When the engine retarder is deactivated, the butterfly valve opens, releases the exhaust back pressure, and the exhaust valves return to normal operation at the next exhaust stroke.

Open Crankcase Breather System

Open Crankcase Breather System Components

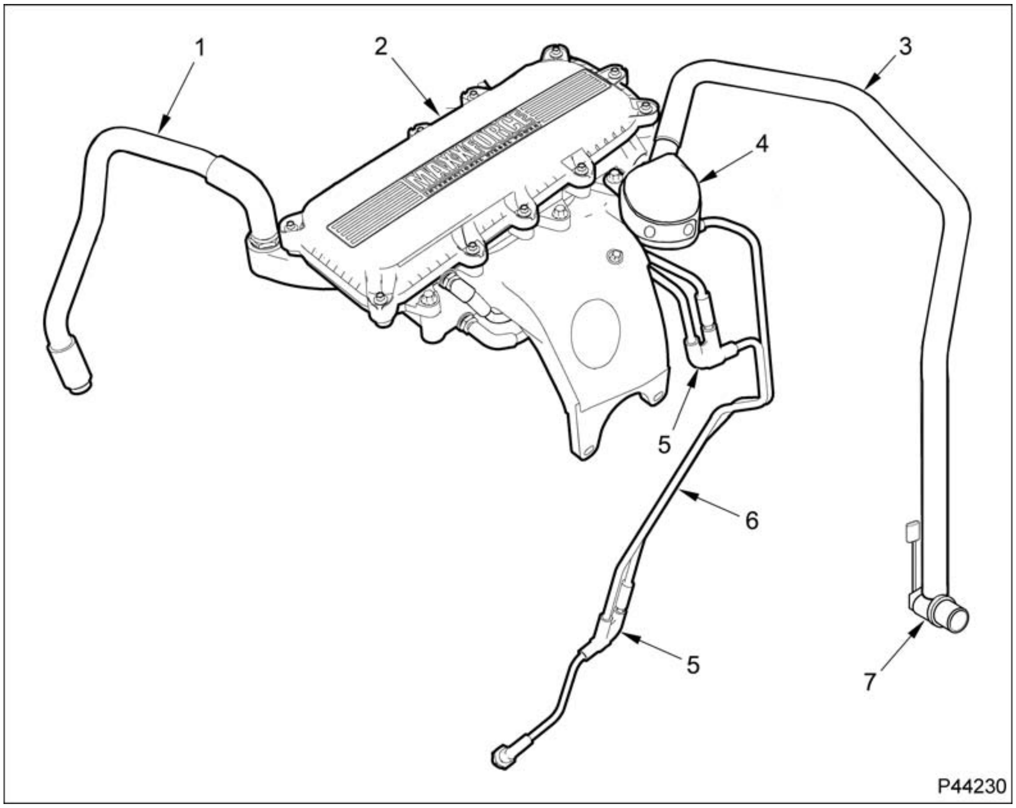


Figure 25 Open crankcase breather system

1. Breather inlet tube assembly
2. Service breather assembly
3. Breather outlet tube and heater assembly
4. Cyclone breather (with housing insulation)
5. Check valve assembly (2)
6. Oil return tube assembly
7. Breather outlet heater assembly

Open Crankcase Breather System Operation

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

The blow-by gases exit the crankcase on the upper side of the oil module and enter the breather system through the breather inlet tube. From the breather inlet tube, blow-by gases enter the service breather assembly, where heavy oil particles are separated and drain into the oil pan through check valves in oil return tubes.

From the service breather assembly, blow-by gases pass through a cyclone breather that passively spins the blow-by gases to remove finer oil mist. Oil captured by the cyclone breather tube also returns to the oil pan through the oil return tubes. The cleaned blow-by gases exit to the atmosphere through the breather outlet tube and heater assembly. The breather outlet heater assembly prevents the end of breather outlet tube from plugging with ice, during cold climate conditions.

Cold Start Assist System

Cold Start Assist System Components

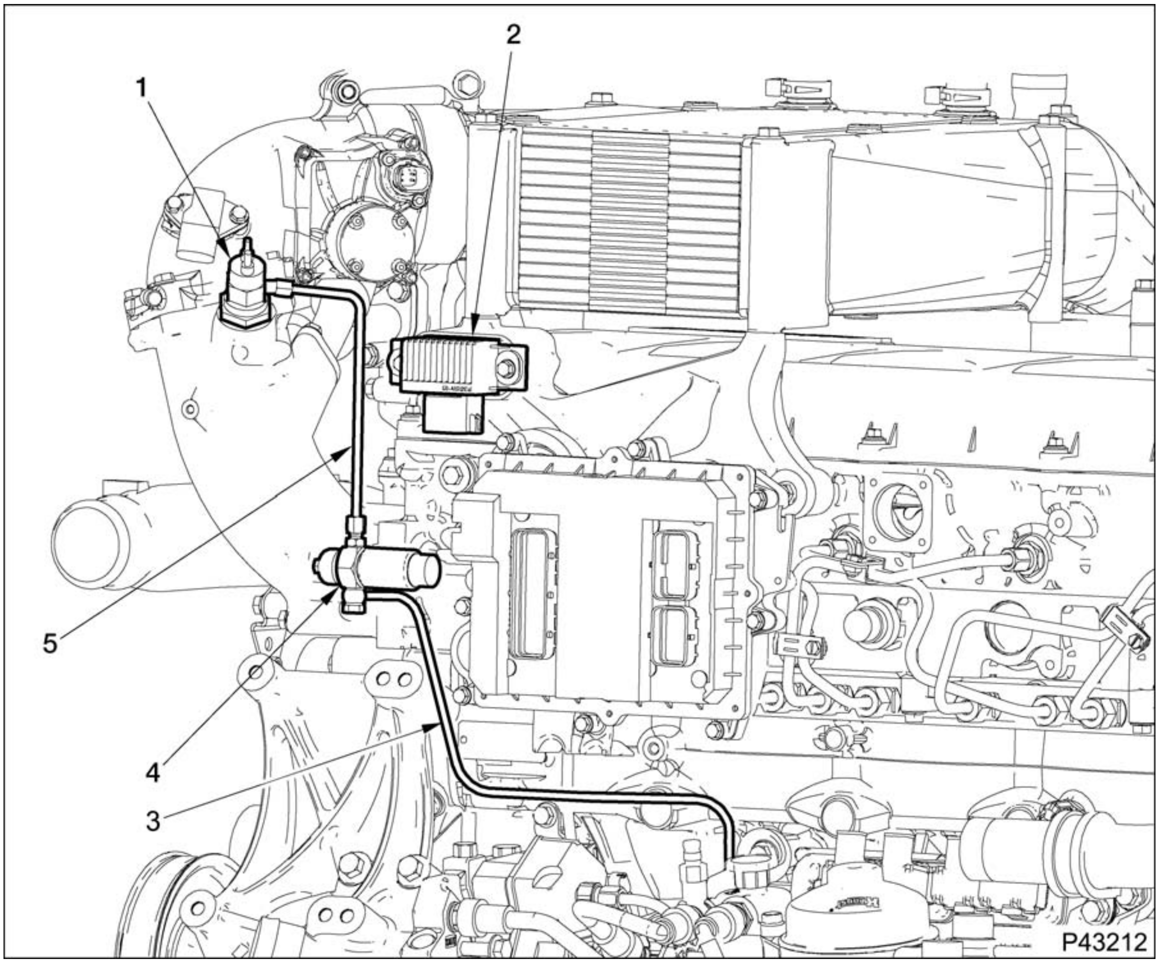


Figure 26 Cold start assist system

1. Glow plug
2. Cold Start Relay (CSR)
3. Cold start supply tube
4. Cold Start Solenoid (CSS) valve
5. MV-glow plug fuel line

Glow Plug

The glow plug is connected to the MV-glow plug fuel line. The function of the glow plug is to heat the intake air by vaporizing and igniting fuel in the air inlet duct.

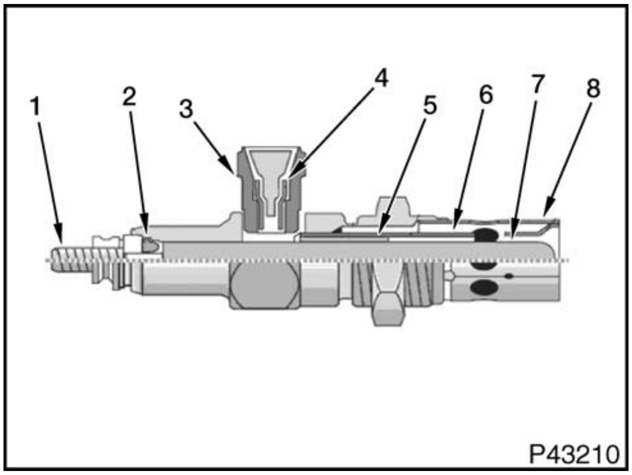


Figure 27 Glow plug

1. Electrical connection
2. Insulation
3. MV-glow plug fuel line connection
4. Metering device
5. Vaporizer filter
6. Vaporizer tube
7. Heater element
8. Protective sleeve

The glow plug has an internal fuel metering device, a vaporizer filter, a vaporizer tube, a heater element, and a protective sleeve. The protective sleeve has holes that allow enough air to pass through the glow plug to enable the fuel vaporization and combustion.

The glow plug is installed on the left front side of the engine in the air inlet duct.

Cold Start Relay (CSR)

The CSR is located on the left side of the engine above the Engine Control Module (ECM). The CSR provides voltage to the glow plug and is controlled by the Engine Interface Module (EIM).

Cold Start Solenoid (CSS) Valve

The CSS valve is located on the left side of the engine and is controlled by the EIM. The CSS valve is supplied with low fuel pressure regulated fuel from the fuel filter housing assembly through the cold start supply tube.

When the EIM provides battery voltage to the CSS valve, the solenoid opens and allows fuel to flow to the glow plug through the MV-glow plug fuel line.

Cold Start Assist System Operation

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

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

Once the glow plug is heated to approximately 1000°C (1832°F), the wait-to-start lamp starts to flash and the operator needs to crank the engine. When the engine starts rotating, the CSS valve opens and allows fuel to enter the glow plug through the MV-glow plug fuel line. Inside the glow plug, the fuel passes through the vaporizer tube. The vaporized fuel then mixes with the intake air and ignites in contact with the heater element.

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

Electronic Control System

Electronic Control System Components

The International® MaxxForce® 11 and 13 engines are equipped with three control modules; Engine Control Module (ECM), Engine Interface Module (EIM) and Aftertreatment Control Module (ACM).

Operation and Function

The control modules monitor and control engine performance to ensure maximum performance and adherence to emissions standards. The ECM, EIM, and ACM perform the following functions:

- Provide reference voltage (VREF)
- Condition input signals
- Process and store control strategies
- Control actuators

Reference Voltage (VREF)

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

Signal Conditioner

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

Microprocessor

The control modules microprocessors store operating instructions (control strategies) and value tables (calibration parameters). The control modules compare stored instructions and values with conditioned input values to determine the correct strategy for all engine operations.

Continuous calculations in the control modules occur in the foreground and background.

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

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

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

Microprocessor Memory

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

ROM

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

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

RAM

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

- Engine temperature
- Engine rpm
- Accelerator pedal position

Actuator Control

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

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

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

Actuators

Control modules control engine operation with the following:

- Coolant Mixer Valve (CMV)
- Coolant Flow Valve (CFV)
- Retarder control
- Exhaust Gas Recirculation (EGR) control valve
- Exhaust Gas Recirculation Position (EGRP) sensor
- Boost Control Solenoid (BCS) valve
- Cold Start Relay (CSR)
- Cold Start Solenoid (CSS) valve
- Intake Throttle Valve (ITV)
- Fuel Pressure Control Valve (FPCV)

Coolant Mixer Valve (CMV) and Coolant Flow Valve (CFV)

The CMV and CFV are a combined solenoid assembly that regulate coolant flow and temperature through the Charge Air Coolers (CACs).

CFV controls the rate of coolant flow through the CACs and CMV regulates the temperature of the coolant, by directing the coolant either through the low temperature radiator or through an internal bypass. Both valves are controlled by the ECM.

The CMV and CFV are mounted on the Coolant Control Valve (CCV), which is located on the right side of the front cover.

Retarder Control

The retarder control is a proportional valve with integrated exhaust back pressure sensor that controls the butterfly valve in the retarder exhaust manifold.

The retarder control regulates the amount of air pressure applied to the pneumatic cylinder. The pneumatic cylinder actuates the engine retarder butterfly valve in the exhaust system in response to commands by the ECM.

The retarder control is mounted on a bracket on the lower right side of the engine, near the front.

Exhaust Gas Recirculation (EGR) Control Valve

The EGR control valve controls the EGR throttle valve.

The EGR control valve receives the desired EGR position from the ECM to activate the EGR throttle valve for exhaust gas recirculation. The EGR control valve then regulates the amount of air pressure applied to the pneumatic actuator that controls the flow of exhaust gases through the EGR system.

The EGR control valve is mounted to the EGR module on top of the engine.

Exhaust Gas Recirculation Position (EGRP) Sensor

The EGRP sensor monitors the position of the EGR throttle valve.

The closed loop control system uses the EGR position signal. The ECM monitors the EGRP signal and determines the amount of air pressure the EGR control valve should then provide to the EGR throttle valve actuator.

The EGRP sensor is contained within the EGR throttle valve actuator on the right side of the EGR module at the top right side of the engine. The EGRP sensor is not serviced individually.

Boost Control Solenoid (BCS) Valve

The BCS valve controls the boost control actuator on the high pressure turbocharger.

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

The BCS valve is mounted on a bracket on the lower right side of the engine, near the front.

Cold Start Relay (CSR)

The cold start assist system aids cold engine starting by warming the incoming air supply prior to, and during, cranking.

The EIM is programmed to energize the glow plug elements through the CSR while monitoring certain programmed conditions for engine coolant temperature, intake air temperature, engine oil temperature, and atmospheric pressure.

The EIM activates the CSR. The relay delivers battery voltage (VBAT) to the heater element for a set time, depending on engine coolant temperature and altitude. The ground circuit is supplied directly from the battery ground at all times. The relay is controlled by switching on a voltage source from the EIM.

Cold Start Solenoid (CSS) Valve

The CSS valve controls the fuel flow to the glow plug during cold start assist operation.

When the cold start assist is required, the EIM provides voltage to open the CSS valve during cranking.

The CSS valve is mounted on the air inlet duct on the top left side of the engine.

Intake Throttle Valve (ITV)

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

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

The ITV is mounted on the air inlet duct on the top front of the engine.

Fuel Pressure Control Valve (FPCV)

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

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

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

Engine and Vehicle Sensors

Thermistor Sensor

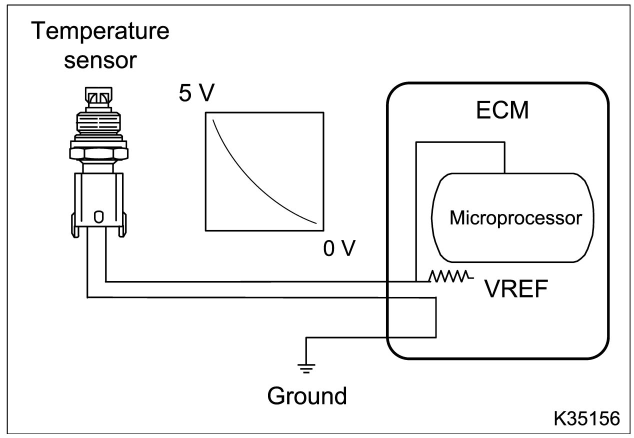


Figure 28 Thermistor

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

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

Thermistor type sensors include the following:

- Aftertreatment temperature sensors
- Engine Coolant Temperature (ECT) sensors
- Engine Oil Temperature (EOT) sensor
- Intake Air Temperature (IAT) sensor
- Manifold Absolute Pressure/ Intake Air Temperature 2 (MAP/IAT2) Sensor
- Manifold Air Temperature (MAT) sensor

Aftertreatment Temperature Sensors

Three sensors used in the Aftertreatment System include the following:

- Exhaust Gas Temperature 1 (EGT1) sensor
- EGT2 sensor
- EGT3 sensor

The EGT1 sensor provides a feedback signal to the Aftertreatment Control Module (ACM) indicating Diesel Oxidation Catalyst (DOC) inlet temperature. The EGT1 sensor is the first temperature sensor installed past the turbocharger and just before the DOC.

The EGT2 sensor provides a feedback signal to the ACM indicating Diesel Particulate Filter (DPF) inlet temperature. The EGT2 sensor is the second temperature sensor installed past the turbocharger and just after the DOC.

The EGT3 sensor provides a feedback signal to the ACM indicating DPF outlet temperature. The EGT3 sensor is the third temperature sensor installed past the turbocharger and just after the DPF.

During a catalyst regeneration, the ACM and the ECM monitor all three sensors along with the EGR system and ITV.

Engine Coolant Temperature (ECT) Sensor

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

This engine has two ECT sensors. The ECT sensor is installed in the underside of the EGR coolant elbow at the back of the engine. The ECT2 sensor is installed in the Charge Air Cooler (CAC) coolant return pipe on the upper right side of the engine.

The ECT and ECT2 signals are monitored by the ECM for operation of the instrument panel temperature gauge, coolant temperature compensation, charge air temperature control, optional Engine Warning Protection System (EWPS), and the wait to start lamp. The ECM uses ECT sensor input as a backup, if EOT sensor values are out of range.

Engine Oil Temperature (EOT) Sensor

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

The EOT signal is monitored by the ECM for cold start assist, EGR valve control, and engine fueling calculations.

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

Intake Air Temperature (IAT) Sensor

The Engine Interface Module (EIM) monitors the IAT signal to control injector timing and fuel rate during cold starts. The IAT signal is also used to control EGR position and intake throttle control. The IAT sensor is installed in the intake tube next to the air cleaner, on top of the engine.

Manifold Absolute Pressure/Intake Air Temperature 2 (MAP/IAT2) Sensor

The MAP/IAT2 sensor is used to measure the absolute charge-air pressure and intake air temperature.

The MAP/IAT2 sensor is installed in the ITV on top of the engine.

Manifold Air Temperature (MAT) Sensor

The MAT sensor is a thermistor sensor that monitors the temperature of recirculated exhaust gas.

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

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

Variable Resistance Sensor

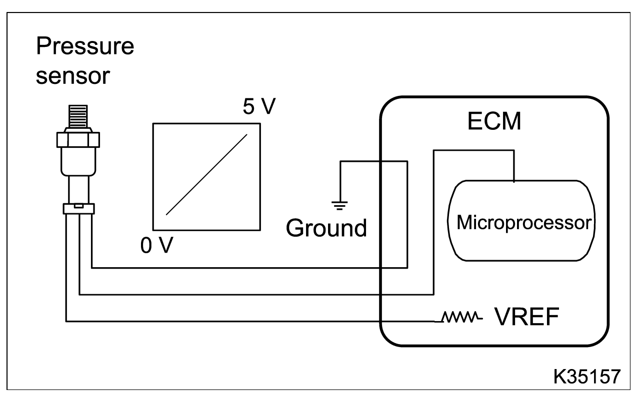


Figure 29 Variable resistance sensor

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

The sensor is connected to the control module through the VREF, signal, and signal ground wires.

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

Variable resistance sensors include the following:

- Exhaust Gas Differential Pressure (EGDP) sensor
- Engine Fuel Pressure (EFP) sensor
- Engine Oil Pressure (EOP) sensor
- Fuel Rail Pressure (FRP) sensor

Exhaust Gas Differential Pressure (EGDP) Sensor

The EGDP sensor provides a feedback signal to the Aftertreatment Control Module (ACM) indicating the pressure difference between the inlet and outlet of the particulate filter. During a catalyst regeneration, the ACM and the ECM monitor this sensor along with three aftertreatment system thermistor sensors, the EGR system, and the ITV.

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

Engine Fuel Pressure (EFP) Sensor

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

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

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

Engine Oil Pressure (EOP) Sensor

The EOP sensor is a variable resistance sensor that detects engine oil pressure.

The EOP signal is monitored by the ECM for operation of the instrument panel pressure gauge and optional EWPS.

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

Fuel Rail Pressure (FRP) Sensor

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

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

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

Magnetic Pickup Sensor

A magnetic pickup sensor contains a permanent magnet core that is surrounded by a coil of wire. The sensor generates a voltage signal through the collapse of a magnetic field that is created by a moving metal trigger. The movement of the trigger then creates an AC voltage in the sensor coil.

Magnetic pickup sensors used include the following:

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

Crankshaft Position (CKP) Sensor

The CKP sensor is a magnetic pickup sensor that indicates crankshaft speed and position.

The CKP sensor sends a pulsed signal to the Engine Control Module (ECM) as the crankshaft turns. The CKP sensor reacts to a 60 tooth timing disk machined into the flywheel. For crankshaft position reference, teeth 59 and 60 are missing. By comparing the CKP signal with the CMP signal, the ECM calculates engine rpm and timing requirements.

The CKP sensor is installed in the top left of the flywheel housing.

Camshaft Position (CMP) Sensor

The CMP sensor is a magnetic pickup sensor that indicates camshaft speed and position.

The CMP sensor sends a pulsed signal to the ECM as a toothed wheel on the camshaft rotates past the CMP sensor. The ECM calculates camshaft speed and position from CMP signal frequency.

The CMP sensor is installed in the left rear of the cylinder head.

Vehicle Speed Sensor (VSS)

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

Potentiometer

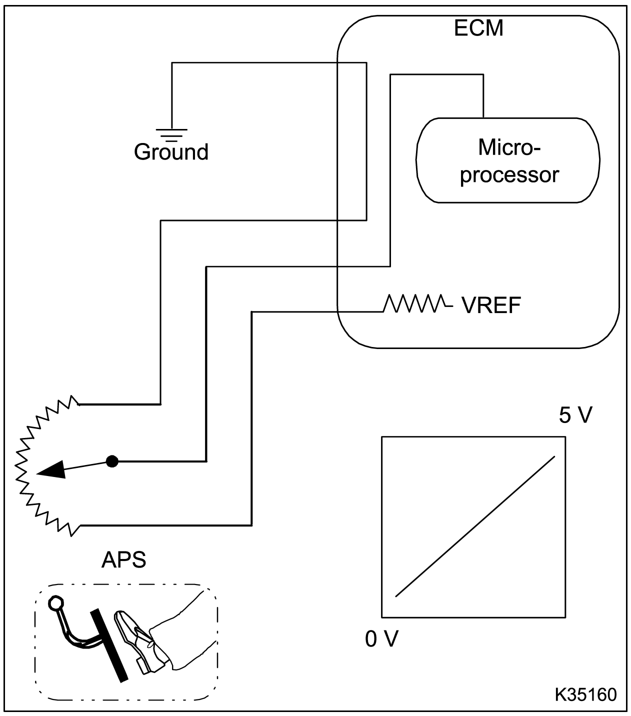


Figure 30 Potentiometer

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

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

Accelerator Position Sensor (APS)

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

Switches

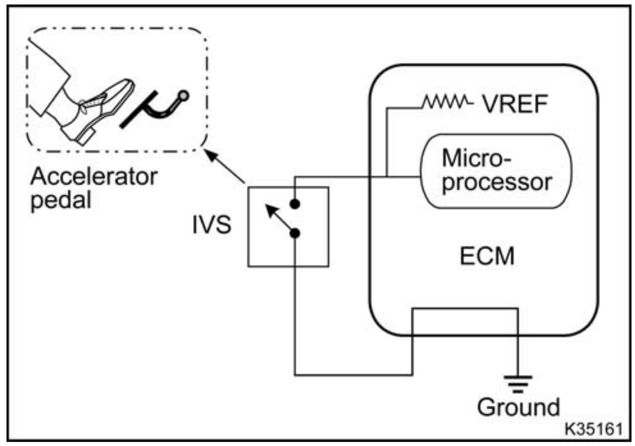


Figure 31 Switch

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

Switches include the following:

- Driveline Disengagement Switch (DDS)
- Engine Coolant Level (ECL)
- Idle Validation Switch (IVS)

Driveline Disengagement Switch (DDS)

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

Engine Coolant Level (ECL) Switch

The ECL switch is part of the Engine Warning Protection System (EWPS). The ECL switch is located on the deaeration tank. When the magnetic switch is open, the tank is considered full of coolant.

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

Idle Validation Switch (IVS)

The IVS is a redundant switch that provides the Engine Interface Module (EIM) with a signal that verifies when the APS is in the idle position. The IVS is located on the APS.

Exhaust Lambda Sensor (ELS)

The ELS monitors oxygen levels in exhaust gases.

The ELS is used to tune the engine operation to a specified air-to-fuel ratio in the exhaust.

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

The ELS is installed in the turbo exhaust pipe, directly after the exhaust valve with butterfly.

Table of Contents

Standard Features

Electronic Governor Control

International® engines are electronically controlled for all operating ranges.

American Trucking Association (ATA) Datalink

Vehicles are equipped with the ATA datalink for communication between the Engine Interface Module (EIM), the Transmission Control Module (TCM) (automatic transmission only) and the Electronic Service Tool (EST). The ATA datalink is accessed through the vehicle diagnostic connector.

The ATA datalink supports:

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

For additional information, see ATA Datalink (page 248) in “Electronic Control Systems Diagnostics” section in this manual.

Controller Area Network (CAN) Datalink

The vehicle is equipped with two CAN networks:

- The public CAN is used for diagnostics and calibration for the Engine Interface Module (EIM), Engine Control Module (ECM) and the Aftertreatment Control Module (ACM).
- The private CAN is used for communications between the EIM, ECM and the ACM. The private CAN is not accessible through the vehicle diagnostic connector.

The public CAN is accessed through the vehicle diagnostic connector pins C and D. The public CAN provides communication between the EIM and the Electronic Service Tool (EST).

The CAN datalink supports:

- Transmission of engine parameter data
- Transmission and clearing of DTCs
- Diagnostics and troubleshooting
- Intermodule communication between the:
  - ECM
  - EIM
  - Automatic transmission controller
  - Instrument cluster
  - Electronic System Controller (ESC) module
  - ACM
  - EST
- Programming engine and vehicle features
- Programming calibrations and strategies

For additional information, see CAN Communications (Controller Area Network) (Public) (page 256) in “Electronic Control Systems Diagnostics” section in this manual.

Service Diagnostics

The EST provides diagnostic information using the ATA datalink. The EST requires MasterDiagnostics® software provided by International®.

Faults from sensors, actuators, electronic components, and engine systems are detected by the ECM and EIM. The faults are then accessed by the EST through the EIM as DTCs. Effective engine diagnostics require and rely on DTCs.

Event Logging System

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

Electronic Speedometer and Tachometer

The engine control system calibrates vehicle speed up to 157,157 pulses per mile. The calculated vehicle speed is a function of transmission tail shaft speed, number of teeth on the tail shaft, rear axle ratio, and tire revolutions per mile. Use the EST with

MasterDiagnostics® software to program new speed calibrations into the EIM.

The tachometer signal is generated by the ECM by computing the signals from the Camshaft Position (CMP) sensor and the Crankshaft Position (CKP) sensor. The calculated engine speed is then sent to the instrument cluster through the J1939 Public Data Link.

Aftertreatment (AFT) System

The AFT system, part of the larger exhaust system, processes engine exhaust so that it meets tailpipe emission requirements. The AFT system traps particulate matter (soot) and prevents it from leaving the tailpipe. The trapped particulate matter is then rendered to ash by heating the exhaust and injecting fuel through a process called regeneration. Regeneration reduces the frequency of AFT system maintenance without adversely affecting emissions.

For additional information, see Aftertreatment (AFT) System in “Engine Systems” section of this manual.

Cold Start Assist

The cold start assist feature improves engine start-up in cold weather. The ECM controls the Cold Start Relay (CSR) and monitors the Engine Oil Temperature (EOT), the Intake Air Temperature (IAT) and the Engine Coolant Temperature 2 (ECT2) sensors. When the key is turned to the ON position, the ECM monitors the ECT2 and IAT sensors and if either sensor is below 11 °C (52 °F), the ECM enables the CSR. The CSR energizes the cold start assist glow plug. When the cold start assist glow plug is at operating temperature, the wait to start lamp flashes. As the engine is cranked, the ECM energizes the Cold Start Solenoid (CSS) valve introducing fuel into the intake which ignites and warms the air being drawn into the engine. Do not accelerate the engine until the wait to start lamp goes out.

For additional information, see Cold Start Assist System in “Engine Systems” section of this manual.

Fast Idle Advance

The ECM monitors the Engine Coolant Temperature (ECT) sensor. If the engine coolant temperature is below 10°C (50°F) the ECM activates the fast idle advance.

Fast idle advance increases engine idle speed up to 700 rpm for a period of up to 100 seconds to assist in faster warm-up to operating temperature. This occurs by the ECM monitoring the engine coolant temperature and adjusting the fuel injector operation accordingly.

Low idle speed is resumed when the engine coolant temperature reaches temperatures above 10 °C (50 °F) or the 100 second period times out.

Cold Ambient Protection (CAP)

CAP protects the engine from damage caused by prolonged idle at no load condition during cold weather.

CAP maintains engine coolant temperature by increasing the engine rpm to a programmed value. CAP also improves cab warm-up.

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

Coolant Temperature Compensation (CTC)

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

CTC reduces fuel delivery if the engine coolant temperature is above cooling system specifications.

Before standard engine warning or optional warning/protection systems engage, the ECM begins reducing fuel delivery when the engine coolant temperature reaches approximately 107 °C (225 °F). A rapid reduction of 15 percent is achieved when engine coolant temperature reaches approximately 110 °C (230 °F).

Engine Crank Inhibit (ECI)

The ECI will not allow the starting motor to engage when the engine is running and the drivetrain is engaged.

The ECI allows the starting motor to engage with the engine running if the key is turned to START while the clutch pedal is pressed.

Change Engine Oil Interval Message

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

Engine Warning Protection System (EWPS)

NOTE: Emergency vehicles are not equipped with EWPS.

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

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

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

Idle Shutdown Timer (IST)

All Vehicles Except California

The IST feature allows the ECM to shut down the engine when an extended idle condition occurs. The IST can be programmed by the customer to automatically shut the engine down for idle times that range from 2 to 120 minutes.

Thirty seconds before engine shutdown, the red ENGINE lamp flashes and an audible alarm sounds. The red ENGINE lamp and audible alarm continue until the engine shuts down or the low idle timer is reset.

Idle time is measured from the last clutch or brake pedal transition. The engine must be out of gear for the IST to work.

For additional information, see IST (Idle Shutdown Timer) System (Federal - Optional) (page 406) in “Electronic Control Systems Diagnostics” section of this manual.

California Vehicles

The IST feature allows the ECM to shut down the engine when an extended idle condition occurs. Engine idle duration is limited for California Air Resources Board (CARB) engine shutdown systems regulation compliant engines as follows:

- When the parking brake is set, the idle shutdown time is limited to the CARB requirement of five minutes.
- When the parking brake is released, the idle shutdown time is limited to the CARB requirement of 15 minutes.

Thirty seconds before engine shutdown, the red ENGINE lamp flashes and an audible alarm sounds. The red ENGINE lamp and audible alarm continue until the engine shuts down or the low idle timer is reset.

Idle time is measured from the last clutch or brake pedal transition. The engine must be out of gear for the IST to work.

For additional information, see IST (Idle Shutdown Timer) System (California - Standard) (page 404) in “Electronic Control Systems Diagnostics” section of this manual.

Electronic Fan (EFAN)

Engine electronics allow for the operation of an electronic fan or an air fan solenoid. For additional information, see Single and Two-Speed EFAN Control (page 428) or Variable EFAN Control (page 431) in “Electronic Control Systems Diagnostics” section of this manual.

Optional Features

Engine Retarder System

International® offers an optional engine retarder to enhance braking capabilities. For a detailed feature description, see Engine Retarder System in "Engine Systems" section of this manual.

Road Speed Limiting

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

Cruise Control

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

Traction Control

Traction control is a system that identifies when a wheel is spinning faster than the other wheels during acceleration.

When a traction control condition occurs, a datalink message is sent to the ECM to limit fuel for the purpose of reducing engine torque.

Vehicles must have a transmission and an Antilock Brake System (ABS) that supports traction control.

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 the ignition switch to the ON position. Do not start the engine.

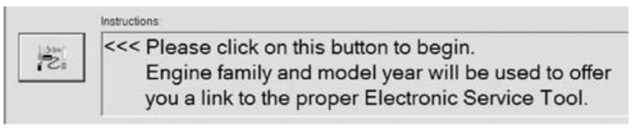


Figure 32 Diagnostic window

NOTE: If the EST does not communicate with the vehicle, refer to the IC4 Interface Device Self Test (page 62).

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

Retrieve Engine Information

Figure 33 Engine information

1. The Service Assistant displays the detected engine information and model year.
2. Make sure the View CAN Data button on the right side of Service Assistant window is selected.
3. Verify the collected data matches the engine being diagnosed.
4. To view the Service Assistant version number, right click the title bar and select About Service Assistant.

Open MasterDiagnostics®

1. Make sure the View CAN Data button on the right side of Service Assistant window is selected.
2. The engine family and model year should match the engine being diagnosed. If incorrect, use the drop-down menu to select the correct engine family and model year.
3. Select Launch EST.

Electronic Service Tool (EST) Communication Diagnostics

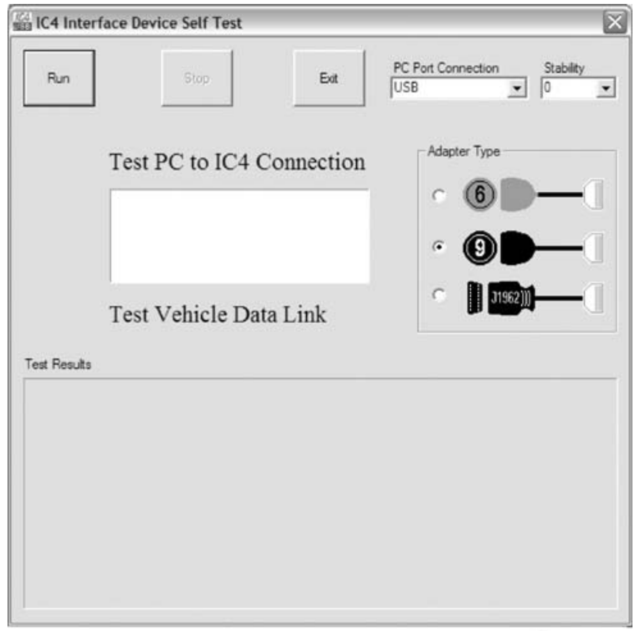
IC4 Interface Device Self Test

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

P08263

Figure 34 Vehicle diagnostics folder

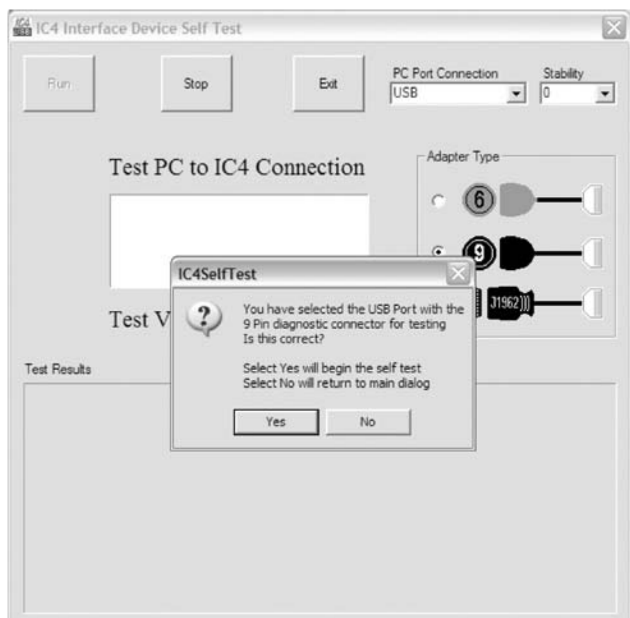
3. From the EST desktop, open the Vehicle Diagnostics folder.
4. Double-click the IC4 Self Test icon.



P08242

Figure 35 Self Test Run command

5. Select Run button.



P08243

Figure 36 Connector confirmation

6. Verify the correct interface connector is selected.

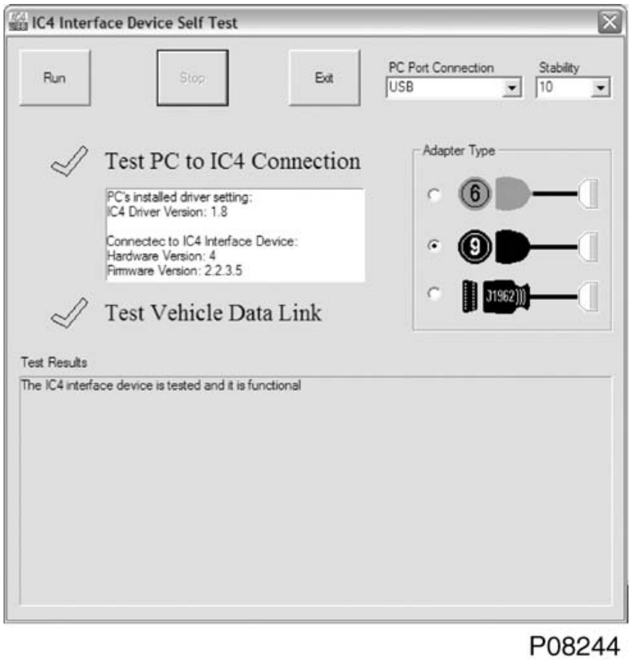


Figure 37 Test result

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

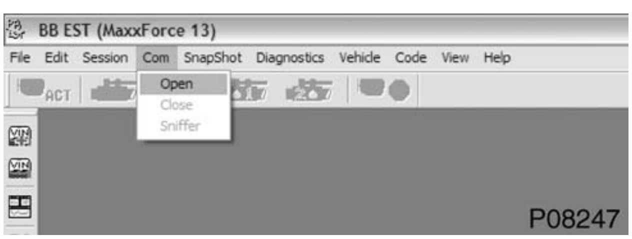


Figure 38 Open COM

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

Figure 39 COM open confirmation

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

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

Close Communications

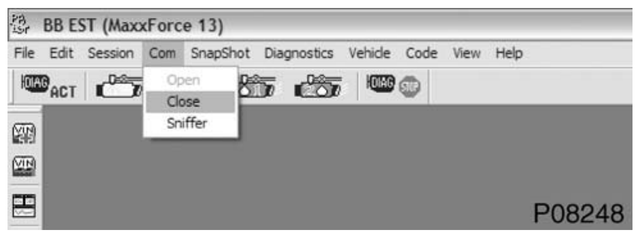


Figure 40 Close COM

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

Diagnostic Trouble Codes (DTCs)

Reading DTCs

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

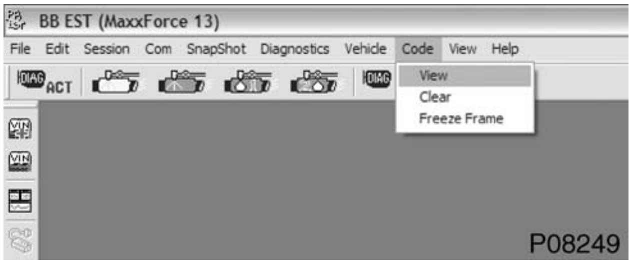


Figure 41 Retrieving DTCs

3. Select Code from the menu bar.
4. Select View from the drop-down menu.

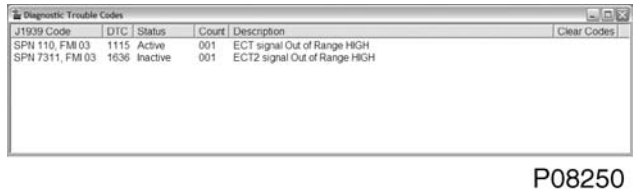


Figure 42 Viewing DTCs

5. The DTC window displays active and inactive DTCs stored in the control modules.

DTC Help Menu

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

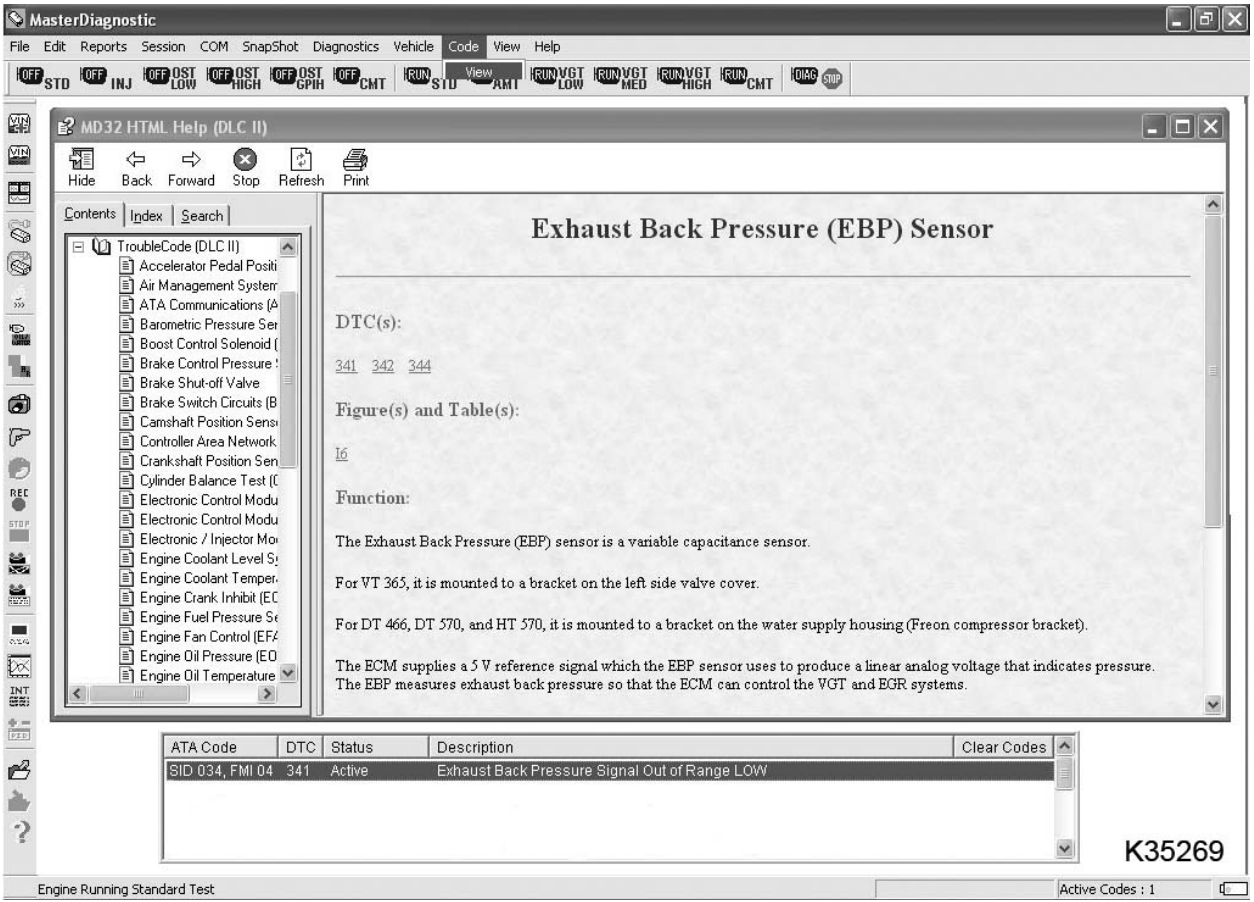


Figure 43 DTC help menu

2. The Help program displays information for the circuit associated with the DTC.

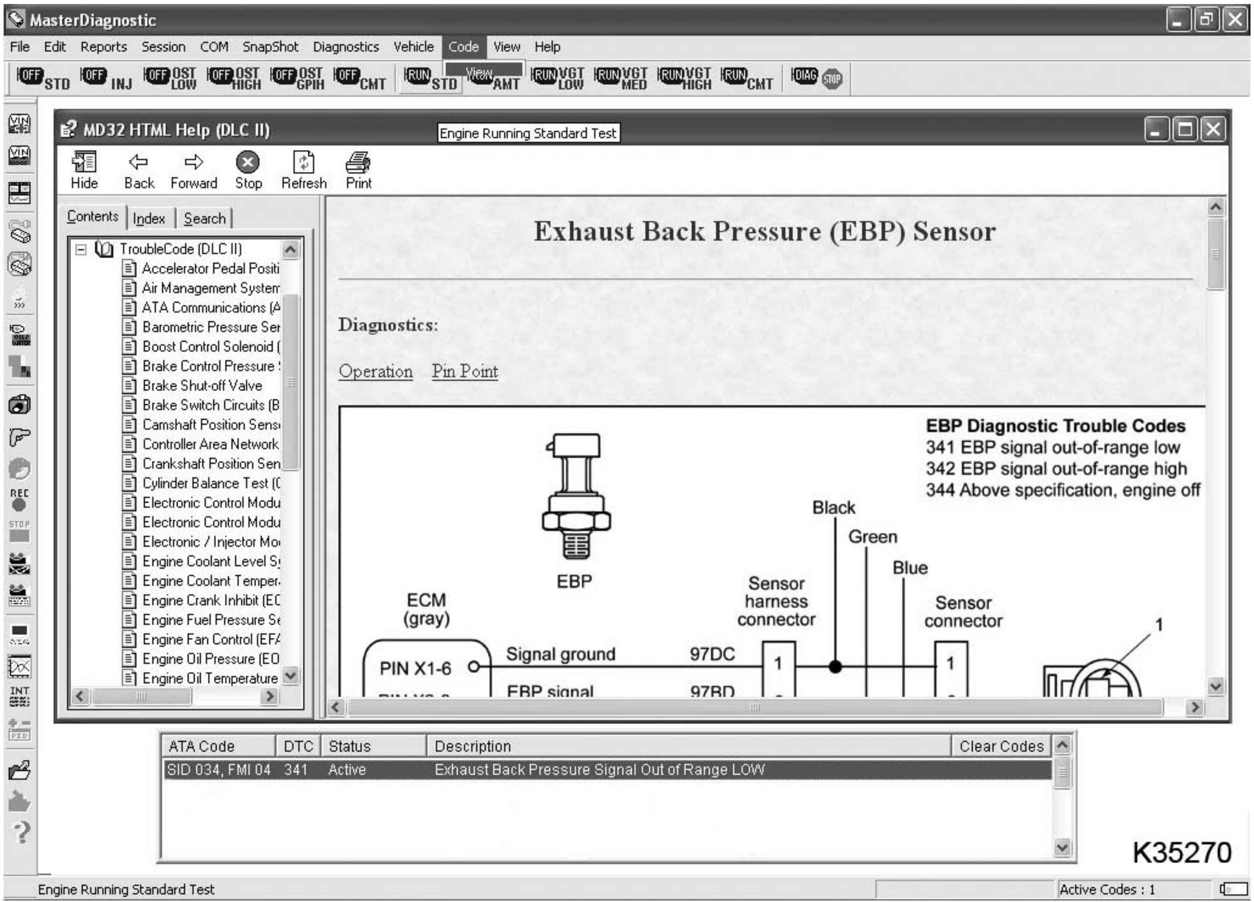
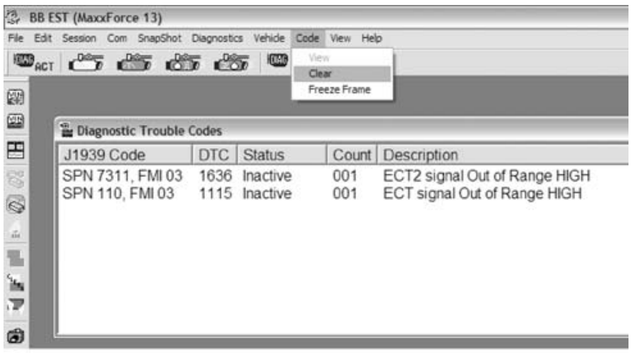


Figure 44 DTC help menu – circuit information

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

Clearing DTCs

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



P08251

Figure 45 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 and the session file saved, the default session file cannot be recovered. Always select No when prompted to save the session before closing.

Opening Session Files

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

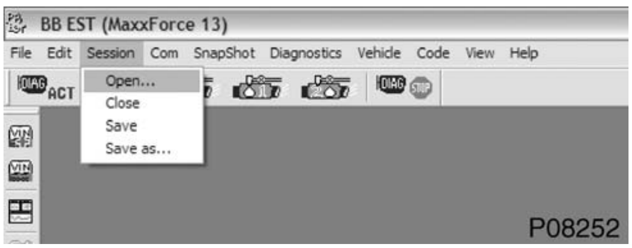


Figure 46 Open session file

3. Select Session from the menu bar.
4. Select Open from the drop-down menu.

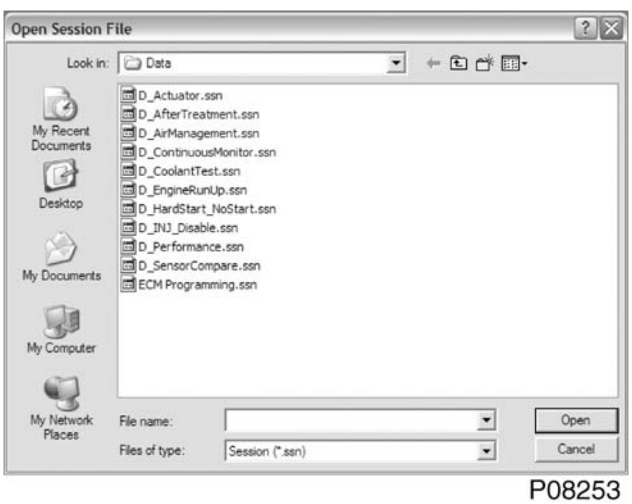


Figure 47 Select session file

5. Select the desired session file.
6. Select Open.

Adding and Deleting Session Parameter Identifiers (PIDs)

1. Open desired session file.
2. On the session file, click the window where PIDs are to be added or edited.

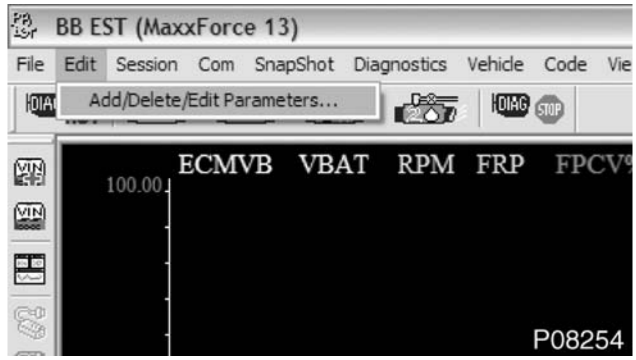


Figure 48 Add/Delete/Edit parameters

3. Select Edit from the menu bar, or right click the desired window.
4. Select Add/Delete/Edit Parameters from the drop-down menu.

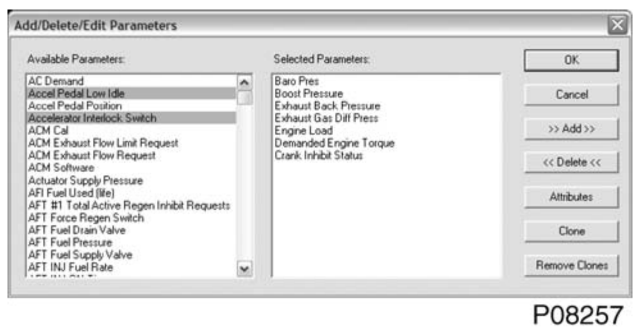
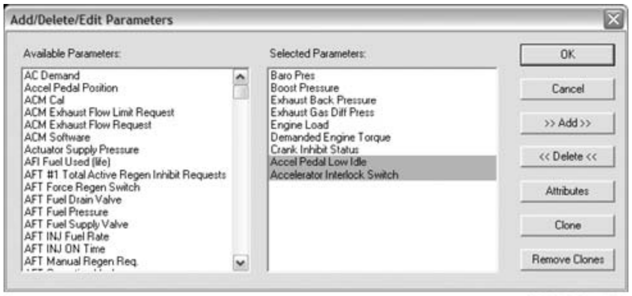


Figure 49 Add/Delete/Edit parameters window

5. Select additional PIDs in the left column. Press and hold the CTRL key to select multiple PIDs. Selections are highlighted in blue.
6. To add the selected PIDs, select the Add button and the PIDs move to the right column.



P08258

Figure 50 Additional PIDS added to session

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

NOTE: An alternative to steps 5 and 6 is to double-click PIDs in the left column to automatically add them to the right column. Also, an alternative to step 7 is to double-click PIDs in the right column to automatically move them back to the left column.

8. Select OK to complete action.

Closing Session Files

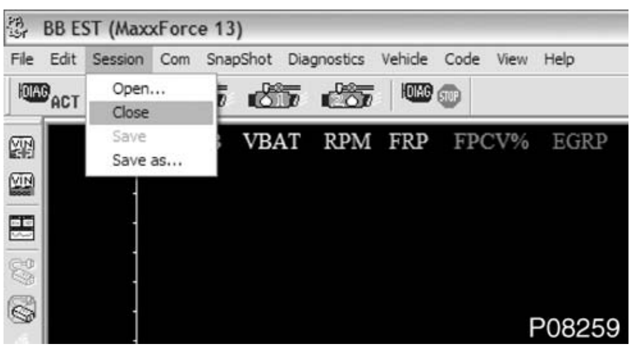


Figure 51 Closing session file

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

NOTE: Selecting Yes when prompted to save 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 No Start Diagnostic Form.

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

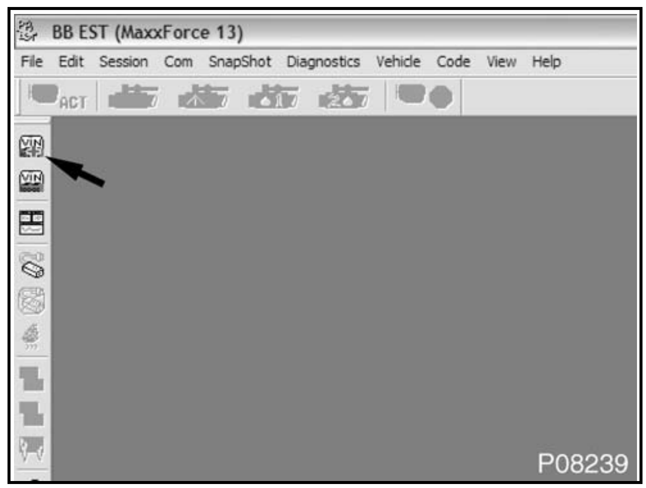
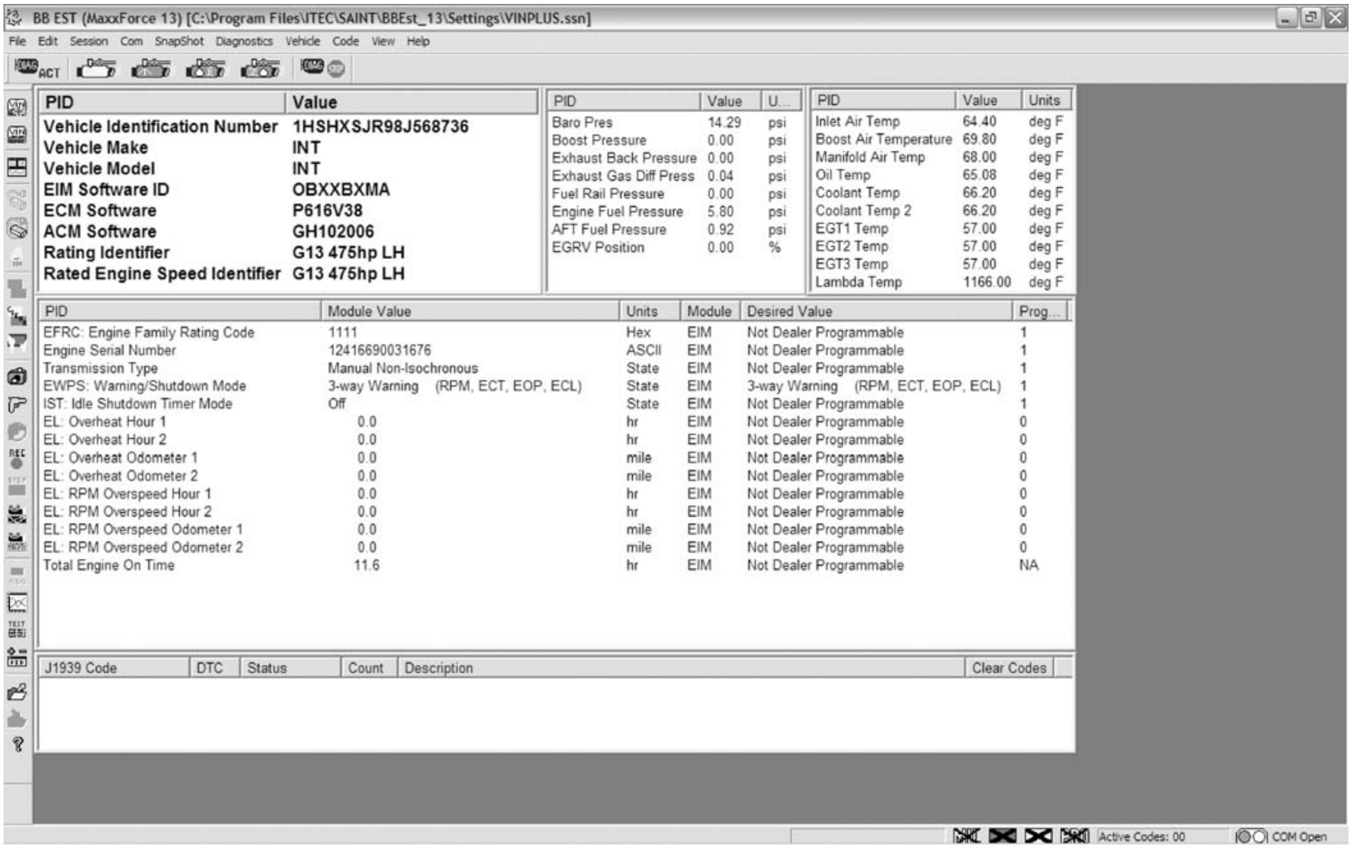


Figure 52 Select VIN+ icon

3. Select the VIN+ icon.



P08240

Figure 53 VIN+ session (example)

4. The VIN+ session is displayed on screen.

Engine Diagnostics Tests

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

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

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

AFT Cleanliness Test

This procedure is used to induce a DPF regeneration cycle. The regeneration process may take up to one hour depending on the condition of the DPF.

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

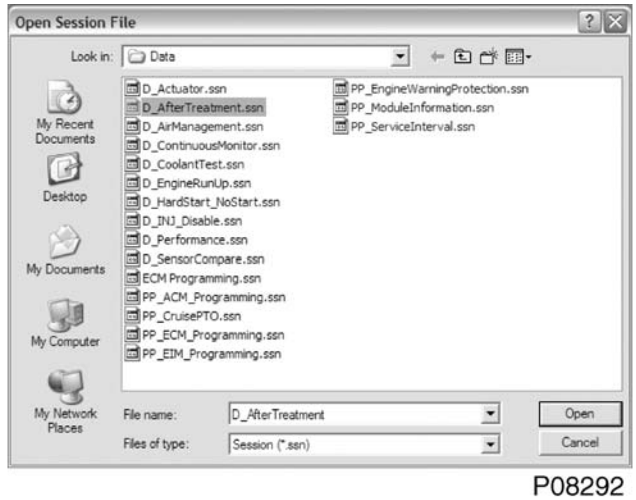


Figure 54 Aftertreatment session file

3. Open D_Aftertreatment.ssn file from the open session menu.
4. Start and idle the engine until the engine reaches operating temperature.

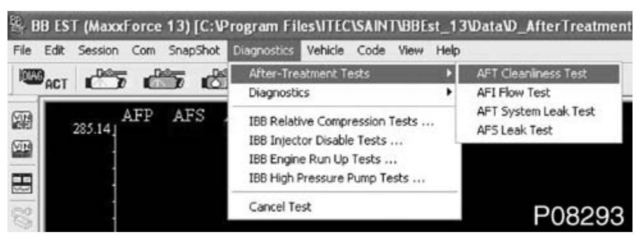


Figure 55 AFT Cleanliness Test

NOTE: Make sure engine has warmed to at least operating temperature (71 °C [160 °F]) before starting AFT Cleanliness Test.

5. Select Diagnostics from the menu bar and then After-Treatment Tests from the drop-down menu.
6. Select AFT Cleanliness Test.

AFI Flow Test

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

This test verifies the condition of the Aftertreatment Fuel Injector (AFI). The test runs for 60 seconds and injects fuel in a pulsing mist pattern. During this test the AFI injects approximately 177 ml (6 oz.) of fuel.

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

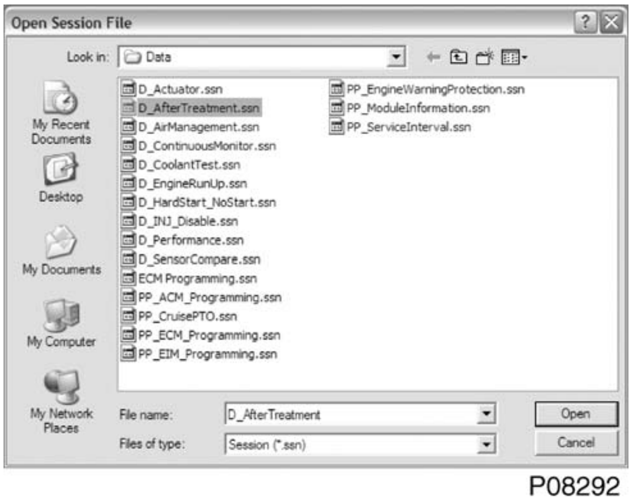


Figure 56 Aftertreatment session file

3. Open D_Aftertreatment.ssn file from the open session menu.
4. Start the engine.

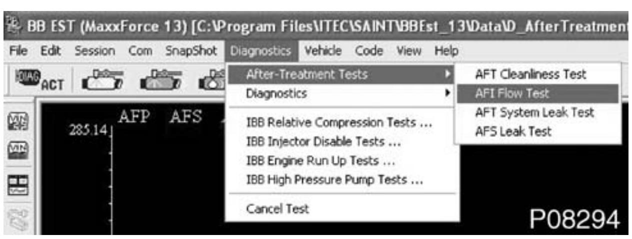


Figure 57 AFI Flow Test command

5. Select Diagnostics from the menu bar and then After-Treatment Tests from the drop-down menu.
6. Select AFI Flow Test.

AFT System Leak Test

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

This test verifies the Aftertreatment Fuel Injector (AFI) and the AFI fuel supply lines do not leak. This test runs for 120 seconds. Once started, the Aftertreatment Fuel Supply (AFS) valve is energized for 60 seconds. The Aftertreatment Fuel Pressure (AFP) sensor may be monitored to verify fuel pressure is supplied to the AFI. During these 60 seconds, the AFI and the AFI fuel supply lines can be monitored for any signs of leakage. At the end of the first 60 seconds, the AFS valve is de-energized and the Aftertreatment Fuel Drain (AFD) valve is energized for 60 seconds. During this time, the aftertreatment fuel pressure drops to less than 6.9 kPa (1 psi).

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

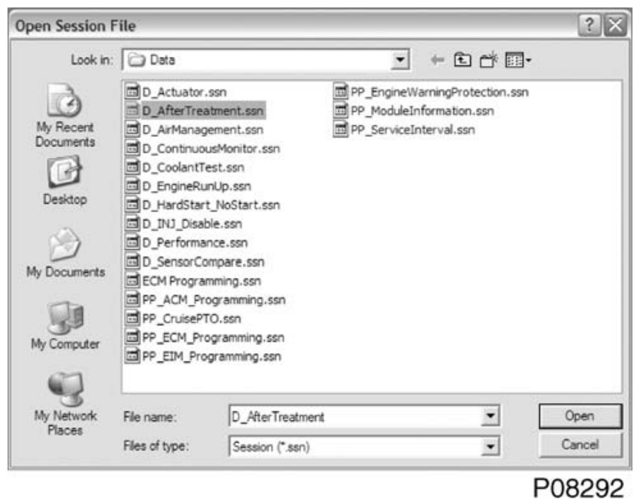


Figure 58 Aftertreatment session file

3. Open D_Aftertreatment.ssn file from the open session menu.
4. Start the engine.

Figure 59 AFT System Leak Test command

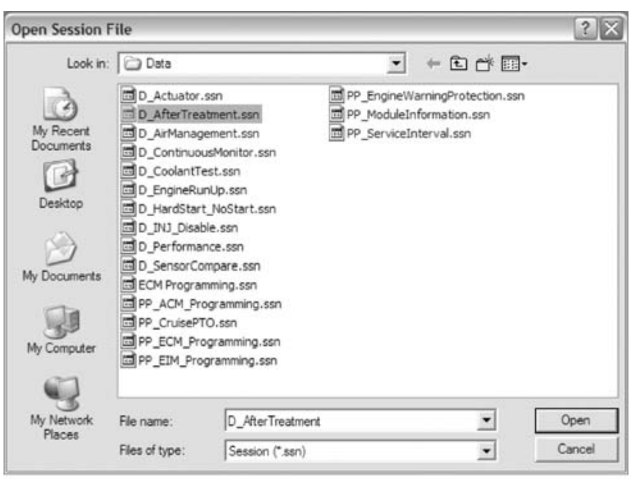
5. Select Diagnostics from the menu bar and then After-Treatment Tests from the drop-down menu.
6. Select AFT System Leak Test.

AFS Leak Test

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

This test verifies the Aftertreatment Fuel Supply (AFS) valve does not leak after it is closed. This test runs for 60 seconds, during which time AFS valve and the Aftertreatment Fuel Injector (AFI) are closed, and the Aftertreatment Fuel Drain (AFD) valve is opened.

1. Connect the Fuel Inlet Restriction and Aeration Tool to the Hydrocarbon (HC) cut-off valve return port and position the open end into a suitable container.
2. Turn the ignition switch to the ON position. Do not start the engine.
3. Open MasterDiagnostics® and establish communication with the vehicle.



P08292

Figure 60 Aftertreatment session file

4. Open D_Aftertreatment.ssn file from the open session menu.
5. Start the engine.

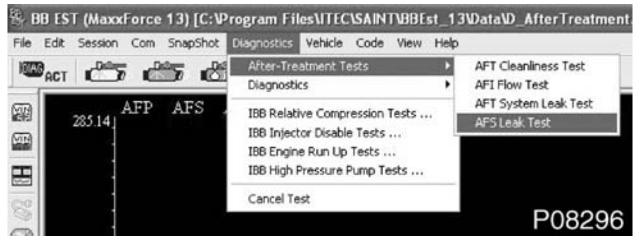


Figure 61 AFS Leak Test

6. Select Diagnostics from the menu bar and then After-Treatment Tests from the drop-down menu.
7. Select AFS Leak Test.

Actuator Test

The actuator test allows a technician to test the actuators by measuring voltage changes and visually monitoring actuator movement. During this test, each actuator is activated for 3.5 seconds in the following sequence. For air-actuated components, the truck air system is required to be charged to a minimum of 621 kPa (90 psi) for the actuator to function properly.

NOTE: The Cold Start Relay (CSR), Engine Crank Inhibit (ECI), and Electronic Engine Fan (EFAN), are activated and deactivated simultaneously.

- Intake Throttle Valve (ITV)
- Boost Control Solenoid (BCS) valve
- Exhaust Gas Recirculation (EGR) control valve
- Coolant Mixer Valve (CMV)
- Retarder Control
- Coolant Flow Valve (CFV)
- Aftertreatment Fuel Injector (AFI)
- Aftertreatment Fuel Supply (AFS) valve
- Aftertreatment Fuel Drain (AFD) valve
- CSR, ECI, EFAN simultaneously

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

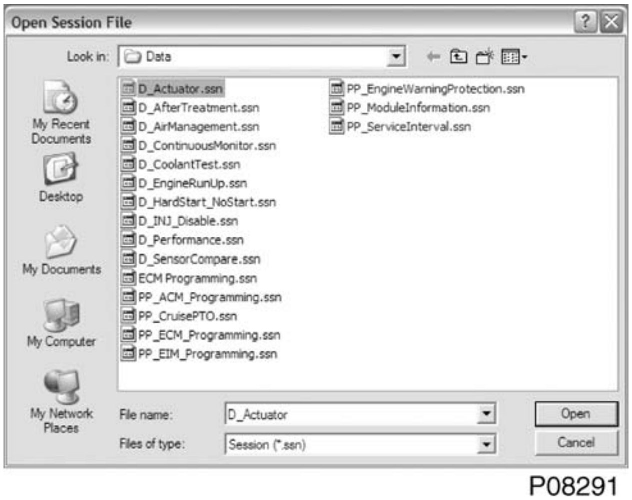


Figure 62 Actuator session file

3. Open D_Actuator.ssn file from the open session menu.

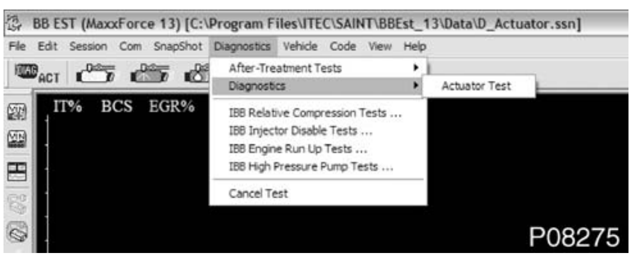


Figure 63 Actuator Test command

4. Select Diagnostics from the menu bar and then Diagnostics from the drop-down menu.
5. Select Actuator Test.

Relative Compression Test

This test determines cylinder integrity. The Engine Control Module (ECM) measures the time it takes for each piston to travel upward during the compression stroke. Timing is based on information from the Camshaft Position (CMP) sensor and Crankshaft Position (CKP) sensor. A cylinder with low compression allows the piston to travel faster during the compression stroke.

This test is accomplished by cranking the engine and following the on-screen instructions. The engine does not start when running this test.

Read and be familiar with all the steps and time limits in this procedure before starting.

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

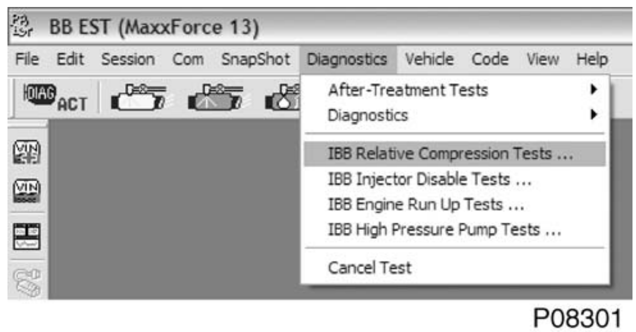


Figure 64 IBB Relative Compression Tests command

4. Select Diagnostics from the menu bar and then IBB Relative Compression Tests from the drop-down menu.

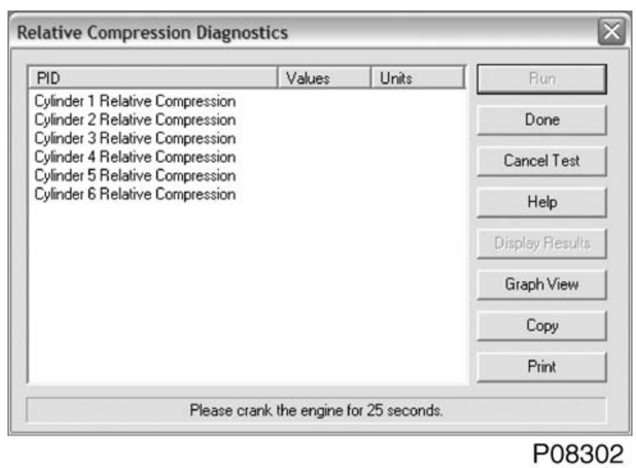
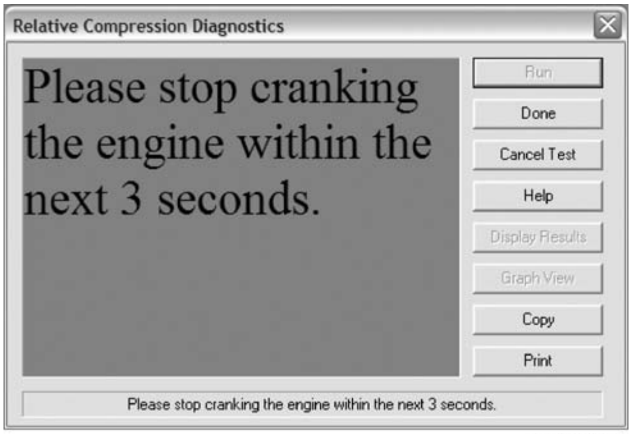


Figure 65 Run command

5. Select Run on the Relative Compression Diagnostics window. Within five seconds of selecting Run, crank the engine until prompted on screen to stop cranking.

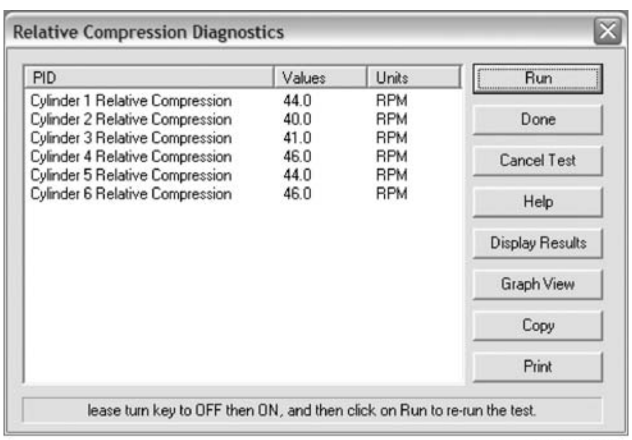


P08303

Figure 66 Stop cranking message

NOTE: Do not turn ignition switch to OFF when instructed to stop cranking. If the ignition switch is turned to OFF, the results are lost.

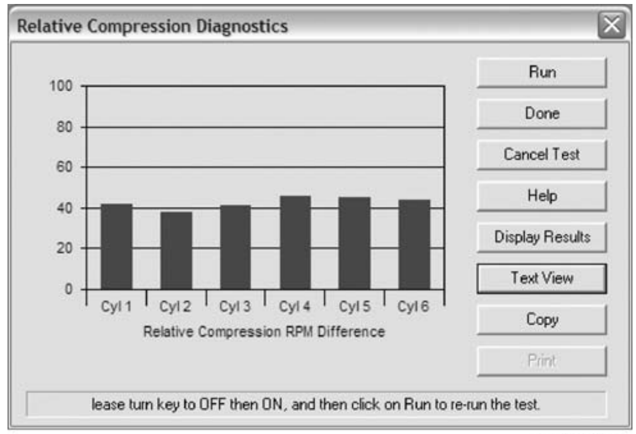
6. Stop cranking when indicated on screen but leave the ignition switch in the ON position. Select Display Results.



P08304

Figure 67 Test results – text format

7. The results are displayed in text format. Select Graph View to view the results in graph format.



P08305

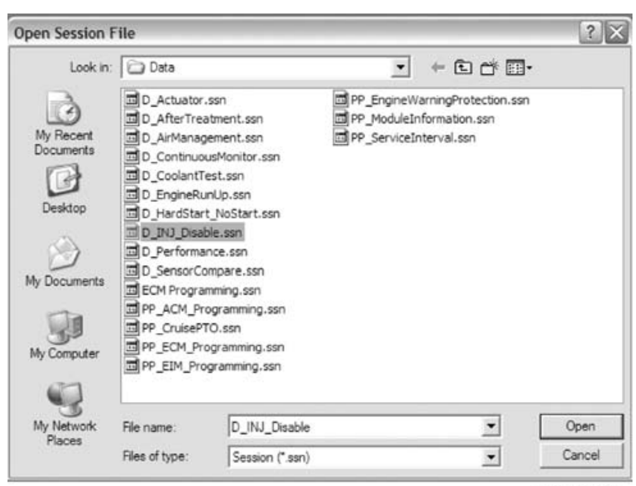
Figure 68 Test results – graph format

8. The results are displayed in graph format. If desired, select Text View to view the results in text format.

Injector Disable Test

This test determines the contribution of each injector by manually disabling each of the injectors, and determining if there is a change in engine performance.

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



P08281

Figure 69 Injector disable session file

3. Open D_INJ_Disable.ssn file from the open session menu.
4. Start the engine.

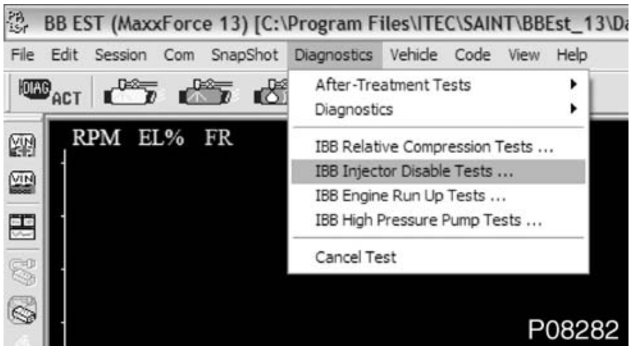


Figure 70 IBB Injector Disable Tests command

5. Select Diagnostics from the menu bar and then IBB Injector Disable Tests from the drop-down menu.

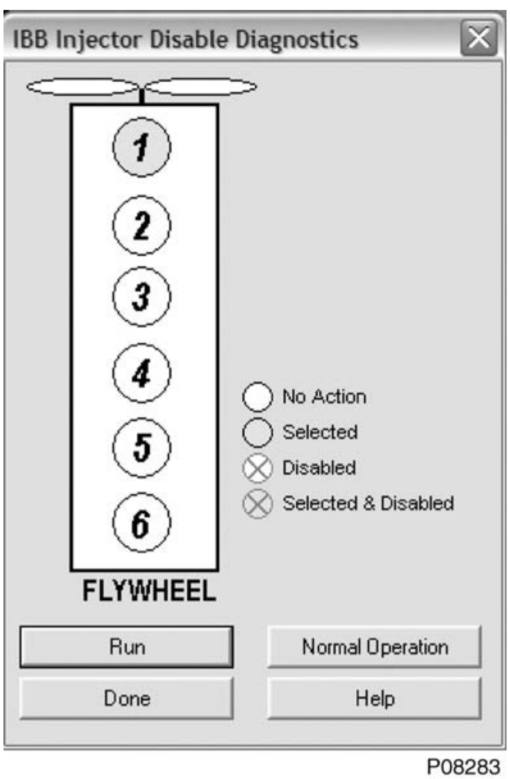


Figure 71 Injector selection

The injector number that is selected to be disabled is highlighted in blue.

6. Select the injector number to be disabled and then select Run.

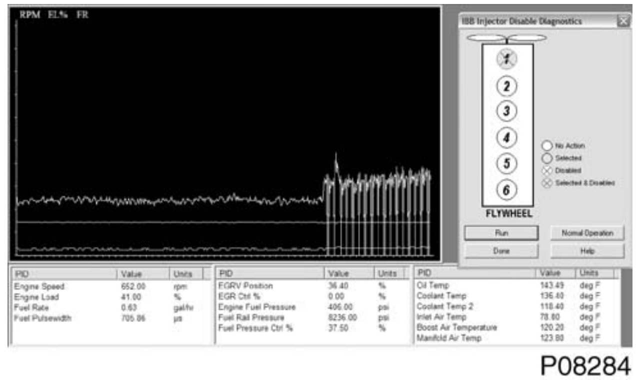


Figure 72 Injector disabled

7. The injector indicated with a red X is disabled. A change in the engine noise tone should be noticed.
8. Select Normal Operation to enable the injector and then repeat steps 6 through 8 for the remaining injectors.

Engine Run Up Test

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.

This test determines cylinder contribution by accelerating the engine from low idle to 1400 rpm, while disabling each of the injectors in sequence. A baseline test is performed with all of the injectors enabled at both the beginning, and end of the test.

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

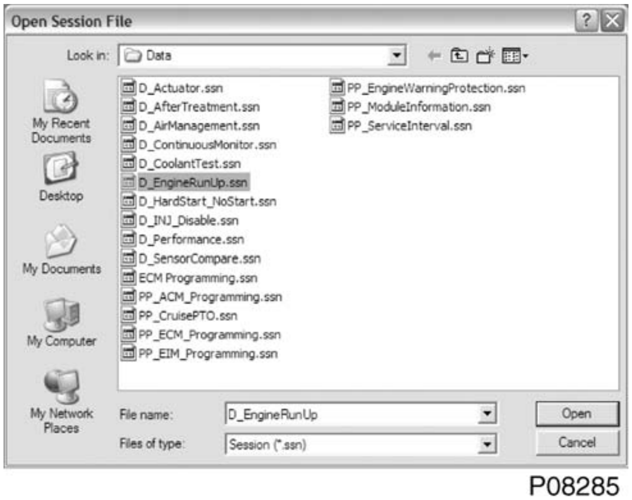


Figure 73 Engine run up session file

3. Open D_EngineRunUp.ssn file from the open session menu.
4. Start the engine.

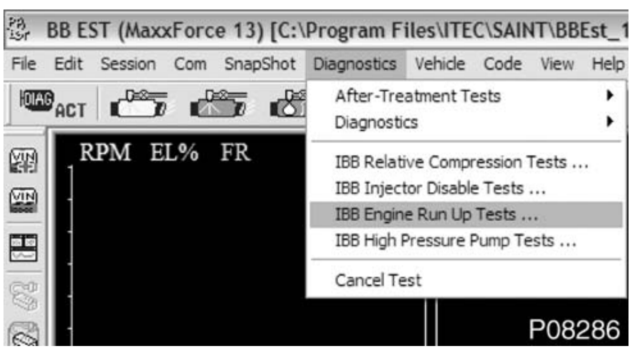


Figure 74 IBB Engine Run Up Tests command

5. Select Diagnostics from the menu bar and then IBB Engine Run Up Tests from the drop-down menu.

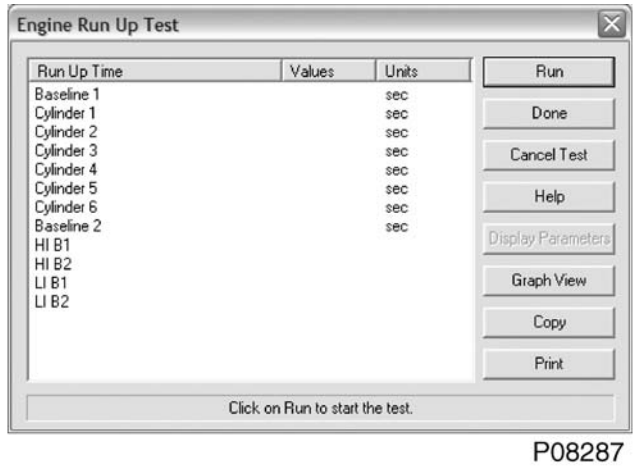


Figure 75 Run command

6. Select Run and the observe the message bar at the bottom of the Engine Run Up Test window for further instructions.

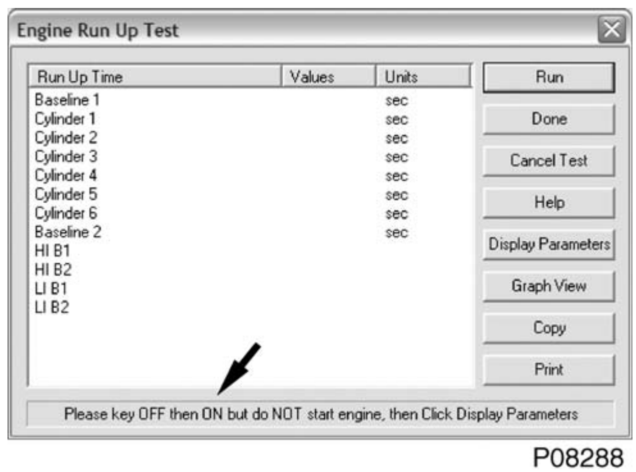
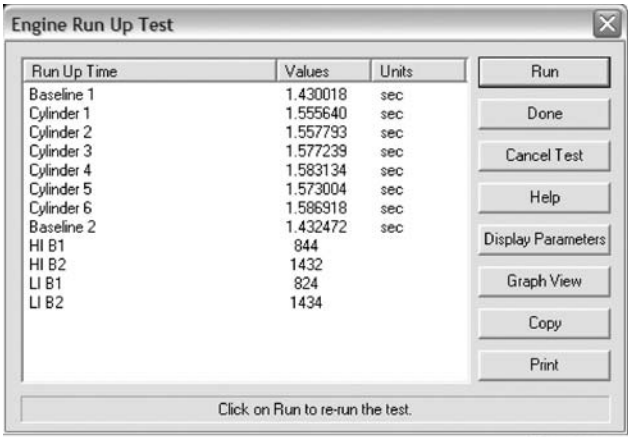


Figure 76 Key OFF command

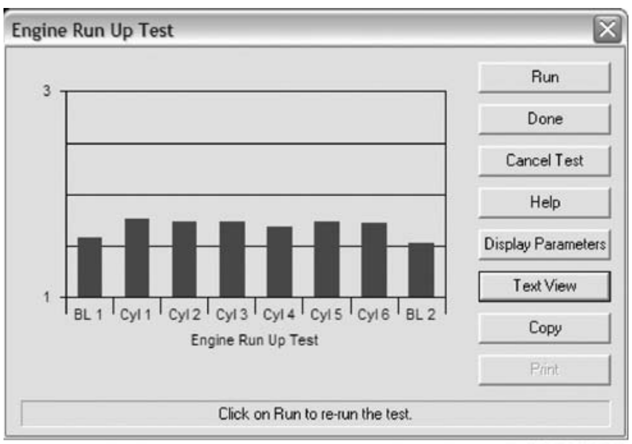
7. Turn the ignition switch OFF and then ON when instructed on screen.
8. Select Display Parameters.



P08289

Figure 77 Test results – text format

9. The results are displayed in text format. Select Graph View to view the results in graph format.



P08290

Figure 78 Test results – graph format

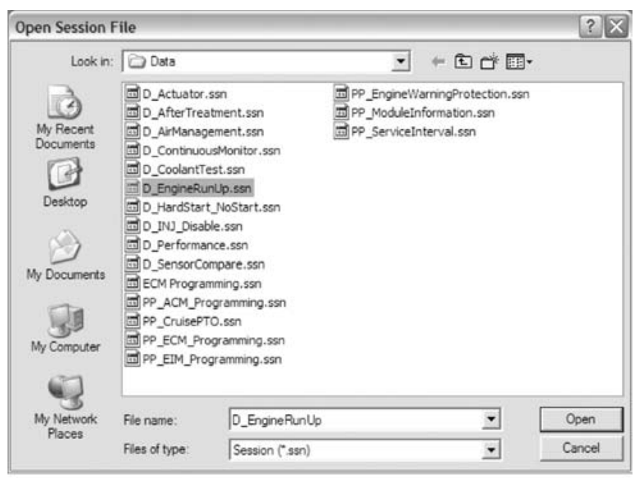
10. The results are displayed in graph format. If desired, select Text View to view the results in text format.

High Pressure Pump Test

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.

This test determines the integrity of the low or high pressure fuel system. This test does not identify a specific system component failure. When activated, the test accelerates the engine in steps, from low idle to 1100, 1300, 1450, and 1600 rpm. During each of these runs, the fuel pressure in the pressure pipe rail is increased from 7250 psi (500 bar) to approximately 26,100 psi (1800 bars), followed by fuel pressure drop to 7250 psi (500 bar). The ECM monitors the time for fuel pressure to increase and drop.

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



P08285

Figure 79 Engine run up session file

3. Open D_EngineRunUp.ssn file from the open session menu.
4. Start the engine.

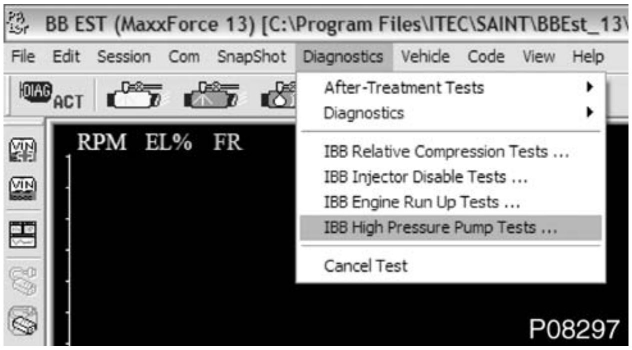
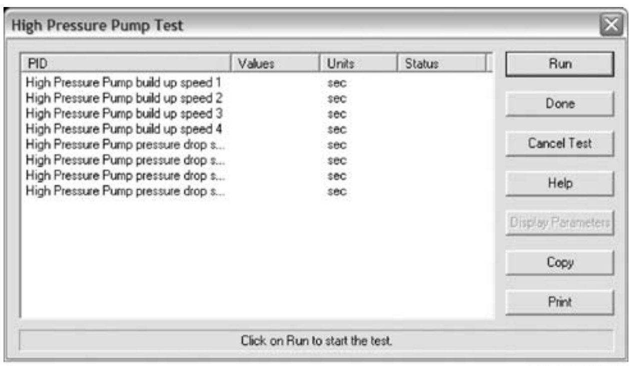


Figure 80 IBB High Pressure Pump Tests command

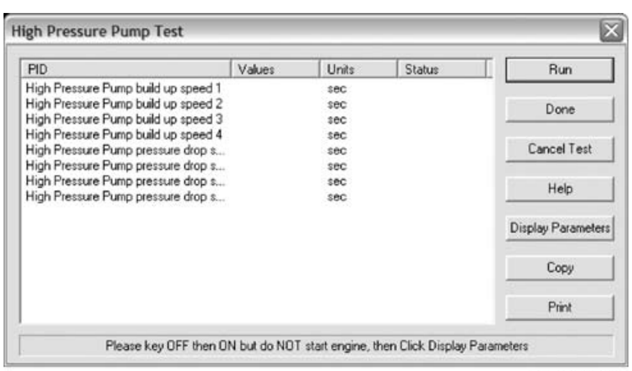
5. Select Diagnostics from the menu bar and then IBB High Pressure Pump Tests from the drop-down menu.



P08298

Figure 81 Run command

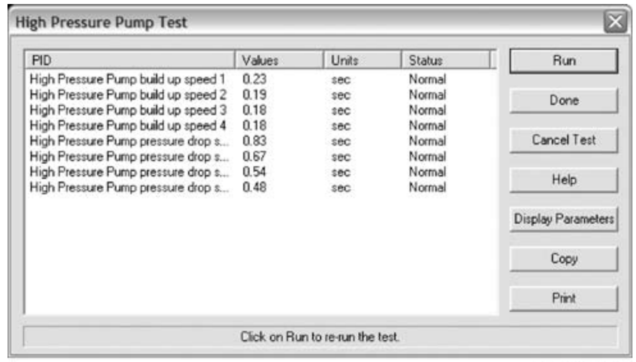
6. Select Run and the observe the message bar at the bottom of the High Pressure Pump Test window for further instructions.



P08299

Figure 82 Key OFF command

7. Turn the ignition switch OFF and then ON when instructed on screen.
8. Select Display Parameters.



P08300

Figure 83 Test results

9. The results are displayed in text format.

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 software.

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

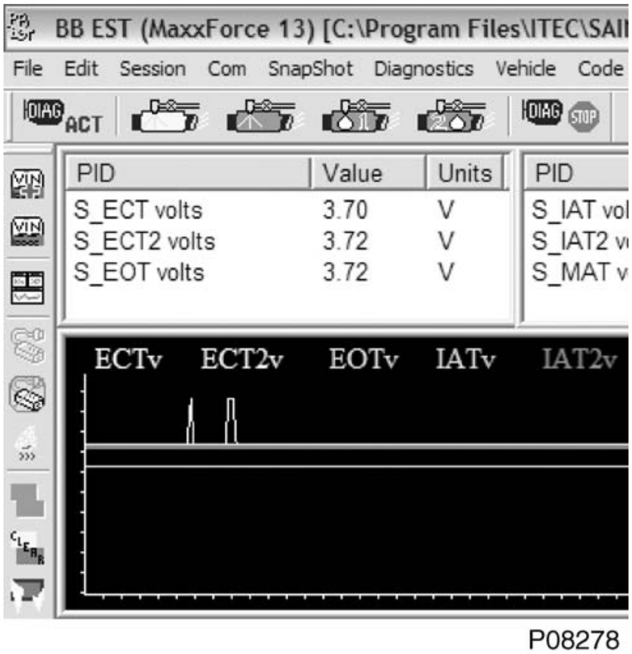


Figure 84 Continuous monitoring

NOTE: All sensors active in the software are reading an actual value. Refer to the Diagnostic Trouble Code (DTC) pinpoint 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.

Snapshots

Opening Specific Snapshots

Opening a session file prior to setting up a snapshot results in default snapshot settings related to the session file.

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

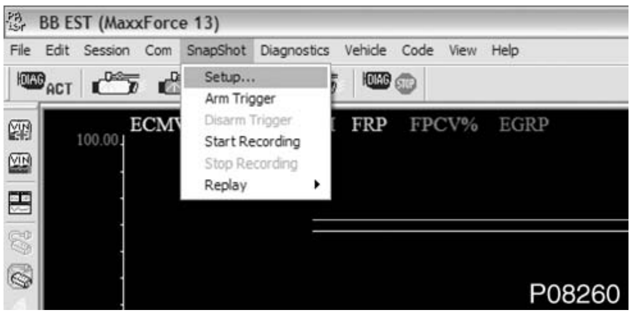


Figure 85 Opening specific snapshot

3. Select SnapShot from the menu bar.

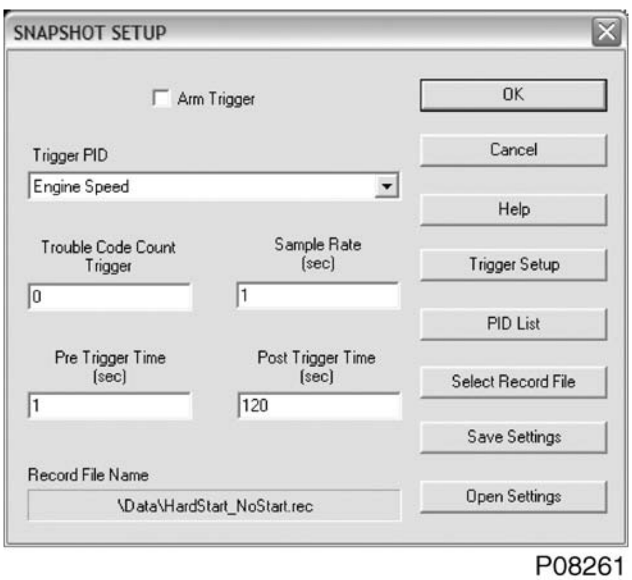


Figure 86 Specific snapshot setup

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 all settings are adjusted to obtain a useful snapshot.

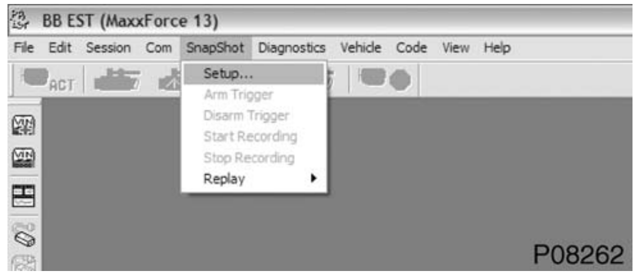


Figure 87 Opening basic snapshot

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

Snapshot Setup

Snapshot Trigger using Active Diagnostic Trouble Codes (DTCs)

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

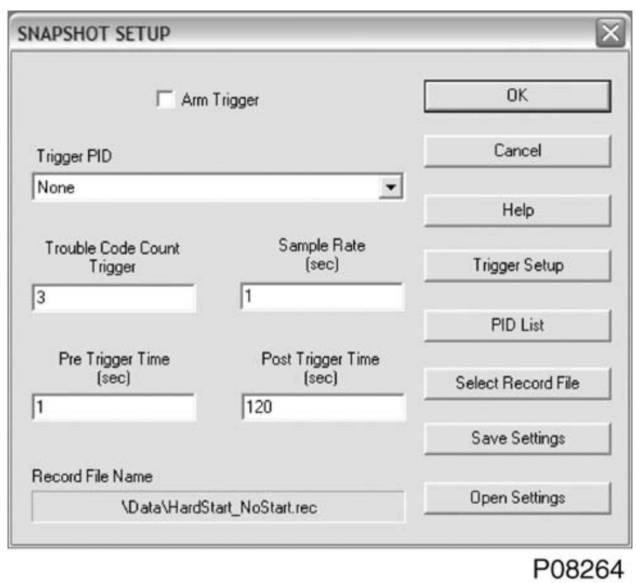


Figure 88 Opening basic snapshot

1. Enter None in Trigger PID drop-down menu.
2. Enter desired number of active DTCs in Trouble Code Count Trigger field.

Figure 89 Arm trigger box

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

Snapshot Trigger using Parameter Identifier (PID)

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

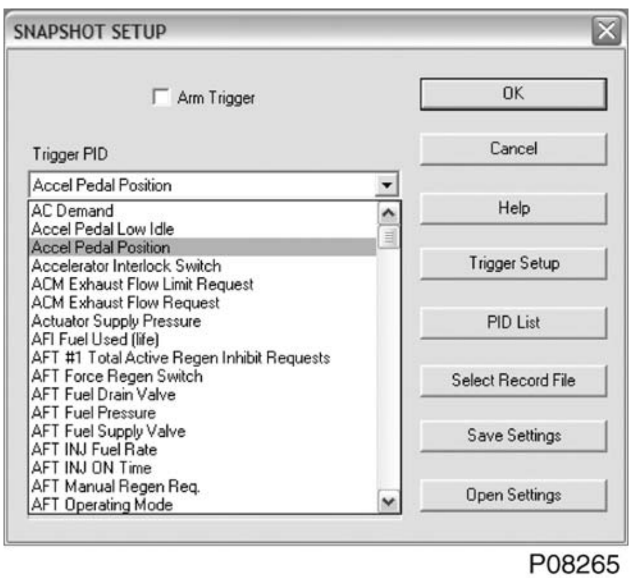


Figure 90 Selecting PID trigger

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

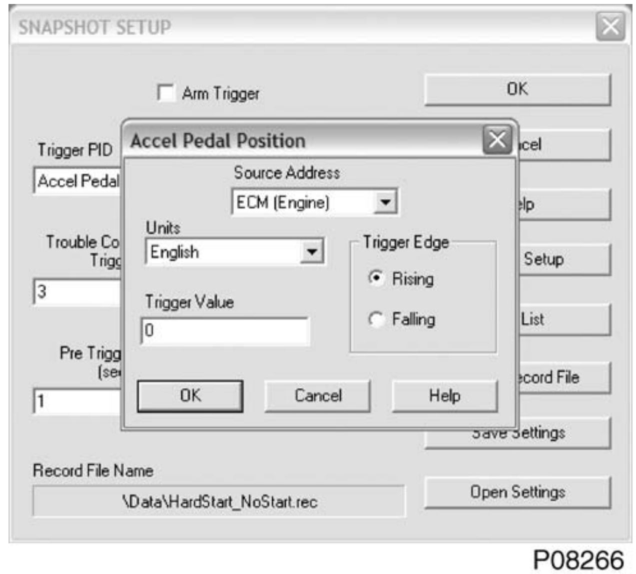


Figure 91 PID trigger set-up

2. Select Trigger Setup button.
3. Adjust units, trigger value, and trigger edge.
   - Units can be switched between English and metric values.
   - Trigger Value sets the PID value that begins snapshot recording.

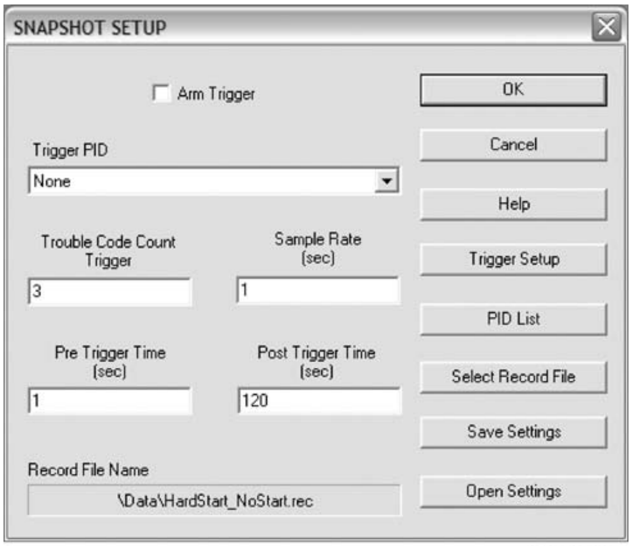
     Example: Trigger using APS at 100 percent, starts the recording when the APS reaches 100 percent.
   - Trigger Edge can be switched between rising and falling. Rising edge is used if the PID value starts lower than the Trigger value. Falling edge is used if the PID value starts higher than the Trigger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

Figure 92 Arm trigger box

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

Sample Rates, Pre Trigger, and Post Trigger Times

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



P08264

Figure 93 PID trigger set-up

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

   Sample Rate adjusts the interval for each recording.

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

   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 Time box.

   Pre Trigger Time 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 Time is useful when recording conditions before a diagnostic event or fault occurs.

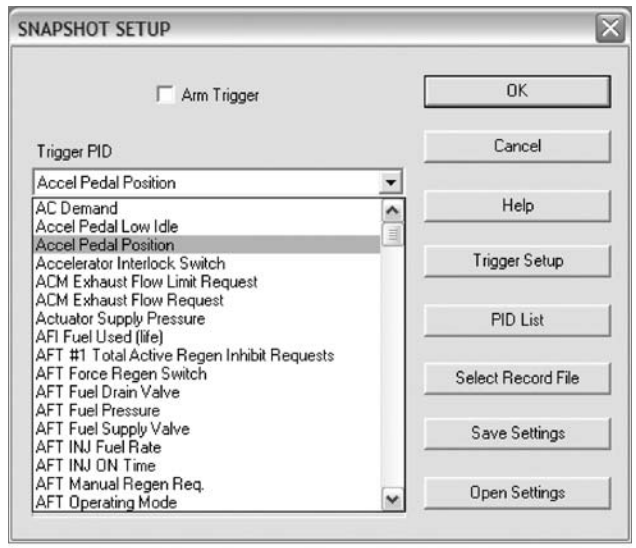
3. Enter desired time (seconds) in Post Trigger Time box.

   Post Trigger Time 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

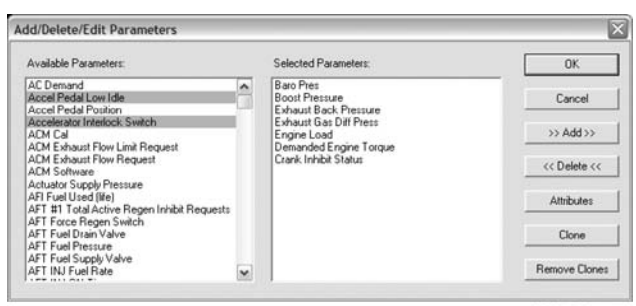
Verify the snapshot PID list contains each PID of concern. Adding or deleting PIDs from the PID session list does not alter the snapshot PID list.



P08265

Figure 94 Selecting PIDs to record

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



P08257

Figure 95 Selecting additional parameters for snapshot

2. Select additional PIDs in the left column. Press and hold the CTRL key to select multiple PIDs. Selections are highlighted in blue.
3. To add the selected PIDs, select the Add button and the PIDs move to the right column.

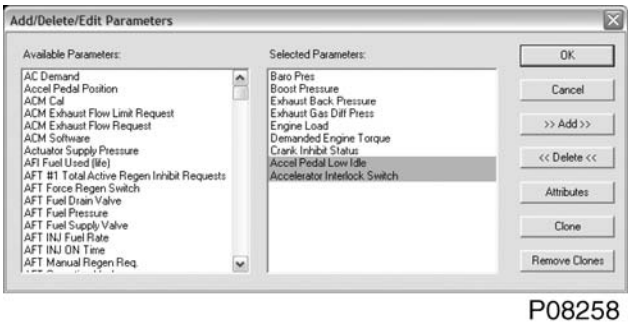


Figure 96 Additional PIDS added to snapshot

4. To delete PIDs from the snapshot, select the PIDs to remove from Selected Parameters and then select Delete.

NOTE: An alternative to steps 2 and 3 is to double-click PIDs in the left column to automatically add them to the right column. Also, an alternative to step 4 is to double-click PIDs in the right column to automatically move them back to the left column.

5. Select OK to complete action and to return to the Snapshot Setup window.

Rename REC Files

The REC file name can be changed to assist in finding the file for review or data exchange for technical help. The default name can be changed to a VIN or ID label for example.

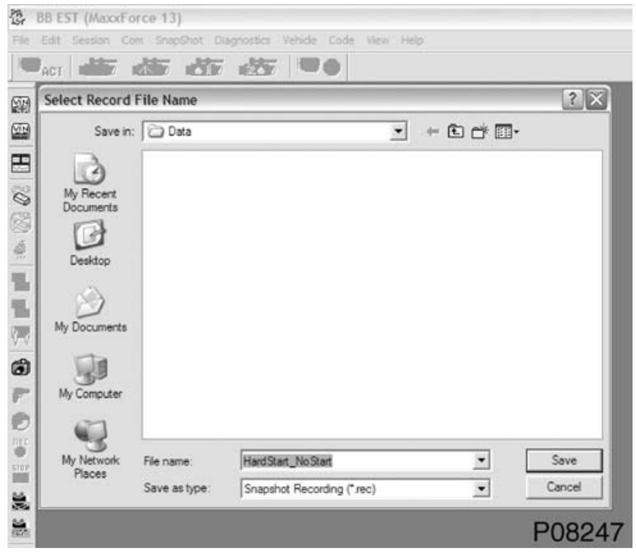


Figure 97 Naming REC file

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

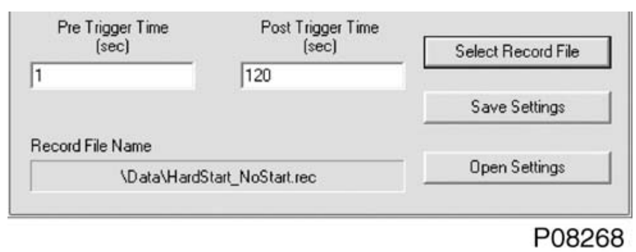


Figure 98 Verify REC file name

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

Manual Trigger Snapshots

1. Open MasterDiagnostics® and establish communication with the vehicle.
2. Open desired session file.
3. Open desired snapshot. Setup for desired recording.

4. Select snapshot REC button on the side toolbar.

Figure 99 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.

Figure 100 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 101 Snapshot replay

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.

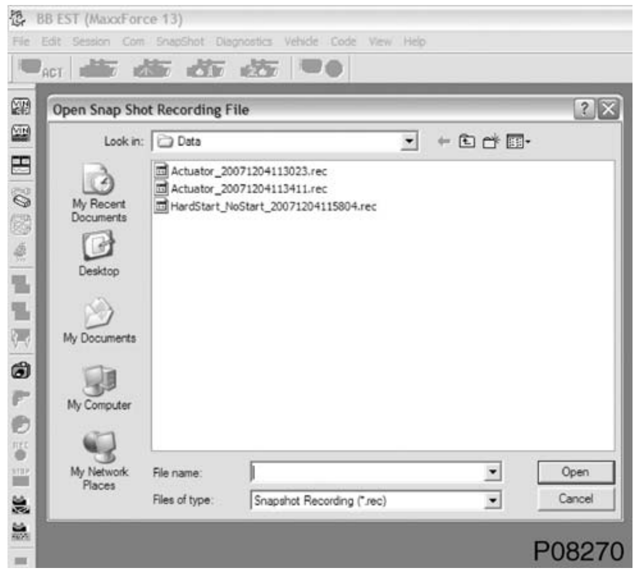


Figure 102 Replaying REC file

4. Select the desired snapshot file.
5. Select Open.

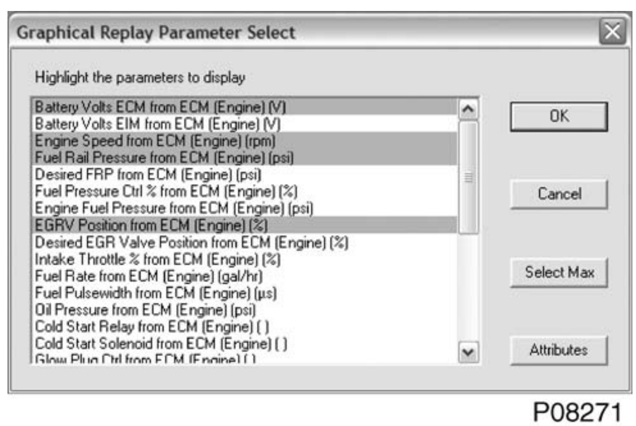


Figure 103 Selecting PIDs to replay

6. Select desired PIDs. Press and hold the CTRL key to select multiple PIDs. Select the Select Max button to select all recorded PIDs in text format, or

a maximum of 14 PIDS in graph format. Selected PIDs are highlighted in blue.

7. Select the OK button.

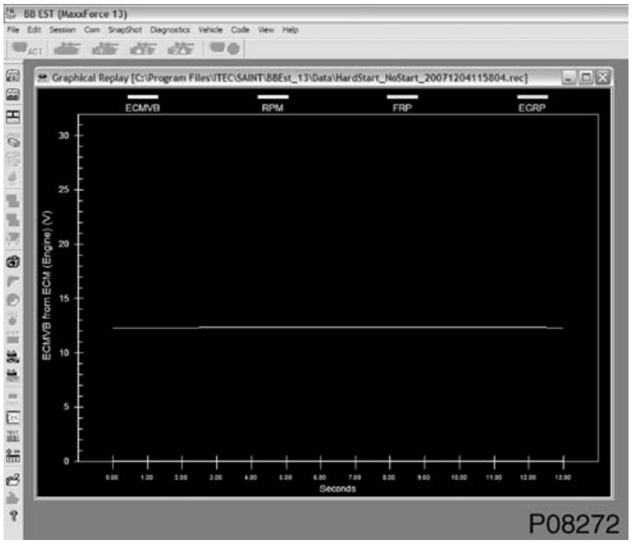


Figure 104 REC file graph view

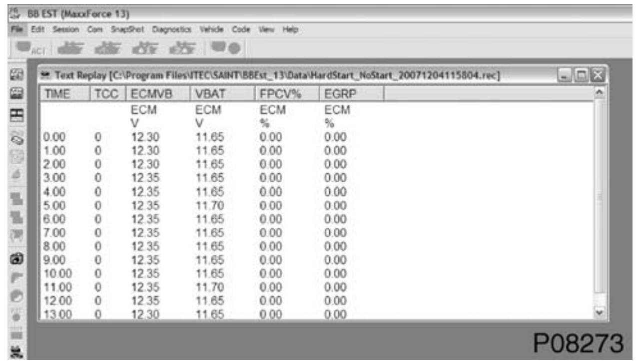


Figure 105 REC file text view

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

Service Interval Messages Reset

Reset Message

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

NOTE: If password is not entered or entered incorrectly, an error message is displayed. The service interval cannot be reset.

NOTE: The password is a default setting, unless the customer has changed the password. If the default password does not work, contact the customer for the correct password.

9. Enter password in dialog box.
10. Select OK.
11. Right click SI: Service Interval Reset parameter to display pop-up menu.
12. Select Program from the pop-up menu. The Edit Parameter window opens.
13. Click the arrow in the New Value dialog box.
14. Select Yes in the pull-down menu.
15. Select OK.
16. Verify the following changes have been made to SI: Service Interval Reset parameter and accepted by the control module:
    - Module Value has changed from No to Yes.
    - Original number in Program Count has increased by one.
17. The service interval has been set. Close session window.

General Information

Installed MasterDiagnostics® Version

1. Open MasterDiagnostics® on EST computer.

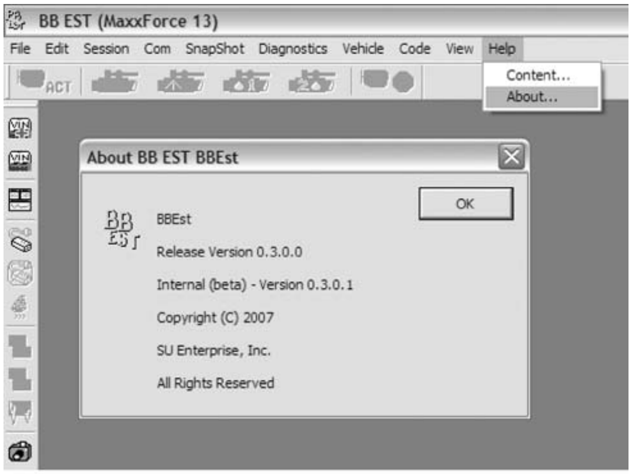


Figure 106 Software version display

2. Select Help from the menu bar.
3. Select About from the drop-down menu.
4. The software release version is displayed.
5. The Tech Central representative may ask for this version number in addition to the diagnostic issues.

Approved Interface Cable

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

   NOTE: Unapproved or outdated interface cables may have limited or no functionality or low accuracy.

2. The Tech Central representative may ask which interface cable is being used in addition to the diagnostic issues.

Table of Contents

Description

Diagnostic test procedures help technicians find problems systematically and quickly to avoid unnecessary repairs. In this section, diagnostic and test procedures help identify causes for known problems and conditions.

WARNING: To prevent personal injury or death, read all safety instructions in the foreword of this manual. Follow all warnings, cautions, and notes.

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

Low Power

See “Performance Diagnostics” section of this manual.

Hard Start/No Start

See “Hard Start and No Start Diagnostics” section of this manual.

Misfire/Rough Low Idle

See “Performance Diagnostics” section of this manual.

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.

Coolant Loss

Symptom

Coolant loss is identified by a consistent need to refill the deaeration tank.

Possible Causes

- Improper servicing
- Damaged or failed deaeration tank
- Damaged or failed deaeration cap
- Damaged or failed radiator
- Damaged or failed distributor housing
- Damaged or failed heater core
- Loose or failed coolant hoses
- Failed High Pressure Charge Air Cooler (HPCAC)
- Failed Low Pressure Charge Air Cooler (LPCAC)
- Failed Exhaust Gas Recirculation (EGR) module
- Failed Aftertreatment Fuel Injector (AFI)
- Failed air compressor
- Cracked cylinder head
- Porous or cracked cylinder liner

Tools

- Radiator Pressure Testing Kit (page 451)
- Plastic Surge Tank Cap Adaptor (page 451)
- Cylinder head test plate (Contact Tech Central at 1-800-336-4500)
- EGR Cooler Pressure Test Plates (page 448)
- 1 inch pipe plug
- Electronic Service Tool (EST) with Master Diagnostics® Software (page 445)
- IC4 USB Interface Cable (page 445)

Procedure

1. Check the service records to determine the frequency and quantity of coolant added.
   - If the vehicle’s cooling system is being overfilled there will be a small coolant loss everyday. Educate the driver on correct coolant level.
   - If the cooling system maintenance is correct proceed to the next step.

NOTE: Make sure the engine oil and coolant are within normal operating ranges and there is no visible evidence of coolant on the oil level gauge before running the engine.

2. Start and idle the engine at the high idle/no load specification and inspect for coolant overflow.
   - If coolant overflow is detected, see Coolant Overflow (page 93) in this section.
   - If no coolant overflow is detected, proceed to the next step.

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

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

3. Remove deaeration tank cap.

4. Visually inspect sealing surfaces of deaeration cap and deaeration tank for damage.
   - If sealing surfaces are damaged, install new components as necessary. Retest the cooling system.
   - If sealing surfaces are not damaged, proceed to next step.
5. Connect Radiator Pressure Testing Kit with Plastic Surge Tank Cap Adaptor to the deaeration cap.
6. Pressurize deaeration cap to its rated pressure.
   - If deaeration cap does not hold the rated pressure, install a new deaeration cap. Retest the cooling system.
   - If deaeration cap holds the rated pressure, proceed to next step.
7. If equipped, plug in the block heater and warm the coolant.

NOTE: If the vehicle is equipped with a secondary surge tank, clamp the secondary surge tank port on the deaeration cap.

8. Connect Radiator Pressure Testing Kit with Plastic Surge Tank Cap Adaptor to the deaeration tank.
9. Pressurize cooling system to 117 kPa (17 psi) for 15 minutes.
10. Visually inspect for external coolant leaks.

    Inspect the following components for external leaks:
    - Radiator
    - Deaeration tank
    - Deaeration cap
    - Coolant hoses
    - Heater core
    - Charge Air Coolers (CACs)
    - Water pump
    - AFI
    - Any vehicle specific coolant supplied components
11. If a external coolant leak is identified, repair as necessary. Retest the cooling system.

    If no external leak is detected, proceed to the next step.
12. Obtain a fuel sample from the fuel tank and test for coolant contamination.
    - If the fuel sample has coolant contamination, see Coolant Leak to Fuel (page 97) in this section.
    - If the fuel sample has no coolant contamination, proceed to the next step.
13. Remove Intake Throttle Valve (ITV) following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
14. Inspect the intake manifold and the HPCAC outlet for evidence of coolant.
    - If evidence of coolant in the intake manifold or the HPCAC outlet is detected, see Coolant Leak to Intake (page 98) in this section.
    - If no evidence of coolant in the intake manifold or the HPCAC outlet is detected, proceed to next step.
15. Obtain an oil sample from the engine and test for coolant contamination.
    - If the oil sample has coolant contamination, see Coolant Leak to Lube Oil (page 99) in this section.
    - If the oil sample has no coolant contamination, see Coolant Leak to Exhaust (page 95) in this section.

Coolant Overflow

Symptom

Coolant overflow is coolant flowing or bubbling from the deaeration tank.

Possible Causes

- Failed air compressor
- Failed HPCAC
- Failed LPCAC
- Failed EGR module
- Cracked cylinder liner

- Cracked cylinder head

Tools

- Radiator Pressure Testing Kit (page 451)
- Plastic Surge Tank Cap Adaptor (page 451)
- Air Compressor Coolant Bypass Hose (obtain locally)
- 1/2 in I.D. hose (obtain locally)
- 1 in I.D. hose (obtain locally)
- 1 in O.D. pipe plug (obtain locally)
- 1 in O.D. pipe plug with air fitting and shut-off valve (obtain locally)

Procedure

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

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

1. Partially drain the cooling system.

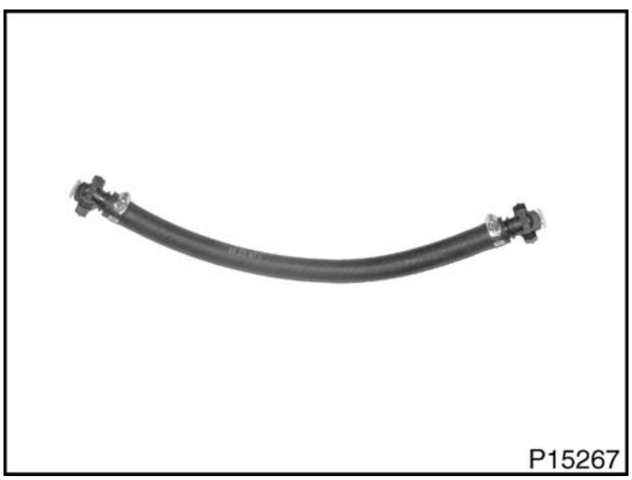


Figure 107 Air compressor coolant bypass hose

2. Assemble an air compressor coolant bypass hose using the connectors from a new air compressor coolant pipe, two hose clamps and 48 cm (18 in) of 1/2 in I.D. hose.
3. Using the air compressor coolant bypass hose, bypass the coolant hoses for the air compressor at the cylinder block.
4. Refill the cooling system to operating level.

CAUTION: To prevent engine damage, do not run the engine for more than 1 minute. This can overheat the air compressor.

5. Run the engine, for a maximum of one minute, to test the coolant system for combustion leakage.
   - If coolant continues overflowing from the deaeration tank, proceed to next step.
   - If coolant stops overflowing from deaeration tank, install a new air compressor following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
6. Remove Intake Throttle Valve (ITV) following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.

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

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

7. Remove deaeration tank cap.
8. Connect Radiator Pressure Testing Kit with Plastic Surge Tank Cap Adaptor to the deaeration tank.
9. Pressurize cooling system to 117 kPa (17 psi) for 15 minutes.

10. Inspect the intake manifold and the HPCAC outlet for evidence of coolant.
    - If evidence of coolant in the intake manifold or the HPCAC outlet is detected, see Coolant Leak to Intake (page 98) in this section.
    - If no evidence of coolant in the intake manifold or the HPCAC outlet is detected, proceed to next step.
11. Drain the engine coolant.
12. Disconnect the coolant hoses from the LPCAC.
13. Using a suitable hose with a 1 inch I.D., and a plug, block off the LPCAC coolant outlet port.

WARNING: To prevent personal injury or death, wear safety glasses with side shields. Limit compressed air pressure to 207 kPa (30 psi).

14. Attach a air pressure regulator to a pressurized air source and regulate the pressure to 207 kPa (30 psi).
15. Using a suitable hose with a 1 inch I.D. and a valve, connect the air pressure regulator with the pressurized air source to the LPCAC coolant inlet port.
16. Pressurize the LPCAC to 207 kPa (30 psi).
17. Remove the air pressure source.
18. Monitor the air pressure in the LPCAC for a period of five minutes.
    - If the air pressure in the LPCAC drops, install a new LPCAC following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
    - If the air pressure in the LPCAC remains constant, go to the next step.

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

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.

19. Pressure test the EGR module in vehicle following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
    - If a leak is detected, install a new EGR module as described in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
    - If a leak is not detected, see Coolant Leak to Lube Oil (page 99) in this section.

Coolant Leak to Exhaust

Symptoms

Coolant leaks to the exhaust may be detected externally or internally. See the following list of symptoms for identification of coolant leaks to the exhaust.

- Coolant residue at exhaust manifold flanges
- Observation of coolant loss without engine overheating
- Coolant smell in exhaust
- Coolant leaking from exhaust
- Severe case - engine hydraulic lock
- Failed Aftertreatment Fuel Injector (AFI)
- Plugged Diesel Particulate Filter (DPF) or Diesel Oxidation Catalyst (DOC)

Possible Causes

- Failed EGR module
- Failed AFI
- Cracked cylinder head
- Cracked cylinder liner

Tools

- Radiator Pressure Testing Kit (page 451)
- Plastic Surge Tank Cap Adaptor (page 451)

Aftertreatment Fuel Injector (AFI) Coolant Leak Inspection

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

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

1. Remove deaeration tank cap.
2. Install Radiator Pressure Testing Kit with Plastic Surge Tank Cap Adaptor.

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

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.

3. Disconnect exhaust pipe from turbo exhaust pipe.
4. Pressurize cooling system to 117 kPa (17 psi) for 15 minutes.

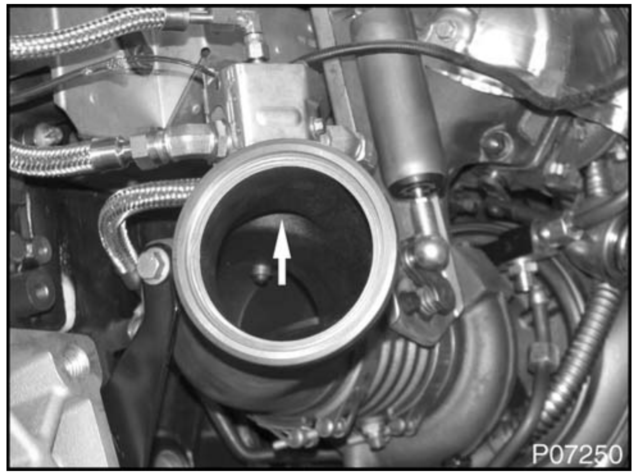


Figure 108 AFI nozzle

5. Inspect inside of turbo exhaust pipe at AFI nozzle.
   - If coolant is evident at AFI nozzle inside turbo exhaust pipe, install a new AFI following the procedures in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - If no coolant is evident at AFI nozzle inside the turbo exhaust pipe, proceed to next test.

EGR Module Leak Inspection

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

WARNING: To prevent personal injury or death, 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.

1. Visually inspect EGR module for cracks or leaks.
   - If an external leak or crack is identified, install a new EGR module as described in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - If no external leaks or cracks are identified, proceed to next step.

CAUTION: To prevent engine damage, do not reuse front or rear EGR tubes.

2. Remove front and rear inner and outer tubes from EGR module following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
3. Pressure test the EGR module in vehicle following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - If the pressure test indicates a leak, install a new EGR module following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - If the pressure test does not indicate a leak, see Cylinder Head Leak Test (page 101) in this section.

Coolant Leak to Fuel

Symptom

When fuel is contaminated with coolant, the fuel has a noticeable coolant separation in the fuel sample.

Possible Causes

- Coolant heater auxiliary fuel filter (if equipped)
- Failed AFI
- Cracked cylinder head

Tools

- Radiator Pressure Testing Kit (page 451)
- Plastic Surge Tank Cap Adaptor (page 451)
- Cylinder head test plate (Contact Tech Central at 1-800-336-4500)
- Fuel Inlet Restriction and Aeration Tool (page 449)

Procedure

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

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

1. Remove deaeration tank cap.
2. Install Radiator Pressure Testing Kit with Plastic Surge Tank Cap Adaptor.
3. Pressurize cooling system to 117 kPa (17 psi) for 15 minutes.
4. Disconnect fuel line from the AFI.
5. Inspect AFI for coolant leaking from the fuel inlet.
   - If coolant is leaking from AFI, install a new AFI following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - If coolant is not leaking from AFI, proceed to next step.
6. Restore fuel system to running condition.
7. Remove the hollow screw at the rear of the cylinder head.
8. Pressurize cooling system to 117 kPa (17 psi) for 30 minutes.
9. Monitor the fuel return port in the cylinder head for coolant.
   - If coolant is present in the fuel return port, install a new cylinder head following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - If coolant is not present in the fuel return port, proceed to next step.
10. Pressurize cooling system to 117 kPa (17 psi).

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

11. Monitor fuel return port for coolant.
    - If coolant is present in the fuel return port, install a new cylinder head following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
    - If no coolant is present in the fuel return port, the fuel in the fuel tank may have been contaminated.

Coolant Leak to Intake

Symptom

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

Possible Causes

- Failed HPCAC
- Failed LPCAC
- Failed EGR module
- Cracked cylinder head

Tools

- Radiator Pressure Testing Kit (page 451)
- Plastic Surge Tank Cap Adaptor (page 451)
- Cylinder head test plate (Contact Tech Central at 1-800-336-4500)
- EST with Master Diagnostics® software (page 445)
- IC4 USB interface cable (page 445)
- Fuel Inlet Restriction and Aeration Tool (page 449)

Procedure

1. Verify the location of the coolant evidence.
    - If the coolant evidence is in the HPCAC outlet, proceed to the next step.
    - If the coolant evidence is in the intake manifold, skip to step 12.
2. Remove five M10 x 160 hex bolts from the HPCAC.

NOTE: Do not disconnect CAC supply and return coolant pipes from HPCAC.

3. Separate HPCAC from high pressure turbocharger. Position HPCAC aside to allow visual inspection of the inlet and outlet ports.
4. Install Radiator Pressure Testing Kit with Plastic Surge Tank Cap Adaptor on the deaeration tank.
5. Pressurize cooling system to 117 kPa (17 psi) for 15 minutes.
6. Inspect the inside of the HPCAC for coolant leaks.
    - If HPCAC is leaking coolant, install a new HPCAC as described in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
    - If HPCAC is not leaking coolant, proceed to next step.
7. Inspect high pressure turbocharger outlet for evidence of coolant.
    - If there is evidence of coolant, proceed to next step.
    - If there is no evidence of coolant, skip to step 12.
8. Visually inspect LPCAC for cracks or leaks.
    - If an external leak or crack is identified, install a new LPCAC as described in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
    - If no external leaks or cracks are identified, proceed to next step.
9. Drain cooling system.
10. Remove LPCAC as described in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
11. Test LPCAC following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
    - If LPCAC is leaking, install a new LPCAC as described in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
    - If LPCAC is not leaking, proceed to next step.

12. Visually inspect EGR module for cracks or leaks.
    - If an external leak or crack is identified, install a new EGR module as described in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
    - If no external leaks or cracks are identified, proceed to next step.

CAUTION: To prevent engine damage, do not reuse front or rear EGR tubes.

13. Remove front inner and outer tubes from EGR module following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
14. Pressure test the EGR module in vehicle following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
    - If a leak is detected, install a new EGR module as described in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
    - If no leak is found, proceed to next step.
15. Test cylinder head for coolant leaks in the intake area. See Cylinder Head Leak Test (page 101) in this section.
    - If a coolant leak is identified in the cylinder head, install a new cylinder head following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
    - If a coolant leak is not identified in the cylinder head, restore the engine to operational condition and retest the cooling system.
16. Restore the cooling system to operational condition.
17. Test cooling system again to validate the repair.

Coolant Leak to Lube Oil

Symptom

When the crankcase lube oil is contaminated with coolant, the oil has a dark gray or black sludgy appearance. The crankcase may also be overfilled.

Possible Causes

- Failed EGR module
- Failed HPCAC
- Failed LPCAC
- Failed oil cooler
- Failed air compressor
- Cracked cylinder head
- Cracked or cavitated front cover
- Cracked cylinder liner
- Cracked crankcase

Tools

- Radiator Pressure Testing Kit (page 451)
- Plastic Surge Tank Cap Adaptor (page 451)

Lube Oil Contamination Inspection

1. Check coolant level and oil level gauge to verify oil contamination complaint.
    - The presence of coolant in the oil generally causes oil to thicken and coagulate giving a dark gray or black chunky appearance.
    - If coolant in oil cannot be verified, take an oil sample for analysis.
2. Remove the oil sump following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.

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

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

3. Remove deaeration tank cap.
4. If equipped, plug in the block heater to warm the coolant.
5. Install Radiator Pressure Testing Kit with Plastic Surge Tank Cap Adaptor on the deaeration tank.

6. Pressurize cooling system to 117 kPa (17 psi) for 15 minutes.

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

7. Inspect the inside of the crankcase for evidence of coolant.
   - If coolant is evident at the air compressor drain, install a new air compressor following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - If coolant leak is from the oil cooler, install a new oil cooler following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - If coolant is evident at the front cover area, proceed to next step.
   - If coolant is evident at the rear gear train area, inspect the freeze plug on the rear of the cylinder head and repair as necessary.
   - If coolant is evident on the bottom edge of a cylinder liner(s), skip to step 10.
   - If coolant leak is from cracks in the crankcase, install a new crankcase following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
8. Remove distributor housing following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.

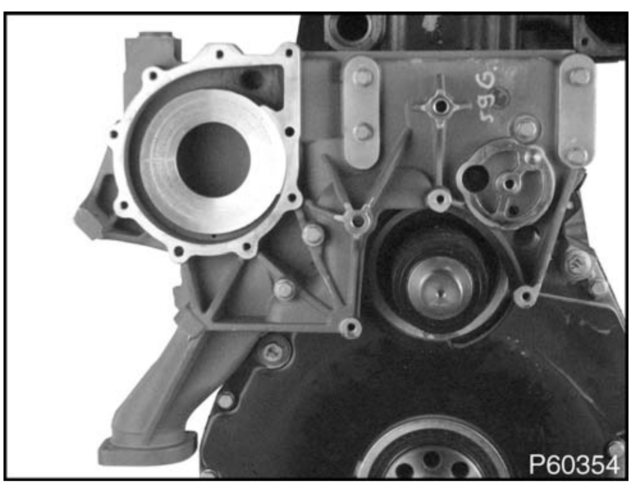


Figure 109 Distributor Housing

9. Inspect gear train area for coolant leaks.
   - If there is coolant leaking into gear train area, remove distributor housing and inspect for leak sources. Repair as necessary.
   - If no coolant is leaking into the gear train area, inspect the distributor housing and gasket for leak sources. Repair as necessary.
10. Inspect lower edges of cylinder liners for coolant leaks. Note cylinder number(s) that yields coolant leak evidence.
    - If coolant is leaking on the outside of cylinder liner, install new cylinder liner O-rings following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
    - If coolant is leaking on inside of cylinder liner, proceed to next step.

CAUTION: To prevent engine damage, do not reuse front or rear EGR tubes.

11. Remove front inner and outer tubes from EGR module following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
12. Remove rear inner and outer tubes from EGR module following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
13. Pressure test EGR module in vehicle following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
    - If a leak is detected, install a new EGR module as described in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
    - If no leak is found, proceed to next step.
14. Test cylinder head for coolant leaks. See Cylinder Head Leak Test (page 101) in this section.
15. Test cooling system again after any repair to validate the repair.

Cylinder Head Leak Test

Tools

- Cylinder head test plate (Contact Tech Central at 1-800-336-4500)

Procedure

1. Contact Tech Central at 1-800-336-4500 for a set of cylinder head test plates.
2. Remove cylinder head following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
3. Install cylinder head test plates.
4. Pressurize cylinder head to 139 kPa (20 psi).
5. Inspect cylinder head.
   - If a leak in cylinder head is noticed, install a new cylinder head following the procedures in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - If no leaks are identified, proceed to next step.
6. If cylinder head is in good condition, inspect all of the cylinders following the procedures in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - Inspect for damaged cylinders. Repair or replace as necessary.
   - Inspect crankcase for cracks in coolant passages. Repair or replace as necessary.
7. Test cooling system again to validate the repair.

Coolant Over-Temperature

Symptom

Coolant over-temperature is identified by the red ENGINE lamp illuminating and flashing and the audible alarm sounding, or the cooling system setting Diagnostic Trouble Codes (DTCs).

Possible Causes

- Damaged fan belt
- Low engine coolant level
- External coolant leaks
- Internal or external radiator blockage
- Broken/worn accessory drive belt
- Accessory belt tensioner failure
- HPCAC failure
- LPCAC failure
- Coolant control valve(s) failure
- EGR cooler failure
- One or both coolant thermostats missing or stuck (closed)
- Slipping cooling fan drive clutch
- Water pump failure
- Cooling fan blade assembly wrong or damaged
- Instrument panel gauge error
- Engine Coolant Temperature (ECT) sensor biased
- Incorrect radiator
- Internal coolant leak
- Damaged fan shroud
- Chassis effects, transmission, or aftermarket equipment

Tools

- Radiator Pressure Testing Kit (page 451)
- Plastic Surge Tank Cap Adaptor (page 451)
- EST with Master Diagnostics® Software (page 445)
- IC4 USB interface cable (page 445)
- Digital Multimeter (DMM) (page 442)
- Hose pinch off pliers

Coolant Over-Temperature Conditions Inspection

1. Install EST and check for active and inactive DTCs related to engine coolant over-temp conditions.
2. Correct any sensor fault DTCs before proceeding. See “Electronic Control Systems Diagnostics” in this manual.

3. Check coolant deaeration tank for correct fill level.
   - If coolant level is low and a coolant leak is suspected, fill cooling system and verify no coolant leaks. See Coolant Loss (page 92) in this section.
   - If coolant level is low and a boil over is suspected, fill cooling system. Proceed to next step.
4. Inspect condition of the cooling fan blade, shroud, accessory drive belt(s), accessory drive belt tensioner(s), cooling fan drive clutch, and radiator.
   - Inspect for damaged fan drive. If damaged, install a new fan drive following the procedures in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - If vehicle is new or recently repaired, verify correct part number for any component related to the cooling system.
   - Verify cooling fan blade, cooling fan drive clutch, and radiator are clean of debris and dirt build-up. Clean areas as required.
   - Start and run engine up to operating temperature and verify cooling fan clutch engages at desired temperature.
     - If fan does not operate, verify air or electrical supply to fan drive. If air or electrical supply to fan drive is damaged, repair as necessary.
     - If fan operates, proceed to next step.
5. If engine has not been operated for 8 to 12 hours, using the EST, compare ECT, Engine Coolant Temperature 2 (ECT2), Engine Oil Temperature (EOT), Manifold Air Temperature (MAT), Intake Air Temperature (IAT) and Intake Air Temperature 2 (IAT2) sensors with Key On Engine Off (KOEO). All of the sensors should read within 2 °C (5 °F) of each other.

CAUTION: To prevent engine damage, do not hold the wand of high-pressure hose too close to radiator fins.

6. Attempt to duplicate the operator’s concern of coolant over-temperature.
   - If concern cannot be duplicated, clean radiator fins (if not done previously). Flush radiator fins with water on cooling fan side of the radiator. Do not continue with diagnostics.
   - If coolant over-temperature is duplicated, proceed to next step.

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

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

7. Remove deaeration tank cap.
8. Install Radiator Pressure Test Kit with Plastic Surge Tank Cap Adaptor on deaeration tank cap and pressurize cap to the normal value of deaeration tank cap.
   - If deaeration tank cap holds pressure, proceed to next step.
   - If deaeration tank cap loses pressure, install a new deaeration tank cap.
9. Install Radiator Pressure Test Kit with Plastic Surge Tank Cap Adaptor on deaeration tank and run engine at elevated idle. Monitor pressure in system using tester gauge to see if pressure rises above normal value of deaeration tank cap.
   - If pressure is higher than the pressure rating of the cooling system cap, continue with Coolant Overflow (page 93) in this section.
   - If pressure gauge reading is below pressure rating of system, proceed to next step.
10. Using EST, measure the coolant temperature for ECT and ECT2 sensors.
    - If the coolant temperature reading for ECT2 sensor is below ECT sensor reading, continue with Coolant Over-Temperature - Engine Cooling (page 103) in this section.
    - If the coolant temperature reading for ECT2 sensor is above ECT sensor reading, continue with Coolant Over-Temperature – Charge Air Cooling (page 103) in this section.

Coolant Over-Temperature – Charge Air Cooling

Procedure

1. Connect EST.
2. Start engine and set RPM to 1400 RPM.
3. Allow engine to reach operating temperature.
4. Using an infrared thermometer, measure and record coolant inlet and outlet temperatures on secondary radiator tanks.
5. Using EST, monitor and record temperature readings from ECT, ECT2 and IAT2 sensors. Record the readings on the Performance Diagnostics Form.
6. Calculate secondary radiator cooling by subtracting the coolant inlet temperature from the outlet temperature. Record this number as secondary radiator difference.
7. Calculate CAC cooling by subtracting the ECT2 sensor temperature from the IAT2 sensor temperature. Record this number as cooler difference.
8. Use the recorded data to determine if the coolant flow and coolant mixing valves are operating correctly.
   - If the cooler difference is higher than the secondary radiator difference, or is within 3˚C (5˚F) of the secondary radiator difference, the Coolant Flow Valve (CFV) is stuck in the fully closed position. Install a new Coolant Control Valve (CCV) assembly following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - If the ambient temp is lower than 4˚C (40˚F) then add 2˚C (4˚F) to the ECT and IAT2.

     If the ECT sensor reading is higher than IAT2 sensor reading by less than 11˚C (20˚F), the Coolant Mixer Valve (CMV) is stuck in the fully closed position. Install a new CCV assembly following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - If cooler difference is lower than secondary radiator difference and ECT sensor reading is higher than IAT2 reading by 11˚C (20˚F), the CCV is functioning normally. Proceed to the next step.
9. If over-temperature condition remains, remove secondary radiator and have flow checked at radiator repair facility.

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

Coolant Over-Temperature — Engine Cooling

Procedure

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

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

1. Remove deaeration tank cap.
2. Drain engine coolant.
3. Remove water pump following the procedures in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
4. Visually inspect water pump for damage, such as broken vanes, damaged impeller or a damaged shaft.

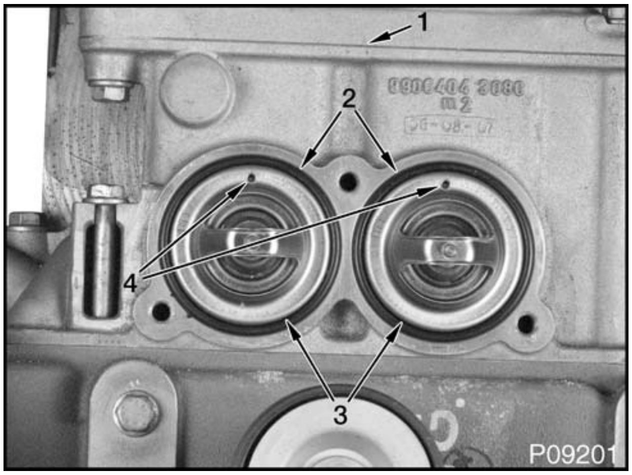


Figure 110 Thermostat elements

1. Thermostat housing assembly
2. 60 x 4 O-ring (2)
3. Thermostat element (2)
4. Ball valves (part of thermostat elements)

5. Remove and inspect thermostats following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*. Check for opening temperature on both thermostats.
   - Replace as needed. Retest for condition after repair.
   - If both thermostats pass test, proceed to next step.
6. If the vehicle is equipped with an automatic transmission, use appropriate vehicle service/diagnostics manual to review automatic transmission diagnostics.
7. If over-temperature condition remains, remove radiator and have flow checked at radiator repair facility.

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

Lubrication System

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

Visual Oil Level Inspection

1. Use oil level gauge to verify oil level in engine while vehicle is parked on level ground.

   If the engine has been running, allow a 15 minute oil drain down period before checking oil level.

Incorrect Maintenance

1. Check service maintenance records and discuss with customer to determine if the lube oil has been overfilled unintentionally.
   - If maintenance is unknown, change the oil and filter and retest to see if complaint reoccurs.

Dilution from Coolant

1. Lube oil with coolant dilution can be described different ways, depending on the quantity of coolant that has been introduced into the oil.
   - A “milky” substance left under the valve cover and in the oil fill tube is the result of ethylene glycol based coolant which has not had the moisture evaporated from the coolant/oil mixture.
   - Once the moisture has evaporated from the coolant contaminated oil, a dark gray, thick, sludge consistency is present.
2. If the lube oil exhibits coolant dilution, do Coolant Leak to Lube Oil (page 99) in this section.

Power Steering Fluid Leak to Lube Oil

Symptom

Power steering fluid leaking into the oil is difficult to identify other than the oil level increases and the power steering fluid level decreases at the same time.

Possible Causes

- Power steering pump leak

Procedure

1. Adjust oil level to full max range.
2. Adjust power steering fluid to full range.
3. Start and run vehicle.
4. Turn the key to the OFF position.
5. Monitor the lube oil and power steering fluid levels.
   - If the power steering level is decreasing and the lube oil level is increasing, install a new power steering pump following the procedures in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - If the power steering level is not decreasing and the lube oil level is not increasing, the system is operating normally at this time.

Lube Oil to Coolant

Symptom

The coolant is contaminated with an oily residue that is apparent in deaeration tank.

Possible Causes

- Oil cooler
- Oil module

Procedure

1. Verify coolant is contaminated by inspecting deaeration tank for presence of oil.
2. Place a coolant drain pan under oil module.
3. Remove oil module from engine following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.

4. Remove oil cooler from oil module following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
5. Pressure test oil cooler following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - If oil cooler fails pressure test, install a new oil cooler following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - If oil cooler passes pressure test, install a new oil module and oil cooler following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.

Lube Oil to Intake

Symptom

There is a light film of lube oil normally present in the intake due to the configuration of the closed crankcase breather system. These tests should only be done when there is a customer complaint of high lube oil consumption.

Possible Causes

- Crankcase breather system
- High pressure turbocharger
- Low pressure turbocharger
- High crankcase pressure

Procedure

1. Remove Intake Throttle Valve (ITV) assembly to verify volume of lube oil entering intake system.
   - If droplets of lube oil is present at ITV, continue with next step.
   - If light film of lube oil is present at ITV, the system is operating as designed and no repair is necessary.
2. Remove air cleaner duct from low pressure turbocharger inlet and inspect for oil saturation from crankcase breather system.
   - If droplets of lube oil are present at crankcase breather to low pressure turbo inlet duct, inspect and repair crankcase breather system as necessary.

     If crankcase breather system is okay, diagnose high crankcase pressure, see High Crankcase Pressure (page 181) in the "Performance Diagnostics" section of this manual.
   - If a light film of lube oil is present at the crankcase breather to low pressure turbo inlet duct, proceed to next step.
3. Remove Low Pressure Charge Air Cooler (LPCAC) assembly following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
4. Inspect for lube oil at LPCAC.
   - If droplets of lube oil are present at the LPCAC assembly, check and repair low pressure turbocharger assembly following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - If a light film of lube oil is present at the LPCAC assembly, check and repair high pressure turbocharger assembly following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.

Lube Oil to Exhaust

Symptom

These tests should only be done when there is a customer complaint of high lube oil consumption or plugged Diesel Particulate Filter (DPF) or Diesel Oxidation Catalyst (DOC). If the complaint is "wet exhaust" or leakage of exhaust system joints, verify Aftertreatment Fuel Injector (AFI) and/or system is functioning properly.

Possible Causes

- High pressure turbocharger
- Low pressure turbocharger
- Internal engine damage

Procedure

1. Remove retarder control system exhaust manifold with butterfly from low pressure turbocharger following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*. Identify if lube oil is present at turbine side of low pressure turbocharger.
   - If no oil is present at exhaust outlet of low pressure turbocharger, the leak into the exhaust is most likely fuel. Verify the AFI and/or system is functioning properly see Fuel to Exhaust (page 113) in this section.
   - If oil is present at exhaust outlet of low pressure turbocharger, remove low pressure turbocharger following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual* and proceed to the next step.
2. Inspect turbine housing on high pressure turbocharger and identify if lube oil is present at turbine side of the high pressure turbocharger.
   - If no oil is present at turbine of high pressure turbocharger, the leak into exhaust is from low pressure turbocharger. Install a new low pressure turbocharger following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - If oil is present at turbine of high pressure turbocharger, remove high pressure turbocharger following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual* and proceed to next step.
3. Inspect the inside of the high pressure turbine inlet of exhaust manifold for presence of lube oil.
   - If no oil is present inside of high pressure turbine inlet of exhaust manifold, the leak into exhaust is from high pressure turbocharger. Install a new high pressure turbocharger following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - If oil is present at inside of high pressure turbine inlet of exhaust manifold, remove three exhaust manifolds from cylinder head following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual* and proceed to next step to pinpoint the power cylinder of concern.
4. Repair power cylinder following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual* for repair of specific component.

Lube Oil to Fuel

Symptom

Lube oil to fuel is a very uncommon occurrence. The customer should be questioned to verify maintenance practices. These tests should only be done when there is a customer complaint of high lube oil consumption.

Possible Causes

- Customer adding used lube oil to fuel
- Cracked cylinder head

Tools

- High Pressure Return Line Tester (19 mm) (page 451)
- Fuel Inlet Restriction and Aeration Tool (page 449)

Procedure

1. Take a fuel sample from the fuel tank and inspect for lube oil contamination.
   - If fuel sample is contaminated, replace contaminated fuel with clean fuel. Advise the driver not to add lube oil to fuel tanks. Retest the system.
   - If the fuel sample is not contaminated, proceed to next step.

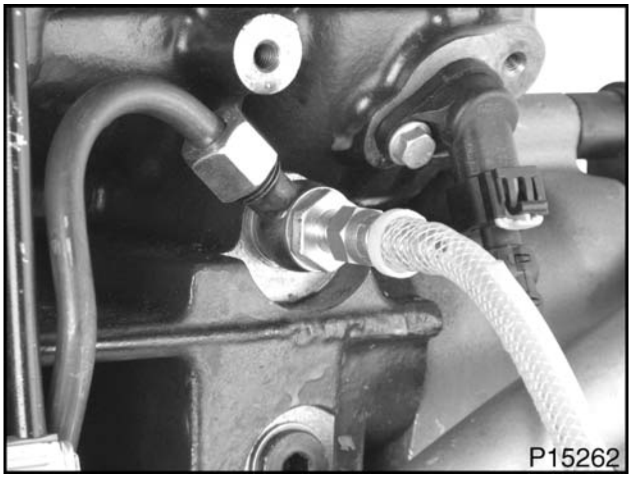


Figure 111 High Pressure Return Line Tester (19 mm)

2. Remove hollow screw at the rear of cylinder head and install High Pressure Return Line Tester (19 mm) in cylinder head fuel return port. Run open end into a clean container.
3. Disconnect high pressure pump inlet line.

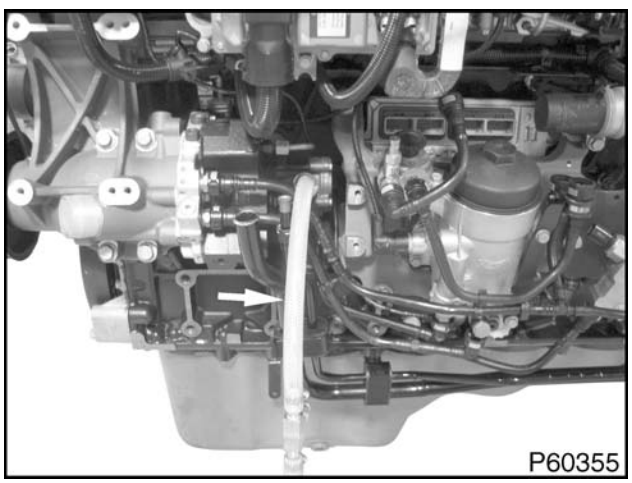


Figure 112 Fuel Inlet Restriction and Aeration Tool

4. Connect Fuel Inlet Restriction and Aeration Tool to high pressure pump inlet and a clean fuel source.
5. Start engine and run at low idle for 10 minutes.
6. If fuel is cloudy on return from cylinder head, cylinder head is porous or cracked. Install a new cylinder head following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.

Low Oil Pressure

Causes

- Low oil level
- High oil level/oil contamination
- Incorrect oil viscosity
- Inaccurate Engine Oil Pressure (EOP) sensor/circuit
- Restricted oil filter
- Oil sump/oil suction line damage
- Camshaft bearing wear/damage
- Oil pressure regulator wear/damage
- Broken, missing or loose piston cooling tube(s)
- Internal engine bearing wear/damage
- Scored or damaged oil pump
- Missing oil gallery cup plugs (front or rear)

Tools

- EST with Master Diagnostics® Software (page 445)
- IC4 USB interface cable (page 445)
- Gauge Bar Tool (page 450)

Procedure

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

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

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.

NOTE: Engine oil level varies depending on temperature of engine.

1. Park the vehicle on level ground and shut down the engine for 5 minutes.
2. 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.
   - If oil is not contaminated, proceed to next step.
   - If oil is contaminated, go to Fuel in Lube Oil (page 112) or Coolant Leak to Lube Oil (page 99) in this section.
3. Verify low engine oil pressure complaint on dash oil pressure gauge.
   - If the dash oil pressure gauge shows low oil pressure, verify Engine Oil Pressure (EOP) with EST. Check for a Low Oil Active DTC and investigate any active DTCs associated with low oil pressure.
     — If EST indicates low EOP proceed to next step.
     — If EST indicates normal EOP investigate failed or malfunctioning oil pressure gauge on dash. See the appropriate Vehicle Model Service Manual.
   - If the dash oil pressure gauge shows normal oil pressure, verify EOP with EST. Check for a Low Oil Active DTC and investigate any active DTCs associated with low oil pressure.

Figure 113 Oil pressure gauge connection

4. Connect fitting on test line with fuel/oil pressure test coupler to a 0 to 1723 kPa (0 to 250 psi) gauge.
5. Connect fuel/oil pressure test coupler to diagnostic coupling assembly on the side of the oil module behind the LPCAC.
6. Start 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: Performance Specifications", and the oil pressure indicator indicates low pressure, perform Engine Oil Pressure (EOP) Sensor diagnostics (page 363) in the "Electronic Control Systems Diagnostics" section of this manual. Repair or replace oil pressure indicator as required.
   - If oil pressure does not read within specification, proceed to next step.
7. Remove the oil filter and inspect for debris.
   - If oil filter has debris, install a new oil filter. Inspect oil by-pass valve located in oil module housing. If debris is present in the oil by-pass valve clean the oil by-pass valve as necessary. Retest system.

- If oil filter does not have debris, install oil filter and retest system.
- If the vehicle fails a retest, proceed to next step.

8. Remove oil sump, following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
9. Inspect oil suction line for damage.
   - If oil suction line is damaged, install a new oil suction line following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*. Retest the engine for correct oil pressure.
   - If oil suction line is not damaged, install a new oil sump following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*. Proceed to the next step.
10. Drain oil from engine using a clean drain pan. Inspect oil drain plug magnet and drained oil for debris. An oil sample can be taken to determine level of engine wear metals and contaminants in oil.
11. Remove oil sump following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
12. Visually inspect for missing, loose or damaged oil suction line, O-ring, piston cooling tubes, and bearing inserts.
    - If visual inspection identifies any concerns, repair as necessary and retest system.
    - If visual inspection does not identify any concerns, proceed to next step.
13. Connect regulated shop air line to the oil filter module diagnostic coupling assembly.
14. Slowly apply air pressure in 34.5 kPa (5 psi) increments up to 345 kPa (50 psi).

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

15. Check for audible loss of air pressure. If air loss is identified in the following areas, inspect and repair the associated components as necessary:
    - Front of engine right side – oil pressure regulator, oil galley plugs
    - If a continues flow if oil is coming out of the oil return port remove and replace oil pressure relief valve.
    - Rear of engine – oil galley plugs
    - Main and rod bearings
    - Upper engine – camshaft bearings (removal of the valve cover is required)
    - If no leak has been found, remove the front cover of the engine and inspect the oil pump following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.

Fuel System

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

Excessive Fuel Consumption

Symptom

More fuel is required to perform the same task.

Possible Causes

Operator effects

- Inaccurate record keeping or tank filling
- Winter blend, kerosene or No. 1 diesel fuel
- Unrealistic expectations

Application effects

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

Chassis effects

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

Engine effects

- Incorrect or inoperative thermostat(s)
- Failed turbocharger control system
- Fuel system performance loss
- Fuel system leaks
- Base engine performance loss
- Exhaust Gas recirculation (EGR) system failure
- Intake Throttle Valve (ITV) system failure

Procedure

1. Review operator records and fueling procedures. Measurement errors are common. Fuel consumption taken only from one tank of use is susceptible to significant error because of filling procedures and vehicle application differences during operation. Accurate fuel consumption must be measured over time with a record of what the vehicle was doing during the measurement period.
2. Loss of fuel economy is normal if winter blend fuel, kerosene or No. 1 diesel fuel is being used.
3. Review vehicle specifications to determine if fuel consumption is normal for type of application and use of vehicle. Compare consumption with similar vehicles in the same application and TCAPE report.
4. Do all tests on Performance Diagnostic form or in “Performance Diagnostics” section of this manual.

   These tests verify the operating condition of the following engine and chassis systems:

   - Intake system
   - Exhaust system
   - Fuel delivery and filtration
   - High pressure fuel system
   - Injector operation
   - EGR system operation
   - ITV system operation
   - Boost pressure actuator operation
   - Base engine condition

- Electronic control system condition

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

Fuel in Coolant

Symptom

Coolant has a diesel fuel odor.

Causes

- Leaking coolant heated auxiliary fuel filter (if equipped)
- Cracked or porous cylinder head casting in fuel return area

Tools

- Gauge Bar Tool (page 450)

Procedure

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

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

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

2. Remove deaeration tank cap.

NOTE: Do not reinstall deaeration cap at this time.

3. Fill deaeration tank with coolant to a level above deaeration tank inlet.
4. Disconnect electrical connector to Aftertreatment Fuel Injector (AFI).
5. Disconnect the fuel supply line from the AFI.
6. Connect a regulated air pressure source to fuel inlet of AFI and pressurize to 207 kPa (30 psi) for up to 20 minutes.
   - If air bubbles are observed at deaeration tank, install a new AFI following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - If no air bubbles are present at deaeration tank, proceed to next step.

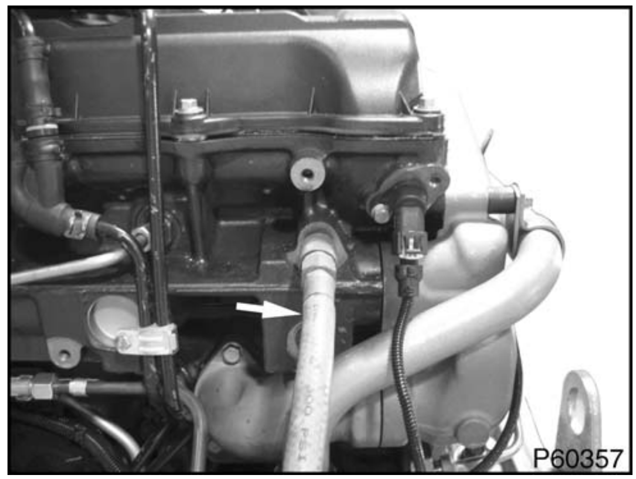


Figure 114 Cylinder head fuel leak test

7. Remove hollow screw at the rear of cylinder head and adapt compressed air source to cylinder head.
8. Pressurize cylinder head to 550 to 690 kPa (80 to 100 psi) for up to 20 minutes.
9. Observe deaeration tank for air bubbles or loss of pressure at gauge. If air bubbles are observed at the deaeration tank, install a new the cylinder head following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.

Fuel in Lube Oil

Symptom

Oil has a diesel fuel odor and oil level in engine consistently increases.

Possible Causes

- Fuel injector(s)

- High pressure fuel pump
- Cylinder misfire (wash down)

Tools

- Alternate supply of clean diesel fuel
- UV Leak Detection Kit (page 452)
- UV Leak Detection Fluorescent Dye Cartridge

Procedure

1. If the engine has a misfire, see Special Tests (page 177) in the ”Performance Diagnostics” section of this manual. Use procedures in the International® MaxxForce® 11 and 13 *Engine Service Manual* for repair of specific component.
2. Verify oil contamination by performing a white paper test or oil analysis.
   - Place one drop of suspect diluted oil on a clean sheet of printer or copier paper.
   - If the oil wicks away rapidly into the paper, there is fuel contamination.
   - If the oil maintains a uniform and slow expanding stain, there is no fuel contamination.
3. Inspect the fuel system for leaks.

NOTE: The UV Leak Detection Kit requires warm-up time. Turn on the UV Leak Detection Kit.

4. Verify there is no dye in the oil before starting the dye test.
5. Supply engine with an alternate supply of clean diesel fuel with dye mixed to manufacturers specification.
6. Turn ignition switch to ON position, run the engine at high idle for a maximum of five minutes. Turn ignition switch to OFF position.
7. Remove oil fill tube.
8. Using the UV Leak Detection Kit, inspect for leaks in the following areas:
   - Inspect front seal of high pressure pump for leakage. If a leak is located, install a new pump following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - Remove valve cover following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual* for injector body inspection. If a leak is located, install a new fuel injector and pressure pipe neck.
9. If no leaks are located, contact Tech Central at 1-800-336-4500 for further assistance.

Fuel to Intake

Symptom

Fuel leaking into the intake results in black smoke and eventual Diesel Particulate Filter (DPF) codes.

Possible Causes

- Cold Start Solenoid (CSS) valve
- CSS valve control

Procedure

1. If the engine has a misfire, see Special Tests (page 177) in the “Performance Diagnostics” section of this manual.
2. Disconnect electrical connector from the CSS valve.
3. Disconnect glow plug supply fuel line from glow plug.
4. Hand pump primer and check for fuel leakage from CSS valve.
5. Start engine and run at low idle. Check for fuel leakage from CSS valve.
   - If leakage is observed, install a new CSS valve following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - If no leakage is observed, check the CSS valve control circuit. See CSS Valve Control (page 291) in the “Electronic Control System Diagnostics” section of this manual.

Fuel to Exhaust

Symptom

Fuel leaking into the exhaust results in a wet exhaust system and possibly damage the DPF.

Possible Causes

- AFI
- Internal engine damage

Procedure

1. Disconnect fuel line from AFI.

WARNING: To prevent personal injury or death, wear safety glasses with side shields. Limit compressed air pressure to 207 kPa (30 psi).

2. Connect a regulated air pressure source with a shut-off valve to fuel inlet of AFI and pressurize to 207 kPa (30 psi).
3. Close the shut-off valve and monitor air pressure for two minutes.
   - If the air pressure drops, install a new AFI following the procedures in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - If pressure remains constant, proceed to next step.
4. If engine has a misfire, see Special Tests (page 177) in the “Performance Diagnostics” section of this manual.
5. Remove exhaust manifold from the cylinder head following the procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual* and pinpoint the power cylinder of concern.

Fuel Pressure and Aeration

Symptom

Fuel aeration exhibits one or more of the following characteristics:

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

Possible Cause

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

Procedure

See Fuel System in the “Hard Start and No Start Diagnostics” section of this manual.

Water in the Fuel

Symptom

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

- Engine stall during operation
- Rough running engine
- No start if water has frozen

Possible Causes

- Water in fuel supply system
- Ice in fuel lines

Tools

- Clean drain pan, flat with a wide opening

Procedure

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

WARNING: To prevent personal injury or death, do not mix gasoline, gasohol, or alcohol with diesel fuel. An open heat source, spark, cell phone or electronic device can ignite these fuel mixtures. This creates a fire hazard and possible explosion.

1. Put a clean flat drain pan under the filter housing.
2. Drain the water separator following the procedures in the International® MaxxForce®

11 and 13 *Engine Operation and Maintenance Manual*.

3. Check the fuel in the drain pan for engine coolant or other contamination. Dispose of the contents in the drain pan properly in accordance with local requirements.
   - Excessive water or contaminants may indicate the tank and fuel system need to be flushed and cleaned.
   - Some sediment and water may be present if fuel filter has not been replaced for a long period of time, or if the sediment and water have not been drained recently.
   - The fuel should be clear, not cloudy. Cloudy fuel indicates that it is not a suitable grade for cold temperatures.
   - The fuel should not be dyed red or blue, these colors indicate off-highway fuel.
   - The fuel should not indicate evidence of waxing or gelling. Waxing or gelling in some fuels in cold weather could clog fuel filters and the fuel pump and cause restrictions in the fuel or low fuel pressure.
4. If fuel sample indicates water in fuel, obtain a fuel sample from fuel tanks.
   - If fuel sample indicates water in fuel, drain fuel tanks and refuel tanks with clean fuel.
   - If fuel sample does not indicate water in fuel, the source of water is probably the fuel strainer.

Priming the Fuel System

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

CAUTION: To prevent damage to engine, 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 exhibits pulsating fuel pressure. See Low Pressure Fuel System (page 137) in the "Hard Start and No Start Diagnostics" section of this manual.

Procedure

Perform this procedure when the following conditions occur:

- Fuel tank is drained or runs dry
- The primary fuel filter is removed or replaced
- Any fuel connection between fuel tank and 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 suction side of low pressure fuel system:
   a. Tighten primary fuel filter components that were removed (canister filter element, seals, or bowl) to specified torque values.
   b. Unscrew the piston knob on manual fuel priming pump and start pumping until fuel pressure builds up on delivery side of primer pump. The pressure build up is indicated by higher pumping force on manual priming pump.
   c. Fully screw piston knob back in when priming is complete.

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

4. Engage starter for 30 seconds and allow starter to cool for two minutes.
5. If engine does not fire during the first two cranking attempts, connect Electronic Service Tool (EST) and monitor pressure gauge during third cranking attempt.
   a. If pressure does not build up during third cranking attempt, unscrew primary filter cap and separate filter element from filter cap.
   b. Make sure filter element is fully seated on the standpipe.
   c. Reassemble the primary fuel filter assembly.

6. Engage starter for 30 seconds and allow starter to cool for two minutes, monitor the Engine Fuel Pressure (EFP) sensor on the EST. If engine does not start and there is no increase in pressure, then repeat steps 3 and 4.
7. If engine does not fire after five crank events, de-energize the FPCV in the high pressure pump.

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

8. Engage starter for 30 seconds to purge any trapped air from high pressure pump. Allow starter to cool for two minutes.
9. Re-energize the FPCV. Engage starter for 30 seconds and allow starter to cool for two minutes. If engine does not start, contact Tech Central at 1-800-336-4500.

Low Fuel Rail Pressure

Symptom

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

Possible Causes

- Fuel Rail Pressure (FRP) sensor or circuit
- FPCV or circuit
- Engine Control Module (ECM)
- High pressure fuel line leaks (internal or external fuel lines)
- High pressure fuel pump
- Fuel injectors
- Insufficient low pressure fuel pressure
- Plugged fuel filter
- Aerated fuel

Tools

- EST with Master Diagnostics® Software (page 445)
- IC4 USB interface cable (page 445)
- Digital Multimeter (DMM) (page 442)
- CMP, CKP and FPCV Breakout Harness (page 442)

Test FRP Sensor

NOTE: Verify adequate fuel supply pressure.

1. Connect the EST to vehicle.
2. Open COM device.
3. Verify correct engine family and model year is selected.
4. Launch EST.
5. Select Sessions drop-down menu.
6. Select D_HardStartNoStart.ssn file.
7. Using EST, measure low pressure fuel pressure while idling engine.
   - If low pressure fuel system pressure is at or above specification, proceed to next step.
   - If low pressure fuel system pressure is below specification, see Low Pressure Fuel System (page 137) in the “Hard Start and No Start Diagnostics” section of this manual.
8. Turn ignition key to OFF position.

NOTE: Disconnecting FPCV causes high pressure fuel pump to default to a 800-900 bar (11,603-13,053 psi) fuel pressure.

9. Disconnect FPCV electrical connector.
10. Start and idle engine.
11. Monitor and record fuel pressure reading from FRP sensor.
    - If FRP sensor reading is 800-900 bar (11,603-13,053 psi), FRP sensor is operating correctly
    - If FRP sensor is not reading between 800-900 bar (11,603-13,053 psi), proceed to the next test.

Check FPCV Coil Resistance

1. Disconnect FPCV.
2. Connect CCMP, CKP and FPCV Breakout Harness to the FPCV.

3. Measure resistance between pins 1 and 2 of the CMP, CKP and FPCV Breakout Harness.
4. The resistance specification is 2-4 ohms.
   - If resistance is out of specification, see Fuel Pressure Control Valve (FPCV) (page 377) in the “Electronic Control Systems Diagnostics” section of this manual.
   - If resistance is within specification, verify that ECM is controlling FPCV. See FPCV Duty Cycle Control (page 117) in this section.

FPCV Duty Cycle Control

Measuring the duty cycle of the FPCV verifies that ECM is controlling high pressure fuel pump.

1. Connect EST to vehicle.
2. Open COM device.
3. Verify correct engine family and model year is selected.
4. Verify CAN is selected.
5. Launch EST.
6. Select the Sessions drop-down menu.
7. Select D_HardStartNoStart.ssn file.
8. Connect CMP, CKP and FPCV Breakout Harness to FPCV and engine harness.
9. Connect positive lead of the DMM to a battery positive connection. Connect negative lead to CMP, CKP and FPCV Breakout Harness pin 2.
10. Set DMM to voltage, press the duty cycle button, and press trigger button to make sure DMM is set to positive trigger.
11. Turn ignition switch to ON position and crank engine. Measure the duty cycle using DMM. The measurement should be approximately 50% duty cycle positive trigger value, and the desired duty cycle using the EST.
    - If duty cycle is out of specification or does not match desired duty cycle, see Fuel Pressure Control Valve (FPCV) (page 377) in the “Electronic Control Systems Diagnostics” section of this manual.
    - If duty cycle is within specification and matches desired duty cycle, measure pump output. See High Pressure Fuel System (page 140) in the “Hard Start and No Start Diagnostics” section of this manual.

Engine Inspection

Symptom

Excessive low power on take-off or intermittent low power from drive cycle to drive cycle

- Low power at steady speed complaints may indicate a low pressure turbocharger issue.
- Low power on acceleration complaints may indicate a high pressure turbocharger or boost control issue.

Possible Causes

Low Power

- Electrical power or ground issue
- Inoperative turbocharger assembly
- Failed Boost Control Solenoid (BCS) valve
- Stuck Exhaust Gas Recirculation (EGR) control valve
- Aerated fuel
- Engine Control Module (ECM) or electronic control system faults
- Poor fuel quality
- Low pressure fuel pressure below specification
- High pressure fuel pressure below specification
- Fuel injectors not working properly
- Inoperative Intake Throttle Valve (ITV)
- Power cylinder problems
- Valve train problems
- Failed Charge Air Cooler(s) (CAC)
- Failed extension tube(s)
- Aftertreatment (AFT) system issues
- Plugged Diesel Particulate Filter (DPF)
- Stuck closed Retarder Control

Rough Idle

- Poor fuel quality
- Low pressure fuel pressure below specification
- High pressure fuel pressure below specification
- Inoperative ITV
- Aerated fuel
- ECM or electronic control system faults
- Fuel injectors not working properly
- EGR control valve stuck open
- Power cylinder problems
- Valve train problems
- Engine or flywheel balance problems
- Exhaust system to cab/chassis contact
- AFT problems
- Loose/worn engine mounts
- Failed CAC(s)
- Failed extension tube(s)
- Plugged DPF
- Plugged Diesel Oxidation Catalyst (DOC)

Tools

- Digital Multimeter (DMM) (page 442)
- Boost Control Solenoid Breakout Harness (page 440)
- EST with Master Diagnostics® Software (page 445)
- IC4 USB interface cable (page 445)

Low Power (Turbocharger Assembly and Actuator)

1. Carry out the actuator test. See Actuator Test (page 162) in the “Performance Diagnostics” section of this manual.
   - If actuator test fails, proceed to next step.

- If actuator test passes, the turbocharger or boost control actuator may not be cause of low power.
    - Inspect the High Pressure Charge Air Cooler (HPCAC) and Low Pressure Charge Air Cooler (LPCAC) for boost leaks to atmosphere.
    - Verify all tests in the “Performance Diagnostics” section of this manual do not indicate another cause.
    - If low power complaint is intermittent, and all tests in “Performance Diagnostics” section of this manual do not indicate another cause, proceed to next step.

2. Connect Boost Control Solenoid Breakout Harness between engine harness and BCS valve. Measure duty cycle between BCS valve power and ground terminals while testing system with actuator test.
    - If actuator test fails, and duty cycle commands BCS valve to operate, replace BCS valve.
    - If low power complaint is intermittent, and duty cycle commands the BCS valve to operate, inspect BCS valve signal wires for corroded or loose connections.
        - If signal wires are properly connected, not corroded, and tests in the “Performance Diagnostics” section of this manual, do not indicate another cause, replace BCS valve following the procedures in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
    - If duty cycle does not command BCS valve to open, repair signal control problem. See Boost Control Solenoid (BCS) Valve (page 251) in the “Electronic Control System Diagnostics” section of this manual.
        - Retest system for correct operation.

High Crankcase Pressure

Possible Causes

- Air compressor
- Turbocharger(s)
- Cylinder damage
- Internal engine damage

Procedure

1. For high crankcase pressure diagnostics, see High Crankcase Pressure Test (page 181) in the “Performance Diagnostics” section of this manual.

Electrical System

Engine Control Module (ECM) Reset (Intermittent Engine Stumble)

Symptom

An 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
- Cold start assist glow plug recycles 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 momentarily stumbles and ECM goes through a normal key on cycle. This includes the following:

- Illuminating the WAIT TO START lamp
- Validating the accelerator pedal position

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

An ECM reset occurs when the ECM momentarily reboots or is turned off and on while engine is operating.

Procedure

1. Using the Electronic Service Tool (EST) with MasterDiagnostics® software, check for DTCs for the engine and chassis modules.
   - If DTC 5541 (unexpected reset fault EIM) is present as an active or inactive code, skip to step 4.
   - If any other engine DTCs are active, perform appropriate diagnostics and repairs before continuing with these procedures.
   - If any chassis DTCs are active when checking the Electronic System Controller (ESC), perform appropriate diagnostics and repairs before continuing.
2. Inspect the fuel system. See Fuel System 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.

3. Check all ECM and Engine Interface Module (EIM) related fuses.
4. Check the EIM power relay.
5. Check all battery, V_{IGN} and ground connections for ECM.
6. Monitor ECM power and ground with breakout box under operator complaint conditions.
7. If root cause has not been identified in previous steps, continue diagnosis by doing the remaining tests in “Performance Diagnostics” section of this manual.

Table of Contents

Diagnostic Form

The Engine Performance 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. Use this manual with the form and referenced for supplemental test information. Use the form as a worksheet to record all test results.

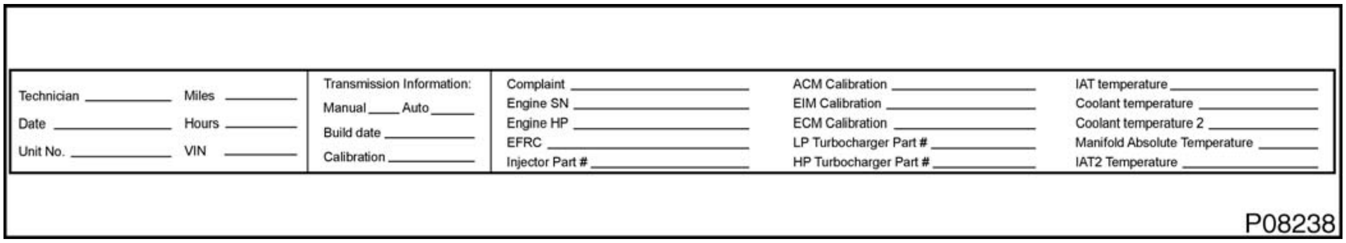
Do all tests in sequence, unless otherwise stated. Doing a test out of sequence can cause incorrect results. If a problem was found and corrected, it is not necessary to complete the remaining tests.

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

Order Information

Diagnostic Form EGED-425 Engine Performance is available in 50 sheet pads. To order technical service literature, contact your International® dealer.

Header Information



Technician ____ Miles ____
Date ____ Hours ____
Unit No. ____ VIN ____
Transmission Information:
Manual ____ Auto ____
Build date ____
Calibration ____
Complaint ____
Engine SN ____
Engine HP ____
EFRC ____
Injector Part # ____
ACM Calibration ____
EIM Calibration ____
ECM Calibration ____
LP Turbocharger Part # ____
HP Turbocharger Part # ____
IAT temperature ____
Coolant temperature ____
Coolant temperature 2 ____
Manifold Absolute Temperature ____
IAT2 Temperature ____
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Entering Header Information

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

Vehicle Information

The Vehicle Identification Number (VIN) is located on the VIN plate. Obtain the VIN information from ISIS.

5. VIN – the last 8 digits (verify to VIN plate)
6. Build date (verify to VIN plate)
7. Engine horsepower (hp)
8. Engine Interface Module (EIM) calibration
9. Engine Control Module (ECM) calibration
10. Aftertreatment Control Module (ACM) calibration
11. Transmission type
12. Engine Serial Number (ESN)

Performance Specification Information

13. See "Appendix A: Performance Specifications" in this manual or Technical Service Information (TSI) to obtain the following header information:

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

- Engine Family Rating Code (EFRC)
- Turbocharger Part No.(s)

Verify EIM Calibration with Vehicle Specifications

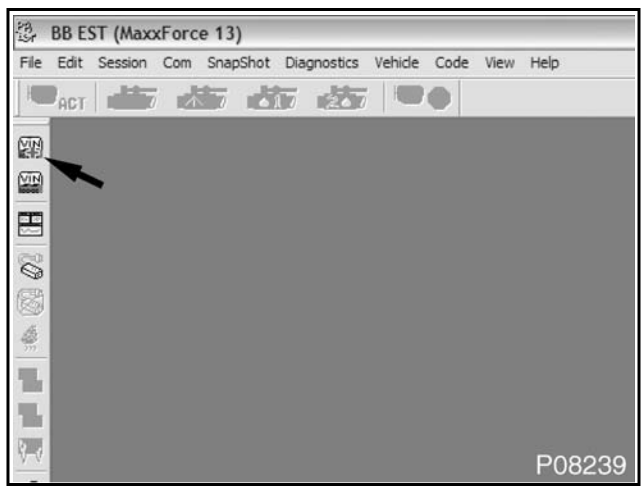

Figure 116 Select VIN + session (example)

14. Using the Electronic Service Tool (EST) with MasterDiagnostics® software, open the VIN session by selecting the VIN+ icon.

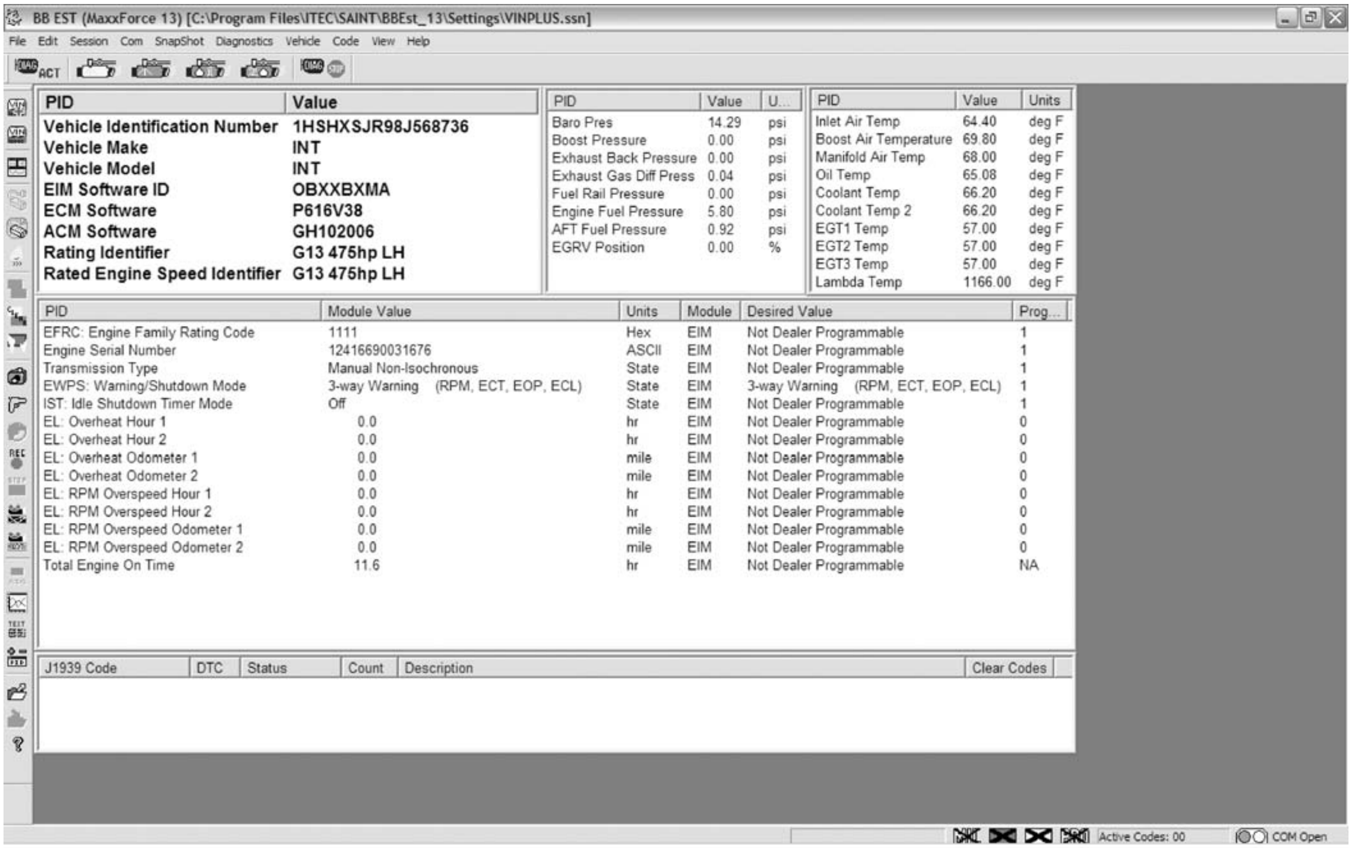

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Figure 117 VIN session (example)

15. Verify the following match vehicle specifications:
    - VIN
    - EIM calibration
    - ECM calibration
    - ACM calibration
    - Rated hp
    - EFRC
    - ESN

      Note: The ESN is located on the engine block, on the left side of the crankcase above the high pressure pump and on the exhaust emission label on the valve cover.
    - Transmission
16. Enter the following information:
    - Odometer (miles)
    - Engine hours
    - Intake Air Temperature (IAT)
    - Intake Air Temperature 2 (IAT2)
    - Engine Coolant Temperature (ECT)
    - Engine Coolant Temperature 2 (ECT2)
    - Engine Oil Temperature (EOT)
    - Manifold Absolute Temperature (MAP)
    - Barometric Absolute Pressure (BAP)

Required Test Procedures

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

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

1. Visual Inspection

Purpose

To check all fluid levels and inspect engine systems for problems such as leaks, open connections and harness chaffing.

Tools

- Inspection lamp

Engine Oil

1. Park the vehicle on level ground and shut down the engine for five minutes.
2. Use oil level gauge to verify engine oil level.
3. Record results on Engine Performance Diagnostic Form (Hard Start and No Start side).

Possible Causes

Engine oil is within normal operating range

- No repair is required

Engine oil is below normal operating range

- Improper servicing
- Oil leaks
- Oil consumption

Engine oil is above normal operating range

- Improper servicing
- Fuel dilution
- Coolant contamination
- Power steering fluid contamination

Fuel Level and Quality

NOTE: Engine should not be running. Make sure levels have stabilized.

1. Park vehicle on level ground.
2. Use dash gauge and inspect fuel tank fill ports to verify fuel level.

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.

3. Retrieve a fuel sample from the fuel tank.
4. Check for water, waxing, sediment, gasoline, or kerosene.
   - If the fuel quality is satisfactory, no action is required.
   - If the fuel quality is questionable, correct the issue. Take another sample to verify fuel quality.
5. Visually inspect the fuel strainer for debris.
   - If debris is observed, clean the fuel strainer and retest.
   - If no debris is observed, proceed with the next step.
6. Obtain a fuel sample from the fuel filter housing drain.
7. Inspect the fuel sample for debris, icing and contamination.
   - If any visual fuel issues exist, correct the issue and retest the system.
   - If no visual fuel issues exist, proceed with the next step.

8. Record results on Engine Performance Diagnostic Form (Hard Start and No Start side).
   - If fuel level is sufficient, and no tank contamination is evident, no repair is required.
   - If fuel level is low, fill the fuel tanks to a level that is sufficient to operate the engine. Inspect for leaks, fuel dilution or inoperable tank transfer pump.

Possible Causes

- Fuel contamination
- Incorrect fuel grade for cold temperatures
- Fuel leaks
- Fuel line damage

Engine Coolant Level

NOTE: Engine should not be running.

1. Park vehicle on level ground.
2. Check coolant level as indicated on deaeration tank level window.
3. Record results on Engine Performance Diagnostic Form (Hard Start and No Start side).

Possible Causes

Engine coolant is within normal operating range

- No repair is required

Engine coolant is below normal operating range

- Improper servicing
- External coolant leaks
- Coolant in combustion cylinder(s)
- Coolant leak in the Low Pressure Charge Air Cooler (LPCAC)
- Coolant leak in the High Pressure Charge Air Cooler (HPCAC)
- Coolant leak in the Exhaust Gas Recirculation (EGR) module
- Coolant leak in the Aftertreatment (AFT) system

Intake Air System

1. Inspect the air cleaner restriction indicator.
2. Inspect the intake air system including the LPCAC system, the HPCAC system, the air inlet duct, Intake Throttle Valve (ITV) and piping for damage or restrictions.
3. Inspect all intake air system connections and clamps.
   - If the intake air system is okay, no repair is required.
   - If an intake air system issue is found, repair as required.

Possible Causes

- Loose or damaged clamps
- Damaged connectors
- Restricted air filter
- Restricted air intake (debris)
- Stuck closed ITV

Exhaust System

1. Inspect exhaust system (engine and vehicle) for leaks or damage that would restrict exhaust flow. Some conditions that could restrict the exhaust are damaged exhaust, plugged Diesel Oxidation Catalyst (DOC), plugged Diesel Particulate Filter (DPF), or exhaust manifold with butterfly stuck closed.
   - If exhaust system is okay, no repair is required.
   - If exhaust system issue is found, repair as required.

Possible Causes

- Loose or damaged clamps
- Damaged exhaust pipes
- Exhaust manifold with butterfly stuck closed
- AFT system regeneration required
- Restricted AFT system
- Failed turbocharger or turbochargers

Electrical System

NOTE: The engine will not start if any of the following components are damaged, failed or disconnected:

- Batteries
- Starter
- Engine Interface Module (EIM)
- Engine Control Module (ECM)
- Camshaft Position (CMP) sensor (the engine starts but crank time is extended)
- Crankshaft Position (CKP) sensor (the engine starts but crank time is extended)
- Driveline Disengagement Switch (DDS)

1. Check all battery cables and fuse connections for corrosion. Inspect for open or blown fuses. All connections must be properly connected, in good condition and free of corrosion or damage. Repair as necessary.
2. Inspect the engine wiring harness for correct routing and protection from chafing.

Possible Causes

- Damaged, failed or incorrectly installed electrical connectors
- Open or blown fuses
- Damaged or failed EIM
- Damaged or failed ECM
- Damaged or failed CMP sensor (the engine starts but crank time is extended)
- Damaged or failed CKP sensor (the engine starts but crank time is extended)
- Damaged or failed DDS
- Damaged or failed batteries
- Damaged or failed starter

2. Initial Ignition Switch ON (Do not start)

Purpose

To determine if the Engine Interface Module (EIM) and Engine Control Module (ECM) are powered up.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)
- Air pressure gauge

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 position. Do not start the engine.
2. Connect the EST to the vehicle.
   - Press the VIN+ button.
   - If the EIM and ECM are powered up and communicating, the ECM and EIM calibrations are displayed.
3. If the ECM and EIM calibrations are not displayed, cycle the ignition switch and test again.
   - If the ECM and EIM calibrations are not displayed on the second attempt, the ECM or EIM may not be powered up. Check for Diagnostic Trouble Codes (DTCs). If the EIM is not communicating with the EST, see CAN Communications (Controller Area Network) (Public) (page 256) in the "Electronic Control System Diagnostics" section of this manual.

Possible Causes

- No key power (V_{IGN})
- No voltage from the main power relay to the EIM
- EIM grounds
- No voltage from the main power relay to the ECM
- ECM grounds
- WAIT TO START lamp malfunction at temperatures below 11°C (52°F) (will not cause a starting issue)
- EIM failure
- ECM failure
- Public CAN link to instrument panel is not working (will not cause hard start or no start)
- Private CAN network failure

3. Engine Cranking

Purpose

To determine if crankshaft rotates at correct rpm and if instrument panel is receiving signals from the Engine Interface Module (EIM).

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)

Procedure

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

1. See “Appendix A: Performance Specifications” in this manual for specifications. Enter data in spec column for rpm on Diagnostic Form.
2. If an EST is available, connect it to the vehicle.

   If an EST is not available monitor the engine rpm on the instrument cluster.
3. Turn ignition switch to ON position. Do not start engine.
4. Open COM device.
5. Open the D_HardstartNostart.ssn file and monitor the rpm and battery voltage Parameter Identifiers (PIDs).
6. Turn the ignition switch to START position.
7. Check rpm on the instrument panel and the EST. Record results on Engine Performance Diagnostic Form (Hard Start and No Start side). If engine speed is below minimum cranking speed, the engine will not start.

   NOTE: If the rpm is at or above minimum cranking speed and the engine does not start correctly, on cold starts below 11°C (52°F) only, the cause may be the cold start assist system. Proceed to Cold Start Assist System (page 145) in this section.

Possible Causes

Engine will not rotate

- Loose or corroded battery connections
- Low or no battery power
- No key power (v_{IGN})
- Insufficient power to EIM
- Loose or damaged connections at the EIM or the Engine Control Module (ECM)
- Starting system failure
- Circuit fault for Engine Crank Inhibit (ECI)
- Cylinder hydraulic lock
- Cylinder mechanical lock (timing incorrect, valve/piston contact)
- Driveline Disengagement Switch (DDS)

Insufficient rpm

- Loose or corroded battery connections
- Low battery power/cold batteries
- Starter motor problem
- Incorrect oil viscosity for climate
- Starting system failure
- Internal engine damage

4. Diagnostic Trouble Codes (DTCs)

Purpose

- To determine if the Engine Interface Module (EIM) has detected any DTCs.
- To check for abnormal sensor readings.

NOTE: Before continuing with testing, fill out the Engine Performance Diagnostic Form (Hard Start and No Start side) header information.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)

Check for DTCs

1. Connect the EST to the vehicle and start the EST.
   - Select Service Assistant icon.
   - Turn the ignition to the ON position.
   - Start the software and record values given onto the Engine Performance Diagnostic Form (Hard Start and No Start side).
2. Launch the software using the LAUNCH button in the lower right corner.
3. Click the VIN+ button.
   - Record all DTCs on the Engine Performance Diagnostic Form (Hard Start and No Start side). See "Appendix B: Diagnostic Trouble Code Index" in this manual.
   - Correct the cause of the active DTCs before continuing.
   - Clear the DTCs.

Reading DTCs

Codes associated with a Suspect Parameter Number (SPN), Parameter Identifier (PID) and a 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 displays 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 off, inactive DTCs from a previous ignition switch cycle, remain in the Engine Control Module (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

Possible Causes

- Electronics failure
- Failure of the high pressure fuel system
- Failure of the Air Management System (AMS)
- Failure of the low pressure fuel system
- Failure of the Aftertreatment (AFT) system
- Failure of the Intake Throttle Valve (ITV)
- Failure of the cold start assist system

5. Actuator Test

Purpose

The actuator test allows a technician to test the actuators by measuring voltage changes and visually monitoring actuator movement.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)
- Air pressure gauge

Entering Vehicle Information Using The EST

1. Set the parking brake.
2. Turn the ignition key to the ON position.
3. Select Diagnostics from the menu and select Actuator Test.

NOTE: The air pressure in the truck air tank must be at least 620 kPa (90 psi) to operate the actuators correctly.

NOTE: This diagnostic test also operates the engine fan control (air and electrical operated fans), the Boost Control Solenoid (BCS) valve, the aftertreatment system valves and the coolant control valves. These components do not have an effect on engine starting and do not require verification at this time.

4. The Engine Interface Module (EIM) commands the engine actuators to cycle once energizing each actuator for 3.5 seconds. Visually verify the range operation of the throttle valve actuator, the Intake Throttle Valve (ITV), and the engine retarder actuator. Failure of any of these actuators may cause a hard start/no start condition.
5. Listen for movement at the Cold Start Relay (CSR). Failure of the CSR may cause a hard start/no start condition on a cold start.
6. Record all Diagnostic Trouble Codes (DTCs) on the Engine Performance Diagnostic Form (Hard Start and No Start side). See “Appendix B: Diagnostic Trouble Code Index” in this manual.
7. Correct any problems identified by DTC or actuators functioning outside of specification. If the ITV is suspect, proceed to the next step.
8. Remove the ITV. Refer to the procedures in the International® MaxxForce® 11 and 13 *Engine Service Manual*. Do not disconnect the ITV electrical connector.
9. Repeat the actuator test and visually observe the ITV.
   - If the ITV does not cycle, diagnose the ITV. Refer to ITV (page 408) in the “Electronic Control System Diagnostics” section of this manual.
   - If the ITV does cycle, the system is operating correctly at this time.

Possible Causes

- Electrical components or circuit failure
- Failed actuator or insufficient air pressure

6. Electronic Service Tool (EST) Data List

Purpose

- To determine if the engine systems meet operating specifications needed to start the engine.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)
- Digital Multimeter (DMM) (page 442)
- 4-Pin Round Gray Breakout Harness (page 437)
- FRP Breakout Harness (page 445)

NOTE: Make sure the vehicle batteries are fully charged before carrying out the following procedures.

Monitoring Engine Systems Using An EST

NOTE: Inspect exhaust system (engine and vehicle) for leaks or damage that would restrict exhaust flow. Some conditions that could restrict the exhaust are damaged exhaust, plugged Diesel Oxidation Catalyst (DOC), plugged Diesel Particulate Filter (DPF), or exhaust manifold with butterfly stuck closed. Repair any exhaust issues prior to using the EST to diagnose the vehicle.

1. See “Appendix A: Performance Specifications” in this manual for engine cranking specifications.
2. Open the D_HardStart_NoStart.ssn to monitor engine operations.
3. Turn the ignition key to the ON position.
4. Use EST to check Key On Engine Off (KOEO) values for the temperature and pressure sensors. Record the results on the Engine Performance Diagnostic Form (Hard Start and No Start side).
   - If the engine has not been operated for 8 to 12 hours, the Engine Coolant Temperature (ECT), Engine Coolant Temperature 2 (ECT2), Engine Oil Temperature (EOT), Intake Air Temperature 2 (IAT2), Manifold Air Temperature (MAT), Exhaust Gas Temperature 1 (EGT1), Exhaust Gas Temperature 2 (EGT2) and Exhaust Gas Temperature 3 (EGT3) sensors should be within 1°C (2° F) of each other. The Intake Air Temperature (IAT) sensor may be a few ° F higher or lower due to outside air temperature changes. The IAT2 sensor may be hotter than other sensors if the cold start assist system is activated.
   - The Engine Fuel Pressure (EFP) sensor, Fuel Rail Pressure (FRP) sensor, Aftertreatment Fuel Pressure (AFP), sensor, EOP sensor, and the Manifold Air Pressure (MAP) sensor values may fluctuate as much as 7 kPa (1 psi).
   - Barometric Absolute Pressure (BAP) should be equal to local barometric readings. Are the values normal?
   - If the BAP readings are out-of-range based on local barometric pressure readings, record the BAP reading on the Engine Performance Diagnostic Form (Hard Start and No Start side) and see operational voltage tables on the Signal Values Form for applicable sensors.
5. Crank the engine for 20 seconds and read the EST to monitor the following Parameter Identifiers (PIDs).
   - Cranking system PIDs: IVPWR (expected VBAT), RPM and VBAT
   - Fuel system PIDs: FPCV duty cycle, desired FRP, EFP and fuel rate
   - Exhaust system PIDs: DELTA_P and exhaust backpressure
   - Actuator PIDs: Intake Throttle Valve (ITV) position, Exhaust Gas Recirculation (EGR) desired position and EGR position

NOTE: Make sure the batteries are fully charged. If the voltage to the Engine Control Module (ECM) drops below 9 volts, the ECM will not remain powered up.

NOTE: If the battery voltage IVPWR PID is less than the actual battery voltage or the EST is not communicating with the Engine Interface Module (EIM), see EIM/ACM Power (Engine Interface Module/Aftertreatment Control Module) (page 350) in the "Electronic Control System Diagnostics" section of this manual.

NOTE: Engine cranking speed must generate the required pressure pipe rail pressure to fuel the fuel injectors. Make sure that the engine cranking speed exceeds 100 rpm.

6. Record the values on the Engine Performance Diagnostic Form (Hard Start and No Start side) for IVPWR, CKP, CMP, FRP, EFP, EOP, ITV and EGRP. Compare the values with expected values for each parameter.
   - If any IVPWR, CKP, CMP, EOP, ITV and EGRP values are out of the ranges of the allowed specifications, refer to "Electronic Control System Diagnostics" section of this manual for diagnosis.
   - If any FRP values are out of the ranges of the allowed specifications, refer to High Pressure Fuel System (page 140) in this section for diagnosis.
   - If any EFP values are out of the ranges of the allowed specifications, refer to Low Pressure Fuel System (page 137) in this section for diagnosis.
   - If the values are within acceptable specifications, continue with the next test.
7. Monitor the Exhaust Gas Differential Pressure (EGDP) sensor. Record the values on the Engine Performance Diagnostic Form (Hard Start and No Start side), and compare the actual readings with the expected values.
   - If the value is out of the range of allowed specification, carry out diagnostics for excessive exhaust backpressure.
   - If the value is within the range of allowed specification, proceed to Relative Compression Test (page 136) in this section.

Monitoring Engine Systems Without An EST

NOTE: Inspect exhaust system (engine and vehicle) for leaks or damage that would restrict exhaust flow. Some conditions that could restrict the exhaust are damaged exhaust, plugged Diesel Oxidation Catalyst (DOC), plugged Diesel Particulate Filter (DPF), or exhaust manifold with butterfly stuck closed. Repair any exhaust issues prior to diagnosing the vehicle.

1. Disconnect the EFP sensor electrical connector.

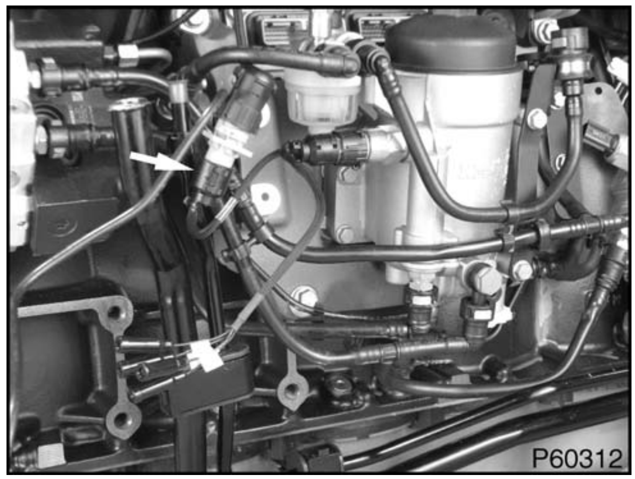

Figure 118 4-pin round gray breakout harness installed

2. Install 4-pin round gray breakout harness between the EFP sensor electrical connector and the EFP sensor.
3. Crank the engine and monitor the EFP sensor voltage.
   - If the EFP voltage is less than 1 volt, see Low Pressure Fuel System (page 137) in this section.
   - If the EFP voltage is 1 volt or greater, proceed to the next step.
4. Disconnect the FRP sensor electrical connector.

Figure 119 FRP breakout harness installed

5. Install FRP breakout harness between FRP sensor electrical connector and FRP sensor.
6. Crank engine and monitor FRP sensor voltage.
   - If the FRP voltage is less than 1 volt, see High Pressure Fuel System (page 140) in this section.
   - If the FRP voltage is 1 volt or greater, proceed to the next test.

7. Relative Compression Test

Purpose

This test determines cylinder integrity. The Engine Control Module (ECM) measures the time it takes for each piston to travel upward during the compression stroke. Timing is based on information from the Camshaft Position (CMP) sensor and Crankshaft Position (CKP) sensor. A cylinder with low compression allows the piston to travel faster during the compression stroke.

This test is accomplished by cranking the engine and following the on-screen instructions. The engine does not start when running this test.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)

Procedure

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

1. Turn the ignition switch to ON position. Do not start engine.
2. Connect the EST with MasterDiagnostics® software to the vehicle.
3. Open the COM device.
4. Verify correct engine family and model year is selected.
5. Launch EST.
6. Select Diagnostics drop–down menu.
7. Select IBB Relative Compression Test from the menu.
8. When the EST requests, crank the engine.
9. When the EST requests, stop cranking the engine.

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Figure 120 EST Display

10. Select Display Data.
11. The EST displays the compression stroke timing.
    - If one cylinder is significantly faster than the others, the cylinder is suspect for compression loss.
    - If all cylinders exhibit comparable compression times, the engine has passed the IBB Relative Compression Test.

Relative Compression Test Interpretation

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

Possible Causes

- Valve train damage
- Valves out of adjustment
- Worn or broken piston rings
- Excessive cylinder wall wear
- Damaged piston

Special Test Procedures

The following test should only be completed if referred to by a previous procedure.

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

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

8. Fuel System

8.1. Low Pressure Fuel System

Purpose

To check for correct fuel pressure and aerated fuel.

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

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)
- Vacuum gauge
- Fuel Pressure Gauge (page 450)
- Fuel Inlet Restriction and Aeration Tool (page 449)
- Fuel Block Off Tool (page 448)
- Fuel Line Disconnect Tool (11.8 mm) (page 449)
- Fuel Line Disconnect Tool (16 mm) (page 449)

Procedure

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

1. See "Appendix A: Performance Specifications" in this manual for correct specification. Obtain the correct specifications for the engine and application in question. Proceed to step 2.
2. Connect the EST to the vehicle.
3. Open the COM device.
4. Verify correct engine family and model year is selected.
5. Launch EST.
6. Select the Sessions drop down–menu.
7. Select the D_HardStartNoStart.ssn file.
8. Read the Engine Fuel Pressure (EFP) sensor pressure using the EST. Read while cranking the engine.
   - If the low pressure fuel system pressure is at or above specification, see High Pressure Fuel System (page 140) in this section.
   - If the low pressure fuel system pressure is below specification, proceed to the next step.

Figure 121 Restriction Measurement

9. Using a locally available adaptor, connect a vacuum gauge to the test fitting on the fuel primer pump. Measure the restriction while cranking the engine.
   - If the restriction is below 7 in-Hg, skip to step 13.
   - If the restriction is above 7 in-Hg, proceed to the next step.

10. Clean the fuel strainer element and install a new fuel pre-filter. See the International® MaxxForce® 11 and 13 *Engine Operation and Maintenance Manual*.
11. Measure the restriction while cranking the engine.
    - If the restriction is below 7 in-Hg, skip to step 13.
    - If the restriction is above 7 in-Hg, proceed to the next step.
12. Check the fuel supply for kinked fuel lines or debris in the fuel tank. Repair as necessary and retest the system.
13. Remove the locally available adaptor and the vacuum gauge.
14. Using the EST, test the low pressure fuel pressure.
    - If low pressure fuel pressure is within specification, the system is operating normally and the cause was debris in the fuel strainer.
    - If low pressure fuel pressure is below specification, proceed to the next step.
15. Remove the EFP sensor.

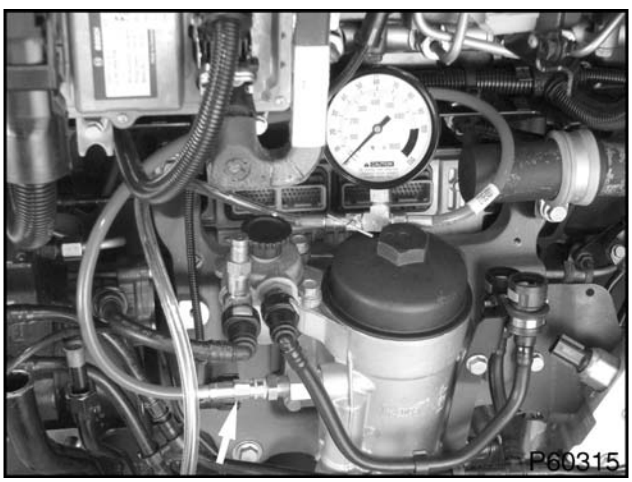


Figure 122 Fuel Pressure Gauge

16. Using a locally available adaptor, connect a Fuel Pressure Gauge to the fuel filter housing in the EFP sensor location.

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

17. Route the drain hose into a suitable container.
18. Open the valve and crank the engine for no more than 30 seconds and check the fuel in the drain hose for aeration and flow.
    - If fuel aeration or no fuel flow is present, proceed to the next step.
    - If no fuel aeration is present, proceed to step 29.
19. Disconnect the pre-filter supply fuel line at the engine connector.

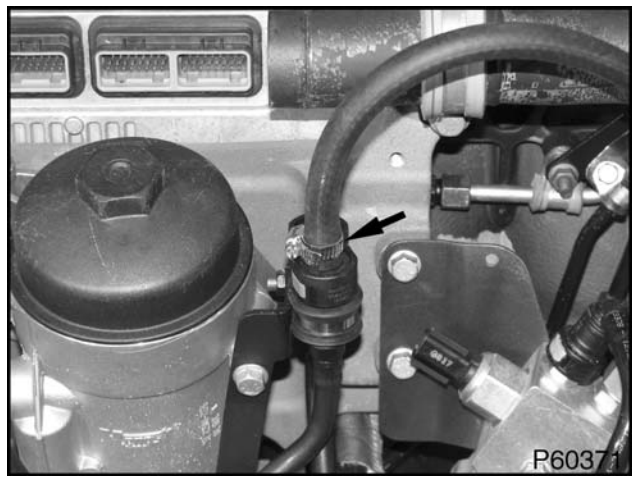


Figure 123 Fuel supply hose

NOTE: Fabricate a clean fuel supply hose using a fuel line connector and a locally obtained fuel hose.

20. Using a clean fuel supply hose, connect a clean fuel supply to the pre-filter supply fuel line inlet.
21. Crank the engine and check the fuel in the drain hose for aeration and flow.
    - If no fuel aeration or flow is present, repair the fuel line between the fuel tank and the engine. Restore the fuel system to operating condition.
    - If fuel aeration is present, proceed to the next step.
22. Reconnect the fuel line to pre-filter supply fuel line inlet.

23. Disconnect the pre-filter supply fuel line at the fuel primer pump assembly.

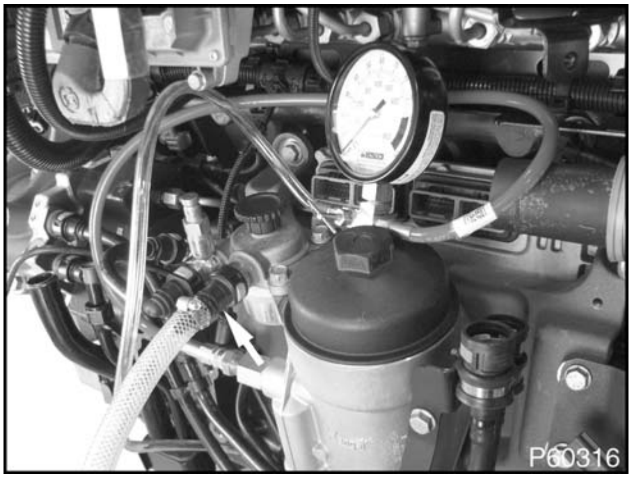


Figure 124 Fuel Inlet Restriction and Aeration Tool installed

24. Connect Fuel Inlet Restriction and Aeration Tool to the fuel pump primer assembly and a clean fuel source.
25. Crank the engine and check the fuel in Fuel Pressure Gauge for aeration.
    - If no fuel aeration is present, proceed to the next step.
    - If fuel aeration is present, install a new pre-filter supply fuel line.
26. Restore the fuel system to operating condition.
27. Disconnect the preliminary filter feed fuel line from the fuel primer pump assembly.
28. Disconnect the preliminary filter feed fuel line from the low pressure pump.

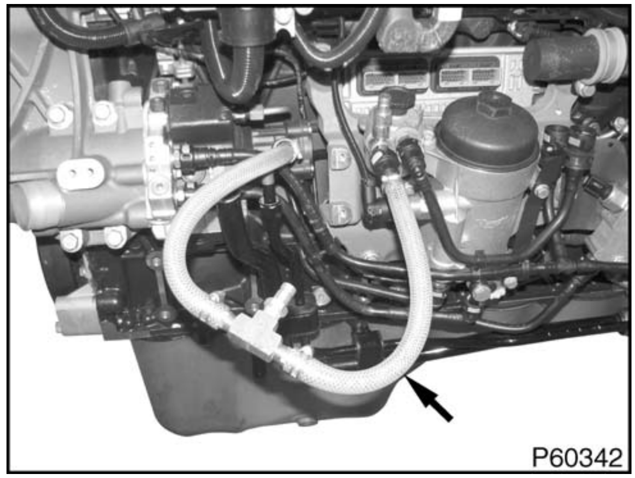


Figure 125 Check for fuel aeration

29. Connect Fuel Inlet Restriction and Aeration Tool to the fuel primer pump assembly and the low pressure pump inlet.
30. Crank the engine and check the fuel for aeration.
    - If no fuel aeration is present, see High Pressure Fuel System (page 140) in this section.
    - If fuel aeration is present, inspect the fuel primer pump assembly for air leaks. Repair as necessary and retest the system.

NOTE: Make sure the fuel connection to the high pressure fuel pump and surrounding area is clean. If the connection area needs to be cleaned, pressure wash or steam clean the area.

NOTE: To prevent water intrusion do not directly spray electrical connectors with a pressure washer.

31. Disconnect the filter T-connector fuel line at the high pressure pump.

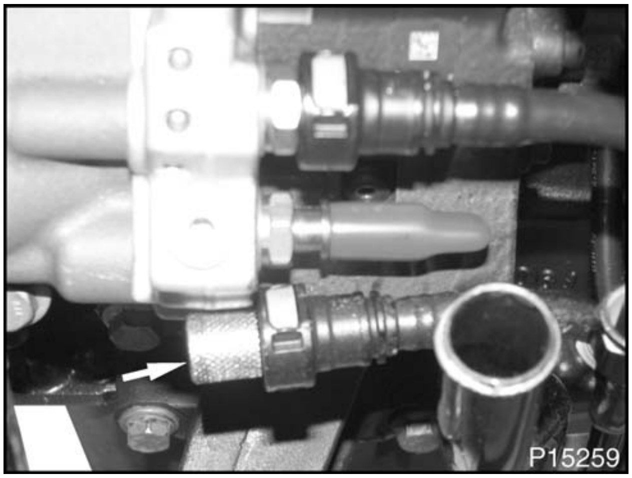


Figure 126 Fuel Block Off Tool installed

NOTE: Make sure that the Fuel Block Off Tool is clean.

32. Install Fuel Block Off Tool in the end of the filter T-connector fuel line.
33. Crank the engine and monitor the EFP sensor.
    - If the fuel pressure is below minimum specification, install a new high pressure pump. See high pressure pump in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
    - If the fuel pressure meets or exceeds specification, proceed to High Pressure Fuel System (page 140) in this section.

Possible Causes

- Blocked pre-filter or filter element in the housing
- Blocked fuel strainer element
- Fuel grade incorrect for cold temperatures
- Fuel line damage or blockage
- Failed high pressure pump
- Air leak in suction side fuel line or filter assembly
- Combustion gases entering fuel supply system

8.2. High Pressure Fuel System

Purpose

To check for correct pressure pipe rail pressure.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)
- Fuel Pressure Gauge (page 450)
- Fuel Inlet Restriction and Aeration Tool (page 449)
- Fuel Block Off Tool (page 448)
- Fuel Line Disconnect Tool (11.8 mm) (page 449)
- Aftertreatment 2 Pin Breakout Harness (page 439)
- CMP, CKP and FPCV Breakout Harness (page 442)
- Fuel Fitting Adapter (page 448)
- High Pressure Return Line Tester (17 mm) (page 451)
- High Pressure Return Line Tester (19 mm) (page 451)
- High Pressure Rail Plugs (page 450)
- Fuel Line Coupler

Procedure

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

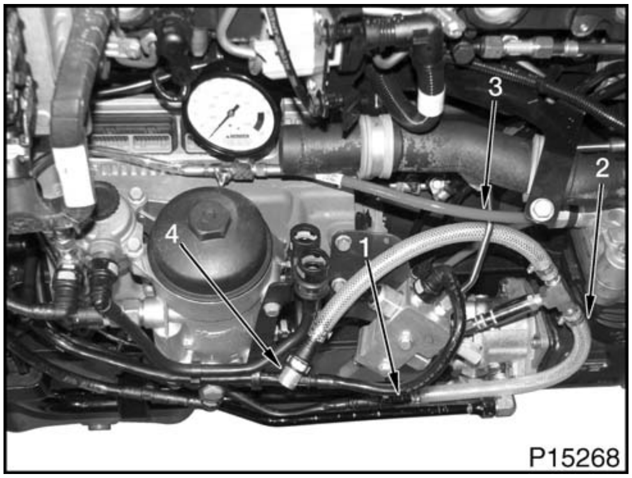


Figure 127 Fuel Pressure Gauge installed

1. Fuel Line Coupler
2. Fuel Inlet Restriction and Aeration Tool
3. Fuel Pressure Gauge
4. Fuel Block Off Tool

NOTE: Make sure that the fuel connection to the Hydrocarbon (HC) cut-off valve and surrounding area is clean. If the connection area needs to be cleaned, pressure wash or steam clean the area.

NOTE: To prevent water intrusion do not directly spray electrical connectors with a pressure washer.

1. Disconnect the filter T-connector fuel line from the HC cut-off valve.
2. Using the Fuel Line Coupler connect the Fuel Inlet Restriction and Aeration Tool to the filter T-connector fuel line.
3. Using a locally available adaptor, connect the Fuel Pressure Gauge to the Fuel Inlet Restriction and Aeration Tool.
4. Install Fuel Block Off Tool in the end of the Fuel Inlet Restriction and Aeration Tool.
5. Crank the engine and monitor the aftertreatment fuel pressure.
   - If the aftertreatment fuel pressure is more than 41 kPa (6 psi) lower than the fuel pressure recorded in step 33 of Low Pressure Fuel System, install a new fuel filter. See fuel filter in the International® MaxxForce® 11 and 13 *Engine Service Manual*. Retest the system for correct operation.
   - If the aftertreatment fuel pressure is less than 41 kPa (6 psi) of the fuel pressure recorded in step 33 of Low Pressure Fuel System, proceed to the next step.
6. Disconnect the Fuel Rail Pressure (FRP) sensor electrical connector and attempt to start the vehicle.
   - If the vehicle starts, diagnose the FRP circuits. See FRP Sensor (Fuel Rail Pressure) (page 381) in the “Electronic Control System Diagnostics” section of this manual.
   - If the vehicle does not start, proceed to the next step.
7. Disconnect the Fuel Pressure Control Valve (FPCV) electrical connector.

Figure 128 CMP, CKP and FPCV Breakout Harness installed

8. Connect the CMP, CKP and FPCV Breakout Harness to the FPCV.
9. Attempt to start the engine.
   - If the vehicle starts, proceed to the next step.
   - If the vehicle does not start, skip to step 12.
10. Connect the engine wiring harness to the CMP, CKP and FPCV Breakout Harness.

11. Using a Digital Multimeter (DMM), measure and record the FPCV duty cycle while cranking and idling the engine.
    - If the duty cycle is between 10 and 60%, proceed to the next step.
    - If the duty cycle is not between 10 and 60%, see FPCV (page 377) in “Electronic Control System Diagnostics” section of this manual.
12. Restore the fuel system to operational condition.
13. Disconnect the fuel return line at the high pressure pump.

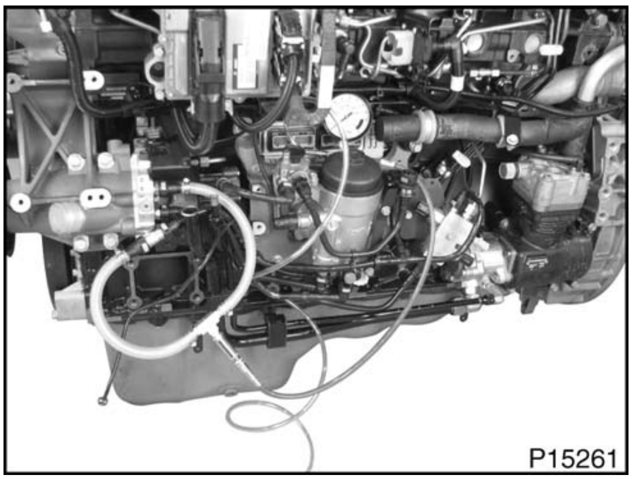


Figure 129 Measuring fuel return line pressure

14. Connect Fuel Fitting Adapter in series to Fuel Inlet Restriction and Aeration Tool, and the fuel return line from the high pressure pump. Using a locally available adaptor, connect the Fuel Pressure Gauge to the fitting on the Fuel Inlet Restriction and Aeration Tool. Crank the engine and record the pressure reading.
    - If the reading is above 21 kPa (3 psi), repair/replace the fuel return lines to the fuel tank.
    - If the reading is below 21 kPa (3 psi), proceed to the next step.
15. Restore the fuel system to operational condition.

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

16. Allow the engine fuel system to depressurize by turning the engine off and waiting 5 minutes before opening any high pressure fuel line.

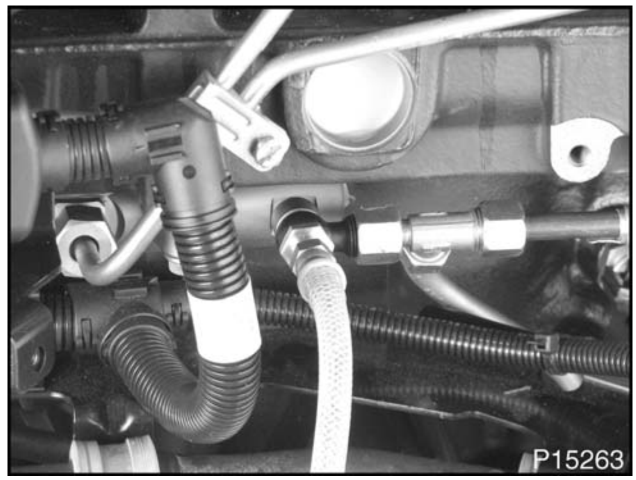


Figure 130 High Pressure Return Line Tester (17 mm) installed

17. Remove the size 8 hollow screw in the pressure pipe rail return and install the High Pressure Return Line Tester (17 mm). Crank or start and idle the engine and watch for fuel coming from the pressure pipe rail.
    - If a continuous flow of fuel comes out from the pressure pipe rail, install a new fuel rail pressure relief valve. Retest the vehicle for normal operation.
    - If no continuous flow of fuel comes out from the pressure pipe rail, proceed to the next step.
18. Restore the fuel system to operational condition.

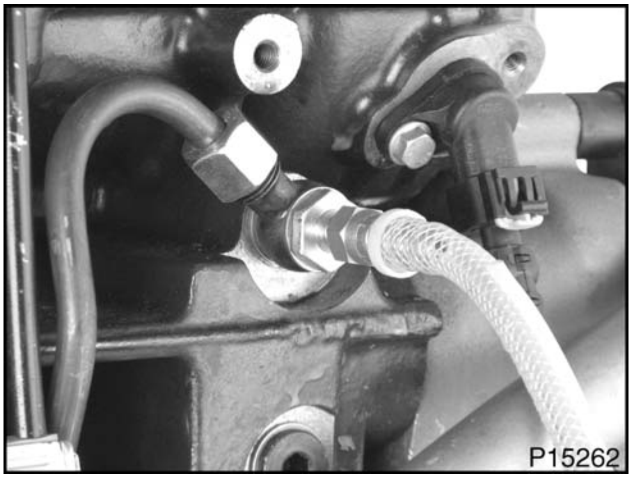


Figure 131 High Pressure Return Line Tester (19 mm) installed

19. Remove the hollow screw and install High Pressure Return Line Tester (19 mm) in the cylinder head fuel return port. Start and run the engine.

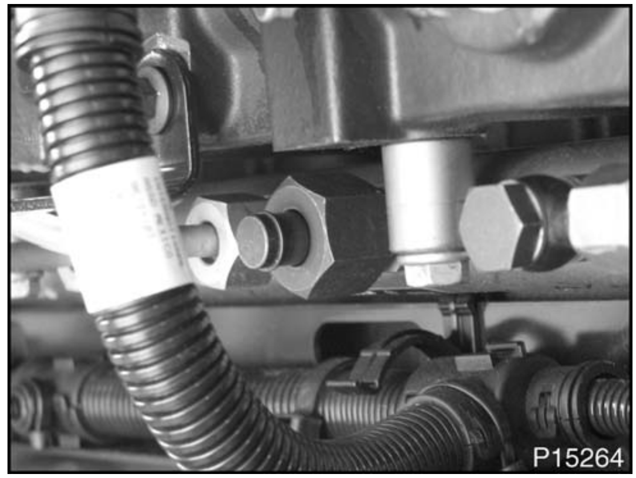


Figure 132 High Pressure Rail Plug installed

- If fuel flow is greater than 150 ml per minute flow rate, install Injector Fuel Blocking tool and check each injector, if a decrease of more than 20 ml per minute is found install a new injector and pressure tube.
- If flow rate is less an 150 ml per minute install a new high pressure fuel pump. See high pressure fuel pump in the International® MaxxForce® 11 and 13 *Engine Service Manual*. Retest system.

Possible Causes

- Failed fuel rail regulator valve
- Failed high pressure pump
- Air leak in suction side fuel line or fuel filter housing assembly
- Combustion gases entering fuel system
- Fuel injector and pressure pipe

9. Aftertreatment (AFT) System

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

Purpose

To check AFT system performance.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)

Procedure

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

1. See “Appendix A: Performance Specifications” in this manual for correct specification.
2. Turn the ignition switch to ON position.
3. Open COM device.
4. Open Aftertreatment session.
5. Record sensor value results on the Engine Performance Diagnostic Form (Hard Start and No Start side).

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

6. Verify Exhaust Gas Temperature 1 (EGT1), Exhaust Gas Temperature 2 (EGT2) and Exhaust Gas Temperature 3 (EGT3) sensors are operating at similar values.
7. Using EST, verify soot loading is less than 2.
   - If soot level is less than 2, continue with the next test.
   - If soot level is 2 or greater, run the Aftertreatment (AFT) Cleanliness Test. See Aftertreatment (AFT) Cleanliness Test (page 172) in the “Performance Diagnostics” section of this manual.
8. Start the engine.

NOTE: Make sure that the engine is at or above operating temperature (71 °C [160 °F]) before starting AFT Cleanliness Test.

9. Select Diagnostic Tests, then the Aftertreatment Tests from the drop-down menu.

   The Aftertreatment Control Module (AFCM) starts the AFT Cleanliness Test and commands the engine to accelerate to a default rpm to prepare for regeneration.

   The AFCM monitors the effects of the regeneration system by using feedback signals from the temperature and pressure sensors.

   - If no problems are detected, the test completes the regeneration cycle and resumes low idle rpm.
   - If a problem is detected, the AFCM cancels the test, sets a Diagnostic Trouble Code (DTC), and resumes low idle rpm.
10. Record sensor value results on Diagnostic Form.
11. Compare test result readings to pretest readings.
    - If EGT2 temperature exceeded 482 °C (900 °F) and soot level is 0, test the performance complaint again.
    - If EGT2 temperature did not exceed 482 °C (900 °F) and soot level is above 0, inspect AFT system components.

Possible Causes

- High Diesel Particulate Filter (DPF) loading
- EGDP sensor circuit faults or sensor failure
- DPF damage (plugged, cracked or leaking substrate)

10. Cold Start Assist System

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

Purpose

The engine requires a starting aid for efficient starting when temperatures are below 11° C (52° F). The purpose of the cold start assist test is to check for correct operation of the system.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)
- Digital Multimeter (DMM) (page 442)
- Amp Clamp (page 440)
- Cold Start Relay Breakout Harness (page 441)
- 4-Pin Round Black Breakout Harness (page 437)
- Fuel Pressure Gauge (page 450)

Procedure

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

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: The cold start assist system only operates when one or more of the Engine Oil Temperature (EOT), Engine Coolant Temperature (ECT), Engine Coolant Temperature 2 (ETC2), Intake Air Temperature (IAT) or Intake Air Temperature 2 (IAT2) signal values is at or below 11° C (52° F).

1. Verify vehicle is within temperature for the cold start assist system to be active.
2. Connect the EST and select D_HardstartNostart.ssn from the session list.
3. Turn the ignition switch to the Engine Run Position. The Wait-to-Start lamp will illuminate indicating that the pre-glow plug cycle has been activated for 40 seconds. Monitor the IAT2 sensor reading during the pre-glow cycle.
   - If the IAT2 sensor temperature reading does not rise, go to step 6.
   - If the IAT2 sensor temperature reading rises, proceed to the next step.

NOTE: Limit the number of unnecessary test cycles on the glow-plug to minimize the possibility of premature failure of the glow-plug.

4. Monitor the EOT, MAT, IAT, IAT2, ECT and ECT2 sensor readings using the EST to verify temperature.
5. Crank the engine when the Wait-to-Start lamp starts to flash and monitor the MAT sensor reading while cranking the engine. The temperature reading for the MAT sensor should rise slowly.
   - If the MAT sensor temperature does not rise, go to step 11.
   - If the MAT sensor temperature rises, the system is operating correctly. Return to Cold Start Assist System test to continue diagnostics.
6. Using a DMM and an Amp Clamp simultaneously, measure the amperage draw on both of the glow plug connector wire, with the ignition switch ON.
   - If the amperage draw is less than 20 amps, proceed to the next step.
   - If the amperage draw is greater than 20 amps, the glow plug is working correctly, skip to step 11.

WARNING: To prevent personal injury or death, do not touch the area around the glow plugs. This area becomes very hot when the glow plugs cycle on and heat up.

7. Measure voltage at the glow plug.
   - If the voltage is B+, and greater than 9.5 volts during engine crank and run, install a new glow plug. See International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - If the voltage is B+, and less than 9.5 volts during engine crank and run, proceed to the next step.

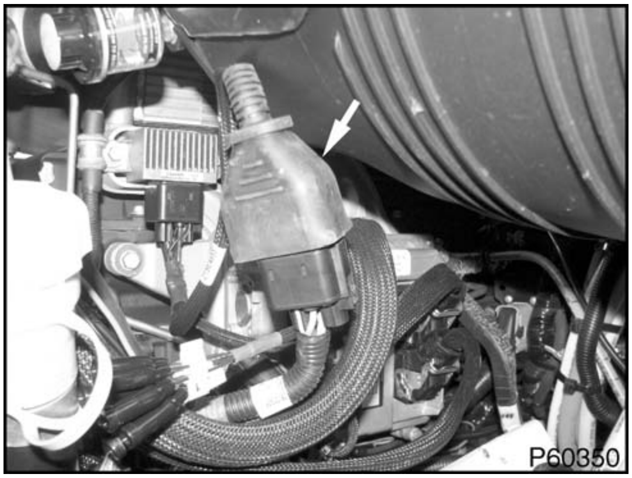


Figure 133 Cold Start Relay Breakout Harness installed

8. Install the Cold Start Relay Breakout Harness on the Cold Start Relay (CSR).
9. Cycle the ignition switch to the OFF position for 20 seconds then back to the ON position to reactivate the cold start assist system.
10. Measure voltage at pin 3.
    - If voltage is less than B+, inspect wire from the B+ cable to the CSR pin 3 for an open, short, or high resistance. Repair as necessary.
    - If voltage is B+, check control side of cold start assist relay, see Cold Start Relay (page 285) . If the control side of the relay is OK, install a new CSR. See International® MaxxForce® 11 and 13 *Engine Service Manual*.

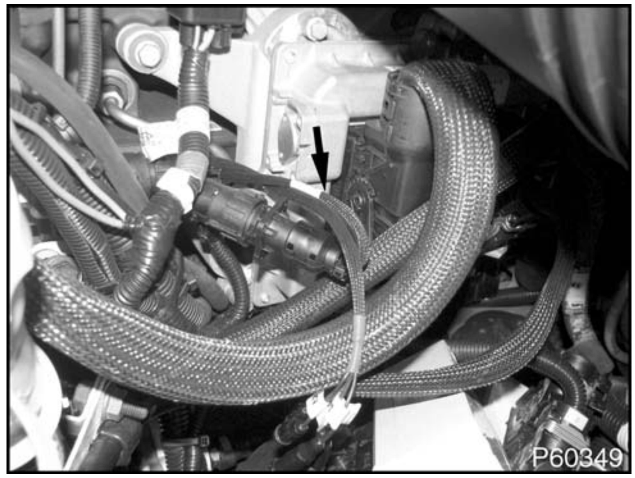


Figure 134 4-Pin Round Black Breakout Harness installed

11. Install 4-Pin Round Black Breakout Harness between the Cold Start Solenoid (CSS) valve and the engine harness.
12. Measure voltage between pins 1 and 2 while cranking the engine for 20 seconds.
    - If voltage is less than B+, diagnose the CSS voltage circuit. See Cold Start Relay (page 285) .
    - If the voltage is B+, proceed to the next step.

NOTE: Make sure that no dirt or debris enters the fuel line.

13. Disconnect the MV-glow plug fuel line from the glow plug and route the fuel into an approved container.
14. Install Fuel Pressure Gauge setup with valve.
15. Crank the engine.
16. Using Fuel Pressure Gauge, verify fuel flow with the valve open. Close the valve and verify fuel pressure of 68 kPa (10 psi) from the fuel line.
    - If there is fuel flow and pressure, install a new glow plug.
    - If there is no fuel flow or pressure, reconnect the fuel line and proceed to the next step.

NOTE: Make sure that no dirt or debris enters the fuel line.

17. Disconnect the fuel line from the CSS valve inlet and route the fuel into an approved container.

18. Install Fuel Pressure Gauge setup with valve.
19. Crank the engine.
20. Using Fuel Pressure Gauge, verify fuel flow with the valve open. Close the valve and verify fuel pressure of 68 kPa (10 psi) from the fuel line.
    - If there is fuel flow and pressure, install a new CSS valve.
    - If there is no fuel flow or pressure, reconnect the fuel line and proceed to the next step.

NOTE: Make sure that no dirt or debris enters the fuel line.

21. Disconnect the cold start supply tube from the fuel filter housing assembly and route the fuel into an approved container.
22. Install Fuel Pressure Gauge setup with valve.
23. Crank the engine.
24. Using Fuel Pressure Gauge, verify fuel flow with the valve open. Close the valve and verify fuel pressure of 68 kPa (10 psi) from the fuel line.
    - If there is fuel flow and pressure, the cold start system is operating correctly.
    - If there is no fuel flow or pressure:
        - Check the remainder of the fuel system for the lack of fuel (blocked or plugged fuel filter, low pressure pump, no fuel in the fuel tanks).
        - Check to see if the orifices to the fuel line are plugged. Clean the orifice in the fuel filter housing assembly and retest the system. If the system fails a second time, install a new fuel filter housing assembly. See International® MaxxForce® 11 and 13 *Engine Service Manual*.

Possible Causes

- Failed CSR
- CSR circuit faults
- Failed CSS valve
- CSS valve circuit faults

Table of Contents

Diagnostic Form

Engine Performance form assists technicians in troubleshooting International® diesel engines. The diagnostic tests help technicians find problems to avoid unnecessary repairs.

This section shows detailed instructions of 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.

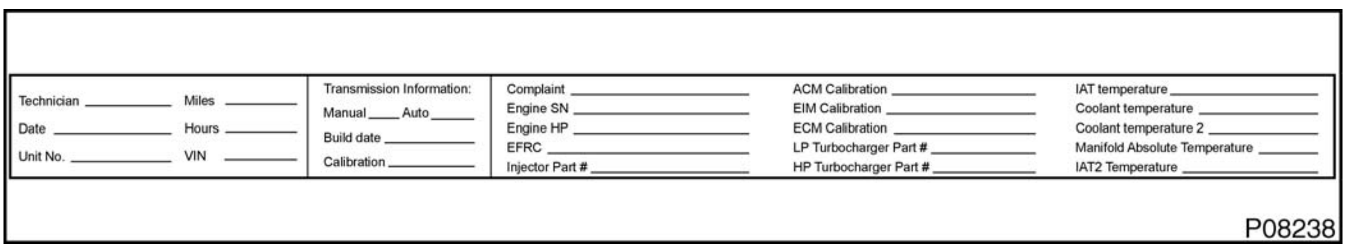
Do all tests in sequence, unless otherwise stated. Doing a test out of sequence can cause incorrect results. If a problem was found and corrected, it is not necessary to complete the remaining tests.

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

Order Information

Engine Performance Form EGED-425 is available in 50 sheet pads. To order technical service literature, contact your International®dealer.

Header Information


Technician ____ Miles ____
Date ____ Hours ____
Unit No. ____ VIN ____
Transmission Information:
Manual ____ Auto ____
Build date ____
Calibration ____
Complaint ____
Engine SN ____
Engine HP ____
EFRC ____
Injector Part # ____
ACM Calibration ____
EIM Calibration ____
ECM Calibration ____
LP Turbocharger Part # ____
HP Turbocharger Part # ____
IAT temperature ____
Coolant temperature ____
Coolant temperature 2 ____
Manifold Absolute Temperature ____
IAT2 Temperature ____

P08238

Entering Header Information

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

Vehicle Information

The Vehicle Identification Number (VIN) is located on VIN plate. Obtain the VIN information from ISIS.

5. VIN – last 8 digits (verify to VIN plate)
6. Build date (verify to VIN plate)
7. Engine Horsepower (hp)
8. Engine Interface Module (EIM) calibration
9. Engine Control Module (ECM) calibration
10. Aftertreatment Control Module (ACM) calibration
11. Transmission type
12. Engine Serial Number (ESN)

Performance Specification Information

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

13. See “Appendix A: Performance Specifications” in this manual, or TSI to obtain the following header information:
    - Engine Family Rating Code (EFRC)
    - Turbocharger No.

Verify EIM Calibration with Vehicle Specifications

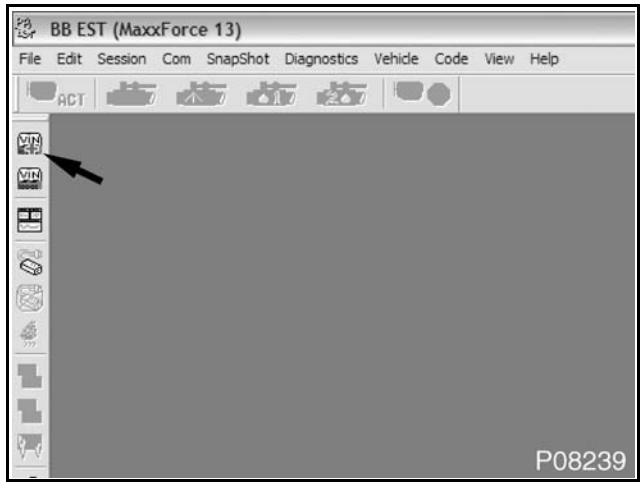


Figure 136 Select VIN + session (example)

14. Using Electronic Service Tool (EST) with MasterDiagnostics®, open VIN session by selecting VIN+ icon.

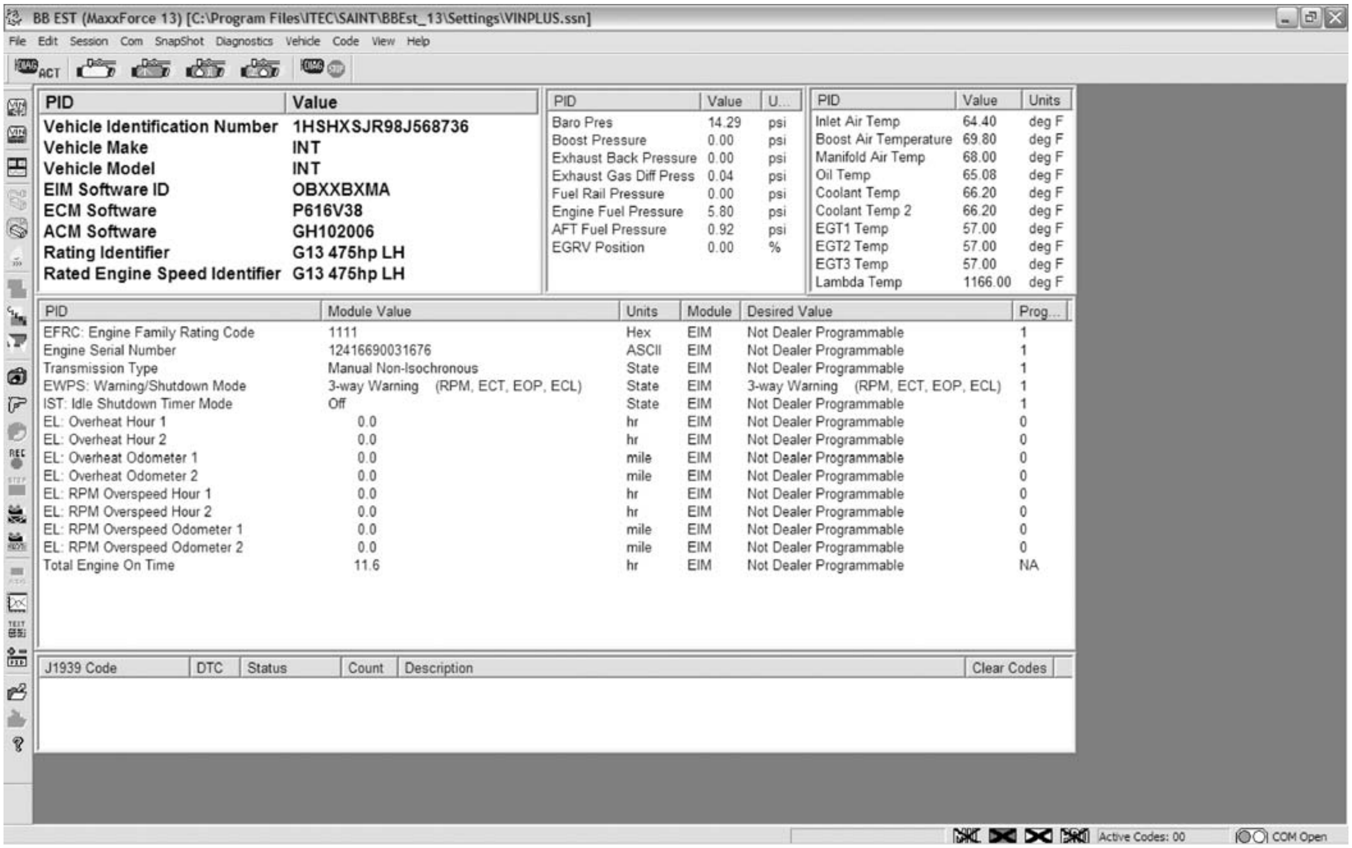


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Figure 137 VIN session (example)

15. Verify the following match vehicle specifications:
    - VIN
    - EIM calibration
    - ECM calibration
    - ACM calibration
    - Rated hp
    - EFRC
    - ESN

      Note: The ESN is located on the engine block, on the left side of the crankcase above the high pressure pump, and on the exhaust emission label on the valve cover.
    - Transmission
16. Enter the following information:
    - Odometer (miles)
    - Engine hours
    - Intake Air Temperature (IAT)
    - Intake Air Temperature 2 (IAT2)
    - Engine Coolant Temperature (ECT)
    - Engine Coolant Temperature 2 (ECT2)
    - Engine Oil Temperature (EOT)
    - Manifold Absolute Temperature (MAT)
    - Barometric Absolute Pressure (BAP)

Test Procedures

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

1. Visual Inspection

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

Purpose

To check all fluid levels and inspect engine systems for problems such as leaks, open connections and harness chaffing.

Tools

- Inspection lamp

Engine Oil

1. Park the vehicle on level ground and shut down the engine for five minutes.
2. Use oil level gauge to verify engine oil level.
3. Record results on Engine Performance Form.
    - If level is within operating range, no repair is required.
    - If level is below operating range, inspect for leaks, oil consumption, or improper servicing.
    - If level is above operating range, inspect for fuel dilution, coolant contamination, or improper servicing.

Fuel Level

NOTE: Engine should not be running.

1. Park the vehicle on level ground.
2. Use dash gauge to verify fuel level. Inspect fuel tank fill ports.
3. Record results on Engine Performance Form.
    - If level is within operating range, and no tank contamination is evident, no repair is required.
    - If level is below operating range, inspect for leaks, fuel dilution, inoperable tank transfer pump, or improper servicing.

Engine Coolant Level

NOTE: Engine should not be running.

1. Park the vehicle on level ground.
2. Check engine coolant level as indicated on deaeration tank level window.
3. Record results on Engine Performance Form.
    - If level is within operating range, and no deaeration tank contamination is evident, no repair is required.
    - If level is below operating range, inspect for leaks, coolant in oil, coolant in combustion, coolant in exhaust, or improper servicing.

Charge Air Cooler (CAC) System

1. Inspect CAC system, including the HPCAC, LPCAC and piping for leaks.
2. Inspect all CAC connections and clamps.
    - If CAC system shows no signs of damage or evidence of leakage, no repair is required.
    - If any CAC system issues are found, repair as required.

Intake Air System

1. See "Appendix A Performance Specifications" in this manual for Intake Restriction specifications and record on Engine Performance Form.
2. Locate and reset air restriction indicator. Run engine at high idle, no load.

3. Record intake restriction on Engine Performance Form.
   - If restriction is not apparent, no repair is required.
   - If restriction is detected, repair as required. Test again to validate repair.

Exhaust System

1. Inspect exhaust system (engine and vehicle) for leaks or damage that would restrict exhaust flow.

Some conditions that could restrict the exhaust are damaged exhaust, plugged Diesel Oxidation Catalyst (DOC), plugged Diesel Particulate Filter (DPF), or exhaust manifold with butterfly stuck closed.

- If the exhaust system shows no signs of damage or evidence of leakage, no repair is required.
- If an exhaust system issue is found, repair as required.

2. Fuel System

2.1 Fuel Quality

Purpose

To check fuel quality.

Tools

- Clear container (approximately 1 liter [1 quart])

Procedure

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

1. Retrieve a fuel sample from the fuel tank.
2. Check for water, waxing, sediment, gasoline, or kerosene.
   - If fuel quality is satisfactory, no action is required.
   - If fuel quality is questionable, correct problem. Take another sample to verify fuel quality.

Possible Causes

- Debris, water, or ice in fuel system
- Oil, gasoline, or kerosene present in fuel tank
- Incorrect fuel grade for cold temperatures

2.2. Low Pressure Fuel System

Purpose

To check for correct fuel pressure and aerated fuel.

NOTE: Plugged supplemental filters or separators mounted on vehicle influence fuel pressure, restriction, and aeration. Make sure that any supplemental filters or separators have been maintained following the manufacturer's recommendations.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)
- Vacuum gauge
- Fuel Pressure Gauge (page 450)
- Fuel Inlet Restriction and Aeration Tool (page 449)
- Fuel Block Off Tool (page 448)

Procedure

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

1. See "Appendix A: Performance Specifications", in this manual for correct specification. Obtain the correct specifications for the engine and application in question. Proceed to step 2.
2. Connect the EST to the vehicle.
3. Open the COM device.
4. Verify correct engine family and model year is selected.
5. Launch EST.
6. Select the Sessions drop down–menu.
7. Select the D_HardStartNoStart.ssn file.
8. Read the low pressure fuel sensor pressure using the EST. Read while cranking the engine.
   - If the low pressure fuel system pressure is at or above specification, See High Pressure Fuel System (page 140) in the "Hard Start and No Start Diagnostics" section of this manual.
   - If the low pressure fuel system pressure is below specification, proceed to the next step.

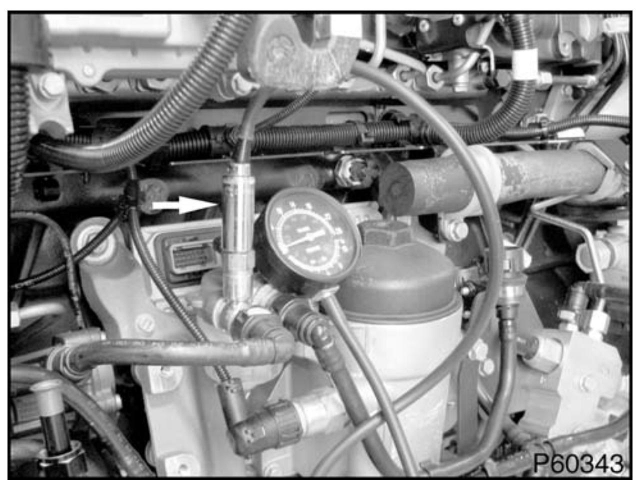


Figure 138 Restriction measurement

9. Using a locally available adaptor, connect a vacuum gauge to the test fitting on the fuel primer pump. Measure the restriction while idling the engine at the low and high idle specification.
   - If the restriction is below 7 in-Hg, skip to step 13.
   - If the restriction is above 7 in-Hg, proceed to the next step.
10. Clean the fuel strainer element and install a new fuel pre-filter. See the International® MaxxForce® 11 and 13 *Engine Operation and Maintenance Manual*. Inspect the fuel lines between the fuel strainer and the fuel tank, repair as required.
11. Measure the restriction while idling the engine at the low and high idle specification.
    - If the restriction is below 7 in-Hg, skip to step 13.
    - If the restriction is above 7 in-Hg, proceed to the next step.
12. Check the fuel supply for kinked fuel lines or debris in the fuel tank. Repair as necessary and retest the system.
13. Remove the locally available adaptor and the vacuum gauge.
14. Using the EST, test the low pressure fuel pressure.
    - If low pressure fuel pressure is within specification, the system is operating normally and the cause was debris in the fuel strainer.
    - If low pressure fuel pressure is below specification, proceed to the next step.
15. Remove the EFP sensor.

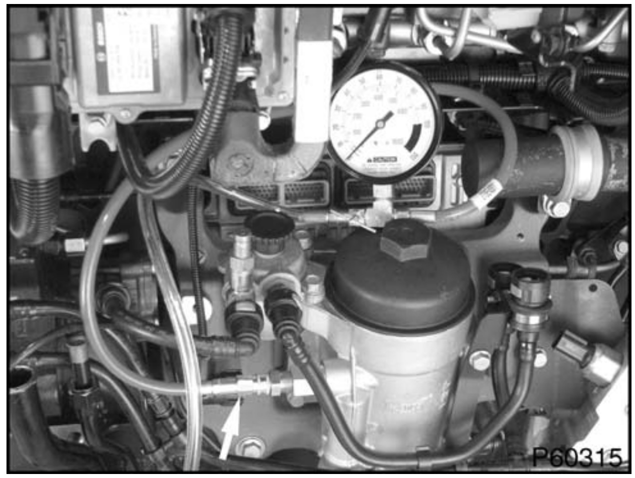


Figure 139 Fuel Pressure Gauge

16. Using a locally available adaptor, connect the Fuel Pressure Gauge to the fuel filter housing in the EFP sensor location.

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

17. Route the drain hose into a suitable container.
18. Open the valve and idle the engine at the low and high idle specification and check the fuel in the drain hose for aeration and flow.
    - If fuel aeration or no fuel flow is present, proceed to the next step.
    - If no fuel aeration is present, proceed to step 29.
19. Disconnect the pre-filter supply fuel line at the engine connector.

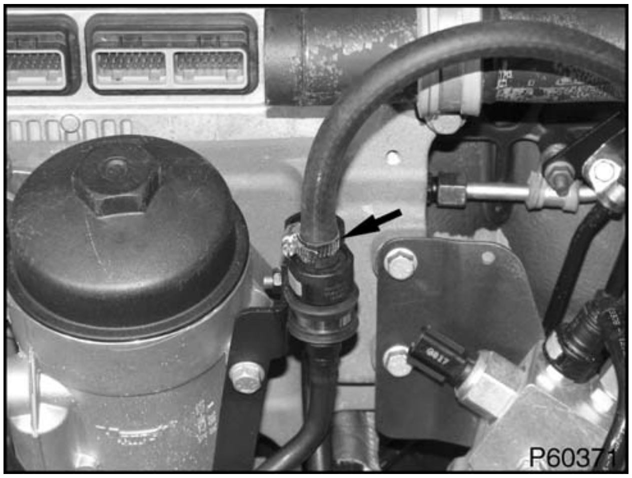


Figure 140 Fuel supply hose

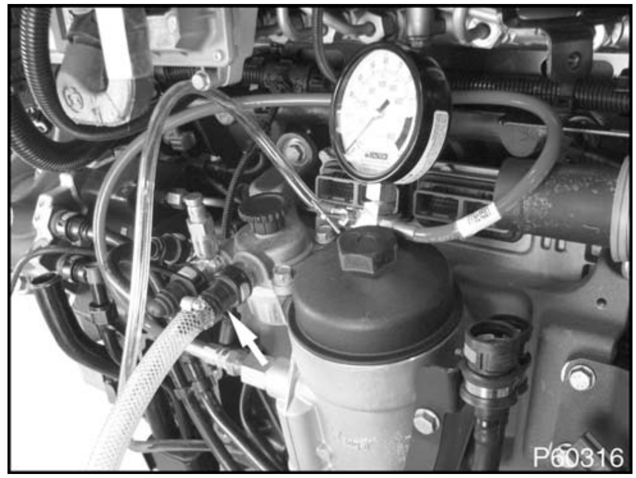


Figure 141 Fuel Inlet Restriction and Aeration Tool installed

NOTE: Fabricate a clean fuel supply hose using a fuel line connector and a locally obtained fuel hose.

20. Using a clean fuel supply hose, connect a clean fuel supply to the pre-filter supply fuel line inlet.
21. Idle the engine at the low and high idle specification and check the fuel in the drain hose for aeration and flow.
    - If no fuel aeration or flow is present, repair the fuel line between the fuel tank and the engine. Restore the fuel system to operating condition.
    - If fuel aeration is present, proceed to the next step.
22. Reconnect the fuel line to pre-filter supply fuel line inlet.
23. Disconnect the pre-filter supply fuel line at the fuel primer pump assembly.
24. Connect Fuel Inlet Restriction and Aeration Tool to the fuel pump primer assembly and a clean fuel source.
25. Idle the engine at the low and high idle specification and check the fuel in Fuel Pressure Gauge for aeration.
    - If no fuel aeration is present, proceed to the next step.
    - If fuel aeration is present, install a new pre-filter supply fuel line.
26. Restore the fuel system to operating condition.
27. Disconnect the preliminary filter feed fuel line from the fuel primer pump assembly.
28. Disconnect the preliminary filter feed fuel line from the low pressure pump.

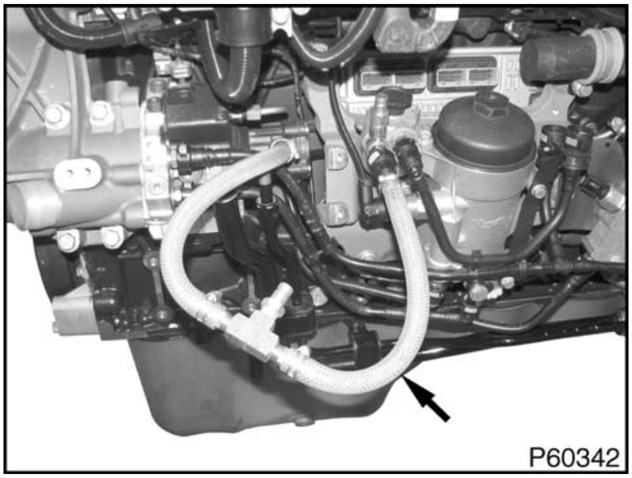


Figure 142 Check for fuel aeration

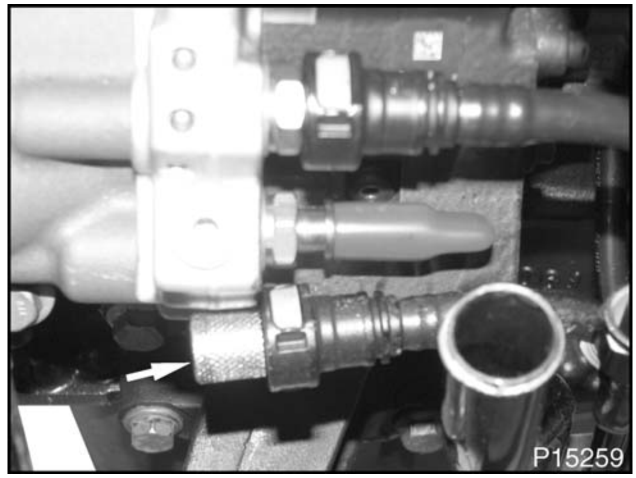


Figure 143 Fuel Block Off Tool installed

29. Connect Fuel Inlet Restriction and Aeration Tool to the fuel primer pump assembly and the low pressure pump inlet.
30. Idle the engine at the low and high idle specification and check the fuel for aeration.
    - If no fuel aeration is present, see High Pressure Fuel System (page 140) in the “Hard Start and No Start Diagnostics” section of this manual.
    - If fuel aeration is present, inspect the fuel primer pump assembly for air leaks. Repair as necessary and retest the system.

NOTE: Make sure the fuel connection to the high pressure fuel pump and surrounding area is clean. If the connection area needs to be cleaned, pressure wash or steam clean the area.

NOTE: To prevent water intrusion do not directly spray electrical connectors with a pressure washer.

31. Disconnect the filter T-connector fuel line at the high pressure pump.

NOTE: Make sure the Fuel Block Off Tool is clean.

32. Install Fuel Block Off Tool in the end of the filter T-connector fuel line.
33. Crank the engine and monitor EFP sensor.
    - If fuel pressure is below minimum fuel system specification, install a high pressure pump. See High Pressure Pump in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
    - If fuel pressure meets or exceeds fuel system specification, proceed to High Pressure Fuel Pump Run Up Test (page 180) in this section.

Possible Causes

- Fuel filter or strainer blocked
- Incorrect fuel grade for cold temperatures
- Fuel supply line damage or blockage
- Failed high pressure pump
- Air leak in suction side fuel line or filter assembly
- Combustion gases entering fuel supply system

3. Sensor Compare / Diagnostic Trouble Codes (DTCs) and Engine Control Module (ECM)

3.1 Checking ECM and Engine Interface Module (EIM) Calibration

Purpose

- To verify ECM and EIM calibrations match the vehicle.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)

Procedure

1. Turn ignition switch to ON. Do not start the engine.
2. Using EST with MasterDiagnostics® software, open VIN session. Select VIN+ icon.
3. Verify the vehicle information on ECM, EIM, and ACM match vehicle. See Vehicle Information (page 151) in this section of manual.
4. Record the calibration level on the Engine Performance Form.

3.2 Checking for DTCs

Purpose

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

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)

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

Status: Indicates active or inactive DTCs

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

Description: Defines each DTC

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

3.3 Sensor Compare

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

Purpose

To validate sensor accuracy.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)

Procedure

NOTE: Batteries must be fully charged before doing this test. If multiple tests are required, use a battery charger during testing to prevent battery drain.

1. Turn ignition switch to ON. Do not start engine.
2. Connect EST with Master Diagnostics® software to vehicle.
3. Open COM device by clicking the connection button.
4. Verify correct engine family and model year is selected.

5. Launch EST.
6. Open D_SensorCompare.ssn session by:
   - Click Session drop-down menu.
   - Click open.
   - Select D_SensorCompare.ssn file.
   - Click OPEN.
7. Record results on Engine Performance Form.

NOTE:

- If engine has not been run for 8 to 12 hours, Engine Coolant Temperature (ECT), Engine Coolant Temperature 2 (ECT2), Engine Oil Temperature (EOT), and Manifold Air Temperature (MAT) sensors should be within 2 °C (5 °F) of each other. The Intake Air Temperature (IAT), Intake Air Temperature 2 (IAT2), Exhaust Gas Temperature 1 (EGT1), Exhaust Gas Temperature 2 (EGT2) and Exhaust Gas Temperature 3 (EGT3) sensors could be a few degrees higher or lower due to faster outside engine temperature change.
- The Engine Fuel Pressure (EFP) and Fuel Rail Pressure (FRP) values may fluctuate and affect performance.

  Engine Oil Pressure (EOP), Manifold Air Pressure (MAP), and Exhaust Back Pressure (EBP) sensors values may fluctuate as much as 7 kPa (1 psi).
- Barometric Absolute Pressure (BAP) sensor value should equal barometric reading for your region.

8. Verify if sensor values are normal.
   - If sensor values differ significantly from current conditions, see “Electronic Control Systems Diagnostics” section of this manual for applicable sensor.
   - If sensor values do not differ significantly from current conditions, no repair is required. Continue to next test.

Possible Causes

- Failed sensor circuits
- Biased or damaged sensor
- Faulty ground circuits

4. Actuator Test

Purpose

This test determines if the actuators listed below are functioning properly.

The actuator test activates each of the actuators in the sequence listed below for 3.5 seconds.

For the air actuated component, the truck air system is required to be charged to a minimum of 621 kPa (90 psi) for the actuator to function properly.

NOTE: The Engine Interface Module (EIM) controlled actuators are energized, and de-energized at the same time.

Engine Control Module (ECM) controlled actuators are:

- Intake Throttle Valve (ITV)
- Boost Control Solenoid (BCS) valve
- Exhaust Gas Recirculation (EGR) control valve
- Coolant Mixer Valve (CMV)
- Retarder Control
- Coolant Flow Valve (CFV)

Aftertreatment Control Module (ACM) controlled actuators are:

- Aftertreatment Fuel Injector (AFI)
- Aftertreatment Fuel Supply (AFS) valve
- Aftertreatment Fuel Drain (AFD) valve

EIM controlled actuators are:

- Cold Start Relay (CSR)
- Engine Crank Inhibit (ECI)
- Electronic Engine Fan (EFAN)

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)
- Air pressure gauge

Entering Vehicle Information Using The EST

1. Set parking brake.

NOTE: The air pressure in truck air tank must be at least 621 kPa (90 psi) to operate the air operated actuators correctly.

2. Check for system air pressure using instrument panel gauge.
   - If instrument panel gauge reads 621 kPa (90 psi) or greater, proceed to next step.
   - If instrument panel gauge reads less than 621 kPa (90 psi), charge the truck air system to 827 kPa (120 psi).
   - If instrument panel gauge does not build to 621 kPa (90 psi), diagnose truck air system. Repair as necessary.
3. Select Diagnostics from menu and select Actuator Test.
4. The EIM and ECM command engine actuators to cycle once, energizing each actuator for 3.5 seconds. Visually verify range operation of the EGR throttle valve actuator, the ITV, the boost control solenoid (BCS) valve and retarder control. Failure of any of these actuators may cause a performance problem or a hard start/no start condition.
5. If the ambient temperature is below 11°C (52°F), listen for activation at the CSR. Failure of the CSR may cause a hard start/no start condition on a cold start.
6. Record any active Diagnostic Trouble Codes (DTCs) on the Engine Performance Form. See “Appendix B: Diagnostic Trouble Code Index” in this manual for any DTCs.
7. Correct any problems identified by active DTC or actuators functioning outside of specification. If ITV is suspect, proceed to the step.

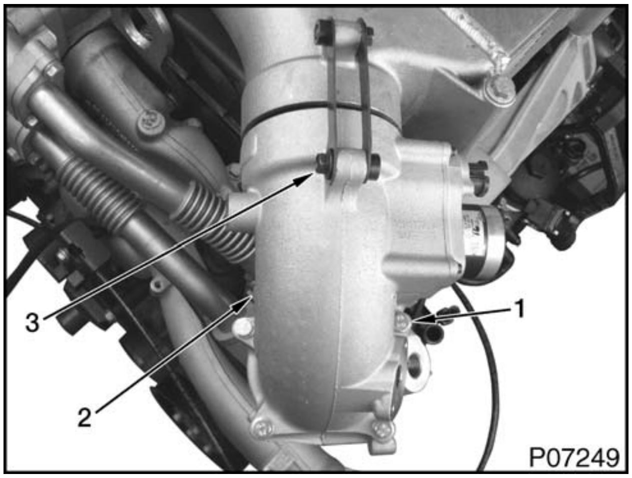


Figure 144 ITV

1. ITV bolt (4)
2. ITV
3. M10 x 30 hex bolt

8. Disengage the four captured bolts and remove one M10 x 30 hex bolt and the ITV. Do not disconnect ITV electrical connector.
9. Position the ITV so that the ITV plate is visible.
10. Repeat Actuator Test and visually observe ITV movement.

Possible Causes

- Electrical components or circuitry failure
- Failed actuator or insufficient air pressure

5. Air Supply System

Purpose

To determine if the air system operating the actuators is working correctly.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)
- Air pressure gauge

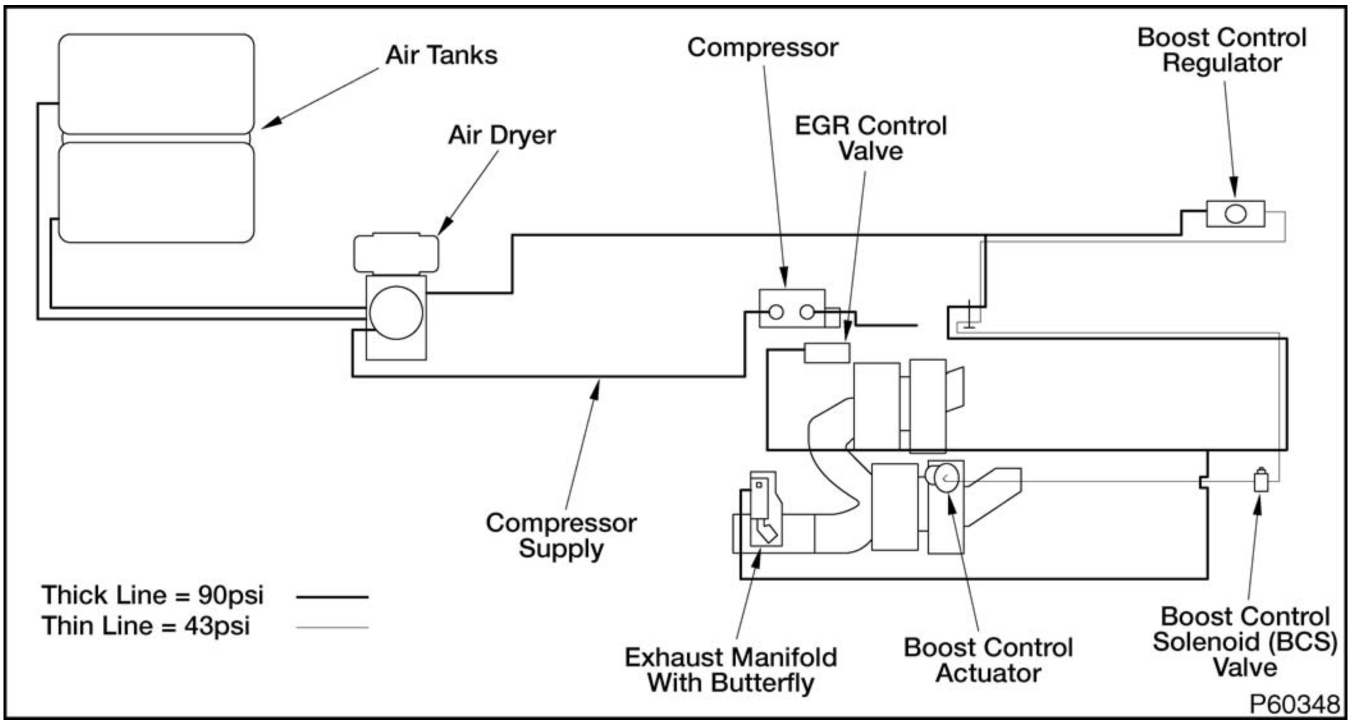


Figure 145 Air Supply System

Procedure

NOTE: The air supply system is only diagnosed due to a failed actuator test.

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

1. Check for system air pressure using instrument panel gauge.
   - If instrument panel gauge reads 621 kPa (90 psi) or greater, proceed to next step.
   - If instrument panel gauge reads less than 621 kPa (90 psi), charge the truck air system to 827 kPa (120 psi).
   - If instrument panel gauge does not build to 621 kPa (90 psi), diagnose truck air system. Repair as necessary.
2. Carry out actuator test and identify inoperative air actuated component.
   - If Exhaust Gas Recirculation (EGR) throttle valve does not actuate, proceed to next step.

- If the Retarder Control does not chatter or actuate the exhaust manifold with butterfly, skip to step 8.
- If high pressure turbocharger does not actuate, skip to step 16.

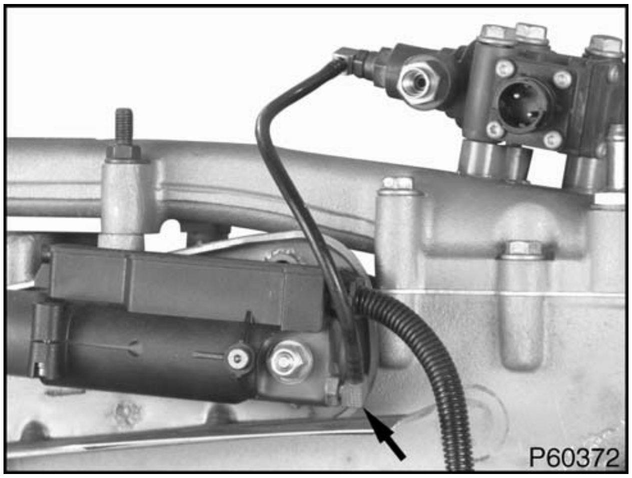


Figure 146 EGR throttle valve connection

3. Disconnect EGR control valve – EGR module air line assembly from EGR throttle valve and connect an air pressure gauge to EGR control valve – EGR module air line assembly.

NOTE: The air pressure in truck air tank must be at least 621 kPa (90 psi) to operate actuators correctly.

4. Carry out actuator test, see Actuator Test (page 162) in this section.
   - If air pressure reading on the gauge is at least 621 kPa (90 psi) when the EGR control valve is activated, install a new EGR throttle valve following procedures in International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - If air pressure reading on the gauge is less than 621 kPa (90 psi) when the EGR control valve is activated, proceed to next step.

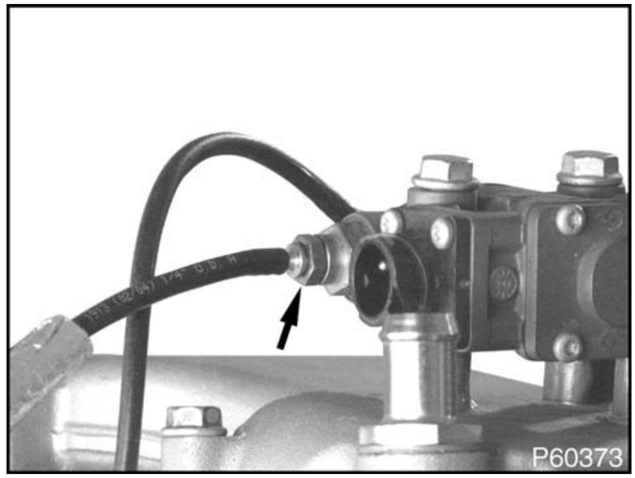


Figure 147 EGR control valve connection

5. Connect EGR control valve - EGR module air line assembly to EGR control valve and disconnect air supply line assembly from EGR control valve.
6. Connect an air pressure gauge to air supply line assembly.

NOTE: The air pressure in truck air tank must be at least 621 kPa (90 psi) to operate actuators correctly.

7. Measure the air pressure at air supply line assembly.
   - If air pressure reading on gauge is at least 621 kPa (90 psi), diagnose EGR control circuits, see EGR (page 325) in the “Electronic Control System Diagnostics” section of this manual. If control circuits are OK, install a new EGR control valve following procedures in International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - If air pressure reading on gauge is less than 621 kPa (90 psi), diagnose truck air system. Repair as necessary.

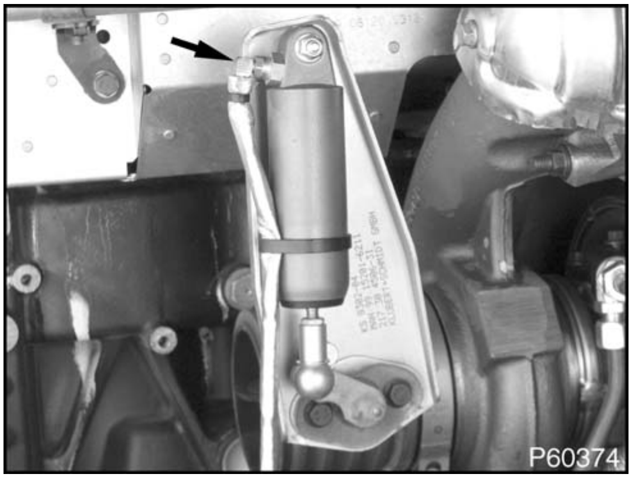


Figure 148 Exhaust manifold with butterfly connection

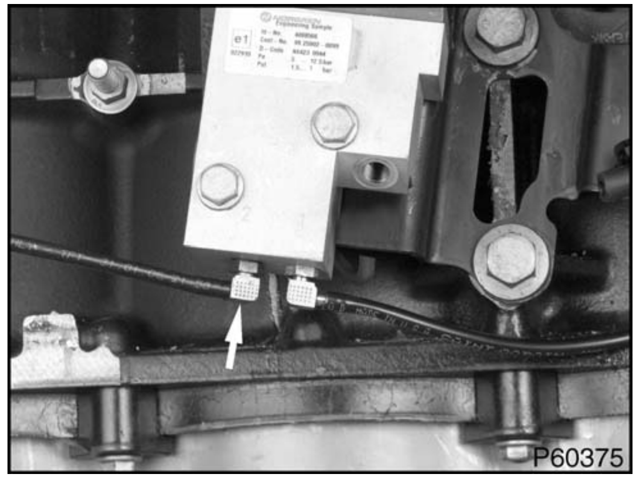


Figure 149 Retarder control connection

8. Disconnect pressure air line from the Retarder Control on the exhaust manifold with butterfly, and connect an air pressure gauge to pressure air line.

NOTE: The air pressure in truck air tank must be at least 621 kPa (90 psi) to operate actuators correctly.

9. Carry out Actuator Test, see Actuator Test (page 162) in this section.
   - If air pressure reading on gauge is at least 621 kPa (90 psi), when retarder control is activated, install a new exhaust manifold with butterfly following procedures in International® MaxxForce® 11 and 13 *Engine Service Manual*.
   - If air pressure reading on gauge is less than 621 kPa (90 psi), when retarder control valve is activated, proceed to next step.

10. Connect pressure air line to exhaust manifold with butterfly and disconnect pressure air line from retarder control.
11. Connect an air pressure gauge to retarder control outlet port.

NOTE: The air pressure in truck air tank must be at least 621 kPa (90 psi) to operate actuators correctly.

12. Carry out Actuator Test, see Actuator Test (page 162) in this section.
    - If air pressure reading on gauge is at least 621 kPa (90 psi), when retarder control is activated, install a new pressure air line following procedures in International® MaxxForce® 11 and 13 *Engine Service Manual*.
    - If air pressure reading on gauge is less than 621 kPa (90 psi), when the retarder control is activated, proceed to next step.

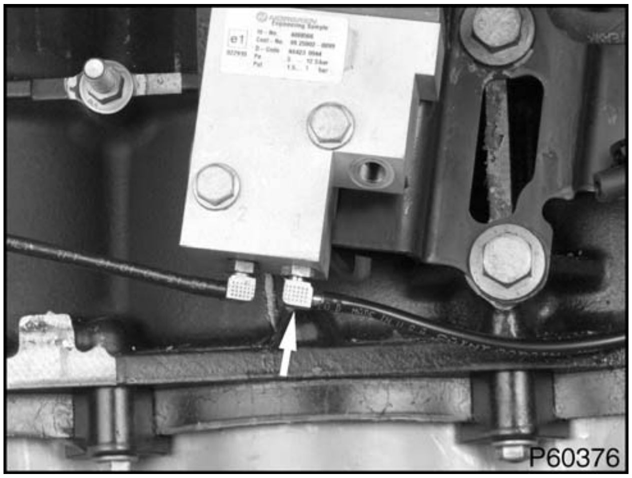


Figure 150 Air supply line assembly connection

13. Connect pressure air line to retarder control and disconnect air supply line assembly from retarder control.
14. Connect an air pressure gauge to air supply line assembly.

NOTE: The air pressure in truck air tank must be at least 621 kPa (90 psi) to operate actuators correctly.

15. Measure air pressure.
    - If air pressure is at least 621 kPa (90 psi), diagnose the retarder control circuits see Retarder Control (page 423) in the "Electronic Control System Diagnostics" section of this manual. If control circuits are OK, install a new retarder control valve following procedures in International® MaxxForce® 11 and 13 *Engine Service Manual*.
    - If air pressure is less than 621 kPa (90 psi), diagnose truck air system. Repair as necessary.

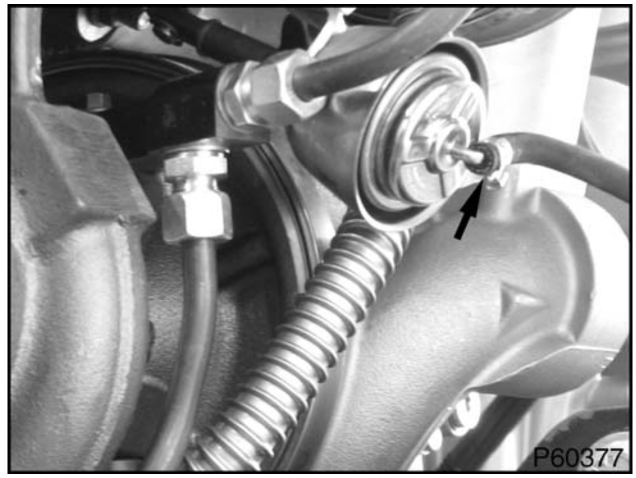


Figure 151 High pressure turbocharger air line connection

16. Disconnect air line from high pressure turbocharger and install an air pressure gauge on air line.

NOTE: The air pressure in truck air tank must be at least 621 kPa (90 psi) to operate actuators correctly.

17. Carry out the Actuator Test, see Actuator Test (page 162) in this section.
    - If air pressure reading on the gauge is 296 kPa (43 psi) when Boost Control Solenoid (BCS) valve is activated and high pressure turbocharger has not passed actuator test, install a new high pressure turbocharger assembly following procedures in International® MaxxForce® 11 and 13 *Engine Service Manual*.
    - If air pressure reading on gauge is below 296 kPa (43 psi) when the BCS valve is activated, proceed to next step.

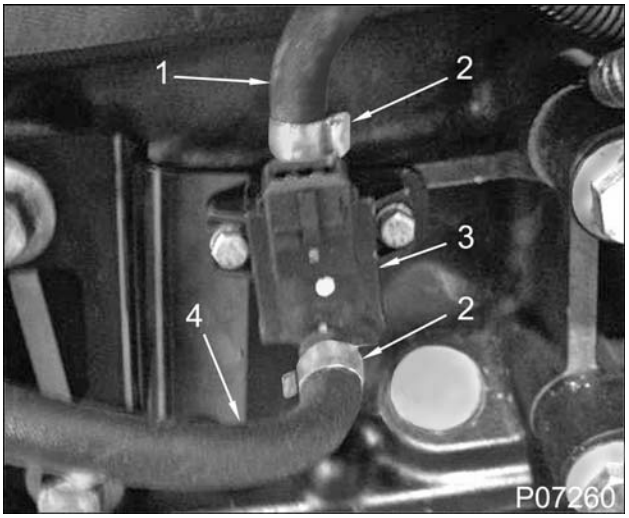


Figure 152 BCS valve lines

1. BCS valve line (supply)
2. Crimp clamp
3. BCS valve
4. BCS valve line (output)

18. Connect air line to high pressure turbocharger and disconnect air line from BCS valve.
19. Install an air pressure gauge on BCS valve outlet port.

NOTE: The air pressure in truck air tank must be at least 621 kPa (90 psi) to operate actuators correctly.

20. Carry out actuator test, see Actuator Test (page 162) in this section.
    - If air pressure reading on the gauge is 296 kPa (43 psi) when the BCS valve is activated, install a new air line to the high pressure turbocharger.
    - If air pressure reading on the gauge is below 296 kPa (43 psi) when the BCS valve is activated, proceed to next step.
21. Connect air line to BCS valve and disconnect pressure air line (supply) from BCS valve.
22. Install an air pressure gauge on pressure air line.

NOTE: The air pressure in truck air tank must be at least 621 kPa (90 psi) to operate actuators correctly.

23. Measure air pressure.
    - If air pressure is at least 296 kPa (43 psi), install a new BCS valve following procedures in International® MaxxForce® 11 and 13 *Engine Service Manual*.
    - If air pressure is less than 296 kPa (43 psi), proceed to next step.
24. Connect pressure air line to BCS valve and disconnect pressure air line from boost control regulator.
25. Install an air pressure gauge on boost control regulator outlet port.

NOTE: The air pressure in truck air tank must be at least 621 kPa (90 psi) to operate actuators correctly.

26. Measure air pressure.
    - If air pressure is 296 kPa (43 psi), repair or install a new pressure air line as necessary.
    - If air pressure is below 296 kPa (43 psi), install a new boost control regulator following procedures in the appropriate vehicle service manual.
    - If air pressure is above 296 kPa (43 psi), adjust the boost control regulator and retest the system. If the air pressure remains above 296 kPa (43 psi) after the second test, install a new boost control regulator following procedures in the appropriate vehicle service manual.

Possible Causes

- Air leaks or blockage in the system air lines
- Failed air compressor
- Failed air dryer
- Failed boost control regulator
- Failed EGR throttle valve
- Failed EGR control valve
- Failed BCS valve
- Failed high pressure turbocharger
- Failed retarder control
- Failed engine retarder control on the exhaust manifold with butterfly

6. Road Test (Full load, rated speed)

6.1 On Road Session

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

Purpose

To verify engine performance at full load and rated speeds.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)

Procedure

1. See "Appendix A: Performance Specifications" in this manual for specifications and record on Engine Performance Form.
2. Turn ignition switch to ON and start engine.

   NOTE: Make sure engine is at or above minimum operating temperature of 71 °C (160 °F) and the engine is in closed loop by monitoring Exhaust Lambda Sensor (ELS) and verifying that readings are greater than 1. If ELS reading is exactly 1, the vehicle is in open loop. See Exhaust Lambda Sensor (ELS) (page 356) in the "Electronic Control System Diagnostics" section of this manual.
3. Open COM device.
4. Open D_Performance.ssn session.
5. Set the Performance snapshot to record at 0.2 second interval for the following PIDs:
   - Engine speed (rpm)
   - Manifold Absolute Pressure (MAP)
   - Engine Fuel Pressure (EFP)
   - Fuel Rail Pressure (FRP) actual
   - FRP desired
   - Exhaust Gas Recirculation (EGR) actual
   - EGR desired
   - Engine load (EL %)
   - Exhaust Gas Differential Pressure (EGDP)
   - Accelerator Position Sensor (APS)
   - Intake Throttle Valve (ITV)
6. Find an open stretch of road and start snapshot recording. When driving conditions are safe, select a suitable gear, press accelerator pedal fully to the floor, and accelerate to rated speed at 100% load.
7. When road test is complete, stop snapshot recording.
8. Save snapshot for review and future reference.
9. Replay snapshot in graphic or text view to review results for RPM, MAP, EFP, FRP, EGR and EL %.
   - Pay close attention to rated HP and peak TQ rpm.
   - EL % should be near 100 percent.
10. Record results on Engine Performance Form.
    - If results are in normal operating range for driving conditions, no repair is required.
    - If results are out of normal operating range for driving conditions, proceed to next step.
11. Address out of range concerns in the following order:
    1. If EFP sensor is out of range (low or high), repair as necessary.
    2. If FRP sensor is out of range (low), repair as necessary.
    3. If Delta_P is out of range, repair as necessary.
    4. If EGR actuator and position sensor are out of range, repair as necessary.
    5. If Brake Control Pressure (BCP) sensor is out of range, repair as necessary.
    6. If above repairs do not correct the concern, proceed to Road Test Results Interpretation (page 169) in this section.

6.2 Road Test Results Interpretation

NOTE: Performance road test readings can be interrelated and the following steps identify some interrelated readings and the possible causes to be investigated.

1. Monitor the MAP sensor and EGDP sensor readings taken during the snapshot recording.
   - If the MAP reading is LOW and EGDP reading is HIGH, the Diesel Particulate Filter (DPF) is suspect. Proceed to Aftertreatment Cleanliness Test (page 172) in this section.
   - If the MAP reading is LOW and EGDP reading is NORMAL, the intake air system leaks, EGR system, exhaust system leaking before DOC or a plugged Diesel Oxidation Catalyst (DOC) are suspect.

     Inspect for leaks, proceed to Visual Inspection (page 154) in this section.

     Diagnose the EGR activation, proceed to Air Supply System (page 164) in this section.

     Diagnose the DOC, proceed to Aftertreatment Cleanliness Test (page 172) in this section.
   - If the MAP reading is HIGH and EGDP reading is NORMAL, the boost control system is suspect. Proceed to Air Supply System (page 164) in this section.
   - If the MAP reading is NORMAL and EGDP reading is NORMAL, exhaust system leaks are suspect. Inspect for leaks, proceed to Visual Inspection (page 154) in this section.
2. If the previous testing does not correct the problem, review the concern and specific conditions that may cause it, with the customer then attempt to duplicate the concern.

Low Boost Possible Causes

- Boost leaks
- Restricted intake or exhaust
- Control system faults
- Biased BAP or MAP sensors
- Power cylinder condition
- Low fuel pressure
- Failed EGR control valve
- Failed turbocharger
- Failed fuel injectors
- Failed ITV
- Failed Charge Air Coolers (CACs)

Low Fuel Pressure Possible Causes

- Fuel filter or strainer blockage
- Incorrect fuel grade for cold temperatures
- Debris, water, or ice in fuel system
- Oil, gasoline, or kerosene present in fuel system
- Combustion gases entering fuel system
- Fuel supply line leak, damage, or blockage
- Air leak in suction side fuel line or filter assembly
- Failed high pressure pump

Exhaust or Intake System Possible Causes

- Intake air filter restriction
- Collapsed intake hose
- Exhaust restriction
- Charge air leak to atmosphere
- Charge air leak to coolant

7. Aftertreatment (AFT) System

7.1. Aftertreatment (AFT) Cleanliness Test

NOTE: The vehicle does not complete a regeneration if the Exhaust Gas Recirculation (EGR) control valve or the Intake Throttle Valve (ITV) are damaged.

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

Purpose

This procedure is used to induce a Diesel Particulate Filter (DPF) regeneration cycle. The regeneration process may take up to one hour depending on the condition of the DPF.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)

Procedure

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

1. Park the vehicle outside of the building during the test.
2. See "Appendix A: Performance Specifications" in this manual for correct specification.
3. Start and idle the engine for two minutes.
4. Open COM device.
5. Open D_Aftertreatment.ssn session.
6. Record sensor value results on Engine Performance Form.
7. Verify and record the operating values on the Engine Performance Form for Exhaust Gas Temperature 1 (EGT1), Exhaust Gas Temperature 2 (EGT2), and Exhaust Gas Temperature 3 (EGT3) sensors. The sensors should be operating at similar values.
8. Verify and record the operating value on the Engine Performance Form for Exhaust Gas Differential Pressure (EGDP) sensor. The EGDP should be operating near zero.
9. Verify soot and ash loading.
   - If soot and ash loading are below allowable maximum, system is operating correctly at this time.
   - If soot and ash loading are above the allowable maximum, proceed to the next step.
10. Make sure engine is at or above minimum operating temperature of (71 °C [160 °F]) before starting Activation Regen.
11. Select Diagnostics tests from the EST menu, select After-Treatment Tests then the AFT Cleanliness Test from the drop-down menu.

    The ECM waits 15 seconds then starts the Activation Regen and commands the engine to accelerate to a preset or default rpm to prepare for regeneration.

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

    - If no problems are detected, the test completes the regeneration cycle and resumes low idle rpm.
    - If a problem is detected, the ECM cancels the test, sets a DTC, and resumes low idle rpm.
12. Record sensor value results on the Engine Performance Form.

NOTE: An undamaged cleaned DPF will have no visual evidence of plugging or discoloration on the output side of the filter, or collapsed media.

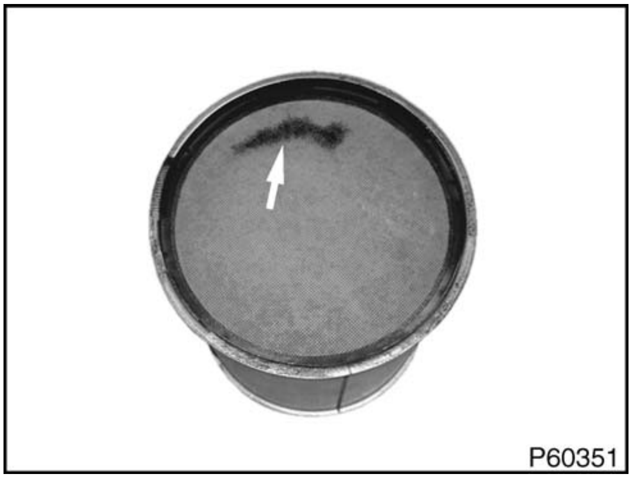


Figure 153 Damaged DPF

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

NOTE: Do not carry out the Aftertreatment Fuel Injector (AFI) Flow Test, Aftertreatment (AFT) System Leak Test or Aftertreatment Fuel Supply (AFS) valve Leak Test unless the vehicle fails the Aftertreatment (AFT) Cleanliness Test.

13. Compare EGDP sensor test result readings to pretest readings.
    - If a significant drop in the EGDP reading occurs, retest the performance complaint.
    - If a significant drop in EGDP reading does not occur, remove and inspect the DPF and DOC for signs of damage, plugged media or contamination. Clean the DPF following the procedures in the vehicle *Operator's Manual*. Verify the aftertreatment fuel system is operating correctly. See Aftertreatment Fuel Injector (AFI) Flow Test (page 173), Aftertreatment Fuel Supply (AFS) Valve Leak Test (page 176) and Aftertreatment (AFT) System Leak Test (page 174) in this section. Repeat the Aftertreatment Cleanliness Test.
    - If the Activation Regen fails a second time install a new DPF.

Possible Causes

- High DPF loading
- AFT sensor circuit faults or sensor failure
- DPF damage (cracked or leaking substrate)
- DPF contamination

7.2. Aftertreatment Fuel Injector (AFI) Flow Test

NOTE: Do not carry out this procedure unless referred here by the Aftertreatment Cleanliness Test.

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

Purpose

This test verifies the condition of the Aftertreatment Fuel Injector (AFI). The test runs for 60 seconds and injects fuel in a pulsing mist pattern. During this test the AFI injects approximately 177 ml (6 oz.) of fuel.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)

Procedure

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

NOTE: The engine should be relatively cool before carrying out this test.

1. See “Appendix A: Performance Specifications” in this manual for correct specification.
2. Remove the AFI from the exhaust manifold using the procedures in International® MaxxForce® 11 and 13 *Engine Service Manual*, except do not disconnect the fuel line, the coolant lines or the electrical connector from the AFI.

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

WARNING: To prevent personal injury or death, wear safety glasses with side shields when doing the following procedure.

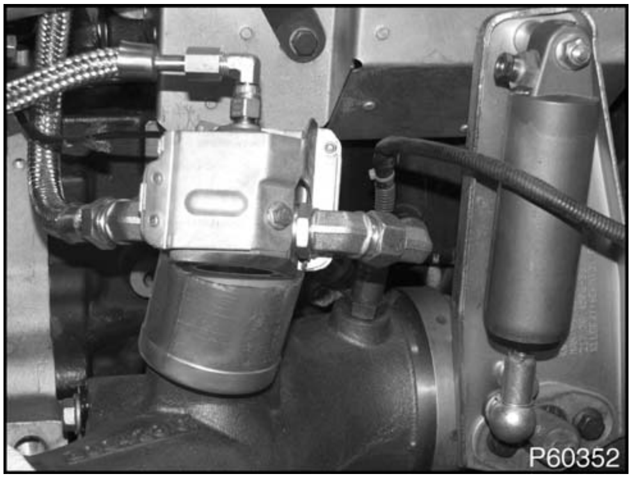


Figure 154 AFI

3. Position the AFI in a suitable metal container that can hold at least 296 mL (10 oz) of fuel.
4. Turn the ignition switch to ON.
5. Open COM device.
6. Open D_Aftertreatment.ssn session.
7. Start and idle the engine for two minutes.
8. Select the AFI Flow Test.
9. The test starts after 15 seconds and runs for 60 seconds. The AFI should inject fuel at a rate of 3 mL (0.1 oz)/second for a total of 177 mL (6 oz).
10. Monitor the fuel flow and spray from the AFI.
    - If the AFI does not spray any fuel, diagnose the AFI control circuits. See “Electronic Control Systems Diagnostics” in this manual. Install the AFI injector following the procedures in International® MaxxForce® 11 and 13 *Engine Service Manual*.
    - If the AFI does not spray the specified amount of fuel in a pulsed mist, install a new AFI following the procedures in the International® MaxxForce® 11 and 13 *Engine Service Manual*.
    - If the AFI is operating correctly, reinstall the AFI injector using a new AFI injector gasket using the procedures in International® MaxxForce® 11 and 13 *Engine Service Manual*. Proceed to next test.

Possible Causes

- Failed AFI
- AFI circuit faults

7.3. Aftertreatment (AFT) System Leak Test

NOTE: Do not carry out this procedure unless referred here by the Aftertreatment Cleanliness Test.

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

Purpose

This test verifies the AFI does not leak when de-energized, and there are no leaks in the fuel lines leading to the AFI. This test runs for 120 seconds. Once started the Aftertreatment Fuel Supply (AFS) valve is energized for 60 seconds, this may be verified by monitoring the Aftertreatment Fuel Pressure (AFP), and monitoring the AFI for any signs of fuel leakage. At the end of the first 60 seconds, the AFS valve is de-energized and the Aftertreatment Fuel Drain (AFD) valve is energized for 60 seconds, this drops the AFP to less than 7 kPa (1 psi).

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)

Procedure

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

1. See “Appendix A: Performance Specifications” in this manual for correct specification.
2. Start and idle the engine for two minutes.
3. Open COM device.

4. Open D_Aftertreatment.ssn session.
5. Select the AFT System Leak Test.
6. The test starts after 15 seconds and runs for two minutes. The test energizes the Aftertreatment Fuel Supply (AFS) valve for 60 seconds. After 60 seconds the test deenergizes the AFS valve and energizes the AFD valve for 60 seconds. The AFI should not leak any fuel.
7. Monitor the AFI fuel pressure and Engine Fuel Pressure (EFP) Parameter Identifiers (PIDs) during the test. The AFI fuel pressure should be within 34 kPa (5 psi) of the EFP sensor reading when the HC cut-off valve is energized and under 34 kPa (5 psi) when the AFD valve is energized.
8. If the test indicates a leak, inspect the aftertreatment fuel system for an external leak.
   - If an external leak is located, repair as necessary.
   - If an external leak is not located, proceed to the next step.
9. Remove the AFI from the exhaust manifold using the procedures in International® MaxxForce® 11 and 13 *Engine Service Manual*, except do not disconnect the fuel line or coolant lines from the AFI.
10. Using a clean shop rag, clean any fuel from the AFI tip.

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

WARNING: To prevent personal injury or death, wear safety glasses with side shields when doing the following procedure.

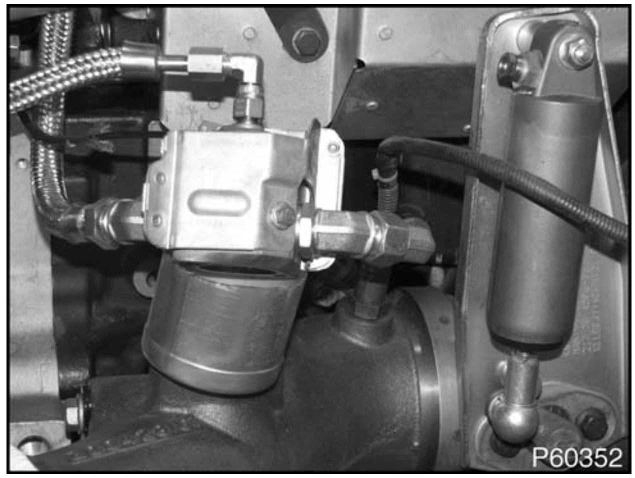


Figure 155 AFI

11. Position the AFI in a suitable metal container that can hold at least 296 mL (10 oz) of fuel.
12. Start and idle the engine for two minutes.
13. Open COM device.
14. Open D_Aftertreatment.ssn session.
15. Select the AFT System Leak Test.
16. The test starts after 15 seconds and runs for two minutes. The test energizes the AFS valve for 60 seconds. After 60 seconds the test deenergizes the AFS valve and energizes the AFD valve for 60 seconds. The AFI should not leak any fuel.
17. Monitor the AFI fuel pressure and EFP PIDs during the test. The AFI fuel pressure should be within 34 kPa (5 psi) of the EFP sensor reading when the AFS is energized and under 34 kPa (5 psi) when the AFD valve is energized.
18. Monitor the fuel flow from the AFI.
   - If the AFI does not leak or spray fuel, the HC cut-off valve is operating correctly. Install the AFI injector following the procedures in International® MaxxForce® 11 and 13 *Engine Service Manual*
   - If the AFI has fuel leakage (dripping), install a new AFI following the procedures in the International® MaxxForce® 11 and 13 *Engine Service Manual*.

- If the fuel supply assembly is leaking fuel, repair or replace the fuel supply assembly following the procedures in the International® MaxxForce® 11 and 13 *Engine Service Manual*. Install the AFI injector following the procedures in International® MaxxForce® 11 and 13 *Engine Service Manual*.

Possible Causes

- Failed AFI
- Failed AFS valve
- Failed AFD valve

7.4. Aftertreatment Fuel Supply (AFS) Valve Leak Test

NOTE: Do not do this procedure unless referred here by the Aftertreatment Cleanliness Test.

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

Purpose

This test verifies the Aftertreatment Fuel Supply (AFS) valve does not leak after it is closed. This test runs for 60 seconds, during which time AFS valve and the Aftertreatment Fuel Injector (AFI) are closed, and the Aftertreatment Fuel Drain (AFD) valve is opened.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)
- Fuel Inlet Restriction and Aeration Tool (page 449)

Procedure

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

1. See “Appendix A: Performance Specifications” in this manual for correct specification.
2. Remove fuel return line from HC cut off valve.
3. Connect Fuel Inlet Restriction and Aeration Tool to HC cut-off valve return port and route the open end into a suitable container that can hold at least 296 mL (10 oz) of fuel.

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

4. Start and idle the engine for two minutes.
5. Open COM device.
6. Open D_Aftertreatment.ssn session.
7. Select the AFS Leak Test.
8. The test starts after 15 seconds and will run for 60 seconds, the AFI should not inject any fuel.
9. Inspect the Fuel Inlet Restriction & Aeration Tool for fuel.
   - If the Fuel Inlet Restriction & Aeration Tool has continuous fuel flow, install a new HC cut off valve following the procedures in the International® MaxxForce® 11 and 13 *Engine Service Manual*. Retest the system.
   - If the Fuel Inlet Restriction and Aeration Tool does not have fuel in the tube, the system is operating correctly at this time.

Possible Causes

- Failed AFS valve
- AFS valve circuit faults

Special Tests

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

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

8. Relative Compression Test

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

Purpose

This test determines cylinder integrity. The Engine Control Module (ECM) measures the time it takes for each piston to travel upward during the compression stroke. Timing is based on information from the Camshaft Position (CMP) sensor and Crankshaft Position (CKP) sensor. A cylinder with low compression allows the piston to travel faster during the compression stroke.

This test is accomplished by cranking the engine and following the on-screen instructions. The engine does not start when running this test.

NOTE: Batteries must be fully charged before doing this test. If multiple tests are required, use a battery charger during the test to prevent battery drain.

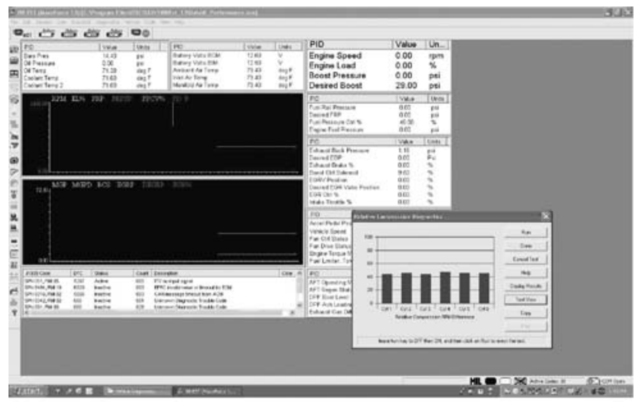
NOTE: If running a second test, wait two minutes between tests to allow the starter motor to cool.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)

Procedure

1. Turn ignition switch to ON. Do not start engine.
2. Open COM device.
3. Select IBB Relative Compression Test from Diagnostics drop-down menu.
4. Follow on-screen instructions.



P08280

Figure 156 Relative Compression Test Results

5. Record results on Engine Performance Form.
   - If Relative Compression Test or Injector Disable Test do not identify a suspect cylinder, no action is required.
   - If Relative Compression Test and Injector Disable test identify the same suspect cylinder, check for cylinder mechanical issue. Proceed to the next test.

   NOTE: If only the Injector Disable Test identifies a suspect cylinder, check for injector issue first.

Relative Compression Test Interpretation

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

Possible Causes

- Incorrect valve lash adjustment
- Loose fuel injector
- Valve train damage
- Power cylinder damage

9. Engine Run-up Test

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

Purpose

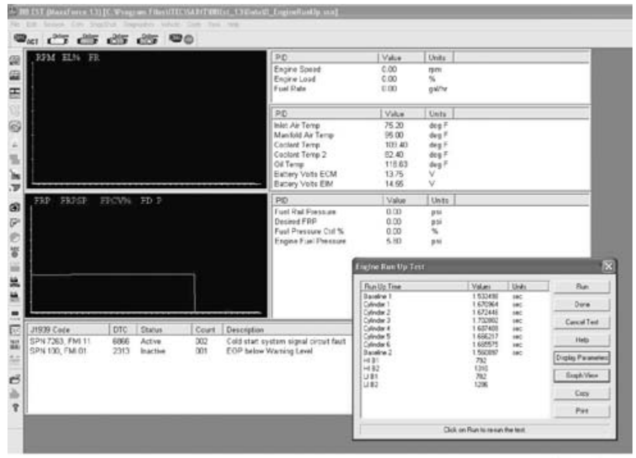
This test determines cylinder contribution. The engine accelerates from low engine idle to 1400 rpm and disables each of the injectors in sequence. A baseline test is run with all of the injectors enabled at both the beginning and end of the test.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)

Procedure

1. Start and idle the engine.
2. Open COM device.
3. Select IBB Engine Run-up Tests from the Diagnostics drop-down menu.
4. Follow the on-screen instructions.



P60359

Figure 157 Engine Run-up Test Results

5. Record results on Engine Performance Form.
   - If the engine run-up test does not identify a suspect cylinder, no action is required.
   - If the engine run-up identifies a suspect cylinder, check for cylinder mechanical issue.

Engine Run-Up Test Interpretation

The test results may be displayed in either numerical or graphical form. A problem cylinder has the same run-up period as the baseline test.

Possible Causes

- Incorrect valve lash adjustment
- Valve train damage
- Power cylinder damage
- Failed injector

10. Injector Disable Test

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

Purpose

This test is used to determine the contribution of each injector by manually disabling each of the injectors.

NOTE: The Injector Disable Test is used in conjunction with Relative Compression Test (page 177) and Engine Run Up Test (page 178) to distinguish between an injector problem or a mechanical problem.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)

Procedure

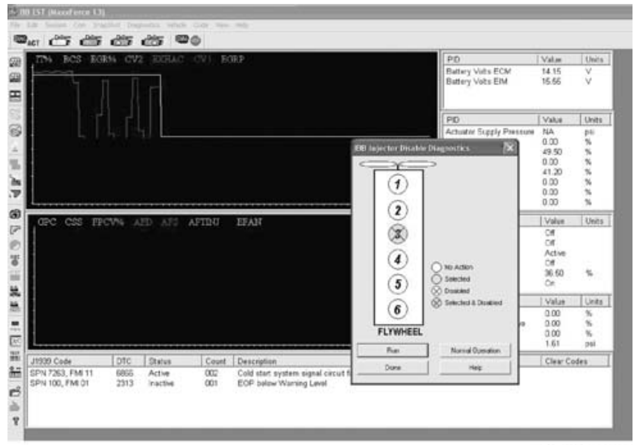
WARNING: To prevent personal injury or death, make sure the parking brake is set, the transmission is in neutral or park, and the wheels are blocked when running the engine in the service bay.

NOTE: Before doing this test, complete all preceding tests.

1. Turn ignition switch to ON.
2. Open COM device.
3. Start and idle the engine.
4. Select Diagnostics from menu bar.
5. Select IBB Injector Disable Tests from drop down menu.

   NOTE: Run Injector Disable Test only when engine temperature reaches 71 °C (160 °F) or higher.

   The Engine Oil Temperature (EOT) indicator changes from red to green when engine temperature reaches 71 °C (160 °F) or higher.



P60358

Figure 158 Injector Disable Test

6. Select cylinder number 1 and select Run. (Injector selected will be disabled and engine noise should change.)
7. Record results on Engine Performance Form.
8. Select Normal Operation. Injector will be enabled and engine noise should return to previous state of operation.
9. Repeat steps 6 and 7 for remaining 5 cylinders. Listen for tone changes from cylinder to cylinder.
   - If test does not identify a suspect cylinder, do Relative Compression Test (page 177) and Engine Run Up Test (page 178).
   - If test identifies a suspect cylinder, do Relative Compression Test (page 177) and Engine Run Up Test (page 178). Do not attempt to repair injectors without completing tests first.

Injector Disable Test Interpretation

Test interpretation is through a visual, or audible change in engine performance.

Possible Causes

- Open or short injector wiring
- Scuffed or failed injector
- Failed Engine Control Module (ECM)
- Power cylinder issue

11. High Pressure Pump Run-up Test

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

Purpose

This test determines the integrity of the low and high pressure fuel systems. This test does not identify a specific system component failure. The test accelerates the engine from idle speed to each of the following steps, 1100, 1300, 1450, and 1600 rpm. During each of these runs the high pressure fuel in the fuel rail is increased from 500 bar (7250 psi) to 1800 bar (26,100 psi), and then drops back to 500 bar (7250 psi). The Engine Control Module (ECM) monitors the time for fuel pressure to increase and drop back to the starting fuel pressure.

- Engine RPM during test; 1100, 1300, 1450, 1600 rpm.
- Fuel rail pressure increases during this test in increments of 1800 bar (26,100 psi).

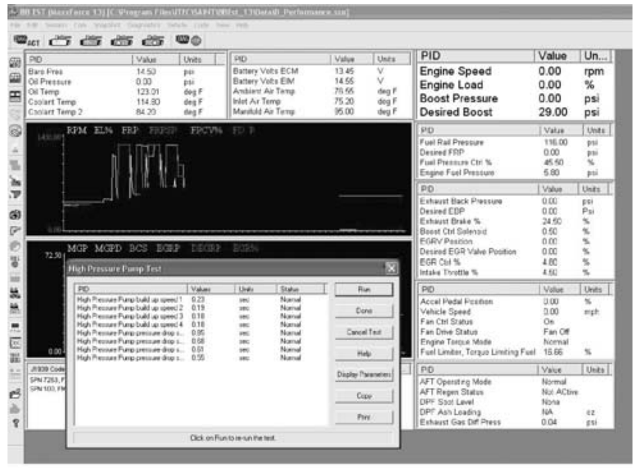
Results are displayed as cylinder status of normal, slow or fast during run-up.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)

Procedure

1. Start and idle the engine.
2. Open COM device.
3. Select IBB High Pressure Fuel Pump Tests from the Diagnostics drop-down menu.
4. Follow the on-screen instructions.



P60360

Figure 159 High pressure pump run-up test results

5. Record results on Engine Performance Form.
   - If the results of the test show the high pressure pump output is at specification at the 4 measurement points, no action is required.
   - If the results of the test show the high pressure pump output is below specification at any of the measurement points, diagnose the fuel system, do Low Pressure Fuel System (page 156) in this section and the High Pressure Fuel System (page 140) in the “Hard Start and No Start Diagnostics” section of this manual.

High Pressure Run-Up Test Interpretation

Test results are displayed in text only. Test results may be displayed as normal, slow, or fast. A normal indicates no problems with the fuel system. A fast or slow return indicates a problem which requires investigation of the low and high pressure fuel systems.

Possible Causes

- Fuel system issues

12. High Crankcase Pressure Test

Purpose

This test identifies the cause of high crankcase pressure. High crankcase pressure may cause oil leaks around the engine and/or failed engine seals.

NOTE: During extreme cold weather, there is a possibility the crankcase breather outlet can freeze if the heater circuit fails. A failed engine fan clutch in cold weather will accelerate freezing of the crankcase heater tube. Verify proper operation of the crankcase heater circuit. See Electronic Control Systems Diagnostics section in this manual.

Possible Causes

- Plugged service breather filter
- Failed air compressor, cracked or porous cylinder head
- Failed turbocharger(s), failed seals
- Cylinder damage
- Internal engine damage
- Icing and clogging of the service breather outlet heater
- Kinked or bent road draft tube

Tools

- Crankcase Pressure Test Adapter (ZTSE4039) (page 447)
- Gauge Bar Tool (ZTSE4408) (page 450)
- Slack Tube Manometer (ZTSE2217A) (page 452)

Procedure

NOTE: Be sure the engine is up to normal operating temperature, minimum 60 °C (140 °F) when running this test.

Figure 160 Breather Inlet tube assembly

1. Install wheel chocks on the vehicle’s wheels.
2. Release clamp, disconnect breather inlet tube assembly from service breather assembly.

NOTE: Do not plug Crankcase Pressure Adapter tool when measuring crankcase breather flow. Adapter should be allowed to vent to the atmosphere.

3. Install the Crankcase Pressure Adapter and Gauge bar to the inlet breather tube assembly.
4. Start and run the engine at high idle/no load.
5. Using the gauge bar, measure and record crankcase flow.
   - If crankcase flow is greater than 8 inches H_2O, reassemble the crankcase breather inlet tube, go to step 14.
   - If crankcase flow is less than or equal to 8 inches H_2O, go to the next step.
6. Before verifying crankcase pressure, inspect the crankcase breather system for any restrictions, damage to components, leaks, or clogged drain lines.

NOTE: When measuring crankcase pressure, be sure to plug the open-end of the Crankcase Pressure Test Adapter.

7. Measure crankcase pressure at the oil fill tube using the Crankcase Pressure Test Adapter and the Gauge Bar Tool.

8. Use the Gauge Bar tool to measure and record the crankcase pressure.
   - If the crankcase pressure is less than 14 H_2O, the system is operating correctly.
   - If the crankcase pressure is greater than 14 H_2O, install oil fill cap and go to next step.
9. Inspect and correct the following:
   - Check breather outlet tube and heater assembly for damage or blockage. Remove from cyclone breather and retest, if system test is good, replace breather outlet tube and heater assembly.
   - Check service breather element and oil drain lines for blockage. If blocked, replace service breather element and retest.
   - Check cyclone breather for blockage. If blocked, replace service breather element and retest CSP.

NOTE: With a protective cover installed on the crankcase breather system, signs of damage or blockage may not be visible.

If excessive oil or coking is present, replace the service breather element. See *Engine Operation and Maintenance Manual* for the service procedure. Retest once filter is changed.

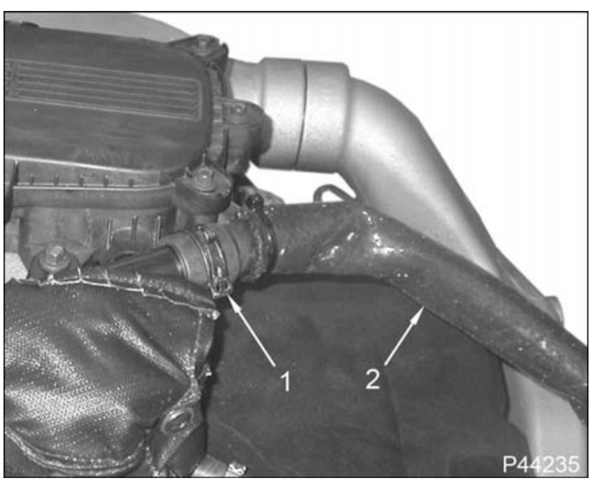


Figure 161 Breather outlet tube and heater assembly

1. Clamp
2. Breather outlet tube and heater assembly

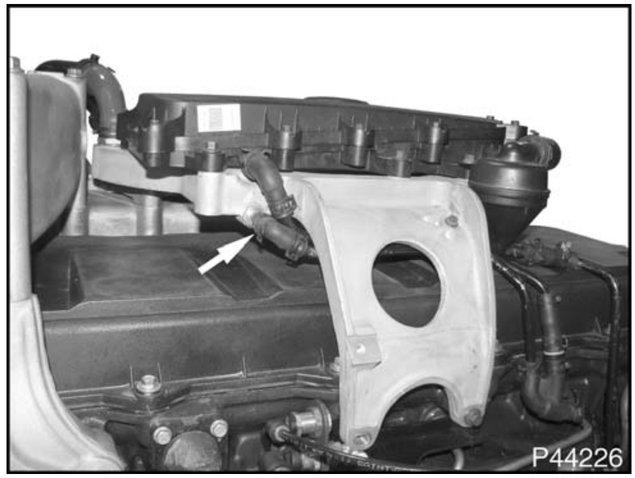


Figure 162 Upper tube assembly at lower fitting

10. Disconnect upper oil drain tube assembly from lower fitting on service breather assembly and plug the upper tube assembly.

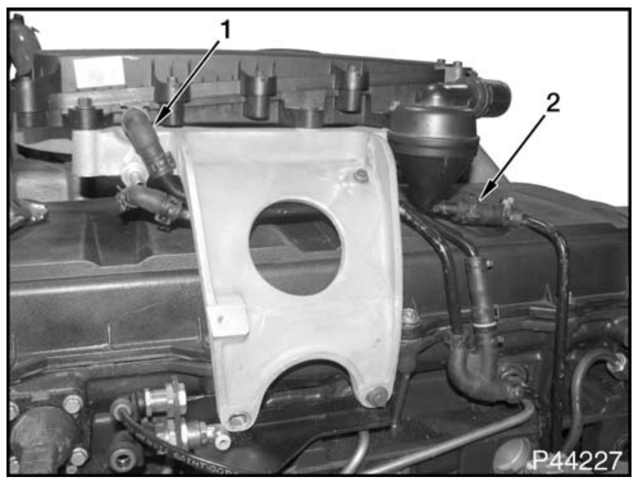


Figure 163 Upper tube assembly at upper fitting and middle tube assembly connections

1. Upper tube assembly
2. Middle tube assembly

11. Disconnect the upper tube assembly and the middle tube assembly from the service breather assembly.

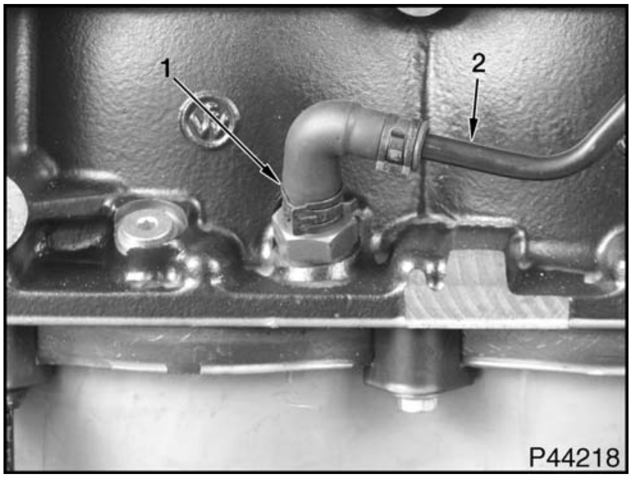


Figure 164 Lower tube assembly

1. Clamp
2. Lower tube assembly

12. Release clamp and disconnect the lower tube assembly from the M26 x 1.5 threaded union.
13. Test the check valves by applying regulated shop air 14-34 kPa (2-5 psi) to the lower tube assembly connection and inspect the open upper and middle tube assembly connections for air flow.
    - If any air flow is present, install a new upper or middle tube assembly as necessary.
    - If no air flow is present, proceed to next step.
14. Test the check valves by applying regulated shop air 14-34 kPa (2-5 psi) to the open upper and middle tube assembly connections and inspect the lower tube assembly connection for air flow.
    - If any air flow is present, proceed to next step.
    - If no air flow is present, install a new upper or middle tube assembly as necessary.
15. Install upper oil drain tube assembly.
16. Disconnect the air compressor from the unloader regulator located on the left front frame rail.
17. Start and idle the engine at the high idle/no load specification.
18. Using the Gauge Bar Tool, measure and record the crankcase pressure.
    - If the reading is within specification, install a new air compressor following procedures in the *Engine Service Manual*. Retest the system.
    - If the reading is above specification, proceed to next step.
19. Turn ignition switch to OFF.
20. Restore connection at unloader.

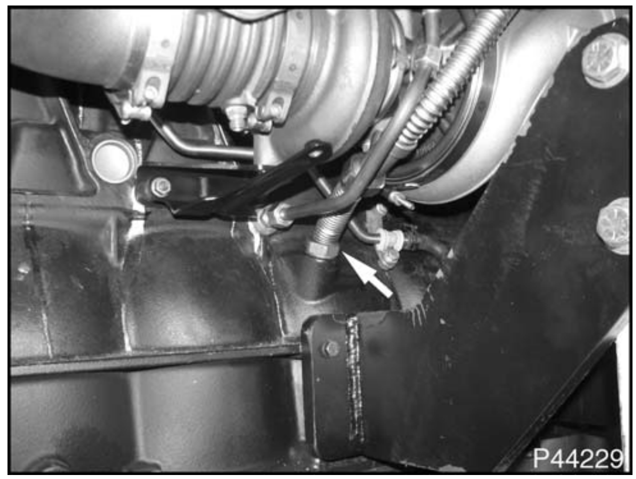


Figure 165 Low pressure turbocharger oil return pipe

21. Disconnect the low-pressure turbocharger oil return pipe nut from the crankcase and route the pipe into a clean 5 gallon bucket.
22. Plug the low pressure turbocharger oil return pipe nut port in the crankcase.
23. Start and idle the engine at the high idle/no load specification.

NOTE: Once the engine has been running at high idle, let the engine return to low idle before turning the ignition switch to OFF.

24. Using the Gauge Bar Tool, measure and record the crankcase pressure then quickly return engine to low idle and shut down engine to prevent excessive oil loss.
    - If the reading is within specification, install a new turbocharger assembly following procedures in the *Engine Service Manual*. Retest the system.
    - If the reading is above specification, proceed to next step.
25. Reinstall the low-pressure turbocharger oil return system.
26. Observe the Crankcase Pressure Test Adapter gauge fitting with the engine running at low idle.
    - If the engine has high crankcase pressure and heavy pulsations from the Crankcase Pressure Test Adapter gauge fitting, do the IBB relative compression test to isolate a scored cylinder. See Relative Compression Test (page 177).
    - If the engine has high crankcase pressure but does not have heavy pulsations from the Crankcase Pressure Test Adapter gauge fitting, proceed to the next step.
27. Inspect for leaks in the inlet piping between the air filter element and the low-pressure turbocharger.

    If leaks are located, the engine may be dusted (dirt ingestion into the engine) or the piston rings worn causing compression loss. Proceed to next step.

NOTE: Call Technical Central before removing the cylinder head. Contact 1 800 336-4500 for further information.

28. Remove the cylinder head following the procedures in the *Engine Service Manual*.
29. Inspect the cylinder liners for polishing.

    If the cylinder wall hatch marks are polished off the cylinder liner, the engine needs to be rebuilt. See the procedures in the *Engine Service Manual*.

Possible Causes

- Air compressor
- Turbocharger(s)
- Cylinder damage
- Internal engine damage
- Restricted crankcase breather system

13. Exhaust Restriction

Purpose

To check for exhaust system restrictions.

Tools

- Electronic Service Tool (EST) with MasterDiagnostics® software (page 445)
- IC4 USB interface cable (page 445)

Procedure

1. See "Appendix A: Performance Specifications" in this manual for Exhaust Restriction specifications and record on Engine Performance Form.
2. Turn the ignition switch to ON.
3. Open COM device.
4. Open D_AirManagement.ssn session.
5. Disconnect the Exhaust Gas Recirculation (EGR) control valve connector during the test. Ignore the Diagnostic Trouble Code (DTC) that sets.

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.

6. Run engine at high idle, no load.
7. Record Exhaust Back Pressure (EBP) on Engine Performance Form.
   - If EBP is in specification, reconnect EGR control valve and clear DTCs. No repair is required.
   - If EBP is above specification, continue to next step.
8. Remove exhaust pipe from turbo exhaust pipe and test again.
   - If EBP is in specification, reconnect EGR control valve, clear DTCs, and repair issue between turbocharger outlet and tailpipe.
   - If EBP is above specification, reconnect exhaust pipe, reconnect EGR control valve, clear DTCs, and repair issue with turbocharger(s).

Possible Causes

- Damaged or biased EBP sensor
- Restricted or collapsed exhaust piping
- Restricted or damaged exhaust components
- Turbocharger issue

14. Valve Lash and Retarder Lash

The valve lash and retarder lash cannot be verified through simple measurement. Adjust the valve lash and retarder lash following the complete procedure in the International® MaxxForce® 11 and 13 *Engine Service Manual*.