Table of Contents

Description

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

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

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

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

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

Diagnostic Form Information

Figure 165 Diagnostic Form EGED-290-1 (Hard Start and No Start Diagnostics side)

Diagnostic Form EGED-290-1 is available in 50 sheet pads. To order technical service literature, contact your International dealer.

Test Procedures

1. Initial Ignition Switch ON (Do not start)

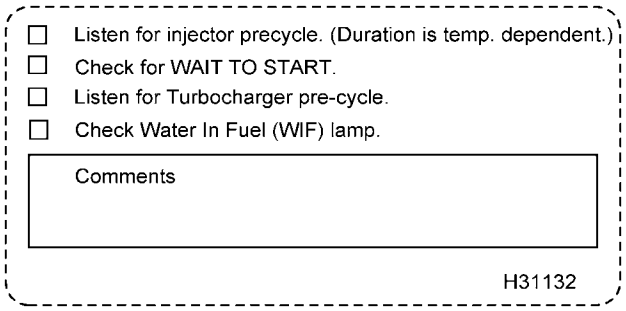

Figure 166

Purpose

To determine the following:

- Is the Injector Drive Module (IDM) powered up?
- Is the Electronic Control Module (ECM) powered up?
- Is water in the fuel?

Tools

- None

Procedure

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

1. Turn ignition switch to ON. (Do not start the engine.) Check or listen for the following:
   - WAIT TO START lamp
   - WATER IN FUEL lamp (If the Water In Fuel lamp comes on, check for water in fuel filter housing.)
   - Injector pre-cycle (Shop noise can drown out the sound of injector pre-cycle.)
   - Turbocharger pre-cycle

   NOTE: Do not mistake the sound of the instrument panel cycle self-test or the Antilock Brake System (ABS) self-check for injector or turbocharger pre-cycle.
2. If pre-cycle noise was not heard or missed, cycle the ignition switch and listen again.
   - If pre-cycle noise is still not heard, the ECM may not be powered up. Check for DTCs. If the EST is not communicating with the ECM, see Electronic Control Module Power (ECM PWR) in Section 7 (page 381).
   - If injectors did not pre-cycle, the IDM may not be powered up. Check DTCs and 12–way connector.
   - If the water in fuel light is on, check for water in the fuel system. Drain water from the fuel filter housing. Verify that the fuel source is not contaminated.
   - If the turbocharger did not pre-cycle, there may be an open circuit. Check the engine 12–way connector. Check for DTCs.
   - If the turbocharger and injector pre-cycle, and the WAIT TO START lamp and WATER IN FUEL lamp come on and off, continue to the next diagnostic test.

Possible Causes

No injector pre-cycle

- No key power (v_{IGN})
- Failed IDM ground circuit
- No power from main power relay to IDM.
- ICP sensor bias high (above 3.45 MPa [500 psi])
- Failed ECM ground circuit
- No power from main power relay to ECM
- CAN 2 link is not working.
- IDM failure
- ECM failure

WAIT TO START lamp does not illuminate

- No key power (v_{IGN})
- Failed ECM ground circuit
- No power from main power relay to ECM
- ECM failure
- Amber WAIT TO START lamp is out (will not cause hard start or no start).

- CAN 1 link to instrument panel is not working (will not cause hard start or no start).

No turbocharger pre-cycle

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

WATER IN FUEL lamp illuminates

- Water in fuel
- Electrical circuit failure

2. Engine Cranking

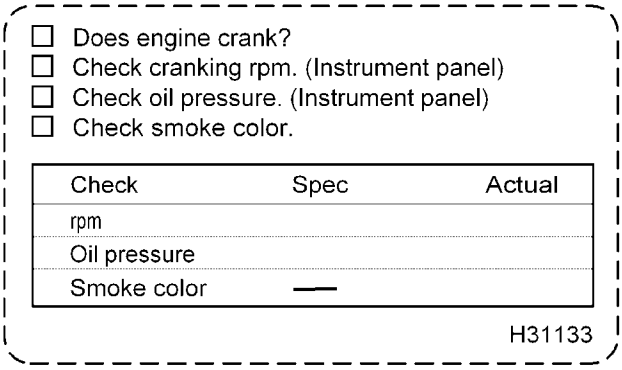

Figure 167

Purpose

To determine the following:

- Does the crankshaft rotate?
- Does the instrument panel receive a signal from the Electronic Control Module (ECM) and is rpm sufficient?
- Is oil pressure sufficient?
- Is fuel getting into the cylinders?

Tools

- None

Procedure

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

1. See "DT 466 Performance Specifications" – Appendix A (page 595) or "DT 570 and HT 570 Performance Specifications" – Appendix B (page 619) for specifications, and enter data in spec column for rpm and oil pressure on Diagnostic Form.
2. Turn the ignition switch to START.

   NOTE: If equipped, push optional push button to crank engine.
3. Check rpm on instrument panel. Record results on Diagnostic Form.
   - If engine speed is below specification, the engine will not start. Check batteries and DTCs if engine seems to be turning over fast enough to start and no rpm is noticed on instrument panel.
4. Check oil pressure (instrument panel). Record results on Diagnostic Form.
   - If oil pressure does not build while cranking the engine, oil may not be feeding the high-pressure oil system. Check oil level.
5. Check for exhaust smoke and record color on Diagnostic Form.

   NOTE: Typically smoke indicates that fuel is getting into the cylinders. However, fuel pressure should be measured to ensure sufficient fuel supply.
   - If there is no smoke from the exhaust during engine crank, fuel may not be getting to the engine cylinders. See "Priming the Fuel System" in Section 4 (page 132) for procedure.

Possible Causes

Engine will not turn over

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

- Cylinder mechanical lock (timing incorrect; valve/piston contact)

Insufficient rpm

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

Insufficient oil pressure

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

Excessive exhaust smoke with hard start or no start concern

- Poor fuel quality
- Insufficient cylinder temperature
- Loose injector
- Low compression
- Inoperable inlet air heater system – if equipped
- Excessive air inlet or exhaust restriction
- Damaged injector – split tip
- Base engine timing incorrect
- Combustion leak to fuel

No exhaust smoke / cylinders not receiving fuel

- Fuel supply system concern
- ECM and IDM communication failure
- ICP sensor bias high (above 3.45 MPa [500 psi])
- Combustion leak to fuel supply (fuel rail)
- Base engine timing incorrect

3. Diagnostic Trouble Codes

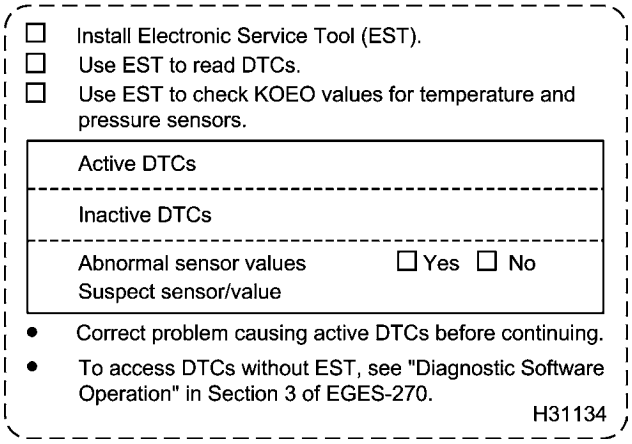

Figure 168

Purpose

- To determine if the ECM has detected Diagnostic Trouble Codes (DTCs) indicating conditions that could cause engine problems
- To fill out Diagnostic Form heading
- To check for abnormal sensor readings

Tools

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

Vehicle Information for Form Heading

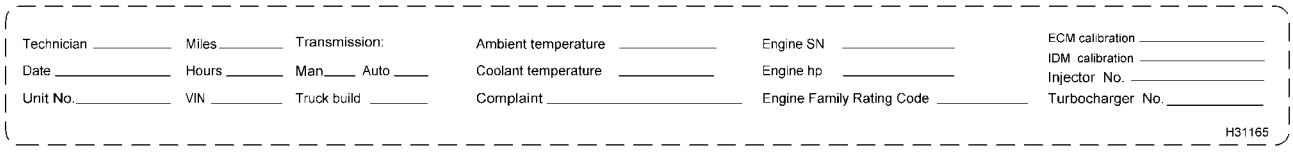

Figure 169

NOTE: Before continuing diagnostic tests, fill out the form heading on Diagnostics Form EGED-290.

Entering Vehicle Information without using the EST

1. Enter the following information in the form heading:
   - Technician
   - Date (for warranty)
   - Unit No (dealer's quick reference for customer's vehicle identification)
   - Truck build (date)
   - Complaint (for warranty)

2. Do the following procedure “Entering Vehicle Information using the EST” to complete the rest of the form heading:

Entering Vehicle Information using the EST

Figure 170 American Trucking Association (ATA) connector

Figure 171 EZ-Tech® interface cable

Figure 172 EZ-Tech® interface cable

⚠ WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the “Safety Information” section of this manual.

1. Connect the EZ-Tech® interface cable to the EST and the ATA connector.
2. Boot-up EST.

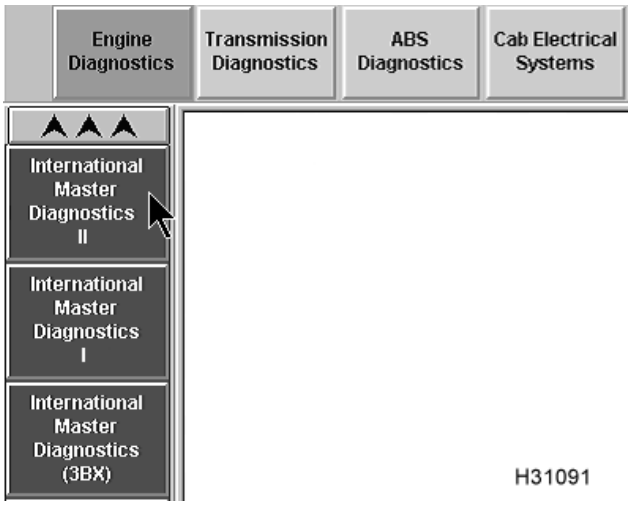

Figure 173 International® launchpad

3. Select Engine Diagnostics, then International® MasterDiagnostics® II.

4. Turn the ignition switch to ON.

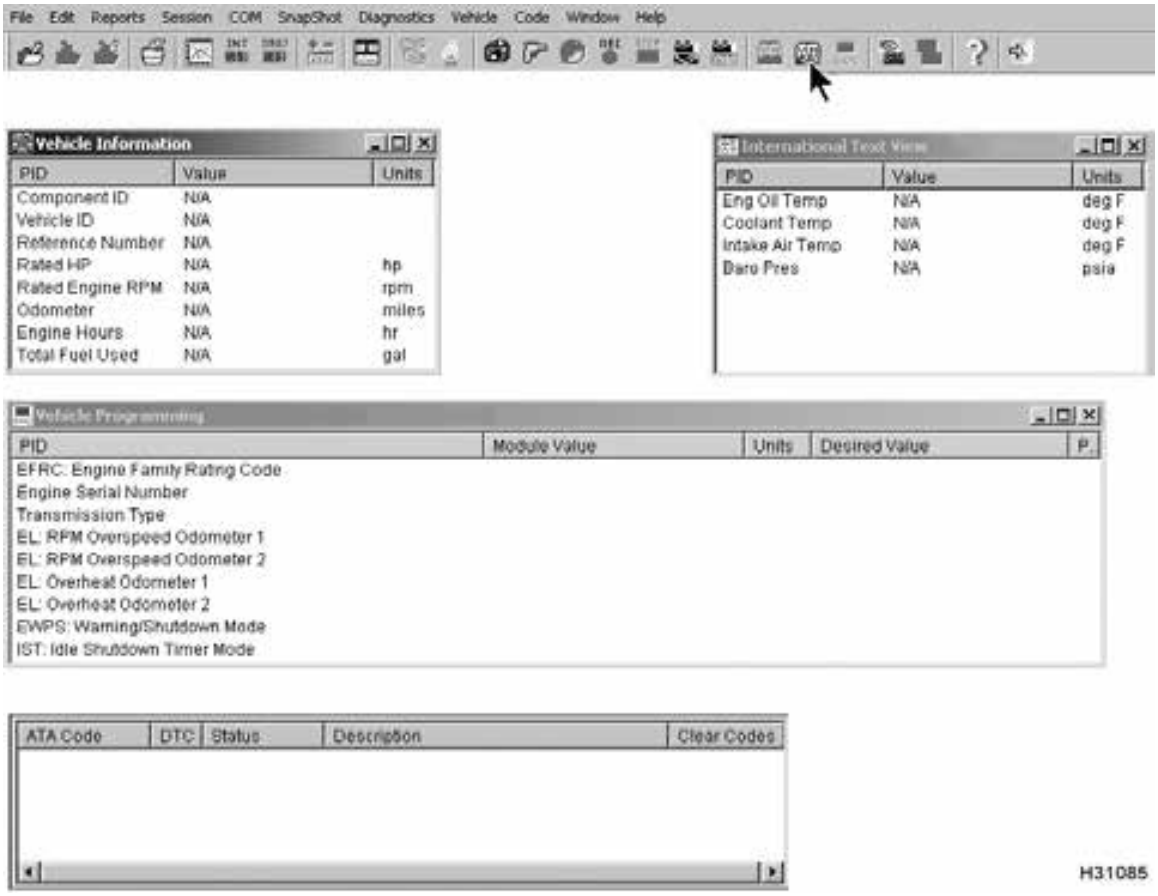

Figure 174 Open VIN+ session

5. Select VIN+ icon to open VIN+ session.
6. Use the on-screen information and the following “Information List” to complete the form heading.

Table 1

Heading Information	VIN+ session PID
Miles	Odometer
Hours	Engine Hours
VIN	Vehicle ID
Transmission	Transmission Type
	Manual Non-Isochronous
	Manual Isochronous
	Allison AT/MT
	Allison MD
Ambient temperature	Intake Air Temp
Coolant temperature.	Coolant Temp
Engine SN	Engine Serial Number
Engine HP	Rated HP
Engine Family Rating Code	EFRC: Engine Family Rating Code
ECM calibration	Reference Number
(Example for reference only)	PRE1PJ02
	(First group)
IDM calibration	Reference Number
(Example for reference only)	ANZKLA02
	(Second group)

Information List

- Miles (for warranty)
- Hours (for warranty)
- VIN (for warranty, ordering parts, and service information) The Vehicle Identification Number is also on the door jamb on the operators side.
- Transmission: Manual/Auto
- Ambient temperature
- Coolant temperature
- Engine SN (for ordering parts and service information)

  The engine serial number is stamped on a crankcase pad on the right side of the crankcase below the cylinder head. The engine serial number is also on the engine emission label on the valve cover.

  Compare the Engine SN in the Vehicle Programming window of the VIN+ session with the Engine SN on the engine. The engine could have been replaced without a programming change to the ECM to upgrade the Engine SN.
- Engine HP (for correct engine application)
- Engine Family Rating Code (for warranty)
- ECM calibration
- IDM calibration

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

- Injector No. (requires removal of valve cover and high-pressure oil rail)
- Turbocharger No. (Check for plate on turbocharger – may require removal of paint from plate)

Accessing DTCs

WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the “Safety Information” section of this manual.

NOTE: When opening VIN+ session to fill out form heading, the DTC window automatically appears.

NOTE: If an EST is not available, see “Accessing DTCs” in Section 3 .

Figure 175 DTC window

1. Record all DTCs from DTC window on Diagnostic Form. See “Diagnostic Trouble Codes” – Appendix C (page 643) for DTCs.
2. Correct problem causing active DTCs before continuing.
3. Clear DTCs.
4. Use EST to check KOEO values for temperature and pressure sensors. Record results on Diagnostic Form.
    - If engine has not been run for 8 to 12 hours, the Engine Coolant Temperature (ECT), Engine Oil Temperature (EOT), and Manifold Air Temperature (MAT) should be within 2 °C (5 °F) of each other. The Intake Air Temperature (IAT) could be a few degrees higher or lower due to faster outside engine temperature change.
    - The Injection Control Pressure (ICP) and Brake Control Pressure (BCP) values may fluctuate as much as 345 kPa (50 psi). Electromagnetic Interference (EMI) or ground shift can cause an insignificant voltage shift that does not indicate a problem.
    - Engine Oil Pressure (EOP), Manifold Air Pressure (MAP), and Exhaust Back Pressure (EBP) values may fluctuate as much as 7 kPa (1 psi). Electromagnetic Interference (EMI) or ground shift can cause an insignificant voltage shift that does not indicate a problem.
    - Barometric Absolute Pressure (BAP) values should equal the barometric reading for your region.
    - Are values normal?
    - If abnormal values are suspected, record on Diagnostic Form and see Operational Voltage tables in Section 7 (page 283) for applicable sensor.
5. Continue with KOEO Standard Test.

Reading DTCs

ATA code: Codes associated with a Subsystem Identifier (SID), Parameter Identifier (PID), and Failure Mode Indicator (FMI)

DTC: Diagnostic Trouble Code

Status: Indicates active or inactive DTCs

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

Description: Defines each DTC

Possible Causes

- Electronics failure
- Failure of the ICP sensor or ICP system
- Failure of the Air Management System (AMS)
- Failure of Diamond Logic® engine brake

4. KOEO Standard Test

☐ Use EST to run KOEO Standard Test.

Active DTCs

- Correct problem causing active DTCs before continuing.
- To do KOEO Standard Test without EST, see "Diagnostic Software Operation" in Section 3 of EGES-270.

H31135

Figure 176

Purpose

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

Tools

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

NOTE: If an EST is not available, see “Standard Test Using Cruise Switches” in Section 3 (page 72).

Procedure

WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the “Safety Information” section of this manual.

1. Set parking brake to ensure the correct signal from the Electronic System Controller (ESC).
2. Turn the ignition switch to ON. (Do not crank engine.)

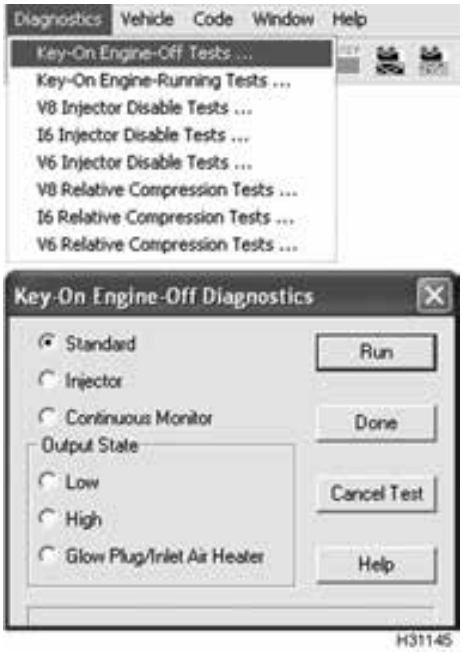

Figure 177 KOEO Standard Test

3. Select Diagnostics from the menu bar.
4. Select Key-On Engine-Off Tests from the drop down menu.

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

5. From the KOEO Diagnostics menu, select Standard, then select Run to start the test.

   The ECM will complete an internal self-test and an OCC. When the OCC is over, the DTC window will show DTCs, if there is a problem.

   NOTE: This test takes less than 5 seconds. While the test is running, the MasterDiagnostics® screen displays message Diagnostics Running .
6. Record all DTCs on Diagnostic Form. See “Diagnostic Trouble Codes” – Appendix C (page 643) for DTCs.
7. Correct problem causing active DTCs.
8. Clear DTCs.

Possible Causes

- Failed electrical components or circuitry

- OCC fault for the IPR valve or brake shut-off valve (if equipped)
- Inlet Air Heater (IAH)
  - — For initial calibrations, if the system voltage is less than 13 volts, DTC 251 may become active.
  - — Later calibrations and current hardware levels do not support DTC 251.

5. KOEO Injector Test

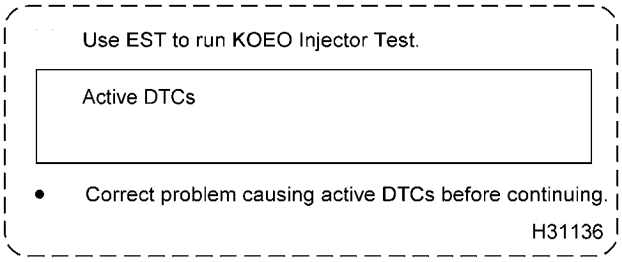

Figure 178

Purpose

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

Tools

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

Procedure

WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

NOTE: The KOEO Injector Test can only be done with the EST using MasterDiagnostics® software.

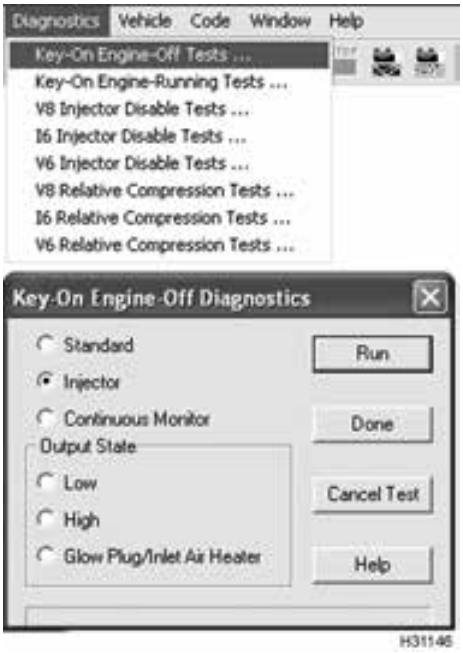

Figure 179 KOEO Injector Test

1. Select Diagnostics from the menu bar.
2. Select Key-On Engine-Off Tests from the drop down menu.

   NOTE: When using the EST to do KOEO or KOER diagnostic tests, Standard Test is always selected and run first. If the ignition switch is not cycled, the Standard Test does not have to be run again.
3. From the KOEO Diagnostics menu, select Injector, then select Run to start the test.

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

   The DTC window will show DTCs for electrical problems.
4. Record DTCs on Diagnostic Form. See "Diagnostic Trouble Codes" – Appendix C (page 643) for DTCs.
5. Correct problem causing active DTCs.
6. Clear DTCs.

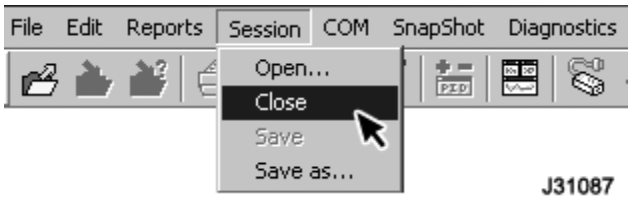

Figure 180 Close session

7. When finished with this test, close the VIN+ session. Select Session from menu bar, then Close.

Possible Causes

- Injector wiring harness open or shorted
- Under Valve Cover (UVC) wiring
- Valve cover gasket
- Faulty wiring harness connection on injector coil
- Failed injector coil
- Failed Injector Drive Module (IDM)
- Failed ECM (not sending test request to IDM)

Hard Start and No Start Only

- Faulty wiring CAN2 datalink
- Faulty wiring IDM power and ground
- Faulty wiring IDM main power relay

6. EST Data List

☐ Monitor KOEO values and enter in KOEO column.
☐ Enter data in the Cranking Spec column.
☐ Crank engine and monitor DATA for 20 seconds. (See note 4.)
☐ Enter data in the Cranking Actual column.

PID	KOEO	Cranking Spec	Cranking Actual
VBAT			
RPM			
ICP			
EOP			
EGRP			
BCP (if equipped)			

- If voltage is below spec, see "ECM Self Diagnostics" - Section 7.
- If no rpm is noted, check DTCs.
- If ICP is below spec, do "Low ICP System Pressure" - Test 14.
- If EOP is below spec, see "Engine Symptoms Diagnostics" - Section 4.
- EGRP should equal 0.
- If BCP is out of range, see "BCP Sensor" - Section 7.

H31138

Figure 181

Purpose

To determine if engine systems meet operating specifications to start engine

Monitoring Engine Systems using an EST

Tools

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

Procedure

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

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

Batteries must be fully charged before doing the following steps.

1. See "DT 466 Performance Specifications" – Appendix A (page 595) or "DT 570 and HT 570 Performance Specifications" – Appendix B (page 619) for specifications, and record on Diagnostic Form.

Figure 182 D_HardStart_ NoStart.ssn

2. Open D_HardStart_NoStart.ssn to monitor engine operation.
3. Turn the ignition switch to ON.
4. Record KOEO readings on Diagnostic Form.
5. Crank engine for 20 seconds and read EST to measure VBAT, RPM, ICP, EOP, EGRP, and BCP.
6. Record readings on Diagnostic Form.
   - Battery voltage must be 7 V or more. If voltage to the ECM drops below 7 V, the ECM will not remain powered up.

     Note: If the battery volt (VBAT) PID is less than actual battery voltage or the EST is not communicating with the ECM, see Electronic Control Module Power (ECM PWR) in Section 7 (page 381).
   - Engine cranking speed must generate the required injection control pressure to operate the fuel injectors and create required compression to ignite the fuel.

- If the EST shows 0 rpm during engine cranking, the ECM may not be receiving a signal from the Crankshaft Position (CKP) sensor or Camshaft Position (CMP) sensor. The ECM will not send the fueling command to the IDM without a correct CKP or CMP signal. See CKP sensor (page 351) and CMP sensor (page 355) in Section 7.
- If the EST indicates low or no injection control pressure, do Test 14 – “Low ICP System Pressure” (page 186).

  If the ICP sensor is biased high, see “ICP Sensor” in Section 7 (page 457).
- If oil pressure is low, the ICP system may not be receiving enough oil.
- If EGR valve is open at start-up it can disrupt the air fuel mixture enough to inhibit engine operation.
- BCP values may fluctuate as much as 345 kPa (50 psi). Electromagnetic interference (EMI) or ground shift can cause an insignificant voltage shift that does not indicate a problem. If above 7 MPa (1000 psi), brake actuation may occur. If over 345 kPa (50 psi), ICP operation may be inhibited for fuel injectors.

Possible Causes

Low battery voltage

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

Low cranking rpm

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

Low Injection Control Pressure

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

Low oil pressure

- Failed oil pressure regulator relief valve
- Failed gerotor oil pump or front cover
- Failed pickup tube or gasket
- Internal lube oil pressure leak

EGR valve

- Stuck or inoperative valve

BCP

- Inoperative brake shut-off valve
- Failed BCP sensor
- Failed BCP sensor wiring
- Porosity or sand hole in high-pressure oil rail (injector oil gallery to brake oil gallery)

Monitoring ICP using VC Gasket Breakout Harness

NOTE: Do this procedure, if an EST is not available. This is an alternate method.

Tools

- VC Gasket Breakout Harness
- Digital Multimeter (DMM)

Procedure

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

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

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

1. See "DT 466 Performance Specifications" – Appendix A (page 595) or "DT 570 and HT 570 Performance Specifications" – Appendix B (page 619) and Section 7 for specifications, operational voltages, and values. Record on Diagnostic Form.

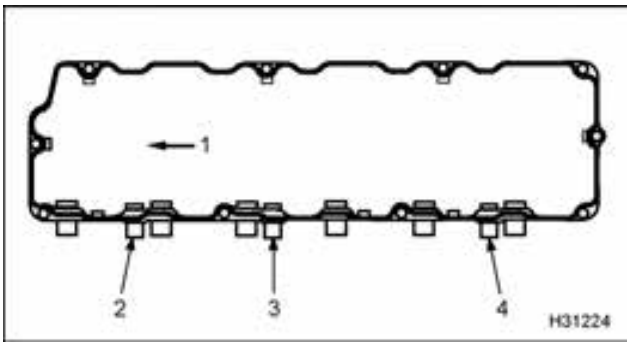

Figure 183 Valve cover gasket

1. Front of engine
2. Pass-through connector for BCP sensor
3. Pass-through connector for brake shut-off valve
4. Pass-through connector for ICP sensor

2. Disconnect engine harness connector from pass-through connector for ICP sensor.

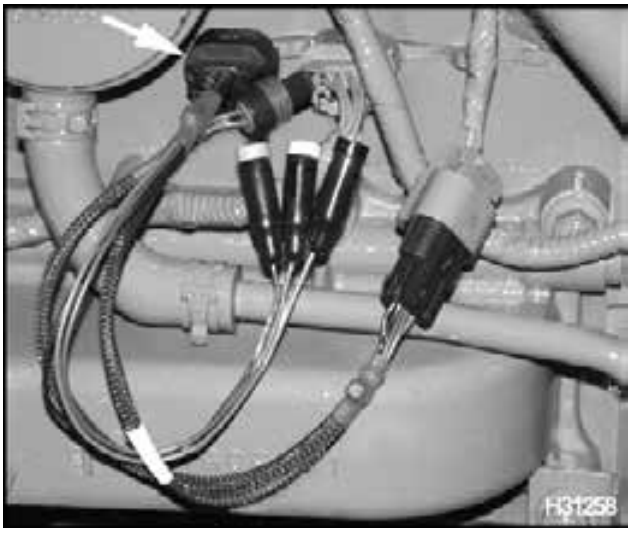

Figure 184 VC Gasket Breakout Harness connector to pass-through connector for ICP sensor

3. Connect VC Gasket Breakout Harness to pass-through connector and engine harness.

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

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

4. Use DMM to measure injection control pressure (ICP signal voltage) KOEO.
   - Connect POS to green (signal circuit) and NEG to black (signal ground).
5. Record KOEO reading on Diagnostic Form.
6. Take another measurement while cranking the engine for 20 seconds.
7. Record reading on Diagnostic Form.
   - If ICP voltage is out of specification at KOEO only, see "ICP Sensor" in Section 7 (page 457).

- If ICP voltage is out of specification at engine crank only, do Test 14 – “Low ICP System Pressure” (page 186).
- If ICP voltage is in specification at KOEO and builds to cranking voltage during engine crank, continue to “Monitoring BCP using VC Gasket Breakout Harness” test

Monitoring BCP using VC Gasket Breakout Harness

NOTE: Do this procedure, if an EST is not available. This is an alternate method.

Tools

- VC Gasket Breakout Harness
- Digital Multimeter (DMM)

Procedure

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

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

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

NOTE: BCP should be zero, when engine brake is inactive. BCP values may fluctuate as much as 50 psi. Electromagnetic Interference (EMI) or ground shift can cause an insignificant voltage shift that does not indicate a problem. This should be equal to KOEO BCP signal voltage.

1. See "DT 466 Performance Specifications" – Appendix A (page 595) or "DT 570 and HT 570 Performance Specifications" – Appendix B (page 619) and Section 7 for specifications, operational voltages, and values. Record on Diagnostic Form.

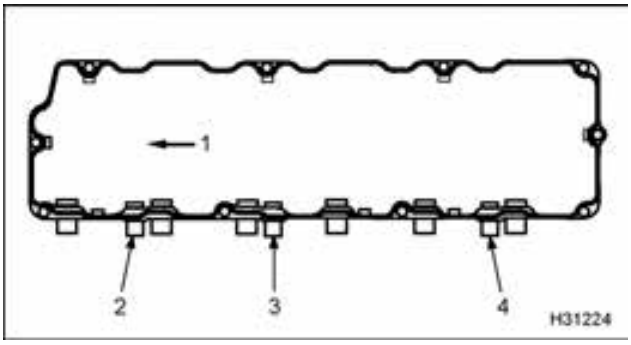

Figure 185 Valve cover gasket

1. Front of engine
2. Pass-through connector for BCP sensor
3. Pass-through connector for brake shut-off valve
4. Pass-through connector for ICP sensor

2. Disconnect engine harness connector from the pass-through connector for the BCP sensor.

Figure 186 VC Gasket Breakout Harness to pass-through connector for BCP sensor

3. Connect VC Gasket Breakout Harness to pass-through connector and engine harness.

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

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

4. Use DMM to measure brake control pressure (BCP signal voltage) KOEO.
   - Connect POS to green (signal circuit) and NEG to black (signal ground).
5. Record KOEO reading on Diagnostic Form.
6. Take another measurement while cranking engine for 20 seconds.
7. Record reading on Diagnostic Form and compare KOEO reading.
   - If BCP cranking signal voltage is significantly more than KOEO BCP signal voltage, when engine brake is inactive, diagnose BCP sensor, circuit, and engine brake components.
   - If BCP cranking signal voltage is equal to KOEO BCP, signal voltage BCP is not a problem.

Monitoring EOP at EOT Sensor Port

NOTE: Do this procedure, if an EST is not available. This is an alternate method.

Tool

- Gauge bar (0 - 160 psi gauge)
- ICP system test adapter (VT 365)
- Test hose assembly
- Socket or wrench (EOT sensor removal and installation)

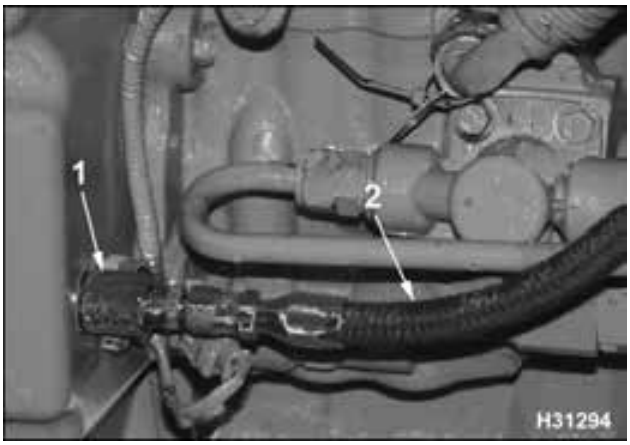

Figure 187 ICP test adapter and test hose assembly

1. ICP system test adapter
2. Test hose assembly

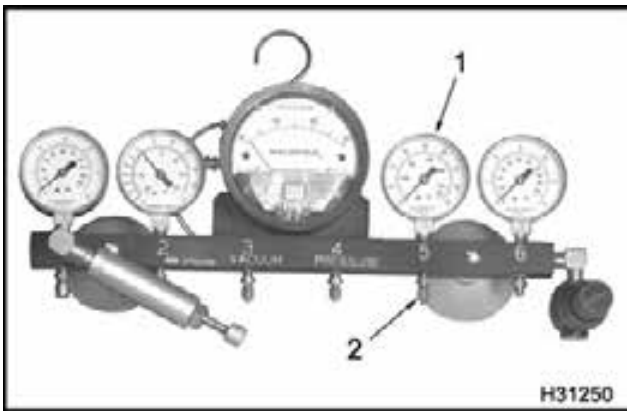

Figure 188 Test hose connection to 0 - 160 psi gauge

1. 0 - 160 psi gauge
2. Test hose connection

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

1. See "DT 466 Performance Specifications" – Appendix A (page 595) or "DT 570 and HT 570 Performance Specifications" – Appendix B (page 619) and Section 7 for specifications, operational voltages, and values. Record on Diagnostic Form.
2. Make a test hose that will connect the ICP system test adapter to the gauge bar or equivalent gauge.
3. Connect test hose to ICP adapter.
4. Remove the EOT sensor from the front cover. **Oil will spill out. Catch oil in container. Quickly install ICP system adapter and test hose assembly. Position hose so oil will not drain out.** If oil does not spill out of the EOT port, oil supply is the problem.

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

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

5. Connect test hose to gauge bar (0-160 psi gauge) or equivalent gauge.
6. Crank engine for 20 seconds and monitor EOP.
7. Record pressure on Diagnostic Form.
   - If oil pressure is below specification, diagnose lube oil pressure system, see Section 4 – "Engine Symptoms Diagnostics" (page 101).
   - If oil pressure is at specification, remove test hose and gauge bar. Quickly remove ICP system adapter and test hose assembly. **Oil will spill out. Catch oil in container** and install EOT sensor. Follow the procedure in *Engine Service Manual*.

Monitoring Engine Systems using Breakout Box

NOTE: Do this procedure, if an EST is not available. This is an alternate method.

Tools

- Breakout Box
- Digital Multimeter (DMM)

Procedure

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

1. See "DT 466 Performance Specifications" – Appendix A (page 595) or "DT 570 and HT 570 Performance Specifications" – Appendix B (page 619) and Section 7 for specifications, operational voltages, and values. Record on Diagnostic Form.
2. Turn the ignition switch to OFF and ensure all accessories are turned off.
3. Remove X1, X2 and X3, X4 connectors from ECM.

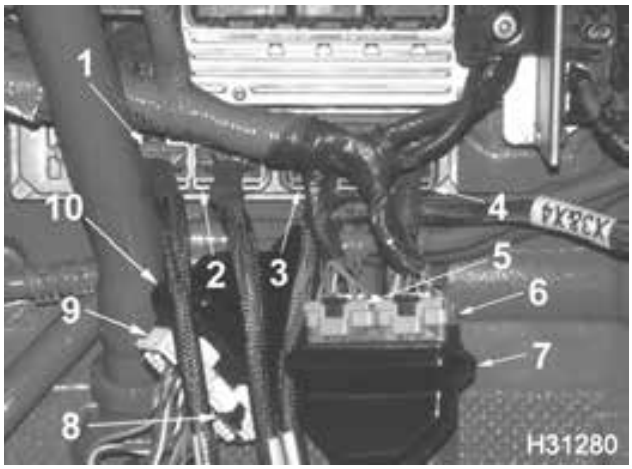

Figure 189 Engine and chassis breakout box connections

1. Breakout box connector X4 to ECM
2. Breakout box connector X3 to ECM
3. Breakout box connector X2 to ECM
4. Breakout box connector X1 to ECM
5. Engine wiring harness ECM connector X2 to breakout box header
6. Engine wiring harness ECM connector X1 to breakout box header
7. Breakout box header X1 and X2 engine to breakout box
8. Chassis wiring harness connector to breakout box header
9. Chassis wiring harness connector to breakout box header
10. Breakout box header X3 and X4 breakout box to chassis

4. Connect breakout box connectors X1, X2 and X3, X4 to ECM.
5. Connect wiring harness connectors to breakout box headers X1, X2 and X3, X4.

Figure 190 Breakout box

6. Connect DMM leads to breakout box.

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

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

7. Use DMM to measure KOEO values for the following:
   - V_{BAT} (DMM set to DC V)
     - — POS X3–3 to NEG X3–7 (V_{IGN} Pwr)
     - — POS X4–1 to NEG X3–6 (ECM PWR)
     - — POS X4–2 to NEG X3–7 (ECM PWR)
   - rpm (DMM set to DC mV Hz)
     - — POS X1–1 to NEG X3–7 (CKP)
   - rpm (DMM set to DC mV rpm^2)
     - — POS X1–9 to NEG X3–7 (CMP)
   - ICP (DMM set to DC V)
     - — POS X1–20 to NEG X1–6
   - EOP (DMM set to DC V)
     - — POS X2–7 to NEG X1–6
   - BCP (DMM set to DC V)
     - — POS X2 –11 to NEG X1– 6
8. Record KOEO reading on Diagnostic Form.
9. Take another measurement while cranking engine for 20 seconds.
   - If ECM voltage is below specification, see “Electronic Control Module Power (ECM PWR)” in Section 7 (page 381).
   - If CKP DCmV Hz is not in specification during crank, see “CKP Sensor” in Section 7 (page 351).
   - If CMP DCmV RPM2 is not in specification during crank, see “CMP Sensor” in Section 7 (page 355).
   - If EOP is not in specification during crank, see “Low Oil Pressure” in Section 4 (page 128).
   - If BCP is not in specification during crank, see “BCP” Sensor” in Section 7 (page 457).
   - If all measurements are in specification, continue with the next diagnostic test.
10. Record readings on Diagnostic Form.

7. Fuel

☐ Fuel level in tank
☐ Free of water, icing, and clouding
☐ Free of contaminants
☐ Correct fuel grade
☐ Check water in fuel lamp

Note: If unit was run out of fuel, see "Priming the Fuel System" in Section 4.

Comments

H31128

Figure 191

Purpose

To check fuel level and quality for efficient engine operation

- Ask the operator if the amber WATER IN FUEL lamp was on during vehicle operation.
- If engine has an optional Engine Fuel Pressure (EFP) sensor, ask the operator if the amber FUEL FILTER lamp was on during vehicle operation. If the lamp was on, change the fuel filter and retest for poor engine operation.

Tools

- Clear container (approximately 1 liter or 1 quart US)
- Fuel pressure test adapter
- Pocket screw driver

Procedure

WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

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

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

1. Check fuel level in fuel tank and for odors other than diesel fuel – kerosene and gasoline, for example.

CAUTION: Be sure to place a rag or suitable container under the fuel pressure test valve when bleeding the fuel rail. Dispose of fuel in a correct container clearly marked DIESEL FUEL according to local regulations.

NOTE: Engine fuel can be a threat to the environment. Never dispose of engine fuel by putting it in the trash, pouring on the ground, in the sewers, in streams, or bodies of water.

Figure 192 Shrader valve assembly

1. Valve
2. Center stem

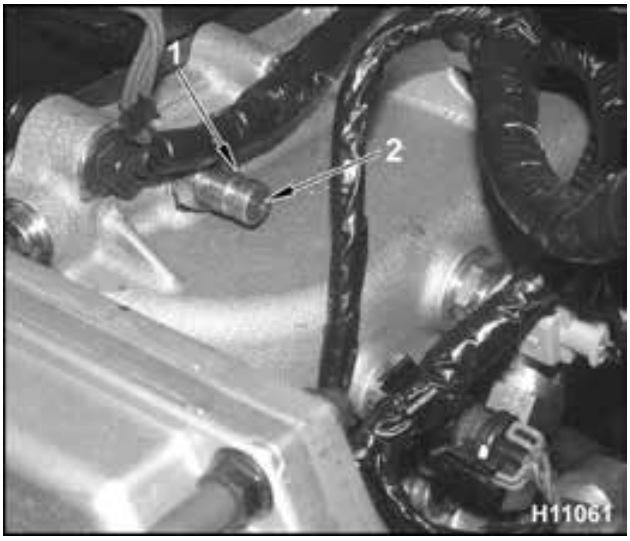

Figure 193 Diagnostic coupling

1. Valve
2. Center section

NOTE: Engines are equipped with a fuel pressure test valve in the form of either a Shrader valve or a diagnostic coupling.

2. Check for indications of aerated fuel in the fuel system. Relieve pressure from the fuel rail using the fuel pressure test valve.
   - As fuel pressure is relieved, a steady stream of fuel, without air from the fuel pressure test valve, means that air is not in the fuel system.
   - An erratic air/fuel mixture surge suggests that air is in the fuel system.

Figure 194 Fuel pressure test adapter

NOTE: It is recommended to use the fuel pressure test adapter to avoid bending the needle in the fuel pressure test valve.

Figure 195 Fuel test fitting

NOTE: Some engines will have a diagnostic coupling instead of a Shrader valve. Press end of coupling with a pocket screwdriver to relieve pressure.

Figure 196 Water drain valve

1. Water drain valve
2. Plastic tube

Figure 197 Fuel strainer drain valve

3. Open water drain valve and collect a fuel sample using a clear container. Check for the following conditions:
   - Fuel must be the correct grade, clean, and undiluted.
   - Gasoline, kerosene or other chemicals in the diesel fuel

     (If diesel fuel is contaminated, correct the condition and retest.)
   - If the fuel filter was not serviced or drained for a long time, some sediment or water could be in the fuel filter housing.

   NOTE: Cold weather can cause fuel waxing in some grades of diesel fuel. Waxing will restrict or stop fuel flow through the fuel filter.
4. Open fuel strainer drain valve. Collect a fuel sample using a clear container. If fuel is contaminated do the following:
   a. Pull drain valve down and out of bowl.
   b. Remove strainer bowl and check strainer for sediment, debris, or rust. Clean and replace as required.
   c. Check fuel tanks and fuel lines. Clean and flush if necessary.
5. Prime fuel system. See “Priming the Fuel System” in Section 4 (page 132) for procedure.

Possible Causes

- Low fuel level in fuel tank.
- Inline fuel valve (if equipped) could be shut-off.
- Fuel supply line could be broken or crimped.
- The fuel tank pickup tube could be clogged or cracked.
- Supplemental filters or water separators may be plugged or leaking allowing air to enter the fuel system.
- Failed seal for inlet fitting in fuel filter housing
- Water or contaminants in fuel tank

- Ice in fuel lines
- Debris in fuel tank
- Cloudy fuel indicates unsuitable fuel grade for cold temperatures.
- Fuel could be waxed or jelled. (usually Grade 2-D)

8. Engine Systems

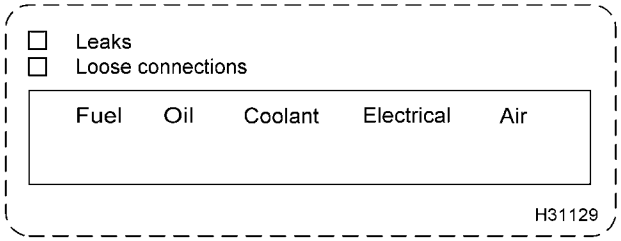

Figure 198

Purpose

To inspect engine and control system for damage (leaks, open connections, or harness chaffing)

Tools

- Inspection lamp

Procedure

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

1. Inspect fuel supply system (including tank and lines) for leaks and damage.
2. Check high-pressure oil line from high-pressure pump to supply manifold for major leaks.
3. Check engine for oil leaks.
4. Inspect cooling system for leaks.
5. Check sensor, relay, and control module connections. All connections must be seated, in good condition, and free of damage or corrosion.

   NOTE: The engine will not start if the following components are disconnected or damaged:

   - Injection Pressure Regulator (IPR) valve
   - Camshaft Position (CMP) sensor
   - Crankshaft Position (CKP) sensor
   - Electronic Control Module (ECM)
   - Injector Driver Module (IDM)
6. Inspect battery cable and fuse connections for corrosion. All connections must be seated, in good condition, and free of damage or corrosion.
7. Inspect engine wiring harness for correct routing and protection against rubbing or chaffing.
8. Check the following components of the air induction system for leaks:

   - Inspect air filter housing for damage or distortion that could allow unfiltered air into the engine.
   - Inspect air filter housing for end seal movement. End seal movement is indicated if the seal contact area is polished. A polished contact area indicates that unfiltered air has passed by the filter element and into the engine.
   - Inspect air filter element for end cap dents, holes, damaged seals, and soot.
   - Inspect air intake hoses and clamps for tightness and positioning over sealing beads.
   - Inspect the chassis mounted Charge Air Cooler (CAC) and piping.

   NOTE: Unfiltered air will cause accelerated engine wear.
9. Record identified problems on Diagnostic Form.

   - If problems were identified, repair as necessary and verify if a hard start and no start condition still exists.
   - If no problems were identified, continue with the next diagnostic test.

Possible Causes

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

9. Engine Oil

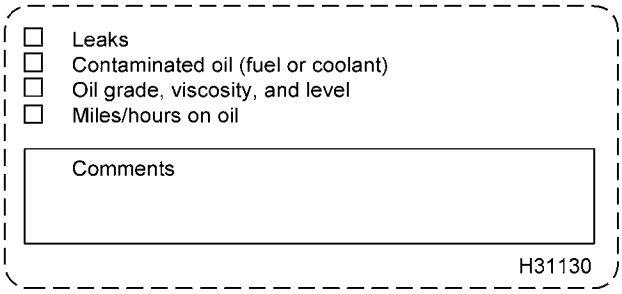

Figure 199

Purpose

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

Tools

- None

Procedure

WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

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

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

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

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

   - Engine oil level will vary depending on temperature of engine.
   - If oil is contaminated, see "Fuel in Lube Oil" (page 124) or "Coolant in Lube Oil" (page 109) in Section 4.
   - If oil level is low, fill to correct level and test again.
4. Check engine service records for correct oil grade and viscosity for ambient operating temperatures. **Do not use 15W-40 oil below -7 °C (20 °F)**. Long oil drain intervals can increase oil viscosity; thicker oil will make engine cranking and starting more difficult below freezing temperatures. See "Lubrication Requirements" in the *Engine Operation and Maintenance Manual* (for this engine's model number and model year). Confirm that oil meets correct API category.
5. Record concerns on Diagnostic Form.

Possible Causes

Low oil level

- Oil leak
- Oil consumption
- Incorrect servicing

High oil level

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

Coolant in oil

- Cylinder head gasket leak
- Failed cup plug in cylinder head
- Injector sleeve leak
- Front cover gasket leak
- Front cover, cylinder head, or crankcase porosity
- Accessory leak (water cooled air compressor)
- Failed crevice seal (piston sleeve)

Fuel in oil

- Injector O-ring leak
- Cylinder head porosity
- Leaking injector

10. Intake and Exhaust Restriction

☐ Hoses and piping
☐ Filter minder
☐ Intake and exhaust restriction

Comments

H31131

Figure 200

Purpose

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

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

Tools

- None

Procedure

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

1. Inspect the following parts for restriction, damage, or incorrect installation:
   - Air filter inlet and duct (could include hood, cowling, etc.)
   - Hoses and clamps
   - Air filter housing, filter element, and gaskets
   - Exhaust pipes
   - Chassis mounted CAC and piping
   - Air filter restriction indicator or gauge

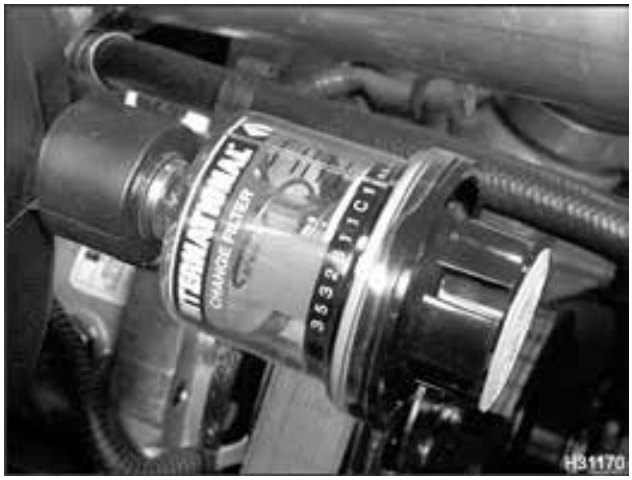

Figure 201 Low-restriction

Figure 202 High-restriction

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

2. Record concerns on Diagnostic Form.

Possible Causes

- Air filter element clogged or dirty
- Snow in air filter inlet
- Ice in air filter inlet
- Plastic bags or other foreign material in air filter inlet
- Collapsed air filter
- Collapsed inlet piping or hoses
- On engines recently repaired, rags or cap plugs may have been left in the intake system.
- Tailpipe or muffler may be damaged or collapsed.
- Exhaust restriction (muffler or catalytic converter)
- Restricted or plugged Catalyzed Diesel Particulate Filter (CDPF) – if equipped

11. Main Power Relay to ECM

☐ Connect breakout harness between ECM main power relay and power distribution center.

☐ Crank engine and use DMM to measure voltage to ECM (Min 130 rpm for 20 seconds. See note 4.)

☐ Check voltage between connector pin 87 and ground.

Instrument	Spec	Actual
DMM	7V (min)	

H31139

Figure 203

Figure 204 Relay Breakout Harness to power distribution center

Purpose

To determine correct power supplied to operate the ECM

The ECM requires 7 V minimum for correct operation.

Voltage Measurement with Breakout Harness at Main Power Relay

Tools

- Relay Breakout Harness
- DMM

Procedure

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

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

1. Turn the ignition switch to OFF and ensure all accessories are turned off.
2. Connect Relay Breakout Harness between ECM main power relay and power distribution center or chassis harness depending on application.

   NOTE: Depending on application, the relay could be one of two kinds. Check power distribution center or cab cowl.
3. Connect DMM POS to lead 87 and NEG to ground terminal on cowl.
4. Crank engine for 20 seconds and measure voltage.
5. Record the lowest voltage on Diagnostic Form.
   - If the voltage is below 7 V, the ECM main power relay may be resetting, due to low voltage and current from the batteries, or problems in the ignition circuit and power feed circuits. See Electronic Control Module Power (ECM PWR) in Section 7 (page 381).
   - If the voltage is above 7 V, continue with Hard Start and No Start Diagnostic tests.

   NOTE: Results can be above 7 V, but there may be a problem between the main power relay and the ECM. If a Hard Start / No Start problem remains after all Diagnostic Form tests are complete, do Voltage Measurement at ECM with Breakout Box.

Possible Causes

Low battery voltage

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

Low or no battery voltage to the ECM

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

Voltage Measurement at ECM with Breakout Box

NOTE: If the breakout box was used to do Test 6 – EST Data List, the following procedures do not have to be done.

Use the following procedures when any of the following situations exist:

- A Relay Breakout Harness is not available
- Expected voltages were not to spec, when using the Relay Breakout Harness
- Voltages were to spec, using the Relay Breakout Harness and Hard Start No Start Diagnostics is complete – but a concern remains

Tools

- Breakout Box
- Digital Multimeter (DMM)

Procedure

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

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

1. Turn the ignition switch to OFF and ensure all accessories are turned off.
2. Remove two white connectors (X3 and X4) from ECM.

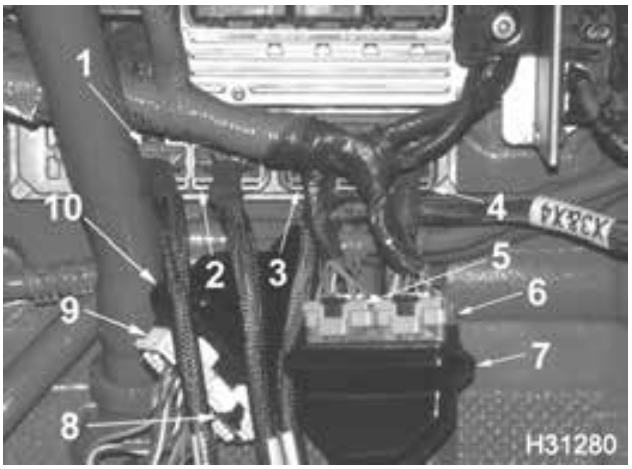

Figure 205 Engine and chassis breakout box connections

1. Breakout box connector X4 to ECM
2. Breakout box connector X3 to ECM
3. Breakout box connector X2 to ECM
4. Breakout box connector X1 to ECM
5. Engine wiring harness ECM connector X2 to breakout box header
6. Engine wiring harness ECM connector X1 to breakout box header
7. Breakout box header X1 and X2 engine to breakout box
8. Chassis wiring harness connector to breakout box header
9. Chassis wiring harness connector to breakout box header
10. Breakout box header X3 and X4 breakout box to chassis

3. Connect breakout box connectors (X3 and X4) to connections on ECM.
4. Connect chassis harness connectors to breakout box header (X3 and X4).

Figure 206 Breakout box

5. Connect leads of the DMM to the following test points on the breakout box:
   - POS X3–3 to NEG X3–7 (V_{IGN} Pwr)
   - POS X4–2 to NEG X3–7 (ECM PWR)
   - POS X4–1 to NEG X3–7 (ECM PWR)
6. Crank engine for 20 seconds and measure voltage.
7. Record the lowest voltage on Diagnostic Form.
   - If the voltage is below 7 V, the ECM power relay may be resetting, resulting from low voltage and current from the batteries, or problems in the ignition circuit and power feed circuits. See “ECM PWR, Electronic Control Module Power” in Section 7 (page 381).
   - If the voltage is above 7 V, continue with Hard Start and No Start Diagnostic tests.

12. Main Power Relay to IDM

☐ Connect 12 - Pin Breakout Harness between engine and chassis harness.

☐ Crank engine and use DMM to measure voltage to IDM. (Min. 130 rpm for 20 seconds. See note 4.)

☐ Check voltage between connector Pin 12 and Pin 1.

Instrument	Spec	Actual
DMM	7V (min)	

H31140

Figure 207

Purpose

To determine correct power supplied to operate the IDM

The IDM requires 7 V minimum for correct operation.

Voltage Measurement at 12–Pin Connection with Breakout Harness

Tools

- 12-Pin Breakout Harness
- Digital Multimeter (DMM)

Procedure

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

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

1. Turn the ignition switch to OFF and ensure all accessories turned off.
2. Disconnect 12-pin connector above the ECM and IDM.

CAUTION: When disconnecting the 12-pin connector, the lock can come loose. Put the lock back in the correct place before reconnecting the connector.

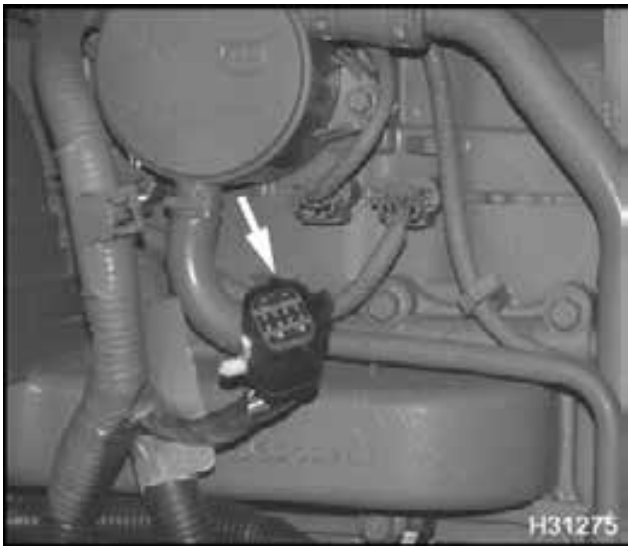

Figure 208 12-pin Engine Harness Connector

3. Connect 12-pin Breakout Harness between both engine and chassis connectors.
4. Connect leads of the DMM to each of the following test points:
   - POS 12 to NEG 1 (IDM PWR to IDM GND)
   - POS 9 to NEG 1 (V_{IGN} to IDM GND)
   - POS 9 to NEG 8 (V_{IGN} to MPR)
   - POS 6 to NEG 1 (IDM Logic PWR to IDM GND)
5. Crank engine for 20 seconds and measure voltage.
6. Record the lowest voltage on Diagnostic Form.
   - If the voltage is below 7 V, the IDM main power relay may be resetting, resulting from low voltage and current from the batteries or problems in the ignition circuit or power feed circuits. See "IDM PWR, Injector Drive Module Power" (page 479) in Section 7.
   - If the voltage is above 7 V, continue with Hard Start And No Start diagnostic tests.

   NOTE: Results can be above 7 V, but there may be a problem between the 12-pin connector and the IDM. If a Hard Start / No Start problem remains after all Diagnostic Form tests are complete, check voltage at IDM connector.

Possible Causes

Low battery voltage

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

Low or no battery voltage to the IDM main power relay

- High-resistance or an open power feed circuit to the IDM or IDM main power relay.
- The IDM power circuit fuse in battery box may be open.
- IDM main power relay may have failed.
- V_{IGN} circuit problem
- Failed IDM

Voltage Measurement with Breakout Harness at Main Power Relay

NOTE: This is an alternate procedure for any of the following:

- A 12-pin Breakout Harness is not available
- Expected voltages were not to spec, when using the 12-pin Breakout Harness

Tools

- Relay Breakout Harness
- Digital Multimeter (DMM)

Procedure

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

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

1. Turn the ignition switch to OFF and ensure all accessories are turned off.

Figure 209 Relay Breakout Harness

2. Connect Relay Breakout Harness between IDM main power relay and power distribution center or chassis harness depending on application.

   NOTE: Depending on application, the relay could be one of two kinds. Check power distribution center or cab cowl.

3. Connect DMM POS lead to 87 and NEG to ground terminal on cowl.
4. Crank engine for 20 seconds and measure voltage.
5. Record the lowest voltage on Diagnostic Form.
   - If the voltage is below 7 V, the IDM main power relay may be resetting, resulting from low voltage and current from the batteries or problems in the ignition circuit or power feed circuits. See "IDM PWR, Injector Drive Module Power" in Section 7 (page 479).
   - If the voltage is above 7 V, continue with Hard Start and No Start tests.

   NOTE: Results can be above 7 V, but there may be a problem between the main power relay and IDM. If a Hard Start / No Start problem remains after all Diagnostic Form tests are complete, check voltage at 12-pin connector and IDM connector.

13. Fuel Pressure and Aerated Fuel

☐ Measure pressure at fuel rail (intake manifold).
☐ Minimum cranking speed 130 rpm for 20 seconds. (See note 4.)
☐ Check for Aerated fuel.

Instrument	Spec	Actual
0-100 psi Gauge		
Visual	Aerated fuel	Yes____ No ____
Vacuum gauge	> 12 in Hg	_____

Note: If unit was run out of fuel, see "Priming the Fuel System" in Section 4.

- If fuel pressure is below spec, replace fuel filter, clean strainer, and retest.
- Correct for aerated fuel before continuing.
- If still below spec, check fuel pump operation

H31141

Figure 210

Purpose

To check for correct fuel pressure and aerated fuel

NOTE: Do the following:

- Ask the operator if the amber WATER IN FUEL lamp was on during vehicle operation.
- If engine has an optional Engine Fuel Pressure (EFP) sensor, ask the operator if the amber FUEL FILTER lamp was on during vehicle operation. If the lamp was on, change the fuel filter and retest for poor engine operation.
- If unit was run out of fuel, make sure the fuel system was primed. See “Priming the Fuel System” in Section 4 (page 132) for procedure.
- See “Combustion Leaks to Fuel” in Section 4 (page 104) if all three of the following conditions are noted:
  - Fuel system will not prime
  - White to black exhaust smoke
  - Pulsating fuel pressure

Tools

- Fuel pressure test gauge
- Fuel Pressure Test Kit
- 1 to 5 gallon bucket
- Fuel/Oil Pressure Test Coupler

Fuel Pressure

Procedure

WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the “Safety Information” section of this manual.

1. See “DT 466 Performance Specifications” – Appendix A (page 595) or “DT 570 and HT 570 Performance Specifications” – Appendix B (page 619) for fuel pressure specifications and record on Diagnostic Form.

NOTE: If engine is equipped with optional Engine Fuel Pressure (EFP) sensor, use EST with MasterDiagnostics® software to monitor fuel pressure. Compare the EST values to gauge readings.

CAUTION: Be sure to place a rag or suitable container under the fuel pressure test valve when bleeding the fuel rail. Dispose of fuel in a correct container clearly marked DIESEL FUEL according to local regulations.

NOTE: Engine fuel can be a threat to the environment. Never dispose of engine fuel by putting it in the trash, pouring on the ground, in the sewers, in streams, or bodies of water.

Figure 211 Shrader valve assembly

1. Valve
2. Center stem

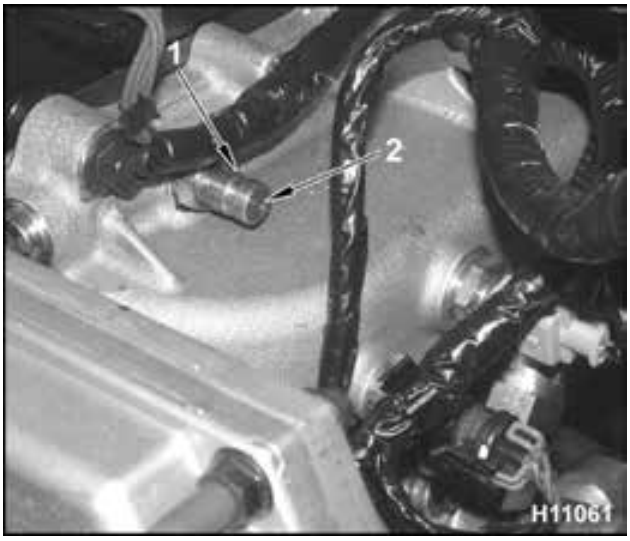

Figure 212 Diagnostic coupling

1. Valve
2. Center section

NOTE: Engines are equipped with a fuel pressure test valve in the form of either a Shrader valve or a diagnostic coupling.

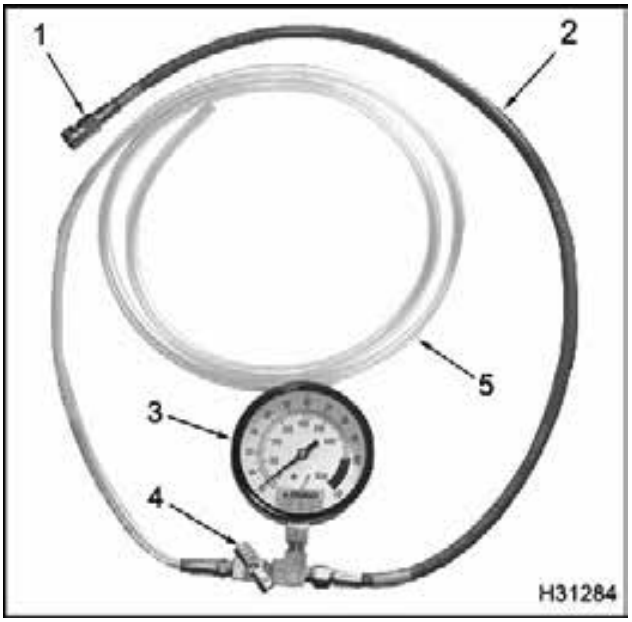

Figure 213 Fuel Pressure Gauge

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

Figure 214 Fuel Pressure Test Adapter

NOTE: If the engine is equipped with a Shrader valve, use the Fuel Pressure Test Adapter.

Figure 215 Fuel/Oil Pressure Test Coupler

NOTE: If the engine is equipped with a diagnostic coupling, adapt the Fuel/Oil Pressure Test Coupler to the Fuel Pressure Gauge.

Figure 216 Fuel Pressure Gauge to fuel pressure test adapter

2. Connect Fuel Pressure Gauge with shut-off valve and clear 3/8” diameter hose to test valve.
3. Route the clear hose into a drain pan.

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

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

4. Start or crank the engine for 20 seconds. Measure the fuel pressure with the shut-off valve closed. Open the shut-off valve to check for aeration.

   NOTE: Breaking any fuel system joint will induce air into the fuel system. The air should pass in a short period of time. As fuel pressure is relieved, a steady stream of fuel without air bubbles indicates the fuel is not aerated.

   NOTE: If a Fuel Pressure Gauge with shut-off valve and clear 3/8” diameter hose is not available to check for aeration, see alternative test “Checking for Aerated Fuel using Spare Fuel Line.”

5. Record results on Diagnostic Form.
   - If fuel pressure is below specification and fuel is not aerated, replace the fuel filter and clean the strainer. Test the fuel pressure again.
   - If fuel is aerated, see “Aerated Fuel” in Section 4.
   - If fuel pressure is still low and fuel is not aerated after replacing the fuel filter and cleaning the strainer, do “Operation of the Fuel Pump Test.”
   - If fuel pressure is in specification and the fuel is not aerated, do not continue testing the fuel system. Continue to the next diagnostic test.

Possible Causes

No fuel

- Low fuel level in fuel tank
- Debris in tank can cause high-restriction and low fuel pressure.
- Inline fuel valve (if equipped) could be shut-off
- Failed seals or fuel lines between fuel tanks
- Ice in fuel lines
- Inoperative fuel tank transfer pump
- Fuel tank pickup tube cracked

Low fuel pressure

- Dirty filter element
- Debris or rust in fuel strainer

- Restriction from the fuel tank to the fuel filter housing inlet can cause high-restriction and low fuel pressure.
- Plugged supplemental filters or water separators can cause high-restriction and low fuel pressure.
- Debris in tank can cause high-restriction and low fuel pressure.
- A kinked or bent fuel supply line or a blocked pickup tube can cause high-restriction and low fuel pressure.
- Waxed or jelled fuel in the fuel filter will cause high-restriction and low fuel pressure. (Usually Grade 2-D)
- Ice in fuel lines.
- A restriction between the fuel inlet fitting, strainer, and fuel pump can cause high-restriction and low fuel pressure.
- Debris in the fuel regulator valve
- Failed fuel pressure regulator valve.
- Failed fuel pump
- Failed high-pressure oil pump (can not operate fuel pump)

Aerated fuel

- Failed seal for inlet fitting in fuel filter housing
- Supply filter or water separator leaking
- A loose fuel line on the suction side of the fuel system can ingest air into the system and cause low fuel pressure (most noticeable under load).
- Strainer drain valve loose or damaged
- Strainer bowl warped or damaged
- Missing O-ring from strainer bowl
- Damaged seals on steel inlet tube to fuel pump
- Primer pump seals damaged

Fuel restriction

- Dirty filter element
- Debris or rust in fuel strainer
- Restriction from the low-pressure fuel filter housing inlet to the fuel tank can cause high-restriction and low fuel pressure.
- Plugged supplemental filters or water separators can cause high-restriction and low fuel pressure.
- Debris in tank can cause high-restriction and low fuel pressure.
- A kinked or bent fuel supply line or a blocked pickup tube can cause high-restriction and low fuel pressure.
- Waxed or jelled fuel in the fuel filter will cause high-restriction and low fuel pressure. (Usually Grade 2-D)
- Ice in fuel lines.
- A restriction between the fuel inlet fitting, strainer, and fuel pump can cause high-restriction and low fuel pressure.

High fuel pressure (pulsating fuel pressure)

- Debris in the fuel regulator valve
- Inoperative fuel pressure regulator valve.
- Combustion gases leaking into fuel system

Checking for Aerated Fuel using Spare Fuel Line

NOTE: This is an alternative test. Do this procedure, only if Fuel Pressure Gauge with shut-off valve is not available.

Tools

- Spare fuel line (filter housing to fuel supply pump)
- Clear plastic line
- Hose clamp (2)

Procedure

 **WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the “Safety Information” section of this manual.**

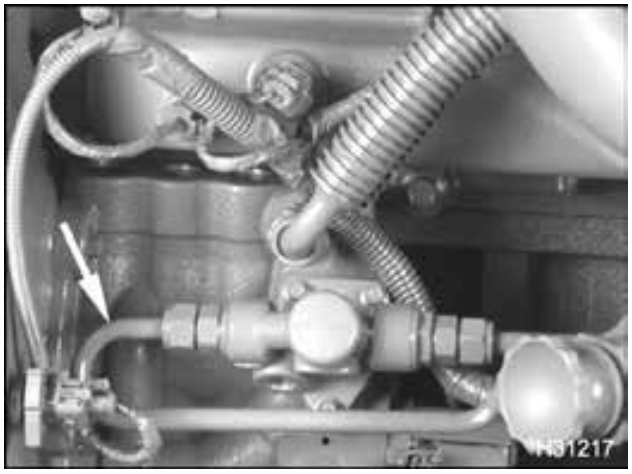

Figure 217 Fuel supply line

1. Remove fuel supply line from suction side of fuel pump and fuel filter housing.

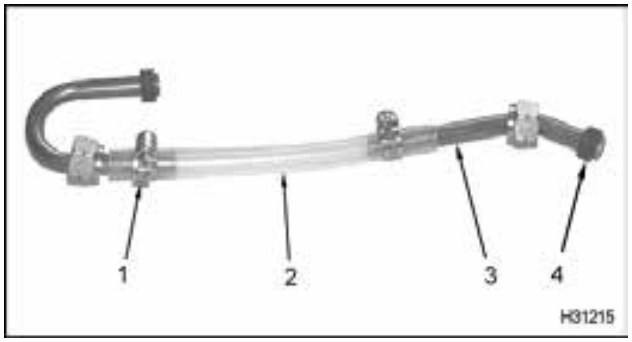

Figure 218 Test fuel line

1. Clamp (2)
2. Clear plastic tube
3. Spare fuel line (half)
4. Sleeve seal (2)

2. Make a test fuel line.
   - Use spare fuel line. (Make sure both sleeve seals are good.) Cut a 3 inch section from the center of the fuel line. Install clear plastic line in place of removed section and secure plastic line with clamps.

   NOTE: The mechanic is expected to keep the fuel test line for future diagnostics. Expense the fuel test line as an essential tool and keep it with other diagnostic tools. Warranty will not cover the cost of the fuel test line.

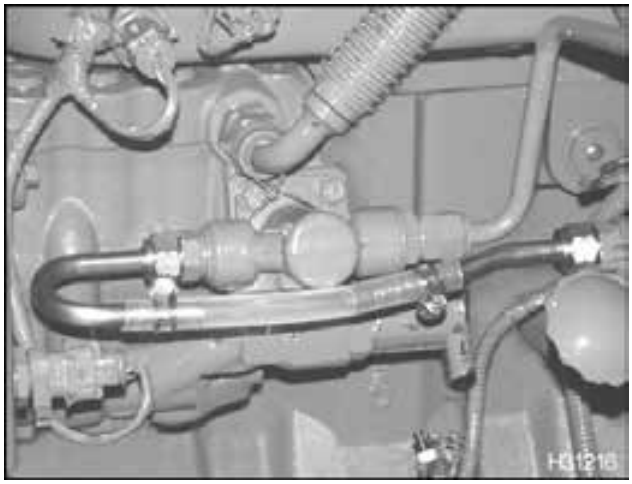

Figure 219 Test line installed

3. Install test fuel line.

   NOTE: Verify that sleeve seals are in good condition.

4. Do one of the following:
   - For **Hard Start and No Start Diagnostics**, crank engine for 20 seconds and check for air bubbles in the clear plastic line.
   - For **Performance Diagnostics**, run engine at high idle, no load and check for air bubbles in the clear plastic line.

5. Record results on Diagnostic Form.

   NOTE: Initially, fuel will be aerated due to draining fuel from filter housing and strainer in previous test.
   - If fuel is aerated check for a leak in the suction side of fuel system. See “Aerated Fuel” in Section 4.
   - If fuel is not aerated and fuel pressure is good, continue with next test.
   - If fuel is not aerated and fuel pressure is low, do “Operation of Fuel Pump”.

6. Remove fuel test line and install original fuel line.

   NOTE: Verify that sleeve seals are in good condition.

Operation of Fuel Pump

Tools

- Vacuum Pump And Gauge (kit)
- Hose clamp
- Fuel pressure test gauge
- Fuel Pressure Test Kit
- Fuel/Oil Pressure Test Coupler
- 1 to 5 gallon bucket

Procedure

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

Figure 220 Test hose to fuel line

1. Fuel line (suction side)
2. Hose clamp
3. Test hose

NOTE: The fuel pressure gauge with the inline shut-off valve is still connected to the fuel pressure test valve. If shut-off valve is not opened, test will result in false readings. Do the following procedure:

1. Open the shut-off valve.
2. Disconnect fuel line (suction side) from fuel filter housing.

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

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

3. Slide test hose onto fuel line and secure with hose clamp or use cone adapter (vacuum pump kit) that fits into end of fuel line.

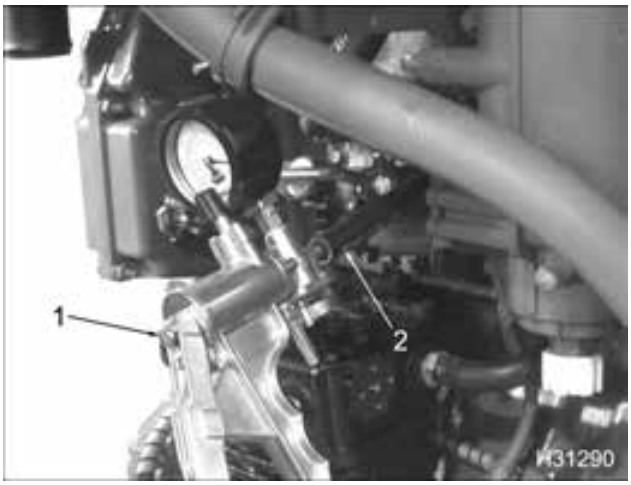

Figure 221

4. Insert vacuum pump nozzle into test hose.
5. Crank engine, check gauge reading, and record on Diagnostic Form.
   - If less than 12 in Hg., check steel line and test connections between the air vacuum test gauge and fuel pump. Verify integrity of test hose adapter
   - If vacuum is still below specification, replace the fuel pump following procedures in the *Engine Service Manual*.
   - If greater than 12 in Hg., the fuel pump is working. Replace fuel regulator and retest fuel pressure.
   - If fuel pressure is still low after replacing the fuel pump and regulator, check for restriction between the filter housing and fuel tank.

14. Low ICP System Pressure

☐ Do only the low ICP tests below, if ICP was not to spec during Test 6.
☐ Start and continue Test 14.1 System Function, if lube oil pressure is not a concern and terminals on IPR valve and engine harness are not damaged or corroded.
☐ If test result is yes for 14.1 System Function, **do not do tests 14.2 through 14.5 for low ICP**.

Low ICP Tests

Test	Question	Result
14.1 - System Function	IPR connectors: Corroded, bent or pushed back pins	☐ Yes ☐ No
	Greater than 28 Mpa (4061 psi) 4.45 V?	☐ Yes ☐ No
14.2 - Oil Reservoir Level	Oil level full?	☐ Yes ☐ No
14.3 - IPR and High-pressure Pump Operation	Greater than 28 Mpa (4061 psi) 4.45 V?	☐ Yes ☐ No
14.4 - UVC Leak Test	Audible air leak? If equipped with engine brake, it is normal to have air passing through the system.	☐ Yes ☐ No
14.5 - IPR Function	Audible crankcase air leak?	Unplugged ☐ Yes ☐ No B+ and gnd applied ☐ Yes ☐ No

H31175

Figure 222

Purpose

To determine the cause of low injection control pressure that prevents engine starting

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Digital Multimeter (DMM)
- Actuator Breakout Harness
- Jumper harness (from Terminal Test Kit)
- Pressure Sensor Breakout Harness
- Socket or wrench (EOT sensor)
- Compressed air source 689 kPa (100 psi)
- Spare VT 365 ICP sensor (Part No. -1845274C92 or equivalent)
- Spare high-pressure hose (Part No.-1842571C91 or equivalent)

NOTE: The mechanic is expected to keep the spare ICP sensor and high-pressure hose for future diagnostics. Expense the spare ICP sensor and high-pressure hose as essential tools and keep it with other diagnostic tools. Warranty will not cover the cost of the spare ICP sensor and high-pressure hose.

Possible Causes

- ICP system leakage
- Failed ICP sensor circuit
- Failed ICP sensor
- Failed IPR wiring (power and control)
- Failed IPR valve
- Low or no lube oil pressure
- Inoperative high-pressure oil pump
- Failed BCP sensor circuit
- Failed BCP sensor
- Inoperative brake shut-off valve of Diamond Logic® engine brake
- BCP system leakage
- If ECM detects low boost pressure, an incorrect feedback signal from APS or the ICP sensor, the ECM commands the IPR valve to reduce ICP.

14.1 – System Function

Start Test 14.1 System Function – continue Low ICP System Pressure diagnostics, if no concerns are found with the following:

- Lube oil pressure system has the ability to build engine oil pressure while the engine is cranking.
- Inspect Injection Pressure regulator (IPR) valve and engine wiring harness connector for corrosion.

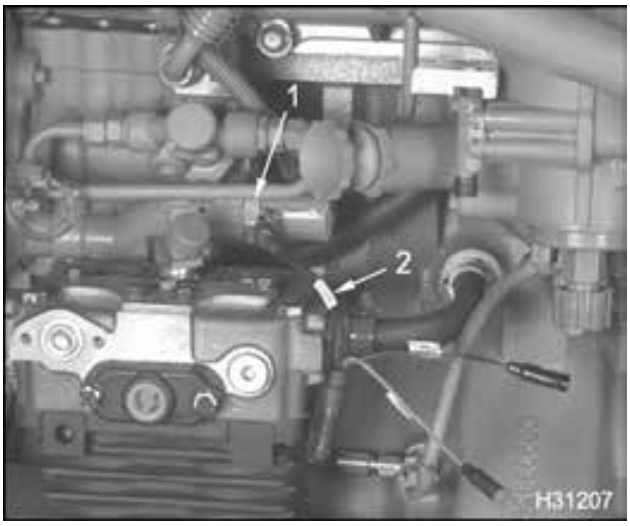

Figure 223 Actuator Breakout Harness to IPR

1. IPR valve
2. Actuator Breakout Harness

Procedure

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

1. Disconnect engine wiring harness connector from IPR valve and inspect engine harness terminals and IPR valve for corrosion, bent pins, or pins pushed back.
   - If the harness connector or the IPR valve is corroded, replace the harness connector and IPR valve. Retest injection control pressure.
   - If pins are bent or pushed back, repair as necessary. Retest injection control pressure.
   - If the wiring harness connector and the IPR valve are not corroded or damaged, continue with step 2.
2. Connect Actuator Breakout Harness to IPR. **Do not connect engine harness**.

CAUTION: If the engine harness is connected to the actuator breakout harness, the ignition switch fuse will blow or cause damage to wiring harness.

Figure 224 B+ on power distribution terminal

Figure 225 Ground to terminal on cowl

3. Apply B+ volts and ground to the IPR valve.

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

While cranking the engine, the engine could start.

- **Set the parking brake**
- **Put transmission in neutral**
- **Block wheels.**

CAUTION: Do not leave the IPR valve energized longer than 120 seconds — this can damage the IPR valve.

NOTE: If the engine starts, disconnect ground and B+ at the Actuator Breakout Harness.

4. Using the EST, monitor injection control pressure while cranking the engine for 20 seconds.

   NOTE: If an EST is not available, use alternate method – Measuring Voltage on ICP Sensor using a Pressure Sensor Breakout Harness.

5. Record results on Diagnostic Form.

   - If injection control pressure increases above 28 MPa (4061 psi) (4.45 V), the mechanical system is operating correctly for the engine to start. **Either the ECM is not controlling the IPR or the IPR circuit has failed. Do not continue with Low ICP System Tests.**

     Check DTCs found during Test 8 (KOEO Standard Test). Make sure problems were corrected.

   - For problems in the electrical circuit, see “IPR (Injection Pressure Regulator)” in Section 7 (page 494).
   - If 28 MPa (4061 psi) (4.45 V) can not be reached. Continue with the next test, 14.2 – Oil Reservoir Level.

14.2 – Oil Reservoir Level

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the “Safety Information” section of this manual.

Figure 226 EOT sensor

1. Disconnect engine harness connector from EOT sensor installed in the rear of the front cover, left of the high-pressure oil pump assembly.
2. Slowly loosen the EOT sensor from the EOT port until oil flows out, indicating that the oil level is above the sensor. **Oil will spill out, if the sensor is removed. Catch oil in a container.**If oil does not flow out remove sensor.

   - If the oil level was above the EOT sensor, tighten sensor and reconnect the harness.

     Do test 14.3 – IPR and High-pressure Pump Operation.

   - If oil level is low, place container under port to catch oil. Crank engine and check if oil flows out.
   - If oil does not flow out while cranking, the lube oil pump may not be supplying oil to the reservoir. See “Low Oil Pressure” in Section 4 (page 128).

14.3 – IPR and High-pressure Pump Operation

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the “Safety Information” section of this manual.

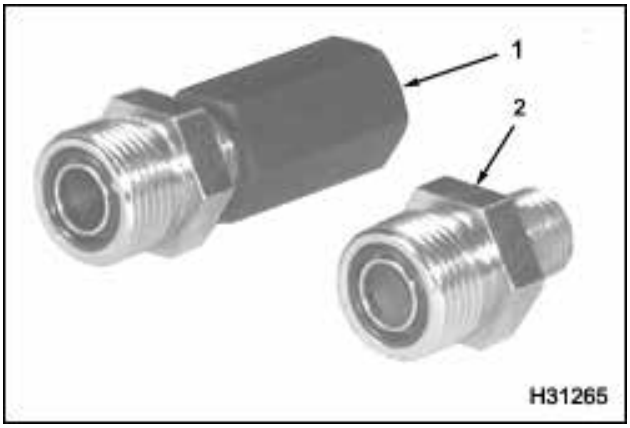

Figure 227 ICP Test Kit

1. ICP sensor adapter
2. Fitting, 13/16-16 NPT

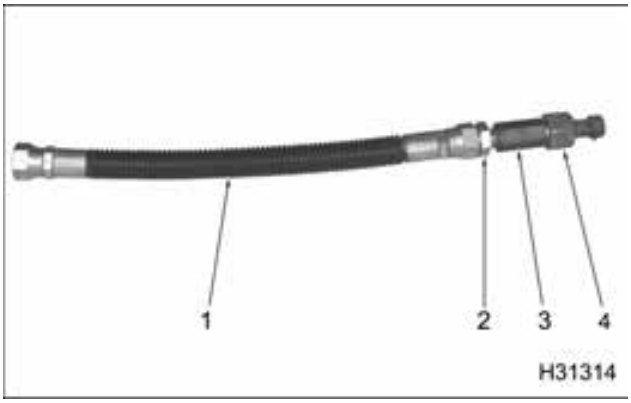

Figure 228 High-pressure oil hose assembly

1. High-pressure hose
2. Fitting, 13/16-16 NPT
3. ICP sensor adapter
4. ICP sensor

1. Make test hose assembly with the following components:
   - ICP sensor adapter
   - High-pressure hose (Part No. - 1842571C91 or equivalent)
   - VT 365 ICP sensor (Part No. - 1845274C92 or equivalent)

   NOTE: The mechanic is expected to keep the spare ICP sensor and high-pressure hose for future diagnostics. Expense the spare ICP sensor and high-pressure hose as essential tools and keep both with other diagnostic tools. Warranty will not cover the cost of the spare ICP sensor and high-pressure hose.

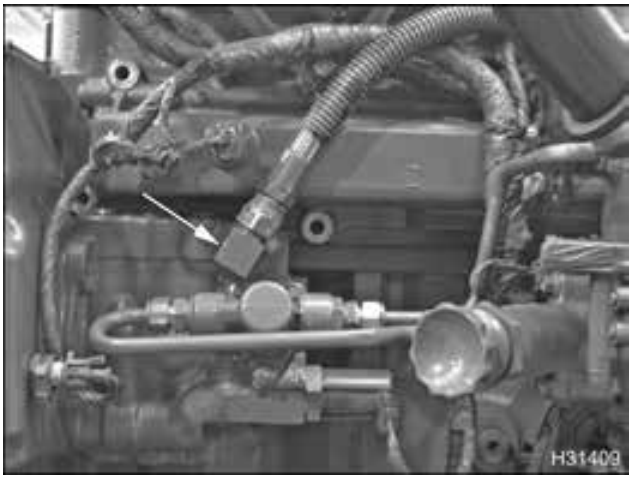

Figure 229 High-pressure pump fitting

2. Disconnect high-pressure oil hose from high-pressure pump fitting.

   NOTE: Oil will spill from hose. Position the high-pressure oil hose so oil will not spill.

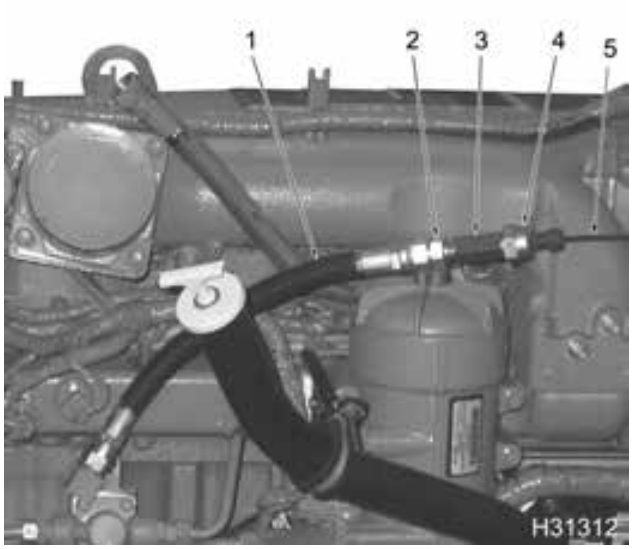

Figure 230 High-pressure oil hose, ICP Test Kit, sensor, and Pressure Sensor Breakout Harness

1. High-pressure hose
2. Fitting, 13/16-16 NPT
3. ICP sensor adapter
4. ICP sensor
5. VC Gasket Breakout Harness

3. Install test hose assembly to high-pressure pump.

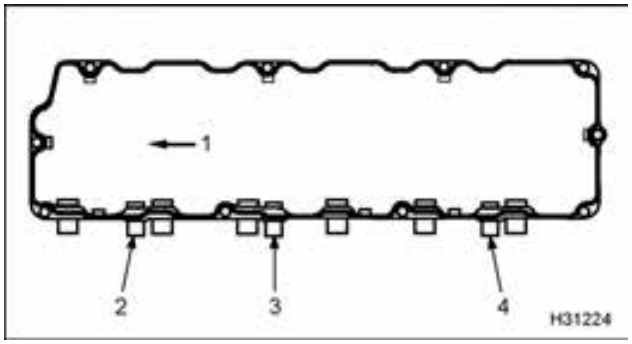

Figure 231 Valve cover gasket

1. Front of engine
2. Pass-through connector for BCP sensor
3. Pass-through connector for brake shut-off valve
4. Pass-through connector for ICP sensor

4. Disconnect engine wiring harness from valve cover gasket (ICP connector).

5. Connect VC Gasket Breakout Harness between high-pressure hose assembly and engine wiring harness only.

   NOTE: If connected to the valve cover, gasket connector – readings will be wrong, because the harness will be connected to the ICP sensor under the valve cover.

6. Connect Actuator Breakout Harness to IPR. **Do not connect engine harness**.

   CAUTION: If the engine harness is connected to the actuator breakout harness, the ignition switch fuse will blow or cause damage to wiring harness.

Figure 232 B+ on power distribution terminal

Figure 233 Ground to terminal on cowl

7. Apply B+ volts and ground to the IPR valve.

8. Using the EST or DMM, monitor injection control pressure while cranking engine for 20 seconds.
9. Record results on Diagnostic Form.
   - If injection control pressure increases above 28 MPa (4061 psi) (4.45 V), the high-pressure pump and IPR are operating correctly for the engine to start. Remove test hose assembly from high-pressure pump. Do test 14.4 – Under Valve Cover Leak Test.
   - If 28 MPa (4061 psi) (4.45 V) can not be reached, continue with test 14.5 - IPR Function.

14.4 – Under Valve Cover Leak Test

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

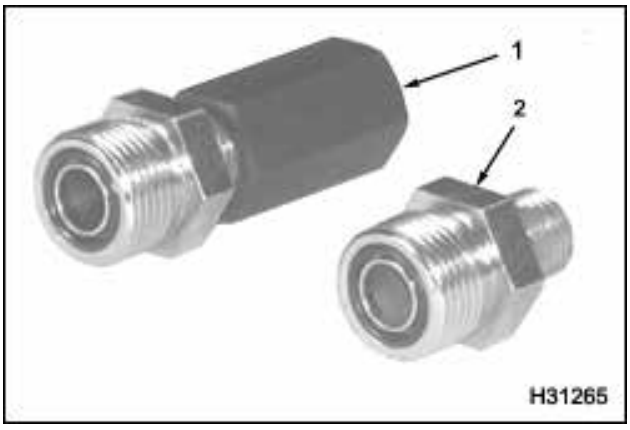

Figure 234 ICP Test Kit

1. ICP sensor adapter
2. Fitting, 13/16-16 NPT

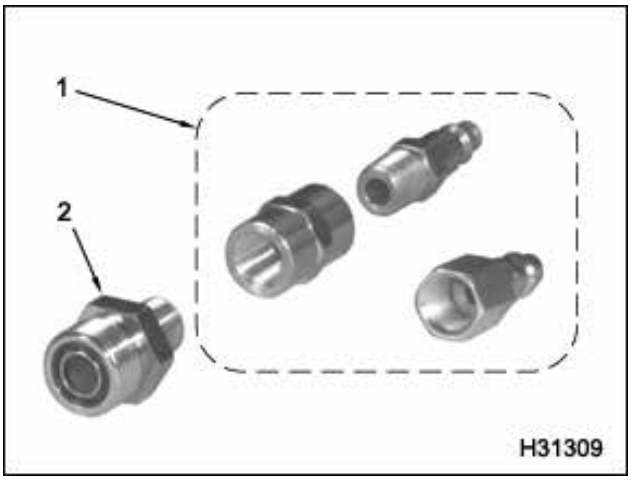

Figure 235 13/16-16 NPT fitting and air chuck adapters

1. Air chuck adapters
2. Fitting, 13/16-16 NPT

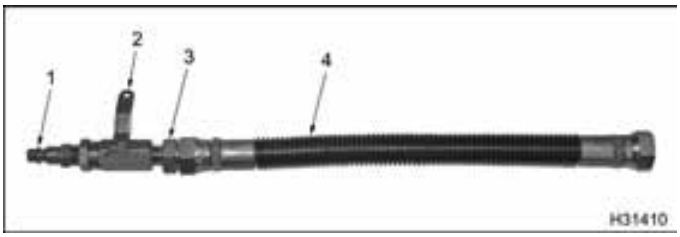

Figure 236 High-pressure oil hose, fitting, and air chuck

1. Air chuck
2. Shut-off valve
3. Fitting, 13/16-16 NPT
4. High-pressure hose

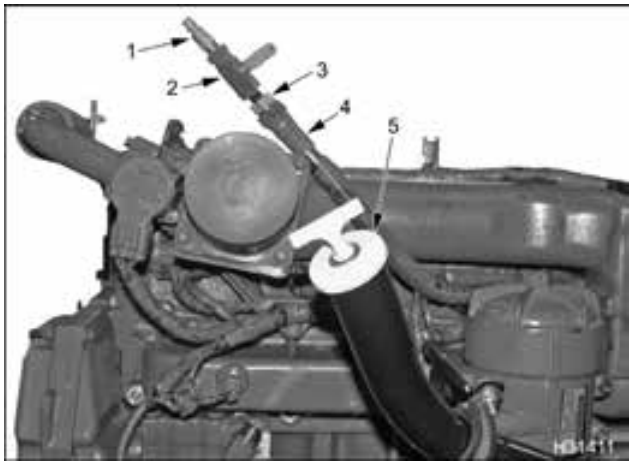

Figure 237 High-pressure oil hose with test fittings installed

1. Air chuck
2. Shut-off valve
3. Fitting, 13/16-16 NPT
4. High-pressure hose
5. Oil level gauge

1. Install 13/16-16 NPT fitting, shut-off valve, and air chuck fitting to high-pressure oil hose connected to cylinder head.

   WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, do the following:

   - **Install an inline shut-off valve.**

     If system does not leak when air is applied, the system will maintain pressure.

     When hose is removed, oil will be released with air pressure.

   - **Use inline shut-off valve to control and contain bleed-off pressure mixture (air and oil).**

2. Remove oil level gauge from oil fill tube.
3. Close shut-off valve.
4. Connect shop air supply line to test hose.
5. Apply 689 kPa (100 psi) of pressure. Slowly open the shut-off valve.
6. Listen for an air leak in the crankcase through the oil fill tube.

   NOTE: Engines with engine brake option will have a small amount of air passing through the system. Air will pass through brake shut-off valve into the brake oil gallery. The air will leak off through the actuator pistons and the relief valve at the end of the rail.

7. Record results on Diagnostic Form.

   - If a leak is not heard, check previous test results.
   - If a leak is heard, check components under the valve cover. Continue with step 8.

8. Close inline shut-off valve to stop air flow.
9. Remove the valve cover following procedures in the *Engine Service Manual*.

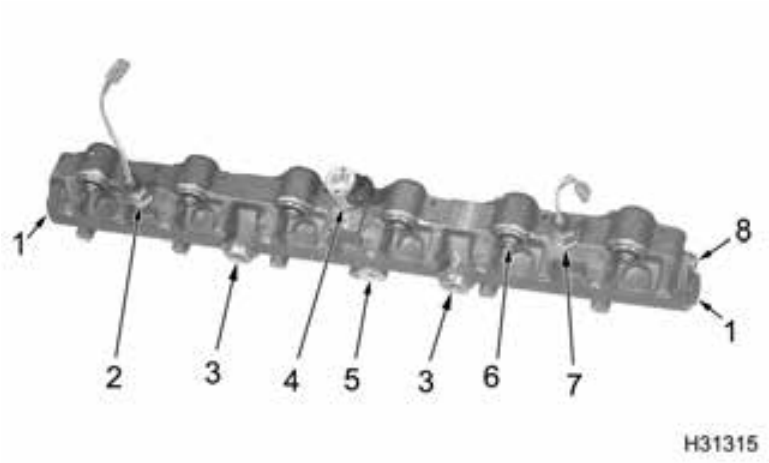

Figure 238 High-pressure oil rail with engine brake (leak locations)

1. End plug (2)
2. ICP sensor
3. Attenuator assembly (2)
4. Brake shut-off valve
5. Machined surface (oil inlet to cylinder head)
6. Inlet adapter (6)
7. BCP sensor
8. Brake pressure relief valve

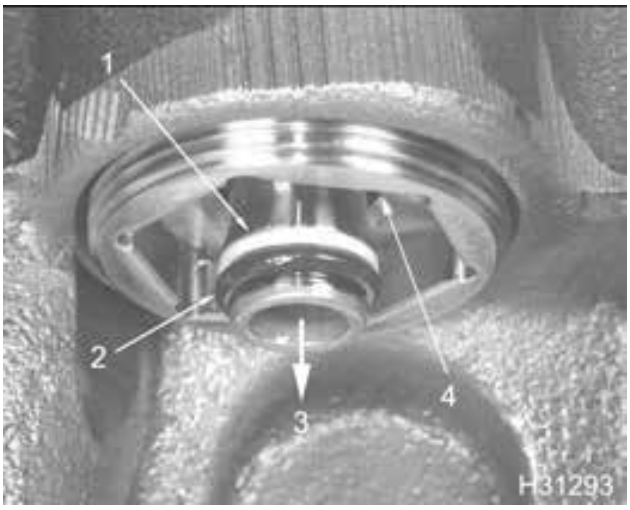

Figure 239 Injector oil inlet adapter in high-pressure oil rail

1. Backup ring
2. Seal
3. To injectors
4. O-ring

Figure 240 O-ring for high-pressure oil manifold

1. O-ring
2. Oil inlet fitting

10. Open inline shut-off valve and listen for leaks. Check the following components:
    - Injector oil inlet adapter O-rings (Figure 239)
    - Injector oil inlet adapter (Figure 239)
    - ICP sensor (Figure 238)
    - O-ring for high-pressure oil rail (Figure 240)

- End plugs in high-pressure oil rail (Figure 238)
- Loose brake shut-off valve (optional) (Figure 238)

11. Replace or repair components, if necessary.
12. Install the valve cover following the procedures in the *Engine Service Manual*.

    NOTE: Make sure all under valve cover wiring is routed correctly. Follow procedures in the *Engine Service Manual*.

    - If engine is equipped with Diamond Logic® Engine Brake, and the high-pressure oil manifold has been removed, adjust the engine brake lash. Follow the procedure in Section 6 - Performance Diagnostics, Brake Lash.

14.5 – IPR Function

⚠ WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

1. Remove ICP sensor adapter and spare ICP sensor from test hose assembly.

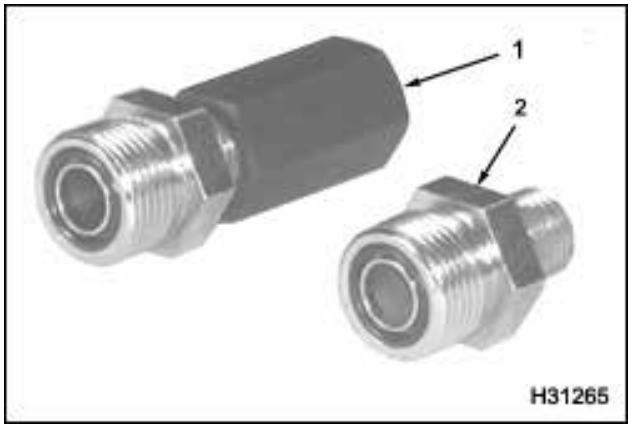

Figure 241 ICP Test Kit

1. ICP sensor adapter
2. Fitting 13/16-16 NPT

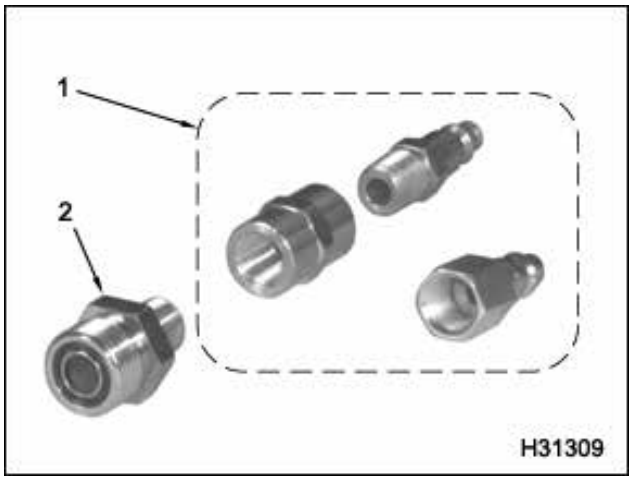

Figure 242 13/16-16 NPT fitting and air chuck adapters

1. Air chuck adapters
2. Fitting, 13/16-16 NPT

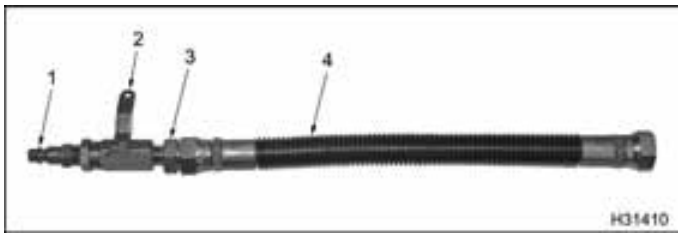

Figure 243 High-pressure oil hose, fitting, and air chuck

1. Air chuck
2. Shut-off valve
3. 13/16-16 NPT fitting
4. High-pressure hose

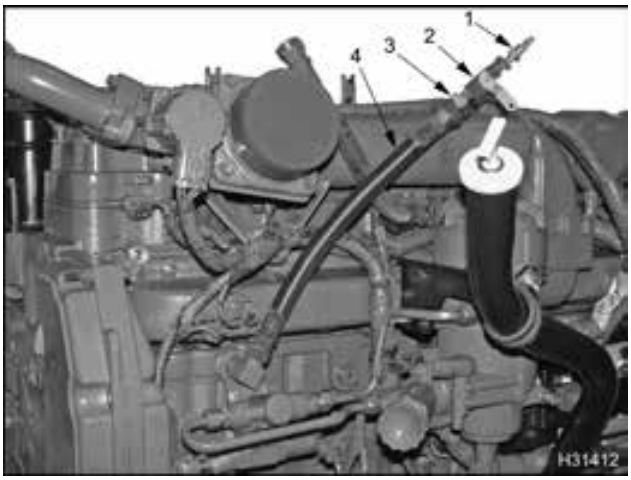

Figure 244 High-pressure oil hose with test fittings installed

1. Air chuck
2. Shut-off valve
3. 13/16-16 NPT fitting
4. High-pressure hose

2. Install 13/16-16 NPT fitting, shut-off valve, and air chuck fitting to test hose.
3. Remove oil level gauge from oil fill tube.
4. Close the shut-off valve.
5. Connect shop air supply line to test hose.
6. Apply 689 kPa (100 psi) of pressure. Slowly open the shut-off valve.
7. Listen for an air leak in the crankcase through the oil fill tube.
   - A leak should be heard through the IPR valve when the IPR valve is not energized.

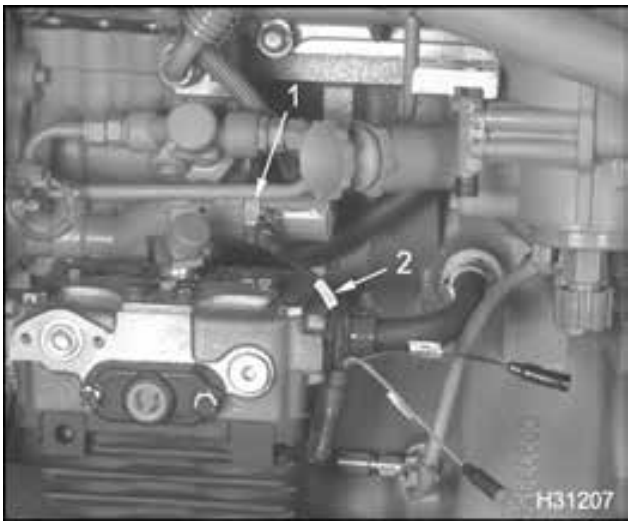

Figure 245 Actuator Breakout Harness to IPR

8. Connect Actuator Breakout Harness to IPR. **Do not connect engine harness**.

   CAUTION: If the engine harness is connected to the actuator breakout harness, the ignition switch fuse will blow or cause damage to wiring harness.

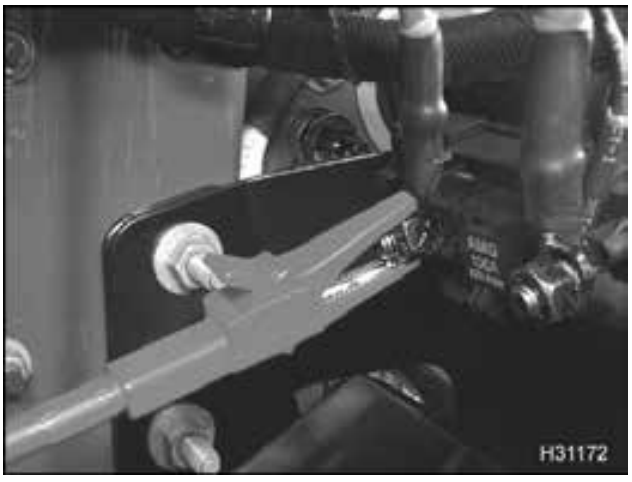

Figure 246 B+ on power distribution terminal

Figure 247 Ground to terminal on cowl

CAUTION: Do not leave the IPR valve energized longer than 120 seconds — this can damage the IPR valve.

9. Apply B+ volts and ground to the IPR valve. Listen for air leak in crankcase.
10. Record results on Diagnostic Form.
    - If the IPR valve is energized, the air leak should stop.
    - If the air leak does not stop, replace the IPR valve following the procedures in the *Engine Service Manual*. Repeat test 14.3 - IPR and High-pressure Pump Operation.
    - If the air leak stops the IPR is functioning. The high-pressure pump is suspect because injection control pressure does not increase. Continue with next step.
11. Remove the high-pressure pump following procedures in the *Engine Service Manual*
    - If high-pressure pump gear is loose, tighten, and reinstall high-pressure pump. Retest injection control pressure.

      If ICP pressure is still below specification, replace the high-pressure pump.
    - If high-pressure pump gear is tight, but the high-pressure pump cam does not rotate, suspect damage in the high-pressure pump. Replace the high-pressure pump and test.

      Note: To inspect high-pressure pump cam, the fuel pump must be removed.

15. Inlet Air Heater System

☐ Install Amp Clamp around one of the two feed wires and do the Output State Test. After 2 seconds, measure amperage for each air heater wire.

☐ If amperage reading is not to spec for Test 15.1, do tests 15.2, 15.3, 15.4, and 15.5 for that circuit.

Test	Air Heater Wire Circuit 1	Spec	Circuit 2
15.1 - Amperage draw		125 ± 10 amps	
15.2 - Voltage at element		BAT V	
15.3 - Element continuity	☐ Yes ☐ No		☐ Yes ☐ No
15.4 - Wiring Harness continuity and resistance		< 5 ohms	
15.5 - Relay operation Battery feed Relay output		 B+ B+	

H31144

Figure 248

Purpose

To determine if the Inlet Air Heater assembly is operating correctly

Tools

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

15.1 – Current Amperage Draw

Procedure

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

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

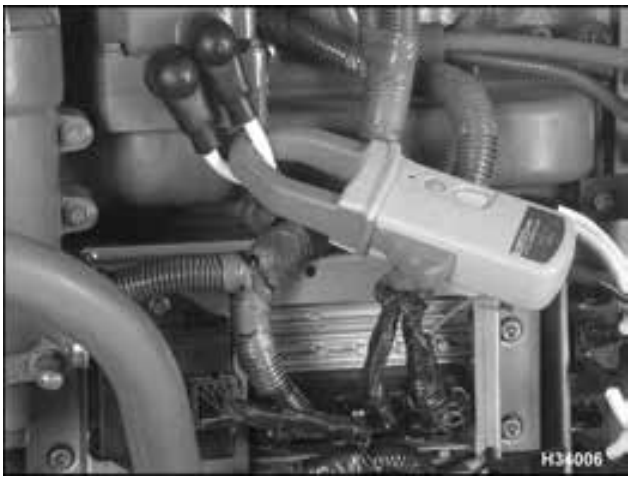

Figure 249 Amp Clamp

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

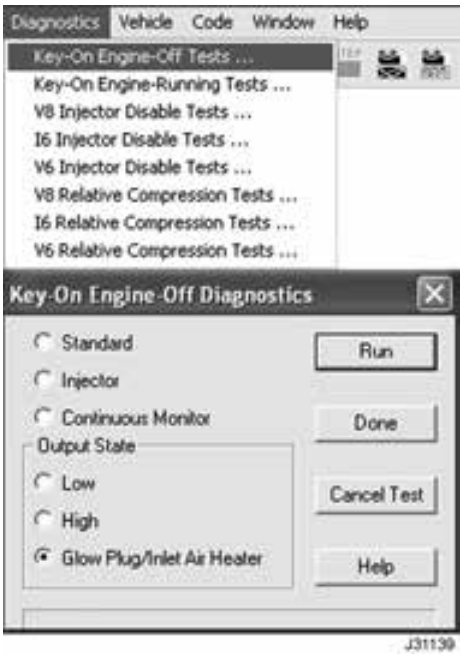

Figure 250 Inlet Air Heater Output State Test

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

3. Select Diagnostics from the menu bar.

4. Select Key-On Engine-Off Tests from the drop down menu.
5. From the KOEO Diagnostics menu, select Glow Plug/Inlet Air Heater, then select Run to start the test.
6. Use the DMM and Amp Clamp to measure amperage. Record results on Diagnostic Form.
7. Repeat the above procedure for other feed wire circuit. Record results on Diagnostic Form.
   - If amperage draw for both circuits meets specifications, do not continue with test. The Inlet Air Heater system is working correctly.
   - If both circuits are not operational, confirm that the ECM is programmed and enabled for the Inlet Air Heater.
   - When a failed circuit has been identified, check that circuit only.
   - If amperage draw does not meet specification, continue with test 15.2 – Voltage at Element.

15.2 – Voltage at Element Terminal

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

Figure 251 Element terminal

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

Figure 252 Ground terminal (left side of crankcase)

2. Connect DMM negative lead to the ground terminal.
3. Turn the ignition switch to ON.

Figure 253 Inlet Air Heater Output State Test

4. Select Diagnostics from the menu bar.
5. Select Key-On Engine-Off Tests from the drop down menu.

   NOTE: When using the EST to do KOEO or KOER diagnostic tests, Standard Test is always selected and run first. If the ignition switch is not cycled, the Standard Test does not have to be run again.
6. From the KOEO Diagnostics menu, select Glow Plug/Inlet Air Heater, then select Run to start the test.
7. Use the DMM to measure voltage.
8. Record results on Diagnostic Form.
   - If voltage is B+, do 15.3 Element Terminal Continuity.
   - If voltage is not B+, do 15.4 - Wiring Harness Continuity and Resistance.

15.3 – Element Terminal Continuity

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

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

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

Figure 254 Element terminal

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

Figure 255 Ground terminal (left side of crankcase)

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

15.4 – Wiring Harness Continuity and Resistance

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

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

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

Figure 256 Element terminal

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

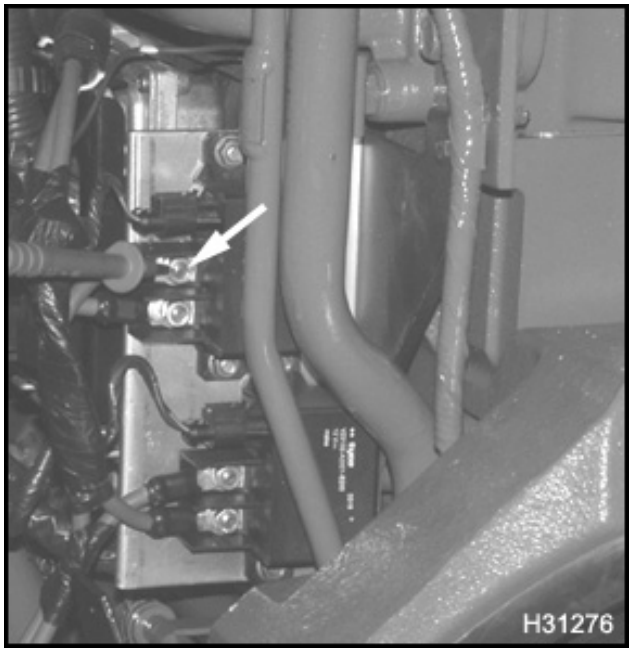

Figure 257 Relay terminal

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

4. Contact DMM positive lead to relay terminal.
5. Record results on Diagnostic Form.
   - If wiring resistance is > 5 Ω, repair or replace, if necessary.
   - If wiring resistance is < 5 Ω, continue with test 15.5 - Relay Operation.

15.5 – Relay Operation

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

Figure 258 Ground terminal (left side of crankcase)

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

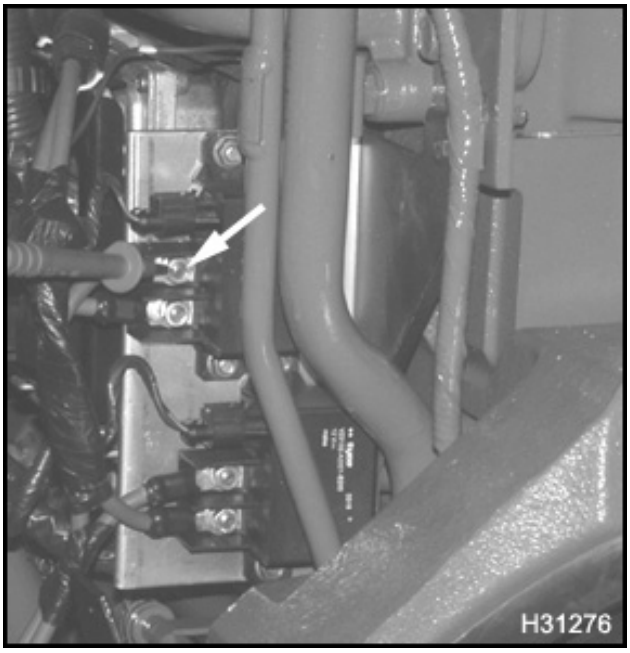

Figure 259 Relay terminal

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

2. Contact DMM positive lead to relay terminal of battery feed to relay.
3. Record results on Diagnostic Form.
   - If DMM voltage at relay terminal is B+, continue with step 4 and measure relay output to element.
   - If voltage of relay terminal is less than B+, repair or replace wire from starter to relay. Retest to verify repair.
4. Turn the ignition switch to ON.
5. Contact DMM positive lead to relay output terminal, relay to element.

Figure 260 Glow Plug/Inlet Air Heater Output State Test

6. Select Diagnostics from the menu bar.
7. Select Key-On Engine-Off Tests from the drop down menu.

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

8. From the KOEO Diagnostics menu, select Glow Plug/Inlet Air Heater, then select Run to start the test.
9. Record results on Diagnostic Form.
   - If both relays are not operational, confirm that the ECM is programmed and enabled for the Inlet Air Heater.
   - If both relays are not operational and the ECM programming is correct, do the following checks in “IAH System” – Section 7:
     — Actuator Voltage Checks at ECM (page 449)
     — Harness Resistance Checks – Relay to ECM (page 450)
     — Harness Resistance Checks – Relay to 12–pin Connector (page 450)
   - If voltage is not B+, do the following checks in “IAH System” – Section 7:
     — Harness Resistance Checks – Relay to ECM (page 450)
     — Harness Resistance Checks – Relay to 12–pin Connector (page 450)

     If the control circuit wiring to the relay is correct, replace relay.
   - If voltage is B+, verify previous test results.

     Check wiring from the relay to element. The wiring may have continuity and low resistance. However, a poor crimp, loose connector, or corrosion could prevent ability to handle circuit load.

Possible Causes

- Failed wiring harness or connection
- Poor ground connection
- Failed relay
- Failed element
- Failed ECM
- ECM not programmed (inlet air heater)

Table of Contents

Description

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

The Diagnostic Form (Performance side) directs technicians to systematically troubleshoot a performance condition and avoid unnecessary repairs.

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

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

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

Diagnostic Form Information

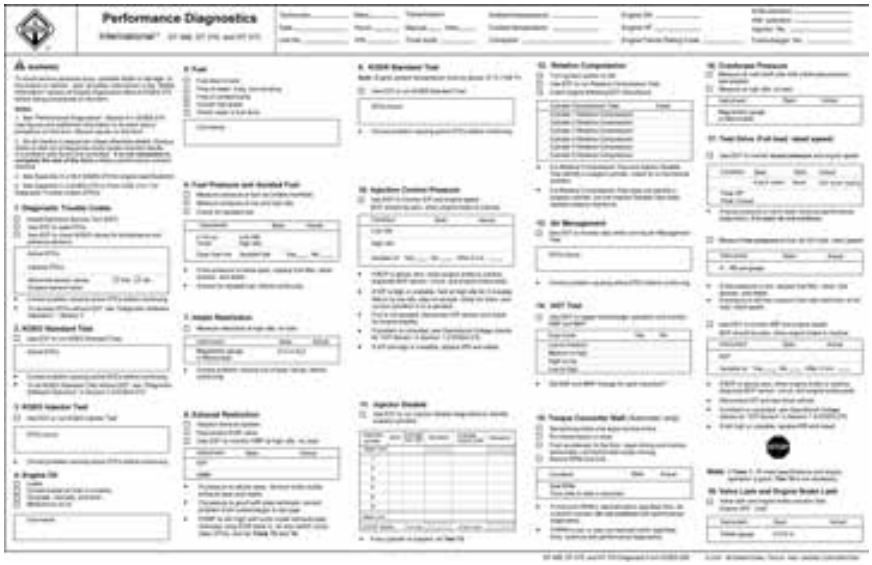

Figure 261 Diagnostic Form EGED-290-1 (Performance Diagnostics side)

Diagnostic Form EGED-290–1 is available in 50 sheet pads. To order technical service literature, contact your International dealer.

Test Procedures

1. Diagnostic Trouble Codes

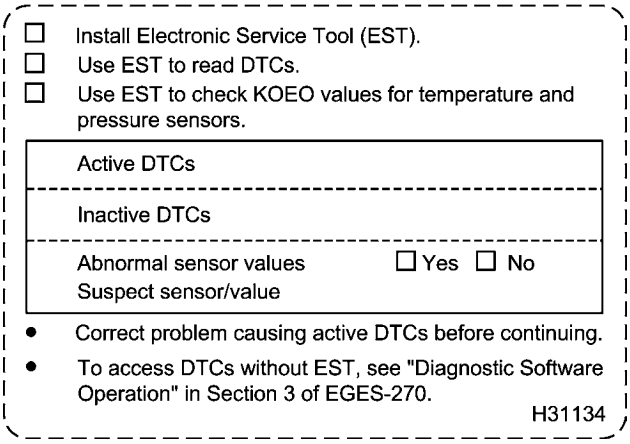

Figure 262

Purpose

- To determine if the ECM has detected Diagnostic Trouble Codes (DTCs) indicating conditions that could cause engine problems
- To fill out Diagnostic Form heading
- To check for abnormal sensor readings

Tools

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

Vehicle Information for Form Heading

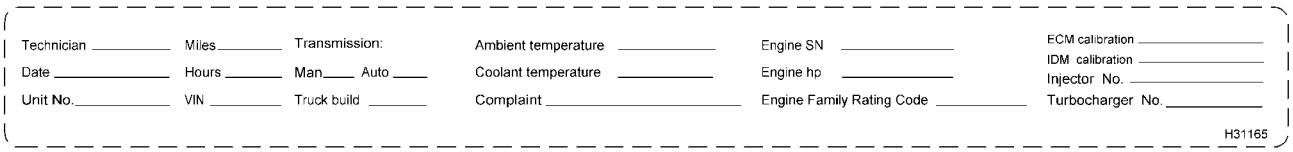

Figure 263

NOTE: Before continuing diagnostic tests, fill out the form heading on Diagnostics Form EGED-290.

Entering Vehicle Information without using the EST

1. Enter the following information in the form heading:
   - Technician
   - Date (for warranty)

- Unit No (dealer's quick reference for customer's vehicle identification)
- Truck build (date)
- Complaint (for warranty)

2. Do the following procedure "Entering Vehicle Information using the EST" to complete the rest of the form heading:

Entering Vehicle Information using the EST

Figure 264 American Trucking Association (ATA) connector

Figure 265 EZ-Tech® interface cable

Figure 266 EZ-Tech® interface cable

⚠ WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

1. Connect the EZ-Tech® interface cable to the EST and the ATA connector.
2. Boot-up EST.
3. Select Engine Diagnostics, then International® MasterDiagnostics® II.
4. Turn the ignition switch to ON.

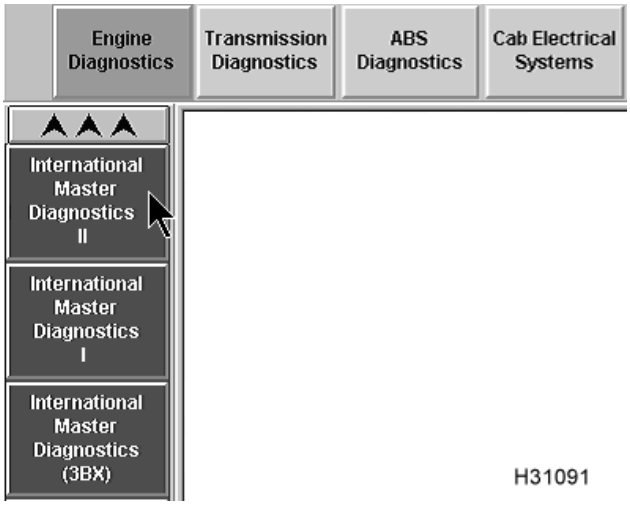

Figure 267 International® launchpad

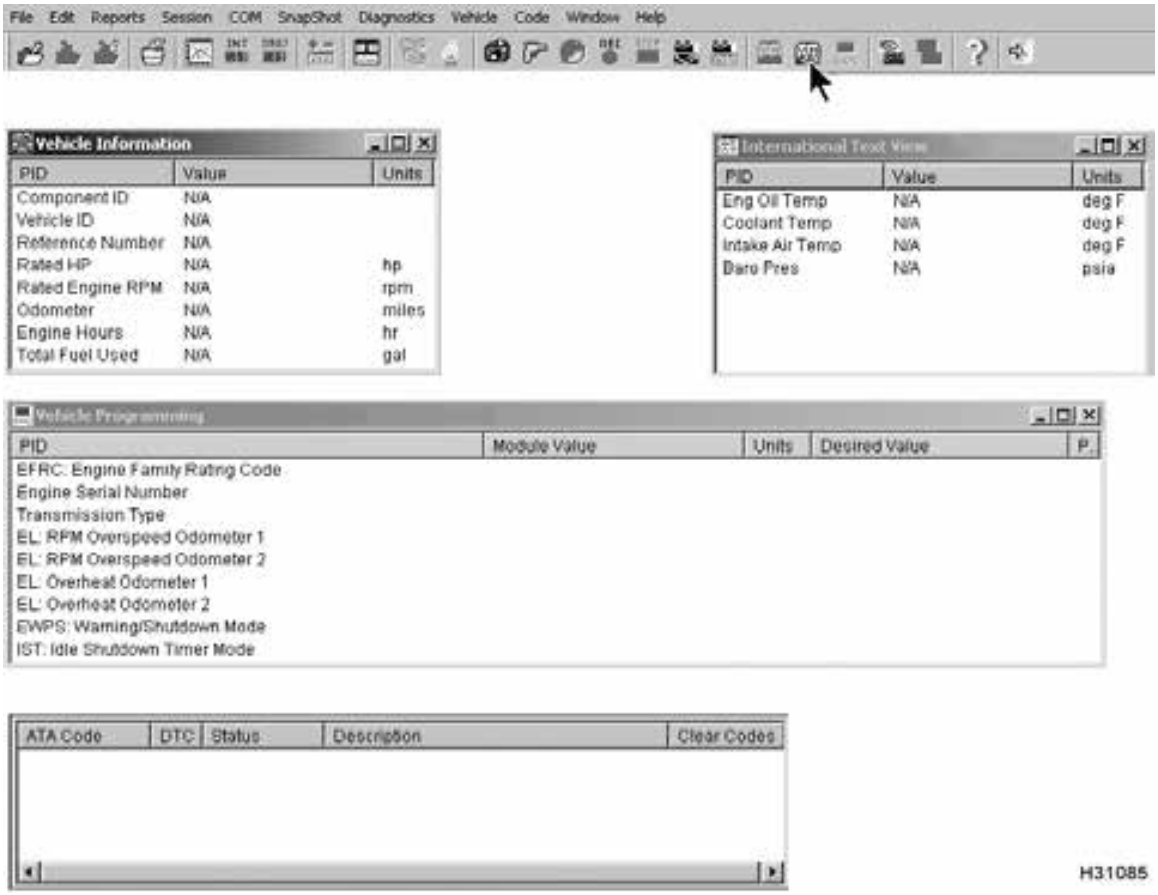

Figure 268 Open VIN+ session

5. Select VIN+ icon to open VIN+ session.
6. Use the on-screen information and the following “Information List” to complete the form heading.

Table 2

Heading Information	VIN+ session PID
Miles	Odometer
Hours	Engine Hours
VIN	Vehicle ID
Transmission	Transmission Type
	Manual Non-Isochronous
	Manual Isochronous
	Allison AT/MT
	Allison MD
Ambient temperature	Intake Air Temp
Coolant temperature.	Coolant Temp
Engine SN	Engine Serial Number
Engine HP	Rated HP
Engine Family Rating Code	EFRC: Engine Family Rating Code
ECM calibration	Reference Number
(Example for reference only)	PRE1PJ02
	(First group)
IDM calibration	Reference Number
(Example for reference only)	ANZKLA02
	(Second group)

Information List

- Miles (for warranty)
- Hours (for warranty)
- VIN (for warranty, ordering parts, and service information) The Vehicle Identification Number is also on the door jamb on the operators side.
- Transmission: Manual/Auto
- Ambient temperature
- Coolant temperature
- Engine SN (for ordering parts and service information)

  The engine serial number is stamped on a crankcase pad on the right side of the crankcase below the cylinder head. The engine serial number is also on the engine emission label on the valve cover.

  Compare the Engine SN in the Vehicle Programming window of the VIN+ session with the Engine SN on the engine. The engine could have been replaced without a programming change to the ECM to upgrade the Engine SN.
- Engine HP (for correct engine application)
- Engine Family Rating Code (for warranty)
- ECM calibration
- IDM calibration

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

- Injector No. (requires removal of valve cover and high-pressure oil rail)
- Turbocharger No. (Check for plate on turbocharger – may require removal of paint from plate)

Accessing DTCs

WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the “Safety Information” section of this manual.

NOTE: When opening VIN+ session to fill out form heading, the DTC window automatically appears.

NOTE: If an EST is not available, see “Accessing DTCs” in Section 3 .

Figure 269 DTC window

1. Record all DTCs from DTC window on Diagnostic Form. See “Diagnostic Trouble Codes” – Appendix C (page 643) for DTCs.
2. Correct problem causing active DTCs before continuing.
3. Clear DTCs.
4. Use EST to check KOEO values for temperature and pressure sensors. Record results on Diagnostic Form.
    - If engine has not been run for 8 to 12 hours, the Engine Coolant Temperature (ECT), Engine Oil Temperature (EOT), and Manifold Air Temperature (MAT) should be within 2 °C (5 °F) of each other. The Intake Air Temperature (IAT) could be a few degrees higher or lower due to faster outside engine temperature change.
    - The Injection Control Pressure (ICP) and Brake Control Pressure (BCP) values may fluctuate as much as 345 kPa (50 psi). Electromagnetic Interference (EMI) or ground shift can cause an insignificant voltage shift that does not indicate a problem.
    - Engine Oil Pressure (EOP), Manifold Air Pressure (MAP), and Exhaust Back Pressure (EBP) values may fluctuate as much as 7 kPa (1 psi). Electromagnetic Interference (EMI) or ground shift can cause an insignificant voltage shift that does not indicate a problem.
    - Barometric Absolute Pressure (BAP) values should equal the barometric reading for your region.
    - Are values normal?
    - If abnormal values are suspected, record on Diagnostic Form and see Operational Voltage tables in Section 7 (page 283) for applicable sensor.
5. Continue with KOEO Standard Test.

Reading DTCs

ATA code: Codes associated with a Subsystem Identifier (SID), Parameter Identifier (PID), and Failure Mode Indicator (FMI)

DTC: Diagnostic Trouble Code

Status: Indicates active or inactive DTCs

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

Description: Defines each DTC

Possible Causes

- Electronics failure
- Failure of the ICP sensor or ICP system
- Failure of the Air Management System (AMS)
- Failure of Diamond Logic® engine brake

2. KOEO Standard Test

☐ Use EST to run KOEO Standard Test.

Active DTCs

- Correct problem causing active DTCs before continuing.
- To do KOEO Standard Test without EST, see "Diagnostic Software Operation" in Section 3 of EGES-270.

H31135

Figure 270

Purpose

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

Tools

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

NOTE: If an EST is not available, see “Standard Test Using Cruise Switches” in Section 3 (page 72).

Procedure

⚠ WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the “Safety Information” section of this manual.

1. Set parking brake to ensure the correct signal from the Electronic System Controller (ESC).
2. Turn the ignition switch to ON. (Do not crank engine.)

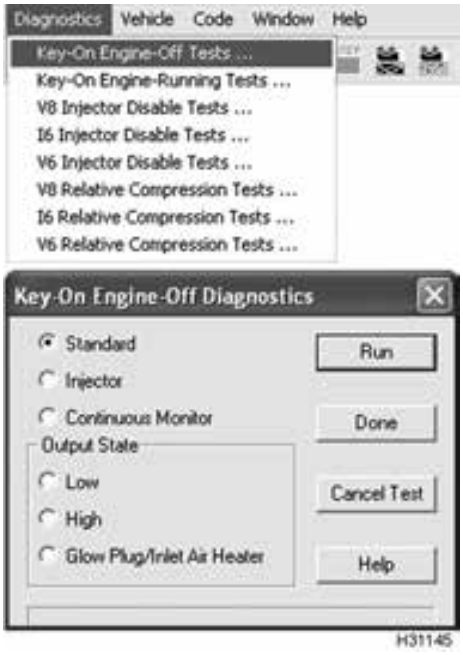

Figure 271 KOEO Standard Test

3. Select Diagnostics from the menu bar.
4. Select Key-On Engine-Off Tests from the drop down menu.

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

5. From the KOEO Diagnostics menu, select Standard, then select Run to start the test.

   The ECM will complete an internal self-test and an OCC. When the OCC is over, the DTC window will show DTCs, if there is a problem.

   NOTE: This test takes less than 5 seconds. While the test is running, the MasterDiagnostics® screen displays message Diagnostics Running .
6. Record all DTCs on Diagnostic Form. See “Diagnostic Trouble Codes” – Appendix C (page 643) for DTCs.
7. Correct problem causing active DTCs.
8. Clear DTCs.

Possible Causes

- Failed electrical components or circuitry

- OCC fault for the IPR valve or brake shut-off valve (if equipped)
- Inlet Air Heater (IAH)
  - — For initial calibrations, if the system voltage is less than 13 volts, DTC 251 may become active.
  - — Later calibrations and current hardware levels do not support DTC 251.

3. KOEO Injector Test

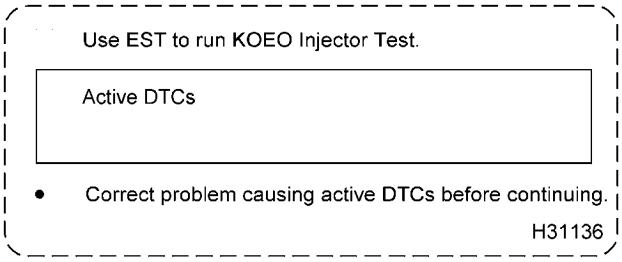

Figure 272

Purpose

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

Tools

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

Procedure

WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

NOTE: The KOEO Injector Test can only be done with the EST using MasterDiagnostics® software.

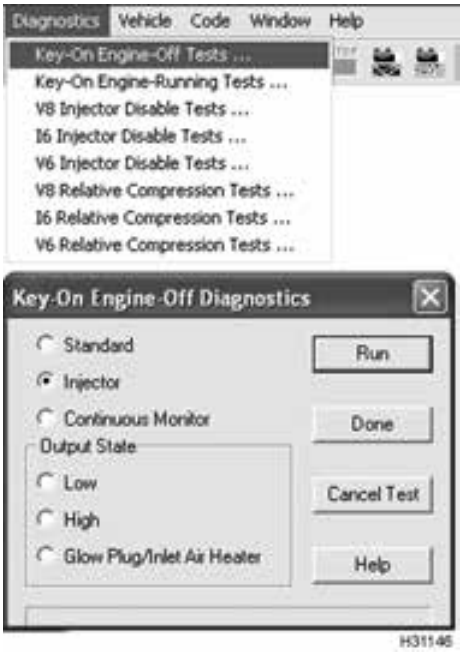

Figure 273 KOEO Injector Test

1. Select Diagnostics from the menu bar.
2. Select Key-On Engine-Off Tests from the drop down menu.

   NOTE: When using the EST to do KOEO or KOER diagnostic tests, Standard Test is always selected and run first. If the ignition switch is not cycled, the Standard Test does not have to be run again.
3. From the KOEO Diagnostics menu, select Injector, then select Run to start the test.

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

   The DTC window will show DTCs for electrical problems.
4. Record DTCs on Diagnostic Form. See "Diagnostic Trouble Codes" – Appendix C (page 643) for DTCs.
5. Correct problem causing active DTCs.
6. Clear DTCs.

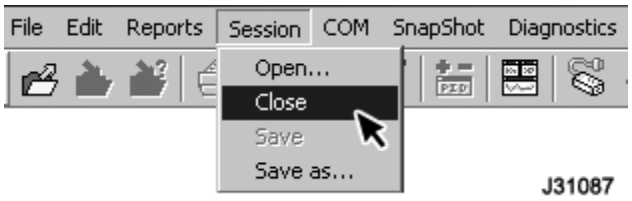

Figure 274 Close session

7. When finished with this test, close the VIN+ session. Select Session from menu bar, then Close.

Possible Causes

- Injector wiring harness open or shorted
- Under Valve Cover (UVC) wiring
- Valve cover gasket
- Faulty wiring harness connection on injector coil
- Failed injector coil
- Failed Injector Drive Module (IDM)
- Failed ECM (not sending test request to IDM)

Hard Start and No Start Only

- Faulty wiring CAN2 datalink
- Faulty wiring IDM power and ground
- Faulty wiring IDM main power relay

4. Engine Oil

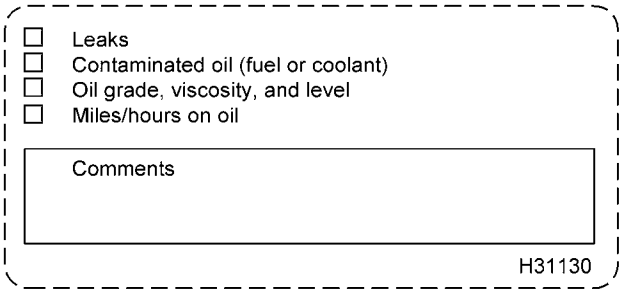

Figure 275

Purpose

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

Tools

- None

Procedure

WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

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

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

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

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

   - Engine oil level will vary depending on temperature of engine.
   - If oil is contaminated, see "Fuel in Lube Oil" (page 124) or "Coolant in Lube Oil" (page 109) in Section 4.
   - If oil level is low, fill to correct level and test again.
4. Check engine service records for correct oil grade and viscosity for ambient operating temperatures. **Do not use 15W-40 oil below -7 °C (20 °F)**. Long oil drain intervals can increase oil viscosity; thicker oil will make engine cranking and starting more difficult below freezing temperatures. See "Lubrication Requirements" in the *Engine Operation and Maintenance Manual* (for this engine's model number and model year). Confirm that oil meets correct API category.
5. Record concerns on Diagnostic Form.

Possible Causes

Low oil level

- Oil leak
- Oil consumption
- Incorrect servicing

High oil level

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

Coolant in oil

- Cylinder head gasket leak
- Failed cup plug in cylinder head
- Injector sleeve leak
- Front cover gasket leak
- Front cover, cylinder head, or crankcase porosity
- Accessory leak (water cooled air compressor)
- Failed crevice seal (piston sleeve)

Fuel in oil

- Injector O-ring leak
- Cylinder head porosity
- Leaking injector

5. Fuel

☐ Fuel level in tank
☐ Free of water, icing, and clouding
☐ Free of contaminants
☐ Correct fuel grade

Comments

H31169

Figure 276

Purpose

To check fuel level and quality for efficient engine operation

- Ask the operator if the amber WATER IN FUEL lamp was on during vehicle operation.
- If engine has an optional Engine Fuel Pressure (EFP) sensor, ask the operator if the amber FUEL FILTER lamp was on during vehicle operation. If the lamp was on, change the fuel filter and retest for poor engine operation.

Tools

- Clear container (approximately 1 liter or 1 quart US)
- Fuel pressure test adapter
- Pocket screw driver

Procedure

WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

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

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

1. Check fuel level in fuel tank and for odors other than diesel fuel – kerosene and gasoline, for example.

CAUTION: Be sure to place a rag or suitable container under the fuel pressure test valve when bleeding the fuel rail. Dispose of fuel in a correct container clearly marked DIESEL FUEL according to local regulations.

NOTE: Engine fuel can be a threat to the environment. Never dispose of engine fuel by putting it in the trash, pouring on the ground, in the sewers, in streams, or bodies of water.

Figure 277 Shrader valve assembly

1. Valve
2. Center stem

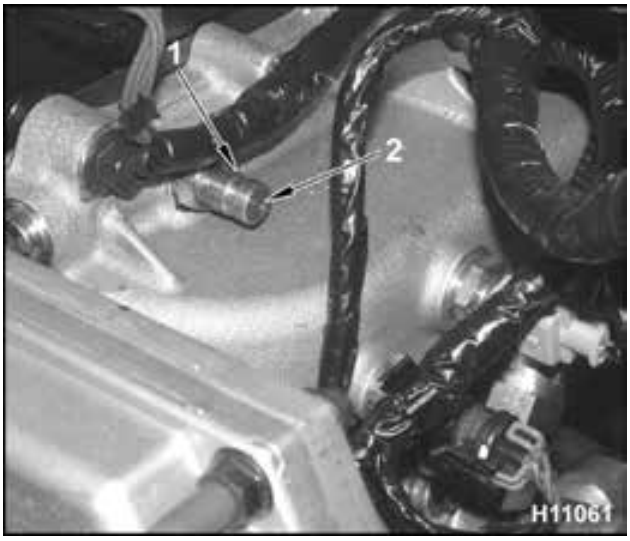

Figure 278 Diagnostic coupling

1. Valve
2. Center section

NOTE: Engines are equipped with a fuel pressure test valve in the form of either a Shrader valve or a diagnostic coupling.

2. Check for indications of aerated fuel in the fuel system. Relieve pressure from the fuel rail using the fuel pressure test valve.
   - As fuel pressure is relieved, a steady stream of fuel, without air from the fuel pressure test valve, means that air is not in the fuel system.
   - An erratic air/fuel mixture surge suggests that air is in the fuel system.

Figure 279 Fuel pressure test adapter

NOTE: It is recommended to use the fuel pressure test adapter to avoid bending the needle in the fuel pressure test valve.

Figure 280 Fuel test fitting

NOTE: Some engines will have a diagnostic coupling instead of a Shrader valve. Press end of coupling with a pocket screwdriver to relieve pressure.

Figure 281 Water drain valve

1. Water drain valve
2. Plastic tube

Figure 282 Fuel strainer drain valve

3. Open water drain valve and collect a fuel sample using a clear container. Check for the following conditions:
   - Fuel must be the correct grade, clean, and undiluted.
   - Gasoline, kerosene or other chemicals in the diesel fuel

     (If diesel fuel is contaminated, correct the condition and retest.)
   - If the fuel filter was not serviced or drained for a long time, some sediment or water could be in the fuel filter housing.

   NOTE: Cold weather can cause fuel waxing in some grades of diesel fuel. Waxing will restrict or stop fuel flow through the fuel filter.
4. Open fuel strainer drain valve. Collect a fuel sample using a clear container. If fuel is contaminated do the following:
   a. Pull drain valve down and out of bowl.
   b. Remove strainer bowl and check strainer for sediment, debris, or rust. Clean and replace as required.
   c. Check fuel tanks and fuel lines. Clean and flush if necessary.
5. Prime fuel system. See “Priming the Fuel System” in Section 4 (page 132) for procedure.

Possible Causes

- Low fuel level in fuel tank.
- Inline fuel valve (if equipped) could be shut-off.
- Fuel supply line could be broken or crimped.
- The fuel tank pickup tube could be clogged or cracked.
- Supplemental filters or water separators may be plugged or leaking allowing air to enter the fuel system.
- Failed seal for inlet fitting in fuel filter housing
- Water or contaminants in fuel tank

- Ice in fuel lines
- Debris in fuel tank
- Cloudy fuel indicates unsuitable fuel grade for cold temperatures.
- Fuel could be waxed or jelled. (usually Grade 2-D)

6. Fuel Pressure and Aerated Fuel

☐ Measure pressure at fuel rail (intake manifold).
☐ Measure pressure at low and high idle.
☐ Measure pressure under load.
(automatic only – torque converter stall)
☐ Check for Aerated fuel.

Instrument		Spec	Actual
0-100 psi Gauge	Low idle		
	High idle		
	Auto only (converter stall)		
Clear fuel line	Aerated fuel	Yes____ No ____	

- If fuel pressure is below spec, replace fuel filter, clean strainer, and retest.
- Correct for aerated fuel, before continuing

H31168

Figure 283

Purpose

To check for correct fuel pressure and aerated fuel

- Ask the operator if the amber WATER IN FUEL lamp was on during vehicle operation.
- If engine has an optional Engine Fuel Pressure (EFP) sensor, ask the operator if the amber FUEL FILTER lamp was on during vehicle operation. If the lamp was on, change the fuel filter and retest for poor engine operation.

Tools

- Fuel pressure test gauge
- Fuel Pressure Test Kit
- 1 to 5 gallon bucket
- Fuel/Oil Pressure Test Coupler

Fuel Pressure

Procedure

WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

1. See "DT 466 Performance Specifications" – Appendix A (page 595) or "DT 570 and HT 570 Performance Specifications" – Appendix B (page 619) for fuel pressure specifications and record on Diagnostic Form.

NOTE: If engine is equipped with optional Engine Fuel Pressure (EFP) sensor, use EST with MasterDiagnostics® software to monitor fuel pressure. Compare the EST values to gauge readings.

CAUTION: Be sure to place a rag or suitable container under the fuel pressure test valve when bleeding the fuel rail. Dispose of fuel in a correct container clearly marked DIESEL FUEL according to local regulations.

NOTE: Engine fuel can be a threat to the environment. Never dispose of engine fuel by putting it in the trash, pouring on the ground, in the sewers, in streams, or bodies of water.

Figure 284 Shrader valve assembly

1. Valve
2. Center stem

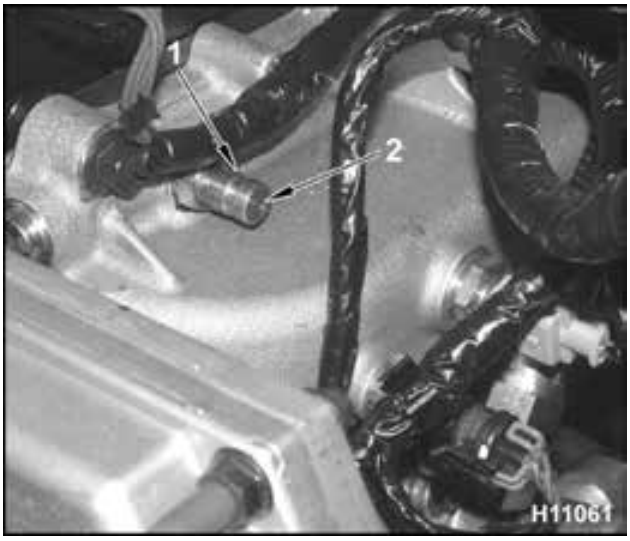

Figure 285 Diagnostic coupling

1. Valve
2. Center section

NOTE: Engines are equipped with a fuel pressure test valve in the form of either a Shrader valve or a diagnostic coupling.

CAUTION: Be sure to place a rag or suitable container under the fuel pressure test valve when bleeding the fuel rail. Dispose of fuel in a correct container clearly marked DIESEL FUEL according to local regulations.

NOTE: Engine fuel can be a threat to the environment. Never dispose of engine fuel by putting it in the trash, pouring on the ground, in the sewers, in streams, or bodies of water.

Figure 286 Shrader valve assembly

1. Valve
2. Center stem

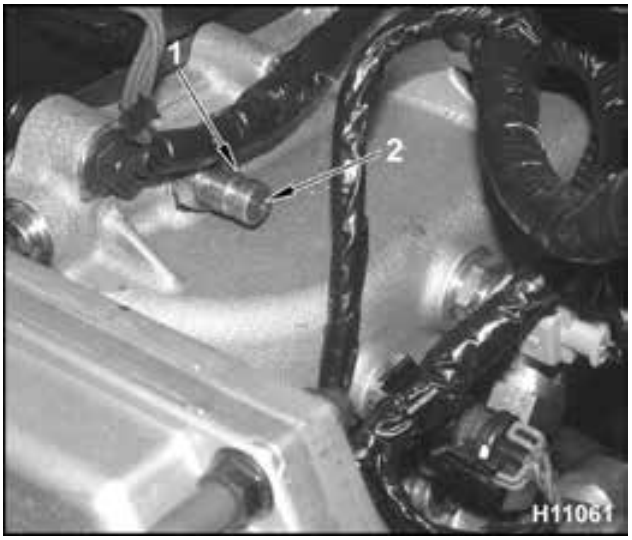

Figure 287 Diagnostic coupling

1. Valve
2. Center section

NOTE: Engines are equipped with a fuel pressure test valve in the form of either a Shrader valve or a diagnostic coupling.

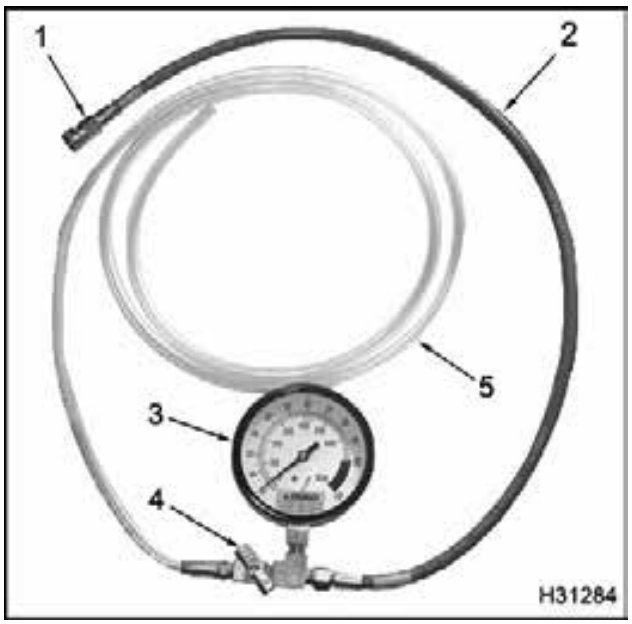

Figure 288 Fuel Pressure Gauge

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

Figure 289 Fuel Pressure Test Adapter

NOTE: If the engine is equipped with a Shrader valve, use the Fuel Pressure Test Adapter.

Figure 290 Fuel/Oil Pressure Test Coupler

NOTE: If the engine is equipped with a diagnostic coupling, adapt the Fuel/Oil Pressure Test Coupler to the Fuel Pressure Gauge.

Figure 291 Fuel Pressure Gauge to fuel pressure test adapter

2. Connect Fuel Pressure Gauge with shut-off valve and clear 3/8” diameter hose to test valve.
3. Route the clear hose into a drain pan.

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

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

4. Start the engine and measure fuel pressure with the shut-off valve closed. Open the shut-off valve to check for aeration.

   NOTE: Breaking any fuel system joint will induce air into the fuel system. The air should pass in a short period of time. As fuel pressure is relieved, a steady stream of fuel without air bubbles indicates the fuel is not aerated.

   NOTE: If a Fuel Pressure Gauge with shut-off valve and clear 3/8" diameter hose is not available to check for aeration, see alternative test "Checking for Aerated Fuel using Spare Fuel Line."

5. Record results on Diagnostic Form.
   - If fuel pressure is below specification and fuel is not aerated, replace the fuel filter and clean the strainer. Test the fuel pressure again.
   - If fuel is aerated, see "Aerated Fuel" in Section 4.
   - If fuel pressure is still low and fuel is not aerated after replacing the fuel filter and cleaning the strainer, do "Operation of the Fuel Pump."
   - If fuel pressure is in specification and fuel is not aerated, continue with step 6.
6. Run the engine at high idle. Measure the fuel pressure with the shut-off valve closed. Open the shut-off valve to check for aeration.
7. Record results on Diagnostic Form.
   - If fuel pressure is below specification, replace the fuel filter and clean the strainer. Test the fuel pressure again.
   - If fuel pressure is still low after replacing the fuel filter and cleaning the strainer, do the "Operation of the Fuel Pump Test."
   - If fuel pressure stays in specification, continue to step 8
8. Does the vehicle have an automatic transmission?
   - If yes, continue to step 9.
   - If no, continue to the next diagnostic test.
9. Set the parking brake and apply service brake.

   WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, make sure brakes are correctly adjusted and in good condition. This procedure should be done in an open lot.

   CAUTION: Avoid damage to the drive train. Do not do this test for more than 10 seconds at a time or more than twice back to back. (If doing twice – wait 2 minutes between tests.)
10. Put transmission in drive.
11. Press accelerator to the floor for no longer than 10 seconds.
12. Record results on Diagnostic Form.
    - If fuel pressure is below specification, replace fuel filter and clean the strainer. Test the fuel pressure again.
    - If fuel pressure is still low after replacing the fuel filter and cleaning the strainer, do the "Operation of the Fuel Pump Test."
    - If fuel pressure is in specification, continue to the next diagnostic test.

Possible Causes

No fuel

- Low fuel level in fuel tank
- Debris in tank can cause high-restriction and low fuel pressure.
- Inline fuel valve (if equipped) could be shut-off
- Failed seals or fuel lines between fuel tanks
- Ice in fuel lines
- Inoperative fuel tank transfer pump
- Fuel tank pickup tube cracked

Low fuel pressure

- Dirty filter element
- Debris or rust in fuel strainer
- Restriction from the fuel tank to the fuel filter housing inlet can cause high-restriction and low fuel pressure.
- Plugged supplemental filters or water separators can cause high-restriction and low fuel pressure.

- Debris in tank can cause high-restriction and low fuel pressure.
- A kinked or bent fuel supply line or a blocked pickup tube can cause high-restriction and low fuel pressure.
- Waxed or jelled fuel in the fuel filter will cause high-restriction and low fuel pressure. (Usually Grade 2-D)
- Ice in fuel lines.
- A restriction between the fuel inlet fitting, strainer, and fuel pump can cause high-restriction and low fuel pressure.
- Debris in the fuel regulator valve
- Failed fuel pressure regulator valve.
- Failed fuel pump
- Failed high-pressure oil pump (can not operate fuel pump)

Aerated fuel

- Failed seal for inlet fitting in fuel filter housing
- Supply filter or water separator leaking
- A loose fuel line on the suction side of the fuel system can ingest air into the system and cause low fuel pressure (most noticeable under load).
- Strainer drain valve loose or damaged
- Strainer bowl warped or damaged
- Missing O-ring from strainer bowl
- Damaged seals on steel inlet tube to fuel pump
- Primer pump seals damaged

Fuel restriction

- Dirty filter element
- Debris or rust in fuel strainer
- Restriction from the low-pressure fuel filter housing inlet to the fuel tank can cause high-restriction and low fuel pressure.
- Plugged supplemental filters or water separators can cause high-restriction and low fuel pressure.
- Debris in tank can cause high-restriction and low fuel pressure.
- A kinked or bent fuel supply line or a blocked pickup tube can cause high-restriction and low fuel pressure.
- Waxed or jelled fuel in the fuel filter will cause high-restriction and low fuel pressure. (Usually Grade 2-D)
- Ice in fuel lines.
- A restriction between the fuel inlet fitting, strainer, and fuel pump can cause high-restriction and low fuel pressure.

High fuel pressure (pulsating fuel pressure)

- Debris in the fuel regulator valve
- Inoperative fuel pressure regulator valve.
- Combustion gases leaking into fuel system

Checking for Aerated Fuel using Spare Fuel Line

NOTE: This is an alternative test. Do this procedure, only if Fuel Pressure Gauge with shut-off valve is not available.

Tools

- Spare fuel line (filter housing to fuel supply pump)
- Clear plastic line
- Hose clamp (2)

Procedure

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the “Safety Information” section of this manual.

Figure 292 Fuel supply line

1. Remove fuel supply line from suction side of fuel pump and fuel filter housing.

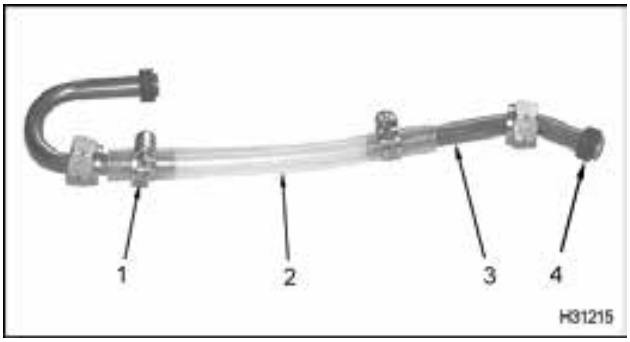

Figure 293 Test fuel line

1. Clamp (2)
2. Clear plastic tube
3. Spare fuel line (half)
4. Sleeve seal (2)

2. Make a test fuel line.

   - Use spare fuel line. (Make sure both sleeve seals are good.) Cut a 3 inch section from the center of the fuel line. Install clear plastic line in place of removed section and secure plastic line with clamps.

   NOTE: The mechanic is expected to keep the fuel test line for future diagnostics. Expense the fuel test line as an essential tool and keep it with other diagnostic tools. Warranty will not cover the cost of the fuel test line.

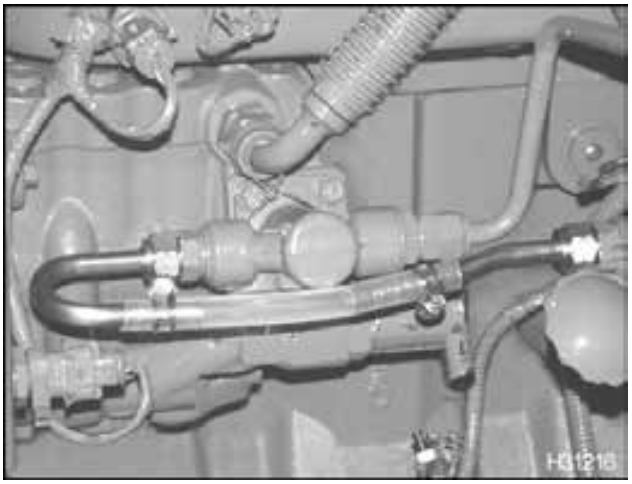

Figure 294 Test line installed

3. Install test fuel line.

   NOTE: Verify that sleeve seals are in good condition.

4. Do one of the following:

   - For **Hard Start and No Start Diagnostics**, crank engine for 20 seconds and check for air bubbles in the clear plastic line.
   - For **Performance Diagnostics**, run engine at high idle, no load and check for air bubbles in the clear plastic line.

5. Record results on Diagnostic Form.

   NOTE: Initially, fuel will be aerated due to draining fuel from filter housing and strainer in previous test.

   - If fuel is aerated check for a leak in the suction side of fuel system. See “Aerated Fuel” in Section 4.
   - If fuel is not aerated and fuel pressure is good, continue with next test.
   - If fuel is not aerated and fuel pressure is low, do “Operation of Fuel Pump”.

6. Remove fuel test line and install original fuel line.

   NOTE: Verify that sleeve seals are in good condition.

Operation of Fuel Pump

Tools

- Vacuum Pump And Gauge (kit)
- Hose clamp
- Fuel pressure test gauge
- Fuel Pressure Test Kit
- Fuel/Oil Pressure Test Coupler
- 1 to 5 gallon bucket

Procedure

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

Figure 295 Test hose to fuel line

1. Fuel line (suction side)
2. Hose clamp
3. Test hose

NOTE: The fuel pressure gauge with the inline shut-off valve is still connected to the fuel pressure test valve. If shut-off valve is not opened, test will result in false readings. Do the following procedure:

1. Open the shut-off valve.
2. Disconnect fuel line (suction side) from fuel filter housing.

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

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

3. Slide test hose onto fuel line and secure with hose clamp or use cone adapter (vacuum pump kit) that fits into end of fuel line.

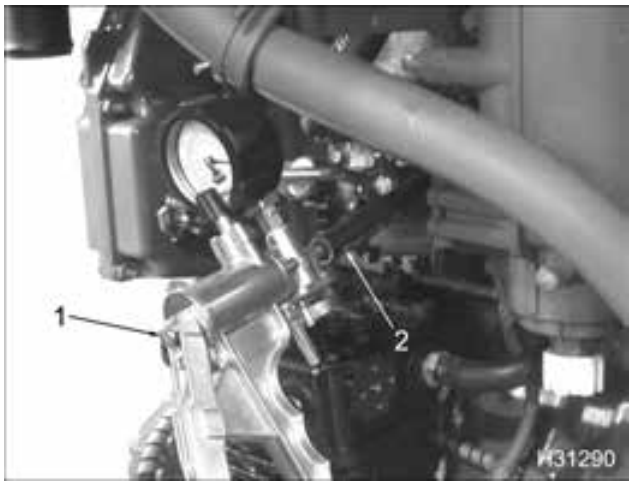

Figure 296

4. Insert vacuum pump nozzle into test hose.
5. Crank engine, check gauge reading, and record on Diagnostic Form.
   - If less than 12 in Hg., check steel line and test connections between the air vacuum test gauge and fuel pump. Verify integrity of test hose adapter
   - If vacuum is still below specification, replace the fuel pump following procedures in the *Engine Service Manual*.
   - If greater than 12 in Hg., the fuel pump is working. Replace fuel regulator and retest fuel pressure.
   - If fuel pressure is still low after replacing the fuel pump and regulator, check for restriction between the filter housing and fuel tank.

7. Intake Restriction

☐ Measure restriction at high idle, no load.

Instrument	Spec	Actual
Magnehelic gauge or Manometer	12.5 in H_2O	

- Correct problem causing out of spec values, before continuing.

H31160

Figure 297

Purpose

To check for restriction in the air intake system likely to cause engine performance problems.

NOTE: High intake or exhaust restriction can cause a large amount of black smoke.

Tools

- Gauge Bar (magnehelic)
- Test line

Procedure

WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

1. Inspect the following parts for restriction, damage or incorrect installation:
   - Air filter inlet and ducting (includes hood)
   - Air inlet hoses and clamps
   - Air filter housing, filter element, and gaskets
   - Chassis mounted CAC and piping
   - Air filter restriction indicator or gauge

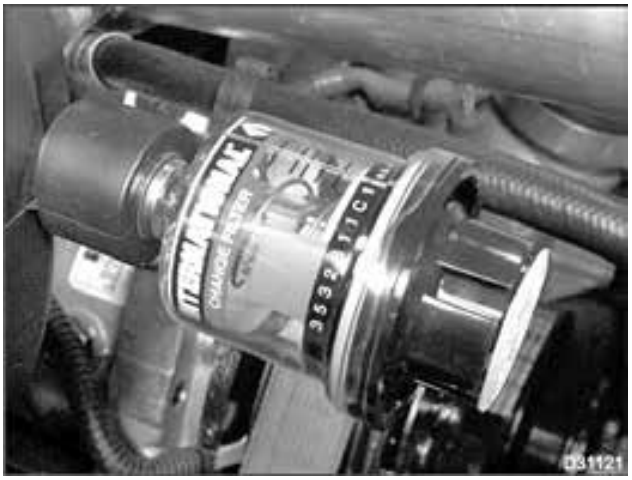

Figure 298 Low restriction

Figure 299 High restriction

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

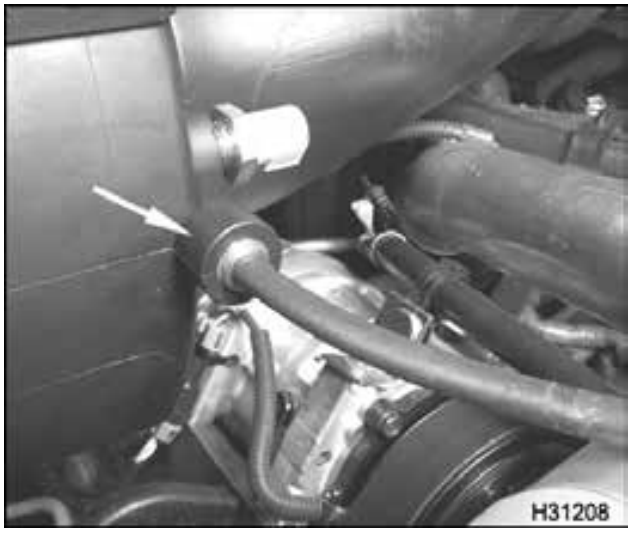

Figure 300 Air filter housing tap

2. Remove air intake restriction indicator or remove line to instrument panel restriction gauge from air filter housing.
3. Attach test line to tap for air filter housing.

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

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

4. Connect line to magnehelic gauge or manometer.

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

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

5. Run engine at high idle, no load.
6. Record reading on Diagnostic Form.
   - If restriction is more than 3.13 kPa (12.5 in H_2O), replace air filter element.
   - If restriction is more than 3.13 kPa (12.5 in H_2O), and a new filter is in place, check for obstructions in air inlet.
   - If restriction is less than 3.13 kPa (12.5 in H_2O), continue with Performance Diagnostics.

NOTE: An equivalent test, using the instrument mounted restriction indicator, can only be done while operating the engine at full load and rated horsepower. The true maximum air filter restriction for this test is 6.22 kPa (25 in H_2O).

Possible Causes

- Clogged air filter element (dust, dirt, or debris)
- Snow in air filter inlet
- Ice in air filter inlet
- Plastic bags or other foreign material in air filter inlet
- Collapsed air filter
- On engines recently repaired, rags or cap plugs may have been left in the intake system.

8. Exhaust Restriction

☐ Inspect exhaust system.
☐ Disconnect EGR valve.
☐ Use EST to monitor EBP at high idle, no load.

Instrument	Spec	Actual
EST		

- If pressure is above spec, remove turbo outlet exhaust pipe and retest.
- If pressure is good with pipe removed, correct problem from turbocharger to tail pipe.
- If EBP is still high with turbo outlet exhaust pipe removed, plug EGR back in, dokey cycle, clear codes, and do **Tests 13** and **14**.

H31159

Figure 301

Purpose

To check for restrictions in the exhaust system likely to cause engine performance problems

NOTE: High intake or exhaust restriction can cause a large amount of black smoke.

Tools

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

WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

Monitoring EBP using EST

NOTE: If an EST is not available, use alternate method – "Monitoring EBP using Pressure Sensor."

1. See "DT 466 Performance Specifications" – Appendix A (page 595) or "DT 570 and HT 570 Performance Specifications" – Appendix B (page 619) for specifications and record on Diagnostic Form.
2. Inspect the exhaust system for damage and restriction.
3. Disconnect the EGR control valve. If EGR control valve is plugged in during the test, results will be incorrect.

   NOTE: When the EGR control valve is disconnected, the ECM will set DTC 163 (Position signal out of range low) and possibly DTC 365 (Position above/below desired level) for the EGR control valve. Ignore and clear DTC 163 and DTC 365, after the test is complete.

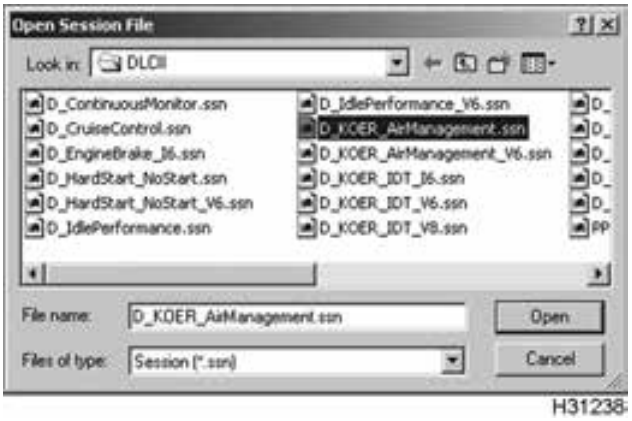

Figure 302 KOER Air Management.ssn

4. Open D_KOER_AirManagement.ssn to monitor EBP at high idle, no load.

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

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

5. Run engine at high idle, no load.

   NOTE: Do not run KOER Air Management test. The session is open to monitor EBP at high idle and to clear DTC after it is set.
6. Record results on Diagnostic Form.
   - If restriction is to specification, do the following:
     a. Turn ignition switch to OFF.
     b. Reconnect EGR control valve.
     c. Turn ignition switch to ON.
     d. Clear all DTCs.
     e. Continue Performance Diagnostics.

- If restriction is above specification, remove exhaust pipe from turbocharger outlet and retest.
- If restriction is to specification with exhaust pipe removed, do the following:
    a. Turn ignition switch to OFF.
    b. Reconnect EGR control valve.
    c. Turn ignition switch to ON.
    d. Clear all DTCs.
    e. Correct problem from turbocharger outlet to tail pipe.
- If exhaust back pressure is still high with pipe removed from turbocharger outlet, do the following:
    a. Turn ignition switch to OFF.
    b. Reconnect EGR control valve.
    c. Turn ignition switch to ON.
    d. Clear all DTCs.
    e. An inoperative turbocharger is suspect. Do Test 13 Air Management and Test 14 VGT Test.

Possible Causes

- Restricted exhaust pipe
- Collapsed exhaust pipe
- Damaged muffler
- Turbocharger malfunction
- Clogged catalytic converter
- Clogged Catalyzed Diesel Particulate Filter (CDPF) – dependent on application

Monitoring EBP using Pressure Sensor Breakout Harness

NOTE: Do this procedure, if an EST is not available. This is an alternate method.

Tools

- Pressure sensor breakout harness
- Digital Multimeter (DMM)

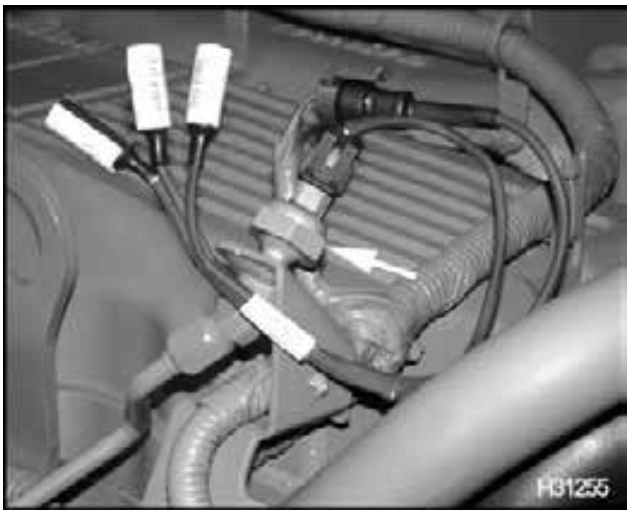

Figure 303 Pressure Sensor Breakout Harness to EBP sensor

1. See “DT 466 Performance Specifications” – Appendix A (page 595) or “DT 570 and HT 570 Performance Specifications” – Appendix B (page 619) for specifications and record on Diagnostic Form.
2. Connect Pressure Sensor Breakout Harness to engine harness and EBP sensor.
3. Use DMM to measure EBP at high idle, no load.
    - Connect POS to green (signal circuit) and NEG to black (signal ground).

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

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

4. Run engine at high idle, no load.
5. Record results on Diagnostic Form.
    - If restriction is to specification, do the following:
        a. Turn ignition switch to OFF.
        b. Reconnect EGR control valve.
        c. Turn ignition switch to ON.
        d. Clear all DTCs.
        e. Continue Performance Diagnostics.
    - If restriction is above specification, remove exhaust pipe from turbocharger outlet and retest.
    - If restriction is to specification with exhaust pipe removed, do the following:
        a. Turn ignition switch to OFF.
        b. Reconnect EGR control valve.
        c. Turn ignition switch to ON.
        d. Clear all DTCs.
        e. Correct problem from turbocharger outlet to tail pipe.
    - If exhaust back pressure is still high with pipe removed from turbocharger outlet, do the following:
        a. Turn ignition switch to OFF.
        b. Reconnect EGR control valve.
        c. Turn ignition switch to ON.
        d. Clear all DTCs.
        e. An inoperative turbocharger is suspect. An EST is needed to run Test 13 Air Management and Test 14 VGT Test.

9. KOER Standard Test

Note: Engine coolant temperature must be 70 °C (158 °F) or higher.

☐ Use EST to run KOER Standard Test.

DTCs found

- Correct problem causing active DTCs before continuing.

H31163

Figure 304

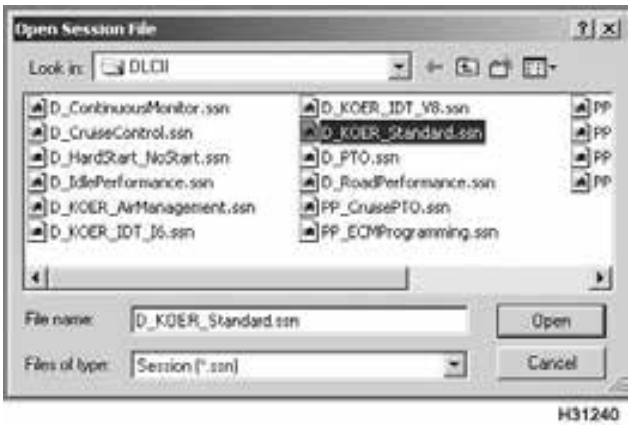

Figure 305 KOER Standard.ssn

Purpose

To verify that the engine sensors and IPR are operating correctly within specified operating ranges

The ECM will actuate the IPR and monitor ICP sensor feedback signals. If an ICP system problem exists, the ECM will transmit DTCs to the EST.

Tools

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

Procedure

WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

NOTE: The KOER Standard test can only be done with the EST; MasterDiagnostics® software is required.

1. Open D_KOER_Standard.ssn to monitor engine operation.

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

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

2. Start and run engine to reach minimum operating temperature 70 °C (158 °F) or higher.

   NOTE: Engine coolant temperature must reach 70 °C (158 °F) minimum for the ECM to accurately test engine actuators and sensors. If engine coolant temperature is below self test range, the EST will display – Coolant temperature is out of range.

Figure 306 KOER Standard Test

3. Select Diagnostics from menu bar.
4. Select Key-On Engine-Running Tests from the drop down menu.

   NOTE: When using the EST to do KOEO or KOER diagnostic tests, Standard test is always selected and run first. If the ignition switch is not cycled, the Standard test does not have to be run again.
5. From the KOER Diagnostics Menu, select Standard Test and select Run to start the test.
6. The ECM will start the Key-On Engine-Running Standard Test and command the engine to accelerate to a predetermined rpm.

   During the test, the ECM commands the IPR through a Step Test to determine if the ICP system is performing as expected. The ECM monitors signal values from the ICP sensor and compares those values to the expected values. When the test is done, the ECM returns the engine to the normal operating mode and transmits any DTCs set during the test.
7. Record DTCs on Diagnostic Form. See “Diagnostic Trouble Codes” – Appendix C (page 643) for DTCs.
8. Correct problems causing active DTCs.
9. Clear DTCs.

Possible Causes

- Oil leakage in injection control pressure system
- Loose or corroded engine wiring harness for ICP sensor or IPR valve
- Open or shorted wiring harness to ICP sensor or IPR valve
- Failed ICP sensor
- Inoperative IPR valve
- Inoperative high-pressure oil pump
- Not enough oil from lube oil system to high-pressure pump

10. Injection Control Pressure

☐ Use EST to monitor ICP and engine speed.
BCP should be zero, when engine brake is inactive.

Condition	Spec	Actual
KOEO		
Low idle		
High idle - Initial		
High idle – After 2 min.		
Aerated oil	Yes ____ No ____	After 2 min. ____

- If BCP is above zero, when engine brake is inactive, diagnose BCP sensor, circuit, and engine brake components.
- If ICP is high or unstable, hold at high idle for 2 minutes. Return to idle, take oil sample, check for foam, and correct condition if oil is aerated.
- If oil is not aerated, disconnect ICP sensor and check for engine stability.
- If problem is corrected, see "Operational Voltage Checks" for ICP Sensor in Section 7 in EGES270.
- If still high or unstable, replace IPR and retest.

H31152

Figure 307

Purpose

To determine if the ICP system is providing enough hydraulic pressure to operate the injectors

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- ICP System Test Adapter
- Oil sample line with inline shut-off valve
- Socket or wrench (EOT sensor)

Monitoring ICP and BCP using EST

WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

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

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

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

1. See "DT 466 Performance Specifications" – Appendix A (page 595) or "DT 570 and HT 570 Performance Specifications" – Appendix B (page 619) for specifications and record on Diagnostic Form.

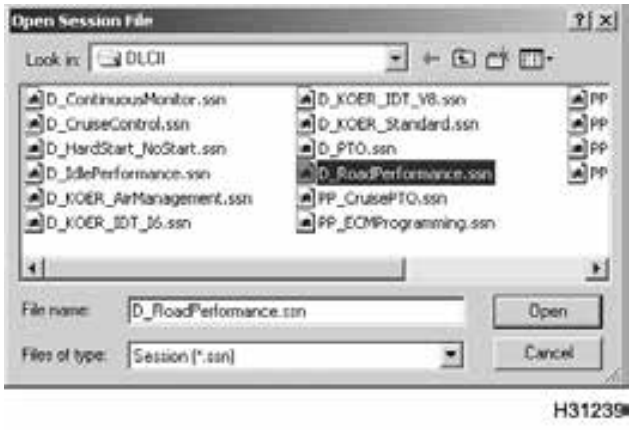

Figure 308 Road Performance.ssn

2. Open D_RoadPerformance.ssn to monitor engine operation.
3. Turn the ignition switch to ON. Do not start engine. Monitor KOEO Inject Ctrl Press (ICP). Record results on Diagnostic Form.
   - If injection control pressure is higher than specification, the ICP sensor or circuitry may be the cause.

     This will cause a lower than normal injection control pressure command. See "ICP Sensor" in Section 7.
   - If injection control pressure is in KOEO specification, continue to step 4.
4. Run engine at low idle, monitor ICP, and record reading on Diagnostic Form.

NOTE: BCP value should be 0 psi. However, BCP values may fluctuate as much as 345 kPa (50 psi). Electromagnetic Interference (EMI) or ground shift can cause an insignificant voltage shift that does not indicate a problem.

5. Run engine at high idle, monitor ICP, and record initial results on Diagnostic Form. Continue to run the engine at high idle for 2 minutes, monitor ICP, and record the 2 minute results on Diagnostic Form. Compare the two ICP readings. ICP that rises above the specification at any point during the two minutes, indicates oil aeration.
   - If ICP is high or unstable for low or high idle, do step 6.
   - If BCP is above zero when engine brake is inactive, diagnose BCP sensor, circuit, and engine brake components.
   - If ICP is to specification, continue with Test 11 Injector Disable.

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

- **When routing oil line, do not run the line too close to moving parts.**
- **Do not let the line touch hot engine surfaces.**
- **Oil is hot. Use protective gloves when taking oil sample. Use caution handling oil sample to avoid spilling.**

WARNING: To avoid serious personal injury or possible death, do not allow engine fluids to stay on your skin. Clean your skin and nails with soap and water, or a good hand cleaner. Wash or properly throw away clothing or rags containing engine fluids. Engine fluids contain certain elements that may be unhealthy for skin and could even cause cancer.

NOTE: Engine fluids, oil, fuel, and coolant, can be a threat to the environment. Never dispose of engine fluids by putting them in the trash, pouring them on the ground, in the sewers, in streams or bodies of water. Collect and dispose of engine fluids according to local regulations.

6. Turn off engine.
7. Use the ICP system test adapter and inline shut-off valve to make a test line assembly to take oil sample.

   NOTE: The mechanic is expected to keep the test line for future diagnostics. Expense the test line as an essential tool and keep it with other diagnostic tools. Warranty will not cover the cost of the test line.

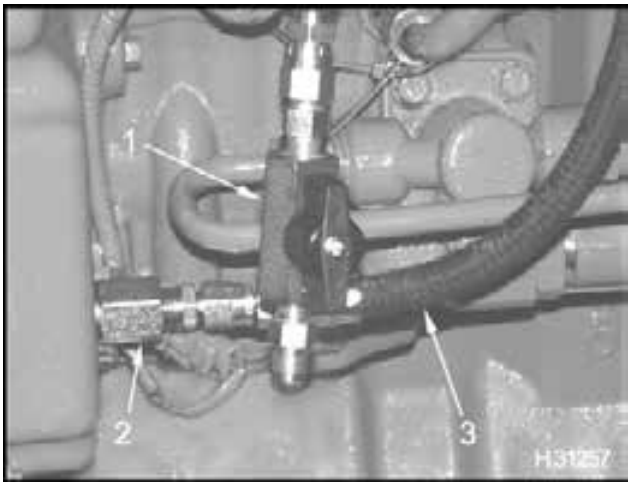

Figure 309 Test line assembly installed

1. Inline shut-off valve
2. ICP system test adapter
3. Oil sample line

8. Remove EOT sensor from EOT port. **Oil will spill out. Quickly install test line assembly**.
9. Run engine at high idle for 2 minutes.
10. Return engine to low idle, take oil sample, and check for aerated oil.
11. Record results on Diagnostic Form.
    - If oil is aerated, a large quantity of air bubbles mixed throughout the oil, or foam build up on top of the oil will be seen. Correct condition.
    - If oil is not aerated, disconnect ICP sensor and check engine stability. If problem is corrected, see “ICP Operational Voltage Checks” in Section 7.

- If ICP is still high or unstable, replace IPR following procedures in *Engine Service Manual* and retest.

Possible Causes

- **Low injection control pressure**
  - Injection control pressure system leakage
  - Failed IPR wiring (power and control)
  - Failed IPR valve
  - Failed injector
  - Cracked or porous high-pressure rail
  - Injector oil inlet adapter O-rings
  - Injector oil inlet adapter
  - O-ring for high-pressure oil rail
  - End plugs in high-pressure oil rail
  - Low oil pressure
  - Inoperative high-pressure oil pump
  - Failed ICP sensor circuit
  - Failed ICP sensor
  - Inoperative brake shut-off valve of Diamond Logic® engine brake
  - Brake pressure relief valve (optional)

    If relief valve is leaking, the brake shut-off valve is suspect.
  - If ECM detect low boost pressure, an incorrect feedback signal from APS or the ICP sensor, the ECM commands the IPR valve to reduce injection control pressure.
- **High injection control pressure**
  - Aerated lube oil
  - Bias high ICP sensor – low duty cycle
- **Erratic injection control pressure**
  - ICP sensor
  - IPR wiring
  - IPR valve
  - Middle seal IPR valve
- **Brake control pressure**
  - Failed BCP sensor circuit
  - Failed BCP sensor
  - Inoperative brake shut-off valve of Diamond Logic® engine brake
  - Brake control pressure system leakage

Monitoring ICP using VC Gasket Breakout Harness

NOTE: Do this procedure, if an EST is not available. This is an alternate method.

Tools

- VC Gasket Breakout Harness
- DMM
- ICP System Test Adapter
- Oil sample line with inline shut-off valve
- Clear container (for oil sample)
- Socket or wrench (EOT sensor)

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

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

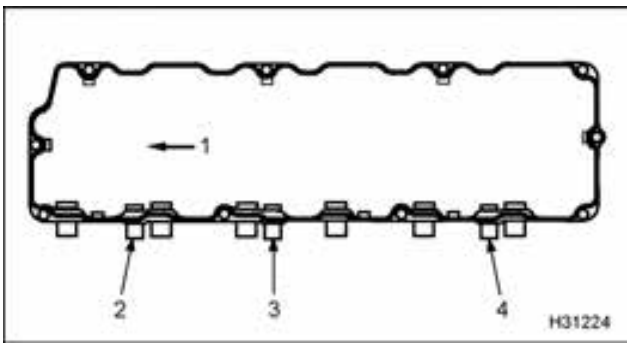

Figure 310 Valve cover gasket

1. Front of engine
2. Pass-through connector for BCP sensor
3. Pass-through connector for brake shut-off valve
4. Pass-through connector for ICP sensor

1. See “DT 466 Performance Specifications” – Appendix A (page 595), “DT 570 and HT 570 Performance Specifications” – Appendix B (page 619) or Section 7 “Operational Voltages Checks” – for specifications and record on Diagnostic Form.
2. Disconnect engine harness connector from valve cover gasket for ICP sensor and do steps 3 to 10.

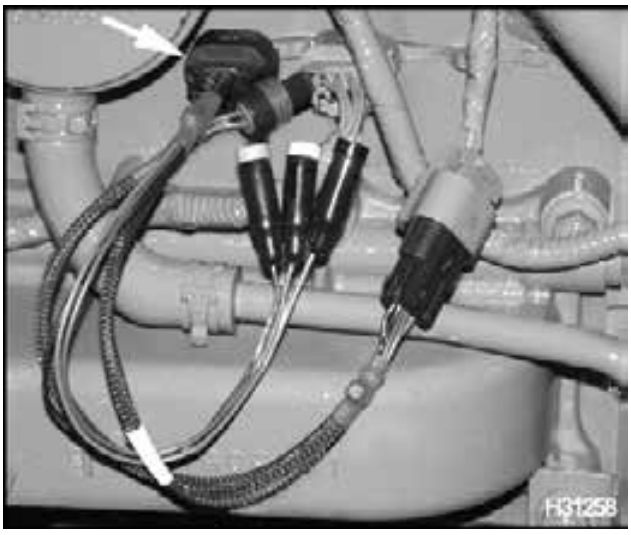

Figure 311 VC Gasket Breakout Harness to pass-through connector for ICP sensor

3. Connect VC Gasket Breakout Harness to the pass-through connector for ICP sensor and engine harness.
4. Use DMM to measure ICP.
   - Connect POS to green (signal circuit) and NEG to black (ground circuit).

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

When routing DMM leads, do not crimp the leads, run the leads too close to moving parts, or let the leads touch hot engine surfaces. Secure the DMM and leads in the cab so as not to obstruct the operator.

5. Turn the ignition switch to ON. (Do not start engine.) Measure KOEO ICP signal voltage and record on Diagnostic Form.
   - If ICP voltage is higher than specification, the ICP sensor or circuitry may be at cause. This will cause a lower than normal injection control pressure command. See “ICP Sensor” in Section 7.
   - If ICP voltage is in KOEO specification, continue to step 6.

6. Run engine at low idle, measure ICP signal voltage, and record on Diagnostic Form.
   - If ICP is high or unstable for low or high idle, do step 8.
   - If ICP is in specification, continue with Test 11 Injector Disable.
7. Run engine at high idle, monitor ICP, and record initial results on Diagnostic Form. Continue to run the engine at high idle for 2 minutes, monitor ICP, and record the 2 minute results on Diagnostic Form. Compare the two ICP readings. ICP that rises above the specification at any point during the two minutes, indicates oil aeration.
   - If ICP is high or unstable for low or high idle, do step 8.
   - If ICP is in specification, continue with Test 11 Injector Disable.

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

- **When routing oil line, do not run the line too close to moving parts.**
- **Do not let the line touch hot engine surfaces.**
- **Oil is hot. Use protective gloves when taking oil sample. Use caution handling oil sample to avoid spilling.**

WARNING: To avoid serious personal injury or possible death, do not allow engine fluids to stay on your skin. Clean your skin and nails with soap and water, or a good hand cleaner. Wash or properly throw away clothing or rags containing engine fluids. Engine fluids contain certain elements that may be unhealthy for skin and could even cause cancer.

NOTE: Engine fluids, oil, fuel, and coolant, can be a threat to the environment. Never dispose of engine fluids by putting them in the trash, pouring them on the ground, in the sewers, in streams or bodies of water. Collect and dispose of engine fluids according to local regulations.

8. Turn off engine.
9. Use the ICP system test adapter and inline shut-off valve to make a test line assembly to take oil sample.

   NOTE: The mechanic is expected to keep the test line for future diagnostics. Expense the test line as an essential tool and keep it with other diagnostic tools. Warranty will not cover the cost of the test line.

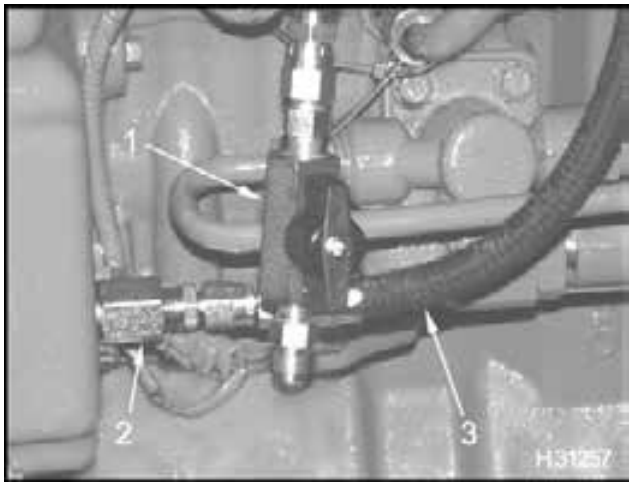

Figure 312 Test hose assembly

1. Inline shut-off valve
2. ICP system test adapter
3. Oil sample line

10. Remove EOT sensor from EOT port. **Oil will spill out. Quickly install test hose assembly and capture oil sample in clear container**.
11. Run engine at high idle for 2 minutes.
12. Return engine to low idle, take oil sample, and check for aerated oil.
13. Record results on Diagnostic Form.
    - If oil is aerated, a large quantity of air bubbles mixed throughout the oil, or foam build up on top of the oil will be seen. Correct condition.
    - If oil is not aerated, disconnect ICP sensor and check engine stability. If problem is corrected, see “ICP Operational Voltage Checks” – Section 7 (page 457).
    - If ICP is still high or unstable, and engine has optional engine brake, continue to “Monitoring BCP using VC Gasket Breakout Harness.”

- If ICP is still high or unstable, and engine does not have optional engine brake, replace the IPR following procedures in *Engine Service Manual* and test again.

Monitoring BCP using VC Gasket Breakout Harness

NOTE: Only do this procedure if directed here from "Monitoring ICP using Gasket Breakout Harness." This is an alternate method when an EST is not available.

Tools

- VC Gasket Breakout Harness
- DMM

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

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

NOTE: BCP should be zero, when engine brake is inactive. However, BCP values may fluctuate as much as 345 kPa (50 psi). Electromagnetic interference (EMI) or ground shift can cause an insignificant voltage shift that does not indicate a problem. This should be equal to KOEO BCP signal voltage.

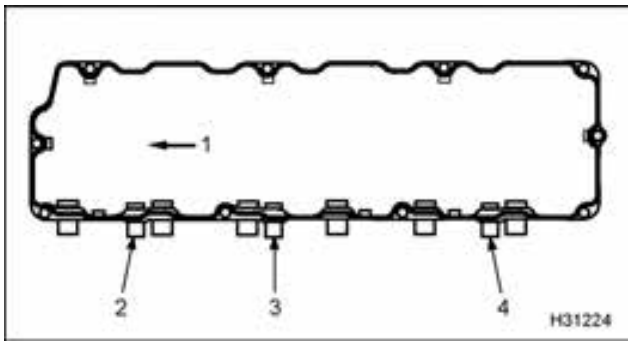

Figure 313 Valve cover gasket

1. Front of engine
2. Pass-through connector for BCP sensor
3. Pass-through connector for brake shut-off valve
4. Pass-through connector for ICP sensor

1. Disconnect engine harness connector from the pass-through connector for the BCP sensor and do steps 2 to 6.

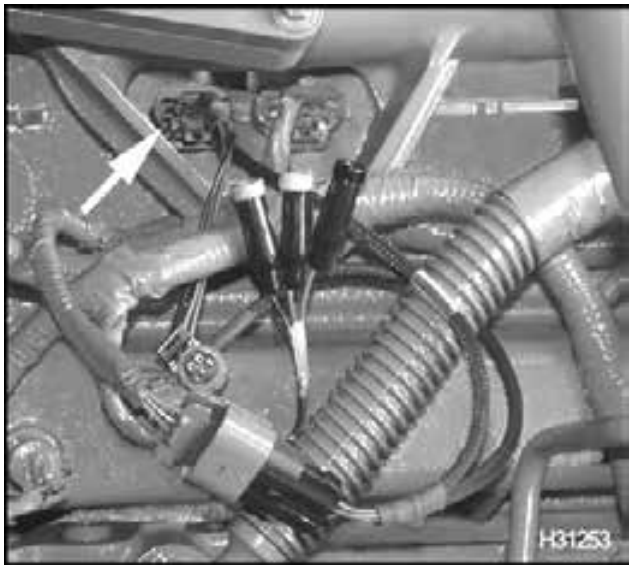

Figure 314 VC Gasket Breakout Harness to pass-through connector for BCP sensor

2. Connect VC Gasket Breakout Harness to the pass-through connector for the BCP sensor and engine harness.
3. Use DMM to measure BCP.
   - Connect POS to green (signal circuit) and NEG to black (ground circuit).

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

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

4. Turn the ignition switch to ON. (Do not start engine.) Measure KOEO BCP signal voltage and record on Diagnostic Form.
   - If BCP signal voltage is above KOEO specification, see "BCP Sensor Operational Diagnostics" in Section 7.
   - If BCP signal voltage is in KOEO specification, continue to step 5.

5. Run engine at low idle and compare KOEO BCP signal voltage to low idle signal voltage.
   - If BCP low idle signal voltage is more than KOEO BCP signal voltage, when engine brake is inactive, diagnose BCP sensor, circuit, and engine brake components. The BCP voltage reading should be zero psi; however, BCP values may fluctuate as much as 345 kPa (50 psi). Electromagnetic interference (EMI) or ground shift can cause an insignificant voltage shift that does not indicate a problem.
   - If BCP low idle signal voltage is equal to KOEO BCP signal voltage, continue with step 6.
6. Run engine at high idle and compare KOEO BCP signal voltage to high idle signal voltage.
   - If BCP high idle signal voltage is more than KOEO BCP signal voltage, when engine brake is inactive, diagnose BCP sensor, circuit, and engine brake components. The BCP voltage reading should be zero psi; however, BCP values may fluctuate as much as 345 kPa (50 psi). Electromagnetic interference (EMI) or ground shift can cause an insignificant voltage shift that does not indicate a problem.
   - If BCP high idle signal voltage is equal to KOEO BCP signal voltage, there is no problem with the BCP sensor signal or the engine brake.

11. Injector Disable Test

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

Selected cylinder	EOT	Average fuel rate	Deviation	Average engine load	Deviation
Base Line					
1					
2					
3					
4					
5					
6					
Base Line					
Cut-off values:		Fuel rate		Engine load	

- If any cylinder is suspect, do **Test 12**.

H31150

Figure 315

Purpose

To determine the cause of rough engine idle

The Injector Disable Tests can only be done with the EST; MasterDiagnostics® software is required.

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

Alternate cylinders are every other cylinder in firing order.

Firing order: 1–5–3–6–2–4

When all cylinders are active, the contribution of each cylinder is 17% of its overall effect to maintain governed speed. When three cylinders are shut off, contribution of each remaining cylinder is 33% of its overall effect to maintain governed speed. The technician should monitor fuel rate and engine load.

NOTE: The Relative Compression Test 12 should be done after doing the Injector Disable Test 11 to distinguish between an injector or mechanical problem.

Tools

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

NOTE: Before doing the Automatic Test or Manual Test for injector disable, make sure Tests 1 through 10 were completed and the following conditions are maintained:

- Make sure accessories are turned off. (Example – engine fan and air conditioning) Items cycled during this test could corrupt the test results.
- Maintain engine idle.
- Keep EOT within a 2 °C (5 °F) range from the beginning to the end of the test. EOT affects injection timing; too much of a change in EOT temperature could corrupt the test results.

Automatic Test – Auto Run

The Automatic Test is best done when comparing cylinder to cylinder test data.

NOTE: If MasterDiagnostics® software does not have the Automatic Test (auto run feature), Injector Disable – Manual Test in Section 3 for procedure to compare cylinder to cylinder.

NOTE: Do KOER Standard test before doing this test.

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

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

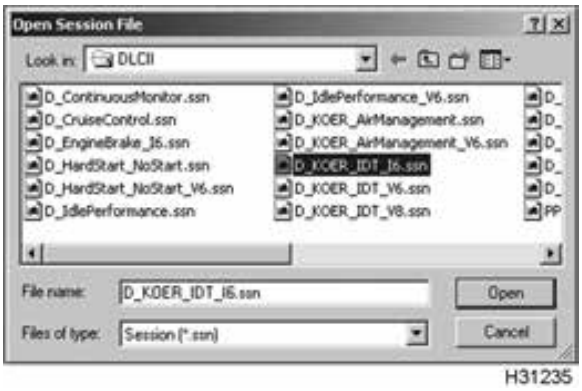

Figure 316 KOER IDT I6 .ssn

1. While engine is running, open D_KOER_ IDT_ I6.ssn to monitor engine operation.

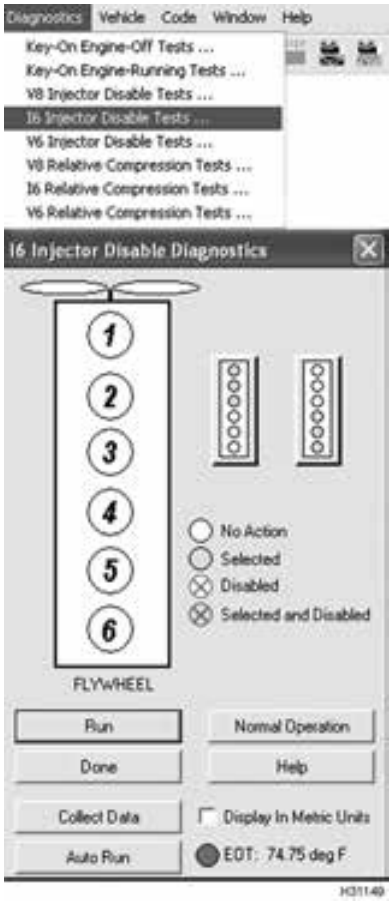

Figure 317 Injector Disable Tests

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

   NOTE: The EOT indicator will change from red to green when engine temperature reaches 70 °C (158 °F) or higher.

   - If the EOT indicator is red, erroneous comparisons are likely from cylinder to cylinder.

     However, when diagnosing a cold misfire, a technician can listen to tone changes from cylinder-to-cylinder.

   - When the EOT indicator is green and the engine temperature is 70 °C (158 °F) or higher, fuel rate and timing are more stable, making comparisons from cylinder to cylinder more accurate. Overall engine operation is more stable.

4. Select Auto Run.

   NOTE: While running the engine, listen for sound variations from cylinder to cylinder.

   NOTE: If any injectors are removed and reinstalled or replaced, test drive vehicle for 20 miles before checking for misfire or rough idle.

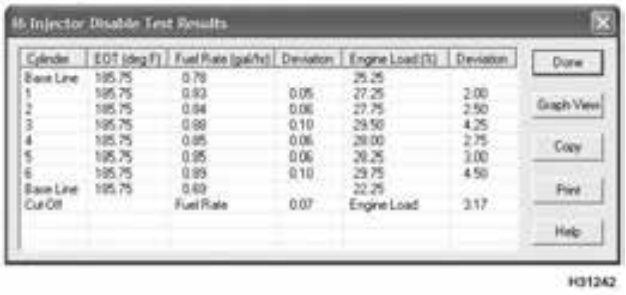

Figure 318 I6 Injector Disable Test Results (Auto Run – Text View)

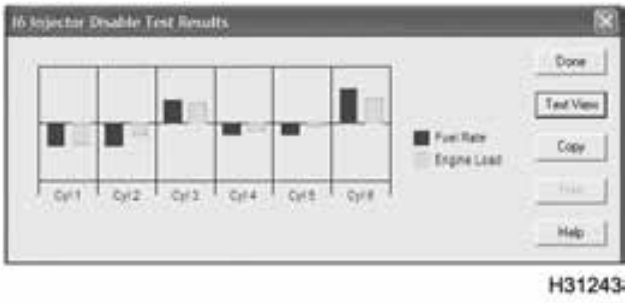

Figure 319 I6 Injector Disable Test Results (Auto Run – Graph View)

During Auto Run, injectors are shut off one at a time (1 through 6 in numerical sequence). Baseline data and results for each cylinder is displayed in the window (Text View) for I6 Injector Disable Test Results. Test data for each injector can also be viewed by selecting the (Graph View).

5. Record data from window (Text View) on Diagnostic Form.
   - If deviation values for average fuel rate and average engine load are less than the cut off values for fuel rate and engine load, the injector is suspect for weak cylinder contribution.
   - If only one deviation value is less than a cut off value, do not suspect that cylinder.
   - If a suspect cylinder(s) is identified, do Test 12 Relative Compression to distinguish between an injector or mechanical problem.
   - If Test 12 shows that cylinders are mechanically sound, but the Injector Disable Test shows that one or more cylinders are bad, continue with step 6.
6. Remove valve cover following procedure in *Engine Service Manual*.
7. Replace faulty injector(s) following procedures in the *Engine Service Manual.*
8. Test drive vehicle for 20 miles to purge air from ICP system and fuel supply system. Check for rough idle.
9. If rough idle continues, do the Injector Disable Test again.

Possible Causes

- Failed connection from wiring harness to injector solenoid
- Open or shorted wiring harness to injector solenoid
- Failed solenoid on fuel injector
- Scuffed or damaged injector
- Failed IDM
- Failed ECM

Manual Test

The Manual Test is best done when diagnosing each cylinder for cold misfire, considering EOT changes.

The EOT indicator will change from red to green when engine temperature reaches 70 °C (158 °F) or higher.

- If the EOT indicator is red, erroneous comparisons are likely from cylinder to cylinder.

  However, when diagnosing a cold misfire, a technician can listen to tone changes from cylinder-to-cylinder.
- When the EOT indicator is green and the engine temperature is 70 °C (158 °F) or higher, fuel rate and timing are more stable, making comparisons from cylinder to cylinder more accurate. Overall engine operation is more stable.

Shut off one injector at a time and listen for changes in exhaust tone.

NOTE: If any injectors are removed and reinstalled or replaced, test drive vehicle for 20 miles before checking for misfire or rough idle.

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

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

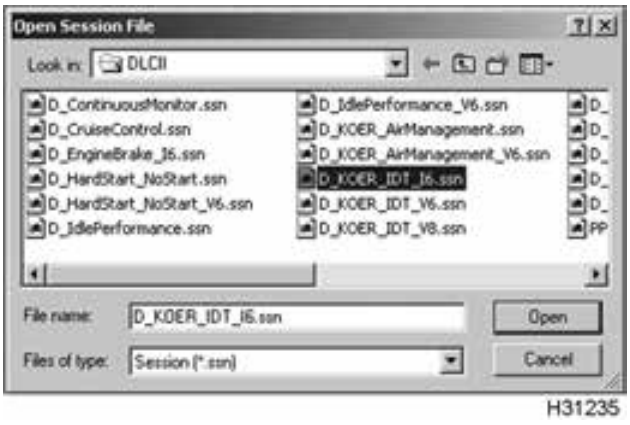

Figure 320 KOER IDT I6 .ssn

1. While engine is running, open D_ KOER_IDT_I6.ssn. to monitor engine operation.

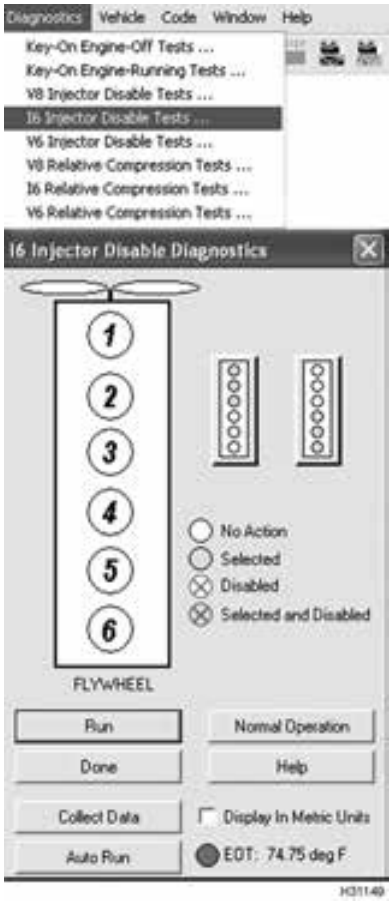

Figure 321 Injector Disable Test

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

   NOTE: The EOT indicator will change from red to green when engine temperature reaches 70 °C (158 °F) or higher.

   - If the EOT indicator is red, erroneous comparisons are likely from cylinder to cylinder.
   - When the EOT indicator is green and the engine temperature is 70 °C (158 °F) or higher, fuel rate and timing are more stable, making comparisons from cylinder to cylinder more accurate. Overall engine operation is more stable.
4. Select cylinder number and select Run. (Injector selected will be disabled and engine noise should change.)
5. Select Normal Operation. Injector will be enabled and engine noise should return to previous state of operation.
6. Repeat steps 4 and 5 for the remaining cylinders.

   NOTE: Listen for tone changes from cylinder to cylinder.

   NOTE: If any injectors are removed and reinstalled or replaced, test drive vehicle for 20 miles before checking for misfire or rough idle.

12. Relative Compression

☐ Turn ignition key to ON.
☐ Use EST to run Relative Compression Test.
☐ Crank engine following EST instructions on screen.

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

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

H31151

Figure 322

Purpose

To determine if compression is too low in any cylinder

NOTE: During this test the IDM shuts off the injectors so no fueling occurs.

NOTE: This test can only be done with the EST; MasterDiagnostics® software is required.

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

The Relative Compression Test provides the difference between the fastest and slowest crankshaft speed during the power stroke of each cylinder.

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

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

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

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

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

NOTE: If not cranked long enough to collect data, the EST will display 255. 255 represents an erroneous rpm value

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

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

The EST will display a value on the screen for each cylinder, as typified by the following example.

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

H31310

Figure 323

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

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

Example

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

H31311

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

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

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

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

When the Relative Compression test is done, the EST indicates, stop cranking the engine, and will display test values.

Test data displayed in this test should be compared with data collected from the Injector Disable test.

Tools

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

Procedure

WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

NOTE: Batteries must be fully charged before doing this test. If multiple tests are necessary, use a battery charger during this test; battery drain can be extensive.

H31236

Figure 325 Relative Compression Test

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

1. Select Diagnostics from the menu bar.
2. Select Relative Compression Tests from the drop down menu.
3. Follow the messages at the bottom of the window.
   - Turn the ignition switch to ON.
   - Select Run.

   WARNING: To avoid serious injury, possible death, or damage to the vehicle – comply with the following: After clicking Run, turn the ignition switch – within 5 seconds – to crank the engine; if not done in 5 seconds, the EST will cancel the test and the engine will start.

   - Crank engine for 15 seconds. (Another message may read Stop Cranking.) **Do not turn ignition switch to OFF**. **If the switch is turned to OFF, test results will be lost**.

   NOTE: If test results are identical to previous test results, the current test failed and the previous results were displayed.

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

Possible Causes

- Broken compression rings
- Leaking or bent valves
- Bent push rods
- Bent connecting rods
- Loose fuel injectors
- Scored cylinder sleeve
- Piston damage
- Incorrect valve lash adjustment

13. Air Management

☐ Use EST to monitor data while running Air Management Test.

DTCs found

- Correct problem causing active DTCs before continuing.

H31155

Figure 326

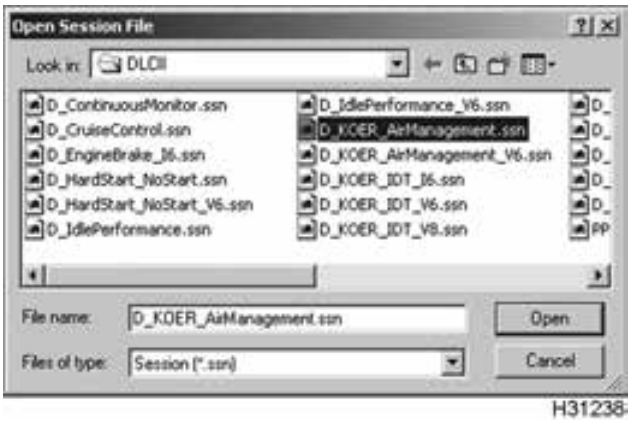

Figure 327 KOER Air Management.ssn

Purpose

To determine if intake, exhaust, VGT, and EGR systems are working correctly

NOTE: Before doing this test, make sure tests 1 through 12 were completed. Problems with other systems (injectors, fuel supply, etc.) can affect air management test results.

Tools

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

Procedure

WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

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

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

NOTE: The KOEO Injector Test can only be done with the EST using MasterDiagnostics® software.

1. Open D_KOER_AirManagement.ssn to monitor engine operation.

Figure 328 Air Management Test

2. Select Diagnostics from menu bar.
3. Select Key-On Engine-Running Tests from the drop down menu.

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

4. From the KOER Diagnostics menu, select Air Management test and select Run to start the test.

   The ECM will start the Air Management Test and command the engine to accelerate to a predetermined rpm. The ECM will monitor the effects of the VGT and EGR control valve movement using feedback signals from the EBP sensor.

   - If a problem is detected the ECM will cancel the test, set a DTC, and restore normal engine operation.

5. Record DTCs on Diagnostic Form. See “Diagnostic Trouble Codes” – Appendix C (page 643) for DTCs.
6. Correct problems causing active DTCs. To help do Test 14 VGT Test.
7. Clear DTCs.

Possible Causes

- Exhaust leaks
- Intake leaks
- Intake and exhaust restrictions
- Plugged EBP tube assembly
- Biased MAP or EBP sensor
- Failed VGT actuator
- Failed turbocharger
- Failed EGR control valve

14. VGT Test

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

Duty Cycle	Yes	No
Low to medium		
Medium to high		
High to low		
Low to high		

- Did EBP and MAP change for each transition?
- If turbocharger is suspected cause of low power, see "Low Power (Turbocharger Assembly and Actuator" in Section 4 of EGES-270.

H31167

Figure 329

Purpose

To determine if EBP and MAP change, as VGT control changes

This is a manual test that allows the technician to set VGT duty to low, medium or high.

Tools

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

Procedure

⚠ WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

NOTE: The KOER VGT Test can only be done with the EST using MasterDiagnostics® software.

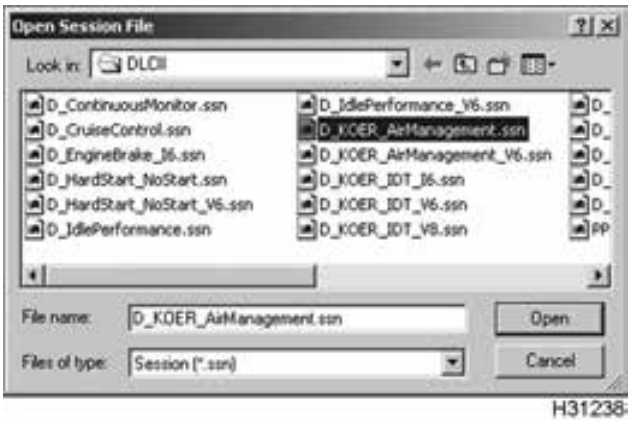

Figure 330 VGT session

1. With the engine running, select D_KOER_AirManagement.ssn from the open session file window and select OPEN to open the session. Monitor EBP and MAP at low, medium, and high duty cycle.

Figure 331

2. Select Diagnostics from the menu bar.
3. Select Key-On Engine-Running Tests from the drop down menu.

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

4. From the KOER Diagnostics menu, select Low Duty cycle from VGT Tests, and select Run to start test:

   Use the suggested toggle sequence below, to check turbocharger operation from one duty cycle to the other.

   - Low to medium
   - Medium to high
   - High to low
   - Low to high

   To toggle between duty cycles, select one of the two remaining duty cycles and select Run to start.

   As the VGT duty cycle increases when toggled through the low, medium, and high duty cycles, the EBP and MAP values should increase in relationship to the VGT duty cycle. Conversely, when duty cycle is reduced, there should be a reduction to the EBP and MAP values.

   If the ECM does not receive a request from the EST, after about 40 seconds, the test will automatically end and the engine will return to normal operation.

5. Record results on Diagnostics Form.
   - Did EBP and MAP change for each transition?
     — If yes, continue to the next diagnostic test.
     — If no, turbocharger is suspect for low power condition. See “Low Power (Turbocharger Assembly and Actuator)” in Section 4.

Possible Causes

- Intake or exhaust leaks
- Intake or exhaust restrictions
- Plugged EBP tube assembly
- Biased MAP or EBP sensor
- Failed VGT actuator
- Failed turbocharger
- Failed EGR control valve

15. Torque Converter Stall (Automatic only)

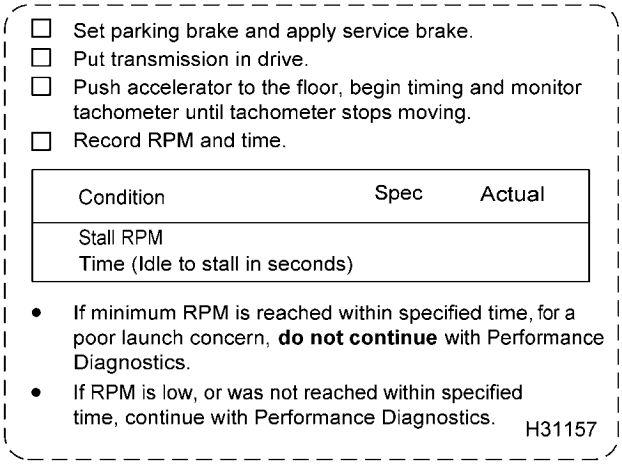

Figure 332

Purpose

To determine if the engine develops specified stall rpm within idle to stall time, when diagnosing a poor launch concern

Tools

- None

Procedure

WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, make sure brakes are correctly adjusted and in good condition. This procedure should be done in an open lot.

CAUTION: Avoid damage to the drive train. Do not do this test for more than 10 seconds at a time or more than twice back to back. (If doing twice – wait 2 minutes between tests.)

1. See "DT 466 Performance Specifications" – Appendix A (page 595) and "DT 570 and HT 570 Performance Specifications" – Appendix B (page 619) for specifications and record on Diagnostic Form.
2. Set parking brake and apply service brake.
3. Put transmission in drive.
4. Press accelerator pedal fully to the floor, begin timing and monitor TACH until TACH stops moving.
5. Record stall RPM and idle to stall time on Diagnostic Form.
   - If minimum RPM is reached in the specified time, with Performance Diagnostics, for a poor launch concern **do not continue** with Performance Diagnostics.
   - If RPM is low or not reached in the specified time, continue Performance Diagnostics.

Possible Causes

- Intake leaks (hoses, clamps)
- Boost leaks
- Restricted intake or exhaust
- Exhaust leaks
- Low fuel pressure
- Low ICP
- Control system faults
- Failed EGR control valve
- Inoperative fuel injectors
- Failed turbocharger
- Diamond Logic® engine brake malfunction
- Biased BAP, EBP, ICP or MAP sensors
- Power cylinder condition

16. Crankcase Pressure

Note: Engine coolant temperature must be above 70 °C (158 °F).

☐ Measure at road draft tube with crankcase pressure test adapter.

☐ Measure at high idle, no load.

Instrument	Spec	Actual
Magnehelic gauge or Manometer		

H31153

Figure 333

Purpose

To measure the condition of the power cylinders

Tools

- Magnehelic gauge on gauge bar or water manometer
- Crankcase pressure test adapter

Procedure

⚠ WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

1. See "DT 466 Performance Specifications" – Appendix A (page 595) or "DT 570 and HT 570 Performance Specifications" – Appendix B (page 619) for specifications and record on Diagnostic Form.
2. Park vehicle on level ground.
3. Make sure the engine oil level is not above operating range and the oil level gauge is secured.
4. Make sure breather tube is clean, secure in valve cover, and the valve cover is tight.
5. Make sure all hoses are secure and not leaking.

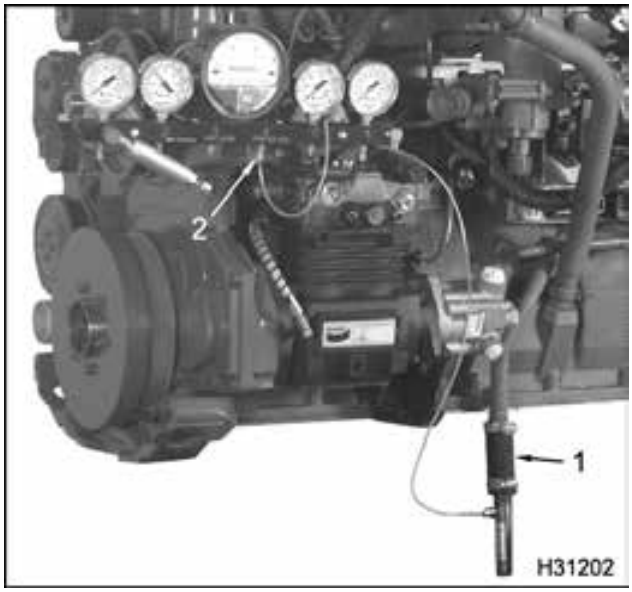

Figure 334 Test line connection to magnehelic gauge

1. Crankcase pressure test adapter
2. Test line with pressure fitting

6. Install crankcase pressure test adapter to road draft tube.

   NOTE: If the engine has a breather extension tube, the extension tube must be removed before testing.

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

- **When routing test line , do not crimp the line, run the line too close to moving parts, or let the line touch hot engine surfaces.**
- **Test line must be free of fluid. Magnehelic gauge can be damaged.**

7. Connect test line from the crankcase pressure test adapter to the magnehelic gauge on the gauge bar or to a water manometer.

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

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

8. Run engine to reach normal engine operating 70 °C (158 °F) or higher, before measuring crankcase pressure.
9. Run engine at high idle (no load) rpm. Allow the gauge reading to stabilize before taking pressure reading.
10. Record crankcase pressure on Diagnostic Form.
    - If pressure is below specification, continue Performance Diagnostics.
    - If pressure is above specification, continue with step 10.

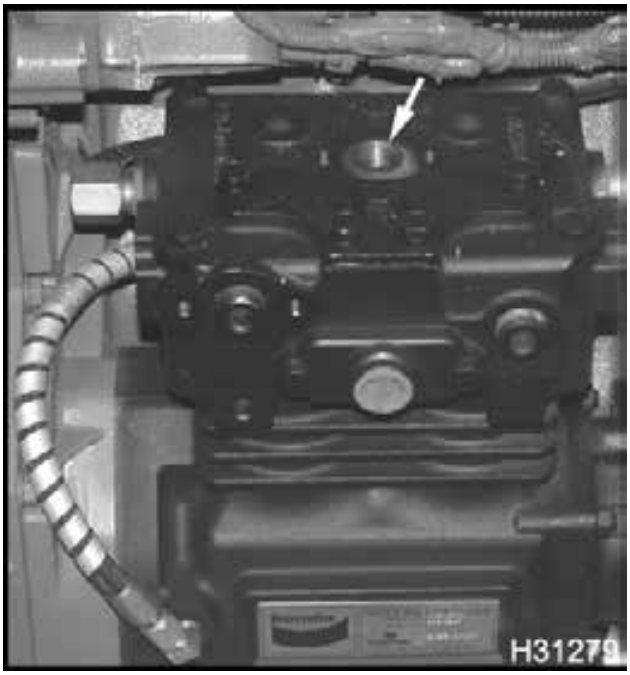

Figure 335 Discharge port

11. If engine has an air compressor, remove discharge air line and retest.
    - If pressure is below specification, repair or replace air compressor.
    - If pressure is above specification, continue with step 11.
12. Disconnect VGT control module and retest.
    - If pressure is below specification, reconnect the VGT control module, and retest doing Test 13 (Air Management) to see if crankcase pressure increases as turbocharger demand increases.

      If pressure fluctuates above and below specification, as the VGT is cycling, replace the turbocharger.
    - If disconnecting or cycling the turbocharger does not bring pressure below specification, continue with step 12.
13. Do Test 12 Relative Compression Test to pin point suspect cylinders.
14. Do Test 11 Injector Disable to further pin point suspect cylinders.
15. Inspect air induction for dirt ingestion.

Possible Causes

High oil consumption and excessive crankcase pressure may indicate the following:

- Dirt in air induction system
- Badly worn or broken rings
- Cylinder sleeves badly worn or scored
- Leaking valve seals or worn valve guides
- A restricted orifice in crankcase pressure test adapter
- Failed turbocharger
- Failed air compressor

Low oil consumption and excessive crankcase pressure may indicate the following:

- Air compressor affecting crankcase pressure.
- A restricted orifice in crankcase pressure test adapter

17. Test Drive (Full load, rated speed)

Monitor the following parameters during one test drive:

- Boost Pressure using EST
- Fuel Pressure using EST (optional, or mechanical gauge)
- ICP and BCP using EST

Monitoring Engine Parameters using EST and Fuel Pressure Gauge

☐ Use EST to monitor **boost pressure** and engine speed.

Condition	Spec	Spec	Actual
	Engine rpm	Boost	EST boost reading
Peak HP Peak Torque			

- If boost pressure is not to spec continue performance diagnostics. **If to spec, do not continue**.

H31156

Figure 336

☐ Measure **Fuel Pressure** at fuel rail (full load, rated speed)

☐ If equipped with optional EFP, use EST to monitor fuel pressure

Instrument/EST	Spec	Actual
0-100 psi gauge		

- If fuel pressure is low, replace fuel filter, clean strainer, and retest.
- If fuel pressure is still low, measure fuel inlet restriction at full load, rated speed.

H31158

Figure 337

☐ Use EST to monitor **ICP** and engine speed.
BCP should be zero, when engine brake is inactive.

Instrument	Spec	Actual
EST Aerated oil Yes____ No____ After 2 min. ____		

- If BCP is above zero, when engine brake is inactive, diagnose BCP sensor, circuit, and engine brake components.
- Disconnect ICP and test drive vehicle.
- If problem is corrected, see Operational Voltage checks for ICP Sensor in Section 7 in EGES270.
- If still high or unstable, replace IPR and retest.

H31267

Figure 338

Purpose

To verify engine performance at full load and rated speeds by means of maximum boost, minimum fuel pressure, and minimum injection control pressure

Tools

- EST with MasterDiagnostics® software
- EZ-Tech® interface cable
- Fuel Pressure Gauge
- Fuel Pressure Test Adapter
- Fuel/Oil Pressure Test Adapter

WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

NOTE: If an EST is not available, use the Fuel Pressure Gauge setup in this procedure with the alternative procedure for testing boost pressure (MAP), injection control pressure (ICP), and brake control pressure (BCP) if equipped.

1. See "DT 466 Performance Specifications" – Appendix A (page 595) or DT 570 and HT 570 Performance Specifications" – Appendix B (page 619) for specifications and record on Diagnostic Form.

2. Does the engine have an optional Engine Fuel Pressure (EFP) sensor?
   - If yes, the EST can record fuel pressure during the road test. Continue to step 5.
   - If no, the fuel pressure must be measured with a mechanical gauge. Continue to step 3.

CAUTION: Be sure to place a rag or suitable container under the fuel pressure test valve when bleeding the fuel rail. Dispose of fuel in a correct container clearly marked DIESEL FUEL according to local regulations.

NOTE: Engine fuel can be a threat to the environment. Never dispose of engine fuel by putting it in the trash, pouring on the ground, in the sewers, in streams, or bodies of water.

Figure 339 Shrader valve assembly

1. Valve
2. Center stem

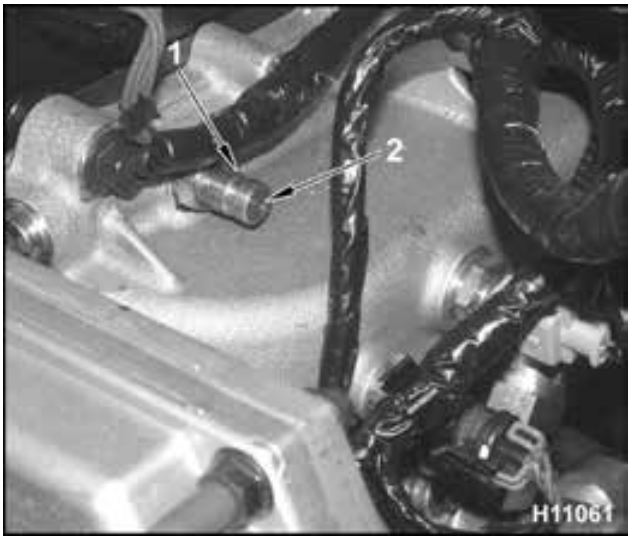

Figure 340 Diagnostic coupling

1. Valve
2. Center section

NOTE: Engines are equipped with a fuel pressure test valve in the form of either a Shrader valve or a diagnostic coupling.

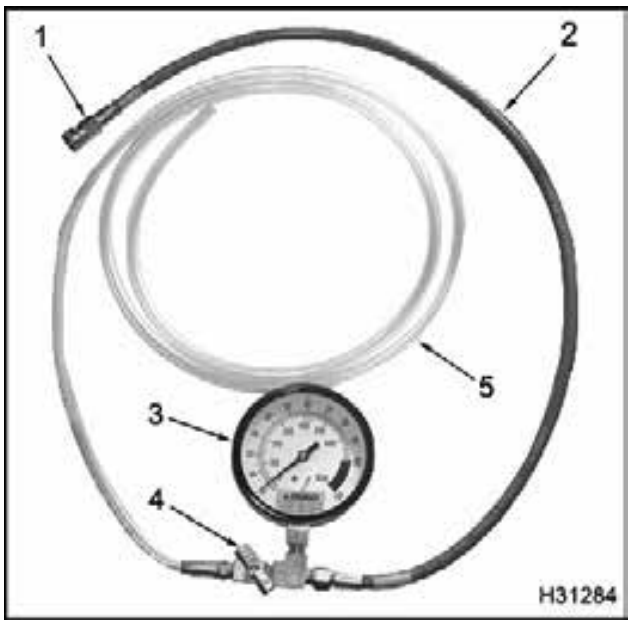

Figure 341 Fuel Pressure Gauge

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

Figure 342 Fuel Pressure Test Adapter

NOTE: If the engine is equipped with a Shrader valve, use the Fuel Pressure Test Adapter.

Figure 343 Fuel/Oil Pressure Test Coupler

NOTE: If the engine is equipped with a diagnostic coupling, adapt the Fuel/Oil Pressure Test Coupler to the Fuel Pressure Gauge.

3. Connect the Fuel Pressure Gauge and shut-off valve to the intake manifold fuel pressure test port.

   NOTE: Breaking any fuel system joint will induce air into the fuel system. The air should pass in a short period of time.

4. Mount the Fuel Pressure Gauge where it can be seen from the drivers seat.

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

   When routing test line, do not crimp the line, run the line too close to moving parts, or let the line touch hot engine surfaces. Secure the gauge and test line in the cab so as not to obstruct the operator.

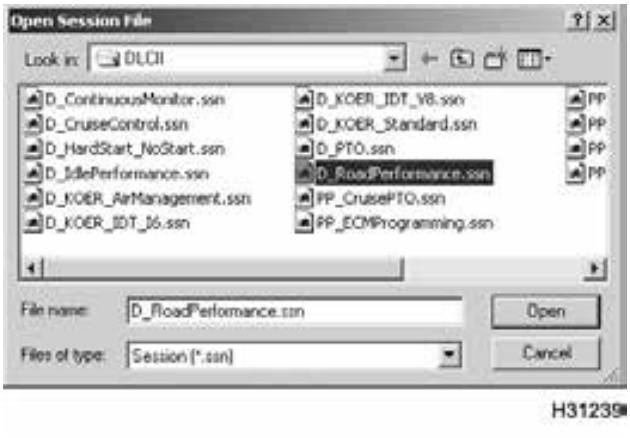

Figure 344 Road Performance. ssn

5. Open D_RoadPerformance.ssn to monitor engine operation.
6. Verify that the following are listed in the session and snapshot setup:
   - Engine Speed (rpm)
   - Engine Load (EL %)
   - Boost Pres (MAP)
   - Inject Ctrl Pres (ICP)
   - Brake Ctrl Pres (BCP) – if equipped
   - Fuel Delivery Pres (EFP) – if equipped
7. Drive vehicle and make sure engine operating temperature reaches 70 °C (158 °F) or higher.
8. Find a long, open stretch of road. When driving conditions are safe, select a suitable gear, press accelerator pedal fully to the floor, and accelerate to rated speed at 100% load. Start the snapshot and, if a gauge is being used, monitor fuel pressure.
9. After the test is complete, park the vehicle. Replay the snapshot by selecting the following:
   - Engine Speed (rpm)
   - Engine Load (EL %)
   - Boost Pres (MAP)
   - Inject Ctrl Pres (ICP)
   - Brake Ctrl Pres (BCP) – if equipped
   - Fuel Delivery Pres (EFP) – if equipped
10. Record results on Diagnostic Form.
11. Review the results of boost pressure.
    - If boost pressure is in specification, vehicle does not have a Performance Diagnostics problem at this time. The issue and symptoms should be discussed with customer.
    - If boost pressure is not to specification, continue to step 12.
12. Review the results of fuel pressure.
    - If fuel pressure is in specification, continue with step 13.
    - If fuel pressure is below specification, replace the filter, clean the strainer, and test again.
    - If fuel pressure is still low after replacing fuel filter and cleaning the strainer, continue to “Fuel Inlet Restriction.”
13. Review the results of Inject Ctrl Pres (ICP).
    - If the injection control pressure is in specification, do not continue with ICP system diagnostics.
    - If the injection control pressure is not in specification, and **is** equipped with optional engine brake, continue to step 14.
    - If the injection control pressure is not in specification, and **is not** equipped with optional engine brake, continue to step 15.
14. Review the results of Brake Ctrl Pres (BCP).

    NOTE: BCP should be reading 0 kPa (0 psi). Values can fluctuate as high as 345 kPa (50 psi). Electromagnetic Interference (EMI) or ground shift can cause an insignificant voltage shift that does not indicate a problem.

    - If BCP is in specification, continue to step 15.
    - If BCP is not zero when engine brake is inactive, diagnose the BCP sensor, circuit, and engine brake components.

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

- **When routing oil line, do not run the line too close to moving parts.**
- **Do not let the line touch hot engine surfaces.**
- **Oil is hot. Use protective gloves when taking oil sample. Use caution handling oil sample to avoid spilling.**

WARNING: To avoid serious personal injury or possible death, do not allow engine fluids to stay on your skin. Clean your skin and nails with soap and water, or a good hand cleaner. Wash or properly throw away clothing or rags containing engine fluids. Engine fluids contain certain elements that may be unhealthy for skin and could even cause cancer.

NOTE: Engine fluids, oil, fuel, and coolant, can be a threat to the environment. Never dispose of engine fluids by putting them in the trash, pouring them on the ground, in the sewers, in streams or bodies of water. Collect and dispose of engine fluids according to local regulations.

15. Turn off engine.

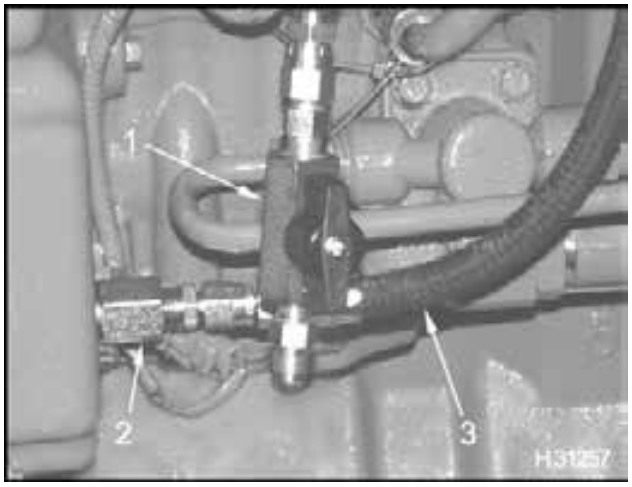

Figure 345 Test hose assembly

1. Inline shut-off valve
2. ICP system test adapter
3. Oil sample line

16. Use the ICP system test adapter and inline shut-off valve to make a test line assembly to take oil sample.

    NOTE: The mechanic is expected to keep the test line for future diagnostics. Expense the test line as an essential tool and keep it with other diagnostic tools. Warranty will not cover the cost of the test line.

17. Remove EOT sensor from EOT port. **Oil will spill out. Quickly install test hose assembly**.
18. Run engine at high idle for 2 minutes.
19. Return engine to low idle, take oil sample, and check for aerated oil.
    - If oil is aerated, a large quantity of air bubbles mixed throughout the oil, or foam build up on top of the oil will be seen. Check for cracked oil pickup tube or a missing or faulty pickup tube gasket.
    - If oil is not aerated, disconnect ICP sensor and check engine stability. If problem is corrected, see “ICP Operational Voltage Checks” in Section 7.
    - If ICP is still high or unstable, replace IPR following procedures in *Engine Service Manual* and retest.

Boost Possible Causes

• Intake leaks (hoses, clamps)	• Failed EGR control valve
• Boost leaks	• Failed EGR control valve
• Restricted intake or exhaust	• Inoperative fuel injectors
• Exhaust leaks	• Failed turbocharger
• Low fuel pressure	• Diamond Logic® engine brake malfunction
• Low ICP	• Biased BAP, EBP, ICP or MAP sensors
• Control system faults	• Power cylinder condition

Injection Control Pressure Possible Causes

Low injection control pressure	
• Injection control pressure system leakage	• Inoperative high-pressure oil pump
• Failed IPR wiring (power and control)	• Failed ICP sensor circuit
• Failed IPR valve	• Failed ICP sensor
• Failed injector	• Inoperative brake shut-off valve of Diamond Logic® engine brake
• Cracked or porous high-pressure rail	• Brake pressure relief valve (optional) If relief valve is leaking, the brake shut-off valve is suspect.
• Injector oil inlet adapter O-rings	• If ECM detect low boost pressure, an incorrect feedback signal from APS or the ICP sensor, the ECM commands the IPR valve to reduce injection control pressure.
• Injector oil inlet adapter	
• O-ring for high-pressure oil rail	
• End plugs in high-pressure oil rail	
• Low oil pressure	
High injection control pressure	
• Aerated lube oil	• Bias high ICP sensor – low duty cycle
Erratic injection control pressure	
• ICP sensor	• IPR valve
• IPR wiring	• Middle seal IPR valve
Brake control pressure	
• Failed BCP sensor circuit	• Inoperative brake shut-off valve of Diamond Logic® engine brake
• Failed BCP sensor	• Brake control pressure system leakage

Fuel Possible Causes

No fuel

- Low fuel level in fuel tank
- Debris in tank can cause high-restriction and low fuel pressure.
- Inline fuel valve (if equipped) could be shut-off
- Failed seals or fuel lines between fuel tanks
- Ice in fuel lines
- Inoperative fuel tank transfer pump
- Fuel tank pickup tube cracked

Low fuel pressure

- Dirty filter element
- Debris or rust in fuel strainer
- Restriction from the fuel tank to the fuel filter housing inlet can cause high-restriction and low fuel pressure.
- Plugged supplemental filters or water separators can cause high-restriction and low fuel pressure.
- Debris in tank can cause high-restriction and low fuel pressure.
- A kinked or bent fuel supply line or a blocked pickup tube can cause high-restriction and low fuel pressure.
- Waxed or jelled fuel in the fuel filter will cause high-restriction and low fuel pressure. (Usually Grade 2-D)
- Ice in fuel lines.
- A restriction between the fuel inlet fitting, strainer, and fuel pump can cause high-restriction and low fuel pressure.
- Debris in the fuel regulator valve
- Failed fuel pressure regulator valve.
- Failed fuel pump
- Failed high-pressure oil pump (can not operate fuel pump)

Aerated fuel

- Failed seal for inlet fitting in fuel filter housing
- Supply filter or water separator leaking
- A loose fuel line on the suction side of the fuel system can ingest air into the system and cause low fuel pressure (most noticeable under load).
- Strainer drain valve loose or damaged
- Strainer bowl warped or damaged
- Missing O-ring from strainer bowl
- Damaged seals on steel inlet tube to fuel pump
- Primer pump seals damaged

Fuel restriction

- Dirty filter element
- Debris or rust in fuel strainer
- Restriction from the fuel filter housing inlet to the fuel tank can cause high-restriction and low fuel pressure.
- Plugged supplemental filters or water separators can cause high-restriction and low fuel pressure.
- Debris in tank can cause high-restriction and low fuel pressure.
- A kinked or bent fuel supply line or a blocked pickup tube can cause high-restriction and low fuel pressure.
- Waxed or jelled fuel in the fuel filter will cause high-restriction and low fuel pressure. (Usually Grade 2-D)
- Ice in fuel lines.
- A restriction between the fuel inlet fitting, strainer, and fuel pump can cause high-restriction and low fuel pressure.

Fuel Possible Causes (cont.)

High fuel pressure (pulsating fuel pressure)

- Debris in the fuel regulator valve
- Inoperative fuel pressure regulator valve.
- Combustion gases leaking into fuel system

Fuel Inlet Restriction

NOTE: This test should only be done if fuel pressure was low during test drive.

Tools

- Gauge bar (0–30 in Hg vacuum gauge)
- Fuel/Oil Pressure Test Coupler
- Test fitting

Procedure

WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

1. See "DT 466 Performance Specifications" – Appendix A (page 595) or "DT 570 and HT 570 Performance Specifications" – Appendix B (page 619) for restriction specifications and record on Diagnostic Form.
2. Remove cap from test fitting.

   NOTE: If an O-ring plug is installed instead of a test fitting, remove O-ring plug and install Fuel Test Fitting.

Figure 346 Fuel Test Fitting

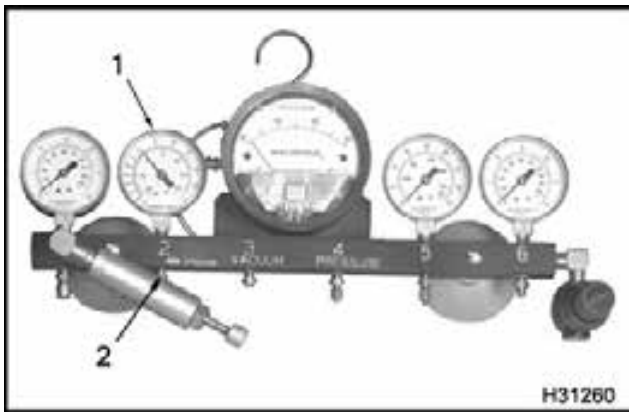

Figure 347 Test line connection to 0–30 in Hg vacuum gauge

1. 0–30 in Hg vacuum gauge
2. Test line connection

3. Connect test line to the Fuel/Oil Pressure Test Coupler and the 0–30 in Hg vacuum gauge.

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

When routing test line, do not crimp the line, run the line too close to moving parts, or let the line touch hot engine surfaces. Secure the gauge bar and test line in the cab so as not to obstruct the operator.

4. Route test line from cab to engine.

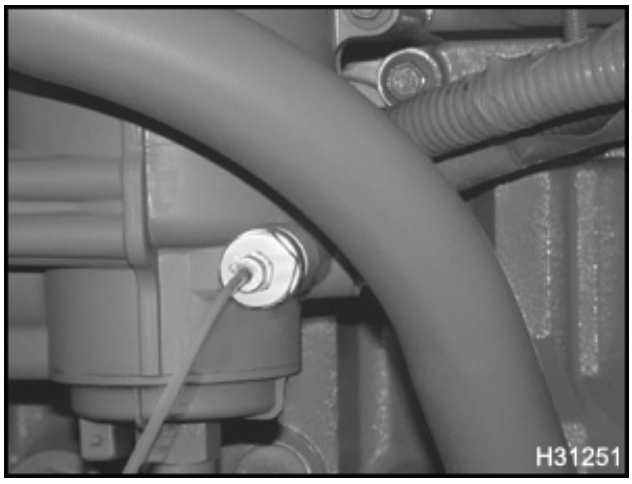

Figure 348 Fuel/oil test coupler with test line

5. Connect Fuel/Oil Test Coupler to test fitting.
6. Drive vehicle and make sure engine operating temperature reaches 70 °C (158 °F) or higher.
7. Find a long, open stretch of road.
8. When driving conditions are safe, select a suitable gear, press accelerator pedal fully to the floor, and accelerate to rated speed at 100% load.
9. Memorize gauge reading for fuel inlet restriction. After parking vehicle, record reading on Diagnostic Form; **do not record reading while driving**.
    - If inlet restriction exceeds specification, find the restriction on the suction side of the fuel system and correct.
    - If inlet restriction is to specification, but fuel pressure is below specification, test Operation of Fuel Pump in Test 6 of this section.
    - If fuel pump is operating correctly, replace fuel regulator valve.
    - If inlet restriction and fuel pressure are to specification, continue with performance diagnostics.

Monitoring Boost Pressure using Pressure Sensor Breakout Harness

NOTE: Do this test only if an EST is not available. This is an alternate method.

Tools

- Pressure Sensor Breakout Harness
- DMM

WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

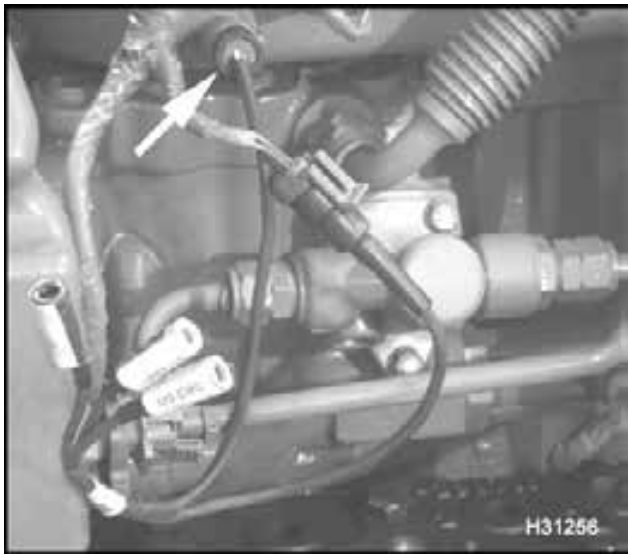

Figure 349 Pressure Sensor Breakout Harness to MAP sensor

1. See "DT 466 Performance Specifications" – Appendix A (page 595) ,"DT 570 and HT 570 Performance Specifications" – Appendix B (page 619) or Section 7 "Operational Voltages Checks" – for specifications and record on Diagnostic Form.
2. Connect Pressure Sensor Breakout Harness to MAP sensor and engine harness.
3. Use DMM to measure MAP at rated speed and full load.
   - Connect POS to green (signal circuit) and NEG to black (ground circuit).
4. Route DMM and leads into cab.

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

When routing DMM leads, do not crimp the leads, run the leads too close to moving parts, or let the leads touch hot engine surfaces. Secure the DMM and leads in the cab so as not to obstruct the operator.

5. Monitor DMM voltage signal for MAP.
6. Drive vehicle and make sure engine operating temperature reaches 70 °C (158 °F) or higher.
7. Find a long, open stretch of road.
8. When driving conditions are safe, select a suitable gear, press accelerator pedal fully to the floor, and accelerate to rated speed at 100% load.
9. Memorize DMM voltage reading for boost pressure. After parking vehicle, record reading for boost pressure on Diagnostic Form; **do not record reading while driving**.
   - If boost pressure is to specification, **do not continue** with Performance Diagnostics.
   - If boost pressure is not to specification, continue Performance Diagnostics.

Monitoring ICP using VC Gasket Breakout Harness

NOTE: Do this test only if an EST is not available. This is an alternate method.

Tools

- VC Gasket Breakout Harness
- DMM
- ICP System Test Adapter
- Oil sample line with inline shut-off valve
- Clear container (for oil sample)
- Socket or wrench (EOT sensor)

WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

1. See "DT 466 Performance Specifications" – Appendix A (page 595) ,"DT 570 and HT 570 Performance Specifications" – Appendix B (page 619) or Section 7 "Operational Voltages Checks" – for specifications and record on Diagnostic Form.

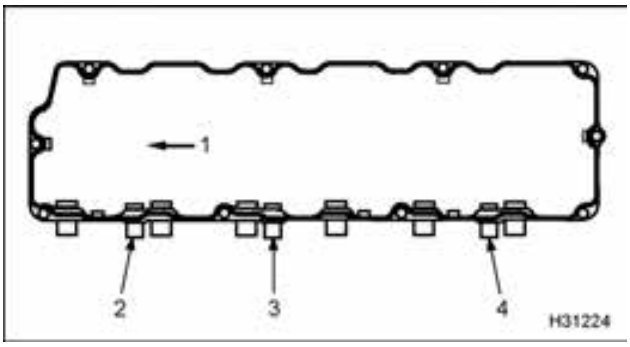

Figure 350 Valve cover gasket

1. Front of engine
2. Pass-through connector for BCP sensor
3. Pass-through connector for brake shut-off valve
4. Pass-through connector for ICP sensor

2. Disconnect engine harness connector from pass-through connector for the ICP sensor and complete steps 3 through 9.

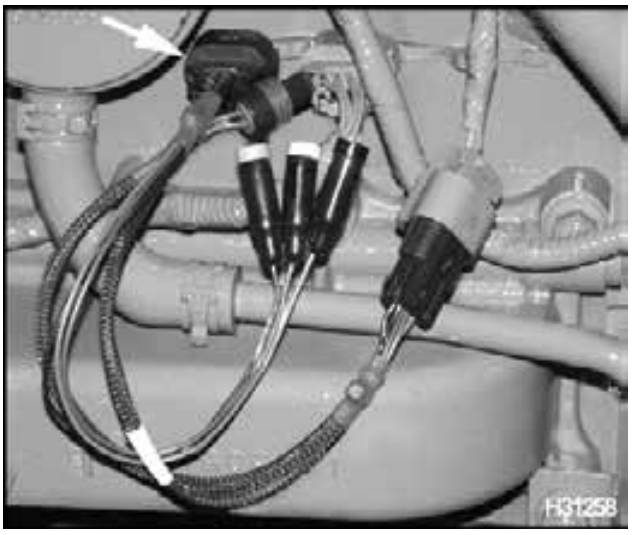

Figure 351 VC Gasket Breakout Harness to pass-through connector for ICP sensor

3. Connect VC Gasket Breakout Harness to the pass-through connector for the ICP sensor and engine harness.
4. Use DMM to measure ICP.
   - Connect POS to green (signal circuit) and NEG to black (ground circuit).

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

When routing DMM leads, do not crimp the leads, run the leads too close to moving parts, or let the leads touch hot engine surfaces. Secure the DMM and leads in the cab so as not to obstruct the operator.

5. Run DMM leads into cab.
6. Drive vehicle and make sure engine operating temperature reaches 70 °C (158 °F).
7. Find a long, open stretch of road.
8. When driving conditions are safe, select a suitable gear, press accelerator pedal fully to the floor, and accelerate to rated speed at 100% load.

9. Memorize DMM voltage for ICP. After parking vehicle, record reading on Diagnostic Form; **do not record reading while driving**.
   - If ICP is to specification, **do not continue** with ICP system diagnostics.
   - If ICP is not to specification, continue with step 10.
   - If ICP is still unstable, replace IPR valve following procedures in the *Engine Service Manual* and retest

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

- **When routing oil line, do not run the line too close to moving parts.**
- **Do not let the line touch hot engine surfaces.**
- **Oil is hot. Use protective gloves when taking oil sample. Use caution handling oil sample to avoid spilling.**

WARNING: To avoid serious personal injury or possible death, do not allow engine fluids to stay on your skin. Clean your skin and nails with soap and water, or a good hand cleaner. Wash or properly throw away clothing or rags containing engine fluids. Engine fluids contain certain elements that may be unhealthy for skin and could even cause cancer.

NOTE: Engine fluids, oil, fuel, and coolant, can be a threat to the environment. Never dispose of engine fluids by putting them in the trash, pouring them on the ground, in the sewers, in streams or bodies of water. Collect and dispose of engine fluids according to local regulations.

10. Turn off engine.

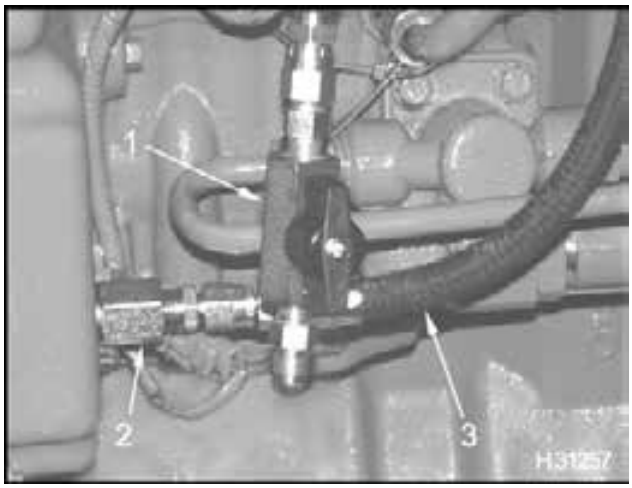

Figure 352 Test hose assembly

1. Inline shut-off valve
2. ICP system test adapter
3. Oil sample line

11. Use the ICP system test adapter and inline shut-off valve to make a test line assembly to take oil sample.

    NOTE: The mechanic is expected to keep the test line for future diagnostics. Expense the test line as an essential tool and keep it with other diagnostic tools. Warranty will not cover the cost of the test line.

12. Remove EOT sensor from EOT port. **Oil will spill out. Quickly install test hose assembly**.
13. Run engine at high idle for 2 minutes. Record ICP initially as high idle is set, then again after 2 minutes. Compare the two ICP readings. ICP that rises above the spec, at any point during the two minutes, indicates aeration.
14. Return engine to low idle, take oil sample, and check for aerated oil.
    - If oil is aerated, a large quantity of air bubbles mixed throughout the oil, or foam build up on top of the oil will be seen. Correct condition.
    - If oil is not aerated, disconnect ICP sensor and check engine stability. If problem is corrected, see “ICP Operational Voltage Checks” in Section 7.

- If ICP is still high or unstable, replace IPR following procedures in *Engine Service Manual* and retest.

Monitoring BCP using VC Gasket Breakout Harness

NOTE: Do this procedure, if an EST is not available. This is an alternate method.

Tools

- VC Gasket Breakout Harness
- DMM

WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

1. See "DT 466 Performance Specifications" – Appendix A (page 595) ,"DT 570 and HT 570 Performance Specifications" – Appendix B (page 619) or Section 7 "Operational Voltages Checks" – for specifications and record on Diagnostic Form.

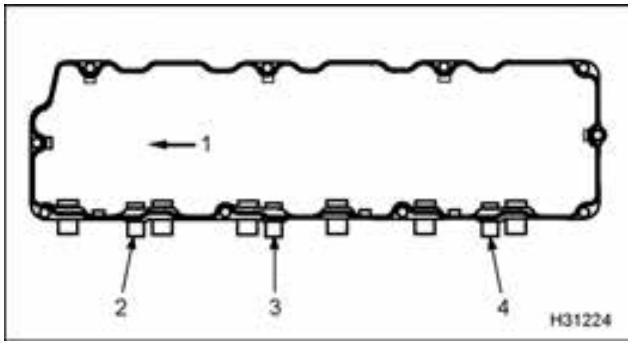

Figure 353 Valve cover gasket

1. Front of engine
2. Pass-through connector for BCP sensor
3. Pass-through connector for brake shut-off valve
4. Pass-through connector for ICP sensor

2. Disconnect engine harness connector from the pass-through connector for the BCP sensor and complete steps 3 through 9.

Figure 354 VC Gasket Breakout Harness to pass-through connector for BCP sensor

3. Connect VC Gasket Breakout Harness to the pass-through connector for the BCP sensor and engine harness.
4. Use DMM to measure BCP.
   - Connect POS to green (signal circuit) and NEG to black (ground circuit).

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

When routing DMM leads, do not crimp the leads, run the leads too close to moving parts, or let the leads touch hot engine surfaces. Secure the DMM and leads in the cab so as not to obstruct the operator.

5. Run DMM leads into cab.
6. Drive vehicle and make sure engine operating temperature reaches 70 °C (158 °F).
7. Find a long, open stretch of road.
8. When driving conditions are safe, select a suitable gear, press accelerator pedal fully to the floor, and accelerate to rated speed at 100% load.

9. Memorize DMM voltage for BCP. After parking vehicle, record reading on Diagnostic Form; **do not record reading while driving**.

   - If BCP signal voltage is more than KOEO BCP signal voltage, when engine brake is inactive, diagnose BCP sensor, circuit, and engine brake components. The BCP voltage reading should be zero psi; however, BCP values may fluctuate as much as 345 kPa (50 psi). Electromagnetic Interference (EMI) or ground shift can cause an insignificant voltage shift that does not indicate a problem.
   - If BCP signal voltage is equal to KOEO BCP signal voltage, there is no problem with the BCP sensor signal or the engine brake.

18. Valve Lash and Brake Lash

Figure 355

NOTE: If Tests 1-17 meet specifications, engine operation is good: Test 18 is not necessary.

☐ Valve lash and engine brake actuator lash:
Engine OFF - Cold.

Instrument	Spec	Actual
Feeler gauge	0.019 in	

H31154

Figure 356

Purpose

- To check or adjust valve lash for intake and exhaust valves
- To check or adjust actuator lash for Diamond Logic® engine brake

Tools

- Feeler gauge
- Straight-blade screwdriver
- Open end wrench (two sizes)
- Torque wrench
- Crows foot (two sizes)

⚠ WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

Valve Lash for Intake and Exhaust Valves

During the procedure to adjust valve lash, the crankshaft is rotated two times:

- Six valve adjustments are made when piston 1 is at Top Dead Center (TDC) compression.
- Six valve adjustments are made when piston 6 is at Top Dead Center (TDC) compression.

If the engine is equipped with the Diamond Logic® engine brake, corresponding brake actuator lash can be adjusted before rotating the crankshaft the second time.

Adjusting Valve Lash

1. Remove valve cover following procedure in *Engine Service Manual*.
2. Turn crankshaft in the direction of engine rotation to remove gear lash from gear train and align the timing mark on the damper pulley with the TDC mark on the front cover.
3. Confirm that piston 1 is at TDC compression by turning both push rods by hand to verify that valves are closed.
   - If push rods are loose and turn easily, piston 1 is at TDC compression and valves are closed. If piston 1 is at TDC compression, see and do steps 4, 5, and 6.
   - If push rods will not turn easily for cylinder 1, piston 6 is at TDC compression. Confirm that valves are closed by making sure that push rods for cylinder 6 are loose and turn easily. If piston 6 is at TDC compression, see and do steps 4, 5, and 6.

Valve and brake lash adjustments (Inches) with piston 1 at TDC compression											
Cylinder 1		Cylinder 2		Cylinder 3		Cylinder 4		Cylinder 5		Cylinder 6	
Intake 1	Exhaust 2	Intake 3	Exhaust 4	Intake 5	Exhaust 6	Intake 7	Exhaust 8	Intake 9	Exhaust 10	Intake 11	Exhaust 12
0.019	0.019	0.019			0.019	0.019			0.019		
Brake	0.019			Brake	0.019			Brake	0.019		

H08044

Figure 357 Valve lash adjustments with piston 1 at TDC compression

Valve and brake lash adjustments (Inches) with piston 6 at TDC compression											
Cylinder 1		Cylinder 2		Cylinder 3		Cylinder 4		Cylinder 5		Cylinder 6	
Intake 1	Exhaust 2	Intake 3	Exhaust 4	Intake 5	Exhaust 6	Intake 7	Exhaust 8	Intake 9	Exhaust 10	Intake 11	Exhaust 12
			0.019	0.019			0.019	0.019		0.019	0.019
		Brake	0.019			Brake	0.019			Brake	0.019

H08045

Figure 358 Valve lash adjustments with piston 6 at TDC compression

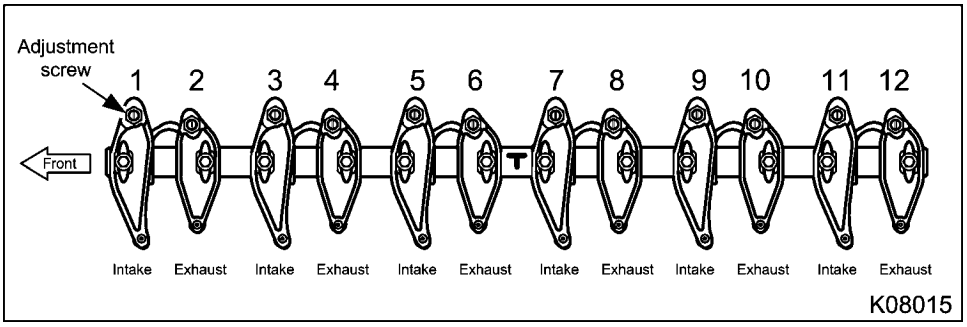

Figure 359 Valve lash adjustment

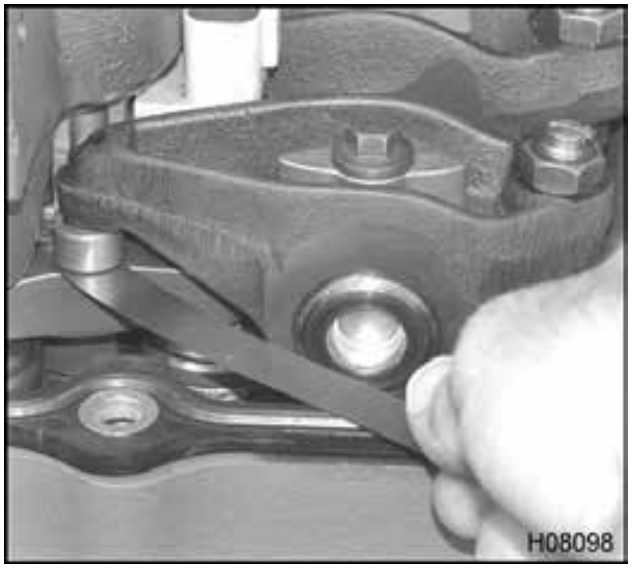

Figure 360 Feeler gauge between the pivot foot and valve bridge

4. Check cold valve lash with a (0.019 in) feeler gauge between the pivot foot and valve bridge. If adjustment is required, loosen the locknut and turn the valve adjustment screw until a light drag is felt.
5. Once valve adjustment is set, tighten the locknut to 27 N·m (20 lbf·ft) and remove the feeler gauge. Recheck for light drag on feeler gauge. If drag is too tight or loose, repeat steps 4 and 5.

   If engine is equipped with the Diamond Logic® engine brake, corresponding brake actuator lash can be adjusted before rotating the crankshaft. See “Brake Actuator Lash” in this section.
6. Turn crankshaft 360° in the direction of engine rotation to remove gear lash from gear train and realign the timing mark on the damper pulley with the TDC mark on the front cover.
   - If first adjustments were with piston 1 at TDC compression, cylinder 6 should be at TDC compression. Confirm that valves are closed by making sure that push rods for cylinder 6 are loose and turn easily. If piston 6 is at TDC compression, see and do steps 4 and 5.
   - If first adjustments were with piston 6 at TDC compression, cylinder 1 should be at TDC compression. Confirm that valves are closed by making sure that push rods for cylinder 1 are loose and turn easily. If piston 1 is at TDC compression, see and do steps 4 and 5.

   Before doing step 7, If engine is equipped with the Diamond Logic® engine brake corresponding brake actuator lash can be adjusted. See “Brake Actuator Lash” in this section.
7. Install valve cover following procedure in *Engine Service Manual*.

Brake Lash

- Three actuators are adjusted when piston 1 is at Top Dead Center (TDC) compression.
- Three actuators are adjusted when piston 6 is at Top Dead Center (TDC) compression.

Corresponding intake and exhaust valve lash should be adjusted before rotating the crankshaft.

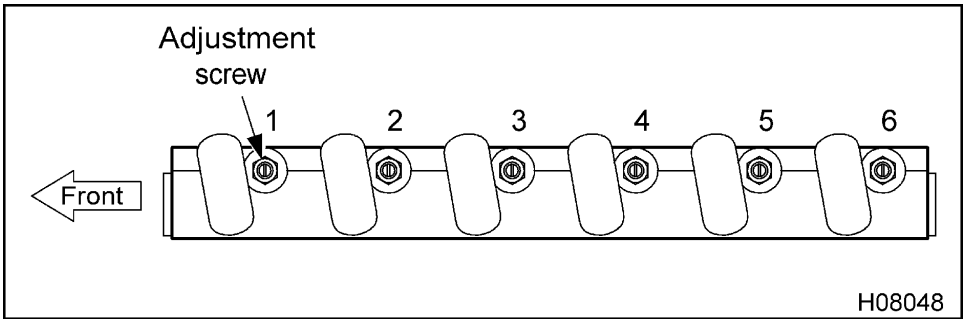

Figure 361 Brake lash adjustment

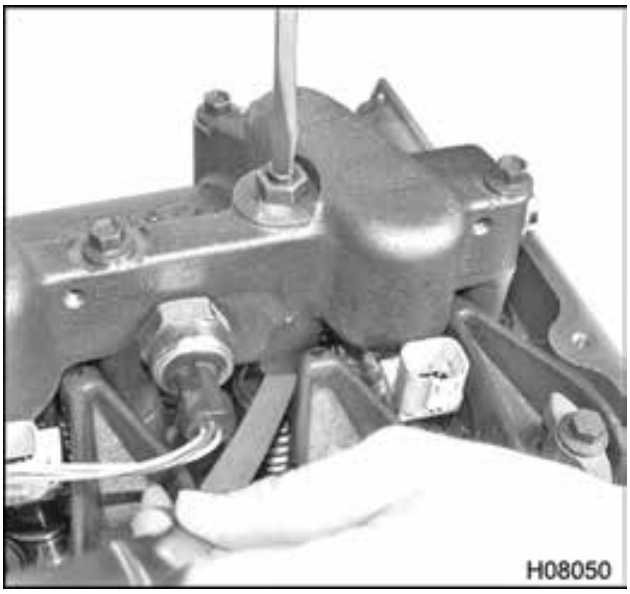

Figure 362 Feeler gauge between the valve bridge and brake actuator

1. Check cold brake lash with a (0.019 in) feeler gauge between the actuator and valve bridge. If adjustment is required, loosen the locknut and turn the actuator adjustment screw until a light drag is felt.
2. Once brake lash is set, tighten the locknut to 27 N·m (20 lbf·ft) and remove the feeler gauge. Recheck for light drag on feeler gauge. If drag is too tight or loose, repeat steps 1 and 2.

Possible Causes

- Worn valve train
- Worn valve seat or valve face
- Worn actuator in Diamond Logic® engine brake