Hard Start or No Start Diagnostic Procedures

E-Series or F-Super Duty

NOTE:

CARRY OUT ONLY THOSE TESTS REQUIRED TO IDENTIFY THE CONCERN THEN REPAIR AS REQUIRED. IT IS NOT NECESSARY TO COMPLETE THE REMAINDER OF THE DIAGNOSTIC PROCEDURE.

CUSTOMER NAME

MODEL YEAR

VEHICLE SERIAL NO. (VIN):

ENGINE SERIAL NUMBER

TRANSMISSION

CUSTOMER CONCERNING (Please list in the box)

WHAT PROBLEMS WERE FOUND AND WHAT REPAIRS WERE COMPLETED?

List Part Name, Number and Serial Number of parts replaced.

NOTE: A hard start/no start concern with EOT temperature below 60°F carry out step 11 first.

1. Visual Engine/Chassis Inspection

   Fuel, Oil, Coolant, Hoses, Leaks and Electrical System
   Method: Check

2. Check Engine Oil Level

   Check for contaminants (fuel, coolant), Correct Grade/Viscosity, Miles/Hours or oil change level.
   Method: Check

3. Intake/Exhaust Restriction

   Inspect air filter and inlet ducts, Inspect exhaust system.
   Check if air filter restriction indicator has been illuminated (F-Super Duty)
   Method: Check

4. Sufficient Clean Fuel

   Check the WATER IN FUEL lamp has been illuminated.
   After verifying that there is fuel in the tank, drain a sample from fuel control module.
   Cetane rating between 40-50 is recommended for optimum start.
   Method: Check

5. Fuel System Delivery

   • Verify that the fuel pump has voltage and ground at key on.
   • Measure fuel pressure using Flow Tester, Diesel Fuel tool.

   Instrument: Spec. Measurement
   Flow Tester, Diesel Fuel E-Series
   202 kPa (30 psi) MIN
   405 kPa (60 psi) MAX
   F-Super Duty
   110 kPa (15 psi) MIN
   593 kPa (87 psi) MAX

6. Electric Fuel Pump Inlet Restriction

   • Measure restriction at fuel pump inlet.
   • Using Flow Tester, Diesel Fuel tool and 0-30 in-Hg Vacuum Gauge, measure the fuel conditioning module inlet vacuum.

   Instrument: Spec. Measurement
   0.30' Hg Vacuum Gauge
   0 in-Hg MAX

7. Carry Out KOEO On-Demand Self Test

   Use scan tool. DTCs set during this test are current faults.
   Diagnostic Trouble Codes

8. Retrieve Continuous DTCs

   Use scan tool. DTCs retrieved during this test are historical faults.
   Diagnostic Trouble Codes

See PC/ED manual, Section 4 for more detail on the above test steps.

When troubleshooting a Hard Start/No Start or Performance concern, this form must be filled out to the point of repair to receive warranty credit for diagnostic time for the parts listed below.

Fuel Injectors (6E527), ICP Sensor (9F838), High Pressure Oil Injection Pump (9B562), Turbocharger Assembly (6K582), Fuel Conditioning Module (6G262), PCM (12A650), EGR Valve (9F402), CKP Sensor (9C315), CMP Sensor (12A673), GPC (12A603), and Slow Plugs (12A342).

Some labor operations are listed in more than one test step. Those operations include time for all occurrences and can be claimed only once.

N0048540

Page 1 of 2

Revised 10/2

http://www.fordservicecontent.com/pubs/content/~WV6C/~MUS~LEN/14/V6C4001.HTM 9/3/2015
E-Series or F-Super Duty
F-Super Duty/Econoline 2006-2007 6.0L Power Stroke Diesel Engine
Hard Start/No Start Diagnostic Guide

NOTE - REFER TO SECTION 4 OF THE PCED MANUAL FOR REPAIR INSTRUCTIONS. CARRY OUT ONLY THOSE TESTS REQUIRED TO IDENTIFY THE CONCERN THEN REPAIR AS REQUIRED. IT IS NOT NECESSARY TO COMPLETE THE REMAINDER OF THE DIAGNOSTIC PROCEDURE.

CUSTOMER NAME

MODEL YEAR

VEHICLE SERIAL NO. (VIN)

ENGINE SERIAL NUMBER

TRANSMISSION

MILEAGE

GROUNDS STYLE

VEHICLE VIN

HASS CLN/PLNBART

I/LRGM TEST

STATE

CUSTOMER CONCERN: (Please list in the box)

NOTE: A hard start/no start concern with EOT temperature below 60°F carry out step 1 first.

9. KOEO Injector Electrical Self Test (Click Test)

Use scan tool. Injector DTCs will be displayed at test end.

All injectors momentarily click, then each injector will click in sequence 1-8. Sequence repeats three times.

Injector Trouble Codes

* If self test codes are retrieved, go to appropriate pinpoint test.

10. Data List

Parameter | Spec | Measurement
----------|------|----------------
10a. E+  | 10.5 x 500 min Oil, engine OFF | 200 min cranking
10b. RCCM/PWR | 8 volts min cranking | 11.5 volts min cranking
10c. RCM/MPWR | 45 volt min | 
10d. RMS | 100 RPM min. | 
10e. ICP | 35 MPa min (500 psi) | 
10f. IPR | 80 V min | 
10g. E+ | 11.5 volts | 
10h. IPR | 30% max at warm engine idles | 
10i. FUEL | Greater than 0% | 
10j. FUEL | 10.5 MPa (150Psi) min | 
10k. FCM | 500-2,500 m/s | 
10l. FCM/Sync | Yes/No | 

A - Check PCM Voltage
B - Check FICM Voltage
C - Check FICM M Voltage to Actuate Injectors
D - Check the RPM Signal while Cranking
E - Monitor the ICP and IPR Duty Cycle While Cranking
F - High Pressure Oil System
G - Pressure check 6005E48, 6005E50
H - High Pressure Oil Pump Test 6005E49
J - Check Fuel Pressure Width Cranking
I - Check FICM Synchronization

11. Glow Plug System Operation

9PCM Operation

Glow Plug ON time is dependent on ambient temperature and altitude. The Glow Plug Control Module (GPCM) comes of between 1 and 120 sec., and does not come on at all if oil temp is above 130°F. Using a scan tool, check Continuous and KOEO OTC's. If codes are present go to Pinpoint Test AF. Verify B+ voltage is being supplied to GPCM. Using the scan tool (SPCM and EOT pads, verify glow plug "on" time. Turn key to run position, measure voltage ("on"time)

(Dependent on oil temperature and altitude)

Time on | Spec | Measurement
--------|------|----------------
1 to 120 seconds | 8 + seconds | 

Wait to Start Lamp "on" time is independent from g/p "on" time

Glow Plug Resistance
Disconnect the 4-pin connector at front of valve cover. Measure each Glow Plug resistance to 5% ground. Measure engine harness resistance to GPCM.

Glow Plug Number | Glow Plug to Ground | Harness to SPCM Connector | 
1 | #1 | #1 |
2 | #2 | #2 |
3 | #3 | #3 |
4 | #4 | #4 |
5 | #5 | #5 |
6 | #6 | #6 |
8 | #8 | #8 |

See PC/ED manual, Section 4 for more detail on the above test steps.

When troubleshooting a Hard Start/No Start or Performance concern, this form must be filled out to the point of repair to receive warranty credit for diagnostic time.

Fuel Injectors (96527), ICP Sensor (91838), High Pressure Oil Injection Pump (96548), Turbocharger Assembly (90682), Fuel Conditioning Module (90678), PCM (124650), EGR Valve (9542), CKP Sensor (93131), CMP Sensor (124073), GPCM (123632), and Glow Plugs (123432).

Some labor operations are listed in more than one test step. Those operations include time for all occurrences and can be claimed only once.

1. Visual Engine and Chassis Inspection

**Note:** For a hard start or no start concern when the engine oil temperature (EOT) is less than 15°C (60°F) carry out the Glow Plug System Operation test in this section.

**Note:** The camshaft position (CMP) sensor, crankshaft position (CKP) sensor, injection pressure regulator (IPR) and the PCM connectors are the most critical electronic sensors and actuators to inspect in no start situations.

**Purpose:**

The purpose of this test is to check the general condition of the engine and look for obvious causes of the hard start or no start condition.

<table>
<thead>
<tr>
<th>Fuel, Oil, Coolant, Hoses, Leaks and Electrical System</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Method</strong></td>
</tr>
<tr>
<td>Visual</td>
</tr>
</tbody>
</table>

**Recommended Procedure:**

Inspect the fuel system, including the fuel tank and the fuel lines for kinks, bends and leakage. Inspect for coolant leaks at the radiator and heater hoses. Inspect the manifold absolute pressure (MAP) sensor and the charge air cooler (CAC) for pinched hoses and leaks. Inspect wiring for correct routing and make sure no rubbing or chafing has occurred. Inspect the engine harness, fuel injector control module (FICM), powertrain control module (PCM) and sensor connectors to make sure they are completely seated and in good condition.

**Possible Causes:**

- Loose or leaking fuel supply lines cause the fuel system to lose its prime
- Kinked or blocked fuel supply lines
- Fuel or oil leaks contribute to no start conditions
- Coolant leaks indicate engine problems
- Electronic connectors may be damaged or incorrectly installed causing a no start condition
- Pinched or open MAP sensor hose
- Pinched or open CAC hose

**Tools Required:**

Inspection light

2. Check Engine Oil Level

**WARNING:** SMOKING OR OPEN FLAME OF ANY TYPE MUST NOT BE PRESENT WHEN
WORKING NEAR FUEL OR FUEL VAPOR. FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN PERSONAL INJURY.

Purpose:

The purpose of this test is to verify the oil quality and determine if there is sufficient oil to operate the injectors.

Check Engine Oil Level

- Check for contaminants (fuel, coolant).
- Correct grade and viscosity.
- Miles or hours on oil, correct level.

<table>
<thead>
<tr>
<th>Method</th>
<th>Check</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual</td>
<td></td>
</tr>
</tbody>
</table>

Recommended Procedure:

Check for the correct oil level using the dipstick with the vehicle on level ground. If there is no oil or very little oil in the crankcase, the injectors will not operate.

If the oil level on the dipstick is overfull, it is possible the engine was incorrectly repaired or fuel or coolant is diluting the oil and filling the crankcase. Recheck the engine oil level. Remove and clean the oil level indicator. Reinsert the oil level indicator into the oil level indicator tube until only the oil level indicator handle touches the top of the oil level indicator tube.

Inspect the oil for color. A milky white oil indicates possible coolant contamination and will have an ethylene glycol odor.

Oil contaminated with diesel fuel has a diesel fuel odor and increases the engine oil level. If the engine oil level is above Max due to diesel fuel dilution, the oil appears thin and watery.

If the oil level is overfilled, drain the oil and the fuel filter housing. Isolate either cylinder head by removing the corresponding fuel line from the fuel filter housing. Remove the fuel pressure test port plug from the secondary filter housing. Install the plug in the outlet port. Install the Adapter, High Pressure Pump Test 303-765 or equivalent and Gauge 0-1,100 kPa (0-160 psi) Bar (part of DSL ENG Pressure Test Kit 014-00761 or equivalent) at the test port to confirm constant fuel pressure.

Using the diagnostic tool, access output state control (OSC) and command the fuel pump ON. Watch for fuel to drain out of the oil pan drain hole. Depending on the severity of the leak, it may take some time before a leak is noticeable. Remove the valve cover at the suspect cylinder head and inspect the injector area for leaks.

Check the maintenance records for appropriate oil change intervals, type and viscosity for the vehicle operating temperature. Single weight or 15W-40 oil is not recommended for cold ambient temperatures. 10W-30 oil is recommended for cold ambient temperatures. Oil that has had extended drain intervals has increased viscosity (become thicker) and makes engine cranking more difficult and starting less reliable at temperatures below freezing. Extended oil change intervals can also cause a runs rough concern. Refer to the lube oil chart in the Workshop Manual or Owner’s Literature for the correct oil selection for temperature.
conditions.

**Possible Causes:**

- Loss of lube oil pressure
- Oil level low — oil leak, oil consumption, incorrect repair
- Oil level high — incorrect repair, fuel dilution from injector O-rings
- Oil contamination with coolant — oil cooler, head gasket, porosity, front cover gasket

**Tools Required:**

Adapter, High Pressure Pump Test 303-765 or equivalent

Gauge 0-1,100 kPa (0-160 psi) Bar (part of DSL ENG Pressure Test Kit 014-00761 or equivalent)

Diagnostic tool

**3. Intake/Exhaust Restriction**

**Purpose:**

This purpose of this test is to determine if an air intake or exhaust restriction is contributing to a no start or hard start condition. If the engine starts with a high air intake or exhaust restriction, a considerable amount of black/blue smoke is produced.

**Intake/Exhaust Restriction**

- Inspect the air filter and inlet ducts.
- Inspect the exhaust system.
- Check for illumination of the air filter restriction indicator (F-Super Duty).

**Recommended Procedure:**

Inspect the air cleaner inlet and ducting to verify it is not blocked or collapsed. Inspect the air cleaner housing and filter for proper installation. Inspect the air filter restriction gauge to make sure the intake restriction is below the red marks. Inspect the exhaust system for damaged or blocked pipes.

**F-Super Duty Air Filter Restriction Gauge**
Possible Causes:

Note: Reset the air filter restriction gauge after repairing a restriction concern.

- Snow, plastic bags, or other foreign material may restrict airflow at the air inlet.
- Misrouted air cleaner ducting.
- On engines recently repaired, rags or cap plugs may have been inadvertently left in an air inlet pipe.
- Tailpipe or muffler may have collapsed or been damaged.
Tools Required:
None

4. Sufficient Clean Fuel

Purpose:
The purpose of this test is to verify the fuel quality.

Sufficient Clean Fuel

- Check for illumination of the water in fuel indicator.
- After verifying that there is fuel in the tank, drain a sample from the fuel conditioning module.
- A cetane rating between 40 and 50 is recommended for optimum performance.

### Recommended Procedure:

Open the drain valve on the fuel conditioning module and fill a clear container until it is half full. Close the drain valve.

Observe the water in fuel indicator. If the indicator is illuminated, the fuel is probably contaminated with water.

Flow out of the drain should be a steady stream. Insufficient flow could indicate fuel supply or fuel system problems. If air bubbles are present, check the fuel supply lines and the in tank fuel pickup tube for leaks. If a fuel supply line or in tank fuel pickup tube leak is found, repair as necessary. If no fuel supply line or in tank fuel pickup tube leaks are found, the fuel level in the fuel tank could be low due to the fuel gauge or fuel level sender reading inaccurately. Refer to the Workshop Manual Section 413-01, Instrumentation and Warning Chimes, Symptom Chart to continue diagnosis. Repair as necessary.

Inspect the fuel in the container. It should be clear, not cloudy. It also should be free of water and contaminants. Dyed red or blue fuel indicates off-highway fuel.

Some sediment and water may be present in the fuel sample if the fuel filter has not been replaced for a prolonged period of time and/or if the sediment and water have not been drained recently. If that is the case, a second sample may be required to determine fuel quality.

F-Super Duty Fuel Conditioning Module Drain Valve
Possible Causes:

- No fuel in the tank.
- Fuel supply line could be broken or crimped.
- Fuel could be gelled (most likely in cold weather with No. 2 fuel).
- Pickup tube screen in tank could be clogged.
- Restricted fuel filters.

Cloudy fuel indicates that the fuel may not be a suitable grade for cold temperatures.

Excessive water or contaminants may indicate that the tank and fuel system may need to be flushed and cleaned.
Tools Required:

Clear container — approximately 0.95 L (1 quart)

5. Fuel System Delivery

⚠️ WARNING: AVOID CONTACT WITH FUEL DURING A VISUAL INSPECTION FOR FUEL LEAKS WITH THE ENGINE RUNNING. DO NOT WORK ON THE FUEL SYSTEM UNTIL THE PRESSURE HAS BEEN RELEASED AND THE ENGINE HAS COOLED. FUEL IN THE HIGH-PRESSURE FUEL SYSTEM IS HOT AND UNDER VERY HIGH PRESSURE. HIGH-PRESSURE FUEL MAY CAUSE CUTS AND CONTACT WITH HOT FUEL MAY CAUSE BURNS. FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN SERIOUS PERSONAL INJURY.

⚠️ WARNING: WHEN HANDLING FUEL, ALWAYS OBSERVE FUEL HANDLING PRECAUTIONS AND BE PREPARED IN THE EVENT OF FUEL SPILLAGE. SPILLED FUEL MAY BE IGNITED BY HOT VEHICLE COMPONENTS OR OTHER IGNITION SOURCES. FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN SERIOUS PERSONAL INJURY.

Note: The Diesel Fuel Flow Tester 310-193 or equivalent provides a pressure reading while simulating maximum fuel consumption at full load on the fuel system. The Diesel Fuel Flow Tester 310-193 uses a 1.193 mm (0.047 in) calibrated orifice integrated in the tool assembly to simulate the fuel consumption.

For E-Series vehicles, measure the fuel system pressure at the right hand cylinder head fuel passage plug on the back of the right hand cylinder head.

For F-Super Duty and Excursion vehicles, measure the fuel system pressure at the secondary fuel filter housing test port.

The fuel pressure value at the secondary fuel filter housing test port is higher than the fuel pressure value at the back of the cylinder head due to a pressure drop through the fuel rails, fuel injectors and other fuel system components.

Note: Make sure the battery voltage is greater than 12.5 volts at all times throughout this procedure. Install a battery charger if necessary. Fuel pumps will not pass the fuel delivery tests if the battery voltage drops below 12.5 volts during the fuel flow tests. This is especially important if the test is carried out on a non-running vehicle because there are significant electrical loads when operating the fuel pump with the engine off. If the battery voltage drops below 12.5 volts, the battery may need to be charged or there may be a charging system concern, refer to the Workshop Manual Section 414-00, Charging System, Symptom Chart to continue diagnosis.

Purpose:

The purpose of this test is to verify the fuel system pressure and flow.

Fuel System Delivery

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Specification</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel Fuel Flow Tester 310-193 or</td>
<td>E-Series 262 kPa (38 psi)</td>
<td>MIN - 455 kPa (66 psi)</td>
</tr>
</tbody>
</table>
Fuel System Delivery Recommended Procedure:

**Note:** Restrictions in the fuel line may cause continuous aeration.

- Verify there is fuel in the tank.
- Verify the fuel temperature is above 0 °C or 32 °F to prevent testing with gelled fuel. Check for sufficient clean fuel, carry out the Sufficient Clean Fuel test in this section.
- Measure the voltage between the fuel pump power and ground circuits. Voltage is present for approximately 20 seconds after the key is turned to the ON position. If the voltage is less than 11.9 volts, GO to Pinpoint Test M.
F-Super Duty

- Make sure the valve on the Diesel Fuel Flow Tester 310-193 or equivalent is closed.
- **NOTICE:** Correct installation of the Diesel Fuel Flow Tester 310-193 or equivalent is necessary to prevent damage to the interior of the vehicle.

For E-Series vehicles, remove the right hand cylinder head fuel passage plug from the back of the cylinder head. Install the Diesel Fuel Flow Tester 310-193 or equivalent using two new sealing washers to seal the banjo bolt and torque to 27 Nm (20 lb-ft). Make sure the banjo fitting is centered over the freeze plug as shown in the illustration and the hose is routed under the right hand exhaust manifold next to the transmission to prevent sealing concerns due to cylinder head casting bosses.

E-Series

- For F-Super Duty vehicles, remove the test port plug from the front of the secondary fuel filter housing. Install the Diesel Fuel Flow Tester 310-193 or equivalent using two new sealing washers to
seal the banjo bolt and torque to 27 Nm (20 lb-ft).

**F-Super Duty**

- Insert the heavy duty black end of the clear yellow hose into the fuel tank filler pipe to drain the fuel into the fuel tank. Make sure the fuel return hose is not pinched or restricted. Do not substitute any other fuel return hose and do not change the hose length of 6.7 m (22 ft) clear yellow hose with 0.91 m (3 ft) heavy duty black hose end or the internal diameter (ID) of 6.35 mm (0.25 in). The heavy duty black end on the hose is used to reduce pinching between the fuel filler door and the vehicle body.
- If the engine starts and does not stall, start the engine and let it idle.
- Open the valve on the Diesel Fuel Flow Tester 310-193 or equivalent.
- If the engine is running, run the engine until fuel flows free from cloudiness, gelling (cold weather) or aeration. If the fuel continues to be cloudy or gelled, refer to the Sufficient Clean Fuel test in this section. If the air bubbles can not be purged, check for kinks or leaks in the vehicle fuel system as well as the test tool.
- If the engine does not start, continue to cycle the key to the ON position until fuel flows free from cloudiness, gelling (cold weather) or aeration. If the fuel continues to be cloudy or gelled, refer to the Sufficient Clean Fuel test in this section. If the air bubbles can not be purged, check for kinks or leaks in the vehicle fuel system as well as the test tool. The fuel pump cycles on, then off after 20 seconds.
- Access and monitor the B+ PID. Verify the battery and charging system are working correctly and the battery voltage is greater than 11.5 volts. Refer to the Workshop Manual Section 414-00, Charging System for diagnosis as necessary.
- Record the indicated fuel pressure while the valve is open and fuel is flowing back to the fuel tank.

If the fuel pressure meets the specification, no concern is present at this time.

If the fuel pressure is below the specification, carry out the Fuel Conditioning Module Pressure test in this section.

If the fuel pressure is above the specification, check the fuel return lines for a restriction. If no restriction is present, install a new fuel pressure regulator valve.

**Possible Causes:**

- Fuel return line restriction
- Fuel pressure regulator valve

**Tools Required:**

Diesel Fuel Flow Tester 310-193 or equivalent

**Fuel Conditioning Module Pressure**

**Purpose:**

The purpose of this test is to verify that the fuel filters are not restricted.

**Fuel Conditioning Module Pressure**

Measure the fuel conditioning module outlet fuel system pressure between the fuel conditioning module and the secondary fuel filter.

Use the Diesel Fuel Flow Tester 310-193 or equivalent to simulate maximum fuel consumption.

Plug the vehicle's fuel return line to isolate the fuel pressure regulator valve.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Specification</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel Fuel Flow Tester 310-193 or equivalent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adapter, Fuel Pressure Test 310-111 or equivalent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gauge 0-1,100 kPa (0-160 psi) Bar (part of DSL ENG Pressure Test Kit 014-00761 or equivalent)</td>
<td>344 kPa (50 psi) MIN</td>
<td></td>
</tr>
</tbody>
</table>

**Fuel Conditioning Module Pressure Test Recommended Procedure:**

**Note:** Restrictions in the fuel line may cause continuous aeration.

- Make sure the valve on the Diesel Fuel Flow Tester 310-193 or equivalent is closed.
- Using the male and female tool plugs included with the Diesel Fuel Flow Tester 310-193 or equivalent, plug the fuel return line between the secondary fuel filter and the fuel conditioning module. Plug the fuel conditioning module fuel return inlet port.
- Install the Adapter, Fuel Pressure Test 310-111 or equivalent with the Gauge 0-1,100 kPa (0-160 psi) Bar (part of DSL ENG Pressure Test Kit 014-00761 or equivalent) between the fuel conditioning module outlet port and the fuel supply line leading to the secondary fuel filter.
If the engine starts and does not stall, start the engine and let it idle.

Open the valve on the Diesel Fuel Flow Tester 310-193 or equivalent.

If the engine is running, run the engine until fuel flows free from cloudiness, gelling (cold weather) or aeration. If the fuel continues to be cloudy or gelled, refer to the Sufficient Clean Fuel test in this section. If the air bubbles cannot be purged, check for kinks or leaks in the vehicle fuel system as well as the test tool.

If the engine does not start, continue to cycle the key to the ON position until fuel flows free from cloudiness, gelling (cold weather) or aeration. If the fuel continues to be cloudy or gelled, refer to the Sufficient Clean Fuel test in this section. If the air bubbles cannot be purged, check for kinks or leaks.
in the vehicle fuel system as well as the test tool. The fuel pump cycles on, then off after 20 seconds.

- Access and monitor the B+ PID. Verify the battery and charging system are working correctly and the battery voltage is greater than 11.5 volts. Refer to the Workshop Manual Section 414-00, Charging System for diagnosis as necessary.
- Record the maximum fuel pressure at the fuel conditioning module outlet while the valve on the Diesel Fuel Flow Tester 310-193 or equivalent is open and fuel is flowing back to the fuel tank.

If the fuel pressure at the fuel conditioning module outlet is below the 344 kPa (50 psi) MIN specification and new primary or secondary fuel filters have not been installed, install new primary and secondary fuel filters. Repeat the Fuel Conditioning Module Pressure test in this section to verify the repair.

If the Fuel Conditioning Module Pressure test has been repeated and the fuel pressure at the fuel conditioning module outlet now meets the 344 kPa (50 psi) MIN specification, remove the fuel return line plugs and connect the fuel return line. Repeat the Fuel System Delivery test in this section to verify the repair.

If the Fuel Conditioning Module Pressure test has been repeated and the fuel pressure at the fuel conditioning module outlet is still below the 344 kPa (50 psi) MIN specification, carry out the Electric Fuel Pump Inlet Restriction test in this section.

If the fuel pressure at the fuel conditioning module outlet is equal to or greater than the 344 kPa (50 psi) MIN specification, carry out the Restricted Secondary Fuel Filter test in this section.

**Possible Causes:**

- Primary fuel filter
- Secondary fuel filter

**Tools Required:**

- Diesel Fuel Flow Tester 310-193 or equivalent
- Adapter, Fuel Pressure Test 310-111 or equivalent
- Gauge 0-1,100 kPa (0-160 psi) Bar (part of DSL ENG Pressure Test Kit 014-00761 or equivalent)

**Restricted Secondary Fuel Filter**

**Purpose:**

The purpose of this test is to determine the condition of the secondary fuel filter.

**Restricted Secondary Fuel Filter**

Measure the fuel pressure difference between the fuel inlet and fuel outlet sides of the secondary fuel filter.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Specification</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel Fuel Flow Tester 310-193 or equivalent</td>
<td>E-Series 83 kPa (12 psi) MAX differential</td>
<td></td>
</tr>
<tr>
<td>Adapter, Fuel Pressure Test 310-111 or equivalent</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Restricted Secondary Fuel Filter Test Recommended Procedure:

**Note:** Restrictions in the fuel line may cause continuous aeration.

- Make sure the valve on the Flow Tester, Diesel Fuel 310-193 or equivalent is closed.
- Using the male and female tool plugs included with the Flow Tester, Diesel Fuel 310-193 or equivalent, plug the fuel return line between the secondary fuel filter and the fuel conditioning module. Plug the fuel conditioning module fuel return inlet port.
- Install the Fuel Pump Adapter 310-111 or equivalent with the Gauge 0-1,100 kPa (0-160 psi) Bar (part of DSL ENG Pressure Test Kit 014-00761 or equivalent) between the fuel conditioning module outlet port and the fuel supply line leading to the secondary fuel filter.
- If the engine starts and does not stall, start the engine and let it idle.
- Open the valve on the Flow Tester, Diesel Fuel 310-193 or equivalent.
- If the engine is running, run the engine until fuel flows free from cloudiness, gelling (cold weather) or aeration. If the air bubbles cannot be purged, check for kinks or leaks.
- If the engine does not start, continue to cycle the key to the ON position until fuel flows free from cloudiness, gelling (cold weather) or aeration. If the air bubbles cannot be purged, check for kinks or leaks. The fuel pump cycles on, then off after 20 seconds.
- Verify the battery voltage is greater than 12.5 volts. If the battery voltage drops below 12.5 volts, the battery may need to be charged or there may be a charging system concern, refer to the Workshop Manual Section 414-00 Charging System, Symptom Chart to continue diagnosis.
- Record the indicated fuel pressure difference between the two installed test gauges while the valve is open and the fuel is flowing back to the fuel tank.

If the fuel pressure difference is greater than the specification, install new primary and secondary fuel filters.

If the fuel pressure difference is less than the specification, install a new fuel pressure regulator valve.

Remove the fuel return line plugs and connect the fuel return line to the fuel conditioning module, repeat the Fuel System Delivery test in this section to verify the repair.

**Possible Causes:**

- Secondary fuel filter
- Fuel pressure regulator valve

**Tools Required:**

- Diesel Fuel Flow Tester 310-193 or equivalent
- Adapter, Fuel Pressure Test 310-111 or equivalent
- Gauge 0-1,100 kPa (0-160 psi) Bar (part of DSL ENG Pressure Test Kit 014-00761 or equivalent)

**6. Electric Fuel Pump Inlet Restriction**
WARNING: AVOID CONTACT WITH FUEL DURING A VISUAL INSPECTION FOR FUEL LEAKS WITH THE ENGINE RUNNING. DO NOT WORK ON THE FUEL SYSTEM UNTIL THE PRESSURE HAS BEEN RELEASED AND THE ENGINE HAS COOLED. FUEL IN THE HIGH-PRESSURE FUEL SYSTEM IS HOT AND UNDER VERY HIGH PRESSURE. HIGH-PRESSURE FUEL MAY CAUSE CUTS AND CONTACT WITH HOT FUEL MAY CAUSE BURNS. FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN SERIOUS PERSONAL INJURY.

WARNING: WHEN HANDLING FUEL, ALWAYS OBSERVE FUEL HANDLING PRECAUTIONS AND BE PREPARED IN THE EVENT OF FUEL SPILLAGE. SPILLED FUEL MAY BE IGNITED BY HOT VEHICLE COMPONENTS OR OTHER IGNITION SOURCES. FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN SERIOUS PERSONAL INJURY.

Note: The Diesel Fuel Flow Tester 310-193 or equivalent provides a pressure reading while simulating maximum fuel consumption at full load on the fuel system. The Diesel Fuel Flow Tester 310-193 uses a 1.193 mm (0.047 in) calibrated orifice integrated in the tool assembly to simulate the fuel consumption.

For E-Series vehicles, measure the fuel system pressure at the right hand cylinder head fuel passage plug on the back of the right hand cylinder head.

For F-Super Duty and Excursion vehicles, measure the fuel system pressure at the secondary fuel filter housing test port.

The fuel pressure value at the secondary fuel filter housing test port is higher than the fuel pressure value at the back of the cylinder head due to a pressure drop through the fuel rails, fuel injectors and other fuel system components.

Note: Make sure the battery voltage is greater than 12.5 volts at all times throughout this procedure. Install a battery charger if necessary. Fuel pumps will not pass the fuel delivery tests if the battery voltage drops below 12.5 volts during the fuel flow tests. This is especially important if the test is carried out on a non-running vehicle because there are significant electrical loads when operating the fuel pump with the engine off. If the battery voltage drops below 12.5 volts, the battery may need to be charged or there may be a charging system concern, refer to the Workshop Manual Section 414-00, Charging System, Symptom Chart to continue diagnosis.

Purpose:

To detect concerns with the fuel conditioning module inlet, fuel filters or fuel pump.

Electric Fuel Pump Inlet Restriction

Measure the fuel inlet vacuum on the fuel tank side of the fuel conditioning module.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Specification</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Tester, Diesel Fuel 310-193 or equivalent</td>
<td>6 in-Hg MAX</td>
<td></td>
</tr>
<tr>
<td>Fuel Pump Adapter 310-111 or equivalent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-30 in-Hg Vacuum Gauge (part of DSL ENG Pressure Test Kit 014-00761 or equivalent)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Recommended Procedure:

**Note:** Restrictions in the fuel line may cause continuous aeration.

- Verify there is fuel in the tank.
- Verify the fuel temperature is above 0 °C or 32 °F to prevent testing with gelled fuel. Check for sufficient clean fuel, carry out the Sufficient Clean Fuel test in this section.

- Make sure the valve on the Flow Tester, Diesel Fuel 310-193 or equivalent is closed.
- **NOTICE:** Correct installation of the Flow Tester, Diesel Fuel 310-193 or equivalent is necessary to prevent damage to the interior of the vehicle.

For E-Series vehicles, remove the right hand cylinder head fuel passage plug from the back of the cylinder head. Install the Flow Tester, Diesel Fuel 310-193 or equivalent using two new sealing washers to seal the banjo bolt and torque to 27 Nm (20 lb-ft). Make sure the banjo fitting is centered over the freeze plug as shown in the illustration and the hose is routed under the right hand exhaust manifold next to the transmission to prevent sealing concerns due to cylinder head casting bosses.

For F-Super Duty vehicles, remove the test port plug from the front of the secondary fuel filter housing. Install the Flow Tester, Diesel Fuel 310-193 or equivalent using two new sealing washers to seal the banjo bolt and torque to 27 Nm (20 lb-ft).
F-Super Duty

- Insert the heavy duty black end of the clear yellow hose into the fuel tank filler pipe to drain the fuel into the fuel tank. Make sure the fuel return hose is not pinched or restricted. Do not substitute any other fuel return hose and do not change the hose length of 6.7 m (22 ft) clear yellow hose with 0.91 m (3 ft) heavy duty black hose end or the internal diameter (ID) of 6.35 mm (0.25 in). The heavy duty black end on the hose is used to reduce pinching between the fuel filler door and the vehicle body.
- If directed to this test from the Fuel System Delivery test, remove the Fuel Pump Adapter 310-111 or equivalent and the Gauge 0-1,100 kPa (0-160 psi) Bar (part of DSL ENG Pressure Test Kit 014-00761 or equivalent) from the fuel conditioning module outlet fuel supply line. Connect the fuel conditioning module outlet fuel supply line to the fuel conditioning module outlet port.
- Install the Fuel Pump Adapter 310-111 or equivalent with the 0-30 in-Hg Vacuum Gauge (part of DSL ENG Pressure Test Kit 014-00761 or equivalent) between the fuel supply line and the fuel conditioning module inlet port.
Using the male and female tool plugs included with the Flow Tester, Diesel Fuel 310-193 or equivalent, plug the fuel return line between the secondary fuel filter and the fuel conditioning module. Plug the fuel conditioning module fuel return inlet port.

- If the engine starts and does not stall, start the engine and let it idle.
- Open the valve on the Flow Tester, Diesel Fuel 310-193 or equivalent.
- If the engine is running, run the engine until fuel flows free from cloudiness, gelling (cold weather) or aeration. If the air bubbles cannot be purged, check for kinks or leaks.
- If the engine does not start, continue to cycle the key to the ON position until fuel flows free from cloudiness, gelling (cold weather) or aeration. If the air bubbles cannot be purged, check for kinks or leaks.
leaks. The fuel pump cycles on, then off after 20 seconds.

- Access and monitor the B+ PID. Verify the battery and charging system are working correctly and the battery voltage is greater than 11.5 volts. Refer to the Workshop Manual Section 414-00, Charging System for diagnosis as necessary.
- Record the indicated vacuum reading while the valve is open and fuel is flowing back to the fuel tank.

If the vacuum reading is greater than the specification, correct the restriction between the fuel tank pickup and the fuel conditioning module, remove the fuel return line plugs and connect the fuel return line. Repeat the Fuel System Delivery test in this section to verify the repair.

If the vacuum reading is within the specification, check the primary fuel filter. If the primary fuel filter is OK, install a new fuel conditioning module, refer to the workshop manual section 310-01, Fuel Tank and Lines, Fuel Conditioning Module. Remove the fuel return line plugs, connect the fuel return line and repeat the Fuel System Delivery test in this section to verify the repair.

Possible Causes:

- Fuel supply line restriction
- Fuel conditioning module
- In tank fuel pickup

Tools Required:

Flow Tester, Diesel Fuel 310-193 or equivalent

Fuel Pump Adapter 310-111 or equivalent

0-30 in-Hg Vacuum Gauge (part of DSL ENG Pressure Test Kit 014-00761 or equivalent)

7. Carry Out The Key On Engine Off (KOEO) On-Demand Self-Test

Purpose:

The purpose of this test is to determine if the PCM has detected any fault conditions that would cause a hard start or no start condition.

 Carry Out The KOEO On-Demand Test

- Use the diagnostic tool. Diagnostic trouble codes (DTCs) set during this test are current faults.

| Diagnostic Trouble Codes (DTCs) |

Recommended Procedure:

Note: To verify that the DTC is a hard fault, first clear continuous DTCs (be sure to record all DTCs and freeze frame information before clearing). Repeat the KOEO on-demand self-test. If the DTC is set again, a hard fault has occurred.
Connect the diagnostic tool. Turn off all accessories. If the vehicle is equipped with a power take-off (PTO) system or auxiliary idle control, it must be turned off to carry out the self-test.

- Carry out the necessary vehicle preparation and a visual inspection. Refer to Section 2, Quick Test Operation.
- Refer to the diagnostic tool operating manual for instructions.
- Key on, engine off.
- Wait 4 seconds for the transmission control module (TCM), PCM, and the FICM to initialize.
- Follow the operating instructions from the diagnostic menu.
- Carry out a KOEO on-demand self-test.
- Record the DTCs and freeze frame information and refer to the appropriate pinpoint test.

Possible Causes:

The most likely PCM detectable faults that will cause a no start or hard start condition are:

- CMP sensor inactive fault.
- CKP sensor inactive fault.
- IPR output circuit check fault.
- FICM enable circuit fault.

Tools Required:

Diagnostic tool

8. Retrieve Continuous DTCs

Purpose:

The purpose of this test is to determine if the PCM has detected any historical or intermittent fault conditions that would cause a hard start/no start symptom. The condition that caused a continuous DTC may no longer exist.

Retrieve Continuous DTCs

- DTCs retrieved during this test are historical faults.

Recommended Procedure:

Connect the diagnostic tool. Turn off all accessories. If the vehicle is equipped with a power take-off (PTO) system or auxiliary idle control, it must be turned off to carry out the self-test.

- Carry out the necessary vehicle preparation and a visual inspection. Refer to Section 2, Quick Test Operation.
- Refer to the diagnostic tool operating manual for instructions.
- Key on, engine off.
- Follow operating instructions from the menu.
- Record the continuous DTCs and freeze frame information and carry out the appropriate pinpoint test for continuous DTC diagnostics.
- Continuous DTCs must be cleared after a repair.

**Tools Required:**

Diagnostic tool

**9. KOEO Injector Electrical Self-Test (Click Test)**

*Note:* If unable to carry out the KOEO Injector Electrical Self-Test (Click Test), disconnect the FICM connector and check the injector for shorts or opens.

*Note:* DTCs can be historical if not cleared from a previous test.

*Note:* When all 8 fuel injector DTCs are retrieved together or all fuel injectors within an engine bank indicate a concern GO to Pinpoint Test S.

**Purpose:**

The purpose of this test is to determine if the harness, FICM circuit, injector solenoids and valves are functioning by clicking all injectors together and then each injector in numerical sequence (1 through 8).

**KOEO Injector Electrical Self-Test (Click Test)**

*Note:* Sequence repeats three times.

- Use the diagnostic tool. Injector DTCs are displayed after the self-test is completed.
- All injectors momentarily click, then each injector clicks in sequence 1 through 8.

**Injector Trouble Codes**

**6.0L Engine, Cylinder and Fuel Injector Location**
Recommended Procedure:

This test determines if the injector circuits and solenoids are electrically operating correctly. All injectors will first click together for approximately 2 seconds, then each injector will click for approximately 1 second in numerical order (1 through 8). If a concern is present, a DTC will be present on the data link at the end of the test when requested by a diagnostic tool. Only KOEO and KOER DTCs will be displayed.

Connect the diagnostic tool. Turn off all accessories. If vehicle is equipped with a power take-off (PTO) system or auxiliary idle control, it must be turned OFF to carry out the self-test.

- Carry out the necessary vehicle preparation and a visual inspection. Refer to Section 2, Quick Test Operation.
- Refer to the diagnostic tool operating manual for instructions.
- Key ON, engine OFF.
- Follow the operating instructions from the diagnostic menu.
- Carry out the KOEO Injector Electrical Self-Test (Click Test).
- Record the DTCs and Refer to the appropriate pinpoint test to continue diagnosis.

Possible Causes:

- Open or short injector circuit
- Injector connector
- Injector solenoid
- FICM power or ground circuit
- FICM

Tools Required:

Diagnostic tool

10a. Check PCM Voltage

Note: Greater than average crank times are encountered if the battery voltage is less than 9.5 volts. If excessive crank time is a concern, verify battery voltage is greater than 9.5 volts.

Note: Battery voltage below 9.5 volts causes the diagnostic tool to reset. If the diagnostic tool resets during
a self-test or while monitoring a PID, it may be necessary to install a battery charger to maintain correct system voltage.

**Note:** You may need to use an outside power source for the diagnostic tool.

**Purpose:**

The purpose of this test is to verify the PCM power supply.

**Data List**

- The diagnostic tool may reset below 9.5 volts.
- Select the parameters indicated from the diagnostic tool parameter list and monitor.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>B+</td>
<td>11.5 volts minimum</td>
<td>Key ON, Engine OFF</td>
</tr>
<tr>
<td>B+</td>
<td>8 volts minimum</td>
<td>Engine Cranking</td>
</tr>
</tbody>
</table>

*A If a low voltage condition is present, check the battery, charging system or power and ground circuits to the PCM.

**Recommended Procedure:**

- Access and monitor the B+ PID. Verify the battery and charging system are working correctly and the battery voltage is greater than 11.5 volts. Refer to the Workshop Manual Section 414-00, Charging System for diagnosis as necessary.
- Connect the diagnostic tool.
- Key ON, engine OFF (KOEO).
- Access and monitor the B+ PID with the key ON, engine OFF, compare to the specification.
- Access and monitor the B+ PID while cranking the engine, compare to the specification.

If the B+ voltage does not meet the specification, GO to Pinpoint Test A to diagnose a voltage concern.

**Possible Causes:**

- Battery cables
- Low battery voltage
- Charging system
- Power circuit and ground concerns to the PCM
- PCM relay

**Tools Required:**

Diagnostic tool
10b. Check FICM Voltage

**NOTICE:** The 11.5 volt specification represents the minimum battery voltage required to avoid long term damage to the FICM.

**Note:** The diagnostic tool may reset if the system voltage drops below 9.5 volts. You may need to use an outside voltage source for the diagnostic tool.

**Purpose:**

The purpose of this test is to verify FICM voltage.

**Data List**

Select the parameters indicated from the diagnostic tool parameter list and monitor.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Key ON, Engine OFF</td>
<td></td>
</tr>
<tr>
<td>FICMLPWR</td>
<td>11.5 volts minimum</td>
<td></td>
</tr>
<tr>
<td>FICMVPWR</td>
<td>11.5 volts minimum</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Engine Cranking</td>
<td></td>
</tr>
<tr>
<td>FICMLPWR</td>
<td>8 volts minimum</td>
<td></td>
</tr>
<tr>
<td>FICMVPWR*B</td>
<td>8 volts minimum</td>
<td></td>
</tr>
</tbody>
</table>

*B No or low voltage indicated is caused by a 12-way connector issues.

**Recommended Procedure:**

- Access and monitor the B+ PID. Verify the battery and charging system are working correctly and the battery voltage is greater than 11.5 volts. Refer to the Workshop Manual Section 414-00, Charging System for diagnosis as necessary.
- Connect the diagnostic tool.
- Key ON, engine OFF.
- Access and monitor the FICMLPWR and FICMVPWR PIDS with the key ON, engine OFF. Compare to the specification.
- Access and monitor the FICMLPWR and FICMVPWR PIDS while cranking the engine. Compare to the specification.

If FICMLPWR does not meet the specification, GO to Pinpoint Test S for diagnosis.

If FICMVPWR does not meet the specification, GO to Pinpoint Test AS for diagnosis.

If FICMLPWR and FICMVPWR meet the specification, voltage supply to the FICM has been confirmed. Proceed to the next step. Check FICM M Voltage to ensure the FICM is capable to supply sufficient voltage to the injectors.

**Possible Causes:**
- Low or no battery voltage to the FICM
- High resistance or an open FICM voltage circuit
- FICM power relay
- Battery cables
- Low battery voltage
- Charging system

**Tools Required:**
Diagnostic tool

**10c. Check FICM M Voltage to Actuate Injectors**

**Note:** The diagnostic tool may reset if the system voltage drops below 9.5 volts. You may need to use an outside voltage source for the diagnostic tool.

**Note:** Ignore any DTCs set during this diagnostic.

**Purpose:**
The purpose of this test is to verify FICM supplies sufficient voltage to actuate the injectors.

**Data List**
Select the parameters indicated from the diagnostic tool parameter list and monitor.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>FICMMPWR</td>
<td>45 volts minimum with the engine oil temperature less than 0°C (32°F)³</td>
<td></td>
</tr>
</tbody>
</table>

³ If the engine oil temperature is higher, use Instrument Gauge System Tester 014-R1063 or equivalent to simulate a cold engine.

**Recommended Procedure:**

- Access and monitor the B+ PID. Verify the battery and charging system are working correctly and the battery voltage is greater than 11.5 volts. Refer to the Workshop Manual Section 414-00, Charging System for diagnosis as necessary.
- Verify the voltage supplied to the FICM meets specification. Refer to Check FICM Voltage in this section.
- Disconnect the Glow Plug Control Module (GPCM) VPWR circuit to isolate the GPCM and alternator from the FICM and provide more consistent FICM testing.
- Disconnect the fuel heater relay if equipped.
- Connect the diagnostic tool.
- Key ON, engine OFF.
- Using the diagnostic tool, verify the engine oil temperature is less than 0°C (32°F). If engine oil temperature is greater than the specification:
  - Key OFF
  - Disconnect the engine oil temperature (EOT) sensor
Set the Instrument Gauge System Tester 014-R1063 or equivalent to 100,000 ohms resistance.
Verify the resistance with a Rotunda 73III Automotive Meter 105-R0057 or equivalent. Input impedance 10 megaohm minimum.
Connect the Instrument Gauge System Tester 014-R1063 or equivalent between the EOT signal and SIGRTN circuits at the harness side of the EOT connector.
Key ON, engine OFF
Verify EOT PID is less than 0°C (32°F) and proceed.

- Access the PCM and monitor the FICM_MPWR PID.
- Record the FICM_MPWR PID value.
- Verify the voltage is greater than 45 volts during the entire duration of the last 10 seconds of the fuel injectors clicking.

If FICMMPWR does not meet the specification, GO to Pinpoint Test S for diagnosis.

**Possible Causes:**

- Low or no battery voltage to the FICM
- High resistance or an open FICM voltage circuit
- FICM power relay
- FICM

**Tools Required:**

Diagnostic tool
Instrument Gauge System Tester 014-R1063 or equivalent
Rotunda 73III Automotive Meter 105-R0057 or equivalent. Input impedance 10 megaohm minimum

**10d. Check The RPM Signal While Cranking**

**Note:** The diagnostic tool may reset if the system voltage drops below 9.5 volts. You may need to use an outside voltage source for the diagnostic tool.

**Note:** No FICM synchronization while cranking the engine with correct ICP, RPM and VPWR signals usually indicates a loss of the CMP or CKP synchronization signal. Refer to the appropriate pinpoint test for diagnosis. Refer to Section 6, Control System Diagnostic Sheet Reference for normal operating values.

**Purpose:**

This purpose of this test is to verify the CKP sensor, the CMP sensor, and related circuits are functioning.

**Data List**

Select the parameters indicated from the diagnostic tool parameter list and monitor while cranking the engine.
Low RPM may indicate a concern with the starting system or the charging system. No RPM while cranking may indicate a concern with the CKP sensor system.

**Recommended Procedure:**

- Connect the diagnostic tool.
- Key ON, engine OFF.
- Monitor the RPM while cranking the engine.

**Possible Causes:**

- Low battery voltage
- High resistance in the starting system
- Charging system
- CKP sensor
- CMP sensor

**Tools Required:**

Diagnostic Tool

**10e. Monitor the ICP and IPR Duty Cycle While Cranking**

**Note:** If the IPR screen is damaged or debris is present, clean or install a new screen as necessary and retest the system. Do not install a new high pressure oil pump due to debris being present on the screen.

**Note:** A complaint of engine stalls when warm followed by a crank no start indicates a high pressure oil system concern. This may be accompanied by DTC P2290 with or without DTC P2291. Follow this procedure to isolate the cause of the concern.

**Note:** Higher oil temperatures are more effective to diagnose high pressure oil system leaks.

**Purpose:**

The purpose of this test is to determine if the injection control pressure (ICP) system can supply sufficient injection control pressure to sustain starting and to determine if oil leaks are present in the high pressure oil system.

**Data List**

- The diagnostic tool may reset below 9.5 volts.
- Select the parameters indicated from the diagnostic tool parameter list and monitor while cranking the engine.
A minimum of 3.5 MPa (500 psi) is required before the injectors are enabled. No or low oil in the system, system leakage, injector O-rings, damaged IPR or high pressure pump could cause low pressure. **IPR duty cycle defaults to 14% [2.1 MPa (300 psi)] without a CKP signal.**  

Voltage reading below specification indicates low ICP during crank.

### Recommended Procedure:

- Connect the diagnostic tool.
- Ignition ON, engine OFF.
- Access and monitor the ICP, ICP_V, IPR, EOT and RPM PIDS.
- If the ICP voltage is not between 0.15 and 0.35 volts with the ignition ON, engine OFF, GO to Pinpoint Test Q.
- If the engine does not start, disconnect the ICP sensor connector and attempt to start the engine. If the engine starts with the ICP sensor disconnected, GO to Pinpoint Test Q.
- If the engine does not start with the ICP sensor disconnected, carry out the High Pressure Oil System Air Pressure Check in this section.
- If the engine starts, warm the engine up until the EOT temperature is greater than 80°C (176°F), then turn the ignition to the OFF position.
- If the ICP sensor connector is disconnected, connect the ICP sensor connector.
- Crank the engine and attempt to restart.
- Compare the PID data to the specification and the graphs during engine start-up.

**Note:** A CKP signal is required before the IPR is commanded above 14%.

If the ICP does not meet the minimum specification of 3.5 MPa (500 psi), the injectors are not enabled by the PCM because of insufficient rail pressure.

If the IPR duty cycle is greater than the specification at warm idle, a leak in the high pressure oil system is suspect. Carry out the High Pressure Oil System Air Pressure Check in this section.

If the IPR duty cycle is greater than 14%, ICP pressure should increase above 3.5 MPa (500 psi) provided that the IPR valve is not stuck open, the high pressure pump is building pressure and there is not an injection control pressure system leak between the high pressure pump and the injectors.

Not all high injection control pressure oil system issues result in a no start condition. Intermittent hard start or slow start conditions may be the result of a small leak in the injection control pressure system.

If the oil is leaking from the ICP system or if air is trapped in the ICP system, the IPR valve may be commanded fully closed (85% duty cycle) while the starter is engaged in an attempt to exceed 3.5 MPa (500 psi). Monitoring RPM, IPR duty cycle, and ICP while cranking the engine, after 5 minute soak, may assist in ICP system diagnosis. ICP system leaks results in no start, hard start, slow start or intermittent hard start conditions. The symptoms caused by small leaks are present only with excessive ICP after engine start and are more prevalent on warm engines when the oil viscosity is lower.

**Good Start Expected Response**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICP&lt;sup&gt;E&lt;/sup&gt;</td>
<td>3.5 MPa (500 psi) Minimum (Engine Cranking)</td>
<td></td>
</tr>
<tr>
<td>ICP_&lt;sub&gt;V&lt;/sub&gt;&lt;sup&gt;F&lt;/sup&gt;</td>
<td>0.80 Volts Minimum (Engine Cranking)</td>
<td></td>
</tr>
<tr>
<td>IPR</td>
<td>30% Maximum@670 RPM during Engine Idle with EOT greater than 80°C (176°F)</td>
<td></td>
</tr>
</tbody>
</table>
A sharp increase in IPR duty cycle followed by a steep rise in ICP pressure is expected. If the ICP and IPR response resemble the Good Start Expected Response as shown, carry out the Injection Pressure Regulator Test in this section.

**Hard Start, Stall, No Start Engine Hot, Entrapped Air or Oil Leak Expected Response**
If the ICP and IPR response resemble the Hard Start, Stall, No Start Engine Hot, Entrapped Air or Oil Leak Expected Response as shown, carry out the High Pressure Oil System Air Pressure Check in this section.

No Start or Oil Leak Expected Response

<table>
<thead>
<tr>
<th>Item</th>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>—</td>
<td>ICP Pressure</td>
</tr>
<tr>
<td>2</td>
<td>—</td>
<td>ICP Voltage</td>
</tr>
<tr>
<td>3</td>
<td>—</td>
<td>IPR Duty Cycle</td>
</tr>
<tr>
<td>4</td>
<td>—</td>
<td>Engine RPM</td>
</tr>
</tbody>
</table>
If the ICP and IPR response resemble the No Start or Oil Leak Expected Response as shown, carry out the High Pressure Oil System Air Pressure Check in this section.

**Possible Causes:**

- Low base engine oil pressure or level
- ICP system leak
- High pressure oil branch tube adapter leak
- Damaged discharge tube
- Damaged high pressure oil branch tube
- Leaking high pressure tube assembly male or female fitting
- Damaged stand-pipe or oil supply tube
- Damaged or missing stand-pipe O-ring
- Damaged or missing oil supply tube O-ring
- Damaged high pressure oil rail plug
- Damaged or missing high pressure oil rail plug O-ring
- Damaged or missing O-ring between discharge tube and high pressure pump
- Damaged or missing discharge tube O-ring that fits inside high pressure pump cover
- Damaged or missing high pressure pump inlet O-ring
- Damaged or missing O-ring between high pressure oil rail and the injector
- IPR failure
- Damaged high pressure pump

**Possible Leak Locations**

**High Pressure Oil System**

<table>
<thead>
<tr>
<th>Item</th>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>—</td>
<td>ICP Sensor</td>
</tr>
<tr>
<td>2</td>
<td>—</td>
<td>High Pressure Oil Rail Plug</td>
</tr>
<tr>
<td>3</td>
<td>—</td>
<td>High Pressure Oil Branch Tube Adapter</td>
</tr>
<tr>
<td>4</td>
<td>—</td>
<td>High Pressure Oil Branch Tube</td>
</tr>
<tr>
<td>5</td>
<td>—</td>
<td>High Pressure Stand Pipe</td>
</tr>
<tr>
<td>6</td>
<td>—</td>
<td>High Pressure Oil Rail</td>
</tr>
<tr>
<td>7</td>
<td>—</td>
<td>IPR Valve</td>
</tr>
<tr>
<td>8</td>
<td>—</td>
<td>High Pressure Pump</td>
</tr>
<tr>
<td>9</td>
<td>—</td>
<td>High Pressure Pump Cover</td>
</tr>
<tr>
<td>10</td>
<td>—</td>
<td>Injector</td>
</tr>
</tbody>
</table>
10f. High Pressure Oil System Air Pressure Check

**Note:** An air leak on the high pressure oil pump shaft lip seal is normal while carrying out this procedure. This is not an indication of a high pressure oil leak and the high pressure oil pump should not be replaced for this condition. If the pump is suspect, carry out the High Pressure Oil Pump Test to verify the pump generates sufficient pressure to start the engine.

**Note:** The replacement parts may leak if all the surfaces are not oil saturated under system pressure and the seals are not correctly seated during installation.

**Note:** Never replace the high pressure oil pump until all high pressure oil system leaks have been repaired and the high pressure oil system is retested.

**Note:** A complaint of engine stalls followed by a crank no start while the engine is warm indicates a leak in the high pressure oil system. This may or may not be accompanied by DTCs P2290 or P2291. Follow this procedure to isolate the leak.

**Note:** If an intermittent no start condition or delayed ICP pressure rise during restart after a 15-minute soak exists, a small leak is suspect. Refer to the Hard Start illustration of the previous test. Remove the valve covers to inspect for leaks.

**Note:** Higher oil temperatures are more effective for diagnosis of high pressure oil system leaks.

### Purpose:

The purpose of this test is to verify IPR valve operation and to isolate leaks in the high pressure oil system.

### Recommended Procedure:

- Verify the base engine oil pressure. Refer to the Workshop Manual Section 303-01C, Engine, Inspection and Verification.
- If the engine will start, warm the engine until the EOT is greater than 80 °C (176 °F).
- For E-series vehicles, install the Adapter, High Pressure Pump Test 303-765 or equivalent by removing the test port plug on the top of the high pressure oil pump. For F-Super Duty vehicles, install the Adapter, High Pressure Pump Test 303-765 or equivalent by removing the ICP sensor.
- **Note:** It is easier to find small leaks with higher pressure.
- Pressurize the high pressure oil system up to 1379 kPa (200 psi) using a suitable tool.
- Key ON, engine OFF.
- Using the diagnostic tool, open the IPR valve by decreasing the IPR duty cycle to 0%.
- Allow oil to drain through the IPR valve for two (2) minutes. An air leak should be heard.
- Using the diagnostic tool, close the IPR valve by increasing the IPR duty cycle to 85%.
- Listen for an air noise change.
- Use a stethoscope through the oil fill tube or left valve cover crankcase vent hole to isolate the location of the air noise change.
- Cycle the IPR valve open (IPR duty cycle 0%) and closed (IPR duty cycle 85%) as needed to help isolate the location of the air noise. An air noise at the base of the high pressure oil pump with the IPR duty cycle at 0% is normal.
- If no air noise change is heard, the IPR valve may not be functioning as commanded. GO to Pinpoint Test R to diagnose IPR circuit DTCs. If no DTCs are present and the engine will start, carry out the Injection Pressure Regulator Test in this section to verify IPR function. If the engine will not start, install a new IPR valve and repeat the air pressure check. Refer to the Workshop Manual Section

- If no air noise change is heard and the IPR valve has already been replaced, carry out the High Pressure Oil Pump Test in this section.
- If an air noise change is heard under a valve cover, remove the cover(s) to isolate the location of the leak. Refer to the Workshop Manual Section 303-01C, Engine, Valve Cover. Listen for leaks around the fuel injector O-Rings, stand pipes, and oil rail plugs.
- If an air noise change is heard at the back of the engine, a leak at the high pressure oil branch tube adapter or the high pressure oil branch tube is suspect. Refer to the Workshop Manual Section 303-04C, Fuel Charging and Controls, High Pressure Oil Branch Tube Adapter and High Pressure Oil Branch Tube.
- After completing all repairs, verify the high pressure oil system integrity by re-pressurizing the system and listening again for any remaining leaks while cycling the IPR valve duty cycle. Repeat the Monitor the ICP and IPR Duty Cycle While Cranking test to verify the repair.

Possible Causes:

- Low base engine oil pressure or level
- ICP system leak
- High pressure oil branch tube adapter leak
- Damaged discharge tube
- Damaged high pressure oil branch tube
- Leaking high pressure tube assembly male and female fitting
- Damaged stand-pipe or oil supply tube
- Damaged or missing stand-pipe O-ring
- Damaged or missing oil supply tube O-ring
- Damaged high pressure oil rail plug
- Damaged or missing high pressure oil rail plug O-ring
- Damaged or missing O-ring between discharge tube and high pressure pump
- Damaged or missing discharge tube O-ring that fits inside high pressure pump cover
- Damaged or missing high pressure pump inlet O-ring
- Damaged or missing O-ring between high pressure oil rail and the injector
- IPR failure
- Damaged high pressure pump

Possible Leak Locations

High Pressure Oil System
Tools Required:

- Diagnostic tool
- Stethoscope
- Adapter, High Pressure Pump Test 303-765 or equivalent

10g. High Pressure Oil Pump Test

**Note:** Never replace the high pressure oil pump due to debris on the IPR valve screen. Remove the debris
and retest the system.

**Note:** Higher oil temperatures are more effective for diagnosis of high pressure oil system leaks.

**Note:** To maintain command of the IPR valve while cranking the engine, it is necessary to disconnect the crankshaft position (CKP) sensor.

**Note:** Make sure the battery voltage is greater than 12.5 volts at all times throughout this procedure. High pressure oil pumps will not pass the high pressure oil pump tests if the battery voltage drops below 12.5 volts during the procedure. The high pressure oil pump is dependent on cranking speed to generate sufficient injection control pressure. If the battery voltage drops below 12.5 volts, the battery may need to be charged or there may be a charging system concern, refer to the Workshop Manual Section 414-00, Charging System, Symptom Chart to continue diagnosis.

**Purpose:**

The purpose of this test is to isolate the high pressure oil branch tube and the high pressure oil pump from the rest of the high pressure oil system, and to verify pump function.

**Data List**

- The diagnostic tool may reset below 9.5 volts.
- Select the parameters indicated from the diagnostic tool parameter list and monitor while cranking the engine.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>B+</td>
<td>11.5 volts</td>
<td></td>
</tr>
<tr>
<td>IPR</td>
<td>Greater than 60%</td>
<td></td>
</tr>
<tr>
<td>ICP(^G)</td>
<td>10.5 MPa (1500 psi) minimum</td>
<td></td>
</tr>
</tbody>
</table>

\(^G\) After the ICP signal has stabilized and is not changing.

No or low oil in the system, system leakage, damaged IPR or high pressure pump could cause low pressure.

**Recommended Procedure:**

- Remove the left and right hand valve covers. Refer to the Workshop Manual Section 303-01C, Engine, Valve Cover.
- Remove both upper crankcase to head tubes (stand pipes).
- Remove the ICP sensor.
- Install the ICP sensor into the Adapter, ICP Test 303-1163/1 and into the rear of the right high pressure oil rail where the upper stand pipe was removed.
- Install the Adapter, ICP Test 303-1163/2 into the rear of the left high pressure oil rail where the upper stand pipe was removed.
- Install the Adapter Cable, ICP/EBC 418-D003 (D94T-50-A) or equivalent to the existing ICP sensor connector.
- Remove the FICM relay.
- Disconnect the crankshaft position (CKP) sensor.
- Connect the diagnostic tool.
• Access and monitor the ICP, ICP_V, IPR, and B+ PIDS.
• Using the scan tool, command the IPR duty cycle above 60%.
• Crank the engine until the ICP PIDs are stable and not changing.
• Compare to the specification.

If the minimum ICP specification is achieved, a leak in the high pressure oil system is suspect. Remove both oil rail plugs and head tubes (stand pipe front plugs and both stand pipes) from the oil rails, as equipped, and inspect the seals as a possible leak source. Replace the damaged components as necessary. Refer to the Workshop Manual Section 303-01C, Engine. Carry out the High Pressure Oil System Air Pressure Test in this section to verify the repair.

If the minimum ICP specification is not achieved, a leaking high pressure oil branch tube, high pressure oil branch tube adapter, or damaged high pressure oil pump is suspect. Remove the pump cover and inspect for leaks. Repair any leaks and repeat the test or replace the pump if no leaks are present. Refer to the Workshop Manual Section 303-04C, Fuel Charging and Controls, Oil Pump.

If the high pressure oil branch tube adapter is leaking, replace the fitting, reinstall the pump, and verify that the pump pressure meets the specification.

Possible Causes:

• High pressure oil branch tube
• High pressure oil branch tube adapter
• High pressure oil pump

Tools Required:

• Diagnostic tool
• Adapter, ICP Test 303-1163 or equivalent
• Adapter Cable, ICP/EBC 418-D003 (D94T-50-A) or equivalent

10h. Check Fuel Pulse Width While Cranking

Purpose:

The purpose of this test is to verify the fuel delivery signal is correct.

Data List

• The diagnostic tool may reset below 9.5 volts.
• Select the parameters indicated from the diagnostic tool parameter list and monitor while cranking the engine.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>FUEL PW(^H)</td>
<td>5 μS to 2 mS</td>
<td>(0)</td>
</tr>
</tbody>
</table>

\(^H\) Pulse width defaults to \(0\) with no CMP or CKP signal.

Recommended Procedure:
Connect the diagnostic tool.
Key ON, engine OFF.
Access and monitor the FUEL PW PID while cranking the engine.

No fuel command signal when the ICP, RPM and VPWR signals are correct usually indicates a loss of the CMP signal. GO to Pinpoint Test V.

A 5 μs to 2 ms fuel pulse width (FUEL PW) is sent to the FICM if the system voltage is greater than 8 volts during cranking, engine cranking speed is above 100 RPM, injection control pressure is above 3.5 MPa (500 psi) and is in sync. Note that low fuel pressure or no glow plug operation could still be the cause of the no start or hard start condition. A FUEL PW PID of 0 ms (a no fueling pulse) is sent by the PCM when a sync pulse has not been received from the CMP sensor and if insufficient injection control pressure is present.

**Possible Causes:**

- PCM
- FICM
- CKP signal
- CMP signal

**Tools Required:**

Diagnostic tool

**10i. Check FICM Synchronization While Cranking**

**Purpose:**

The purpose of this test is to verify the PCM and FICM synchronization.

**Data List:**

- The diagnostic tool may reset below 9.5 volts.
- Select the parameters indicated from the diagnostic tool parameter list and monitor while cranking the engine.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>FICMSYNCΩ</td>
<td>YES/NO</td>
<td></td>
</tr>
</tbody>
</table>

Ω No synchronization could be caused by a CMP or CKP fault.

**Recommended Procedure:**

- Connect the diagnostic tool.
- Key ON, engine OFF.
- Access and monitor the FICMSYNC PID while cranking the engine.

No FICM synchronization while cranking the engine with the ICP, RPM and VPWR signals correct usually
indicates a loss of the CMP or CKP synchronization signal. Refer to the appropriate pinpoint test for diagnosis. Refer to Section 6, Typical Diagnostic Reference Values for normal operating values.

Possible Causes:

- PCM
- FICM
- CKP synchronization signal
- CMP synchronization signal

Tools Required:

Diagnostic tool

11. Glow Plug System Operation

Note: Glow plug on time is dependent on oil temperature and altitude. The GPCM commands the glow plugs on for 1 to 120 seconds. The GPCM does not operate if the oil temperature is above 55°C (131°F).

Purpose:

The purpose of this test is to verify the glow plug system operation.

Glow Plug Control Module (GPCM) Operation

- Connect the diagnostic tool.
- Retrieve the KOEO and continuous DTCs. If GPCM DTCs are present, GO to Pinpoint Test AF.
- Verify battery voltage is supplied to the GPCM.
- Note: The wait to start indicator on time (1-10 seconds) is independent from glow plug on time.

- Monitor the GPCTM and EOT PIDs to verify sufficient glow plug ON time.
- Key ON, measure the glow plug voltage ON time.

<table>
<thead>
<tr>
<th>On Time</th>
<th>Specification</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 120 seconds</td>
<td>Battery voltage</td>
<td></td>
</tr>
</tbody>
</table>

Glow Plug Resistance

Note: Check for incorrect connections or loose fitting pins.

Note: Incorrect measurements result if all glow plug connectors are not disconnected.

- Disconnect the glow plug bus bar connector.
- Measure the resistance between the glow plug bus bar connector, component side and battery ground.
- Disconnect the GPCM.
- Measure the resistance between the GPCM connector, harness side and the glow plug bus bar connector, harness side.

<table>
<thead>
<tr>
<th>Glow Plug Number</th>
<th>Glow Plug to Ground (0.1 to 2 ohms)</th>
<th>Glow Plug Connector to GPCM Connector (less than 5 ohms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Recommended Procedure:**

The glow plug monitor self-test is a KOER functional test of the glow plug system. The self-test is carried out on-demand with the engine running and the A/C off. The PCM will activate the GPCM which monitors the glow plugs. The accelerator pedal may be used to increase the engine speed to increase voltage if needed. For fault detection, the self-test requires a concern present at the time of testing.
Possible Causes:

- GPCM power circuits
- Glow plugs
- Glow plug bus bar
- GPCM Circuitry

Tools Required:

- Rotunda 73III Automotive Meter 105-R0057 or equivalent. Input impedance 10 megaohm minimum.
- Diagnostic tool

12a. Combustion Gas In The Fuel Rail Test — Bubble Test

**Note:** Bubbles in the secondary fuel filter bowl indicate combustion gas is leaking into the fuel rail. Combustion gases displace fuel in the fuel rail leading to incomplete injector filling on one or more cylinders. This typically occurs on cylinders adjacent to the leak source on the same fuel rail bank and also appears as low contributing cylinders in the Power Balance Test. Depending on the severity of the leak and the length of time the vehicle has been operated, injectors adjacent to the leaking injector or the full bank of new injectors may need to be installed.

**Note:** The bubble test is used as a screening test prior to carrying out the balloon test. Depending on the leak rate, bubbles in the secondary fuel filter bowl may be present even with all glow plugs removed.

**Note:** Intermittent combustion gas leaks may be present as an intermittent drivability concern. Operating the engine over a range of temperatures and load conditions can assist with diagnosis.

**Purpose:**
The purpose of this test is to check if any combustion gas is leaking into the fuel rail.

**Recommended Procedure:**

- Remove the secondary fuel filter cover and the fuel filter.
- Cycle the key momentarily to raise the fuel level in the bowl and submerge the fuel inlet stand pipe.
- Disconnect the fuel injection control module (FICM) relay.
- While cranking the engine, observe if bubbles are present in the secondary fuel bowl. Bubbles indicate combustion gas is leaking into the fuel rail.

If bubbles are present, carry out the Combustion Gas In The Fuel Rail Test — Balloon Test to isolate the suspect injector.

If bubbles are not present, reassemble the fuel system.

**Possible Causes:**

- Low fuel pressure
- Fuel injector
- Fuel injector lower O-ring
- Fuel injector copper gasket

**12b. Combustion Gas In The Fuel Rail Test — Balloon Test**

**Purpose:**

The purpose of this test is to check if any combustion gas leaks past the injector's needle and seat or past the copper combustion gasket.

<table>
<thead>
<tr>
<th>Bank 1</th>
<th>Bank 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder 1 (YES/NO)</td>
<td>Cylinder 2 (YES/NO)</td>
</tr>
<tr>
<td>Cylinder 3 (YES/NO)</td>
<td>Cylinder 4 (YES/NO)</td>
</tr>
<tr>
<td>Cylinder 5 (YES/NO)</td>
<td>Cylinder 6 (YES/NO)</td>
</tr>
<tr>
<td>Cylinder 7 (YES/NO)</td>
<td>Cylinder 8 (YES/NO)</td>
</tr>
</tbody>
</table>

Carry out the Combustion Gas In The Fuel Rail Test to verify the repair.

When the repair is verified, carry out the Fuel System Delivery test in this section.

**Recommended Procedure:**

**Note:** The bubble test is used as a screening test prior to carrying out the balloon test. Depending on the leak rate, bubbles in the secondary fuel filter bowl can be present even with all glow plugs removed.

**Note:** If injectors have been removed or the high pressure oil system repaired, it may be necessary to
operate the vehicle and carry out at least 12 short high demand acceleration cycles to purge air from the oil system.

- If the bubble test indicated that combustion gas is leaking into the fuel system, disconnect both fuel lines from the secondary fuel filter.
- Install a latex balloon over each fuel line and secure with a tie strap.
- Disconnect the fuel injection control module (FICM) relay.
- Crank the engine and observe the latex balloons for compression pulses. Identify which bank is a cause of the concern.
- To isolate multiple combustion gas leaks, remove all but 1 glow plug from the bank that leaks the combustion gas in the rail. Crank the engine and observe the latex balloon for compression pulses. Repeat to isolate the leak.
- For cylinders that leak combustion gas into the fuel rail, remove the injector and inspect the lower O-ring and copper gasket for an even circular crush pattern.

If a combustion gas leak is verified, install new injectors as necessary.

If an even circular crush pattern is visible on the copper gasket, install a new injector. Refer to the Workshop Manual Section 303-04, Fuel Charging and Controls. Carry out the Combustion Gas In The Fuel Rail Test to verify the repair. When the repair is verified, carry out the Fuel System Delivery test in this section.

If the copper gasket is missing and burnt away, the lower O-ring is damaged or the injector is loose, install a new fuel injector and fuel injector hold down assembly. The most likely cause of a burnt or missing copper gasket is incorrect torque of the hold down assembly. Refer to the Workshop Manual Section 303-04, Fuel Charging and Controls. Carry out the Combustion Gas In The Fuel Rail Test to verify the repair. When the repair is verified, carry out the Fuel System Delivery test in this section.

**Possible Causes:**

- Fuel injector
- Fuel injector lower O-ring
- Fuel injector copper gasket

**Tools Required:**

- latex balloons
- tie straps