ENGINE

Engine Heating and Cooling - Escalade, Suburban, Tahoe, Yukon

SPECIFICATIONS

FASTENER SPECIFICATIONS

Application	Specification	
	Metric	English
Coolant Heater (L83, L86)	50 N.m	37 lb ft
Engine Coolant Air Bleed Pipe Bolt (L96)	12 N.m	106 lb in
Engine Coolant Fan Rear Fan Shroud Bolt (L83, L86)	7 N.m	62 lb in
Engine Coolant Manifold Fastener (L83, L86)	25 N.m	18 lb ft
Engine Coolant Thermostat Housing Bolt (L96)	15 N.m	11 lb ft
Surge Tank Bolt (L83, L86)	10 N.m	89 lb in
Surge Tank Nut (L83, L86)	10 N.m	89 lb in
Thermostat Housing Bolt (L83, L86)	10 N.m	89 lb in
Water Pump Fastener (L83, L86)	10 N.m	89 lb in
Water Pump Fastener (L96)	Â	Â
• First Pass	15 N.m	11 lb ft
• Second Pass	30 N.m	22 lb ft

APPROXIMATE FLUID CAPACITIES

Application	Specification	
	Metric	US English
Cooling System		
5.3L (L83)	15.73 L	16.62 qt
6.2L (L86)	15.73 L	16.62 qt

ADHESIVES, FLUIDS, LUBRICANTS, AND SEALERS

Application	Type of Material	GM Part Number	
		United States	Canada
Extended Life Coolant Leak Detection Dye	Dye	89022219	89022220
DEX-COOLÂ®	Coolant	12346290	10953464

SCHEMATIC WIRING DIAGRAMS

ENGINE HEATING/COOLING WIRING SCHEMATICS

Engine Cooling Fans

Fig. 1: Engine Cooling Fans
Courtesy of GENERAL MOTORS COMPANY

DIAGNOSTIC INFORMATION AND PROCEDURES

DTC P0480, P0691, OR P0692: COOLING FAN SPEED

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- **Diagnostic Procedure Instructions** provides an overview of each diagnostic category.

DTC Descriptors

DTC P0480

Cooling Fan Speed Output Circuit

DTC P0691

Cooling Fan Speed Output Circuit Low Voltage

DTC P0692

Cooling Fan Speed Output Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
G10L Cooling Fan Motor - Left Ignition Voltage	1	2	-	-
G10L Cooling Fan Motor - Left Ground	-	-	-	-
G10L Cooling Fan Motor - Left Control	P0691 or 2	P0480 or 2	P0692 or 2	-
G10R Cooling Fan Motor - Right Ignition Voltage	3	4	-	-

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
G10R Cooling Fan Motor - Right Ground	-	-	-	-
G10R Cooling Fan Motor - Right Control	P0691 or 4	P0480 or 4	P0692 or 4	Â

1. Opens left cooling fan fuse without a DTC.
2. Left fan inoperative without a DTC.
3. Opens right cooling fan fuse without a DTC.
4. Right cooling fan inoperative without a DTC.

Circuit/System Description

The engine control module (ECM) commands the speed of the cooling fans based on cooling requirements. The ECM controls the cooling fan speed by commanding the cooling control module. The cooling fan control module supplies separate power and ground circuits for each cooling fan. The ECM sends a pulse width modulated (PWM) signal to the cooling fan control module. The cooling fan control module interprets the signal and operates the cooling fans at the commanded speeds.

Conditions for Running the DTC

- The ignition voltage is 11 volts or greater.
- The engine speed is 400 RPM or greater.
- The ECM driver transitions from ON to OFF or from OFF to ON.
- DTCs P0480, P0691, and P0692 run continuously once the above conditions are met.

Conditions for Setting the DTC

The ECM detects that the commanded state of the driver and the actual state of the control circuit do not match for greater than 5 seconds.

Action Taken When the DTC Sets

- DTCs P0480, P0691, and P0692 are Type B DTCs.

Conditions for Clearing the MIL/DTC

- DTCs P0480, P0691, and P0692 are Type B DTCs.

Diagnostic Aids

- A delay or ramp up of approximately 12 seconds may occur before the cooling fan activates or changes speed when being commanded with a scan tool.

Reference Information

Schematic Reference

Engine Heating/Cooling Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Cooling Fan Description and Operation

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

K20 Engine Control Module: Scan Tool Information for scan tool information

Circuit/System Verification

NOTE: **There is a slight delay before the cooling fans activate.**

1. Engine operating, command the Cooling Fans from 0 % to 90 % with a scan tool.
2. Verify the G10 Cooling Fan Motors activates in each available speed.
   - **The cooling fan does not activate or increase in speed as commanded**

     Refer to Circuit/System Testing

   - **The cooling fan activates and increases in speed as commanded**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing

   - **If the DTC does not set**
5. All OK.

Circuit/System Testing

NOTE: **Both cooling fan motors must be disconnected or incorrect diagnosis may result.**

1. Ignition OFF, disconnect the following G10 Cooling Fan Motors.
   - G10L Cooling Fan Motor Left.
   - G10R Cooling Fan Motor Right.
2. Ignition ON, verify that a test lamp illuminates between the following terminals and ground.
   - G10L Cooling Fan Motor Left - terminal 2
   - G10R Cooling Fan Motor Right - terminal 2
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition OFF, remove the test lamp and turn all vehicle systems OFF. It may take up to 2 minutes for all vehicle systems to power down.
   2. Test for less than 2 Ω in the appropriate B+ circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**

1. Ignition OFF, remove the test lamp and turn all vehicle systems OFF. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for infinite resistance between the terminals listed below and ground.
    - G10L Cooling Fan Motor Left - terminal 2.
    - G10R Cooling Fan Motor Right - terminal 2
    - If less than infinite resistance, repair the short to ground in the circuit.
    - If infinite resistance, replace the appropriate G10 Cooling Fan Motor.
- **If the test lamp illuminates**

NOTE: **The cooling fan speed output circuit is pulled-up to a voltage within the ECM, 3-4 volts on the output circuit is normal.**

3. Ignition OFF, disconnect the following G10 Cooling Fan Motors.
    - G10L Cooling Fan Motor Left
    - G10R Cooling Fan Motor Right
4. Connect a DMM, set on the diode setting, between the following terminals and ground.
    - G10L Cooling Fan Motor Left - terminal 4
    - G10R Cooling Fan Motor Right - terminal 4
5. Ignition ON, verify the DMM reading is greater than 2.5 V or displays O.L. with the cooling fan commanded OFF.
    - **If 2.5 V or less**
    1. Ignition OFF, all vehicle systems OFF. It may take up to 2 minutes for all vehicle systems to power down.
    2. Disconnect the K20 Engine Control Module harness connector X1.
    3. Test for infinite resistance between the appropriate G10 Cooling Fan Motor control circuit terminal 4 and ground.
        - If less than infinite resistance, repair the short to ground in the circuit.
        - If infinite resistance, replace the K20 Engine Control Module.
    - **If greater than 2.5 V or displays O.L.**
6. Command the Cooling Fan ON to 90 % with a scan tool.
7. Verify the DMM reading is less than 1 V.
    - **If 1 V or greater**
    1. Ignition OFF, disconnect harness connector X1 at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the appropriate G10 Cooling Fan Motor control circuit terminal 4 and ground.

- If 1 V or greater, repair the short to voltage on the circuit.
- If less than 1 V.

3. Ignition OFF, and all vehicle systems OFF, it may take up to 2 minutes for all vehicle systems to power down.
4. Test for less than 2 Ω in the G10 Cooling Fan Motor control circuit terminal 4, end to end.
    - If 2 Ω or greater, repair the open/high resistance in the control circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If less than 1 V**

8. Test or replace the appropriate G10 Cooling Fan Motor.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the diagnostic procedure.

- **Fan Blade Replacement (L83 L86)** for G10 Cooling Fan Motor Replacement.
- **Control Module References** for ECM replacement, setup, and programming

DTC P1258: ENGINE COOLANT OVER TEMPERATURE - PROTECTION MODE ACTIVE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- **Diagnostic Procedure Instructions** provides an overview of each diagnostic category.

DTC Descriptor

DTC P1258

Engine Coolant Over temperature - Protection Mode Active

Circuit/System Description

The engine control module (ECM) uses the engine coolant temperature (ECT) sensor to monitor the engine for an over-temperature condition. This condition occurs when the coolant temperature is above a calibrated value for a calibrated length of time. The ECM will disable half of the cylinders by turning OFF the fuel injectors. By disabling half of cylinders, the ECM is able to reduce the temperature of the coolant.

Conditions for Running the DTC

The engine is operating.

Conditions for Setting the DTC

All V8

The coolant temperature is warmer than 129Â°C (264Â°F) for greater than 10 seconds.

Action Taken When the DTC Sets

- DTC P1258 is a Type A DTC.
- The engine will operate in the Overheated Engine Protection Operating Mode.
- The engine coolant temperature indicator lamp, if equipped, will illuminate.
- The driver information center (DIC), if equipped, may display a message.
- If the protection mode is active and an ECT sensor DTC sets, the protection mode will activate during the next drive cycle until the ECT sensor DTC runs and passes.

Conditions for Clearing the DTC

DTC P1258 is a Type A DTC.

Reference Information

Description and Operation

- **Cooling System Description and Operation**
- **Instrument Cluster Description and Operation**
- **Indicator/Warning Message Description and Operation**
- **Audible Warnings Description and Operation**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0480, P0691 or P0692 is not set.
   - **If a DTC is set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .

   - **If no DTCs is set**

NOTE: **A short delay occurs before the ECM changes the cooling fan speed.**

3. Verify the cooling fan operates at each available speed as commanded with a scan tool.
   - **Cooling fan does not operate**

     Refer to **Cooling Fan Inoperative**.

   - **Cooling fan operates**
4. Verify that the engine does not overheat.
   - **Engine overheats**

     Refer to **Engine Overheating**.

   - **Engine does not overheat**
5. Operate the vehicle within the Conditions for Running the DTC.
   - **If the DTC sets**

     Refer to **Symptoms - Engine Cooling**.

   - **If the DTC does not set**
6. All OK

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the diagnostic procedure.

SYMPTOMS - ENGINE COOLING

Important Preliminary Inspections Before Starting

Before using the Symptom diagnosis, perform the following:

- Perform **Diagnostic System Check - Vehicle** and verify all of the following items:
  - Engine control module (ECM) and malfunction indicator lamp (MIL) are operating correctly.
  - There are no diagnostic trouble codes (DTCs) stored.
  - Scan tool data is within a normal operating range.
- Verify the customer concern.
- Perform the Visual/Physical Inspection in this section. The visual/physical inspection is extremely important, and can lead to correcting a condition without additional testing. It may also help reveal the cause of an intermittent condition.
- Locate the correct symptom. Perform the tests and inspections associated with the symptom.

Review the entire cooling system operation in order to familiarize yourself with the system functions. Refer to **Cooling Fan Description and Operation**, and **Cooling System Description and Operation**.

Visual/Physical Inspection

CAUTION: Use the connector test adapter kit EL-35616-F for any test that requires probing the following items:

- **The control module harness connectors**
- **The electrical center fuse/relay cavities**
- **The component terminals**
- **The component harness connector**

Using this kit will prevent damage caused by the improper probing of connector terminals.

Several of the symptom procedures call for a careful visual and physical inspection. This can lead to correcting a condition without further tests and can save time. This inspection should include the following:

- Ensure that the control module grounds are clean, tight, and correctly located.
- Inspect cooling system hoses and pipes for splits, kinks, and improper connections. Inspect thoroughly for any type of leak or restriction.

- Inspect for a dirty or restricted radiator or HVAC condenser.
- Inspect for aftermarket devices which could affect the operation of the cooling system.
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.
- Inspect the coolant recovery reservoir for proper coolant level.

Identifying Intermittent Conditions

Many intermittent conditions occur with harness or connector movement due to engine torque, rough pavement, vibration or physical movement of a component. Refer to the following for a list to help isolate an intermittent condition:

- Water intrusion in connectors, terminals, or components
- Poor connector mating
- Terminal contact
- High circuit or component resistance-High resistance can include any resistance, regardless of the amount, which can interrupt the operation of the component.
- Harness' that are routed too tight, or chaffed circuits
- High or low ambient temperatures
- High or low engine coolant temperatures
- High underhood temperatures
- Heat build up in components or circuits due to circuit resistance, poor terminal contact, or high electrical load
- High or low system voltage
- High vehicle load conditions
- Rough road surface
- Electro-magnetic interference (EMI)/circuit interference from relays, solenoids or other electrical surge
- Incorrect installation of non-factory, aftermarket, or after factory add on accessories

If an intermittent fault is detected, refer to **Testing for Intermittent Conditions and Poor Connections** for specific strategies in diagnosing intermittent conditions.

Symptom List

Refer to a symptom diagnostic procedure from the following list in order to diagnose the symptom:

- Cooling Fan Always On
- Cooling Fan Inoperative
- Engine Overheating
- Loss of Coolant (L86 L83)Loss of Coolant (L96)
- Thermostat Diagnosis
- Engine Fails To Reach Normal Operating Temperature

COOLING FAN ALWAYS ON

Diagnostic Instructions

- Perform the Diagnostic System Check - Vehicle prior to using this diagnostic procedure.
- Review Strategy Based Diagnosis for an overview of the diagnostic approach.
- Diagnostic Procedure Instructions provides an overview of each diagnostic category.

Circuit/System Description

The engine cooling fan system is composed of two electric cooling fans. The engine control module (ECM) controls the fan speed by sending a pulse width modulated (PWM) signal to the cooling fan control modules. The cooling fan control module varies the voltage drop across the cooling fan motor in relation to the pulse width modulated signal, which enables cooling fan operation at variable speeds. The cooling fan control module is thermally protected to prevent module damage in the case of a short circuit condition in the cooling fan motor.

Diagnostic Aids

- Certain resistance conditions with IAT or ECT sensors may cause unwarranted cooling fan activation. If the ECM is commanding the cooling fan ON for no apparent reason and without any component or system DTCs set, the IAT or ECT sensor may be skewed. If this condition is suspected, refer to the temperature versus resistance tables in the appropriate engine controls subsection.
- The cooling fans will not operate when the scan tool Cooling Fan Motor Command parameter displays 0 %. This is a normal condition.

Reference Information

Schematic Reference

Engine Heating/Cooling Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Cooling Fan Description and Operation

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC P0480, P0691, or P0692, is not set.
   - **If a DTC is set**

     Refer to **DTC P0480, P0691, or P0692**.

   - **If no DTC is set.**
3. Verify the scan tool Cooling Fan Motor Command parameter is 0 %.
   - **If greater than 0 %**

     Refer to Diagnostic Aids and **Symptoms - Engine Cooling** for further diagnosis.

   - **If 0 %**
4. Verify that the G10 Cooling Fan Motors are not operating.
   - **If a G10 Cooling Fan Motor is operating**

     Test or replace the appropriate G10 Cooling Fan Motor.

- **If the G10 Cooling Fan Motor is not operating**

5. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the diagnostic procedure.

- **Fan Blade Replacement (L83 L86)** for G10 Cooling Fan Motor Replacement.
- **Control Module References**

COOLING FAN INOPERATIVE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- **Diagnostic Procedure Instructions** provides an overview of each diagnostic category.

Circuit/System Description

The engine cooling fan system is composed of two electric cooling fans. The engine control module (ECM) controls the fan speed by sending a pulse width modulated (PWM) signal to the cooling fan control modules. The cooling fan control module varies the voltage drop across the cooling fan motor in relation to the pulse width modulated signal, which enables cooling fan operation at variable speeds. The cooling fan control module is thermally protected to prevent module damage in the case of a short circuit condition in the cooling fan motor.

Diagnostic Aids

A delay or ramp up of approximately 12 seconds may occur before the cooling fan activates or changes speed when being commanded with a scan tool.

Reference Information

Schematic Reference

Engine Heating/Cooling Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Cooling Fan Description and Operation

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC P0480, P0691, or P0692, is not set.
   - **If a DTC is set**

     Refer to **DTC P0480, P0691, or P0692**.

   - **If no DTC is set.**

NOTE: **A slight delay may occur before the cooling fan activates.**

3. Verify the G10 Cooling Fan Motor activates and increases in speed with each command using a scan tool.
   - **The cooling fan does not activate or increase in speed**

     Refer to Circuit/System Testing

   - **The cooling fan activates and increases in speed**
4. All OK.

Circuit/System Testing

1. Ignition OFF, disconnect the appropriate G10 Cooling Fan Motor harness connector.
2. Ignition ON, verify that a test lamp illuminates between ground circuit terminal 1 and B+.
   - **If the test lamp does not illuminate**
   1. Ignition OFF, test for less than 2 Ω in the ground circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, repair the open/high resistance in the ground connection.
   - **If the test lamp illuminates**
3. Verify that a test lamp illuminates between B+ circuit terminal 2 and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition OFF, test for less than 2 Ω in the appropriate B+ circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**
   1. Ignition OFF, test for infinite resistance between the appropriate B+ circuit terminal and ground.
      - If less than infinite resistance, repair the short to ground in the circuit.
      - If infinite resistance, replace the appropriate G10 Cooling Fan Motor.
   - **If the test lamp illuminates**

NOTE: **Both G 10 Cooling Fan Motors must be disconnected or incorrect diagnosis may result.**

4. Ignition OFF, disconnect the other G 10 Cooling Fan Motor harness connector.
5. Ignition ON, test appropriate G 10 Cooling Fan Motor for 3-4 volts on the control circuit terminal 4.
   - **If 3 V or less**
   1. Ignition OFF, all vehicle systems OFF. It may take up to 2 minutes for all vehicle systems to power down.
   2. Test for less than 2 Ω between the terminals listed below:
      - G10L Cooling Fan Motor Left - terminal 4
      - G10R Cooling Fan Motor Right - terminal 4
      - If 2 Ω or greater, repair the open/high resistance in the circuit.

- **If 3-4 V**

6. Test or replace the appropriate G 10 Cooling Fan Motor.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the diagnostic procedure.

- **Fan Blade Replacement (L83 L86)** for G10 Cooling Fan Motor replacement.
- **Control Module References**

ENGINE OVERHEATING

Step	Action	Yes	No
DEFINITION: The engine temperature lamp comes on and stays on, or temperature gauge shows hot, or coolant overflows from the surge tank onto the ground while the engine is running.			
1	Check for a loss of coolant. Refer to **Loss of Coolant (L86 L83)Loss of Coolant (L96)**. Is there a loss of coolant?	Go to **Step 2**	Go to **Step 3**
2	Fill the system to the specified level. Does the engine still overheat?	Go to **Step 3**	System OK
3	Check for kinked or pinched surge tank hoses, especially at the radiator. Are any surge tank hoses kinked or pinched?	Go to **Step 4**	Go to **Step 5**
4	1. Relieve any kinks by rerouting the hoses. 2. Replace the hoses, if necessary. Does the engine still overheat?	Go to **Step 5**	System OK
5	Check for loose, missing, or damaged radiator air seals or deflectors. Are there any loose, missing, or damaged radiator air seals or deflectors?	Go to **Step 6**	Go to **Step 7**
6	Repair or replace any loose, missing, or damaged radiator air seals or deflectors. Does the engine still overheat?	Go to **Step 7**	System OK
7	Check the coolant concentration. Does the coolant concentration test correctly?	Go to **Step 9**	Go to **Step 8**

Step	Action	Yes	No
8	Replace the coolant, if necessary. Does the engine still overheat?	Go to **Step 9**	System OK
9	**NOTE:** **Use the correct pressure cap.** Check the system for loss of pressure. Refer to **Pressure Cap Testing**Is there a loss of pressure?	Go to **Step 10**	Go to **Step 11**
10	Repair any leaks, as necessary. Does the engine still overheat?	Go to **Step 11**	System OK
11	Check for a faulty engine coolant temperature sensor. Is the engine coolant temperature sensor faulty?	Go to **Step 12**	Go to **Step 13**
12	Replace the engine coolant temperature sensor. Refer to **Engine Coolant Temperature Sensor Replacement** Does the engine still overheat?	Go to **Step 13**	System OK
13	Check the radiator for any air flow obstructions or bent fins. Is there any airflow obstruction or bent fins?	Go to **Step 14**	Go to **Step 15**
14	1. Remove or relocate add-on parts that block air flow to the radiator. 2. Clean any debris from the radiator core. Does the engine still overheat?	Go to **Step 15**	System OK
15	Check for any blocked cooling system passages. Are there any blocked cooling system passages?	Go to **Step 16**	Go to **Step 17**
16	1. Remove any obstruction. 2. Flush the cooling system, as required. 3. Refill the coolant. Does the engine still overheat?	Go to **Step 17**	System OK
17	Check for an inoperative cooling fan. Is the cooling fan inoperative?	Go to **Step 18**	Go to **Step 19**

Step	Action	Yes	No
18	Replace the cooling fan. Refer to **Fan Blade Replacement (L83 L86)**. Does the engine still overheat?	Go to **Step 19**	System OK
19	Check for a thermostat that is stuck closed. Is the thermostat stuck closed?	Go to **Step 20**	Go to **Step 21**
20	Replace the thermostat. Refer **Engine Coolant Thermostat Housing Replacement (L83, L86)Engine Coolant Thermostat Housing Replacement (L96)**. Does the engine still overheat?	Go to **Step 21**	System OK
21	Check for a faulty water pump. The impeller blades may be eroded or broken. Is the water pump faulty?	Go to **Step 22**	-
22	Replace the water pump. Refer to **Water Pump Replacement (L83, L86)Water Pump Replacement (L96)**. Does the engine still overheat?	-	System OK

LOSS OF COOLANT (L86 L83)

Step	Action	Yes	No
DEFINITION: The cooling system is loosing coolant either internally or externally.			
1	Were you sent here from Symptoms, or another diagnostic table?	Go to **Step 2**	Go to **Symptoms - Engine Cooling**
2	Repair any present DTCs. Refer to **Diagnostic System Check - Vehicle** . Is the action complete?	Go to **Step 3**	-
3	Inspect the coolant level. Is the coolant at the proper level?	Go to **Step 5**	Go to **Step 4**
4	Fill the cooling system to the proper level. Refer to **Cooling System Draining and Filling (Static Fill L96)Cooling System Draining and Filling (Vac N Fill L96)Cooling System Draining and Filling (Vac N Fill L83 L86)Cooling System Draining and Filling (Static Fill L83 L86)**. Is the action complete?	Go to **Step 5**	-
5	Engine overheating can cause a loss of coolant. Is the engine overheating?	Go to **Step 19**	Go to **Step 6**

Step	Action	Yes	No
6	1. Idle the engine at normal operating temperature. 2. Inspect for heavy white smoke coming out of the exhaust pipe. Is a heavy white smoke present from the exhaust pipe?	Go to **Step 7**	Go to **Step 8**
7	1. Coolant in the exhaust system creates a distinctive, burning coolant odor in the exhaust. 2. Condensation in the exhaust system can cause an odorless white smoke during engine warm up. Does the white smoke have a burning coolant type odor?	Go to **Step 20**	Go to **Step 8**
8	Visually inspect the hoses, pipes and hose clamps. Are any of the hoses, clamps or pipes leaking?	Go to **Step 21**	Go to **Step 9**
9	Visually inspect the following components: • Block heater • Coolant pressure cap • Core plugs • Throttle body • Engine block • Intake manifold • Radiator • Thermostat housing • Water pump Are any of the listed components leaking?	Go to **Step 21**	Go to **Step 10**
10	1. Pressure test the cooling system. Refer to **Cooling System Leak Testing (L96)Cooling System Leak Testing (L83, L86)**. 2. With the cooling system pressurized, visually inspect the components listed in steps 7 and 8.	Go to **Step 21**	Go to **Step 11**

Step	Action	Yes	No
	Are any leaks present?		
11	Pressure test the coolant pressure cap. Refer to **Pressure Cap Testing**. Does the coolant pressure cap hold pressure?	Go to **Step 12**	Go to **Step 16**
12	Inspect for the following conditions: • A coolant smell inside of the vehicle • Coolant in the HVAC module drain tube • Coolant on the vehicle floor covering near the HVAC module Is coolant present?	Go to **Step 21**	Go to **Step 13**
13	Inspect the underside of the engine oil fill cap for a gray/white milky substance. Is there a milky substance under the oil fill cap?	Go to **Step 14**	Go to **Step 15**
14	Inspect the engine oil fluid level indicator for a gray/white milky substance. Is there a milky substance on the engine oil fluid level indicator?	Go to **Step 17**	Go to **Step 15**
15	Inspect the automatic transmission oil fluid level indicator, if equipped, for a gray/white milky substance. Is there a milky substance on the automatic transmission fluid level indicator?	Go to **Step 18**	Go to **Step 22**
16	Replace the coolant pressure cap. Is the repair complete?	Go to **Step 22**	-
17	1. Replace the radiator. Refer to **Radiator Replacement (L83 L86)Radiator Replacement (L96)**. 2. Replace the oil and filter. Refer to **Engine Oil and Oil Filter Replacement** . Is the repair complete?	Go to **Step 22**	-
18	1. Replace the radiator. Refer to **Radiator Replacement (L83 L86)Radiator Replacement (L96)**. 2. Service the automatic transmission. Refer to the following: **Engine**	Go to **Step 22**	-

Step	Action	Yes	No
	Coolant/Water in Transmission . Is the repair complete?		
19	Repair the engine overheating condition. Refer to Engine Overheating. Is the repair complete?	Go to **Step 22**	-
20	Repair the engine internal coolant leak. Refer to Coolant in Combustion Chamber , or, Coolant in Engine Oil . Is the repair complete?	Go to **Step 22**	-
21	Repair or replace the leaking component. Refer to the appropriate repair. Is the repair complete?	Go to **Step 22**	-
22	Operate the system in order to verify the repair. Did you find and correct the condition?	System OK	Go to **Step 2**

LOSS OF COOLANT (L96)

Step	Action	Yes	No
DEFINITION: The cooling system is loosing coolant either internally or externally.			
1	Were you sent here from Symptoms, or another diagnostic table?	Go to **Step 2**	Go to Symptoms - Engine Cooling
2	Repair any present DTCs. Refer to Diagnostic System Check - Vehicle . Is the action complete?	Go to **Step 3**	-
3	Inspect the coolant level. Is the coolant at the proper level?	Go to **Step 5**	Go to **Step 4**
4	Fill the cooling system to the proper level. Refer to Cooling System Draining and Filling (Static Fill L96)Cooling System Draining and Filling (Vac N Fill L96)Cooling System Draining and Filling (Vac N Fill L83 L86)Cooling System Draining and Filling (Static Fill L83 L86). Is the action complete?	Go to **Step 5**	-
5	Engine overheating can cause a loss of coolant. Is the engine overheating?	Go to **Step 19**	Go to **Step 6**
6	1. Idle the engine at normal operating temperature.	Go to **Step 7**	Go to **Step 8**

Step	Action	Yes	No
	2. Inspect for heavy white smoke coming out of the exhaust pipe. Is a heavy white smoke present from the exhaust pipe?		
7	1. Coolant in the exhaust system creates a distinctive, burning coolant odor in the exhaust. 2. Condensation in the exhaust system can cause an odorless white smoke during engine warm up. Does the white smoke have a burning coolant type odor?	Go to **Step 20**	Go to **Step 8**
8	Visually inspect the hoses, pipes and hose clamps. Are any of the hoses, clamps or pipes leaking?	Go to **Step 21**	Go to **Step 9**
9	Visually inspect the following components: • Block heater • Coolant pressure cap • Core plugs • Throttle body • Engine block • Intake manifold • Radiator • Thermostat housing • Water pump Are any of the listed components leaking?	Go to **Step 21**	Go to **Step 10**
10	1. Pressure test the cooling system. Refer to **Cooling System Leak Testing (L96)Cooling System Leak Testing (L83, L86)**. 2. With the cooling system pressurized, visually inspect the components listed in steps 7 and 8. Are any leaks present?	Go to **Step 21**	Go to **Step 11**

Step	Action	Yes	No
11	Pressure test the coolant pressure cap. Refer to **Pressure Cap Testing**. Does the coolant pressure cap hold pressure?	Go to **Step 12**	Go to **Step 16**
12	Inspect for the following conditions: • A coolant smell inside of the vehicle • Coolant in the HVAC module drain tube • Coolant on the vehicle floor covering near the HVAC module Is coolant present?	Go to **Step 21**	Go to **Step 13**
13	Inspect the underside of the engine oil fill cap for a gray/white milky substance. Is there a milky substance under the oil fill cap?	Go to **Step 14**	Go to **Step 15**
14	Inspect the engine oil fluid level indicator for a gray/white milky substance. Is there a milky substance on the engine oil fluid level indicator?	Go to **Step 17**	Go to **Step 15**
15	Inspect the automatic transmission oil fluid level indicator, if equipped, for a gray/white milky substance. Is there a milky substance on the automatic transmission fluid level indicator?	Go to **Step 18**	Go to **Step 22**
16	Replace the coolant pressure cap. Is the repair complete?	Go to **Step 22**	-
17	1. Replace the radiator. Refer to **Radiator Replacement (L83 L86)Radiator Replacement (L96)**. 2. Replace the oil and filter. Refer to **Engine Oil and Oil Filter Replacement** . Is the repair complete?	Go to **Step 22**	-

Step	Action	Yes	No
18	1. Replace the radiator. Refer to **Radiator Replacement (L83 L86)Radiator Replacement (L96)**. 2. Service the automatic transmission. Refer to the following: **Engine Coolant/Water in Transmission** . Is the repair complete?	Go to **Step 22**	-
19	Repair the engine overheating condition. Refer to **Engine Overheating**. Is the repair complete?	Go to **Step 22**	-
20	Repair the engine internal coolant leak. Refer to **Coolant in Combustion Chamber** , or, **Coolant in Engine Oil** . Is the repair complete?	Go to **Step 22**	-
21	Repair or replace the leaking component. Refer to the appropriate repair. Is the repair complete?	Go to **Step 22**	-
22	Operate the system in order to verify the repair. Did you find and correct the condition?	System OK	Go to **Step 2**

THERMOSTAT DIAGNOSIS

Thermostat Test Procedure Using Glycol

Inspect the operation of the thermostat by hanging the thermostat on a hook in a 33 percent glycol solution.

In order to inspect if the thermostat valve is opening properly, perform the following test:

Fig. 2: View Of Thermostat Test Procedure Using Glycol
Courtesy of GENERAL MOTORS COMPANY

1. Completely submerge the thermostat in a glycol solution. The solution should be 11Â°C (22Â°F) above the temperature indicated on the thermostat valve.

2. Thoroughly agitate the solution. Under these conditions, the thermostat valve should open.

In order to inspect if the thermostat valve is closing properly, perform the following test:

1. Completely submerge the thermostat in a glycol solution. The solution should be 6Â°C (10Â°F) below the temperature indicated on the thermostat valve.
2. Thoroughly agitate the solution. Under these conditions, the thermostat valve should close completely.

ENGINE FAILS TO REACH NORMAL OPERATING TEMPERATURE

Step	Action	Yes	No
1	1. Ensure that the cooling system is full. 2. Allow the engine to cool. 3. Start the engine. 4. Turn the air conditioning system off. 5. Inspect the engine cooling fan(s). Is the electric cooling fan on?	Go to **Step 2**	Go to **Step 3**
2	1. Diagnose and repair the cooling fan system. Refer to **Cooling Fan Always On**. 2. Verify the customer complaint. Does the engine still fail to reach normal operating temperature?	Go to **Step 3**	System OK
3	Install the Scan Tool to the DLC. Compare the Scan Tool coolant temperature reading to the I/P cluster coolant temperature. Is the I/P cluster coolant temperature close to the reading on the Scan Tool?	Go to **Step 5**	Go to **Step 4**
4	1. Diagnose and repair the coolant temperature gauge system. 2. Verify the customer complaint. Does the engine still fail to reach normal operating temperature?	Go to **Step 5**	System OK
5	Inspect the thermostat for proper operation. Refer to **Thermostat Diagnosis**. Is the thermostat operating properly?	Go to **Step 1**	Go to **Step 6**

Step	Action	Yes	No
6	1. Replace the thermostat. Refer to **Engine Coolant Thermostat Housing Replacement (L83, L86)Engine Coolant Thermostat Housing Replacement (L96)**. 2. Verify the customer complaint. Does the engine still fail to reach normal operating temperature?	Go to **Step 1**	System OK

PRESSURE CAP TESTING

Special Tools

- **EN-24460-A** Cooling System Pressure Tester
- **GE-42401-A** Radiator Cap / Surge Tank Test Adapter

For equivalent regional tools, Refer to **Special Tools**

Pressure Cap Testing

WARNING: To avoid being burned, do not remove the radiator cap or surge tank cap while the engine is hot. The cooling system will release scalding fluid and steam under pressure if radiator cap or surge tank cap is removed while the engine and radiator are still hot.

1. Remove the pressure cap.
2. Wash the pressure cap sealing surface with water.

Fig. 3: Identifying Pressure Cap Tester
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Lubricate J-42401-1 and pressure cap o-rings with coolant and press cap to seat o-ring on J-42401-1 before turning to engage threads.**

3. Use the **EN-24460-A** Cooling System Pressure Tester (1) with **GE-42401-A** Radiator Cap / Surge Tank Test Adapter (2) in order to test the pressure cap.
4. Test the pressure cap for the following conditions:
   - Pressure release when the **EN-24460-A** Cooling System Pressure Tester exceeds the pressure rating of the pressure cap.
   - Maintain the rated pressure for at least 10 seconds.

     Note the rate of pressure loss.
5. Replace the pressure cap under the following conditions:
   - The pressure cap does not release pressure which exceeds the rated pressure of the cap.

- The pressure cap does not hold the rated pressure.

COOLANT LEAK TESTING (L96)

Special Tools

- **J-24460-01** Cooling System Pressure Tester
- **J-42401** Radiator Cap/Surge Tank Test Adapter

For equivalent regional tools, refer to **Special Tools**.

WARNING: Under pressure, the temperature of the solution in the radiator can be considerably higher, without boiling. Removing the radiator cap while the engine is hot (pressure is high), will cause the solution to boil instantaneously, with explosive force. The solution will spew out over the engine, fenders, and the person removing the cap. Serious bodily injury may result. Flammable antifreeze, such as alcohol, is not recommended for use at any time. Flammable antifreeze could cause a serious fire.

WARNING: In order to help avoid being burned, do not remove the radiator cap while the engine and the radiator are hot. Scalding fluid and steam can be blown out under pressure if the cap is removed too soon.

1. Remove the pressure cap.
2. Test the operation of the pressure cap. Refer to **Pressure Cap Testing**.
3. Wash the pressure cap mating surface with water.

Fig. 4: Radiator Cap/Surge Tank Test Adapter
Courtesy of GENERAL MOTORS COMPANY

4. Use the **J-24460-01** cooling system pressure tester (1) with the **J-42401** radiator cap/surge tank test adapter (2) in order to apply pressure to the cooling system.

   Do not exceed the pressure cap rating.

5. The cooling system should hold the rated pressure for at least 2 minutes.

   Observe the gauge for any pressure loss.

6. Repair any leaks as required.

COOLANT LEAK TESTING (L83, L86)

Special Tools

- **J-24460-01** Cooling System Pressure Tester
- **J-42401** Radiator Cap/Surge Tank Test Adapter

For equivalent regional tools, refer to **Special Tools**.

WARNING: Under pressure, the temperature of the solution in the radiator can be considerably higher, without boiling. Removing the radiator cap while the engine is hot (pressure is high), will cause the solution to boil instantaneously, with explosive force. The solution will spew out over the engine, fenders, and the person removing the cap. Serious bodily injury may result. Flammable antifreeze, such as alcohol, is not recommended for use at any time. Flammable antifreeze could cause a serious fire.

WARNING: In order to help avoid being burned, do not remove the radiator cap while the engine and the radiator are hot. Scalding fluid and steam can be blown out under pressure if the cap is removed too soon.

1. Remove the pressure cap.
2. Test the operation of the pressure cap. Refer to **Pressure Cap Testing**.
3. Wash the pressure cap mating surface with water.

Fig. 5: Cooling System Pressure Tester
Courtesy of GENERAL MOTORS COMPANY

4. Use the **J-24460-01** cooling system pressure tester (1) with the **J-42401** radiator cap/surge tank test adapter (2) in order to apply pressure to the cooling system.

   Do not exceed the pressure cap rating.

5. The cooling system should hold the rated pressure for at least 2 minutes.

   Observe the gauge for any pressure loss.

6. Repair any leaks as required.

REPAIR INSTRUCTIONS

HOSE CLAMP REPLACEMENT GUIDELINES - SPRING TYPE

Special Tools

- **BO-38185** Hose Clamp Pliers
- **GE-47622** Hose Clamp Pliers.

Equivalent regional tools:**Special Tools**

Spring Type Hose Clamp Replacement Guidelines

Fig. 6: Spring Type Hose Clamps
Courtesy of GENERAL MOTORS COMPANY

Vehicles utilize spring type hose clamps (1) to secure joints in which fluids, gases, or engine vacuum can travel to various vehicle systems. Spring type hose clamps are engineered to provide the proper amount of tension to maintain a leak & maintenance free joint for the life of the vehicle.

Spring type hose clamps have a special coating applied to the exterior of the clamp that is engineered to resist rust/corrosion, improve durability and increase the life of the hose clamp. If the coating is damaged, rust/corrosion could form resulting in the need to replace the hose clamp.

Many spring type hose clamps within GM utilize a small amount of adhesive placed directly on the hose clamp to secure the clamp to the mating hose for manufacturing purposes. Over time the strength of the adhesive will deteriorate. It is extremely important when a technician is attempting to service a joint or remove the hose clamp, that the clamp is not rotated or repositioned so that is tears and/or damages the hose. In this case, the hose and clamp must both be replaced.

When repairing a vehicle it is very important to observe the condition of both the hose and the spring type hose clamp as well as the orientation of the clamp to the hose.

If the spring type hose clamp(s) have any of the following conditions on any area of the clamp, replace the clamp(s) immediately.

- Rust/Corrosion
- Cracks
- Physical damage
- Leakage attributed to the retention of the clamp

Removing The Spring Type Hose Clamp

While keeping the hose stationary, use BO-38185 Hose Clamp Pliers or GE-47622 Hose Clamp Pliers and release the spring type hose clamp tension while attempting to separate the hose clamp from the hose.

- If the spring type hose clamp will not easily separate from the hose and/or the clamp tears or damages the hose, both the hose and hose clamp must be replaced
- If the spring type hose clamp is easily removed from the hose, the clamp can be reused provided that the clamp does not have any of the conditions as noted above.

If The Spring Type Hose Clamp Is Being Reused

It is extremely important that the spring type hose clamp is orientated to the hose in the exact same position as it was installed during vehicle

assembly so that the hose clamp is not damaged or the hose clamp does not contact or damage any adjacent components. Do not use any type of adhesive on the hose clamp prior to installation.

When Reusing The Spring Type Hose Clamp and Replacing The Hose

- The inside and outside hose diameter must be identical between the new hose and the existing hose to guarantee proper hose clamp tension and joint integrity.
- Always place the existing spring type hose clamp in the same orientation as it was positioned prior to separating the joint. The new hose might have a marking on the hose indicating the correct position of a hose clamp, which should re-confirm the correct hose clamp position. The hose clamp should not contact any adjacent components after installation.

When Reusing The Spring Type Hose Clamp with an Existing Hose

Always place the existing spring type hose clamp in the same orientation as it was positioned prior to separating the joint. The existing hose might have an indentation or compression mark on the hose from where the hose clamp was installed previously. The hose clamp should identically overlay this position. The existing hose might also have a marking on the hose indicating the correct position of the hose clamp, which should re-confirm the correct hose clamp position. The hose clamp should not contact any adjacent components after installation.

If The Spring Type Hose Clamp Is Being Replaced

If the hose clamp needs to be replaced, always replace the hose as part of the service repair. It is extremely important that a new spring type hose clamp is orientated to the hose in the exact same position as it was installed during vehicle assembly so that the hose clamp is not damaged or the hose clamp does not contact or damage any adjacent components. Do not use any type of adhesive on the hose clamp prior to installation.

When Replacing The Spring Type Hose Clamp and Replacing The Hose

- The inside and outside hose diameter must be identical between the new hose and the existing hose to guarantee proper hose clamp tension and joint integrity.
- Always place the new spring type hose clamp in the same orientation as it was positioned prior to separating the joint. The new hose might have a marking on the hose indicating the correct position of a hose clamp, which should re-confirm the correct hose clamp position. The hose clamp should not contact any adjacent components after installation.

When Replacing The Spring Type Hose Clamp with an Existing Hose

Always place the new spring type hose clamp in the same orientation as it was positioned prior to separating the joint. The existing hose might have an indentation or compression mark on the hose from where a hose clamp was installed previously. The hose clamp should identically overlay this position. The existing hose might also have a marking on the hose indicating the correct position of the hose clamp, which should re-confirm the

correct hose clamp position. The hose clamp should not contact any adjacent components after installation.

COOLING SYSTEM DRAINING AND FILLING (STATIC FILL L96)

Special Tools

- **J-26568** Coolant and Battery Tester
- **J-38185** Hose Clamp Pliers

Draining Procedure

WARNING: To avoid being burned, do not remove the radiator cap or surge tank cap while the engine is hot. The cooling system will release scalding fluid and steam under pressure if radiator cap or surge tank cap is removed while the engine and radiator are still hot.

1. Follow the steps below in order to remove the surge tank fill cap:
    1. Slowly rotate the cap counterclockwise.
    2. Stop rotating and allow the hissing to stop.
    3. After all the hissing stops, continue turning counterclockwise in order to remove the cap.
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
3. Place a drain pan under the lower radiator hose and/or drain cock.
4. Reposition the lower radiator hose and/or drain cock from the radiator.
5. Drain the cooling system.

Fig. 7: Engine Block Coolant Drain Hole Plugs
Courtesy of GENERAL MOTORS COMPANY

6. If a complete engine block drain is required, remove the left and right engine block coolant drain hole plugs (1) and engine block coolant drain hole plug gaskets (2).
7. Inspect the coolant.

8. Follow the appropriate procedure based on the condition of the coolant:
    - Normal in appearance-Follow the filling procedure.
    - Discolored-Follow the flush procedure. Refer to **Flushing**.

Filling Procedure

CAUTION: The procedure below must be followed. Improper coolant level could result in a low or high coolant level condition, causing engine damage.

1. Install the lower radiator hose and/or drain cock to the radiator.

Fig. 8: Engine Block Coolant Drain Hole Plugs
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

2. If the left and right engine block coolant drain hole plugs (1) and engine block coolant drain hole plug gaskets (2) were removed, install the

engine block coolant drain hole plugs (1) and engine block coolant drain hole plug gaskets (2). Refer to **Engine Block Plug Installation** .

3. Lower the vehicle.

NOTE: **Use a 50/50 mixture of DEX-COOL antifreeze and clean, drinkable water.**

4. Slowly fill the cooling system with a 50/50 coolant mixture. Refer to **Approximate Fluid Capacities**.
5. Install the coolant pressure cap.
6. Start the engine.
7. Run the engine at 2, 000-2, 500 RPM until the engine reaches normal operating temperature.

   Engine should reach an operating temperature of 90Â°C (194Â°F) and the upper radiator hose should be HOT.

8. Allow the engine to idle for 3 minutes.
9. Shut the engine OFF.
10. Allow the engine to cool.
11. Top off the coolant as necessary.
12. Inspect the concentration of the engine coolant using the **J-26568** coolant and battery tester.
13. Rinse away any excess coolant from the engine and the engine compartment.

COOLING SYSTEM DRAINING AND FILLING (VAC N FILL L96)

Special Tools

- **GE-47716** Vac-N-Fill Coolant Refill Tool
- **J-26568** Coolant and Battery Tester
- **J-42401** Radiator Cap and Surge Tank Test Adapter

Draining Procedure

WARNING: **With a pressurized cooling system, the coolant temperature in the radiator can be considerably higher than the boiling point of the solution at atmospheric pressure. Removal of the surge tank cap, while the cooling system is hot and under high pressure, causes the solution to boil instantaneously with explosive force. This will cause the solution to spew out over the engine, the fenders, and the person removing the cap. Serious bodily injury may result.**

1. Park the vehicle on a level surface.
2. Remove the coolant pressure cap.
3. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
4. Place a drain pan under the drain cock and/or lower radiator hose.
5. Reposition the radiator drain cock and/or lower radiator hose.
6. Drain the cooling system.

Fig. 9: Engine Block Coolant Drain Hole Plugs
Courtesy of GENERAL MOTORS COMPANY

7. If a complete engine block drain is required, remove the left and right engine block coolant drain hole plugs (1) and engine block coolant drain hole plug gaskets (2).
8. Inspect the coolant.

9. Follow the appropriate procedure based on the condition of the coolant.
    - Normal in appearance-Follow the filling procedure.
    - Discolored-Follow the flush procedure. Refer to **Flushing**.

Vac-N-Fill Procedure

NOTE: **To prevent boiling of the coolant/water mixture in the vehicles cooling system, do not apply vacuum to a cooling system above 49Â°C (120Â°F). The tool will not operate properly when the coolant is boiling.**

Fig. 10: Engine Block Coolant Drain Hole Plugs
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

1. If the left and right engine block coolant drain hole plugs (1) and engine block coolant drain hole plug gaskets (2) were removed, install the

engine block coolant drain hole plugs (1) and engine block coolant drain hole plug gaskets (2). Refer to **Engine Block Plug Installation** .

2. Install the **J-42401** radiator cap and surge tank test adapter.

Fig. 11: Radiator Cap & Surge Tank Test Adapter
Courtesy of GENERAL MOTORS COMPANY

3. Attach the Vac-N-Fill cap (1) to the vehicles coolant fill port.

Fig. 12: Vacuum Gauge Assembly & Vac N Fill Cap
Courtesy of GENERAL MOTORS COMPANY

4. Attach the vacuum gauge assembly (1) to the Vac-N-Fill cap (2).

Fig. 13: Vacuum Gauge Assembly & Fill Hose
Courtesy of GENERAL MOTORS COMPANY

5. Attach the fill hose (1) to the barb fitting on the vacuum gauge assembly (2).

   Ensure that the valve is closed.

Fig. 14: Graduated Reservoir, Vacuum Tank & Cut-Out Area
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Use a 50/50 mixture of DEX-COOL antifreeze and clean, drinkable water.**

Always use more coolant than necessary. This will eliminate air from being drawn into the cooling system.

6. Pour the coolant mixture into the graduated reservoir (1).

7. Place the fill hose in the graduated reservoir (1).

NOTE: **Prior to installing the vacuum tank onto the graduated reservoir, ensure that the drain valve located on the bottom of the tank is closed.**

8. Install the vacuum tank (2) on the graduated reservoir with the fill hose routed through the cut-out area (3) in the vacuum tank.

Fig. 15: Vacuum Tank & Venturi Assembly

Courtesy of GENERAL MOTORS COMPANY

9. Attach the venturi assembly (1) to the vacuum tank (2).

Fig. 16: Venturi Assembly & Valve
Courtesy of GENERAL MOTORS COMPANY

10. Attach a shop air hose to the venturi assembly (1).

Ensure the valve (2) on the venturi assembly is closed.

Fig. 17: Vacuum Hose, Gauge Assembly & Tank
Courtesy of GENERAL MOTORS COMPANY

11. Attach the vacuum hose (1) to the vacuum gauge assembly (2) and the vacuum tank (3).

12. Clamp off the overflow hose.

Fig. 18: Valve & Venturi Assembly
Courtesy of GENERAL MOTORS COMPANY

13. Open the valve (1) on the venturi assembly (2). The vacuum gauge will begin to rise and a hissing noise will be present.

Fig. 19: Vacuum Gauge Needle
Courtesy of GENERAL MOTORS COMPANY

14. Continue to draw vacuum until the needle stops rising (1). This should be 610-660 mm Hg (24-26 in Hg).

    Cooling hoses may start to collapse. This is normal due to vacuum draw.

15. To aid in the fill process, position the graduated reservoir above the coolant fill port.

Fig. 20: Vacuum Gauge Assembly & Needle
Courtesy of GENERAL MOTORS COMPANY

16. Slowly open the valve (1) on the vacuum gauge assembly (2). When the coolant reaches the top of the fill hose, close the valve. This will eliminate air from the fill hose.
17. Close the valve on the venture assembly.
18. If there is a suspected leak in the cooling system, allow the system to stabilize under vacuum and monitor for vacuum loss.

If vacuum loss is observed, refer to **Loss of Coolant (L86 L83)Loss of Coolant (L96)**.

19. Open the valve on the vacuum gauge assembly. The vacuum gauge will drop as coolant is drawn into the system.

Fig. 21: Vacuum Gauge At Zero
Courtesy of GENERAL MOTORS COMPANY

20. Once the vacuum gauge reaches zero (1), close the valve on the vacuum gauge assembly and repeat steps 11-17.

21. Remove the **J-42401** radiator cap and surge tank test adapter.
22. Detach the Vac-N-Fill cap from the vehicles coolant fill port.
23. Add coolant to the system as necessary.
24. Inspect the concentration of the coolant mixture using **J-26568** coolant and battery tester.

NOTE: **After filling the cooling system, the extraction hose can be used to remove excess coolant to achieve the proper coolant level.**

25. Detach the vacuum hose form the vacuum gauge assembly.

Fig. 22: Vacuum Hose & Extraction Hose
Courtesy of GENERAL MOTORS COMPANY

26. Attach the extraction hose (1) to the vacuum hose (2).

Fig. 23: Venturi Assembly & Valve
Courtesy of GENERAL MOTORS COMPANY

27. Open the valve (1) on the venturi assembly (2) to start a vacuum draw.

Fig. 24: Coolant Extraction Hose
Courtesy of GENERAL MOTORS COMPANY

28. Use the extraction hose (1) to draw out coolant to the proper level.
29. The vacuum tank has a drain valve on the bottom of the tank. Open the valve to drain coolant from the vacuum tank into a suitable container for disposal.

COOLING SYSTEM DRAINING AND FILLING (VAC N FILL L83 L86)

Special Tools

- **GE-47716** Vac-N-Fill Coolant Refill Tool
- **J-26568** Coolant and Battery Tester
- **J-42401** Radiator Cap and Surge Tank Test Adapter

Draining Procedure

WARNING: With a pressurized cooling system, the coolant temperature in the radiator can be considerably higher than the boiling point of the solution at atmospheric pressure. Removal of the surge tank cap, while the cooling system is hot and under high pressure, causes the solution to boil instantaneously with explosive force. This will cause the solution to spew out over the engine, the fenders, and the person removing the cap. Serious bodily injury may result.

1. Park the vehicle on a level surface.
2. Remove the coolant pressure cap.
3. Raise and support the vehicle. **Lifting and Jacking the Vehicle** .
4. Place a drain pan under the radiator drain cock.
5. Install a suitable length of hose to the radiator drain cock nipple and route the hose to allow free drain of coolant.
6. Open the radiator drain cock.
7. Drain the cooling system.

Fig. 25: Engine Block Coolant Drain Hole Plugs
Courtesy of GENERAL MOTORS COMPANY

8. If a complete engine block drain is required, remove the left and right engine block coolant drain hole plugs (1).
9. Inspect the coolant.
10. Follow the appropriate procedure based on the condition of the coolant.

- Normal in appearance-Follow the filling procedure.
- Discolored-Follow the flush procedure. **Flushing**.

Vac-N-Fill Procedure

NOTE: **To prevent boiling of the coolant/water mixture in the vehicles cooling system, do not apply vacuum to a cooling system above 49Â°C (120Â°F). The tool will not operate properly when the coolant is boiling.**

Fig. 26: Engine Block Coolant Drain Hole Plugs
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

1. If the left and right engine block coolant drain hole plugs (1) were removed, install the engine block coolant drain hole plugs (1). **Engine Block**

Plug Installation .

2. Install the **J-42401** radiator cap and surge tank test adapter.

Fig. 27: Radiator Cap & Surge Tank Test Adapter
Courtesy of GENERAL MOTORS COMPANY

3. Attach the Vac-N-Fill cap (1) to the vehicles coolant fill port.

Fig. 28: Vacuum Gauge Assembly & Vac N Fill Cap
Courtesy of GENERAL MOTORS COMPANY

4. Attach the vacuum gauge assembly (1) to the Vac-N-Fill cap (2).

Fig. 29: Vacuum Gauge Assembly & Fill Hose
Courtesy of GENERAL MOTORS COMPANY

5. Attach the fill hose (1) to the barb fitting on the vacuum gauge assembly (2).

   Ensure that the valve is closed.

Fig. 30: Graduated Reservoir, Vacuum Tank & Cut-Out Area
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Use a 50/50 mixture of DEX-COOL antifreeze and clean, drinkable water.**

Always use more coolant than necessary. This will eliminate air from being drawn into the cooling system.

6. Pour the coolant mixture into the graduated reservoir (1).

7. Place the fill hose in the graduated reservoir (1).

NOTE: **Prior to installing the vacuum tank onto the graduated reservoir, ensure that the drain valve located on the bottom of the tank is closed.**

8. Install the vacuum tank (2) on the graduated reservoir with the fill hose routed through the cut-out area (3) in the vacuum tank.

Fig. 31: Vacuum Tank & Venturi Assembly

Courtesy of GENERAL MOTORS COMPANY

9. Attach the venturi assembly (1) to the vacuum tank (2).

Fig. 32: Venturi Assembly & Valve
Courtesy of GENERAL MOTORS COMPANY

10. Attach a shop air hose to the venturi assembly (1).

Ensure the valve (2) on the venturi assembly is closed.

Fig. 33: Vacuum Hose, Gauge Assembly & Tank
Courtesy of GENERAL MOTORS COMPANY

11. Attach the vacuum hose (1) to the vacuum gauge assembly (2) and the vacuum tank (3).

12. Clamp off the overflow hose.

Fig. 34: Valve & Venturi Assembly
Courtesy of GENERAL MOTORS COMPANY

13. Open the valve (1) on the venturi assembly (2). The vacuum gauge will begin to rise and a hissing noise will be present.

Fig. 35: Vacuum Gauge Needle
Courtesy of GENERAL MOTORS COMPANY

14. Continue to draw vacuum until the needle stops rising (1). This should be 610-660 mm Hg (24-26 in Hg).

    Cooling hoses may start to collapse. This is normal due to vacuum draw.

15. To aid in the fill process, position the graduated reservoir above the coolant fill port.

Fig. 36: Vacuum Gauge Assembly & Needle
Courtesy of GENERAL MOTORS COMPANY

16. Slowly open the valve (1) on the vacuum gauge assembly (2). When the coolant reaches the top of the fill hose, close the valve. This will eliminate air from the fill hose.
17. Close the valve on the venture assembly.
18. If there is a suspected leak in the cooling system, allow the system to stabilize under vacuum and monitor for vacuum loss.

If vacuum loss is observed, refer to **Loss of Coolant (L86 L83)**.

19. Open the valve on the vacuum gauge assembly. The vacuum gauge will drop as coolant is drawn into the system.

Fig. 37: Vacuum Gauge At Zero
Courtesy of GENERAL MOTORS COMPANY

20. Once the vacuum gauge reaches zero (1), close the valve on the vacuum gauge assembly and repeat steps 11-17.

21. Remove the **J-42401** radiator cap and surge tank test adapter.
22. Detach the Vac-N-Fill cap from the vehicles coolant fill port.
23. Add coolant to the system as necessary.
24. Inspect the concentration of the coolant mixture using **J-26568** coolant and battery tester.

NOTE: **After filling the cooling system, the extraction hose can be used to remove excess coolant to achieve the proper coolant level.**

25. Detach the vacuum hose form the vacuum gauge assembly.

Fig. 38: Vacuum Hose & Extraction Hose
Courtesy of GENERAL MOTORS COMPANY

26. Attach the extraction hose (1) to the vacuum hose (2).

Fig. 39: Venturi Assembly & Valve
Courtesy of GENERAL MOTORS COMPANY

27. Open the valve (1) on the venturi assembly (2) to start a vacuum draw.

Fig. 40: Coolant Extraction Hose
Courtesy of GENERAL MOTORS COMPANY

28. Use the extraction hose (1) to draw out coolant to the proper level.
29. The vacuum tank has a drain valve on the bottom of the tank. Open the valve to drain coolant from the vacuum tank into a suitable container for disposal.

COOLING SYSTEM DRAINING AND FILLING (STATIC FILL L83 L86)

Special Tool

J-26568 Coolant and Battery Tester

Draining Procedure

WARNING: To avoid being burned, do not remove the radiator cap or surge tank cap while the engine is hot. The cooling system will release scalding fluid and steam under pressure if radiator cap or surge tank cap is removed while the engine and radiator are still hot.

1. Follow the steps below in order to remove the surge tank fill cap:
    1. Slowly rotate the cap counterclockwise.
    2. Stop rotating and allow the hissing to stop.
    3. After all the hissing stops, continue turning counterclockwise in order to remove the cap.
2. Raise and support the vehicle. **Lifting and Jacking the Vehicle** .
3. Place a drain pan under the radiator drain cock.
4. Install a suitable length of hose to the radiator drain cock nipple and route the hose to allow free drain of coolant.
5. Open the radiator drain cock.
6. Drain the cooling system.

Fig. 41: Engine Block Coolant Drain Hole Plugs
Courtesy of GENERAL MOTORS COMPANY

7. If a complete engine block drain is required, remove the left and right engine block coolant drain hole plugs (1).
8. Remove the engine block coolant heater, if equipped. **Coolant Heater Replacement**.
9. Inspect the coolant.

10. Follow the appropriate procedure based on the condition of the coolant:
    - Normal in appearance-Follow the filling procedure.
    - Discolored-Follow the flush procedure. **Flushing**.

Filling Procedure

CAUTION: The procedure below must be followed. Improper coolant level could result in a low or high coolant level condition, causing engine damage.

1. Close the radiator drain cock.
2. Remove the drain hose.

Fig. 42: Engine Block Coolant Drain Hole Plugs
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

3. If the left and right engine block coolant drain hole plugs (1) were removed, install the engine block coolant drain hole plugs (1). **Engine Block**

Plug Installation .

4. Install the engine block coolant heater, if equipped. Coolant Heater Replacement.
5. Lower the vehicle.

NOTE: **Use a 50/50 mixture of DEX-COOL antifreeze and clean, drinkable water.**

6. Slowly fill the cooling system with a 50/50 coolant mixture. Approximate Fluid Capacities.
7. Install the coolant pressure cap.
8. Start the engine.
9. Run the engine at 2, 000-2, 500 RPM until the engine reaches normal operating temperature.

   Engine should reach an operating temperature of 90Â°C (194Â°F) and the upper radiator hose should be HOT.

10. Allow the engine to idle for 3 minutes.
11. Shut the engine OFF.
12. Allow the engine to cool.
13. Top off the coolant as necessary.
14. Inspect the concentration of the engine coolant using the **J-26568** coolant and battery tester.
15. Rinse away any excess coolant from the engine and the engine compartment.

FLUSHING

NOTE:

- **When the cooling system becomes contaminated, the cooling system should be flushed thoroughly to remove the contaminants before the engine is seriously damaged.**
- **This procedure is effective in removing contaminants caused by the use of improper coolants, coolant at the end of its life, or some liquid chemical flushing agents. This procedure is NOT effective for removing debris contamination caused by component failure, or the use of 'stop leak' additives. When the system is contaminated by this type of debris, use the system flow diagrams to identify components that may need replacement to restore proper system flow.**
- **Do not use chemical flush agents.**
- **Store used coolant in the proper manner, such as in a used engine coolant holding tank. Do not pour used coolant down a drain. Ethylene glycol antifreeze is a very toxic chemical. Do not dispose of coolant into the sewer system or ground water. This is illegal and ecologically unsound.**

- **Various methods and equipment can be used to flush the cooling system. If special equipment is used, such as a back flusher, follow the manufacturer's instruction. Always remove the thermostat before flushing the cooling system.**

1. Block the drive wheels.
2. Place the transmission in park (P) or neutral (N).
3. Engage the park brake.
4. Run the engine until the thermostat opens.
5. Stop the engine.
6. Follow the drain and fill procedure using only clean drinkable water. Repeat the procedure if necessary, until the fluid is nearly colorless. **Cooling System Draining and Filling (Static Fill L83 L86)**.
7. Fill the coolant reservoir to the FULL HOT mark.
8. Fill the cooling system. **Cooling System Draining and Filling (Static Fill L83 L86)**.

RADIATOR CLEANING

WARNING: NEVER spray water on a hot heat exchanger. The resulting steam could cause personal injury.

CAUTION: The heat exchanger fins are necessary for good heat transfer. Do not brush the fins. This may cause damage to the fins, reducing heat transfer.

NOTE: Remove bugs, leaves, dirt and other debris by blowing compressed air through the engine side of the radiator.

Keep compressed air stream perpendicular to the core face and allow adequate distance of the air nozzle to the core face so not to cause fin damage.

- Some conditions may require the use of warm water and a mild (non caustic) detergent.
- Clean the A/C condenser fins.
- Clean between the A/C condenser and radiator.
- Clean the charge air cooler fins, if equipped.
- Clean between the air cooler fins and radiator, if equipped.

- Clean the radiator cooling fins.
- Straighten any damaged cooling fins.

RADIATOR SURGE TANK REPLACEMENT (L83 L86)

Fig. 43: Radiator Surge Tank (L83, L86)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures	
1. Drain the cooling system. Refer to **Cooling System Draining and Filling (Vac N Fill L83 L86)Cooling System Draining and Filling (Static Fill L83 L86)**.	
2. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .	

Callout	Component Name
3. Remove the radiator surge tank inlet hoses from the radiator surge tank. Refer to **Radiator Surge Tank Inlet Hose Replacement (Surge Tank To Radiator L83 L86)Radiator Surge Tank Inlet Hose Replacement (Surge Tank To Water Outlet L83 L86)**. 4. Remove the radiator outlet hose from the radiator surge tank. Refer to **Radiator Outlet Hose Replacement (L83 L86)**.	
1	Surge Tank Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
2	Surge Tank Nut **Tighten** 10 N.m (89 lb in)
3	Surge Tank **Procedures** 1. Fill the cooling system to the proper level. 2. Inspect the cooing system for leaks.

RADIATOR SURGE TANK REPLACEMENT (L96)

Fig. 44: Radiator Surge Tank
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Remove Radiator Surge Tank Inlet Hose @ Radiator Surge Tank -**Radiator Surge Tank Inlet Hose Replacement (L96)** 2. Remove Radiator Surge Tank Overflow Hose @ Radiator Surge Tank -**Radiator Surge Tank Overflow Hose Replacement (L96)** 3. Remove Radiator Surge Tank Outlet Hose @ Radiator Surge Tank -**Radiator Surge Tank Outlet Hose Replacement (L96)**	
1	Surge Tank Bolt **CAUTION:**

Callout	Component Name
	Refer to **Fastener Caution** . **Tighten** 10 N.m (89 lb in)
2	Surge Tank Nut **Tighten** 10 N.m (89 lb in)
3	Surge Tank **Procedures** 1. Fill the cooling system to the proper level. 2. Inspect the cooing system for leaks.

RADIATOR SURGE TANK INLET HOSE REPLACEMENT (SURGE TANK TO RADIATOR L83 L86)

Fig. 45: Radiator Surge Tank Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Drain the cooling system. Refer to **Cooling System Draining and Filling (Vac N Fill L83 L86)Cooling System Draining and Filling (Static Fill L83 L86)**.	
1	Radiator Surge Tank Inlet Hose Clamps (Qty: 2) **Procedure** Using **BO-38185** hose clamp pliers, reposition the radiator surge tank inlet hose clamps. **Special Tools** **BO-38185** Hose Clamp Pliers For equivalent regional tools, refer to **Special Tools**.

Callout	Component Name
2	Radiator Surge Tank Inlet Hose **Procedures** 1. Fill the cooling system to the proper level. 2. Inspect the cooing system for leaks.

RADIATOR SURGE TANK INLET HOSE REPLACEMENT (SURGE TANK TO WATER OUTLET L83 L86)

Fig. 46: Radiator Surge Tank Inlet Hose (Surge Tank To Water Outlet L83, L86)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Callout	Component Name
CAUTION: **Use caution when removing the hose from the thermostat housing. The plastic thermostat housing may break if excessive force is used.**	**Preliminary Procedure** 1. Drain the cooling system. Refer to **Cooling System Draining and Filling (Vac N Fill L83 L86)Cooling System Draining and Filling (Static Fill L83 L86)**. 2. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)** **Air Cleaner Outlet Duct Replacement (Cadillac)** .
1	Radiator Surge Tank Inlet Hose Clamps (Qty: 2) **Procedure** Using **BO-38185** hose clamp pliers, reposition the radiator surge tank inlet hose clamps. **Special Tools** **BO-38185** Hose Clamp Pliers For equivalent regional tools, refer to **Special Tools**.
2	Radiator Surge Tank Inlet Hose Retainers (Qty: 2) **Procedure** Remove radiator surge tank inlet hose from retainers.
3	Radiator Surge Tank Inlet Hose **Procedures** 1. Fill the cooling system to the proper level. 2. Inspect the cooing system for leaks.

RADIATOR SURGE TANK INLET HOSE REPLACEMENT (L96)

Fig. 47: Radiator Surge Tank Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Drain the cooling system. **Cooling System Draining and Filling (Static Fill L96)Cooling System Draining and Filling (Vac N Fill L96)**	
1	Radiator Surge Tank Inlet Hose Clamp (Qty: 2) **Procedure** Disengage tension on the radiator surge tank inlet hose clamps using **BO-38185** hose clamp pliers and remove the radiator surge tank inlet hose and clamps. **Special Tools** **BO-38185** Hose Clamp Pliers For equivalent regional tools, refer to **Special Tools**.

Callout	Component Name
2	Radiator Surge Tank Inlet Hose **Procedures** 1. Fill the engine cooling system to the proper level. **Cooling System Draining and Filling (Static Fill L96)Cooling System Draining and Filling (Vac N Fill L96)** 2. Inspect the cooling system for leaks. **Cooling System Leak Testing (L83, L86)** 3. Install the air cleaner assembly. **Air Cleaner Assembly Replacement**

RADIATOR SURGE TANK OUTLET HOSE REPLACEMENT (L96)

Removal Procedure

1. Drain the cooling system. **Cooling System Draining and Filling (Static Fill L96)Cooling System Draining and Filling (Vac N Fill L96)**.
2. Remove the air cleaner assembly. **Air Cleaner Assembly Replacement** .

Fig. 48: Radiator Surge Tank Outlet Hose Clamp
Courtesy of GENERAL MOTORS COMPANY

3. Disengage Radiator Surge Tank Outlet Hose Clamp@Radiator Surge Tank. **Hose Clamp Replacement Guidelines - Spring Type**
4. Remove Radiator Surge Tank Outlet Hose@Radiator Surge Tank.
5. Disengage Radiator Surge Tank Outlet Hose Clamp@Engine Coolant Thermostat Housing.**Hose Clamp Replacement Guidelines - Spring Type**
6. Remove Radiator Surge Tank Outlet Hose@ Engine Coolant Thermostat Housing.
7. Disconnect the quick connect at the heater core outlet pipe (4).
8. Remove the radiator surge tank outlet hose (1) from the vehicle.

Installation Procedure

Fig. 49: Radiator Surge Tank Outlet Hose Clamp
Courtesy of GENERAL MOTORS COMPANY

1. Install the radiator surge tank outlet hose (1).

2. Connect the quick connect at the heater core outlet pipe (4).
3. Install Radiator Surge Tank Outlet Hose@Radiator Surge Tank(3).
4. Engage Radiator Surge Tank Outlet Hose Clamp@Radiator Surge Tank. **Hose Clamp Replacement Guidelines - Spring Type**
5. Install Radiator Surge Tank Outlet Hose@ Engine Coolant Thermostat Housing(2).
6. Engage Radiator Surge Tank Outlet Hose Clamp@Engine Coolant Thermostat Housing. **Hose Clamp Replacement Guidelines - Spring Type**
7. Install the air cleaner assembly. **Air Cleaner Assembly Replacement** .
8. Fill the engine cooling system to the proper level. **Cooling System Draining and Filling (Static Fill L96)Cooling System Draining and Filling (Vac N Fill L96)**.
9. Inspect the cooling system for leaks. **Cooling System Leak Testing (L96)**.

RADIATOR SURGE TANK OVERFLOW HOSE REPLACEMENT (L96)

Fig. 50: Radiator Surge Tank Overflow Hose
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure 1. Drain the cooling system. **Cooling System Draining and Filling (Static Fill L96)Cooling System Draining and Filling (Vac N Fill L96)**. 2. **Intake Manifold Cover Replacement** 3. **Air Cleaner Resonator Outlet Duct Replacement**	
1	Radiator Surge Tank Overflow Hose Clamp (Qty: 2) **Procedure** **Hose Clamp Replacement Guidelines - Spring Type**
2	Radiator Surge Tank Overflow Hose **Procedures** 1. Fill the engine cooling system to the proper level. **Cooling System Draining and Filling (Static Fill L96)Cooling System Draining and Filling (Vac N Fill L96)** 2. Inspect the cooling system for leaks. **Cooling System Leak Testing (L96)**

RADIATOR INLET HOSE REPLACEMENT (L83 L86)

Fig. 51: Radiator Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure 1. Drain the cooling system. Refer to **Cooling System Draining and Filling (Vac N Fill L83 L86)Cooling System Draining and Filling (Static Fill L83 L86)**. 2. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)** **Air Cleaner Outlet Duct Replacement (Cadillac)** .	
1	Radiator Inlet Hose Clamps (Qty: 2) **Procedure** Using **BO-38185** hose clamp pliers, reposition the radiator inlet hose clamps.

Callout	Component Name
	Special Tools **BO-38185** Hose Clamp Pliers For equivalent regional tools, refer to **Special Tools**.
2	Radiator Inlet Hose **Procedures** 1. Fill the cooling system to the proper level. 2. Inspect the cooing system for leaks.

RADIATOR INLET HOSE REPLACEMENT (L96)

Fig. 52: Radiator Inlet Hose

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure 1. Drain the cooling system **Cooling System Draining and Filling (Static Fill L96)Cooling System Draining and Filling (Vac N Fill L96)** 2. Remove Air Cleaner Assembly -**Air Cleaner Assembly Replacement**	
1	Radiator Inlet Hose Clamp (Qty: 2) **Hose Clamp Replacement Guidelines - Spring Type**
2	Radiator Inlet Hose Retainer (Qty: 2)
3	Radiator Inlet Hose **Procedures** 1. Fill the cooling system to the proper level. **Cooling System Draining and Filling (Static Fill L96)Cooling System Draining and Filling (Vac N Fill L96)** 2. Inspect the cooing system for leaks.

RADIATOR OUTLET HOSE REPLACEMENT (L83 L86)

Fig. 53: Radiator Outlet Hose Retainers
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Drain the cooling system. Refer to **Cooling System Draining and Filling (Vac N Fill L83 L86)Cooling System Draining and Filling (Static Fill L83 L86)**. 2. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)** **Air Cleaner Outlet Duct Replacement (Cadillac)** .	
1	Radiator Outlet Hose Clamp (Qty: 3) **Procedure** Using **BO-38185** hose clamp pliers, reposition the radiator outlet hose clamps.

Callout	Component Name
	Special Tools **BO-38185** Hose Clamp Pliers For equivalent regional tools, refer to **Special Tools**.
2	Radiator Outlet Hose Retainer (Qty: 3) **Procedure** Remove the radiator outlet hose retainers from the engine coolant fan rear shroud and the radiator outlet pipe bracket.
3	Radiator Outlet Hose **Procedure** 1. Fill the cooling system to the proper level. 2. Inspect the cooing system for leaks.

RADIATOR OUTLET HOSE REPLACEMENT (L96)

Fig. 54: Radiator Outlet Hose
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Drain the cooling system. Refer to **Cooling System Draining and Filling (Static Fill L96)Cooling System Draining and Filling (Vac N Fill L96)**. 2. Remove the air cleaner resonator outlet duct. **Air Cleaner Resonator Outlet Duct Replacement** . 3. Remove the air cleaner assembly. **Air Cleaner Assembly Replacement**	
1	Radiator Outlet Hose Clamp **Procedure** Disengage tension on the radiator outlet hose clamp using **BO-38185** hose clamp pliers. **Hose Clamp Replacement**

Callout	Component Name
	Guidelines - Spring Type **Special Tools** **BO-38185** Hose Clamp Pliers For equivalent regional tools, refer to Special Tools.
2	Radiator Outlet Hose **Procedure** 1. Fill the engine cooling system to the proper level. Cooling System Draining and Filling (Static Fill L96)Cooling System Draining and Filling (Vac N Fill L96). 2. Inspect the cooling system for leaks. Cooling System Leak Testing (L96).

FAN BLADE REPLACEMENT (L83 L86)

Fig. 55: Engine Coolant Fan
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove engine coolant fan rear shroud. Refer to **Engine Coolant Fan Rear Shroud Replacement (L96)**. **NOTE:** **The left and right side fan blades are different. Ensure you install the**	

Callout	Component Name
left or right side fan blades on the proper side.	
1	Fan Blade Fastener (Qty: 6) Three Per Motor **CAUTION:** **Refer to Fastener Caution .**
2	Fan Blade (Qty: 2)

ENGINE COOLANT THERMOSTAT HOUSING REPLACEMENT (L83, L86)

Fig. 56: Engine Coolant Thermostat Housing (L83 With Thermostat)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
CAUTION: **Use caution when removing the hose from the thermostat housing. The plastic thermostat**	

Callout	Component Name
housing may break if excessive force is used. **Preliminary Procedures** 1. Drain the cooling system. Refer to **Cooling System Draining and Filling (Vac N Fill L83 L86)Cooling System Draining and Filling (Static Fill L83 L86)**. 2. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)** **Air Cleaner Outlet Duct Replacement (Cadillac)** . 3. Disconnect the radiator inlet hose from the thermostat housing. Refer to **Radiator Inlet Hose Replacement (L83 L86)**. 4. Disconnect the radiator surge tank inlet hose from the thermostat housing. Refer to **Radiator Surge Tank Inlet Hose Replacement (Surge Tank To Radiator L83 L86)Radiator Surge Tank Inlet Hose Replacement (Surge Tank To Water Outlet L83 L86)**.	
1	Thermostat Housing Bolt (Qty: 3) **CAUTION:** **Refer to Fastener Caution .** **Procedure** Remove the thermostat housing bolts. **Tighten** 10 N.m (89 lb in)
2	Thermostat Housing
3	Thermostat Housing Gasket **Procedure** Install a new thermostat gasket.

ENGINE COOLANT THERMOSTAT HOUSING REPLACEMENT (L96)

Fig. 57: Engine Coolant Thermostat Housing
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. **Cooling System Draining and Filling (Static Fill L96)Cooling System Draining and Filling (Vac N Fill L96)** 2. **Air Cleaner Resonator Outlet Duct Replacement** 3. Disconnect Radiator Outlet Hose@Engine Coolant Thermostat Housing -**Radiator Outlet Hose Replacement (L96)**	
1	Engine Coolant Thermostat Housing Bolt (Qty: 2) **CAUTION:**

Callout	Component Name
	Refer to **Fastener Caution** . **Tighten** 15 N.m (11 lb ft)
2	Engine Coolant Thermostat Housing Seal
3	Engine Coolant Thermostat Housing

ENGINE COOLANT THERMOSTAT REPLACEMENT (L96)

Fig. 58: Engine Coolant Thermostat

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure **Engine Coolant Thermostat Housing Replacement (L96)**	
1	**NOTE:** **Install a NEW engine coolant thermostat housing seal.** Engine Coolant Thermostat Housing Seal
2	Engine Coolant Thermostat

ENGINE COOLANT MANIFOLD REPLACEMENT (L83, L86)

Fig. 59: Engine Coolant Manifold
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Preliminary Procedures

1. Drain the cooling system. Refer to **Cooling System Draining and Filling (Vac N Fill L83 L86)Cooling System Draining and Filling (Static Fill L83 L86)**.
2. Disconnect the engine coolant temperature sensor.
3. Remove the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Accessory** .
4. Remove the generator and drive belt tensioner bracket. Refer to **Generator Bracket Replacement** .
5. Disconnect the radiator surge tank inlet hose from the engine coolant manifold. Refer to **Radiator Surge Tank Inlet Hose Replacement (Surge Tank To Radiator L83 L86)Radiator Surge Tank Inlet Hose Replacement (Surge Tank To Water Outlet**

Callout	Component Name
	L83 L86). 6. Disconnect the radiator inlet and outlet hoses from the engine coolant manifold. Refer to, and **Radiator Outlet Hose Replacement (L83 L86)**. 7. Disconnect the heater inlet and outlet hoses from the engine coolant manifold. Refer to **Heater Inlet Hose Replacement (L83 L86)** , and **Heater Outlet Hose Replacement (L83 L86)** . 8. Separate the engine electrical wiring harness from the engine coolant manifold and reposition the harness.
1	Engine Coolant Manifold Fastener (Qty: 7) **CAUTION:** **Refer to Fastener Caution .** **Procedure** Clean the fastener threads and apply thread locker. Refer to **Adhesives, Fluids, Lubricants, and Sealers**. **NOTE:** **Tighten the water pump bolts in the sequence shown.** **Tighten** 25 N.m (18 lb ft)
2	Engine Coolant Manifold Gaskets **Procedure** Install a new engine coolant manifold gaskets.
3	Engine Coolant Manifold **Procedure**

Callout	Component Name
	If replacing the engine coolant manifold perform the following: 1. Engine Coolant Manifold Disassemble 2. Engine Coolant Manifold Cleaning and Inspection 3. Engine Coolant Manifold Assemble

ENGINE COOLANT AIR BLEED PIPE REPLACEMENT (L96)

Fig. 60: Engine Coolant Air Bleed Pipe
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Callout	Component Name
Preliminary Procedure Disconnect Radiator Surge Tank Overflow Hose @Engine Coolant Air Bleed Pipe -**Radiator Surge Tank Overflow Hose Replacement (L96)**	
1	Engine Coolant Air Bleed Pipe Bolt (Qty: 2) **CAUTION:** **Refer to Fastener Caution .** **Tighten** 12 N.m (106 lb in)
2	Engine Coolant Air Bleed Pipe O-Ring (Qty: 2) **Procedure** Install a NEW O-ring seal.
3	Engine Coolant Air Bleed Pipe

WATER PUMP REPLACEMENT (L83, L86)

Fig. 61: Water Pump
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Drain the cooling system. Refer to **Cooling System Draining and Filling (Vac N Fill L83 L86)Cooling System Draining and Filling (Static Fill L83 L86)**. 2. Remove the drive belt. Refer to **Drive Belt Replacement - Accessory** .	
1	Water Pump Bolt (Qty: 6) **CAUTION:**

Callout	Component Name
	Refer to **Fastener Caution** . **Procedure** Remove the water pump bolts. **Tighten** 10 N.m (89 lb in)
2	Water Pump
3	Water Pump Gasket **Procedure** Install a new water pump gasket.

WATER PUMP REPLACEMENT (L96)

Removal Procedure

1. Drain the cooling system. **Cooling System Draining and Filling (Static Fill L96)Cooling System Draining and Filling (Vac N Fill L96)**
2. Remove Air Cleaner Resonator Outlet Duct.**Air Cleaner Resonator Outlet Duct Replacement** .
3. Remove Drive Belt - Accessory. **Drive Belt Replacement - Accessory** .

Fig. 62: Hoses
Courtesy of GENERAL MOTORS COMPANY

4. Disconnect Radiator Inlet Hose (1).
5. Disconnect Heater Inlet Hose (2).
6. Disconnect Radiator Surge Tank Inlet Hose (3).

7. Disconnect Radiator Outlet Hose (4)

Fig. 63: Water Pump Bolt
Courtesy of GENERAL MOTORS COMPANY

8. Remove Water Pump Bolt (1).

9. Remove Water Pump (3).
10. Remove Water Pump Gasket (2) and DISCARD
11. Transfer components as necessary.

Installation Procedure

CAUTION: **DO NOT use cooling system seal tabs, or similar compounds, unless otherwise instructed. The use of cooling system seal tabs, or similar compounds, may restrict coolant flow through the passages of the cooling system or the engine components. Restricted coolant flow may cause engine overheating and/or damage to the cooling system or the engine components/assembly.**

NOTE: **All gaskets surfaces are to be free of oil or other foreign material during assembly.**

1. Carefully clean the water pump sealing surfaces.

Fig. 64: Water Pump Bolt
Courtesy of GENERAL MOTORS COMPANY

2. Install a NEW water pump gasket (2).
3. Install Water Pump (3).

CAUTION: Refer to Fastener Caution .

4. Install Water Pump Bolt (1) and tighten
   - First Pass 15 N.m (11 lb ft)
   - Second Pass 30 N.m (22 lb ft)

Fig. 65: Hoses
Courtesy of GENERAL MOTORS COMPANY

5. Connect Radiator Outlet Hose (4)
6. Connect Radiator Surge Tank Inlet Hose (3)
7. Connect Heater Inlet Hose (2)
8. Connect Radiator Inlet Hose (1)
9. Install Drive Belt - Accessory. **Drive Belt Replacement - Accessory**
10. Install Air Cleaner Resonator Outlet Duct. **Air Cleaner Resonator Outlet Duct Replacement**
11. Fill the cooling system to the proper level. **Cooling System Draining and Filling (Static Fill L96)Cooling System Draining and Filling (Vac N Fill L96)**

RADIATOR DRAIN COCK REPLACEMENT (L83 L86)

Fig. 66: Radiator Drain Cock (L83 L86)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** . 2. Place a drain pan under the radiator drain cock. 3. Remove the right side front wheelhouse liner. Refer to **Front Wheelhouse Liner Replacement - Right Side (Cadillac)** **Front Wheelhouse Liner Replacement - Right Side (Chevrolet)** **Front Wheelhouse Liner Replacement - Right Side (GMC)** . 4. Attach a rubber hose to the radiator drain port to guide the coolant into the drain pan 5. Drain the engine coolant. Refer to **Cooling System Draining and Filling (Vac N Fill L83 L86)**Cooling System Draining and Filling **(Static Fill L83 L86)**.	
1	Radiator Drain Cock **CAUTION:** **Refer to** **Fastener Caution** **.** **Procedures** 1. Fill the cooling system to the proper level. 2. Inspect the cooing system for leaks.

ENGINE COOLANT FAN REAR SHROUD REPLACEMENT (L83, L86)

Removal Procedure

1. Remove the air cleaner outlet duct. **Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)** **Air Cleaner Outlet Duct Replacement (Cadillac)**
2. Remove the front compartment front sight shield. **Front Compartment Front Sight Shield Replacement (GMC)** **Front Compartment Front Sight Shield Replacement (Chevrolet)** **Front Compartment Front Sight Shield Replacement (Cadillac)**

Fig. 67: Radiator Surge Tank Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

3. Unclip the radiator surge tank inlet hose (3) from the engine coolant fan rear shroud and reposition out of the way. **Radiator Surge Tank Inlet Hose Replacement (Surge Tank To Radiator L83 L86)Radiator Surge Tank Inlet Hose Replacement (Surge Tank To Water Outlet L83 L86)**
4. Unclip the electrical harness from the engine coolant fan rear shroud.
5. Disconnect the electrical connectors from the engine coolant fans and reposition out of the way.

Fig. 68: Radiator Outlet Hose Retainers
Courtesy of GENERAL MOTORS COMPANY

6. Unclip the radiator outlet hose retainers (2) from the engine coolant fan rear shroud. **Radiator Outlet Hose Replacement (L83 L86)**
7. Remove the transmission fluid cooler inlet and outlet pipe from the radiator. **Transmission Fluid Cooler Inlet and Outlet Pipe Replacement (L83 MYC)** **Transmission Fluid Cooler Inlet and Outlet Pipe Replacement (L86 M5U)**
8. Unclip the transmission fluid cooler inlet and outlet pipe from the engine coolant fan rear shroud.
9. Remove the engine oil cooler hose from the radiator. **Engine Oil Cooler Hose Replacement**
10. Unclip the engine oil cooler hose from the engine coolant fan rear shroud.

Fig. 69: Engine Coolant Fan Rear Shroud Bolts
Courtesy of GENERAL MOTORS COMPANY

11. Remove the engine coolant fan rear shroud bolts (1).

Fig. 70: Engine Coolant Fan Rear Shroud
Courtesy of GENERAL MOTORS COMPANY

12. Remove the engine coolant fan rear shroud (1) from the vehicle.

Fig. 71: Engine Coolant Fan
Courtesy of GENERAL MOTORS COMPANY

13. Remove the fan blade (2) from the engine coolant fan rear shroud. **Fan Blade Replacement (L83 L86)**

Installation Procedure

Fig. 72: Engine Coolant Fan
Courtesy of GENERAL MOTORS COMPANY

1. Install the fan blade (2) to the engine coolant fan rear shroud. **Fan Blade Replacement (L83 L86)**

Fig. 73: Engine Coolant Fan Rear Shroud
Courtesy of GENERAL MOTORS COMPANY

2. Install the engine coolant fan rear shroud (1) to the radiator.

Fig. 74: Engine Coolant Fan Rear Shroud Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

3. Install the engine coolant fan rear fan shroud bolts (1) and tighten to 7 N.m (62 lb in).
4. Install the engine oil cooler hose to the radiator. **Engine Oil Cooler Hose Replacement**

5. Install the engine oil cooler hose to the engine coolant fan rear shroud.
6. Install the transmission fluid cooler inlet and outlet pipe to the radiator. **Transmission Fluid Cooler Inlet and Outlet Pipe Replacement (L83 MYC)** **Transmission Fluid Cooler Inlet and Outlet Pipe Replacement (L86 M5U)**
7. Install the transmission fluid cooler inlet and outlet pipe to the engine coolant fan rear shroud.

Fig. 75: Radiator Outlet Hose Retainers
Courtesy of GENERAL MOTORS COMPANY

8. Install the radiator outlet hose retainers (2) to the engine coolant fan rear shroud. **Radiator Outlet Hose Replacement (L83 L86)**
9. Connect the electrical connectors to the engine coolant fans.
10. Install the electrical harness to the engine coolant fan rear shroud.

Fig. 76: Radiator Surge Tank Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

11. Install the radiator surge tank inlet hose (3) to the engine coolant fan rear shroud. **Radiator Surge Tank Inlet Hose Replacement (Surge Tank To Radiator L83 L86)Radiator Surge Tank Inlet Hose Replacement (Surge Tank To Water Outlet L83 L86)**
12. Install the front compartment front sight shield. **Front Compartment Front Sight Shield Replacement (GMC)** **Front Compartment Front Sight Shield Replacement (Chevrolet)** **Front Compartment Front Sight Shield Replacement (Cadillac)**
13. Install the air cleaner outlet duct. **Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)** **Air Cleaner Outlet Duct Replacement (Cadillac)**

ENGINE COOLANT FAN REAR SHROUD REPLACEMENT (L96)

Removal Procedure

1. Remove Air Cleaner Resonator Outlet Duct -**Air Cleaner Resonator Outlet Duct Replacement**

2. Remove Air Cleaner Assembly -**Air Cleaner Assembly Replacement**
3. Disconnect Engine Oil Cooler Hose@Engine Coolant Fan Rear Shroud -**Engine Oil Cooler Hose Replacement**

Fig. 77: Radiator Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

4. Disconnect Radiator Inlet Hose (1) @Radiator **Radiator Inlet Hose Replacement (L96)**

Fig. 78: Radiator Outlet Hose
Courtesy of GENERAL MOTORS COMPANY

5. Disconnect Radiator Outlet Hose (1) @Radiator **Radiator Outlet Hose Replacement (L96)**
6. Without disconnecting the transmission fluid cooler lines at the radiator, unclip the retainers at the shroud and position the lines out of the way.

Fig. 79: Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

7. Disconnect Electrical Connector (1) @Cooling Fan

Fig. 80: Engine Coolant Fan Shroud Bolt
Courtesy of GENERAL MOTORS COMPANY

8. Remove Engine Coolant Fan Shroud Bolt (1)

Fig. 81: Engine Coolant Fan Rear Shroud
Courtesy of GENERAL MOTORS COMPANY

9. Remove Engine Coolant Fan Rear Shroud (1)

Installation Procedure

Fig. 82: Engine Coolant Fan Rear Shroud
Courtesy of GENERAL MOTORS COMPANY

1. Install Engine Coolant Fan Rear Shroud (1).

Fig. 83: Engine Coolant Fan Shroud Bolt
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

2. Install Engine Coolant Fan Shroud Bolt (1) and tighten 17 N.m (13 lb ft)

Fig. 84: Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

3. Connect Electrical Connector (1) @Cooling Fan
4. Reposition Transmission Fluid Cooler Lines @Radiator

Fig. 85: Radiator Outlet Hose
Courtesy of GENERAL MOTORS COMPANY

5. Connect Radiator Outlet Hose (1) @Radiator **Radiator Outlet Hose Replacement (L96)**

Fig. 86: Radiator Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

6. Connect Radiator Inlet Hose (1) @Radiator **Radiator Inlet Hose Replacement (L96)**
7. Connect Engine Oil Cooler Hose@Engine Coolant Fan Rear Shroud **Engine Oil Cooler Hose Replacement**
8. Install Air Cleaner Assembly **Air Cleaner Assembly Replacement**
9. Install Air Cleaner Resonator Outlet Duct **Air Cleaner Resonator Outlet Duct Replacement**

RADIATOR REPLACEMENT (L83 L86)

Removal Procedure

1. Drain the cooling system. Refer to **Cooling System Draining and Filling (Vac N Fill L83 L86)Cooling System Draining and Filling (Static Fill L83 L86)**.
2. Remove the engine coolant fan rear shroud. Refer to **Engine Coolant Fan Rear Shroud Replacement (L83, L86)**.

Fig. 87: Radiator Air Upper Baffle And Deflector
Courtesy of GENERAL MOTORS COMPANY

3. Remove the radiator air upper baffle and deflector (1). Refer to **Radiator Air Upper Baffle and Deflector Replacement (Top of Radiator L83 L86)Radiator Air Upper Baffle and Deflector Replacement (Right of Radiator L83 L86)**.

Fig. 88: Radiator Surge Tank Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

4. Remove the radiator surge tank inlet hose (2) from the radiator. Refer to **Radiator Surge Tank Inlet Hose Replacement (Surge Tank To Radiator L83 L86)Radiator Surge Tank Inlet Hose Replacement (Surge Tank To Water Outlet L83 L86)**.

Fig. 89: Radiator Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

5. Remove the radiator inlet hose (2) from the radiator. Refer to **Radiator Inlet Hose Replacement (L83 L86)**.

Fig. 90: Radiator Outlet Hose Retainers
Courtesy of GENERAL MOTORS COMPANY

6. Remove the radiator outlet hose (3) from the radiator. Refer to **Radiator Outlet Hose Replacement (L83 L86)**.
7. Remove the transmission fluid auxiliary cooler inlet pipe. Refer to **Transmission Fluid Auxiliary Cooler Inlet Pipe Replacement (L83 L86)** .
8. Remove the transmission fluid auxiliary cooler outlet pipe. Refer to **Transmission Fluid Auxiliary Cooler Outlet Pipe Replacement (L83 L86)** .

Fig. 91: Air Conditioning Condenser Bracket
Courtesy of GENERAL MOTORS COMPANY

9. Remove the air conditioning condenser bracket (2) from the radiator. Refer to **Air Conditioning Condenser Bracket Replacement** .
10. Without disconnecting the air conditioning compressor and condenser hoses, carefully lift the air conditioning condenser assembly off the radiator and position out of the way.

Fig. 92: Radiator
Courtesy of GENERAL MOTORS COMPANY

11. Tilt the radiator rearward and release the radiator air lower baffle retaining tabs from the radiator. Refer to **Radiator Air Lower Baffle Replacement (L83 L86)**.
12. Remove the radiator (1) from the vehicle.
13. If replacing the radiator transfer the components as necessary.

Installation Procedure

Fig. 93: Radiator
Courtesy of GENERAL MOTORS COMPANY

1. Install the radiator (1) to the vehicle.
2. Ensure the radiator air lower baffle retaining tabs are engaged to the radiator. Refer to **Radiator Air Lower Baffle Replacement (L83 L86)**.
3. Carefully install the air conditioning condenser assembly to the radiator.

Fig. 94: Air Conditioning Condenser Bracket
Courtesy of GENERAL MOTORS COMPANY

4. Install the air conditioning condenser bracket (2) to the radiator. Refer to **Air Conditioning Condenser Bracket Replacement** .
5. Install the transmission fluid auxiliary cooler outlet pipe. Refer to **Transmission Fluid Auxiliary Cooler Outlet Pipe Replacement (L83 L86)** .
6. Install the transmission fluid auxiliary cooler inlet pipe. Refer to **Transmission Fluid Auxiliary Cooler Inlet Pipe Replacement (L83 L86)** .

Fig. 95: Radiator Outlet Hose Retainers
Courtesy of GENERAL MOTORS COMPANY

7. Install the radiator outlet hose (3) to the radiator. Refer to **Radiator Outlet Hose Replacement (L83 L86)**.

Fig. 96: Radiator Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

8. Install the radiator inlet hose (2) to the radiator. Refer to **Radiator Inlet Hose Replacement (L83 L86)**.

Fig. 97: Radiator Surge Tank Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

9. Install the radiator surge tank inlet hose (2) to the radiator. Refer to **Radiator Surge Tank Inlet Hose Replacement (Surge Tank To Radiator L83 L86)Radiator Surge Tank Inlet Hose Replacement (Surge Tank To Water Outlet L83 L86)**.

Fig. 98: Radiator Air Upper Baffle And Deflector
Courtesy of GENERAL MOTORS COMPANY

10. Install the radiator air upper baffle and deflector (1). Refer to **Radiator Air Upper Baffle and Deflector Replacement (Top of Radiator L83 L86)Radiator Air Upper Baffle and Deflector Replacement (Right of Radiator L83 L86)**.
11. Install the engine coolant fan rear shroud. Refer to **Engine Coolant Fan Rear Shroud Replacement (L83, L86)**.
12. Fill the cooling system to the proper level. Refer to **Cooling System Draining and Filling (Vac N Fill L83 L86)Cooling System Draining and Filling (Static Fill L83 L86)**.
13. Inspect the cooling system for leaks. Refer to **Cooling System Leak Testing (L83, L86)**.

RADIATOR REPLACEMENT (L96)

Removal Procedure

1. Drain the cooling system. **Cooling System Draining and Filling (Static Fill L96)Cooling System Draining and Filling (Vac N Fill L96)**

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Fig. 99: Radiator Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

2. Disconnect Radiator Inlet Hose (1) @Radiator -**Radiator Inlet Hose Replacement (L96)**

Fig. 100: Radiator Outlet Hose
Courtesy of GENERAL MOTORS COMPANY

3. Disconnect Radiator Outlet Hose (1) @Radiator -**Radiator Outlet Hose Replacement (L96)**

Fig. 101: Radiator Surge Tank Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

4. Disconnect Radiator Surge Tank Inlet Hose (2) @Radiator -**Radiator Surge Tank Inlet Hose Replacement (L96)**

Fig. 102: Transmission Fluid Auxiliary Cooler Inlet Pipe
Courtesy of GENERAL MOTORS COMPANY

5. Remove Transmission Fluid Auxiliary Cooler Inlet Pipe (1).**Transmission Fluid Auxiliary Cooler Inlet Pipe Replacement (L83 L86)**
6. Remove Transmission Fluid Cooler Inlet and Outlet Pipe@Radiator -**Transmission Fluid Cooler Inlet and Outlet Pipe Replacement (L83 MYC)** **Transmission Fluid Cooler Inlet and Outlet Pipe Replacement (L86 M5U)**
7. Remove Engine Oil Cooler Hose@Radiator -**Engine Oil Cooler Hose Replacement**

Fig. 103: Engine Coolant Fan Rear Shroud
Courtesy of GENERAL MOTORS COMPANY

8. Remove Engine Coolant Fan Rear Shroud (1).**Engine Coolant Fan Rear Shroud Replacement (L96)**
9. Remove Radiator Air Upper Baffle -**Radiator Air Upper Baffle and Deflector Replacement (Top of Radiator L83 L86)Radiator Air Upper Baffle and Deflector Replacement (Right of Radiator L83 L86)**
10. Disconnect Air Conditioning Evaporator Tube@Radiator -**Air Conditioning Evaporator Tube Replacement (L96)**
11. Disconnect Air Conditioning Condenser Hose@Radiator -**Air Conditioning Condenser Hose Replacement (L96)**
12. Remove Air Conditioning Condenser Bracket -**Air Conditioning Condenser Bracket Replacement**

Fig. 104: Radiator Upper Mount Bracket Bolt
Courtesy of GENERAL MOTORS COMPANY

13. Remove Radiator Upper Mount Bracket Bolt (1)
14. Tilt the radiator rearward and release the condenser retaining tabs.
15. Lift the condenser off of the radiator and set aside.

Fig. 105: Radiator
Courtesy of GENERAL MOTORS COMPANY

16. Remove Radiator (1).
17. If replacing the radiator transfer the components as necessary.

Installation Procedure

Fig. 106: Radiator
Courtesy of GENERAL MOTORS COMPANY

1. Radiator (1).
2. Connect the condenser to the radiator.

Fig. 107: Radiator Upper Mount Bracket Bolt
Courtesy of GENERAL MOTORS COMPANY

3. Install Radiator Upper Mount Bracket Bolt (1) and tighten 25 N.m (18 lb ft)
4. Install Air Conditioning Condenser Bracket -**Air Conditioning Condenser Bracket Replacement**
5. Connect Air Conditioning Condenser Hose@Radiator -**Air Conditioning Condenser Hose Replacement (L96)**
6. Connect Air Conditioning Evaporator Tube@Radiator -**Air Conditioning Evaporator Tube Replacement (L96)**
7. Install Radiator Air Upper Baffle -**Radiator Air Upper Baffle and Deflector Replacement (Top of Radiator L83 L86)Radiator Air Upper Baffle and Deflector Replacement (Right of Radiator L83 L86)**

Fig. 108: Engine Coolant Fan Rear Shroud
Courtesy of GENERAL MOTORS COMPANY

8. Install Engine Coolant Fan Rear Shroud -**Engine Coolant Fan Rear Shroud Replacement (L96)**
9. Install Engine Oil Cooler Hose@Radiator -**Engine Oil Cooler Hose Replacement**
10. Install Transmission Fluid Cooler Inlet and Outlet Pipe@Radiator -**Transmission Fluid Cooler Inlet and Outlet Pipe Replacement (L83 MYC)** **Transmission Fluid Cooler Inlet and Outlet Pipe Replacement (L86 M5U)**

Fig. 109: Transmission Fluid Auxiliary Cooler Inlet Pipe
Courtesy of GENERAL MOTORS COMPANY

11. Install Transmission Fluid Auxiliary Cooler Inlet Pipe -**Transmission Fluid Auxiliary Cooler Inlet Pipe Replacement (L83 L86)**

Fig. 110: Radiator Surge Tank Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

12. Connect Radiator Surge Tank Inlet Hose (2) @Radiator -**Radiator Surge Tank Inlet Hose Replacement (L96)**

Fig. 111: Radiator Outlet Hose
Courtesy of GENERAL MOTORS COMPANY

13. Connect Radiator Outlet Hose (1) @Radiator -**Radiator Outlet Hose Replacement (L96)**

Fig. 112: Radiator Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

14. Connect Radiator Inlet Hose (1) @Radiator -**Radiator Inlet Hose Replacement (L96)**
15. Fill the cooling system to the proper level. **Cooling System Draining and Filling (Static Fill L96)Cooling System Draining and Filling (Vac N Fill L96)**
16. Inspect the cooling system for leaks. **Cooling System Leak Testing (L96)**

RADIATOR UPPER INSULATOR REPLACEMENT (L96)

Fig. 113: Radiator Upper Insulator
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the front end upper tie bar support. Refer to **Front End Upper Tie Bar Support Replacement** .	
1	Radiator Upper Mount Bracket Bolt (Qty: 2) **CAUTION:** **Refer to Fastener Caution .**

Callout	Component Name
	Tighten 25 N.m (18 lb ft)
2	Radiator Upper Insulator (Qty: 2) **Procedure** Carefully move the top of the radiator rearward to remove the radiator upper insulators.

RADIATOR UPPER INSULATOR REPLACEMENT (L83, L86)

Fig. 114: Radiator Upper Insulator (L83, L86)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Radiator Upper Mount Bracket Bolt (Qty: 2)

Callout	Component Name
	CAUTION: **Refer to** **Fastener Caution .** **Tighten** 25 N.m (18 lb ft)
2	Radiator Upper Insulator <p01> **Procedure** Carefully move the top of the radiator rearward to remove the radiator upper insulators.

RADIATOR LOWER INSULATOR REPLACEMENT (L96)

Fig. 115: Radiator Lower Insulator
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the radiator. Refer to **Radiator Replacement (L96)**.	
1	Radiator Lower Insulator (Qty: 2)

RADIATOR LOWER INSULATOR REPLACEMENT (L83 L86)

Fig. 116: Radiator Lower Insulator (L83 L86)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Callout	Component Name
Preliminary Procedure Reposition the radiator as necessary. Refer to **Radiator Replacement (L83 L86)**.	
1	Radiator Lower Insulator (Qty: 2)

RADIATOR SUPPORT BAFFLE REPLACEMENT (L96)

Fig. 117: Radiator Support Baffle
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .	

Callout	Component Name
2. Unclip the electrical harness retainer from the radiator support baffle and reposition out of the way.	
1	Radiator Support Baffle Retainer (Qty: 6)
2	Radiator Support Baffle

RADIATOR AIR BAFFLE REPLACEMENT - LEFT (L83 L86)

Fig. 118: Radiator Air Baffle - Left (L83, L86)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the air conditioning condenser from the vehicle. Refer to **Air Conditioning Condenser Replacement (L83 L86)** .	

Callout	Component Name
1	Radiator Air Baffle Left **Procedure** Remove the radiator air baffle left from the radiator air lower baffle and remove from the condenser.

RADIATOR AIR BAFFLE REPLACEMENT - RIGHT (L83 L86)

Fig. 119: Radiator Air Baffle - Right (L83, L86)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the air conditioning condenser from the vehicle. Refer to **Air Conditioning Condenser Replacement (L83 L86)** .	

Callout	Component Name
1	Radiator Air Baffle Right **Procedure** Remove the radiator air baffle right from the radiator air lower baffle and remove from the condenser.

RADIATOR AIR LOWER BAFFLE REPLACEMENT (L83 L86)

Fig. 120: Radiator Air Lower Baffle (L83, L86)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Remove the engine coolant fan rear shroud from the vehicle. Refer to **Engine Coolant Fan Rear Shroud Replacement (L83, L86)**.	

Callout	Component Name
2. Remove the front end upper tie bar support. Refer to **Front End Upper Tie Bar Support Replacement** . 3. Raise the condenser and radiator as and assembly (CRA) upward and support CRA above lower tie-bar. 4. Push downward on radiator air lower baffle to remove the left and right radiator air baffle retaining tabs from the radiator air lower baffle. Refer to **Radiator Air Baffle Replacement - Left (L83 L86)**, and **Radiator Air Baffle Replacement - Right (L83 L86)**. **NOTE:** **Some early builds have 1 or 2 tie straps holding the baffle to the radiator at the inner tabs. Cut tie strap before removing baffle.**	
1	Radiator Air Lower Baffle **Procedure** Push each of the four radiator air lower baffle retaining tabs inward to disengage the radiator air lower baffle from the radiator.

RADIATOR AIR LOWER BAFFLE REPLACEMENT (L96)

Fig. 121: Radiator Air Lower Baffle
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure 1. Remove the Front Bumper Impact Bar. Refer to **Front Bumper Impact Bar Replacement (GMC)** **Front Bumper Impact Bar Replacement (Chevrolet)** **Front Bumper Impact Bar Replacement (Cadillac)** .	
1	Radiator Air Lower Baffle Retainer (Qty: 2)
2	Radiator Air Lower Baffle **Procedure** 1. Remove the electrical wiring harness retainer from the radiator air lower baffle and reposition out of the way.

Callout	Component Name
	2. Unclip the transmission fluid auxiliary cooler from the radiator air lower baffle.

RADIATOR AIR UPPER BAFFLE AND DEFLECTOR REPLACEMENT (TOP OF RADIATOR L83 L86)

Fig. 122: Radiator Air Upper Baffle And Deflector
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures	
	1. Remove the front compartment front sight shield. Refer to **Front Compartment Front Sight Shield Replacement (GMC)** **Front Compartment Front Sight Shield Replacement (Chevrolet)** **Front Compartment Front Sight Shield Replacement (Cadillac)** .

Callout	Component Name
2. Remove the front end upper tie bar support. Refer to **Front End Upper Tie Bar Support Replacement** .	
1	Radiator Air Upper Baffle and Deflector **Procedure** Unclip the radiator air upper baffle and deflector from the radiator and lift up to remove.

RADIATOR AIR UPPER BAFFLE AND DEFLECTOR REPLACEMENT (RIGHT OF RADIATOR L83 L86)

Fig. 123: Radiator Air Upper Baffle and Deflector (Right of Radiator L83 L86)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures	

Callout	Component Name
1. Air Cleaner Bracket Replacement 2. Unclip the electrical harness retainer from the radiator air upper baffle and deflector and reposition out of the way.	
1	Radiator Air Upper Baffle and Deflector Retainer (Qty: 6)
2	Radiator Air Upper Baffle and Deflector

RADIATOR AIR SEAL REPLACEMENT (L83 L86)

Fig. 124: Radiator Air Seal
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure	

Callout	Component Name
Remove the headlamp radiator grille mount panel from the vehicle. Refer to **Headlamp and Radiator Grille Mount Panel Replacement** .	
1	Radiator Air Seal Retainer (Qty: 15)
2	Radiator Air Seal

RADIATOR AIR SEAL REPLACEMENT (L96)

Fig. 125: Radiator Air Seal
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the headlamp and radiator grille mount panel. **Headlamp and Radiator Grille Mount Panel Replacement** .	
1	Radiator Air Seal Retainer (Qty: 8)

Callout	Component Name
2	Radiator Air Seal

COOLANT HEATER REPLACEMENT

Fig. 126: Coolant Heater
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure	
1. Drain the cooling system. **Cooling System Draining and Filling (Static Fill L96)Cooling System Draining and Filling (Vac N Fill L96)Cooling System Draining and Filling (Vac N Fill L83 L86)Cooling System Draining and Filling (Static Fill L83 L86)**	
2. If equipped **Front Axle Propeller Shaft Replacement (NPO)** **Front Axle Propeller Shaft Replacement (NQH)** **Front Axle**	

Callout	Component Name
Propeller Shaft Replacement (Heavy Duty)	
1	Coolant Heater Cord **Procedure** Remove Coolant Heater Cord Retaining Clip
2	Coolant Heater **CAUTION:** **Refer to Fastener Caution .** **Tighten** 50 N.m (37 lb ft)

COOLANT HEATER CORD REPLACEMENT

Fig. 127: Coolant Heater Cord
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .	
1	Coolant Heater Cord Connector
2	Coolant Heater Cord Retainers
3	Coolant Heater Cord **Procedure** Note the location and routing of the coolant heater cord prior to removal in order to ensure proper installation.

DESCRIPTION AND OPERATION

COOLING FAN DESCRIPTION AND OPERATION

Cooling Fan Control

The engine cooling fan system is composed of 2 electric cooling fans, fan motors, and a control module. The engine control module (ECM) controls the fan speed by sending a pulse width modulated (PWM) signal to the cooling fan control module. The cooling fan control module varies the voltage drop across the cooling fan motors in relation to the pulse width modulated signal, which allows the cooling fans to operate at variable speeds.

The cooling fan speed is effected by many different conditions and the ECM will adjust the duty cycle from 0-100 percent based on cooling system requirements. The scan tool output control is only capable of operating the cooling fan increments, between 10-90 percent. 90 percent is considered high speed fan. When multiple cooling fan speed requests are received, the ECM operates the fan at the highest of speed requests. The ECM commands the fans ON under the following conditions:

- The engine coolant temperature is warmer than a predetermined temperature.
- The engine oil temperature is warmer than a predetermined temperature.
- The A/C pressure reaches a predetermined pressure.
- If the engine coolant temperature at key-off is warmer than a predetermined value, or the A/C pressure is greater than a predetermined value, the cooling fan will operate at a low speed. The fan will shut OFF if the temperature or pressure drops below the predetermined value, but will only operate for 2 minutes, regardless of the coolant temperature or A/C pressure.

COOLING SYSTEM DESCRIPTION AND OPERATION

Engine Coolant Indicators

ENGINE COOLANT HOT

The instrument panel cluster (IPC) displays ENGINE COOLANT HOT message when the IPC receives a message from the powertrain control module (PCM) requesting illumination of this driver warning.

ENGINE OVERHEATED

The IPC displays ENGINE OVERHEATED message when the IPC receives a message from the PCM requesting illumination of this driver warning.

REDUCED ENGINE POWER

The IPC displays REDUCED ENGINE POWER message when the IPC detects a reduced engine power condition from the PCM. The IPC receives a message from the PCM requesting illumination when the engine temperature exceeds a calibrated value.

Coolant Heater (If Equipped)

The optional engine coolant heater (RPO K05) operates using 110-volt AC external power and is designed to warm the coolant in the engine block area for improved starting in very cold weather -18Â°C (0Â°F). The coolant heater helps reduce fuel consumption when a cold engine is warming up. The unit is equipped with a detachable AC power cord. A weather shield on the cord is provided to protect the plug when not in use.

Cooling System

The cooling system's function is to maintain an efficient engine operating temperature during all engine speeds and operating conditions. The cooling system is designed to remove approximately one-third of the heat produced by the burning of the air-fuel mixture. When the engine is cold, the coolant does not flow to the radiator until the thermostat opens. This allows the engine to warm quickly.

Cooling Cycle

Coolant is drawn from the radiator outlet and into the water pump inlet by the water pump. Coolant will then be pumped through the water pump outlet and into the engine block. In the engine block, the coolant circulates through the water jackets surrounding the cylinders, where it absorbs heat.

Some coolant is also pumped from the water pump to the heater core, then back to the water pump. This provides the passenger compartment with heat and defrost.

The coolant is then forced through the cylinder head gasket openings and into the cylinder heads. In the cylinder heads, the coolant flows through the water jackets surrounding the combustion chambers and valve seats, where it absorbs additional heat.

Coolant

The engine coolant is a solution made up of a 50-50 mixture of DEX-COOL and suitable drinking water. The coolant solution carries excess heat away from the engine to the radiator, where the heat is dissipated to the atmosphere.

Radiator

The radiator is a heat exchanger. It consists of a core and two tanks. The aluminum core is a tube and fin crossflow design that extends from the inlet tank to the outlet tank. Fins are placed around the outside of the tubes to improve heat transfer to the atmosphere.

The inlet and outlet tanks are a molded, high temperature, nylon reinforced plastic material. A high temperature rubber gasket seals the tank flange edge to the aluminum core. The tanks are clamped to the core with clinch tabs. The tabs are part of the aluminum header at each end of the core.

The radiator also has a drain cock (except HD), located in the bottom of the right hand tank. The drain cock unit includes the drain cock and drain cock seal.

The radiator removes heat from the coolant passing through it. The fins on the core transfer heat from the coolant passing through the tubes. As air passes between the fins, it absorbs heat and cools the coolant.

Surge Tank

The surge tank is a plastic tank with a threaded pressure cap. The tank is mounted at a point higher than all other coolant passages. The surge tank provides an air space in the cooling system that allows the coolant to expand and contract. The surge tank provides a coolant fill point and a central air bleed location.

During vehicle use, the coolant heats and expands. The increased coolant volume flows into the surge tank. As the coolant circulates, any air is allowed to bubble out. Coolant without air bubbles absorbs heat much better than coolant with bubbles.

During vehicle use, the coolant heats and expands. The increased coolant volume can in some conditions push past the pressure cap and through a channel into the overflow bottle. As the coolant circulates, air is allowed to bubble out. This air is then transferred to the overflow bottle, through the surge tank cap, where it returns to the atmosphere. Coolant without air bubbles absorbs heat much better than coolant with bubbles. When the engine cools, the coolant, without air bubbles, contracts back into the surge tank from the bottom of the overflow bottle.

Pressure Cap

The pressure cap seals the cooling system. It contains a blow off or pressure relief valve and a vacuum or atmospheric valve. The pressure valve is held against its seat by a spring, which protects the radiator from excessive cooling system pressure. The vacuum valve is held against its seat by a spring, which permits opening of the valve to relieve vacuum created in the cooling system as it cools off. The vacuum, if not relieved, might cause the radiator and/or coolant hoses to collapse.

The pressure cap allows cooling system pressure to build up as the temperature increases. As the pressure builds, the boiling point of the coolant increases. Engine coolant can be safely run at a temperature much higher than the boiling point of the coolant at atmospheric pressure. The hotter the coolant is, the faster the heat transfers from the radiator to the cooler, passing air.

The pressure in the cooling system can get too high. When the cooling system pressure exceeds the rating of the pressure cap, it raises the pressure valve, venting the excess pressure.

As the engine cools down, the temperature of the coolant drops and a vacuum is created in the cooling system. This vacuum causes the vacuum valve to open, allowing outside air into the surge tank. This equalizes the pressure in the cooling system with atmospheric pressure, preventing the radiator and coolant hoses from collapsing.

Air Baffles and Seals

The cooling system uses deflectors, air baffles and air seals to increase cooling system capability. Deflectors are installed under the vehicle to redirect

airflow beneath the vehicle and through the radiator to increase engine cooling. Air baffles are also used to direct airflow through the radiator and increase cooling capability. Air seals prevent air from bypassing the radiator and A/C condenser, and prevent recirculation of hot air for better hot weather cooling and A/C condenser performance.

Cooling Fan and Clutch

The engine cooling fan and clutch are driven by the crankshaft via the drive belt. The cooling fan draws air through the radiator to improve the transfer of heat from the coolant to the atmosphere. As the fan blades spin, they pull cool, outside air past the radiator core. The fan clutch drives the cooling fan. The fan clutch controls the amount of torque that is transmitted from the crankshaft to the fan blades. The clutch allows more torque to engage on the fan when the engine operating temperature increases and/or the vehicle speed is low. As the torque increases, the fan turns more quickly. The fan clutch decreases the torque applied to the cooling fan when the engine temperature decreases and/or the vehicle speed is high. As the torque decreases, the fan speed decreases.

Transmission Oil Cooler

The transmission oil cooler is a heat exchanger. It is located inside the right side (V6) or left side (V8), end tank of the radiator. The transmission fluid temperature is regulated by the temperature of the engine coolant that surrounds the oil cooler as the transmission fluid passes through the cooler.

The transmission oil pump, pumps the fluid through the transmission oil cooler feed line to the oil cooler. The fluid then flows through the cooler while the engine coolant absorbs heat from the fluid. The fluid is then pumped through the transmission oil cooler return line, to the transmission.

Engine Oil Cooler

The engine oil cooler is a heat exchanger located inside the left side (V6) or right side (V8), end tank of the radiator. The engine oil temperature is controlled by the temperature of the engine coolant that surrounds the oil cooler in the radiator.

The engine oil pump, pumps the oil through the engine oil cooler line to the oil cooler. The oil then flows through the cooler where the engine coolant absorbs heat from the oil. The oil is then pumped through the oil cooler return line, to the engine block system.

Cooling Fan Control - Two Fan System

The engine cooling fan system consists of 2 electrical cooling fans, with a microcontroller that receives and allows the powertrain control module (PCM) to operate both fans together at several speeds. The cooling fans and fan PWM Signal receive battery positive voltage from the underhood fuse block.

During closed loop mode (PWM signal between 10% and 91%), both cooling fans will run at a controlled speed, depending on the percentage of PWM signal is being sent. At this closed loop mode, both fans will run at the speed it is being indicated according to the signal is being read by the

microcontroller.

During open loop mode (PWM signal between 92% and 95%), both cooling fans will run at a non-controlled speed, this mode is when the fans will run at the maximum speed giving the maximum airflow, this mode is activated when conditions being mentioned later in this document activate it.

NOTE: **The right and left cooling fan connectors are interchangeable. When servicing the fans be sure that the connectors are plugged into the correct fan.**

The PCM commands the low speed cooling fans ON under the following conditions:

- Engine coolant temperature exceeds a calibrated value.
- A/C refrigerant pressure exceeds a calibrated value.
- After the vehicle is shut OFF if the engine coolant temperature at key-off is:
  - 107Â°C-112Â°C then enable low speed fans.
  - 105Â°C then disable low speed fans.
  - 112Â°C then enable high speed fan.
  - 105Â°C then disable high speed fans.
  - The fans (high and low speed) will turn off after a maximum 5 min.

The PCM commands the high speed fans ON under the following conditions:

- Engine coolant temperature exceeds a calibrated value.
- A/C refrigerant pressure exceeds a calibrated value.
- When certain DTCs set.

At idle and very low vehicle speeds the cooling fans are only allowed to increase in speed if required. This insures idle stability by preventing the fans from cycling between high and low speed.

SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

Illustration	Tool Number/ Description

Illustration	Tool Number/ Description
	BO 38185 J 38185 Hose Clamp Pliers

Illustration	Tool Number/ Description
	EL 35616-F J 35616-F Connector Test Adapter Kit

Illustration	Tool Number/ Description
	EN 24460-A J 24460-01 Cooling System Pressure Tester

Illustration	Tool Number/ Description
	GE 26568 J 26568 Coolant and Battery Fluid Tester

Illustration	Tool Number/ Description
	GE 42401-A J 42401 Radiator Cap and Surge Tank Test Adapter

Illustration	Tool Number/ Description
	GE 47716 Vac N Fill Coolant Refill Tool

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ENGINE

Engine Mechanical - 5.3L (L83) or 6.2L (L86) - Escalade, Suburban, Tahoe, Yukon

SPECIFICATIONS

FASTENER SPECIFICATIONS

Application	Specification	
	Metric	English
Accessory Drive Belt Tensioner Bolts	58 N.m	43 lb ft
Automatic Transmission Flex Plate Bolts (1)		
• First Pass	15 N.m	11 lb ft
• Second Pass	30 N.m	22 lb ft
• Final Pass	45 degrees	
Camshaft Position (CMP) Actuator Magnet Bolts	10 N.m	89 lb in
Camshaft Position (CMP) Actuator Solenoid Valve (1)		
• First Pass	65 N.m	48 lb ft
• Final Pass	90 degrees	
Camshaft Position (CMP) Sensor Bolt	25 N.m	18 lb ft
Camshaft Position (CMP) Sensor Wire Harness Bolt	25 N.m	18 lb ft
Camshaft Retainer Bolts - TORX Head Bolts	15 N.m	11 lb ft
Connecting Rod Bolts (1)		
• First Pass	20 N.m	15 lb ft
• Final Pass	85 degrees	

Application	Specification	
	Metric	English
Coolant Temperature Sensor	20 N.m	15 lb ft
Cooler Line Bracket Bolt	10 N.m	89 lb in
Crankshaft Balancer Bolt - Installation Pass with Used Bolt - to Ensure the Balancer is Completely Installed	330 N.m	243 lb ft
Crankshaft Balancer Bolt - New Bolt P/N with Flanged Head		
• First Pass	120 N.m	89 lb ft
• Second Pass	Loosen 360 degrees	
• Third Pass	80 N.m	59 lb ft
• Final Step	125 degrees	
Crankshaft Balancer Bolt - New Bolt with Retained Rotating Washer		Â
• First Pass	120 N.m	15 lb ft
• Second Pass	Loosen 360 degrees	
• Third Pass	80 N.m	15 lb ft
• Final Step	200 degrees	
Crankshaft Bearing Cap Bolts (1)		
• Inner Bearing Cap Bolts - First Pass in Sequence[1]	20 N.m	15 lb ft
• Inner Bearing Cap Bolts - Final Pass in Sequence[1]	110 degrees	
• Outer Bearing Cap Bolts - First Pass in Sequence	20 N.m	15 lb ft

Application	Specification	
	Metric	English
• Outer Bearing Cap Bolts - Final Pass in Sequence	80 degrees	
• Bearing Cap Side Bolts - First Pass in Sequence	25 N.m	18 lb ft
• Bearing Cap Side Bolts - Final Pass in Sequence	60 degrees	
Crankshaft Oil Deflector Bolts	10 N.m	89 lb in
Crankshaft Position (CKP) Sensor Bolt	25 N.m	18 lb ft
Crankshaft Rear Oil Seal Housing Bolts	25 N.m	18 lb ft
Cylinder Head Bolts (1)		
• Cylinder Head Bolts - Internal Hex - LH Cylinder Head forward most fastener - First Pass in Sequence	80 N.m	59 lb ft
• Cylinder Head Bolts - Internal Hex - LH Cylinder Head forward most fastener - Second Pass in Sequence	90 degrees	
• Cylinder Head Bolts - Internal Hex - LH Cylinder Head forward most fastener - Final Pass in Sequence	40 degrees	
• Cylinder Head Bolts - Standard Hex - First Pass in Sequence	80 N.m	59 lb ft
• Cylinder Head Bolts - Standard Hex - Second Pass in Sequence	90 degrees	
• Cylinder Head Bolts - Standard Hex - Final Pass in Sequence	60 degrees	
Engine Block Coolant Drain Hole Plug	60 N.m	44 lb ft
Engine Block Coolant Heater	50 N.m	37 lb ft
Engine Block Oil Gallery Plugs	30 N.m	22 lb ft
Engine Harness Fastener	10 N.m	89 lb in
Exhaust Manifold Bolts		

Application	Specification	
	Metric	English
• Exhaust Manifold Bolts - If installing on existing cylinder head	23 N.m	17 lb ft
• Exhaust Manifold Bolts - If installing on NEW cylinder head	27 N.m	20 lb ft
Exhaust Manifold Heat Shield Bolts	10 N.m	89 lb in
Engine Oil Cooler Adapter	12 N.m	106 lb in
Flywheel Inspection Cover Bolts	10 N.m	89 lb in
Front Cover Bolts	25 N.m	18 lb ft
Low Pressure Fuel Feed Pipe to Rocker Arm Cover Bolt	10 N.m	89 lb in
Flex Plate to Torque Converter Fastener	60 N.m	44 lb ft
Fuel Pump Bolts	25 N.m	18 lb ft
Fuel Rail Pressure Sensor	33 N.m	24 lb ft
High Pressure Fuel Feed Pipe Fittings (1)	30 N.m	22 lb ft
Low Pressure Fuel Feed Pipe to Rocker Arm Cover Bolt	10 N.m	89 lb in
Fuel Injection Fuel Rail Bolts	25 N.m	18 lb ft
Fuel Injection Fuel Rail Crossover Pipe Bolt	10 N.m	89 lb in
Fuel Pump Lifter Follower Guide Bolt	25 N.m	18 lb ft
Generator Bracket Bolts	50 N.m	37 lb ft
Ignition Coil Bracket-to-Valve Rocker Arm Cover Bolts	10 N.m	89 lb in
Intake Manifold Bolts		
• First Pass in Sequence	5 N.m	44 lb in
• Final Pass in Sequence	10 N.m	89 lb in
Intake Manifold Cover Studs	4.5 N.m	40 lb in
Intake Manifold Cover Bolts	4.5 N.m	40 lb in
Knock Sensor Bolts	25 N.m	18 lb ft
Knock Sensor Heat Shield Bolt	25 N.m	18 lb ft
Oil Filter	3/4 to 1 full turn after gasket makes contact with the sealing surface on the filter mounting flange	

Application	Specification	
	Metric	English
Oil Filter Fitting	55 N.m	41 lb ft
Oil Level Indicator Tube Bolt	10 N.m	89 lb in
Oil Pan Cover Bolts	10 N.m	89 lb in
Oil Pan Drain Plug	25 N.m	18 lb ft
Oil Pan Bolts - Oil Pan-to-Rear Housing	12 N.m	106 lb in
Oil Pan Bolts - Oil Pan-to-Engine Block and Oil Pan-to-Front Cover	25 N.m	18 lb ft
Oil Pan Bolts - Lower Oil Pan to Upper Oil Pan	10 N.m	89 lb in
Oil Pressure Sensor	35 N.m	26 lb ft
Oil Level Sensor Bolts	10 N.m	89 lb in
Oil Pump Screen Bolts	10 N.m	89 lb in
Oil Pump-to-Engine Block Bolts	25 N.m	18 lb ft
PCV Valve	6 N.m	53 lb in
Spark Plugs	20 N.m	15 lb ft
Throttle Body Bolts	10 N.m	89 lb in
Transmission to Engine Fastener	50 N.m	37 lb ft
Transmission to Oil Pan Bolts	50 N.m	37 lb ft
Map Sensor Bolt	4.5 N.m	40 lb in
Evap Purge Valve Bolt	4.5 N.m	40 lb in
Timing Chain Tensioner Bolts	30 N.m	22 lb ft
Valley Cover Bolts	25 N.m	18 lb ft
Valve Lifter Guide Bolts	12 N.m	106 lb in
Valve Lifter Oil Manifold Bolts		
• First Pass in Sequence	15 N.m	11 lb ft
• Final Pass in Sequence	30 N.m	22 lb ft
Valve Lifter Oil Manifold Filter Plug	30 N.m	22 lb ft
Valve Rocker Arm Bolts	30 N.m	22 lb ft
Valve Rocker Arm Cover Bolts - In Sequence	10 N.m	89 lb in

Application	Specification	
	Metric	English
Water Inlet Housing Bolts	10 N.m	89 lb in
Water Pump Impeller Bolts	10 N.m	89 lb in
Engine Coolant Manifold Bolts	25 N.m	18 lb ft
Vacuum Pump Bolt	25 N.m	18 lb ft
Starter Heat Shield Bolt - Side	10 N.m	89 lb in
Starter Heat Shield Bolt - Rear	25 N.m	18 lb ft
1. Use NEW fastener.		

APPROXIMATE FLUID CAPACITIES

Application	Specification	
	Metric	English
5.3L (L83)		
• Oil Capacity - with Filter	7.6 Liters	8.0 Quarts
• Oil Capacity - without Filter	7.1 Liters	7.5 Quarts
6.2L (L86)		
• Oil Capacity - with Filter	7.6 Liters	8.0 Quarts
• Oil Capacity - without Filter	7.1 Liters	7.5 Quarts

ENGINE MECHANICAL SPECIFICATIONS (L83)

Application	Specification	
	Metric	English
General		
• Engine Type	V8	

Application	Specification	
	Metric	English
• Displacement	5.3L	323 CID
• RPO	L83	
• VIN	C	
• Bore	96.0 mm	3.779 in
• Stroke	92.0 mm	3.622 in
• Compression Ratio	11.0:1	
• Firing Order	1-8-7-2-6-5-4-3	
• Spark Plug Gap	0.95-1.10 mm	0.037-0.043 in
Block		
• Camshaft Bearing Bore 1 and 5 Diameter	59.58-59.63 mm	2.345-2.347 in
• Camshaft Bearing Bore 2 and 4 Diameter	59.08-59.13 mm	2.325-2.327 in
• Camshaft Bearing Bore 3 Diameter	58.58-58.63 mm	2.306-2.308 in
• Crankshaft Main Bearing Bore Diameter	69.870-69.890 mm	2.75-2.751 in
• Crankshaft Main Bearing Bore Out-of-Round	0.008 mm	0.0003 in
• Cylinder Bore Diameter	96.0-96.02 mm	3.779-3.780 in

Application	Specification	
	Metric	English
• Cylinder Head Deck Height - Measuring from the Centerline of Crankshaft to the Deck Face	234.58-234.83 mm	9.235-9.245 in
• Cylinder Head Deck Surface Flatness - Measured Within a 150.0 mm (5.9 in) Area	0.05 mm	0.0014 in
• Cylinder Head Deck Surface Flatness - Measuring the Overall Length of the Block Deck	0.1 mm	0.0039 in
• Valve Lifter Bore Diameter	21.417-21.443 mm	0.843-0.844 in
Valve Lifter Follower Bore Diameter	29.187-29.213 mm	1.149-1.150
Camshaft		
• Camshaft End Play	0.025-0.305 mm	0.001-0.012 in
• Camshaft Journal Diameter	54.99-55.015 mm	2.164-2.166 in
• Camshaft Bearing Diameter	55.063-55.088 mm	2.1678-2.1688 in
• Camshaft Journal-to-Bearing Clearance	0.048-0.098 mm	0.0002-0.0038 in
• Camshaft Journal Out-of-Round	0.006 mm	0.0002 in
• Camshaft Lobe Lift - Exhaust Non AFM	6.97 mm	0.2741 in
• Camshaft Lobe Lift - Exhaust AFM	7.10 mm	0.279 in
• Camshaft Lobe Lift - Intake Non AFM	7.08 mm	0.278 in
• Camshaft Lobe Lift - Intake AFM	7.21 mm	0.283 in

ENGINE MECHANICAL SPECIFICATIONS (L86)

Application	Specification	
	Metric	English
General		
• Engine Type	V8	
• Displacement	6.2L	376 CID
• RPO	L86	
• VIN	J	
• Bore	103.0 mm	4.055 in
• Stroke	92.0 mm	3.622 in
• Compression Ratio	11.5:1	
• Firing Order	1-8-7-2-6-5-4-3	
• Spark Plug Gap	0.95-1.10 mm	0.037-0.043 in
Block		
• Camshaft Bearing Bore 1 and 5 Diameter	59.58-59.63 mm	2.345-2.347 in
• Camshaft Bearing Bore 2 and 4 Diameter	59.08-59.13 mm	2.325-2.327 in
• Camshaft Bearing Bore 3 Diameter	58.58-58.63 mm	2.306-2.308 in
• Crankshaft Main Bearing Bore Diameter	69.869-69.891 mm	2.751-2.752 in

Application	Specification	
	Metric	English
• Crankshaft Main Bearing Bore Out-of-Round	0.008 mm	0.00031 in
• Cylinder Bore Diameter	103.239-103.261 mm	4.0645-4.0654 in
• Cylinder Head Deck Height - Measuring from the Centerline of Crankshaft to the Deck Face	234.575-234.825 mm	9.235-9.245 in
• Cylinder Head Deck Surface Flatness - Measured Within a 150.00 mm (5.9 in) Area	0.05 mm	0.002 in
• Cylinder Head Deck Surface Flatness - Measuring the Overall Length of the Block Deck	0.1 mm	0.0039 in
• Valve Lifter Bore Diameter	21.417-21.443 mm	0.843-0.844 in
• Valve Lifter Follower Bore Diameter	29.187-29.213 mm	1.149-1.150 in
Camshaft		
• Camshaft End Play	0.025-0.305 mm	0.001-0.012 in
• Camshaft Journal Diameter	54.990-55.015 mm	2.164-2.166 in
• Camshaft Bearing Diameter	55.063-55.088 mm	2.1678-2.1688 in
• Camshaft Journal-to-Bearing Clearance	0.048-0.098 mm	0.0019-0.0038 in
• Camshaft Journal Out-of-Round	0.006 mm	0.0002 in
• Camshaft Lobe Lift - Exhaust Non AFM	7.360 mm	0.290 in

Application	Specification	
	Metric	English
• Camshaft Lobe Lift - Exhaust AFM	7.490 mm	0.295 in
• Camshaft Lobe Lift - Intake Non AFM	7.760 mm	0.306 in
• Camshaft Lobe Lift - Intake AFM	7.890 mm	0.311 in
• Fuel Pump Lobe Lift	5.70 mm	0.224 in
• Camshaft Runout - Measured at the Intermediate Journals	0.05 mm	0.002 in
Camshaft Position Actuator		
• Range of Authority	62 degrees	
• Park Position	7 degrees Advanced	
Connecting Rod		
• Connecting Rod Bearing Clearance - Production	0.024-0.064 mm	0.0009-0.0025 in
• Connecting Rod Bearing Clearance - Service	0.023-0.076 mm	0.0009-0.0029 in
• Connecting Rod Bore Diameter - Bearing End	56.505-56.525 mm	2.224-2.225 in
• Connecting Rod Bore Out-of-Round - Bearing End - Production	0.006 mm	0.00023 in
• Connecting Rod Bore Out-of-Round - Bearing End - Service	0.008 mm	0.0003 in
• Connecting Rod Side Clearance	0.125-0.495 mm	0.004-0.019 in
Crankshaft		

Application	Specification	
	Metric	English
• Connecting Rod Journal Diameter - Production	53.320-53.336 mm	2.0992-2.0998 in
• Connecting Rod Journal Diameter - Service	53.31 mm	2.0996 in
• Connecting Rod Journal Out-of-Round - Production	0.005 mm	0.0002 in
• Connecting Rod Journal Out-of-Round - Service	0.01 mm	0.0004 in
• Connecting Rod Journal Taper - Maximum for 1/2 of Journal Length - Production	0.008 mm	0.0003 in
• Connecting Rod Journal Taper - Maximum for 1/2 of Journal Length - Service	0.015 mm	0.00059 in
• Crankshaft End Play	0.040-0.220 mm	0.0015-0.0086 in
• Crankshaft Main Bearing Clearance - Production	0.02-0.052 mm	0.0008-0.0021 in
• Crankshaft Main Bearing Clearance - Service	0.02-0.065 mm	0.0008-0.0025 in
• Crankshaft Main Journal Diameter - Production	64.992-65.008 mm	2.558-2.559 in
• Crankshaft Main Journal Diameter - Service	64.982 mm	2.558 in
• Crankshaft Main Journal Out-of-Round - Production	0.005 mm	0.00019 in
• Crankshaft Main Journal Out-of-Round - Service	0.01 mm	0.0004 in
• Crankshaft Main Journal Taper - Production	0.008 mm	0.0003 in

Application	Specification	
	Metric	English
• Crankshaft Main Journal Taper - Service	0.015 mm	0.00059 in
• Crankshaft Rear Flange Runout	0.025 mm	0.00098 in
• Crankshaft Reluctor Ring Runout - Measured 1.0 mm (0.04 in) Below Tooth Diameter	0.7 mm	0.028 in
• Crankshaft Thrust Surface - Production	26.14-26.22 mm	1.029-1.0315 in
• Crankshaft Thrust Surface - Service	26.22 mm	1.0315 in
• Crankshaft Thrust Surface Runout	0.04 mm	0.002 in
Cylinder Head		
• Cylinder Head Height/Thickness - Measured from the Cylinder Head Deck to the Valve Rocker Arm Cover Seal Surface	132.5 mm	5.216 in
• Surface Flatness - Block Deck - Measured Within a 152.4 mm (6.0 in) Area	0.05 mm	0.0019 in
• Surface Flatness - Block Deck - Measuring the Overall Length of the Cylinder Head	0.1 mm	0.004 in
• Surface Flatness - Exhaust Manifold Face	0.1 mm	0.004 in
• Surface Flatness - Intake Manifold Face	0.1 mm	0.004 in
• Valve Guide Installed Height - Measured from the Spring Seat Surface to the Top of the Guide	17.05-17.55 mm	0.671-.691 in

Application	Specification	
	Metric	English
• Injector Bore Diameter	7.65-7.87 mm	0.301-0.309 in
Intake Manifold		
• Surface Flatness - Measured at Gasket Sealing Surfaces and Measured Within a 200 mm (7.87 in) Area that Includes 2 Runner Port Openings	0.3 mm	0.118 in
Lubrication System		
• Oil Pressure - Minimum - Hot	152 kPa at 1,000 engine RPM 207 kPa at 2,000 engine RPM 228 kPa at 3,000 engine RPM	22 psig at 1,000 engine RPM 30 psig at 2,000 engine RPM 33 psig at 3,000 engine RPM
• Active Fuel Management Relief Valve Oil Pressure - as Measured at Oil Pressure Sensor Location	379-517 kPa Maximum	55-75 psig Maximum
Oil Pan		
• Front Cover Alignment - at Oil Pan Surface	0.0-0.5 mm	0.0-0.02 in
• Crankshaft Rear Oil Seal Housing Alignment - at Oil Pan Surface	0.0-0.5 mm	0.0-0.02 in
• Oil Pan Alignment - to Rear of Engine Block at Transmission Bell Housing Mounting Surface	0.0-0.1 mm	0.0-0.004 in
Piston Rings		
• Piston Ring End Gap - First Compression Ring - Measured in Cylinder Bore - Production	0.23-0.39 mm	0.009-0.0153 in
• Piston Ring End Gap - First Compression Ring - Measured in Cylinder Bore - Service	0.23-0.45 mm	0.009-0.0177 in
• Piston Ring End Gap - Second Compression Ring - Measured in Cylinder Bore - Production	0.32-0.63 mm	0.0126-0.0248 in

Application	Specification	
	Metric	English
• Piston Ring End Gap - Second Compression Ring - Measured in Cylinder Bore - Service	0.32-0.69 mm	0.0126-0.0272 in
• Piston Ring End Gap - Oil Control Ring - Measured in Cylinder Bore - Production	0.22-0.79 mm	0.0086-0.0311 in
• Piston Ring End Gap - Oil Control Ring - Measured in Cylinder Bore - Service	0.22-0.85 mm	0.0086-0.0335 in
• Piston Ring-to-Groove Clearance - First Compression Ring - Production	0.040-0.083 mm	0.0016-0.0033 in
• Piston Ring-to-Groove Clearance - First Compression Ring - Service	0.040-0.083 mm	0.0016-0.0033 in
• Piston Ring-to-Groove Clearance - Second Compression Ring - Production	0.040-0.083 mm	0.0016-0.0033 in
• Piston Ring-to-Groove Clearance - Second Compression Ring - Service	0.040-0.083 mm	0.0016-0.0033 in
• Piston Ring-to-Groove Clearance - Oil Control Ring - Production	0.013-0.201 mm	0.0005-0.0079 in
• Piston Ring-to-Groove Clearance - Oil Control Ring - Service	0.013-0.201 mm	0.0005-0.0079 in
Pistons and Pins		
• Pin - Piston Pin Clearance-to-Piston Pin Bore - Production	0.002-0.01 mm	0.00008-0.0004 in
• Pin - Piston Pin Clearance-to-Piston Pin Bore - Service	0.002-0.015 mm	0.00008-0.0006 in
• Pin - Piston Pin Diameter	23.952-23.955 mm	0.9430-0.9431 in
• Pin - Piston Pin Fit in Connecting Rod Bore - Production	0.007-0.02 mm	0.00027-0.00078 in

Application	Specification	
	Metric	English
• Pin - Piston Pin Fit in Connecting Rod Bore - Service	0.007-0.022 mm	0.00027-0.00086 in
• Piston - Piston Diameter - Measured Over Skirt Coating	103.258-103.289 mm	4.0653-4.0665 in
• Piston - Piston to Bore Clearance - Production	-0.048 to +0.001 mm	-0.0019 to +0.000 in
• Piston - Piston to Bore Clearance - Service Limit With Skirt Coating Worn Off	0.052 mm	0.0020 in
Valve System		
• Valves - Valve Face Angle	45 degrees	
• Valves - Valve Face Width	1.25 mm	0.05 in
• Valves - Valve Lash	Net Lash - No Adjustment	
• Valve Lift - Exhaust Non AFM	13.250 mm	0.521 in
• Valve Lift - Exhaust	13.503 mm	0.531 in
• Valve Lift - Intake Non AFM	14.000 mm	0.551 in
• Valve Lift - Intake	14.253 mm	0.561
• Valves - Valve Seat Angle	45 degrees	
• Valves - Valve Seat Runout	0.05 mm	0.002 in
• Valves - Valve Seat Runout	0.08 mm	0.003 in

Application	Specification	
	Metric	English
• Valves - Valve Seat Width - Exhaust	2.52 mm	0.099 in
• Valves - Valve Seat Width - Intake	1.98 mm	0.078 in
• Valves - Valve Stem Diameter - Production	7.955-7.976 mm	0.313-0.314 in
• Valves - Valve Stem Diameter - Service	7.95 mm	0.313 in
NOTE: **For valve stem to guide clearance - valve guide inner diameter measurements must be recorded at a depth of 7 mm (0.26 in) in the valve guide bore.**		
• Valves - Valve Stem-to-Guide Clearance - Production - Exhaust	0.025-0.066 mm	0.001-0.0026 in
• Valves - Valve Stem-to-Guide Clearance - Service - Exhaust	0.093 mm	0.0037 in
• Valves - Valve Stem-to-Guide Clearance - Production - Intake	0.025-0.066 mm	0.001-0.0026 in
• Valves - Valve Stem-to-Guide Clearance - Service - Intake	0.093 mm	0.0037 in
• Valves - Valve Stem Height - Measured from Spring Seat - Intake and Exhaust	51.945-52.695 mm	2.045-2.074 in

ENGINE CONTENT SPECIFICATIONS

RPO	VIN	Displacement	Camshaft Position (CMP) Actuator Control System	Active Fuel Management Control System	E85 Capable	Block Material
L83	C	5.3L	Yes	Yes	Yes	Aluminum
L86	J	6.2L	Yes	Yes	No	Aluminum

ADHESIVES, FLUIDS, LUBRICANTS, AND SEALERS

Application	Type of Material	GM Part Number	
		United States	Canada
Camshaft Retainer Bolts	Threadlocker	12345382	10953489
Engine Block to the Crankshaft Rear Oil Seal Housing *	Sealant	12378521	88901148
Engine Block to the Engine Front Cover *	Sealant	12378521	88901148
Engine Block to Oil Pan *	Sealant	12378521	88901148
Lower Oil Pan to Upper Oil Pan *	Sealant	12378521	88901148
Engine Block Coolant Drain Hole Plug	Sealant	12346004	10953480
Engine Block Oil Gallery Plug	Sealant	12346004	10953480
Engine Oil	0W-20	19259487	19259784
Engine Oil Pressure Sensor Threads	Sealant	12346004	10953480
Engine Coolant Temperature (ECT) Sensor	Sealant	12346004	10953480
Exhaust Manifold Bolts	Threadlocker	89021297	10953488
Engine Coolant Manifold Bolts	Threadlocker	12345382	10953489
Fuel Rail Bolts	Threadlocker	12345382	10953489
Intake Manifold Bolts	Threadlocker	12345382	10953489
Spark Plug Wires	Lubricant	19260901	19260902
Valve Lifter Oil Filter Plug	Sealant	12346004	10953480
* Ensure proper use of room temperature vulcanizing (RTV) sealant. Refer to **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant**			

THREAD REPAIR SPECIFICATIONS

Engine Block - Front/Rear Views

Fig. 1: Engine Block - Front/Rear Views
Courtesy of GENERAL MOTORS COMPANY

Engine Block - Front/Rear Views

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth - Maximum mm (in)	Tap Depth - Maximum mm (in)
J-42385-								
1	M8 x 1.25	210	206	207	208	209	23.0 (0.907)	23.0 (0.907)
2	M10 x 1.5	420	211	212	213	214	34.0 (1.35)	34.0 (1.35)
3	M8 x 1.25	61	206	207	208	209	29.0 (1.14)	29.0 (1.14)

Engine Block - Left/Right Side Views

Fig. 2: Engine Block - Left/Right Side Views
Courtesy of GENERAL MOTORS COMPANY

Engine Block - Left/Right Side Views

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth - Maximum mm (in)	Tap Depth - Maximum mm (in)
Standard Bolts J-42385-								
1	M8 x 1.25	210	206	207	208	209	23.0 (0.907)	23.0 (0.907)
2	M10 x 1.25	420	211	212	213	214	34.0 (1.35)	34.0 (1.35)
3	M8 x 1.25	61	206	207	208	209	29.0 (1.14)	29.0 (1.14)
4	M12 x 1.75	865	856	857	858	859	16.0 (0.629)	16.0 (0.629)
Head Bolts EN-42385-								
5	M12 x 1.75	62	856	857	858	859	23.0 (0.907)	23.0 (0.907)

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth - Maximum mm (in)	Tap Depth - Maximum mm (in)
6	M12 x 1.75	58	51	N/A	52	53	58.0 (2.28)	58.0 (2.28)
7	M12 x 1.75	58	51	57 (Stop Collar)	52	53	58.0 (2.28)	58.0 (2.28)
Cylinder head bolt hole (7) has a unique shallow depth. Use stop collar **EN-42385-57** . Stop tap and driver at first line. Refer to **Thread Repair** for head bolt thread repair hardware and procedure.								

Engine Block - Top/Bottom Views

Fig. 3: Engine Block - Top/Bottom Views
Courtesy of GENERAL MOTORS COMPANY

Engine Block - Top/Bottom Views

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth -	Tap Depth -

							Maximum mm (in)	Maximum mm (in)
J-42385-								
1	M6 x 1.0	63	201	202	203	204	23.0 (0.907)	23.0 (0.907)
2	M8 x 1.25	61	206	207	208	209	29.0 (1.14)	29.0 (1.14)
3	M8 x 1.25	210	206	207	208	209	23.0 (0.907)	23.0 (0.907)
4	M10 x 2.0	104	101	N/A	102	103	30.0 (1.18)	30.0 (1.18)
5	M10 x 2.0	104	101	N/A	102	103	52.0 (2.05)	52.0 (2.05)
6	M10 x 1.5	N/A	N/A	N/A	N/A	N/A	34.0 (1.35)	34.0 (1.35)

- Bolt hole 4 has a 1.5 mm (0.059 in) counterbore included in the 30.0 mm (1.18 in) drill depth. Use sleeve **J-42385-316** with the drill tap. For the proper hardware and procedure, refer to **Thread Repair**.
- Bolt hole 5 has a 15.5 mm (0.807 in) counterbore included in the 52.0 mm (2.05 in) drill depth. For the proper hardware and procedure, refer to **Thread Repair**.

Cylinder Head - Top/End Views

Fig. 4: Cylinder Head - Top/End Views
Courtesy of GENERAL MOTORS COMPANY

Cylinder Head - Top/End Views

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth - Maximum mm (in)	Tap Depth - Maximum mm (in)
J 42385-								
1	M8 x 1.25	N/A	N/A	N/A	N/A	N/A	23.0 (0.907)	23.0 (0.907)
2	M6 x 1.0	205	201	202	203	204	23.0 (0.907)	23.0 (0.907)
3	M10 x 1.5	420	211	212	213	214	30.0 (1.18)	30.0 (1.18)
4	M8 x 1.25	210	206	207	208	209	23.0 (0.907)	23.0 (0.907)
Bolt Hole 1 (Rocker Arm Supports) are not serviceable.								

Cylinder Head - Intake/Exhaust Side Views

Fig. 5: Cylinder Head - Intake/Exhaust Side Views
Courtesy of GENERAL MOTORS COMPANY

Cylinder Head - Intake/Exhaust Side Views

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth - Maximum mm (in)	Tap Depth - Maximum mm (in)
				J 42385-				
1	M8 x 1.25	210	206	207	208	209	23.0 (0.907)	23.0 (0.907)
2	M6 x 1.0	205	201	202	203	204	21.0 (0.825)	21.0 (0.825)
3	M10 x 1.5	420	211	212	213	214	34.0 (1.35)	34.0 (1.35)
4	M8 x 1.25	210	206	207	208	209	29.0 (1.14)	29.0 (1.14)

Hole	Thread Size	Insert	Drill	Counterbore Tool	Tap	Driver	Drill Depth - Maximum mm (in)	Tap Depth - Maximum mm (in)
5	M14 x 1.25	N/A	N/A	N/A	N/A	N/A	26.0 (1.023)	26.0 (1.023)
Bolt Hole 5 (Spark Plug Port) is not serviceable.								

SCHEMATIC WIRING DIAGRAMS

ENGINE MECHANICAL WIRING SCHEMATICS

Engine Oil Level and Pressure Control

Fig. 6: Engine Oil Level and Pressure Control

Courtesy of GENERAL MOTORS COMPANY

COMPONENT LOCATOR

DISASSEMBLED VIEWS

Cylinder Head/Upper Engine - With Active Fuel Management

Fig. 7: Exploded View Of Cylinder Head/Upper Engine With Active Fuel Management

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Valve Rocker Arm Cover
2	Valve Rocker Arm Cover Bolt
3	Ignition Coil Assembly
4	Ignition Coil Bolt
5	Spark Plug Wire Assembly
6	Valve Rocker Arm Cover Gasket
7	Valve Rocker Arm Pivot Support Bolt
8	Valve Rocker Arm Assembly
9	Valve Push Rod Assembly
10	Valve Stem Key
11	Valve Spring Cap
12	Valve Spring
13	Valve Stem Oil Seal
14	Cylinder Head Bolt
15	Cylinder Head Bolt
16	Cylinder Head Bolt
17	Cylinder Head
18	Engine Lift Front Bracket
19	Engine Lift Front Bracket Bolt
20	Exhaust Manifold Gasket
21	Spark Plug Assembly
22	Exhaust Manifold Assembly - Left Side
23	Exhaust Manifold Heat Shield Bolt
24	Exhaust Manifold Heat Shield
25	Exhaust Manifold Bolt
26	Valve Lifter Guide Bolt
27	Valve Lifter Guide
28	Valve Lifter
29	Valve Lifter

Callout	Component Name
30	Exhaust Valve
31	Intake Valve
32	Cylinder Head Gasket
33	Exhaust Manifold Heat Shield Bolt
34	Exhaust Manifold Heat Shield
35	Exhaust Manifold Bolt
36	Exhaust Manifold Assembly - Right Side
37	Exhaust Manifold Gasket
38	Cylinder Head
39	Valve Rocker Arm Cover Gasket
40	Valve Rocker Arm Cover
41	Engine Lift Rear Bracket
42	Engine Lift Rear Bracket Bolt

Front of Engine

Fig. 8: Exploded View Of Front of Engine
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Balancer Bolt
2	Crankshaft Balancer Bolt Washer
3	Crankshaft Balancer Assembly
4	Crankshaft Balancer Key

Callout	Component Name
5	Crankshaft Front Oil Seal
6	Camshaft Position Sensor Wire Assembly Bracket Bolt
7	Camshaft Position Sensor Wire Assembly
8	Camshaft Position Sensor Assembly
9	Camshaft Position Sensor Seal
10	Camshaft Position Actuator Magnet Bolt
11	Camshaft Position Actuator Magnet
12	Camshaft Position Actuator Magnet Gasket
13	Camshaft Position Sensor Wire Assembly Bracket Bolt
14	Engine Front Cover Bolt
15	Engine Front Cover Bolt
16	Engine Front Cover Bolt Retainer
17	Engine Front Cover Assembly
18	Oil Pump Flow Control Solenoid Valve Wire Clip
19	Oil Pump Flow Control Solenoid Valve Wire
20	Camshaft Position Actuator Solenoid Valve
21	Camshaft Position Actuator Assembly
22	Timing Chain Assembly
23	Crankshaft Sprocket Washer
24	Crankshaft Sprocket Assembly
25	Crankshaft Sprocket Washer
26	Timing Chain Tensioner Bolt
27	Timing Chain Tensioner Kit
28	Camshaft Retainer Bolt
29	Camshaft Retainer
30	Camshaft Assembly
31	Camshaft Bearings
32	Camshaft Bearing
33	Engine Block Assembly
34	Engine Coolant Manifold Bolt

Callout	Component Name
35	Drive Belt Tensioner Bolt
36	Drive Belt Tensioner
37	Engine Coolant Manifold Bolt
38	Engine Coolant Manifold Bolt
39	Engine Coolant Thermostat Housing Gasket
40	Engine Coolant Thermostat Assembly
41	Engine Coolant Thermostat Housing
42	Engine Coolant Thermostat Housing Bolt
43	Engine Coolant Manifold Gasket
44	Engine Coolant Manifold Assembly
45	Vacuum Pump Gasket
46	Vacuum Pump Assembly
47	Vacuum Pump Bolt
48	Vacuum Pump Bolt
49	Vacuum Pump Bolt
50	Oil Pump Assembly
51	Oil Pump Bolt Retainer
52	Oil Pump Bolt

Fuel Delivery System and Components

Fig. 9: Exploded View Of Fuel Delivery System and Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Fuel Pump Insulator
2	Fuel Pump Bolt
3	Fuel Pump Cover
4	Fuel Pump Assembly

Callout	Component Name
5	Fuel Pump Gasket
6	Direct Fuel Injection Fuel Rail Assembly - Left Side
7	Valve Lifter Oil Manifold Bolt
8	Valve Lifter Oil Manifold Assembly
9	Valve Lifter Follower Guide Assembly Bolt
10	Valve Lifter Follower Guide Assembly
11	Valve Lifter Oil Manifold Gasket
12	Engine Oil Pressure Sensor Assembly
13	Engine Oil Pressure Sensor Assembly Seal
14	Valve Lifter Oil Manifold Plug Seal
15	Valve Lifter Oil Manifold Plug
16	PCV Assembly
17	PCV Pipe Assembly
18	Fuel Injection Fuel Rail Bolt
19	Fuel Feed Intermediate Pipe
20	Fuel Feed Pipe Bolt
21	Fuel Feed Pipe Assembly
22	Fuel Feed Intermediate Pipe Bolt
23	Fuel Feed Intermediate Pipe
24	Direct Fuel Injection Fuel Rail Assembly - Right Side
25	Fuel Injection Fuel Rail Bolt

Lower Engine and Components

Fig. 10: Exploded View Of Lower Engine and Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Connecting Rod Bushing
2	Connecting Rod Assembly
3	Piston Pin Retainer
4	Piston Pin

Callout	Component Name
5	Piston
6	Piston Ring Set
7	Engine Block Assembly
8	Oil Level Indicator Tube
9	Oil Level Indicator Tube Bolt
10	Oil Level Indicator Assembly
11	Piston Oil Nozzle Assembly
12	Crankshaft Bearing Cap
13	Crankshaft Bearing Cap Bolt
14	Crankshaft Bearing Cap Bolt
15	Crankshaft Bearing Cap Bolt
16	Crankshaft Oil Deflector Bolt
17	Crankshaft Oil Deflector
18	Oil Pump Suction Pipe Bracket Bolt
19	Oil Pump Screen Assembly (w/Suction Pipe)
20	Oil Level Indicator Switch Seal
21	Oil Level Indicator Switch Bolt
22	Oil Level Indicator Switch
23	Oil Pan High Pressure Port Seal
24	Upper Oil Pan
25	Oil Pan Cover Gasket
26	Oil Pan Cover
27	Oil Pan Cover Bolt
28	Upper Oil Pan Bolt Retainer
29	Upper Oil Pan Bolt
30	Oil Filter Fitting
31	Oil Filter
32	Lower Oil Pan
33	Oil Pan Drain Plug
34	Oil Pan Drain Plug Seal

Callout	Component Name
35	Lower Oil Pan Bolt
36	Lower Oil Pan Gasket
37	Oil Pan Cup Plug
38	Upper Oil Pan Bolt
39	Upper Oil Pan Bolt Retainer
40	Oil Level Sensor Lead Clip
41	Oil Pan Front Seal
42	Crankshaft Lower Bearing
43	Crankshaft Assembly
44	Crankshaft Upper Bearing
45.	Engine Oil Cooler Gasket - Model Dependent
46	Engine Oil Cooler - Model Dependent
47	Engine Oil Cooler Bolt - Model Dependent

Rear of Engine

Fig. 11: Exploded View Of Rear of Engine
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Block
2	Crankshaft Rear Oil Seal Housing Locating Pin
3	Crankshaft Rear Oil Seal Housing Gasket
4	Crankshaft Rear Oil Seal Housing
5	Crankshaft Rear Oil Seal
6	Automatic Transmission Flex Plate
7	Automatic Transmission Flex Plate Bolt
8	Crankshaft Rear Oil Seal Housing Bolt
9	Crankshaft Rear Oil Seal Housing Locating Pin
10	Transmission Locating Pin

Oil Pump Assembly

Fig. 12: Exploded View Of Oil Pump Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Pump Cover Bolt
2	Bolt Retainer
3	Oil Pump Cover Bolt
4	Oil Pump Cover
5	Oil Pump Vane Ring
6	Oil Pump Vane
7	Oil Pump Vane Rotor
8	Oil Pump Vane Ring

Callout	Component Name
9	Oil Pump Slide Seal
10	Oil Pump Slide Spring
11	Oil Pump Slide
12	Oil Pump Intermediate Housing
13	Oil Pump Rear Cover Bolt
14	Oil Pump Slide Pivot Pin
15	Oil Pump Rear Cover
16	Oil Pump Flow Control Solenoid Retainer
17	Oil Pump Housing
18	Oil Pump Flow Control Solenoid O-ring
19	Oil Pump Flow Control Solenoid O-ring
20	Oil Pump Flow Control Solenoid
21	Oil Pressure Relief Valve
22	Oil Pressure Relief Valve Spring
23	Oil Pressure Relief Valve Bore Plug

Intake Manifold and Components

Fig. 13: Exploded View Of Intake Manifold and Components
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Intake Manifold Cover Stud
2	Intake Manifold Cover Assembly
3	Intake Manifold Cover Assembly Bolt
4	Intake Manifold Assembly

Callout	Component Name
5	EVAP Emission Canister Purge Valve Seal
6	EVAP Emission Canister Purge Valve
7	EVAP Emission Canister Purge Valve Bolt
8	Intake Manifold Gasket
9	Throttle Body Bolt
10	Throttle Body Assembly
11	Throttle Body Gasket
12	Intake Manifold Bolt
13	MAP Sensor Seal
14	MAP Sensor
15	MAP Sensor Bolt

Engine Block Plugs/Sensors

Fig. 14: Exploded View Of Engine Block Plugs/Sensors
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Block
2	Engine Front Cover Locating Pin
3	Engine Block Plug
4	Engine Block Plug

Callout	Component Name
5	Knock Sensor Assembly
6	Knock Sensor Bolt
7	Knock Sensor Shield
8	Knock Sensor Shield Bolt
9	Knock Sensor Bolt
10	Knock Sensor Assembly
11	Crankshaft Position Sensor Bolt
12	Crankshaft Position Sensor Assembly
13	Engine Block Plug
14	Transmission Locating Pin
15	Crankshaft Rear Oil Housing Locating Pin
16	Engine Block Oil Gallery Plug

ENGINE IDENTIFICATION

Fig. 15: Vehicle Identification Number (VIN)
Courtesy of GENERAL MOTORS COMPANY

The vehicle identification number (VIN) is located on the left side rear of the engine block (1) and is typically an 11 digit number stamped or laser-etched onto the engine at the vehicle assembly plant.

- The first digit identifies the division.
- The second digit identifies the model year.
- The third digit identifies the assembly plant.
- The fourth through eleventh digits are the last 8 digits of the VIN.

Engine identification can also be made through use of the Engine Traceability label (2) on the rear of the left cylinder head, or the Engine Traceability label (3) on the engine block as shown.

Fig. 16: Engine Traceability Label
Courtesy of GENERAL MOTORS COMPANY

1. Broadcast Code
2. Machine Readable 2D Matrix
3. VPPS Code
4. Part Sequence Number
5. Reserved use
6. Broadcast Code
7. Model year
8. Julian Date
9. Build Year
10. Shift ID
11. Plant ID
12. GM Part Number
13. Plant DUNS Number
14. Sequence Number
15. RPO/Engine Family Code

DIAGNOSTIC INFORMATION AND PROCEDURES

DTC P06DA-P06DC: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE CONTROL CIRCUIT

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P06DA

Engine Oil Pressure Control Solenoid Valve Control Circuit

DTC P06DB

Engine Oil Pressure Control Solenoid Valve Control Circuit Low Voltage

DTC P06DC

Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open / High Resistance	Short to Voltage	Signal Performance
Ignition	P0030, P0031, P0050, P0051, P0135, P0155, P0300, P0443, P0458, P0506, P06DA, P3401, P3403, P3417, P3425, P3427, P3441, P3443,	P06DA	P0690	-

Circuit	Short to Ground	Open / High Resistance	Short to Voltage	Signal Performance
	P3449, P3451			
Control	P06DB	P06DA	P06DC	P06DA

Circuit/System Description

The engine oil pressure control solenoid is a two port solenoid valve used to control engine oil pressure inside the mechanical engine oil pump. The ECM controls the commanded states of the engine oil pressure control solenoid with the following ECM input's.

- Engine Speed
- Engine Oil Temperature (calculated from the Engine Coolant Temperature Sensor)
- Engine Oil Pressure
- Engine Run Time

With the engine oil pressure control solenoid commanded Off, engine oil pressure is higher. When commanded On engine oil pressure is lower. The purpose of this diagnostic is to isolate an electrical problem with the engine oil pressure control solenoid or wiring.

Conditions for Running the DTC

- The system voltage is greater than 11 V.
- DTC P06DA, P06DB or P06DC runs continuously when the above conditions are met.

Conditions for Setting the DTC

The ECM detects that the commanded state of the driver and the actual state of the control circuit do not match for a minimum of 0.25 s.

Action Taken When the DTC Sets

- DTC P06DA, P06DB and P06DC are Type B DTCs.
- ECM commands the engine oil pressure control solenoid valve OFF.
- ECM commands Reduced Engine Power.

Conditions for Clearing the MIL/DTC

- DTC P06DA, P06DB and P06DC are Type B DTC.

Reference Information

Schematic Reference

Engine Mechanical Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify the parameters listed below do not display Malfunction when commanding the Engine Oil Pressure Control Solenoid Valve ON and OFF with a scan tool.
    - Engine Oil Pressure Control Solenoid Valve Control Circuit Low Voltage Test Status
    - Engine Oil Pressure Control Solenoid Valve Control Circuit Open Test Status
    - Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage Test Status
    - **If Malfunction is displayed**

      Refer to Circuit/System Testing.

- **If Malfunction is not displayed**

3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.
   - **If any DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
5. All OK.

Circuit/System Testing

1. Ignition OFF, disconnect the oil pressure control solenoid jumper harness X173. Refer to **Master Electrical Component List** .
2. Ignition ON.
3. Verify that a test lamp illuminates between the ignition circuit terminal 1 and ground, engine harness side.
   - **If the test lamp does not illuminate and the circuit fuse is good**

   1. Ignition OFF, remove the test lamp.

      NOTE: **An internal short in any component supplied by the fuse may cause the fuse to open and set a DTC when the component is activated.**

   2.
   3. Test for less than 2 Ω in the ignition circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω verify the fuse is not open and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**

   1. Ignition OFF, remove the test lamp.
   2. Test for infinite resistance between the ignition circuit and ground.
      - If less than infinite resistance, repair the short to ground in the circuit.
      - If infinite resistance, test all the components connected to fuse and replace as necessary.
   - **If the test lamp illuminates**

4. Verify that a test lamp does not illuminate between the ignition circuit terminal 1 and the control circuit terminal 2.
    - **If the test lamp illuminates**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the control circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance, replace the K20 Engine Control Module.
    - **If the test lamp does not illuminate**
5. Remove the test lamp, command the Q44 Engine Oil Pressure Control Solenoid Valve ON with a scan tool.
6. Verify the scan tool Engine Oil Pressure Control Solenoid Valve Control Circuit High Voltage Test Status parameter displays OK.
    - **If OK is not displayed**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the control circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If OK is displayed**
7. Install a 3 A fused jumper wire between the control circuit terminal 2 and the ignition circuit terminal 1.
8. Verify the scan tool Engine Oil Pressure Control Solenoid Valve Circuit High Voltage Test Status parameter is displaying Malfunction when commanding the Engine Oil Pressure Control Solenoid Valve ON and OFF with a scan tool.
    - **If Malfunction is not displayed**
    1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for less than 2 Ω in the control circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω replace the K20 Engine Control Module.
    - **If Malfunction is displayed**
9. Test or replace the Q44 Engine Oil Pressure Control Solenoid Valve.

Component Testing

Static Test

1. Ignition OFF, disconnect the harness connector at the Q44 Engine Oil Pressure Control Solenoid Valve.

2. Test for 10-30 Ω between the control terminal 2 and the ignition voltage terminal 1.
   - **If not between 10.0-30.0 Ω**

     Replace the Q44 Engine Oil Pressure Control Solenoid Valve.

   - **If between 10.0-30.0 Ω**
3. Test for infinite resistance between each terminal and the Q44 Engine Oil Pressure Control Solenoid Valve housing.
   - **If not OL**

     Replace the Q44 Engine Oil Pressure Control Solenoid Valve.

   - **If OL**
4. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Oil Pump Flow Control Solenoid Valve Replacement** for Q44 Engine Oil Pressure Control Solenoid Valve Replacement
- Refer to **Control Module References** for ECM replacement, programming, and setup

DTC P06DD: ENGINE OIL PRESSURE CONTROL SOLENOID VALVE STUCK OFF

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P06DD

Engine Oil Pressure Control Solenoid Valve Stuck Off

Circuit/System Description

The engine oil pressure control solenoid is a two port solenoid valve used to control engine oil pressure inside the mechanical engine oil pump. The

ECM controls the commanded states of the engine oil pressure control solenoid with the following ECM input's.

- Engine Speed
- Engine Oil Temperature (calculated from the Engine Coolant Temperature Sensor)
- Engine Oil Pressure
- Engine Run Time

With the engine oil pressure control solenoid commanded Off, engine oil pressure is higher. When commanded On engine oil pressure is lower. The purpose of this diagnostic is to isolate either a stuck on or stuck off engine oil pressure control solenoid.

Conditions for Running the DTC

P06DD

- DTC P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0128, P0335, P0336, P0521, P0522, P0523, P06DA, P06DB, P06DC, P111E, P2227, P2228, P2229 or P2230 is not set.
- Engine speed within range of 1, 200 RPM to 2,500 RPM.

Conditions for Setting the DTC

P06DD

Engine oil pressure is above or below a calibrated amount during the time the solenoid is changing from ON to OFF states.

Action Taken When the DTC Sets

P06DD

DTC P06DD is a Type B DTC.

Conditions for Clearing the DTC

P06DD

DTC P06DD is a Type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Verify correct engine oil level and condition. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.
2. Engine Running, increase and maintain the engine speed at 1, 200 RPM.

   NOTE: **Selecting the scan tool line graph function may make it easier to identify Engine Oil Pressure changes.**

3. Verify the scan tool Engine Oil Pressure parameter changes greater than 30 kPa (4 PSI) when commanding the Engine Oil Pressure Control Solenoid On and Off.
   - **If the parameter does not change**

     Replace the Q44 Engine Oil Pressure Control Solenoid.

   - **If the parameter changes**
4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

5. Verify the DTC does not set.
    - **If the DTC sets**

      Refer to **Oil Pressure Diagnosis and Testing**.

    - **If the DTC does not set**
6. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

Refer to **Oil Pump Flow Control Solenoid Valve Replacement** Oil Pump Flow Control Solenoid Valve Replacement.

SYMPTOMS - ENGINE MECHANICAL

Strategy Based Diagnostics

1. Perform the **Diagnostic System Check - Vehicle** before using the symptom tables.
2. Review the system operations in order to familiarize yourself with the system functions. Refer to **Disassembled Views**, **Engine Content Specifications**, **Engine Component Description**, **Lubrication Description**, **Camshaft Position Actuator and Solenoid Valve Description**, and **Cylinder Deactivation (Active Fuel Management) System Description**.

All diagnosis on a vehicle should follow a logical process. Strategy based diagnostics is a uniform approach for repairing all systems. The diagnostic flow may always be used in order to resolve a system condition. The diagnostic flow is the place to start when repairs are necessary. For a detailed explanation, refer to **Strategy Based Diagnosis** .

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the engine. Refer to **Checking Aftermarket Accessories** .
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.
- Inspect for the correct oil level, proper oil viscosity, and correct filter application.
- Verify the exact operating conditions under which the concern exists. Note factors such as engine RPM, ambient temperature, engine temperature, amount of engine warm-up time, and other specifics.
- Compare the engine sounds, if applicable, to a known good engine and make sure you are not trying to correct a normal condition.

Intermittent

Test the vehicle under the same conditions that the customer reported in order to verify the system is operating properly.

Symptom List

Refer to a symptom diagnostic procedure from the following list in order to diagnose the symptom:

- **Base Engine Misfire without Internal Engine Noises**
- **Base Engine Misfire with Abnormal Internal Lower Engine Noises**
- **Base Engine Misfire with Abnormal Valve Train Noise**
- **Base Engine Misfire with Coolant Consumption**
- **Base Engine Misfire with Excessive Oil Consumption**
- **Engine Noise on Start-Up, but Only Lasting a Few Seconds**
- **Upper Engine Noise, Regardless of Engine Speed**
- **Lower Engine Noise, Regardless of Engine Speed**
- **Engine Noise Under Load**
- **Engine Will Not Crank - Crankshaft Will Not Rotate**
- **Coolant in Combustion Chamber**
- **Coolant in Engine Oil**
- **Cylinder Deactivation (Active Fuel Management) System Diagnosis**
- **Engine Compression Test**
- **Cylinder Deactivation (Active Fuel Management) System Test**
- **Cylinder Leakage Test**
- **Oil Consumption Diagnosis**
- **Oil Pressure Diagnosis and Testing**
- **Cylinder Deactivation (Active Fuel Management) Valve Lifter Oil Manifold Diagnosis and Testing**
- **Camshaft Position Actuator and Solenoid Valve Diagnosis and Testing**
- **Oil Leak Diagnosis**
- **Crankcase Ventilation System Inspection/Diagnosis**
- **Drive Belt Chirping, Squeal, and Whine Diagnosis**
- **Drive Belt Rumbling and Vibration Diagnosis**

- Drive Belt Falls Off and Excessive Wear Diagnosis
- Drive Belt Tensioner Diagnosis

BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

Cause	Correction
High oil pressure	• Verify oil pressure. Refer to Oil Pressure Diagnosis and Testing. • Repair or replace damaged components as required.
Worn, damaged, or improperly installed accessory drive belt - severe cracking, bumps or missing segments A misfire DTC may be present without an actual misfire condition.	• Inspect the accessory drive system components. • Repair or replace damaged components as required. Refer to Drive Belt Replacement - Accessory.
Worn, damaged, or improperly installed accessory drive system components A misfire DTC may be present without an actual misfire condition.	• Inspect the accessory drive system components. • Repair or replace damaged components as required.
Damaged, loose or improperly installed crankshaft balancer A misfire DTC may be present without an actual misfire condition.	• Inspect the crankshaft balancer. • Repair or replace damaged components as required. Refer to Crankshaft Balancer Replacement.
Worn, damaged, or improperly installed crankshaft reluctor wheel A worn or damaged crankshaft reluctor wheel can result in different symptoms depending on the severity and location of the wear or damage. • Systems with electronic communications, DIS or coil per cylinder, and severe reluctor ring damage may exhibit periodic loss of crankshaft position, stop delivering a signal, and then re-sync the crankshaft position. • Systems with electronic communication, DIS or coil per cylinder, and slight reluctor ring damage may exhibit no loss of crankshaft position and no misfire may occur. However, a DTC	• Inspect the crankshaft position sensor. • Inspect the crankshaft reluctor wheel. • Inspect the crankshaft. • Repair or replace damaged components as required.

Cause	Correction
P0300 may be set. • Systems with mechanical communications, high voltage switch, and severe reluctor ring damage may cause additional pulses and effect fuel and spark delivery. A DTC P0300 or P0336 may be set.	
Damaged, improperly installed or restricted exhaust system, collapsed or dented pipes, plugged mufflers or malfunctioning catalytic converters A DTC may be present without an actual fault condition.	• Inspect the exhaust system components. • Repair or replace damaged components as required.
Worn, damaged or improperly installed vacuum hoses	• Inspect the vacuum system components. • Repair or replace damaged components as required.
Damaged or improperly installed MAP sensor, sealing grommet nicked, torn or missing	• Inspect the MAP sensor. • Repair or replace damaged components as required.
Damaged or improperly installed throttle body	• Inspect the throttle body. • Repair or replace damaged components as required.
Damaged or improperly installed intake manifold	• Inspect the intake manifold. • Repair or replace damaged components as required.
Damaged or improperly installed cylinder head Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs. Refer to **Spark Plug Inspection** . • Verify engine compression. Refer to **Engine Compression Test**. • Inspect the cylinder heads. • Inspect the engine block. • Repair or replace damaged components as required.
Worn, damaged or loose valve rocker arm	• Inspect the valve rocker arms.

Cause	Correction
	• Repair or replace damaged components as required.
Worn, damaged or loose valve rotator	• Inspect the valve rotators. • Repair or replace damaged components as required.
Worn, damaged, loose or broken valve spring	• Inspect the valve springs. • Repair or replace damaged components as required.
Worn, damaged or stuck valve, carbon on the valve stem or valve seat	• Inspect the valves. • Inspect the valve guides. • Repair or replace damaged components as required.
Worn or damaged valve guide	• Inspect the valve guides. • Inspect the valves. • Repair or replace damaged components as required.
Worn, damaged, loose or bent valve push rod	• Inspect the valve push rods. • Repair or replace damaged components as required.
Worn, damaged or dirty valve lifter	• Inspect the valve lifters. • Inspect the camshaft. • Repair or replace damaged components as required.
Worn or damaged camshaft lobe	• Inspect the camshaft. • Inspect the valve lifters. • Repair or replace damaged components as required.
Worn, damaged or loose timing chain and sprockets	• Inspect the timing chain and sprockets. • Repair or replace damaged components as required.

Cause	Correction
Worn, damaged or improperly installed piston Pistons must be installed with the mark, or dimple, on the top of the piston, facing the front of the engine; piston pins must be centered in the connecting rod pin bore. Oil consumption may or may not cause the engine to misfire.	• Inspect the spark plugs. Refer to **Spark Plug Inspection** . • Verify engine compression. Refer to **Engine Compression Test**. • Inspect the cylinder bores. • Inspect the pistons. • Inspect the piston pins. • Inspect the connecting rods. • Repair or replace damaged components as required.

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

Cause	Correction
Abnormalities, such as severe cracking, bumps or missing areas in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations, noises similar to a faulty lower engine and also lead to a misfire condition. A misfire code may be present without an actual misfire condition.	Replace the drive belt. Refer to **Drive Belt Replacement - Accessory**.
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout A misfire code may be present without an actual misfire condition.	Inspect the components and repair or replace, as required.
Loose or improperly installed engine flex plate or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flex plate and/or balancer, as required. Refer to **Automatic Transmission Flex Plate Removal**, and **Automatic Transmission Flex Plate Installation**, or **Crankshaft Balancer Removal**, and **Crankshaft Balancer Installation**.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	1. Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** . 2. Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. 3. Perform cylinder leak down and compression testing to

Cause	Correction
	determine the cause. Refer to **Cylinder Leakage Test**. 4. Repair or replace, as required.
Worn crankshaft thrust bearings Severely worn thrust surfaces on the crankshaft and/or thrust bearing may permit fore and aft movement of the crankshaft and create a DTC without an actual misfire condition.	Replace the crankshaft and bearings, as required.

BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

Cause	Correction
Worn or loose rocker arms The rocker arm bearing end caps and/or needle bearings should be intact within the rocker arm assembly.	Replace the valve rocker arms, as required.
Worn or bent pushrods	• Replace the pushrods. • Inspect the top of the pistons for valve contact. If the top of the piston shows valve contact, replace the piston and pin assembly.
Stuck valves Carbon buildup on the valve stem can cause the valve to not close properly.	Repair or replace, as required.
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets, as required.
Worn camshaft lobes	Replace the camshaft and valve lifters.
Sticking lifters	Replace, as required.
Cut or damaged oil pump screen O-ring seal which may cause aeration of the engine oil	Repair, as required. Refer to **Oil Pressure Diagnosis and Testing**.
Improper operation of the active fuel management system	Repair, as required. Refer to **Cylinder Deactivation (Active Fuel Management) System Diagnosis**.
Improper operation of the camshaft position (CMP) actuator and/or control system	Repair, as required. Refer to **Camshaft Position Actuator and Solenoid Valve Diagnosis and Testing**.

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

Cause	Correction
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages Coolant consumption may or may not cause the engine to overheat.	1. Inspect for spark plugs saturated by coolant. Refer to **Spark Plug Inspection** . 2. Perform a cylinder leak down test. Refer to **Cylinder Leakage Test**. 3. Inspect the cylinder heads and engine block for damage to the coolant passages and/or a faulty head gasket. Refer to **Coolant in Combustion Chamber**. 4. Repair or replace, as required.

BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION

Cause	Correction
Worn valves, valve guides and/or valve stem oil seals	1. Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** . 2. Repair or replace, as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	1. Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** . 2. Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. 3. Perform cylinder leak down and compression testing to determine the cause. Refer to **Cylinder Leakage Test**. 4. Repair or replace, as required.

ENGINE NOISE ON START-UP, BUT ONLY LASTING A FEW SECONDS

Cause	Correction
Fuel injector harness connectors are connected to the incorrect fuel injectors/cylinders	Relocate the fuel injector harness connectors, as necessary.

Cause	Correction
Abnormalities, such as severe cracking, bumps, or missing areas in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations and lead to a misfire diagnostic trouble code (DTC). A misfire code may be present without an actual misfire condition.	Replace the drive belt. Refer to **Drive Belt Replacement - Accessory**.
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout May lead to a misfire DTC. A misfire code may be present without an actual misfire condition.	Inspect the components and repair or replace, as required.
Loose or improperly installed engine flex plate or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flex plate and/or balancer, as required. Refer to **Automatic Transmission Flex Plate Replacement**, or **Crankshaft Balancer Replacement**.
Restricted exhaust system A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a DTC. Possible causes of restrictions include collapsed or dented pipes or plugged mufflers and/or catalytic converters.	Repair or replace, as required.
Improperly installed or damaged vacuum hoses	Repair or replace, as required.
Improper sealing between the intake manifold and cylinder heads or throttle body	Replace the intake manifold, gaskets, cylinder heads, and/or throttle body, as required.
Improperly installed or damaged manifold absolute pressure (MAP) sensor The sealing grommet of the MAP sensor should not be torn or damaged.	Repair or replace the MAP sensor, as required.
Worn or loose rocker arms The rocker arm bearing end caps and/or needle bearings should be intact and in the proper position.	Replace the valve rocker arms, as required.
Worn or bent pushrods	• Replace the pushrods. • Inspect the top of the pistons for valve contact. If the top of the piston shows valve contact, replace the piston and pin assembly.

Cause	Correction
Stuck valves Carbon buildup on the valve stem can cause the valve to not close properly.	Repair or replace, as required.
Excessively worn or mis-aligned timing chain	Replace the timing chain and sprockets, as required.
Worn camshaft lobes	Replace the camshaft and valve lifters.
Excessive oil pressure A lubrication system with excessive oil pressure may lead to excessive valve lifter pump-up and loss of compression.	1. Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. 2. Repair or replace the oil pump, as required.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages Coolant consumption may or may not cause the engine to overheat.	1. Inspect for spark plugs saturated by coolant. Refer to **Spark Plug Inspection** . 2. Inspect the cylinder heads, engine block, and/or head gaskets. Refer to **Coolant in Combustion Chamber**. 3. Repair or replace, as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	1. Inspect the spark plugs for oil deposits. Refer to **Spark Plug Inspection** . 2. Inspect the cylinders for a loss of compression. Refer to **Engine Compression Test**. 3. Perform cylinder leak down and compression testing to identify the cause. Refer to **Cylinder Leakage Test**. 4. Repair or replace, as required.
A damaged crankshaft reluctor wheel A damaged crankshaft reluctor wheel can result in different symptoms depending on the severity and location of the damage. • Systems with electronic communications, DIS or coil per cylinder, and severe reluctor ring damage may exhibit periodic loss of crankshaft position, stop delivering a signal, and then sync the crankshaft position. • Systems with electronic communication, DIS or coil per	Replace the sensor and/or crankshaft, as required.

Cause	Correction
cylinder, and slight reluctor ring damage may exhibit no loss of crankshaft position and no misfire may occur. However, a P0300 DTC may be set. • Systems with mechanical communications, high voltage switch, and severe reluctor ring damage may cause additional pulses and effect fuel and spark delivery to the point of generating a P0300 DTC or P0336.	
Improper operation of the active fuel management system	Repair, as required. Refer to **Cylinder Deactivation (Active Fuel Management) System Diagnosis**.
Improper operation of the camshaft position (CMP) actuator and/or control system	Repair, as required. Refer to **Camshaft Position Actuator and Solenoid Valve Diagnosis and Testing**.

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. 2. Repair or replace, as required.
Loose and/or worn valve rocker arm attachments	1. Inspect the valve rocker arm, bolt, and pedestal. 2. Repair or replace, as required.
Worn or damaged valve rocker arm	1. Inspect the rocker arm for wear or missing needle bearings 2. Replace the valve rocker arms, as required.
Bent or damaged push rod	Inspect the following components and replace, as required: • The valve rocker arm • The valve push rod • The valve lifter • The valve lifter guide

Cause	Correction
	• The piston Inspect the top of the pistons for valve contact. If the top of the piston shows valve contact, replace the piston and pin assembly.
Improper lubrication to the valve rocker arms	Inspect the following components and repair or replace, as required: • The valve rocker arm • The valve push rod • The valve lifter • The oil filter bypass valve • The oil pump and pump screen • Improper operation of the active fuel management oil pressure relief valve • The engine block oil galleries
Broken valve spring	Replace the valve spring and spring shim.
Worn or dirty valve lifters	Replace the valve lifters, as required.
Active fuel management valve lifter with a broken spring	Replace the valve lifters, as required.
Improper operation of the camshaft position (CMP) actuator and/or control system	Repair, as required. Refer to **Camshaft Position Actuator and Solenoid Valve Diagnosis and Testing**.
Stretched or broken timing chain and/or damaged sprocket teeth	Replace the timing chain and sprockets.
Worn engine camshaft lobes	1. Inspect the engine camshaft lobes. 2. Replace the camshaft and valve lifters, as required.
Worn valve guides or valve stems	Inspect the following components and repair, as required: • The valves • The valve guides
Stuck valves Carbon on the valve stem or valve seat may cause the valve to stay	Inspect the following components and repair, as required:

Cause	Correction
open.	• The valves • The valve guides
Cut or damaged oil pump screen O-ring seal which may cause aeration of the engine oil	Repair, as required. Refer to **Oil Pressure Diagnosis and Testing**.

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. 2. Repair or replace damaged components, as required.
Worn accessory drive components Abnormalities such as severe cracking, bumps or missing areas in the accessory drive belt and/or misalignment of system components.	1. Inspect the accessory drive system. 2. Repair or replace, as required.
Loose or damaged crankshaft balancer	1. Inspect the crankshaft balancer. 2. Repair or replace, as required.
Detonation or spark knock	Verify the correct operation of the ignition controls system. Refer to **Symptoms - Engine Mechanical**.
Loose torque converter bolts	1. Inspect the torque converter bolts and flex plate. 2. Repair or replace, as required.
Loose or damaged flywheel or flex plate	Repair or replace the flywheel or flex plate.
Oil pump screen loose, damaged, or restricted	1. Inspect the oil pump screen. 2. Repair or replace, as required.
Excessive piston-to-cylinder bore clearance	1. Inspect the piston and cylinder bore. 2. Repair, as required.

Cause	Correction
Excessive piston pin-to-bore clearance	1. Inspect the piston, pin, and connecting rod. 2. Replace the piston and pin as an assembly, as required.
Excessive connecting rod bearing clearance	Inspect the following components and repair, as required: • The connecting rod bearings • The connecting rods • The crankshaft • The crankshaft journals
Excessive crankshaft bearing clearance	Inspect the following components and repair, as required: • The crankshaft bearings • The crankshaft journals
Incorrect piston, piston pin, and connecting rod installation Pistons must be installed with the mark or dimple on the top of the piston facing the front of the engine. Piston pins must be centered in the connecting rod pin bore.	1. Verify the pistons, piston pins and connecting rods are installed correctly. Refer to **Piston, Connecting Rod, and Bearing Installation**. 2. Repair, as required.

ENGINE NOISE UNDER LOAD

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to **Oil Pressure Diagnosis and Testing**. 2. Repair or replace, as required.
Detonation or spark knock	Verify the correct operation of the ignition controls. Refer to **Symptoms - Engine Mechanical**.
Loose torque converter bolts	1. Inspect the torque converter bolts and flex plate. 2. Repair, as required.

ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

Cause	Correction
Seized accessory drive system component	1. Remove accessory drive belts. 2. Rotate crankshaft by hand at the balancer or flywheel location.
Hydraulically locked cylinder • Coolant/antifreeze in cylinder • Oil in cylinder • Fuel in cylinder	1. Remove spark plugs and check for fluid. 2. Inspect for broken head gasket. 3. Inspect for cracked engine block or cylinder head. 4. Inspect for a sticking fuel injector.
Seized automatic transmission torque converter	1. Remove the torque converter bolts. 2. Rotate crankshaft by hand at the balancer or flywheel location.
Seized manual transmission	1. Disengage the clutch. 2. Rotate crankshaft by hand at the balancer or flywheel location.
Broken timing chain and/or gears	• Inspect timing chain and gears. • Repair as required.
Seized balance shaft	• Inspect balance shaft. • Repair as required.
Material in cylinder • Broken valve • Piston material • Foreign material	• Inspect cylinder for damaged components and/or foreign materials. • Repair or replace as required.
Seized crankshaft or connecting rod bearings	• Inspect crankshaft and connecting rod bearings. • Repair as required.

COOLANT IN COMBUSTION CHAMBER

Cause	Correction
DEFINITION: Excessive white smoke and/or coolant type odor coming from the exhaust pipe may indicate coolant in the combustion chamber. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage. **NOTE:** **While not always conclusive, use of hydrocarbon block test kits may reveal hydrocarbons indicating combustion chamber gases in cooling system. It is important to follow the kit instructions. This is not a substitute for service information. Combustion leak tests are available from a wide variety of aftermarket**	

Cause	Correction
suppliers. 1. A slower than normal cranking speed may indicate coolant entering the combustion chamber. Refer to **Engine Will Not Crank - Crankshaft Will Not Rotate**. 2. Remove the spark plugs and inspect for spark plugs saturated by coolant or coolant in the cylinder bore. 3. Inspect by performing a cylinder leak-down test. During this test, excessive air bubbles within the coolant may indicate a faulty gasket or damaged component. 4. Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block, with low compression, may indicate a failed cylinder head gasket. Refer to **Engine Compression Test**.	
Cracked intake manifold or failed gasket	Replace the components as required.
Faulty cylinder head gasket	Replace the head gasket and components as required. Refer to **Cylinder Head Cleaning and Inspection**, and **Cylinder Head Replacement - Left Side**, or **Cylinder Head Replacement - Right Side**.
Warped cylinder head	Machine the cylinder head to the proper flatness, if applicable and replace the cylinder head gasket. Refer to **Cylinder Head Cleaning and Inspection**.
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder liner or engine block	Replace the components as required.
Cylinder head or engine block porosity	Replace the components as required.

COOLANT IN ENGINE OIL

Cause	Correction
DEFINITION: Foamy or discolored oil or an engine oil "overfill" condition may indicate coolant entering the engine crankcase. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an "overtemperature" condition which may cause engine component damage. Contaminated engine oil and oil filter should be changed. 1. Inspect the oil for excessive foaming or an overfill condition. Oil diluted by coolant may not properly lubricate the crankshaft bearings and may lead to component damage. Refer to **Lower Engine Noise, Regardless of Engine Speed**. 2. Inspect by performing a cylinder leak-down test. During this test, excessive air bubbles within the cooling system may indicate a faulty gasket or damaged component.	

Cause	Correction
3. Inspect by performing a cylinder compression test. Two cylinders "side-by-side" on the engine block with low compression may indicate a failed cylinder head gasket. Refer to **Engine Compression Test**.	
Faulty external engine oil cooler	Replace the components as required.
Faulty cylinder head gasket	Replace the head gasket and components as required. Refer to **Cylinder Head Cleaning and Inspection**, and **Cylinder Head Replacement - Left Side**, or **Cylinder Head Replacement - Right Side**.
Warped cylinder head	Machine the cylinder head to proper flatness, if applicable, and replace the cylinder head gasket. Refer to **Cylinder Head Cleaning and Inspection**.
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder liner or engine block	Replace the components as required.
Cylinder head, block, or manifold porosity	Replace the components as required.

CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) SYSTEM DIAGNOSIS

1. Measure the engine oil level. Fill, as required.
2. Using the scan tool, inspect for diagnostic codes within the engine control module (ECM). Refer to **Diagnostic System Check - Vehicle** . Repair, as required.
3. Verify proper engine oil pressure and operation of the active fuel management oil pressure relief valve. Refer to **Oil Pressure Diagnosis and Testing**.
4. Verify proper operation of the active fuel management system components. Refer to **Cylinder Deactivation (Active Fuel Management) System Test**.
5. Remove the valve lifter oil manifold. Refer to **Valve Lifter Oil Manifold Replacement**.
6. Verify proper operation of the valve lifter oil manifold. Refer to **Cylinder Deactivation (Active Fuel Management) Valve Lifter Oil Manifold Diagnosis and Testing**.
7. Replace the active fuel management valve lifters, as required. Both intake and exhaust lifters should be replaced in pairs. Refer to **Valve Lifter Replacement**.

ENGINE COMPRESSION TEST

Engine Compression Test

Special Tools

EN-22794 Spark Plug Port Adapter

Equivalent regional tools:**Special Tools**

A compression pressure test of the engine cylinders determines the condition of the piston rings, the valves and the head gaskets.

1. Run the engine until it reaches normal operating temperature. The battery must be at or near full charge. You may wish to connect a battery charger for the duration of the test to maintain an adequate battery level.
2. Turn the engine OFF.
3. Remove the spark plug wires. Refer to **Spark Plug Wire Replacement**
4. Remove the spark plugs. Refer to **Spark Plug Replacement**
5. Connect the GDS2 to the vehicle and select "Compression Test". Enabling the Compression Test will disable the fuel pump, fuel injectors, and spark. The throttle body is opened to a Wide Open Throttle (WOT) position. The GDS2 will also automatically control the cranking procedure for many applications. If cranking control is not available use a remote start switch in place of the Starter Relay to control cranking.
6. Measure the engine compression, using the following procedure:
    1. Thread the **EN-22794** spark plug port adapter into the spark plug hole.
    2. Thread the compression gauge into the **EN-22794** spark plug port adapter.
    3. Enable cranking via the GDS2 or remote start switch (If using a remote switch, crank the engine for four compression strokes). Record the reading after cranking is complete.
    4. When the compression measurement is normal, the compression builds up quickly and evenly to the specified compression on each cylinder.
    5. Repeat the compression test for each cylinder.
7. Compare the compression readings from all of the cylinders.
    - The lowest reading should not be less than 70 percent of the highest reading.
    - No cylinder reading should be less than 690 kPa (100 PSI).
8. The following are indicators of potential problems:
    - When low compression is caused by the piston rings, compression is low on the first stroke and tends to build up on the following strokes, but does not reach normal. Compression improves considerably with the addition of oil to the cylinder. Use approximately 3 squirts of oil from a plunger-type oiler into the cylinder and replace the gauge and measure again.
    - When low compression is caused by the valves, the measurement is low on the first stroke and does not build up even with the addition

of oil.

- Leaking head gaskets will provide the same results as worn valves but engine coolant may be identified in the crankcase. In addition, a leaking head gasket will give low readings on paired cylinders

9. Disconnect the GDS2 diagnostic tool ore remote start switch.
10. Install the spark plugs. Refer to **Spark Plug Replacement**
11. Install the spark plug wires. Refer to **Spark Plug Wire Replacement**

CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) SYSTEM TEST

The Cylinder Deactivation (Active Fuel Management) System Test is a functional test of the valve lifter oil manifold and valve lifters. Using a scan tool, the technician can command the active fuel management solenoid for each cylinder on and off and monitor a specific cylinders ability to go into and out of active fuel management.

1. Measure the engine oil level. Fill, as required.
2. Perform the Diagnostic System Check - Vehicle. Refer to **Diagnostic System Check - Vehicle** .
3. Connect the scan tool.
4. Start the engine and idle.
5. Using the scan tool output controls, command the solenoid ON, for the cylinder to be deactivated. If the active fuel management system is working correctly, the engine should stumble and an engine RPM drop of at least 100 RPM should be observed.
6. Using the scan tool, de-energize the solenoid and perform step 5 for the remaining cylinders.
7. Test each of the 4 active fuel management cylinders, 1 at a time. If the behavior described in step 5 is not observed, remove, and test the valve lifter oil manifold, as required. Refer to **Valve Lifter Oil Manifold Replacement**, and **Cylinder Deactivation (Active Fuel Management) Valve Lifter Oil Manifold Diagnosis and Testing**.
8. If the system test has been performed and all active fuel management cylinders are operating normally, the active fuel management system is performing as designed and no repairs are required.
9. Clear the diagnostic trouble codes (DTCs) with a scan tool.

CYLINDER LEAKAGE TEST

Special Tools

J 35667-A Cylinder Head Leakdown Tester, or equivalent

For equivalent regional tools, refer to **Special Tools**.

NOTE: **A leakage test may be performed in order to measure cylinder/combustion chamber leakage. High cylinder leakage may indicate one or more of the following conditions:**

- **Worn or burnt valves**
- **Broken valve springs**
- **Stuck valve lifters**
- **Incorrect valve lash**
- **Damaged piston**
- **Worn piston rings**
- **Worn or scored cylinder bore**
- **Damaged cylinder head gasket**
- **Cracked or damaged cylinder head**
- **Cracked or damaged engine block**

WARNING: **Refer to Battery Disconnect Warning .**

1. Disconnect the battery ground negative cable.
2. Remove the spark plugs. Refer to **Spark Plug Replacement** .
3. Rotate the crankshaft to place the piston in the cylinder being tested at top dead center (TDC) of the compression stroke.
4. Install the **J 35667-A** tester, or equivalent.

NOTE: **It may be necessary to hold the crankshaft balancer bolt to prevent the crankshaft from rotating.**

5. Apply shop air pressure to the **J 35667-A** tester and adjust according to the manufacturers instructions.
6. Record the cylinder leakage value. Cylinder leakage that exceeds 25 percent is considered excessive and may require component service. In excessive leakage situations, inspect for the following conditions:
   - Air leakage noise at the throttle body or air inlet hose that may indicate a worn or burnt intake valve or a broken valve spring.
   - Air leakage noise at the exhaust system tailpipe that may indicate a worn or burnt exhaust valve or a broken valve spring.
   - Air leakage noise from the crankcase, oil level indicator tube, or oil fill tube that may indicate worn piston rings, a damaged piston, a worn or scored cylinder bore, a damaged engine block or a damaged cylinder head.
   - Air bubbles in the cooling system may indicate a damaged cylinder head or a damaged cylinder head gasket.

7. Perform the leakage test on the remaining cylinders and record the values.

OIL CONSUMPTION DIAGNOSIS

Checks	Causes
Excessive oil consumption, not due to leaks, is the use of 1 L (1 qt) or more of engine oil within 3,200 kilometers (2,000 miles).	
Preliminary	The causes of excessive oil consumption may include the following conditions: • External oil leaks Refer to **Oil Leak Diagnosis**. • Incorrect oil level or improper reading of the oil level indicator With the vehicle on a level surface, run the engine for a few minutes, allow adequate drain down time, 2-3 minutes, and measure for the correct engine oil level. • Improper oil viscosity Refer to the vehicle owners manual and use the recommended SAE grade and viscosity for the prevailing temperatures. • Continuous high speed driving and/or severe usage • Crankcase ventilation system restrictions or malfunctioning components Refer to **Crankcase Ventilation System Inspection/Diagnosis**. • Worn valve guides and/or valve stems • Worn or improperly installed valve stem oil seals Refer to **Spark Plug Inspection** . • Piston rings broken, worn, or not seated properly Allow adequate time for the rings to seat. Replace worn piston rings, as necessary.

Checks	Causes
	Refer to **Cylinder Leakage Test**. • Piston and rings improperly installed or not fitted to the cylinder bore Refer to **Lower Engine Noise, Regardless of Engine Speed**.

OIL PRESSURE DIAGNOSIS AND TESTING

Special Tools

- **EN-21867** Pressure Gauge
- **EN-21867-850** Active Fuel Management Oil Pressure Adapter

For equivalent regional tools, refer to **Special Tools**.

1. With the vehicle on a level surface, run the vehicle for a few minutes. Allow adequate drain down time, 2-3 minutes, and measure the oil level.
2. If required, add the recommended grade engine oil and fill the crankcase until the oil level measures full on the oil level indicator.
3. Run the engine briefly, 10-15 seconds, and verify low or no oil pressure on the vehicle gauge or light.
4. Listen for a noisy valve train or a knocking noise.
5. Inspect for the following conditions:
    - Oil diluted by water or glycol antifreeze

      Refer to **Coolant in Engine Oil**.

    - Foamy oil, which may be caused by a cut or damaged oil pump screen O-ring seal

Fig. 17: Oil Pressure Sensor And Seal
Courtesy of GENERAL MOTORS COMPANY

6. Remove the oil pressure sensor (1) and seal (2).

Fig. 18: Active Fuel Management Oil Pressure Adapter
Courtesy of GENERAL MOTORS COMPANY

7. Install the **EN-21867-850** active fuel management oil pressure adapter (2) and **EN-21867** pressure gauge (1), or equivalent.
8. Run the engine until the engine reaches normal operating temperature and measure the engine oil pressure.
9. Compare the readings to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.
10. If the engine oil pressure is below specifications, inspect the engine for 1 or more of the following conditions:

- Valve lifter oil manifold filter plugged or damaged. Refer to **Valve Lifter Oil Manifold Cleaning and Inspection**.
- Check if the engine oil cooler or oil cooler lines are plugged or damaged.
- Oil pump worn or dirty. Refer to **Oil Pump Cleaning and Inspection**.
- Oil pump-to-engine block bolts loose. Refer to **Oil Pump Installation**.
- Oil pump screen loose, plugged, or damaged.
- Oil pump screen O-ring seal missing or damaged.
- Excessive debris in the oil pan and/or oil filter (possibly indicating internal engine damage).
- Malfunctioning oil pump pressure relief valve. Refer to **DTC P06DA-P06DC**, or **DTC P06DD**.
- Excessive bearing clearance and/or bearing damage. Refer to **Crankshaft and Bearing Cleaning and Inspection**, and **Camshaft and Bearings Cleaning and Inspection**.
- Cracked, porous, or restricted oil galleries.
- Oil gallery plugs missing or incorrectly installed. Refer to **Engine Block Plug Installation**.

CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) VALVE LIFTER OIL MANIFOLD DIAGNOSIS AND TESTING

Special Tools

- **EN-46999** Active Fuel Management Tester
- **EN-46999-18** Active Fuel Management Tester Air Adapter
- **EN-46999-20** Active Fuel Management Tester Harness - Small Block V8

For equivalent regional tools, refer to **Special Tools**

NOTE:

- **A minimum shop air source of 206 kPa (30 psi) is required for manifold testing.**
- **A water bleed is located on the side of the EN-46999 tester. Occasionally, depress the valve in order to remove excess water from the tool.**

Fig. 19: Displacement On-Demand Tester
Courtesy of GENERAL MOTORS COMPANY

The manifold bench test provides a maximum 206 kPa (30 psi) of filtered shop air to the manifold and will test each solenoid/valve for the following conditions:

- Proper operation
- A stuck open condition - constant air flow

- A stuck closed condition - no air flow
- A flow restriction within the manifold

1. Individually depress each of the buttons 1-4 on the **EN-46999** tester in order to activate each of the solenoid/valves. When activating each solenoid/valve, a loud click should be heard from the solenoid and an increased amount of air will exit the outlet ports.
    - Button 1 will energize the solenoid/valve 1 for engine cylinder number 1.
    - Button 2 will energize the solenoid/valve 2 for engine cylinder number 4.
    - Button 3 will energize the solenoid/valve 3 for engine cylinder number 6.
    - Button 4 will energize the solenoid/valve 4 for engine cylinder number 7.

Fig. 20: Valve Lifter Oil Manifold
Courtesy of GENERAL MOTORS COMPANY

2. Do not lift the manifold assembly by the electrical lead frame.

Fig. 21: Active Fuel Management Tester Air Adapter, Air Out Hose And Air Supply Switch
Courtesy of GENERAL MOTORS COMPANY

3. Connect **EN-46999-18** active fuel management tester air adapter (9) to the air out hose (2) of the **EN-46999** tester (5). This will make it possible to connect an air nozzle fitted with a standard 1/4 in NPT female air fitting. Verify the air supply switch (4) is in the off position.
4. Connect the air out hose (6) of the **EN-46999** tester (5) to a shop air source.
5. Connect the 12 volt power supply connectors (7) of the **EN-46999** tester (5) to a 12 volt power supply. Verify the Power light (8) on the tool is

illuminated. If the light on the tool is not illuminated when connected to a 12 volt power supply, test and/or replace the 3 amp fuse.

6. Connect the **EN-46999-20** active fuel management tester harness - small block V8 (3) to the tester. Connect **EN-46999-20** active fuel management tester harness - small block V8 to the electrical connector of the manifold.
7. Connect an air nozzle fitted with a tapered rubber tip to **EN-46999-18** active fuel management tester air adapter (9). Hold the tip of the air nozzle in the oil passage directly below the Valve Lifter Oil Manifold Oil Filter (1).

Fig. 22: Turning Air Supply Switch Of EN-46999 Tester To ON Position

Courtesy of GENERAL MOTORS COMPANY

8. Turn the air supply switch of the **EN-46999** tester to the ON position. With the air supply connected to the manifold assembly and the solenoid/valves in the closed position, a limited amount of air will exit from the outlet ports (1, 2) of the manifold.

Fig. 23: Depressing Button Number 1 On Tool To Activate Solenoid/Valve 1
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The manifold must be tested in the proper position to ensure the solenoid/valves operate as designed.**

9. Position the manifold assembly onto a bench at a 45 degree angle in order to test solenoid/valves 1 and 4.
10. Depress button number 1 on the tool to activate solenoid/valve 1. With button 1 depressed, the solenoid/valve (1) should open, allowing an increased amount of air to exit the outlet ports (2) of the manifold.
11. Depress button number 4 on the tool to activate solenoid/valve 4. With button 4 depressed, the solenoid/valve (4) should open, allowing an increased amount of air to exit the outlet ports (3) of the manifold.

Fig. 24: Repositioning Manifold Assembly Onto Bench At 45 Degree Angle
Courtesy of GENERAL MOTORS COMPANY

12. Reposition the manifold assembly onto a bench at a 45 degree angle in order to test solenoid/valves 2 and 3.
13. Depress button number 2 on the tool to activate solenoid/valve 2. With button 2 depressed, the solenoid/valve (2) should open, allowing an increased amount of air to exit the outlet ports (4) of the manifold.
14. Depress button number 3 on the tool to activate solenoid/valve 3. With button 3 depressed, the solenoid/valve (3) should open, allowing an increased amount of air to exit the outlet ports (1) of the manifold.
15. When the test is completed, turn the air source switch on the **EN-46999** tester to the off position and disconnect the tool from the 12 volt power supply, and shop air source. Disconnect air nozzle.
16. If after testing, it has been determined that one or more of the solenoid/valves is not functioning properly, replace the manifold as an assembly.
17. If after testing, it has been determined that the solenoid/valves are functioning properly, replace the valve lifters as required. Both intake and exhaust lifters should be replaced in pairs.

CAMSHAFT POSITION ACTUATOR AND SOLENOID VALVE DIAGNOSIS AND TESTING

1. Measure the engine oil level. Fill, as required.
2. Using the scan tool, inspect for diagnostic codes within the engine control module (ECM). Refer to **Diagnostic System Check - Vehicle** . Repair, as required.
3. Verify proper engine oil pressure and operation of the active fuel management oil pressure relief valve. Refer to **Oil Pressure Diagnosis and Testing**.
4. Inspect the CMP actuator solenoid valve for proper operation. Refer to **Camshaft Position Actuator Solenoid Valve Inspection**.
   - If valve inspection confirms proper movement of the spool, replace the CMP actuator and CMP valve.
   - If valve inspection confirms improper movement of the spool, replace only the CMP valve.
5. Verify proper operation of the CMP actuator control system. Refer to **Diagnostic System Check - Vehicle** .

OIL LEAK DIAGNOSIS

Step	Action	Yes	No
IMPORTANT: You can repair most fluid leaks by first visually locating the leak, repairing or replacing the component, or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the cause of the leak as well as the leak itself.			

Step	Action	Yes	No
1	1. Operate the vehicle until it reaches normal operating temperature. 2. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 3. Wait 15 minutes. 4. Inspect for drippings. Are drippings present?	Go to **Step 2**	System OK
2	Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 3**
3	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Inspect for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 4**
4	1. Completely clean the entire engine and surrounding components. 2. Operate the vehicle for several kilometers, miles, at normal operating temperature and at varying speeds. 3. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 4. Wait 15 minutes. 5. Identify the type of fluid, and the approximate location of the leak. Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 5**
5	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Inspect for leaks at the following locations: • Sealing surfaces • Fittings	Go to **Step 10**	Go to **Step 6**

Step	Action	Yes	No
	• Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?		
6	1. Completely clean the entire engine and surrounding components. 2. Apply an aerosol-type powder, baby powder, foot powder, etc., to the suspected area. 3. Operate the vehicle for several kilometers, miles, at normal operating temperature and at varying speeds. 4. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface. Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 7**
7	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Inspect for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 8**
8	Use the **J 28428-E** High-Intensity Black Light Kit in order to identify the type of fluid, and the approximate location of the leak. Refer to the manufacturer's instructions when using the tool. Can you identify the type of fluid and the approximate location of the leak?	Go to **Step 10**	Go to **Step 9**
9	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Inspect for leaks at the following locations: • Sealing surfaces • Fittings • Cracked or damaged components	Go to **Step 10**	System OK

Step	Action	Yes	No
	Can you identify the type of fluid and the approximate location of the leak?		
10	1. Inspect the engine for mechanical damage. Special attention should be shown to the following areas: • Higher than recommended fluid levels • Higher than recommended fluid pressures • Plugged or malfunctioning fluid filters or pressure bypass valves • Plugged or malfunctioning engine ventilation system • Improperly tightened or damaged fasteners • Cracked or porous components • Improper sealants or gaskets, where required • Improper sealant or gasket installation • Damaged or worn gaskets or seals • Damaged or worn sealing surfaces 2. Inspect the engine for customer modifications. Is there mechanical damage, or customer modifications to the engine?	Go to **Step 11**	System OK
11	Repair or replace all damaged or modified components. Does the engine still leak oil?	Go to **Step 1**	System OK

CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS

Symptom	Correction
External oil leak	Inspect for any of the following conditions: • Restricted or kinked PCV hose or engine vent hose • Damaged, incorrect, or incorrectly installed PCV hose • Excessive crankcase pressure • Restricted or blocked PCV valve

Symptom	Correction
Rough Idle	Inspect for any of the following conditions: • Restricted or kinked PCV hose or engine vent hose • Leaking (damaged) PCV hose • Vacuum hoses worn or not properly installed • PCV valve leaking or stuck open
Stalling or slow idle speed	Inspect for any of the following conditions: • Restricted or kinked engine vent hose • Leaking (damaged) PCV hose • Restricted or blocked PCV valve
High idle speed	Inspect for the following conditions: • Inspect for a leaking (damaged) PCV hose • PCV valve leaking or stuck open • PCV tube from PCV valve to intake manifold disconnected
Sludge in the engine	Inspect for restricted or kinked PCV hose or engine vent hose

DRIVE BELT CHIRPING, SQUEAL, AND WHINE DIAGNOSIS

Diagnostic Aids

- A chirping or squeal noise may be intermittent due to moisture on the drive belts or the pulleys. It may be necessary to spray a small amount of water on the drive belts in order to duplicate the customers concern. If spraying water on the drive belt duplicates the symptom, cleaning the belt pulleys may be the probable solution.
- If the noise is intermittent, verify the accessory drive components by varying their loads making sure they are operated to their maximum capacity. An overcharged A/C system, power steering system with a pinched hose or wrong fluid, or a generator failing are suggested items to inspect.
- A chirping, squeal or whine noise may be caused by a loose or improper installation of a body or suspension component. Other items of the vehicle may also cause the noise.

- The drive belts will not cause a whine noise.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2

The noise may not be engine related. This step is to verify that the engine is making the noise. If the engine is not making the noise do not proceed further with this table.

3

The noise may be an internal engine noise. Removing the drive belts one at a time and operating the engine for a brief period will verify the noise is related to the drive belt. When removing the drive belt the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belts removed.

4

Inspect all drive belt pulleys for pilling. Pilling is the small balls or pills or it can be strings in the drive belt grooves from the accumulation of rubber dust.

6

Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.

10

Inspecting of the fasteners can eliminate the possibility that a wrong bolt, nut, spacer, or washer was installed.

12

Inspecting the pulleys for being bent should include inspecting for a dent or other damage to the pulleys that would prevent the drive belt from not seating properly in all of the pulley grooves or on the smooth surface of a pulley when the back side of the belt is used to drive the pulley.

14

This test is to verify that the drive belt tensioner operates properly. If the drive belt tensioner is not operating properly, proper belt tension may not be achieved to keep the drive belt from slipping which could cause a squeal noise.

15

This test is to verify that the drive belt is not too long, which would prevent the drive belt tensioner from working properly. Also if an incorrect length drive belt was installed, it may not be routed properly and may be turning an accessory drive component in the wrong direction.

16

Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.

17

This test is to verify that the pulleys are the correct diameter or width. Using a known good vehicle compare the pulley sizes.

19

Replacing the drive belt when it is not damaged or there is not excessive pilling will only be a temporary repair.

Step	Action	Yes	No
CAUTION: **Refer to Belt Dressing Caution .** DEFINITION: The following items are indications of chirping: • A high pitched noise that is heard once per revolution of the drive belt or a pulley. • Chirping may occur on cold damp start-ups and will subside once the vehicle reaches normal operating temp. DEFINITION: The following items are indications of drive belt squeal: • A loud screeching noise that is caused by a slipping drive belt. This is unusual for a drive belt with multiple ribs.			

Step	Action	Yes	No
• The noise occurs when a heavy load is applied to the drive belt, such as an air conditioning compressor engagement snapping the throttle, or slipping on a seized pulley or a faulty accessory drive component. DEFINITION: The following items are indications of drive belt whine: • A high pitched continuous noise. • The noise may be caused by an accessory drive component failed bearing.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a chirping, squeal or whine noise. Does the engine make the chirping squeal or whine noise?	Go to **Step 3**	Go to Diagnostic Aids
3	1. Remove the drive belt. If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the chirping, squeal or whine noise still exist?	Go to **Symptoms - Engine Mechanical**	Go to **Step 4**
4	• If diagnosing a chirping noise, inspect for severe pilling exceeding 1/3 of the belt groove depth. • If diagnosing a squeal or whine noise, proceed to step 13. Do the belt grooves have pilling?	Go to **Step 5**	Go to **Step 6**
5	Clean the drive belt pulleys with a suitable wire brush. Did you complete the repair?	Go to **Step 20**	Go to **Step 6**
6	Inspect for misalignment of the pulleys. Are any of the pulleys misaligned?	Go to **Step 7**	Go to **Step 8**
7	Replace or repair any misaligned pulleys. Did you complete the repair?	Go to **Step 20**	Go to **Step 8**

Step	Action	Yes	No
8	Inspect for bent or cracked brackets. Did you find any bent or cracked brackets?	Go to **Step 9**	Go to **Step 10**
9	Replace any bent or cracked brackets. Did you complete the repair?	Go to **Step 20**	Go to **Step 10**
10	Inspect for improper, loose or missing fasteners. Did you find the condition?	Go to **Step 11**	Go to **Step 12**
11	**CAUTION:** **Refer to Fastener Caution .** 1. Tighten any loose fasteners. Refer to **Fastener Specifications**. 2. Replace any improper or missing fasteners. Did you complete the repair?	Go to **Step 20**	Go to **Step 12**
12	Inspect for a bent pulley. Did you find the condition?	Go to **Step 18**	Go to **Step 13**
13	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. If diagnosing a whine noise and the condition still exist, proceed to Diagnostic Aids. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 14**
14	Test the drive belt tensioner for proper operation. Refer to **Drive Belt Tensioner Diagnosis**. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 15**
15	Inspect for the correct drive belt length. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 16**
16	Inspect for misalignment of a pulley. Did you find and correct the condition?	Go to **Step 20**	Go to **Step 17**
17	Inspect for the correct pulley size. Did you find and correct the condition?	Go to **Step 20**	Go to Diagnostic Aids

Step	Action	Yes	No
18	Replace the bent pulley. Did you complete the repair?	Go to **Step 20**	Go to **Step 19**
19	Replace the drive belt. Refer to **Drive Belt Replacement - Accessory**, or **Air Conditioning Compressor Belt Replacement**. Did you complete the repair?	Go to **Step 20**	Go to Diagnostic Aids
20	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

DRIVE BELT RUMBLING AND VIBRATION DIAGNOSIS

Diagnostic Aids

The accessory drive components can have an affect on engine vibration. Vibration from the engine operating may cause a body component or another part of the vehicle to make rumbling noise. Vibration can be caused by, but not limited to the air conditioning (A/C) system over charged, the power steering system restricted or the incorrect fluid, or an extra load on the generator. To help identify an intermittent or an improper condition, vary the loads on the accessory drive components.

The drive belt may have a rumbling condition that can not be seen or felt. Sometimes replacing the drive belt may be the only repair for the symptom.

If replacing the drive belt, completing the diagnostic table, and the noise is only heard when the drive belts are installed, there might be an accessory drive component with a failure. Varying the load on the different accessory drive components may aid in identifying which component is causing the rumbling noise.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2

This test is to verify that the symptom is present during diagnosing. Other vehicle components may cause a similar symptom.

3

This test is to verify that one of the drive belts is causing the rumbling noise or vibration. Rumbling noise may be confused with an internal engine noise due to the similarity in the description. Remove only one drive belt at a time if the vehicle has multiple drive belts. When removing the drive belts the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belts removed.

4

Inspecting the drive belts is to ensure that they are not causing the noise. Small cracks across the ribs of the drive belt will not cause the noise. Belt separation is identified by the plys of the belt separating and may be seen at the edge of the belt or felt as a lump in the belt.

5

Small amounts of pilling is normal condition and acceptable. When the pilling is severe the drive belt does not have a smooth surface for proper operation.

9

Inspecting of the fasteners can eliminate the possibility that the wrong bolt, nut, spacer, or washer was installed.

11

This step should only be performed if the water pump is driven by the drive belt. Inspect the water pump shaft for being bent. Also inspect the water pump bearings for smooth operation and excessive play. Compare the water pump with a known good water pump.

12

Accessory drive component brackets that are bent, cracked, or loose may put extra strain on that accessory component causing it to vibrate.

Step	Action	Yes	No

CAUTION:
Refer to Belt Dressing Caution .
 	
DEFINITION: The following items are indications of drive belt rumbling:
• A low pitch tapping, knocking, or thumping noise heard at or just above idle.
• Heard once per revolution of the drive belt or a pulley.
• Rumbling may be caused from:
  • Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove
  • The separation of the drive belt			

Step	Action	Yes	No
	• A damaged drive belt DEFINITION: The following items are indications of drive belt vibration: • The vibration is engine-speed related. • The vibration may be sensitive to accessory load.		
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	Verify that there is a rumbling noise or that the vibration is engine related. Does the engine make the rumbling noise or vibration?	Go to **Step 3**	Go to Diagnostic Aids
3	**NOTE:** **If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed.** 1. Remove the drive belt. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the rumbling or vibration still exist?	Go to **Symptoms - Engine Mechanical**, or **Vibration Analysis - Engine**	Go to **Step 4**
4	Inspect the drive belts for wear, damage, separation, sections of missing ribs, and debris build-up. Did you find any of these conditions?	Go to **Step 7**	Go to **Step 5**

Step	Action	Yes	No
5	Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves. Did you find severe pilling?	Go to **Step 6**	Go to **Step 7**
6	1. Clean the drive belt pulleys using a suitable wire brush. 2. Reinstall the drive belts. Refer to **Drive Belt Replacement - Accessory**, or **Air Conditioning Compressor Belt Replacement**. Did you correct the condition?	Go to **Step 8**	Go to **Step 7**
7	Install a new drive belt. Refer to **Drive Belt Replacement - Accessory**, or **Air Conditioning Compressor Belt Replacement**. Did you complete the replacement?	Go to **Step 8**	Go to **Step 9**
8	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 9**
9	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	Go to **Step 10**	Go to **Step 11**
10	**CAUTION:** **Refer to Fastener Caution .** 1. Tighten any loose fasteners. Refer to **Fastener Specifications**. 2. Replace improper or missing fasteners. Did you complete the repair?	Go to **Step 13**	Go to **Step 11**
11	Inspect for a bent water pump shaft. Refer to **Water Pump Replacement (L83, L86)** . Did you find and correct the condition?	Go to **Step 13**	Go to **Step 12**
12	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to **Step 13**	Go to Diagnostic Aids
13	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 3**

DRIVE BELT FALLS OFF AND EXCESSIVE WEAR DIAGNOSIS

Diagnostic Aids

If the drive belt repeatedly falls off the drive belt pulleys, this is because of pulley misalignment.

An extra load that is quickly applied on released by an accessory drive component may cause the drive belt to fall off the pulleys. Verify the accessory drive components operate properly.

If the drive belt is the incorrect length, the drive belt tensioner may not keep the proper tension on the drive belt.

Excessive wear on a drive belt is usually caused by an incorrect installation or the wrong drive belt for the application.

Minor misalignment of the drive belt pulleys will not cause excessive wear, but will probably cause the drive belt to make a noise or to fall off.

Excessive misalignment of the drive belt pulleys will cause excessive wear but may also make the drive belt fall off.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2

This inspection is to verify the condition of the drive belt. Damage may of occurred to the drive belt when the drive belt fell off. The drive belt may of been damaged, which caused the drive belt to fall off. Inspect the belt for cuts, tears, sections of ribs missing, or damaged belt plys.

4

Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure of that pulley.

5

Inspecting the pulleys for being bent should include inspecting for a dent or other damage to the pulleys that would prevent the drive belt from not seating properly in all of the pulley grooves or on the smooth surface of a pulley when the back side of the belt is used to drive the pulley.

6

Accessory drive component brackets that are bent or cracked will let the drive belt fall off.

7

Inspection of the fasteners can eliminate the possibility that a wrong bolt, nut, spacer, or washer was installed. Missing, loose, or the wrong fasteners may cause pulley misalignment from the bracket moving under load. Over tightening of the fasteners may cause misalignment of the accessory component bracket.

13

The inspection is to verify the drive belt is correctly installed on all of the drive belt pulleys. Wear on the drive belt may be caused by mis-positioning the drive belt by one groove on a pulley.

14

The installation of a drive belt that is too wide or too narrow will cause wear on the drive belt. The drive belt ribs should match all of the grooves on all of the pulleys.

15

This inspection is to verify the drive belt is not contacting any parts of the engine or body while the engine is operating. There should be sufficient clearance when the drive belt accessory drive components load varies. The drive belt should not come in contact with an engine or a body component when snapping the throttle.

Step	Action	Yes	No
CAUTION: **Refer to Belt Dressing Caution .** DEFINITION: The drive belt falls off the pulleys or may not ride correctly on the pulleys.DEFINITION: Wear at the outside ribs of the drive belt due to an incorrectly installed drive belt.			
1	Did you review the Drive Belt Symptom operation and perform the necessary inspections?	Go to **Step 2**	Go to **Symptoms - Engine Mechanical**
2	• If diagnosing excessive wear, proceed to step 13. • If diagnosing a drive belt that falls off, inspect for a damaged drive	Go to **Step 3**	Go to **Step 4**

Step	Action	Yes	No
	belt. Did you find the condition?		
3	Install a new drive belt. Refer to **Drive Belt Replacement - Accessory**, or **Air Conditioning Compressor Belt Replacement**. Does the drive belt continue to fall off?	Go to **Step 4**	System OK
4	Inspect for misalignment of the pulleys. Did you find and repair the condition?	Go to **Step 12**	Go to **Step 5**
5	Inspect for a bent or dented pulley. Did you find and repair the condition?	Go to **Step 12**	Go to **Step 6**
6	Inspect for a bent or a cracked bracket. Did you find and repair the condition?	Go to **Step 12**	Go to **Step 7**
7	Inspect for improper, loose or missing fasteners. Did you find loose or missing fasteners?	Go to **Step 8**	Go to **Step 9**
8	**CAUTION:** **Refer to Fastener Caution .** 1. Tighten any loose fasteners. Refer to **Fastener Specifications**. 2. Replace improper or missing fasteners. Does the drive belt continue to fall off?	Go to **Step 9**	System OK
9	Test the drive belt tensioner for operating correctly. Refer to **Drive Belt Tensioner Diagnosis**. Does the drive belt tensioner operate correctly?	Go to **Step 11**	Go to **Step 10**
10	Replace the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Accessory**. Does the drive belt continue to fall off?	Go to **Step 11**	System OK
11	Inspect for failed drive belt idler and drive belt tensioner pulley bearings. Did you find and repair the condition?	Go to **Step 12**	Go to Diagnostic Aids

Step	Action	Yes	No
12	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to **Step 13**
13	Inspect the drive belt for the proper installation. Refer to **Drive Belt Replacement - Accessory**, or **Air Conditioning Compressor Belt Replacement**. Did you find this condition?	Go to **Step 16**	Go to **Step 14**
14	Inspect for the proper drive belt. Did you find this condition?	Go to **Step 16**	Go to **Step 15**
15	Inspect for the drive belt rubbing against a bracket, hose, or wiring harness. Did you find and repair the condition?	Go to **Step 17**	Go to Diagnostic Aids
16	Replace the drive belt. Refer to **Drive Belt Replacement - Accessory**, or **Air Conditioning Compressor Belt Replacement**. Did you complete the replacement?	Go to **Step 17**	-
17	Operate the system in order to verify the repair. Did you correct the condition?	System OK	-

DRIVE BELT TENSIONER DIAGNOSIS

Step	Action	Yes	No
1	Remove the drive belt. Refer to **Drive Belt Replacement - Accessory**. Inspect the drive belt tensioner pulley. Is the drive belt tensioner pulley loose or misaligned?	Go to **Step 4**	Go to **Step 2**
2	Rotate the drive belt tensioner. Does the tensioner rotate without any unusual resistance or binding?	Go to **Step 3**	Go to **Step 4**
3	1. Use a torque wrench in order to measure the torque required to move the tensioner off of the stop. 2. Use a torque wrench on a known good tensioner in order to measure the torque required to move the tensioner off of the stop. Is the first torque reading within 10% of the second torque reading?	System OK	Go to **Step 4**
4	Replace the drive belt tensioner. Refer to **Drive Belt Tensioner Replacement - Accessory**.	System OK	-

Step	Action	Yes	No
	Is the repair complete?		

REPAIR INSTRUCTIONS - ON VEHICLE

VACUUM PUMP BELT REPLACEMENT

Removal Procedure

1. Remove the air conditioning compressor belt. Refer to **Air Conditioning Compressor Belt Replacement**.

Fig. 25: Vacuum Pump Belt
Courtesy of GENERAL MOTORS COMPANY

2. Cut the belt (1) from the vacuum pump and crankshaft pulleys.

Installation Procedure

Fig. 26: Vacuum Pump Belt
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The OEM replacement stretchy belt is packaged with a disposable installation tool.**

1. Position the belt on the crankshaft balancer (1) at the last belt placement inward and partially onto the vacuum pump pulley (2).
2. Install the belt installation tool (3) onto the vacuum pump pulley.

Fig. 27: Drive Belt Installation Tool
Courtesy of GENERAL MOTORS COMPANY

3. Slide the belt installation tool (1) downward, partially installing the belt (2) onto the vacuum pump pulley.
4. Slide the belt installation tool downward, applying light tension to the belt.

Fig. 28: Rotating Engine Clockwise
Courtesy of GENERAL MOTORS COMPANY

5. With the belt in position, rotate the engine clockwise to completely install the belt onto the vacuum pump and crankshaft pulleys.

Fig. 29: Inspecting Ribbed Area Of Belt For Correct Alignment
Courtesy of GENERAL MOTORS COMPANY

6. Once the belt is installed, rotate the engine 360 degrees and inspect the ribbed area of the belt (1) to ensure that it is correctly aligned with the pulleys grooves (2).

Fig. 30: Inspecting Back Side Of Vacuum Pump Belt
Courtesy of GENERAL MOTORS COMPANY

7. Inspect the back side of the vacuum pump belt (1) for proper orientation after rotating the engine.
8. Install the air conditioning compressor belt. Refer to **Air Conditioning Compressor Belt Replacement**.

DRIVE BELT REPLACEMENT - ACCESSORY

Fig. 31: Accessory Drive Belt Routing
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)** **Air Cleaner Outlet Duct Replacement (Cadillac)** .	
1	Drive Belt Tensioner **Procedure** Rotate the drive belt tensioner counterclockwise to release the drive belt tension.
2	Drive Belt **Procedure**

Callout	Component Name
	1. Slide the drive belt off of the belt idler pulley. 2. Slowly release the drive belt tensioner.

AIR CONDITIONING COMPRESSOR BELT REPLACEMENT

Removal Procedure

1. Remove Drive Belt - **Drive Belt Replacement - Accessory**
2. Remove Steering Gear Skid Shield - **Steering Gear Skid Shield Replacement** .

Fig. 32: Cutting Accessory Drive Belt
Courtesy of GENERAL MOTORS COMPANY

3. Cut the belt (1) from air conditioning (A/C) and crankshaft pulleys.

Installation Procedure

NOTE: **The OEM replacement stretchy belt is packaged with a disposable installation tool and installation instructions.**

1. Install the air conditioning belt following the instructions included with the belt.

Fig. 33: Drive Belt Alignment

Courtesy of GENERAL MOTORS COMPANY

2. Inspect the drive belt (1) for proper installation and alignment.

Fig. 34: A/C Compressor Drive Belt
Courtesy of GENERAL MOTORS COMPANY

3. Rotate the balancer (1) and additional 360 degrees to ensure proper belt installation.
4. Install Steering Gear Skid Shield - **Steering Gear Skid Shield Replacement** .
5. Install Drive Belt - **Drive Belt Replacement - Accessory**

DRIVE BELT TENSIONER REPLACEMENT - ACCESSORY

Fig. 35: Drive Belt Tensioner - Accessory
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures Remove the drive belt. Refer to **Drive Belt Replacement - Accessory**.	
1	Tensioner Bolt **Tighten**

Callout	Component Name
	58 N.m (43 lb ft)
2	Drive Belt Tensioner - Accessory

ENGINE MOUNT INSPECTION

CAUTION: Broken or deteriorated mounts can cause misalignment and destruction of certain drive train components. When a single mount breaks, the remaining mounts are subjected to abnormally high stresses.

CAUTION: When raising or supporting the engine for any reason, do not use a jack under the oil pan, any sheet metal, or the crankshaft pulley. Due to the small clearance between the oil pan and the oil pump screen, jacking against the oil pan may cause the pan to be bent against the pump screen. This will result in a damaged oil pickup unit.

1. Measure the engine movement at the engine mount in order to check for damage to the rubber portions of the mount.
    1. Apply the park brake.
    2. Start the engine.
    3. Firmly apply and hold the primary brakes.
    4. Have an assistant stand to the side of the vehicle in order to observe for engine movement.
    5. Slightly load the engine shifting from drive to reverse a few times.
    6. If the engine moves more than 24 mm (0.945 in) from the at rest position, in either direction, check for loose engine mount bolts.
2. If the engine mount bolt torque is within specifications, check the condition of the engine mount.
3. Replace the engine mount if any of the following conditions exist:
    - Heat check cracks cover the rubber cushion surface.
    - The rubber cushion is separated from the metal plate of the mount.
    - There is a split through the rubber cushion.

ENGINE MOUNT REPLACEMENT - LEFT SIDE

Removal Procedure

CAUTION: When raising or supporting the engine for any reason, do not use a jack under any sheet metal, or the crankshaft pulley, or damage may occur.

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection (Dual Battery)** **Battery Negative Cable Disconnection and Connection (Single Battery)** .
2. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)** **Air Cleaner Outlet Duct Replacement (Cadillac)** .
3. If equipped with 4WD, remove the front axle. Refer to **Front Axle Replacement (8.25 Inch LD Axle)** **Front Axle Replacement (9.25 Inch HD Axle)** .
4. Remove the drivetrain and front suspension frame front crossmember. Refer to **Drivetrain and Front Suspension Frame Front Crossmember Replacement** .
5. Remove the left wheelhouse liner. Refer to **Front Wheelhouse Liner Replacement - Left Side (Cadillac)** **Front Wheelhouse Liner Replacement - Left Side (GMC)** **Front Wheelhouse Liner Replacement - Left Side (Chevrolet)** .
6. Remove the vacuum pump. Refer to **Vacuum Pump Replacement** .

Fig. 36: Engine Mount To Frame Bolts
Courtesy of GENERAL MOTORS COMPANY

7. Remove the engine mount to frame bolts (1).
8. Remove exhaust manifold heat shield. Refer to **Exhaust Manifold Heat Shield Replacement - Left Side (L83, L86)** .
9. Position a screw jack and a block of wood under the lower engine oil pan.

Fig. 37: Engine Mount To Engine Block Bolts
Courtesy of GENERAL MOTORS COMPANY

10. Working through the wheelhouse opening, remove the engine mount to engine block bolts (1).

Fig. 38: Engine Mount
Courtesy of GENERAL MOTORS COMPANY

11. Remove the engine mount (1) toward the front of the vehicle.

Installation Procedure

1. Apply threadlocker or equivalent to the threads of the engine mount to engine mount bracket bolts. Refer to **Adhesives, Fluids, Lubricants,**

and Sealers.

Fig. 39: Engine Mount
Courtesy of GENERAL MOTORS COMPANY

2. Position the engine mount (1) to the engine block.

Fig. 40: Engine Mount To Engine Block Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

3. Working through the wheelhouse opening, install the engine mount to engine block bolts (1) and tighten to 65 N.m (48 lb ft).
4. Using the adjustable jack, lower the engine until the engine mount is sitting flush on the frame.

5. Remove the adjustable jack and block of wood from the engine oil pan.

Fig. 41: Engine Mount To Frame Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Clean the threads of the engine mount to frame bolts (1) using denatured alcohol or equivalent.
7. Apply threadlocker or equivalent to the threads of the engine mount to engine mount bracket bolts. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

8. Install the engine mount to frame bolts and tighten to 50 N.m (37 lb ft).
9. If equipped with 4WD, install the front axle. Refer to **Front Axle Replacement (8.25 Inch LD Axle)** **Front Axle Replacement (9.25 Inch HD Axle)** .
10. Install the drivetrain and front suspension frame front crossmember. Refer to **Drivetrain and Front Suspension Frame Front Crossmember Replacement** .
11. Install exhaust manifold heat shield. Refer to **Exhaust Manifold Heat Shield Replacement - Left Side (L83, L86)** .
12. Install the vacuum pump. Refer to **Vacuum Pump Replacement** .
13. Install the left wheelhouse liner. Refer to **Front Wheelhouse Liner Replacement - Left Side (Cadillac)** **Front Wheelhouse Liner Replacement - Left Side (GMC)** **Front Wheelhouse Liner Replacement - Left Side (Chevrolet)** .
14. Lower the vehicle.
15. Install the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)** **Air Cleaner Outlet Duct Replacement (Cadillac)** .
16. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection (Dual Battery)** **Battery Negative Cable Disconnection and Connection (Single Battery)** .

ENGINE MOUNT REPLACEMENT - RIGHT SIDE

Removal Procedure

CAUTION: When raising or supporting the engine for any reason, do not use a jack under any sheet metal, or the crankshaft pulley, or damage may occur.

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection (Dual Battery)** **Battery Negative Cable Disconnection and Connection (Single Battery)** .
2. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)** **Air Cleaner Outlet Duct Replacement (Cadillac)** .
3. If equipped with 4WD, remove the front axle. Refer to **Front Axle Replacement (8.25 Inch LD Axle)** **Front Axle Replacement (9.25 Inch HD Axle)** .
4. Remove the drivetrain and front suspension frame front crossmember. Refer to **Drivetrain and Front Suspension Frame Front Crossmember Replacement** .
5. Remove the right wheelhouse liner. Refer to **Front Wheelhouse Liner Replacement - Right Side (Cadillac)** **Front Wheelhouse Liner Replacement - Right Side (Chevrolet)** **Front Wheelhouse Liner Replacement - Right Side (GMC)** .

Fig. 42: Right Upper Engine Mount Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Remove the engine mount to frame bolts (1).
7. Remove exhaust manifold heat shield. Refer to **Exhaust Manifold Heat Shield Replacement - Right Side (L83, L86)** .
8. Position a screw jack and a block of wood under the lower engine oil pan.

Fig. 43: Engine Mount To Engine Block Bolts
Courtesy of GENERAL MOTORS COMPANY

9. Working through the wheelhouse opening, remove the engine mount to engine block bolts (1).
10. Remove the air conditioning compressor belt. Refer to **Air Conditioning Compressor Belt Replacement**

Fig. 44: Air Conditioning Compressor (L83, L86)
Courtesy of GENERAL MOTORS COMPANY

11. Remove the air conditioning compressor nut (1) and bolt (3).
12. Position the air conditioning compressor (4) aside.

Fig. 45: Engine Mount
Courtesy of GENERAL MOTORS COMPANY

13. Remove the engine mount (1) toward the front of the vehicle.

Installation Procedure

1. Apply threadlocker or equivalent to the threads of the engine mount to engine mount bracket bolts. Refer to **Adhesives, Fluids, Lubricants,**

and Sealers.

Fig. 46: Engine Mount
Courtesy of GENERAL MOTORS COMPANY

2. Position the engine mount (1) to the engine block.

Fig. 47: Engine Mount To Engine Block Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

3. Working through the wheelhouse opening, install the engine mount to engine block bolts (1) and tighten to 65 N.m (48 lb ft).

Fig. 48: Air Conditioning Compressor (L83, L86)
Courtesy of GENERAL MOTORS COMPANY

4. Install the air conditioning compressor (4). Refer to **Air Conditioning Compressor Replacement (L83 L86)**
5. Install NEW air conditioning compressor belt. Refer to **Air Conditioning Compressor Belt Replacement**
6. Using the adjustable jack, lower the engine until the engine mount is sitting flush on the frame.
7. Remove the adjustable jack and block of wood from the engine oil pan.

Fig. 49: Right Upper Engine Mount Bolts
Courtesy of GENERAL MOTORS COMPANY

8. Clean the threads of the engine mount to frame bolts (1) using denatured alcohol or equivalent.
9. Apply threadlocker or equivalent to the threads of the engine mount to engine mount bracket bolts. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
10. Install the engine mount to frame bolts and tighten to 50 N.m (37 lb ft).

11. If equipped with 4WD, install the front axle. Refer to **Front Axle Replacement (8.25 Inch LD Axle)** **Front Axle Replacement (9.25 Inch HD Axle)** .
12. Install the drivetrain and front suspension frame front crossmember. Refer to **Drivetrain and Front Suspension Frame Front Crossmember Replacement** .
13. Install exhaust manifold heat shield. Refer to **Exhaust Manifold Heat Shield Replacement - Right Side (L83, L86)** .
14. Install the right wheelhouse liner. Refer to **Front Wheelhouse Liner Replacement - Right Side (Cadillac)** **Front Wheelhouse Liner Replacement - Right Side (Chevrolet)** **Front Wheelhouse Liner Replacement - Right Side (GMC)** .
15. Lower the vehicle.
16. Install the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)** **Air Cleaner Outlet Duct Replacement (Cadillac)** .
17. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection (Dual Battery)** **Battery Negative Cable Disconnection and Connection (Single Battery)** .

POSITIVE CRANKCASE VENTILATION HOSE/PIPE/TUBE REPLACEMENT (LEFT SIDE - L83, L86)

Fig. 50: Positive Crankcase Ventilation Hose/Pipe/Tube (L83, L86 - Left Side)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Positive Crankcase Ventilation Tube **Procedure** Remove tube from valve cover and air cleaner outlet tube. Refer to **Plastic Collar Quick Connect Fitting Service** .

POSITIVE CRANKCASE VENTILATION HOSE/PIPE/TUBE REPLACEMENT (RIGHT SIDE - L83, L86)

Fig. 51: Positive Crankcase Ventilation Hose/Pipe/Tube (L83, L86 - Right Side)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Positive Crankcase Ventilation Tube **Procedure** Remove tube from valve cover and air cleaner outlet tube. Refer to **Plastic Collar Quick Connect Fitting Service** .

POSITIVE CRANKCASE VENTILATION HOSE/PIPE/TUBE REPLACEMENT (CENTER - L83)

Fig. 52: Positive Crankcase Ventilation Hose/Pipe/Tube (L83 - Center)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)** **Air Cleaner Outlet Duct Replacement (Cadillac)** . 2. Disconnect the evaporative emissions canister purge valve tube from the valve and position aside. Refer to **Evaporative Emission Canister Purge Tube Replacement** . 3. Detach the engine harness from the intake manifold and position aside.	
1	Positive Crankcase Ventilation Tube **Procedure**

Callout	Component Name
	Disconnect the tube from the PCV valve and intake manifold. Refer to **Plastic Collar Quick Connect Fitting Service** .

POSITIVE CRANKCASE VENTILATION HOSE/PIPE/TUBE REPLACEMENT (CENTER - L86)

Fig. 53: Positive Crankcase Ventilation Hose/Pipe/Tube (L86 - Center)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)** **Air Cleaner Outlet Duct Replacement (Cadillac)** . 2. Disconnect the evaporative emissions canister purge valve tube from the valve and position aside. Refer to **Evaporative Emission**	

Callout	Component Name
Canister Purge Tube Replacement .	
1	Positive Crankcase Ventilation Tube **Procedure** Disconnect the tube from the PCV valve and intake manifold. Refer to Plastic Collar Quick Connect Fitting Service .

POSITIVE CRANKCASE VENTILATION VALVE REPLACEMENT

Fig. 54: Positive Crankcase Ventilation Valve
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures	

Callout	Component Name
1. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)** **Air Cleaner Outlet Duct Replacement (Cadillac)** . 2. Remove the center PCV Hose. Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (Center - L83)** **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (Center - L86)**.	
1	Positive Crankcase Ventilation Valve **CAUTION:** **Refer to Component Fastener Tightening Caution .** **Tighten** 6 N.m (53 lb in)

INTAKE MANIFOLD REPLACEMENT

Removal Procedure

1. Disconnect the battery ground cable. Refer to **Battery Negative Cable Disconnection and Connection (Dual Battery)** **Battery Negative Cable Disconnection and Connection (Single Battery)** .
2. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)** **Air Cleaner Outlet Duct Replacement (Cadillac)** .

Fig. 55: Engine Wiring Harness Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

3. Disconnect the engine wiring harness electrical connector (1) from the manifold absolute pressure (MAP) sensor.
4. Disconnect the engine harness electrical connector (2) from the throttle actuator.

Fig. 56: EVAP Canister Purge Tube
Courtesy of GENERAL MOTORS COMPANY

5. Disconnect the EVAP canister purge tube (1) quick connect fitting from the EVAP canister purge solenoid valve. Refer to **Plastic Collar Quick Connect Fitting Service** .

Fig. 57: Engine Harness Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

6. Disconnect the engine harness electrical connector (1) from the evaporative emission (EVAP) canister purge solenoid valve.

Fig. 58: Engine Harness Retainers
Courtesy of GENERAL MOTORS COMPANY

7. Remove the engine harness retainers (1) from the intake manifold.
8. Disconnect the center positive crankcase ventilation (PCV) hose from the intake manifold fitting and position aside. Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (Center - L83)Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (Center - L86)**.

Fig. 59: Engine Harness Retainers And Intake Manifold
Courtesy of GENERAL MOTORS COMPANY

9. Remove the engine harness retainers (1) from the intake manifold.

Fig. 60: Intake Manifold Bolts
Courtesy of GENERAL MOTORS COMPANY

10. Loosen the 10 intake manifold bolts (1) and position the manifold forward to gain access to the rear engine harness retainers.

Fig. 61: Engine Harness Retainers And Intake Manifold
Courtesy of GENERAL MOTORS COMPANY

11. Remove the engine harness retainers (1) from the intake manifold.

NOTE: **The aid of an assistant may be helpful in holding the engine harness up out of the way so the upper intake manifold cover does not get caught against the engine harness.**

12. Remove the intake manifold.
13. Cover the cylinder head passages in order to prevent dirt or debris from entering the passages.

Fig. 62: Discard Intake Manifold Gaskets
Courtesy of GENERAL MOTORS COMPANY

14. Remove and discard the intake manifold gaskets (1).
15. Clean and inspect the intake manifold. Refer to **Intake Manifold Cleaning and Inspection**.

16. Transfer components as necessary.

Installation Procedure

Fig. 63: Intake Manifold Gaskets
Courtesy of GENERAL MOTORS COMPANY

1. Install NEW intake manifold gaskets (1) to the intake manifold.

2. Apply a 5 mm (0.20 in) band of threadlock to the threads of the intake manifold bolts. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
3. Remove the covers from the cylinder head passages.

Fig. 64: Intake Manifold
Courtesy of GENERAL MOTORS COMPANY

4. Install the intake manifold (2).

Fig. 65: Engine Harness Retainers And Intake Manifold
Courtesy of GENERAL MOTORS COMPANY

5. Attach the engine harness retainers (1) to the intake manifold.

NOTE: **The aid of an assistant may be helpful in holding the engine harness up out of the way so the upper intake manifold cover does not get caught against the engine harness.**

6. Install the intake manifold bolts (1) finger tight.

Fig. 66: Intake Manifold Bolts Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

7. Tighten the intake manifold bolts to specifications.

Tighten

- Tighten the bolts a first pass in the sequence shown to 5 N.m (44 lb in).
- Tighten the bolts a final pass in the sequence shown to 10 N.m (89 lb in).

Fig. 67: Engine Harness Retainers And Intake Manifold
Courtesy of GENERAL MOTORS COMPANY

8. Attach the engine harness retainers (1) to the intake manifold.
9. Connect the center positive crankcase ventilation (PCV) hose from the intake manifold fitting and position aside. Refer to **Plastic Collar Quick Connect Fitting Service** .

Fig. 68: Engine Harness Retainers
Courtesy of GENERAL MOTORS COMPANY

10. Attach the engine harness retainers (1) to the intake manifold.

Fig. 69: Engine Harness Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

11. Connect the engine harness electrical connector (1) to the evaporative emission (EVAP) canister purge solenoid valve.

Fig. 70: EVAP Canister Purge Tube
Courtesy of GENERAL MOTORS COMPANY

12. Connect the EVAP canister purge tube (1) quick connect fitting to the EVAP canister purge solenoid. Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (Center - L83)Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (Center - L86)**.

Fig. 71: Engine Wiring Harness Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

13. Connect the engine harness electrical connector (2) to the throttle actuator.
14. Connect the engine wiring harness electrical connector (1) to the manifold absolute pressure (MAP) sensor.
15. Install the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)** **Air Cleaner Outlet Duct Replacement (Cadillac)** .

16. Connect the battery ground cable. Refer to **Battery Negative Cable Disconnection and Connection (Dual Battery)** **Battery Negative Cable Disconnection and Connection (Single Battery)** .

INTAKE MANIFOLD COVER REPLACEMENT

Fig. 72: Intake Manifold Cover
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Intake Manifold Cover **Procedure** Pull up on the cover to remove.

VALVE LIFTER OIL MANIFOLD REPLACEMENT

Removal Procedure

1. Remove the fuel pump. Refer to **Fuel Pump Replacement** .
2. Remove the fuel injection fuel rail assemblies. Refer to **Fuel Injection Fuel Rail Assembly Replacement - Bank 1** , and **Fuel Injection Fuel Rail Assembly Replacement - Bank 2** .

Fig. 73: Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

3. Disconnect the two electrical connectors (1).

Fig. 74: Valve Lifter Oil Manifold Bolts
Courtesy of GENERAL MOTORS COMPANY

4. Remove the valve lifter oil manifold bolts (1).
5. Remove the valve lifter oil manifold (2).
6. Remove the gasket (3) from the valve lifter oil manifold and discard.

7. Transfer parts as necessary.

Installation Procedure

NOTE: **All gasket surfaces should be free of oil or other foreign material during assembly.**

Fig. 75: Valve Lifter Oil Manifold (With Tightening Sequence)
Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW gasket (1) on the valve lifter oil manifold.
2. Set the valve lifter oil manifold (2) onto the engine.
3. Install the valve lifter oil manifold bolts (3).

Tighten

1. First pass in sequence 15 N.m (11 lb ft).
2. Final pass in sequence 30 N.m (22 lb ft).

Fig. 76: Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

4. Connect the two electrical connectors (1).
5. Install the fuel injection fuel rail assemblies. Refer to **Fuel Injection Fuel Rail Assembly Replacement - Bank 1** , and **Fuel Injection Fuel Rail Assembly Replacement - Bank 2** .
6. Install the fuel pump. Refer to **Fuel Pump Replacement** .

VALVE LIFTER OIL FILTER REPLACEMENT

Removal Procedure

1. Remove the fuel pump insulator. Refer to **Fuel Pump Insulator Replacement** .

Fig. 77: Drive Motor Oil Filler Hole Plug, Washer And Valve Lifter Oil Filter
Courtesy of GENERAL MOTORS COMPANY

2. Remove the drive motor oil filler hole plug (1) and washer (2).
3. Remove and discard the valve lifter oil filter (3).

Installation Procedure

Fig. 78: Drive Motor Oil Filler Hole Plug, Washer And Valve Lifter Oil Filter
Courtesy of GENERAL MOTORS COMPANY

1. Install the NEW valve lifter oil filter (3).
2. Apply approved GM sealant or equivalent to the threads of the drive motor oil filler hole plug. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

CAUTION: Refer to Fastener Caution .

3. Install the drive motor oil filler hole plug washer (2) and plug (1).

Tighten

Tighten the sensor to 30 N.m (22 lb ft).

4. Install the fuel pump insulator. Refer to **Fuel Pump Insulator Replacement** .

VALVE ROCKER ARM COVER INSULATOR REPLACEMENT - LEFT SIDE

Fig. 79: Valve Rocker Arm Cover Insulator - Left Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Remove the left side positive crankcase ventilation tube. Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (Left Side - L83, L86)**. 2. Remove the oil filler cap.	

Callout	Component Name
1	Valve Rocker Arm Cover Insulator **Procedure** Grasp the valve rocker arm cover insulator and lift up disengaging the grommets from the studs.

VALVE ROCKER ARM COVER INSULATOR REPLACEMENT - RIGHT SIDE

Fig. 80: Valve Rocker Arm Cover Insulator - Right Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Remove the right side positive crankcase ventilation tube. Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement**	

Callout	Component Name
	(Right Side - L83, L86). **NOTE:** **It is not necessary to disconnect the heater hose.** 2. Detach the heater hose from the cylinder head bracket and position aside.
1	Valve Rocker Arm Cover Insulator **Procedure** Grasp the valve rocker arm cover insulator and lift up disengaging the grommets from the studs.

VALVE ROCKER ARM COVER REPLACEMENT - LEFT SIDE

Removal Procedure

1. Remove the oil indicator tube. Refer to **Oil Level Indicator Tube Replacement**.
2. Remove the left side PCV hose/pipe. Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (Left Side - L83, L86)**.
3. Remove the ignition coils. Refer to **Ignition Coil Replacement** .

Fig. 81: Valve Rocker Arm Cover Bolts
Courtesy of GENERAL MOTORS COMPANY

4. Remove the valve rocker arm cover bolts (1).

Fig. 82: Valve Rocker Arm Cover And Valve Rocker Arm Gasket
Courtesy of GENERAL MOTORS COMPANY

5. Remove the valve rocker arm cover (1).
6. Remove and DISCARD valve rocker arm gasket (2). Refer to **Replacing Engine Gaskets**.
7. Clean and inspect the rocker arm cover. Refer to **Valve Rocker Arm Cover Cleaning and Inspection**.

Installation Procedure

Fig. 83: Valve Rocker Arm Cover And Valve Rocker Arm Gasket
Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW valve rocker arm gasket (2).
2. Install the valve rocker arm cover (1).

Fig. 84: Valve Rocker Arm Cover Bolts
Courtesy of GENERAL MOTORS COMPANY

3. Install valve rocker arm cover bolts (1) and hand tighten.

Fig. 85: Valve Rocker Arm Cover Bolts Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

4. Tighten the bolts in sequence to 10 N.m (89 lb in) as shown.
5. Install the oil indicator tube. Refer to **Oil Level Indicator Tube Replacement**.

6. Install the left side PCV hose/pipe. Refer to **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (Left Side - L83, L86)**.
7. Install the ignition coil. Refer to **Ignition Coil Replacement** .

VALVE ROCKER ARM COVER REPLACEMENT - RIGHT SIDE

Removal Procedure

1. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)** **Air Cleaner Outlet Duct Replacement (Cadillac)** .
2. Detach the heater inlet and outlet hose bracket retainer and reposition the bracket.
3. Remove the ignition coils. Refer to **Ignition Coil Replacement** .

Fig. 86: Valve Rocker Arm Cover Bolts
Courtesy of GENERAL MOTORS COMPANY

4. Remove the valve rocker arm cover bolts (1).

Fig. 87: Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS COMPANY

5. Remove the valve rocker arm cover (1).
6. Remove and DISCARD valve rocker arm gasket (2). Refer to **Replacing Engine Gaskets**.
7. Clean and inspect the rocker arm cover. Refer to **Valve Rocker Arm Cover Cleaning and Inspection**.

Installation Procedure

Fig. 88: Valve Rocker Arm Cover
Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW valve rocker arm gasket (2).
2. Install the valve rocker arm cover (1).

Fig. 89: Valve Rocker Arm Cover Bolts
Courtesy of GENERAL MOTORS COMPANY

3. Install valve rocker arm cover bolts (1) and hand tighten.

Fig. 90: Valve Rocker Arm Cover Bolts Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

4. Tighten the bolts in sequence to 10 N.m (89 lb in) as shown.
5. Install the ignition coil. Refer to **Ignition Coil Replacement** .

6. Position and attach the heater inlet and outlet hose bracket retainer.
7. Install the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)** **Air Cleaner Outlet Duct Replacement (Cadillac)** .

VALVE ROCKER ARM AND PUSH ROD REPLACEMENT

Removal Procedure

1. Remove the valve rocker arm cover. Refer to **Valve Rocker Arm Cover Replacement - Left Side**, or **Valve Rocker Arm Cover Replacement - Right Side**.

Fig. 91: Valve Rocker Arm And Bolt Assembly And Pushrod
Courtesy of GENERAL MOTORS COMPANY

2. Remove the valve rocker arm and bolt assembly (1).
3. Remove the pushrod (2).
4. Clean and inspect the rocker arms and/or pushrods, if necessary. Refer to **Valve Rocker Arm and Push Rod Cleaning and Inspection**.

Installation Procedure

NOTE: **Be sure to keep parts in order. Parts must be reinstalled into the original location and position.**

Fig. 92: Pushrod Socket, Roller Pivot & Valve Stem Tip
Courtesy of GENERAL MOTORS COMPANY

1. Apply lubricant to the following rocker arm contact surfaces:
    - Pushrod socket (1)
    - Roller pivot (2)
    - Valve stem tip (3)

Fig. 93: Valve Rocker Arm And Bolt Assembly And Pushrod
Courtesy of GENERAL MOTORS COMPANY

2. Install the pushrod (2).

Fig. 94: Proper Seating Of Push Rod
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

NOTE:

- **When using the valve train components again, always install the components to the original location and position.**
- **Valve lash is net build. No valve adjustment is required.**
- **Lubricate the flange of the valve rocker arm bolts with clean engine oil.**
- **Lubricate the valve rocker arms and pushrods with clean engine oil.**
- **Ensure the pushrods seat properly to the valve lifter sockets.**
- **The rocker arm bolts are not serviced separately.**
- **Ensure the pushrods seat properly to the ends of the rocker arms.**
- **DO NOT tighten the rocker arm bolts at this time.**

3. Install the rocker arm and bolt assembly.

Fig. 95: Camshaft And Crankshaft Sprocket Alignment Marks
Courtesy of GENERAL MOTORS COMPANY

4. Rotate the crankshaft until number 1 piston is at top dead center of compression stroke.

   In this position, cylinder number 1 rocker arms will be off lobe lift, and the crankshaft sprocket key will be at the 1:30 position. The camshaft and crankshaft sprocket alignment marks (1, 2) will be in the 12 o'clock position. If viewing from the rear of the engine, the additional crankshaft pilot hole, non-threaded, will be in the 10:30 position.

The engine firing order is 1, 8, 7, 2, 6, 5, 4, 3.

Cylinders 1, 3, 5, and 7 are left bank.

Cylinders 2, 4, 6, and 8 are right bank.

CAUTION: Refer to Fastener Caution

5. With the engine in the number 1 firing position, tighten the following valve rocker arm bolts:
    1. Tighten the exhaust valve rocker arm bolts 1, 2, 7, and 8 to 30 N.m (22 lb ft).
    2. Tighten the intake valve rocker arm bolts 1, 3, 4, and 5 to 30 N.m (22 lb ft).
6. Rotate the crankshaft 360 degrees.
7. Tighten the following valve rocker arm bolts:
    - Tighten the exhaust valve rocker arm bolts 3, 4, 5, and 6 to 30 N.m (22 lb ft).
    - Tighten the intake valve rocker arm bolts 2, 6, 7, and 8 to 30 N.m (22 lb ft).
8. Install the valve rocker arm cover. Refer to **Valve Rocker Arm Cover Replacement - Left Side**, or **Valve Rocker Arm Cover Replacement - Right Side**.

VALVE STEM OIL SEAL AND VALVE SPRING REPLACEMENT

Special Tools

- **J-22794** Spark Plug Port Adapter
- **J-38606** Valve Spring Compressor

For equivalent regional tools, refer to **Special Tools**.

Removal Procedure

1. Remove the valve rocker arms as needed. Refer to **Valve Rocker Arm and Push Rod Replacement**.
2. Remove the spark plugs as needed. Refer to **Spark Plug Replacement** .

Fig. 96: Compressed Air Adapter Hose
Courtesy of GENERAL MOTORS COMPANY

3. Install the **J- 22794** adapter into the spark plug hole.
4. Connect a shop air supply hose and apply compressed air in order to hold the valves in place.

Fig. 97: Compressing Valve Spring (Cylinder Head Installed) Using Special Tools
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Completely engage the J 38606 jaws on the valve spring. The J 38606 may slip off and scratch the valve spring. Replace the valve spring if the valve spring becomes scratched.

5. Use **J 38606** compressor.

6. Apply steady pressure on the valve spring cap until the valve keys are accessible.

Fig. 98: Valve Components
Courtesy of GENERAL MOTORS COMPANY

7. Remove the valve keys (1).
8. Carefully release the valve spring tension.

9. Remove the **J-38606** compressor.
10. Remove the valve spring cap (2) and valve spring (3).
11. Remove the valve stem oil seal (4).

Installation Procedure

Fig. 99: Valve Components

Courtesy of GENERAL MOTORS COMPANY

1. Install the valve stem oil seal (4).
2. Install the valve spring (3).
3. Install the valve spring cap (2) onto the valve spring (3), over the valve stem.

Fig. 100: Compressing Valve Spring (Cylinder Head Installed) Using Special Tools
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Completely engage the J 38606 jaws on the valve spring. The J 38606 may slip off and scratch the valve spring. Replace the valve spring if the valve spring becomes scratched.

4. Use the **J-38606** compressor.
5. Apply steady pressure on the valve spring cap until the valve key groves are accessible.

NOTE: Use grease in order to hold the valve stem keys in place.

6. Install the valve stem keys.
7. Carefully release the valve spring pressure, making sure the valve stem keys stay in place.

CAUTION: The valve stem keys must correctly seat in the valve spring cap. Engine damage may occur by not installing properly.

8. Remove the **J-38606** compressor.
    1. Look to ensure that the valve stem keys seat properly in the upper groove of the valve stem.
    2. Tap the end of the valve stem with a plastic faced hammer in order to seat the valve stem keys, if necessary.

Fig. 101: Compressed Air Adapter Hose
Courtesy of GENERAL MOTORS COMPANY

9. Remove the **J-22794** adapter.
10. Install the spark plugs. Refer to **Spark Plug Replacement** .
11. Install the valve rocker arms. Refer to **Valve Rocker Arm and Push Rod Replacement**.

OIL LEVEL INDICATOR TUBE REPLACEMENT

Fig. 102: Oil Level Indicator Tube
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the bank 1 valve rocker arm cover insulator. Refer to **Valve Rocker Arm Cover Insulator Replacement - Left Side**	
1	Oil Level indicator Tube fastener **CAUTION:** **Refer to** **Fastener Caution .**

Callout	Component Name
	Tighten 10 N.m (89 lb in)
2	Oil Level Indicator Tube **Procedure** 1. Inspect the oil level indicator tube seal for damage or cuts. 2. Replace the oil level indicator tube seal as needed. 3. Use clean engine oil to lubricate the oil level indicator tube seal prior to installing the tube.

CYLINDER HEAD REPLACEMENT - LEFT SIDE

Removal Procedure

1. Drain the coolant system. Refer to **Cooling System Draining and Filling (Vac N Fill L83 L86)** **Cooling System Draining and Filling (Static Fill L83 L86)** .
2. Remove the fuel injector rail. Refer to **Fuel Injection Fuel Rail Assembly Replacement - Bank 1** .
3. Remove the exhaust manifold. Refer to **Exhaust Manifold Replacement - Left Side (L83, L86)** .
4. Remove the valve rocker arms and push rods. Refer to **Valve Rocker Arm and Push Rod Replacement**.

Fig. 103: Cylinder Head Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Ensure to DISCARD all cylinder head bolts.**

5. Remove the cylinder head bolts (1).
6. Disconnect electrical connectors as necessary.

7. Remove cylinder head (2).
8. Remove and DISCARD cylinder head gasket (3). Refer to **Replacing Engine Gaskets**.
9. For cleaning and inspection. Refer to **Cylinder Head Cleaning and Inspection**.
10. For cylinder head disassemble. Refer to **Cylinder Head Disassemble**.

Installation Procedure

1. For cylinder head assemble. Refer to **Cylinder Head Assemble**.
2. Clean any debris or residual fastener thread sealant from the engine block cylinder head bolt holes to ensure proper torque or clamp load.

Fig. 104: Cylinder Head, Gasket And Bolts With Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

3. Install a NEW cylinder head gasket (1).
4. Install cylinder head (2).

5. Hand start cylinder head bolts (3 and 4).

CAUTION: **Refer to Fastener Caution .**

CAUTION: **Refer to Torque-to-Yield Fastener Caution .**

NOTE: **The forward most fastener on the Left Side Cylinder Head is unique to all other cylinder head fasteners. It is shorter, has an internal hex drive and has a lower final tightening torque angle.**

6. Tighten cylinder head bolts (4) in sequence.
    1. First Pass tighten to 80 N.m (59 lb ft)
    2. Second pass tighten + 90Â°
    3. Final pass tighten + 60Â°
7. Tighten cylinder head bolt (3) in sequence.
    1. First Pass tighten to 80 N.m (59 lb ft)
    2. Second pass tighten + 90Â°
    3. Final pass tighten + 40Â°
8. Connect electrical connectors as necessary.
9. Install the valve rocker arms and push rods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
10. Install the exhaust manifold. Refer to **Exhaust Manifold Replacement - Left Side (L83, L86)** .
11. Install the fuel injector rail. Refer to **Fuel Injection Fuel Rail Assembly Replacement - Bank 1** .
12. Refill the coolant system. Refer to **Cooling System Draining and Filling (Vac N Fill L83 L86)** **Cooling System Draining and Filling (Static Fill L83 L86)** .

CYLINDER HEAD REPLACEMENT - RIGHT SIDE

Removal Procedure

1. Drain the coolant system. Refer to **Cooling System Draining and Filling (Vac N Fill L83 L86)** **Cooling System Draining and Filling (Static Fill L83 L86)** .
2. Remove the fuel injector rail. Refer to **Fuel Injection Fuel Rail Assembly Replacement - Bank 2** .
3. Remove the generator bracket. Refer to **Generator Bracket Replacement** .
4. Remove the exhaust manifold. Refer to **Exhaust Manifold Replacement - Right Side (L83, L86)** .

5. Remove the valve rocker arms and push rods. Refer to **Valve Rocker Arm and Push Rod Replacement**.

Fig. 105: Cylinder Head Bolts And Cylinder Head Gasket
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Ensure to DISCARD all cylinder head bolts.**

6. Remove the cylinder head bolts (1).

7. Disconnect electrical connectors as necessary.
8. Remove cylinder head (2).
9. Remove and DISCARD cylinder head gasket (3). Refer to **Replacing Engine Gaskets**.
10. For cleaning and inspection. Refer to **Cylinder Head Cleaning and Inspection**.
11. For cylinder head disassemble. Refer to **Cylinder Head Disassemble**.

Installation Procedure

1. For cylinder head assemble. Refer to **Cylinder Head Assemble**.
2. Clean any debris or residual fastener thread sealant from the engine block cylinder head bolt holes to ensure proper torque or clamp load.

Fig. 106: Cylinder Head Bolts And Cylinder Head Gasket
Courtesy of GENERAL MOTORS COMPANY

3. Install a NEW cylinder head gasket (3).
4. Install cylinder head (2).
5. Hand start cylinder head bolts (1).

Fig. 107: Cylinder Head Bolts Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

CAUTION: Refer to Torque-to-Yield Fastener Caution .

6. Tighten cylinder head bolts in sequence.

1. First Pass tighten to 80 N.m (59 lb ft)
2. Second pass tighten + 90Â°
3. Final pass tighten + 60Â°

7. Connect electrical connectors as necessary.
8. Install the valve rocker arms and push rods. Refer to **Valve Rocker Arm and Push Rod Replacement**.
9. Install the exhaust manifold. Refer to **Exhaust Manifold Replacement - Right Side (L83, L86)** .
10. Install generator bracket. Refer to **Generator Bracket Replacement** .
11. Install the fuel injector rail. Refer to **Fuel Injection Fuel Rail Assembly Replacement - Bank 2** .
12. Refill the coolant system. Refer to **Cooling System Draining and Filling (Vac N Fill L83 L86)** **Cooling System Draining and Filling (Static Fill L83 L86)** .

VALVE LIFTER FOLLOWER GUIDE ASSEMBLY REPLACEMENT

Fig. 108: Valve Lifter Follower Guide Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the valve lifter oil manifold. Refer to **Valve Lifter Oil Manifold Replacement**.	
1	Valve Lifter Follower Guide Fastener **CAUTION:** **Refer to** **Fastener Caution .** **Tighten** 12 N.m (106 lb in)
2	Valve Lifter Follower Guide
3	Valve Lifter Follower

VALVE LIFTER FOLLOWER GUIDE REPLACEMENT

Fig. 109: Valve Lifter Follower Guide Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the valve lifter oil manifold. Refer to **Valve Lifter Oil Manifold Replacement**.	
1	Valve Lifter Follower Guide Fastener **CAUTION:** **Refer to Fastener Caution .**

Callout	Component Name
	Tighten 12 N.m (106 lb in)
2	Valve Lifter Follower Guide
3	Valve Lifter Follower **Procedure** Clean and inspect the valve lifter follower. Refer to **Valve Lifter and Guide Cleaning and Inspection**.

VALVE LIFTER REPLACEMENT

Removal Procedure

1. Remove the cylinder head and gasket. Refer to **Cylinder Head Replacement - Left Side**, or **Cylinder Head Replacement - Right Side**.

Fig. 110: Valve Lifter Guide Bolt
Courtesy of GENERAL MOTORS COMPANY

2. Remove the valve lifter guide bolt (1).
3. Remove the valve lifter guides (2) with the lifters. Note the installed position of the guides. The notched area of the guides is to align with the locating tab on the engine block.

Fig. 111: Valve Lifters And Guide
Courtesy of GENERAL MOTORS COMPANY

4. Remove the valve lifters (1) from the guide (2).

Fig. 112: Aligning Notched Area Of Guide With Raised Surface On Side Of Lifter
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The active fuel management lifters are installed into the guide by aligning the notched area of the guide (1) with the raised surface on the side of the lifter (2).**

5. Organize or mark the components so that they can be installed in the same location from which they were removed, if required.
6. Clean and inspect the valve lifters, if required. Refer to **Valve Lifter and Guide Cleaning and Inspection**.

Installation Procedure

IMPORTANT:

- When reusing valve lifters, install the lifters to their original locations.
- If camshaft replacement is required, the valve lifters must also be replaced.
- Each of the 4 valve guide assemblies will contain 2 active fuel management valve lifters and 2 non active fuel management valve lifters.
- With the lifters and guides properly installed, cylinders 1, 4, 6, and 7 lifter bores will each contain 2 active fuel management valve lifters.

Fig. 113: Valve Lifters And Guide
Courtesy of GENERAL MOTORS COMPANY

1. Lubricate the valve lifters (1) and engine block valve lifter bores with clean engine oil.

Fig. 114: Aligning Notched Area Of Guide With Raised Surface On Side Of Lifter
Courtesy of GENERAL MOTORS COMPANY

2. Insert the valve lifters into the lifter guides.
    - Align the flat area (3) on the top of the non active fuel management lifter with the flat area in the lifter guide bore. Push the lifter completely into the guide bore.
    - The active fuel management lifters are to be installed into the guide, with the notch in the guide (1) aligned with the raised area (2) of the

lifter.

Fig. 115: Valve Lifter Guide Bolt
Courtesy of GENERAL MOTORS COMPANY

3. Install the valve lifters and guide (2) to the engine block.

CAUTION: Refer to Fastener Caution .

4. Install the valve lifter guide bolts (1).

   Tighten

   Tighten the bolt to 12 N.m (106 lb in).

5. Install the cylinder head and gasket. Refer to **Cylinder Head Replacement - Left Side**, or **Cylinder Head Replacement - Right Side**.

CRANKSHAFT BALANCER REPLACEMENT

Special Tools

- **EN-41665** Crankshaft Balancer and Sprocket Installer
- **EN-41816** Crankshaft Balancer Remover
- **EN-42386-A** Flywheel Holding Tool
- **EN-45059** Angle Meter

For equivalent regional tools, refer to **Special Tools**.

Removal Procedure

1. Remove the vacuum pump belt. Refer to **Vacuum Pump Belt Replacement**.
2. Remove the starter motor. Refer to **Starter Replacement (L83, L86)** .

Fig. 116: Flywheel Holding Tool And Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Fastener Caution .**

NOTE: **Ensure that the teeth of the EN-42386-A flywheel holding tool mesh with the teeth of the engine flywheel.**

3. Install the **EN-42386-A** flywheel holding tool (2) and bolts. Use one M10-1.5 x 120 mm and one M10-1.5 x 45 mm bolt for proper tool

operation. Tighten the **EN-42386-A** flywheel holding tool bolts (1) to 50 N.m (37 lb ft).

Fig. 117: Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS COMPANY

4. Remove the crankshaft balancer bolt (1). Do not discard the crankshaft balancer bolt at this time. The old balancer bolt will be used during the balancer installation procedure.

Fig. 118: Crankshaft Balancer Remover
Courtesy of GENERAL MOTORS COMPANY

5. Install the **EN-41816** crankshaft balancer remover (1) and **EN-41816-2** crankshaft end protector to the crankshaft balancer.
6. Remove the crankshaft balancer (2).
7. For crankshaft balancer cleaning and inspection, refer to **Crankshaft Balancer Cleaning and Inspection**.

Installation Procedure

NOTE:

- **The crankshaft balancer installation and bolt tightening involves a four stage tightening process. The first pass ensures that the balancer is installed completely onto the crankshaft. The second, third, and fourth passes tighten the NEW bolt to the proper torque.**
- **The used crankshaft balancer bolt will be used ONLY during the first pass of the balancer installation procedure. Install a NEW bolt and tighten as described in the second, third and fourth passes of the balancer bolt tightening procedure.**

Fig. 119: Crankshaft Balancer
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The balancer should be positioned onto the end of the crankshaft as straight as possible prior to tool installation.**

1. Position the crankshaft balancer (1) onto the end of the crankshaft.

Fig. 120: Crankshaft Balancer And Sprocket Installer
Courtesy of GENERAL MOTORS COMPANY

2. Install the **EN-41665** crankshaft balancer and sprocket installer and the threaded rod from the **EN-41478** crankshaft front oil seal installer to crankshaft balancer and install the balancer.
    1. Assemble the threaded rod, nut, washer and installer. Insert the smaller end of the installer into the front of the balancer.
    2. Use a wrench and hold the hex end of the threaded rod.
    3. Use a second wrench and rotate the installation tool nut clockwise until the balancer is started onto the crankshaft.
    4. Remove the tool and reverse the installation tool.

       Position the larger end of the installer against the front of the balancer.

    5. Use a wrench and hold the hex end of the threaded rod.
    6. Use a second wrench and rotate the installation tool nut clockwise until the balancer is installed onto the crankshaft.
    7. Remove the **J 41665** crankshaft balancer and sprocket installer and the threaded rod.

Fig. 121: Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS COMPANY

3. Install the USED crankshaft balancer bolt (1). Tighten the USED bolt to 330 N.m (244 lb ft).
4. Remove the USED crankshaft balancer bolt.

Fig. 122: Crankshaft Balancer And Sprocket Installer
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The nose of the crankshaft should be recessed 2.4-4.48 mm (0.094-0.176 in) into the balancer bore.**

5. Measure for a correctly installed balancer. If the balancer is not installed to the proper dimension, install the **EN-41665** crankshaft balancer and sprocket installer and repeat the installation procedure.

Fig. 123: Crankshaft Balancer Bolt
Courtesy of GENERAL MOTORS COMPANY

6. Install the NEW crankshaft balancer bolt (1).
    1. Tighten the bolt a first pass to 120 N.m (89 lb ft).
    2. Loosen 360 degrees.
    3. Tighten the bolt a first pass to 80 N.m (59 lb ft).

4. Balancer bolt with flanged head, tighten the crankshaft balancer bolt a final pass to 125 degrees using the **J 45059** angle meter.
5. Balancer bolt with retained rotating washer, tighten the crankshaft balancer bolt a final pass to 200 degrees using the **J 45059** angle meter.
6. Remove the **EN-42386-A** flywheel holding tool.

Fig. 124: Flywheel Holding Tool And Bolts
Courtesy of GENERAL MOTORS COMPANY

7. Remove the **EN-42386-A** flywheel holding tool (2) and bolts.
8. Install the starter motor. Refer to **Starter Replacement (L83, L86)** .
9. Install the vacuum pump belt. Refer to **Vacuum Pump Belt Replacement**.

CRANKSHAFT FRONT OIL SEAL REPLACEMENT

Special Tools

- **J-41478-A** Crankshaft Front Oil Seal Installer
- **EN-51091** Crankshaft Front Oil Seal Installer

For equivalent regional tools, refer to **Special Tools**.

Removal Procedure

1. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

Fig. 125: Crankshaft Front Oil Seal And Front Cover
Courtesy of GENERAL MOTORS COMPANY

2. Remove the crankshaft front oil seal (1) from the front cover.

Installation Procedure

Fig. 126: Inspecting Seal For Proper Orientation
Courtesy of GENERAL MOTORS COMPANY

IMPORTANT: For proper orientation, note the installation direction of the oil seal. The oil seal is a reverse-lip design. Install with "THIS SIDE OUT" displayed as shown.

1. Inspect the seal for proper orientation.

Fig. 127: Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS COMPANY

2. Install the crankshaft front oil seal (3) onto the threaded rod, nut and washer from **J-41478-A** crankshaft front oil seal installer (1) and **EN-51091** crankshaft front oil seal installer (2).
3. Install the **J-41478-A** crankshaft front oil seal installer threaded rod, nut and washer (1) and **EN-51091** crankshaft front oil seal installer (2) and oil seal (3), into the end of the crankshaft.

4. Use the **J-41478-A** crankshaft front oil seal installer (1) and **EN-51091** crankshaft front oil seal installer (2) in order to install the oil seal (3) into the cover bore.
    1. Use a wrench and hold the hex on the installer bolt.
    2. Use a second wrench and rotate the installer nut clockwise until the seal bottoms in the cover bore.
    3. Remove the tool.
    4. Inspect the oil seal for proper installation. The oil seal should be installed evenly and completely into the front cover bore.
5. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.

ENGINE FRONT COVER REPLACEMENT

Removal Procedure

1. Remove the upper oil pan. Refer to **Oil Pan Replacement**.
2. Remove the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
3. Remove the vacuum pump. Refer to **Vacuum Pump Replacement** .
4. Remove the engine coolant manifold. Refer to **Engine Coolant Manifold Replacement (L83, L86)** .
5. Remove the A/C compressor. Refer to **Air Conditioning Compressor Replacement (L83 L86)** .

Fig. 128: Electrical Connectors
Courtesy of GENERAL MOTORS COMPANY

6. Disconnect the electrical connectors (1).

Fig. 129: Front Cover
Courtesy of GENERAL MOTORS COMPANY

7. Remove the front cover bolts (1 and 2).
8. Remove front cover (3).
9. Ensure to clean and inspect the engine front cover. Refer to **Engine Front Cover Cleaning and Inspection**.

Installation Procedure

Fig. 130: Bead Of RTV Sealant
Courtesy of GENERAL MOTORS COMPANY

1. Apply a 3 mm (0.118 in) bead of RTV sealant on the engine front cover as shown (a). Apply a 5 mm (0.197 in) bead of RTV sealant on the engine front cover as shown (b). Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

Fig. 131: Front Cover
Courtesy of GENERAL MOTORS COMPANY

2. Install the front cover (3).

CAUTION: Refer to Fastener Caution .

3. Install the front cover bolts (1 and 2).

Fig. 132: Engine Front Cover Bolt Identification & Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

4. Tighten bolts (2 and 3) in sequence as shown above to 25 N.m (18 lb ft).

Fig. 133: Electrical Connectors
Courtesy of GENERAL MOTORS COMPANY

5. Connect the electrical connectors (1).
6. Install the engine coolant manifold. Refer to **Engine Coolant Manifold Replacement (L83, L86)** .
7. Install the crankshaft balancer. Refer to **Crankshaft Balancer Replacement**.
8. Install the A/C compressor. Refer to **Air Conditioning Compressor Replacement (L83 L86)** .

9. Install the vacuum pump. Refer to **Vacuum Pump Replacement** .
10. Install the upper oil pan. Refer to **Oil Pan Replacement**.

OIL PUMP REPLACEMENT

Fig. 134: Oil Pump And Bolts (With Tightening Sequence)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminarily Procedure Remove the engine front cover. Refer to **Engine Front Cover Replacement**. **NOTE:**	

Callout	Component Name
If the oil pump is removed to perform a different repair and is going to be REUSED, the EN-51267 oil pump alignment tool must be installed on the engine block BEFORE the oil pump is removed and left in place until the installation of the original oil pump. If the EN-51267 oil pump alignment tool IS NOT installed prior to oil pump housing removal, AND left in place while	

Callout	Component Name
other repairs are performed, a NEW oil pump MUST be installed.	
1	Oil Pump Bolts **CAUTION:** **Refer to Fastener Caution .** **NOTE:** **Tighten the oil pump bolts in the sequence shown.** **NOTE:** **Upward pressure must be applied to the oil pump while tightening the fasteners. Contact between the oil pump housing and**

Callout	Component Name
	the oil pump alignment tool must be maintained while oil pump bolts are tightened. Prior to removing the oil pump alignment tool, ensure that there is no gap between the oil pump housing and the tool. If there is a gap, the oil pump bolts need to be loosened and the installation procedure repeated. **Procedure** Remove the oil bolts. **Tighten** 25 N.m (18 lb ft)

Callout	Component Name
2	Oil Pump **NOTE:** **Prior to installing the oil pump, ensure that oil pump housing gasket is fully installed in the timing chain tensioner assembly and is not damaged. If the gasket is missing or damaged, replace the tensioner assembly.** **Special Tools** **EN-51267** Oil Pump Alignment Tool For equivalent regional tools, refer to **Special Tools**.

OIL PUMP FLOW CONTROL SOLENOID VALVE REPLACEMENT

Fig. 135: Oil Pump Flow Control Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminarily Procedure Remove the engine front cover. Refer to **Engine Front Cover Replacement**.	
1	Oil Pump Flow Control Solenoid Valve Clip
2	Oil Pump Flow Control Solenoid Valve

CAMSHAFT POSITION ACTUATOR SOLENOID VALVE REPLACEMENT

Fig. 136: Camshaft Position Actuator Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the camshaft position actuator-Magnet. Refer to **Camshaft Position Actuator Magnet Replacement** .	
1	Camshaft Position Actuator Solenoid Valve **CAUTION:** **Refer to Component Fastener Tightening Caution .**

Callout	Component Name
	CAUTION: **The camshaft position actuator solenoid valves must be kept parallel to the engine front cover during removal and installation. The camshaft position actuator solenoid valves can be damaged if they become wedged or stuck during this process.** **NOTE:** **It is possible to push the camshaft rearward when installing the**

Callout	Component Name
	CMP actuator Valve. Please be careful not to push the camshaft while installing the CMP actuator valve. **NOTE:** **The CPA solenoid valve must be Discarded and replaced with a NEW valve.** **Tighten** 1. First pass 65 N.m (48 lb ft). 2. Final pass 90 degrees. **Special Tools** **J 45059** Angle Meter For equivalent regional tools, refer to **Special Tools**.

CRANKSHAFT REAR OIL SEAL REPLACEMENT

Special Tools

- **EN-51096** Crankshaft Rear Seal Remover
- **GE-23907-1** Slide Hammer
- **EN-41479** Crankshaft Rear Oil Seal Installer
- **EN-41479-2A** Crankshaft Rear Oil Seal Installation Guide
- **EN-41479-10** Crankshaft Rear Oil Seal Installer Adapter

For equivalent regional tools, refer to **Special Tools**.

Removal Procedure

1. Remove the automatic transmission flexplate. Refer to **Automatic Transmission Flex Plate Replacement**.

Fig. 137: Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS COMPANY

NOTE: **EN-51096 crankshaft rear seal remover has two ends. The end with the small bend will be used to remove the seal.**

2. Install **EN-51096** crankshaft rear seal remover onto **GE-23907-1** slide hammer.
3. Slide the small bend of **EN-51096** crankshaft rear seal remover between the lip of the rear seal and crankshaft. Ensure that the small bend of

EN-51096 crankshaft rear seal remover engages the rear side of the rear seal (1). While rotating **EN-51096** crankshaft rear seal remover and **GE-23907-1** slide hammer around the seal and use the slide hammer to remove the seal.

4. Remove and DISCARD the crankshaft rear oil seal (1).

Installation Procedure

Fig. 138: Inspecting Seal For Proper Orientation
Courtesy of GENERAL MOTORS COMPANY

IMPORTANT: For proper orientation, note the installation direction of the oil seal. The oil seal is a reverse-lip design. Install with "THIS SIDE OUT" displayed as shown.

1. Inspect the seal for proper orientation.

Fig. 139: Crankshaft Rear Oil Seal Installation Guide Cone
Courtesy of GENERAL MOTORS COMPANY

2. Install the **EN-41479-2A** crankshaft rear oil seal installation guide cone (2) and bolts onto the rear of the crankshaft.
3. Tighten the bolts until snug. Do not overtighten.
4. Install the rear oil seal (1) onto the tapered cone (2) and push the seal to the rear seal bore. Install the oil seal with "THIS SIDE OUT" facing away from the engine.
5. Install the **EN-41479-10** crankshaft rear oil seal installer adapter (3) onto **EN-41479** crankshaft rear oil seal installer (4).
6. Thread the **EN-41479** crankshaft rear oil seal installer threaded rod into the tapered cone until the tool contacts the oil seal.
7. Align the oil seal (1) onto the tool.
8. Rotate the handle of the tool clockwise until the seal enters the rear housing and bottoms into the seal bore.
9. Remove the tool.
10. Install the automatic transmission flexplate. Refer to **Automatic Transmission Flex Plate Replacement**.

CRANKSHAFT REAR OIL SEAL HOUSING REPLACEMENT

Fig. 140: Crankshaft Rear Oil Seal Housing
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure 1. Remove the automatic transmission flex plate. Refer to **Automatic Transmission Flex Plate Replacement**.	
1	Crankshaft Rear Oil Seal Housing Fastener (Qty: 12) **CAUTION:** **Refer to** **Fastener Caution .** **Tighten** 25 N.m (18 lb ft)
2	Crankshaft Rear Oil Seal Housing **Procedure** To separate the rear housing from the engine, pry at the points that are shown by the arrows.
3	Crankshaft Rear Oil Seal Housing Gasket **Procedure** 1. A NEW gasket must be used when installing the rear housing.
4	Crankshaft Rear Oil Seal Housing Sealant **Procedure** Apply a 3 mm (0.118 in) bead of RTV sealant on the engine rear cover as shown. Apply a 5 mm (0.197 in) bead of RTV sealant on the engine rear cover as shown. The 5 mm (0.197 in) bead must be applied only 10 mm (0.393 in) up from the bottom of the rear cover as shown (a). Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

OIL PAN REPLACEMENT

Removal Procedure

1. Remove the oil indicator tube. Refer to **Oil Level Indicator Tube Replacement**.
2. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
3. Remove the steering rack. Refer to **Electric Belt Drive Rack and Pinion Steering Gear Replacement (Light Duty)** .
4. Remove the starter. Refer to **Starter Replacement (L83, L86)** .
5. Remove the drivetrain and front suspension frame front crossmember. Refer to **Drivetrain and Front Suspension Frame Front Crossmember Replacement** .
6. If equipped with 4WD, remove the front axle. Refer to **Front Axle Replacement (8.25 Inch LD Axle)** **Front Axle Replacement (9.25 Inch HD Axle)** .

Fig. 141: Engine Harness Retainers
Courtesy of GENERAL MOTORS COMPANY

7. Remove the engine harness retainers (1).

Fig. 142: Engine Harness Retainers
Courtesy of GENERAL MOTORS COMPANY

8. Remove the engine harness retainers (1).

Fig. 143: Cooler Line Bracket Bolt
Courtesy of GENERAL MOTORS COMPANY

9. Remove the cooler line bracket bolt (1).
10. Disconnect electrical connector (2).
11. Remove the engine harness retainers (3).

Fig. 144: Left Flywheel Inspection Cover
Courtesy of GENERAL MOTORS COMPANY

12. Remove the left flywheel inspection cover.

Fig. 145: Right Flywheel Inspection Cover
Courtesy of GENERAL MOTORS COMPANY

13. Remove the right flywheel inspection cover.

Fig. 146: Oil Cooler Bracket Fastener And Oil Cooler Hoses
Courtesy of GENERAL MOTORS COMPANY

14. Remove the oil cooler bracket fastener (1) and separate the oil cooler hoses (2) from the engine block.
15. Remove the transmission cooler line bracket retaining nut and reposition the bracket.

Fig. 147: Transmission To Oil Pan Bolts
Courtesy of GENERAL MOTORS COMPANY

16. Remove the transmission to oil pan bolts (1).

Fig. 148: Oil Pan And Bolts
Courtesy of GENERAL MOTORS COMPANY

17. Remove the oil pan bolts (1, 2).
18. Remove the oil pan (3).
19. Transfer parts as necessary.
20. For oil pan disassemble, refer to **Oil Pan Disassemble**.

21. For oil pan cleaning and inspection, refer to **Oil Pan Cleaning and Inspection**.

Installation Procedure

1. For oil pan assemble, refer to **Oil Pan Assemble**.

Fig. 149: Applying 3 mm (0.118 in) Bead Of RTV Sealant On Engine Front Cover
Courtesy of GENERAL MOTORS COMPANY

2. Apply a 3 mm (0.118 in) bead of RTV sealant on the engine oil pan mating surface as shown (a). Apply a 5 mm (0.197 in) bead of RTV sealant on the engine front cover and rear oil seal housing as shown (b). Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

Fig. 150: Oil Pan And Bolts
Courtesy of GENERAL MOTORS COMPANY

3. Install the oil pan (3).
4. Install the oil pan bolts (1, 2) and hand tighten.

Fig. 151: Oil Pan Bolts With Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

5. Tighten the oil pan bolts in sequence as shown above.
    1. Oil pan bolts to block and front cover (in sequence 1-13 and 16) 25 N.m (18 lb ft).

2. Oil pan bolts to rear housing (in sequence 14-15) 12 N.m (106 lb in).

Fig. 152: Transmission And Oil Pan Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Reposition the cooler line bracket Install the 2 lower bolts securing the transmission to the engine. Refer to **Transmission Replacement** .
7. Reposition the cooler line bracket and install the retaining nut. Tighten the nut to 10 N.m (89 lb in).

Fig. 153: Oil Cooler Bracket Fastener And Oil Cooler Hoses
Courtesy of GENERAL MOTORS COMPANY

8. position the oil cooler hoses and bracket assembly (2) to the oil pan and install the bracket fastener (1). Tighten the fastener to 9 N.m (80 lb in).

Fig. 154: Right Flywheel Inspection Cover
Courtesy of GENERAL MOTORS COMPANY

9. Install the right flywheel inspection cover and bolt. Refer to **Transmission Replacement** .

Fig. 155: Left Flywheel Inspection Cover
Courtesy of GENERAL MOTORS COMPANY

10. Install the left flywheel inspection cover and bolt. Refer to **Transmission Replacement** .

Fig. 156: Cooler Line Bracket Bolt
Courtesy of GENERAL MOTORS COMPANY

11. Install the cooler line bracket bolt (1) and tighten to 10 N.m (89 lb in).
12. Connect electrical connector (2).
13. Install the engine harness retainers (3).

Fig. 157: Engine Harness Retainers
Courtesy of GENERAL MOTORS COMPANY

14. Install the engine harness retainers (1).

Fig. 158: Engine Harness Retainers
Courtesy of GENERAL MOTORS COMPANY

15. Install the engine harness retainers (1).
16. If equipped with 4WD, install the front axle. Refer to **Front Axle Replacement (8.25 Inch LD Axle)** **Front Axle Replacement (9.25 Inch HD Axle)** .
17. Install the drivetrain and front suspension frame front crossmember. Refer to **Drivetrain and Front Suspension Frame Front Crossmember Replacement** .
18. Install the starter. Refer to **Starter Replacement (L83, L86)** .
19. Install the steering rack. Refer to **Electric Belt Drive Rack and Pinion Steering Gear Replacement (Light Duty)** .
20. Install the oil indicator tube. Refer to **Oil Level Indicator Tube Replacement**
21. Fill the engine with the proper capacity and quality of engine oil. Refer to **Engine Oil and Oil Filter Replacement**.
22. Operate the engine, check for leaks, and oil pressure.

ENGINE OIL LEVEL INDICATOR SWITCH REPLACEMENT (L83)

Removal Procedure

1. Remove the engine oil pan. Refer to **Oil Pan Replacement**.

Fig. 159: Crankshaft Oil Deflector Fasteners
Courtesy of GENERAL MOTORS COMPANY

2. Remove the crankshaft oil deflector fasteners (1) from the oil pan and remove the crankshaft oil deflector (2).

Fig. 160: Oil Level Switch Connector Retaining Clip
Courtesy of GENERAL MOTORS COMPANY

3. Remove the clip (1) securing the oil level switch connector (2).

Fig. 161: Oil Level Switch Fasteners And Oil Level Switch
Courtesy of GENERAL MOTORS COMPANY

4. Remove the oil level switch fasteners (1) then remove the oil level switch (2) from the oil pan.
5. Inspect the oil level switch seal (3) for damage and replace as needed upon installation of the switch.

Installation Procedure

1. Clean and inspect the oil level switch bore for dirt or debris and clean as needed prior to installing the switch.

Fig. 162: Oil Level Switch Fasteners And Oil Level Switch
Courtesy of GENERAL MOTORS COMPANY

2. Lubricate the oil level switch seal (3) with clean engine oil then install the oil level switch fasteners (1) and insert the oil level switch (2) into its bore.

Fig. 163: Securing Oil Level Switch Connector Retaining Clip
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Ensure that the clip is properly seated into the level switch prior to installing the crankshaft oil deflector.**

3. Install the clip (1) to secure the oil level switch connector (2).

Fig. 164: Crankshaft Oil Deflector Fasteners
Courtesy of GENERAL MOTORS COMPANY

4. Install the crankshaft oil deflector fasteners (1) into the crankshaft oil deflector (2) and tighten to 10 N.m (89 lb in).
5. Install the engine oil pan. Refer to **Oil Pan Replacement**.

LOWER OIL PAN REPLACEMENT

Fig. 165: Lower Oil Pan
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Remove the drivetrain and front suspension frame front crossmember. Refer to **Drivetrain and Front Suspension Frame Front Crossmember Replacement** . 2. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**.	
1	Lower Oil Pan Bolt (Qty: 10) **CAUTION:**

Callout	Component Name
	Refer to Fastener Caution . **Tighten** 10 N.m (89 lb in)
2	Lower Oil Pan **NOTE:** **If lower oil pan is removed, it must be replaced. The lower oil pan is not reusable. Replace with NEW.** **Procedure** 1. For cleaning and inspection, refer to **Oil Pan Cleaning and Inspection** 2. Apply a 3 mm (0.118 in) bead of RTV sealant on the lower oil pan to engine mating surface. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

TIMING CHAIN, CRANKSHAFT SPROCKET, CAMSHAFT POSITION ACTUATOR, AND SOLENOID VALVE REPLACEMENT

Special Tools

- **EN 46330** Timing Belt Tensioner Retaining Pin
- **EN-42386-A** Flywheel Holding Tool
- **EN-45059** Angle Meter

For equivalent regional tools, refer to **Special Tools**.

Removal Procedure

1. Remove oil pump. Refer to **Oil Pump Replacement**.

Fig. 166: Timing Chain Tensioner
Courtesy of GENERAL MOTORS COMPANY

2. Push back the timing chain tensioner (1) and install **EN-46330** tension pin (2).

Fig. 167: CMP Actuator Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

3. Remove the CMP actuator solenoid valve (1).
4. Discard the solenoid valve.

Fig. 168: Proper CMP Actuator Removal
Courtesy of GENERAL MOTORS COMPANY

WARNING: Refer to Camshaft Position Actuator Removal and Installation Warning .

5. Loosen and separate the CMP actuator and timing chain from the camshaft. Position fingers behind the actuator sprocket and pull the actuator away from the front of the camshaft. Never pull on the reluctor wheel when attempting to remove the actuator.

Fig. 169: CMP Actuator And Timing Chain
Courtesy of GENERAL MOTORS COMPANY

6. Remove the CMP actuator (1) and timing chain (2).

Fig. 170: Tie Strap Through Center Of Actuator
Courtesy of GENERAL MOTORS COMPANY

7. Insert a tie strap (1) through the center of the actuator and over the reluctor wheel.

Fig. 171: Crankshaft Sprocket And Key
Courtesy of GENERAL MOTORS COMPANY

8. Remove the crankshaft sprocket (4), and key (3).
9. Remove the timing chain tensioner bolts (2) and the timing chain tensioner (1).

Installation Procedure

Fig. 172: Key Into Crankshaft Keyway
Courtesy of GENERAL MOTORS COMPANY

1. Install the key into the crankshaft keyway (1).

Fig. 173: Key Into Keyway
Courtesy of GENERAL MOTORS COMPANY

2. Tap the key (1) into the keyway until both ends of the key bottom onto the crankshaft.

Fig. 174: Crankshaft Sprocket
Courtesy of GENERAL MOTORS COMPANY

3. Install the crankshaft sprocket (1). Align the crankshaft key with the crankshaft sprocket keyway.

Fig. 175: Rotating Crankshaft Until Sprocket Alignment Mark
Courtesy of GENERAL MOTORS COMPANY

4. Rotate the crankshaft until the sprocket alignment mark (1) is in the 12 o'clock position.

Fig. 176: Timing Chain Tensioner Guide And Pin
Courtesy of GENERAL MOTORS COMPANY

5. Compress the timing chain tensioner guide and install the **EN-46330** tension pin (1).

Fig. 177: Timing Chain Tensioner And Left Side Bolt
Courtesy of GENERAL MOTORS COMPANY

6. Install the timing chain tensioner (1) and left side bolt (2) hand tight. Do not install the right side bolt at this time. The right side bolt will be installed after the camshaft position (CMP) actuator and chain have been installed onto the engine.
7. Install the 11 o'clock position balancer shaft retainer bolt hand tight.

Fig. 178: Tie Strap Through Center Of Actuator
Courtesy of GENERAL MOTORS COMPANY

WARNING: Refer to Camshaft Position Actuator Removal and Installation Warning .

8. Remove the tie strap (1) from the actuator.

Fig. 179: Alignment Hole And Locating Pin
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Properly locate the CMP actuator onto the locating pin of the camshaft.**
- **The sprocket teeth and timing chain must mesh**
- **The camshaft and the sprocket alignment marks MUST be aligned properly.**
- **Do not use the CMP solenoid valve again. Install a NEW valve during assembly.**

9. Identify the alignment hole (1) in the rear face of the CMP actuator and the locating pin (2) on the front face of the camshaft.

Fig. 180: CMP Actuator And Timing Chain
Courtesy of GENERAL MOTORS COMPANY

10. Install the CMP actuator and timing chain (1). Use care to install the actuator completely onto the front of the camshaft. Position fingers onto the face of the actuator sprocket and push the actuator onto the front of the camshaft. Never push on the reluctor wheel when attempting to install the actuator.

Fig. 181: Timing Chain Tensioner Guide And Pin
Courtesy of GENERAL MOTORS COMPANY

11. Remove the **EN-46330** tension pin (1).

Fig. 182: Inspecting For Proper Installation Of CMP Actuator And Timing Chain
Courtesy of GENERAL MOTORS COMPANY

NOTE: **It is possible to push the camshaft rearward when installing the CMP actuator. Verify that the camshaft lobes are centered in the valve lifter bores after the CMP actuator is installed.**

12. Locate a straight edge across the front face of the engine block and inspect for proper installation of the CMP actuator and timing chain. With the CMP actuator properly and completely installed onto the front of camshaft, the timing chain will not protrude beyond the front face of

engine block.

Fig. 183: NEW CMP Actuator Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Component Fastener Tightening Caution .

13. Install a NEW CMP actuator solenoid valve (1). With the CMP actuator properly positioned onto the camshaft, the CMP actuator solenoid

valve can be threaded completely into the camshaft using light hand pressure. Tighten by hand until snug.

1. First pass 65 N.m (48 lb ft).
2. Final pass 90 degrees.

Fig. 184: CMP Actuator Sprocket And Crankshaft Sprocket Alignment Marks
Courtesy of GENERAL MOTORS COMPANY

14. Inspect the sprockets for proper alignment. The mark on the CMP actuator sprocket (1) should be located in the 6 o'clock position and the mark

on the crankshaft sprocket (2) should be located in the 12 o'clock position.

Fig. 185: Timing Chain Tensioner
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

15. Install the right side bolt (1) into the timing chain tensioner and tighten both bolts to 30 N.m (22 lb ft).

16. Install oil pump. Refer to **Oil Pump Replacement**.

CAMSHAFT REPLACEMENT

Removal Procedure

1. Remove the engine. Refer to **Engine Replacement**.
2. Remove the valve lifter oil manifold. Refer to **Valve Lifter Oil Manifold Replacement**.
3. Remove the valve lifters. Refer to **Valve Lifter Replacement**.
4. Remove the CMP actuator and timing chain. Refer to **Timing Chain, Crankshaft Sprocket, Camshaft Position Actuator, and Solenoid Valve Replacement**

Fig. 186: Camshaft Retainer Bolts
Courtesy of GENERAL MOTORS COMPANY

5. Remove the camshaft retainer bolts (1).
6. Remove the camshaft retainer (2).
7. Remove the camshaft (3).
8. For camshaft and bearing cleaning and inspection, refer to **Camshaft and Bearings Cleaning and Inspection**.

Installation Procedure

NOTE: **he threads of the camshaft retainer bolts and threaded holes of the engine block must be free of residue and debris prior to the application of threadlocker to ensure proper adhesion and fastener retention.**

1. Prepare the camshaft retainer bolts and engine block threaded holes for assembly:
   - Thoroughly clean the residue from the bolt threads with denatured alcohol and allow to dry.
   - Thoroughly clean the residue from the threaded holes of the engine block with denatured alcohol and allow to dry.
   - Apply threadlocker to 2/3 of the threaded length of the camshaft retainer bolts. Refer to **Adhesives, Fluids, Lubricants, and Sealers** .
   - Ensure there are no gaps in the threadlocker along the filled area of the bolts.
   - Allow the threadlocker to cure approximately 10 minutes before installation.

Fig. 187: Camshaft, Camshaft Retainer And Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Install the camshaft (1), camshaft retainer (2), and camshaft retainer bolts (3). Refer to **Camshaft Installation**.
3. Install the CMP actuator and timing chain. Refer to **Timing Chain, Crankshaft Sprocket, Camshaft Position Actuator, and Solenoid Valve Replacement**
4. Install the valve lifters. Refer to **Valve Lifter Replacement**.
5. Install the valve lifter oil manifold. Refer to **Valve Lifter Oil Manifold Replacement**.
6. Install the engine. Refer to **Engine Replacement**.

AUTOMATIC TRANSMISSION FLEX PLATE REPLACEMENT

Special Tools

EN-45059 Angle Meter

For equivalent regional tools, refer to **Special Tools** .

Removal Procedure

1. Remove the automatic transmission. Refer to **Transmission Replacement** .

NOTE: **Note the position and direction of the automatic transmission flex plate before removal.**

Fig. 188: Automatic Transmission Flex Plate Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Remove and DISCARD the automatic transmission flex plate bolts (1).
3. Remove the scuff plate (2)
4. Remove the automatic transmission flex plate (3).

Installation Procedure

NOTE:

- **The automatic transmission flex plate does not use a locating pin for alignment and will not initially seat against the crankshaft flange or spacer, if applicable, but will be pulled onto the crankshaft by the automatic transmission flex plate bolts.**
- **This procedure requires a three stage tightening process to properly seat the automatic transmission flex plate.**

Fig. 189: Automatic Transmission Flex Plate Bolts
Courtesy of GENERAL MOTORS COMPANY

1. Install the automatic transmission flex plate (3), scuff plate (2), and NEW bolts (1) to the crankshaft. Hand tight only at this time.

Fig. 190: Identifying NEW Engine Flex Plate Bolts (With Tightening Sequence)
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

2. Tighten the automatic transmission flex plate bolts using the following sequence:
    1. Tighten the engine flex plate bolts (1-8) a first pass in sequence to 15 N.m (11 lb ft).

2. Tighten the engine flex plate bolts (1-8) a second pass in sequence to 30 N.m (22 lb ft).
3. Tighten the engine flex plate bolts (1-8) a final pass in sequence an additional 45 degrees using **EN-45059** angle meter.

3. Install the automatic transmission. Refer to **Transmission Replacement** .

ENGINE REPLACEMENT

Special Tools

- **J-21366** Converter Holding Strap
- **J-36857** Engine Lift Bracket (Qty 2)

For equivalent regional tools, refer to **Special Tools** .

Removal Procedure

1. Place the hood in the service position. Refer to **Hood Service Positioning** .

Fig. 191: Radiator Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

2. Remove the radiator inlet hose (2). Refer to **Radiator Inlet Hose Replacement (L83 L86)** .

Fig. 192: Radiator Outlet Hose Retainers
Courtesy of GENERAL MOTORS COMPANY

3. Remove the radiator outlet hose (3). Refer to **Radiator Outlet Hose Replacement (L83 L86)** .
4. Drain the engine oil. Refer to **Engine Oil and Oil Filter Replacement**

Fig. 193: Radiator
Courtesy of GENERAL MOTORS COMPANY

5. Remove the radiator. Refer to **Radiator Replacement (L83 L86)** .

Fig. 194: Air Conditioning Condenser
Courtesy of GENERAL MOTORS COMPANY

6. Remove the air conditioning condenser. Refer to **Air Conditioning Condenser Replacement (L83 L86)** .
7. Remove the headlamp and radiator grille mount panel. Refer to **Headlamp and Radiator Grille Mount Panel Replacement** .

Fig. 195: Heater Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

8. Remove the heater inlet hose (1). Refer to **Heater Inlet Hose Replacement (L83 L86)** .
9. Remove the heater outlet hose. Refer to **Heater Outlet Hose Replacement (L83 L86)** .

Fig. 196: Generator Bracket
Courtesy of GENERAL MOTORS COMPANY

10. Remove the generator bracket (6) from the engine assembly. Refer to **Generator Bracket Replacement** .

Fig. 197: Fuel Injection Fuel Rail Assembly - Bank 1
Courtesy of GENERAL MOTORS COMPANY

11. Remove the fuel injection fuel rail assembly - bank 1 (2). Refer to **Fuel Injection Fuel Rail Assembly Replacement - Bank 1** .

Fig. 198: Front Engine Lift Bracket
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Ensure using a correct length bolt to keep the engine lift bracket firmly against the cylinder head.**

12. Install the front engine lift bracket (1) to the position shown.

Fig. 199: Rear Engine Lift Bracket
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Ensure using a correct length bolt to keep the engine lift bracket firmly against the cylinder head.**

13. Install the rear engine lift bracket (1) to the position shown.

Fig. 200: Engine Control Module
Courtesy of GENERAL MOTORS COMPANY

14. Remove the engine control module (1). Refer to **Engine Control Module Replacement** .
15. Disconnect the lever lock connector at the underhood electrical center and disconnect the harness retainers.
16. If equipped with 4WD, disconnect the front differential vent hose from the wiring harness.

Fig. 201: Underhood Electrical Center/Junction Block
Courtesy of GENERAL MOTORS COMPANY

17. Disconnect the engine main wiring harness from the engine wiring harness junction block (1). Refer to **Underhood Electrical Center or Junction Block Replacement** .
18. Remove the main engine harness retainer bolt and disconnect the main engine wire harness from the left side of the engine coolant manifold and water inlet housing.
19. Disconnect the wiring harness at the left shock tower as necessary.
20. Position the engine main wiring harness on to the engine assembly.
21. Disconnect the generator cable retainer at the bracket on the right front cylinder head.
22. Disconnect the air conditioning pressure sensor electrical connector and position aside. Refer to **Air Conditioning (A/C) Refrigerant Pressure Sensor Replacement (L83 L86)** .
23. Disconnect the MAF sensor harness retainers at the bulkhead and right side battery box panel.

24. Disconnect the battery current sensor electrical connector. Refer to **Battery Current Sensor Replacement (L83, L86)** .
25. Position and secure the oil cooler hoses to the engine.
26. Raise and suitably support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
27. If the vehicle is equipped with a transfer case, remove the front propeller shaft. Refer to **Front Axle Propeller Shaft Replacement (NPO)** **Front Axle Propeller Shaft Replacement (NQH)** **Front Axle Propeller Shaft Replacement (Heavy Duty)** .

Fig. 202: Left Flywheel Inspection Cover

Courtesy of GENERAL MOTORS COMPANY

28. Remove the left flywheel inspection cover.
29. Remove the starter motor. Refer to **Starter Replacement (L83, L86)** .

Fig. 203: Right Flywheel Inspection Cover
Courtesy of GENERAL MOTORS COMPANY

30. Remove the right flywheel inspection cover.
31. Support the transmission with a transmission jack.

Fig. 204: Transmission Crossmember, Crossmember Bolts & Nuts
Courtesy of GENERAL MOTORS COMPANY

32. Remove the transmission crossmember (4). Refer to **Transmission Support Crossmember Replacement (2WD)** **Transmission Support Crossmember Replacement (4WD)** .

Fig. 205: Exhaust Front Pipe
Courtesy of GENERAL MOTORS COMPANY

33. Remove the exhaust front pipe (2). Refer to **Three-Way Catalytic Converter Replacement** .

Fig. 206: Flywheel To Torque Converter Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Note the position and direction of the automatic transmission flex plate before removal.**

34. Remove the 3 flex plate to torque converter bolts.
35. Disconnect the bank oxygen sensor wire harness retainers at the frame and bulkhead and position the harness to the engine.

36. Lower the transmission to gain access to the top and sides of the transmission.
37. If equipped with four wheel drive, disconnect the wire harness electrical connectors and harness retainers at the transfer case.

Fig. 207: Transmission Heat Shield And Bolts
Courtesy of GENERAL MOTORS COMPANY

38. Remove the transmission heat shield bolts and heat shield at the right side of the transmission.

Fig. 208: Transmission Wiring Harness And Retainers
Courtesy of GENERAL MOTORS COMPANY

39. Remove the transmission wire harness retainer bolt at the right side of the transmission.
40. Disconnect the electrical connectors from the transmission assembly, then position the wiring harness on the engine assembly.
41. Lower the vehicle.
42. Disconnect the transmission wire harness retainers on the back side of the engine.

43. Disconnect the bank 2 fuel rail electrical connector from the engine harness.
44. If equipped, position the transfer case wiring harness on the engine.
45. Position the bank 2 oxygen sensor wiring harness on the engine.
46. Remove the ground cable bolt at the right side of the engine and position the cable out of the way.

Fig. 209: Transmission Dip Stick Retaining Nut, Dip Stick Tube And Seal
Courtesy of GENERAL MOTORS COMPANY

47. Remove the transmission dip stick tube retaining nut (1).
48. Reposition the transmission dip stick tube (2).

Fig. 210: Wire Harness/Vent Tube Bracket Nut & Converter Housing Stud
Courtesy of GENERAL MOTORS COMPANY

49. Remove the vent tube bracket retaining nut from the back side of the engine.

Fig. 211: Fuel Line Bracket And Nut
Courtesy of GENERAL MOTORS COMPANY

50. Remove the fuel line bracket bolt at the back of the engine.

Fig. 212: Fuel Line Bracket Retainers
Courtesy of GENERAL MOTORS COMPANY

51. Remove the fuel line bracket retainers (1) at the left side of the transmission and reposition the fuel lines.

Fig. 213: Transmission Mounting Bolts
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Leave the two lower transmission bolts in place.**

52. Remove the 6 upper bolts securing the transmission to the engine.
53. Raise the transmission to the original installation position.

Fig. 214: Transmission Crossmember, Crossmember Bolts & Nuts
Courtesy of GENERAL MOTORS COMPANY

54. Temporary install the transmission crossmember (4) to support the transmission.
55. Remove the jack supporting the transmission.
56. Remove the two lower transmission to engine retaining bolts.
57. Lower the vehicle.

Fig. 215: Right Upper Engine Mount Bolts
Courtesy of GENERAL MOTORS COMPANY

58. Remove the right upper engine mount bolts (1). Refer to **Engine Mount Replacement - Right Side**.

Fig. 216: Left Upper Engine Mount
Courtesy of GENERAL MOTORS COMPANY

59. Remove the left upper engine mount bolts (1). Refer to **Engine Mount Replacement - Left Side**.

Fig. 217: Transmission Fluid Cooler Inlet And Outlet Pipe
Courtesy of GENERAL MOTORS COMPANY

60. Remove the transmission fluid cooler inlet and outlet pipe (1) from the transmission fluid cooler pipe clip (2).

Fig. 218: Power Brake Booster Vacuum Sensor And Pipe Assembly
Courtesy of GENERAL MOTORS COMPANY

61. Disconnect the vacuum line and the vacuum sensor electrical connector (1) from the vacuum booster.
62. If equipped, disconnect the engine block heater harness retainers and position the harness on the engine.
63. Remove the nut holding the engine ground strap to the bulk head on the left side.
64. Position a floor jack with a block of wood under the transmission.

65. Install a suitable chain as tight as possible to the two engine lift brackets.
66. Using a suitable engine lifting device, remove the engine from the vehicle.
67. Install the **J-21366** strap onto the transmission bell housing to retain the torque converter.
68. Transfer components as necessary.
69. Drain the engine oil.

Installation Procedure

1. Remove the **J-21366** strap from the transmission bell housing which is retaining the torque converter.
2. Install the engine to the vehicle.
3. Align and install the engine to the transmission. Raise or lower the transmission as required using a suitable jack.
4. Working through the left and right side wheelhouse openings, install 2 of the transmission to engine retaining bolts.
5. Remove the engine lift device and chain.
6. Remove the floor jack from under the transmission.

CAUTION: Refer to Fastener Caution .

7. Install the ground strap and nut at the left side of the bulkhead. Tighten the nut to 10 N.m (89 lb in).
8. If equipped, position the engine block heater wire harness to the body and connect the harness retainers.

Fig. 219: Power Brake Booster Vacuum Sensor And Pipe Assembly
Courtesy of GENERAL MOTORS COMPANY

9. Connect the vacuum line and the vacuum sensor electrical connector (1) to the vacuum booster.

Fig. 220: Left Upper Engine Mount Bolts
Courtesy of GENERAL MOTORS COMPANY

10. Install the left upper engine mount bolts (1). Refer to **Engine Mount Replacement - Left Side**.

Fig. 221: Right Upper Engine Mount Bolts
Courtesy of GENERAL MOTORS COMPANY

11. Install the right upper engine mount bolts (1). Refer to **Engine Mount Replacement - Right Side**.
12. Install the 2 lower bolts securing the transmission to the engine. Refer to **Transmission Replacement** .
13. Raise the vehicle.
14. Support the transmission with an appropriate transmission jack.

15. Remove the transmission cross member. Refer to **Transmission Support Crossmember Replacement (2WD)** **Transmission Support Crossmember Replacement (4WD)** .
16. Lower the transmission to gain access to the top and sides of the transmission.

Fig. 222: Transmission Mounting Bolts
Courtesy of GENERAL MOTORS COMPANY

17. Install the remaining bolts securing the transmission to the engine and tighten all. Refer to **Transmission Replacement** .

Fig. 223: Fuel Line Bracket And Nut
Courtesy of GENERAL MOTORS COMPANY

18. Position the fuel line bracket retainer at the left side of the transmission and install the fuel line bracket nut. Tighten the nut to 25 N.m (18 lb ft).

Fig. 224: Wire Harness/Vent Tube Bracket Nut & Converter Housing Stud
Courtesy of GENERAL MOTORS COMPANY

19. Position the vent tube bracket and install the retaining nut to the back side of the engine. Tighten the nut to 25 N.m (18 lb ft).

Fig. 225: Transmission Dip Stick Retaining Nut, Dip Stick Tube And Seal
Courtesy of GENERAL MOTORS COMPANY

20. Reposition the transmission dip stick tube (2).
21. Install the transmission dip stick tube retaining nut (1). Tighten the nut to 22 N.m (16 lb ft).
22. Position the ground cable to the right side of the engine and install the bolt. Tighten the bolt to 22 N.m (16 lb ft).
23. Lower the vehicle.

24. Position, route and clip the oxygen sensor wiring harnesses to the bulkhead and frame.
25. Connect the electrical connector to the bank 2 fuel rail.
26. Position and attach the transmission wiring harness to the engine.
27. Raise the vehicle.

Fig. 226: Transmission Wiring Harness And Retainers
Courtesy of GENERAL MOTORS COMPANY

28. Connect the harness retainers and electrical connectors to the transmission assembly.
29. Install the transmission wiring harness retaining bolt at the right side of the transmission. Tighten the bolt to 10 N.m (89 lb in).

Fig. 227: Transmission Heat Shield And Bolts
Courtesy of GENERAL MOTORS COMPANY

30. Install the transmission heat shield and heat shield bolts at the right side of the transmission. Tighten the bolt to 17 N.m (13 lb ft).
31. If equipped with four wheel drive, connect the wire harness electrical connectors and harness retainers at the transfer case.

32. Raise the transmission.
33. Connect the oxygen sensor wiring harness at the frame.

Fig. 228: Flywheel To Torque Converter Bolts
Courtesy of GENERAL MOTORS COMPANY

34. Align the torque converter bolt holes to the flex plate bolt holes.
35. Install the flex plate to torque converter bolts. Refer to **Transmission Replacement** .

Fig. 229: Exhaust Front Pipe
Courtesy of GENERAL MOTORS COMPANY

36. Install the exhaust front pipe (2). Refer to **Three-Way Catalytic Converter Replacement** .

Fig. 230: Transmission Crossmember, Crossmember Bolts & Nuts
Courtesy of GENERAL MOTORS COMPANY

37. Install the transmission crossmember (4). Refer to **Transmission Support Crossmember Replacement (2WD)** **Transmission Support Crossmember Replacement (4WD)** .

Fig. 231: Right Flywheel Inspection Cover
Courtesy of GENERAL MOTORS COMPANY

38. Install the right flywheel inspection cover and bolt. Refer to **Transmission Replacement** .
39. Install the starter motor. Refer to **Starter Replacement (L83, L86)** .

Fig. 232: Left Flywheel Inspection Cover
Courtesy of GENERAL MOTORS COMPANY

40. Install the left flywheel inspection cover and bolt. Refer to **Transmission Replacement** .
41. If the vehicle is equipped with a transfer case, install the front propeller shaft. Refer to **Front Axle Propeller Shaft Replacement (NPO)** **Front Axle Propeller Shaft Replacement (NQH)** **Front Axle Propeller Shaft Replacement (Heavy Duty)** .
42. Lower the vehicle.

43. Connect the battery current sensor electrical connector. Refer to **Battery Current Sensor Replacement (L83, L86)** .

Fig. 233: Underhood Electrical Center/Junction Block
Courtesy of GENERAL MOTORS COMPANY

44. Connect the engine main wiring harness to the engine wiring harness junction block (1). Refer to **Underhood Electrical Center or Junction Block Replacement** .
45. Route and connect remaining engine harnesses and connectors.

Fig. 234: Engine Control Module
Courtesy of GENERAL MOTORS COMPANY

46. Install the engine control module (1). Refer to **Engine Control Module Replacement** .
47. Remove the engine lift brackets.

Fig. 235: Fuel Injection Fuel Rail Assembly - Bank 2
Courtesy of GENERAL MOTORS COMPANY

48. Install the fuel injection fuel rail assembly - bank 2 (2). Refer to **Fuel Injection Fuel Rail Assembly Replacement - Bank 2** .

Fig. 236: Generator Bracket
Courtesy of GENERAL MOTORS COMPANY

49. Install the generator bracket (6) to the engine assembly. Refer to **Generator Bracket Replacement** .
50. Install the air conditioning tube bracket bolt (1) to the generator and drive belt tensioner bracket and tighten to 22 N.m (16 lb ft).

Fig. 237: Heater Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

51. Install the heater inlet hose (1). Refer to **Heater Inlet Hose Replacement (L83 L86)** .
52. Install the heater outlet hose. Refer to **Heater Outlet Hose Replacement (L83 L86)** .
53. Install the headlamp and radiator grille mount panel. Refer to **Headlamp and Radiator Grille Mount Panel Replacement** .

Fig. 238: Air Conditioning Condenser
Courtesy of GENERAL MOTORS COMPANY

54. Install the air conditioning condenser. Refer to **Air Conditioning Condenser Replacement (L83 L86)** .

Fig. 239: Radiator
Courtesy of GENERAL MOTORS COMPANY

55. Install the radiator. Refer to **Radiator Replacement (L83 L86)** .

Fig. 240: Radiator Outlet Hose Retainers
Courtesy of GENERAL MOTORS COMPANY

56. Install the radiator outlet hose (3). Refer to **Radiator Outlet Hose Replacement (L83 L86)** .

Fig. 241: Radiator Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

57. Install the radiator inlet hose (2). Refer to **Radiator Inlet Hose Replacement (L83 L86)** .

NOTE: **Prelube is necessary if the engine is replaced or overhauled.**

58. If the engine is replaced with a new engine or has been overhauled, perform the Engine Prelubing procedure. Refer to **Engine Prelubing**.
59. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection (Dual Battery)** **Battery Negative Cable Disconnection and Connection (Single Battery)** .
60. Place the hood in the normal operating position. Refer to **Hood Service Positioning** .
61. Fill engine with coolant. Refer to **Cooling System Draining and Filling (Vac N Fill L83 L86)** **Cooling System Draining and Filling (Static Fill L83 L86)**
62. Fill engine with oil. Refer to **Approximate Fluid Capacities** , and **Adhesives, Fluids, Lubricants, and Sealers**

63. Run engine and check for leaks.
64. Perform the crank variation learn procedure. Refer to **Crankshaft Position Variation Learn**

ENGINE OIL AND OIL FILTER REPLACEMENT

Removal Procedure

Fig. 242: Drain Plug

Courtesy of GENERAL MOTORS COMPANY

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Remove the drain plug (1) and drain the engine oil in a suitable container.

Fig. 243: Oil Filter
Courtesy of GENERAL MOTORS COMPANY

3. Remove the oil filter (1).
4. Inspect to ensure the engine oil filter gasket is removed.

Installation Procedure

Fig. 244: Oil Filter
Courtesy of GENERAL MOTORS COMPANY

1. Lubricate the oil filter gasket with clean engine oil.

CAUTION: **Refer to Component Fastener Tightening Caution .**

2. Install the oil filter (1) and tighten to 3/4 to 1 full turn after gasket makes contact with the sealing surface on the filter mounting flange.

Fig. 245: Drain Plug
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Clean and inspect the oil pan drain plug seal, replace parts as necessary.**

3. Install the drain plug (1) and tighten to 25 N.m (18 lb ft).
4. Lower the vehicle.
5. Fill the engine with the appropriate oil type and quantity. Refer to **Approximate Fluid Capacities** , and **Adhesives, Fluids, Lubricants, and Sealers**
6. Operate the engine, check for leaks, and oil pressure.
7. Reset the oil life monitor.

ENGINE OIL COOLER HOSE REPLACEMENT

Removal Procedure

1. Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .

Fig. 246: Engine Oil Cooler Hoses And Retainer
Courtesy of GENERAL MOTORS COMPANY

2. Remove the engine oil cooler hoses (2) from the retainer (1).
3. Disconnect the engine oil cooler hoses (2) from the radiator fittings (3). Refer to **Metal Collar Quick Connect Fitting Service** .
4. Remove the steering gear skid shield. Refer to **Steering Gear Skid Shield Replacement** .

Fig. 247: Oil Cooler Bracket Fastener And Oil Cooler Hoses
Courtesy of GENERAL MOTORS COMPANY

5. Remove the oil cooler bracket fastener (1) and separate the oil cooler hoses (2) from the engine block.

NOTE: **If equipped with 2WD perform steps 6 and 7.**

6. Disconnect the intermediate steering shaft at the steering gear. Refer to **Intermediate Steering Shaft Replacement**

7. Lower the electric belt drive rack and pinion steering gear. Refer to **Electric Belt Drive Rack and Pinion Steering Gear Replacement (Light Duty)** .
8. Using a suitable adjustable Jack, support the front axle.
9. Remove the two left side front axle bolts and lower the axle enough to create clearance for oil cooler line removal.

Fig. 248: Engine Oil Cooler Adapter Fasteners And Oil Cooler Adapter
Courtesy of GENERAL MOTORS COMPANY

10. Remove the engine oil cooler adapter fasteners (1) and separate the oil cooler adapter (2) from the engine block.

    DISCARD the oil cooler adapter gasket (3).

    NOTE: **Note the routing and orientation of the engine oil cooler hoses to insure proper installation.**

11. Remove the oil cooler hoses and gasket from the vehicle.

Installation Procedure

Fig. 249: Engine Oil Cooler Adapter Fasteners And Oil Cooler Adapter
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

1. Install a NEW oil cooler adapter gasket (3) and the oil cooler hose adapter (2) and tighten the fasteners (1) to 12 N.m (9 lb ft).
2. Transfer the oil cooler bracket from the original oil cooler hoses as needed.

Fig. 250: Oil Cooler Bracket Fastener And Oil Cooler Hoses
Courtesy of GENERAL MOTORS COMPANY

3. Install the oil cooler bracket fastener and tighten to 9 N.m (80 lb in).
4. Raise the axle into position.
5. Install the left axle bolts and tighten to 75 N.m (55 lb ft).
6. Remove the adjustable jack.

NOTE: **If equipped with a 2WD follow steps 7 and 8.**

7. Install the electric belt drive rack and pinion steering gear. Refer to **Electric Belt Drive Rack and Pinion Steering Gear Replacement (Light Duty)** .
8. Connect the intermediate steering shaft at the steering gear. Refer to **Intermediate Steering Shaft Replacement**
9. Install the steering gear skid shield. Refer to **Steering Gear Skid Shield Replacement** .
10. Lower the vehicle.

Fig. 251: Engine Oil Cooler Hoses And Retainer
Courtesy of GENERAL MOTORS COMPANY

11. Install the engine oil cooler hoses (2) into the radiator fittings (3). Refer to **Metal Collar Quick Connect Fitting Service** .
12. Install the engine oil cooler hoses (2) into the retainer (1).
13. Install the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement** .

REPAIR INSTRUCTIONS - OFF VEHICLE

DRAINING FLUIDS AND OIL FILTER REMOVAL

Fig. 252: Oil Pan Drain Plug
Courtesy of GENERAL MOTORS COMPANY

1. Remove the oil pan drain plug (1) with O-ring (2).

Fig. 253: Engine Oil Filter
Courtesy of GENERAL MOTORS COMPANY

2. Remove the engine oil filter (1).

Fig. 254: Left Side Rear Engine Block Coolant Drain Hole Plug
Courtesy of GENERAL MOTORS COMPANY

3. Remove the left side rear engine block coolant drain hole plug (1).

Fig. 255: Right Side Rear Engine Block Coolant Drain Hole Plug
Courtesy of GENERAL MOTORS COMPANY

4. Remove the right side rear engine block coolant drain hole plug (1).

CRANKSHAFT BALANCER REMOVAL

Fig. 256: Crankshaft Balancer
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Balancer Bolt **NOTE:**

Callout	Component Name
	Do not discard balancer bolt, it will be used later for installation. **Procedure** 1. Install the **J-42386-A** flywheel holding tool. Use 1 M10 - 1.5 x 120 mm and 1 M10 - 1.5 x 45 mm bolt for proper tool operation and tighten bolts to 50 N.m (37 lb ft). **Special Tools** **J-42386-A** Flywheel Holding Tool For equivalent regional tools, refer to **Special Tools**.
2	Crankshaft Balancer Assembly **Procedure** 1. Install the **EN-41816-2** crankshaft end protector. 2. Install the **EN-41816** crankshaft balancer remover. 3. Using both tools remove the crankshaft balancer. **Special Tools** • **EN-41816** Crankshaft Balancer Remover • **EN-41816-2** Crankshaft End Protector For equivalent regional tools, refer to **Special Tools**.

AUTOMATIC TRANSMISSION FLEX PLATE REMOVAL

Fig. 257: Automatic Transmission Flex Plate
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The flex plate does not use a locating pin for alignment and will not initially seat against the crankshaft flange, but will be pulled onto the crankshaft by the engine flex plate bolts. This procedure requires a 3 stage tightening process.**

1. Mark or scribe the end of the crankshaft and the flex plate before removal.

2. Remove the engine flex plate bolts (2).
3. Remove the flex plate (1).

OIL LEVEL INDICATOR AND TUBE REMOVAL

Fig. 258: Oil Level Indicator and Tube
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Level Indicator
2	Oil Level Indicator Tube Bracket Bolt
3	Oil Level Indicator Tube
4	Oil Level Indicator Tube O-Ring

EXHAUST MANIFOLD REMOVAL - LEFT SIDE

Fig. 259: Exhaust Manifold - Left Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Spark Plug Wire
2	Heat Shield Bolt
3	Heat Shield
4	Exhaust Manifold Bolt
5	Exhaust Manifold
6	Exhaust Manifold Gasket Refer to **Replacing Engine Gaskets**.

EXHAUST MANIFOLD REMOVAL - RIGHT SIDE

Fig. 260: Exhaust Manifold - Right Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Spark Plug Wire
2	Exhaust Manifold Heat Shield Bolt
3	Exhaust Manifold Heat Shield
4	Exhaust Manifold Bolt
5	Exhaust Manifold
6	Exhaust Manifold Gasket Refer to **Replacing Engine Gaskets**.

VACUUM PUMP REMOVAL

Fig. 261: Vacuum Pump
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Vacuum Pump Bolts
2	Vacuum Pump Bolt
3	Vacuum Pump Bolt
4	Vacuum Pump Assembly
5	Vacuum Pump Gasket Refer to **Replacing Engine Gaskets**.

THROTTLE BODY ASSEMBLY REMOVAL

Fig. 262: Throttle Body Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Throttle Body Bolt
2	Throttle Body Assembly
3	Throttle Body Gasket Refer to **Replacing Engine Gaskets**.

INTAKE MANIFOLD REMOVAL

Intake Manifold Cover Removal

Fig. 263: Intake Manifold Cover
Courtesy of GENERAL MOTORS COMPANY

Intake Manifold Cover Removal

Callout	Component Name
1	Intake Manifold Cover Bolt
2	Intake Manifold Cover Stud
3	Intake Manifold Cover Assembly

Intake Manifold Removal

Fig. 264: Intake Manifold
Courtesy of GENERAL MOTORS COMPANY

Intake Manifold Removal

Callout	Component Name
1	PCV Tube Assembly **Procedure**

Callout	Component Name
	1. The PCV tube is connected to the intake manifold and the engine via a plastic collar quick connect fitting. 2. To remove the PCV tube, refer to **Plastic Collar Quick Connect Fitting Service** .
2	Intake Manifold Bolt
3	Intake Manifold Assembly
4	Intake Manifold Gasket Refer to **Replacing Engine Gaskets**.

ENGINE COOLANT MANIFOLD REMOVAL

Fig. 265: Engine Coolant Manifold
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Drive Belt Tensioner Bolt
2	Drive Belt Tensioner
3	Engine Coolant Manifold Bolt
4	Engine Coolant Manifold Bolt
5	Engine Coolant Manifold Bolt
6	Engine Coolant Manifold Bolt
7	Engine Coolant Manifold Assembly
8	Engine Coolant Manifold Gaskets Refer to **Replacing Engine Gaskets**. **NOTE:** **Discard gasket, it is not reusable.**

FUEL PUMP INSULATOR AND FUEL FEED PIPES REMOVAL

Fig. 266: Fuel Pump Insulator
Courtesy of GENERAL MOTORS COMPANY

WARNING: The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.

1. Remove the fuel pump insulator (1).

Fig. 267: Low Pressure Fuel Feed Pipe To LH Rocker Cover Bolt
Courtesy of GENERAL MOTORS COMPANY

2. Remove the low pressure fuel feed pipe to LH rocker cover bolt (4).
3. Remove the redundant clip (3). Remove low pressure fuel feed pipe (1) from the fuel pump (2).

Fig. 268: Crossover Pipe And Fuel Feed Pipe Fittings
Courtesy of GENERAL MOTORS COMPANY

CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

4. Remove the high pressure fuel feed pipe that connects the fuel pump to the crossover pipe (1) by loosening the fuel feed pipe fittings (2).

Fig. 269: RH Fuel Rail Crossover Pipe Bolt
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.**

NOTE:

- **DO NOT reuse the high pressure fuel rail crossover pipe.**
- **The tightening order and torque are critical to proper fuel system fit and function. Be sure to follow installation and tightening steps exactly.**

5. Remove the high pressure LH to RH fuel rail crossover pipe bolt (3).
6. Remove the fuel rail crossover pipe by loosening the pipe fittings (1 and 2).

FUEL RAIL AND INJECTORS REMOVAL

Fig. 270: Fuel Rail and Injectors
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Fuel Injection Fuel Rail Bolt
2	Direct Fuel Injection Fuel Rail Assembly **Procedure** **NOTE:** • **In some cases, the fuel injectors may be difficult to remove because of heavy carbon build-up or other factors. Excessive force with the removal tool can damage the fuel rail, injectors or both. If injectors are difficult to remove, apply solvent to**

Callout	Component Name
	the base of the injector bores, and allow adequate soaking time, to loosen the fuel injectors. • Pull the fuel rail and injectors as an assembly. • To prevent material from entering the combustions chambers make sure the area around each injector is clean and free of debris before the injectors are removed from the injector bores.

Callout	Component Name
	1. Install two sets of **EN-49248** remover. 2. Install one remover in each of the fuel rail fastener bores. 3. Remove by turning each section of the remover an equal amount to pull the fuel rail and injectors out evenly. **Special Tools** **EN-49248** Injector Rail Assembly Remover For equivalent regional tools, refer to **Special Tools**.
3	Fuel Rail Insulator

FUEL PUMP REMOVAL

Fig. 271: Fuel Pump
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	**CAUTION:** **Alternately loosen the fuel pump bolts one turn at a time until the pump is fully disengaged from fuel pump lifter follower. Trying to remove the pump bolts without even side-to-side loosening may result in pump plunger damage** Fuel Pump Bolt
2	Fuel Pump Cover
3	Bolt Retainer
4	Fuel Pump Assembly
5	Fuel Pump Gasket **NOTE:** **Discard gasket, it is not reusable.**

Callout	Component Name
	Refer to **Replacing Engine Gaskets**.

VALVE LIFTER OIL FILTER REMOVAL

Fig. 272: Valve Lifter Oil Filter
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do not allow dirt or debris to enter the oil passages of the manifold. Plug, as required.**

1. Remove the oil pressure sensor (3).
2. Remove the valve lifter oil manifold plug (1) and oil filter (2).

VALVE ROCKER ARM COVER REMOVAL - LEFT SIDE

Fig. 273: Valve Rocker Arm Cover - Left Side
Courtesy of GENERAL MOTORS COMPANY

Valve Rocker Arm Cover Removal - Left Side

Callout	Component Name
1	Valve Rocker Arm Cover Bolt
2	Valve Rocker Arm Cover - Left Side

Callout	Component Name
3	Valve Rocker Arm Cover Gasket Refer to **Replacing Engine Gaskets**.

Valve Rocker Arm Cover Disassemble - Left Side

Fig. 274: Valve Rocker Arm Cover Disassemble - Left Side
Courtesy of GENERAL MOTORS COMPANY

Valve Rocker Arm Cover Disassemble - Left Side

Callout	Component Name
1	Ignition Coil Bolt
2	Ignition Coil

VALVE ROCKER ARM COVER REMOVAL - RIGHT SIDE

Fig. 275: Valve Rocker Arm Cover - Right Side
Courtesy of GENERAL MOTORS COMPANY

Valve Rocker Arm Cover Removal - Right Side

Callout	Component Name
1	Valve Rocker Arm Cover Bolt
2	Valve Rocker Arm Cover - Right Side
3	Valve Rocker Arm Cover Gasket Refer to **Replacing Engine Gaskets**.

Valve Rocker Arm Cover Disassemble - Right Side

Fig. 276: Valve Rocker Arm Cover Disassemble - Right Side
Courtesy of GENERAL MOTORS COMPANY

Valve Rocker Arm Cover Disassemble - Right Side

Callout	Component Name
1	Ignition Coil Bolt
2	Ignition Coil

VALVE ROCKER ARM AND PUSH ROD REMOVAL

Fig. 277: Valve Rocker Arm and Push Rod
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Place the valve rocker arms and valve pushrods in a rack so they can be installed in the same location from which they were removed.**

Callout	Component Name
1	Valve Rocker Arm and Push Rod Assembly **NOTE:** **The rocker arm bolts are not serviced separately.**

CYLINDER HEAD REMOVAL - LEFT SIDE

Fig. 278: Cylinder Head - Left Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure If camshaft lobe lift measurement is required, perform measurement prior to removal of the cylinder heads. Refer to **Camshaft and Bearings Cleaning and Inspection**.	
1	Cylinder Head Bolt
2	Cylinder Head Bolt
3	Cylinder Head Bolt
4	Cylinder Head Assembly

Callout	Component Name
5	Cylinder Head Gasket Refer to **Replacing Engine Gaskets**.

CYLINDER HEAD REMOVAL - RIGHT SIDE

Fig. 279: Cylinder Head - Right Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure If camshaft lobe lift measurement is required, perform measurement prior to removal of the cylinder heads. Refer to **Camshaft and Bearings Cleaning and Inspection**.	
1	Cylinder Head Bolt
2	Cylinder Head Bolt

Callout	Component Name
3	Cylinder Head Assembly
4	Cylinder Head Gasket Refer to **Replacing Engine Gaskets**.

VALVE LIFTER OIL MANIFOLD REMOVAL

Valve Lifter Oil Manifold Removal

Fig. 280: Valve Lifter Oil Manifold
Courtesy of GENERAL MOTORS COMPANY

Valve Lifter Oil Manifold Removal

Callout	Component Name
1	Valve Lifter Oil Manifold Bolt
2	Valve Lifter Oil Manifold Assembly
3	Valve Lifter Oil Manifold Gasket Refer to **Replacing Engine Gaskets**. **NOTE:** **Discard gasket, it is not reusable.**

Valve Lifter Oil Manifold Disassemble

Fig. 281: Valve Lifter Oil Manifold Disassemble
Courtesy of GENERAL MOTORS COMPANY

Valve Lifter Oil Manifold Disassemble

Callout	Component Name
1	Oil Pressure Sensor
2	Valve Lifter Oil Manifold Plug
3	Valve Lifter Oil Filter
4	PCV Valve

VALVE LIFTER FOLLOWER GUIDE REMOVAL

Fig. 282: Valve Lifter Follower Guide
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Valve Lifter Follower Guide Bolt
2	Valve Lifter Follower Guide
3	Valve Lifter Follower

VALVE LIFTER REMOVAL

Fig. 283: Valve Lifters And Guides
Courtesy of GENERAL MOTORS COMPANY

1. Remove the bolts (211).
2. Remove the guides (210) with lifters.

Note the installed position of the guides. The notched area of the guide is to align with the locating tab of the block.

Fig. 284: Exploded View Of Valve Lifters And Guides
Courtesy of GENERAL MOTORS COMPANY

3. Remove the valve lifters (209, 219) from the guide (210).

Fig. 285: Aligning Notched Area Of Guide With Raised Surface On Side Of Lifter
Courtesy of GENERAL MOTORS COMPANY

4. Organize or mark the components so they can be installed in the same location from which they were removed. The active fuel management lifters (4) are installed into the guide by aligning the notched area of the guide (1) with the raised surface on the side of the lifter (2). Refer to **Separating Parts**.

ENGINE OIL COOLER REMOVAL

Fig. 286: Engine Oil Cooler
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Oil Cooler Bolt
2	Engine Oil Cooler
3	Engine Oil Cooler Gasket **Procedure** Refer to **Replacing Engine Gaskets**. **NOTE:** **Discard gasket, it is not reusable.**

OIL PAN REMOVAL

Fig. 287: Oil Pan
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Upper Oil Pan Bolt
2	Upper Oil Pan Bolt
3	Oil Pan Assembly

CRANKSHAFT FRONT OIL SEAL REMOVAL

Fig. 288: Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Front Oil Seal **Procedure** 1. Install **EN-51096** crankshaft rear seal remover onto **GE-23907-1** slide hammer. **NOTE:** **EN-51096 crankshaft rear seal remover has**

Callout	Component Name
	two ends. The end with the small bend will be used to remove the seal. 2. Slide the small bend of **EN-51096** crankshaft rear seal remover between the lip of the front seal and crankshaft. Ensure that the small bend of **EN-51096** crankshaft rear seal remover engages the rear side of the front seal (1). While rotating **EN-51096** crankshaft rear seal remover and **GE-23907-1** slide hammer around the seal, use the slide hammer to remove the seal. **Special Tools** • **EN-51096** Crankshaft Rear Seal Remover • **GE-23907-1** Slide Hammer For equivalent regional tools, refer to **Special Tools**.

ENGINE FRONT COVER REMOVAL

Camshaft Position Sensor Harness, Camshaft Position Sensor and Camshaft Actuator Magnet Removal

Fig. 289: Camshaft Position Sensor Harness, Camshaft Position Sensor and Camshaft Actuator Magnet
Courtesy of GENERAL MOTORS COMPANY

Camshaft Position Sensor Harness, Camshaft Position Sensor and Camshaft Actuator Magnet Removal

Callout	Component Name
1	Camshaft Position Sensor Harness Bolts
2	Camshaft Position Sensor Harness
3	Camshaft Position Sensor

Callout	Component Name
4	Camshaft Position Sensor Seal **NOTE:** **Discard seal, it is not reusable.** Refer to **Replacing Engine Gaskets**.
5	Camshaft Actuator Magnet Bolts
6	Camshaft Actuator Magnet
7	Camshaft Actuator Magnet Gasket **NOTE:** **Discard gasket, it is not reusable.**

Front Cover Removal

Fig. 290: Front Cover
Courtesy of GENERAL MOTORS COMPANY

Front Cover Removal

Callout	Component Name
Preliminary Procedure The oil pump flow control valve harness must be removed before the front cover can be removed.	
1	Engine Front Cover Bolt

Callout	Component Name
2	Engine Front Cover Bolt
3	Engine Front Cover **NOTE:** **To separate the front cover from the engine, pry at the points that are shown by the arrows.**

Oil Pump Flow Control Valve Harness Removal

Fig. 291: Oil Pump Flow Control Valve Harness
Courtesy of GENERAL MOTORS COMPANY

Oil Pump Flow Control Valve Harness Removal

Callout	Component Name
1	Oil Pump Flow Control Valve Harness **Procedure** 1. Remove the wire from the 2 retainer clips. 2. Push the tabs in and pull the harness and connector through the front of the engine front cover

CRANKSHAFT REAR OIL SEAL REMOVAL

Fig. 292: Crankshaft Rear Oil Seal
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Rear Oil Seal **Procedure** 1. Install **EN-51096** crankshaft rear seal remover onto **GE-23907-1** slide hammer. **NOTE:** **EN-51096 crankshaft rear seal remover has**

Callout	Component Name
	two ends. The end with the small bend will be used to remove the seal. 2. Slide the small bend of **EN-51096** crankshaft rear seal remover between the lip of the rear seal and crankshaft. Ensure that the small bend of **EN-51096** crankshaft rear seal remover engages the rear side of the rear seal (1). While rotating **EN-51096** crankshaft rear seal remover and **GE-23907-1** slide hammer around the seal and use the slide hammer to remove the seal. **Special Tools** • **EN-51096** Crankshaft Rear Seal Remover • **GE-23907-1** Slide Hammer For equivalent regional tools, refer to **Special Tools**.

CRANKSHAFT REAR OIL SEAL HOUSING REMOVAL

Fig. 293: Crankshaft Rear Oil Seal Housing
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Rear Oil Seal Housing Bolt
2	Crankshaft Rear Oil Seal Housing **NOTE:** **To separate the rear housing from the engine, pry at the points that are**

Callout	Component Name
	shown by the arrows.
3	Crankshaft Rear Oil Seal Housing Gasket Refer to **Replacing Engine Gaskets**.

OIL PUMP REMOVAL

Fig. 294: Oil Pump
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure If oil pump is being removed to perform a different repair and is going to be reused, then **EN-51267** oil pump alignment tool MUST be	

Callout	Component Name
installed on the engine block before the oil pump is removed and left in place until the oil pump is reinstalled. Failure to do so before the oil pump is removed will result in the original oil pump having to be replaced with a new oil pump.	
1	Oil Pump Bolt **NOTE:** **If the Oil Pump is going to be reused, then prior to removing oil Pump Bolts, install the oil pump alignment tool. If the oil pump is going to be replaced, then just remove the bolts and proceed to step 2.** **Procedure** 1. Hand Tighten the supplied bolts in the positions shown. 2. Hold the alignment tools tight to the oil pump housing and then torque the alignment tool bolts to 10 N.m (86 lb in). **Special Tools** **EN-51267** Oil Pump Alignment Tool For equivalent regional tools, refer to **Special Tools**.
2	Oil Pump Assembly

TIMING CHAIN, CRANKSHAFT SPROCKET, CAMSHAFT POSITION ACTUATOR, AND SOLENOID VALVE REMOVAL

Special Tools

EN-42386-A Flywheel Holding Tool

For equivalent regional tools, refer to **Special Tools**

Fig. 295: Automatic Transmission Flex Plate
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Do not use the camshaft position (CMP) actuator solenoid valve again. Upon installation of the CMP actuator and timing chain, install a NEW valve.**
- **Do not apply threadlock to the flex plate bolts at this time.**

1. Temporarily install the automatic transmission flex plate (1) and bolts (2). Refer to **Automatic Transmission Flex Plate Installation**.

Fig. 296: Flywheel Holding Tool And Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

2. Install the **EN-42386-A** tool (1) and bolts. Use 1 M10 - 1.5 x 120 mm and 1 M10 - 1.5 x 45 mm bolt for proper tool operation. Tighten the **EN-42386-A** tool bolts to 50 N.m (37 lb ft).

Fig. 297: CMP Actuator Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

3. Remove the CMP actuator solenoid valve (234).
4. Discard the solenoid valve.

Fig. 298: Proper CMP Actuator Removal
Courtesy of GENERAL MOTORS COMPANY

WARNING: Refer to Camshaft Position Actuator Removal and Installation Warning .

5. Loosen and separate the CMP actuator and timing chain from the camshaft. Position fingers behind the actuator sprocket and pull the actuator away from the front of the camshaft. Never pull on the reluctor wheel when attempting to remove the actuator.

Fig. 299: CMP Actuator And Timing Chain
Courtesy of GENERAL MOTORS COMPANY

6. Remove the CMP actuator (235) and timing chain (208).

Fig. 300: Tie Strap Through Center Of Actuator
Courtesy of GENERAL MOTORS COMPANY

7. Insert a tie strap (1) through the center of the actuator and over the reluctor wheel.

Fig. 301: Timing Chain Tensioner & Bolts
Courtesy of GENERAL MOTORS COMPANY

8. Remove the bolts (231) and timing chain tensioner (232).

Fig. 302: Crankshaft Sprocket
Courtesy of GENERAL MOTORS COMPANY

9. Remove the crankshaft sprocket (207).

Fig. 303: Crankshaft Key And Keyway
Courtesy of GENERAL MOTORS COMPANY

10. Remove the crankshaft sprocket key, as required.
11. Remove the flex plate and bolts. Refer to **Automatic Transmission Flex Plate Removal**.
12. Remove the **EN-42386-A** tool and bolts.

CAMSHAFT REMOVAL

Fig. 304: Camshaft
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Retainer Bolt
2	Camshaft Retainer
3	Camshaft Assembly

PISTON, CONNECTING ROD, AND BEARING REMOVAL

Special Tools

- **EN-24270** Cylinder Bore Ridge Reamer

- **EN-41556** Connecting Rod Guide

For equivalent regional tools, refer to **Special Tools**.

Fig. 305: Removing Cylinder Bore Ring Ridge
Courtesy of GENERAL MOTORS COMPANY

1. Use the **EN-24270** cylinder bore ridge reamer in order to remove the cylinder bore ring ridge, if required.
    1. Turn the crankshaft until the piston is at the bottom of the stroke.
    2. Place a cloth on top of the piston.
    3. Use the **EN-24270** cylinder bore ridge reamer, or equivalent, in order to remove a cylinder ring ridge.
    4. Turn the crankshaft so the piston is at the top of the stroke.
    5. Remove the cloth.
    6. Remove the cutting debris from the cylinder and piston.

Fig. 306: Matchmarks On Connecting Rods & Caps
Courtesy of GENERAL MOTORS COMPANY

2. Using a paint stick or etching tool, place matchmarks or numbers on the connecting rods and the connecting rod caps. The connecting rods and caps MUST be assembled to their original position and direction.
    - A stamping mark on the side of the connecting rod, at the crankshaft journal, may affect component geometry.
    - Mark the top of the piston to the specific cylinder bore.

Fig. 307: Connecting Rod Bolts, Cap And Bearing
Courtesy of GENERAL MOTORS COMPANY

IMPORTANT: Mark, sort, or organize the connecting rod bearings so they may be installed to their original position and location. The connecting rods and the bearing caps are NOT interchangeable. Refer to **Separating Parts**.

3. Remove the connecting rod bolts (3), cap (2) and bearing (1).

Fig. 308: Crankshaft Protector Pins Installed In Connecting Rod Bolt Holes
Courtesy of GENERAL MOTORS COMPANY

4. Install the **EN-41556** connecting rod guide to the connecting rod.

Fig. 309: Piston, Connecting Rod And Cylinder Bore
Courtesy of GENERAL MOTORS COMPANY

5. Using a hammer, tap lightly on the end of the **EN-41556** connecting rod guide in order to remove the piston and connecting rod assembly from the cylinder bore.
6. Remove the **EN-41556** connecting rod guide.

Fig. 310: Piston, Connecting Rod And Connecting Rod Bearing
Courtesy of GENERAL MOTORS COMPANY

7. Upon removal of the piston and connecting rod assembly, assemble the connecting rod cap and bolts onto the matching connecting rod.

CRANKSHAFT AND BEARING REMOVAL

Special Tools

- **J-6125-1B** Slide Hammer
- **J-41818** Crankshaft Bearing Cap Remover

For equivalent regional tools, refer to **Special Tools**

Fig. 311: Crankshaft Position (CKP) Sensor Bolt And CKP Sensor
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **The crankshaft bearing caps are machined with the engine block, for the proper clearances. Mark or identify each crankshaft bearing cap location and direction before removal. The crankshaft bearing caps MUST be installed to their original position and direction.**
- **All bolts are to be discarded and replaced with NEW.**

1. Remove the crankshaft position (CKP) sensor bolt (1).
2. Remove the CKP sensor (2).
3. Remove the O-ring (3) from the sensor, as required.

Fig. 312: Crankshaft Inner Bearing Cap Bolts And Outer Bearing Cap Bolts
Courtesy of GENERAL MOTORS COMPANY

4. Remove and discard the crankshaft inner bearing cap bolts (1) and outer bearing cap bolts (2).
5. Remove and discard the bearing cap side bolts (3).

Fig. 313: Removing Crankshaft Bearing Caps
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

6. Install the **J-41818** remover (2) and tighten to 11 N.m (100 lb in).
7. Install the **J-6125-1B** hammer (1) to the **J 41818** remover (2) in order to remove the crankshaft bearing caps.

Fig. 314: Crankshaft Bearing Caps
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Before removal note the direction of the bearing caps arrows and location.**

8. Remove the bearing caps (1).

Fig. 315: Crankshaft
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Use care when handling the crankshaft. Avoid damage to the CKP sensor reluctor ring teeth. Nicks, burrs or other damage to the teeth may affect on-board diagnostics (OBD) II system performance.**

9. Remove the crankshaft (1).
10. Lay the crankshaft onto 2 wooden V-blocks or other protective surface.

Fig. 316: Crankshaft Bearings And Bearing Caps
Courtesy of GENERAL MOTORS COMPANY

11. Remove the crankshaft bearings (2, 3, and 4) from the bearing caps (1) and the engine block.
12. Mark, sort, or organize the crankshaft bearings so they may be installed to their original position and location. Refer to **Separating Parts**.

ENGINE BLOCK PLUG REMOVAL

Plug Removal - Left Side

Fig. 317: Plug - Left Side
Courtesy of GENERAL MOTORS COMPANY

Plug Removal - Left Side

Callout	Component Name
1	Oil Pump Locating Pin
2	Engine Block Oil Gallery Plug
3	Engine Block Plug
4	Engine Block Plug
5	Knock Sensor Shield Bolt
6	Knock Sensor Shield
7	Knock Sensor Bolt

Callout	Component Name
8	Knock Sensor Assembly

Plug Removal - Right Side

Fig. 318: Plug - Right Side
Courtesy of GENERAL MOTORS COMPANY

Plug Removal - Right Side

Callout	Component Name
1	Piston Oil Nozzle Assembly
2	Transmission Locating Pin
3	Knock Sensor Bolt
4	Knock Sensor Assembly

Callout	Component Name
5	Engine Block Plug

ENGINE BLOCK CLEANING AND INSPECTION

Special Tools

J 8087 Cylinder Bore Gauge

For equivalent regional tools, refer to **Special Tools**

Cleaning Procedure

Fig. 319: Engine Block And Main Bearing Caps
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Do not use a caustic solution to clean the aluminum engine block.

NOTE: When cleaning the engine block in a thermal type oven, do not exceed 232Â°C (450Â°F).

Clean the following components:

- Remove all sludge, dirt, or debris using a cleaning solvent or thermal type oven. Refer to **Cleanliness and Care**.
- Gasket surfaces

  Refer to **Replacing Engine Gaskets**.

- Coolant passages
- Oil galleries
- Main bearing caps
- Cylinder head bolt holes to remove threadlocking material

Inspection Procedure

1. Inspect the following components:

   NOTE: **Check the cylinder condition. Some light vertical marks may be visible on the cylinder wall. In these areas, check that the honing marks are still visible in this marked area. If they are, the cylinder surface has not been compromised and the engine block can be used.**

   - Cylinder walls for excessive scratches, gouging, or ring ridge
   - Cylinder bores for excessive ring ridge at the top of the cylinder
   - Coolant jacket for cracks
   - Valve lifter bores for excessive scoring or wear
   - Crankshaft bearing webs for cracks
   - Gasket sealing surfaces for excessive scratches or gouging

     Refer to **Replacing Engine Gaskets**.

   - Oil galleries for restrictions
   - Threaded bolt holes for damaged threads
   - Cylinder bores for excessive ring ridge at the top of the cylinder
2. Measure the cylinder bores for an oversize condition:

Measuring the Cylinder for Oversize

Fig. 320: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS COMPANY

1. Adjust the micrometer to a dimension slightly smaller than the bore size. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.
2. Insert the **J 8087** gauge into the micrometer and zero the bore gauge dial.

Fig. 321: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS COMPANY

3. Use the **J 8087** gauge and measure the cylinder bore for oversize.

   Slide the bore gauge up and down throughout the length of the cylinder bore. Measure the bore, both parallel and perpendicular to the centerline of the crankshaft, at the top, center, and bottom of the bore. A cylinder bore that exceeds the maximum diameter must be serviced with an oversized piston. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.

PISTON OIL NOZZLE CLEANING AND INSPECTION

NOTE: **The piston oil nozzle assembly is designed to provide oil to the bottom side of the piston for cooling purposes. The internal check ball is held in the normally closed position by the spring until system oil pressure exceeds 300 kPa (43.5 psi).**

Fig. 322: Piston Oil Nozzle Assembly
Courtesy of GENERAL MOTORS COMPANY

1. Clean the nozzle assembly in solution.
2. Inspect the nozzle assembly for the following:
    - damaged bolt threads
    - damaged or cut O-ring seal
    - bent nozzle
    - A restricted or stuck-open nozzle assembly
3. With no oil pressure, the check ball should be seated and not permit flow through the nozzle tube. Using a blow gun, apply air pressure to the inlet portion of the bolt. Air pressure should unseat the check ball and permit flow through and out of the nozzle tube.

CRANKSHAFT AND BEARING CLEANING AND INSPECTION

Special Tools

- **J 7872** Magnetic Base Dial Indicator Set
- **J 43690** Rod Bearing Checking Tool
- **J 43690-100** Rod Bearing Checking Tool - Adapter Kit

For equivalent regional tools, refer to **Special Tools**

Cleaning Procedure

Fig. 323: Oil Passages And CKP Reluctor Ring Teeth
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Use care when handling the crankshaft. Avoid damage to the bearing surfaces or the lobes of the crankshaft position (CKP) reluctor ring. Damage to the teeth of the CKP reluctor ring may affect on-board diagnostics (OBD) II system performance.**

1. Clean the crankshaft with solvent.
2. Thoroughly clean all oil passages (2) and inspect for restrictions or burrs.

WARNING: Refer to Safety Glasses Warning .

3. Dry the crankshaft with compressed air.

Inspection Procedure

Fig. 324: CKP Reluctor Ring Teeth
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The reluctor ring teeth should not have imperfections on the rising or falling edges. Imperfections of the reluctor ring teeth may affect OBD II system performance.**

1. Inspect the CKP reluctor ring teeth (1) for damage.

Fig. 325: Crankshaft Journals
Courtesy of GENERAL MOTORS COMPANY

2. Inspect the crankshaft journals for wear.

   Journals should be smooth (1) with no signs of scoring, wear, or damage.

3. Inspect the crankshaft journals for grooves or scoring (2).
4. Inspect the crankshaft journals for scratches or wear (3).
5. Inspect the crankshaft journals for pitting or imbedded bearing material (4).
6. Inspect the crankshaft rear oil seal surface (5) for grooves or scoring.

Fig. 326: Crankshaft Key, Keyway And Threaded Hole

Courtesy of GENERAL MOTORS COMPANY

7. Inspect the crankshaft key (122), keyway (1), and threaded hole (2) for damage.

Fig. 327: Measuring Connecting Rod Journals For Out-Of-Round And Taper
Courtesy of GENERAL MOTORS COMPANY

8. Measure the connecting rod journals for out-of-round and taper.

Fig. 328: Measuring Crankshaft Thrust Wall Width
Courtesy of GENERAL MOTORS COMPANY

9. Measure the crankshaft thrust wall width.

   A crankshaft with a thrust wall width in excess of 26.2 mm (1.0315 in) (a) must be replaced.

Fig. 329: Measuring Crankshaft Runout
Courtesy of GENERAL MOTORS COMPANY

10. Measure the crankshaft runout.

    Use wooden V-blocks or a fixture to support the crankshaft on the front and rear journals.

11. Use the **J 7872** set in order to measure the crankshaft runout at the front and rear intermediate journals.

12. Use the **J 7872** set in order to measure the runout of the crankshaft rear flange.
13. Use the **J 7872** set in order to measure the runout of the crankshaft position reluctor ring. Reluctor ring runout should be measured 1.0 mm (0.04 in) below the ring teeth.

    If the front and rear intermediate journals, crankshaft rear flange, or reluctor ring runout exceeds specification, replace the crankshaft. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.

Fig. 330: Inspecting Bearings For Craters Or Pockets
Courtesy of GENERAL MOTORS COMPANY

14. Inspect crankshaft bearings for craters or pockets. Flattened sections on the bearing halves also indicate fatigue.

Fig. 331: Inspecting Bearings For Scoring Or Discoloration
Courtesy of GENERAL MOTORS COMPANY

15. Inspect the crankshaft bearings for excessive scoring or discoloration.
16. Inspect the crankshaft bearings for dirt or debris imbedded into the bearing material.

Fig. 332: Inspecting Bearings For Improper Seating
Courtesy of GENERAL MOTORS COMPANY

17. Inspect the crankshaft bearings for improper seating, indicated by bright, polished sections of the bearing.

If the lower half of the bearing is worn or damaged, both upper and lower halves should be replaced.

Generally, if the lower half is suitable for use, the upper half should also be suitable for use.

Measuring Main Bearing Clearance - Gaging Plastic Method

Fig. 333: Gaging Plastic Installed On Crankshaft Journal

Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **The crankshaft main bearings are a precision insert type. Main bearing caps are machined with the engine block, for proper clearance, and cannot be shimmed or filed for bearing fit. If the clearances are found to be excessive, new bearings and/or engine block and cap repair or replacement may be required.**
- **Do not rotate the crankshaft while gaging plastic is between the crankshaft journal and the bearing surface.**
- **The crankshaft bearing clearances are critical. Excessive bearing clearance may affect crankshaft position sensor signals and may affect OBD II system operation.**
- **Remove the bearing cap side bolts prior to cap removal.**

1. Remove the bearing caps, bearing half, and bolts. Refer to **Crankshaft and Bearing Removal**.
2. Install gaging plastic onto the crankshaft journal. Install the gaging plastic the full width of the crankshaft bearing journal.
3. Install the bearing caps, bearing half, and bolts. Refer to **Crankshaft and Bearing Installation**.
4. Remove the bearing caps, bearing half, and bolts. Refer to **Crankshaft and Bearing Removal**.

Fig. 334: Measuring Gaging Plastic
Courtesy of GENERAL MOTORS COMPANY

5. Using the scale supplied with the plastic gaging kit, measure the gaging plastic at its widest area.
    - If the gaging plastic shows irregularity in the journal, exceeding 0.025 mm (0.001 in), remove the crankshaft and measure the journal with a micrometer.

- If clearance cannot be brought to specifications, replace the crankshaft or engine block as required. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.

Measuring Connecting Rod Bearing Clearance - Gaging Plastic Method

Fig. 335: Gaging Plastic Installed On Crankshaft Journal
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Connecting rod bearings are a precision insert type. Connecting rods are of a powdered metal design and cannot be shimmed or filed for bearing fit. If clearances are found to be excessive, a new bearing and/or connecting rod is required.**
- **Do not rotate the crankshaft while gaging plastic is between the crankshaft journal and the bearing surface.**

1. Remove the bearing cap, bearing half, and bolts. Refer to **Piston, Connecting Rod, and Bearing Removal**.
2. Install the gaging plastic onto the connecting rod bearing journal. Install the gaging plastic the full width of the journal.
3. Install the bearing cap, bearing half, and bolts. Refer to **Piston, Connecting Rod, and Bearing Installation**.
4. Remove the bearing cap, bearing half, and bolts. Refer to **Piston, Connecting Rod, and Bearing Removal**.

Fig. 336: Measuring Gaging Plastic
Courtesy of GENERAL MOTORS COMPANY

5. Using the scale supplied with the plastic gaging kit, measure the gaging plastic at its widest area. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.

Measuring Connecting Rod Bearing Clearance - Using J 43690/J 43690-100

J 43690 tool and **J 43690-100** kit have been developed as a more accurate method to measure connecting rod bearing clearances. The instructions below provide an overview of tool set-up and usage. For more detailed information, refer to the tool instruction sheets supplied by the tool manufacturer.

Fig. 337: Rod Bearing Clearance Checking Tool Kit

Courtesy of GENERAL MOTORS COMPANY

J 43690 tool

- J 43690-20 Swivel Base (1)
- J 43690-19 Dial Indicator (2)
- J 43690-2 Base (3)
- J 43690-5, J 43690-6 Handle (4)
- J 43690-10, J 43690-11 Foot (5)
- 280307 Screw (6)
- J 43690-1 Pivot Arm Assembly (7)
- J 43690-3, J 43690-7, J 43690-8 Screws (8)
- 280319 Screw (9)
- 280311 Screw (10)
- J 43690-17, J 43690-18 Adapter (11)
- 280310 Pin (12)

Fig. 338: Rod Bearing Clearance Tool - Adapter Kit
Courtesy of GENERAL MOTORS COMPANY

J 43690 Rod Bearing Checking Tool

- J 43690-104 Spacer (1)

- J 43690-105 Retainer Plate (2)
- 505478 Bolt (3)
- 511341 Bolt (4)
- J 43690-106 Retainer Plate (5)
- J 43690-107 Cap (6)
- J 43690-102 Foot (7)
- J 43690-101 Pivot Arm Assembly (8)
- J 43690-103 Adapter (9)
- 505439 Adapter (10)

Fig. 339: Bearing Cap, Bolt And Bearing Half
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The crankshaft must be secure, with no movement or rotation, in order to obtain an accurate reading.**

1. Rotate the crankshaft until the journal/connecting rod to be measured is in the 12 o'clock position.

2. Remove a bearing cap and bolts (1).
3. Remove the bearing half (2).
4. Insert a piece of paper card stock onto the crankshaft journal.
5. Install the bearing half (2) and cap and bolts (1). Refer to **Fastener Specifications**.

Fig. 340: Special Tool Installed On Engine Block

Courtesy of GENERAL MOTORS COMPANY

6. Install the following:
    1. J 43690-2 (5)
    2. J 43690-3 (4)
    3. J 43690-101 (2)
    4. 280310 (3)
    5. J 43690-5 (1)

Fig. 341: Swivel Base And Dial Indicator
Courtesy of GENERAL MOTORS COMPANY

7. Install the swivel base (1) and dial indicator (2).
8. Adjust per the manufacturers instructions and measure the connecting rod bearing clearance.

A connecting rod with a clearance in excess of 0.076 mm (0.003 in) is considered excessive. Service components, as required.

CRANKSHAFT BALANCER CLEANING AND INSPECTION

Fig. 342: Crankshaft Balancer
Courtesy of GENERAL MOTORS COMPANY

1. Clean the crankshaft balancer in solvent.
2. Clean the belt grooves of all dirt or debris with a wire brush.
3. Dry the crankshaft balancer with compressed air.
4. Inspect the crankshaft balancer for the following conditions:
    - Worn, grooved, or damaged hub seal surface

      A crankshaft balancer hub seal surface with excessive scoring, grooves, rust or other damage must be replaced.

      Minor imperfections on the hub seal surface may be removed with polishing compound or fine grade emery cloth.

      IMPORTANT: In order for the belt to track properly, the belt grooves should be free of all dirt or debris.

    - Dirty or damaged belt grooves

      The balancer belt grooves should be free of any nicks, gouges, or other damage that may not allow the belt to track properly.

      Minor imperfections may be removed with a fine file.

    - Worn, chunking, or deteriorated rubber between the hub and pulley

AUTOMATIC TRANSMISSION FLEX PLATE CLEANING AND INSPECTION

Fig. 343: Inspecting Automatic Transmission Flex Plate For Damage
Courtesy of GENERAL MOTORS COMPANY

1. Clean the flex plate in solvent.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

2. Dry the flex plate with compressed air.

3. Inspect the flex plate for the following conditions:
   - Damaged ring gear teeth (1)
   - Stress cracks around the flex plate-to-crankshaft bolt hole locations (2)

     NOTE: **Do not attempt to repair the welded areas that retain the ring gear to the flex plate. Install a new flex plate.**

   - Welded areas (3) that retain the ring gear onto the flex plate for cracking

PISTON AND CONNECTING ROD DISASSEMBLE

Fig. 344: Piston, Connecting Rod And Connecting Rod Bearing
Courtesy of GENERAL MOTORS COMPANY

1. Remove the connecting rod bearings from the rod and cap.

Fig. 345: Removing Piston Rings From Piston Using Piston Ring Pliers
Courtesy of GENERAL MOTORS COMPANY

2. Using piston ring pliers, remove the piston rings from the piston.

Fig. 346: Rotating Piston Pin Retainers Until Ring End Gaps Are Positioned In Cutout Area
Courtesy of GENERAL MOTORS COMPANY

3. Rotate the piston pin retainers until the ring end gaps are positioned in the cutout area (1) of the pin bore.

Fig. 347: Removing Retainers Starting In Cutout Area Of Pin Bore
Courtesy of GENERAL MOTORS COMPANY

4. Remove the retainers starting in the cutout area of the pin bore.

Fig. 348: Removing Pin From Piston And Connecting Rod
Courtesy of GENERAL MOTORS COMPANY

5. Remove the pin from the piston and connecting rod.
6. The piston and pin are a matched set and are not to be serviced separately.

   Mark, sort, or organize the piston and the matching piston pin.

PISTON, CONNECTING ROD, AND BEARING CLEANING AND INSPECTION

Piston, Pin, and Piston Rings

Fig. 349: Piston, Connecting Rod & Bearings
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Replace pistons, pins, and connecting rods that are damaged or show signs of excessive wear.**

- **The piston and pin are to be serviced as an assembly.**
- **Do not wire brush any part of the piston.**
- **Measurement of the components should be taken with the components at normal room temperature.**

1. Clean the varnish and carbon from the piston (107) using cleaning solvent.

   WARNING: Refer to Safety Glasses Warning .

2. Dry the components with compressed air.

Fig. 350: Cleaning Piston Ring Grooves
Courtesy of GENERAL MOTORS COMPANY

3. Clean the piston ring grooves with a suitable ring groove cleaning tool.
4. Clean the oil lubrication holes and slots.

Fig. 351: Piston Damage Inspection Areas
Courtesy of GENERAL MOTORS COMPANY

5. Inspect the piston for the following conditions:
    - Cracks in the piston ring lands, the piston skirt, or pin bosses
    - Piston ring grooves for nicks, burrs, or warpage which may cause the piston ring to bind

MINOR imperfections may be removed from the piston with a fine file.

- Eroded areas at the top of the piston (1)
- Scuffed or damaged skirts (2)
- Scoring to the piston pin bore (3) or piston pin

Fig. 352: Inserting Piston Ring Into Ring Groove
Courtesy of GENERAL MOTORS COMPANY

6. Insert the edge of the piston ring into the piston ring groove.

   Roll the piston ring completely around the piston. If binding is caused by a distorted ring groove, MINOR imperfections may be removed with a fine file. If binding is caused by a distorted piston ring, replace the rings, as required.

Fig. 353: Measuring Piston Ring Side Clearance
Courtesy of GENERAL MOTORS COMPANY

7. Measure the piston ring side clearance with a feeler gauge. If side clearance is not within specifications, try another piston ring. If the proper ring-to-groove clearance cannot be obtained, replace the piston and pin as an assembly. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.

Fig. 354: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS COMPANY

8. To determine piston pin-to-bore clearance, use a micrometer and measure the piston pin outside diameter (OD).

Fig. 355: Measuring Piston Pin-To-Bore Clearance
Courtesy of GENERAL MOTORS COMPANY

9. To determine the piston pin-to-bore clearance, use an inside micrometer and measure the piston pin bore inside diameter (ID).
10. Subtract the piston pin OD measurement from the piston pin bore ID measurement to determine pin-to-bore clearance. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.

Measuring Piston Ring End Gap

Fig. 356: Measuring Piston Ring End Gap

Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Do not attempt to file the end of the piston ring to achieve the proper end gap clearance.**
- **Measure the piston ring in the cylinder in which it will be used.**

1. Place the piston ring into the cylinder bore 6.5 mm (0.25 in) below the top of the ring travel area. Both rings should be installed with the orientation marks facing the top of the piston.
2. Insert a feeler gauge and measure the piston ring end gap. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.

Connecting Rod and Bearings

Fig. 357: Piston, Connecting Rod & Bearings
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **The powdered metal connecting rod and cap are machined for proper clearances. The connecting rod and cap must be used as an assembly with no repair or modifications to either mating surface. Do not attempt to repair the rod or cap. If service is required, replace the rod and cap as an assembly.**

- **Do not attempt to repair the bolt hole threads of the connecting rod.**

1. Clean the connecting rod (105) and cap (103) in solvent.

WARNING: Refer to Safety Glasses Warning .

2. Dry the components with compressed air.

Fig. 358: Connecting Rod Inspection Areas
Courtesy of GENERAL MOTORS COMPANY

3. Inspect the connecting rod for the following conditions:
    - Twisting (1)
    - Proper fit of the connecting rod and cap mating surfaces (2)
    - Nicks or gouges in the bearing bore (3)
    - Damage to the bearing locating slots (4)

Fig. 359: Measuring Connecting Rod Bearing Bore For Out-Of-Round
Courtesy of GENERAL MOTORS COMPANY

4. Measure the connecting rod bearing bore for an out-of-round condition. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.

Fig. 360: Measuring Piston Pin Diameter
Courtesy of GENERAL MOTORS COMPANY

5. To determine piston pin-to-connecting rod bore clearance, use a micrometer and measure the piston pin OD.

Fig. 361: Measuring Connecting Rod Pin Bore Inside Diameter
Courtesy of GENERAL MOTORS COMPANY

6. To determine the piston pin-to-connecting rod bore clearance, use a micrometer and measure the connecting rod pin bore (1) ID.
7. Subtract the piston pin OD measurement from the connecting rod pin bore ID measurement to determine pin-to-bore clearance. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.

Fig. 362: Inspecting Bearings For Damage
Courtesy of GENERAL MOTORS COMPANY

8. Inspect the connecting rod bearings for craters or pockets. Flattened sections on the bearing halves indicate fatigue.

Fig. 363: Inspecting Connecting Rod Bearings For Excess Scoring Or Discoloration
Courtesy of GENERAL MOTORS COMPANY

9. Inspect the connecting rod bearings for excessive scoring or discoloration.
10. Inspect the connecting rod bearings for dirt or debris imbedded into the bearing material.

Fig. 364: Inspecting Bearings For Improper Seating
Courtesy of GENERAL MOTORS COMPANY

11. Inspect the connecting rod bearings for improper seating indicated by bright, polished sections of the bearing surface.
12. Measure the connecting rod bearings for excessive connecting rod bearing-to-crankshaft journal clearance. Refer to **Crankshaft and Bearing**

Cleaning and Inspection.

PISTON AND CONNECTING ROD ASSEMBLE

Special Tools

EN-46745 Piston Pin Clip Remover/Installer

For equivalent regional tools, refer to **Special Tools**.

1. Lubricate the piston pin bores in the piston, the piston pin, and the connecting rod pin bore with clean engine oil.

Fig. 365: Top Of Piston And Dimple On Rod
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The left side and right side piston and rod assemblies are assembled differently.**

2. Ensure that on the right side piston and rod assemblies, the arrow on the top of the piston (1) and the dimple on the rod (2) are facing the same direction.

Fig. 366: Top Of Piston And Dimple On Rod
Courtesy of GENERAL MOTORS COMPANY

3. Ensure that on the left side piston and rod assemblies, the arrow on the top of the piston (1) and the dimple on the rod (2) are facing the opposite direction.

Fig. 367: Piston Pin
Courtesy of GENERAL MOTORS COMPANY

4. Install the piston pin (1) to the piston and connecting rod.

Fig. 368: Installing NEW Piston Pin Retainers
Courtesy of GENERAL MOTORS COMPANY

NOTE: **NEW piston pin retainers must be used. Never reuse the piston pin retainers.**

5. Install NEW piston pin retainers using the **EN-46745** remover/installer. Align the **EN-46745** remover/installer to one of the notches (1) in the piston.

Fig. 369: Installing Piston Rings Onto Piston Using Piston Ring Pliers
Courtesy of GENERAL MOTORS COMPANY

NOTE: **When installing piston rings, use a ring expander plier type tool. Do not roll the rings into the grooves of the piston. Use caution and care to expand the rings only slightly larger than the outside diameter (OD) of the piston.**

6. Using piston ring pliers, install the piston rings onto the piston.

7. Position the oil control ring end gaps 180 degrees opposite each other.

Fig. 370: Positioning Compression Ring End Gaps 180 Degrees Opposite Each Other
Courtesy of GENERAL MOTORS COMPANY

Fig. 371: Positioning Compression Ring End Gaps 180 Degrees Opposite Each Other
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **The upper compression ring has a dimple on the top of the ring. The dimple on upper compression ring should face the top of the piston.**
- **The lower compression ring has a groove on the bottom of the ring. The groove on the lower compression ring should face the bottom of the piston.**

8. Position the compression ring end gaps 180 degrees opposite each other.

Fig. 372: Piston, Connecting Rod And Connecting Rod Bearing
Courtesy of GENERAL MOTORS COMPANY

9. Install the connecting rod bearings to the rod and cap.

CAMSHAFT BEARING REMOVAL

Special Tools

J 33049 Camshaft Bearing Service Set

For equivalent regional tools, refer to **Special Tools**.

Fig. 373: Camshaft Bearings
Courtesy of GENERAL MOTORS COMPANY

IMPORTANT: A loose camshaft bearing may be caused by an enlarged, out of round, or damaged engine block bearing bore.

1. Prior to bearing removal, inspect the camshaft bearings for loose fit in the engine block bearing bores. Refer to **Camshaft and Bearings Cleaning and Inspection**.
2. Repair or replace the components, as required.

Fig. 374: Camshaft Bearing Service Kit Components
Courtesy of GENERAL MOTORS COMPANY

3. Select the expanding driver (4-8) and washer (2 or 3) from the **J 33049** service set.
4. Assemble the tool.
5. Insert the tool through the front of the engine block and into the bearing.
6. Tighten the expander assembly (15) nut until snug.
7. Push the guide cone (1) into the front camshaft bearing in order to align the tool.

Fig. 375: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS COMPANY

8. Drive the bearing from the block bore.

IMPORTANT: In order to remove the inner camshaft bearings, operate the tool from either end of the block, using the driver bar extension and the guide cone in the front or rear camshaft bearing bore.

9. Repeat the above procedures in order to remove the remaining bearings.

Tool Usage Information

Bearing, Expander, and Expander Driver Information

Fig. 376: Camshaft Bearing Service Kit Components

Courtesy of GENERAL MOTORS COMPANY

- The tool consists of a guide cone (1), driving washers (2 or 3), expander bearing drivers (4-8), driver bars (9 or 10), expander jaws (11), expander sleeve (12), expander cone (13), expander shaft (14), and expander assembly (15).

NOTE: **The expander bearing drivers (4-8) in the J 33049 service set are stamped with a number (1-5) to assist in identifying the appropriate diameter driver.**

- Expander assembly (15) is used as a driver for the bearing when inside diameter is 28.575-37.465 mm (1.125-1.475 in) and is used with the small washer.
- Expander bearing driver number 1 inside diameter is 37.465-43.18 mm (1.475-1.7 in) and is used with the expander assembly (15) and the small washer.
- Expander bearing driver number 2 inside diameter is 43.18-48.895 mm (1.7-1.925 in) and is used with the expander assembly (15) and the large washer.
- Expander bearing driver number 3 inside diameter is 48.895-54.61 mm (1.925-2.15 in) and is used with the expander assembly (15) and the large washer.
- Expander bearing driver number 4 inside diameter is 54.61-60.325 mm (2.150-2.375 in) and is used with expander assembly (15) and the large washer.
- Expander bearing driver number 5 inside diameter is 60.325-68.326 mm (2.375-2.69 in) and is used with expander assembly (15) and the large washer.

Tool Assembly and Operation

1. Select the proper expanding driver and washer from the expanding driver and washer information.

IMPORTANT: To install or remove the expanding driver, always push on or pull from the ends.
Pressure on the outside diameter may cause a bind against the rubber expanding sleeve.

2. Place the expanding driver onto the expander assembly.
3. Ensure the separation lines between the segments of the expanding driver align with the separation lines of the expander assembly.
4. With the small end of the cone facing the driver assembly, place the guide cone over the driving bar.
5. Place the driving washer over the threaded portion of the expander assembly.
6. Screw the expander assembly, with driving washer, onto the driving bar.

For removal of the inner bearings, it may be necessary to install the driver bar extension.

Fig. 377: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS COMPANY

7. Insert the tool (1) into an inner camshaft bearing and tighten until snug.

   Operate the tool from the front or rear of the engine block.

On some engine blocks, the nut on the expander assembly is inaccessible, except from either end. In this case, you must use a socket and extension to enlarge and reduce the expander assembly.

8. Slide the nylon cone (2) into the front or rear camshaft bearing. This will properly align the tool.
9. Drive the bearing out of or into the engine block.
10. Repeat the procedure for the additional inner bearings.

Fig. 378: Driving Bearing Out Of Or Into Engine Block

Courtesy of GENERAL MOTORS COMPANY

11. For the end bearings, front, position number 1, and the rear, position number 5, remove the nylon cone and driver bar extension.
12. Drive the bearings out of or into the engine block.

CAMSHAFT AND BEARINGS CLEANING AND INSPECTION

Special Tools

- **J 7872** Magnetic Base Dial Indicator Set
- **J 8520** Camshaft Lobe Lift Indicator

For equivalent regional tools, refer to **Special Tools**

Measuring Camshaft Lobe Lift

0
10
20
30
40
50
60
70
J 8520 – 10
J 8520

Fig. 379: Measuring Camshaft Lobe Lift
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Measuring camshaft lobe lift is a procedure used to determine if the camshaft lobes have worn. This test is to be performed prior to engine disassembly and with the camshaft and valve train components installed in the engine.**

1. Using the **J 8520** indicator, measure camshaft lobe lift.
2. Remove the valve rocker arms and bolts.
3. Install the dial indicator mounting stud into the valve rocker arm bolt hole.
4. Assemble the components of the **J 8520** indicator and position onto the stud.
5. Position the shaft of the dial indicator onto the end of the pushrod.
6. Rotate the face of the dial indicator to zero.
7. Slowly rotate the crankshaft clockwise, until the dial indicator obtains its highest and lowest readings.
8. Compare the total to specifications. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**. The total lobe lift is the difference between the highest and lowest reading.

Fig. 380: Camshaft Inspection Points
Courtesy of GENERAL MOTORS COMPANY

1. Clean the components in solvent.

WARNING: **Refer to Safety Glasses and Compressed Air Warning**

2. Dry the components with compressed air.
3. Inspect the camshaft bearing journals (1) for scoring or excessive wear.
4. Inspect the camshaft valve lifter lobes (2) for scoring or excessive wear.
5. Inspect the camshaft position (CMP) actuator oil passages (3) for restrictions.
6. Inspect the threaded bolt hole (4) in the front of the camshaft for damaged threads or debris.
7. Inspect the camshaft sprocket pin (204) for damage.
8. Inspect the camshaft retainer plate for wear or a damaged sealing gasket.

If the camshaft retainer plate sealing gasket is not cut or damaged, it may be used again.

Fig. 381: Measure Camshaft Journals With Micrometer
Courtesy of GENERAL MOTORS COMPANY

9. Using a micrometer, measure the camshaft journals for wear and out-of-round. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.
    - If the camshaft bearing journals are out-of-round, replace the camshaft.

- If the camshaft bearing journal diameter is not within specification, replace the camshaft.

Fig. 382: Measuring Camshaft Lobes
Courtesy of GENERAL MOTORS COMPANY

10. Using a micrometer, measure the camshaft lobes for wear. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.

Fig. 383: Measuring Camshaft Runout
Courtesy of GENERAL MOTORS COMPANY

11. Measure the camshaft runout.
    1. Mount the camshaft in wooden V-blocks or between centers on a fixture.
    2. Using the **J 7872** set, measure the runout of the intermediate camshaft bearing journals.

3. If camshaft runout is not within specification, the camshaft is bent and should be replaced. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.

Fig. 384: Camshaft Bearings
Courtesy of GENERAL MOTORS COMPANY

12. Inspect the camshaft bearings for the following:
    - Excessive wear, evidence of galling, pitting, scoring, or embedded debris. The appearance of the bearing material being different shades

of gray are considered normal, and are not guideline for bearing replacement. Measure the bearing inside diameter (ID) as required for an over-sized condition. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.

- Proper fit in the engine block. Camshaft bearings have an interference fit to the engine block and should not be loose in the engine block bearing bores.
- The oil lubrication feed hole in the bearing must be in alignment with the drilled out passage in the block.
- The oil lubrication feed hole is not plugged by debris.
- Bearings with excessive wear or scoring must be replaced.
- Bearings with excessive wear, galling, pitting, scoring, or embedded debris must be replaced.

CAMSHAFT BEARING INSTALLATION

Special Tools

J 33049 Camshaft Bearing Service Set

For equivalent regional tools, refer to **Special Tools**

Fig. 385: Camshaft Bearing Service Kit Components
Courtesy of GENERAL MOTORS COMPANY

1. Select the expanding driver (4-8) and washer (2 or 3) from the **J 33049** set. Refer to **Camshaft Bearing Removal**.
2. Assemble the tool.

Fig. 386: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS COMPANY

3. Insert the tool (1) through the front or rear of the engine block and into the bearing. For installation of inner bearings, it may be necessary to install the driver bar extension.
4. Tighten the expander assembly nut until snug.
5. Push the guide cone (2) into the front camshaft bearing in order to align the tool.

Fig. 387: Positioning Camshaft Bearing With Oil Feed Hole
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Camshaft bearings must be installed with bearing oil feed hole in alignment with the drilled oil passage in the block bore to ensure proper oil flow to the camshaft. If the bearings have a split seam, the split seam in the bearing must be installed in the 12 o'clock position towards the top of the block. Improperly installed bearings may restrict oil flow causing engine damage.**

6. Position the camshaft bearing with oil feed hole (1) in alignment with drilled oil passage in block bore (2).

Fig. 388: Driving Bearing Out Of Or Into Engine Block
Courtesy of GENERAL MOTORS COMPANY

7. Drive the bearing into the block bore. During installation, ensure the bearing is installed straight.
8. Remove **J 33049** service set, inspect bearing to confirm the oil hole in the bearing is in alignment with the drilled oil passage in the block bore.
9. Repeat procedure to install the remaining bearings into the block.

CAMSHAFT TIMING CHAIN AND SPROCKET CLEANING AND INSPECTION

Fig. 389: Camshaft Timing Chain And Crankshaft Sprocket
Courtesy of GENERAL MOTORS COMPANY

1. Clean the components with cleaning solvent.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

2. Dry the components with compressed air.
3. Inspect the timing chain for binding or wear.
4. Inspect the crankshaft sprocket for worn, damaged, or chipped teeth.
5. Inspect for a damaged keyway.
6. Inspect for worn oil pump drive splines.

Fig. 390: Timing Chain Tensioner Inspection Points

Courtesy of GENERAL MOTORS COMPANY

7. Inspect the timing chain tensioner for the following conditions:
    - Damaged or broken tension spring (1)
    - Excessive wear or scoring on the chain guide surfaces (2, 3)

CAMSHAFT POSITION ACTUATOR CLEANING AND INSPECTION

Fig. 391: Tie Strap Through Center Of Actuator
Courtesy of GENERAL MOTORS COMPANY

WARNING: Refer to Camshaft Position Actuator Removal and Installation Warning .

1. Insert a tie strap (1) through the center of the camshaft position (CMP) actuator and over the reluctor wheel.

Fig. 392: Inspecting CMP Actuator For Broken Spring

Courtesy of GENERAL MOTORS COMPANY

2. Clean the CMP actuator with cleaning solvent.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

3. Dry the components with compressed air.
4. Inspect the CMP actuator for a broken spring (1).

Fig. 393: CMP Actuator Inspection Points
Courtesy of GENERAL MOTORS COMPANY

5. Inspect the CMP actuator for the following conditions:
    - Improper positioning of the CMP reluctor wheel. The actuator return spring should reposition the reluctor wheel to the PARK position. Inspect for proper alignment of the mark on the face of the sprocket (1) with the flat edge of the reluctor wheel (2). If the reluctor wheel is not properly positioned, the internal components of the actuator are sticking or the return spring is broken and the actuator should be replaced as an assembly.
    - Nicked or damaged edges (3) on the CMP reluctor wheel
    - Damaged timing sprocket teeth (4)

Fig. 394: CMP Actuator Oil Passages
Courtesy of GENERAL MOTORS COMPANY

6. Inspect the CMP actuator for dirt, debris, or restrictions within the oil passages (1, 2, 3).

Fig. 395: Timing Chain Tensioner Inspection Points
Courtesy of GENERAL MOTORS COMPANY

7. Inspect the timing chain tensioner for the following conditions:
    - Damaged or broken tension spring (1)
    - Excessive wear or scoring on the chain guide surfaces (2, 3)

CAMSHAFT POSITION ACTUATOR MAGNET CLEANING AND INSPECTION

Fig. 396: Camshaft Position Actuator Magnet
Courtesy of GENERAL MOTORS COMPANY

IMPORTANT: If checking the operating range of the CMP magnet pintle, DO NOT energize the magnet with a 12V power supply. Use steps 2 thru 5 below to check pintle operating range. To dynamically test the magnet pintle with a power supply, refer to the dynamic test instructions listed under the component testing portion of DTC P0011. Refer to **DTC P0011** .

1. Inspect the CMP magnet for the following conditions:

- A damaged electrical connector
- An accumulation of dirt or debris in the recessed area around the pintle
- A build-up of burnt engine oil on the shaft of the pintle which may cause the pintle to stick and not move freely within the proper range of travel

2. Holding the CMP magnet with the pintle facing upward, measure the pintle retracted position (a). Record the dimension.

Fig. 397: Measuring Pintle Extended Position

Courtesy of GENERAL MOTORS COMPANY

3. Holding the CMP magnet with the pintle facing downward, measure the pintle extended position (b). Record the dimension.
4. Subtract the retracted dimension (a) from the extended dimension (b) to determine pintle travel. A properly moving pintle will travel 3.0-5.5 mm (0.12-0.22 in).
5. If the pintle of the CMP magnet is binding or does not move within the proper range of travel, replace the CMP magnet as an assembly.

CAMSHAFT POSITION ACTUATOR SOLENOID VALVE INSPECTION

Fig. 398: Camshaft Position Actuator Solenoid Valve Inspection
Courtesy of GENERAL MOTORS COMPANY

IMPORTANT: Do not use the camshaft position (CMP) actuator solenoid valve again. Install a NEW valve during assembly. The inspection procedure below is provided for off-vehicle diagnostic purposes only.

1. Inspect the CMP valve for the following conditions:
   - Dirt, debris, or restrictions within the oil passages (1)
   - Damaged threads (2)

     If the threads of the valve are damaged, also inspect the threads in the front of the camshaft for damage.

   - Dirt, debris, or restrictions within the oil inlet (3)

     If debris is detected, the engine assembly should be inspected to determine the source of contamination.

Fig. 399: Camshaft Position Actuator Solenoid Valve Inspection
Courtesy of GENERAL MOTORS COMPANY

2. Inspect for a sticking valve spool or broken valve spool spring.
3. Depress the valve spool into the housing. The valve should move freely with no binding or sticking and minimal resistance inward. When released, the valve spring should return the spool to the proper extended position (1) of 6.52-6.92 mm (0.257-0.272 in).

VALVE ROCKER ARM AND PUSH ROD CLEANING AND INSPECTION

Fig. 400: Valve Rocker Arm Components
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Parts that are to be used again must be marked, sorted or organized for assembly.**

1. Mark, sort, or organize the components for assembly. Refer to **Separating Parts**.
2. Clean the components with cleaning solvent.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

3. Dry the components with compressed air.
4. Inspect the valve rocker arms bearings (2) for binding or roughness.
5. Inspect the valve rocker arm pushrod sockets (3) and valve stem mating surfaces (1). These surfaces should be smooth with no scoring or exceptional wear.
6. Inspect the pushrods for worn or scored ends. These surfaces should be smooth with no scoring or exceptional wear.
7. Inspect the pushrods for bends. Roll the pushrod on a flat surface to determine if the pushrod is bent.
8. Inspect the pushrod oil passages for restrictions.
9. Inspect the rocker arm pivot supports for cracks, wear, or other damage.

VALVE LIFTER AND GUIDE CLEANING AND INSPECTION

Non Active Fuel Management Valve Lifters

Fig. 401: Valve Lifter Inspection Areas
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Components that are to be used again must be marked, sorted or organized for assembly.**

1. Clean the components in cleaning solvent.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

2. Dry the components with compressed air.
3. Inspect the valve lifters for the following conditions:
   - Bent or broken clip (1)
   - Worn pushrod socket (2)
   - Scuffed or worn sides (3)

     If the valve lifter shows wear, inspect the engine block lifter bores for wear or damage.

   - Flat spots on the roller (4)
   - Loose or damaged pin (5)
   - Plugged oil hole (6)
   - Worn or damaged roller bearing

     The roller should rotate freely with no binding or roughness.

Active Fuel Management Valve Lifters

Fig. 402: Displacement On-Demand Valve Lifters Assembly
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Components that are to be used again must be marked, sorted or organized for assembly.**

1. Clean the components in cleaning solvent.

WARNING: **Refer to Safety Glasses and Compressed Air Warning .**

2. Dry the components with compressed air.
3. Inspect the valve lifters for the following conditions:
    - Broken or collapsed spring (1)
    - Worn pushrod socket (2)
    - Plugged lubrication hole (3)
    - Plugged lifter oil-switching hole (4)
    - Flat spots on the roller (5)
    - Worn or damaged roller bearing (6)

      The roller should rotate freely with no binding or roughness.

    - Scuffed or worn sides (7)

Valve Guides

Fig. 403: Inspecting Valve Lifter Guides
Courtesy of GENERAL MOTORS COMPANY

Inspect the valve lifter guides for the following conditions:

- Cracks or damage (1)
- Excessive wear in the lifter mounting bores (2)

CYLINDER HEAD DISASSEMBLE

Fig. 404: Cylinder Head Disassemble
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Valve Stem Key

Callout	Component Name
	Procedure 1. Install the **J-8062** compressor (3) onto the head. 2. Remove the valve stem keys. **Special Tools** **J-8062** Valve Spring Compressor For equivalent regional tools, refer to **Special Tools**.
2	Valve Stem Spring Cap
3	Valve Spring
4	Valve Stem Oil Seal **NOTE:** **NEVER reuse a valve stem oil seal.**
5	Valve

CYLINDER HEAD CLEANING AND INSPECTION

Special Tools

- **J 8089** Carbon Removal Brush
- **J 9666** Valve Spring Tester

For equivalent regional tools, refer to **Special Tools**.

Fig. 405: Cleaning Carbon
Courtesy of GENERAL MOTORS COMPANY

WARNING: **Refer to Safety Glasses Warning .**

NOTE:

- **When cleaning a cylinder head in a thermal type oven, do not exceed 204Â°C (400Â°F).**

- **Be careful not to scuff the chamber.**

1. Clean the following components:
   - Use the **J 8089** brush in order to remove the carbon from the combustion chambers.
   - Gasket surfaces

     Refer to **Replacing Engine Gaskets**.

   - Valve stems and heads on a buffing wheel
   - Bolt hole threads

     Remove all dirt, debris, or threadlocking material from the bolt holes.

2. Inspect the cylinder head for the following conditions:
   1. Cracks in the exhaust ports and combustion chambers
   2. External cracks in the water chambers
   3. Gasket surfaces for excessive scratches or gouging

      Refer to **Replacing Engine Gaskets**.

   4. Bolt hole threads for debris or damaged threads

      Refer to **Thread Repair**, or **Thread Repair Specifications**.

Fig. 406: Inspecting Cylinder Head For Warpage
Courtesy of GENERAL MOTORS COMPANY

3. Inspect the cylinder head for warpage. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.

Fig. 407: Measuring Valve Spring Tension
Courtesy of GENERAL MOTORS COMPANY

4. Use the **J 9666** tester in order to measure the valve spring tension. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.

VALVE GUIDE REAMING, AND VALVE AND SEAT GRINDING

Valve Guide Reaming

Fig. 408: Valve Guide Reaming, Valve and Seat Grinding
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Excessive valve stem-to-guide clearance may cause a noisy valve train, premature valve stem oil seal wear, component damage, and/or excessive engine oil consumption.**

CAUTION: Insufficient valve stem-to-guide clearance will result in noisy or sticking valves. Valves that are too tight may disturb engine smoothness or lead to component damage.

1. Measure the valve stem to guide clearance.
    1. Using a micrometer (1) measure the diameter of the valve stem (a).
    2. Using a ball style measuring gauge, measure the inner diameter (b) of the valve guide at the specified depth. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.
    3. Subtract the valve stem diameter (a) from the valve guide inner diameter (b) to obtain the valve stem to guide clearance.
2. If the clearance measurement between the valve stem and guide is not within specification, the valve and/or the cylinder head must be replaced. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.

Fig. 409: Inspection Points For Valve Stems
Courtesy of GENERAL MOTORS COMPANY

3. Inspect the valve stems for excessive scoring, wear, or warpage.
    - A valve stem that has excessive scoring (3 or 4) or wear (4 or 6) must be replaced.
    - If a valve guide is worn or has excessive stem-to-guide clearance, the cylinder head should be replaced.

4. Measure the valve stem diameter. If the valve stem diameter is not within specification, the valve must be replaced. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.

   If the valve stem diameter is within specifications, and the stem-to-guide clearance is excessive, the cylinder head must be replaced.

Valve and Seat Grinding

Fig. 410: Inspection Points For Valve Seats
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Reconditioning the valve seats is very important. The seating of the valves must be perfect for the engine to deliver optimum power and performance. Several different types of equipment are available for grinding valve seats.**
- **Another important factor is the cooling of the valve head. Good contact between the valve and the seat will ensure that heat will be properly dissipated.**
- **The recommendations of the equipment manufacturer should be followed carefully to obtain the proper results. Regardless of the type of equipment used, it is essential that valve guide bores be free of carbon or dirt to ensure proper centering of the tool pilot in the guide.**
- **Valves that are pitted or have stems that stems that show excessive wear, or valves that are warped excessively must be replaced.**
- **DO NOT reface valves. Valves with excessive wear or damage MUST be replaced.**

1. Inspect the valve for the following conditions:
    - Burnt or eroded areas (1)
    - A worn margin (2)
    - A bent stem (3)
    - A worn or scored stem (4)
    - A worn key groove (5)
    - A worn stem tip (6)

Fig. 411: Inspecting Valve Face For Damage
Courtesy of GENERAL MOTORS COMPANY

2. Inspect the valve face for the following conditions:
    - Worn or no margin (1 or 4)
    - Pitted surfaces (2)

- Burnt or eroded areas (3)

Fig. 412: Inspecting Valve Margin
Courtesy of GENERAL MOTORS COMPANY

3. Inspect the valve margin.

   If the margin has worn away, it can lead to breakage, burning or pre-ignition due to heat localizing on this edge. If the vertical edge of the valve head, margin, is not visible and only a sharp edge remains, replace the valve.

4. Inspect for a loose valve seat in the cylinder head. The valve seat has an interference fit to the cylinder head.
5. Clean the valve guide bores with a suitable tool. Remove all carbon or dirt from the bores.

   The valve guide must be clean for the seat grinding tool to obtain proper results.

6. Grind the valve seat.

   The recommendations of the equipment manufacturer should be followed carefully to obtain the proper results. Regardless of the type of equipment used, it is essential that valve guide bores be free from carbon or dirt to ensure proper centering of the tool pilot in the guide.

7. Inspect the valve seats.
   - The valve seats should be concentric to the centerline of the guide, measure valve seat runout. The total indicator runout reading must be within specification. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.
   - If the valve seat has been ground, measure the valve stem height after reassembly of the cylinder head. The cylinder head, and/or valve must be replaced if the valve stem height is not within specification after seat grinding. Refer **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.

CYLINDER HEAD ASSEMBLE

Fig. 413: Cylinder Head Assemble
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Valve
2	Valve Stem Oil Seal **NOTE:**

Callout	Component Name
	NEVER reuse a valve stem oil seal.
3	Valve Spring
4	Valve Stem Spring Cap
5	Valve Stem Key **Procedure** 1. Install the **J-8062** compressor (3) onto the head. 2. Install the valve stem keys. **Special Tools** **J-8062** Valve Spring Compressor For equivalent regional tools, refer to **Special Tools**.

OIL PUMP CLEANING AND INSPECTION

Fig. 414: Exploded View Of Oil Pump Components
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The internal components of the oil pump assembly are not serviced separately. If the oil pump components are worn or damaged, replace the oil pump as an assembly.**

1. Clean the components in solvent.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

2. Dry the components with compressed air.
3. Inspect the oil pump housing (12), intermediate cover (11), intermediate housing (9), and the housing cover (1) for cracks, excessive wear, scoring, or casting imperfections.
4. Inspect the oil pump housing-to-oil pan sealing surface for scratches or gouging.
5. Inspect the oil pump base-to-engine block oil gallery surfaces for scratches or gouging.
6. Inspect the oil pump base for damaged bolt hole threads.
7. Inspect the pump slide (8) for excessive wear, scoring, or gouges.
8. Inspect the oil pump internal oil passages for restrictions.
9. Inspect the oil pump rotor (4) and vanes (3) for cracks, wear, or damage.
10. Inspect the oil pump slide spring (7) for breakage.
11. Inspect the oil pump slide (8) and slide seals (6) for cuts or damage.
12. Inspect the Oil Pressure Relief Valve Plug (15) for leaks or damage.
13. Inspect the Oil Flow Control Solenoid O-rings (16, 17) cracks or damage.

ENGINE FRONT COVER CLEANING AND INSPECTION

Fig. 415: Engine Front Cover Components
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Do not use the crankshaft front oil seal again. Install a NEW crankshaft front oil seal during assembly.**
- **Do not use the front cover-to-engine block gasket again. Install a NEW gasket during assembly.**
- **Do not use the camshaft position (CMP) actuator magnet gasket again. Install a NEW gasket during**

assembly.

1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Refer to **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant**
2. Clean the cover in solvent. Remove the sealant from the cover oil pan surface. Refer to **Replacing Engine Gaskets**

WARNING: Refer to Safety Glasses and Compressed Air Warning .

3. Dry the cover with compressed air.
4. Inspect the gasket sealing surfaces (1) for excessive scratches or gouging.
5. Inspect the threaded bolt holes (2, 3, and 5) for damaged threads or debris.
6. Inspect the camshaft position sensor pass-thru hole and sealing surface (4) for excessive scratches or gouging.
7. Inspect the oil flow control valve connector pass-thru hole and sealing surface (6) for excessive scratches or gouging.

CRANKSHAFT REAR OIL SEAL HOUSING CLEANING AND INSPECTION

Fig. 416: Crankshaft Rear Oil Seal Housing
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Do not use the crankshaft rear oil seal again. Install a NEW crankshaft oil seal during assembly.**
- **Do not use the rear housing-to-engine block gasket again. Install a NEW gasket during assembly.**

1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Refer to **Use of Room Temperature Vulcanizing (RTV) and Anaerobic**

Sealant

2. Clean the housing in solvent. Remove the sealant from the housing oil pan surface. Refer to **Replacing Engine Gaskets**

WARNING: Refer to Safety Glasses Warning .

3. Dry the housing with compressed air.
4. Inspect the gasket sealing surfaces (3) for excessive scratches or gouging.
5. Inspect the housing-to-oil pan threaded bolt holes for damaged threads or debris.
6. Inspect the crankshaft oil seal mounting bore for damage (1).

VALVE LIFTER OIL MANIFOLD CLEANING AND INSPECTION

NOTE:

- **DO NOT allow dirt or debris to enter the oil passages of the Valve Lifter Oil Manifold (VLOM). Plug, as required.**
- **DO NOT disassemble the electrical components from the VLOM.**
- **DO NOT submerge the electrical components in cleaning solvent.**
- **DO NOT use the VLOM outer gasket again. Remove the VLOM outer gasket and install a NEW VLOM outer gasket during assembly.**

Fig. 417: Identifying Improper Lifting Of VLOM
Courtesy of GENERAL MOTORS COMPANY

1. DO NOT lift the VLOM (2) by the electrical lead frame (1).

Fig. 418: Oil Pressure Sensor And VLOM
Courtesy of GENERAL MOTORS COMPANY

2. Remove the oil pressure sensor (1) from the VLOM.
3. Remove the VLOM plug (2).
4. Remove the PCV assembly (3).

WARNING: Refer to Safety Glasses and Compressed Air Warning .

5. Clean the VLOM with compressed air.

Fig. 419: Electrical Solenoids
Courtesy of GENERAL MOTORS COMPANY

6. Inspect for loose electrical solenoids (1-4) or loose or missing bolts.

7. Inspect for damage to the electrical lead frame (5).
8. Inspect for a damaged electrical connector, for bent or corroded pins.

Fig. 420: Sealing Gaskets
Courtesy of GENERAL MOTORS COMPANY

9. Inspect for damaged VLOM inner gaskets (1-8). If the VLOM inner gaskets are damaged, the VLOM must be replaced as an assembly.
10. Inspect for a damaged VLOM outer gasket (9) or scored gasket surfaces.

11. Inspect for debris or restrictions within the oil passages of the VLOM. Refer to **Cylinder Deactivation (Active Fuel Management) Valve Lifter Oil Manifold Diagnosis and Testing**.

VALVE ROCKER ARM COVER CLEANING AND INSPECTION

Fig. 421: Valve Rocker Arm Cover Components
Courtesy of GENERAL MOTORS COMPANY

IMPORTANT:
- Do not use the valve rocker arm cover gasket again. Install a NEW gasket during assembly.
- Remove the ignition bolts (1) and coils (2) before cleaning the cover in solvent. Do not submerge the ignition coils in solvent.

1. Inspect the covers (3) for the following conditions:
   - Scoring or damage to the gasket surfaces
   - Ventilation system passages for restrictions
   - Threaded bolt holes for damage or debris

OIL PAN DISASSEMBLE

Crankshaft Oil Deflector, High Pressure Port Seal, Lower Oil Pan, and Oil Level Indicator Switch Removal

Fig. 422: Crankshaft Oil Deflector, High Pressure Port Seal, Lower Oil Pan and Oil Level Indicator Switch
Courtesy of GENERAL MOTORS COMPANY

Crankshaft Oil Deflector, High Pressure Port Seal, Lower Oil Pan, and Oil Level Indicator Switch Removal

Callout	Component Name
1	Crankshaft Oil Deflector Bolt
2	Crankshaft Oil Deflector
3	Oil Level Sensor Lead Clip

Callout	Component Name
4	Oil Level Indicator Switch Bolt
6	Oil Level Indicator Switch
6	Oil Level Indicator Switch Seal **NOTE:** **Discard seal it is not reusable.**
7	Oil Pan Front Seal **NOTE:** **Discard seal it is not reusable.**
8	Oil Pan High Pressure Port Seal **NOTE:** **Discard seal it is not reusable.**
9	Lower Oil Pan Bolt
10	Lower Oil Pan **NOTE:** **If lower oil pan is removed it must be replaced. The lower oil pan is not reusable.**

Oil Filter Fitting and Cup Plug Removal

Fig. 423: Oil Filter Fitting and Cup Plug
Courtesy of GENERAL MOTORS COMPANY

Oil Filter Fitting and Cup Plug Removal

Callout	Component Name
1	Oil Pan Cup Plug
2	Oil Filter Fitting

OIL PAN CLEANING AND INSPECTION

Fig. 424: Oil Pan
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Do not remove the pickup tube.**
- **If lower oil pan is removed it must be replaced. The lower oil pan is not reusable**

Inspect the oil pan for the following conditions:

- Damaged upper oil pan gasket and sealing surfaces
- Restrictions within the oil passages of the pan
- Damaged oil filter seal surface

OIL PAN ASSEMBLE

Oil Filter Fitting and Cup Plug Installation

Fig. 425: Oil Filter Fitting and Cup Plug
Courtesy of GENERAL MOTORS COMPANY

Oil Filter Fitting and Cup Plug Installation

Callout	Component Name
1	Oil Pan Cup Plug

Callout	Component Name
2	Oil Filter Fitting **Tighten** 55 N.m (40 lb ft)

Crankshaft Oil Deflector, High Pressure Port Seal, Lower Oil Pan, and Oil Level Indicator Switch Installation

Fig. 426: Crankshaft Oil Deflector, High Pressure Port Seal, Lower Oil Pan and Oil Level Indicator Switch (With Lower Oil Pan Bolt

Tightening Sequence)

Courtesy of GENERAL MOTORS COMPANY

Crankshaft Oil Deflector, High Pressure Port Seal, Lower Oil Pan, and Oil Level Indicator Switch Installation

Callout	Component Name
1	Lower Oil Pan **NOTE:** **Do not reuse lower oil pan. If the lower oil pan is removed, it must be replaced.** **Procedure** 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Refer to **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant** 2. Apply a 3 mm (0.118 in) bead of RTV sealant on the engine front cover as shown (a). Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
2	Lower Oil Pan Bolt **Procedure** Tighten the lower oil pan bolts in the sequence shown. **Tighten** 10 N.m (88 lb in)
3	Oil Pan High Pressure Port Seal **NOTE:** **Must use a NEW seal.**
4	Oil Pan Front Seal

Callout	Component Name
	NOTE:
5	Oil Level Indicator Switch Seal **Must use a NEW seal.** **NOTE:** **Must use a NEW seal.**
6	Oil Level Indicator Switch
7	Oil Level Indicator Switch Bolt **Tighten** 10 N.m (88 lb in)
8	Oil Level Sensor Lead Clip
9	Crankshaft Oil Deflector
10	Crankshaft Oil Deflector Bolt **Tighten** 10 N.m (88 lb in)

ENGINE OIL COOLER CLEANING AND INSPECTION

Fig. 427: Engine Oil Cooler
Courtesy of GENERAL MOTORS COMPANY

Inspect the engine oil cooler adapter for the following conditions:

- Damage to the engine oil cooler adapter gasket surface
- Restrictions within the oil passages of the adapter
- Damage to the oil cooler hose fittings

VACUUM PUMP CLEANING AND INSPECTION

Fig. 428: Vacuum Pump
Courtesy of GENERAL MOTORS COMPANY

1. Remove the old gasket from the vacuum pump sealing surfaces. Refer to **Replacing Engine Gaskets**.
2. Clean all excess dirt and debris from the vacuum pump housing.
3. Inspect the vacuum pump for the following conditions:

- Gasket and hose sealing surfaces for excessive scratches or gouging
- Excessive side-to-side play in the pulley shaft
- Leakage at the vacuum inlet housing or rear cover
- Leakage at the vacuum pump vent hole
- Wear or damage in the belt tracking area of the pulley

INTAKE MANIFOLD CLEANING AND INSPECTION

Cleaning Procedure

Fig. 429: Intake Manifold-To-Cylinder Head Gaskets
Courtesy of GENERAL MOTORS COMPANY

1. Remove and discard the intake manifold-to-cylinder head gaskets (1).

Fig. 430: Manifold Absolute Pressure (MAP) Sensor Bolt, MAP Sensor And Seal
Courtesy of GENERAL MOTORS COMPANY

2. Remove the manifold absolute pressure (MAP) sensor bolt (1), MAP sensor (2), and seal (3).
3. Remove the evaporative emission (EVAP) canister purge solenoid valve bolt (5), EVAP canister purge solenoid valve (6), and seal (7).
4. Clean the intake manifold in solvent.

WARNING: Refer to Safety Glasses and Compressed Air Warning .

5. Dry the intake manifold with compressed air.

Inspection Procedure

1. Inspect the manifold for the following conditions:
    - Damaged gasket or sealing surfaces
    - Loose threaded inserts or studs
    - Debris or restrictions within the passages of the manifold
    - Damaged or broken vacuum fittings
    - Inspect the composite intake manifold assembly for cracks or other damage.

Fig. 431: Inspecting Intake Manifold Cylinder Head Deck For Warpage
Courtesy of GENERAL MOTORS COMPANY

2. Inspect the intake manifold cylinder head deck for warpage.
    1. Locate a straight edge across the intake manifold cylinder head deck surface.

       Position the straight edge across a minimum of two runner port openings.

2. Insert a feeler gauge between the intake manifold and the straight edge.

An intake manifold with warpage in excess of 3 mm (0.118 in) over a 200 mm (7.87 in) area is warped and should be replaced.

EXHAUST MANIFOLD CLEANING AND INSPECTION

Fig. 432: Exhaust Manifold And Heat Shield
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do not use the exhaust manifold-to-cylinder head gaskets again. Upon installation of the exhaust manifold, install a NEW gasket. An improperly installed gasket or leaking exhaust system may affect on-board diagnostics (OBD) II system performance.**

1. Clean the exhaust manifold (1) and heat shield (2) in solvent.

WARNING: **Refer to Safety Glasses Warning .**

2. Dry the exhaust manifold with compressed air.
3. Inspect the exhaust manifold-to-cylinder head gasket surface for excessive scratches or gouging.
4. Inspect for a loose, damaged, or cracked heat shield (2).
5. Inspect the bolts (3 and 4) for damaged threads.

Fig. 433: Measuring Exhaust Manifold To Cylinder Head Surface For Warpage
Courtesy of GENERAL MOTORS COMPANY

6. Use a straight edge and a feeler gauge and measure the exhaust manifold cylinder head deck for warpage.

An exhaust manifold deck with warpage in excess of 0.25 mm (0.01 in) within the 2 front or 2 rear runners or 0.5 mm (0.02 in) overall, may cause an exhaust leak and may affect OBD II system performance. Exhaust manifolds not within specifications must be replaced.

ENGINE COOLANT MANIFOLD DISASSEMBLE

Fig. 434: Engine Coolant Manifold
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Water Pump Assembly Bolts
2	Water Pump Assembly
3	Water Pump Assembly Gasket **NOTE:** **Discard gasket, it is not reusable.**
4	Engine Coolant Temperature Sensor
5	Water Pump Outlet Bolts
6	Water Pump Outlet Assembly (with Thermostat)
7	Water Pump Outlet Gasket **NOTE:** **Discard gasket, it is not reusable.**

ENGINE COOLANT MANIFOLD CLEANING AND INSPECTION

Fig. 435: Engine Coolant Manifold Housing
Courtesy of GENERAL MOTORS COMPANY

1. Clean all excess dirt and debris from the engine coolant manifold housing.
2. Inspect for leakage between the water output flange (4) and the thermostat housing (3).
3. Inspect the engine coolant manifold for the following conditions:
    - Gasket and hose sealing surfaces for excessive scratches or gouging

- Restrictions within the internal coolant passages
- Excessive side-to-side play in the pulley shaft
- Leakage at the water inlet housing or rear cover
- Leakage at the water outlet housing or water pump outlet assembly
- Leakage at the water pump vent hole

  A stain around the vent hole is acceptable. If leakage, dripping, occurs with the engine running and the cooling system pressurized, replace the water pump.

- Wear or damage in the belt tracking area of the pulley

ENGINE COOLANT MANIFOLD ASSEMBLE

Fig. 436: Engine Coolant Manifold
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Water Pump Outlet Gasket **NOTE:**

Callout	Component Name
	Install a NEW Gasket.
2	Water Pump Outlet Assembly (with Thermostat)
3	Water Pump Outlet Bolts **CAUTION:** **Refer to Fastener Caution .** **Procedure** 1. Install and hand tighten all three bolts. 2. Tighten bolts to final torque. **Tighten** 10 N.m (88 lb in)
4	Engine Coolant Temperature Sensor **Tighten** 20 N.m (15 lb ft)
5	Water Pump Assembly Gasket **NOTE:** **Install a NEW Gasket.**
6	Water Pump Assembly
7	Water Pump Assembly Bolts **Tighten** 10 N.m (88 lb in)

FUEL RAIL AND INJECTORS CLEANING AND INSPECTION

Special Tools

- **EN-49245** Injector Seal Installer Kit
- **EN-51097** Injector Retaining Clip Installer and Sizer
- **EN-51105** Injector Seal Installer and Sizer

For equivalent regional tools, refer to **Special Tools**.

Fig. 437: Fuel Rail Wiring Harnesses
Courtesy of GENERAL MOTORS COMPANY

1. Disconnect and remove the fuel rail wiring harnesses (1).

Fig. 438: Fuel Injector Retainer Clips
Courtesy of GENERAL MOTORS COMPANY

2. Remove and discard the fuel injector retainer clips (1) by installing **EN-51097** injector retaining clip installer and spreading both sides of the clip evenly.
3. Remove the fuel injector collars (2).

Fig. 439: Fuel Injector Dust Seal
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Some vehicles were not originally equipped with fuel injector dust seals. A NEW seal must be installed when the injectors are removed.**

4. Remove and DISCARD the fuel injector dust seal (1).

Fig. 440: Fuel Injector O-Ring And Plastic Spacer
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Do not use a metal tool to remove O-rings, spacers or injector seals. Care must be taken not to scratch or damage the tubes of the injector.

5. Remove and discard the fuel injector O-ring (1) and plastic spacer (2).
6. Remove and discard the fuel injector seals (3).

Fig. 441: Fuel Pressure Sensor And LH Fuel Rail
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Applying force to the plastic housing of the sensor will destroy the sensor. To tighten or loosen, only apply force to the attached hexagon.**

7. Remove the fuel pressure sensor (1) from the LH fuel rail.

NOTE: **Do not soak or submerge the fuel rail or injectors in solvent.**

8. Clean the exterior of the fuel rail and injectors with solvent.

Fig. 442: Inspecting Fuel Rail And Components
Courtesy of GENERAL MOTORS COMPANY

9. Inspect the fuel rail and components for the following conditions:

- Damage, debris or restrictions to the fuel rail
- Damage, debris or restrictions to the fuel ports in the fuel rail
- Damage to the mounting area for the fuel rail
- Damage to the fuel rail mounting bolts or mounting bolt grommets/isolators
- Damage to the threads on the fuel rail feed fitting
- Damage to the threads in the fuel pressure sensor bore
- Damage to the fuel pressure sensor connector, threads, or sealing face

Fig. 443: Fuel Pressure Sensor
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Applying force to the plastic housing of the sensor will destroy the sensor. To tighten or loosen, only apply force to the attached hexagon.**

10. Install the fuel pressure sensor (1).

NOTE: **Ensure that the fuel rail threads have been cleaned of any excess fuel or the fuel pressure sensor will NOT seal properly.**

11. Lubricate the threads and the sealing area in the fuel rail with silicon free engine oil. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for recommended lubricant.
12. Lubricate the threads and the sealing area on the fuel pressure sensor with silicon free engine oil. Refer to **Adhesives, Fluids, Lubricants, and Sealers** for recommended lubricant.
13. Install the fuel pressure sensor hand tight.
14. Remove the fuel pressure sensor and re-lubricate.

CAUTION: **Refer to Fastener Caution .**

15. Install the fuel pressure sensor and tighten to 33 N.m (24 lb ft)

Fig. 444: Fuel Injector Components
Courtesy of GENERAL MOTORS COMPANY

16. Inspect the fuel injectors for the following conditions:
    - Damage to the fuel injector connector (1)
    - Damage to the fuel inlet cone (2)
    - Damage to the O-ring (cracking, splitting, tearing) and the O-ring sealing surface (3)

Damaged O-rings can result in fuel odor, fuel leaks, and other symptoms. Refer to **Symptoms - Engine Controls** .

- Damage to the fuel injector body (4)
- Damage to the fuel injector tip (5)

17. Replace the fuel rail or injector if any damage is found. Do not attempt to repair a fuel rail or injector.

Fig. 445: Fuel Injector Dust Seal
Courtesy of GENERAL MOTORS COMPANY

NOTE: **If there was not previously a dust seal installed on the fuel injector, install a new one.**

18. Install a NEW fuel injector dust seal (1).

Fig. 446: Installing NEW Spacer On Fuel Injector
Courtesy of GENERAL MOTORS COMPANY

19. Install a NEW spacer (2) on the fuel injector.
20. Lubricate the NEW O-ring (1) with a drop of clean engine oil and install on injector.
21. Install injector collar (3) on fuel injector.

Fig. 447: Injector Assembly And Fuel Rail
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do NOT install the injector tip/bore seals until AFTER the injectors are installed on the fuel rail.**

22. Lubricate the socket (3) of the fuel rail with clean engine oil. Holding the largest diameter/body of the injector only, indicated by arrow in graphic, insert the injector assembly (1) into the fuel rail. Ensure correct orientation of the electrical connector (2). LH Rail: Electrical connectors face the front of the engine. RH Rail: Electrical connectors face the rear of the engine.

Fig. 448: Installing Fuel Injector Clip Onto EN-51097 Injector Retaining Clip Installer
Courtesy of GENERAL MOTORS COMPANY

23. Install the fuel injector clip onto the **EN-51097** injector retaining clip installer.
24. Using **EN-51097** injector retaining clip installer spread the retainer clip (1) and install onto the fuel rail. Inspect the front and side windows of the retainer clip to ensure that the flange on the rail (3) and the tab on the injector collar (2) are completely captured and firmly seated in the retainer clip (1) as shown.

25. Repeat for remaining injectors until all are installed and retained in fuel rail.

Fig. 449: Fuel Rail Wiring Harnesses
Courtesy of GENERAL MOTORS COMPANY

26. Install the fuel rail wiring harnesses (1).

Fig. 450: Identifying Fuel Injector Tip And Seals
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do not use any type of lubricant when installing the NEW seals (2) on the fuel injector.**

27. Install **EN-51105-1** long protector (3) onto the fuel injector tip, covering the first recessed area closest to the tip. Place a new seal (2) on **EN-51105-1** long protector.
28. Using **EN-49245-3** pusher (1), install the seal into the second recessed area (4) of the fuel injector.

NOTE: **The EN-49245-4 sizer is two sided, and either direction will size the seal correctly.**

29. Compress the seal with your fingers, then resize the seal if using the **EN-49245-4** sizer (5).

Fig. 451: Identifying Fuel Injector Tip And Seals
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do not use any type of lubricant when installing the NEW seals (2) on the fuel injector.**

30. Install **EN-51105-2** short protector (3) onto the fuel injector tip. Place a NEW seal (2) on **EN-51105-2** short protector.
31. Using **EN-49245-3** pusher (1), install the seal into the first recessed area (4) of the fuel injector.

NOTE: **The EN-49245-4 sizer is two sided, and either direction will size the seal correctly.**

32. Compress the seal with your fingers, then resize the seal using the **EN-49245-4** sizer (5).

THREAD REPAIR

Special Tools

- **EN-42385-50** Head/Main Bolt Thread Repair Kit
- **J 42385-200** Fixtures and Hardware Kit
- **J 42385-300** Fixtures and Hardware Kit

For equivalent regional tools, refer to **Special Tools**

General Thread Repair

Fig. 452: Bushing Type Insert And Base Material
Courtesy of GENERAL MOTORS COMPANY

The thread repair process involves a solid, thin walled, self-locking, carbon steel, bushing type insert (1). During the bushing installation process, the driver tool expands the bottom external threads of the insert into the base material (2). This action mechanically locks the insert in place. Also, when installed to the proper depth, the flange of the insert will be seated against the counterbore of the repaired hole.

Fig. 453: Drilling And Tapping Threads
Courtesy of GENERAL MOTORS COMPANY

WARNING: **Refer to Safety Glasses Warning .**

NOTE:

- **The use of a cutting type fluid GM P/N 1052864 (Canadian P/N 992881), WD 40Â®, or equivalent, is**

recommended when performing the drilling, counterboring, and tapping procedures.

- **Driver oil MUST be used on the installer driver tool.**
- **The tool kits are designed for use with either a suitable tap wrench or drill motor.**

1. Drill out the threads of the damaged hole (1).
    - M6 inserts require a minimum drill depth of 15 mm (0.59 in).
    - M8 inserts require a minimum drill depth of 20 mm (0.79 in).
    - M10 inserts require a minimum drill depth of 23.5 mm (0.93 in).
2. Using compressed air, clean out any chips.

Fig. 454: Counterboring Hole
Courtesy of GENERAL MOTORS COMPANY

3. Counterbore the hole to the full depth permitted by the tool (1).
4. Using compressed air, clean out any chips.

Fig. 455: Drilling And Tapping Threads
Courtesy of GENERAL MOTORS COMPANY

5. Using a tap wrench (2), tap the threads of the drilled hole.
    - M6 inserts require a minimum tap depth of 15 mm (0.59 in).
    - M8 inserts require a minimum tap depth of 20 mm (0.79 in).

- M10 inserts require a minimum tap depth of 23.5 mm (0.93 in).

6. Using compressed air, clean out any chips.
7. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463), or equivalent, into the hole.
8. Using compressed air, clean any cutting oil and chips out of the hole.

Fig. 456: Lubricating Installer Tool Threads

Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do not allow oil or other foreign material to contact the outside diameter (OD) of the insert.**

9. Lubricate the threads of the installer tool (2) with the driver oil (1).

Fig. 457: Bushing Type Insert & Driver Tool

Courtesy of GENERAL MOTORS COMPANY

10. Install the insert (2) onto the driver tool (1).

Fig. 458: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS COMPANY

11. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent, to the insert OD threads (2).

Fig. 459: Insert In Tapped Bolt Hole
Courtesy of GENERAL MOTORS COMPANY

12. Install the insert (2) into the hole.

Install the insert until the flange of the insert contacts the counterbored surface. Continue to rotate the installer tool (1) through the insert.

The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

Fig. 460: Bushing Type Insert And Base Material
Courtesy of GENERAL MOTORS COMPANY

13. Inspect the insert for proper installation into the hole.

    A properly installed insert (1) will be either flush or slightly below flush with the surface of the base material (2).

Cylinder Head Bolt Hole Thread Repair

1
2
3
4
5
6

Fig. 461: Cylinder Head Bolt Hole Thread Repair Kit
Courtesy of GENERAL MOTORS COMPANY

1. The cylinder head bolt hole thread repair kit consists of the following items:
    - **EN-42385-51** The drill (1)
    - **EN-42385-52** The tap (2)
    - **EN-42385-53** The installer (3)
    - **EN-42385-57** The sleeve (4)
    - **EN-42385-55** The alignment pin (5)
    - **EN-42385-54** The bushing (6)
    - **EN-42385-56** The bolts (7)
    - **J-42385-301** The fixture plate (8) (Part of **J-42385-300** Fixtures and Hardware Kit

Fig. 462: Fixture Plate, Bolts, Bushing And Cylinder Hole
Courtesy of GENERAL MOTORS COMPANY

WARNING: **Refer to Safety Glasses Warning .**

NOTE:

- **The use of a cutting type fluid GM P/N 1052864 (Canadian P/N 992881), WD 40Â®, or equivalent, is**

recommended when performing the drilling and tapping procedures.

- **Driver oil MUST be used on the installer driver tool.**
- **The tool kits are designed for use with either a suitable tap wrench or drill motor.**

2. Install the fixture plate (3), bolts (1), and bushing (2) onto the engine block deck.

   Position the fixture plate and bushing over the hole that is to be repaired (4).

Fig. 463: Alignment Pin And Fixture Retaining Bolts
Courtesy of GENERAL MOTORS COMPANY

3. Position the alignment pin (1) through the bushing and into the hole.
4. With the alignment pin in the desired hole, tighten the fixture retaining bolts (2).
5. Remove the alignment pin from the hole.

Fig. 464: Stop Collar And Counterbore Drill
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **For the hole on the upper front corner of cylinder #1 (Left Cylinder Bank), install EN-42385-57 sleeve onto the drill. The depth of this hole is shallower than the others. If the sleeve is not used, damage to the engine block will occur.**

6. Install the sleeve (2) onto the drill (1).

Fig. 465: Drilling Cylinder Head Bolt Hole
Courtesy of GENERAL MOTORS COMPANY

NOTE: **During the reaming process, it is necessary to repeatedly remove the drill and clean the chips from the hole.**

7. Drill out the threads of the damaged hole.

   Drill the hole until the stop collar of the drill bit or the sleeve contacts the bushing.

8. Using compressed air, clean out any chips.

Fig. 466: Tapping Threads Of Drilled Hole Using Tapping Wrench

Courtesy of GENERAL MOTORS COMPANY

9. Using a tap wrench, tap the threads of the drilled hole.

Fig. 467: Tap Upper & Lower Marks, Fixture Plate & Bushing
Courtesy of GENERAL MOTORS COMPANY

10. For the hole on the upper front corner of cylinder #1 (Left Cylinder Bank) only, rotate the tap into the hole until the first mark (1) on the tap aligns with the top of the drill bushing (3).

    For all other cylinder head bolt holes, rotate the tap into the hole until the second mark (4) on the tap aligns with the top of the drill bushing (3).

11. Remove the fixture plate (2), bushing (3), and bolts.
12. Using compressed air, clean out any chips.
13. Spray cleaner GM P/N 12346139, GM P/N 12377981 (Canadian P/N 10953463), or equivalent, into the hole.
14. Using compressed air, clean any cutting oil and chips out of the hole.

Fig. 468: Lubricating Threads Of Installer Tool
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do not allow oil or foreign material to contact the OD of the insert.**

15. Lubricate the threads of the installer tool (2) with the driver oil (1).

Fig. 469: Insert And Driver Tool
Courtesy of GENERAL MOTORS COMPANY

16. Install the insert (2) onto the driver tool (1).

Fig. 470: Applying Threadlock
Courtesy of GENERAL MOTORS COMPANY

17. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent, to the insert OD threads (2).

Fig. 471: Insert And Driver
Courtesy of GENERAL MOTORS COMPANY

18. Install the insert and driver (1) into the hole.

    For the hole on the upper front corner of cylinder #1 (Left Cylinder Bank) only, rotate the driver tool until the lower mark on the driver tool aligns with the deck surface of the engine block.

For all other cylinder head bolt holes, rotate the driver tool until the upper mark on the driver tool aligns with the deck surface of the engine block.

1. Rotate the driver tool until the upper mark on the driver tool aligns with the deck surface of the engine block.
2. The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

Main Cap Bolt Hole Thread Repair

1
2
3
4
5
6

Fig. 472: Thread Repair Kit Components
Courtesy of GENERAL MOTORS COMPANY

1. The main cap bolt hole thread repair kit consists of the following items:
    - The drill (1)
    - The tap (2)
    - The installer (3)
    - The fixture plate (4)
    - The long bolts (5)
    - The short bolts (6)
    - The alignment pin (7)
    - The bushing (8)

Fig. 473: Fixture Plate, Bolt And Bushing
Courtesy of GENERAL MOTORS COMPANY

2. Install the fixture plate, bolt, and bushing onto the engine block.

   Position the fixture plate and bushing over the hole that is to be repaired.

3. Position the alignment pin in the desired hole and tighten the fixture retaining bolts.

Fig. 474: Crankshaft Main Bearing Cap Bolt Holes
Courtesy of GENERAL MOTORS COMPANY

4. Drill out the damaged hole.

The outer bolt hole locations 11-20 have the shallower counterbores. Use sleeve J 42385-316 with the drill.

Drill until the stop collar of the drill bit or the sleeve contacts the bushing.

5. Using compressed air, clean out any chips.

Fig. 475: Tap Upper & Lower Marks, Fixture Plate & Bushing

Courtesy of GENERAL MOTORS COMPANY

6. Using a tap wrench, tap the threads of the drilled hole.

   In order to tap the new threads to the proper depth, rotate the tap into the hole until the mark on the tap aligns with the top of the bushing.

   For the deeper main cap holes 1-10, rotate the tap until the upper mark (4) on the tap aligns with the top of the bushing (3).

   For the shallower main cap holes 11-20, rotate the tap until the lower mark (1) on the tap aligns with top of the bushing (3).

7. Using compressed air, clean out any chips.
8. Spray cleaner GM P/N 12346139 (Canadian P/N 10953463), or equivalent, into the hole.
9. Using compressed air, clean any cutting oil and chips out of the hole.

Fig. 476: Lubricating Installer Tool Using Driver Oil
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do not allow oil or foreign material to contact the OD of the insert.**

10. Lubricate the threads of the installer tool (2) with the driver oil (1).

Fig. 477: Installing Insert Onto Driver Tool
Courtesy of GENERAL MOTORS COMPANY

11. Install the insert (2) onto the driver tool (1).

Fig. 478: Applying Threadlock To Insert
Courtesy of GENERAL MOTORS COMPANY

12. Apply threadlock LOCTITE™ 277, J 42385-109 (1), or equivalent, to the insert OD threads (2).

Fig. 479: Fixture Plate, Drill Bushing And Tool Marking
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The fixture plate and bushing remains installed onto the engine block during the insert installation procedure.**

13. Install the insert and driver (1) through the fixture plate and bushing and into the hole.

Rotate the driver tool until the mark on the tool (3) aligns with the top of the bushing (2).

The installer tool will tighten up before screwing completely through the insert. This is acceptable. You are forming the bottom threads of the insert and mechanically locking the insert to the base material threads.

SERVICE PRIOR TO ASSEMBLY

- Dirt or debris will cause premature wear of the rebuilt engine. Clean all components. Refer to **Cleanliness and Care**.
- Use the proper tools to measure components when inspecting for excessive wear. Components that are not within the manufacturers specifications must be repaired or replaced.
- When the components are installed into an engine, return the components to their original location, position and direction. Refer to **Separating Parts**.
- During assembly, lubricate all moving parts with clean engine oil. This provides initial lubrication when the engine is first started.

ENGINE BLOCK PLUG INSTALLATION

Plug Installation - Left Side

Fig. 480: Plug - Left Side
Courtesy of GENERAL MOTORS COMPANY

Plug Installation - Left Side

Callout	Component Name
1	Oil Pump Locating Pin
2	Engine Block Oil Gallery Plug
3	Engine Block Plug **Tighten** 30 N.m (22 lb ft)
4	Engine Block Plug **Tighten** 60 N.m (44 lb ft)
5	Knock Sensor Assembly

Callout	Component Name
6	Knock Sensor Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 25 N.m (18 lb ft)
7	Knock Sensor Shield
8	Knock Sensor Shield Bolt **Tighten** 25 N.m (18 lb ft)

Plug Installation - Right Side

Fig. 481: Plug - Right Side
Courtesy of GENERAL MOTORS COMPANY

Plug Installation - Right Side

Callout	Component Name
1	Piston Oil Nozzle Assembly **Tighten** 20 N.m (15 lb ft)
2	Transmission Locating Pin
3	Knock Sensor Assembly
4	Knock Sensor Bolt **Tighten** 25 N.m (18 lb ft)

Callout	Component Name
5	Engine Block Plug **Tighten** 30 N.m (22 lb ft)

CRANKSHAFT AND BEARING INSTALLATION

Special Tools

J-45059 Angle Meter

For equivalent regional tools, refer to **Special Tools**

Fig. 482: Crankshaft Bearings And Bearing Caps
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Crankshaft bearing clearances are critical. Excessive crankshaft bearing clearance may affect crankshaft position (CKP) sensor signals and/or on-board diagnostic (OBD) II system performance.**
- **Crankshaft bearing caps must be installed to the proper location and direction.**
- **When installing the crankshaft bearings, align the locating tabs on the bearings with the locating**

notches in the engine block journal bore and the bearing cap.

- **Always install crankshaft bearings with their machined partner. Do not file bearings or mix bearing halves.**
- **In order to prevent engine block oil leakage, install NEW crankshaft bearing cap side bolts.**

1. Install the crankshaft bearings (2 and 3) to the engine block and bearing caps (1). The thrust bearings (4) are to be installed into center journal.
2. Lubricate the bearing surfaces and crankshaft journals with clean engine oil.

Fig. 483: Crankshaft
Courtesy of GENERAL MOTORS COMPANY

CAUTION: To maintain proper crankshaft end play, use extreme care during crankshaft installation. Avoid scoring or damaging the thrust bearing.

3. Install the crankshaft (1).

Fig. 484: Crankshaft Bearing Caps
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The bearing caps (1) must be installed in the proper location and direction. The arrows on the bearing caps must point toward front of engine.**

4. Install the crankshaft bearing caps (1), with bearings, into the engine block.

Fig. 485: Crankshaft Inner Bearing Cap Bolts And Outer Bearing Cap Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.**

NOTE: **The inner bearing cap bolts are longer than the outer bearing cap bolts.**

5. Install NEW inner bearing cap bolts (1) and NEW outer bearing cap bolts (2)
6. Using a plastic-face hammer, tap the bearing caps into place.
7. Install the NEW bearing cap side bolts (3).

Fig. 486: Inner Bearing Cap Bolts Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

8. Tighten the inner bearing cap bolts (1-10) a first pass in sequence to 20 N.m (22 lb ft).

NOTE: To properly align the crankshaft thrust bearings, the final thrust of the crankshaft MUST be in the forward

direction.

9. Using a plastic-face hammer, tap the crankshaft rearward, then forward in order to align the thrust bearings.
    - Tighten the inner bearing cap bolts (1-10) a final pass in sequence 110 degrees using the **J-45059** meter.
    - Tighten the outer bearing cap bolts (11-20) a first pass in sequence to 20 N.m (15 lb ft).
    - Tighten the outer bearing cap bolts (11-20) a final pass in sequence 80 degrees using the **J 45059** meter.

Fig. 487: Crankshaft Main Bearing Cap Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

10. Tighten the main bearing cap side bolts (1-10).
    - Tighten the bearing cap side bolts (1-10) a first pass in sequence to 25 N.m (18 lb ft).
    - Tighten the bearing cap side bolts (1-10) a final pass in sequence to 60 degrees using the **J 45059** meter.

Fig. 488: Crankshaft Position (CKP) Sensor Bolt And CKP Sensor

Courtesy of GENERAL MOTORS COMPANY

11. Install the CKP sensor (2).
    1. Inspect the CKP sensor O-ring seal (3). If the O-ring seal is not cut or damaged, it may be used again.
    2. Coat the O-ring seal (3) with clean engine oil.
    3. Install the O-ring seal (3) onto the sensor.
    4. Install the sensor (2). Rotate the sensor until the locating hole in the bracket aligns with the bolt hole in the block.
    5. Install the sensor bolt (1) and tighten to 25 N.m (18 lb ft).

Fig. 489: Measuring Crankshaft End Play
Courtesy of GENERAL MOTORS COMPANY

12. Measure the crankshaft end play.
    1. Thrust the crankshaft forward or rearward.
    2. Insert a feeler gauge between the center crankshaft bearing and the bearing surface of the crankshaft and measure the bearing clearance.

       The proper crankshaft end play clearance is 0.04-0.2 mm (0.0015-0.0078 in).

3. If the bearing clearance is not within specifications, inspect the thrust surfaces for nicks, gouges or raised metal. Minor imperfections may be removed with a fine stone.

PISTON, CONNECTING ROD, AND BEARING INSTALLATION

Special Tools

- **EN-8087** Cylinder Bore Gauge
- **EN-41556** Connecting Rod Guide
- **EN-45059** Angle Meter

For equivalent regional tools, refer to **Special Tools**.

Piston Selection

Fig. 490: Measuring Piston Outside Diameter
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Measurements of all components should be taken with the components at normal room temperature. For proper piston fit, the engine block cylinder bores must not have excessive wear or taper. A used piston, pin, and connecting rod assembly may be installed if, after inspection is within specifications.**

1. With a micrometer at a right angle, measure the piston outside diameter (OD). Measure the diameter 43 mm (1.69 in) from the top of the

piston. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.

2. Record the piston OD.

Fig. 491: Measuring Bore Gauge With Micrometer
Courtesy of GENERAL MOTORS COMPANY

3. Adjust the micrometer to the recorded piston OD.
4. Insert the **EN-8087** bore gauge into the micrometer and zero the gauge dial.

Fig. 492: Measuring Cylinder Bore
Courtesy of GENERAL MOTORS COMPANY

5. Using the **EN-8087** bore gauge, measure the cylinder bore inside diameter (ID). Measure at a point 64 mm (2.5 in) from the top of the cylinder.
6. Record the cylinder bore ID.
7. Subtract the piston OD from the cylinder bore ID in order to determine the piston-to-bore clearance. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.

8. If the proper clearance cannot be obtained, select another piston and pin assembly and measure the clearances again. If the proper fit cannot be obtained, the cylinder bore may require honing for an oversize piston.

Piston, Pin, and Connecting Rod Installation

Fig. 493: Piston, Connecting Rod And Connecting Rod Bearing
Courtesy of GENERAL MOTORS COMPANY

1. Lubricate the following components with clean engine oil:
    - Piston
    - Piston rings
    - Cylinder bore
    - Bearings and bearing surfaces
2. Install the bearings to the connecting rod and cap.
3. Position the oil control ring end gaps a minimum of 25 mm (1.0 in) from each other.
4. Position the compression ring end gaps 180 degrees opposite each other.

Fig. 494: Crankshaft Protector Pins Installed In Connecting Rod Bolt Holes
Courtesy of GENERAL MOTORS COMPANY

5. Install the **EN-41556** rod guide to the connecting rod.

Fig. 495: Top Of Piston And Dimple On Rod
Courtesy of GENERAL MOTORS COMPANY

6. Identify the proper installation direction of the piston and connecting rod assembly. The right and left side are assembled differently. Right Side: The arrow on top of the piston and the dimple (2) on the rod face the same direction. When installing the right side piston and rod (3) assemblies, the arrow on top of the piston and the dimple (2) on the rod face the front of the engine. the raised bump (4) on bottom of rod (3) will be closest to the outside of the engine.

Fig. 496: Top Of Piston And Dimple On Rod
Courtesy of GENERAL MOTORS COMPANY

7. Left Side: the arrow on top of the piston and the dimple on the rod face the opposite direction. When installing the left side piston and rod (2) assemblies, the arrow on top of the piston faces the front of the engine and the dimple on the rod faces the rear of the engine. The raised bump (3) on the bottom of rod will be closest to the outside of engine.

NOTE: **When installing a piston into a cylinder, use a ring compressor sleeve or equivalent for best results. The**

following features should be looked for when selecting a ring compressor sleeve.

- **Hard anodized and Teflon coated for low friction and prolonged wear resistance.**
- **Smooth radius that tapers down to the specific bore size.**
- **Sleeve should compress the piston rings smoothly and evenly.**
- **Using a ring compressor sleeve greatly reduces the difficulty with installing thin high-performance oil rings.**

If a ring compressor sleeve is unavailable, a universal ring compressor will work, but is more difficult to use.

8. Compress the piston rings using a ring compressor sleeve or equivalent.

Fig. 497: Fuel Bowls
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The arrow on the top of the piston MUST face the front of the engine block. The deepest portion of the fuel bowls (1) must be toward the outside of the engine.**

9. Install the piston, pin, and connecting rod assembly into the cylinder bore. Tap the piston into the bore with a wooden hammer handle. Guide the connecting rod to the crankshaft journal using the **J-41556** rod guide while gently tapping the piston into place. Hold the ring compressor

sleeve or equivalent against the engine block until all rings have entered the cylinder bore.

10. Remove the **EN-41556** rod guide from the connecting rod.

Fig. 498: Connecting Rod Bolts, Cap And Bearing
Courtesy of GENERAL MOTORS COMPANY

CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use

fastener could cause damage to the vehicle or component.

CAUTION: **Refer to Fastener Caution .**

NOTE:

- **The connecting rod and cap must be assembled with the mating surfaces properly aligned.**
- **If re-using connecting rods, DO NOT re-use connecting rod fasteners. During an installation procedure, the new connecting rod bolts can be re-tightened a maximum of 3 times.**

11. Install the bearing (1), bearing cap (2), and bolts (3).
    1. Tighten the bolts a first pass to 20 N.m (15 lb ft).
    2. Tighten the bolts a final pass to 85 degrees using the **EN-45059** angle meter.

Fig. 499: Measuring Connecting Rods For Proper Side Clearance
Courtesy of GENERAL MOTORS COMPANY

12. Measure the connecting rods for the proper side clearance. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.

CAMSHAFT INSTALLATION

Fig. 500: Camshaft
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Assembly
2	Camshaft Retainer
3	Camshaft Retainer Bolt (Qty: 4) **CAUTION:** **Refer to Fastener Caution .** **Procedure**

Callout	Component Name
	Tighten the retainer bolts in the sequence shown. **NOTE:** **Clean the threads of the cam retainer bolts and apply a sealant.** **Tighten** 15 N.m (11 lb ft) Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

TIMING CHAIN, CRANKSHAFT SPROCKET, CAMSHAFT POSITION ACTUATOR, AND SOLENOID VALVE INSTALLATION

Special Tools

- **EN 46330** Timing Belt Tensioner Retaining Pin
- **EN-42386-A** Flywheel Holding Tool
- **EN-45059** Angle Meter

For equivalent regional tools, refer to **Special Tools**.

Fig. 501: Crankshaft Sprocket
Courtesy of GENERAL MOTORS COMPANY

1. Install the crankshaft sprocket (1) onto the front of the crankshaft. Align the crankshaft key with the crankshaft sprocket keyway.

Fig. 502: Rotating Crankshaft Until Sprocket Alignment Mark
Courtesy of GENERAL MOTORS COMPANY

2. Rotate the crankshaft sprocket until the sprocket alignment mark (1) is in the 12 o'clock position.

Fig. 503: Timing Chain Tensioner Guide And Pin
Courtesy of GENERAL MOTORS COMPANY

3. Compress the timing chain tensioner guide and install the **EN 46330** pin (1).

Fig. 504: Timing Chain Tensioner And Left Side Bolt
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

4. Install the timing chain tensioner and left side bolt (1). Do not install the right side bolt at this time. The right side bolt will be installed after the camshaft position (CMP) actuator and chain have been installed onto the engine.

Fig. 505: Tie Strap Through Center Of Actuator
Courtesy of GENERAL MOTORS COMPANY

WARNING: Refer to Camshaft Position Actuator Removal and Installation Warning .

5. Remove the tie strap (1) from the actuator.

Fig. 506: Alignment Hole And Locating Pin
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Properly locate the CMP actuator onto the locating pin of the camshaft.**
- **The sprocket teeth and timing chain must mesh.**
- **The camshaft and the crankshaft sprocket alignment marks MUST be aligned properly.**
- **Do not use the CMP solenoid valve again. Install a NEW valve during assembly.**

6. Identify the alignment hole (1) in the rear face of the CMP actuator and the locating pin (2) on the front face of the camshaft.

Fig. 507: Proper Installation Of CMP Actuator
Courtesy of GENERAL MOTORS COMPANY

WARNING: Refer to Camshaft Position Actuator Removal and Installation Warning .

7. Install the CMP actuator and timing chain. Align the hole in the rear face of the CMP actuator with the locating pin on the front face of the camshaft. If necessary, rotate the camshaft or crankshaft sprockets in order to align the timing marks. Use care to install the actuator completely onto the front of the camshaft. Position fingers onto the face of the actuator sprocket and push the actuator onto the front of the camshaft. Never push on the reluctor wheel when attempting to install the actuator.

Fig. 508: NEW CMP Actuator Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

8. Install a NEW CMP actuator solenoid valve (1). With the CMP actuator properly positioned onto the camshaft, the CMP actuator solenoid

valve can be threaded completely into the camshaft using light hand pressure. Tighten by hand until snug.

1. Tighten a first pass to 65 N.m (48 lb ft).
2. Tighten a final pass an additional 90 degrees using **EN-45059** angle meter.

Fig. 509: Inspecting For Proper Installation Of CMP Actuator And Timing Chain
Courtesy of GENERAL MOTORS COMPANY

NOTE: **It is possible to push the camshaft rearward when installing the CMP valve. Verify that the camshaft lobes are centered in the valve lifter bores after the CMP actuator is installed.**

9. Locate a straight edge across the front face of the engine block and inspect for proper installation of the CMP actuator and timing chain. With the CMP actuator properly and completely installed onto the front of camshaft, the timing chain will not protrude beyond the front face of engine block.

Fig. 510: CMP Actuator Sprocket And Crankshaft Sprocket Alignment Marks

Courtesy of GENERAL MOTORS COMPANY

10. Inspect the sprockets for proper alignment. The mark on the CMP actuator sprocket (1) should be located in the 6 o'clock position and the mark on the crankshaft sprocket (2) should be located in the 12 o'clock position.

Fig. 511: Timing Chain Tensioner
Courtesy of GENERAL MOTORS COMPANY

11. Install the right side bolt (1) into the timing chain tensioner and tighten both bolts to 25 N.m (18 lb ft).

Fig. 512: Pin
Courtesy of GENERAL MOTORS COMPANY

12. Remove the **EN 46330** pin.

OIL PUMP INSTALLATION

Fig. 513: Oil Pump And Oil Pump Bolts (With Tightening Sequence)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure **If oil pump is removed to perform a different repair and is going to be REUSED, the alignment tool EN-51267 oil pump alignment tool MUST be installed on the engine block BEFORE the oil pump is removed and left in place until the installation of the original oil pump. If EN-51267 oil pump alignment tool IS NOT installed prior the oil pump being removed AND left in place while other repairs are performed, a NEW oil pump MUST be installed.**	
1	Oil Pump Assembly **NOTE:** **Prior to installing the**

Callout	Component Name
Preliminary Procedure **If oil pump is removed to perform a different repair and is going to be REUSED, the alignment tool EN-51267 oil pump alignment tool MUST be installed on the engine block BEFORE the oil pump is removed and left in place until the installation of the original oil pump. If EN-51267 oil pump alignment tool IS NOT installed prior the oil pump being removed AND left in place while other repairs are performed, a NEW oil pump MUST be installed.**	
	oil pump, ensure that oil pump housing gasket is fully installed in the timing chain tensioner assembly and is not damaged. If the gasket is missing or damaged, replace the tensioner assembly.
2	Oil Pump Bolt **CAUTION:** **Refer to Fastener Caution .** **NOTE:** **Upward pressure**

Callout	Component Name
Preliminary Procedure **If oil pump is removed to perform a different repair and is going to be REUSED, the alignment tool EN-51267 oil pump alignment tool MUST be installed on the engine block BEFORE the oil pump is removed and left in place until the installation of the original oil pump. If EN-51267 oil pump alignment tool IS NOT installed prior the oil pump being removed AND left in place while other repairs are performed, a NEW oil pump MUST be installed.**	
	must be applied to the oil pump while tightening the fasteners. Contact between the oil pump housing and the oil pump alignment tool must be maintained while oil pump bolts are tightened. Prior to removing the oil pump alignment tool, ensure that there is no gap between the oil pump housing and the tool. If

Callout	Component Name
Preliminary Procedure **If oil pump is removed to perform a different repair and is going to be REUSED, the alignment tool EN-51267 oil pump alignment tool MUST be installed on the engine block BEFORE the oil pump is removed and left in place until the installation of the original oil pump. If EN-51267 oil pump alignment tool IS NOT installed prior the oil pump being removed AND left in place while other repairs are performed, a NEW oil pump MUST be installed.**	
	there is a gap, the oil pump bolts need to be loosened and the installation procedure repeated. **Procedure** Tighten the oil pump bolts in the sequence shown. **Tighten** 25 N.m (18 lb ft) **Special Tools** **EN-51267** Oil Pump Alignment Tool For equivalent regional tools, refer to **Special Tools**.

CRANKSHAFT REAR OIL SEAL HOUSING INSTALLATION

Fig. 514: Crankshaft Rear Oil Seal Housing Installation (With Tightening Sequence)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Rear Oil Seal Housing Gasket **NOTE:**

Callout	Component Name
	Must use a NEW gasket when installing the rear housing.
2	Crankshaft Rear Oil Seal Housing **Procedure** 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant** 2. Apply a 3 mm (0.118 in) bead of RTV sealant on the engine front cover as shown (a). Apply a 5 mm (0.197 in) bead of RTV sealant on the engine front cover as shown (b). Refer to **Adhesives, Fluids, Lubricants, and Sealers** for recommended sealant.
3	Crankshaft Rear Oil Seal Housing Bolt **CAUTION:** **Refer to Fastener Caution .** **Procedure** Tighten the rear oil seal housing bolts in the sequence shown. **Tighten** 25 N.m (18 lb ft)

CRANKSHAFT REAR OIL SEAL INSTALLATION

Special Tools

- **EN-41479** Crankshaft Rear Oil Seal Installer

- **EN-41479-2A** Crankshaft Rear Oil Seal Installation Guide
- **EN-41479-10** Crankshaft Rear Oil Seal Installer Adapter

For equivalent regional tools, refer to **Special Tools**.

Fig. 515: Inspecting Seal For Proper Orientation
Courtesy of GENERAL MOTORS COMPANY

IMPORTANT: For proper orientation, note the installation direction of the oil seal. The oil seal is a reverse-lip design. Install with "THIS SIDE OUT" displayed as shown.

1. Inspect the seal for proper orientation.

Fig. 516: Crankshaft Rear Oil Seal Installation Guide Cone
Courtesy of GENERAL MOTORS COMPANY

2. Install the **EN-41479-2A** crankshaft rear oil seal installation guide cone (2) and bolts onto the rear of the crankshaft.
3. Tighten the bolts until snug. Do not overtighten.
4. Install the rear oil seal (1) onto the tapered cone (2) and push the seal to the rear seal bore. Install the oil seal with "THIS SIDE OUT" facing away from the engine.
5. Install the **EN-41479-10** crankshaft rear oil seal installer adapter (3) onto **EN-41479** crankshaft rear oil seal installer (4).
6. Thread the **EN-41479** crankshaft rear oil seal installer threaded rod into the tapered cone until the tool contacts the oil seal.
7. Align the oil seal (1) onto the tool.
8. Rotate the handle of the tool clockwise until the seal enters the rear housing and bottoms into the seal bore.
9. Remove the tool.

ENGINE FRONT COVER INSTALLATION

Oil Pump Flow Control Valve Harness Installation

Fig. 517: Oil Pump Flow Control Valve Harness
Courtesy of GENERAL MOTORS COMPANY

Oil Pump Flow Control Valve Harness Installation

Callout	Component Name
1	Oil Pump Flow Control Valve Harness **Procedure** 1. Install the harness through the front of the engine front cover and push connector into engine front cover until it clicks. 2. Install the wire into the 2 retainer clips.

Front Cover Installation

Fig. 518: Engine Front Cover (With Tightening Sequence)
Courtesy of GENERAL MOTORS COMPANY

Front Cover Installation

Callout	Component Name
1	Engine Front Cover **NOTE:**

Callout	Component Name
	Install and align the front cover within 10 minutes of applying the sealer. **Procedure** 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Refer to **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant** 2. Apply a 3 mm (0.118 in) bead of RTV sealant on the engine front cover as shown (a). Apply a 5 mm (0.197 in) bead of RTV sealant on the engine front cover as shown (b). Refer to **Adhesives, Fluids, Lubricants, and Sealers**. 3. Connect the oil pump flow control valve harness connector after installing the engine front cover.
2	Engine Front Cover Bolt **CAUTION:** **Refer to Fastener Caution .** **Procedure** Tighten the engine front cover bolts in the sequence shown. **Tighten** 25 N.m (18 lb ft)
3	Engine Front Cover Bolt **Procedure** Tighten the engine front cover bolts in the sequence shown. **Tighten** 25 N.m (18 lb ft)

Camshaft Position Sensor Harness, Camshaft Position Sensor and Camshaft Actuator Magnet Installation

Fig. 519: Camshaft Position Sensor Harness, Camshaft Position Sensor and Camshaft Actuator Magnet
Courtesy of GENERAL MOTORS COMPANY

Camshaft Position Sensor Harness, Camshaft Position Sensor and Camshaft Actuator Magnet Installation

Callout	Component Name
1	Camshaft Actuator Magnet Gasket **NOTE:** **Must use a NEW gasket.**
2	Camshaft Actuator Magnet
3	Camshaft Actuator Magnet Bolts **Tighten**

Callout	Component Name
	10 N.m (88 lb in)
4	Camshaft Position Sensor Seal **NOTE:** **Must use a NEW seal.**
5	Camshaft Position Sensor
6	Camshaft Position Sensor Harness
7	Camshaft Position Sensor Harness Bolts **Tighten** 25 N.m (18 lb ft)

CRANKSHAFT FRONT OIL SEAL INSTALLATION

Special Tools

- **J-41478-A** Crankshaft Front Oil Seal Installer
- **EN-51091** Crankshaft Front Oil Seal Installer

For equivalent regional tools, refer to **Special Tools**

Fig. 520: Inspecting Seal For Proper Orientation
Courtesy of GENERAL MOTORS COMPANY

IMPORTANT: For proper orientation, note the installation direction of the oil seal. The oil seal is a reverse-lip design. Install with "THIS SIDE OUT" displayed as shown.

1. Inspect the seal for proper orientation.

Fig. 521: Crankshaft Front Oil Seal
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Do not lubricate the oil seal sealing surface.**
- **Do not use the crankshaft front oil seal again.**

2. Install the crankshaft front oil seal (3) onto the threaded rod, nut and washer from **J-41478-A** crankshaft front oil seal installer (1) and

EN-51091 crankshaft front oil seal installer (2).

3. Install the **J-41478-A** crankshaft front oil seal installer threaded rod, nut and washer (1) and **EN-51091** crankshaft front oil seal installer (2) and oil seal (3), into the end of the crankshaft.
4. Use the **J-41478-A** crankshaft front oil seal installer (1) and **EN-51091** crankshaft front oil seal installer (2) in order to install the oil seal (3) into the cover bore.
    1. Use a wrench and hold the hex on the installer bolt.
    2. Use a second wrench and rotate the installer nut clockwise until the seal bottoms in the cover bore.
    3. Remove the tool.
    4. Inspect the oil seal for proper installation. The oil seal should be installed evenly and completely into the front cover bore.

OIL PAN INSTALLATION

Fig. 522: Upper Oil Pan (With Tightening Sequence)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Upper Oil Pan **NOTE:**

Callout	Component Name
	Install and align the oil pan within 10 minutes of applying the sealer. **Procedure** 1. Ensure proper use of room temperature vulcanizing (RTV) sealant. Refer to **Use of Room Temperature Vulcanizing (RTV) and Anaerobic Sealant** 2. Apply a 3 mm (0.118 in) bead of RTV sealant on the engine front cover as shown (a). Apply a 5 mm (0.197 in) bead of RTV sealant on the engine front cover as shown (b). Refer to **Adhesives, Fluids, Lubricants, and Sealers**.
2	Upper Oil Pan Bolt **Procedure** Tighten the upper oil pan bolts in the sequence shown. **CAUTION:** **Refer to Fastener Caution .** **Tighten** 12 N.m (106 lb in)
3	Upper Oil Pan Bolt **Procedure** Tighten the upper oil pan bolts in the sequence shown. **Tighten** 25 N.m (18 lb ft)

ENGINE OIL COOLER INSTALLATION

Fig. 523: Engine Oil Cooler
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Oil Cooler Gasket
2	Engine Oil Cooler
3	Engine Oil Cooler Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten**

Callout	Component Name
	12 N.m (106 lb in)

OIL FILTER INSTALLATION

Fig. 524: Oil Filter
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Pan Drain Plug Seal
2	Oil Pan Drain Plug **CAUTION:** **Refer to**

Callout	Component Name
	Fastener Caution . **Tighten** 25 N.m (18 lb ft)
3	Oil Filter Assembly **Tighten** 3/4 to 1 full turn after gasket makes contact with the sealing surface on the filter mounting flange

VALVE LIFTER FOLLOWER GUIDE INSTALLATION

Fig. 525: Valve Lifter Follower Guide
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Valve Lifter Follower
2	Valve Lifter Follower Guide
3	Valve Lifter Follower Guide Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 12 N.m (106 lb in)

VALVE LIFTER OIL MANIFOLD INSTALLATION

Valve Lifter Oil Manifold Assemble

Fig. 526: Valve Lifter Oil Manifold
Courtesy of GENERAL MOTORS COMPANY

Valve Lifter Oil Manifold Assemble

Callout	Component Name
1	PCV Valve **CAUTION:** **Refer to Fastener Caution .** **Tighten** 6 N.m (53 lb in)

Callout	Component Name
2	Valve Lifter Oil Filter
3	Valve Lifter Oil Manifold Plug **Procedure** Apply sealant GM P/N 12346004 (Canadian P/N 10953480) to the threads of the sensor. Refer to **Adhesives, Fluids, Lubricants, and Sealers**. **Tighten** 30 N.m (22 lb ft)
4	Oil Pressure Sensor **Procedure** Apply sealant GM P/N 12346004 (Canadian P/N 10953480) to the threads of the sensor. Refer to **Adhesives, Fluids, Lubricants, and Sealers**. **Tighten** 35 N.m (26 lb ft)

Valve Lifter Oil Manifold Installation

Fig. 527: Valve Lifter Oil Manifold (With Tightening Sequence)
Courtesy of GENERAL MOTORS COMPANY

Valve Lifter Oil Manifold Installation

Callout	Component Name
1	Valve Lifter Oil Manifold Gasket **NOTE:**

Callout	Component Name
	Must use a NEW gasket.
2	Valve Lifter Oil Manifold Assembly
3	Valve Lifter Oil Manifold Bolt **Tighten** 1. Tighten the bolts a first pass in sequence to 15 N.m (11 lb ft). 2. Tighten the bolts a final pass in sequence to 30 N.m (22 lb ft).

VALVE LIFTER INSTALLATION

Fig. 528: Valve Lifters And Guide
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **When using the valve lifters again, install the lifters to their original locations.**
- **If camshaft replacement is required, the valve lifters must also be replaced.**
- **Each of the 4 valve guide assemblies will contain 2 active fuel management valve lifters and 2 non-active fuel management valve lifters.**

- **With the lifters and guides properly installed, cylinders 1, 4, 6, and 7 lifter bores will each contain 2 active fuel management valve lifters.**

1. Lubricate the valve lifters (209, 219) and engine block valve lifter bores with clean engine oil.

Fig. 529: Aligning Notched Area Of Guide With Raised Surface On Side Of Lifter
Courtesy of GENERAL MOTORS COMPANY

2. Insert the valve lifters into the lifter guides.
   - Align the flat area (3) on the top of the non-active fuel management lifter with the flat area in the lifter guide bore. Push the lifter completely into the guide bore.
   - The active fuel management lifters (4) are to be installed into the guide, with the notch in the guide (1) aligned with the raised area (2) of the lifter.

Fig. 530: Valve Lifters And Guides

Courtesy of GENERAL MOTORS COMPANY

3. Install the valve lifters and guide assembly (210) to the engine block.

CAUTION: Refer to Fastener Caution .

4. Install the valve lifter guide bolts (211) and tighten to 12 N.m (106 lb in).

CYLINDER HEAD INSTALLATION - LEFT SIDE

Fig. 531: Cylinder Head - Left Side (With Tightening Sequence)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure	
Clean the holes in the block of any debris or residual fastener thread sealant. Failing to do so can cause the bolts not to reach proper	

torque and/or clamp load.	
1	Cylinder Head Gasket **NOTE:** **Must use NEW gasket.**
2	Cylinder Head Assembly
3	Cylinder Head Bolt **CAUTION:** **This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or**

	component. **CAUTION:** **Refer to Fastener Caution .** **NOTE:** **The forward most fastener on the Left Side Cylinder Head is unique to all other cylinder head fasteners. It is shorter, has an internal hex drive and has a lower final tightening torque angle.** **Tighten** 80 N.m (59 lb ft) + 90Â° + 40Â°
4	Cylinder Head Bolt **Procedure** Tighten the cylinder head bolts each pass in the sequence shown.

	Tighten 80 N.m (59 lb ft) + 90Â° + 60Â°

CYLINDER HEAD INSTALLATION - RIGHT SIDE

Fig. 532: Cylinder Head - Right Side (With Tightening Sequence)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure **Clean the holes in the block of any debris or residual fastener thread sealant. Failing to do so can cause the bolts not to reach proper torque and/or clamp load.**	
1	Cylinder Head Gasket **NOTE:**

Callout	Component Name
Preliminary Procedure **Clean the holes in the block of any debris or residual fastener thread sealant. Failing to do so can cause the bolts not to reach proper torque and/or clamp load.**	
	Must use NEW gasket.
2	Cylinder Head Assembly
3	Cylinder Head Bolt **CAUTION:** **This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or**

Callout	Component Name
Preliminary Procedure **Clean the holes in the block of any debris or residual fastener thread sealant. Failing to do so can cause the bolts not to reach proper torque and/or clamp load.**	
	component. **CAUTION:** **Refer to** **Fastener Caution .** **Procedure** Tighten the cylinder head bolts each pass in the sequence shown. **Tighten** 80 N.m (59 lb ft) + 90Â° + 60Â°

VALVE ROCKER ARM AND PUSH ROD INSTALLATION

Fig. 533: Proper Seating Of Push Rod
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Ensure the pushrods seat properly to the ends of the rocker arms.**

1. Inspect the rocker arm and pushrod assemblies before installation.

Fig. 534: Valve Rocker Arm And Push Rod
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **When using the valve train components again, always install the components to the original location and position.**
- **Valve lash is net build. No valve adjustment is required.**
- **Lubricate the flange of the valve rocker arm bolts with clean engine oil.**

- **Lubricate the valve rocker arms and pushrods with clean engine oil.**
- **Ensure the pushrods seat properly to the valve lifter sockets.**
- **The rocker arm bolts are not serviced separately.**
- **Ensure the pushrods seat properly to the ends of the rocker arms.**
- **DO NOT tighten the rocker arm bolts at this time.**

2. Install the valve rocker arm and pushrod assemblies (1).

Fig. 535: Camshaft And Crankshaft Sprocket Alignment Marks
Courtesy of GENERAL MOTORS COMPANY

3. Rotate the crankshaft until number 1 piston is at top dead center of compression stroke.

   In this position, cylinder number 1 rocker arms will be off lobe lift, and the crankshaft sprocket key will be at the 1:30 position. The camshaft and crankshaft sprocket alignment marks (1, 2) will be in the 12 o'clock position. If viewing from the rear of the engine, the additional crankshaft pilot hole, non-threaded, will be in the 10:30 position.

The engine firing order is 1, 8, 7, 2, 6, 5, 4, 3.

Cylinders 1, 3, 5, and 7 are left bank.

Cylinders 2, 4, 6, and 8 are right bank.

CAUTION: Refer to Fastener Caution

4. With the engine in the number 1 firing position, tighten the following valve rocker arm bolts:
    1. Tighten the exhaust valve rocker arm bolts 1, 2, 7, and 8 to 30 N.m (22 lb ft).
    2. Tighten the intake valve rocker arm bolts 1, 3, 4, and 5 to 30 N.m (22 lb ft).
5. Rotate the crankshaft 360 degrees.
6. Tighten the following valve rocker arm bolts:
    - Tighten the exhaust valve rocker arm bolts 3, 4, 5, and 6 to 30 N.m (22 lb ft).
    - Tighten the intake valve rocker arm bolts 2, 6, 7, and 8 to 30 N.m (22 lb ft).

VALVE ROCKER ARM COVER INSTALLATION - LEFT SIDE

Valve Rocker Arm Cover Assemble - Left Side

Fig. 536: Valve Rocker Arm Cover - Left Side
Courtesy of GENERAL MOTORS COMPANY

Valve Rocker Arm Cover Assemble - Left Side

Callout	Component Name
1	Ignition Coil
2	Ignition Coil Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten**

Callout	Component Name
	10 N.m (89 lb in)

Valve Rocker Arm Cover Installation - Left Side

Fig. 537: Valve Rocker Arm Cover - Left Side (With Tightening Sequence)
Courtesy of GENERAL MOTORS COMPANY

Valve Rocker Arm Cover Installation - Left Side

Callout	Component Name
1	Valve Rocker Arm Cover Gasket **NOTE:** **Must use a NEW gasket.**

Callout	Component Name
2	Valve Rocker Arm Cover - Left Side
3	Valve Rocker Arm Cover Bolt **CAUTION:** **Refer to** **Fastener Caution .** **Procedure** Tighten the valve rocker arm cover bolts in the sequence shown. **Tighten** 10 N.m (89 lb in)

VALVE ROCKER ARM COVER INSTALLATION - RIGHT SIDE

Valve Rocker Arm Cover Assemble - Right Side

Fig. 538: Valve Rocker Arm Cover - Right Side
Courtesy of GENERAL MOTORS COMPANY

Valve Rocker Arm Cover Assemble - Right Side

Callout	Component Name
1	Ignition Coil
2	Ignition Coil Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten**

Callout	Component Name
	10 N.m (89 lb in)

Valve Rocker Arm Cover Installation - Right Side

Fig. 539: Valve Rocker Arm Cover - Right Side (With Tightening Sequence)
Courtesy of GENERAL MOTORS COMPANY

Valve Rocker Arm Cover Installation - Right Side

Callout	Component Name
1	Valve Rocker Arm Cover Gasket **NOTE:** **Must use a NEW gasket.**

Callout	Component Name
2	Valve Rocker Arm Cover - Right Side
3	Valve Rocker Arm Cover Bolt **CAUTION:** **Refer to** **Fastener Caution .** **Procedure** Tighten the valve rocker arm cover bolts in the sequence shown. **Tighten** 10 N.m (89 lb in)

VALVE LIFTER OIL FILTER INSTALLATION

Fig. 540: Valve Lifter Oil Filter
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do not allow dirt or debris to enter the oil passages of the manifold. Plug, as required.**

1. Install a NEW oil filter (2).
2. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) to the threads of the plug. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

CAUTION: Refer to Fastener Caution .

3. Install the valve lifter oil manifold plug (1). Tighten to 30 N.m (22 lb ft).
4. Apply sealant GM P/N 12346004 (Canadian P/N 10953480) to the threads of the sensor. Install the oil pressure sensor (3).
5. Tighten the oil pressure sensor to 35 N.m (26 lb ft).

FUEL PUMP INSTALLATION

Special Tools

EN-51092 Fuel Pump Installation Gauge

For equivalent regional tools, refer to **Special Tools**.

Fig. 541: Lifter Oil Manifold Assembly
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The camshaft must be in the base circle position before the high pressure fuel pump is installed.**

1. Use the **EN-51092** alignment gauge (2) to ensure that the camshaft lobe is in the base circle position. At base circle position, the tool will be flush with the top surface of the Lifter Oil Manifold Assembly (1).

Fig. 542: High Pressure Fuel Pump Components
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Ensure that the high pressure fuel pump roller lifter is oriented properly, the camshaft is at base circle and the number 1 piston is at top dead center (TDC) on the exhaust stroke.**

NOTE: **Ensure the plastic bolt retainers (3) are installed in the high pressure fuel pump mounting holes before installing.**

2. Install a NEW high pressure fuel pump gasket (1).
3. Install the high pressure fuel pump (2) and high pressure fuel pump cover (4).

CAUTION: **Refer to Fastener Caution .**

CAUTION: **Alternately hand-tighten the fuel pump bolts one turn at a time until the pump is fully seated. Trying to draw down the pump without even side-to-side tightening may result in pump plunger damage.**

4. Start and hand-tighten the high pressure fuel pump bolts (5) evenly and tighten the high pressure fuel pump bolts to 25 N.m (18 lb ft).

FUEL RAIL AND INJECTORS INSTALLATION

Fig. 543: Fuel Rail and Injectors
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Fuel Rail Insulator
2	Direct Fuel Injection Fuel Rail Assembly **CAUTION:** **Make sure the fuel injectors are free from debris and lubricant. Lubricant can burn and ruin the fuel injector seals.** • **CAUTION:** **The fuel rail assemblies must be drawn down evenly before final torque. Failure to draw down the fuel rail assemblies evenly may result in scoring of the lifter bores.**

Callout	Component Name
	• **NOTE:** • **If re-using injectors be sure to replace lower compression seals.** • **Do not lubricate the combustion seals when replacing.** • **Clean the holes in the cylinder head of any debris or residual fastener thread sealant. Failing to do so can cause the bolts not to reach proper torque and/or clamp load.**

Callout	Component Name
	Refer to **Fuel Rail and Injectors Cleaning and Inspection**.
3	Fuel Injection Fuel Rail Bolt **NOTE:** **Clean the threads and apply a threadlocker.** Refer to **Adhesives, Fluids, Lubricants, and Sealers**. **Tighten** 25 N.m (18 lb ft)

FUEL PUMP INSULATOR AND FUEL FEED PIPES INSTALLATION

Fig. 544: RH Fuel Rail Crossover Pipe Bolt
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.**

NOTE:

- **DO NOT reuse the high pressure fuel rail crossover pipe.**
- **The tightening order and torque are critical to proper fuel system fit and function. Be sure to follow installation and tightening steps exactly.**

1. Install the NEW high pressure LH to RH fuel rail crossover pipe by starting both fuel crossover pipe fitting nuts (1 and 2) to finger-tight only.
2. Install the high pressure LH to RH fuel rail crossover pipe bolt (3) and hand tighten only.
3. Tighten the fuel rail crossover pipe fittings to 28 N.m (21 lb ft) in the following order: Left Fuel Rail (1) then Right Fuel Rail (2).

Fig. 545: Crossover Pipe And Fuel Feed Pipe Fittings
Courtesy of GENERAL MOTORS COMPANY

CAUTION: This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.

4. Tighten the crossover pipe bolt (3) to 10 N.m (89 lb in).
5. Install the NEW high pressure fuel feed pipe that connects the fuel pump to the crossover pipe (1). Finger-tighten both fuel pipe fitting nuts (2).
6. Tighten the high pressure fuel feed pipe fittings to 28 N.m (21 lb ft) in the following order: at the fuel pump (1) then at the crossover (2).

Fig. 546: Low Pressure Fuel Feed Pipe To LH Rocker Cover Bolt
Courtesy of GENERAL MOTORS COMPANY

7. Install low pressure fuel feed pipe (1) to the fuel pump (2). Press fuel pipe until an audible click is heard. Install redundant clip (3).
8. Install low pressure fuel feed pipe to LH rocker cover. Tighten fuel feed bolt (4) to 10 N.m (89 lb in).

Fig. 547: Fuel Pump Insulator
Courtesy of GENERAL MOTORS COMPANY

WARNING: The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.

9. Install the fuel pump insulator (1).

ENGINE COOLANT MANIFOLD INSTALLATION

Fig. 548: Engine Coolant Manifold (With Tightening Sequence)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Engine Coolant Manifold Gaskets **NOTE:** **Must use a NEW gasket.**
2	Engine Coolant Manifold Assembly
3	Engine Coolant Manifold Bolt

Callout	Component Name
	CAUTION: **Refer to** **NOTE:** er **Caution** **Clean the threads and apply a threadlocker.** Refer to **Adhesives, Fluids, Lubricants, and Sealers**. **Procedure** Tighten the engine coolant manifold bolts in the sequence shown. **Tighten** 25 N.m 18 lb ft)
4	Engine Coolant Manifold Bolt **NOTE:** **Clean the threads and apply a threadlocker.** Refer to **Adhesives, Fluids, Lubricants, and Sealers**. **Procedure** Tighten the engine coolant manifold bolts in the sequence shown. **Tighten** 25 N.m (18 lb ft)
5	Engine Coolant Manifold Bolt **NOTE:** **Clean the threads and apply a**

Callout	Component Name
	threadlocker. Refer to **Adhesives, Fluids, Lubricants, and Sealers**. **Procedure** Tighten the engine coolant manifold bolts in the sequence shown. **Tighten** 25 N.m (18 lb ft)
6	Engine Coolant Manifold Bolt **NOTE:** **Clean the threads and apply a threadlocker.** Refer to **Adhesives, Fluids, Lubricants, and Sealers**. **Procedure** Tighten the engine coolant manifold in the sequence shown. **Tighten** 25 N.m (18 lb ft)
7	Drive Belt Tensioner
8	Drive Belt Tensioner Bolt **Tighten** 58 N.m (43 lb ft)

INTAKE MANIFOLD INSTALLATION

Intake Manifold Install

Fig. 549: Intake Manifold (With Tightening Sequence)
Courtesy of GENERAL MOTORS COMPANY

Intake Manifold Install

Callout	Component Name
1	Intake Manifold Gasket **NOTE:**

Callout	Component Name
	A NEW gasket must be used when installing the intake manifold assembly.
2	Intake Manifold Assembly
3	Intake Manifold Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten:** • Tighten the bolts a first pass in the sequence shown to 5 N.m (44 lb in). • Tighten the bolts a final pass in the sequence shown to 10 N.m (89 lb in).
4	PCV Tube Assembly **Procedure** 1. The PCV tube is connected to the intake manifold and the engine via a plastic collar quick connect fitting. 2. To install the PCV tube, refer to **Plastic Collar Quick Connect Fitting Service** .

Intake Manifold Cover Install

Fig. 550: Intake Manifold Cover
Courtesy of GENERAL MOTORS COMPANY

Intake Manifold Cover Install

Callout	Component Name
1	Intake Manifold Cover Assembly
2	Intake Manifold Cover Stud **Tighten** 4.5 N.m (40 lb in)
3	Intake Manifold Cover Bolt **Tighten** 4.5 N.m (40 lb in)

THROTTLE BODY ASSEMBLY INSTALLATION

Fig. 551: Throttle Body Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Throttle Body Gasket **NOTE:** **A NEW gasket must be used when installing the throttle body assembly.**
2	Throttle Body Assembly

Callout	Component Name
3	Throttle Body Bolt **CAUTION:** **Refer to** **Fastener Caution .** **Tighten** 10 N.m (89 lb in)

VACUUM PUMP INSTALLATION

Fig. 552: Vacuum Pump (With Tightening Sequence)

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Vacuum Pump Gasket **NOTE:** **Must use NEW gasket when installing vacuum pump.**
2	Vacuum Pump Assembly
3	Vacuum Pump Bolt **CAUTION:** **Refer to Fastener Caution .** **Procedure** Tighten the vacuum pump bolts in the sequence shown. **Tighten** 25 N.m (18 lb ft)
4	Vacuum Pump Bolts **Procedure** Tighten the vacuum pump bolts in the sequence shown. **Tighten** 25 N.m (18 lb ft)
5	Vacuum Pump Bolt **Procedure** Tighten the vacuum pump bolts in the sequence shown. **Tighten** 25 N.m (18 lb ft)

EXHAUST MANIFOLD INSTALLATION - LEFT SIDE

Fig. 553: Exhaust Manifold - Left Side (With Tightening Sequence)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Exhaust Manifold Gasket

Callout	Component Name
	NOTE:
2	Exhaust Manifold **Must use a NEW gasket.**
3	Exhaust Manifold Bolts **CAUTION:** **Refer to Fastener Caution .** **Procedure** Tighten the exhaust manifold bolts in the sequence shown. 1. If installing on existing cylinder head - Tighten the bolts to 23 N.m (17 lb ft). 2. If installing on NEW cylinder head - Tighten bolts to 27 N.m (20 lb ft)
4	Heat Shield
5	Heat Shield Bolts **Tighten** 12 N.m (106 lb in)
6	Spark Plug Wires **Procedure** Inspect the inside of the spark plug wire boot for a thin, even coat of grease. If there is no grease present or additional grease is necessary, complete the following procedure: 1. Apply a thin coating of dielectric grease evenly to the inside of the spark plug wire boot, up to a depth of 15 mm from the end of the boot. Refer to **Adhesives, Fluids, Lubricants, and Sealers**. 2. Remove any excess grease from around the end of the boot, and ensure there is not an excessive amount within the boot. **NOTE:** **Only apply dielectric**

Callout	Component Name
	grease to the spark plug side of the spark plug wire boot.

EXHAUST MANIFOLD INSTALLATION - RIGHT SIDE

Fig. 554: Exhaust Manifold - Right Side (With Tightening Sequence)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Exhaust Manifold Gasket **NOTE:** **Must use a NEW gasket.**
2	Exhaust Manifold
3	Exhaust Manifold Bolt **CAUTION:** **Refer to Fastener Caution .** **Procedure** Tighten the exhaust manifold bolts in the sequence shown. 1. If installing on existing cylinder head - Tighten the bolts to 23 N.m (17 lb ft). 2. If installing on NEW cylinder head - Tighten bolts to 27 N.m (20 lb ft)
4	Exhaust Manifold Heat Shield
5	Heat Shield Bolt **Tighten** 10 N.m (88 lb in)
6	Spark Plug Wires **Procedure** Inspect the inside of the spark plug wire boot for a thin, even coat of grease. If there is no grease present or additional grease is necessary, complete the following procedure: 1. Apply a thin coating of dielectric grease evenly to the inside of the spark plug wire boot, up to a depth of 15 mm from the end of the boot. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

Callout	Component Name
	2. Remove any excess grease from around the end of the boot, and ensure there is not an excessive amount within the boot. **NOTE:** **Only apply dielectric grease to the spark plug side of the spark plug wire boot.**

OIL LEVEL INDICATOR AND TUBE INSTALLATION

Fig. 555: Oil Level Indicator and Tube
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Oil Level Indicator Tube O-Ring
2	Oil Level Indicator Tube
3	Oil Level Indicator Tube Bracket Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
4	Oil Level Indicator

AUTOMATIC TRANSMISSION FLEX PLATE INSTALLATION

Special Tools

EN-45059 Angle Meter

For equivalent regional tools, refer to **Special Tools**.

Fig. 556: Automatic Transmission Flex Plate
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The flex plate does not use a locating pin for alignment and will not initially seat against the crankshaft flange, but will be pulled onto the crankshaft by the engine flex plate bolts. This procedure requires a 3 stage tightening process.**

1. Install the flex plate (1) to the crankshaft.

Fig. 557: Identifying NEW Engine Flex Plate Bolts (With Tightening Sequence)
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component.**

CAUTION: **Refer to Fastener Caution .**

NOTE: **Must use NEW bolts.**

2. Install the NEW engine flex plate bolts (2).
    1. Tighten the engine flex plate bolts (1-8) a first pass in sequence to 15 N.m (11 lb ft).
    2. Tighten the engine flex plate bolts (1-8) a second pass in sequence to 30 N.m (22 lb ft).
    3. Tighten the engine flex plate bolts (1-8) a final pass in sequence an additional 45 degrees using **EN-45059** angle meter.

CRANKSHAFT BALANCER INSTALLATION

Fig. 558: Crankshaft Balancer
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Crankshaft Balancer Assembly **CAUTION:** **Refer to Fastener Caution .** **NOTE:** • **Ensure the teeth of the tool engage the engine flywheel teeth.** • **The used crankshaft balancer bolt is used only during the installation procedure. Install a NEW crankshaft balancer bolt during final assembly.**

Callout	Component Name
	Procedure 1. Install the **EN-42386-A** flywheel holding tool. Use 1 M10 - 1.5 x 120 mm and 1 M10 - 1.5 x 45 mm bolt for proper tool operation and tighten bolts to 50 N.m (37 lb ft). 2. Assemble the **EN-41478** installer threaded rod, nut, washer and the **EN-41665** installer. 3. Insert the smaller end of the installer into the front of the balancer. Use a wrench and hold the hex end of the threaded rod. Use a second wrench and rotate the installation tool nut clockwise until the balancer is started onto the crankshaft. 4. Remove the tool and reverse the installation tool. Position the larger end of the installer against the front of the balancer. Use wrench and hold the hex end of the threaded rod. Use a second wrench and rotate the nut clockwise until the balancer is installed onto the crankshaft. 5. Remove the balancer installation tools. **Special Tools** • **EN-41478** Crankshaft Front Oil Seal Installer • **EN-41665** Crankshaft Balancer and Sprocket Installer • **EN-42386-A** Flywheel Holding Tool For equivalent regional tools, refer to **Special Tools**.
2	Crankshaft Balancer Bolt **CAUTION:** **This vehicle is equipped with torque-to-yield or single use fasteners. Install a NEW torque-**

Callout	Component Name
	to-yield or single use fastener when installing this component. Failure to replace the torque-to-yield or single use fastener could cause damage to the vehicle or component. **NOTE:** The nose of the crankshaft (a) should be recessed 2.40-4.48 mm (0.094-0.176 in) into the balancer bore. **Procedure**

Callout	Component Name
	1. Install the used crankshaft balancer bolt and tighten to 330 N.m (240 lb ft) to fully seat the balancer. 2. Remove the used crankshaft balancer bolt. 3. Measure for correctly installed balancer. If the balancer is not installed to proper dimensions, install the **EN-41665** installer and repeat the installation procedure. 4. Install the NEW crankshaft balancer bolt: 1. Tighten the crankshaft balancer bolt to 120 N.m (110 lb ft). 2. Loosen the crankshaft balancer bolt 360 degrees. 3. Tighten the crankshaft balance bolt to 80 N.m (59 lb ft). 4. Tighten the crankshaft balancer bolt a final pass to: • Balancer bolt with flanged head tighten to 125 degrees using the **EN-45059** angle meter. • Balancer bolt with retained rotating washer tighten to 200 degrees using the **EN-45059** angle meter. 5. Remove the **EN-42386-A** flywheel holding tool. **Special Tools** • **EN-41665** Crankshaft Balancer and Sprocket Installer • **EN-42386-A** Flywheel Holding Tool • **EN-45059** Angle Meter For equivalent regional tools, refer to **Special Tools**.

ENGINE PRELUBING

Special Tools

J 45299 Engine Preluber

For equivalent regional tools, refer to **Special Tools**

Fig. 559: 5.3 and 6.2 Liter V8 Engines
Courtesy of GENERAL MOTORS COMPANY

NOTE: **A constant and continuous flow of clean engine oil is required in order to properly prime the engine. Use an approved engine oil as specified in the owners manual.**

1. Remove the engine oil filter and fill with clean engine oil.

CAUTION: Refer to Fastener Caution .

2. Install the oil filter and tighten 3/4 to 1 full turn after gasket makes contact with the sealing surface on the filter mounting flange.
3. Ensure that the oil drain plug is installed and tightened to 25 N.m (18 lb ft).
4. Locate the engine block left rear oil gallery plug.
5. Install the M16 x 1.5 adapter P/N 509375.

Fig. 560: Engine Preluber
Courtesy of GENERAL MOTORS COMPANY

6. Install the flexible hose to the adapter and open the valve.
7. Pump the handle on the **J 45299** preluber in order to flow a minimum of 1-1.9 liters (1-2 quarts) engine oil. Observe the flow of engine oil through the flexible hose and into the engine assembly.

8. Close the valve and remove the flexible hose and adapter from the engine.
9. Install the gallery plug to the engine and tighten to 30 N.m (22 lb ft).
10. Top-off the engine oil to the proper level.

DESCRIPTION AND OPERATION

CRANKCASE VENTILATION SYSTEM DESCRIPTION

A closed crankcase ventilation system is used in order to provide a more complete scavenging of the crankcase vapors. Fresh air from the throttle body is supplied to the crankcase, mixed with blow-by gases, and then passed through a crankcase ventilation valve into the intake manifold.

The primary control is through the crankcase ventilation valve which meters the flow at a rate depending on manifold vacuum. To maintain idle quality, the crankcase ventilation valve restricts the flow when intake manifold vacuum is high. If abnormal operating conditions arise, the system is designed to allow excessive amounts of blow-by gases to back flow through the crankcase vent tube into the engine air inlet to be consumed by normal combustion.

Filtered fresh air is routed from up-stream of the throttle blade to the front of the right and left rocker arm covers via formed rubber hoses. To reduce the potential of oil pullover into the throttle bore area due to back flow of the ventilation system, the fittings in the rocker arm covers are shielded from the rocker arms. From there fresh air and gases are routed through the crankcase and up to the front of the Valve Lifter Oil Manifold where the positive crankcase ventilation (PCV) valve is located. Gases are then routed through a hose to the intake manifold.

ENGINE COMPONENT DESCRIPTION

The 5.3 and 6.2 Liter V8 Engines

Fig. 561: 5.3 and 6.2 Liter V8 Engines
Courtesy of GENERAL MOTORS COMPANY

To assist in determining the applicable hardware and control system for each engine RPO, refer to **Engine Content Specifications**.

Camshaft and Drive System - RPO L83/L86

A billet steel 1-piece camshaft is supported by 5 bearings pressed into the engine block. The camshaft has a tri-lobe forward of the rear journal for

actuating the direct injection fuel pump. The CMP actuator is mounted to the front of the camshaft and retained by the CMP solenoid valve. The CMP actuator is driven by the crankshaft sprocket through the camshaft timing chain. The CMP sensor wheel is incorporated into the front face of the CMP actuator with the CMP sensor and CMP actuator magnet mounted in the engine front cover. A timing chain tensioner is mounted to the front of the engine block above the crankshaft sprocket. The externally splined crankshaft sprocket is positioned to the crankshaft by a key and keyway. The crankshaft sprocket external splines drive the oil pump drive gear. A retaining plate mounted to the front of the engine block maintains camshaft location. Refer to **Camshaft Position Actuator and Solenoid Valve Description**.

Crankshaft L83

The crankshaft is made of cast nodular iron. The crankshaft is supported by 5 crankshaft bearings. The bearings are retained by crankshaft bearing caps which are machined with the engine block for proper alignment and clearance. The crankshaft journals are undercut and rolled. The center main journal is the thrust journal. A CKP reluctor ring is press-fit mounted at the rear of the crankshaft. The reluctor ring is not serviceable separately.

Crankshaft L86

The crankshaft is made of hardened forged steel. The crankshaft is supported by 5 crankshaft bearings. The bearings are retained by crankshaft bearing caps which are machined with the engine block for proper alignment and clearance. The crankshaft journals are undercut and rolled. The center main journal is the thrust journal. A CKP reluctor ring is press-fit mounted at the rear of the crankshaft. The reluctor ring is not serviceable separately.

Cylinder Heads

The cylinder heads are cast aluminum and have pressed in place powdered metal valve guides and valve seats. The valve rocker arm covers are retained to the cylinder head by 10 perimeter mounted rocker arm cover bolts. Cylinder heads are a high-flow design with offset intake valve rocker arms.

Engine Block

The engine block is a cam-in-block deep skirt 90 degree V-configuration with 5 crankshaft bearing caps. The engine block is cast aluminum. The 5 crankshaft bearing caps each have 4 vertical M10 and 2 horizontal M8 mounting bolts. The camshaft is supported by 5 camshaft bearings pressed into the block. The left bank of cylinders are number 1-3-5-7 (#1 is front left) and the right bank of cylinders are 2-4-6-8 (#2 is front right) viewed from the flywheel end of the engine. The engine firing order is 1-8-7-2-6-5-4-3.

Exhaust Manifolds

The exhaust manifolds are a 1-piece cast iron design. The exhaust manifolds direct exhaust gasses from the combustion chambers to the exhaust system. Each manifold also has an externally mounted heat shield that is retained by bolts.

Intake Manifold

The intake manifold is a 1-piece composite design that incorporates brass threaded inserts for mounting the throttle body, and wire harness studs. Each side of the intake manifold is sealed to the cylinder head by 8 silicone push in place gaskets. The electronically actuated throttle body bolts to the front of the intake manifold. The throttle body is sealed by a 1-piece push in place silicone gasket. The intake manifold covers the direct injected fuel rail assembly, fuel pipes and fuel pump. The manifold absolute pressure (MAP) sensor is installed and retained to the left front of the intake manifold behind the throttle body. The evaporative (EVAP) emission canister purge solenoid valve is mounted left front of the intake manifold below the MAP sensor.

Fuel System

The fuel system consists of 8 separate direct injection fuel injectors, two high pressure fuel rails, a high pressure cross-over fuel pipe (connects the two fuel rails), a high pressure fuel feed pipe (connects the cross-over pipe to the high pressure fuel pump), a high pressure fuel pump and a low pressure fuel feed pipe. The injectors are each seated into their individual bores in the cylinder heads with two combustion seals to provide sealing. The high pressure fuel pump mounts to the rear of the Valve Lifter Oil Manifold in the engine valley. Motion is transmitted to the pump from a tri-lobe on the rear of the camshaft through a hydraulic roller lifter.

Oil Pan

The structural rear-sump oil pan is a two-piece design that has a cast aluminum upper and a stamped steel lower pan. Incorporated into the design is the oil filter mounting boss, drain plug opening, baffle, oil deflector, oil pump screen, and oil level sensor. The oil filter bypass valve is in the oil filter assembly. The oil pan is sealed to the oil pump with a silicone push in place gasket and to the engine block with RTV sealant. Dowels are pressed into the pan for aid in alignment to the engine block during assembly.

Piston and Connecting Rod Assembly

The pistons are cast aluminum. The pistons use 2 compression rings and 1 oil control ring assembly. The piston is a low friction, lightweight design with a recessed top and barrel shaped skirt. The piston pins are chromium steel and are a full-floating design. The connecting rods are powdered metal. The connecting rods are fractured at the connecting rod journal and then machined for the proper clearance. All applications use a piston with a graphite coated skirt. The piston and pin are to be serviced as an assembly.

Valve Rocker Arm Cover Assemblies

The valve rocker arm covers are cast aluminum and use a pre-molded silicon gasket for sealing. Mounted to each rocker cover are the coil assemblies. Incorporated into the left and right valve rocker arm covers are the positive crankcase ventilation (PCV) fresh air passages. Incorporated into the left cover is the oil fill tube.

Valve Train - RPO L83/L86

Motion is transmitted from the camshaft through the hydraulic roller valve lifters and tubular pushrods to the roller type rocker arms. The nylon valve

lifter guides position and retain the valve lifters. The valve rocker arms are mounted on individual pedestals or pivot supports that are incorporated into the cylinder heads. Each rocker arm is retained by a bolt. Valve lash is net build. Cylinders 1, 4, 6, and 7 are active fuel management. Refer to **Cylinder Deactivation (Active Fuel Management) System Description**.

CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) SYSTEM DESCRIPTION

System Operation

General Motors Active Fuel Management engine control system has the ability, under certain light load driving conditions, to provide maximum fuel economy by deactivating 4 of the engines 8 cylinders. The engine will normally operate on 8 cylinders in V8 mode during starting, idling, and medium or heavy throttle conditions. When commanded ON, the engine control module (ECM) will direct the active fuel management system and deactivate cylinders 1 and 7 on the left bank and cylinders 4 and 6 on the right bank, forcing V4 mode. Refer to **Lubrication Description**, and **Cylinder Deactivation (Active Fuel Management) System Description** .

Valve Lifter Oil Manifold Assembly

Fig. 562: Valve Lifter Oil Manifold Assembly
Courtesy of GENERAL MOTORS COMPANY

The valve lifter oil manifold assembly (1) is bolted to the top of the engine block beneath the intake manifold assembly. The oil manifold consists of 4 electrically operated and normally-closed solenoids (4). Each solenoid directs the flow of pressurized engine oil to the active fuel management intake and exhaust valve lifters (5).

When enabling conditions are met for active fuel management operation, the ECM will ground each solenoid control circuit in firing order sequence, allowing current to flow through the solenoid windings. With the windings energized, the solenoid valves open and direct pressurized engine oil

through the valve lifter oil manifold into 8 vertical passages in the engine block lifter valley. The 8 vertical passages, 2 per AFM cylinder, direct pressurized oil to the valve lifter bores of the cylinders to be deactivated. When vehicle operating conditions require a return to V8 mode, the ECM will turn OFF the ground circuit for the solenoids, allowing the solenoid valves to close. When the solenoid valves are closed, remaining oil pressure is exhausted through the bleed passages of the valve lifter oil manifold into the engine block lifter valley. The housing of the oil manifold incorporates a vent orifice that continuously purges trapped air from the manifold

To help control contamination within the active fuel management hydraulic system, a small replaceable oil filter (3) is located in the valve lifter oil manifold oil inlet passage. The oil pressure sensor (10) monitors engine oil pressure and provides information to the ECM.

Active Fuel Management Valve Lifters

Fig. 563: Displacement On Demand Valve Lifters
Courtesy of GENERAL MOTORS COMPANY

When operating in V8 mode, the active fuel management valve lifters function similar to the non-active fuel management valve lifters. The active fuel management oil manifold solenoids are in the closed position, with no pressurized oil directed to the valve lifters. The pushrod (1) travels

upward and downward to actuate the rocker arm and valve. The spring loaded locking pins (5) of the lifter are extended outward and mechanically lock the pin housing (4) to the outer body of the valve lifter (3).

When the active fuel management system is commanded ON, the ECM will direct the solenoids of the oil manifold to open and direct pressurized oil to the valve lifters. Oil travels through the valve lifter oil manifold and engine block oil galleries and enters the inlet port (6) of the valve lifter.

When operating in V4 mode, pressurized oil forces the locking pins (11) inward. The pushrod (7) remains in a constant position and does not travel upward and downward. The outer body of the lifter (9) moves upward and downward independently from the pin housing (10). The valve lifter spring (8) retains tension on the valve train components to eliminate valve train noise.

When the active fuel management system is commanded OFF, the ECM directs the solenoids of the oil manifold to close, stopping the flow of pressurized oil to the valve lifters. The oil pressure within the lifter will decrease and the locking pins will move outward to mechanically lock the pin housing and outer body.

Engine Block

Fig. 564: Engine Block
Courtesy of GENERAL MOTORS COMPANY

The active fuel management engine block incorporates additional features to support active fuel management system operation. Engine oil pressure is routed to the valve lifter oil manifold assembly from an oil gallery (2) in the front of the cylinder block. Cylinders 1, 4, 6, and 7 each have 2 vertical, cast-in-block oil passages (1). The vertical oil passages permit oil flow from the manifold assembly to the valve lifter bores.

Engine Control Module (ECM)

Refer to **Cylinder Deactivation (Active Fuel Management) System Description** .

CAMSHAFT POSITION ACTUATOR AND SOLENOID VALVE DESCRIPTION

Camshaft

Fig. 565: Camshaft Lubrication Path
Courtesy of GENERAL MOTORS COMPANY

The camshaft is designed to provide a lubrication path for pressurized engine oil to flow to the camshaft position (CMP) actuator. Pressurized engine oil enters the camshaft at bearing journal location number 2. Oil travels through the camshaft, out the front, and into the CMP actuator solenoid valve.

CMP Actuator Solenoid Valve

Fig. 566: CMP Actuator Solenoid Valve Components
Courtesy of GENERAL MOTORS COMPANY

The CMP actuator solenoid valve consists of a housing, spool valve (1), spool return spring (2), oil filter (3), inlet check ball return spring (4), and inlet check ball (5). Pressurized engine oil enters the valve and travels through the filter to the spool. Spool position is controlled by the CMP magnet and engine control module (ECM). When the spool is moved to the proper position, oil flow is directed through the valve and into the CMP actuator assembly. The CMP solenoid valve is a torque-to-yield design and should be replaced each time it is removed.

CMP Actuator Magnet

Fig. 567: CMP Actuator Magnet
Courtesy of GENERAL MOTORS COMPANY

The CMP actuator magnet (2) is located in the engine front cover and is sealed by a press in place gasket (3). The CMP actuator magnet is controlled by a 12-volt 150 Hz pulse width 0-100 percent duty cycle signal from the ECM. When energized, the solenoid uses electromagnetic force on the magnet pintle to position the spool valve of the CMP solenoid valve.

CMP Actuator

Fig. 568: CMP Actuator Components
Courtesy of GENERAL MOTORS COMPANY

The CMP actuator is a vane type design that hydraulically changes angle or timing of the camshaft relative to crankshaft position. The CMP actuator allows earlier or later intake and exhaust valve opening during the 4-stroke engine cycle. The CMP actuator cannot vary the duration of valve opening or valve lift. The CMP actuator is to be serviced as an assembly. For system operation, refer to **Camshaft Actuator System Description** .

The CMP actuator consists of the CMP reluctor wheel (1), wheel retaining pins (2), return spring (3), front cover (4), park position pin (5), park position pin spring (6), vanes and vane springs (7), rotor (8), housing with chain sprocket (9), sealing cover/thrust plate (10), and bolts (11).

CMP System Operation

Fig. 569: CMP Actuator
Courtesy of GENERAL MOTORS COMPANY

A CMP actuator dynamically changes valve timing events relative to piston timing by controlling camshaft position. This is sometimes referred to as variable valve timing or camshaft phasing. Variable valve timing or camshaft phasing does not change duration or lift.

- By advancing camshaft timing, an improvement in low end torque can be achieved.
- By retarding camshaft timing slightly, an improvement in high end power can be achieved.
- By retarding camshaft timing significantly, an improvement in light load fuel economy can be achieved.

There are 5 cavities divided by vanes within the CMP actuator.

- When oil is directed to the advance cavities (1), the camshaft timing is advanced.
- When oil is directed to the retard cavities (2), the camshaft timing is retarded.
- When oil is directed to both cavities, the camshaft is held stationary.

Fig. 570: Degree Range Of Authority At Crankshaft
Courtesy of GENERAL MOTORS COMPANY

The CMP actuator has a 62 degree range of authority at the crankshaft (31 degrees at the camshaft). With the engine not running and no engine oil pressure to the CMP actuator, the high tension spring positions camshaft timing at the 7 degree advanced park position at the crankshaft (3.5 degrees at the camshaft). During normal engine operation, and based on performance requirements, the ECM may adjust camshaft timing, as required, within a range from 7 degrees advanced at the crankshaft (3.5 degrees at the camshaft) to 55 degrees retard at the crankshaft (27.5 degrees at the camshaft).

CMP System Lubrication Flow and Actuator Operation

Fig. 571: Cutaway View Of Actuator
Courtesy of GENERAL MOTORS COMPANY

1. Oil enters the camshaft at the second main bearing journal (1).
2. Oil travels through the camshaft into the CMP actuator valve check ball (2) and filter (3).
3. Oil exits the valve and travels through the internal passages of the camshaft (4).
4. Oil exits the camshaft and enters the actuator oil entry ports.
5. Oil travels through the actuator and is directed back into the valve (5).
6. Valve spool position directs oil to the advance or retard passages of the actuator.

The valve may also, under certain conditions, be positioned in a neutral position with alternating low, balanced oil flow between the advance and retard passages of the actuator.

Fig. 572: Actuator Passages
Courtesy of GENERAL MOTORS COMPANY

1. Oil flows from the camshaft into the valve inlet (3) through the internal check ball and filter.
2. Oil exits the valve (2) and travels within the internal passages of the camshaft into the entry ports (7) of the actuator.
3. The center oil groove of the actuator is pressurized and oil reenters the valve (1).
4. Valve spool position directs oil out of the valve advance (5) or retard (4) ports to the actuator.

The valve may also, under certain conditions, be positioned in a neutral position with alternating low, balanced oil flow between the advance and retard passages of the actuator.

Fig. 573: Advance And Retard Cavities
Courtesy of GENERAL MOTORS COMPANY

1. Pressurized oil enters the retard cavities (2) of the actuator and moves the park pin (3) from the locked position.
2. As pressure increases within the retard cavities (2), the rotor and camshaft rotate counter clockwise retarding valve timing.
3. As the duty cycle decreases, the spool is repositioned and oil is sent to the advance cavities (1), rotating the rotor and camshaft clockwise, advancing valve timing.

- With a 0 percent duty cycle signal to the magnet, the spool is positioned in the fully extended position and there is full flow to the advance cavities of the actuator. As duty cycle increases to near 50 percent, flow to the advance cavities is decreased.
- With a 50 percent duty cycle, the spool is positioned neutral, with no flow to either the advance and retard cavities.
- With a 51-100 percent duty cycle, the spool is positioned to provide oil flow to retard cavities. As the duty cycle increases, the flow to retard cavities increases.
- With a 100 percent duty cycle, there is full flow to the retard cavities of the actuator.
- The above duty cycle percentage values are only a guideline, as the actual duty cycle values may vary based on engine oil temperature, solenoid magnet coil temperature, magnet coil resistance, and other specifics.

CMP Actuator Park Position Verification

Fig. 574: CMP Actuator Park Position
Courtesy of GENERAL MOTORS COMPANY

The CMP actuator can be visually inspected to determine if the tension spring has returned the reluctor wheel and rotor to the park position.

With the reluctor wheel returned to the proper parked position, the edge of the notched area of the wheel (2) aligns with the marking (1) on the camshaft sprocket.

CMP Actuator Handling Safety

Fig. 575: Proper CMP Actuator Removal
Courtesy of GENERAL MOTORS COMPANY

WARNING: Refer to Camshaft Position Actuator Removal and Installation Warning .

Fig. 576: Tie Strap Through Center Of Actuator
Courtesy of GENERAL MOTORS COMPANY

Install tie wrap (1) to retain the reluctor wheel to the sprocket. The reluctor wheel is mounted to the actuator body with 3 roll pins.

NEW PRODUCT INFORMATION

The purpose of New Product Information is to highlight, or indicate, important product changes from the previous model year.

Changes may include 1 or more of the following items:

- Torque values and/or fastener tightening strategies
- Changed engine specifications
- New sealants and/or adhesives
- Disassembly and assembly procedure revisions
- Engine mechanical diagnostic procedure revisions
- New special tools required
- A component comparison from the previous year

Changed Engine Specifications

A variety of specifications have been revised based on the new design L83 and L86 engines. Refer to **Engine Mechanical Specifications (L83)Engine Mechanical Specifications (L86)**.

Torque Values and/or Fastener Tightening Strategies

- All fasteners and threaded holes on the L83 and L86 engines utilize metric threads.
- Cylinder head, connecting rod, crankshaft balancer, camshaft sprocket, and main bearing cap bolts still apply a torque and angle tightening strategy.
- Certain fasteners should not be used again. Bolts, studs, or other fasteners that must be replaced, will be called out in the specific service procedure.

New Sealants and/or Adhesives

Sealers and adhesives, as required, are identified within the specific service procedures. Refer to **Adhesives, Fluids, Lubricants, and Sealers**.

Disassembly and Assembly Procedure Revisions

A variety of procedures have been revised based on the new design L83 and L86 engines.

Engine Mechanical Diagnostic Procedure Revisions

Diagnosis on a vehicle should follow a logical process. Strategy based diagnostics is a uniform approach for repairing all systems. The diagnostic flow may always be used in order to resolve a system condition. The diagnostic flow is the place to start when repairs are necessary. For a detailed explanation, refer to **Diagnostic Starting Point - Vehicle** .

New Special Tools Required

A variety of new special tools are required for the new design L83 and L86 engines. Refer to **Special Tools**.

A Component Comparison from the Previous Year

- The 4.8L L20 VIN A, 5.3L LC9 VIN 7 and LMG VIN 0 Gen 4 engines are replaced by the 5.3L L83 VIN C Gen 5 engine. Refer to **Engine Component Description**
- The 6.2L L9H VIN 2 Gen 4 engine is replaced by the 6.2L L86 VIN J Gen 5 engine. Refer to **Engine Component Description**.

LUBRICATION DESCRIPTION

Fig. 577: Lubrication System Diagram
Courtesy of GENERAL MOTORS COMPANY

Engine lubrication is supplied by a variable displacement two-stage vane-type oil pump assembly (11). An oil control solenoid valve, controlled by the engine control module (ECM), mounted to the oil pump provides two stage functionality. The oil pump is mounted on the front of the engine block and driven directly by the crankshaft sprocket. The pump rotor and vanes rotate and draw oil from the oil pan sump through a pick-up screen and pipe (9). The oil is pressurized as it passes through the pump and is sent through the engine block lower oil gallery.

Pressurized oil is directed through the engine block lower oil gallery to the full flow oil filter (8) where harmful contaminants are removed. A bypass

valve is incorporated into the oil filter, which permits oil flow in the event the filter becomes restricted.

Oil exits the oil filter and is then directed to the external oil cooler (10) located in the radiator and back to the left side of the oil pan. The oil is then directed to the upper main oil galleries and the valve lifter manifold assembly (6). Oil from the left upper oil gallery is directed to the crankshaft and camshaft bearings. Oil that has entered both the upper main oil galleries also pressurizes the valve lifter assemblies and is then pumped through the pushrods to lubricate the valve rocker arms and valve stems. Oil returning to the pan is directed by the crankshaft oil deflector. The oil pressure sensor is located at the top front of the engine.

An oil passage at camshaft bearing location 2 permits oil flow into the center of the camshaft. Oil enters the camshaft exiting at the front and into the camshaft position (CMP) actuator solenoid valve (2). The CMP valve spool position is controlled by the engine control module (ECM) and CMP magnet (1). When commanded by the ECM, the CMP magnet repositions the CMP actuator solenoid valve spool directing pressurized oil into the CMP actuator to control valve timing. Refer to **Camshaft Position Actuator and Solenoid Valve Description**.

With active fuel management activated, the ECM commands the 4 solenoids to open, directing oil through the engine block oil galleries to the intake and exhaust valve lifters for cylinders 1, 4, 6, and 7.

CLEANLINESS AND CARE

- Throughout this section, it should be understood that proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice, even if not specifically stated.
- When any internal engine parts are serviced, care and cleanliness is important.
- When components are removed for service, they should be marked, organized or retained in a specific order for assembly. Refer to **Separating Parts**.
- At the time of installation, components should be installed in the same location and with the same mating surface as when removed.
- An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in millimeters or thousandths of an inch. These surfaces should be covered or protected to avoid component damage.
- A liberal coating of clean engine oil should be applied to friction areas during assembly.
- Proper lubrication will protect and lubricate friction surfaces during initial operation.

SEPARATING PARTS

IMPORTANT:

- Many internal engine components will develop specific wear patterns on their friction surfaces.
- When disassembling the engine, internal components MUST be separated, marked, or organized in a way to ensure installation to their original location and position.

Separate, mark, or organize the following components:

- Piston and the piston pin
- Piston to the specific cylinder bore
- Piston rings to the piston
- Connecting rod location and orientation to the crankshaft journal
- Connecting rod to the bearing cap

  A paint stick or etching/engraving type tool are recommended. Stamping the connecting rod or cap near the bearing bore may affect component geometry.

- Crankshaft main and connecting rod bearings
- Camshaft and valve lifters
- Valve lifters, lifter guides, pushrods and rocker arm assemblies
- Valve to the valve guide
- Valve spring to the cylinder head location
- Engine block main bearing cap location and direction
- Oil pump drive and driven gears

REPLACING ENGINE GASKETS

Special Tools

J 28410 Gasket Remover

For equivalent regional tools, refer to **Special Tools**.

Gasket Use and Applying Sealants

- Do not use any gasket again unless specified.
- Gaskets that can be used again will be identified in the service procedure.
- Do not apply sealant to any gasket or sealing surface unless called out in the service information.

Separating Components

- Use a rubber mallet to separate components.
- Bump the part sideways to loosen the components.
- Bumping should be done at bends or reinforced areas to prevent distortion of parts.

Cleaning Gasket Surfaces

- Remove all gasket and sealing material from the part using the **J 28410** remover or equivalent.
- Care must be used to avoid gouging or scraping the sealing surfaces.
- Do not use any other method or technique to remove sealant or gasket material from a part.
- Do not use abrasive pads, sand paper, or power tools to clean the gasket surfaces.
    - These methods of cleaning can cause damage to the component sealing surfaces.
    - Abrasive pads also produce a fine grit that the oil filter cannot remove from the oil.
    - This grit is abrasive and has been known to cause internal engine damage.

Assembling Components

CAUTION: Refer to Sealant Caution .

- When assembling components, use only the sealant specified or equivalent in the service procedure.
- Sealing surfaces should be clean and free of debris or oil.
- Specific components such as crankshaft oil seals or valve stem oil seals may require lubrication during assembly.
- Components requiring lubrication will be identified in the service procedure.
- When applying sealant to a component, apply the amount specified in the service procedure.
- Tighten bolts to specifications. Do not overtighten.

USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALANT

Cleaning Mating Part Surfaces for RTV Joints

RTV sealant depends greatly on adhesion to the mating parts in order to form and maintain a robust sealed joint. As with any adhesion system, proper surface preparation of the bonded parts is extremely important to ensure good adhesion over the life of the product.

CAUTION: When cleaning the sealing surfaces of engine components, DO NOT use bristle discs, abrasive pads, wire wheels or surface conditioning discs. These types of devices should not be used because they produce a very

fine grit that is abrasive and known to cause internal engine damage. The bristle discs and pads are embedded with abrasive material and wear down as they clean, continually exposing fresh abrasive to the surface of the component.

Abrasive pads, wire wheels and bristle discs can remove enough metal to affect the engine front cover, cylinder head, engine block, oil pan rail, and intake manifold runner surface flatness, which can then result in engine coolant leaks, engine oil leaks and air leaks. It takes about 15 seconds to remove 0.203 mm (0.008 in) of metal with an abrasive pad.

Abrasive pads, wire wheels and bristle discs used with high speed grinders produce airborne debris that can travel throughout the shop contaminating other work being performed outside of the immediate work area.

When cleaning engine gasket sealing surfaces and/or cleaning parts from an engine that are to be reused, surface conditioning discs, typically constructed of woven fiber or molded bristles that contain abrasives, such as a high amount of aluminum oxide, should NOT be used. The use of such surface conditioning discs dislodges aluminum oxide from the disk and metal component particles, which can lead to premature engine bearing failure. The presence of aluminum oxide in engine oil has been shown to cause premature engine bearing failure. In some cases, this failure occurs in as little as 1,600 km (1,000 mi) or less after the repair has been made.

Surface conditioning discs may grind the component material and embed it into the disc. This can result when more aggressive grinding of the gasket surface takes place.

General Motors strongly recommends using a plastic razor blade, plastic gasket scraper, a wood scraper or a non-metallic scraper to remove all sealer/gasket material on the surface of engine components that are to be reused. Do not use any other method or technique to remove the sealant or the gasket material from a part.

- Do not gouge or scratch any engine sealing surface during the cleaning process.
- It is not necessary to remove every speck of the old sealer.

To remove the old RTV sealant from the sealing surface, spray GM Low VOC Cleaner or an equivalent, on the mating surfaces and allow it to soak to loosen the old gasket material. Use care to avoid getting GM Low VOC Cleaner in any area other than the mating surface to be cleaned.

Use a plastic razor blade, that mounts in a scraper device or a hand held plastic razor blade, to remove old RTV sealant from a sealing surface. Use a new blade for each corresponding engine component surface. Hold the blade as parallel to the flat surface as possible.

To properly clean the sealing surfaces prior to reassembly, spray GM Low VOC Cleaner on a folded lint free shop cloth. Wipe the mating surfaces on the engine and front cover and rotate the shop cloth until there are no more visible signs of contamination on the cloth.

After the final cleaning of the parts, allow up to 5 minutes for the components to dry before applying new RTV sealant.

NOTE: **After the final cleaning with GM Low VOC Cleaner and before reassembly, DO NOT touch the cleaned surfaces with your hand. Oils from your skin WILL CONTAMINATE the surface and prevent proper bonding of the new RTV sealant.**

Typical Applications

This procedure is intended for use in the following operations:

- Building of engines in a manual low volume build process where the use of assembly lubricants and other typical conditions exist which may contaminate the component sealing surfaces in an RTV joint.
- Cleaning of surfaces contaminated with oil or other substance during the assembly operation as a special case event.

In the typical situation, both the part being assembled, and the assembly to which it is to be sealed will be cleaned. An example is an oil pan assembled to a block/front cover/rear cover assembly using an RTV seal applied to the pan or the block. Both the pan and the block assembly should be cleaned prior to RTV application.

Any loose gaskets that are part of the RTV joint should not be cleaned unless it is known that they have been contaminated during the build process. Examples of loose gaskets are intake side and end seals which contact RTV used to seal a T-joint.

Assemblies supplied to GM with gaskets in place should not be cleaned unless they are known to be contaminated during the build process. Examples are rocker/cam covers with press in place gaskets using RTV at corners or T-joints.

Materials Needed

Use clean dry lint free cloths to wipe surface with approved solvent based cleaner. Examples are:

- GM Good Wrench Service Low VOC Brake Parts Cleaner
- AC Delco Non-Chlorinated Brake Parts Cleaner
- Loctite ODC - Free Cleaner & Degreaser

Procedure:

1. Identify the surfaces to which the RTV will come into contact in the assembled joint.
2. Using an approved solvent based cleaner, thoroughly soak an appropriate portion of a clean, dry cloth. Immediately wipe the surfaces with the cloth to remove any residue of oil, soap, etc.
3. Repeat step 2 using a clean portion of the cloth as many times as required until the cleanliness of the cloth after wiping the surface becomes constant in appearance. There is typically some discoloration of the cloth after wiping however a clean surface should produce the same level

of discoloration with successive wiping with a clean cloth and solvent.

4. If crevices exist in the joint such that wiping the surface would not be sufficient to clean the crevice, the approved solvent based cleaner should be directly sprayed on the joint to ensure wetting of the surfaces and removal of the contaminant. DO NOT spray rubber components directly. Care must be used to avoid getting solvent in areas other than necessary to clean the joint. Then continue with step 3.
5. Allow the surfaces to dry for a minimum of 1 minute or longer if necessary for the solvent to evaporate from the surface.
6. Do not touch the cleaned surface with anything prior to RTV application.
7. The surface is now prepared for RTV application.

Sealant Types

NOTE: **The correct sealant and amount of sealant must be used in the proper location to prevent oil leaks, coolant leaks, or the loosening of the fasteners. DO NOT interchange the sealants. Use only the sealant, or equivalent, as specified in the service procedure.**

The following two major types of sealant are commonly used in engines:

- Room Temperature Vulcanizing (RTV)
- Anaerobic sealant, which include the following:
  - Gasket Eliminator
  - Pipe Sealant
  - Threadlock

Room Temperature Vulcanizing (RTV) Sealer

This type of sealant is used where two components, such as the intake manifold and the engine block, are assembled together.

Use the following information when using RTV sealant:

- Do not use RTV sealant in areas where extreme temperatures are expected. These areas include:
  - The exhaust manifold
  - The head gasket
  - Any other surfaces where a different type of sealant is specified in the service procedure
- Do not use RTV sealant unless the ambient air temperature is at least 18Â°C (65Â°F) degrees or higher.
- Always follow all the safety recommendations and the directions that are on the RTV sealant container.

- Use a plastic or wood scraper in order to remove all the RTV sealant from the components.

CAUTION: **Do not allow the RTV sealant to enter any blind threaded hole. RTV sealant that is allowed to enter a blind threaded hole can cause hydraulic lock of the fastener when the fastener is tightened. Hydraulic lock of a fastener can lead to damage to the fastener and/or the components. Hydraulic lock of a fastener can also prevent the proper clamping loads to be obtained when the fastener is tightened. Improper clamping loads can prevent proper sealing of the components allowing leakage to occur. Preventing proper fastener tightening can allow the components to loosen or separate leading to extensive engine damage.**

NOTE: **The bead size is critical and is easier to maintain consistency and application with a RTV dispensing tool. This also helps to eliminate waste.**

- The surfaces to be sealed must be clean and dry.
- Use a RTV sealant bead size as specified in the service procedure.
- Apply the RTV sealant bead to the inside of any bolt holes areas.

NOTE: **Do not wait for the RTV sealant to skin over.**

- Assemble the components while the RTV sealant is still wet to the touch, within 10 minutes.

NOTE: **Do not overtighten the fasteners.**

- Tighten the fasteners in sequence, if specified, and to the proper torque specifications.

Anaerobic Type Gasket Eliminator Sealant

Anaerobic type gasket eliminator sealant cures in the absence of air. This type of sealant is used where two rigid parts, such as castings, are assembled together. When two rigid parts are disassembled and no sealant or gasket is readily noticeable, then the two parts were probably assembled using an anaerobic type gasket eliminator sealant.

Use the following information when using gasket eliminator sealant:

- Always follow all the safety recommendations and directions that are on the gasket eliminator sealant container.
- Apply a continuous bead of gasket eliminator sealant to one flange.
- The surfaces to be sealed must be clean and dry.

CAUTION: **Do not allow the sealant to enter a blind hole. The sealant may prevent the fastener from achieving proper clamp load, cause component damage when the fastener is tightened, or lead to component failure.**

- Do not allow the gasket eliminator sealed joint to cure more than 5 minutes before torquing to specification. This will result in an incorrect clamp load of assembled components.
- Do not overtighten the fasteners.
  - Apply the gasket eliminator sealant evenly to get a uniform thickness of the gasket eliminator sealant on the sealing surface.
  - Tighten the fasteners in sequence, if specified, and to the proper torque specifications.
  - After properly tightening the fasteners, remove the excess gasket eliminator sealant from the outside of the joint.

Anaerobic Type Threadlock Sealant

Anaerobic type threadlock sealant cures in the absence of air. This type of sealant is used for threadlocking and sealing of bolts, fittings, nuts, and studs. This type of sealant cures only when confined between two close fitting metal surfaces.

Use the following information when using threadlock sealant:

- Always follow all safety recommendations and directions that are on the threadlock sealant container.
- The threaded surfaces to be sealed must be clean and dry.
- Apply the threadlock sealant as specified on the threadlock sealant container.

NOTE:

- **Do not allow the threadlock sealant to cure more than 5 minutes before torquing to specification. This will result in an incorrect clamp load of assembled components.**
- **Do not overtighten the fasteners.**

- Tighten the fasteners in sequence, if specified, and to the proper torque specifications.

Anaerobic Type Pipe Sealant

Anaerobic type pipe sealant cures in the absence of air and remains pliable when cured. This type of sealant is used where two parts are assembled together and require a leak proof joint.

Use the following information when using pipe sealant:

- Do not use pipe sealant in areas where extreme temperatures are expected. These areas include:

  - The exhaust manifold
  - The head gasket
  - Surfaces where a different sealant is specified
- Always follow all the safety recommendations and the directions that are on the pipe sealant container.
- The surfaces to be sealed must be clean and dry.
- Use a pipe sealant bead of the size or quantity as specified in the service procedure.

CAUTION: Do not allow the sealant to enter a blind hole. The sealant may prevent the fastener from achieving proper clamp load, cause component damage when the fastener is tightened, or lead to component failure.

- Apply the pipe sealant bead to the inside of any bolt hole areas.
- Apply a continuous bead of pipe sealant to one sealing surface.

NOTE: Do not overtighten the fasteners.

- Tighten the fasteners in sequence, if specified, and to the proper torque specifications.

TOOLS AND EQUIPMENT

Special tools are listed and illustrated throughout this section, with a complete listing at the end of the section. These tools, or their equivalents, are specially designed to quickly and safely accomplish the operations for which they are intended. The use of these special tools also minimize possible damage to engine components. Some precision measuring tools are required for inspection of certain critical components. Torque wrenches and a torque angle meter are necessary for the proper tightening of various fasteners.

To properly service the engine assembly, the following items should be readily available:

- Approved eye protection and safety gloves
- A clean, well lit, work area
- A suitable parts cleaning tank
- A compressed air supply
- Trays or storage containers to keep parts and fasteners organized
- An adequate set of hand tools
- Approved engine repair stand

- An approved engine lifting device that will adequately support the weight of the components

SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

Illustration	Tool Number/Description

Illustration	Tool Number/Description
	EN-22794 J-22794 Spark Plug Port Adapter

Illustration	Tool Number/Description
	EN-42385-50 Head/Main Bolt Thread Repair Kit

Illustration	Tool Number/Description
	EN-46330 Timing Belt Tensioner Retaining Pin

Illustration	Tool Number/Description
	EN-46999 Active Fuel Management Tester

Illustration	Tool Number/Description
	EN-46999-18 Active Fuel Management Tester Air Adapter

Illustration	Tool Number/Description
	EN-46999-20 Active Fuel Management Tester Harness - Small Block V8

Illustration	Tool Number/Description
	EN-47971 Oil Pressure Gauge Adapter

Illustration	Tool Number/Description
	EN-49245 Fuel Injection Seal Installer Sizer

Illustration	Tool Number/Description
	EN-51092 Fuel Pump Installation Gauge

Illustration	Tool Number/Description
	EN-51097 Injector Retaining Clip Installer

Illustration	Tool Number/Description
	EN-51105 Injector Seal Installer and Sizer

Illustration	Tool Number/Description
	EN-51267 Oil Pump Alignment Tool

Illustration	Tool Number/Description
	GE-02619-A J-02619-A Slide Hammer

Illustration	Tool Number/Description
	GE-6125-1B J-6125-1B Slide Hammer with Adapter

Illustration	Tool Number/Description
	GE-7872 J-7872 Magnetic Base Dial Indicator Set

Illustration	Tool Number/Description
	GE-8001 J-8001 Dial Indicator Set

Illustration	Tool Number/Description
	EN-8062 J-8062 Valve Spring Compressor - Head Off

Illustration	Tool Number/Description
	EN-8087 J-8087 Cylinder Bore Gauge

Illustration	Tool Number/Description
	EN-8089 J-8089 Carbon Removal Brush

Illustration	Tool Number/Description
	GE-8433 J-8433 Two Jaw Puller

Illustration	Tool Number/Description
	EN-8520 J-8520 Cam Lobe Lift Indicator

Illustration	Tool Number/Description
	EN-22738-B J-9666 Valve Spring Tester

Illustration	Tool Number/Description
	DT-21366 J-21366 Converter Holding Strap

Illustration	Tool Number/Description
	GE-21867-A J-21867-A Pressure Gauge

Illustration	Tool Number/Description
	J-21867-850 Oil Pressure Adapter

Illustration	Tool Number/Description
	GE-2307-1 J-23907-1 Slide Hammer with Bearing Adapter

Illustration	Tool Number/Description
	EN-24270 J-24270 Cylinder Bore Ridge Reamer

Illustration	Tool Number/Description
	EN-28410 J-28410 Gasket Remover

Illustration	Tool Number/Description
	GE-42220 J-28428-E High-Intensity Black Light Kit

Illustration	Tool Number/Description
	EN-33049 J-33049 Camshaft Bearing Service Set

Illustration	Tool Number/Description
	EN-35667-A J-35667-A Cylinder Head Leakdown Tester

Illustration	Tool Number/Description
	EN-38606 J-38606 Valve Spring Compressor

Illustration	Tool Number/Description
	EN-41478-A Crankshaft Front Oil Seal Installer

Illustration	Tool Number/Description
	EN-41479-B J-41479-B Crankshaft Rear Oil Seal Installer

Illustration	Tool Number/Description
	EN-41479-2A J-41479-2A Crankshaft Rear Oil Seal Installation Guide

Illustration	Tool Number/Description
	EN-41479-10 J-41479-10 Crankshaft Rear Oil Seal Installer Adapter

Illustration	Tool Number/Description
	EN-41556 J-41556 Connecting Rod Guide

Illustration	Tool Number/Description
	EN-41665-A J-41665-A J-41665 Crankshaft Balancer and Sprocket Installer

Illustration	Tool Number/Description
	EN-41816 J-41816 Crankshaft Balancer Remover

Illustration	Tool Number/Description
	EN-49102 J-41818 Crankshaft Bearing Cap Remover

Illustration	Tool Number/Description
	EN-42385-100 J-42385-100 Head/Main Bolt Thread Repair Kit

Illustration	Tool Number/Description
	EN-42385-200 J-42385-200 Common Thread Repair Kit

Illustration	Tool Number/Description
	EN-42385-300 J-42385-300 Fixtures and Hardware Kit

Illustration	Tool Number/Description
	EN-42386-A J-42386-A Flywheel Holding Tool

Illustration	Tool Number/Description
	EN-43690-A J-43690-A Rod Bearing Clearance Checking Tool

Illustration	Tool Number/Description
	EN-45059 J-45059 Angle Meter

Illustration	Tool Number/Description
	EN-45299 J-45299 Engine Preluber

Illustration	Tool Number/Description
	CH-48027 Digital Pressure Gauge

Illustration	Tool Number/Description
	EN-46745 J-46354 Piston Pin Clip Remover/Installer

Illustration	Tool Number/Description
	EN-47909 Injector Bore and Sleeve Cleaning Kit

Illustration	Tool Number/Description
	EN-49248 Injector Rail Assembly Remover

Illustration	Tool Number/Description
	EN-51091 Crankshaft Front Oil Seal Installer

Illustration	Tool Number/Description
	EN-51096 Rear Main Seal Remover

Illustration	Tool Number/Description
	EN-36857 J-36857 Engine Lift Bracket

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SPECIFICATIONS

FASTENER SPECIFICATIONS

Application	Specification	
	Metric	English
Catalytic Converter to Exhaust Manifold Fasteners (L83, L86, L96)	50 N.m	37 lb ft
Exhaust Manifold Fasteners (L83, L86)		
• Installing to existing cylinder head	23 N.m	17 lb ft
• Installing to NEW cylinder head	27 N.m	20 lb ft
Exhaust Manifold Fasteners (L96)		
• First pass	15 N.m	11 lb ft
• Second Pass	20 N.m	15 lb ft
Exhaust Manifold Heat Shield Fasteners (L83, L86, L96)	10 N.m	89 lb in
Exhaust Manifold Stud (L83, L86, L96)	10 N.m	89 lb in
Exhaust Muffler Pipe Clamp Nut (L83, L86, L96)	30 N.m	22 lb ft
Front Body Exhaust Heat Shield Fastener (L83, L86, L96)	9 N.m	80 lb in
Rear Body Exhaust Heat Shield Fastener (L83, L86, L96)	9 N.m	80 lb in

DIAGNOSTIC INFORMATION AND PROCEDURES

SYMPTOMS - ENGINE EXHAUST

- Review the exhaust system description in order to familiarize yourself with the exhaust system components and the intended function of the components.

- All diagnostics on a vehicle should follow a logical process. Strategy Based Diagnostics is a uniform approach for repairing all systems. The diagnostic flow is the place to start when repairs are necessary and may always be used in order to resolve a system problem. For a detailed explanation, refer to **Strategy Based Diagnosis** .

Visual/Physical Inspection

- Inspect for aftermarket or non-OEM devices such as, but not limited to; tailpipe extensions, headers, and exhaust cutouts. Any aftermarket exhaust system devices could affect the operation and proper performance of the exhaust system.
- Verify the exact operating conditions under which the concern exists. Note factors such as engine RPM, engine temperature, engine load, and frequency of concern.
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause any symptom.

Intermittent

Test the vehicle under the same conditions that the customer reported in order to verify the system is operating as designed.

Symptom List

Refer to a symptom diagnostic procedure from the following list in order to diagnose the symptom:

- Loss of power

  Refer to **Restricted Exhaust**

- Poor acceleration

  Refer to **Restricted Exhaust**

- Poor fuel economy

  Refer to **Restricted Exhaust**

- Excessive smoke diesel

  Refer to **Restricted Exhaust**

- Exhaust hissing noise

  Refer to **Exhaust Leakage**

- Exhaust popping noise

  Refer to **Exhaust Leakage**

- Exhaust rattle noise

  Refer to **Exhaust Noise**

- Loud exhaust noise

  Refer to **Exhaust Noise**

- Exhaust buzz, groan, hum noise

  Refer to **Exhaust Noise**

RESTRICTED EXHAUST

- Review the exhaust system description in order to familiarize yourself with the exhaust system components and the intended function of the components.
- All diagnostics on a vehicle should follow a logical process. Strategy Based Diagnostics is a uniform approach for repairing all systems. The diagnostic flow is the place to start when repairs are necessary and may always be used in order to resolve a system problem. For a detailed explanation, refer to **Strategy Based Diagnosis** .

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- Inspect for aftermarket or non-OEM devices such as, but not limited to; tailpipe extensions, headers, and exhaust cutouts. Any aftermarket exhaust system devices could affect the operation and proper performance of the exhaust system.
- Verify the exact operating conditions under which the concern exists. Note factors such as engine RPM, engine temperature, engine load, and frequency of concern.
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause any symptom.

Intermittent

Test the vehicle under the same conditions that the customer reported in order to verify the system is operating as designed.

Symptom List

Refer to a symptom diagnostic procedure from the following list in order to diagnose the symptom:

- Loss of power

  Refer to **Restricted Exhaust**

- Poor acceleration

  Refer to **Restricted Exhaust**

- Poor fuel economy

  Refer to **Restricted Exhaust**

- Excessive smoke diesel

  Refer to **Restricted Exhaust**

- Exhaust hissing noise

  Refer to **Exhaust Leakage**

- Exhaust popping noise

  Refer to **Exhaust Leakage**

- Exhaust rattle noise

  Refer to **Exhaust Noise**

- Loud exhaust noise

  Refer to **Exhaust Noise**

- Exhaust buzz, groan, hum noise

  Refer to **Exhaust Noise**

EXHAUST LEAKAGE

Problem	Action
WARNING: **While engine is operating, the exhaust system will become extremely hot. To prevent burns avoid contacting a hot exhaust system.** DEFINITION: An exhaust leak may show stains at the area of the leak. The leak may be felt by holding a hand close to the suspected areas or using a smoke pencil. The leak may make a popping or hissing noise.Refer to **Symptoms - Engine Exhaust** prior to beginning this table.	
Misaligned or improperly installed exhaust system components	• Align and tighten the exhaust system components to the specifications. Refer to **Fastener Specifications**. • Ensure the exhaust hangers are in the proper locations and not loose.
Exhaust leaks at the following connections: • Exhaust manifold to pipe • Flanges • Pipe clamps	Tighten the components to the specifications. Refer to **Fastener Specifications**.
Seals or gaskets leaking • Exhaust manifold to cylinder head • Exhaust pipes to exhaust manifold • Catalytic converter connection • EGR connections • AIR connections to the exhaust	Replace the leaking seal or gasket. Refer to the affected components procedure for service.

Problem	Action
manifold or cylinder head	
Irregularities at the mating surfaces on the flange connections	Repair as required or replace the affected component. Refer to the affected components procedure for service.
Exhaust manifold cracked or broken	Replace the exhaust manifold. Refer to the affected component's procedure for service.
Exhaust system component connection welds leaking	Replace the leaking component. Refer to the affected component's procedure for service.
Muffler or resonator (if equipped) damaged or leaking at the seams	Replace the affected muffler or resonator. Refer to the affected component's procedure for service.

EXHAUST NOISE

Condition	Action
WARNING: **While engine is operating, the exhaust system will become extremely hot. To prevent burns avoid contacting a hot exhaust system.** DEFINITION: An audible or physical noise due to a faulty component or damaged components causing a loose or misaligned exhaust system resulting in a rattle or vibration noise, i.e. buzz, groan, hum.Refer to **Symptoms - Engine Exhaust** prior to beginning this table.	
Popping or hissing noise	Exhaust leak. Refer to **Exhaust Leakage**.
Loud exhaust	1. Compare to a known good vehicle. 2. Inspect for a damaged or failed muffler. 3. Repair or replace the affected component. Refer to the affected

Condition	Action
	component's service procedure.
External rattle or vibration noise	1. Inspect for a bent or loose hanger, loose heat shield, or loose clamp. 2. Inspect for an exhaust pipe causing interference. 3. Repair or replace the affected component. Refer to the affected component's service procedure.
Internal rattle	1. Test the components by tapping with a rubber mallet to confirm a rattle. 2. Repair or replace the affected component. Refer to the affected component's service procedure.

REPAIR INSTRUCTIONS

EXHAUST MANIFOLD REPLACEMENT - LEFT SIDE (L83, L86)

Fig. 1: Exhaust Manifold - Left Side (L83, L86)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
WARNING: **Refer to Hot Exhaust System Warning** **Preliminary Procedure** 1. Refer to **Intermediate Steering Shaft Replacement** 2. Disconnect the spark plug wire at the spark plug.	

Callout	Component Name
3. Remove Oil Level Indicator Tube. Refer to **Oil Level Indicator Tube Replacement** 4. Remove Front Wheelhouse Liner. Refer to **Front Wheelhouse Liner Replacement - Left Side (Cadillac)** **Front Wheelhouse Liner Replacement - Left Side (GMC)** **Front Wheelhouse Liner Replacement - Left Side (Chevrolet)** 5. Remove Exhaust Manifold Heat Shield. Refer to **Exhaust Manifold Heat Shield Replacement - Left Side (L83, L86)** 6. Disconnect Three-Way Catalytic Converter. Refer to **Three-Way Catalytic Converter Replacement**	
1	Exhaust Manifold Fastener (Qty: 5) **CAUTION:** **Refer to** **Fastener** **Caution .** • When installing exhaust manifold to the existing cylinder head: **Tighten** 23 N.m (17 lb ft) • When installing exhaust manifold to a NEW cylinder head: **Tighten** 27 N.m (20 lb ft)
2	Gasket
3	Exhaust Manifold **Procedure** Install a NEW exhaust manifold gasket.

EXHAUST MANIFOLD REPLACEMENT - LEFT SIDE (L96)

Removal Procedure

WARNING: **Refer to Hot Exhaust System Warning**

1. Remove Spark Plugs. Refer to **Spark Plug Replacement**
2. Disconnect Three-Way Catalytic Converter @ Exhaust Manifold. Refer to **Three-Way Catalytic Converter Replacement**

Fig. 2: Exhaust Manifold Fasteners
Courtesy of GENERAL MOTORS COMPANY

3. Remove Exhaust Manifold Fastener (1) (Qty: 6)

Fig. 3: Exhaust Manifold And Gasket
Courtesy of GENERAL MOTORS COMPANY

4. Remove Exhaust Manifold (1)

5. Remove and DISCARD Exhaust Manifold Gasket (2)

Fig. 4: Exhaust Manifold Heat Shield And Bolts
Courtesy of GENERAL MOTORS COMPANY

6. Remove Exhaust Manifold Heat Shield Bolt (1) (Qty: 5)

7. Remove Exhaust Manifold Heat Shield (2)

Installation Procedure

1. Clean the exhaust manifold sealing surface.

Fig. 5: Exhaust Manifold Heat Shield And Bolts

Courtesy of GENERAL MOTORS COMPANY

2. Install Exhaust Manifold Heat Shield (2)

CAUTION: Refer to Fastener Caution .

3. Install and tighten Exhaust Manifold Heat Shield Bolt (1) (Qty: 5) to 10 N.m (89 lb in)

Fig. 6: Exhaust Manifold And Gasket
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Install a NEW exhaust manifold gasket.**

4. Install Exhaust Manifold Gasket (2)

5. Install Exhaust Manifold (1)

Fig. 7: Exhaust Manifold Fasteners
Courtesy of GENERAL MOTORS COMPANY

6. Tighten Exhaust Manifold Fastener (1) in sequence (Qty: 6)

1. Tighten the exhaust manifold bolts a first pass to 15 N.m (11 lb ft). Tighten the exhaust manifold bolts beginning with the center 2 bolts. Alternate from side-to-side, and work toward the outside bolts.
2. Tighten the exhaust manifold bolts a final pass to 20 N.m (15 lb ft). Tighten the exhaust manifold bolts beginning with the center 2 bolts. Alternate from side-to-side, and work toward the outside bolts.

7. Connect Three-Way Catalytic Converter @ Exhaust Manifold. Refer to **Three-Way Catalytic Converter Replacement**
8. Install Spark Plugs. Refer to **Spark Plug Replacement**

EXHAUST MANIFOLD REPLACEMENT - RIGHT SIDE (L83, L86)

Removal Procedure

WARNING: Refer to Hot Exhaust System Warning

1. Remove Valve Rocker Arm Cover Insulator - Right Side. Refer to **Valve Rocker Arm Cover Insulator Replacement - Right Side**
Â»Remove

Fig. 8: Heater Inlet and Outlet Hose Bracket Bolt
Courtesy of GENERAL MOTORS COMPANY

2. Remove Heater Inlet and Outlet Hose Bracket Bolt (1)
3. Reposition Heater Inlet and Outlet Hose Bracket (2)

Fig. 9: Air Conditioning Evaporator Hose Bracket Bolt
Courtesy of GENERAL MOTORS COMPANY

4. Remove Air Conditioning Evaporator Hose Bracket Bolt (1) @ Generator Bracket
5. Reposition Air Conditioning Evaporator Hose Bracket (2)
6. Disconnect the spark plug wire at the spark plug.

7. Remove Front Wheelhouse Liner. Refer to **Front Wheelhouse Liner Replacement - Right Side (Cadillac)** **Front Wheelhouse Liner Replacement - Right Side (Chevrolet)** **Front Wheelhouse Liner Replacement - Right Side (GMC)**
8. Remove Three-Way Catalytic Converter. Refer to **Three-Way Catalytic Converter Replacement**

Fig. 10: Exhaust Manifold - Right Side (L83, L86)
Courtesy of GENERAL MOTORS COMPANY

9. Remove Exhaust Manifold Fastener (1) (Qty: 5)
10. Remove Exhaust Manifold (3)
11. Remove and DISCARD Gasket (2)
12. Remove Exhaust Manifold Heat Shield. Refer to **Exhaust Manifold Heat Shield Replacement - Right Side (L83, L86)**

Installation Procedure

1. Install Exhaust Manifold Heat Shield - Right Side. Refer to **Exhaust Manifold Heat Shield Replacement - Right Side (L83, L86)**

Fig. 11: Exhaust Manifold - Right Side (L83, L86)
Courtesy of GENERAL MOTORS COMPANY

2. Install a NEW exhaust manifold gasket. (2)
3. Install Exhaust Manifold (3)

CAUTION: Refer to Fastener Caution .

4. Install Exhaust Manifold Fastener (1) (Qty: 5)
   - When installing exhaust manifold to the existing cylinder head:

     Tighten

23 N.m (17 lb ft)

- When installing exhaust manifold to a NEW cylinder head:

  Tighten

  27 N.m (20 lb ft)

5. Install Three-Way Catalytic Converter. Refer to **Three-Way Catalytic Converter Replacement**
6. Install Front Wheelhouse Liner. Refer to **Front Wheelhouse Liner Replacement - Right Side (Cadillac)** **Front Wheelhouse Liner Replacement - Right Side (Chevrolet)** **Front Wheelhouse Liner Replacement - Right Side (GMC)**
7. Install the spark plug wire to the spark plug.

Fig. 12: Air Conditioning Evaporator Hose Bracket Bolt
Courtesy of GENERAL MOTORS COMPANY

8. Install Air Conditioning Evaporator Hose Bracket (2)
9. Install and tighten Air Conditioning Evaporator Hose Bracket Bolt (1) @ Generator Bracket to 22 N.m (16 lb ft)

Fig. 13: Heater Inlet and Outlet Hose Bracket Bolt
Courtesy of GENERAL MOTORS COMPANY

10. Install Heater Inlet and Outlet Hose Bracket (2)
11. Install and tighten Heater Inlet and Outlet Hose Bracket Bolt (1) to 9 N.m (80 lb in)
12. Install Valve Rocker Arm Cover Insulator. Refer to **Valve Rocker Arm Cover Insulator Replacement - Right Side**

EXHAUST MANIFOLD REPLACEMENT - RIGHT SIDE (L96)

Removal Procedure

WARNING: Refer to Hot Exhaust System Warning

1. Remove Spark Plugs. Refer to **Spark Plug Replacement**
2. Remove Oil Level Indicator Tube. Refer to **Oil Level Indicator Tube Replacement**
3. Disconnect Three-Way Catalytic Converter @ Exhaust Manifold. Refer to **Three-Way Catalytic Converter Replacement**

Fig. 14: Exhaust Manifold Fasteners
Courtesy of GENERAL MOTORS COMPANY

4. Remove Exhaust Manifold Fastener (1) (Qty: 6)

Fig. 15: Exhaust Manifold And Gasket
Courtesy of GENERAL MOTORS COMPANY

5. Remove Exhaust Manifold (2)
6. Remove and DISCARD Exhaust Manifold Gasket (1)

Fig. 16: Exhaust Manifold Heat Shield And Bolts
Courtesy of GENERAL MOTORS COMPANY

7. Remove Exhaust Manifold Heat Shield Bolt (1) (Qty: 6)
8. Remove Exhaust Manifold Heat Shield (2)

Installation Procedure

1. Clean the exhaust manifold sealing surface.

Fig. 17: Exhaust Manifold Heat Shield And Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Install Exhaust Manifold Heat Shield (2)

CAUTION: Refer to Fastener Caution .

3. Install and tighten Exhaust Manifold Heat Shield Bolt (1) (Qty: 6) to 10 N.m (89 lb in)

Fig. 18: Exhaust Manifold And Gasket
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Install a NEW exhaust manifold gasket.**

4. Install Exhaust Manifold Gasket (1)
5. Install Exhaust Manifold (2)

Fig. 19: Exhaust Manifold Fasteners
Courtesy of GENERAL MOTORS COMPANY

6. Tighten Exhaust Manifold Fastener (1) in sequence (Qty: 6)
    1. Tighten the exhaust manifold bolts a first pass to 15 N.m (11 lb ft). Tighten the exhaust manifold bolts beginning with the center 2 bolts. Alternate from side-to-side, and work toward the outside bolts.

2. Tighten the exhaust manifold bolts a final pass to 20 N.m (15 lb ft). Tighten the exhaust manifold bolts beginning with the center 2 bolts. Alternate from side-to-side, and work toward the outside bolts.

7. Connect Three-Way Catalytic Converter @ Exhaust Manifold. Refer to **Three-Way Catalytic Converter Replacement**
8. Install Oil Level Indicator Tube. Refer to **Oil Level Indicator Tube Replacement**
9. Install Spark Plugs. Refer to **Spark Plug Replacement**

EXHAUST SEAL REPLACEMENT (L83, L86)

Removal Procedure

WARNING: Refer to Exhaust Service Warning .

WARNING: Refer to Eye Protection Warning .

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

Fig. 20: Front U-joint Yoke Retainer Bolts And Front Axle Propeller Shaft

Courtesy of GENERAL MOTORS COMPANY

2. If equipped with 4WD, remove the front U-joint yoke retainer bolts (1) of the front axle propeller shaft (2) and reposition the propeller shaft. Refer to **Front Axle Propeller Shaft Replacement (NPO)** **Front Axle Propeller Shaft Replacement (NQH)** **Front Axle Propeller Shaft Replacement (Heavy Duty)** .
3. Disconnect the heated oxygen sensor bank 1 sensor 1. Refer to **Heated Oxygen Sensor Replacement - Bank 1 Sensor 1** .
4. Disconnect the heated oxygen sensor bank 1 sensor 2. Refer to **Heated Oxygen Sensor Replacement - Bank 1 Sensor 2** .
5. Disconnect the heated oxygen sensor bank 2 sensor 1. Refer to **Heated Oxygen Sensor Replacement - Bank 2 Sensor 1** .
6. Disconnect the heated oxygen sensor bank 2 sensor 2. Refer to **Heated Oxygen Sensor Replacement - Bank 2 Sensor 2** .
7. Remove the transmission support cross member. Refer to **Transmission Support Crossmember Replacement (2WD)** **Transmission Support Crossmember Replacement (4WD)** .

Fig. 21: Exhaust Front Pipe
Courtesy of GENERAL MOTORS COMPANY

8. Loosen the exhaust muffler clamp fastener (1) and detach the exhaust front pipe (2) from the exhaust muffler.
9. Support the exhaust front pipe (2) with mechanics wire.

Fig. 22: Exhaust Front Pipe Right Catalytic Converter Fasteners
Courtesy of GENERAL MOTORS COMPANY

10. Remove the exhaust front pipe right catalytic converter fasteners (1) and if necessary, remove the exhaust manifold studs (2).
11. Remove the right catalytic converter (5), from the right exhaust manifold (4), and discard the exhaust manifold seal (3).

Fig. 23: Exhaust Front Pipe Left Catalytic Converter Fasteners
Courtesy of GENERAL MOTORS COMPANY

12. Remove the exhaust front pipe left catalytic converter fasteners (1) and if necessary, remove the left exhaust manifold studs (2).
13. Remove the left catalytic converter (5), from the left exhaust manifold (4), and discard the exhaust manifold seal (3).

Fig. 24: Exhaust Front Pipe
Courtesy of GENERAL MOTORS COMPANY

NOTE: **If replacing the exhaust front pipe, transfer the heated oxygen sensors to the NEW exhaust front pipe.**

14. Lower the exhaust front pipe (2) to the floor.

Installation Procedure

Fig. 25: Exhaust Front Pipe
Courtesy of GENERAL MOTORS COMPANY

1. Install the exhaust front pipe (2) into position.

Fig. 26: Exhaust Front Pipe Right Catalytic Converter Fasteners
Courtesy of GENERAL MOTORS COMPANY

2. Install the exhaust front pipe right catalytic converter (5) to the right exhaust manifold (4) with a NEW seal (3.).

CAUTION: Refer to Fastener Caution .

3. Install the exhaust manifold studs and tighten to 10 N.m (89 lb in).

4. Install the right catalytic converter fasteners (1) and tighten to 50 N.m (37 lb ft).

Fig. 27: Exhaust Front Pipe Left Catalytic Converter Fasteners
Courtesy of GENERAL MOTORS COMPANY

5. Install the exhaust front pipe left catalytic converter (5) to the left exhaust manifold (4) with a NEW seal (3).
6. Install the exhaust manifold studs (2) and tighten to 10 N.m (89 lb in).
7. Install the left catalytic converter fasteners (1) and tighten to 50 N.m (37 lb ft).

Fig. 28: Exhaust Front Pipe
Courtesy of GENERAL MOTORS COMPANY

8. Install the exhaust front pipe (2) into the exhaust muffler and tighten the exhaust clamp (1) to 30 N.m (22 lb ft).
9. Install the transmission support cross member. Refer to **Transmission Support Crossmember Replacement (2WD)** **Transmission Support Crossmember Replacement (4WD)** .
10. Connect the heated oxygen sensor bank 1 sensor 1. Refer to **Heated Oxygen Sensor Replacement - Bank 1 Sensor 1** .

11. Connect the heated oxygen sensor bank 1 sensor 2. Refer to **Heated Oxygen Sensor Replacement - Bank 1 Sensor 2** .
12. Connect the heated oxygen sensor bank 2 sensor 1. Refer to **Heated Oxygen Sensor Replacement - Bank 2 Sensor 1** .
13. Connect the heated oxygen sensor bank 2 sensor 2. Refer to **Heated Oxygen Sensor Replacement - Bank 2 Sensor 2** .

Fig. 29: Front U-joint Yoke Retainer Bolts And Front Axle Propeller Shaft
Courtesy of GENERAL MOTORS COMPANY

14. If equipped with 4WD, install the front axle propeller shaft (2) and tighten the U-joint yoke retainer bolts (1) to 25 N.m (18 lb ft). Refer to **Front Axle Propeller Shaft Replacement (NPO)** **Front Axle Propeller Shaft Replacement (NQH)** **Front Axle Propeller Shaft Replacement (Heavy Duty)** .
15. Start the engine and check for exhaust leaks.

EXHAUST SEAL REPLACEMENT (L96)

Removal Procedure

WARNING: Refer to Exhaust Service Warning

WARNING: Refer to Hot Exhaust System Warning

1. Disconnect the heated oxygen sensor (HO2S). Refer to the following:
   - **Heated Oxygen Sensor Replacement - Bank 1 Sensor 1**
   - **Heated Oxygen Sensor Replacement - Bank 1 Sensor 2**
   - **Heated Oxygen Sensor Replacement - Bank 2 Sensor 1**
   - **Heated Oxygen Sensor Replacement - Bank 2 Sensor 2**
2. Support the transmission with a suitable transmission jack.
3. Remove the transmission support crossmember. Refer to **Transmission Support Crossmember Replacement (2WD)** **Transmission Support Crossmember Replacement (4WD)**

Fig. 30: Exhaust Manifold Pipe Nuts
Courtesy of GENERAL MOTORS COMPANY

4. Remove the exhaust muffler to exhaust manifold pipe nuts (1).

Fig. 31: Exhaust Manifold Nuts And Seal
Courtesy of GENERAL MOTORS COMPANY

5. Remove the exhaust manifold pipe to exhaust manifold nuts (1) and replace the seal (2) with a NEW one.

Fig. 32: Catalytic Converter And Nuts
Courtesy of GENERAL MOTORS COMPANY

6. Remove the right catalytic converter (3) from the exhaust manifold studs with the nuts (1).

Installation Procedure

Fig. 33: Exhaust Manifold Nuts And Seal
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

1. Install a NEW seal (2) to the left manifold exhaust pipe. Tighten the nuts (1) to 50 N.m (37 lb ft)

Fig. 34: Catalytic Converter And Nuts
Courtesy of GENERAL MOTORS COMPANY

2. Inspect the seal (2) and replace if worn or damaged.
3. Install the right catalytic converter to the exhaust manifold with nuts (1) and tighten to 50 N.m (37 lb ft).

Fig. 35: Exhaust Manifold Pipe Nuts
Courtesy of GENERAL MOTORS COMPANY

4. Install the exhaust muffler to catalytic converter (2) with nuts (1) and tighten to 45 N.m (33 lb ft).
5. Install the transmission support crossmember. Refer to **Transmission Support Crossmember Replacement (2WD)** **Transmission Support Crossmember Replacement (4WD)**
6. Remove the support from the transmission.

7. Connect the HO2S sensors. Refer to the following:
    - **Heated Oxygen Sensor Replacement - Bank 1 Sensor 1**
    - **Heated Oxygen Sensor Replacement - Bank 1 Sensor 2**
    - **Heated Oxygen Sensor Replacement - Bank 2 Sensor 1**
    - **Heated Oxygen Sensor Replacement - Bank 2 Sensor 2**
8. Start the engine and check the front exhaust system for leaks.

THREE-WAY CATALYTIC CONVERTER REPLACEMENT

Removal Procedure

WARNING: Refer to Exhaust Service Warning .

WARNING: Refer to Eye Protection Warning .

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

Fig. 36: Front U-joint Yoke Retainer Bolts And Front Axle Propeller Shaft
Courtesy of GENERAL MOTORS COMPANY

2. If equipped with 4WD, remove the front U-joint yoke retainer bolts (1) of the front axle propeller shaft (2) and reposition the propeller shaft. Refer to **Front Axle Propeller Shaft Replacement (NPO)** **Front Axle Propeller Shaft Replacement (NQH)** **Front Axle Propeller Shaft Replacement (Heavy Duty)** .
3. Disconnect the heated oxygen sensor bank 1 sensor 1. Refer to **Heated Oxygen Sensor Replacement - Bank 1 Sensor 1** .
4. Disconnect the heated oxygen sensor bank 1 sensor 2. Refer to **Heated Oxygen Sensor Replacement - Bank 1 Sensor 2** .
5. Disconnect the heated oxygen sensor bank 2 sensor 1. Refer to **Heated Oxygen Sensor Replacement - Bank 2 Sensor 1** .
6. Disconnect the heated oxygen sensor bank 2 sensor 2. Refer to **Heated Oxygen Sensor Replacement - Bank 2 Sensor 2** .
7. Remove the transmission support cross member. Refer to **Transmission Support Crossmember Replacement (2WD)** **Transmission Support Crossmember Replacement (4WD)** .

Fig. 37: Exhaust Front Pipe
Courtesy of GENERAL MOTORS COMPANY

8. Loosen the exhaust muffler clamp fastener (1) and detach the exhaust front pipe (2) from the exhaust muffler.
9. Support the exhaust front pipe (2) with mechanics wire.

Fig. 38: Exhaust Front Pipe Right Catalytic Converter Fasteners
Courtesy of GENERAL MOTORS COMPANY

10. Remove the exhaust front pipe right catalytic converter fasteners (1) and if necessary, remove the exhaust manifold studs (2).
11. Remove the right catalytic converter (5), from the right exhaust manifold (4), and discard the exhaust manifold seal (3).

Fig. 39: Exhaust Front Pipe Left Catalytic Converter Fasteners
Courtesy of GENERAL MOTORS COMPANY

12. Remove the exhaust front pipe left catalytic converter fasteners (1) and if necessary, remove the left exhaust manifold studs (2).
13. Remove the left catalytic converter (5), from the left exhaust manifold (4), and discard the exhaust manifold seal (3).

Fig. 40: Exhaust Front Pipe
Courtesy of GENERAL MOTORS COMPANY

NOTE: **If replacing the exhaust front pipe, transfer the heated oxygen sensors to the NEW exhaust front pipe.**

14. Lower the exhaust front pipe (2) to the floor.

Installation Procedure

Fig. 41: Exhaust Front Pipe
Courtesy of GENERAL MOTORS COMPANY

1. Install the exhaust front pipe (2) into position.

Fig. 42: Exhaust Front Pipe Right Catalytic Converter Fasteners
Courtesy of GENERAL MOTORS COMPANY

2. Install the exhaust front pipe right catalytic converter (5) to the right exhaust manifold (4) with a NEW seal (3.).

CAUTION: Refer to Fastener Caution .

3. Install the exhaust manifold studs and tighten to 10 N.m (89 lb in).

4. Install the right catalytic converter fasteners (1) and tighten to 50 N.m (37 lb ft).

Fig. 43: Exhaust Front Pipe Left Catalytic Converter Fasteners
Courtesy of GENERAL MOTORS COMPANY

5. Install the exhaust front pipe left catalytic converter (5) to the left exhaust manifold (4) with a NEW seal (3).
6. Install the exhaust manifold studs (2) and tighten to 10 N.m (89 lb in).
7. Install the left catalytic converter fasteners (1) and tighten to 50 N.m (37 lb ft).

Fig. 44: Exhaust Front Pipe
Courtesy of GENERAL MOTORS COMPANY

8. Install the exhaust front pipe (2) into the exhaust muffler and tighten the exhaust clamp (1) to 30 N.m (22 lb ft).
9. Install the transmission support cross member. Refer to **Transmission Support Crossmember Replacement (2WD)** **Transmission Support Crossmember Replacement (4WD)** .
10. Connect the heated oxygen sensor bank 1 sensor 1. Refer to **Heated Oxygen Sensor Replacement - Bank 1 Sensor 1** .

11. Connect the heated oxygen sensor bank 1 sensor 2. Refer to **Heated Oxygen Sensor Replacement - Bank 1 Sensor 2** .
12. Connect the heated oxygen sensor bank 2 sensor 1. Refer to **Heated Oxygen Sensor Replacement - Bank 2 Sensor 1** .
13. Connect the heated oxygen sensor bank 2 sensor 2. Refer to **Heated Oxygen Sensor Replacement - Bank 2 Sensor 2** .

Fig. 45: Front U-joint Yoke Retainer Bolts And Front Axle Propeller Shaft
Courtesy of GENERAL MOTORS COMPANY

14. If equipped with 4WD, install the front axle propeller shaft (2) and tighten the U-joint yoke retainer bolts (1) to 25 N.m (18 lb ft). Refer to **Front Axle Propeller Shaft Replacement (NPO)** **Front Axle Propeller Shaft Replacement (NQH)** **Front Axle Propeller Shaft Replacement (Heavy Duty)** .
15. Start the engine and check for exhaust leaks.

EXHAUST MUFFLER WITH RESONATOR, EXHAUST, AND TAIL PIPE REPLACEMENT

Fig. 46: Exhaust Muffler with Resonator, Exhaust, and Tail Pipe
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure 1. Remove Rear Suspension Lateral Link. Refer to **Rear Suspension Lateral Link Replacement** 2. Remove Spare Wheel Hoist. Refer to **Spare Wheel Hoist Replacement** 3. Remove Spare Wheel Heat Shield. refer to **Spare Wheel Heat Shield Replacement**	
1	Exhaust Muffler Clamp Fastener **WARNING:**

Callout	Component Name
	Refer to Hot Exhaust System Warning . **WARNING:** **Refer to Eye Protection Warning .** **CAUTION:** **Refer to Fastener Caution .** **Tighten** 30 N.m (22 lb ft)
2	Exhaust Muffler Isolator (Qty: 4) **NOTE:** **Clean and lubricate the exhaust isolators for ease of installation.**
3	Exhaust Muffler **Procedure** With the aid of an assistant, lower the exhaust system from the vehicle.

INTERMEDIATE BODY EXHAUST HEAT SHIELD REPLACEMENT

Removal Procedure

1. Lower the exhaust muffler with resonator, exhaust, and tail pipe assembly, as required. Refer to **Exhaust Muffler with Resonator, Exhaust, and Tail Pipe Replacement**.
2. Remove the left front floor panel exhaust heat shield nuts and heat shield, as required.

Fig. 47: Floor Panel Exhaust Heat Shield Nuts And Heat Shields
Courtesy of GENERAL MOTORS COMPANY

3. If the vehicle is a Tahoe, Yukon, Yukon Denali, or a Escalade, remove the exhaust heat shield nuts and heat shields, as required.

Fig. 48: Floor Panel Exhaust Heat Shield Nuts & Heat Shields
Courtesy of GENERAL MOTORS COMPANY

4. If the vehicle is a Suburban, Yukon XL, Yukon Denali XL, Escalade ESV, Escalade EXT or a Avalanche, remove the exhaust heat shield nuts and heat shields, as required.

Fig. 49: Rear Floor Panel Exhaust Heat Shield Nuts And Heat Shield
Courtesy of GENERAL MOTORS COMPANY

5. Remove the rear floor panel exhaust heat shield nuts and heat shield, as required

Installation Procedure

Fig. 50: Rear Floor Panel Exhaust Heat Shield Nuts And Heat Shield
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

1. Position the rear floor panel exhaust heat shield to the studs and install the heat shield nuts and tighten to 9 N.m (80 lb in).

Fig. 51: Floor Panel Exhaust Heat Shield Nuts & Heat Shields
Courtesy of GENERAL MOTORS COMPANY

2. If the vehicle is a Suburban, Yukon XL, Yukon Denali XL, Escalade ESV, Escalade EXT or a Avalanche, position the exhaust heat shield to the studs and install the heat shield nuts, as required and tighten to 9 N.m (80 lb in).

Fig. 52: Floor Panel Exhaust Heat Shield Nuts And Heat Shields
Courtesy of GENERAL MOTORS COMPANY

3. If the vehicle is a Tahoe, Yukon, Yukon Denali, or a Escalade, position the exhaust heat shield to the studs and install the heat shield nuts, as required and tighten to 9 N.m (80 lb in).

Fig. 53: Left Front Floor Panel Exhaust Heat Shield Nuts And Heat Shield
Courtesy of GENERAL MOTORS COMPANY

4. Position the left front floor panel exhaust heat shield to the studs and install the heat shield nuts and tighten to 9 N.m (80 lb in).
5. Install the exhaust muffler with resonator, exhaust, and tail pipe assembly, as required. Refer to **Exhaust Muffler with Resonator, Exhaust, and Tail Pipe Replacement**.

FRONT BODY EXHAUST HEAT SHIELD REPLACEMENT

Fig. 54: Front Body Exhaust Heat Shield
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .	
1	Front Body Exhaust Heat Shield Fasteners (Qty: 6) **WARNING:** **Refer to Hot Exhaust System Warning .**

Callout	Component Name
	CAUTION: **Refer to Fastener Caution .** Tighten 9 N.m (80 lb in)
2	Front Body Exhaust Heat Shield

EXHAUST MANIFOLD HEAT SHIELD REPLACEMENT - RIGHT SIDE (L83, L86)

Fig. 55: Exhaust Manifold Heat Shield - Right Side (L83, L86)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Callout	Component Name
Preliminary Procedure Reposition the heater inlet and outlet hoses from the retaining bracket.	
1	Exhaust Manifold Heat Shield - Right Fasteners (Qty: 3) **WARNING:** **Refer to Hot Exhaust System Warning .** **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
2	Exhaust Manifold Heat Shield - Right

EXHAUST MANIFOLD HEAT SHIELD REPLACEMENT - RIGHT SIDE (L96)

Fig. 56: Exhaust Manifold Heat Shield - Right Side (L96)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure **WARNING:** **Refer to Hot Exhaust System Warning .** 1. Reposition the heater hose, and secure hose away from exhaust manifold heat shield.	

Callout	Component Name
1	Exhaust Manifold Heat Shield Bolt (Qty: 6) **CAUTION:** **Refer to** **Fastener Caution .** **Tighten** 10 N.m (89 lb in)
2	Exhaust Manifold Heat Shield

EXHAUST MANIFOLD HEAT SHIELD REPLACEMENT - LEFT SIDE (L83, L86)

Fig. 57: Exhaust Manifold Heat Shield - Left Side (L83, L86)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Exhaust Manifold Heat Shield - Left Fasteners (Qty: 3) **WARNING:** **Refer to Hot Exhaust System Warning .** **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
2	Exhaust Manifold Heat Shield - Left

EXHAUST MANIFOLD HEAT SHIELD REPLACEMENT - LEFT SIDE (L96)

Fig. 58: Exhaust Manifold Heat Shield - Left Side (L96)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
WARNING: **Refer to Hot Exhaust System Warning .**	
1	Exhaust Manifold Heat Shield Bolt (Qty: 5) **CAUTION:** **Refer to**

Callout	Component Name
	Fastener Caution . **Tighten** 10 N.m (89 lb in)
2	Exhaust Manifold Heat Shield

DESCRIPTION AND OPERATION

EXHAUST SYSTEM DESCRIPTION

IMPORTANT: Use of non-OEM parts may cause driveability concerns.

The exhaust system carries exhaust gases, treated by the catalytic converter, through the muffler and into a resonator, if applicable where exhaust noise is lessened.

In order to secure the exhaust muffler assembly to the exhaust manifold, a flange and seal-joint coupling is utilized. The exhaust system may utilize a slip-joint coupling design with a clamp and a U-bolt or a flange connection with a gasket.

Exhaust hangers and rubber insulators help to support the weight of the exhaust system along with insulating any exhaust system vibration, rattle, or noise.

Exhaust hangers also space the exhaust system away from the underbody of the vehicle and allows the exhaust system to expand as the exhaust system warms up.

Exhaust heat shields are used to protect the underbody and other components from damage due to the heat from the exhaust system.

The exhaust system may be comprised of the following components:

- Catalytic converter
- Exhaust hanger
- Exhaust heat shield
- Exhaust insulator

- Exhaust manifold
- Exhaust muffler
- Exhaust pipe
- Exhaust resonator, if equipped
- Exhaust tail pipe, if equipped

Catalytic Converter

The catalytic converter is an emission control device added to the engine exhaust system in order to reduce hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NOx) pollutants from the exhaust gas.

The catalytic converter is comprised of a ceramic monolith substrate, supported in insulation and housed within a sheet metal shell. The substrate may be washcoated with 3 noble metals:

- Palladium (Pd)
- Platinum (Pt)
- Rhodium (Rh)

The catalyst in the converter is not serviceable.

Muffler

The exhaust muffler reduces the noise levels of the engine exhaust by the use of tuning tubes. The tuning tubes create channels inside the exhaust muffler that lower the sound levels created by the combustion of the engine.

Passive Exhaust Valve

Equipped on all Light Duty trucks, the passive valve, located rear of the muffler, acts as a broadband tuner in both V4 and V8 mode for a more refined sound.

Resonator

Some exhaust systems may be equipped with a resonator. The resonator, located either before or after the muffler, allows the use of mufflers with less back pressure. Resonators are used when vehicle characteristics require specific exhaust tuning.

SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS

Illustration	Tool Number/Description
	J 35314-A/BT-8515/BT-8515A Exhaust Back Pressure Tester

Illustration	Tool Number/Description
	J 38185 Hose Clamp Pliers

Illustration	Tool Number/Description
	J 44626 Oxygen Sensor Socket

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ENGINE

Maintenance and Lubrication - Escalade, Suburban, Tahoe, Yukon

SPECIFICATIONS

APPROXIMATE FLUID CAPACITIES

Maintenance Procedure	Link
Hydraulic Brake System Capacities	Approximate Fluid Capacities
Front Drive Axle Capacities	Approximate Fluid Capacities
Rear Drive Axle Capacities	Approximate Fluid Capacities
Engine Heating and Cooling Capacities	Approximate Fluid Capacities
HVAC Capacities	Approximate Fluid Capacities
Engine Controls and Fuel Capacities - 5.3L (L83) or 6.2L (L86)	Approximate Fluid Capacities
Engine Mechanical Capacities - 5.3L (L83) or 6.2L (L86)	Approximate Fluid Capacities
Automatic Transmission Fluid Capacities - 6L80 (MYC) or 6L90 (MYD)	Approximate Fluid Capacities
Automatic Transmission Fluid Capacities - 8L90 (M5U)	Approximate Fluid Capacities
Transfer Case Capacities - MP 3010 (NP0)	Approximate Fluid Capacities
Transfer Case Capacities - MP 3023/3024 (NQH)	Approximate Fluid Capacities

FLUID AND LUBRICANT RECOMMENDATIONS

Usage	Fluid/Lubricant
Engine Oil	The engine requires engine oil approved to the dexos™ specification. Oils meeting this specification can be identified with the dexos™ certification mark. Look for and use only an engine oil that displays the dexos™ certification mark of the proper viscosity grade. SAE 0W-20 GM P/N 19259487 (Canadian P/N 19289784) is the best viscosity grade for the 5.3L and 6.2L V8 engines.
Engine Coolant	50/50 mixture of clean, drinkable water and use only DEX-COOL Coolant.
Hydraulic Brake System	DOT 3 Hydraulic Brake Fluid (GM Part No. 19299818, in Canada 19299819).
Windshield Washer	Automotive windshield washer fluid that meets regional freeze protection requirements.
Automatic Transmission (6-Speed)	DEXRONÂ®-VI Automatic Transmission Fluid.

Usage	Fluid/Lubricant
Automatic Transmission (8-Speed)	DEXRONÂ®-HP Automatic Transmission Fluid. GM P/N 19300536 (Canadian P/N 19300537)
Key Lock Cylinders	Multi-Purpose Lubricant, Superlube (GM Part No. 12346241, in Canada 10953474).
Chassis Lubrication	Chassis Lubricant (GM Part No. 12377985, in Canada 88901242) or lubricant meeting requirements of NLGI #2, Category LB or GC-LB.
Front Axle -1500, 2500/3500 Series Vehicles with Four-Wheel Drive	SAE 75W-90 Synthetic Axle Lubricant (GM Part No. 88900401, in Canada 89021678).
Rear Axle HD/LD	SAE 75W-90 Synthetic Gear Oil (GM Part No. 88900401, in Canada 89021678) through 2013 model year for all 8.6/9.5 LD axles (or equivalent meeting GM specification 9986115) Use this fluid in 10.5/11.5 HD axles for all model years. Synthetic Gear Oil GM 19300457 (Canadian 19300458) 75W85 (or equivalent meeting GM specifications 9986375) for 2014 model year and newer 8.6/9.5/9.76 axles.
Transfer Case - Four-Wheel Drive	DEXRONÂ®-VI Automatic Transmission Fluid.
Front Axle Propshaft Spline or One-Piece Propshaft Spline (Two-Wheel Drive with Auto. Trans.)	Spline Lubricant, Special Lubricant (GM Part No. 19257121, in Canada 19257122).
Hood Hinges	Multi-Purpose Lubricant, Superlube (GM Part No. 12346241, in Canada 10953474).
Outer Tailgate Handle Pivot Points	Multi-Purpose Lubricant, Superlube (GM Part No. 12346241, in Canada 10953474).
Weatherstrip Conditioning	Weatherstrip Lubricant (GM Part No. 3634770, in Canada 10953518) or Dielectric Silicone Grease (GM Part No. 12345579, in Canada 10953481).
Weatherstrip Squeaks	Synthetic Grease with Teflon, Superlube (GM Part No. 12371287, in Canada 10953437).

MAINTENANCE ITEMS

Maintenance Procedure	Link
Approximate Fluid Capacities	**Approximate Fluid Capacities**
Fluid and Lubricant Recommendations	**Fluid and Lubricant Recommendations**
Maintenance Replacement Parts	**Maintenance Replacement Parts**
GM Oil Life System Resetting	**GM Oil Life System ResettingGM Oil Life System Resetting (With Scan Tool)**
Remote Control Door Lock Transmitter Learn	**Remote Control Door Lock Transmitter Learn (without BTM)** **Remote Control Door Lock Transmitter Learn (with BTM)**
Tire Rotation	**Tire Rotation**

Maintenance Procedure	Link
Tire Pressure Indicator Sensor Learn	Tire Pressure Indicator Sensor Learn
Passenger Compartment Air Filter Replacement	Passenger Compartment Air Filter Replacement (Utilities) Passenger Compartment Air Filter Replacement (Z75)
Brake Pad Inspection	Brake Pad Inspection
Cooling System Draining and Filling	Cooling System Draining and Filling (Static Fill L96) Cooling System Draining and Filling (Vac N Fill L96) Cooling System Draining and Filling (Vac N Fill L83 L86) Cooling System Draining and Filling (Static Fill L83 L86)
Hydraulic Brake System Bleeding	Hydraulic Brake System Bleeding (Pressure) Hydraulic Brake System Bleeding (Manual)
Air Cleaner Element Replacement - 5.3L (L83) or 6.2L (L86)	Air Cleaner Element Replacement - 5.3L (L83) or 6.2L (L86)
Spark Plug Replacement - 5.3L (L83) or 6.2L (L86)	Spark Plug Replacement - 5.3L (L83) or 6.2L (L86)
Drive Belt Replacement - 5.3L (L83) or 6.2L (L86)	Drive Belt Replacement - Accessory - 5.3L (L83) or 6.2L (L86)

MAINTENANCE REPLACEMENT PARTS

Replacement parts identified below by name, part number, or specification can be obtained from your dealer.

Part	GM Part Number	ACDelco Part Number
Engine Air Cleaner/Filter	22845992	A3181C
Oil Filter	89017525	PF63
Passenger Compartment Air Filter	22808781	CF188
Spark Plugs	12622441	41-114
Wiper Blades		
• Driver Side - 55 cm (21.7 in)	22756331	-
• Passenger Side - 55 cm (21.7 in)	22756331	-
• Rear - 33 cm (13.0 in)	22956295	-

MAINTENANCE

MAINTENANCE SCHEDULE

The Maintenance Schedule information will only be found in the Owner's Manual.

Refer to the Maintenance Schedule subsection of the Owner's Manual, or you may be able to use the Search information function using the words Scheduled Maintenance.

GM OIL LIFE SYSTEM RESETTING

When the system has calculated that oil life has been diminished, it will indicate that an oil change is necessary. A CHANGE ENGINE OIL SOON message will come on. Change the engine oil as soon as possible within the next 1,000 km (600 miles). It is possible that, if driving under the best conditions, the oil life system may not indicate that an oil change is necessary for over a year. However, the engine oil and filter must be changed at least once a year and at this time the system must be reset.

If the system is ever reset accidentally, change the engine oil at 5,000 km (3,000 miles) since last oil change.

How to Reset the Engine Oil Life System

Reset the system whenever the engine oil is changed so that the system can calculate the next engine oil change. Always reset the engine oil life to 100% after every oil change. It will not reset itself. To reset the system on most vehicles:

1. Display the OIL LIFE REMAINING on the DIC by pressing the Vehicle Information button located on the instrument panel, next to the steering wheel. If the vehicle does not have DIC buttons, the vehicle must be in P (Park) to access this display.
2. Press and hold the SET/RESET button on the DIC, or the trip odometer reset stem if the vehicle does not have DIC buttons, for more than five seconds. The oil life will change to 100%.

On all vehicles, the Engine Oil Life System can be reset as follows:

1. Turn the ignition to ON/RUN with the engine OFF.
2. Fully press the accelerator pedal slowly three times within five seconds.
3. Display the OIL LIFE REMAINING on the DIC. If the display shows 100%, the system is reset.

If the vehicle has a CHANGE ENGINE OIL SOON message and it comes back on when the vehicle is started and/or the OIL LIFE REMAINING is near 0%, the engine oil life system has not been reset. Repeat the procedure.

GM OIL LIFE SYSTEM RESETTING (WITH SCAN TOOL)

When the system has calculated that oil life has been diminished, it will indicate that an oil change is necessary. A ENGINE OIL light message will

come on. Change the engine oil as soon as possible within the next 600 miles (1,000 km). It is possible that, if driving under the best conditions, the oil life system may not indicate that an oil change is necessary for over a year. However, the engine oil and filter must be changed at least once a year and at this time the system must be reset.

With Scan Tool (If applicable)

1. Ignition On/Vehicle In Service Mode
2. Select: Module Diagnostics
3. Select: K20 Engine Control Module
4. Select: Configuration/Reset Functions
5. Select: Reset Functions
6. Select: Engine Oil Life Reset
7. Enter the desired value
8. Select: Continue

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ENGINE PERFORMANCE

Engine Controls and Fuel - 5.3L (L83) or 6.2L (L86) - Description and Operation - Escalade, Suburban, Tahoe, Yukon

DESCRIPTION AND OPERATION

ENGINE CONTROL MODULE DESCRIPTION

The Engine Control Module (ECM) interacts with many emission related components and systems, and monitors emission related components and systems for deterioration. OBD II diagnostics monitor the system performance and a diagnostic trouble code (DTC) sets if the system performance degrades. The ECM is part of a network and communicates with various other vehicle control modules.

Malfunction indicator lamp (MIL) operation and DTC storage are dictated by the DTC type. A DTC is ranked as a Type A or Type B if the DTC is emissions related. Type C is a non-emissions related DTC.

The ECM is the control center of the engine controls system. Review the components and wiring diagrams in order to determine which systems are controlled by the ECM.

The ECM constantly monitors the information from various sensors and other inputs, and controls the systems that affect engine performance and emissions. The ECM also performs diagnostic tests on various parts of the system and can turn on the MIL when it recognizes an operational problem that affects emissions. When the ECM detects a malfunction, the ECM stores a DTC. The condition area is identified by the particular DTC that is set. This aids the technician in making repairs.

ECM Function

The ECM can supply 5 V or 12 V to various sensors or switches. This is done through pull-up resistors to regulated power supplies within the ECM. In some cases, even an ordinary shop voltmeter will not give an accurate reading due to low input resistance. Therefore, a digital multimeter (DMM) with at least 10 megaohms input impedance is required in order to ensure accurate voltage readings.

The ECM controls the output circuits by controlling the ground or the power feed circuit through transistors or a device called an output driver module.

EEPROM

The electronically erasable programmable read only memory (EEPROM) is an integral part of the ECM. The EEPROM contains program and calibration information that the ECM needs in order to control engine operation.

Special equipment, as well as the correct program and calibration for the vehicle, are required in order to reprogram the ECM.

Data Link Connector (DLC)

The data link connector (DLC) provides serial data communication for ECM diagnosis. This connector allows the technician to use a scan tool in order to monitor various serial data parameters, and display DTC information. The DLC is located inside the driver's compartment, underneath the instrument panel.

Malfunction Indicator Lamp (MIL)

The malfunction indicator lamp (MIL) is inside the instrument panel cluster (IPC). The MIL is controlled by the ECM and illuminates when the ECM detects a condition that affects vehicle emissions.

ECM Service Precautions

The ECM, by design, can withstand normal current draws that are associated with vehicle operations. However, care must be used in order to avoid overloading any of these circuits. When testing for opens or shorts, do not ground or apply voltage to any of the ECM circuits unless the diagnostic procedure instructs you to do so. These circuits should only be tested with a DMM unless the diagnostic procedure instructs otherwise.

Emissions Diagnosis For State I/M Programs

This OBD II equipped vehicle is designed to diagnose any conditions that could lead to excessive levels of the following emissions:

- Hydrocarbons (HC)
- Carbon monoxide (CO)
- Oxides of nitrogen (NOx)
- Evaporative emission (EVAP) system losses

Should this vehicle's on-board diagnostic system (ECM) detect a condition that could result in excessive emissions, the ECM turns ON the MIL and stores a DTC that is associated with the condition.

Aftermarket (Add-On) Electrical And Vacuum Equipment

CAUTION: Do not attach add-on vacuum operated equipment to this vehicle. The use of add-on vacuum equipment may result in damage to vehicle components or systems.

CAUTION: Connect any add-on electrically operated equipment to the vehicle's electrical system at the 12 V battery (power and ground) in order to prevent damage to the vehicle.

Aftermarket, add-on, electrical and vacuum equipment is defined as any equipment installed on a vehicle after leaving the factory that connects to the vehicle's electrical or vacuum systems. No allowances have been made in the vehicle design for this type of equipment.

Add-on electrical equipment, even when installed to these strict guidelines, may still cause the powertrain system to malfunction. This may also include equipment not connected to the vehicle electrical system, such as portable telephones and radios. Therefore, the first step in diagnosing any powertrain condition is to eliminate all of the aftermarket electrical equipment from the vehicle. After this is done, if the problem still exists, the problem may be diagnosed in the normal manner.

Electrostatic Discharge (ESD) Damage

NOTE: **In order to prevent possible electrostatic discharge damage to the ECM, DO NOT touch the connector pins on the ECM.**

The electronic components that are used in the control systems are often designed to carry very low voltage. These electronic components are susceptible to damage caused by electrostatic discharge. Less than 100 V of static electricity can cause damage to some electronic components. By comparison, it takes as much as 4, 000 V for a person to even feel a static discharge.

There are several ways for a person to become statically charged. The most common methods of charging are by friction and by induction. An example of charging by friction is a person sliding across a car seat.

Charging by induction occurs when a person with well insulated shoes stands near a highly charged object and momentarily touches ground. Charges of the same polarity are drained off leaving the person highly charged with the opposite polarity. Static charges can cause damage, therefore, it is important to use care when handling and testing electronic components.

Emissions Control Information Label

The underhood Vehicle Emissions Control Information Label contains important emission specifications. This identifies the year, the displacement of the engine in liters, and the class of the vehicle.

This label is located in the engine compartment of every General Motors vehicle. If the label has been removed, it can be ordered from GM service parts operations (GMSPO).

CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) SYSTEM DESCRIPTION

Fig. 1: Cylinder Deactivation (Active Fuel Management) System Diagram
Courtesy of GENERAL MOTORS COMPANY

To provide maximum fuel economy under light load driving conditions, the engine control module (ECM) will command the cylinder deactivation system ON to deactivate engine cylinders 1, 7, 6, and 4, switching to a V4 mode. The engine will operate on 8 cylinders, or V8 mode, during engine starting, engine idling, and medium to heavy throttle applications.

Manifold absolute pressure (MAP) and the conditions listed below determine when cylinder deactivation is enabled.

- Engine has been running for greater than 30 s
- Engine speed is between 700 and 2800 rpm
- Engine oil pressure is between 187-455 kPa (27-66 psi)
- Engine coolant temperature is between 40-129Â°C (100-264Â°F)
- Engine oil temperature is between 16-128Â°C (61-263Â°F)

- Throttle angle is 6% or less
- Ignition voltage is greater than 11 V
- Transmission is not in first, second, or reverse gear
- Vehicle speed is greater than 25 kph (15.5 mph)
- Brake booster pressure is greater than 42.0 kPa (6 psi)
- Vehicle is not in fuel shut of mode
- Vehicle is not in heater performance mode
- Vehicle is not in tip in bump acceleration mode
- Vehicle is not in oil aeration mode
- Vehicle is not in low range (if equipped)

When cylinder deactivation is commanded, the ECM will determine what cylinder is firing and begin deactivation on the next closest deactivated cylinder in firing order sequence. For example, if cylinder number 1 is on its combustion event when cylinder deactivation is commanded ON, the next cylinder in the firing order sequence that can be deactivated is cylinder number 7. If cylinder number 5 is on its combustion event when cylinder deactivation is commanded ON, then the next cylinder in the firing order sequence that can be deactivated is cylinder number 4.

Cylinder deactivation is accomplished by not allowing the intake and exhaust valves to open on the selected cylinders by using special valve lifters. The deactivation lifters contain spring loaded locking pins that connect the internal pin housing of the lifter to the outer housing.

The pin housing contains the lifter plunger and pushrod seat which interfaces with the pushrod. The outer housing contacts the camshaft lobe through a roller. During V8 mode, when all cylinders are active, the locking pins are pushed outward by spring force, locking the pin housing and outer housing together causing the lifter to function as a normal lifter. When cylinder deactivation is commanded ON, the locking pins are pushed inward with engine oil pressure directed from the valve lifter oil manifold assembly solenoids. When the lifter pin housing is unlocked from the outer housing, the pin housing will remain stationary, while the outer housing will move with the profile of the camshaft lobe, which results in the valve remaining closed. One valve lifter oil manifold assembly solenoid controls both the intake and exhaust valves for each deactivating cylinder. There are 2 distinct oil passages going to each cylinder deactivation lifter bore, one for the hydraulic lash-adjusting feature of the lifter, and one for controlling the locking pins used for cylinder deactivation.

Although both intake and exhaust valve lifters are controlled by the same solenoid in the valve lifter oil manifold assembly, the intake and exhaust valves do not become deactivated at the same time. Cylinder deactivation is timed so that the cylinder is on an intake event. During an intake event, the intake cam lobe is pushing the valve lifter upwards to open the intake valve against the force of the valve spring. The force exerted by the valve spring is acting on the side of the lifter locking pins, preventing them from moving until the intake valve has closed. When the intake valve lifter reaches the base circle of the camshaft lobe, the valve spring force is reduced, allowing the locking pins to move, deactivating the intake valve. However, when cylinder deactivation is commanded ON, the exhaust valve for the deactivated cylinder is in the closed position, allowing the locking

pins on the valve lifter to move immediately, and deactivate the exhaust valve.

By deactivating the exhaust valve first, this allows the capture of a burnt air/fuel charge, or exhaust gas charge, in the combustion chamber. The capture of exhaust gases in the combustion chamber will contribute to a reduction in oil consumption, noise and vibration levels, and exhaust emissions when operating in V4 mode cylinder deactivation mode.

During the transition from V8 to V4 mode, the Fuel Injectors will be turned OFF on the deactivated cylinders. To help prevent spark plug fouling, the ignition system secondary voltage or spark is still present across the spark plug electrodes on the deactivated cylinders. If all enabling conditions are met and maintained for cylinder deactivation operation, the ECM calibrations will limit cylinder deactivation to a cycle time of 10 minutes in V4 mode, then return to V8 mode for 1 minute.

Switching between V8 and V4 modes is accomplished in less than 250 milliseconds, making the transitions seamless and transparent to the vehicle operator. The 250 milliseconds includes the time for the ECM to sequence the transitions, the response time for the valve lifter oil manifold assembly solenoids to energize, and the time for the valve lifters to deactivate, all within 2 revolutions of the engine crankshaft.

Valve Lifter Oil Manifold Assembly

The cylinder deactivation system uses an electro-hydraulic actuator device called the valve lifter oil manifold assembly. The valve lifter oil manifold assembly is bolted to the top of the engine valley, below the intake manifold assembly. The valve lifter oil manifold assembly consists of 4 electrically operated normally closed solenoids. Each solenoid controls the application of engine oil pressure to the intake and exhaust valve lifters on the cylinders selected to deactivate. Engine oil pressure is routed to the valve lifter oil manifold assembly from an internal oil passage on the rear of the cylinder block.

All 4 valve lifter oil manifold assembly solenoids are connected in parallel to a fused ignition 1 voltage circuit, supplied by the powertrain relay. The ground or control circuit for each solenoid is connected to a low side driver internal to the engine control module (ECM).

When all enabling conditions are met for cylinder deactivation, the ECM will ground each solenoid control circuit in firing order sequence, allowing current to flow through the solenoid windings. With the coil windings energized, the solenoid valve opens, redirecting engine oil pressure through the valve lifter oil manifold assembly into 8 separate vertical passages in the engine lifter valley. The 8 vertical passages, 2 per cylinder, are connected to the valve lifter bores of the cylinders to be deactivated. When vehicle-operating conditions require a return to V8 mode, the ECM will turn OFF the control circuit for the solenoids, allowing the solenoid valves to close. With the solenoid valves closed, engine oil pressure in the control ports is exhausted through the body of the solenoids into the engine block lifter valley. The housing of the valve lifter oil manifold assembly incorporates several bleeds in the oil passages to purge any air trapped in the valve lifter oil manifold assembly or engine block.

To help control contamination to the hydraulic circuits, a small replaceable oil screen is located in the valve lifter oil manifold assembly oil inlet passage, below the oil pressure sensor. The oil pressure sensor is a 3-wire sensor which provides oil pressure information to the ECM.

During service, use extreme care in keeping the valve lifter oil manifold assembly free of any contamination or foreign material.

Cylinder deactivation may be inhibited for many reasons including the following:

- Engine coolant temperature out of range for cylinder activation
- Engine vacuum out of range
- Brake booster vacuum out of range
- Transmission gear incorrect or shift in progress
- Accelerator pedal out of range or rate of pedal application to fast
- Engine oil pressure and temperature out of range
- Engine speed out of range
- Vehicle speed out of range
- Minimum time in V8 mode not met
- Maximum V4 mode time exceeded
- Decel fuel cutoff is active
- Reduced engine power is active
- Torque management is active
- Catalytic converter over temperature protection is active
- Piston protection is active, knock detected
- Cylinder deactivation solenoid driver circuit faults

THROTTLE ACTUATOR CONTROL (TAC) SYSTEM DESCRIPTION

Fig. 2: Throttle Actuator Control (TAC) System Diagram
Courtesy of GENERAL MOTORS COMPANY

The engine control module (ECM) is the control center for the throttle actuator control (TAC) system. The ECM determines the driver's intent based on input from the accelerator pedal position sensors, then calculates the appropriate throttle response based on the throttle position sensors. The ECM achieves throttle positioning by providing a pulse width modulated voltage to the throttle actuator motor. The throttle blade is spring loaded in both directions, and the default position is slightly open.

Modes Of Operation

Normal Mode

During the operation of the TAC system, several modes, or functions, are considered normal. The following modes may be entered during normal operations:

- Minimum pedal value - At key-up, the ECM updates the learned minimum pedal value.
- Minimum throttle position values - At key-up, the ECM updates the learned minimum throttle position value. In order to learn the minimum throttle position value, the throttle blade is moved to the Closed position.
- Ice break mode - If the throttle blade is not able to reach a predetermined minimum throttle position, the ice break mode is entered. During the ice break mode, the ECM commands the maximum pulse width several times to the throttle actuator motor in the closing direction.
- Battery saver mode - After a predetermined time without engine speed, the ECM commands the battery saver mode. During the battery saver mode, the TAC module removes the voltage from the motor control circuits, which removes the current draw used to maintain the idle position and allows the throttle to return to the spring loaded default position.

Reduced Engine Power Mode

When the ECM detects a condition with the TAC system, the ECM may enter a reduced engine power mode. Reduced engine power may cause one or more of the following conditions:

- Acceleration limiting - The ECM will continue to use the accelerator pedal for throttle control, however, the vehicle acceleration is limited.
- Limited throttle mode - The ECM will continue to use the accelerator pedal for throttle control, however, the maximum throttle opening is limited.
- Throttle default mode - The ECM will turn OFF the throttle actuator motor, and the throttle will return to the spring loaded default position.
- Forced idle mode - The ECM will perform the following actions:
    - Limit engine speed to the idle position
    - Ignore the accelerator pedal input.
- Engine shutdown mode - The ECM will disable fuel and de-energize the throttle actuator.

Throttle/Idle Learn

The engine control module (ECM) learns the airflow through the throttle body to ensure the correct idle. The learned airflow values are stored within the ECM. These values are learned to adjust for production variation and will continuously learn during the life of the vehicle to compensate for reduced airflow due to throttle body coking. Anytime the throttle body airflow rate changes, for example due to cleaning or replacing, the values must be relearned.

An engine that had a heavily coked throttle body that has been cleaned or replaced may take several drive cycles to unlearn the coking. To accelerate the process, the scan tool has the ability to reset all learned values back to zero. A new ECM will also have values set to zero.

The idle may be unstable or a DTC may set if the learned values do not match the actual airflow.

A un-metered air leak in the induction system or a small vacuum leak may not set a DTC. If the condition goes undetected, the ECM may learn an incorrect Throttle Body Idle Airflow Compensation value over time. The incorrectly learned value may cause various symptoms to occur such as rough or unstable idle speeds, and/or engine stall. If this condition is detected and repaired it will be necessary perform the Idle Learn procedure to ensure any symptoms are corrected.

CAMSHAFT ACTUATOR SYSTEM DESCRIPTION

Fig. 3: Camshaft Actuator System Diagram
Courtesy of GENERAL MOTORS COMPANY

Camshaft Position (CMP) Actuator System

The camshaft position (CMP) actuator system is used for a variety of engine performance enhancements. These enhancements include lower emission output through exhaust gas recirculation (EGR) control, a wider engine torque range, improved gas mileage, and improved engine idle stability. The CMP actuator system commanded by the ECM accomplishes these enhancements by controlling the valve timing relative to piston position.

CMP Actuator System Operation

The camshaft position (CMP) actuator system is controlled by the control module. The control module sends a pulse width modulated signal to a CMP actuator solenoid in order to control the amount of engine oil flow to a camshaft actuator passage. There are 2 different passages for oil to flow through, a passage for CAM advance and a passage for CAM retard. The camshaft actuator is attached to the front of the camshaft, and is hydraulically operated in order to change the angle of the camshaft relative to crankshaft position (CKP). Engine oil pressure (EOP), viscosity, temperature, engine oil level, and aftermarket engine oil additives can have an adverse affect on camshaft phaser performance.

CMP Actuator Solenoid Circuit Diagnostic

The engine control module (ECM) monitors the control circuit of the camshaft position (CMP) actuator solenoid for electrical faults. The control module has the ability to determine if a control circuit is open, shorted high, or shorted low. If the control module detects a fault with the CMP actuator solenoid control, DTC P0010 will set.

CMP Actuator System Performance Diagnostic

The engine control module (ECM) monitors the performance of the camshaft position (CMP) actuator system by monitoring the calibrated desired position and the actual position of the camshaft, through the 4X signal of the CMP sensor. If the difference between the actual and the desired position is greater than a calibrated angle for a calibrated amount of time, DTC P0011 will set.

FUEL SYSTEM DESCRIPTION

Fuel System Overview

The fuel system is an electronic returnless on-demand design. A returnless fuel system reduces the internal temperature of the fuel tank by not returning hot fuel from the engine to the fuel tank. Reducing the internal temperature of the fuel tank results in lower evaporative emissions.

An electric turbine style fuel pump attaches to the fuel tank fuel pump module inside the fuel tank. The fuel pump supplies fuel through the fuel feed pipe to the high pressure fuel pump. The high pressure fuel pump supplies fuel to a variable-pressure fuel rail. Fuel enters the combustion chamber through precision multi-hole fuel injectors. The high pressure fuel pump, fuel rail pressure, fuel injection timing, and injection duration are controlled by the engine control module (ECM).

Electronic Returnless Fuel System

The electronic returnless fuel system is a microprocessor controlled fuel delivery system which transports fuel from the tank to the fuel rail. It functions as an electronic replacement for a traditional, mechanical fuel pressure regulator. The pressure relief regulator valve within the fuel tank provides an added measure of over pressure protection. Desired fuel pressure is commanded by the engine control module (ECM), and transmitted to the fuel pump driver control module via a GMLAN serial data message. A fuel pressure sensor located on the fuel feed pipe provides the feedback the engine control module requires for Closed Loop fuel pressure control.

Fuel Pump Driver Control Module

The fuel pump driver control module is a serviceable GMLAN module. The fuel pump driver control module receives the desired fuel pressure message from the engine control module (ECM) and controls the fuel pump located within the fuel tank to achieve the desired fuel pressure. The fuel pump driver control module sends a 25 kHz PWM signal to the fuel pump, and pump speed is changed by varying the duty cycle of this signal. Maximum current supplied to the fuel pump is 22 A.

Fuel Pressure Sensor

The fuel pressure sensor is a serviceable 5 V, 3-pin device. It is located on the fuel feed line forward of the fuel tank, and receives power and ground from the engine control module through a vehicle wiring harness. The sensor provides a fuel pressure signal to the engine control module, which is used to provide Closed Loop fuel pressure control.

Flexible Fuel Sensor

The flexible fuel sensor measures the ethanol-gasoline ratio of the fuel being used in a flexible fuel vehicle. Flexible fuel vehicles can be operated with a blend of ethanol and gasoline, up to 85 percent ethanol. In order to adjust the ignition timing and the fuel quantity to be injected, the engine management system requires information about the percentage of ethanol in the fuel.

The flexible fuel sensor uses quick-connect style fuel connections, an incoming fuel connection, and an outgoing fuel connection. All fuel passes through the flexible fuel sensor before continuing on to the fuel rail. The flexible fuel sensor measures two different fuel related parameters, and sends an electrical signal to the engine control module (ECM) to indicate ethanol percentage, and fuel temperature.

The flexible fuel sensor has a three-wire electrical harness connector. The three wires provide a ground circuit, a power source, and a signal output to the ECM. The power source is ignition positive voltage and the ground circuit connects to a chassis ground. The signal circuit carries both the ethanol percentage and fuel temperature within the same signal, on the same wire.

The flexible fuel sensor uses a microprocessor inside the sensor to measure the ethanol percentage and fuel temperature, and changes the output signal accordingly. The electrical characteristic of the flexible fuel sensor signal is a square-wave digital signal. The signal is both variable frequency and variable pulse width. The frequency of the signal indicates the ethanol percentage, and the pulse width indicates the fuel temperature. The ECM provides an internal pull-up to 5 V on the signal circuit, and the flexible fuel sensor pulls the 5 V to ground in pulses. The output frequency is linear to the percentage of ethanol content in the fuel. The normal range of operating frequency is between 50 and 150 Hz, with 50 Hz representing 0

percent ethanol, and 150 Hz representing 100 percent ethanol. The normal pulse width range of the digital pulses is between 1 and 5 ms, with 1 ms representing -40Â°C (-40Â°F), and 5 ms representing 151.25Â°C (304.25Â°F).

The microprocessor inside the sensor is capable of a certain amount of self-diagnosis. An output frequency of 180 Hz indicates either that the fuel is contaminated, or that an internal sensor electrical fault has been detected. Certain substances dissolved in the fuel can cause the fuel to be contaminated, raising the output frequency higher than the actual ethanol percentage should indicate. Examples of these substances include water, sodium chloride (salt), and methanol.

It should be noted that it is likely that the Flexible Fuel Sensor will indicate a slightly lower ethanol percentage than what is advertised at the fueling station. This is not a fault of the sensor. The reason has to do with government requirements for alcohol-based motor fuels. Government regulations require that alcohol intended for use as motor fuel be denatured. This means that 100 percent pure ethanol is first denatured with approximately 4 1/2 percent gasoline, before being mixed with anything else. When an ethanol gasoline mixture is advertised as E85, the 85 percent ethanol was denatured before being blended with gasoline, meaning an advertised E85 fuel contains only about 81 percent ethanol. The Flexible Fuel Sensor measures the actual percentage of ethanol in the fuel.

Fuel Tank

The fuel tank is molded from high density polyethylenes and stores the fuel supply. The fuel tank is located on the left side of the vehicle and held in place by 2 metal straps that attach to the frame.

Fuel Tank Fuel Pump Module

The electric turbine style fuel pump attaches to the fuel tank fuel pump module inside the fuel tank and supplies fuel through the fuel feed pipe to the high pressure fuel pump. The fuel tank fuel pump module contains a reverse flow check valve. The check valve maintains fuel pressure in the fuel feed pipe in order to prevent long cranking times.

The fuel tank fuel pump module is located inside of the fuel tank. The fuel tank fuel pump module consists of the following major components:

- The fuel level sensor
- The fuel pump and reservoir assembly
- The pressure relief regulator valve
- The fuel strainer
- The primary jet pump

Fuel Level Sensor

The fuel level sensor consists of a float, a wire float arm, and a ceramic resistor card. The position of the float arm indicates the fuel level. The fuel

level sensor contains a variable resistor which changes resistance in correspondence with the position of the float arm. The engine control module (ECM) sends the fuel level information via high speed CAN-bus to the body control module (BCM). The BCM then sends the fuel level percentage via low speed CAN-bus to the instrument panel cluster (IPC) in order to control the fuel gauge. The control module monitors the signal circuit of the fuel level sensor in order to determine the fuel level.

Fuel Pump

The fuel pump is mounted in the fuel tank fuel pump module reservoir. The fuel pump is an electric pump. Fuel is pumped to the high pressure fuel pump at a pressure that is based on feedback from the fuel pressure sensor. The fuel pump delivers a constant flow of fuel even during low fuel conditions and aggressive vehicle maneuvers. The fuel pump flex pipe acts to dampen the fuel pulses and noise generated by the fuel pump.

Pressure Relief Regulator Valve

The pressure relief regulator valve replaces the typical fuel pressure regulator used on a mechanical returnless fuel system. The pressure relief regulator valve is closed during normal vehicle operation. The pressure relief regulator valve is used to vent pressure during hot soaks and also functions as a fuel pressure regulator in the event of the fuel pump driver control module defaulting to 100% pulse width modulation (PWM) of the fuel pump. Due to variation in the fuel system pressures, the opening pressure for the pressure relief regulator valve is set higher than the pressure that is used on a mechanical returnless fuel system pressure regulator.

Primary Jet Pump

The primary jet pump is located in the fuel tank fuel pump module. Fuel pump flow loss, caused by vapor expulsion in the pump inlet chamber, is diverted to the primary jet pump through a restrictive orifice located on the pump cover. The primary jet pump fills the reservoir of the fuel tank fuel pump module.

Nylon Fuel Pipes

WARNING: In order to reduce the risk of fire and personal injury observe the following items:

- **Replace all nylon fuel pipes that are nicked, scratched or damaged during installation, do not attempt to repair the sections of the nylon fuel pipes**
- **Do not hammer directly on the fuel harness body clips when installing new fuel pipes. Damage to the nylon pipes may result in a fuel leak.**
- **Always cover nylon vapor pipes with a wet towel before using a torch near them. Also, never expose the vehicle to temperatures higher than 115Â°C (239Â°F) for more than one hour, or more than 90Â°C (194Â°F) for any extended period.**
- **Apply a few drops of clean engine oil to the male pipe ends before connecting fuel pipe fittings. This will**

ensure proper reconnection and prevent a possible fuel leak. (During normal operation, the O-rings located in the female connector will swell and may prevent proper reconnection if not lubricated.)

Nylon pipes are constructed to withstand maximum fuel system pressure, exposure to fuel additives, and changes in temperature.

Heat resistant rubber hose or corrugated plastic conduit protect the sections of the pipes that are exposed to chafing, high temperature, or vibration.

Nylon fuel pipes are somewhat flexible and can be formed around gradual turns under the vehicle. However, if nylon fuel pipes are forced into sharp bends, the pipes kink and restrict the fuel flow. Also, once exposed to fuel, nylon pipes may become stiffer and are more likely to kink if bent too far. Take special care when working on a vehicle with nylon fuel pipes.

Quick-Connect Fittings

Quick-connect fittings provide a simplified means of installing and connecting fuel system components. The fittings consist of a unique female connector and a compatible male pipe end. O-rings, located inside the female connector, provide the fuel seal. Integral locking tabs inside the female connector hold the fittings together.

High Pressure Fuel Pump

The high fuel pressure necessary for direct injection is supplied by the high pressure fuel pump. The high pressure fuel pump is mounted on the rear of the engine under the intake manifold and is driven by a three-lobe cam on the camshaft. This high pressure fuel pump also regulates the fuel pressure using an actuator in the form of an internal solenoid-controlled valve. In order to keep the engine running efficiently under all operating conditions, the engine control module (ECM) requests pressure ranging from 2 to 15 MPa (290 to 2, 176 psi), depending on engine speed and load. Output drivers in the ECM provide the high pressure fuel pump control circuit with a 12 V pulse-width modulated (PWM) signal, which regulates fuel pressure by opening and closing the control valve at specific times during pump strokes. This effectively regulates the portion of each pump stroke that is delivered to the fuel rail. The high pressure fuel pump is normally closed and will not deliver an increase in fuel pressure when the control solenoid is NOT powered. In the event of pump control failure, the high pressure system is protected by a relief valve in the pump that prevents the pressure from exceeding 21.5 MPa (3, 118 psi).

Fuel Rail Assembly

The fuel rail assembly attaches to each cylinder head. The fuel rail distributes high pressure fuel to the fuel injectors. The fuel rail assembly consists of the following components:

- The direct fuel injectors
- The fuel rail pressure sensor

Fuel Injectors

The fuel injection system is a high pressure, direct injection, returnless on-demand design. The fuel injectors are mounted in the cylinder head beneath the intake ports and spray fuel directly into the combustion chamber. Direct injection requires high fuel pressure due to the fuel injector's location in the combustion chamber. Fuel pressure must be higher than compression pressure requiring a high pressure fuel pump. The fuel injectors also require more electrical power due to the high fuel pressure. The ECM supplies a separate high voltage supply circuit and a high voltage control circuit for each fuel injector. The injector high voltage supply circuit and the high voltage control circuit are both controlled by the ECM. The ECM energizes each fuel injector by grounding the control circuit. The ECM controls each fuel injector with 65 V. This is controlled by a boost capacitor in the ECM. During the 65 V boost phase, the capacitor is discharged through an injector, allowing for initial injector opening. The injector is then held open with 12 V.

The fuel injector assembly is an inside opening electrical magnetic injector. The injector has six precision machined holes that generate a cone shaped oval spray pattern. The fuel injector has a slim extended tip in order to allow a sufficient cooling jacket in the cylinder head.

Fuel Rail Pressure Sensor

The fuel rail pressure sensor is a dual analog sensor that detects fuel pressure within the fuel rail. The engine control module (ECM) provides a 5 V reference voltage on the 5 V reference circuit and ground on the low reference circuit. The ECM receives a varying signal voltage on two separate signal circuits. The ECM monitors the voltage on the fuel rail pressure sensor circuits. When the fuel pressure is high, the signal voltage is high. When the fuel pressure is low, the signal voltage is low.

Fuel Metering Modes of Operation

The ECM monitors voltages from several sensors in order to determine how much fuel to give the engine. The ECM controls the amount of fuel delivered to the engine by changing the fuel injector pulse width. The fuel is delivered under one of several modes.

Starting Mode

The ECM supplies voltage to the fuel pump control module when the ECM detects that the ignition is ON. The voltage from the ECM to the fuel pump control module remains active for 2 s, unless the engine is in Crank or Run. While this voltage is being received, the fuel pump control module closes the ground switch of the fuel tank fuel pump module and also supplies a varying voltage to the fuel tank fuel pump module in order to maintain the desired fuel line pressure. The ECM calculates the air/fuel ratio based on inputs from the engine coolant temperature (ECT), manifold absolute pressure (MAP), mass air flow (MAF), and throttle position sensors. The system stays in starting mode until the engine speed reaches a predetermined RPM.

During a cold start, the Engine Control Module (ECM) commands dual-pulse mode during Open Loop operation to improve cold start emissions. In dual-pulse mode, the injectors are energized twice during each injection event.

Clear Flood Mode

If the engine floods, the engine can be cleared by pressing the accelerator pedal down to the floor and then cranking the engine. When the throttle position sensor is at wide open throttle (WOT), the ECM reduces the fuel injector pulse width in order to increase the air to fuel ratio. The ECM holds this injector rate as long as the throttle stays wide open and the engine speed is below a predetermined RPM. If the throttle is not held wide open, the ECM returns to the starting mode.

Run Mode

The run mode has 2 conditions called Open Loop and Closed Loop. When the engine is first started and the engine speed is above a predetermined RPM, the system begins Open Loop operation. The ECM ignores the signal from the heated oxygen sensor (HO2S). The ECM calculates the air/fuel ratio based on inputs from the engine coolant temperature (ECT), manifold absolute pressure (MAP), mass air flow (MAF), and throttle position sensors. The system stays in Open Loop until meeting the following conditions:

- The HO2S has varying voltage output, showing that the HO2S is hot enough to operate properly.
- The ECT sensor is above a specified temperature.
- A specific amount of time has elapsed after starting the engine.

Specific values for the above conditions exist for each different engine, and are stored in the electrically erasable programmable read-only memory (EEPROM). The system begins Closed Loop operation after reaching these values. In Closed Loop, the ECM calculates the air/fuel ratio, injector ON time, based upon the signal from various sensors, but mainly from the HO2S. This allows the air/fuel ratio to stay very close to 14.7:1.

Acceleration Mode

When the driver pushes on the accelerator pedal, air flow into the cylinders increases rapidly. To prevent possible hesitation, the ECM increases the pulse width to the injectors to provide extra fuel during acceleration. This is also known as power enrichment. The ECM determines the amount of fuel required based upon throttle position, engine coolant temperature (ECT), manifold absolute pressure (MAP), mass air flow (MAF), and engine speed.

Deceleration Mode

When the driver releases the accelerator pedal, air flow into the engine is reduced. The ECM monitors the corresponding changes in throttle position, mass air flow (MAF), and manifold absolute pressure (MAP). The ECM shuts OFF fuel completely if the deceleration is very rapid, or for long periods, such as long, closed-throttle coast-down. The fuel shuts OFF in order to prevent damage to the catalytic converters.

Battery Voltage Correction Mode

When the battery voltage is low, the ECM compensates for the weak spark delivered by the ignition system in the following ways:

- Increasing the amount of fuel delivered
- Increasing the idle RPM
- Increasing the ignition dwell time

Fuel Cutoff Mode

The ECM cuts OFF fuel from the fuel injectors when the following conditions are met in order to protect the powertrain from damage and improve driveability:

- The ignition is OFF. This prevents engine run-on.
- The ignition is ON but there is no ignition reference signal. This prevents flooding or backfiring.
- The engine speed is too high, above red line.
- The vehicle speed is too high, above rated tire speed.
- During an extended, high speed, closed throttle coast down-This reduces emissions and increases engine braking.
- During extended deceleration, in order to prevent damage to the catalytic converters

Fuel Trim

The ECM controls the air/fuel metering system in order to provide the best possible combination of driveability, fuel economy, and emission control. The ECM monitors the heated oxygen sensor (HO2S) signal voltage while in Closed Loop and regulates the fuel delivery by adjusting the pulse width of the injectors based on this signal. The ideal fuel trim values are around 0 percent for both short and long term fuel trim. A positive fuel trim value indicates the ECM is adding fuel in order to compensate for a lean condition by increasing the pulse width. A negative fuel trim value indicates that the ECM is reducing the amount of fuel in order to compensate for a rich condition by decreasing the pulse width. A change made to the fuel delivery changes the long and short term fuel trim values. The short term fuel trim values change rapidly in response to the HO2S signal voltage. These changes fine tune the engine fueling. The long term fuel trim makes coarse adjustments to fueling in order to re-center and restore control to short term fuel trim. A scan tool can be used to monitor the short and long term fuel trim values. The long term fuel trim diagnostic is based on an average of several of the long term speed load learn cells. The ECM selects the cells based on the engine speed and engine load. If the ECM detects an excessively lean or rich condition, the ECM will set a fuel trim diagnostic trouble code (DTC).

EVAPORATIVE EMISSION CONTROL SYSTEM DESCRIPTION

Typical Evaporative Emission (EVAP) System Hose Routing Diagram

Fig. 4: Typical Evaporative Emission (EVAP) System Hose Routing Diagram
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Evaporative Emissions (EVAP) Purge Solenoid Valve
2	Purge Tube Check Valve, Turbo-Charged Applications Only
3	EVAP Canister
4	EVAP Vapor Tube

Callout	Component Name
5	Vapor Recirculation Tube (ORVR)
6	Fuel Tank Pressure Sensor
7	Fuel Filler Cap (Some Vehicles May Have A Capless Design)
8	Fuel Tank
9	Fuel Fill Pipe Inlet Check Valve
10	Liquid Fuel
11	Fill Limit Vent Valve (FLVV)
12	Fuel Vapor
13	EVAP Canister Vent Solenoid Valve
14	Vent hose
15	EVAP Purge Tube
16	EVAP Canister Purge Tube Connector

EVAP System Operation

The EVAP control system limits fuel vapors from escaping into the atmosphere. Fuel tank vapors are allowed to move from the fuel tank, due to pressure in the tank, through the EVAP vapor tube, into the EVAP canister. Carbon in the canister absorbs and stores the fuel vapors. Excess pressure is vented through the vent hose and EVAP vent solenoid valve to the atmosphere. The EVAP canister stores the fuel vapors until the engine is able to use them. At an appropriate time, the engine control module (ECM) will command the EVAP purge solenoid valve ON, allowing engine vacuum to be applied to the EVAP canister. With the normally open EVAP vent solenoid valve OFF, fresh air is drawn through the vent solenoid valve and the vent hose to the EVAP canister. Fresh air is drawn through the canister, pulling fuel vapors from the carbon. The air/fuel vapor mixture continues through the EVAP purge tube and EVAP purge solenoid valve into the intake manifold to be consumed during normal combustion. The ECM uses several tests to determine if the EVAP system is leaking or restricted.

Purge Solenoid Valve Leak Test

If the EVAP purge solenoid valve does not seal properly fuel vapors could enter the engine at an undesired time, causing driveability concerns. The ECM tests for this by commanding the EVAP purge solenoid valve OFF and the vent solenoid valve ON which seals the system. With the engine running, the ECM then monitors the fuel tank pressure sensor for an increase in vacuum. The ECM will set a DTC if a vacuum develops in the tank under these test conditions.

Large Leak Test

This diagnostic creates a vacuum condition in the EVAP system. When the enabling criteria has been met, the ECM commands the normally open

EVAP vent solenoid valve closed and the EVAP purge solenoid valve open, creating a vacuum in the EVAP system. The ECM then monitors the fuel tank pressure sensor voltage to verify that the system is able to reach a predetermined level of vacuum within a set amount of time. Failure to achieve the expected level of vacuum indicates the presence of a large leak in the EVAP system or a restriction in the purge path. The ECM will set a DTC if it detects a weaker than expected vacuum level under these test conditions.

Canister Vent Restriction Test

If the EVAP vent system is restricted, fuel vapors will not be properly purged from the EVAP canister. The ECM tests this by commanding the EVAP purge solenoid valve ON while commanding the EVAP vent solenoid valve OFF, and then monitoring the fuel tank pressure sensor for an increase in vacuum. If the vacuum increases more than the expected amount, in a set amount of time, a fault will be logged by the ECM.

Small Leak Test

The engine off natural vacuum diagnostic is the small-leak detection diagnostic for the EVAP system. The engine off natural vacuum diagnostic monitors the EVAP system pressure with the ignition OFF. Because of this, it may be normal for the ECM to remain active for up to 40 min after the ignition is turned OFF. This is important to remember when performing a parasitic draw test on vehicles equipped with engine off natural vacuum.

When the vehicle is driven, the temperature rises in the tank due to heat transfer from the exhaust system. After the vehicle is parked, the temperature in the tank continues to rise for a period of time, then starts to drop. The engine off natural vacuum diagnostic relies on this temperature change, and the corresponding pressure change in a sealed system, to determine if an EVAP system leak is present.

The engine off natural vacuum diagnostic is designed to detect leaks as small as 0.51 mm (0.020 in).

EVAP System Components

The EVAP system consists of the following components:

EVAP Purge Solenoid Valve

The EVAP purge solenoid valve controls the flow of vapors from the EVAP system to the intake manifold. The purge solenoid valve opens when commanded ON by the ECM. This normally closed valve is pulse width modulated (PWM) by the ECM to precisely control the flow of fuel vapor to the engine. The valve will also be opened during some portions of the EVAP testing when the engine is running, allowing engine vacuum to enter the EVAP system.

Purge Tube Check Valve

NOTE: **The presence of this one-way check valve prevents pressure testing the EVAP system for leaks at the EVAP canister purge tube connector.**

Turbocharged vehicles have a check valve in the purge tube between the EVAP purge solenoid valve and the intake manifold to prevent pressurization of the EVAP system under boost conditions. Some applications may have this check valve between the EVAP purge solenoid valve and the EVAP canister.

EVAP Canister

The canister is filled with carbon pellets used to absorb and store fuel vapors. Fuel vapor is stored in the canister until the ECM determines that the vapor can be consumed in the normal combustion process.

Vapor Recirculation Tube

A vapor path between the fuel fill pipe and the vapor tube to the carbon canister is necessary for Vehicle Onboard Diagnostics to fully diagnose the EVAP system. It also accommodates service diagnostic procedures by allowing the entire EVAP system to be diagnosed from either end of the system.

The On-Board Refueling Vapor Recovery System is an on-board vehicle system designed to recover fuel vapors during the vehicle refueling operation. The flow of liquid fuel down the fuel filler pipe provides a liquid seal which prevents vapor from leaving the fuel filler pipe. An EVAP pipe transports the fuel vapor to the EVAP canister for use by the engine.

Fuel Tank Pressure Sensor

The fuel tank pressure sensor measures the difference between the pressure or vacuum in the fuel tank and outside air pressure. Depending on the vehicle, the sensor can be located in the vapor space on top of the fuel tank, in the vapor tube between the canister and the tank, or on the EVAP canister. A high fuel tank pressure sensor voltage indicates a low fuel tank pressure or vacuum. A low fuel tank pressure sensor voltage indicates a high fuel tank pressure.

Fuel Fill Pipe Check Valve

The check valve on the fuel fill pipe is there to prevent spit-back during refueling.

EVAP Vent Solenoid Valve

The EVAP vent solenoid valve controls fresh airflow into the EVAP canister. The valve is normally open. The canister vent solenoid valve is closed only during EVAP system tests performed by the ECM like large leak and engine off natural vacuum test.

Fuel Fill Cap

The fuel fill cap is equipped with a seal and a vacuum relief valve and is tethered. A torque-limiting device prevents the cap from being over

tightened. To install the cap, turn the cap clockwise until you hear clicks. This indicates that the cap is correctly torqued and fully seated. A built-in device indicates that the fuel filler cap is fully seated. A fuel filler cap that is not fully seated may cause a malfunction in the emission system.

Capless Fuel Fill

Some vehicles may have a capless fuel fill design behind a locking fuel door. There is no fuel fill cap to remove. One just fully inserts the fuel nozzle into the fill neck, making sure it latches before refueling. Flapper valves close to seal this interface once the fill nozzle is removed.

Fill Limit Vent Valve

This acts as a shut off valve during refueling. This will vary based on fuel tank design. The fuel limit vent valve has the following functions:

- The fuel limit vent valve is located on the inside top of the fuel tank
- This valve is not serviced separately
- Controls the fuel tank fill level by closing the primary vent from the fuel tank and forcing the fuel fill nozzle to shut off.
- Prevents liquid fuel from exiting the fuel tank via the EVAP pipe to the canister.
- Provides fuel-spillage protection in the event of a vehicle rollover by closing the vapor path from the tank to the EVAP canister.

ELECTRONIC IGNITION SYSTEM DESCRIPTION

Electronic Ignition System Operation

The electronic ignition system produces and controls the high energy secondary spark. This spark ignites the compressed air/fuel mixture at precisely the correct time, providing optimal performance, fuel economy, and control of exhaust emissions. The engine control module (ECM) primarily collects information from the crankshaft position and camshaft position sensors to control the sequence, dwell, and timing of the spark.

Crankshaft Position Sensor

The crankshaft position sensor is an internally magnetic biased digital output integrated circuit sensing device. The sensor detects magnetic flux changes of the teeth and slots of the reluctor wheel on the crankshaft. The reluctor wheel is spaced at 60-tooth spacing, with two missing teeth for the reference gap. The reference gap is used to identify the crankshaft position at each start-up. The crankshaft position sensor produces an ON/OFF DC voltage of varying frequency, with 58 output pulses per crankshaft revolution. The crankshaft position sensor sends a digital signal to the ECM as each tooth on the reluctor wheel rotates past the crankshaft position sensor. The ECM uses each crankshaft position signal pulse to determine crankshaft speed position. This information is then used to determine the optimum ignition and injection points of the engine. The ECM also uses crankshaft position sensor output information to determine the camshaft relative position to the crankshaft, to control camshaft phasing, and to detect cylinder misfire.

The ECM also has a dedicated replicated crankshaft position sensor signal output circuit that may be used as an input signal to other modules for monitoring engine RPM.

Camshaft Position Sensor

The camshaft position sensor detects magnetic flux changes between the four narrow and wide tooth slots on the reluctor wheel. The camshaft position sensor provides a digital ON/OFF DC voltage of varying frequency per each camshaft revolution. The ECM will recognize the narrow and wide tooth patterns to identify camshaft position, or which cylinder is in compression and which is in exhaust. The information is then used to determine the correct time and sequence for fuel injection and ignition spark events.

The ECM also has a dedicated replicated camshaft position sensor signal output circuit that may be used as an input signal to other modules for monitoring engine RPM.

Knock Sensor

The knock sensor system enables the engine control module (ECM) to control the ignition timing for the best possible performance while protecting the engine from potentially damaging levels of detonation, also known as spark knock. The knock sensor system uses one or two flat response 2-wire sensors. The sensor uses piezo-electric crystal technology that produces an AC voltage signal of varying amplitude and frequency based on the engine vibration or noise level. The amplitude and frequency are dependant upon the level of knock that the knock sensor detects. The ECM receives the knock sensor signal through two isolated signal circuits for each knock sensor.

The control module learns a minimum noise level, or background noise, at idle from the knock sensor and uses calibrated values for the rest of the RPM range. The control module uses the minimum noise level to calculate a noise channel. A normal knock sensor signal will ride within the noise channel. As engine speed and load change, the noise channel upper and lower parameters will change to accommodate the normal knock sensor signal, keeping the signal within the channel. In order to determine which cylinders are knocking, the control module only uses knock sensor signal information when each cylinder is near top dead center (TDC) of the firing stroke. If knock is present, the signal will range outside of the noise channel.

If the control module has determined that knock is present, it will retard the ignition timing to attempt to eliminate the knock. The control module will always try to work back to a zero compensation level, or no spark retard. An abnormal knock sensor signal will stay outside of the noise channel or will not be present. knock sensor diagnostics are calibrated to detect faults with the knock sensor circuitry inside the control module, the knock sensor wiring, or the knock sensor voltage output. Some diagnostics are also calibrated to detect constant noise from an outside influence such as a loose/damaged component or excessive engine mechanical noise.

Ignition Coils

Each ignition coil has an ignition 1 voltage feed and a ground circuit. The engine control module (ECM) supplies a low reference and an ignition control circuit. Each ignition coil contains a solid state driver module. The ECM will command the ignition control circuit ON, which allows the

current to flow through the primary coil windings. When the ECM commands the ignition control circuit OFF, this will interrupt current flow through the primary coil windings. The magnetic field created by the primary coil windings will collapse across the secondary coil windings, which induces a high voltage across the spark plug electrodes.

Engine Misfire Detection

The crankshaft position sensor is used to determine when an engine misfire is occurring. The camshaft position sensor is used to determine which cylinder is misfiring. By monitoring variations in the crankshaft rotation speed for each cylinder, the ECM is able to detect individual misfire events. For accurate detection of engine misfire, the ECM must distinguish between crankshaft deceleration caused by actual misfire and deceleration caused by rough road conditions. The antilock brake system (ABS) can detect if the vehicle is on a rough road based on wheel acceleration/deceleration data supplied by the wheel speed sensors. If the ABS detects rough road above a predetermined threshold, this information is sent to the ECM. The ECM uses the rough road information when calculating engine misfire. Under certain driving conditions, a misfire rate can be high enough to cause the 3-way catalytic converter to overheat damaging the converter. The malfunction indicator lamp (MIL) will flash ON and OFF when converter overheating, damaging conditions are present.

.

ENGINE PERFORMANCE

Engine Controls and Fuel - 5.3L (L83) or 6.2L (L86) - Specifications - Escalade, Suburban, Tahoe, Yukon

SPECIFICATIONS

TEMPERATURE VERSUS RESISTANCE - INTAKE AIR TEMPERATURE SENSOR

Temperature CÂ°/FÂ°	Resistance Minimum Ohms	Resistance Maximum Ohms
Hitachi Intake Air Temperature (IAT) Sensor		
-40/-40	37, 527	49, 882
-20/-4	13, 110	16, 329
-10/14	8, 145	9, 851
0/32	5, 205	6, 122
20/68	2, 298	2, 570
25/77	1, 900	2, 100
40/104	1, 073	1, 226
60/140	537	639
80/176	289	356
100/212	165	210
120/248	99	129
140/284	62	83
150/302	49	67

TEMPERATURE VERSUS RESISTANCE (ECT)

Temperature	Resistance
150Â°C (302Â°F)	47 to 49 ohms
140Â°C (284Â°F)	58 to 62 ohms
130Â°C (266Â°F)	76 to 80 ohms
120Â°C (248Â°F)	98 to 104 ohms
110Â°C (230Â°F)	130 to 136 ohms

Temperature	Resistance
100Â°C (212Â°F)	174 to 182 ohms
90Â°C (194Â°F)	237 to 247 ohms
80Â°C (176Â°F)	327 to 341 ohms
70Â°C (158Â°F)	459 to 479 ohms
60Â°C (140Â°F)	656 to 686 ohms
50Â°C (122Â°F)	958 to 1002 ohms
45Â°C (113Â°F)	1167 to 1223 ohms
40Â°C (104Â°F)	1430 to 1500 ohms
35Â°C (95Â°F)	1763 to 1849 ohms
30Â°C (86Â°F)	2185 to 2295 ohms
25Â°C (77Â°F)	2725 to 2865 ohms
20Â°C (68Â°F)	3418 to 3604 ohms
15Â°C (59Â°F)	4318 to 4564 ohms
10Â°C (50Â°F)	5493 to 5823 ohms
5Â°C (41Â°F)	7041 to 7485 ohms
0Â°C (32Â°F)	9097 to 9701 ohms
-5Â°C (23Â°F)	11844 to 12678 ohms
-10Â°C (14Â°F)	15540 to 16700 ohms
-15Â°C (5Â°F)	20559 to 22183 ohms
-20Â°C (-4Â°F)	27439 to 29725 ohms
-30Â°C (-22Â°F)	50264 to 54924 ohms
-40Â°C (-40Â°F)	95953 to 105777 ohms

ALTITUDE VERSUS BAROMETRIC PRESSURE

Altitude Measured in Meters (m)	Altitude Measured in Feet (ft)	Barometric Pressure Measured in Kilopascals (kPa)	Barometric Pressure Measured in Pounds Per Square Inch (PSI)
Determine your altitude by contacting a local weather station or by using another reference source.			
4, 267	14, 000	56-64	8.1-9.3
3, 962	13, 000	58-66	8.4-9.6
3, 658	12, 000	61-69	8.8-10.0

Altitude Measured in Meters (m)	Altitude Measured in Feet (ft)	Barometric Pressure Measured in Kilopascals (kPa)	Barometric Pressure Measured in Pounds Per Square Inch (PSI)
3, 353	11, 000	64-72	9.3-10.4
3, 048	10, 000	66-74	9.6-10.7
2, 743	9, 000	69-77	10.0-11.2
2, 438	8, 000	71-79	10.3-11.5
2, 134	7, 000	74-82	10.7-11.9
1, 829	6, 000	77-85	11.2-12.3
1, 524	5, 000	80-88	11.6-12.8
1, 219	4, 000	83-91	12.0-13.2
914	3, 000	87-95	12.6-13.8
610	2, 000	90-98	13.1-14.2
305	1, 000	94-102	13.6-14.8
0	0 Sea Level	96-104	13.9-15.1
-305	-1, 000	101-105	14.6-15.2

IGNITION SYSTEM SPECIFICATIONS

Application	Specification
Ignition Type	Individual Ignition Coils
Firing Order	1-8-7-2-6-5-4-3
Spark Plug Wire Resistance	170-220 Ω per 25.4 mm (1.0 in)
Spark Plug Torque	Refer to **Fastener Specifications**
Spark Plug Gap	Refer to **Engine Mechanical Specifications (L83)** **Engine Mechanical Specifications (L86)**
Spark Plug Type	Refer to Electronic Parts Catalog

ADHESIVES, FLUIDS, LUBRICANTS, AND SEALERS

Application	Type of Material	GM Part Number
Anti-Seize Compound	Lubricant	GM P/N 88862477 (Canadian P/N 88862478)

Application	Type of Material	GM Part Number
Camshaft Gear Access Hole Plug	Sealant	GM P/N 12346004 (Canadian P/N 10953480)
Coolant Temperature Sensor Threads	Sealant	GM P/N 12346004 (Canadian P/N 10953480)
Engine Oil	0W-20 Oil	GM P/N 19259487 (Canadian P/N 19259784)
Fuel Injection Fuel Rail Bolts	Sealant	GM P/N 12345382 (Canadian P/N 10953489)
Intake Air Temperature Sensor Threads	Sealant	GM P/N 12346004 (Canadian P/N 10953480)
Top Engine Cleaner	Cleaner	GM P/N 1052626 (Canadian P/N 993026)

FASTENER SPECIFICATIONS

Application	Specifications	
	Metric	English
Accelerator Pedal Bolt	9 N.m	80 lb in
Air Cleaner Bracket Bolts	9 N.m	80 lb in
Air Cleaner Housing Screw	3 N.m	27 lb in
Camshaft Position (CMP) Sensor Fastener	25 N.m	18 lb ft
Crankshaft Position (CKP) Sensor Fastener	25 N.m	18 lb ft
Camshaft Position (CMP) Actuator Fasteners	10 N.m	89 lb in
Chassis Control Module Fastener	9 N.m	80 lb in
Engine Coolant Temperature (ECT) Sensor	20 N.m	15 lb ft
Engine Oil Pressure Sensor	35 N.m	26 lb ft
Evaporative Emission (EVAP) Canister Bracket Bolt	25 N.m	18 lb ft
Evaporative Emission (EVAP) Canister Purge Solenoid Valve Fastener	10 N.m	89 lb in
Fuel Feed and Evaporative Emission (EVAP) Hose Nut	25 N.m	18 lb ft
Fuel Feed Intermediate Pipe Fastener	10 N.m	89 lb in
Fuel Feed Intermediate Pipe Fitting	28 N.m	21 lb ft

Application	Specifications	
	Metric	English
Fuel Feed Pipe Bracket Fastener	10 N.m	89 lb in
Fuel Fill Pipe Bracket Bolt	12 N.m	106 lb in
Fuel Pressure Sensor	15 N.m	11 lb ft
Fuel Pump Bolt	25 N.m	18 lb ft
Fuel Pump Cover Fastener	25 N.m	18 lb ft
Fuel Pump Power Control Module Fastener	9 N.m	80 lb in
Fuel Injection Fuel Rail Bolt	25 N.m	18 lb ft
Fuel Injection Fuel Rail Fuel Pressure Sensor	33 N.m	24 lb ft
Fuel Tank Filler Housing to Body Screw	10 N.m	89 lb in
Fuel Tank Fill Hose Clamp	4 N.m	35 lb in
Fuel Tank Strap Bolt	40 N.m	30 lb ft
Ground Wire to Engine Block Fastener	43 N.m	32 lb ft
Heated Oxygen Sensor (HO2S)	42 N.m	31 lb ft
Ignition Coil Fastener	10 N.m	89 lb in
Knock Sensor (KS) Fastener	25 N.m	18 lb ft
Knock Sensor (KS) Shield Fastener	25 N.m	18 lb ft
Manifold Absolute Pressure Sensor Fastener	4.5 N.m	40 lb in
Mass Air Flow (MAF)/Intake Air Temperature (IAT) Sensor Bolt	1.5 N.m	13 lb in
Spark Plug	20 N.m	15 lb ft
Throttle Body Fastener	10 N.m	89 lb in
Vacuum Pump Fastener	25 N.m	18 lb ft

APPROXIMATE FLUID CAPACITIES

Application	Specification	
	Metric	English
Fuel Tank Capacity - Long Wheelbase	119.2 L	31.5 gal
Fuel Tank Capacity - Short Wheelbase	98.4 L	26.0 gal

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.3L ...

ENGINE PERFORMANCE

Engine Controls and Fuel - 5.3L (L83) or 6.2L (L86) - Diagnostic Information and Procedures - Escalade, Suburban, Tahoe, Yukon

DIAGNOSTIC INFORMATION AND PROCEDURES

MALFUNCTION INDICATOR LAMP (MIL) DIAGNOSIS

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

Circuit/System Description

The malfunction indicator lamp (MIL) illuminates to inform the driver that an emission system fault has occurred and the powertrain control system requires service. Ignition voltage is supplied directly to the MIL. The engine control module (ECM) turns the MIL ON by grounding the MIL control circuit when the emission system fault occurs. Under normal operating conditions, the MIL should be ON only when the ignition is ON and the engine is OFF.

Diagnostic Aids

If the condition is intermittent, move the related harnesses and connectors while monitoring the scan tool MIL control circuit status parameters. Perform this test with the ignition ON and the engine OFF, and with the engine running. The MIL control circuit status parameters change from OK or Not Run to Malfunction if there is a condition with a circuit or a connection.

Reference Information

Schematic Reference

- **Engine Controls Schematics**
- **Instrument Cluster Schematics**

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

NOTE: **Any MIL requesting DTCs that may be set should be diagnosed first.**

1. Ignition ON.
2. Verify the parameters listed below do not display Malfunction when commanding the Malfunction Indicator Lamp On and Off with a scan tool.
   - The MIL Control Circuit Low Voltage Test Status
   - The MIL Control Circuit Open Test Status
   - The MIL Control Circuit High Voltage Test Status
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing

   - **If Malfunction is not displayed**
3. Engine running.
4. Verify the parameters listed below do not display Malfunction when commanding the Malfunction Indicator Lamp On and Off with a scan tool.
   - The MIL Control Circuit Low Voltage Test Status
   - The MIL Control Circuit Open Test Status
   - The MIL Control Circuit High Voltage Test Status
   - **If Malfunction is displayed**

Refer to Circuit/System Testing

- **If Malfunction is not displayed**

5. Verify the malfunction indicator lamp turns ON and OFF when commanding the Malfunction Indicator Lamp On and Off with a scan tool.
   - **If the malfunction indicator lamp does not turn ON and OFF**

     Refer to Circuit/System Testing

   - **If the malfunction indicator lamp turns ON and OFF**
6. All OK.

Circuit/System Testing

1. Ignition OFF.
2. Disconnect the X1 harness connector at the K20 Engine Control Module.
3. Ignition ON, verify the malfunction indicator lamp does not illuminate.
   - **If the malfunction indicator lamp illuminates**
   1. Test for infinite resistance between the control circuit terminal X1 46 and ground.
      - If less than infinite resistance, repair the short to ground in the circuit.
      - If infinite resistance, replace the P16 Instrument Cluster.
   - **If the malfunction indicator lamp does not illuminate**
4. Connect a 3 A fused jumper wire between the control circuit terminal X1 46 and ground.
5. Verify the malfunction indicator lamp illuminates.
   - **If the malfunction indicator lamp illuminates**

     Replace the K20 Engine Control Module.

   - **If the malfunction indicator lamp does not illuminate**
   1. Test for less than 1 V between the control circuit terminal X1 46 and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V
   2. Ignition OFF.
   3. Test for less than 2 Ω in the control circuit end to end.

- If 2 Ω or greater, repair the open/high resistance in the circuit.
- If less than 2 Ω.

6. Ignition OFF, disconnect the harness connector at the instrument cluster.
7. Ignition ON, verify a test lamp illuminates between the ignition voltage circuit terminal 8 and ground.
   - **If the test lamp does not illuminate and the circuit fuse is open**
   1. Ignition OFF.
   2. Test for infinite resistance between the ignition voltage circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition OFF.
   2. Test for less than 2 Ω in the ignition voltage circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
   - **If the test lamp illuminates**
8. Replace the P16 Instrument Cluster.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Instrument Cluster Replacement (Chevrolet / GMC)** **Instrument Cluster Replacement (Cadillac)**
- Refer to **Control Module References** for control module replacement, programming, and setup

ENGINE CRANKS BUT DOES NOT RUN

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

Circuit/System Description

This Engine Cranks but Does Not Run diagnostic is an organized approach to identify a condition which causes the engine to crank but does not continue to run. This diagnostic directs the service technician to the appropriate system diagnosis.

Diagnostic Aids

Inspect for any of the following conditions:

- Insufficient fuel can cause a no start condition. Thoroughly inspect the fuel delivery system for sufficient fuel volume to the fuel injectors. Inspect the fuel supply components for partial blockage or restrictions.
- Fuel injectors with partially blocked and restricted nozzles, or a malfunctioning solenoid, can cause a no start condition.
- There may be fuel spray at the fuel injectors and the indicated fuel pressure may be correct, yet there may not be enough fuel to start the engine. If the fuel injectors and the injector circuit are OK and fuel spray is detected, the fuel injector ON time may be inadequate. If the engine control module (ECM) receives incorrect inputs from the various information sensors, the fuel delivered by the fuel injectors may be inadequate to start the engine. Observe all the engine data parameters with a scan tool and compare the values indicated with the expected values or the values from a known good vehicle.
- Observe the Engine Speed parameter while cranking the engine. The scan tool should indicate a steady 200-300 RPM while cranking. If erratic values such as sudden spikes in the engine speed are displayed, the engine reference signal is not stable enough for the engine to start and run properly.
- Inspect the engine for good secure electrical grounds.
- If the engine almost starts and then stalls, inspect for an open in the ground circuits of the CKP sensor and the camshaft position (CMP) sensor.
- Water or foreign material in the fuel can cause a no start or engine will not stay running condition. During freezing weather water can freeze inside the fuel system. The engine may start after 30 minutes in a heated repair shop. The malfunction may not recur until parked overnight in freezing temperatures. Extreme weather conditions can cause contaminated fuel to prevent the vehicle from starting.
- A vehicle that starts and runs after being brought to the repair shop for a no start condition may have an ignition system that is susceptible to moisture. Spray water on the ignition system components and the wiring while cranking the engine to help locate damaged or deteriorated components. Look/listen for arcing or misfiring as the water is applied.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

- **COMPONENT CONNECTOR END VIEWS - INDEX**
- **Electrical Center Identification Views** **Electrical Center Identification Views**

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

J26792 HEI Spark Tester

Circuit/System Verification

NOTE: **This diagnostic assumes the following:**

- **The battery is completely charged.**
- **The engine cranking speed is acceptable.**
- **There is adequate fuel in the fuel tank.**

1. Crank the engine for up to 15 seconds.
2. Verify that DTC P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0201-P0208, P0222, P0223, P0300-P0308, P0335, P0336, P0351-P0358, P0601-P0604, P0606, P062B, P062F, P0630, P0633, P0685-P0687, P0689, P0690, P1631, P1682, P16A0, P16A1, P16A2, P16F3, P2135, or P262B, is not set.
   - **If any of the DTCs are set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .

   - **If none of the DTCs are set**

3. Ignition ON.
4. Verify the security indicator illuminates momentarily.
   - **If the security indicator stays ON or is flashing**

     Review the **Diagnostic Trouble Code (DTC) List - Vehicle** , for immobilizer system DTCs. Refer to **Immobilizer Description and Operation** for additional information.

   - **If the security indicator does not stay ON and is not flashing**
5. Verify the scan tool Engine Speed parameter displays greater than 0 RPM while cranking the engine.
   - **If 0 RPM**

     Refer to **DTC P0335 or P0336** .

   - **If greater than 0 RPM**
6. Ignition OFF.

NOTE: **Perform the spark test on at least 1 cylinder of each cylinder bank.**

7. Install the **J26792** HEI Spark Tester between the boot of a spark plug wire and ground.
8. Verify the spark tester sparks while cranking the engine.
   - **If there is no spark**

     Refer to **Electronic Ignition System Diagnosis**.

   - **If there is spark**
9. Ignition ON.

NOTE: **If the engine is too hot, high fuel pressure readings may result due to hot soak fuel boiling. Do not attempt to record fuel pressure readings until the engine coolant temperature is below 60Â°C (150Â°F).**

10. Command the Fuel Pump Enable ON several times with a scan tool.
11. Verify that the scan tool Fuel Pressure Sensor parameter is between 320-580 kPa (46-84 psi) with the fuel pump running.
    - **If not within the specified range**

      Refer to **Fuel System Diagnosis**.

12. Verify that the fuel pressure decreases to 468-544 kPa (68-79 psi) after the pump is turned off and does not decrease greater than 34 kPa (5 psi) in 1 minute.
    - **If not within the specified range**

      Refer to **Fuel System Diagnosis**.

    - **If within the specified range**
13. Verify the following conditions do not exist:
    - Collapsed air intake duct to the throttle body
    - Restricted air filter element
    - Spark plugs for being fouled
    - A skewed manifold absolute pressure (MAP) sensor - Refer to **DTC P0106** .
    - A skewed engine coolant temperature (ECT) sensor - Refer to **DTC P0116** .
    - Exhaust system restricted - Refer to **Restricted Exhaust** .
    - Fuel contamination - Refer to **Alcohol/Contaminants-in-Fuel Diagnosis**.
    - Engine mechanical condition such as worn timing chain and gears or low compression - Refer to **Symptoms - Engine Mechanical** , or **Engine Compression Test** .
    - **If a condition exists**

      Refer to the appropriate diagnostic or repair the condition as necessary.

    - **If no conditions exist**
14. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

POOR FUEL FILL QUALITY

Problem	Causes
DEFINITION: During the fueling process a continual, occasional, or no-fuel nozzle shut-off condition has occurred.	
Difficult to fill	• Fuel fill limiter vent valve stuck closed

Problem	Causes
	• Evaporative emission (EVAP) canister restricted • EVAP vent valve stuck closed • Hose between canister and canister vent solenoid twisted or kinked if applicable • High fuel temperature • Fuel filler hose is kinked • Faulty dispensing nozzle • Ignition switch ON, vent valve closed
Over fill	• Fill limiter vent valve stuck open or leaking • Fuel inlet check valve stuck open
Pre-mature shut-off of the fuel dispensing nozzle occurs immediately after engaging dispensing nozzle, tank empty	• Restricted vapor lines or fuel fill pipe • High fuel temperature • Inlet check valve at tank stuck closed, fill pipe full of fuel • Fuel tank full, gauge not accurate
Pre-mature shut-off of the fuel dispensing nozzle, more than 1/8 of tank capacity dispensed	• Kinked, pinched or plugged lines in fuel tank vent system • EVAP vent valve stuck closed or restricted • EVAP canister restricted • Fuel limiting vent valve stuck closed or obstruction at top of fuel tank
Fuel Spitback	• Restricted EVAP canister • High fuel temperature • Ignition switch ON, EVAP vent valve closed

FUEL INJECTOR DIAGNOSIS

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.

- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

Circuit/System Description

The engine control module (ECM) supplies a separate high voltage supply circuit and a high voltage control circuit for each fuel injector. The ECM initially opens each fuel injector with 65 V. This high voltage is controlled by a boost capacitor in the ECM. During the 65 V boost phase, the capacitor is discharged through a fuel injector, allowing for initial fuel injector opening. The fuel injector is then held open with 12 V. The ECM varies the amount of time each fuel injector is open to provide proper combustion under all engine load conditions.

A fuel injector coil winding resistance that is too high or too low will affect the engine driveability. The fuel injector coil windings are affected by temperature. The resistance of the fuel injector coil windings will increase as the temperature of the fuel injector increases.

Reference Information

Schematic Reference

Engine Controls Schematics

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

Component Testing

NOTE:

- **The resistance test must be performed at the fuel injector or mis-diagnosis will occur.**
- **The DMM and test leads must be calibrated to 0 Ω in order to prevent mis-diagnosis.**

1. Test for 1.06 Ω +/- 10% @ 20Â°C (68Â°F) between the high voltage supply circuit terminal 2 and the high voltage control circuit terminal 1 at the Q17 Fuel Injector.
   - **If not within the specified range**

     Replace the Q17 Fuel Injector.

- **If within the specified range**

2. Test for infinite resistance between each terminal at the Q17 Fuel Injector and the Q17 Fuel Injector housing/case.
   - **If not infinite resistance**

     Replace the Q17 Fuel Injector.

   - **If infinite resistance**
3. All OK, perform the **Fuel Injector Balance Test**.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

Refer to **Fuel Injector Replacement**

FUEL SYSTEM DIAGNOSIS

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

Circuit/System Description

The engine control module (ECM) supplies voltage to the fuel pump driver control module when the ECM detects that the ignition is ON. The voltage from the ECM to the fuel pump driver control module remains active for 2 s, unless the engine is in Crank or Run. While this voltage is being received, the fuel pump driver control module closes the ground switch of the fuel tank fuel pump module and also supplies a varying voltage to the fuel tank fuel pump module in order to maintain the desired fuel line pressure.

The fuel system is an electronic returnless on-demand design. A returnless fuel system reduces the internal temperature of the fuel tank by not returning hot fuel from the engine to the fuel tank. Reducing the internal temperature of the fuel tank results in lower evaporative emissions.

An electric turbine style fuel pump attaches to the fuel tank fuel pump module inside the fuel tank. The fuel pump supplies fuel through the fuel feed pipe to the high pressure fuel pump. The high pressure fuel pump supplies fuel to a variable-pressure fuel rail. Fuel enters the combustion chamber through precision multi-hole fuel injectors. The high pressure fuel pump, fuel rail pressure, fuel injection timing, and injection duration are controlled by the ECM.

Diagnostic Aids

Observe the Misfire Counters or perform the Fuel Injector Balance Test to help identify a leaking Fuel Injector. Refer to **Fuel Injector Balance Test**.

Reference Information

Description and Operation

Fastener Specifications

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

Scan Tool Reference

Control Module References for scan tool information

Special Tools

CH-37287-1A Fuel Pressure Gauge Adapter

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** **Special Tools (Service Tools)** .

Circuit/System Verification

NOTE:

- **Repair all fuel system related DTCs before performing this diagnostic.**
- **Inspect the fuel system for damage or external leaks before proceeding.**
- **Verify that adequate fuel is in the fuel tank before proceeding.**
- **The Fuel Pump Enable may need to be commanded ON a few times in order to obtain the highest possible fuel pressure.**
- **DO NOT perform the Fuel System Diagnosis if the engine coolant temperature is above 60Â°C (150Â°F). High fuel pressure readings may result due to hot soak fuel boiling. With the engine OFF, the fuel pressure may increase beyond the pressure relief regulator valve's setting point of 690 kPa (100 psi) Â± 5 percent.**

1. Ignition ON, engine OFF, command the Fuel Pump Enable ON several times with a scan tool.
2. Verify the scan tool Fuel Pressure Sensor parameter is between 320-580 kPa (46-84 psi) with the fuel pump running.
   - **If less than 320 kPa (46 psi)**

     Refer to Circuit/System Testing - Fuel Pressure Low.

   - **If greater than 580 kPa (84 psi)**

     Replace the G12 Fuel Pump.

   - **If between 320-580 kPa (46-84 psi)**

NOTE: **The fuel pressure may vary slightly when the fuel pump stops operating. After the fuel pump stops operating, the fuel pressure should stabilize and remain constant.**

3. Verify that the fuel pressure decreases to 468-544 kPa (68-79 psi) after the fuel pump is turned off.
   - **If the fuel pressure does not decrease to 468-544 kPa (68-79 psi)**

     Replace the G12 Fuel Pump.

   - **If the fuel pressure decreases to 468-544 kPa (68-79 psi)**
4. Verify that the fuel pressure does not decrease greater than 34 kPa (5 psi) in 1 minute.
   - **If the fuel pressure decreases greater than 34 kPa (5 psi)**

     Refer to Circuit/System Testing - Fuel Pressure Leaks Down.

   - **If the fuel pressure does not decrease greater than 34 kPa (5 psi)**
5. Relieve the fuel pressure to 69 kPa (10 psi), refer to **Fuel Pressure Relief** .
6. Verify that the fuel pressure does not decrease greater than 14 kPa (2 psi) in 5 minutes.
   - **If the fuel pressure decreases greater than 14 kPa (2 psi)**

     Replace the G12 Fuel Pump.

   - **If the fuel pressure does not decrease greater than 14 kPa (2 psi)**

WARNING: **Road test a vehicle under safe conditions and while obeying all traffic laws. Do not attempt any**

maneuvers that could jeopardize vehicle control. Failure to adhere to these precautions could lead to serious personal injury and vehicle damage.

7. Operate the vehicle within the conditions of the customer's concern while monitoring the Fuel Pressure Sensor parameter with a scan tool.
8. Verify the fuel pressure does not drop off during acceleration, cruise or hard cornering.
   - **If the fuel pressure drops off**

     Refer to Circuit/System Testing - Fuel Pressure Drops OFF.

   - **If the fuel pressure does not drop off**
9. If the fuel system components test normal, refer to **Symptoms - Engine Controls** , **Fuel Injector Diagnosis**, and **Fuel Injector Balance Test** for further diagnosis.

Circuit/System Testing

Fuel Pressure Low

1. Verify none of the conditions listed below exist:
   - Restricted fuel feed pipe
   - Restricted or plugged strainer
   - Poor connections at the fuel pump harness connector and the ground circuits.
   - **If a condition exist**

     Repair as necessary.

   - **If a condition does not exist**
2. Test or replace the G12 Fuel Pump.

Fuel Pressure Leaks Down

1. Ignition OFF, relieve the fuel pressure. Refer to **Fuel Pressure Relief** .
2. Install the **CH-37287-1A** Fuel Pressure Gauge Adapter between the fuel feed pipe and the fuel rail.
3. Open both of the valves on the **CH-37287-1A** Fuel Pressure Gauge Adapter.
4. Ignition ON, command the Fuel Pump Enable ON with a scan tool.

5. Close one of the valves on the **CH-37287-1A** Fuel Pressure Gauge Adapter.
6. Verify that the Fuel Pressure Sensor parameter does not decrease greater than 34 kPa (5 psi) in 1 minute.
    - **If the fuel pressure drops**

      Test or replace the G12 Fuel Pump.

    - **If the fuel pressure does not drop**
7. Locate and replace the leaking Q17 Fuel Injector.

Fuel Pressure Drops OFF

1. Verify none of the conditions listed below exist:
    - Restricted fuel feed pipe
    - Restricted or plugged strainer
    - Poor connections at the Fuel Pump harness connector and the ground circuit.
    - **If a condition exist**

      Repair as necessary.

    - **If a condition does not exist**
2. Test or replace the G12 Fuel Pump.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Fuel Feed Pipe Replacement (At Engine)** **Fuel Feed Pipe Replacement (At Tank)**
- Refer to **Fuel Injector Replacement**
- Refer to **Fuel Feed Hose Replacement**
- Refer to **Fuel Tank Fuel Pump Module Replacement (SWB)** **Fuel Tank Fuel Pump Module Replacement (LWB)** for G12 Fuel Pump replacement

FUEL INJECTOR BALANCE TEST

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

Circuit/System Description

Two methods of testing fuel injector balance are available, the Active Fuel Injector Tester (AFIT) or a scan tool. The Active Fuel Injector Tester and SIDI adaptor connects to the engine control module harness connectors to test the high pressure fuel pump performance, fuel injector wiring, and fuel injector operation. The AFIT displays step by step instructions to precisely determine pressure drop of each fuel injector. The scan tool fuel injector balance test is performed while the engine is running at idle. The scan tool pressurizes the fuel rail to a predetermined pressure before each fuel injector is pulsed for a precise amount of time allowing a measured amount of the fuel to be injected. This causes a drop in the system fuel pressure that is recorded and used to compare each fuel injector.

Diagnostic Aids

- Monitoring the scan tool Cylinder 1 -8 Current Misfire Counters may help to isolate the fuel injector that is causing the condition.
- Operating the vehicle over a wide temperature range may help isolate the fuel injector that is causing the condition.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Scan Tool Reference

Control Module References for scan tool information

Special Tools

- **CH-47976** Active Fuel Injector Tester
- **CH-47976-500** Active Fuel Injection Tester (AFIT) SIDI Adapter Kit

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** **Special Tools (Service Tools)**

Circuit/System Verification

1. Ignition ON.
2. Verify the scan tool Fuel Remaining parameter is greater than 10%.
   - **If the Fuel Remaining parameter is less than 10%** , add fuel to the fuel tank.
   - **If the Fuel Remaining parameter is 10% or greater**
3. Verify the scan tool ECT Sensor parameter is less than 60Â°C (140Â°F).
   - **If the ECT Sensor parameter is greater than 60Â°C (140Â°F)** , allow the engine temperature to cool.
   - **If the ECT Sensor parameter is 60Â°C (140Â°F) or less**
4. Verify the battery is fully charged and all accessories are Off.
   - **If the battery is not fully charged** , charge or repair battery as necessary.
   - **If the battery is fully charged**
5. Preform the appropriate Fuel Injector Balance Test in Circuit System Testing.

Circuit System Testing

Fuel Injector Balance Test with Active Fuel Injector Tester

1. Ignition OFF, all vehicle systems OFF. Install the **CH-47976** Active Fuel Injector Tester and the **CH-47976-500** Active Fuel Injection Tester (AFIT) SIDI Adapter Kit, refer to the Active Fuel Injector Tester User Guide. It may take up to 2 minutes for all vehicle systems to power down.
2. Turn ON the Active Fuel Injector Tester and select the vehicle.
3. Ignition ON, perform the Injector Test with the Active Fuel Injector Tester.
   - **If the Active Fuel Injector Tester aborts testing due to fuel pressure or fuel leak down**

     Refer to **Fuel System Diagnosis**.

   - **If the Active Fuel Injector Tester does not abort testing**
4. Compare the test results with the appropriate recommended tolerance.

- **If any fuel injector exceeds the recommended tolerance**

  Replace the appropriate Q17 Fuel Injector(s).

- **If all fuel injectors are within the recommended tolerance**

5. Perform **Fuel Injector Circuit Diagnosis**.

Fuel Injector Balance Test with Scan Tool

1. Ignition ON.
2. Command the Fuel Pump Enable ON with a scan tool.
3. Verify the fuel pressure is between 320-580 kPa (46-84 PSI) with the fuel pump running.
   - **If not within 320-580 kPa (46-84 PSI)**

     Refer to **Fuel System Diagnosis**.

   - **If within 320-580 kPa (46-84 PSI)**

NOTE: **The fuel pressure may vary slightly when the fuel pump stops operating. After the fuel pump stops operating, the fuel pressure should stabilize and remain constant.**

4. Verify the fuel pressure does not decrease greater than 34 kPa (5 PSI) within 1 minute.
   - **If greater than the specified value**

     Refer to **Fuel System Diagnosis**.

   - **If less than the specified value**
5. Engine idling.
6. Verify the scan tool Fuel Rail Pressure Sensor 1 parameter is between 1.9-5.0 MPa (276-725 PSI).
   - **If not between 1.9-5.0 MPa (276-725 PSI)**

     Refer to **Fuel System Diagnosis**.

   - **If between 1.9-5.0 MPa (276-725 PSI)**

NOTE: **The engine speed must be between 600-1,000 RPM to perform this test.**

7. Select the Fuel Injector Balance function within the Control Functions menu of a scan tool.
8. Select and test a Q17 Fuel Injector. Repeat for each Q17 Fuel Injector.
9. Obtain and record a pressure drop value for each Q17 Fuel Injector.
10. Add all of the individual pressure drop values except for the fuel injector suspected of being faulty. This is the total pressure drop.
11. Divide the total pressure drop by the number of fuel injectors that were added together. This is the average pressure drop.
12. Multiply the average pressure drop by 0.20. This is the acceptable variance from the average pressure drop, 20%.
13. Verify the difference between any individual pressure drop and the average pressure drop is not greater than the acceptable variance.
    - **If greater than the acceptable variance**

      Replace the Q17 Fuel Injector.

    - **If within the acceptable variance**
14. Perform **Fuel Injector Circuit Diagnosis**.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

Refer to **Fuel Injector Replacement**

FUEL INJECTOR CIRCUIT DIAGNOSIS

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Fuel Injector 1 Control +	P2147	P0201	P2148	P1248
Fuel Injector 1 Control -	P0261	P0201	P0262	P1248
Fuel Injector 2 Control +	P2150	P0202	P2151	P1249

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Fuel Injector 2 Control -	P0264	P0202	P0265	P1249
Fuel Injector 3 Control +	P2153	P0203	P2154	P124A
Fuel Injector 3 Control -	P0267	P0203	P0268	P124A
Fuel Injector 4 Control +	P2156	P0204	P2157	P124B
Fuel Injector 4 Control -	P0270	P0204	P0271	P124B
Fuel Injector 5 Control +	P216B	P0205	P216C	P124C
Fuel Injector 5 Control -	P0273	P0205	P0274	P124C
Fuel Injector 6 Control +	P216E	P0206	P216F	P124D
Fuel Injector 6 Control -	P0276	P0206	P0277	P124D
Fuel Injector 7 Control +	P217B	P0207	P217C	P124E
Fuel Injector 7 Control -	P0279	P0207	P0280	P124E
Fuel Injector 8 Control +	P217E	P0208	P217F	P124F
Fuel Injector 8 Control -	P0282	P0208	P0283	P124F

Circuit/System Description

The engine control module (ECM) supplies voltage to each fuel injector on the injector high voltage supply circuits. The ECM energizes each fuel injector by grounding the high voltage control circuit of the fuel injector. The ECM monitors the status of the injector high voltage supply circuits and the injector high voltage control circuits. When a fuel injector circuit condition is detected by the ECM, the affected fuel injector(s) is disabled.

Diagnostic Aids

- Performing the fuel injector coil test may help isolate an intermittent condition. Refer to **Fuel Injector Diagnosis**.
- If the condition is intermittent, move the related harnesses and connectors, with the engine operating, while monitoring the scan tool Injector Control Circuit Status parameters. An Injector Control Circuit Status parameter will change from OK or Not Run to Malfunction if there is a condition with the circuit or a connection.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

NOTE: **Do Not perform this procedure unless directed here from the Fuel Injector Balance Test.**

1. Engine idling.
2. Verify the scan tool Cylinder 1-8 Current Misfire Counter parameters do not increment.
   - **If the Cylinder 1-8 Current Misfire Counters increment**

     Refer to Circuit/System Testing.

   - **If the Cylinder 1-8 Current Misfire Counters do not increment**
3. Verify the scan tool Cylinder 1-8 Injector Control Circuit Status parameters display OK.
   - **If the Cylinder 1-8 Injector Control Circuit Status parameters do not display OK**

     Refer to Circuit/System Testing.

   - **If the Cylinder 1-8 Injector Control Circuit Status parameters display OK**

4. All OK.

Circuit/System Testing

1. Ignition OFF, all vehicle systems OFF, disconnect the X3 harness connector at the K20 Engine Control Module. It may take up to 2 min for all vehicle systems to power down.
2. Test for infinite resistance between the appropriate Q17 Fuel Injector control + circuit and ground.
    - **If less than infinite resistance**
    1. Disconnect the harness connector of the Q17 Fuel Injector.
    2. Test for infinite resistance between the Q17 Fuel Injector control + circuit and ground.
        - If infinite resistance
    3. Test for infinite resistance between the Q17 Fuel Injector control - circuit and ground.
        - If less than infinite, repair the short to ground in the circuit.
        - If infinite, replace the Q17 Fuel Injector.
    - **If infinite resistance**
3. Ignition ON.
4. Test for less than 1 V between the Q17 Fuel Injector control + circuit and ground.
    - **If 1 V or greater**
    1. Disconnect the harness connector of the Q17 Fuel Injector, ignition ON.
    2. Test for less than 1 V between the Q17 Fuel Injector control + circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, repair the short to voltage on the control - circuit.
    - **If less than 1 V**
5. Ignition OFF.
6. Test for less than 3 Ω between the Q17 Fuel Injector control + circuit and control - circuit.
    - **If 3 Ω or greater**
    1. Disconnect the harness connector of the Q17 Fuel Injector.
    2. Test for less than 2 Ω on the control + circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω

3. Test for less than 2 Ω on the control - circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the Q17 Fuel Injector.
- **If less than 3 Ω**

7. Replace the K20 Engine Control Module.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Fuel Injector Replacement**
- Refer to **Control Module References** for K20 Engine Control Module replacement, programming, and setup

ALCOHOL/CONTAMINANTS-IN-FUEL DIAGNOSIS

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

Circuit/System Description

Water contamination in the fuel system may cause driveability conditions such as hesitation, stalling, no start, or misfires in one or more cylinders. Water may collect near a single fuel injector at the lowest point in the fuel injection system and cause a misfire in that cylinder. If the fuel system is contaminated with water, inspect the fuel system components for rust or deterioration.

Ethanol concentrations of greater than 10% in non-blended gasoline or greater than 85% with E85 blended gasoline for flexible fuel applications can cause driveability conditions such as hesitation, lack of power, stalling, or no start. Excessive concentrations of ethanol used in vehicles not designed for it may cause fuel system corrosion, deterioration of rubber components, and fuel filter restriction.

Reference Information

Special Tools

CH 44175-A Alcohol Tester Kit, if available

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** **Special Tools (Service Tools)** .

Circuit/System Verification

1. Remove a sample of fuel from the bottom of the fuel tank and place in a clean, clear container.
2. Place the sample on a level surface for 2 min.
3. Verify the sample is clear and bright in color.
   - **If the sample appears cloudy, or contaminated with water, as indicated by a water layer at the bottom of the sample**

     Refer to Circuit/System Testing - Particulate Contaminants in Fuel.

   - **If alcohol contamination is suspected**

     Refer to Circuit/System Testing - Alcohol in Fuel Testing.

   - **If the sample remains clear and bright**
4. All OK.

Circuit/System Testing

Alcohol in Fuel Testing with Special Tool, If Available

1. Test the fuel composition using **CH 44175-A** Alcohol Tester Kit and Instruction Manual.
2. Verify no water appears in the fuel sample.
   - **If water appears in the fuel sample**

     Clean the fuel system.

   - **If no water appears in the fuel sample**
3. Subtract 50 from the reading on the DMM in order to obtain the percentage of alcohol in the fuel sample.
4. Verify the non-blended gasoline fuel sample does not measure greater than 15% or an E85 blended gasoline fuel sample measures greater than 91% ethanol.
   - **If greater than the specified value**
   1. Add fresh regular gasoline to the vehicle's fuel tank.
   2. Remove a new sample of fuel from the tank.

3. Test the fuel composition using **CH 44175-A** Alcohol Tester Kit and Instruction Manual.
4. Subtract 50 from the reading on the DMM in order to obtain the percentage of alcohol in the fuel sample.
5. Verify the non-blended gasoline fuel sample does not measure greater than 15% or an E85 blended gasoline fuel sample measures greater than 91% ethanol.
   - If additional testing indicates that the ethanol percentage is still above 15% for a non-blended gasoline sample, drain and replace the vehicle's fuel. Refer to **Fuel Tank Draining** .
   - If additional testing indicates that the E85 blended gasoline sample still measures above 91%, continue adding fresh, regular gasoline until the ethanol content is 85% or less.

- **If the specified value or less**

5. All OK.

Alcohol in Fuel Testing without Special Tool

NOTE: **This procedure is for non-blended gasoline only. If excessive alcohol content is suspected with E85 fuel add 15% tank volume of fresh, regular gasoline to the fuel tank.**

1. Using a 100 ml (3.38 oz) specified cylinder with 1 ml (0.034 oz) graduation marks, fill the cylinder with fuel to the 90 ml (3.04 oz) mark.
2. Add 10 ml (0.34 oz) of water in order to bring the total fluid volume to 100 ml (3.38 oz) and install a stopper.
3. Shake the cylinder vigorously for 10-15 s.
4. Carefully loosen the stopper in order to release the pressure.
5. Re-install the stopper and shake the cylinder vigorously again for 10-15 s.
6. Put the cylinder on a level surface for approximately 5 min in order to allow adequate liquid separation. If alcohol is present in the fuel, the volume of the lower layer, which would now contain both alcohol and water, will be more than 10 ml (0.34 oz). For example, if the volume of the lower layer is increased to 15 ml (0.51 oz), this indicates at least 5% alcohol in the fuel. The actual amount of alcohol may be somewhat more because this procedure does not extract all of the alcohol from the fuel.
7. Verify the non-blended gasoline fuel sample does not measure greater than 15%.
   - **If greater than the specified value**

   1. Add fresh regular gasoline to the vehicle's fuel tank.
   2. Remove a new sample of fuel from the tank.
   3. Test the fuel composition of the new sample.
   4. Verify the non-blended gasoline fuel sample does not measure greater than 15%.

    - If greater than the specified value, drain and replace the vehicle's fuel. Refer to **Fuel Tank Draining** .
    - If the specified value or less, all OK.
  - **If the specified value or less**
8. All OK.

Particulate Contaminants in Fuel

1. Using an approved fuel container, draw approximately 0.5 liter (0.53 qt) of fuel from the bottom of the fuel tank.
2. Place the container on a level surface for approximately 5 min in order to allow settling of the particulate contamination. Particulate contamination will show up in various shapes and colors. Sand will typically be identified by a white or light brown crystals. Rubber will appear as black and irregular particles.
3. Verify there are no physical contaminants or water present in the fuel sample.
   - **If any physical contaminants or water are present**

     Clean the fuel system.

   - **If no physical contaminants or water are present**
4. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

Refer to **Fuel System Cleaning**

ELECTRONIC IGNITION SYSTEM DIAGNOSIS

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

Circuit/System Description

This ignition system uses an individual ignition coil for each cylinder. The engine control module (ECM) controls the spark events by transmitting

the timing pulses on the ignition control (IC) circuits to the individual ignition coil in firing order sequence.

Diagnostic Aids

- This engine application may use 2 fuses, one for each bank, to supply ignition voltage to the ignition module/coil assemblies and also to the fuel injectors. A good indication that a fuse is open is that all misfire counters are incrementing on one side of the engine.
- An open/high resistance on the low reference circuit to the ignition coil may cause a misfire.
- An erratic or weak spark is considered a no spark condition.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Electronic Ignition System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

Scan Tool Reference

Control Module References

Special Tools

EL 26792 HEI Spark Tester

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** **Special Tools (Service Tools)** .

Circuit/System Verification

Verify the following conditions. Refer to **Spark Plug Wire Inspection** , and **Ignition System Specifications** .

- The ignition coils and spark plug wires are correctly connected
- The spark plug wire resistance is within specifications
- The correct spark plug type
- The correct spark plug gap
- The correct spark plug torque

- **If a condition was found**

  Repair or replace as necessary.

- **If a condition was not found**

  Refer to Circuit/System Testing.

Circuit/System Testing

NOTE: **Do not perform this diagnostic procedure unless you were sent here from a misfire DTC or the Engine Cranks But Does Not Run diagnostic.**

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the appropriate T8 Ignition Coil. It may take up to 2 min for all vehicle systems to power down.
2. Test for less than 5 Ω between the ground circuit terminal 1 and ground.
   - **If 5 Ω or greater**
   1. Ignition OFF.
   2. Test for less than 2 Ω in the ground circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, repair the open/high resistance in the ground connection.
   - **If less than 5 Ω**
3. Test for less than 5 Ω between the low reference circuit terminal 2 and ground.

- **If 5 Ω or greater**

1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
2. Test for less than 2 Ω in the low reference circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If less than 5 Ω**

4. Ignition ON.
5. Verify a test lamp illuminates between the ignition circuit terminal 4 and ground.
    - **If the test lamp does not illuminate**

    1. Ignition OFF.
    2. Test for less than 2 Ω in the ignition circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.

    - **If the test lamp illuminates**

6. Ignition OFF, exchange the suspect T8 Ignition Coil with the T8 Ignition Coil of a known functioning cylinder.
7. Engine Running.
8. Verify the scan tool Cylinder 1-8 Current Misfire Counter does not increment for the same cylinder that the suspect T8 Ignition Coil was removed from.
    - **If increments**

      Replace the K20 Engine Control Module.

    - **If does not increment**

9. Test or replace the T8 Ignition Coil.

Component Testing

NOTE: **You must perform the Circuit/System Testing before proceeding with Component Testing.**

1. Ignition OFF, connect the **EL 26792** HEI Spark Tester to the appropriate T8 Ignition Coil, engine Running.
2. Verify the spark output of the T8 Ignition Coil.

- **If no output or the output is weak**

  Replace the T8 Ignition Coil

- **If the output is good**

3. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Ignition Coil Replacement**
- Refer to **Spark Plug Replacement**
- Refer to **Spark Plug Wire Replacement**
- Refer to **Control Module References** for engine control module replacement, programming, and setup.

EVAPORATIVE EMISSION SYSTEM DIAGNOSIS

Special Tools

EN 41413-VLV EVAP Service Port Vent Fitting

Operating Instructions for the Evaporative Emission System Tester

Vehicle Setup

WARNING: **Refer to Fuel and Evaporative Emission Pipe Warning .**

CAUTION: **Refer to Clean, Dry, Low Pressure Gas Source Caution .**

NOTE: **When servicing the evaporative emission (EVAP) system, test pressure must not exceed 13 in H20 (0.5 PSI) as pressure in excess of this could cause system components to perform inaccurately.**

NOTE: **A large difference between the vehicle temperature and shop temperature will seriously affect the accuracy of the tests. Always allow at least 15 min for the vehicle temperature to adjust to the shop temperature. Refer to Temperature Variation Instructions for more information about vehicle versus shop temperatures.**

1. Engine OFF, open the hood. Position a large fan to blow air under the vehicle onto the fuel tank area.
2. Connect the red battery clip from the tester to the positive battery terminal.

NOTE: **The vehicle battery must be fully charged for optimum tester performance.**

3. Connect the black battery clip from the tester to chassis ground.

Flow Meter Test - Leak Detection

CAUTION: **Refer to Fuel and Evaporative Emission Hose/Pipe Connection Cleaning Caution .**

1. Open the Nitrogen tank valve and turn the NITROGEN / SMOKE valve on the front control panel to NITROGEN.
2. Connect the hose to the correct test orifice on the bottom front of the tester. For orifice size, refer to the vehicle specific information found in service procedures for DTCs that relate to EVAP system leaks.
3. Press and release the remote switch to activate the tester.

NOTE: **The tester will time out after about 15 min. You may press the remote switch to reactivate the tester as desired.**

4. Position the sliding red flag on the flow meter to align with the floating indicator. When the red flag is set, press and release the remote switch to deactivate the tester.
5. Remove the hose from the test orifice and install the hose onto the vehicle. For proper connection location, and the special tool numbers for any adapters that may be required, refer to the service procedures for DTCs that relate to EVAP system leaks.
6. Ignition ON, seal the EVAP system per instructions in the service procedures for DTCs that relate to EVAP system leaks. Most systems can be sealed using a scan tool output control for the EVAP Vent Solenoid Valve, other systems require that the vent system be plugged.

NOTE:

- **Larger volume fuel tanks, and/or those with lower fuel levels, may require several minutes to fill with nitrogen.**
- **Static buildup may cause the float indicator to stick. It may be necessary to tap on the flow meter to free up the float.**
- **If fuel level is 90% or greater it will take longer to fill the system with smoke because the fuel fill tube check valve will be closed and force any smoke to pass through the on-board refueling vapor recovery pipe and orifice.**

7. Press and release the remote switch to activate the nitrogen flow and fill the system.
8. Verify the stable floating indicator position to the red flag.
   - **Above the red flag, result is unacceptable - fail**

     Go to the Smoke Procedure

   - **Below the red flag - pass. Test complete**
9. Press and release the remote switch to deactivate the tester.

Smoke Procedure - Locate the Leak

NOTE: **It is not recommended to use the tester in an outside repair bay area because wind and sunlight may affect temperature and your ability to see the smoke.**

1. Turn OFF any fans that may cause air movement around or near the vehicle.

NOTE: **Completely unwind the nitrogen/smoke hose from the bracket to optimize the tester's performance.**

2. Connect the nitrogen/smoke hose to the vehicle as directed in the service procedures. Some vehicles require that the nitrogen/smoke hose be connected at the front of the EVAP system at the EVAP service port. An adapter may be necessary. Other vehicles require the connection be made at the rear of the system using an adapter at the fuel fill cap or capless fuel fill. Consult the service procedures for DTCs that relate to EVAP system leaks for vehicle specific instructions regarding connection location and adapters.
3. Open the Nitrogen tank valve and turn the nitrogen/smoke valve on the control panel to smoke.

NOTE: **The remote switch operates on a push ON, push OFF fashion.**

4. Press and release the remote switch to activate the tester and inject smoke into the EVAP system.
5. Verify smoke has filled the EVAP system by opening the system opposite the end where smoke is injected.

NOTE:
- **When injecting smoke at the service port, remove the fuel fill cap until smoke is observed. Then close the system and continue testing.**
- **If using a special tool fuel fill cap adapter at the filler neck, vent the system at the service port, with special tool EN 41413-VLV until smoke is observed then remove the vent fitting tool and close the system to continue with the test.**
- **Inject smoke in less than 2 min cycles for optimum tester performance.**

6. Press and release the remote switch to deactivate the tester.

NOTE: **For optimum visual smoke performance, deactivate the smoke flow and allow the system pressure to drop. Allowing the smoke to exit small holes at a low flow rate greatly enhances visibility.**

7. Introduce smoke into the system for an additional 60 s. Continue introducing smoke at 15 s intervals, as necessary until leak source is identified.
8. Using a high-intensity white light, inspect the entire EVAP system path, and look for the source of the leak indicated by the exiting smoke.
   - **Smoke seen leaking**

     Repair or replace the affected component.

   - **No smoke seen leaking**
9. All OK

Temperature Variation Instructions

The Concern

Ideal circumstances for conducting the EVAP flow meter test require equal temperatures between the Nitrogen gas and the vehicle EVAP system. Significant differences in temperature between them can result in a flow or pressure change during testing, causing misleading results. Typically, the evaporative emission system tester is stored indoors, approximately 21Â°C (70Â°F). Vehicles brought in for diagnosis may have an EVAP system at significantly different temperatures.

For Example

NOTE: **With no temperature difference between the Nitrogen gas and EVAP system, the resulting vehicle EVAP system pressure will remain stable at 13 in. H20 (0.5 PSI) once pressurized, providing no leaks are present.**

When the EVAP flow meter tests are performed with significant differences in temperature between the Nitrogen gas and the vehicle EVAP system, the following results can occur:

- An increase in flow during the flow meter test can be caused by a vehicle's warm EVAP system cooling down.
- A decrease in flow during the flow meter test can be caused by a vehicle's cool EVAP system warming up.

The Solution

When working on a vehicle with significant temperature differences between the vehicle EVAP system and the Nitrogen gas, allow the vehicle EVAP system temperature to stabilize as close as possible to the temperature of the Nitrogen gas before conducting the flow meter test.

CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) SYSTEM DIAGNOSIS

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

Circuit Description

To provide maximum fuel economy under light load driving conditions, the engine control module (ECM) will command the valve lifter oil manifold assembly solenoids ON, to deactivate engine cylinders 1 and 7 on the left bank, and cylinders 4 and 6 on the right bank. The valve lifter oil manifold assembly consists of 4 electrically operated normally closed solenoids, which directs pressurized engine oil to 8 deactivating valve lifters. All 4 valve lifter oil manifold assembly solenoids are connected in parallel to a fused ignition circuit supplied by the powertrain relay. The control circuit for each solenoid is connected to an individual low side driver internal to the ECM. When enabling conditions for V4 mode are met, the ECM will command each low side driver to turn ON, in engine firing order sequence.

Diagnostic Aids

- Observe the scan tool Cylinder Deactivation Inhibit reasons to assist in determining the cause of the concern.
- Review scan tool Cylinder Deactivation Disable History to determine reason for disabling cylinder deactivation.
- A restricted valve lifter oil filter may cause a cylinder deactivation system concern. Inspect the valve lifter oil filter for a restriction or blockage. Refer to **Valve Lifter Oil Filter Replacement** .

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Cylinder Deactivation (Active Fuel Management) System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Verify the engine oil level is within the specified level.
    - **If not within the specified level**

      Repair as necessary.

    - **If within the specified level**
2. Verify the engine oil pressure is within the specified range, refer to **Oil Pressure Diagnosis and Testing** .
    - **If not within the specified range**

      Repair as necessary.

    - **If within the specified range**
3. Ignition ON.
4. Verify no DTCs are set.
    - **If DTCs are set**

      Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** for further diagnosis.

    - **If no DTCs are set**
5. Engine idling at the normal operating temperature.

6. Verify there is no abnormal engine noise.
   - **If there is an abnormal engine noise**

     Refer to **Symptoms - Engine Mechanical** for further diagnosis.

   - **If no abnormal engine noise**
7. Perform the **Cylinder Deactivation (Active Fuel Management) System Test** .
   - **If system test failed**

     Test the Q43 Valve Lifter Oil Manifold Assembly, refer to **Cylinder Deactivation (Active Fuel Management) Valve Lifter Oil Manifold Diagnosis and Testing** .

   - **If system test passes**
8. Refer to Circuit/System Testing.

Circuit/System Testing

WARNING: Road test a vehicle under safe conditions and while obeying all traffic laws. Do not attempt any maneuvers that could jeopardize vehicle control. Failure to adhere to these precautions could lead to serious personal injury and vehicle damage.

1. Operate the vehicle within the conditions of the customer's concern while monitoring the Cylinder Deactivation Inhibit parameters.
2. Verify all Cylinder Deactivation Inhibit parameters display NO.
   - **If any parameter displays YES**

     Refer to the appropriate vehicle system to determine the cause for cylinder deactivation inhibit.

   - **Symptoms - Engine Controls**
   - **Symptoms - Engine Cooling**
   - **Symptoms - Engine Electrical**
   - **Symptoms - Engine Mechanical**
   - **If none of the parameters display YES**
3. Refer to **Cylinder Deactivation (Active Fuel Management) Valve Lifter Oil Manifold Diagnosis and Testing** .

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

INSPECTION/MAINTENANCE SYSTEM CHECK

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

Description

Several states require that a vehicle pass on-board diagnostic (OBD) system tests and the inspection/maintenance (I/M) emission inspection in order to renew license plates. This is accomplished by viewing the I/M System Status display on a scan tool. Using a scan tool, the technician can observe the I/M System Status in order to verify that the vehicle meets the criteria that comply with the local area requirements.

Conditions for Updating the I/M System Status

NOTE: **New vehicles may not report an Inspection/Maintenance System Check pass or fail status for certain post catalyst oxygen sensor or heated oxygen sensor 2 diagnostics prior to 700 miles. After replacing a catalytic converter on a vehicle with greater than 700 miles, it may require up to an additional 700 miles to prevent a false failure status.**

Each system monitor requires at least one, and sometimes several diagnostic tests. The result of each test is reported by a DTC. A system monitor is complete when either all of the DTCs composing the monitor have Run and Passed, or when any one of the DTCs comprising the monitor has illuminated the malfunction indicator lamp (MIL). Once the system monitor is complete, the I/M System Status display will indicate YES in the Completed column.

For example, when the HO2S Heater Status indicates YES, either all of the oxygen sensor heater tests have passed or one of the tests has illuminated the MIL. If the vehicle has 4 heated oxygen sensors, either all 4 heater circuit tests have passed or one of the heater circuit tests has illuminated the MIL. The I/M System Status will indicate NO under the Completed column when any of the required tests for that system have not run. The following is a list of conditions that would set the I/M System Status indicator to NO:

- The vehicle is new from the factory and has not yet been driven through the necessary drive conditions to complete the tests.
- The battery has been disconnected or discharged below operating voltage.
- The control module power or ground has been interrupted.
- The control module has been reprogrammed.

- The control module DTCs have been cleared.

Monitored Emission Control Systems

The OBD II System monitors all emission control systems that are on-board. The OBD II regulations require monitoring of the following:

- The air conditioning system
- The catalytic converter efficiency
- Comprehensive component monitoring - Emission related inputs and outputs
- The evaporative emission (EVAP) system
- The fuel delivery system
- Heated catalyst monitoring
- Misfire monitoring
- The oxygen sensor system (O2S or HO2S)
- The oxygen sensor heater system (HO2S heater)

For the specific DTCs required for each system, refer to **Inspection/Maintenance (I/M) System DTC Table**. Systems such as fuel delivery, misfire, and comprehensive components may not be listed in a system status list. These tests run continuously and do not require an I/M System Status indicator.

Circuit/System Verification

1. Verify that all I/M System Status indicators report YES, and that no I/M Test DTCs are present.
   - **If any I/M Test DTCs are set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .

   - **If no I/M Test DTCs are set**
2. All OK.

Circuit/System Testing

NOTE: **Many DTC related repairs will instruct the technician to clear the DTC information. Clearing the DTC will reset the I/M System Status indicators to NO. Performing the I/M Complete System Set Procedure will set each of the I/M System Status indicators to YES.**

1. Verify no I/M DTCs are present.
   - **If an I/M DTC is set that would prevent the I/M System Status tests from completing, diagnose that DTC before continuing.**

     Refer to **Inspection/Maintenance (I/M) System DTC Table**.

   - **If no I/M DTCs are set**
2. Review applicable service bulletins for software updates that would prevent the I/M System Status tests from completing.
   - **If a control module re-program or other repair is required,**

     Perform the **Inspection/Maintenance Complete System Set Procedure** after repair.

   - **If no repair is required**
3. Observe the I/M System Status indicators.
   - **If any I/M System Status indicators report NO**

     Perform the **Inspection/Maintenance Complete System Set Procedure**.

   - **If no I/M System Status indicators report NO**
4. All OK.

INSPECTION/MAINTENANCE COMPLETE SYSTEM SET PROCEDURE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

Description

The purpose of the Inspection/Maintenance (I/M) Complete System Set Procedure is to satisfy the enable criteria necessary to execute all of the I/M readiness diagnostics and complete the drive cycles for those particular diagnostics. When all I/M monitored diagnostic tests are completed, the I/M System Status indicators are set to YES. Perform the I/M Complete System Set Procedure if any I/M System Status indicators are set to NO.

Conditions for Meeting a Cold Start

- The ignition voltage between 11-18 volts.

- The barometric pressure (BARO) is more than 75 kPa.
- The start-up engine coolant temperature (ECT) is between 4-30Â°C (39-86Â°F).
- The start-up intake air temperature (IAT) is between 4-30Â°C (39-86Â°F).
- The difference between the IAT and the ECT is less than or equal to 6Â°C (10.8Â°F).
- The ambient air temperature is between 4-30Â°C (39-86Â°F).
- The fuel level is between 15-85 percent.

Circuit/System Verification

1. Verify that all I/M System Status indicators report YES, and that no I/M Test DTCs are present.
   - **If any I/M Test DTCs are set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .

   - **If no I/M Test DTCs are set**
2. All OK.

Inspection/Maintenance (I/M) System Set Procedure

NOTE: **Whenever the ignition is turned ON, ignition positive voltage is supplied to the heated oxygen sensor (HO2S) heaters. After verifying the enable criteria, turn OFF the ignition for approximately 5 minutes to allow the sensors to cool before continuing with the test. Once the engine is started, do NOT turn the engine OFF for the remaining portion of the set procedure.**

1. Ensure that the vehicle meets the conditions for a cold start listed above.
2. The evaporative emission (EVAP) I/M System Status indicator should display YES.
   - If the EVAP I/M System Status indicator displays NO, perform the EVAP Service Bay Test, if applicable. If the EVAP Service Bay Test is NOT available, it may take up to 6 drive cycles, with up to 17 hours between drive cycles, for the EVAP I/M System Status indicator to transition to YES.
3. The O2S Heater I/M System Status indicator should display YES.
   - If the O2S Heater I/M System Status indicator displays NO, ensure that the ignition has been turned OFF for at least 10 hours.
4. Turn OFF all accessories; HVAC system, other electrical loads, including aftermarket/add-on equipment, etc.
5. Set the vehicle parking brake and ensure the vehicle is in Park for automatic transmission or Neutral for manual transmission.
6. Turn OFF all accessories; HVAC system, other electrical loads, including aftermarket/add-on equipment, etc.

7. Start and idle the engine for at least 2 minutes and until 65Â°C (149Â°F) is achieved.
8. Run the engine for 6.5 minutes within the following conditions:
    - MAF parameter between 4-30 g/s
    - Engine speed steady between 1,000-3,000 RPM
9. Return the engine to idle for 1 minute.
10. Apply and hold the brake pedal, and shift to Drive for automatic transmission, or apply the clutch pedal for manual transmission and operate the vehicle within the following conditions for 2 minutes:
    - Depress the accelerator pedal until throttle position (TP) sensor angle is more than 2 percent.
    - Mass air flow (MAF) signal between 15-30 g/s
    - RPM steady between 1,200-2,000 RPM

NOTE: **DO NOT touch the accelerator pedal during the idle period. A change in TP sensor angle or an increase in engine speed may invalidate this portion of the test.**

11. Release the accelerator pedal and shift the vehicle to Park for automatic transmission, or Neutral and release the clutch pedal for manual transmission, and allow the engine to idle for 2 minutes.
12. Quickly depress the accelerator pedal until TP sensor angle is more than 8 percent and return to idle, repeat 3 times.
13. Allow engine to idle for at least 2 minutes.

WARNING: **Refer to Road Test Warning .**

14. Release the parking brake and drive vehicle at 24 km/h (15 mph) or slower for 2 minutes.
15. Continue to drive the vehicle for at least 5.5 miles between 45-112 km/h (28-70 mph) with the vehicle reaching at least 80 km/h (50 mph).
16. Release the accelerator pedal for at least 2 seconds. This will allow the vehicle to enter decel fuel cut-off.
17. Depress the accelerator pedal until the TP sensor angle is increased 3-20 percent and maintain a safe speed for 1 minute.
18. Safely stop the vehicle, with the engine in Drive for automatic transmission or in Neutral with the clutch pedal depressed and parking brake applied for manual transmission, idle for 2 minutes.
19. Shift to Park for automatic and apply the parking brake, or neutral and release clutch pedal for manual.

NOTE: **Do NOT disturb the vehicle or turn ON the ignition until told to do so. Disturbing the vehicle may invalidate this portion of the test.**

20. Turn OFF the ignition and exit the vehicle. Do NOT disturb the vehicle for 60 minutes.
21. Observe the Inspection/Maintenance (I/M) System Status with a scan tool. All of the I/M System Status indicators should display YES.
    - If the EVAP I/M System Status indicator displays NO, turn OFF the ignition for 17 hours, ensure that the vehicle meets the conditions for a cold start, and repeat steps 12-18 six more times, or until the EVAP I/M System Status indicator transitions to YES. If the indicator continues to display NO, refer to the **Inspection/Maintenance (I/M) System DTC Table** to identify the DTCs that did not run. Follow the Conditions for Running the DTC in order to set the EVAP I/M System Status indicator
    - If any of the I/M System Status indicators display NO, refer to the **Inspection/Maintenance (I/M) System DTC Table** for the indicator which did not display YES. The I/M System DTC Table identifies the DTCs associated with each I/M System Status Indicator. Follow the Conditions for Running the DTC in order to set the associated status indicator.
22. Observe the engine DTC information with a scan tool. Verify no DTCs are present.
    - If a DTC is set, diagnose using the **Diagnostic Trouble Code (DTC) List - Vehicle** . After repairs, perform the **Inspection/Maintenance Complete System Set Procedure** to verify no further DTCs are set.

INSPECTION/MAINTENANCE (I/M) SYSTEM DTC TABLE

System	DTCs Required to Set System Status to YES
If an I/M System Status indicator did NOT update to YES during the **Inspection/Maintenance Complete System Set Procedure**, review each indicator and reference this table to determine each DTC associated with the I/M System Status Indicator. Each DTC listed below has specific conditions that must be met for the diagnostic to run. Included within the conditions are additional DTCs which, if set, may inhibit the DTCs listed below from running. Reviewing and operating the vehicle within the Conditions for Running for each DTC listed below will allow the I/M System Status Indicators to transition to YES.	
Catalyst	**DTC P0420 or P0430**
EVAP	• **DTC P0442** • **DTC P0446** • **DTC P0455**
Fuel System	**DTC P219A or P219B**
Oxygen Sensor	• **DTC P0131, P0132, P0137, P0138, P0151, P0152, P0157, or P0158** • **DTC P0030-P0032, P0036-P0038, P0050-P0054, P0056-P0060, P0135, P0141, P0155, or P0161**
Oxygen Sensor Heater	**DTC P0030-P0032, P0036-P0038, P0050-P0054, P0056-P0060, P0135, P0141, P0155, or P0161**
Camshaft System	**DTC P0011**

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ENGINE PERFORMANCE

Engine Controls and Fuel - 5.3L (L83) or 6.2L (L86) - Diagnostic Information and Procedures - Escalade, Suburban, Tahoe, Yukon

DIAGNOSTIC INFORMATION AND PROCEDURES

DTC P0010, P2088, OR P2089: CAMSHAFT POSITION ACTUATOR SOLENOID VALVE CONTROL CIRCUIT

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P0010

Camshaft Position Actuator Solenoid Valve Control Circuit

DTC P2088

Camshaft Position Actuator Solenoid Valve Control Circuit Low Voltage

DTC P2089

Camshaft Position Actuator Solenoid Valve Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control	P0010, P2088	P0010, P2089	P0010, P0011, P0016, P0106, P0107, P0690, P2089	P0011

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Low Reference	-	P0010, P0011, P2089	-	P0011

Circuit/System Description

The camshaft position (CMP) actuator system enables the engine control module (ECM) to change the timing of the camshaft while the engine is operating. The ECM controls the camshaft position actuator magnet duty cycle by controlling the amount of On time. The magnet controls the amount of engine oil flow to the CMP actuator by extending a pintle within the solenoid. The pintle acts against a spool valve in the CMP actuator mechanism which is attached to the front of the camshaft. As the spool valve is moved, oil is directed to the CMP actuator, which rotates the camshaft. The ECM can only command the camshaft position actuator to retard the valve timing from the camshaft park position, or advance the valve timing back to the park position.

The ECM controls the camshaft position actuator magnet by supplying a 12 V pulse width modulated (PWM) signal. The ECM supplies a ground to the low reference circuit.

Conditions for Running the DTC

- The ignition switch is in the crank or run position.
- The system voltage is between 11-18 V.
- The CMP actuator is command On.
- The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

The ECM detects that the commanded state of the driver and the actual state of the control circuit do not match for greater than 5 s.

Action Taken When the DTC Sets

- DTC P0010, P2088 and P2089 are Type B DTCs.
- The camshaft position actuator is commanded to the park position.

Conditions for Clearing the DTC

DTC P0010, P2088 and P2089 are Type B DTCs.

Diagnostic Aids

A stuck camshaft position actuator causing the valve timing to be retarded may result in setting DTC P00C6 along with a crank/no start condition.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Description and Operation

Camshaft Actuator System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information.

Circuit/System Verification

NOTE: **If a crankshaft or camshaft position sensor DTC is set, the scan tool Camshaft Position Actuator output**

control will not function.

1. Ignition On. Verify that DTC P0335, P0336, P0340, or P0341 is not set.
   - **If any of the DTCs are set**

     If any of the DTCs are set, refer to **Diagnostic Trouble Code (DTC) List - Vehicle** for further diagnosis.

   - **If none of the DTCs are set**
2. Verify the scan tool parameters listed below do not display Malfunction:
   - Camshaft Position Actuator Solenoid Valve Control Circuit Open Test Status.
   - Camshaft Position Actuator Solenoid Valve Control Circuit Low Voltage Test Status.
   - Camshaft Position Actuator Solenoid Valve Control Circuit High Voltage Test Status.
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing.

   - **If Malfunction is not displayed**
3. Engine idling at normal operating temperature.
4. Verify the scan tool parameters listed below do not display Malfunction when commanding the scan tool Camshaft Position Actuator from 0-25Â° and back to 0Â° with a scan tool:
   - Camshaft Position Actuator Solenoid Valve Control Circuit Open Test Status.
   - Camshaft Position Actuator Solenoid Valve Control Circuit Low Voltage Test Status.
   - Camshaft Position Actuator Solenoid Valve Control Circuit High Voltage Test Status.
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing.

   - **If Malfunction is not displayed**
5. Operate the vehicle within the Conditions for Running. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

- **If the DTC does not set**

6. All OK.

Circuit/System Testing

1. Ignition Off and all vehicle systems Off, disconnect the harness connector at the Q6 Camshaft Position Actuator Solenoid Valve. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal 1 and ground.
   - **If 5 Ω or greater**
   1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If less than 5 Ω**

NOTE: **A test lamp must be used for this test. The control circuit is pulled-up to a low current voltage. The current is too low to illuminate a test lamp. A voltage on the control circuit is normal.**

3. Ignition On.
4. Verify that a test lamp does not illuminate between the control circuit terminal 2 and ground.
   - **If the test lamp illuminates**
   1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module, ignition On.
   2. Test for less than 1 V between the control circuit and ground.
   - If 1 V or greater, repair the short to voltage on the circuit.
   - If less than 1 V, replace the K20 Engine Control Module.
   - **If the test lamp does not illuminate**
5. Remove the test lamp.
6. Connect the DMM negative lead to the control circuit terminal 2. Connect the DMM positive lead to B+. Set the DMM on the diode setting. Command the Camshaft Position Actuator Solenoid On and Off with a scan tool. The DMM should transition from OL when commanded Off to less than 1 V when commanded On.
   - **If the parameter does not correspond to the specified values**

1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
2. Test for less than 2 Ω in the control circuit end to end.
   - If 2 Ω or greater, repair the open/high resistance or short to ground in the circuit.
   - If less than 2 Ω, replace the K20 Engine Control Module.
- **If the parameter corresponds to the specified values**

7. Test or replace the Q6 Camshaft Position Actuator Solenoid Valve.

Component Testing

Static Test

1. Ignition Off, disconnect the harness connector at the appropriate Q6 Camshaft Position Actuator Solenoid Valve.
2. Test for 5-12 Ω between the control terminal 2 and the low reference terminal 1.
   - **If not between 5-12 Ω**

     Replace the Q6 Camshaft Position Actuator Solenoid Valve.

   - **If between 5-12 Ω**
3. Test for infinite resistance between each terminal and the Q6 Camshaft Position Actuator Solenoid Valve housing.
   - **If not infinite resistance**

     Replace the camshaft position actuator magnet and camshaft position actuator solenoid valve.

   - **If infinite resistance**
4. All OK.

Dynamic Test

1. Remove the camshaft position actuator magnet.

NOTE:

- **The camshaft position actuator magnet pintle should be facing downward for this test.**
- **Do not allow electrical current to flow through the camshaft position actuator magnet for greater than 1-2 s.**

2. Install a fused jumper wire between the control circuit terminal 2 and 12 V. Momentarily install a jumper wire between the low reference terminal 1 and ground. The pintle should extend.
   - **If the function does not perform as specified**

     Replace the camshaft position actuator magnet and camshaft position actuator solenoid valve.

   - **If the function does perform as specified**
3. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Camshaft Position Actuator Solenoid Valve Replacement**
- Refer to **Camshaft Position Actuator Magnet Replacement**
- Refer to **Control Module References** for K20 Engine Control Module replacement, programming, and setup

DTC P0011: INTAKE CAMSHAFT POSITION SYSTEM PERFORMANCE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P0011

Intake Camshaft Position System Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Camshaft Position Actuator Solenoid High Control	P0010, P2088	P0010	P0010, P0011, P0016, P0106,	P0011

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
			P0107, P0690, P2089	
Low Reference	-	P0010, P0011	-	P0011

Circuit/System Description

The camshaft position (CMP) actuator system enables the engine control module (ECM) to change the timing of the camshaft while the engine is operating. The ECM controls the camshaft position actuator magnet duty cycle by controlling the amount of On time. The magnet controls the amount of engine oil flow to the CMP actuator by extending a pintle within the solenoid. The pintle acts against a spool valve in the CMP actuator mechanism which is attached to the front of the camshaft. As the spool valve is moved, oil is directed to the CMP actuator, which rotates the camshaft. The ECM can only command the camshaft position actuator to retard the valve timing from the camshaft park position, or advance the valve timing back to the park position.

The ECM controls the camshaft position actuator magnet by supplying a 12 V pulse width modulated (PWM) signal. The ECM supplies a ground to the low reference circuit.

Conditions for Running the DTC

- DTC P0010, P0016, P0335, P0336, P0340, and P0341 is not set.
- The engine is running.
- The system voltage is between 11-32 V.
- The CMP actuator is enabled and commanded greater than 0 degrees.
- The power take off (PTO) is not active - If equipped.
- The desired camshaft position does not vary greater than 7.5 degrees for 2 s.
- DTC P0011 runs continuously when the above conditions are met.

Conditions for Setting the DTC

The ECM detects the difference between the desired camshaft position angle and the actual camshaft position angle is greater than 8 degrees for greater than 20 s

Action Taken When the DTC Sets

- DTC P0011 is a Type B DTC.

- The CMP actuator is commanded to the park position.

Conditions for Clearing the DTC

DTC P0011 is a Type B DTC.

Diagnostic Aids

- The engine oil condition has a major impact on the camshaft actuator system.
- A low oil level condition may set this DTC. The engine may require an oil change. Inquire with the customer when the last oil change was performed. You may also monitor the scan tool Engine Oil Life parameter. Advise the customer an oil change may be required.
- Inspect the engine for any recent engine mechanical repairs. An incorrectly installed camshaft, camshaft actuator, or timing chain can cause this DTC to set.
- A stuck camshaft position actuator causing the valve timing to be retarded may result in setting DTC P00C6 along with a crank/no start condition.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Description and Operation

Camshaft Actuator System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**

- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information.

Circuit/System Verification

NOTE:

- **The engine oil level and the oil pressure are critical to the correct operation of the camshaft position (CMP) actuator system. Verify that the engine has the correct oil level and the correct oil pressure before continuing with this diagnostic.**
- **The engine oil condition has a major impact on the camshaft actuator system. Debris in the oil can interfere with the camshaft position actuator solenoid and the mechanical camshaft actuator operation. Inspect for dirty or degraded crankcase oil. The engine may require an oil change. Inquire with the customer when the last oil change was performed. You may also monitor the scan tool Engine Oil Life Remaining parameter. Advise the customer an oil change may be required.**

1. Ignition On.
2. Verify the engine has the correct oil level and correct oil pressure. Refer to Oil Pressure Diagnosis and Testing .
   - **If the oil level and the oil pressure are not correct**

     Repair as necessary

   - **If the oil level and the oil pressure are correct**

NOTE: **If a crankshaft or camshaft position sensor DTC is set, the scan tool Camshaft Position Actuator output control will not function.**

3. Verify that DTC P0010, P0016, P0335, P0336, P0340, P0341, P0345, P0346, P0365, P0366, P0390 or P0391, is not set.
   - **If any of the DTCs are set**

Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** for further diagnosis.

- **If none of the DTCs are set**

4. Engine idling.
5. Verify the scan tool Desired Camshaft parameter and the Camshaft Position angle parameter match when commanding the Camshaft Position Actuator to 20 degrees with a scan tool.
   - **If the parameters do not match**

     Refer to Circuit/System Testing.

   - **If the parameters match**
6. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
7. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
8. All OK.

Circuit/System Testing

1. Ignition Off and all vehicle systems Off, disconnect the harness connector at the Q6 Camshaft Position Actuator Solenoid Valve. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal 1 and ground.
   - **If 5 Ω or greater**
   1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If less than 5 Ω**

NOTE: **A test lamp must be used for this test. The control circuit is pulled-up to a low current voltage. The current**

is too low to illuminate a test lamp. A voltage on the control circuit is normal.

3. Ignition On.
4. Verify that a test lamp does not illuminate between the control circuit terminal 2 and ground.
   - **If the test lamp illuminates**
   1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module, ignition On.
   2. Test for less than 1 V between the control circuit and ground.
   - If 1 V or greater, repair the short to voltage on the circuit.
   - If less than 1 V, replace the K20 Engine Control Module.
   - **If the test lamp does not illuminate**
5. Remove the test lamp.
6. Connect the DMM negative lead to the control circuit terminal 2. Connect the DMM positive lead to B+. Set the DMM on the diode setting. Command the Camshaft Position Actuator Solenoid On and Off with a scan tool. The DMM should transition from OL when commanded Off to less than 1 V when commanded On.
   - **If the parameter does not correspond to the specified values**
   1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the control circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance or short to ground in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If the parameter corresponds to the specified values**
7. Remove the camshaft position actuator magnet. Perform the **Camshaft Position Actuator Magnet Cleaning and Inspection** . The camshaft position actuator magnet should pass the inspection.
   - **If the inspection does not pass**

     Replace the camshaft position actuator magnet

   - **If the inspection does pass**
8. Perform the **Camshaft Position Actuator and Solenoid Valve Diagnosis and Testing** . The camshaft position actuator solenoid valve should pass the inspection.
   - **If the test does not pass**

Replace the camshaft position actuator solenoid valve

- **If the test does pass**

9. Test or replace the Q6 Camshaft Position Actuator Solenoid Valve and magnet.

Component Testing

Static Test

1. Ignition Off, disconnect the harness connector at the appropriate Q6 Camshaft Position Actuator Solenoid Valve.
2. Test for 5-12 Ω between the control terminal 1 and the low reference terminal 2.
   - **If not between 5-12 Ω**

     Replace the Q6 Camshaft Position Actuator Solenoid Valve.

   - **If between 5-12 Ω**
3. Test for infinite resistance between each terminal and the Q6 Camshaft Position Actuator Solenoid Valve housing.
   - **If not infinite resistance**

     Replace the Q6 Camshaft Position Actuator Solenoid Valve.

   - **If infinite resistance**
4. Ignition Off, remove the camshaft position actuator magnet.
5. Test for 5.0-9.0 Ω between the solenoid control terminal 2 and the low reference terminal 1 at the camshaft position actuator magnet.
   - **If not within the specified range**

     Replace the camshaft position actuator magnet

   - **If within the specified range**
6. Test for infinite resistance between each terminal of the magnet and the magnet housing.
   - **If not within the specified value**

     Replace the camshaft position actuator magnet

   - **If within the specified value**

7. All OK.

Dynamic Test

1. Remove the camshaft position actuator magnet.

NOTE:

- **The camshaft position actuator magnet pintle should be facing downward for this test.**
- **Do not allow electrical current to flow through the camshaft position actuator magnet for greater than 1-2 s.**

2. Install a 20 A fused jumper wire between the control circuit terminal 2 and 12 V. Momentarily install a jumper wire between the low reference terminal 1 and ground. The pintle should extend.
   - **If the function does not perform as specified**

     Replace the camshaft position actuator magnet

   - **If the function does perform as specified**
3. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Camshaft Position Actuator Cleaning and Inspection**
- Refer to **Camshaft Position Actuator Magnet Replacement**
- Refer to **Control Module References** for K20 Engine Control Module replacement, programming, and setup.

DTC P0016: CRANKSHAFT POSITION - CAMSHAFT POSITION NOT PLAUSIBLE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P0016

Crankshaft Position - Camshaft Position Not Plausible

Circuit/System Description

The engine control module (ECM) uses the crankshaft position sensor and camshaft position sensor information to monitor the correlation between the crankshaft and camshaft position.

Conditions for Running the DTC

- DTC P0335, P0336, P0340, or P0341 is not set.
- Crankshaft and camshaft position signals are synchronized.
- The engine is cranking or running.
- The camshaft position actuator solenoid valve is in the parked position.
- Time since last execution of the diagnostic is less than 1 s.

The DTCs run continuously once the above conditions are met.

Conditions for Setting the DTC

The ECM detects that 2 camshaft position sensor pulses occur more than 11 crank degrees before or 11 crank degrees after the nominal position in 1 camshaft revolution during 2 out of 3 tests.

Action Taken When the DTC Sets

DTC P0016 is a Type B DTC.

Conditions for Clearing the DTC

DTC P0016 is a Type B DTC.

Reference Information

Description and Operation

Camshaft Actuator System Description

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0335, P0336, P0340, or P0341 is not set.
   - **If any of the DTCs are set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .

   - **If none of the DTCs are set**
3. Engine Running at normal operating temperature.
4. Verify DTC P0016 is not set.
   - **If the DTC is set**

     Inspect for the following and repair as necessary:

   - A Q6 Camshaft Position Actuator Solenoid Valve that is stuck in the full advance or retard position (if equipped).
   - The correct installation of the Q6 Camshaft Position Actuator Solenoid Valve (if equipped).
   - The correct installation of the B23 Camshaft Position Sensor.
   - The correct installation of the B26 Crankshaft Position Sensor.
   - A timing chain tensioner condition.
   - An incorrectly installed timing chain.
   - Excessive play in the timing chain or sprockets.
   - A timing chain that jumped teeth.
   - **If the DTC is not set**
5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify the DTC does not set.

- **If the DTC sets**

  A mechanical condition listed above still exists.

- **If the DTC does not set**

7. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Camshaft Position Actuator Cleaning and Inspection**
- Refer to **Camshaft Position Actuator Magnet Cleaning and Inspection**
- Refer to **Camshaft Position Actuator Solenoid Valve Inspection**
- Refer to **Camshaft Position Sensor Replacement**
- Refer to **Camshaft Timing Chain and Sprocket Cleaning and Inspection**
- Refer to **Crankshaft Position Sensor Replacement**

DTC P0030-P0032, P0036-P0038, P0050-P0054, P0056-P0060, P0135, P0141, P0155, OR P0161: HO2S HEATER CONTROL CIRCUITS/HO2S HEATER RESISTANCE/HO2S HEATER PERFORMANCE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0030

HO2S Heater Control Circuit Bank 1 Sensor 1

DTC P0031

HO2S Heater Control Circuit Low Voltage Bank 1 Sensor 1

DTC P0032

HO2S Heater Control Circuit High Voltage Bank 1 Sensor 1

DTC P0036

HO2S Heater Control Circuit Bank 1 Sensor 2

DTC P0037

HO2S Heater Control Circuit Low Voltage Bank 1 Sensor 2

DTC P0038

HO2S Heater Control Circuit High Voltage Bank 1 Sensor 2

DTC P0050

HO2S Heater Control Circuit Bank 2 Sensor 1

DTC P0051

HO2S Heater Control Circuit Low Voltage Bank 2 Sensor 1

DTC P0052

HO2S Heater Control Circuit High Voltage Bank 2 Sensor 1

DTC P0053

HO2S Heater Resistance Bank 1 Sensor 1

DTC P0054

HO2S Heater Resistance Bank 1 Sensor 2

DTC P0056

HO2S Heater Control Circuit Bank 2 Sensor 2

DTC P0057

HO2S Heater Control Circuit Low Voltage Bank 2 Sensor 2

DTC P0058

HO2S Heater Control Circuit High Voltage Bank 2 Sensor 2

DTC P0059

HO2S Heater Resistance Bank 2 Sensor 1

DTC P0060

HO2S Heater Resistance Bank 2 Sensor 2

DTC P0135

HO2S Heater Performance Bank 1 Sensor 1

DTC P0141

HO2S Heater Performance Bank 1 Sensor 2

DTC P0155

HO2S Heater Performance Bank 2 Sensor 1

DTC P0161

HO2S Heater Performance Bank 2 Sensor 2

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
HO2S Heater Ignition Voltage	P0030, P0031, P0036, P0037, P0050, P0051,	P0030, P0031, P0036, P0037, P0050, P0051, P0056, P0057, P0132,	P0690	P0135, P0141, P0155, P0161

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
	P0056, P0057, P0102, P0132, P0134, P0135, P0138, P0141, P0152, P0154, P0155, P0158, P0161, P0300, P0443, P0458, P06DA, P3401, P3403, P3425, P3441, P3443, P3449, P3451, *	P0134, P0135, P0138, P0140, P0141, P0152, P0154, P0155, P0157, P0158, P0160, P0161		
HO2S Heater Control	P0030, P0031, P0036, P0037, P0050, P0051, P0053, P0054, P0056, P0057, P0059, P0060, P0135, P0141, P0155, P0161	P0030, P0031, P0036, P0037, P0050, P0051, P0053, P0054, P0056, P0057, P0059, P0060, P0132, P0134, P0135, P0138, P0140, P0141, P0151, P0152, P0154, P0155, P0158, P0160, P0161	P0030, P0032, P0036, P0038, P0050, P0052, P0056, P0058, P0132, P0134, P0135, P0138, P0140, P0141, P0152, P0154, P0155, P0157, P0158, P0160, P0161, P0506, P0690	P0135, P0141, P0155, P0161
* Opens Fuse				

Typical Scan Tool Data

HO2S Heater Bank 1 or 2 Sensor 1 or 2

Circuit	Short to Ground	Open	Short to Voltage
Parameter Normal Range: 0.2-1.5 A			
Ignition Voltage	0 A	0 A	0.2-2 A
Low Control	0 A	0 A	0 A

Circuit/System Description

Heated oxygen sensors (HO2S) are used for fuel control and post catalyst monitoring. Each HO2S compares the oxygen content of the surrounding air with the oxygen content in the exhaust stream. The HO2S must reach operating temperature to provide an accurate voltage signal. A heating element inside the HO2S minimizes the time required for the sensors to reach operating temperature. Voltage is provided to the heater by an ignition voltage circuit through a fuse. With the engine running, ground is provided to the heater by the HO2S heater low control circuit through a low side driver within the engine control module (ECM). The ECM uses pulse width modulation (PWM) to control the HO2S heater operation to maintain a specific HO2S operating temperature range.

Conditions for Running the DTC

P0030-P0032, P0036-P0038, P0050-P0052, or P0056-P0058

- The ignition voltage is between 11-32 V.
- The engine speed is greater than 400 RPM.
- The DTCs run continuously when the above conditions are met.

P0053, P0054, P0059, or P0060

- DTCs P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0125, P0128, or P2610 are not set.
- The engine run time is less than 0.4 s.
- The ignition voltage is less than 32 V.
- The ignition is OFF for greater than 8 h.
- The engine coolant temperature (ECT) is between -30 to +45Â°C (-22 to +113Â°F) at engine start-up.
- The ECT and the intake air temperature (IAT) are within 8Â°C (14Â°F) at engine start-up.
- The DTCs run once per drive cycle when the above conditions are met.

P0135, P0141, P0155, or P0161

- DTCs P0116, P0117, P0118, P0125, or P0128 are not set.
- The ignition voltage is between 10-32 V.
- The HO2S is at operating temperature.
- The HO2S is commanded ON.
- The DTCs run once per drive cycle when the above conditions are met for 120 s.

Conditions for Setting the DTC

P0030, P0036, P0050, or P0056

The engine control module detects an open circuit in the heater output low side driver circuit of the heated oxygen sensor when the heater is commanded OFF for greater than 5 s.

P0031, P0037, P0051, or P0057

The engine control module detects a short to ground in the heater output low side driver circuit of the heated oxygen sensor when the heater is commanded OFF for greater than 5 s.

P0032, P0038, P0052, or P0058

The engine control module detects a short to voltage in the heater output low side driver circuit of the heated oxygen sensor when the heater is commanded ON for greater than 5 s.

P0053, P0054, P0059, or P0060

The engine control module detects the HO2S heater is not within a specified resistance range at engine start-up.

P0135 or P0155

The engine control module detects that the HO2S 1 heater current is greater than 3.1 amps, or less than 0.3 amps for greater than 8 s.

P0141 or P0161

The engine control module detects that the HO2S 2 heater current is greater than 2.9 amps, or less than 0.3 amps for greater than 8 s.

Action Taken When the DTC Sets

DTCs P0030-P0032, P0036-P0038, P0050-P0054, P0056-P0060, P0135, P0141. P0155, and P0161 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P0030-P0032, P0036-P0038, P0050-P0054, P0056-P0060, P0135, P0141. P0155, and P0161 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON. Engine Running.
2. Verify the parameters listed below do not display Malfunction when commanding the HO2S Heater Bank 1 or 2 Sensor 1 or 2 to 0% and 100% with a scan tool:
   - HO2S Heater Control Circuit Low Voltage Test Status Bank 1 or 2 Sensor 1 or 2
   - HO2S Heater Control Circuit Open Test Status Bank 1 or 2 Sensor 1 or 2
   - HO2S Heater Control Circuit High Voltage Test Status Bank 1 or 2 Sensor 1 or 2
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing.

   - **If Malfunction is not displayed**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

4. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
5. All OK.

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the appropriate B52 Heated Oxygen Sensor. Ignition ON.
2. Verify that a test lamp illuminates between the ignition voltage circuit terminal 2 and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition OFF, remove the test lamp.
   2. Test for less than 2 Ω in the ignition circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, verify the fuse is OK and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**
   1. Ignition OFF.
   2. Test for infinite resistance between the ignition circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, test all components connected to the fuse and replace as necessary.
   - **If the test lamp illuminates**
3. Verify that a test lamp does not illuminate between the ignition voltage circuit terminal 2 and the control circuit terminal 1.
   - **If the test lamp illuminates**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the control circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.
   - **If the test lamp does not illuminate**
4. Remove the test lamp.

5. Ignition On.
6. Verify the scan tool HO2S Heater Control Circuit High Voltage Test Status Bank 1 or 2 Sensor 1 or 2 parameter is OK.
   - **If the parameter is not OK**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module. Ignition ON.
   2. Test for less than 1 V between the control circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If the Parameter is OK**

NOTE:
- **Less than 10 Ω of additional resistance on the ignition voltage circuit, or control circuit may set a DTC. If there is a resistance on a circuit, the driver will remain ON and the scan tool HO2S High Voltage Test Status parameter will display OK.**
- **Performing this test may set additional DTCs.**

7. Install a 10 A fused jumper wire between the control circuit terminal 1 and the ignition voltage circuit terminal 2.

NOTE: **This test may only be performed once per key cycle. If test is repeated, ignition OFF, allow the engine control module to shut down completely, then ignition ON.**

8. Verify the scan tool HO2S Heater Control Circuit High Voltage Test Status Bank 1 or 2 Sensor 1 or 2 parameter is Malfunction.
   - **If the Parameter is not Malfunction**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the control circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If the Parameter is Malfunction**
9. Test or replace the B52 Heated Oxygen Sensor.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Heated Oxygen Sensor Replacement - Bank 1 Sensor 1**
- Refer to **Heated Oxygen Sensor Replacement - Bank 1 Sensor 2**
- Refer to **Heated Oxygen Sensor Replacement - Bank 2 Sensor 1**
- Refer to **Heated Oxygen Sensor Replacement - Bank 2 Sensor 2**
- Perform the scan tool Heated Oxygen Sensor Resistance Learn Reset after replacing an HO2S.
- Refer to **Control Module References** for ECM replacement, programming and setup

DTC P0068 OR P1101: THROTTLE BODY AIR FLOW PERFORMANCE/INTAKE AIR FLOW SYSTEM PERFORMANCE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P0068

Throttle Body Air Flow Performance

DTC P1101

Intake Air Flow System Performance

Circuit/System Description

The engine control module (ECM) compares actual air flow based on throttle position (TP) to a calculated air flow based on manifold absolute pressure (MAP) sensor, and mass air flow (MAF).

Conditions for Running the DTC

DTC P0068

- The engine speed is greater than 800 RPM.
- The ignition voltage is greater than 6.5 V.
- The DTC runs continuously when the above conditions are met.

DTC P1101

- DTCs P001, P0102, P0103, P0107, P0108, P0111, P0112, P0113, P0114. P0116, P0117, P0118, P0128, P0335, or P0336 are not set
- The engine speed is between 500-6,800 RPM
- The engine coolant temperature (ECT) is between -7 to +150Â°C (+19 to +302Â°F).
- The intake air temperature (IAT) sensor 1 is between -20 to +125Â°C (-4 to +257Â°F).
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

The ECM detects that the actual air flow rate is greater than the calculated air flow.

Action Taken When the DTC Sets

- DTC P0068 is a type A DTC.
- DTC P1101 is a type B DTC.

Conditions for Clearing the DTC

- DTC P0068 is a type A DTC.
- DTC P1101 is a type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC P0641, P0651, P0697, or P06A3 is not set.
   - **If any of the DTCs are set**

     Refer to **DTC P0641, P0651, P0697, or P06A3** for further diagnosis.

   - **If none of the DTCs are set**
3. Verify the scan tool Throttle Body Idle Air Flow Compensation parameter is less than 90%.
   - **90% or greater**

     Refer to **Throttle Body Cleaning** .

   - **If less than 90%**
4. Verify the scan tool Throttle Position Sensors 1 and 2 Agree/Disagree parameter displays Agree while performing the Throttle Sweep Test with a scan tool.
   - **If Disagree**

     Refer to **DTC P0121-P0123, P0222, P0223, P16A0-P16A2, or P2135** for further diagnosis.

   - **If Agree**
5. Determine the current vehicle testing altitude.

6. Verify the scan tool MAP Sensor pressure parameter is within the range specified in the **Altitude Versus Barometric Pressure** table.
   - **If the MAP Sensor parameter is not in range**

     Refer to **DTC P0106** for further diagnosis.

   - **If the MAP Sensor parameter is in range**
7. Verify the scan tool MAF Sensor g/s parameter changes smoothly and gradually as the engine speed is increased and decreased while performing the actions listed below.
   1. Engine idling
   2. Perform the scan tool snapshot function.
   3. Increase the engine speed slowly to 3,000 RPM and then back to idle.
   4. Exit from the scan tool snapshot and review the data.
   5. Observe the MAF Sensor parameter frame by frame with a scan tool.
   - **The MAF Sensor parameter does not change smoothly and gradually**

     Refer to **DTC P0101** for further diagnosis.

   - **The MAF Sensor parameter changes smoothly and gradually**
8. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
9. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set.**
10. All OK.

Circuit/System Testing

NOTE: **You must perform the Circuit/System Verification before proceeding with Circuit/System Testing.**

1. Verify the integrity of the entire air induction system by verifying that none of the conditions listed below exist:
   - Any damaged, improperly installed, collapsed, or restricted components

- Loose clamps, cracks, or other damage
- An air flow restriction
- Restricted air filter
- Splits, kinks, leaks, or improper connections at the vacuum hoses
- Vacuum leaks at the intake manifold, MAP sensor, and throttle body
- Water intrusion
- Any snow or ice buildup, in cold climates
- Contamination of the MAF sensor element
- Improper operation of the crankcase ventilation system - Refer to **Crankcase Ventilation System Inspection/Diagnosis** for further diagnosis.
- Missing, restricted, or leaking exhaust components - Refer to **Symptoms - Engine Exhaust** for further diagnosis.
- **If a condition is found**

  Repair or replace component as appropriate.

- **If no condition is found**

2. Test the engine for a mechanical condition. Refer to **Symptoms - Engine Mechanical** for diagnosis.
   - **If a condition is found**

     Repair or replace component as appropriate.

   - **If no condition is found**
3. All OK

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

Refer to **Control Module References** for engine control module replacement, programming, and setup.

DTC P0089, P228C, OR P228D: FUEL PRESSURE REGULATOR PERFORMANCE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.

- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0089

Fuel Pressure Regulator Performance

DTC P228C

Fuel Pressure Regulator Control Performance - Low Pressure

DTC P228D

Fuel Pressure Regulator Control Performance - High Pressure

Circuit/System Description

The high fuel pressure necessary for direct injection is supplied by the high pressure fuel pump. The high pressure fuel pump is mounted on the rear of the engine under the intake manifold and is driven by a three-lobe cam on the camshaft. This high pressure fuel pump also regulates the fuel pressure using an actuator in the form of an internal solenoid-controlled valve. In order to keep the engine running efficiently under all operating conditions, the engine control module (ECM) requests pressure ranging from 2 to 15 MPa (290 to 2, 176 PSI), depending on engine speed and load. Output drivers in the ECM provide the high pressure fuel pump control circuit with a 12 V pulse-width modulated (PWM) signal, which regulates fuel pressure by opening and closing the control valve at specific times during pump strokes. This effectively regulates the portion of each pump stroke that is delivered to the fuel rail. The high pressure fuel pump is normally closed and will not deliver an increase in fuel pressure when the control solenoid is NOT powered. In the event of pump control failure, the high pressure system is protected by a relief valve in the pump that prevents the pressure from exceeding 21.5 MPa (3,118 PSI).

The fuel rail pressure sensor is a dual analog sensor that provides the feedback necessary to the ECM to control the high pressure fuel pump and the fuel injectors. The sensor is diagnosed separately from the fuel pressure control system.

The ECM monitors the fuel rail pressure sensor and the high pressure fuel pump solenoid to determine if the commanded and actual pressures are within a predetermined range during engine cranking and at all times while the engine is running. The ECM also monitors the high pressure fuel pump solenoid to make sure it is operating within expected limits.

Conditions for Running the DTC

- DTCs P0010, P0011, P0016, P0089, P0090, P0091, P0092, P0096, P0097, P0098, P0099, P00C8, P00C9, P00CA, P0117, P0118, P0178, P0179, P018B, P018C, P018D, P0191, P0192, P0193, P0231, P0232, P023F, P0335, P0336, P0340, P0341, or P1682 are not present.
- Fuel rail pressure is greater than 0.275 MPa (40 PSI).
- Battery voltage is greater than 11 V.
- Fuel temperature is between -10Â°C (14Â°F) and 100Â°C (212Â°F).
- Intake air temperature is greater than -10Â°C (14Â°F).
- The engine has been running for greater than 2 m.
- Barometer pressure is greater than 70 kPa.
- Vehicle is not in a low fuel state.
- The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

P0089

- The high pressure fuel pump has exceeded the control limits. This condition exists when the high pressure fuel pump actuator command is 0Â° or greater than 130Â°.
- The above condition exists for 750 out of 938 counts, approximately 30 seconds at idle or 7 seconds at 2,700 RPM.

P228C

- The fuel rail pressure is greater than 3.00 MPa (435 PSI) below the desired fuel rail pressure.
- The above condition exists for 750 out of 938 counts, approximately 30 seconds at idle or 7 seconds at 2,700 RPM.

P228D

- The fuel rail pressure is greater than 3.00 MPa (435 PSI) above the desired fuel rail pressure.
- The above condition exists for 750 out of 938 counts, approximately 30 seconds at idle or 7 seconds at 2,700 RPM.

Action Taken When the DTC Sets

- DTC P0089 is a Type B DTC.
- DTCs P228C and P228D are Type A DTCs.

Conditions for Clearing the DTC

- DTC P0089 is a Type B DTC.
- DTCs P228C and P228D are Type A DTCs.

Diagnostic Aids

- A leak in the high pressure fuel system may set a DTC.
- A faulty valve, plunger, or solenoid in the high pressure fuel pump may set a DTC. High pressure fuel pump damage will most likely be undetectable upon visual inspection.
- A restricted fuel feed pipe between the high pressure fuel pump and the fuel rail pressure sensor may set a DTC.
- Any problem with the camshaft may set fuel pressure DTCs due to the location and design of the high pressure fuel pump. If camshaft position control DTCs are current or in history, a cam control issue may be the root cause.
- A leaking or restricted fuel injector may set the DTC.
- As little as 2 Ω on either circuit of the high pressure fuel pump solenoid will cause a DTC to set. Test the circuits of the high pressure fuel pump solenoid for a high resistance if you suspect a condition.
- Vapor lock may set DTC P0089

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0010, P0011, P0016, P0090, P0091, P0092, P00C8, P00C9, P00CA, P018B, P018C, P018D, P0191, P0192, P0193, P0231, P0232, P023F, P0335, P0336, P0340, P0341, P127C, P127D, or P163A are not set.
   - **If the DTC is set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .

   - **If the DTC is not set**
3. Engine at idle.
4. Verify the Fuel Rail Pressure Sensor parameter is between 1.9-6.0 MPa (276-870 PSI).
   - **If not between 1.9-6.0 MPa (276-870 PSI)**

     Refer to Circuit/System Testing.

   - **If between 1.9-6.0 MPa (276-870 PSI)**
5. Verify the scan tool Fuel Rail Pressure parameter increases or decreases while commanding an increase and decrease in Fuel Rail Pressure with a scan tool.
   - **If the pressure does not increase or decrease with each command**

     Refer to Circuit/System Testing.

   - **If the pressure increases or decreases with each command**

WARNING: Road test a vehicle under safe conditions and while obeying all traffic laws. Do not attempt any maneuvers that could jeopardize vehicle control. Failure to adhere to these precautions could lead to serious personal injury and vehicle damage.

6. Verify the scan tool Fuel Pressure Sensor parameter does not drop off during acceleration, cruise or hard cornering.
   - **If the pressure drops off**

     Refer to **Fuel System Diagnosis** .

   - **If the pressure does not drop off**
7. Road test the vehicle and perform a wide open acceleration from a stop until the transmission shifts into second gear. On manual transmission applications, shift to second gear or stop the test near 5,600 RPM. Repeat the test at least three times.
8. Verify DTC P0089, P228C, or P228D is not set.
   - **If the DTC is set**

     Refer to Circuit/System Testing.

   - **If the DTC is not set**
9. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed in the Freeze Frame/Failure Records data.
10. Verify DTC P0089, P228C, or P228D is not set.
    - **If the DTC is set**

      Refer to Circuit/System Testing.

    - **If the DTC is not set**
11. All OK.

Circuit/System Testing

1. Ignition OFF, all vehicle systems OFF, disconnect the harness connector at the K20 Engine Control Module. It may take up to 2 min for all vehicle systems to power down.
2. Disconnect the harness connector at the G18 High Pressure Fuel Pump.
3. Test for less than 2 Ω between G18 High Pressure Fuel Pump connector terminal 1 and the K20 Engine Control Module high control circuit terminal 16.
   - **If greater than 2 Ω**

     Repair the high resistance in the circuit.

- **If 2 Ω or less**

4. Test for less than 2 Ω between the G18 High Pressure Fuel Pump connector terminal 2 and the K20 Engine Control Module low control circuit terminal 32.
   - **If greater than 2 Ω**

     Repair the high resistance in the circuit.

   - **If 2 Ω or less**
5. Remove the G18 High Pressure Fuel Pump.
6. Verify the lobes on the camshaft does not have unusual wear or are worn.
   - **If the lobes have unusual wear or are worn**

     Replace the Camshaft.

   - **If the lobes do not have unusual wear or are not worn**
7. Test or replace the G18 High Pressure Fuel Pump.

Component Testing

1. Ignition OFF, disconnect the harness connector at the G18 High Pressure Fuel Pump.

   NOTE: **The DMM and test leads must be calibrated to 0 Ω in order to prevent misdiagnosis.**

2. Test for 0.34 - 0.44 Ω at 20Â°C (68Â°F) between the low control circuit terminal 2 and the high control circuit terminal 1.
   - **If not within the specified range**

     Replace the G18 High Pressure Fuel Pump.

   - **If within the specified range**
3. Test for infinite resistance between each terminal and the G18 High Pressure Fuel Pump housing.
   - **If less than infinite resistance**

     Replace the G18 High Pressure Fuel Pump.

   - **If infinite resistance**

4. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Fuel Pump Replacement** for G18 High Pressure Fuel Pump replacement.
- Refer to **Camshaft Replacement**

NOTE: **Some vehicles do not support the Fuel Rail Pressure Relief Valve Reset procedure. Applications not supporting this procedure will return an error message stating "Parameter ID not supported. Check for proper vehicle selection."**

- Perform the Fuel Rail Pressure Relief Valve Reset procedure.

DTC P0090-P0092, P00C8, P00C9, OR P00CA: FUEL PRESSURE REGULATOR CONTROL CIRCUITS

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0090

Fuel Pressure Regulator Control Circuit

DTC P0091

Fuel Pressure Regulator Control Circuit Low Voltage

DTC P0092

Fuel Pressure Regulator Control Circuit High Voltage

DTC P00C8

Fuel Pressure Regulator High Control Circuit Open

DTC P00C9

Fuel Pressure Regulator High Control Circuit Low Voltage

DTC P00CA

Fuel Pressure Regulator High Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
High Control	P0091, P00C9	P0090, P00C8	P0092, P00C9, P00CA, P0690	P0089, P226C, P226D
Low Control	P0091, P00C9	P0090, P00C8	P0092, P00C9, P00CA, P0690	P0089, P226C, P226D

Circuit/System Description

High pressure fuel is regulated by the high pressure fuel pump actuator solenoid valve, which is a part of the high pressure fuel pump. The engine control module (ECM) provides battery voltage on the solenoid high control circuit and ground on the solenoid low control circuit. Both circuits are controlled through output drivers within the ECM. When deactivated, both drivers are disabled. When activated, the high control circuit driver energizes the high pressure fuel pump solenoid and the low control circuit driver pulse-width modulates (PWM) the low control circuit to ground. The ECM monitors the voltage on the circuits to detect a failure.

Conditions for Running the DTC

- DTCs P0010, P0011, P0016, P0089, P0090, P0091, P0092, P0096, P0097, P0098, P0099, P00C8, P00C9, P00CA, P0117, P0118, P0178, P0179, P018B, P018C, P018D, P0192, P0193, P0231, P0232, P023F, P0335, P0336, P0340, P0341, or P1682 are not present.
- The ignition voltage is greater than 11 V.
- The engine speed is greater than 50 RPM.
- The DTCs run continuously within the enabling conditions.

Conditions for Setting the DTC

P0090

- The engine control module detects an open circuit in the high pressure fuel pump actuator low control circuit.
- The DTC sets when the above condition is present for 4 s.

P0091

- The engine control module detects a short to ground in the high pressure fuel pump actuator low control circuit.
- The DTC sets when the above condition is present for 4 s.

P0092

- The engine control module detects a short to voltage in the high pressure fuel pump actuator low control circuit.
- The DTC sets when the above condition is present for 4 s.

P00C8

- The engine control module detects an open circuit in the high pressure fuel pump actuator high control circuit.
- The DTC sets when the above condition is present for 4 s.

P00C9

- The engine control module detects a short to ground in the high pressure fuel pump actuator high control circuit.
- The DTC sets when the above condition is present for 4 s.

P00CA

- The engine control module detects a short to voltage in the high pressure fuel pump actuator high control circuit.
- The DTC sets when the above condition is present for 4 s.

Action Taken When the DTC Sets

- DTCs P0090, P0091, P0092, P00C8, P00C9, and P00CA are Type A DTCs.
- A message center or an indicator displays Reduced Engine Power.

Conditions for Clearing the DTC

DTCs P0090, P0091, P0092, P00C8, P00C9, and P00CA are Type A DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTCs P0090, P0091, P0092, P00C8, P00C9, and P00CA is not set.
    - **If any of the DTCs are set**

      Refer to Circuit/System Testing.

- **If none of the DTCs are set**

3. Engine at idle.
4. Verify the parameters listed below do not display Malfunction when commanding an increase and decrease in Fuel Rail Pressure with a scan tool:
   - Fuel Pressure Regulator Control Circuit Low Voltage Test Status
   - Fuel Pressure Regulator Control Circuit Open Test Status
   - Fuel Pressure Regulator Control Circuit High Voltage Test Status
   - Fuel Pressure Regulator High Control Circuit Low Voltage Test Status
   - Fuel Pressure Regulator High Control Circuit Open Test Status
   - Fuel Pressure Regulator High Control Circuit High Voltage Test Status
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing.

   - **If Malfunction is not displayed**
5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
7. All OK.

Circuit/System Testing

1. Ignition OFF, all vehicle systems OFF, disconnect the X3 harness connector at the K20 Engine Control Module. It may take up to 2 min for all vehicle systems to power down.

NOTE:

- **The DMM and test leads must be calibrated to 0 Ω in order to prevent misdiagnosis.**
- **To prevent terminal damage, verify the proper test adaptors are used according to the Component Connector End View list.**

2. Verify less than 5 Ω between the X3 harness connector high control circuit terminal 32 and the low control circuit terminal 16.
    - **If 5 Ω or greater**
    1. Disconnect the harness connector at the G18 High Pressure Fuel Pump.
    2. Test for less than 2 Ω in the low control circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω
    3. Test for less than 2 Ω in the high control circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, test or replace the G18 High Pressure Fuel Pump.
    - **If less than 5 Ω**
3. Test for infinite resistance between the X3 harness connector low control circuit terminal 16 and ground.
    - **If less than infinite resistance**
    1. Disconnect the harness connector at the G18 High Pressure Fuel Pump.
    2. Test for infinite resistance between the low control circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for infinite resistance between the high control circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance, test or replace the G18 High Pressure Fuel Pump.
    - **If infinite resistance**
4. Ignition ON.
5. Verify less than 1 V between the X3 harness connector low control circuit terminal 16 and ground.
    - **If 1 V or greater**
    1. Ignition OFF, disconnect the harness connector at the G18 High Pressure Fuel Pump.
    2. Ignition ON.
    3. Test for less than 1 V between the low control circuit and ground.
        - If 1 V or greater, repair the short to voltage on the low control circuit.
        - If less than 1 V, repair the short to voltage on the high control circuit.
    - **If less than 1 V**

6. Replace the K20 Engine Control Module.

Component Testing

1. Ignition OFF, disconnect the harness connector at the G18 High Pressure Fuel Pump.

NOTE: **The DMM and test leads must be calibrated to 0 Ω in order to prevent misdiagnosis.**

2. Test for 0.34 - 0.44 Ω at 20Â°C (68Â°F) between the low control circuit terminal 2 and the high control circuit terminal 1.
   - **If not within the specified range**

     Replace the G18 High Pressure Fuel Pump.

   - **If within the specified range**
3. Test for infinite resistance between each terminal and the G18 High Pressure Fuel Pump housing.
   - **If less than infinite resistance**

     Replace the G18 High Pressure Fuel Pump.

   - **If infinite resistance**
4. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Fuel Pump Replacement** for G18 High Pressure Fuel Pump replacement.
- Refer to **Control Module References** for K20 Engine Control Module replacement, programming, and setup

NOTE: **Some vehicles do not support the Fuel Rail Pressure Relief Valve Reset procedure. Applications not supporting this procedure will return an error message stating "Parameter ID not supported. Check for proper vehicle selection."**

- Perform the Fuel Rail Pressure Relief Valve Reset procedure.

DTC P0096 OR P0111: INTAKE AIR TEMPERATURE (IAT) SENSOR 2 PERFORMANCE/INTAKE AIR TEMPERATURE (IAT) SENSOR 1 PERFORMANCE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0096

Intake Air Temperature (IAT) Sensor 2 Performance

DTC P0111

Intake Air Temperature (IAT) Sensor 1 Performance

Diagnostic Fault Information

IAT Sensor 1

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	P0112, P0114, P2199	P0111, P0113, P0114, P2199	P0113, P0114, P2199*	P0111, P2199
Low Reference	-	P0111, P0113, P0114, P2199, P2229, P2230	P0113, P0114, P2199, P2227, P2229*	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

IAT Sensor 2

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0096, P0097, P00F4, P0102, P0178, P2199	P0096, P0097, P00F4, P0101, P0102, P2199, P2230	P0690	P0096, P0101, P0103
Signal	P0096, P0097, P00F5, P2199	P0096, P0097, P00F4, P2199	P0096, P0097, P00F4, P2199*	P0096

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ground	-	P0096, P0097, P00F4, P0102, P2199	-	P0096, P0102
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

IAT Sensor 1

Circuit	Short to Ground	Open or High Resistance	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** Varies with ambient temperature			
Signal	150Â°C (302Â°F)	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
Low Reference	-	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
*Internal ECM or sensor damage may occur if the circuit is shorted to B+			

IAT Sensor 2

Circuit	Short to Ground	Open or High Resistance	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** Varies with ambient temperature			
Ignition Voltage	-40Â°C (-40Â°F) 10 Hz	-40Â°C (-40Â°F) 10 Hz	-
Signal	-40Â°C (-40Â°F) 10 Hz	-40Â°C (-40Â°F) 10 Hz	-40Â°C (-40Â°F)* 10 Hz
Ground	-	-40Â°C (-40Â°F) 10 Hz	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

ECT Sensor

Circuit	Short to Ground	Open or High Resistance	Short to Voltage
Operating Conditions: Engine Running			

Circuit	Short to Ground	Open or High Resistance	Short to Voltage
Parameter Normal Range: Varies with coolant temperature			
Signal	150Â°C (302Â°F)	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
Low Reference	-	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

Circuit/System Description

The sensors listed below are integrated within the multifunction intake air sensor:

- IAT sensor 1
- IAT sensor 2
- Humidity sensor
- MAF sensor
- BARO pressure sensor

The intake air temperature (IAT) sensor 1 is a variable resistor that changes the voltage on the engine control module (ECM) supplied 5 V signal circuit. The signal varies with inlet air temperature in the sensor bore and is displayed by the scan tool as Â°C (Â°F). The IAT sensor 2 and the humidity sensor share the same circuit. The IAT sensor 2 signal is displayed by the scan tool as Hertz (Hz) and Â°C (Â°F).

The sensors listed below share an ECM supplied 5 V reference circuit:

- IAT sensor 2
- Humidity sensor
- Barometric pressure (BARO) sensor

The sensors listed below share an ECM supplied low reference circuit:

- IAT sensor 1
- IAT sensor 2
- Humidity sensor
- Barometric pressure (BARO) sensor

IAT Sensor 1 - Temperature, Resistance, Voltage Table

IAT Sensor 1	IAT Sensor 1 Resistance	IAT Sensor 1 Signal Voltage
Cold	High	High
Warm	Low	Low

IAT Sensor 2 - Temperature, Frequency Table

IAT Sensor 2	IAT Sensor 2 Frequency	IAT Sensor 2 Temperature
Cold	45 Hz	-40Â°C (-40Â°F)
Warm	302 Hz	104Â°C (219Â°F)

Conditions for Running the DTCs

P0096 and P0111

- DTCs P0097, P0098, P0112, P0113, P0117, P0118, P0119, or P1682 are not set.
- The vehicle has been OFF at least 8 hours.
- Ignition voltage is at least 11 V.
- These DTCs run once per ignition cycle when the enabling conditions are met.

Conditions for Setting the DTCs

P0096

- The ECM determines the absolute difference between IAT sensor 1 start-up temperature and the IAT sensor 2 start-up temperature is greater than 10Â°C (50Â°F).

  AND

- The absolute difference between ECT start-up temperature and the IAT sensor 2 start-up temperature is greater than the absolute difference between ECT start-up temperature and the IAT sensor 1 start-up temperature.
- This DTC runs once per ignition cycle when the enabling conditions are met.

P0111

- The ECM determines the absolute difference between IAT sensor 1 start-up temperature and the IAT sensor 2 start-up temperature is greater than 10Â°C (50Â°F).

AND

- The absolute difference between ECT start-up temperature and the IAT sensor 1 start-up temperature is greater than the absolute difference between ECT start-up temperature and the IAT sensor 2 start-up temperature.
- This DTC runs once per ignition cycle when the enabling conditions are met.

Action Taken When the DTCs Set

DTCs P0096 and P0111 are Type B DTCs.

Conditions for Clearing the DTCs

DTCs P0096 and P0111 are Type B DTCs.

Diagnostic Aids

- With the ignition ON, when the engine is OFF and cold; properly functioning IAT sensors 1 and 2 will gradually increase the scan tool IAT Sensor 1 and 2 parameters. This is due to the heat that is generated by the multifunction intake air sensor internal heating elements.
- The humidity sensor and the IAT sensor 2 signals are sent to the ECM on the same circuit. If the IAT Sensor 2 parameter displays the values: 10 Hz; -40Â°C (-40Â°F), and there are also Humidity Sensor DTCs, check for a circuit problem.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**

- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL-38522-A Variable Signal Generator

For equivalent regional tools, refer to Special Tools (Diagnostic Tools) Special Tools (Service Tools) .

Circuit/System Verification

NOTE: **To minimize the effects of residual engine heat and sensor internal heating elements, perform Steps 1 and 2 of this verification procedure only if the ignition has been OFF for 8 hours or more.**

1. Ignition ON.
2. Verify the following scan tool parameters are within 25Â°C (45Â°F) of each other.
   - Start-Up IAT Sensor 1
   - Start-Up IAT Sensor 2
   - Start-Up ECT
   - **If not within 25Â°C (45Â°F)**

     Refer to Circuit/System Testing.

   - **If within 25Â°C (45Â°F)**
3. Engine idling, verify the following scan tool parameters are between -38 to +149Â°C (-36 to +300Â°F).
   - IAT Sensor 1
   - IAT Sensor 2

- ECT Sensor
- **If not between -38 to +149Â°C (-36 to +300Â°F)**

  Refer to Circuit/System Testing.

- **If between -38 to +149Â°C (-36 to +300Â°F)**

4. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
5. Verify the DTCs do not set.
   - **If any DTC sets**

     Refer to Circuit/System Testing.

   - **If no DTC sets**
6. All OK

Circuit/System Testing

NOTE: **You must perform the Circuit/System Verification before proceeding with Circuit/System Testing.**

1. Verify none of the conditions listed below exist:
   - A restricted or collapsed air intake duct
   - A misaligned or damaged air intake duct
   - Any water intrusion in the induction system
   - An intake manifold resonator with a leaking seal, or a cracked or broken housing
   - **If a condition exists**

     Repair or replace component as appropriate.

   - **If no condition exists**
2. Ignition OFF and all systems OFF, it may take up to for 2 min for all vehicle systems to power down. Disconnect the harness connector at the B75C Multifunction Intake Air Sensor.
3. Test for less than 2 Ω between the low reference circuit terminal 3 and ground.
   - **If 2 Ω or greater**

1. Disconnect the harness connector at the K20 Engine Control Module.
2. Test for less than 2 Ω in the low reference circuit end to end.
    - If 2 Ω or greater, repair the open or high resistance in the circuit.
    - If less than 2 Ω replace the K20 Engine Control Module.

- **If less than 2 Ω**

4. Ignition OFF, all vehicle systems OFF, test for less than 2 Ω between the ground circuit terminal 7 and ground.

- **If 2 Ω or greater**

1. Disconnect the sensor chassis ground.
2. Test for less than 2 Ω in the ground circuit end to end.
    - If 2 Ω or greater, repair the open or high resistance in the circuit.
    - If less than 2 Ω, repair the open/high resistance in the ground connection.

- **If less than 2 Ω**

5. Ignition ON, verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.

- **If the test lamp does not illuminate and the circuit fuse is good**

1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
2. Test for less than 2 Ω in the ignition voltage circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.

- **If the test lamp does not illuminate and the circuit fuse is open**

1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
2. Test for infinite resistance between the ignition voltage circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance, test all components connected to the ignition circuit, replace as necessary.

- **If a test lamp illuminates**

6. Ignition ON.
7. Verify the scan tool IAT Sensor 1 parameter is colder than -39Â°C (-38Â°F).

- **If warmer than -39Â°C (-38Â°F).**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the signal circuit terminal 1 and ground.

- If less than infinite resistance, repair the short to ground on the circuit.
- If infinite resistance

3. Test for less than 2 Ω in the signal circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If colder than -39Â°C (-38Â°F).**

8. Ignition OFF, install a 3 A fused jumper wire between the signal circuit terminal 1 and the low reference circuit terminal 3, ignition ON.
9. Verify the scan tool IAT Sensor 1 parameter is warmer than 149Â°C (300Â°F).

- **If colder than 149Â°C (300Â°F).**

1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the signal circuit and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V
3. Ignition OFF.
4. Test for less than 2 Ω in the signal circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If warmer than 149Â°C (300Â°F).**

10. Test for 4.8-5.2 V between the intake air temperature signal 2 circuit terminal 8 and ground.

- **If less than 4.8 V**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the signal circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance
3. Test for less than 2 Ω in the signal circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If greater than 5.2 V**

NOTE: **If the signal circuit is shorted to a voltage the engine control module or the sensor may be damaged.**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the signal circuit and ground.
   - If 1 V or greater, repair the short to voltage on the circuit.
   - If less than 1 V, replace the K20 Engine Control Module.

- **If between 4.8-5.2 V**

11. Determine if **EL-38522-A** Variable Signal Generator or equivalent is available.

- **EL-38522-A, Variable Signal Generator; or equivalent is not available**

1. Test or replace the B75C Multifunction Intake Air Sensor.
2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
3. Verify the DTC does not set.
   - **If the DTC sets**

     Replace the K20 Engine Control Module.

   - **If no DTCs set**
4. All OK.

- **EL-38522-A, Variable Signal Generator; or equivalent is available**

12. Ignition OFF, connect the leads of the **EL-38522-A** Variable Signal Generator as listed below:
    - Red lead to the signal circuit terminal 8 at the harness connector
    - Black leads to ground
    - Battery voltage supply lead to B+
13. Set the **EL-38522-A** Variable Signal Generator to the specifications listed below:
    - Signal switch to 5 V
    - Duty Cycle switch to 50% (Normal)
    - Frequency switch to 30 Hz
14. Ignition ON.
15. Verify the scan tool IAT Sensor 2 parameter is between 28-32 Hz.

- **If not between 28-32 Hz**

  Replace the K20 Engine Control Module.

- **If between 28-32 Hz**

16. Test or replace the B75C Multifunction Intake Air Sensor.

Component Testing

Multifunction Intake Air Sensor - IAT Sensor 1

1. Ignition OFF, disconnect the harness connector at the B75C Multifunction Intake Air sensor.

   NOTE: **A thermometer can be used to test the sensor off the vehicle.**

2. Test the IAT sensor 1 by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the **Temperature Versus Resistance - Intake Air Temperature Sensor** table for Hitachi Sensors. The resistance values should be in range of the table values.
   - **If not within the table values.**

     Replace the B75C Multifunction Intake Air sensor.

   - **If within the table values.**
3. All OK

Multifunction Intake Air Sensor - IAT Sensor 2

1. Test the IAT Sensor 2 by varying the sensor temperature while monitoring the air temperature with a thermometer. Compare the readings with the scan tool IAT Sensor 2 parameter. The values should be within 5%.
   - **If not within 5%**

     Replace the B75C Multifunction Intake Air sensor.

   - **If within 5%**
2. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement** for multifunction intake air sensor replacement
- Refer to **Control Module References** for engine control module replacement, programming, and setup.

DTC P0097, P0098, OR P0099: INTAKE AIR TEMPERATURE (IAT) SENSOR 2 CIRCUIT

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0097

Intake Air Temperature (IAT) Sensor 2 Circuit Low Voltage

DTC P0098

Intake Air Temperature (IAT) Sensor 2 Circuit High Voltage

DTC P0099

Intake Air Temperature (IAT) Sensor 2 Circuit Intermittent

Diagnostic Fault Information

IAT Sensor 2

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0096, P0097, P00F4, P0102, P0178, P2199	P0096, P0097, P00F4, P0101, P0102, P2199, P2230	P0690	P0096, P0101, P0103
Signal	P0096, P0097, P00F5, P2199	P0096, P0097, P00F4, P2199	P0096, P0097, P00F4, P2199*	P0096

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ground	-	P0096, P0097, P00F4, P0102, P2199, P2230	-	P0096, P0102
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

IAT Sensor 2

Circuit	Short to Ground	Open or High Resistance	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** Varies with ambient temperature			
Ignition Voltage	-40Â°C (-40Â°F) 10 Hz	-40Â°C (-40Â°F) 10 Hz	-
Signal	-40Â°C (-40Â°F) 10 Hz	-40Â°C (-40Â°F) 10 Hz	-40Â°C (-40Â°F)* 10 Hz
Ground	-	-40Â°C (-40Â°F) 10 Hz	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

Circuit/System Description

The sensors listed below are integrated within the mass air flow/multifunction intake air sensor:

- IAT sensor 1
- IAT sensor 2
- Humidity sensor
- MAF sensor
- BARO pressure sensor

The IAT sensor 2 and the humidity sensor share the same circuit. The IAT sensor 2 signal is displayed by the scan tool as Hertz (Hz) and Â°C (Â°F).

The sensors listed below share an ECM supplied 5 V reference circuit:

- IAT sensor 2
- Humidity sensor
- Barometric pressure (BARO) sensor

The sensors listed below share an ECM supplied low reference circuit:

- IAT sensor 1
- IAT sensor 2
- Humidity sensor
- Barometric pressure (BARO) sensor

IAT Sensor 1 - Temperature, Resistance, Voltage Table

IAT Sensor 1	IAT Sensor 1 Resistance	IAT Sensor 1 Signal Voltage
Cold	High	High
Warm	Low	Low

IAT Sensor 2 - Temperature, Frequency Table

IAT Sensor 2	IAT Sensor 2 Frequency	IAT Sensor 2 Temperature
Cold	45 Hz	-40Â°C (-40Â°F)
Warm	302 Hz	104Â°C (219Â°F)

Conditions for Running the DTCs

P0097, P0098, and P0099

- The ignition is ON, or the engine is running.
- The Ignition voltage is at least 11 V.
- The DTCs run continuously within the enabling conditions.

Conditions for Setting the DTCs

P0097

NOTE: **The scan tool display range is between -40 to +150Â°C (-40 to +302Â°F).**

The ECM detects that the IAT sensor 2 signal is less than 13 Hz, colder than -60Â°C (-76Â°F), for greater than 5 s.

P0098

The ECM detects that the IAT sensor 2 signal is greater than 390 Hz, warmer than 150Â°C (302Â°F), for greater than 5 s.

P0099

The ECM detects that the IAT sensor 2 signal is intermittent or has abruptly changed for longer than 5 s.

Action Taken When the DTC Sets

- DTCs P0097, P0098, and P0099 are Type B DTCs.
- The ECM commands the cooling fans ON.

Conditions for Clearing the MIL/DTC

DTCs P0097, P0098, and P0099 are Type B DTCs.

Diagnostic Aids

- With the ignition ON, the engine OFF and the engine is cold, a properly functioning IAT sensor 2 will gradually increase the scan tool IAT Sensor 2 parameter. This is due to the heat that is generated by the MAF sensor heating elements.
- The humidity sensor and the IAT sensor 2 signals are sent to the ECM on the same circuit. If the IAT Sensor 2 parameter displays the values: 10 Hz; -40Â°C (-40Â°F), and there are also Humidity Sensor DTCs, check for a circuit problem.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL-38522-A Variable Signal Generator

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** **Special Tools (Service Tools)** .

Circuit/System Verification

1. Engine idling.
2. Verify the scan tool IAT Sensor 2 parameter is between -38 to +149Â°C (-36 to +300Â°F).
   - **If not between -38 to +149Â°C (-36 to +300Â°F)**

     Refer to Circuit System Testing.

   - **If between -38 to +149Â°C (-36 to +300Â°F)**
3. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
4. Verify the DTC does not set.
   - **If the DTC does set**

     Refer to Circuit/System Testing.

- **If the DTC does not set**

5. All OK

Circuit/System Testing

NOTE: **You must perform the Circuit/System Verification before proceeding with Circuit/System Testing.**

1. Ignition OFF and all systems OFF, it may take up to for 2 min for all vehicle systems to power down. Disconnect the harness connector at the B75C Multifunction Intake Air Sensor.
2. Test for less than 2 Ω between the low reference circuit terminal 3 and ground.
   - **If 2 Ω or greater**
   1. Disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open or high resistance in the circuit.
      - If less than 2 Ω replace the K20 Engine Control Module.
   - **If less than 2 Ω**
3. Test for less than 2 Ω between the ground circuit terminal 7 and ground.
   - **If 2 Ω or greater**
   1. Disconnect the sensor chassis ground.
   2. Test for less than 2 Ω in the ground circuit end to end.
      - If 2 Ω or greater, repair the open or high resistance in the circuit.
      - If less than 2 Ω, repair the open/high resistance in the ground connection.
   - **If less than 2 Ω**
4. Ignition ON.
5. Verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
   2. Test for less than 2 Ω in the ignition voltage circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.

- **If the test lamp does not illuminate and the circuit fuse is open**

1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
2. Test for infinite resistance between the ignition voltage circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance, test all components connected to the ignition circuit, replace as necessary.

- **If a test lamp illuminates**

6. Ignition ON, test for 4.8-5.2 V between the intake air temperature sensor 2 signal circuit terminal 8 and ground.

- **If less than 4.8 V**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the signal circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance
3. Test for less than 2 Ω in the signal circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If greater than 5.2 V**

NOTE: **If the signal circuit is shorted to a voltage the engine control module or the sensor may be damaged.**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the signal circuit and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.

- **If between 4.8-5.2 V**

7. Determine if **EL-38522-A** Variable Signal Generator or equivalent is available.

- **EL-38522-A, Variable Signal Generator; or equivalent is not available**

1. Test or replace the B75C Multifunction Intake Air Sensor.
2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
3. Verify the DTC does not set.

- **If the DTC sets**

  Replace the K20 Engine Control Module.

- **If no DTCs set**

4. All OK.

- **EL-38522-A, Variable Signal Generator; or equivalent is available**

8. Ignition OFF, connect the leads of the **EL-38522-A** Variable Signal Generator as listed below:
   - Red lead to the signal circuit terminal 8 at the harness connector
   - Black leads to ground
   - Battery voltage supply lead to B+
9. Set the **EL-38522-A** Variable Signal Generator to the specifications listed below:
   - Signal switch to 5 V
   - Duty Cycle switch to 50% (Normal)
   - Frequency switch to 30 Hz
10. Ignition ON.
11. Verify the scan tool IAT Sensor 2 parameter is between 28-32 Hz.
    - **If not between 28-32 Hz**

      Replace the K20 Engine Control Module.

    - **If between 28-32 Hz**
12. Test or replace the B75C Multifunction Intake Air Sensor.

Component Testing

1. Test the IAT Sensor 2 by varying the sensor temperature while monitoring the air temperature with a thermometer. Compare the readings with the scan tool IAT Sensor 2 parameter. The values should be within 5%.
   - **If not within 5%**

     Replace the B75C Multifunction Intake Air Sensor.

   - **If within 5%**

2. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement** for multifunction intake air sensor replacement.
- Refer to **Control Module References** for engine control module replacement, programming, and setup.

DTC P00C6: FUEL RAIL PRESSURE LOW DURING ENGINE CRANKING

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P00C6

Fuel Rail Pressure Low During Engine Cranking

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
High Pressure Fuel Pump Actuator High Control	P0091, P00C9	P0090, P00C8	P0092, P00C9, P00CA, P0690	P0089, P226C, P226D
High Pressure Fuel Pump Actuator Low Control	P0091, P00C9	P0090, P00C8	P0092, P00C9, P00CA, P0690	P0089, P226C, P226D

Circuit/System Description

High pressure fuel is regulated by the high pressure fuel pump actuator, which is a part of the high pressure fuel pump. The high pressure fuel pump actuator is a solenoid valve. The engine control module (ECM) provides battery voltage on the solenoid high control circuit and ground on the solenoid low control circuit. Both circuits are controlled through output drivers within the ECM. When deactivated, both drivers are disabled. When activated, the high control circuit driver energizes the high pressure fuel pump solenoid and the low control circuit driver pulse-width modulates

(PWM) the low control circuit to ground. Before the engine is started the engine control module determines fuel rail pressure and engine coolant temperature (ECT) before the engine is cranked. If the fuel rail pressure is less than the target set point before the engine is cranked, the Pressure Rise Diagnostic is used. If the fuel rail pressure is greater than the target set point before the engine is cranked, the Pressure Fall Diagnostic is used. If the fuel rail pressure does not match the target set point in a calibrated time the DTC may set.

Conditions for Running the DTC

P00C6

- DTCs P0010, P0011, P0016, P0089, P0090, P0091, P0092, P0096, P0097, P0098, P0099, P00C8, P00C9, P00CA, P0117, P0118, P0178, P0179, P018B, P018C, P018D, P0191, P0192, P0193, P0231, P0232, P023F, P0335, P0336, P0340, P0341, or P1682 are not present.
- Run/Crank voltage is greater than 8 V.
- Engine coolant temperature is between -100Â°C (-148Â°F) and 65Â°C (149Â°F).
- Low side fuel pressure is greater than 0 kPa (0 PSI).
- Engine is not running
- Vehicle is not in a low fuel condition
- Barometric pressure is greater than 70.0 kPa
- Intake air temperature is greater the -10Â°C (14Â°F)
- The DTC runs once for each engine start.

Conditions for Setting the DTC

Condition 1

- If the fuel rail pressure is less than the target set point before the engine is cranked, the pressure rise diagnostic is used.
- The pressure rise diagnostic will fail if the fuel pressure has not increased to the target set point within 10 seconds at -10Â°C (14Â°F) ECT or within 5 s if ECT is greater than 0Â°C (32Â°F).

Condition 2

- If the fuel rail pressure is greater than the target set point before the engine is cranked, the pressure fall diagnostic is used.
- The pressure fall diagnostic will fail if the fuel rail pressure has dropped below 2 MPa (290 PSI) for 10 engine cycles if the ECT is less than -10Â°C (14Â°F) or 0.6 MPa (87 PSI) for 10 engine cycle if the ECT is between -10Â°C (14Â°F) and 16Â°C (60Â°F) and 0.45 MPa (65 PSI) for 10 cycles if ECT is greater than 16Â°C (60Â°F).

The above conditions must occur for two consecutive starts for the DTC to set.

Action Taken When the DTC Sets

DTC P00C6 is a Type B DTC

Conditions for Clearing the DTC

DTC P00C6 is a Type B DTC

Diagnostic Aids

- A restricted fuel feed pipe between the fuel feed pipe fuel pressure sensor and the high pressure fuel pump may set a DTC.
- A condition with the fuel tank fuel pump module or the fuel pump driver control module may set a DTC.
- A skewed fuel rail pressure sensor, or an intermittent condition in the fuel rail pressure sensor circuits may set a DTC.
- A leaking or restricted fuel injector may set a DTC.
- A short to voltage in the crankshaft position signal circuit may set a DTC.
- A short to voltage in the camshaft position actuator solenoid valve control circuit may set a DTC.
- A stuck camshaft position actuator may cause the fuel pump synchronization logic to fail and set DTC P00C6.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Electrical Information Reference

- **Circuit Testing**

- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

NOTE: **If vehicle is a no start, refer to Engine Cranks But Does Not Run .**

1. Ignition ON.
2. Verify DTCs P0010, P0011, P0016, P0089, P0090, P0091, P0092, P0096, P0097, P0098, P0099, P00C8, P00C9, P00CA, P0117, P0118, P0178, P0179, P018B, P018C, P018D, P0191, P0192, P0193, P0231, P0232, P023F, P0335, P0336, P0340, P0341, P1682 are not present.
   - **If any of the DTCs are set**

     Refer to Diagnostic Trouble Code (DTC) List - Vehicle

   - **If none of the DTCs are set**
3. Verify the scan tool Fuel Pressure Sensor parameter is between 320-580 kPa (46-84 PSI) while commanding the Fuel Pump Enable ON several times with a scan tool.
   - **If less than 320 kPa (46 PSI)**

     Refer to Fuel System Diagnosis

   - **If greater than 580 kPa (84 PSI)**

     Replace the G12 Fuel Pump.

   - **If between 320-580 kPa (46-84 PSI)**

NOTE: **The fuel pressure may vary slightly when the fuel pump stops operating. After the fuel pump stops operating, the fuel pressure should stabilize and remain constant.**

4. Verify that the fuel pressure decreases to 468-544 kPa (68-79 PSI) after the fuel pump is turned off.
   - **If the fuel pressure does not decrease to 468-544 kPa (68-79 PSI)**

     Replace the G12 Fuel Pump.

   - **If the fuel pressure decreases to 468-544 kPa (68-79 PSI)**
5. Verify DTC P00C6 is not set.
   - **If the DTC is set**

     Refer to Circuit/System Testing.

   - **If the DTC is not set**
6. Engine at idle.
7. Verify the parameters listed below do not display Malfunction when commanding an increase and decrease in Fuel Rail Pressure with a scan tool:
   - Fuel Pressure Regulator Control Circuit Low Voltage Test Status
   - Fuel Pressure Regulator Control Circuit Open Test Status
   - Fuel Pressure Regulator Control Circuit High Voltage Test Status
   - Fuel Pressure Regulator High Control Circuit Low Voltage Test Status
   - Fuel Pressure Regulator High Control Circuit Open Test Status
   - Fuel Pressure Regulator High Control Circuit High Voltage Test Status
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing.

   - **If Malfunction is not displayed**
8. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
9. Verify the DTC does not set.
   - **If the DTC sets**

Refer to Circuit/System Testing.

- **If the DTC does not set**

10. All OK.

Circuit/System Testing

1. Clear the DTCs.

WARNING: **Road test a vehicle under safe conditions and while obeying all traffic laws. Do not attempt any maneuvers that could jeopardize vehicle control. Failure to adhere to these precautions could lead to serious personal injury and vehicle damage.**

NOTE: **Circuit/System Verification must be performed first or misdiagnosis may result.**

2. Road test the vehicle and perform a wide open acceleration from a stop until the transmission shifts into second gear. On manual transmission applications, shift to second gear or stop the test near 6,000 RPM. Repeat the test at least three times.
3. Verify the scan tool Fuel Rail Pressure Sensor parameter displays between 14-17 MPa (2,031-2,466 PSI) while the engine speed is near 5,600 RPM.
   - **If not between 14-17 MPa (2,031-2,466 PSI)**

     Replace the G18 High Pressure Fuel Pump.

   - **If between 14-17 MPa (2,031-2,466 PSI)**
4. Ignition OFF, disconnect the harness connector at the G18 High Pressure Fuel Pump, ignition ON.
5. Verify that a test lamp does not illuminate between the high control circuit terminal 1 and ground.
   - **If the test lamp illuminates**
   1. Ignition OFF, remove the test lamp, disconnect the X3 harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the high control circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If the test lamp does not illuminate**
6. Verify that a test lamp does not illuminate between the low control circuit terminal 2 and ground.
   - **If the test lamp illuminates**

1. Ignition OFF, remove the test lamp, disconnect the X3 harness connector at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the low control circuit and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.

- **If the test lamp does not illuminate**

7. Verify that a test lamp does not illuminate between the high control circuit terminal 1 and B+.

- **If the test lamp illuminates**

1. Ignition OFF, remove the test lamp, disconnect the X3 harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the high control circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance, replace the K20 Engine Control Module.

- **If the test lamp does not illuminate**

8. Verify that a test lamp does not illuminate between the low control circuit terminal 2 and B+.

- **If the test lamp illuminates**

1. Ignition OFF, remove the test lamp, disconnect the X3 harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the low control circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance, replace the K20 Engine Control Module.

- **If the test lamp does not illuminate**

9. Remove the test lamp, connect a 3 A fused jumper wire between the high control circuit terminal 1 and ground.
10. Verify the Fuel Pressure Regulator High Control Circuit Low Voltage Test Status transitions from OK to Malfunction.

- **If Malfunction is not displayed**

1. Ignition OFF, remove the fused jumper, disconnect the X3 harness connector at the K20 Engine Control Module.
2. Test for less than 2 Ω in the high control circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If Malfunction is displayed**

11. Connect a 3 A fused jumper wire between the low control circuit terminal 2 and B+.
12. Verify the Fuel Pressure Regulator Control Circuit High Voltage Test Status transitions from OK to Malfunction.

- **If Malfunction is not displayed**

1. Ignition OFF, remove the fused jumper, disconnect the X3 harness connector at the K20 Engine Control Module.
2. Test for less than 2 Ω in the low control circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If Malfunction is displayed**

13. Verify none of the conditions listed below exist:
    - Restricted fuel feed pipe
    - Restricted or plugged strainer
    - Poor connections at the high pressure fuel pump solenoid
    - **If a condition exist**

      Repair as necessary.

    - **If a condition does not exist**
14. Test or replace the G18 High Pressure Fuel Pump.

Component Testing

1. Ignition OFF, disconnect the harness connector at the G18 High Pressure Fuel Pump.

NOTE: **The DMM and test leads must be calibrated to 0 Ω in order to prevent misdiagnosis.**

2. Test for 0.34 - 0.44 Ω at 20Â°C (68Â°F) between the low control circuit terminal 2 and the high control circuit terminal 1.
    - **If not within the specified range**

      Replace the G18 High Pressure Fuel Pump.

    - **If within the specified range**
3. Test for infinite resistance between each terminal and the G18 High Pressure Fuel Pump housing.
    - **If less than infinite resistance**

      Replace the G18 High Pressure Fuel Pump.

- **If infinite resistance**

4. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Fuel Feed Pipe Replacement (At Engine)** **Fuel Feed Pipe Replacement (At Tank)**
- Refer to **Fuel Pump Replacement** for G18 High Pressure Fuel Pump replacement
- Refer to **Fuel Tank Fuel Pump Module Replacement (SWB)** **Fuel Tank Fuel Pump Module Replacement (LWB)** for G12 Fuel Pump replacement
- Refer to **Control Module References** for K20 Engine Control Module replacement, programming, and setup

DTC P00C7: INTAKE AIR PRESSURE MEASUREMENT SYSTEM - MULTIPLE SENSORS NOT PLAUSIBLE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P00C7

Intake Air Pressure Measurement System - Multiple Sensors Not Plausible

Circuit/System Description

The Intake Air Pressure Measurement System consists of (2) sensors, the barometric pressure (BARO) sensor, the manifold absolute pressure (MAP) sensor.

Conditions for Running the DTC

- Before the ECM can report that DTC P00C7 failed, DTCs P0107, P0108, P2228, and P2229 must run and pass.
- DTC P0106, P0107, P0108, P2227, P2228, P2229, P2230, or P2610 is not set.
- The ignition is ON, engine OFF.

- The time between the current ignition cycle and the previous drive cycle is greater than 5 s
- The manifold absolute pressure (MAP) is between 50-115 kPa (7.25-16.67 PSI).
- The barometric pressure (BARO) is between 50-115 kPa (7.25-16.67 PSI).
- DTC P00C7 runs continuously when the conditions above exist.

Conditions for Setting the DTC

P00C7

The ECM detects an inconsistency between pressure sensors in the induction system in which a particular sensor cannot be identified as the failed sensor. The difference between them is greater than 10 kPa (1.5 PSI).

Action Taken When the DTC Sets

DTC P00C7 is a Type B DTC.

Conditions for Clearing the DTC

DTC P00C7 is a Type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0106, P0107, P0108, P2227, P2228, P2229, or P2230 is not set.
   - **If any of the DTCs are set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** for further diagnosis.

   - **If none of the DTCs are set**
3. Verify the scan tool parameters listed below are within range of the **Altitude Versus Barometric Pressure** table.
   - BARO Sensor
   - MAP Sensor
   - **If a sensor parameter is not within range**

     Refer to the appropriate diagnostic listed below for further diagnosis.

   - BARO Sensor, refer to **DTC P2227-P2230** .
   - MAP Sensor, refer to **DTC P0106**.
   - **If the parameters are within range**
4. All OK

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

Refer to **Control Module References** for Engine Control Module replacement, programming and setup.

DTC P00F4-P00F6: INTAKE AIR HUMIDITY SENSOR CIRCUIT

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P00F4

Intake Air Humidity Sensor Circuit Low Voltage

DTC P00F5

Intake Air Humidity Sensor Circuit High Voltage

DTC P00F6

Intake Air Humidity Sensor Circuit Erratic

Diagnostic Fault Information

Intake Air Humidity

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0096, P0097, P0102, P00F4, P0178, P2199	P0096, P0097, P0101, P0102, P00F4, P2199	P0690	P0096, P0101, P0103
Signal	P0096, P0097, P00F5, P2199	P0096, P0097, P00F4, P2199	P0096, P0097, P00F4, P2199*	P0096
Ground	-	P0096, P0097, P0102, P00F4, P2199, P2230	-	P0096, P0102
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

Intake Air Humidity

Circuit	Short to Ground	Open or High Resistance	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** Varies with ambient humidity and temperature; and engine bay conditions			
Ignition	0 %	0 %	-
Signal	100 %	0 %	0 %*
Ground	-	0 %	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

Circuit/System Description

The humidity sensor measures the ambient humidity of the air in the sensor bore. The signal varies with intake air humidity and is displayed by the scan tool as duty cycle %. The ECM applies 5 V to the circuit. The signal circuit is shared by the humidity sensor and the intake air temperature (IAT) sensor 2. Ignition voltage and ground circuits are also supplied to the multifunction intake air sensor's internal circuits for these sensors:

- IAT sensor 2
- Humidity sensor
- MAF sensor

The multifunction intake air sensor houses the following:

- IAT sensor 1
- IAT sensor 2
- Humidity sensor
- MAF sensor
- BARO pressure sensor

Conditions for Running the DTCs

P00F4, P00F5, and P00F6

- DTC P1682 is not set.
- The ignition is ON.
- The ignition voltage is at least 11 V.

- These DTCs run continuously within the enabling conditions.

Conditions for Setting the DTCs

P00F4

The ECM detects that the humidity sensor signal is less than or equal to 5% for greater than 5 s.

P00F5

The ECM detects that the humidity sensor signal is greater than or equal to 95% for greater than 5 s.

P00F6

The ECM detects that the humidity sensor signal is intermittent or has abruptly changed over a period of time greater than 5 s.

Action Taken When the DTC Sets

DTCs P00F4, P00F5, P00F6 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P00F4, P00F5, P00F6 are Type B DTCs.

Diagnostic Aids

- The Intake Air Humidity Signal parameter displays the measured humidity within the air intake system and may differ from atmospheric humidity measured outside the air intake system.
- The humidity sensor and the IAT sensor 2 signals are sent to the ECM on the same circuit. If the Intake Air Humidity parameter displays the value: 0% or 100%, and there are also IAT Sensor 2 DTCs, check for a circuit problem.

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Control Module References for scan tool information

Special Tools

EL-38522-A Variable Signal Generator

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** **Special Tools (Service Tools)** .

Circuit/System Verification

NOTE: **To minimize the effects of residual engine heat and sensor internal heating elements, perform Steps 1 and 2 of this verification procedure only if the ignition has been OFF for 8 hours or more.**

1. Ignition ON.
2. Verify the following scan tool parameters are within 25Â°C (45Â°F) of each other.
    - Start-Up IAT Sensor 1
    - Start-Up IAT Sensor 2
    - Start-Up ECT
    - **If not within 25Â°C (45Â°F)**

Refer to Circuit/System Testing.

- **If within 25Â°C (45Â°F)**

3. Engine idling, verify the scan tool Intake Air Humidity parameter is between 5 and 90%.
   - **If not between 5 and 90%**

     Refer to Circuit/System Testing.

   - **If between 5 and 90%**
4. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
5. Verify the DTCs do not set.
   - **If any DTC sets**

     Refer to Circuit/System Testing.

   - **If no DTCs set**
6. All OK

Circuit/System Testing

1. Ignition OFF and all systems OFF, it may take up to for 2 min for all vehicle systems to power down. Disconnect the harness connector at the B75C Multifunction Intake Air Sensor.
2. Test for less than 2 Ω between the low reference circuit terminal 3 and ground.
   - **If 2 Ω or greater**
   1. Disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open or high resistance in the circuit.
      - If less than 2 Ω replace the K20 Engine Control Module.
   - **If less than 2 Ω**
3. Test for less than 2 Ω between the ground circuit terminal 7 and ground.
   - **If 2 Ω or greater**
   1. Disconnect the sensor chassis ground.

2. Test for less than 2 Ω in the ground circuit end to end.
    - If 2 Ω or greater, repair the open or high resistance in the circuit.
    - If less than 2 Ω, repair the open/high resistance in the ground connection.
- **If less than 2 Ω**

4. Ignition ON, verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.
- **If the test lamp does not illuminate and the circuit fuse is good**

1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
2. Test for less than 2 Ω in the ignition voltage circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.
- **If the test lamp does not illuminate and the circuit fuse is open**

1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
2. Test for infinite resistance between the ignition voltage circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance, test all components connected to the ignition circuit, replace as necessary.
- **If a test lamp illuminates**

5. Ignition ON, test for 4.8-5.2 V between the humidity signal circuit terminal 8 and ground.
- **If less than 4.8 V**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the signal circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance
3. Test for less than 2 Ω in the signal circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.
- **If greater than 5.2 V**

NOTE: **If the signal circuit is shorted to a voltage the engine control module or the sensor may be damaged.**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the signal circuit and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.

- **If between 4.8-5.2 V**

6. Determine if **EL-38522-A** Variable Signal Generator or equivalent is available.

- **EL-38522-A, Variable Signal Generator; or equivalent is not available**

1. Test or replace the B75C Multifunction Intake Air Sensor.
2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
3. Verify the DTC does not set.
    - **If the DTC sets**

      Replace the K20 Engine Control Module.

    - **If no DTCs set**
4. All OK.

- **EL-38522-A, Variable Signal Generator; or equivalent is available**

7. Ignition OFF, connect the leads of the **EL-38522-A** Variable Signal Generator as listed below:
    - Red lead to the signal circuit terminal 8 at the harness connector
    - Black leads to ground
    - Battery voltage supply lead to B+
8. Set the **EL-38522-A** Variable Signal Generator to the specifications listed below:
    - Signal switch to 5 V
    - Frequency switch to 250 Hz
    - Duty Cycle switch to 50% (Normal)
9. Ignition ON.
10. Verify the scan tool Intake Air Humidity Sensor parameter is between 45-55%.

- **If not between 45-55%.**

Replace the K20 Engine Control Module.

- **If between 45-55%.**

11. Test or replace the B75C Multifunction Intake Air Sensor.

Component Testing

Multifunction Intake Air Sensor

1. Test the Intake Air Humidity Sensor by varying the air humidity in the intake duct near the sensor, while observing the scan tool Intake Air Humidity Sensor parameter. The parameter should change and be within 5-95%.
   - **If not within 5-95%, or the parameter does not change.**

     Replace the K20 Engine Control Module.

   - **If within 5-95% and the parameter does change**
2. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement** for multifunction intake air sensor replacement.
- Refer to **Control Module References** for engine control module replacement, programming, and setup.

DTC P0101: MASS AIR FLOW (MAF) SENSOR PERFORMANCE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P0101

Mass Air Flow (MAF) Sensor Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0096, P0097, P00F4, P0102, P0178, P2199	P0096, P0097, P00F4, P0101, P0102, P2199	P0690	P0096, P0101, P0103
Signal	P0102	P0102	P0102*	P0101, P0103, P1101
Ground	-	P0096, P0097, P00F4, P0102, P2199	-	P0096, P0102
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

MAF Sensor

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running at various operating conditions **Parameter Normal Range:** 2,000-10,000 Hz			
Ignition Voltage	0 Hz	0 Hz	-
Signal	0 Hz	0 Hz	0 Hz*
Ground	-	0 Hz	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

Circuit Description

The intake flow rationality diagnostic provides the within-range rationality check for the mass air flow (MAF), manifold absolute pressure (MAP), and the throttle position sensors. This is an explicit model-based diagnostic containing 4 separate models for the intake system.

The estimates of MAF and MAP obtained from this system of models and calculations are then compared to the actual measured values from the MAF, MAP, and the throttle position sensors and to each other to determine the appropriate DTC to fail.

Conditions for Running the DTCs

- DTCs P001, P0102, P0103, P0107, P0108, P0111, P0112, P0113, P0114. P0116, P0117, P0118, P0128, P0335, or P0336 are not set
- The engine speed is between 500 and 6,800 RPM.
- The engine coolant temperature (ECT) is between -7 to +150Â°C (+19 to +302Â°F).

- The intake air temperature (IAT Sensor 1) is between -20 to +125Â°C (-4 to +257Â°F).
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

The engine control module (ECM) detects that the actual measured air flow from the MAF, MAP, and throttle position sensors is not within range of the calculated air flow that is derived from the system of models for greater than 2 s.

Action Taken When the DTC Sets

DTC P0101 is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P0101 is a Type B DTC.

Diagnostic Aids

- Any type of contamination on the MAF sensor heating elements will degrade the proper operation of the sensor. Certain types of contaminants act as a heat insulator, which will impair the response of the sensor to air flow changes. Water or snow can create the opposite effect, and cause the signal to increase rapidly.
- Certain aftermarket air filters may cause this DTC to set.
- Certain aftermarket air induction systems may cause this DTC to set.
- Modifications to the air induction system may cause this DTC to set.

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Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL-38522-A Variable Signal Generator

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** **Special Tools (Service Tools)** .

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC P0641, P0651, P0697, or P06A3 is not set.
   - **If any of the DTCs are set**

     Refer to **DTC P0641, P0651, P0697, or P06A3** for further diagnosis.

   - **If none of the DTCs are set**
3. Verify the scan tool Throttle Body Idle Air Flow Compensation parameter is less than 90%.
   - **90% or greater**

     Refer to **Throttle Body Cleaning** .

   - **If less than 90%**

4. Verify the scan tool Throttle Position Sensors 1 and 2 Agree/Disagree parameter displays Agree while performing the Throttle Sweep Test with a scan tool.
   - **If Disagree**

     Refer to **DTC P0121-P0123, P0222, P0223, P16A0-P16A2, or P2135** for further diagnosis.

   - **If Agree**
5. Determine the current vehicle testing altitude.
6. Verify the scan tool MAP Sensor pressure parameter is within the range specified in the **Altitude Versus Barometric Pressure** table.
   - **If the MAP Sensor parameter is not in range**

     Refer to **DTC P0106** for further diagnosis.

   - **If the MAP Sensor parameter is in range**
7. Engine idling.
8. Verify the scan tool MAP Sensor parameter is between 26-52 kPa (3.8-7.5 PSI) and changes with accelerator pedal input.
   - **If the MAP Sensor parameter is not between 26-52 kPa (3.8-7.5 PSI) or does not change**

     Refer to **DTC P0106** for further diagnosis.

   - **If the MAP Sensor parameter is between 26-52 kPa (3.8-7.5 PSI) and changes**
9. Verify the scan tool MAF Sensor g/s parameter changes smoothly and gradually as the engine speed is increased and decreased while performing the actions listed below.
   1. Engine idling
   2. Perform the scan tool snapshot function.
   3. Increase the engine speed slowly to 3,000 RPM and then back to idle.
   4. Exit from the scan tool snapshot and review the data.
   5. Observe the MAF Sensor parameter frame by frame with a scan tool.
   - **The MAF Sensor parameter does not change smoothly and gradually**

     Refer to Circuit/System Testing for further diagnosis.

   - **The MAF Sensor parameter changes smoothly and gradually**

10. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
11. Verify the DTC does not set.
    - **If the DTC sets**

      Refer to Circuit/System Testing for further diagnosis.

    - **If the DTC does not set**
12. All OK

Circuit/System Testing

NOTE: **You must perform the Circuit/System Verification before proceeding with Circuit/System Testing.**

1. Verify the integrity of the entire air induction system by verifying that none of the conditions listed below exist:
    - Any damaged components
    - Improperly installed components
    - Collapsed, restricted, or damaged components
    - Loose clamps, cracks, or other damage
    - An air flow restriction
    - Restricted air filter
    - Splits, kinks, leaks, or improper connections at the vacuum hoses
    - Vacuum leaks at the intake manifold, MAP sensor, and throttle body
    - Water intrusion
    - Any snow or ice buildup, in cold climates
    - Contamination of the multifunction intake air sensor element
    - **If a condition is found**

      Repair or replace component as appropriate.

    - **If no condition is found**
2. Ignition OFF. Disconnect the harness connector at the B75C Multifunction Intake Air Sensor.
3. Test for less than 2 Ω between the ground circuit terminal 7 and ground.

- **If 2 Ω or greater**

1. Disconnect the sensor chassis ground.
2. Test for less than 2 Ω in the ground circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, repair the open/high resistance in the ground connection.

- **If less than 2 Ω**

4. Ignition ON, verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.

- **If the test lamp does not illuminate and the circuit fuse is good**

1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
2. Test for less than 2 Ω in the ignition voltage circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.

- **If the test lamp does not illuminate and the circuit fuse is open**

1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
2. Test for infinite resistance between the ignition voltage circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance, test all components connected to the ignition circuit, replace as necessary.

- **If a test lamp illuminates**

5. Ignition ON, test for 4.8-5.2 V between the signal circuit terminal 6 and ground.

- **If less than 4.8 V**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the signal circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance
3. Test for less than 2 Ω in the signal circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If greater than 5.2 V**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

2. Test for less than 1 V between the signal circuit and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.
- **If between 4.8-5.2 V**

6. Determine if **EL-38522-A** Variable Signal Generator or equivalent is available.
    - **EL-38522-A, Variable Signal Generator; or equivalent is not available**
    1. Test or replace the B75C Multifunction Intake Air Sensor.
    2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
    3. Verify the DTC does not set.
        - **If the DTC sets**

          Replace the K20 Engine Control Module.

        - **If no DTCs set**
    4. All OK.
    - **EL-38522-A, Variable Signal Generator; or equivalent is available**
7. Ignition OFF, connect the leads of the **EL-38522-A** Variable Signal Generator as listed below:
    - Red lead to the signal circuit terminal 6 at the harness connector
    - Black leads to ground
    - Battery voltage supply lead to B+
8. Set the **EL-38522-A** Variable Signal Generator to the specifications listed below:
    - Signal switch to 5 V
    - Frequency switch to 5 kHz
    - Duty Cycle switch to 50% (Normal)
9. Engine idling.
10. Verify the scan tool MAF Sensor parameter is between 4,950-5,050 Hz.
    - **If not between 4,950-5,050 Hz.**

      If not between 4,950-5,050 Hz, replace the K20 Engine Control Module.

- **If between 4,950-5,050 Hz.**

11. Test or replace the B75C Multifunction Intake Air Sensor.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement** for multifunction intake air sensor replacement.
- Refer to **Control Module References** for engine control module replacement, programming, and setup.

DTC P0102 OR P0103: MASS AIR FLOW (MAF) SENSOR CIRCUIT

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0102

Mass Air Flow (MAF) Sensor Circuit Low Frequency

DTC P0103

Mass Air Flow (MAF) Sensor Circuit High Frequency

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0096, P0097, P00F4, P0102, P0178, P2199	P0096, P0097, P00F4, P0101, P0102, P2199	P0690	P0096, P0101, P0103
Signal	P0102	P0102	P0102*	P0101, P0103, P1101

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ground	-	P0096, P0097, P00F4, P0102, P2199	-	P0096, P0102
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

MAF Sensor

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running at various operating conditions **Parameter Normal Range:** 2,000-10,000 Hz			
Ignition Voltage	0 Hz	0 Hz	-
Signal	0 Hz	0 Hz	0 Hz*
Ground	-	0 Hz	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

Circuit/System Description

The mass air flow (MAF) sensor is integrated with the multifunction intake air sensor. The MAF sensor is an air flow meter that measures the amount of air in the sensor bore. The engine control module (ECM) uses the MAF sensor signal to provide the correct fuel delivery for all engine speeds and loads. A small quantity of air entering the engine indicates a deceleration or idle condition. A large quantity of air entering the engine indicates an acceleration or high load condition.

The ECM applies 5 V to the MAF sensor on the MAF sensor signal circuit. The sensor uses the voltage to produce a variable frequency signal based on the inlet air flow through the sensor bore. The signal varies with engine load and is displayed by the scan tool as Hertz (Hz) and grams per second (g/s). Ignition voltage and ground circuits are also supplied to the multifunction intake air sensor internal circuits for these sensors:

- Intake Air Temperature (IAT) sensor 2
- Humidity sensor
- MAF sensor

The multifunction intake air sensor houses the following:

- IAT sensor 1

- IAT sensor 2
- Humidity sensor
- MAF sensor
- BARO pressure sensor

Conditions for Running the DTC

- The engine speed is greater than 300 RPM.
- The engine is running for greater than 1 s.
- The ignition signal is greater than 10 V.
- The above conditions are met for greater than 1 s.
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

P0102

The ECM detects that the MAF Sensor Signal is less than 800 Hz (about 1.34 g/s) for greater than 10 s.

P0103

The ECM detects that the MAF Sensor Signal is greater than 14,500 Hz (about 1233 g/s) for greater than 10 s.

Action Taken When the DTC Sets

DTCs P0102 and P0103 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P0102 and P0103 are Type B DTCs.

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Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL-38522-A Variable Signal Generator

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** **Special Tools (Service Tools)** .

Circuit/System Verification

1. Ignition ON.
2. Verify the scan tool MAF Sensor g/s parameter changes smoothly and gradually as the engine speed is increased and decreased while performing the actions listed below.
    1. Engine idling
    2. Perform the scan tool snapshot function.
    3. Increase the engine speed slowly to 3,000 RPM and then back to idle.
    4. Exit from the scan tool snapshot and review the data.

5. Observe the MAF Sensor parameter frame by frame with a scan tool.
   - **The MAF Sensor parameter does not change smoothly and gradually**

     Refer to Circuit/System Testing.

   - **The MAF Sensor parameter changes smoothly and gradually**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set.**
5. All OK

Circuit/System Testing

NOTE: **You must perform the Circuit/System Verification before proceeding with Circuit/System Testing.**

1. Ignition OFF and all systems OFF. Disconnect the harness connector at the B75C Multifunction Intake Air Sensor.
2. Test for less than 2 Ω between the ground circuit terminal 7 and ground.
   - **If 2 Ω or greater**
   1. Disconnect the sensor chassis ground.
   2. Test for less than 2 Ω in the ground circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, repair the open/high resistance in the chassis ground connection.
   - **If less than 2 Ω**
3. Ignition ON.
4. Verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
   2. Test for less than 2 Ω in the ignition voltage circuit end to end.

- If 2 Ω or greater, repair the open/high resistance in the circuit.
- If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.

- **If the test lamp does not illuminate and the circuit fuse is open**

1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
2. Test for infinite resistance between the ignition voltage circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance, test all components connected to the ignition circuit, replace as necessary.

- **If a test lamp illuminates**

5. Ignition ON, test for 4.8-5.2 V between the signal circuit terminal 6 and ground.

- **If less than 4.8 V**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the signal circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance
3. Test for less than 2 Ω in the signal circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If greater than 5.2 V**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the signal circuit and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.

- **If between 4.8-5.2 V**

6. Determine if **EL-38522-A** Variable Signal Generator or equivalent is available.

- **EL-38522-A, Variable Signal Generator; or equivalent is not available**

1. Test or replace the B75C Multifunction Intake Air Sensor.
2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
3. Verify the DTC does not set.

- **If the DTC sets**

  Replace the K20 Engine Control Module.

- **If no DTCs set**

4. All OK.

- **EL-38522-A, Variable Signal Generator; or equivalent is available**

7. Ignition OFF, connect the leads of the **EL-38522-A** Variable Signal Generator as listed below:
   - Red lead to the signal circuit terminal 6 at the harness connector
   - Black leads to ground
   - Battery voltage supply lead to B+
8. Set the **EL-38522-A** Variable Signal Generator to the specifications listed below:
   - Signal switch to 5 V
   - Frequency switch to 5 kHz
   - Duty Cycle switch to 50% (Normal)
9. Engine idling.
10. Verify the scan tool MAF Sensor parameter is between 4,950-5,050 Hz.
    - **If not between 4,950-5,050 Hz.**

      If not between 4,950-5,050 Hz, replace the K20 Engine Control Module.

    - **If between 4,950-5,050 Hz.**
11. Test or replace the B75C Multifunction Intake Air Sensor.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement** for multifunction intake air sensor replacement.
- Refer to **Control Module References** for engine control module replacement, programming, and setup.

DTC P0106: MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR PERFORMANCE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P0106

Manifold Absolute Pressure (MAP) Sensor Performance

Diagnostic Fault Information

Circuits	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
5 V Reference	P0106, P0107, P0697	P0106, P0107	P0107	P0106, P0108, P0107, P0697	P0106
Signal	P0106, P0107 P0697	P0106, P0107	P0106, P0107	P0106, P0108*, P0697	P0106, P1101
Low Reference	-	P0106, P0108	P0106, P0108	-	P0106
* Internal ECM or sensor damage may occur if the circuit is shorted to B+.					

Typical Scan Tool Data

MAP Sensor

Circuits	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine operating in closed loop, idling, and accessories OFF **Parameter Normal Range:** 12-103 kPa (1.7-14.9 PSI) (varies with altitude)			
5 V Reference	0 kPa (0 PSI)	0 kPa (0 PSI)	128 kPa (18.6 PSI)
Signal	0 kPa (0 PSI)	0 kPa (0 PSI)	128 kPa (18.6 PSI)*
Low Reference	-	80-128 kPa (11.6-18.6 PSI)	-
* Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

MAP Sensor, if equipped with Turbocharger

Circuits	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running at various operating conditions			

Circuits	Short to Ground	Open	Short to Voltage
Parameter Normal Range: 12-225 kPa (1.7-32.6 PSI) (varies with altitude)			
5 V Reference	0 kPa (0 PSI)	0 kPa (0 PSI)	255 kPa (36.9 PSI)
Signal	0 kPa (0 PSI)	0 kPa (0 PSI)	255 kPa (36.9 PSI)*
Low Reference	-	255 kPa (36.9 PSI)	-
* Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

Circuit/System Description

The manifold absolute pressure (MAP) sensor measures the pressure inside the intake manifold. Pressure in the intake manifold is affected by engine speed, throttle opening, air temperature, barometric pressure (BARO) and if equipped, turbocharger output. A diaphragm within the MAP sensor is displaced by the pressure changes that occur from the varying load and operating conditions of the engine. The sensor translates this action into electrical resistance.

The MAP sensor wiring includes 3 circuits. The engine control module (ECM) supplies a regulated 5 volts to the sensor on a 5 V reference circuit. The ECM supplies a ground on a low reference circuit. The MAP sensor provides a signal voltage to the ECM, relative to the pressure changes, on the MAP sensor signal circuit. The ECM converts the signal voltage input to a pressure value.

Under normal operation the greatest pressure that can exist in the intake manifold is at ignition ON, engine OFF, which is equal to the BARO. If equipped, a turbocharger can increase the pressure above BARO, when the vehicle is operated at wide-open throttle (WOT). The lowest manifold pressure occurs when the vehicle is idling or decelerating. The ECM monitors the MAP sensor signal for pressure outside of the normal range.

Conditions for Running the DTC

- DTCs P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0128, P0335, P0336 or P0401 are not set.
- The engine speed is between 450-5,400 RPM.
- The engine coolant temperature (ECT) sensor is between -7 to 129Â°C (19 to 264Â°F).
- The intake air temperature (IAT) sensor is between -20 to 129Â°C (-4 to 264Â°F).
- This DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

The ECM determines if the MAP Sensor is stuck within the normal operating range. It accomplishes this by running 3 different models within the software to determine the values.

Action Taken When the DTC Sets

DTC P0106 is a Type B DTC.

Conditions for Clearing the DTC

DTC P0106 is a Type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

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- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

GE-23738-A Vacuum Pump

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** **Special Tools (Service Tools)** .

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC P0641, P0651, P0697, or P06A3 is not set.
   - **If any of the DTCs are set**

     Refer to **DTC P0641, P0651, P0697, or P06A3** for further diagnosis.

   - **If none of the DTCs are set**
3. If you were sent here from DTC P0068, P0101, P0121, or P1101; refer to Circuit/System Testing.
4. Verify the scan tool Throttle Body Idle Air Flow Compensation parameter is less than 90%
   - **If 90% or greater**

     Refer to **Throttle Body Cleaning**

   - **If less than 90%**
5. Verify the scan tool Throttle Position Sensors 1 and 2 Agree/Disagree parameter displays Agree while performing the Throttle Sweep with a scan tool.
   - **If Disagree**

     Refer to **DTC P0121-P0123, P0222, P0223, P16A0-P16A2, or P2135** for further diagnosis.

   - **If Agree**
6. Determine the current vehicle testing altitude.
7. Verify the scan tool MAP Sensor parameter is within the range specified in the **Altitude Versus Barometric Pressure** table.
   - **If the MAP Sensor parameter is not in range**

     Refer to Circuit/System Testing.

   - **If the MAP Sensor parameter is within range**
8. Engine idling.
9. Verify the scan tool MAP Sensor parameter is between 26-52 kPa (3.8-7.5 PSI) and changes with accelerator pedal input.

- **If not between 26-52 kPa (3.8-7.5 PSI) or does not change**

  Refer to Circuit/System Testing.

- **If between 26-52 kPa (3.8-7.5 PSI) and changes**

10. Verify the scan tool MAF Sensor parameter changes smoothly and gradually as the engine speed is increased and decreased while performing the actions listed below.
    1. Engine idling
    2. Perform the scan tool snapshot function.
    3. Increase the engine speed slowly to 3,000 RPM and then back to idle.
    4. Exit from the scan tool snapshot and review the data.
    5. Observe the MAF Sensor parameter frame by frame with a scan tool.
    - **If the MAF Sensor parameter does not change smoothly and gradually**

      Refer to **DTC P0101** for further diagnosis.

    - **If the MAF Sensor parameter changes smoothly and gradually**
11. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
12. Verify the DTC does not set.
    - **If the DTC sets**

      Refer to Circuit/System Testing.

    - **If the DTC does not set**
13. All OK.

Circuit/System Testing

1. Verify the integrity of the entire air induction system and verify that none of the following conditions exist:
   - Any damaged components
   - Improper operation of turbocharger wastegate actuator or bypass valve, if equipped
   - Loose or improper installation of the turbocharger and the charge air cooler, including the flexible ductwork, if equipped
   - An air flow restriction

- Any vacuum leak
- Improperly routed vacuum hoses
- In cold climates, inspect for any snow or ice buildup at the BARO port on the ECM, if equipped
- A restriction in the MAP Sensor port or the BARO port, if equipped
- Proper operation of the Positive Crankcase Ventilation (PCV) system
- Missing, restricted or leaking exhaust components. Refer to **Restricted Exhaust** .
- Engine mechanical condition, for example: low compression or incorrect timing chain installation. Refer to **Symptoms - Engine Mechanical**
- **If a condition is found**

  Repair or replace the component as appropriate.

- **If no condition is found**

2. Ignition OFF and all vehicle systems OFF. It may take up to 2 min for all vehicle systems to power down. Disconnect the B74 Manifold Absolute Pressure Sensor.
3. Test for less than 2 Ω between the low reference circuit terminal 2 and ground.
   - **If 2 Ω or greater**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If less than 2 Ω**
4. Ignition ON.
5. Test for 4.8-5.2 V between the 5 V reference circuit terminal 1 and ground.
   - **If less than 4.8 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the 5 V reference circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 Ω in the 5 V reference circuit end to end.

- If 2 Ω or greater, repair the open/high resistance in the circuit.
- If less than 2 Ω, replace the K20 Engine Control Module.

NOTE: **If the signal circuit is shorted to a voltage the ECM or the MAP Sensor may be damaged.**

-
- **If greater than 5.2 V**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Ignition ON, test for less than 1 V between the 5 V reference circuit and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.

- **If between 4.8-5.2 V**

6. Verify the scan tool MAP Sensor parameter is less than 0.5 V.

- **If 0.5 V or greater**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the signal circuit terminal 3 and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.

- **If less than 0.5 V**

7. Install a 3 A fused jumper wire between the signal circuit terminal 3 and the 5 V reference circuit terminal 1.
8. Verify the scan tool MAP Sensor parameter is greater than 4.5 V.

- **If 4.5 V or less**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the signal circuit terminal 3 and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance
3. Test for less than 2 Ω in the signal circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If greater than 4.5 V**

9. Test or replace the B74 Manifold Absolute Pressure Sensor.

Component Testing

NOTE: **You must perform the Circuit/System Testing in order to verify the integrity of the MAP Sensor circuits before proceeding with the Component Testing.**

Skewed Sensor Test

1. Ignition OFF, remove the B74 Manifold Absolute Pressure Sensor from the engine. Connect the harness to the sensor, if disconnected.
2. Ignition ON.
3. Apply 17 kPa (5.0 in Hg) of vacuum to the B74 Manifold Absolute Pressure Sensor, with the **GE-23738-A** .
4. Verify the scan tool MAP Sensor pressure parameter decreases between 13-21 kPa (1.8-3.0 PSI).
   - **If the parameter does not decrease between 13-21 kPa (1.8-3.0 PSI)**

     Replace the B74 Manifold Absolute Pressure Sensor.

   - **If the parameter does decrease between 13-21 kPa (1.8-3.0 PSI)**
5. Apply 34 kPa (10.0 in Hg) of vacuum to the B74 Manifold Absolute Pressure Sensor, with the **GE-23738-A** .
6. Verify the scan tool MAP Sensor pressure parameter decreases between 30-38 kPa (4.4-5.5 PSI).
   - **If the parameter does not decrease between 30-38 kPa (4.4-5.5 PSI)**

     Replace the B74 Manifold Absolute Pressure Sensor.

   - **If the parameter does decrease between 30-38 kPa (4.4-5.5 PSI)**
7. All OK.

Erratic Signal Test

1. Ignition OFF, remove the B74 Manifold Absolute Pressure Sensor and disconnect the harness.
2. Install a 3 A fused jumper wire between the 5 V reference circuit terminal 1 of the sensor and the sensor harness.
3. Install a jumper wire between the low reference circuit terminal 2 of the sensor and ground.
4. Install a jumper wire to the signal circuit terminal 3 of the sensor.

5. Connect a DMM between the jumper wire and ground.
6. Ignition ON, observe the DC voltage on the DMM. Slowly apply between 0-15 kPa (0-4.4 in Hg) of vacuum to the sensor with the **GE-23738-A** .
7. Verify the voltage changes, without any spikes or dropouts, between 0.2-4.9 V.
   - **If not between 0.2-4.9 V or has spikes or dropouts**

     Replace the B74 Manifold Absolute Pressure Sensor.

   - **If between 0.2-4.9 V and there are no spikes or dropouts**
8. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Control Module References** for ECM replacement, programming and setup.
- Refer to **Manifold Absolute Pressure Sensor Replacement** .

DTC P0107 OR P0108: MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR CIRCUIT

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0107

Manifold Absolute Pressure (MAP) Sensor Circuit Low Voltage

DTC P0108

Manifold Absolute Pressure (MAP) Sensor Circuit High Voltage

Diagnostic Fault Information

Circuits	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
5 V Reference	P0107, P0697	P0106, P0107	P0107	P0107, P0108, P0697	P0106
Signal	P0106, P0107, P0697	P0106, P0107	P0106, P0107	P0106, P0108*, P0697	P0106
Low Reference	-	P0106, P0108	P0106, P0108	-	P0106
* Internal ECM or sensor damage may occur if the circuit is shorted to B+.					

Typical Scan Tool Data

MAP Sensor

Circuits	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine operating in closed loop, idling, and accessories OFF. **Parameter Normal Range:** 26-52 kPa (3.8 to 7.6 PSI) (Varies with altitude)			
5 V Reference	0 kPa (0 PSI)	0 kPa (0 PSI)	127 kPa (18.4 PSI)
Signal	0 kPa (0 PSI)	0 kPa (0 PSI)	127 kPa (18.4 PSI)*
Low Reference	-	127 kPa (18.4 PSI)	-
* Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

MAP Sensor, if equipped with Turbocharger

Circuits	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running at various operating conditions **Parameter Normal Range:** 12-225 kPa (1.7 to 32.6 PSI) (Varies with altitude)			
5 V Reference	0 kPa (0 PSI)	0 kPa (0 PSI)	255 kPa (36.9 PSI)
Signal	0 kPa (0 PSI)	0 kPa (0 PSI)	255 kPa (36.9 PSI)*
Low Reference	-	255 kPa (36.9 PSI)	-
* Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

Circuit/System Description

The manifold absolute pressure (MAP) sensor measures the pressure inside the intake manifold. Pressure in the intake manifold is affected by engine speed, throttle opening, air temperature, barometric pressure (BARO); and if equipped turbocharger output. A diaphragm within the MAP sensor is displaced by the pressure changes that occur from the varying load and operating conditions of the engine. The sensor translates this action into electrical resistance.

The MAP sensor wiring includes 3 circuits. The engine control module (ECM) supplies a regulated 5 volts to the sensor on a 5 V reference circuit. The ECM supplies a ground on a low reference circuit. The MAP sensor provides a signal voltage to the ECM, relative to the pressure changes, on the MAP sensor signal circuit. The ECM converts the signal voltage input to a pressure value.

Under normal operation the greatest pressure that can exist in the intake manifold is at ignition ON, engine OFF, which is equal to the BARO. If equipped, a turbocharger can increase the pressure above BARO, when the vehicle is operated at wide-open throttle (WOT). The lowest manifold pressure occurs when the vehicle is idling or decelerating. The ECM monitors the MAP sensor signal for pressure outside of the normal range.

Conditions for Running the DTC

The DTC's run continuously.

Conditions for Setting the DTC

P0107

The ECM detects that the MAP Sensor voltage is less than 0.15 V for greater than 13 ms.

P0108

The ECM detects that the MAP Sensor voltage is more than 4.50 V for greater than 13 ms.

Action Taken When the DTC Sets

DTCs P0107 and P0108 are Type B DTCs.

Conditions for Clearing the DTC

DTCs P0107 and P0108 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

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- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

GE-23738-A Vacuum Pump

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** **Special Tools (Service Tools)** .

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC P0641, P0651, P0697, or P06A3 is not set.
    - **If any of the DTCs are set**

      Refer to **DTC P0641, P0651, P0697, or P06A3** for further diagnosis.

    - **If none of the DTCs are set**
3. Verify the scan tool MAP Sensor parameter is within the range specified in the **Altitude Versus Barometric Pressure** table.
    - **If the MAP Sensor parameter is not in range**

Refer to Circuit/System Testing for further diagnosis.

- **If the MAP Sensor parameter is within range**

4. Engine idling, verify the scan tool MAP Sensor voltage parameter is between the specified value listed below:

   0.3-4.8 V and changes with accelerator pedal input - Without turbocharger

   0.2-4.5 V and changes with accelerator pedal input - With turbocharger

   - **If not between the specified value or does not change**

     Refer to Circuit/System Testing.

   - **If between the specified value and changes**

5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed in the Freeze Frame/Failure Records data.
6. Verify the DTC does not set.
   - **If any DTC sets**

     Refer to Circuit/System Testing.

   - **If no DTC sets**
7. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF. It may take up to 2 min for all vehicle systems to power down. Disconnect the harness connector at the B74 Manifold Absolute Pressure Sensor.
2. Test for less than 2 Ω between the low reference circuit terminal 2 and ground.
   - **If 2 Ω or greater**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If less than 2 Ω**

3. Ignition ON.
4. Test for 4.8-5.2 V between the 5 V reference circuit terminal 1 and ground.
   - **If less than 4.8 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the 5 V reference circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 Ω in the 5 V reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.

NOTE: **If the signal circuit is shorted to a voltage the ECM or the MAP Sensor may be damaged.**

   -
   - **If greater than 5.2 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Ignition ON, test for less than 1 V between the 5 V reference circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If between 4.8-5.2 V**
5. Verify the scan tool MAP Sensor parameter is less than 0.5 V.
   - **If 0.5 V or greater**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the signal circuit terminal 3 and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If less than 0.5 V**
6. Install a 3 A fused jumper wire between the signal circuit terminal 3 and the 5 V reference circuit terminal 1.
7. Verify the scan tool MAP Sensor voltage parameter is greater than 4.5 V.

- **If 4.5 V or less**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the signal circuit terminal 3 and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance
3. Test for less than 2 Ω in the signal circuit end to end.
    - If 2 Ω or greater, repair the open or high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If greater than 4.5 V**

8. Test or replace the B74 Manifold Absolute Pressure Sensor.

Component Testing

NOTE: **You must perform the Circuit/System Testing in order to verify the integrity of the MAP Sensor circuits before proceeding with the Component Testing.**

Skewed Sensor Test

1. Ignition OFF, remove the B74 Manifold Absolute Pressure Sensor from the engine. Connect the harness to the sensor, if disconnected.
2. Ignition ON.
3. Apply 17 kPa (5.0 in Hg) of vacuum to the B74 Manifold Absolute Pressure Sensor, with the **GE-23738-A** .
4. Verify the scan tool MAP Sensor pressure parameter decreases between 13-21 kPa (1.8-3.0 PSI).
    - **If the parameter does not decrease between 13-21 kPa (1.8-3.0 PSI)**

      Replace the B74 Manifold Absolute Pressure Sensor.

    - **If the parameter does decrease between 13-21 kPa (1.8-3.0 PSI)**
5. Apply 34 kPa (10.0 in Hg) of vacuum to the B74 Manifold Absolute Pressure Sensor, with the **GE-23738-A** .
6. Verify the scan tool MAP Sensor pressure parameter decreases between 30-38 kPa (4.4-5.5 PSI).
    - **If the parameter does not decrease between 30-38 kPa (4.4-5.5 PSI)**

      Replace the B74 Manifold Absolute Pressure Sensor.

- **If the parameter does decrease between 30-38 kPa (4.4-5.5 PSI)**

7. All OK.

Erratic Signal Test

1. Ignition OFF, remove the B74 Manifold Absolute Pressure Sensor and disconnect the harness.
2. Install a 3 A fused jumper wire between the 5 V reference circuit terminal 1 of the sensor and the sensor harness.
3. Install a jumper wire between the low reference circuit terminal 2 of the sensor and ground.
4. Install a jumper wire to the signal circuit terminal 3 of the sensor.
5. Connect a DMM between the jumper wire and ground.
6. Ignition ON, observe the DC voltage on the DMM. Slowly apply between 0-15 kPa (0-4.4 in Hg) of vacuum to the sensor with the **GE-23738-A** .
7. Verify the voltage changes, without any spikes or dropouts, between 0.2-4.9 V.
   - **If not between 0.2-4.9 V or has spikes or dropouts**

     Replace the B74 Manifold Absolute Pressure Sensor.

   - **If between 0.2-4.9 V and there are no spikes or dropouts**
8. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Control Module References** for ECM replacement, programming and setup
- Refer to **Manifold Absolute Pressure Sensor Replacement**

DTC P0112, P0113, OR P0114: INTAKE AIR TEMPERATURE (IAT) SENSOR 1 CIRCUIT

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0112

Intake Air Temperature (IAT) Sensor 1 Circuit Low Voltage

DTC P0113

Intake Air Temperature (IAT) Sensor 1 Circuit High Voltage

DTC P0114

Intake Air Temperature (IAT) Sensor 1 Circuit Intermittent

Diagnostic Fault Information

IAT Sensor 1

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	P0112, P0114, P2199	P0111, P0113, P0114, P2199	P0113, P0114, P2199*	P0111, P2199
Low Reference	-	P0111, P0113, P0114, P2199, P2227, P2228, P2229	P0113, P0114, P2199, P2227, P2229*	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

IAT Sensor 1

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running **Parameter Normal Range:** Varies with ambient temperature			
Signal	150Â°C (302Â°F)	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
Low Reference	-	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
*Internal ECM or sensor damage may occur if the circuit is shorted to B+			

Circuit/System Description

The intake air temperature (IAT) sensor 1 is a variable resistor that measures the temperature of the air in the sensor bore. The engine control module (ECM) supplies 5 V to the IAT sensor 1 signal circuit and a ground for the IAT sensor 1 low reference circuit. The signal varies with inlet air temperature and is displayed by the scan tool as Â°C (Â°F).

The multifunction intake air sensor houses the following:

- IAT sensor 1
- IAT sensor 2
- Humidity sensor
- Mass Air Flow (MAF) sensor
- BARO pressure sensor

IAT Sensor 1 - Temperature, Resistance, Voltage Table

IAT Sensor 1	IAT Sensor 1 Resistance	IAT Sensor 1 Signal Voltage
Cold	High	High
Warm	Low	Low

Conditions for Running the DTCs

P0112, P0113, and P0114

- The engine run time is greater than 0 s.
- The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTCs

P0112

NOTE: The scan tool display range is between -40 to +150Â°C (-40 to +302Â°F).

The ECM detects that the IAT sensor 1 signal is warmer than 150Â°C (302Â°F) for greater than 5 s.

P0113

NOTE: The scan tool display range is between -40 to +150Â°C (-40 to +302Â°F).

The ECM detects that the IAT sensor 1 signal is colder than -60Â°C (-76Â°F) for greater than 5 s.

P0114

The ECM detects that the IAT sensor 1 signal is intermittent or has abruptly changed for greater than 5 s.

Action Taken When the DTCs Set

- DTCs P0112, P0113, and P0114 are Type B DTCs.
- The ECM commands the cooling fans ON.

Conditions for Clearing the DTCs

DTCs P0112, P0113, and P0114 are Type B DTCs.

Diagnostic Aids

With the ignition ON, the engine OFF, if the engine is cold, a properly functioning IAT sensor 1 will gradually increase the scan tool IAT Sensor 1 parameter. This is due to the heat that is generated by the MAF sensor heating elements.

Reference Information

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- **Testing for Intermittent Conditions and Poor Connections**

- **Wiring Repairs**

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Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Engine idling.
2. Verify the scan tool IAT Sensor 1 parameter is between -38 to +149Â°C (-36 to +300Â°F).
    - **If not between -38 to +149Â°C (-36 to +300Â°F)**

      Refer to Circuit/System Testing.

    - **If between -38 to +149Â°C (-36 to +300Â°F)**
3. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
4. Verify the DTC does not set.
    - **If the DTC sets.**

      Refer to Circuit/System Testing.

    - **If the DTC does not set.**
5. All OK

Circuit/System Testing

1. Ignition OFF and all systems OFF, it may take up to for 2 min for all vehicle systems to power down. Disconnect the harness connector at the B75C Multifunction Intake Air Sensor.
2. Test for less than 2 Ω between the low reference circuit terminal 3 and ground.
    - **If 2 Ω or greater**
    1. Disconnect the harness connector at the K20 Engine Control Module.

2. Test for less than 2 Ω in the low reference circuit end to end.
    - If 2 Ω or greater, repair the open or high resistance in the circuit.
    - If less than 2 Ω replace the K20 Engine Control Module.
- **If less than 2 Ω**

3. Ignition ON.
4. Test for 4.8-5.2 V between the intake air temperature sensor 1 signal circuit terminal 1 and ground.
    - **If less than 4.8 V**

    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If greater than 5.2 V**

    NOTE: **If the signal circuit is shorted to a voltage the engine control module or the sensor may be damaged.**

    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If between 4.8-5.2 V**
5. Verify the scan tool IAT Sensor 1 parameter is colder than -39Â°C (-38Â°F).
    - **If warmer than -39Â°C (-38Â°F).**

    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit terminal 1 and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance

3. Test for less than 2 Ω in the signal circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.
- **If colder than -39Â°C (-38Â°F).**

6. Ignition OFF, install a 3 A fused jumper wire between the signal circuit terminal 1 and the low reference circuit terminal 3, ignition ON.
7. Verify the scan tool IAT Sensor 1 parameter is warmer than 149Â°C (300Â°F).
    - **If colder than 149Â°C (300Â°F).**
    1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V
    3. Ignition OFF.
    4. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If warmer than 149Â°C (300Â°F).**
8. Test or replace the B75C Multifunction Intake Air Sensor.

Component Testing

Multifunction Intake Air Sensor

1. Ignition OFF, disconnect the harness connector at the B75C Multifunction Intake Air sensor.

NOTE: **A thermometer can be used to test the sensor off the vehicle.**

2. Test the IAT sensor 1 by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the **Temperature Versus Resistance - Intake Air Temperature Sensor** table for Hitachi Sensors. The resistance values should be in range of the table values.
    - **If not within the table values.**

      Replace the B75C Multifunction Intake Air sensor.

    - **If within the table values.**

3. All OK

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement** for multifunction intake air sensor replacement
- Refer to **Control Module References** for engine control module replacement, programming, and setup.

DTC P0116: ENGINE COOLANT TEMPERATURE (ECT) SENSOR PERFORMANCE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P0116

Engine Coolant Temperature (ECT) Sensor Performance

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
Signal	P0117	P0118	P0118	P0118	P0116, P0128
Low Reference	-	P0118	P0118	P0118	P0128

Typical Scan Tool Data

ECT Sensor

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine Running at normal operating temperature **Parameter Normal Range:** 91 to 93Â°C (196 to 200Â°F)			
ECT Sensor	150Â°C (302Â°F)	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
Low Reference	-	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)

Circuit	Short to Ground	Open	Short to Voltage
*ECM or sensor damage may occur if the circuit is shorted to B+.			

Circuit/System Description

The engine coolant temperature (ECT) sensor is a variable resistor that measures the temperature of the engine coolant. The engine control module (ECM) supplies 5 V to the ECT sensor signal circuit and a ground for the low reference circuit.

The ECM uses this high side coolant rationality diagnostic to determine if the input from the ECT sensor is skewed warmer than normal. The internal clock of the ECM will record the amount of time the ignition is OFF. If the calibrated ignition OFF time is met at start-up, the ECM will compare the temperature difference between the ECT and the intake air temperature (IAT) to determine if the temperatures are within an acceptable operating range of each other.

Conditions for Running the DTC

- DTCs P0111, P0112, P0113, P0114, P0117, P0118, P0128, P0502, P0503, P0601, P1621, or P2610 are not set.
- The vehicle has had a minimum ignition OFF time of 8 hours.
- The Ignition is ON.
- The start-up IAT is warmer than -7Â° C (+19Â° F).
- Fuel level is greater than 2.5%
- This DTC runs once per ignition cycle when the above conditions are met.

Conditions for Setting the DTC

- The ECM detects a temperature difference at power-up that indicates that the ECT sensor is 30Â° C (86Â° F) warmer than the IAT sensor for less than 1 s.

  OR

- The ECM detects a temperature difference at power-up that indicates that the ECT sensor is 15Â° C (59Â° F) warmer than the IAT sensor, and NO engine block heater was detected for less than 1 s.

  OR

- The ECM detects a temperature difference at power-up that indicates that the ECT sensor is 15Â° C (59Â° F) warmer than the IAT sensor, the engine cranked for greater than 10 s without starting and NO engine block heater was detected for less than 1 s.

Action Taken When the DTC Sets

DTC P0116 is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P0116 is a Type B DTC.

Diagnostic Aids

- Engine coolant that is leaking through the sensor will create a high resistance short to ground. This condition results in less voltage on the ECT sensor signal circuit, which is interpreted by the ECM as a warmer ECT.
- An IAT sensor that is skewed colder at various ambient temperatures due to greater resistance than is normal will increase the range between these two sensors. Measure and record the resistance of the IAT sensor at various ambient temperatures, then compare those measurements to the **Temperature Versus Resistance - Intake Air Temperature Sensor** table.
- A slight to moderate resistance in the IAT sensor signal circuit or low reference circuit will increase the range between these two sensors. This condition results in a greater voltage on the IAT sensor signal circuit, which is interpreted by the ECM as a colder IAT.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

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- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify the scan tool ECT Sensor parameter is warmer than -40Â° C (-40Â° F) and colder than 150Â° C (302Â° F) and changes with engine run time.
   - **If colder than -39Â° C (-38Â° F) or warmer than 149Â° C (300Â° F) or does not change**

     Refer to Circuit/System Testing.

   - **If warmer than -40Â° C (-40Â°F) and colder than 150Â° C (302Â° F) and changes**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
5. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B34 Engine Coolant Temperature Sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference terminal A and ground.
   - **If 5 Ω or greater**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.

- If 2 Ω or greater, repair the open/high resistance in the circuit.
- If less than 2 Ω, replace the K20 Engine Control Module.

- **If less than 5 Ω**

3. Ignition ON.
4. Verify the scan tool ECT Sensor parameter is colder than -39Â°C (-38Â°F).
   - **If warmer than -39Â°C (-38Â°F)**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the signal circuit terminal B and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.
   - **If colder than -39Â°C (-38Â°F)**

CAUTION: If the fuse in the jumper wire opens, the signal circuit may have a short to a voltage or a short to ground and the sensor might be damaged.

5. Install a 1 A fused jumper wire between the signal circuit terminal B and ground.
6. Verify the scan tool ECT sensor parameter is warmer than 149Â°C (300Â°F).
   - **If colder than the 149Â°C (300Â°F)**
   1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the signal circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V
   3. Ignition OFF
   4. Test for less than 2 Ω in the signal circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If warmer than 149Â°C (300Â°F)**
7. Test or replace the B34 Engine Coolant Temperature Sensor.

Component Testing

1. Ignition OFF, disconnect the harness connector at the B34 Engine Coolant Temperature Sensor.
2. Test the ECT sensor by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the **Temperature Versus Resistance (ECT)** table. The resistance values should be in range of the table values.
   - **If not within the specified range**

     Replace the B34 Engine Coolant Temperature Sensor.

   - **If within the specified range**
3. Test for infinite resistance between each terminal and the sensor housing.
   - **If less than infinite resistance**

     Replace the B34 Engine Coolant Temperature Sensor.

   - **If infinite resistance**
4. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the diagnostic procedure.

- Refer to **Engine Coolant Temperature Sensor Replacement**
- Refer to **Control Module References** for engine control module replacement, setup, and programming.

DTC P0117, P0118, OR P0119: ENGINE COOLANT TEMPERATURE (ECT) SENSOR CIRCUIT

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0117

Engine Coolant Temperature (ECT) Sensor Circuit Low Voltage

DTC P0118

Engine Coolant Temperature (ECT) Sensor Circuit High Voltage

DTC P0119

Engine Coolant Temperature (ECT) Sensor Circuit Intermittent

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
Signal	P0117, P0119	P0118	P0118, P0119	P0118, P0119	P0119, P0128
Low Reference	-	P0118	P0118, P0119	-	P0116, P0128

Typical Scan Tool Data

ECT Sensor

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine Running at normal operating temperature **Parameter Normal Range:** 91 to 93Â°C (196 to 200Â°F)			
ECT Sensor	150Â°C (302Â°F)	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
Low Reference	-	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)
*ECM or sensor damage may occur if the circuit is shorted to B+.			

Circuit/System Description

The engine coolant temperature (ECT) sensor is a variable resistor that measures the temperature of the engine coolant. The engine control module (ECM) supplies 5 V to the ECT sensor signal circuit and a ground for the low reference circuit. This diagnostic checks for an open, short to ground or an intermittent circuit condition between the ECM and ECT sensor.

Conditions for Running the DTC

P0117

- The ignition is ON.

  OR

- The engine is running.
- This DTC runs continuously within the enabling conditions.

P0118

- The ignition is ON.

  OR

- The engine is running for greater than 10 s.

  OR

- The engine run time is less than 10 s when IAT Sensor 1 is warmer than -7Â°C (19Â°F).
- This DTC runs continuously within the enabling conditions.

P0119

- DTC P0117 or P0118 is not set.
- The ignition is ON.
- This DTC runs continuously within the enabling conditions.

Conditions for Setting the DTC

P0117

The ECM detects that the ECT Sensor is warmer than 149Â°C (300Â°F) for greater than 5 s.

P0118

The ECM detects that the ECT Sensor is colder than -39Â°C (-38Â°F) for greater than 5 s.

P0119

The ECM detects that the ECT Sensor is intermittent or has abruptly changed for greater than 3 s.

Action Taken When the DTC Sets

- DTCs P0117, P0118 and P0119 are Type B DTCs
- The cooling fans will be commanded ON.
- The Engine Coolant Temperature Gauge is inoperative.
- The A/C compressor will be commanded OFF.

Conditions for Clearing the DTC

DTCs P0117, P0118 and P0119 are Type B DTCs

Diagnostic Aids

- The engine coolant temperature gauge will display full cold when an ECT DTC set's.
- After starting the engine, the engine coolant temperature (ECT) sensor temperature should rise steadily, then stabilize after the thermostat opens.

Reference Information

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DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify the scan tool ECT Sensor parameter is warmer than -40Â° C (-40Â° F) and colder than 150Â° C (302Â° F) and changes with engine run time.
   - **If colder than -39Â° C (-38Â° F) or warmer than 149Â° C (300Â° F) or does not change**

     Refer to Circuit/System Testing.

   - **If warmer than -40Â° C (-40Â°F) and colder than 150Â° C (302Â° F) and changes**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
5. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the B34 Engine Coolant Temperature sensor harness connector at the sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal A or 2 and ground.
   - **If 5 Ω or greater**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.

- If less than 2 Ω, replace the K20 Engine Control Module.
- **If less than 5 Ω**

3. Ignition ON.
4. Verify the scan tool ECT Sensor parameter is colder than -39Â° C (-38Â° F).
   - **If warmer than -39Â° C (-38Â° F)**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the signal circuit terminal B or 1 and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.
   - **If colder than -39Â° C (-38Â° F)**

CAUTION: If the fuse in the jumper wire opens, the signal circuit may have a short to a voltage or a short to ground and the sensor might be damaged.

5. Install a 1 A fused jumper wire between the signal circuit terminal B and ground.
6. Verify the scan tool ECT sensor parameter is warmer than 149Â° C (300Â° F).
   - **If 149Â° C (300Â° F) or colder**
   1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the signal circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V
   3. Ignition OFF.
   4. Test for less than 2 Ω in the signal circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If warmer than 149Â° C (300Â° F)**
7. Test or replace the B34 Engine Coolant Temperature Sensor.

Component Testing

1. Ignition OFF, disconnect the harness connector at the B34 Engine Coolant Temperature Sensor.

2. Test the ECT sensor by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the **Temperature Versus Resistance (ECT)** table. The resistance values should be in range of the table values.
   - **If not within the specified range**

     Replace the B34 Engine Coolant Temperature Sensor.

   - **If within the specified range**
3. Test for infinite resistance between each terminal and the sensor housing.
   - **If less than infinite resistance**

     Replace the B34 Engine Coolant Temperature Sensor.

   - **If infinite resistance**
4. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Engine Coolant Temperature Sensor Replacement**
- Refer to **Control Module References** for ECM replacement, programming, and setup.

DTC P0121-P0123, P0222, P0223, P16A0-P16A2, OR P2135: THROTTLE POSITION SENSOR 1/THROTTLE POSITION SENSOR 2/SENSOR COMMUNICATION CIRCUIT/THROTTLE POSITION SENSORS 1-2 NOT PLAUSIBLE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0121

Throttle Position Sensor 1 Performance

DTC P0122

Throttle Position Sensor 1 Circuit Low Voltage

DTC P0123

Throttle Position Sensor 1 Circuit High Voltage

DTC P0222

Throttle Position Sensor 2 Circuit Low Voltage

DTC P0223

Throttle Position Sensor 2 Circuit High Voltage

DTC P16A0

Sensor Communication Circuit Low Voltage

DTC P16A1

Sensor Communication Circuit High Voltage

DTC P16A2

Sensor Communication Circuit Performance

DTC P2135

Throttle Position Sensors 1-2 Not Plausible

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P06A3	P0122*, P0222*, P16A0	P06A3	P0121, P16A2, P2135*

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	P0122*, P0222*, P16A0	P0122*, P0222*, P16A1	P0123*, P0223*, P16A1**	P0121, P16A2, P2135*
Low Reference	-	P0123*, P0223*, P16A1	-	P0121, P16A2, P2135*
* This DTC set indicates an internal throttle body condition. ** A short to voltage causes P16A1 to set. If DTC P16A0, P16A1, and P16A2 set at the same time, an intermittent circuit condition exists.				

Typical Scan Tool Data

Throttle Position Sensor 1

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: The engine is operating with the throttle closed. All accessories OFF. **Parameter Normal Range:** Throttle Position Sensor 1 3.75-4.75 V			
5 V Reference	5.0 V	5.0 V	5.0 V
Signal	5.0 V	0.0 V	0.0 V
Low Reference	-	0.0 V	-

Throttle Position Sensor 2

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: The engine is operating with the throttle closed. All accessories OFF. **Parameter Normal Range:** Throttle Position Sensor 2 0.45-0.90 V			
5 V Reference	0.0 V	0.0 V	0.0 V
Signal	0.0 V	5.0 V	5.0 V
Low Reference	-	5.0 V	-

Circuit/System Description

The throttle body assembly contains a contact-less inductive throttle position sensing element that is managed by a customized integrated circuit. The throttle position sensor is mounted within the throttle body assembly and is not serviceable. The engine control module (ECM) supplies the throttle body with a 5 V reference circuit, a low reference circuit, an H-bridge motor directional control circuit, and an asynchronous signal/serial data circuit. The asynchronous signal means communication is only going from the throttle body to the ECM. The throttle body cannot receive data from the ECM over the signal/serial data circuit. The throttle position sensor provides a signal voltage that changes relative to throttle blade angle. The customized integrated circuit translates the voltage based position information into serial data using the Society of Automotive Engineers (SAE)

J2716 Single Edge Nibble Transmission (SENT) protocol. The throttle position sensor information is transmitted between the throttle body and the ECM on the signal/serial data circuit. The ECM decodes the serial data signal and is used as voltages for throttle position sensor 1 and 2.

Conditions for Running the DTC

P0121

- DTCs P0102, P0103, P0107, P0108, P0112, P0113, P0117, P0118, P0335, or P0336 is not set.
- The engine speed is between 500-6,800 RPM.
- The engine coolant temperature (ECT) is -7 to +126Â°C (19-259Â°F).
- The intake air temperature (IAT) is -20 to +125Â°C (-4 to +257Â°F).
- The DTC runs continuously when the above conditions are met.

P0122, P0123, P0222, P0223

- DTC P06A3 is not set.
- The ignition is ON or the engine is running.
- The run/crank or powertrain relay voltage is greater than 6.41 V and reduced power is not active.
- The DTCs run continuously when the above condition are met.

P16A0, P16A1, or P16A2

- DTC P06A3 is not set.
- The ignition is ON or the engine is operating.
- The run/crank voltage is greater than 6.41 V.
- The DTCs run continuously once the above conditions are met for greater than 1 s.

P2135

- DTCs P0122, P0123, P0222, P0223, or P06A3 are not set.
- The ignition is ON or the engine is running.
- The run/crank or powertrain relay voltage is greater than 6.41 V and reduced power is not active.
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

P0121

The ECM detects that the throttle position sensor 1 voltage is stuck in range for greater than 1 s.

P0122

The ECM detects the throttle position sensor 1 signal voltage is less than 0.32 V for greater than 1 s.

P0123

The ECM detects the throttle position sensor 1 signal voltage is greater than 4.7 V for greater than 1 s.

P0222

The ECM detects the throttle position sensor 2 signal voltage is less than 0.25 V for greater than 1 s.

P0223

The ECM detects the throttle position sensor 2 signal voltage is greater than 4.6 V for greater than 1 s.

P16A0

The ECM detects a low voltage circuit condition on the throttle position sensor signal circuit for greater than 1 s.

P16A1

The ECM detects a high voltage circuit condition on the throttle position sensor signal circuit for greater than 1 s.

P16A2

The ECM detects an incorrect message was received over the throttle position sensor signal circuit for greater than 1 s.

P2135

The ECM detects that throttle position sensors 1 and 2 disagree greater than 7-10 percent for greater than 1 s.

Action Taken When the DTC Sets

- DTCs P0121 is a Type B DTC.

- DTCs P0122, P0123, P0222, P0223, P16A0, P16A1, P16A2, and P2135 are Type A DTCs.
- The ECM commands the throttle actuator control (TAC) system to operate in a Reduced Engine Power mode.
- A message center or an indicator displays Reduced Engine Power.
- Under certain conditions, the ECM commands the engine OFF.

Conditions for Clearing the DTC

- DTCs P0121 is a Type B DTC.
- DTCs P0122, P0123, P0222, P0223, P16A0, P16A1, P16A2, and P2135 are Type A DTCs.

Diagnostic Aids

- A high resistance condition on the throttle position and throttle actuator control circuits could cause a DTC to set.
- If the accelerator pedal is pressed to the wide open throttle position, the throttle blade angle or Throttle Position angle is limited to less than 40 percent.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

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Description and Operation

Throttle Actuator Control (TAC) System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. If you were sent here from DTC P0068, P0101, P0106, or P1101 refer to Circuit/System Testing.
3. Verify that DTC P0601-P0606, P06A3, and P16F3 is not set.
   - **If any of the DTCs are set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** for further diagnosis.

   - **If none of the DTCs are set**
4. Verify the scan tool Throttle Body Idle Airflow Compensation parameter is less than 90%.
   - **If 90% or greater**

     Refer to **Throttle Body Cleaning** .

   - **If less than 90%**
5. Verify that DTC P0122, P0123, P0222, P0223, P16A0, P16A1, P16A2, or P2135 are not set.
   - **If DTC P0122, P0123, P0222, P0223, or P2135 are the only DTCs set**

     Replace the Q38 Throttle Body.

   - **If DTC P16A0, P16A1, or P16A2 is set with any of the DTCs**

     Refer to Circuit/System Testing.

   - **If none of the DTCs are set**
6. Verify the scan tool Throttle Position Sensors 1 and 2 Agree/Disagree parameter displays Agree while performing the Throttle Sweep Test with a scan tool.

- **If Agree is not displayed**

  Replace the Q38 Throttle Body.

- **If Agree is displayed**

7. Verify DTC P0122, P0123, P0222, P0223, P16A0, P16A1, P16A2, or P2135 is not set.
   - **If any of the DTCs are set**

     Refer to Circuit/System Testing.

   - **If none of the DTCs are set**
8. Determine the current vehicle testing altitude.
9. Verify the scan tool MAP Sensor pressure parameter is within range specified in the **Altitude Versus Barometric Pressure** table.
   - **If the pressure is not in range**

     Refer to **DTC P0106**.

   - **If the pressure is within range**
10. Engine idling.
11. Verify the scan tool MAP Sensor pressure parameter is between 26-52 kPa (3.8-7.5 psi) and changes with accelerator pedal input.
    - **If not within the specified range or does not change**

      Refer to **DTC P0106**.

    - **If within the specified range and changes**
12. Verify the scan tool MAF Sensor g/s parameter changes smoothly and gradually as the engine speed is increased and decreased while performing the actions listed below.
    1. Engine idling
    2. Perform the scan tool snapshot function.
    3. Increase the engine speed slowly to 3,000 RPM and then back to idle.
    4. Exit from the scan tool snapshot and review the data.
    5. Observe the MAF Sensor parameter frame by frame with a scan tool.
    - **If the parameter does not change smoothly and gradually**

Refer to **DTC P0101**.

- **If the parameter changes smoothly and gradually**

13. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
14. Verify the DTC does not set.
    - **If the DTC sets**

      Refer to Circuit/System Testing.

    - **If the DTC does not set**
15. All OK.

Circuit/System Testing

NOTE: **Disconnecting the throttle body harness connector causes additional DTCs to set.**

1. Ignition OFF, and all vehicle systems OFF, disconnect the harness connector at Q38 Throttle Body Assembly. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal 4 and ground.
    - **If 5 Ω or greater**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for less than 2 Ω in the low reference circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If less than 5 Ω**
3. Ignition ON.
4. Test for 4.8-5.2 V between the 5 V reference circuit terminal 5 and ground.
    - **If less than 4.8 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the 5 V reference circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.

- If infinite resistance

3. Test for less than 2 Ω in the 5 V reference circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If greater than 5.2 V**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the 5 V reference circuit and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.

- **If between 4.8-5.2 V**

5. Test for 4.8-5.2 V between the signal circuit terminal 3 and ground.

- **If less than 4.8 V**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the signal circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance
3. Test for less than 2 Ω in the signal circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If greater than 5.2 V**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the signal circuit and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.

- **If between 4.8-5.2 V**

6. Test or replace the Q38 Throttle Body Assembly.

Repair Instructions

- Refer to **Throttle Body Assembly Replacement**

- Refer to **Control Module References** for engine control module replacement, programming, and setup

Repair Verification

1. Install any components that have been removed or replaced during diagnosis.
2. Perform any adjustments, programming or setup procedures that are required when a component is removed or replaced.
3. Clear the DTCs with a scan tool.
4. Ignition OFF and all vehicle systems OFF. It may take up to 2 minutes for all vehicle systems to power down.
5. Ignition ON.
6. Verify the Throttle Position Sensors 1 and 2 Agree/Disagree parameter displays Agree while performing the Throttle Sweep Test with a scan tool.
   - **If Agree is not displayed**

     Test or replace the Q38 Throttle Body Assembly.

   - **If Agree is displayed**
7. If the repair was related to a DTC, duplicate the Conditions for Running the DTC and use the Freeze Frame/Failure Records, if applicable, in order to verify the DTC does not set.
   - **If DTC sets**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** for further diagnosis.

   - **If DTC does not set**
8. All OK

DTC P0128: ENGINE COOLANT TEMPERATURE (ECT) BELOW THERMOSTAT REGULATING TEMPERATURE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P0128

Engine Coolant Temperature (ECT) Below Thermostat Regulating Temperature

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	P0117, P0119	P0118, P0119	P0118*	P0116, P0128
Low Reference	-	P0118, P0119	-	P0128
*ECM or sensor damage may occur if the circuit is shorted to B+				

Typical Scan Tool Data

ECT Sensor

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running **Parameter Normal Range:** Varies with coolant temperature within a range of -39 to 149Â°C (-38 to 300Â°F)			
ECT Sensor Signal	150Â°C (302Â°F)	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)
Low Reference	-	-40Â°C (-40Â°F)	-

Circuit/System Description

The purpose of this diagnostic is to analyze the performance of the thermostat by using the ECT sensor to determine if the engine coolant will increase at the correct rate, and also to meet the calibrated target temperatures under various operating conditions.

The ECM uses the start-up ECT and the start-up intake air temperature (IAT) to begin the diagnostic calculation. The air flow into the engine is accumulated, and vehicle speed, distance, and engine run time are also factored in to determine if the ECT does increase normally and reach the calibrated target temperatures.

Conditions for Running the DTC

- DTC P0068, P0071, P0072, P0073, P0074, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0223, P0502, P0503, P1101, P1516, P2101, P2135 is not set.
- The start-up ECT is between -40Â° and 60Â°C (-40Â° and 140Â°F).
- The engine OFF time is greater than 30 m.
- The engine run time is between 75 s and 25 m.
- The vehicle has traveled greater than 1.2 km (.75 mi).

- The fuel ethanol percentage is less than 87%.
- This DTC runs once per ignition cycle when the above conditions are met.

Conditions for Setting the DTC

- The ECM determines that the ECT has not met its calibrated target of 65Â°C (149Â°F) when the start-up ambient temperature was between 10 and 52Â°C (50 and 126Â°F), for greater than 1 s.

  OR

- The ECM determines that the ECT has not met its calibrated target of 50Â°C (122Â°F) when the start-up ambient temperature was between -7 and 10Â°C (19 and 50Â°F), for greater than 1 s.

Action Taken When the DTC Sets

- DTC P0128 is a Type B DTC.
- The Engine Coolant Temperature Gauge defaults to cold.
- The A/C is commanded OFF and inoperative.
- The Cooling Fans are commanded ON.

Conditions for Clearing the MIL/DTC

DTC P0128 is a Type B DTC.

Diagnostic Aids

- DTC P0128 occurring with insufficient vehicle interior heating is an indication of improper thermostat operation.
- Inspect the ECT sensor terminals and the ECT harness connector for corrosion. This condition results in a greater voltage on the ECT sensor signal circuit, which is interpreted by the ECM as a colder ECT.
- A slight to moderate resistance in the ECT sensor signal circuit or low reference circuit will affect this diagnostic. This condition results in a greater voltage on the ECT sensor signal circuit, which is interpreted by the ECM as a colder ECT.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Cooling System Description and Operation

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Verify the DTC P0116, P0117, P0118, or P0119 is not set.
   - **If a DTC is set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle**

   - **If a DTC is not set**
2. Verify the cooling system is filled to the correct coolant level. Refer to **Cooling System Draining and Filling (Vac N Fill L83 L86)** **Cooling System Draining and Filling (Static Fill L83 L86)** , and **Loss of Coolant (L86 L83)** .
   - **If the coolant level is not correct**

     Repair as necessary

- **If the coolant level is correct**

3. Engine running for 15 min with the A/C OFF, increase the engine speed to 3,000 RPM.
4. Verify the scan tool ECT Sensor parameter is greater than 80Â°C (176Â°F).
   - **If less than 80Â°C (176Â°F)**

     Replace the Engine Coolant Thermostat.

   - **If greater than 80Â°C (176Â°F)**
5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
7. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the B34 Engine Coolant Temperature sensor harness connector at the sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal A or 2 and ground.
   - **If 5 Ω or greater**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If less than 5 Ω**
3. Ignition ON.
4. Verify the scan tool ECT Sensor parameter is colder than -39Â° C (-38Â° F).
   - **If warmer than -39Â° C (-38Â° F)**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the signal circuit terminal B or 1 and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance, replace the K20 Engine Control Module.

- **If colder than -39Â° C (-38Â° F)**

5. Install a 3 A fused jumper wire between the signal circuit terminal B or 1 and the low reference circuit terminal A or 2.
6. Verify the scan tool ECT sensor parameter is warmer than 149Â° C (300Â° F).

- **If 149Â° C (300Â° F) or colder**

1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the signal circuit and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V
3. Ignition OFF.
4. Test for less than 2 Ω in the signal circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If warmer than 149Â° C (300Â° F)**

7. Test the B34 Engine Coolant Temperature Sensor.

   Refer to Component Testing.

Component Testing

1. Ignition OFF, disconnect the harness connector at the B34 Engine Coolant Temperature Sensor.
2. Test the ECT sensor by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the **Temperature Versus Resistance (ECT)** table. The resistance values should be in range of the table values.

    - **If not within the specified range**

      Replace the B34 Engine Coolant Temperature Sensor.

    - **If within the specified range**

3. Test for infinite resistance between each terminal and the sensor housing.

- **If less than infinite resistance**

  Replace the B34 Engine Coolant Temperature Sensor.

- **If infinite resistance**

4. Refer to **Thermostat Diagnosis** .

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Engine Coolant Temperature Sensor Replacement**
- Refer to **Engine Coolant Thermostat Housing Replacement (L83, L86)** , for engine coolant thermostat replacement.
- Refer to **Control Module References** for engine control module replacement, programming and setup.

DTC P0131, P0132, P0137, P0138, P0151, P0152, P0157, OR P0158: HO2S CIRCUIT LOW VOLTAGE/HO2S CIRCUIT HIGH VOLTAGE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0131

HO2S Circuit Low Voltage Bank 1 Sensor 1

DTC P0132

HO2S Circuit High Voltage Bank 1 Sensor 1

DTC P0137

HO2S Circuit Low Voltage Bank 1 Sensor 2

DTC P0138

HO2S Circuit High Voltage Bank 1 Sensor 2

DTC P0151

HO2S Circuit Low Voltage Bank 2 Sensor 1

DTC P0152

HO2S Circuit High Voltage Bank 2 Sensor 1

DTC P0157

HO2S Circuit Low Voltage Bank 2 Sensor 2

DTC P0158

HO2S Circuit High Voltage Bank 2 Sensor 2

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
HO2S High Signal	P0131, P0137, P0151, P0157, P0174	P0132, P0138, P0152, P0158	P0132, P0137, P0138, P0152, P0158, P0300	P0133, P013A, P013B, P013C, P013D, P013E, P013F, P014A, P014B, P0153, P015A, P015B, P015C, P015D, P2270, P2271, P2272, P2273
HO2S Low Signal	P0131, P0137, P0151, P0157, P0506	P0132, P0137, P0138, P0152, P0158, P0172, P0300, P0506	P0132, P0137, P0138, P0152, P0158	P0133, P013A, P013B, P013C, P013D, P013E, P013F, P014A, P014B, P0153, P015A, P015B, P015C, P015D, P2270, P2271, P2272, P2273

Typical Scan Tool Data

HO2S Bank 1 or 2 Sensor 1 or 2

Circuit	Short to Ground	Open	Short to Voltage

Circuit	Short to Ground	Open	Short to Voltage
Parameter Normal Range: 200-800 mV			
HO2S High Signal	0.00 V	1.7-2.1 V	1.7-2.1 V
HO2S Low Signal	0.00 V	1.7-2.1 V	1.7-2.1 V

Circuit/System Description

The heated oxygen sensors (HO2S) are used for fuel control and catalyst monitoring. Each HO2S compares the oxygen content of the surrounding air with the oxygen content of the exhaust stream. When the engine is started, the control module operates in an Open Loop mode, ignoring the HO2S signal voltage while calculating the air-to-fuel ratio. While the engine runs, the HO2S heats up and begins to generate a voltage within a range of 0-1,000 mV. Once sufficient HO2S voltage fluctuation is observed by the control module, Closed Loop is entered. The control module uses the HO2S voltage to determine the air-to-fuel ratio. An HO2S voltage that increases toward 1,000 mV indicates a rich fuel mixture. An HO2S voltage that decreases toward 0 mV indicates a lean fuel mixture.

The heating elements inside each HO2S heat the sensor to bring the sensor up to operating conditions faster. This allows the system to enter Closed Loop earlier and the control module to calculate the air-to-fuel ratio sooner.

Conditions for Running the DTC

P0131, P0137, P0151, or P0157

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0112, P0113, P0116, P0117, P0118, P0120, P0121, P0122, P0123, P0128, P0201, P0202, P0203, P0204, P0205, P0206, P0207, P0208, P0220, P0222, P0223, P0442, P0443, P0446, P0449, P0455, P0496, P1516, P2101, P2119, P2135, P2176 are not set.
- The ignition voltage is between 10-32 V.
- The fuel system is operating in Closed Loop.
- The fuel level is greater than 10%.
- Ethanol content is less than 87%.
- Decel fuel cut off is not active.
- The DTCs run continuously when the above conditions are met for 2 s.

P0132, P0138, P0152, or P0158

- DTCs P0030, P0031, P0032, P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0112, P0113, P0116, P0117, P0118, P0120, P0121, P0122, P0123, P0128, P0201, P0202, P0203, P0204, P0205, P0206, P0207, P0208, P0220, P0222, P0223, P0442, P0443, P0446, P0449, P0455,

P0496, P1516, P2101, P2119, P2135, P2176 are not set.

- The ignition voltage is between 10-32 V.
- The oxygen sensor heater resistance has been learned.
- The fuel level is greater than 10%.
- Engine run time is greater than 5 s.
- The DTCs run continuously when the above conditions are met for 3 s.

Conditions for Setting the DTC

P0131, P0137, P0151, or P0157

- The engine control module detects that the heated oxygen sensor is shorted to ground if the HO2S voltage is less than 50 mV.
- The DTCs set within 6 s when the above condition is met.

P0132, P0138, P0152, or P0158

- The engine control module detects that the heated oxygen sensor has an open circuit or is shorted to voltage if the HO2S voltage is greater than 1,050 mV.
- The DTCs set within 13 s when the above condition is met.

Action Taken When the DTC Sets

DTCs P0131, P0132, P0137, P0138, P0151, P0152, P0157 and P0158 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P0131, P0132, P0137, P0138, P0151, P0152, P0157 and P0158 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

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Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify no HO2S heater DTCs are set.
   - **If a DTC is set.**

     Refer to **DTC P0030-P0032, P0036-P0038, P0050-P0054, P0056-P0060, P0135, P0141, P0155, or P0161**.

   - **If a DTC is not set.**
3. Engine running.
4. Verify the scan tool HO2S Bank 1 or 2 Sensor 1 or 2 parameters are between 50-1,050 mV.
   - **If not between 50-1,050 mV.**

     Refer to Circuit/System Testing.

   - **If between 50-1,050 mV.**
5. Operate the vehicle within the Conditions for Running. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify the DTC does not set.
   - **If the DTC sets.**

Refer to Circuit/System Testing.

- **If the DTC does not set.**

7. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the appropriate B52 Heated Oxygen Sensor harness connector. It may take up to 2 minutes for all vehicle systems to power down. Ignition ON.
2. Test for 1.7-3.0 V between the high signal circuit terminal 4 and ground.
   - **If less than 1.7 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the high signal circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit and replace fuse.
      - If infinite resistance
   3. Test for less than 2 Ω in the high signal circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If greater than 3.0 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module. Ignition ON.
   2. Test for less than 1 V between the high signal circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If between 1.7-3.0 V**
3. Verify the scan tool heated oxygen sensor Bank 1 or 2 Sensor 1 or 2 parameter is between 1.7-2.1 V.
   - **If less than 1.7 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the low signal circuit terminal 3 and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.
   - **If between 1.7-2.1 V**

4. Connect a 3 A fused jumper wire between the high signal circuit terminal 4 and the low signal circuit terminal 3.

NOTE: **The low signal circuit is tied to a pull-up circuit within the engine control module. A voltage of 0.0-1.10 V on the low signal circuit is normal.**

5. Verify the scan tool HO2S Bank 1 or 2 Sensor 1 or 2 parameter displays 0.0 V.
   - **If greater than 0.0 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module. Ignition ON.
   2. Test for less than 2 Ω in the low signal circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω
   3. Test for less than 1 V between the low signal circuit terminal 3 and ground.
   - If 1 V or greater, repair the short to voltage on the circuit.
   - If less than 1 V, replace the K20 Engine Control Module.
   - **If 0.0 V**
6. Verify none of the conditions listed below exist:
   - Water intrusion in the B52 heated oxygen sensor harness connector
   - Low or high fuel system pressure - Refer to **Fuel System Diagnosis** .
   - Fuel that is contaminated - Refer to **Alcohol/Contaminants-in-Fuel Diagnosis** .
   - Fuel saturation of the evaporative emission (EVAP) canister
   - Exhaust leaks
   - Engine vacuum leaks
   - **If any of the conditions exist**

     Repair as necessary.

   - **If none of the conditions exist**
7. Test or replace the B52 Heated Oxygen Sensor.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Heated Oxygen Sensor Replacement - Bank 1 Sensor 1**
- Refer to **Heated Oxygen Sensor Replacement - Bank 1 Sensor 2**
- Refer to **Heated Oxygen Sensor Replacement - Bank 2 Sensor 1**
- Refer to **Heated Oxygen Sensor Replacement - Bank 2 Sensor 2**
- Perform the scan tool Heated Oxygen Sensor Resistance Learn Reset after replacing a Heated Oxygen Sensor.
- Refer to **Control Module References** for Engine Control Module replacement, programming and setup

DTC P0133, P013A-P013F, P014A, P014B, P0153, P015A-P015D, OR P2270-P2273: HO2S SLOW RESPONSE/HO2S DELAYED RESPONSE/HO2S SIGNAL STUCK

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0133

HO2S Slow Response Bank 1 Sensor 1

DTC P013A

HO2S Slow Response Rich to Lean Bank 1 Sensor 2

DTC P013B

HO2S Slow Response Lean to Rich Bank 1 Sensor 2

DTC P013C

HO2S Slow Response Rich to Lean Bank 2 Sensor 2

DTC P013D

HO2S Slow Response Lean to Rich Bank 2 Sensor 2

DTC P013E

HO2S Delayed Response Rich to Lean Bank 1 Sensor 2

DTC P013F

HO2S Delayed Response Lean to Rich Bank 1 Sensor 2

DTC P014A

HO2S Delayed Response Rich to Lean Bank 2 Sensor 2

DTC P014B

HO2S Delayed Response Lean to Rich Bank 2 Sensor 2

DTC P0153

HO2S Slow Response Bank 2 Sensor 1

DTC P015A

HO2S Delayed Response Rich to Lean Bank 1 Sensor 1

DTC P015B

HO2S Delayed Response Lean to Rich Bank 1 Sensor 1

DTC P015C

HO2S Delayed Response Rich to Lean Bank 2 Sensor 1

DTC P015D

HO2S Delayed Response Lean to Rich Bank 2 Sensor 1

DTC P2270

HO2S Signal Stuck Lean Bank 1 Sensor 2

DTC P2271

HO2S Signal Stuck Rich Bank 1 Sensor 2

DTC P2272

HO2S Signal Stuck Lean Bank 2 Sensor 2

DTC P2273

HO2S Signal Stuck Rich Bank 2 Sensor 2

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
HO2S High Signal	P0131, P0137, P0151, P0157	P0132, P0138, P0152, P0158	P0132, P0138, P0152, P0158,	P0133, P013A, P013B, P013C, P013D, P013E, P013F, P014A, P014B, P0153, P015A, P015B, P015C, P015D, P2270, P2271, P2272, P2273
HO2S Low Signal	P0131, P0137, P0151, P0157	P0132, P0138, P0152, P0158	P0132, P0138, P0152, P0158	P0133, P013A, P013B, P013C, P013D, P013E, P013F, P014A, P014B, P0153, P015A, P015B, P015C, P015D, P2270, P2271, P2272, P2273

Typical Scan Tool Data

HO2S Bank 1 or 2 Sensor 1 or 2

Circuit	Short to Ground	Open	Short to Voltage
Parameter Normal Range: 200-800 mV			
HO2S High Signal	0.00 V	1.7-2.1 V	1.7-2.1 V
HO2S Low Signal	0.00 V	1.7-2.1 V	1.7-2.1 V

Circuit/System Description

The heated oxygen sensors (HO2S) are used for fuel control and catalyst monitoring. Each HO2S compares the oxygen content of the surrounding air with the oxygen content of the exhaust stream. When the engine is started, the control module operates in an Open Loop mode, ignoring the HO2S signal voltage while calculating the air-to-fuel ratio. While the engine runs, the HO2S heats up and begins to generate a voltage within a range of 0-1,000 mV. Once sufficient HO2S voltage fluctuation is observed by the control module, Closed Loop is entered. The control module uses the HO2S voltage to determine the air-to-fuel ratio. An HO2S voltage that increases toward 1,000 mV indicates a rich fuel mixture. An HO2S voltage that decreases toward 0 mV indicates a lean fuel mixture.

The heating elements inside each HO2S heat the sensor to bring the sensor up to operating conditions faster. This allows the system to enter Closed Loop earlier and the control module to calculate the air-to-fuel ratio sooner.

Conditions for Running the DTC

P0133 or P0153

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0120, P0121, P0122, P0123, P0125, P0128, P0131, P0132, P0151, P0152, P0201-P0208, P0220, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282, P0283, P0300-P0308, P0411, P0442, P0443, P0446, P0449, P0452, P0453, P0455, P0458, P0459, P0496, P0498, P0499, P1104, P1248, P1249, P124A-P124F, P1516, P16F3, P2100-P2103, P2119, P2135, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F, P2176, P217B, P217C, P217E, P217F, P2440, P2444 are not set.
- The ignition voltage is between 10-32 V.
- The intake air temperature (IAT) is warmer than -40Â°C (-40Â°F)
- The engine coolant temperature (ECT) is greater than 50Â°C (122Â°F).
- The fuel level is greater than 10%.
- The engine run time is greater than 30 s.
- The engine speed is between 1,000-3,000 RPM.
- The barometric (BARO) pressure is greater than 70 kPa.
- The mass airflow (MAF) is between 20-55 g/s.
- The fuel system is in Closed Loop.
- The fuel control state is not in power enrichment.
- Device controls not active.
- Fuel state is not in decel fuel cut-off mode.
- The DTCs run once per drive cycle when the above conditions are met for greater than 3.5 s.

P013A P013C, P013E, or P014A

- Before the ECM can report DTC P013A, or P013C failed, DTCs P013E, P014A, P2270, and P2272 must run and pass.
- Before the ECM can report DTC P013E, or P014A failed, DTCs P2270 and P2272 must run and pass.
- DTCs P0030, P0036, P0053, P0054, P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111-P0114, P0116-P0118, P0120, P0121, P0122, P0123, P0125, P0128, P0131, P0132, P0133, P0134, P0135, P0137, P0138, P013A, P013B, P013E, P013F, P0140, P0141, P0171, P0172, P0201-P0208, P0220, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282, P0283, P0300 - P0308, P0411, P0442, P0443, P0446, P0449, P0455, P0496, P0498, P0499, P1104, P1248, P1249, P124A - P124F, P1174, P1516, P16F3, P2100-P2103, P2119, P2135, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F, P2176, P217B, P217C, P217E, P217F, P2270, P2271, P2440, P2444 are not set.
- The ignition voltage is between 10-32 V.
- The learned heater resistance is valid.
- The fuel level is greater than 10%.
- The engine run time is equal to or greater than 5 min.
- The accelerator pedal is steady.
- The DTCs run once per ignition cycle, during decel fuel cut-off (DFCO), when the above conditions are met.

P013B P013D, P013F, or P014B

- Before the ECM can report DTC P013B, or P013D failed, DTCs P013A, P013C, P013E, P013F, P014A, P014B, P2270, P2271, P2272, and P2273 must run and pass.
- Before the ECM can report DTC P013F, or P014B failed, DTCs P013A, P013C, P013E, P014A, P2270, P2271, P2272, and P2273 must run and pass.
- DTCs P0030, P0036, P0053, P0054, P0101, P0102, P0103, P0106, P0107, P0108, P0120, P0121, P0122, P0123, P0131, P0132, P0133, P0134, P0135, P0137, P0138, P013A, P013B, P013E, P013F, P0140, P0141, P0171, P0172, P0201, P0202, P0203, P0204, P0220, P0222, P0223, P0300, P0442, P0443, P0446, P0449, P0455, P0496, P1133, P1174, P1516, P2101, P2119, P2135, P2176, P2270, P2271, P2A00 are not set.
- The ignition voltage is between 10-32 V.
- The learned heater resistance is valid.
- The fuel level is greater than 10%.
- The engine run time is equal to or greater than 5 min.
- The DTCs run once per ignition cycle when the above conditions are met.

P015A, P015B, P015C or P015D

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0112, P0113, P0116, P0117, P0118, P0120, P0121, P0122, P0123, P0128, P0201, P0202, P0203, P0204, P0205, P0206, P0207, P0208, P0220, P0222, P0223, P0442, P0443, P0446, P0449, P0455, P0496, P1516, P2101, P2119, P2135, P2176 are not set.
- The ignition voltage is between 10-32 V.
- The intake air temperature (IAT) is warmer than -40Â°C (-40Â°F)
- The engine coolant temperature (ECT) is warmer than 50Â°C (122Â°F).
- The fuel level is greater than 10%.
- The engine run time is greater than 30 s.
- The engine speed is between 1,000-2,500 RPM.
- The vehicle speed is between 63-119 km/h (39-74 mph).
- The mass airflow (MAF) is between 4-20 g/s.
- The fuel system is in Closed Loop.
- Evap is not in control of purge.
- Device controls are not active.
- Oxygen sensor heater on for greater than 60 s.
- Calculated catalyst temperature is between 600-900Â°C (1,122-1,652Â°F).
- When all of the above conditions are met for 1 s, the fuel mixture is forced rich and the HO2S Bank 1 or 2 Sensor 1 is greater than 690 mV, then decel fuel cut-off (DFCO) is entered.
- The DTCs run once per drive cycle when the above conditions are met.

P2270 or P2272

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0112, P0113, P0116, P0117, P0118, P0120, P0121, P0122, P0123, P0128, P013A, P013B, P013E, P013F, P0171, P0172, P0201, P0202, P0203, P0204, P0220, P0222, P0223, P0300, P0411, P0412, P0418, P1174, P1516, P2101, P2119, P2135, P2176, P2270, P2271 are not set.
- The ignition voltage is between 10-32 V.
- The fuel level is greater than 10%.
- The engine speed is between 1,000-2,500 RPM.
- The vehicle speed is between 63-119 km/h (39-74 mph).
- The engine airflow is between 4-20 g/s.
- The fuel state is in Closed Loop.

- The evaporative emission (EVAP) diagnostics are not in control of purge.
- The heated oxygen sensor heaters are ON for greater than 60 s.
- The predicted catalytic converter temperature is between 600-900Â°C (1,112-1,652Â°F).
- This DTC runs once per trip when all of the above conditions have been met for 1 s.

P2271 or P2273

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0112, P0113, P0116, P0117, P0118, P0120, P0121, P0122, P0123, P0128, P013A, P013B, P013E, P013F, P0171, P0172, P0201, P0202, P0203, P0204, P0220, P0222, P0223, P0300, P0411, P0412, P0418, P1174, P1516, P2101, P2119, P2135, P2176, P2270 are not set.
- The ignition voltage is between 10-32 V.
- The fuel level is greater than 10%.
- The engine speed is between 1,000-2,500 RPM.
- The vehicle speed is between 63-119 km/h (39-74 mph).
- The engine airflow is between 4-20 g/s.
- The fueling state is in Closed Loop.
- The evaporative emission (EVAP) diagnostics are not in control of purge.
- Power take-off is not active.
- The heated oxygen sensor heaters have been ON for greater than 60 s.
- The predicted catalytic converter temperature is between 600-900Â°C (1,112-1,652Â°F).
- DTCs P013A, P013C, P013E, P014A, P2270, and P2272 have run and passed.

  THEN

- Decel fuel cut-off is active.
- The accelerator pedal position is stable.
- This DTC runs once per trip when the above conditions are met.

Conditions for Setting the DTC

P0133, P0153, P015A, P015B, P015C or P015D

- The ECM detects that the HO2S 1 rich-to-lean or lean-to-rich average response time is greater than a calibrated value.

- The DTCs set within 60 s when the above condition is met.

P013A or P013C

The ECM detects that the accumulated mass air flow monitored during rich-to-lean transitions between 450-150 mV is greater than calibrated value.

P013B or P013D

The ECM detects that the accumulated mass air flow monitored during lean-to-rich transitions between 350-650 mV is greater than calibrated value.

P013E or P014A

The ECM detects that the O2 sensor voltage has not decreased below 450 mV within a calibrated value of accumulated air flow.

P013F or P014B

The ECM detects that the O2 sensor voltage has not increased above 350 mV within a calibrated value of accumulated air flow.

P2270 or P2272

The ECM does not detect a HO2S voltage greater than 800 mV before accumulated mass air flow exceeds a calibrated value.

P2271 or P2273

The ECM does not detect an HO2S voltage less than 100 mV before accumulated mass air flow exceeds a calibrated value.

Action Taken When the DTC Sets

- DTCs P0133, P013E, P013F, P014A, P014B, P0153, P2270, P2271, P2272, and P2273 are Type B DTCs.
- DTCs P013A, P013B, P013C, P013D, P015A, P015B, P015C, and P015D are Type A DTCs.

Conditions for Clearing the DTC

- DTCs P0133, P013E, P013F, P014A, P014B, P0153, P2270, P2271, P2272, and P2273 are Type B DTCs.
- DTCs P013A, P013B, P013C, P013D, P015A, P015B, P015C, and P015D are Type A DTCs.

Diagnostic Aids

When DTCs P013E, P014A, P015A, and P015C are all set at the same time, fuel saturation of the EVAP system is a possible cause.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify no HO2S heater DTCs are set.
   - **If a DTC is set**

     Refer to **DTC P0030-P0032, P0036-P0038, P0050-P0054, P0056-P0060, P0135, P0141, P0155, or P0161**.

   - **If a DTC is not set**
3. Verify none of the conditions listed below exist:
   - Lean or rich fuel injectors - Refer to **Fuel Injector Diagnosis** .
   - Water intrusion in the HO2S harness connector

- Low or high fuel system pressure - Refer to **Fuel System Diagnosis** .
- Fuel that is contaminated - Refer to **Alcohol/Contaminants-in-Fuel Diagnosis** .
- Fuel saturation of the evaporative emission (EVAP) canister
- Exhaust leaks - Refer to **Exhaust Leakage** .
- Engine vacuum leaks
- Engine oil consumption - Refer to **Oil Consumption Diagnosis** .
- Engine coolant consumption - Refer to **Loss of Coolant (L86 L83)** .
- **If any of the conditions exist**

  Repair as necessary.

- **If none of the conditions exist**

4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
5. Verify the DTC does not set.
   - **If the DTC sets**

     Test or replace the appropriate B52 Heated Oxygen Sensor.

   - **If the DTC does not set**
6. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the diagnostic procedure.

- Refer to **Heated Oxygen Sensor Replacement - Bank 1 Sensor 1**
- Refer to **Heated Oxygen Sensor Replacement - Bank 1 Sensor 2**
- Refer to **Heated Oxygen Sensor Replacement - Bank 2 Sensor 1**
- Refer to **Heated Oxygen Sensor Replacement - Bank 2 Sensor 2**
- Perform the scan tool Heated Oxygen Sensor Resistance Learn Reset after replacing a Heated Oxygen Sensor.
- Refer to **Control Module References** for Engine Control Module replacement, programming and setup

DTC P0171, P0172, P0174, OR P0175: FUEL TRIM SYSTEM LEAN/FUEL TRIM SYSTEM RICH

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0171

Fuel Trim System Lean Bank 1

DTC P0172

Fuel Trim System Rich Bank 1

DTC P0174

Fuel Trim System Lean Bank 2

DTC P0175

Fuel Trim System Rich Bank 2

Circuit/System Description

The engine control module (ECM) controls a Closed Loop air/fuel metering system in order to provide the best possible combination of driveability, fuel economy, and emission control. The ECM monitors the heated oxygen sensor (HO2S) signal voltage, and adjusts the fuel delivery based on the signal voltage while in Closed Loop. A change made to the fuel delivery changes the long and short term fuel trim values. The short term fuel trim values change rapidly in response to the HO2S signal voltages. These changes fine tune the engine fueling. The long term fuel trim values change in response to trends in the short term fuel trim The long term fuel trim makes coarse adjustments to fueling in order to re-center and restore control to short term fuel trim. The ideal fuel trim values are around 0%. A positive fuel trim value indicates that the ECM is adding fuel in order to compensate for a lean condition. A negative fuel trim value indicates that the ECM is reducing the amount of fuel in order to compensate for a rich condition.

Conditions for Running the DTC

- DTCs P0030, P0050, P0053, P0059, P0101, P0102, P0103, P0106, P0107, P0108, P0131-P0135, P0151-P0155, P015A, P015B, P015C,

P015D, P0178, P0179, P0201-P0208, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282, P0283, P0300-P0308, P0442, P0455, P0458, P0496, P0506, P0507, P1248, P1249, P124A, P124B, P124C, P124D, P124E, P124F, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F, P217B, P217C, P217E, P217F, P2227, P2228, P2229, P2230, or P2269 are not set.

- The engine is in Closed Loop status.
- The catalyst monitor diagnostic intrusive test, post HO2S diagnostic intrusive test, device control, and EVAP leak test are not active.
- The engine coolant temperature is between -40 and +150Â°C (-40 and +302Â°F).
- The intake air temperature is between -20 and +150Â°C (-4 and +302Â°F).
- The manifold absolute pressure is between 10-255 kPa (1.5-37 psi).
- The engine speed is between 375-7,000 RPM.
- The mass air flow is between 1-510 g/s.
- The barometric pressure is greater than 70 kPa (10.2 psi).
- The fuel level is greater than 10%.
- This diagnostic runs continuously when the above conditions have been met.

Conditions for Setting the DTC

- The average long term fuel trim weighted average value is greater or less than a calibrated value.
- The above condition is present for approximately 3 min after the Conditions for Running the DTC have been met.

Action Taken When the DTC Sets

DTCs P0171, P0172, P0174, and P0175 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P0171, P0172, P0174, and P0175 are Type B DTCs.

Diagnostic Aids

- Allow the engine to reach operating temperature. With the engine running, observe the HO2S parameter with a scan tool. The HO2S value should vary from approximately 40 mV to approximately 900 mV, and respond to fueling changes.
- The normal Short Term Fuel Trim and Long Term Fuel Trim parameters should be between +10 and -10% with 0% the optimum, with the engine running at operating temperature.
- Any un-metered air into the engine causes this DTC to set. Thoroughly inspect all areas of the engine for vacuum leaks.

- A MAF sensor condition can cause this DTC without setting a MAF DTC. If there is a MAF sensor condition, the MAF sensor parameters will appear to be within range.
- Inspect the air filter for being the correct one for this application. Make sure that the engine oil fill cap is in place and that it is tight. Verify that the engine oil dip stick is fully seated.
- Certain aftermarket air filters may cause a DTC to set.
- Certain aftermarket air induction systems or modifications to the air induction system may cause a DTC to set.
- Certain aftermarket exhaust system components may cause a DTC to set.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify no other DTCs are set.
   - **If any other DTCs are set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** for further diagnosis.

   - **If no other DTCs are set**
3. Verify DTC P0171, P0172, P0174, or P0175 is not set.
   - **If a DTC is set**

     Refer to Circuit/System Testing.

   - **If no DTC is set**
4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed in the Freeze Frame/Failure Records data.
5. Verify DTC P0171, P0172, P0174, or P0175 is not set.
   - **If any of the DTCs set**

     Refer to Circuit/System Testing.

   - **If none of the DTCs set**
6. All OK.

Circuit/System Testing

1. Ignition ON.
2. Verify the MAP sensor pressure parameter is within the range specified for your altitude. Refer to **Altitude Versus Barometric Pressure** .
   - **If not within the specified range**

     Refer to **DTC P0106**.

   - **If within the specified range**
3. Engine running at the operating temperature.

4. Verify the Long Term Fuel Trim Bank 1 or 2 parameter is between -25.5% and +34.5%.
   - **If greater than +34.5%:**
   1. Ignition OFF.
   2. Inspect for the conditions listed below:
      - Mass air flow sensor signal skewed - If the Short Term Fuel Trim parameters for both banks changes greater than 20% when the MAF sensor is disconnected, refer to **DTC P0101**.
      - Contamination of the mass air flow sensor with oil or other foreign material.
      - Fuel contamination - Refer to **Alcohol/Contaminants-in-Fuel Diagnosis** .
      - Missing, restricted, or leaking exhaust components - Refer to **Symptoms - Engine Exhaust** .
      - Malfunctioning fuel injectors - Refer to **Fuel Injector Diagnosis** .
      - Vacuum hoses for splits, kinks, and improper connections.
      - Insufficient fuel in the tank.
      - Partial blockage of the air filter element or other conditions that alter air flow to the mass air flow sensor.
      - Low fuel pressure - Refer to **Fuel System Diagnosis** .
      - Vacuum leaks at the intake manifold, the throttle body, and the injector O-rings.
      - Leaks in the air induction system and the air intake ducts.
      - Missing air filter element.
      - Cracked EVAP canister.
      - Evaporative pipes obstructed or leaking.
      - The crankcase ventilation system for leaks - Refer to **Crankcase Ventilation System Inspection/Diagnosis** .
        - If a condition is found, repair as necessary.
        - If no condition is found, inspect the engine for a mechanical condition. Refer to **Symptoms - Engine Mechanical** .
   - **If less than -25.5%**
   1. Ignition OFF.
   2. Inspect for the conditions listed below:
      - Mass air flow (MAF) sensor signal skewed - If the Short Term Fuel Trim parameters for both banks changes greater than 20% when the MAF sensor is disconnected, refer to **DTC P0101**.
      - Contamination of the mass air flow sensor with oil or other foreign material.
      - Fuel contamination - Refer to **Alcohol/Contaminants-in-Fuel Diagnosis** .

- Missing, restricted, or leaking exhaust components - Refer to **Symptoms - Engine Exhaust** .
- Malfunctioning fuel injectors - Refer to **Fuel Injector Diagnosis** .
- Collapsed or restricted air intake duct.
- Excessive fuel pressure - Refer to **Fuel System Diagnosis** .
- Dirty or restricted air filter.
- Objects blocking the throttle body.
- Improper operation of the evaporative emissions control system.
- Excessive fuel in the crankcase - Change the engine oil as necessary.
    - If a condition is found, repair as necessary.
    - If no condition is found, inspect the engine for a mechanical condition. Refer to **Symptoms - Engine Mechanical** .

- **If between -25.5% and +34.5%**

5. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

Perform the scan tool Fuel Trim Reset after completing the repair.

DTC P0178 OR P0179: FUEL COMPOSITION SENSOR CIRCUIT

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P0178

Fuel Composition Sensor Circuit Low Frequency

DTC P0179

Fuel Composition Sensor Circuit High Frequency

Circuit/System Description

Alcohol content information is supplied to the engine control module (ECM) from the fuel composition sensor. The fuel composition sensor has an ignition positive circuit, a signal circuit, and a ground circuit. The fuel composition sensor uses a microprocessor inside the sensor to measure the ethanol percentage and changes the output signal accordingly. The signal circuit carries the ethanol percentage via the frequency signal. The ECM provides an internal pull up to 5 V on the signal circuit, and the fuel composition sensor pulls the 5 V to ground in pulses. The normal range of operating frequency is between 50-150 Hz. The microprocessor inside the sensor is capable of a certain amount of self-diagnosis. An output frequency between 180 Hz and 190 Hz indicates that the fuel is contaminated.

Conditions for Running the DTC

- The ignition voltage is greater than 11 V.
- The DTC runs continuously when the above condition is met.

Conditions for Setting the DTC

P0178

The engine control module detects that the fuel composition sensor output frequency is less than 45 Hz for greater than 6 s.

P0179

The engine control module detects that the fuel composition sensor output frequency is between 155-185 Hz for greater than 6 s.

Action Taken When the DTC Sets

DTC P0178 and P0179 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTC P0178 and P0179 are Type B DTCs.

Diagnostic Aids

- The fuel composition sensor scan tool parameter reacts immediately to any change in the fuel composition sensor circuits, but may not react long enough to set a DTC.
- An intermittent condition may not be detected because the sensor does not immediately power down and the connection may be restored before

voltage drops below the operating threshold.

- If this DTC will not reset and the parameters are steady, thoroughly inspect all fuel composition sensor circuits for an intermittent open.
- A momentary slug of water in the fuel system may set DTC P0179.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

- **J 38522-A** Variable Signal Generator
- **J 44175-A** Fuel Composition Tester

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** **Special Tools (Service Tools)** .

Circuit/System Verification

1. Engine running,
2. Verify the scan tool Fuel Composition Sensor parameter is between 50-150 Hz.
   - **If not between 50-150 Hz**

     Refer to Circuit/System Testing.

   - **If between 50-150 Hz**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
5. All OK.

Circuit/System Testing

1. Verify that there are no contaminants, water, or too high of a concentration of ethanol in the fuel. Refer to **Alcohol/Contaminants-in-Fuel Diagnosis** and the **J44175-A** Instruction Manual.
2. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B198 Fuel Composition Sensor. It may take up to 2 min for all vehicle systems to power down.
3. Test for less than 5 Ω between the ground circuit terminal 2 and ground.
   - **If 5 Ω or greater**
   1. Ignition OFF.
   2. Test for less than 2 Ω in the ground circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, repair the open/high resistance in the ground connection.
   - **If less than 5 Ω**

4. Ignition ON.
5. Verify that a test lamp illuminates between the ignition circuit terminal 1 and ground.
    - **If the test lamp does not illuminate and the circuit fuse is OK**
    1. Ignition OFF, remove the test lamp.
    2. Test for less than 2 Ω in the ignition circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, verify the fuse is OK and there is voltage at the fuse.
    - **If the test lamp does not illuminate and the circuit fuse is open**
    1. Ignition OFF, remove the test lamp.
    2. Test for infinite resistance between the ignition circuit and ground.
        - If less than infinite resistance, repair the short to ground in the circuit.
        - If infinite resistance, replace the B198 Fuel Composition Sensor.
    - **If the test lamp illuminates**
6. Remove the test lamp, ignition ON.
7. Test for 4.8-5.2 V between the signal circuit terminal 3 and ground.
    - **If less than 4.8 V**
    1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit and ground.
        - If less than infinite resistance, repair the short to ground in the circuit.
        - If infinite resistance
    3. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If greater than 5.2 V**
    1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.
    2. Ignition ON.
    3. Test for less than 1 V between the signal circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.

- **If between 4.8-5.2 V**

8. Ignition OFF, connect the **J 38522-A** Variable Signal Generator as instructed below:
    1. Connect the red lead to the signal circuit terminal 3 at the B198 Fuel Composition Sensor harness connector.
    2. Connect the battery voltage supply lead to B+.
    3. Connect the black lead to ground.
    4. Set the signal to 5 V.
    5. Set the frequency to 60 Hz.
    6. Set the Duty Cycle to Normal.
    7. Ignition ON.
9. Verify the scan tool Fuel Composition Sensor parameter is at 60 Hz.
    - **If not at 60 Hz**

      Replace the K20 Engine Control Module.

    - **If at 60 Hz**
10. Test or replace the B198 Fuel Composition Sensor.

Component Testing

1. Test the fuel composition using the **J 44175-A** Fuel Composition Tester and the J 44175-A Instruction Manual. Record the frequency.
2. Compare the special tool test frequency and the scan tool Fuel Composition Sensor frequency parameter.
3. Verify the difference between the tool and the sensor is 12 Hz or less.
    - **If greater then 12 Hz**

      Replace the B198 Fuel Composition Sensor.

    - **If 12 Hz or less**
4. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Flexible Fuel Sensor Replacement** for B198 Fuel Composition Sensor replacement

- Refer to **Control Module References** for K20 Engine Control Module replacement, programming, and setup

DTC P018B-P018D: FUEL PRESSURE SENSOR

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P018B

Fuel Pressure Sensor Performance

DTC P018C

Fuel Pressure Sensor Circuit Low Voltage

DTC P018D

Fuel Pressure Sensor Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P018C, P0192, P0532, P0641, P2228	P018C	P018D, P0193, P0523, P0641, P2227	P018B
Signal	P018C	P018C	P018D	P018B
Low Reference	-	P018D	P018D	P018B

Circuit/System Description

The fuel pressure sensor is located on the chassis fuel pipe. The fuel pressure sensor provides a fuel pressure signal to the ECM, which is used to provide Closed Loop fuel pressure control.

Conditions for Running the DTC

DTC P018B

- DTCs P018C, P018D, P0231, P0232, P023F, P0641, P1255, P129D, or P12A6 are not set.
- Engine is running
- Fuel pressure is greater than 0 psi
- The DTC runs continuously when the condition above is met.

DTC P018C or P018D

- The engine is cranking or running.
- The DTCs run continuously when the condition above is met.

Conditions for Setting the DTC

P018B

The engine control module does not detect a change in the fuel pressure of at least 30 kPa (4.4 psi) when the fuel pump is operating. The fuel pressure sensor performance diagnostic detects a fuel pressure sensor output that is stuck within the normal operating range of the sensor.

P018C

The engine control module detects that the fuel pressure sensor voltage is less than 0.14 V for 1 s.

P018D

The engine control module detects that the fuel pressure sensor voltage is greater than 4.86 V for 1 s.

Action Taken When the DTC Sets

DTC P018B, P018C, and P018D are Type A DTCs.

Conditions for Clearing the DTC

DTC P018B, P018C, and P018D are Type A DTCs.

Diagnostic Aids

- Using the Failure Records data may help locate an intermittent condition. If you cannot duplicate the DTC, the information in the Failure Records can help determine how many miles since the DTC set. The Fail Counter and Pass Counter can help determine how many ignition cycles that the diagnostic test reported a pass and/or a fail.
- Inspect the fuel system for damage, kinks, or restrictions.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Electrical Information Reference

- **Circuit Testing**
- **Testing for Intermittent Conditions and Poor Connections**
- **Connector Repairs**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC U18A2 is not set or stored in history.

- **If DTC U18A2 is set or stored in history**

  Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .

- **If DTC U18A2 is not set or stored in history**

3. Engine running.
4. Verify the scan tool Fuel Pressure Sensor parameter is between 0.2-4.8 V.
   - **If not between 0.2-4.8 V**

     Refer to Circuit/System Testing.

   - **If between 0.2-4.8 V**
5. Verify the scan tool Fuel Pressure Sensor parameter increases or decreases when commanding an increase and decrease in Fuel Pressure with a scan tool.
   - **If the pressure does not change**

     Refer to Circuit/System Testing.

   - **If the pressure changes**
6. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
7. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
8. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B47 Fuel Pressure Sensor. It may take up to 2 min for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal 2 and ground.
   - **If 5 Ω or greater**

1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.
2. Test for less than 2 Ω in the low reference circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If less than 5 Ω**

3. Ignition ON.
4. Test for 4.8-5.2 V between the 5 V reference circuit terminal 3 and ground.

- **If less than 4.8 V**

1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the 5 V reference circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance
3. Test for less than 2 Ω in the 5 V reference circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If greater than 5.2 V**

1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the 5 V reference circuit and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.

- **If between 4.8-5.2 V**

5. Verify the scan tool Fuel Pressure Sensor parameter is less than 1 V.

- **If 1 V or greater**

1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the signal circuit terminal 1 and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.

- **If less than 1 V**

6. Install a 3 A fused jumper wire between the signal circuit terminal 1 and the 5 V reference circuit terminal 3, wait 15 s.

7. Verify the scan tool Fuel Pressure Sensor parameter is 4.8 V or greater.
    - **If less than 4.8 V**
    1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit terminal 1 and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If 4.8 V or greater**
8. Test or replace the B47 Fuel Pressure Sensor.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Fuel Pressure Sensor Replacement (Fuel Pipe)**
- Refer to **Control Module References** for K20 Engine Control Module replacement, programming, and setup

DTC P0191: FUEL RAIL PRESSURE SENSOR PERFORMANCE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0191

Fuel Rail Pressure Sensor Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference Voltage	P0192, P0193, P0340, P0345, P0365, P0390, P0506, P0641, P2227	P0192	P0193, P0641, P2227, P2229	P0191
Fuel Rail Pressure Sensor Signal 1	P0192	P0192, P0193	P0193	P0191
Fuel Rail Pressure Sensor Signal 2	P127C	P127C, P127D	P127D	P0191
Low Reference	-	P0193	P0193	P0191

Circuit/System Description

The fuel rail pressure sensor is a dual analog sensor that provides two fuel rail pressure signals to the engine control module (ECM). The ECM provides a 5 V reference voltage on the 5 V reference circuit and ground on the low reference circuit. The ECM receives a varying signal voltage on both the fuel rail pressure sensor 1 and fuel rail pressure sensor 2 signal circuits. The ECM monitors the voltage on both of the fuel rail pressure sensor circuits and compares the values to determine if the sensors are accurate. If fuel rail pressure sensor 1 and fuel rail pressure sensor 2 voltage signals do not closely match DTC P0191 may set.

Conditions for Running the DTC

- DTCs P0192, P0193, P127C, and P127D are not set.
- Engine is running.
- Commanded fuel pressure rate of change is greater than 0.70 MPa (101 PSI) for greater than 1.25 s.
- Desired fuel pressure is greater than 0 PSI.
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

NOTE: **Both Condition 1 and Condition 2 must be present to set DTC P0191.**

Condition 1

The engine control module detects fuel rail pressure sensor 1 value is 1 MPa (145 PSI) greater than or less than fuel rail pressure Sensor 2 value for greater than 1.5 s.

Condition 2

The engine control module detects the square root of (fuel rail pressure sensor 1 value divided by fuel rail pressure sensor 2 value) is greater than 1.22 or less than 0.86 for greater than 1.5 s.

Action Taken When the DTC Sets

- DTC P0191 is a Type A DTC.
- A message center or an indicator may display Reduced Engine Power.

Conditions for Clearing the DTC

DTC P0191 is a Type A DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

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- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Engine running.
2. Verify the scan tool Fuel Rail Pressure Sensor 1 and Fuel Rail Pressure Sensor 2 parameters display less than 1 MPa (145 PSI) difference.
   - **If 1 MPa (145 PSI) or greater**

     Refer to Circuit/System Testing.

   - **If less than 1 MPa (145 PSI)**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
5. All OK.

Circuit/System Testing

1. Ignition OFF, and all vehicle systems OFF, disconnect the harness connector at the B47B Fuel Rail Pressure Sensor. It may take up to 2 min for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal 3 and ground.
   - **If 5 Ω or greater**
   1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If less than 5 Ω**

3. Ignition ON.
4. Test for 4.8-5.2 V between the 5 V reference circuit terminal 1 and ground.
    - **If less than 4.8 V**
    1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the 5 V reference circuit and ground.
        - If less than infinite resistance, repair the short to ground in the circuit.
        - If infinite resistance
    3. Test for less than 2 Ω in the 5 V reference circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If greater than 5.2 V**
    1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the 5 V reference circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If between 4.8-5.2 V**
5. Verify the scan tool Fuel Rail Pressure Sensor 2 parameter is less than 0.25 V.
    - **If 0.25 V or greater**
    1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit terminal 2 and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If less than 0.25 V**
6. Install a 3 A fused jumper wire between the signal circuit terminal 2 and the 5 V reference circuit terminal 1.
7. Verify the scan tool Fuel Rail Pressure Sensor 2 parameter is greater than 4.75 V.
    - **If 4.75 V or less**
    1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit terminal 2 and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.

- If infinite resistance

3. Test for less than 2 Ω in the signal circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If greater than 4.75 V**

8. Verify the scan tool Fuel Rail Pressure Sensor 1 parameter is less than 0.25 V.
    - **If 0.25 V or greater**

    1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit terminal 4 and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.

    - **If less than 0.25 V**

9. Install a 3 A fused jumper wire between the signal circuit terminal 4 and the 5 V reference circuit terminal 1.
10. Verify the scan tool Fuel Rail Pressure Sensor 1 parameter is greater than 4.75 V.
    - **If 4.75 V or less**

    1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit terminal 2 and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance

    3. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.

    - **If greater than 4.75 V**

11. Test or replace the B47B Fuel Rail Pressure Sensor.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Fuel Injection Fuel Rail Fuel Pressure Sensor Replacement** for B47B Fuel Rail Pressure Sensor replacement

- Refer to **Control Module References** for K20 Engine Control Module replacement, programming, and setup

DTC P0192 OR P0193: FUEL RAIL PRESSURE SENSOR CIRCUIT VOLTAGE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0192

Fuel Rail Pressure Sensor Circuit Low Voltage

DTC P0193

Fuel Rail Pressure Sensor Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference Voltage	P0192, P0193, P0340, P0345, P0365, P0390, P0506, P0641, P2227	P0192, P127C	P0193, P0641, P2227, P2229	P0191
Fuel Rail Pressure Sensor Signal 1	P0192	P0192, P0193	P0193	P0191
Fuel Rail Pressure Sensor Signal 2	P127C	P127C, P127D	P127D	P0191
Low Reference	-	P0193, P127C	P0193	P0191

Circuit/System Description

The fuel rail pressure sensor is a dual analog sensor that provides two fuel rail pressure signals to the engine control module (ECM). The ECM provides a 5 V reference voltage on the 5 V reference circuit and ground on the low reference circuit. The ECM receives a varying signal voltage on

both the fuel rail pressure sensor 1 and fuel rail pressure sensor 2 signal circuits. The ECM monitors the voltage on both of the fuel rail pressure sensor circuits and compares the values to determine if the sensors are accurate.

Conditions for Running the DTC

- Engine is running.
- Ignition voltage is greater than 11 V.
- The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

P0192

The engine control module detects that the fuel rail pressure sensor 1 signal voltage is less than 0.25 V for greater than 2.5 s.

P0193

The Engine Control Module detects that the fuel rail pressure sensor 1 signal voltage is greater than 4.75 V for greater than 2.5 s.

Action Taken When the DTC Sets

- DTCs P0192 and P0193 are Type A DTCs.
- A message center or an indicator may display Reduced Engine Power.

Conditions for Clearing the DTC

DTCs P0192 and P0193 are Type A DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Engine running.
2. Verify the scan tool Fuel Rail Pressure Sensor parameter is between 0.25-4.75 V.
   - **If not between 0.25-4.75 V**

     Refer to Circuit/System Testing.

   - **If between 0.25-4.75 V**
3. Verify the scan tool Fuel Rail Pressure Sensor parameter increases or decreases when commanding an increase and decrease in Fuel Pressure with a scan tool.
   - **If the pressure does not increase or decrease with each command**

     Refer to Circuit/System Testing.

   - **If the pressure increases or decreases with each command**
4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
5. Verify the DTC does not set.

- **If the DTC sets**

  Refer to Circuit/System Testing.

- **If the DTC does not set**

6. All OK.

Circuit/System Testing

1. Ignition OFF, and all vehicle systems OFF, disconnect the harness connector at the B47B Fuel Rail Pressure Sensor. It may take up to 2 min for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal 3 and ground.
   - **If 5 Ω or greater**
   1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If less than 5 Ω**
3. Ignition ON.
4. Test for 4.8-5.2 V between the 5 V reference circuit terminal 1 and ground.
   - **If less than 4.8 V**
   1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the 5 V reference circuit and ground.
      - If less than infinite resistance, repair the short to ground in the circuit.
      - If infinite resistance
   3. Test for less than 2 Ω in the 5 V reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If greater than 5.2 V**
   1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the 5 V reference circuit and ground.

- If 1 V or greater, repair the short to voltage on the circuit.
- If less than 1 V, replace the K20 Engine Control Module.

- **If between 4.8-5.2 V**

5. Verify the scan tool Fuel Rail Pressure Sensor parameter is less than 0.25 V.
   - **If 0.25 V or greater**
   1. Ignition OFF, disconnect the harness connector X2 at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the signal circuit terminal 4 and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If less than 0.25 V**
6. Install a 3 A fused jumper wire between the signal circuit terminal 4 and the 5 V reference circuit terminal 1.
7. Verify the scan tool Fuel Rail Pressure Sensor parameter is greater than 4.75 V.
   - **If 4.75 V or less**
   1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the signal circuit terminal 4 and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 Ω in the signal circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If greater than 4.75 V**
8. Test or replace the B47B Fuel Rail Pressure Sensor.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Fuel Injection Fuel Rail Fuel Pressure Sensor Replacement** for B47B Fuel Rail Pressure Sensor replacement
- Refer to **Control Module References** for K20 Engine Control Module replacement, programming, and setup

DTC P0201-P0208, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282, OR P0283:

CYLINDER INJECTOR CONTROL CIRCUITS (1-8)

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0201

Cylinder 1 Injector Control Circuit

DTC P0202

Cylinder 2 Injector Control Circuit

DTC P0203

Cylinder 3 Injector Control Circuit

DTC P0204

Cylinder 4 Injector Control Circuit

DTC P0205

Cylinder 5 Injector Control Circuit

DTC P0206

Cylinder 6 Injector Control Circuit

DTC P0207

Cylinder 7 Injector Control Circuit

DTC P0208

Cylinder 8 Injector Control Circuit

DTC P0261

Cylinder 1 Injector Control Circuit Low Voltage

DTC P0262

Cylinder 1 Injector Control Circuit High Voltage

DTC P0264

Cylinder 2 Injector Control Circuit Low Voltage

DTC P0265

Cylinder 2 Injector Control Circuit High Voltage

DTC P0267

Cylinder 3 Injector Control Circuit Low Voltage

DTC P0268

Cylinder 3 Injector Control Circuit High Voltage

DTC P0270

Cylinder 4 Injector Control Circuit Low Voltage

DTC P0271

Cylinder 4 Injector Control Circuit High Voltage

DTC P0273

Cylinder 5 Injector Control Circuit Low Voltage

DTC P0274

Cylinder 5 Injector Control Circuit High Voltage

DTC P0276

Cylinder 6 Injector Control Circuit Low Voltage

DTC P0277

Cylinder 6 Injector Control Circuit High Voltage

DTC P0279

Cylinder 7 Injector Control Circuit Low Voltage

DTC P0280

Cylinder 7 Injector Control Circuit High Voltage

DTC P0282

Cylinder 8 Injector Control Circuit Low Voltage

DTC P0283

Cylinder 8 Injector Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Low Control Cylinder 1	P0261	P0201	P0262	P1248
High Control Cylinder 1	P2147	P0201	P2148	P1248
Low Control Cylinder 2	P0264	P0202	P0265	P1249
High Control Cylinder 2	P2150	P0202	P2151	P1249
Low Control Cylinder 3	P0267	P0203	P0268	P124A
High Control Cylinder 3	P2153	P0203	P2154	P124A
Low Control Cylinder 4	P0270	P0204	P0271	P124B

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
High Control Cylinder 4	P2156	P0204	P2157	P124B
Low Control Cylinder 5	P0273	P0205	P0274	P124C
High Control Cylinder 5	P216B	P0205	P216C	P124C
Low Control Cylinder 6	P0276	P0206	P0277	P124D
High Control Cylinder 6	P216E	P0206	P216F	P124D
Low Control Cylinder 7	P0279	P0207	P0280	P124E
High Control Cylinder 7	P217B	P0207	P217C	P124E
Low Control Cylinder 8	P0282	P0208	P0283	P124F
High Control Cylinder 8	P217E	P0208	P217F	P124F
DTC P0300 may also be present for all fault conditions				

Circuit/System Description

The engine control module (ECM) supplies voltage to each fuel injector on the high control circuits. The ECM energizes each fuel injector by grounding the low control circuit of the fuel injector. The ECM monitors the status of the fuel injector circuits. When a fuel injector circuit condition is detected by the ECM, the affected fuel injector(s) is disabled.

Conditions for Running the DTC

- DTC P062B is not set
- Engine is running.
- Ignition voltage is greater than 11 V.
- The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

DTC P0201, P0202, P0203, P0204, P0205, P0206, P0207, or P0208

The engine control module detects the fuel injector control circuit is open for greater than 2 s.

DTC P0261, P0264, P0267, P0270, P0273, P0276, P0279, or P0282

The engine control module detects the fuel injector control circuit is shorted to ground for greater than 2 s.

DTC P0262, P0265, P0268, P0271, P0274, P0277, P0280, or P0283

The engine control module detects the fuel injector control circuit is shorted to voltage for greater than 2 s.

Action Taken When the DTC Sets

DTCs P0201, P0202, P0203, P0204, P0205, P0206, P0207, P0208, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282 and P0283 are Type A DTCs.

Conditions for Clearing the MIL/DTC

DTCs P0201, P0202, P0203, P0204, P0205, P0206, P0207, P0208, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282 and P0283 are Type A DTCs.

Diagnostic Aids

- The MIL indicator flashes when there is an engine misfire.
- High resistance in the circuits of the fuel injectors may set a misfire DTC without setting a fuel injector DTC. Test the fuel injector circuits of the affected cylinder(s) for a high resistance if you suspect a condition.
- Performing the fuel injector coil test may help isolate an intermittent condition. Refer to **Fuel Injector Diagnosis** .
- If the condition is intermittent, move the related harnesses and connectors, with the engine operating, while monitoring the scan tool Injector Control Circuit Status parameters. An Injector Control Circuit Status parameter will change from OK or Not Run to Malfunction if there is a condition with the circuit or a connection.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P062B is not set.
   - **If the DTC is set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle**

   - **If the DTC is not set**

NOTE: **The engine must be running for the injector circuit status parameters to function.**

3. Engine idling.
4. Verify with a scan tool parameters listed below display OK or Not Run.
   - Cylinder 1 Injector Control Circuit Status
   - Cylinder 2 Injector Control Circuit Status
   - Cylinder 3 Injector Control Circuit Status
   - Cylinder 4 Injector Control Circuit Status
   - Cylinder 5 Injector Control Circuit Status
   - Cylinder 6 Injector Control Circuit Status

- Cylinder 7 Injector Control Circuit Status
- Cylinder 8 Injector Control Circuit Status
- **If OK or Not Run is not displayed**

  Refer to Circuit/System Testing.

- **If OK or Not Run is displayed**

5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify the DTC does not set
   - **If the DTC set**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
7. All OK.

Circuit/System Testing

1. Ignition OFF, all vehicle systems OFF, disconnect the X3 harness connector at the K20 Engine Control Module. It may take up to 2 min for all vehicle systems to power down.
2. Test for infinite resistance between the appropriate Q17 Fuel Injector high control circuit and ground.
   - **If less than infinite resistance**
   1. Disconnect the harness connector of the Q17 Fuel Injector.
   2. Test for infinite resistance between the Q17 Fuel Injector high control circuit and ground.
      - If less than infinite, repair the short to ground in the circuit.
      - If infinite resistance
   3. Test for infinite resistance between the Q17 Fuel Injector low control circuit and ground.
      - If less than infinite, repair the short to ground in the circuit.
      - If infinite, test or replace the Q17 Fuel Injector.
   - **If infinite resistance**
3. Ignition ON.

4. Test for less than 1 V between the Q17 Fuel Injector high control circuit and ground.
    - **If 1 V or greater**
    1. Disconnect the harness connector of the Q17 Fuel Injector, ignition ON.
    2. Test for less than 1 V between the Q17 Fuel Injector high control circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, repair the short to voltage on the low control circuit.
    - **If less than 1 V**
5. Ignition OFF.
6. Test for less than 10 Ω between the Q17 fuel injector high control circuit and low control circuit.
    - **If 10 Ω or greater**
    1. Disconnect the harness connector of the Q17 Fuel Injector.
    2. Test for less than 2 Ω on the high control circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω
    3. Test for less than 2 Ω on the low control circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, test or replace the Q17 Fuel Injector.
    - **If less than 10 Ω**
7. Test or replace the K20 Engine Control Module.

Component Testing

NOTE: **The engine coolant temperature (ECT) sensor must be between 10-32Â°C (50-90Â°F) for an accurate measurement.**

1. Ignition OFF, disconnect the harness connector at the appropriate Q17 Fuel Injector.
2. Test for 1.06 Ω +/- 10% @ 20Â°C (68Â°F) between the terminals of the Q17 Fuel Injector.
    - **If not within the specified range**

      Replace the Q17 Fuel Injector.

- **If within the specified range**

3. Test for infinite resistance between each terminal and the Q17 Fuel Injector housing/case.
   - **If less than infinite resistance**

     Replace the Q17 Fuel Injector.

   - **If infinite resistance**
4. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Fuel Injector Replacement**
- Refer to **Control Module References** for K20 Engine Control Module replacement, programming, and setup

DTC P0231, P0232, OR P023F: FUEL PUMP CONTROL CIRCUIT

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0231

Fuel Pump Control Circuit Low Voltage

DTC P0232

Fuel Pump Control Circuit High Voltage

DTC P023F

Fuel Pump Control Circuit

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control	P0171, P0232, P023F	P0171, P0232, P023F	P0171, P0232, P023F	P023F, P2635
Low Reference	-	P0232, P023F, P0506	P0232, P023F, P0506	P023F, P2635

Circuit/System Description

The engine control module (ECM) supplies voltage to the fuel pump driver control module when the ECM detects that the ignition is on. The voltage from the ECM to the fuel pump driver control module remains active for 2 s, unless the engine is in crank or run. While this voltage is being received, the fuel pump driver control module supplies a varying voltage to the fuel tank fuel pump module in order to maintain the desired fuel line pressure. The fuel pump driver control module monitors the fuel pump voltage to determine if the fuel pump is functioning as commanded.

Conditions for Running the DTC

P0231

- The ignition voltage is greater than 11 V.
- The engine is cranking or running.
- The fuel pump enable circuit is commanded ON.
- The fuel pump power module output current is less than 75 A.
- The DTC runs continuously when the conditions above are met.

P0232

- The ignition voltage is greater than 7 V.
- The fuel pump enable circuit is commanded ON.
- The DTC runs continuously when the conditions above are met.

P023F

- The ignition voltage is greater than 7 V.
- The commanded duty cycle is between 30-60%.

- The DTC runs continuously when the conditions above are met.

Conditions for Setting the DTC

P0231

The fuel pump driver control module detects that the fuel pump current is greater than 14.48 A for 1 s.

P0232

The fuel pump driver control module detects that the fuel pump output circuit voltage is greater than 4.0 V for 1 s when the voltage should be 0 V.

P023F

The fuel pump driver control module detects that the fuel pump current is less than 1 A and the fuel pump duty cycle is approximately 30-60% for 1 s.

Action Taken When the DTC Sets

DTCs P0231, P0232 and P023F are Type A DTCs.

Conditions for Clearing the DTC

DTCs P0231, P0232 and P023F are Type A DTCs.

Diagnostic Aids

- Using the Failure Records data may help locate an intermittent condition. If you cannot duplicate the DTC, the information in the Failure Records can help determine how many miles since the DTC set. The Fail Counter and Pass Counter can help determine how many ignition cycles that the diagnostic test reported a pass and/or a fail.
- On vehicles equipped with a high pressure mechanical pump on direct fuel injection engines, the vehicle may continue to run even though the pump in the fuel tank is not operating.
- The fuel pump control module contains an internal protection diode on the fuel pump low reference circuit. The proper DMM must be used when testing the low reference circuit.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify the fuel pump turns ON and OFF when commanding the Fuel Pump Enable On and Off with a scan tool.
    - **If the fuel pump does not turn ON and OFF**

      Refer to Circuit/System Testing.

    - **If the fuel pump turns ON and OFF**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.

- **If the DTC sets**

  Refer to Circuit/System Testing.

- **If the DTC does not set**

5. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the G12 Fuel Pump. Connect a test lamp between battery positive voltage and the G12 Fuel Pump harness connector terminal 2. It may take up to 2 min for all vehicle systems to power down.
2. Verify the test lamp illuminates.
   - **If the test lamp does not illuminate**
   1. Ignition OFF, disconnect the harness connector at the K111 Fuel Pump Driver Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, refer to Component Testing in this diagnostic.
   - **If the test lamp illuminates**
3. Ignition ON, connect a test lamp between the supply voltage circuit terminal 1 and the low reference circuit terminal 2.
4. Verify the test lamp turns ON and OFF when commanding the Fuel Pump Enable On and Off with a scan tool.
   - **If the test lamp is always OFF**
   1. Ignition OFF, disconnect the harness connector at the K111 Fuel Pump Driver Control Module.
   2. Test for infinite resistance between the supply voltage circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 Ω in the supply voltage circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, test or replace the K111 Fuel Pump Driver Control Module.
   - **If the test lamp is always ON**
   1. Ignition OFF, remove the test lamp, disconnect the harness connector at the K111 Fuel Pump Driver Control Module, ignition ON.
   2. Test for less than 1 V between the supply voltage circuit and ground.

- If 1 V or greater, repair the short to voltage on the circuit.
- If less than 1 V, test or replace the K111 Fuel Pump Driver Control Module.
- **If the test lamp turns ON and OFF**

5. Test or replace the G12 Fuel Pump.

Component Testing

1. Ignition OFF, disconnect the harness connector at the K111 Fuel Pump Driver Control Module.
2. Connect a DMM, set on diode setting, with the positive lead at terminal 16 and the negative lead at terminal 9 of the K111 Fuel Pump Driver Control Module.
3. Verify the DMM displays between 0.4-0.8 V.
   - **If not between 0.4-0.8 V**

     Replace the K111 Fuel Pump Driver Control Module.

   - **If between 0.4-0.8 V**
4. Connect a DMM, set on diode setting, with the positive lead at terminal 9 and the negative lead at terminal 16 of the K111 Fuel Pump Driver Control Module.
5. Verify the DMM displays OL.
   - **If not OL**

     Replace the K111 Fuel Pump Driver Control Module.

   - **If OL**
6. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Fuel Tank Fuel Pump Module Replacement (SWB)** **Fuel Tank Fuel Pump Module Replacement (LWB)** for G12 Fuel Pump replacement
- Refer to **Fuel Pump Power Control Module Replacement** for K111 Fuel Pump Driver Control Module replacement

DTC P0300-P0308: ENGINE MISFIRE DETECTED/CYLINDER MISFIRES DETECTED (1-8)

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0300

Engine Misfire Detected

DTC P0301

Cylinder 1 Misfire Detected

DTC P0302

Cylinder 2 Misfire Detected

DTC P0303

Cylinder 3 Misfire Detected

DTC P0304

Cylinder 4 Misfire Detected

DTC P0305

Cylinder 5 Misfire Detected

DTC P0306

Cylinder 6 Misfire Detected

DTC P0307

Cylinder 7 Misfire Detected

DTC P0308

Cylinder 8 Misfire Detected

Circuit/System Description

The engine control module (ECM) uses information from the crankshaft position sensor and the camshaft position sensor to determine when a engine cylinder misfire is occurring. By monitoring variations in the crankshaft rotation speed for each cylinder, the ECM can detect individual cylinder misfire events.

Extreme cylinder misfire events can cause catalytic converter damage. The malfunction indicator lamp (MIL) will flash when the conditions for catalytic converter damage are present. DTCs P0301 through P0308 correspond to cylinders 1 through 8. When the ECM detects that one or more specific cylinders are misfiring, the DTC for the respective misfiring cylinder will set and up to 2 of the corresponding fuel injectors are disabled for a minimum of 30 s. The ECM will then re-enable the fuel injector and, after approximately 200 engine revolutions, will determine if the misfire is still present. If the misfire is still present, the ECM will disable the fuel injector again repeating the process. If the misfire is not present, the fuel injector will remain enabled by the ECM. In Spark Ignition Direct Injection (SIDI) system applications, if a fuel injector fault DTC is set during a misfire event, the ECM will not re-enable the injector.

Conditions for Running the DTC

- DTC P0010, P0011, P0013, P0014, P0016, P0017, P0018, P0019, P0020, P0021, P0023, P0024, P0068, P0090, P0091, P0093, P00CA, P00C8, P00C9, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0122, P0123, P0191, P0192, P0193, P0222, P0223, P0335, P0336, P0340, P0341, P0345, P0346, P0365, P0366, P0390, P0391, P0443, P0449, P0452, P0453, P0454, P0601, P0604, P0606, P0651, P0697, P2088, P2089, P2090, P2091, P2135, P2771, P3401, P3403, P3404, P3409, P3411, P3412, or P3417 is not set.
- DTC P0806, P0807, or P0808 is not set when equipped with manual transmission.
- The engine speed is less than 1,000 RPM and DTC P0315 is set.
- The engine speed is greater than 1,500 RPM.
- The crankshaft position and camshaft position sensors are synchronized.
- The engine coolant temperature (ECT) is between -7 and 130Â°C (19-266Â°F).
- If the ECT is colder than -7Â°C (19Â°F) at start-up, this diagnostic will not run until the ECT is between 21-130Â° (70-266Â°F).
- The battery voltage is between 9-32 V.
- The vehicle is not in a acceleration or deceleration condition.
- The ECM is not detecting a rough road signal.
- The fuel level is at least 11%.

- The ECM is not in fuel cut-off or deceleration fuel cut-off mode.

The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

P0300

The ECM detects a crankshaft rotation speed variation indicating a misfire rate sufficient to cause emissions levels to exceed a predetermined value or a misfire rate high enough to cause catalyst damage.

P0301, P0302, P0303, P0304, P0305, P0306, P0307, or P0308

The ECM detects a crankshaft rotation speed variation indicating a single cylinder misfire rate sufficient to cause emissions levels to exceed mandated standards.

Action Taken When the DTC Sets

- DTCs P0300-P0308 are Type B DTCs.
- When a catalyst damaging level of misfire is present, the ECM may disable the fuel injectors for up to 2 misfiring cylinders and will flash the malfunction indicator lamp (MIL).

Conditions for Clearing the DTC

DTCs P0300-P0308 are Type B DTCs.

Diagnostic Aids

- A misfire DTC could be caused by an excessive vibration from sources other than the engine. Inspect for the conditions listed below:
  - A tire or wheel that is out of round or out of balance
  - Variable thickness brake rotors
  - An unbalanced drive shaft
  - Certain rough road conditions
  - Transmission operation
  - A damaged or defective accessory drive component or belt
- Observe misfire counters after Active Fuel Management is commanded Off for a sticking lifter.

- High resistance in the circuits of the injectors may set a misfire DTC without setting an injector DTC. Test the injector circuits of the affected cylinder(s) for a high resistance if you suspect a condition.
- If the condition is intermittent, observing the scan tool IC Circuit Test and Fuel Injector Circuit Test Status parameters may help isolate the condition. The circuit test status parameters will change from OK or Not Run to Fault/Malfunction if a condition exists.
- A condition in the heated O2 sensor (HO2S) heater control circuits may set a DTC P0300.

Reference Information

Description and Operation

- **Electronic Ignition System Description**
- **Fuel System Description**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL26792 HEI Spark Tester

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** **Special Tools (Service Tools)** .

Circuit/System Verification

NOTE: **Before starting the engine, review the freeze frame failure records data to determine if the misfire sets during a cold start or at operating temperature. If there is a cold start condition and the engine is started, the engine will need to be cooled down before the next attempt to start the engine within the fail conditions.**

1. Engine Running at normal operating temperature.
2. Verify there is no abnormal engine noise.
    - **If abnormal engine noise is present**

Refer to **Symptoms - Engine Mechanical** .

- **If abnormal engine noise is not present**

3. Perform the scan tool **Crankshaft Position Variation Learn** procedure.
4. Verify no DTCs are set.
   - **If any DTCs other than P0300-P0308 are set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .

   - **If DTC P0300-P0308 is set**

     Refer to Circuit/System Testing.

   - **If no DTCs are set**
5. Verify the scan tool Cylinder 1-8 Current Misfire Counter parameters do not increment.
   - **If increments**

     Refer to Circuit/System Testing.

   - **If does not increment**
6. Engine Running, perform the Cylinder Power Balance Test with a scan tool.
7. Verify the engine speed changes when each injector is disabled and then enabled.
   - **If engine speed does not change**

     Refer to Circuit/System Testing.

   - **If engine speed does change**
8. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
9. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**

10. All OK.

Circuit/System Testing

1. Verify none of the following conditions listed below exist:
    - Damage, carbon tracking, or fluid intrusion of the spark plug boots and/or spark plugs
    - Vacuum hose splits, kinks, and incorrect connections
    - Engine vacuum leaks
    - Crankcase ventilation system for vacuum leaks
    - Fuel pressure that is too low or too high. Refer to **Fuel System Diagnosis** .
    - Contaminated fuel. Refer to **Alcohol/Contaminants-in-Fuel Diagnosis** .
    - Exhaust system restrictions
        - **If a condition exists**

          Repair or replace as necessary.

        - **If no conditions exist**

NOTE: **An erratic or weak spark is considered a no spark condition.**

2.
3. Ignition OFF, connect the **EL 26792** HEI Spark Tester to the appropriate spark plug wire, engine Cranking.
4. Verify the spark output.
    - **If no output or the output is weak**

      Refer to **Electronic Ignition System Diagnosis** .

    - **If the output is good**
5. Ignition OFF.
6. Verify the conditions listed below. Refer to **Ignition System Specifications** .
    - The correct spark plug type
    - The correct spark plug gap
    - The correct spark plug torque

- **If a condition exists**

  Repair or replace as necessary.

- **If no conditions exist**

7. Exchange the suspect spark plug with another cylinder that is operating correctly.
8. Engine Running.
9. Verify the scan tool Cylinder 1-8 Current Misfire Counter does not increment for the cylinder where the suspect spark plug was installed.
   - **If increments**

     Replace the spark plug.

   - **If does not increment**
10. Test or inspect for the conditions listed below:
    - A lean or rich Q17 Fuel Injector - Refer to **Fuel Injector Balance Test** .
    - An engine mechanical condition - Refer to **Symptoms - Engine Mechanical** .

Repair Instructions

Refer to **Spark Plug Replacement**

Repair Verification

1. Install any components or connectors that have been removed or replaced during diagnosis.
2. Perform any adjustment, programming or setup procedures that are required when a component or module is removed or replaced.
3. Clear the DTCs.
4. Turn OFF the ignition for 60 s.
5. If the repair was related to a DTC, duplicate the Conditions for Running the DTC and use the Freeze Frame/Failure Records, if applicable, in order to verify the DTC does not reset. If the DTC resets or another DTC is present, refer to the **Diagnostic Trouble Code (DTC) List - Vehicle** and perform the appropriate diagnostic procedure.
6. Engine Running, verify the scan tool Cylinder 1-8 Current Misfire Counter parameters do not increment.
   - If the misfire counter parameters increment, a misfire condition still exists.
7. To verify that the performance of the catalytic converter has not been affected by the condition that set this DTC, perform the Repair Verification for DTC P0420 or DTC P0430. Refer to **DTC P0420 or P0430** .

DTC P0315: CRANKSHAFT POSITION SYSTEM VARIATION NOT LEARNED

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P0315

Crankshaft Position System Variation Not Learned

Circuit/System Description

The crankshaft position variation learn feature is used to calculate reference period errors caused by slight tolerance variations in the crankshaft, and the crankshaft position sensor. The calculated error allows the engine control module (ECM) to accurately compensate for reference period variations. This enhances the ability of the ECM to detect misfire events over a wider range of engine speed and load conditions.

The crankshaft position system variation compensating values are stored in ECM memory after a learn procedure has been performed and the ignition switch is turned to the OFF position for at least 30 s. If the actual variation is not within the crankshaft position system variation compensating values stored in the ECM, DTC P0300 may set.

If the crankshaft position system variation values are not stored in the ECM memory or a proper ECM power down does not occur after completing the Crankshaft Position Learn Procedure, DTC P0315 sets.

Conditions for Running the DTC

Engine is Running.

The DTC runs continuously when the above condition is met.

Conditions for Setting the DTC

The ECM detects that the crankshaft position system variation values are not stored in memory.

Action Taken When the DTC Sets

DTC P0315 is a Type A DTC.

Conditions for Clearing the MIL/DTC

DTC P0315 is a Type A DTC.

Diagnostic Aids

This test procedure requires that the vehicle battery has passed a load test and is completely charged. Refer to **Battery Inspection/Test** .

Reference Information

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

NOTE: **The Crankshaft Position Variation Learn procedure may have to be repeated up to 5 times before the procedure is successful.**

1. Perform the scan tool **Crankshaft Position Variation Learn** procedure.
2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed in the Freeze Frame/Failure Records data.
3. Verify the DTC is not set.
   - **If the DTC sets**

     Replace the K20 Engine Control Module.

   - **If the DTC does not set**
4. All OK

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

Refer to **Control Module References** for engine control module replacement, programming, and setup

DTC P0324, P0326, P0331, P06B6, OR P06B7: KNOCK SENSOR PERFORMANCE/CONTROL MODULE KNOCK SENSOR PROCESSOR PERFORMANCE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0324

Knock Sensor System Performance

DTC P0326

Knock Sensor Performance Bank 1

DTC P0331

Knock Sensor Performance Bank 2

DTC P06B6

Control Module Knock Sensor Processor 1 Performance

DTC P06B7

Control Module Knock Sensor Processor 2 Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Knock Sensor 1 High Signal	P0327, P06B6	P0325	P0328	P0324*, P0326**
Knock Sensor 2 High Signal	P0332, P06B7	P0330	P0333	P0324*, P0331**
Knock Sensor 1 Low Signal	P0327	P0325	P0328	P0324*, P0326**
Knock Sensor 2 Low Signal	P0332	P0330	P0333	P0324*, P0331**
* Signal Performance High ** Signal Performance Low				

Circuit/System Description

The knock sensors enable the engine control module (ECM) to control the ignition timing for the best possible performance while protecting the engine from potentially damaging levels of detonation. The knock sensors produce an alternating current (AC) voltage signal that varies depending on the vibration level during engine operation. The ECM adjusts the spark timing based on the amplitude and the frequency of the two knock sensor signals. The ECM receives each knock sensor signal through a dedicated circuit. The ECM learns a minimum knock sensor noise level for all of the engine speed ranges and monitors the normal knock sensor signal. The ECM monitors the internal knock sensor processor test circuits which perform the open circuit diagnostic.

Conditions for Running the DTCs

P0324

- Engine is running for 2 s or greater.
- Engine speed is 8,500 RPM or less.
- Engine air flow is between 200-2000 mg per cylinder.
- The engine coolant temperature (ECT) is -40Â°C (-40Â°F) or warmer.
- The intake air temperature (IAT) sensor 1 is -40Â°C (-40Â°F) or warmer.

  AND

- Engine speed is 400 RPM or greater for 80 or more cumulative revolutions.

  OR

- Engine speed is 8,500 RPM or greater for 100 or more cumulative revolutions.

OR

- Engine speed is 8,500 RPM or greater for 20 or more cumulative revolutions.

P0326 and P0331

- Engine is running for 2 s or greater.
- Engine speed is 8,500 RPM or less.
- Engine air flow is between 200-2000 mg per cylinder.
- The engine coolant temperature (ECT) is -40Â°C (-40Â°F) or warmer.
- The intake air temperature (IAT) sensor 1 is -40Â°C (-40Â°F) or warmer.

AND

- Engine speed is 400 RPM or greater for 167 or more cumulative revolutions.

OR

- Engine speed is 8,500 RPM or greater for 100 or more cumulative revolutions.

OR

- Engine speed is 8,500 RPM or greater for 5 or more cumulative revolutions.

P06B6 and P06B7

- Engine is running for 2 s or greater.
- Engine speed is between 400-4,000 RPM for 200 or more cumulative revolutions.
- Engine air flow is between 10-2000 mg per cylinder.

The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTCs

P0324

The ECM detects that either knock sensor signal performance is out of the normal calibrated range due to excessive engine knock on a per cylinder

basis.

P0326

The ECM detects that the knock sensor 1 signal performance is out of the normal calibrated range due to low signal level.

P0331

The ECM detects that the knock sensor 2 signal performance is out of the normal calibrated range due to a low signal level.

P06B6 and P06B7

The ECM has detected a fault in the knock sensor processor open circuit diagnostic internal test circuit.

Action Taken When the DTCs Set

- DTCs P0324, P0326, P0331, P06B6, and P06B7 are Type B DTCs.
- The ignition timing is retarded to reduce the potential of engine damaging spark knock.

Conditions for Clearing the DTCs

DTCs P0324, P0326, P0331, P06B6, and P06B7 are Type B DTCs.

Reference Information

Description and Operation

Electronic Ignition System Description

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Engine Running.

2. Verify DTC P0325, P0327, P0328, P0330, P0332, P0333, P06B6, or P06B7 is not set.
   - **If DTC P0325, P0327, P0328, P0330, P0332, or P0333 is set with P06B6 or P06B7**

     Refer to **DTC P0325, P0327, P0328, P0330, P0332, or P0333**.

   - **If only DTC P06B6 or P06B7 is set**

     Replace the K20 Engine Control Module.

   - **If none of the DTCs are set**
3. Ignition OFF.
4. Verify none of the conditions listed below exist:
   - B68 Knock Sensor or wiring harness damage.
   - Incorrect B68 Knock Sensor installation. Refer to **Fastener Specifications** .
   - B68 Knock Sensor and engine mounting surface burrs, casting flash, and foreign material.
   - Close proximity of hoses, brackets, and engine wiring.
   - Loose brackets.
   - Loose or broken accessory drive belts, brackets, components.
   - An engine mechanical condition. Refer to **Symptoms - Engine Mechanical** .
   - Contaminated or poor quality fuel.
   - **If a condition exists**

     Repair or replace as necessary.

   - **If no conditions exist**
5. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
   - **If the DTCs sets**

     Test or replace the appropriate B68 Knock Sensor.

   - **If the DTC does not set**
6. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Knock Sensor 1 Replacement**
- Refer to **Knock Sensor 2 Replacement**
- Refer to **Control Module References** for engine control module replacement, programming, and setup.

DTC P0325, P0327, P0328, P0330, P0332, OR P0333: KNOCK SENSOR CIRCUITS

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0325

Knock Sensor Circuit

DTC P0327

Knock Sensor Circuit Low Voltage

DTC P0328

Knock Sensor Circuit High Voltage

DTC P0330

Knock Sensor 2 Circuit

DTC P0332

Knock Sensor 2 Circuit Low Voltage

DTC P0333

Knock Sensor 2 Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Knock Sensor 1 High Signal	P0327, P06B6	P0325	P0328	P0324*, P0326**
Knock Sensor 2 High Signal	P0332, P06B7	P0330	P0333	P0324*, P0331**
Knock Sensor 1 Low Signal	P0327	P0325	P0328	P0324*, P0326**
Knock Sensor 2 Low Signal	P0332	P0330	P0333	P0324*, P0331**
* Signal Performance High ** Signal Performance Low				

Circuit/System Description

The knock sensors enable the engine control module (ECM) to control the ignition timing for the best possible performance while protecting the engine from potentially damaging levels of detonation. The knock sensors produce an alternating current (AC) voltage signal that varies depending on the vibration level during engine operation. The ECM adjusts the spark timing based on the amplitude and the frequency of the two knock sensor signals. The ECM receives each knock sensor signal through a dedicated circuit. The ECM learns a minimum knock sensor noise level for all of the engine speed ranges and monitors the normal knock sensor signal. The ECM monitors the internal knock sensor processor test circuits which perform the open circuit diagnostic.

Conditions for Running the DTCs

P0325 and P0330

- Engine is running for 2 s or greater.
- Engine speed is between 400-5,500 RPM for 100 or more cumulative revolutions.
- Engine air flow is between 10-2000 mg per cylinder.
- The engine coolant temperature (ECT) is -40Â°C (-40Â°F) or warmer.
- The intake air temperature (IAT) sensor 1 is -40Â°C (-40Â°F) or warmer.

P0327, P0328, P0332, and P0333

Engine speed is less than 8,500 RPM.

The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTCs

P0325

The ECM detects knock sensor 1 signal circuit is open.

P0327

The ECM detects knock sensor 1 signal circuit is shorted to ground.

P0328

The ECM detects knock sensor 1 signal circuit is shorted to voltage.

P0330

The ECM detects knock sensor 2 signal circuit is open.

P0332

The ECM detects knock sensor 2 signal circuit is shorted to ground.

P0333

The ECM detects knock sensor 2 signal circuit is shorted to voltage.

Action Taken When the DTCs Set

- DTCs P0325, P0327, P0328, P0330, P0332, and P0333 are Type B DTCs.
- The ignition timing is retarded to reduce the potential of engine damaging spark knock.

Conditions for Clearing the DTCs

DTCs P0325, P0327, P0328, P0330, P0332, and P0333 are Type B DTCs.

Diagnostic Aids

The following conditions listed below may cause a knock sensor DTC to set:

- Sensor damage.
- Knock sensor and engine mounting surface burrs, casting flash, and foreign material.
- Close proximity of hoses, brackets, and engine wiring.
- Loose brackets.
- Loose or broken accessory drive belts, brackets, components.
- An engine mechanical condition. Refer to **Symptoms - Engine Mechanical** .

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

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Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Engine Running.
2. Verify DTC P0325, P0327, P0328, P0330, P0332, or P0333, is not set.
   - **If the DTC is set**

     Refer to Circuit/System Testing.

   - **If the DTC is not set**
3. Verify the appropriate B68 Knock Sensor mounting bolt is properly tightened. Refer to **Fastener Specifications** .
   - **If not tightened to the correct specification**

     Repair as necessary.

   - **If tightened to the correct specification**
4. Verify the scan tool parameters listed below display No while moving the related harnesses and connectors of the B68 Knock Sensor.
   - Cylinder 1 Knock Detected
   - Cylinder 2 Knock Detected
   - Cylinder 3 Knock Detected
   - Cylinder 4 Knock Detected
   - Cylinder 5 Knock Detected
   - Cylinder 6 Knock Detected
   - Cylinder 7 Knock Detected
   - Cylinder 8 Knock Detected
   - **If No is not displayed**

     Repair the wiring harness or connectors.

   - **If No is displayed**
5. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

- **If the DTC does not set**

7. All OK.

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the B68 Knock Sensor, ignition ON.
2. Test for 1-2 V between the low signal circuit terminal 2 and ground.
    - **If less than 1 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the low signal circuit terminal 2 and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance.
    3. Test for less than 2 Ω in the low signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If greater than 2 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the low signal circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If between 1-2 V**
3. Test for 2-4 V between the high signal circuit terminal 1 and ground.
    - **If less than 2 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the high signal circuit terminal 1 and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance.
    3. Test for less than 2 Ω in the high signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.

- **If greater than 4 V**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the high signal circuit and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.

- **If between 2-4 V**

4. Test or replace the B68 Knock Sensor.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Knock Sensor 1 Replacement**
- Refer to **Knock Sensor 2 Replacement**
- Refer to **Control Module References** for engine control module replacement, programming, and setup.

ENGINE PERFORMANCE

Engine Controls and Fuel - 5.3L (L83) or 6.2L (L86) - Diagnostic Information and Procedures - Escalade, Suburban, Tahoe, Yukon

DIAGNOSTIC INFORMATION AND PROCEDURES

DTC P0335 OR P0336: CRANKSHAFT POSITION SENSOR

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0335

Crankshaft Position Sensor Circuit

DTC P0336

Crankshaft Position Sensor Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P057C, P0651	P0335	P0651	P0336
Signal	P0335	P0335	P0335	P0336
Low Reference	-	P0335	-	P0336

Circuit/System Description

The crankshaft position sensor circuits consist of an engine control module (ECM) supplied 5 V reference circuit, low reference circuit, and an output signal circuit. The crankshaft position sensor is an internally magnetic biased digital output integrated circuit sensing device. The sensor detects

magnetic flux changes of the teeth and slots of a 58-tooth reluctor wheel on the crankshaft. Each tooth on the reluctor wheel is spaced at 60-tooth spacing, with 2 missing teeth for the reference gap. The crankshaft position sensor produces an ON/OFF DC voltage of varying frequency, with 58 output pulses per crankshaft revolution. The frequency of the crankshaft position sensor output depends on the velocity of the crankshaft. The crankshaft position sensor sends a digital signal, which represents an image of the crankshaft reluctor wheel, to the ECM as each tooth on the wheel rotates past the crankshaft position sensor. The ECM uses each crankshaft position signal pulse to determine crankshaft speed and decodes the crankshaft reluctor wheel reference gap to identify crankshaft position. This information is then used to determine the optimum ignition and injection points of the engine. The ECM also uses crankshaft position sensor output information to determine the camshaft relative position to the crankshaft, to control camshaft phasing, and to detect cylinder misfire.

Conditions for Running the DTC

P0335 Condition 1

- The starter is engaged and the engine control module detects camshaft position sensor pulses.

  Or

- DTCs P0101, P0102 and P0103 are not set.

  And

- The airflow into the engine is greater than 3 g/s.

Condition 2

- The engine is running.
- The starter is not engaged.

Condition 3

- DTCs P0340 and P0341 are not set.
- The engine is running or the starter is engaged.

P0336 Condition 1

- DTCs P0335 is not set.
- The airflow into the engine is greater than 3 g/s.

- Engine speed is greater than 450 RPM.

Condition 2

- The engine is running.
- The starter is not engaged.

Condition 3

- The starter is engaged and the engine control module detects camshaft position sensor pulses.

  Or

- DTCs P0101, P0102, and P0103 are not set.
- The airflow into the engine is greater than 3 g/s.

Condition 4

- DTCs P0340 and P0341 are not set.
- The engine is running or the starter is engaged.

The DTCs run continuously once the above conditions are met.

Conditions for Setting the DTC

P0335 Condition 1

The ECM does not detect a crankshaft position sensor pulse for greater than 4 s.

Condition 2

The ECM does not detect a crankshaft position sensor pulse for greater than 0.3 s.

Condition 3

The ECM does not detect a crankshaft position sensor pulse for 2 out of 10 engine revolutions.

P0336 Condition 1

The ECM detects that 10 or more crankshaft resynchronizations have occurred within 10.0 s.

Condition 2

The ECM does not detect the synchronization gap on the reluctor wheel for greater than 0.4 s.

Condition 3

The ECM does not detect the synchronization gap on the reluctor wheel for 1.5 s after the starter was engaged.

Condition 4

The ECM detects less than 51 or greater than 65 crankshaft position sensor pulses during 1 engine revolution for 8 out of 10 engine revolutions.

Action Taken When the DTC Sets

- DTCs P0335 and P0336 are Type B DTCs.
- The camshaft position sensor is used to determine engine position.
- The camshaft actuators are commanded to the parked position.

Conditions for Clearing the DTC

DTCs P0335 and P0336 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

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- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0651 is not set.
   - **If the DTC is set**

     Refer to **DTC P0641, P0651, P0697, or P06A3**.

   - **If the DTC is not set**
3. Engine Running.
4. Verify the scan tool Crankshaft Position Active Counter parameter increments.
   - **If the counter does not increment**

     Refer to Circuit/System Testing.

   - **If the counter increments**
5. Verify the scan tool Crankshaft Position Resync Counter parameter displays 0 counts and the engine does not stumble or stall while moving the related harness/connectors of the B26 Crankshaft Position Sensor.
   - **If greater than 0 counts and the engine stumbles or stalls**

     Refer to Circuit/System Testing.

   - **If 0 counts and the engine does not stumble or stall**

6. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
7. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
8. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B26 Crankshaft Position Sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal 2 and ground.
   - **If 5 Ω or greater**
   1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If 2 Ω or less, replace the K20 Engine Control Module.
   - **If less than 5 Ω**
3. Ignition ON.
4. Test for 4.8-5.2 V between the 5 V reference circuit terminal 3 and ground.
   - **If less than 4.8 V**
   1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the 5 V reference circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 Ω in the 5 V reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.

- **If greater than 5.2 V**

1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the 5 V reference and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.

- **If between 4.8-5.2 V**

5. Test for 4.8-5.2 V between the signal circuit terminal 1 and ground.

- **If less than 4.8 V**

1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the signal circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance.
3. Test for less than 2 Ω in the signal circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If greater than 5.2 V**

1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the signal circuit and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.

- **If between 4.8-5.2 V**

6. Ignition OFF, connect a 3 A fused jumper wire to the signal circuit terminal 1, ignition ON.

NOTE: **Additional DTCs may set when performing this test.**

7. Verify the scan tool Crankshaft Position Sensor Active Counter parameter increments while rapidly tapping the fused jumper wire end to ground.

- **If the counter does not increment**

  Replace the K20 Engine Control Module.

- **If the counter increments**

8. Verify DTC P0336 is not set.
   - **If the DTC is set**

     Inspect for the conditions listed below:

   - Excessive play or looseness of the B26 Crankshaft Position Sensor or the reluctor wheel
   - Improper installation of the B26 Crankshaft Position Sensor
   - Foreign material passing between the B26 Crankshaft Position Sensor and the reluctor wheel
   - Damaged reluctor wheel
   - Excessive air gap between the B26 Crankshaft Position Sensor and the reluctor wheel
   - Engine oil for debris
   - Timing chain, tensioner, and sprockets for wear or damage
   - If any of the conditions above are found, repair as necessary.
   - If all components test normal, test or replace the B26 Crankshaft Position Sensor.
   - **If the DTC is not set**
9. Test or replace the B26 Crankshaft Position Sensor.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Crankshaft Position Sensor Replacement**
- Refer to **Control Module References** for engine control module replacement, programming, and setup

DTC P0340 OR P0341: CAMSHAFT POSITION SENSOR

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0340

Camshaft Position Sensor Circuit

DTC P0341

Camshaft Position Sensor Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P018C, P0192, P0340, P0452, P0522, P0532, P0641, P127C, P2227, P2228	P0340	P018D, P0193, P0453, P0523, P0533, P0641, P127D, P2227	-
Signal	P0016, P0340	P0340	P0340, P0341	P0341
Low Reference	-	P0340	-	-

Circuit/System Description

The camshaft position sensor has 3 circuits consisting of an engine control module (ECM) supplied 5 V reference circuit, low reference circuit, and an output signal circuit. The camshaft position sensor is an internally magnetic biased digital output integrated circuit sensing device. The sensor detects magnetic flux changes of the teeth and slots of a 4-tooth reluctor wheel attached to the camshaft. As each reluctor wheel tooth rotates past the camshaft position sensor, the resulting change in the magnetic field is used by the sensor electronics to produce a digital output pulse. The sensor returns a digital ON/OFF DC voltage pulse of varying frequency with 4 varying width output pulses per camshaft revolution that represent an image of the camshaft reluctor wheel. The frequency of the camshaft position sensor output depends on the velocity of the camshaft. The ECM decodes the narrow and wide tooth pattern to identify camshaft position. This information is then used to determine the optimum ignition and injection points of the engine. The ECM uses the camshaft position sensor to determine injector and ignition system synchronization. The ECM uses camshaft position sensor output information to determine the camshaft relative position to the crankshaft to control camshaft phasing and limp-home operation.

Conditions for Running the DTC

P0340 Condition 1

- DTCs P0101, P0102, and P0103 are not set.

- The airflow into the engine is greater than 3 g/s.

  OR

- The starter is engaged and the engine control module detects camshaft position sensor pulses.

Condition 2

- The engine is running.
- The starter is not engaged.

Condition 3

- DTC P0335 or P0336 are not set.
- The crankshaft is synchronized.
- The starter is engaged.

Condition 4

- DTC P0335 or P0336 are not set.
- The crankshaft is synchronized.

P0341 Condition 1

- DTC P0335 or P0336 are not set.
- The crankshaft is synchronized.
- The starter is engaged.

Condition 2

- DTC P0335 or P0336 are not set.
- The crankshaft is synchronized.

The DTCs run continuously once the above conditions are met.

Conditions for Setting the DTC

P0340 Condition 1

- The ECM does not detect a camshaft position sensor pulse for greater than 5.5 s.

  OR

- The ECM does not detect a camshaft position sensor pulse for greater than 4.0 s since the time the starter has been engaged.

Condition 2

The ECM detects less than 4 camshaft position sensor pulse for greater than 3.0 s.

Condition 3

The ECM does not detect a camshaft position sensor pulse during the first 2 engine revolutions.

Condition 4

The ECM does not detect a camshaft position sensor pulse during 200 engine revolutions.

P0341 Condition 1

- The ECM detects less than 4 camshaft position sensor pulses during 2 engine revolutions.

  OR

- The ECM detects greater than 8 camshaft position sensor pulses during 2 engine revolutions.

Condition 2

The ECM detects less than 398 or greater than 402 camshaft position sensor pulses during 200 engine revolutions.

Action Taken When the DTC Sets

- DTCs P0340 and P0341 are Type B DTCs.
- The camshaft position actuator is commanded to the Home or Parked position.
- The ignition system defaults to a failed camshaft position sensor limp home mode.

Conditions for Clearing the MIL/DTC

DTCs P0340 and P0341 are Type B DTCs.

Diagnostic Aids

- With a DTC set, the engine may crank for an extended period of time at start-up.
- The camshaft position sensor is used for injector and ignition system synchronization. A stalling condition will occur if the camshaft position sensor signal is intermittent and a DTC will not set. Inspect all camshaft position sensor circuits for poor connections.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

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- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0641 is not set.
   - **If the DTC is set**

     Refer to **DTC P0641, P0651, P0697, or P06A3**.

   - **If the DTC is not set**
3. Engine Running.
4. Verify the scan tool Camshaft Position Active Counter parameter increments.
   - **If the counter does not increment**

     Refer to Circuit/System Testing.

   - **If the counter increments**
5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
7. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B23 Camshaft Position Sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal 2 and ground.
   - **If 5 Ω or greater**
   1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If 2 Ω or less, replace the K20 Engine Control Module.

- **If less than 5 Ω**

3. Ignition ON.
4. Test for 4.8-5.2 V between the 5 V reference circuit terminal 1 and ground.
    - **If less than 4.8 V**
    1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the 5 V reference circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance.
    3. Test for less than 2 Ω in the 5 V reference circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If greater than 5.2 V**
    1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the 5 V reference circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If between 4.8-5.2 V**
5. Test for 4.8-5.2 V between the signal circuit terminal 3 and ground.
    - **If less than 4.8 V**
    1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance.
    3. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If greater than 5.2 V**
    1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit and ground.

    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.
  - **If between 4.8-5.2 V**
6. Verify DTC P0341 is not set.
  - **If the DTC is set**

    Inspect for the conditions listed below:

  - Excessive play or looseness of the B23 Camshaft Position Sensor or the reluctor wheel
  - Improper installation of the B23 Camshaft Position Sensor
  - Foreign material passing between the B23 Camshaft Position Sensor and the reluctor wheel
  - Damaged reluctor wheel
  - Excessive air gap between the B23 Camshaft Position Sensor and the reluctor wheel
  - Engine oil for debris
  - Timing chain, tensioner, and sprockets for wear or damage
    - If any of the conditions above are found, repair as necessary.
    - If all components test normal, test or replace the B23 Camshaft Position Sensor.
  - **If the DTC is not set**
7. Test or replace the B23 Camshaft Position Sensor.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Camshaft Position Sensor Replacement**
- Refer to **Control Module References** for engine control module replacement, programming, and setup

DTC P0351-P0358, P2300, P2301, P2303, P2304, P2306, P2307, P2309, P2310, P2312, P2313, P2315, P2316, P2318, P2319, P2321, OR P2322: IGNITION COIL CONTROL CIRCUITS (1-8)

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.

- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0351

Ignition Coil 1 Control Circuit

DTC P0352

Ignition Coil 2 Control Circuit

DTC P0353

Ignition Coil 3 Control Circuit

DTC P0354

Ignition Coil 4 Control Circuit

DTC P0355

Ignition Coil 5 Control Circuit

DTC P0356

Ignition Coil 6 Control Circuit

DTC P0357

Ignition Coil 7 Control Circuit

DTC P0358

Ignition Coil 8 Control Circuit

DTC P2300

Ignition Coil 1 Control Circuit Low Voltage

DTC P2301

Ignition Coil 1 Control Circuit High Voltage

DTC P2303

Ignition Coil 2 Control Circuit Low Voltage

DTC P2304

Ignition Coil 2 Control Circuit High Voltage

DTC P2306

Ignition Coil 3 Control Circuit Low Voltage

DTC P2307

Ignition Coil 3 Control Circuit High Voltage

DTC P2309

Ignition Coil 4 Control Circuit Low Voltage

DTC P2310

Ignition Coil 4 Control Circuit High Voltage

DTC P2312

Ignition Coil 5 Control Circuit Low Voltage

DTC P2313

Ignition Coil 5 Control Circuit High Voltage

DTC P2315

Ignition Coil 6 Control Circuit Low Voltage

DTC P2316

Ignition Coil 6 Control Circuit High Voltage

DTC P2318

Ignition Coil 7 Control Circuit Low Voltage

DTC P2319

Ignition Coil 7 Control Circuit High Voltage

DTC P2321

Ignition Coil 8 Control Circuit Low Voltage

DTC P2322

Ignition Coil 8 Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Coil 1 Control	P0300, P2300	P0300, P0351	P0300, P2301	P0300, P0351
Ignition Coil 2 Control	P0300, P2303	P0300, P0352	P0300, P2304	P0300, P0352
Ignition Coil 3 Control	P0300, P2306	P0300, P0353	P0300, P2307	P0300, P0353
Ignition Coil 4 Control	P0300, P2309	P0300, P0354	P0300, P2310	P0300, P0354
Ignition Coil 5 Control	P0300, P2312	P0300, P0355	P0300, P2313	P0300, P0355
Ignition Coil 6 Control	P0300, P2315	P0300, P0356	P0300, P2316	P0300, P0356
Ignition Coil 7 Control	P0300, P2318	P0300, P0357	P0300, P2319	P0300, P0357
Ignition Coil 8 Control	P0300, P2321	P0300, P0358	P0300, P2322	P0300, P0358
Ignition Coil 1 Ground	-	P0300, P0351	-	P0300, P0351
Ignition Coil 2 Ground	-	P0300, P0352	-	P0300, P0352
Ignition Coil 3 Ground	-	P0300, P0353	-	P0300, P0353
Ignition Coil 4 Ground	-	P0300, P0354	-	P0300, P0354

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Coil 5 Ground	-	P0300, P0355	-	P0300, P0355
Ignition Coil 6 Ground	-	P0300, P0356	-	P0300, P0356
Ignition Coil 7 Ground	-	P0300, P0357	-	P0300, P0357
Ignition Coil 8 Ground	-	P0300, P0358	-	P0300, P0358

Circuit/System Description

The ignition system on this engine uses an individual coil for each cylinder. The engine control module (ECM) controls the spark event for each cylinder through the 8 individual ignition control circuits. When the ECM commands the ignition control circuit ON, electrical current will flow through the primary winding of the ignition coil, creating a magnetic field. When a spark event is requested, the ECM will command the ignition control circuit OFF, interrupting current flow through the primary winding. The magnetic field created by the primary winding will collapse across the secondary coil windings, producing a high voltage across the spark plug electrodes. The ECM uses information from the crankshaft position sensor, and the camshaft position sensor for sequencing and timing of the spark events. The ECM monitors each ignition control circuit for improper voltage levels.

Conditions for Running the DTC

- The engine is cranking or running.
- Ignition voltage is greater than 5 V.

The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

The ECM detects that the commanded state of the driver and the actual state of the control circuit do not match.

Action Taken When the DTC Sets

DTCs P0351, P0352, P0353, P0354, P0355, P0356, P0357, P0358, P2300, P2301, P2303, P2304, P2306, P2307, P2309, P2310, P2312, P2313, P2315, P2316, P2318, P2319, P2321, and P2322 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P0351, P0352, P0353, P0354, P0355, P0356, P0357, P0358, P2300, P2301, P2303, P2304, P2306, P2307, P2309, P2310, P2312, P2313, P2315, P2316, P2318, P2319, P2321, and P2322 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Electronic Ignition System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL 26792 HEI Spark Tester

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** **Special Tools (Service Tools)** .

Circuit/System Verification

1. Engine Running.

2. Verify the scan tool parameters listed below do not display Malfunction:
   - Ignition Coil 1-8 Control Circuit High Voltage Test Status
   - Ignition Coil 1-8 Control Circuit Low Voltage Test Status
   - Ignition Coil 1-8 Control Circuit Open Test Status
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing.

   - **If Malfunction is not displayed**
3. Operate the vehicle within the Conditions for Running the DTCs. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
5. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the appropriate T8 Ignition Coil. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the ground circuit terminal 1 and ground.
   - **If 5 Ω or greater**
   1. Ignition OFF.
   2. Test for less than 2 Ω in the ground circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, repair the open/high resistance in the ground connection.
   - **If less than 5 Ω**
3. Engine Running.
4. Verify the scan tool Ignition Coil Control Circuit Low Voltage Test Status does not display Malfunction.

- **If Malfunction is displayed**

1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the control circuit and ground.
    - If less than infinite resistance, repair the short to ground on the control circuit.
    - If infinite resistance, replace the K20 Engine Control Module.

- **If Malfunction is not displayed**

5. Verify the scan tool Ignition Coil Control Circuit High Voltage Test Status does not display Malfunction.

- **If Malfunction is displayed**

1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
2. Test for less than 1 V between the control circuit and ground.
    - If 1 V or greater, repair the short to voltage in the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.

- **If Malfunction is not displayed**

6. Ignition OFF, install a 3 A fused jumper wire between the control circuit terminal 3 and ground, engine Running.
7. Verify the scan tool Ignition Coil Control Circuit Low Voltage Test Status displays Malfunction.

- **If Malfunction is not displayed**

1. Ignition OFF, remove the fused jumper, and disconnect the X3 harness connector at the K20 Engine Control Module.
2. Test for less than 2 Ω in the control circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If Malfunction is displayed**

8. Test or replace the T8 Ignition Coil.

Component Test

NOTE: **You must perform the Circuit/System Testing before proceeding with Component Testing.**

1. Ignition OFF, connect the **EL 26792** HEI spark tester to the appropriate T8 Ignition Coil.
2. Engine Running.
3. Verify the spark output of the T8 Ignition Coil.

- **If no output or the output is weak**

  Replace the T8 Ignition Coil.

- **If the output is normal**

4. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Ignition Coil Replacement**
- Refer to **Control Module References** for engine control module replacement, programming, and setup

DTC P0420 OR P0430: CATALYST SYSTEM LOW EFFICIENCY

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P0420

Catalyst System Low Efficiency Bank 1

DTC P0430

Catalyst System Low Efficiency Bank 2

Circuit/System Description

A 3-way catalyst controls emissions of hydrocarbons, carbon monoxide (CO) and nitrogen oxide (NOx). The catalyst within the converter promotes a chemical reaction, which oxidizes the hydrocarbons and the CO that are present in the exhaust gas. This process converts the hydrocarbons and the CO into water vapor and carbon dioxide (CO2), and reduces the NOx, converting the NOx into nitrogen. The catalyst also stores oxygen. The engine control module (ECM) monitors this process by using heated oxygen sensors (HO2S) that are in the exhaust stream before and after the 3- way

catalyst. The HO2S produces an output signal that the ECM uses to calculate the oxygen storage capacity of the catalyst. This indicates the ability of the catalyst to convert the exhaust emissions efficiently. The ECM monitors the efficiency of the catalyst by monitoring the HO2S during an off-idle, decel fuel cut off (DFCO) event. When the catalyst is functioning properly, the post catalyst HO2S response to the fuel conditions during the DFCO event is slow compared to the response of the pre catalyst HO2S. When the post HO2S response is near that of the pre HO2S, the oxygen storage capability and efficiency of the catalyst may be degraded below an acceptable threshold.

Conditions for Running the DTC

- DTC P0030, P0031, P0032, P0036, P0037, P0038, P0050, P0051, P0052, P0053, P0054, P0056, P0057, P0058, P0059, P0060, P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0128, P0131, P0132, P0133, P0135, P0137, P0138, P013A, P013B, P013C, P013D, P013E, P013F, P0141, P014A, P014B, P0151, P0152, P0153, P0155, P0157, P0158, P015A, P015B, P015C, P015D, P0161, P0171, P0172, P0174, P0175, P0201, P0202, P0203, P0204, P0205, P0206, P0207, P0208, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282, P0283, P0300, P0301, P0302, P0303, P0304, P0305, P0306, P0307, P0308, P1248, P1249, P124A, P124B, P124C, P124D, P16F3, P2101, P2135, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216C, P216E, P216F, P2270, P2271, P2272, or P2273 is not set.
- Engine speed is between 1,000-2,500 RPM to enable the catalyst diagnostic. Once the engine speed is in range, the engine speed must be between 950-2,550 RPM to keep the test enabled.
- Accelerator pedal position is at most 100%.
- Ethanol estimation is not active.
- Evaporative emission (EVAP) purge is not active.
- Post HO2S heaters are ON for greater than 60 s.
- Mass air flow (MAF) is between 4-20 g/s.
- System voltage is between 10-32 V.
- Vehicle speed is between 62-120 km/h (38.5-74.6 MPH) to enable the catalyst diagnostic. To keep the test enabled the vehicle speed is between 58-125 km/h (36-77.7 MPH).
- Catalyst calculated temperature is between 600-900Â°C (1,112-1,652Â°F).
- Engine is operating in closed loop.
- Engine is operating in decel fuel cut off (DFCO).

This diagnostic attempts one test during each valid OFF-idle period once the above conditions have been met. This diagnostic attempts up to 3 tests during each drive cycle.

Conditions for Setting the DTC

The ECM determines that the efficiency of the catalyst has degraded below a calibrated threshold.

Action Taken When the DTC Sets

DTC P0420 and P0430 are Type A DTCs.

Conditions for Clearing the DTC

DTC P0420 and P0430 are Type A DTCs.

Diagnostic Aids

Inspect for the following conditions, which may cause a catalytic converter to degrade:

- Engine misfire
- High engine oil or high coolant consumption
- Retarded spark timing
- Weak or poor spark
- Lean fuel mixture
- Rich fuel mixture
- Damaged oxygen sensor or wiring harness

Reference Information

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify there are no other DTCs set.
    - **If a DTC is set**

Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .

- **If a DTC is not set**

3. Operate the vehicle within the Conditions for Running the DTC.
4. Verify the scan tool Catalyst Monitor Not At Idle Test Conditions Met parameter changes to Yes.
   - **If Yes is not displayed**

     Refer to step 3.

   - **If Yes is displayed**
5. Monitor the scan tool Catalyst Monitor Test State parameter. When the parameter indicates Active, the Catalyst Monitor Test is running.

NOTE: **When the test has completed, the Catalyst Monitor Test Counter Bank 1 and Bank 2 parameters will increment by one and the Catalyst Monitor Test Result Bank 1 and Bank 2 parameters will indicate Passed, Failed or No Result.**

6. Continue to monitor the parameter. When the parameter indicates Inactive, the Catalyst Monitor Test has completed.
   - **If the Catalyst Monitor Test Result Bank 1 or Bank 2 parameter indicates No Result**

     Repeat steps 3-6 until the Test Result parameters indicate Passed or Failed

   - **If the Catalyst Monitor Test Result Bank 1 or Bank 2 parameter indicates Failed**

     Refer to Circuit/System Testing

   - **If the Catalyst Monitor Test Result Bank 1 and Bank 2 parameters indicate Passed**
7. All OK.

Circuit/System Testing

1. Verify the conditions listed below do not exist with either catalytic converter:
   - Dents
   - Severe discoloration caused by excessive temperatures
   - Road damage
   - Internal rattles caused by damaged catalyst substrate

- Restrictions
  - **If a condition is found**

    Replace the catalytic converters.

  - **If no condition is found**

2. Verify the conditions listed below do not exist with the exhaust system:
   - Leaks
   - Restrictions
   - Physical damage
   - Loose or missing hardware
     - **If a condition is found**

       Repair or replace the component as necessary.

     - **If no condition is found**
3. Verify the conditions listed below do not exist with the appropriate B52B heated oxygen sensor 2:
   - Not at the correct torque
   - Damage
     - **If a condition is found**

       Replace the B52B heated oxygen sensor 2 or repair the condition as necessary.

     - **If no condition is found**
4. Test or replace the catalytic converters.

Repair Instructions

- Refer to **Exhaust Leakage**
- Refer to **Heated Oxygen Sensor Replacement - Bank 1 Sensor 2**
- Refer to **Heated Oxygen Sensor Replacement - Bank 2 Sensor 2**
- Perform the HO2S Heater Learn procedure with a scan tool after replacing a heated oxygen sensor.
- Refer to **Restricted Exhaust**

- Refer to **Three-Way Catalytic Converter Replacement** for catalytic converter replacement.

Repair Verification

1. Install any components that have been removed or replaced during diagnosis.
2. Perform any adjustments, programming or setup procedures that are required when a component is removed or replaced.
3. Clear the DTCs with a scan tool.
4. Turn OFF the ignition for 60 s
5. Operate the vehicle within the Conditions for Running the DTC.
6. Verify the scan tool Catalyst Monitor Not At Idle Test Conditions Met parameter changes to Yes.
   - **If Yes is not displayed**

     Refer to step 5.

   - **If Yes is displayed**
7. Monitor the scan tool Catalyst Monitor Test State parameter. When the parameter indicates Active, the Catalyst Monitor Test is running.

   NOTE: **When the test has completed, the Catalyst Monitor Test Counter Bank 1 and Bank 2 parameters will increment by one and the Catalyst Monitor Test Result Bank 1 and Bank 2 parameters will indicate Passed, Failed or No Result.**

8. Continue to monitor the parameter. When the parameter indicates Inactive, the Catalyst Monitor Test has completed.
   - **If the Catalyst Monitor Test Result Bank 1 or Bank 2 parameter indicates No Result**

     Repeat steps 5-8 until the Test Result parameters indicate Passed or Failed

   - **If the Catalyst Monitor Test Result Bank 1 or Bank 2 parameter indicates Failed**

     Refer to Circuit/System Testing

   - **If the Catalyst Monitor Test Result Bank 1 and Bank 2 parameters indicate Passed**
9. All OK.

DTC P0442: EVAPORATIVE EMISSION (EVAP) SYSTEM SMALL LEAK DETECTED

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P0442

Evaporative Emission (EVAP) System Small Leak Detected

Circuit/System Description

The engine off natural vacuum test is the small leak detection diagnostic for the evaporative emission system. This diagnostic tests the evaporative emission (EVAP) system for a small leak when the key is turned OFF and the correct conditions are met. Heat from the exhaust system is transferred into the fuel tank while the vehicle is operating. Prior to running this test fuel volatility is analyzed then factored into this test. When the vehicle is turned OFF and the EVAP system is sealed a change in the fuel tank vapor temperature occurs which results in a corresponding pressure change in the fuel tank vapor space. This change is monitored by the engine control module (ECM) using the fuel tank pressure (FTP) sensor input. With a leak in the system, the amount of pressure change will be less than that of a sealed system.

Conditions for Running the DTC

- DTCs P010B, P012B, P012C, P012D, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0128, P012B, P012C, P012D, P0222, P0223, P0236, P0237, P0238, P0443, P0446, P0449, P0452, P0453, P0455, P0458, P0459, P0461, P0462, P0463, P0496, P0498, P0499, P0502, P0503, P0722, P0723, P111E, P117D, P017C, P017D, P017B, P117B, P117F, P117E, P117C, P2066, P2067, P2068, P1221, P222B, P222C, P222D, P222E, P262B, are not set.
- The barometric pressure (BARO) is greater than 70 kPa.
- The fuel level is between 10-90%.
- The cold start-up engine coolant temperature (ECT) and the start-up intake air temperature (IAT) are within 8Â°C (14Â°F).
- The engine coolant temperature (ECT) is greater than 63Â°C (145Â°F).
- The engine run time before engine shut-off was greater than 10 min.
- The drive distance before engine shut-off was greater than 8 km (5 miles).
- The ambient air temperature at the end of the drive cycle is between 0-34Â°C (32-93Â°F).
- DTC P0442 runs once per drive cycle during the hot soak period after the ignition is turned OFF and may require up to 40 min to complete. The control module will not make more than 2 test attempts per day. The time since the last completed engine off natural vacuum test must be at least 17 h if passed or 10 h if failed.

Conditions for Setting the DTC

- The ECM detects a leak in the EVAP system that is greater than a calibrated amount.
- The ECM must complete several engine off natural vacuum test tests before the diagnostic can turn the MIL ON or OFF.

Action Taken When the DTC Sets

DTC P0442 is a Type A DTC.

Conditions for Clearing the DTC

DTC P0442 is a Type A DTC.

Diagnostic Aids

- The EVAP system can be filled with smoke more quickly and completely by opening the system opposite the end where the smoke is injected. When injecting smoke at the service port tool remove the fuel fill cap, or temporarily leave the vent open, until smoke is observed then close the system and continue testing. If using a fuel cap adapter at the filler neck, use the **EN 41413-VLV** at the service port to allow the system to fill faster.
- To help locate intermittent leaks using the **GE 41413-A** , move all EVAP components while observing smoke with the **GE 41413-SPT** .
- Individual components can be isolated and tested using adapters in the **GE 41413-300** .
- A condition may exist where a leak in the EVAP system only exists under a vacuum condition. This type of leak may be detected by using the scan tool Purge/Seal function to create a vacuum in the EVAP system and then observe the FTP sensor parameter for vacuum decay.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Powertrain Component View

Powertrain Component Views

Description and Operation

Evaporative Emission Control System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

- **CH 48096** EVAP Service Access Port Tool
- **EN 41413-VLV** EVAP Service Port Vent Fitting
- **GE 41413-SPT** High Intensity White Light
- **GE 41413-A** Evaporative Emissions System Tester (EEST)
- **GE 41413-300** EVAP Cap and Plug Kit

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** **Special Tools (Service Tools)**

Circuit/System Testing

NOTE:

- **Refer to the GE 41413-A operation manual for detailed instructions in Evaporative Emission System Diagnosis .**
- **Larger volume fuel tanks and/or those with lower fuel levels may require several minutes for the floating indicator to stabilize or produce smoke.**

- **Ensure that the underbody temperature of the vehicle and the tester are similar.**

1. Disconnect the purge tube at the quick connector on the EVAP canister side of the Q12 Evaporative Emission Canister Purge Solenoid Valve and install the **CH 48096** .
2. Connect the **GE 41413-A** to the **CH 48096** .
3. Command the EVAP Purge/Seal function to Not Venting with a scan tool to seal the EVAP system.
4. Use the flow meter on the **GE 41413-A** , calibrated to 0.51 mm (0.020 in) to determine if there is a leak.
   - **If a leak is detected**
   1. Use the **GE 41413-A** to apply smoke to the EVAP system at the purge tube until the leak is located using the **GE 41413-SPT** .
      - If leak is detected, repair or replace the affected component as necessary.
   - **If no leak is detected**
5. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

DTC P0443, P0458, OR P0459: EVAPORATIVE EMISSION (EVAP) PURGE SOLENOID VALVE CONTROL CIRCUIT

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0443

Evaporative Emission (EVAP) Purge Solenoid Valve Control Circuit

DTC P0458

Evaporative Emission (EVAP) Purge Solenoid Valve Control Circuit Low Voltage

DTC P0459

Evaporative Emission (EVAP) Purge Solenoid Valve Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition	P0030, P0031, P0033, P0034, P0050, P0051, P0443, P0458, P06DA, P06DB, P3403, P3427, P3443, P03451	P0030, P0031, P0033, P0034, P0050, P0051, P0443, P0458, P06DA, P3403, P3427, P3443, P3451	P0690	-
Control	P0443, P0458	P0443, P0458	P0459, P0690	-

Circuit/System Description

The evaporative emission (EVAP) purge solenoid valve is used to purge fuel vapor from the EVAP canister to the intake manifold. The EVAP purge solenoid valve is pulse width modulated (PWM). Ignition voltage is supplied directly to the EVAP purge solenoid valve. The engine control module (ECM) controls the solenoid valve by grounding the control circuit with a solid state device called a driver. The driver is equipped with a feedback circuit that is pulled-up to a voltage. The ECM can determine if the control circuit is open, shorted to ground, or shorted to a voltage by monitoring the feedback voltage.

Conditions for Running the DTC

- The ignition voltage is greater than 11 V.
- The DTCs run continuously once the above conditions are met.

Conditions for Setting the DTC

P0443

The ECM detects the EVAP purge solenoid valve control circuit is open within 0.25 s.

P0458

The ECM detects the EVAP purge solenoid valve control circuit is shorted to ground within 0.25 s.

P0459

The ECM detects the EVAP purge solenoid valve control circuit is shorted to voltage within 0.25 s.

Action Taken When the DTC Sets

DTC P0443, P0458 and P0459 are Type B DTCs.

Conditions for Clearing the DTC

DTC P0443, P0458 and P0459 are Type B DTCs.

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- **Connector Repairs**
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- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

NOTE: **The audible clicking intensity will vary depending on mounting locations and interference with the fuel injectors clicking. You may also feel a change in the frequency of clicking.**

1. Ignition ON.
2. Verify the EVAP Purge Solenoid Valve control circuit status parameters while commanding the solenoid from 0% to 50% and back to 0% with a scan tool:
   - EVAP Purge Solenoid Valve Control Circuit Open Test Status
   - EVAP Purge Solenoid Valve Control Circuit Low Voltage Test Status
   - EVAP Purge Solenoid Valve Control Circuit High Voltage Test Status
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing.

   - **If Malfunction is not displayed**
3. Verify the EVAP Purge Solenoid Valve Control Circuit parameters above do not display Malfunction when moving the related harnesses and connectors of the Q12 Evaporative Emission Purge Solenoid Valve.
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing.

   - **If Malfunction is not displayed**
4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
5. Verify the DTC does not set.
   - **If the DTC sets**

Refer to Circuit/System Testing.

- **If the DTC does not set**

6. All OK.

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the Q12 Evaporative Emission Purge Solenoid Valve. Ignition ON,
2. Verify that a test lamp illuminates between the ignition voltage circuit terminal B or 1 and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition OFF, remove the test lamp.
   2. Test for less than 2 Ω in the ignition circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse
   - **If the test lamp does not illuminate and the circuit fuse is open**
   1. Ignition OFF, remove the test lamp.
   2. Test for infinite resistance between the ignition circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, test all components connected to the ignition voltage circuit for a short and replace as necessary.
   - **If the test lamp illuminates**
3. Verify that a test lamp does not illuminate between the ignition circuit terminal B or 1 and the control circuit terminal A or 2.
   - **If the test lamp illuminates**
   1. Ignition OFF, remove the test lamp, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the control circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.
   - **If the test lamp does not illuminate**
4. Remove the test lamp.
5. Verify the EVAP Purge Solenoid Valve Control Circuit High Voltage Test Status parameter is OK when commanding the EVAP Purge Solenoid Valve to 50% with a scan tool.
   - **If OK is not displayed**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the control circuit and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.

- **If OK is displayed**

6. Install a 3 A fused jumper wire between the control circuit terminal A or 2 and the ignition circuit terminal B or 1.
7. Verify the EVAP Purge Solenoid Valve Control Circuit High Voltage Test Status parameter is Malfunction when commanding the EVAP Purge Solenoid Valve to 50% with a scan tool.

- **If Malfunction is not displayed**

1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module.
2. Test for less than 2 Ω in the control circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω replace the K20 Engine Control Module.

- **If Malfunction is displayed**

8. Test or replace the Q12 Evaporative Emission Purge Solenoid Valve.

Component Testing

Static Test

1. Ignition OFF, disconnect the harness connector at the Q12 Evaporative Emission Purge Solenoid Valve.
2. Test for 10-30 Ω between the control terminal A or 2 and the ignition, terminal B or 1.

- **If not between 10-30 Ω**

  Replace the Q12 Evaporative Emission Purge Solenoid Valve.

- **If between 10-30 Ω**

3. All OK.

Dynamic Test

1. Ignition OFF, disconnect the harness connector at the Q12 Evaporative Emission Purge Solenoid Valve.
2. Install a 3 A fused jumper wire between the ignition terminal B or 1 and 12 V. Install a jumper wire between the control terminal A or 2 and

ground.

3. Verify the Evaporative Emission Purge Solenoid Valve turns on & off/clicks and flows vacuum.
   - **If it does not turn on & off/click or flow vacuum.**

     Replace the Q12 Evaporative Emission Purge Solenoid Valve.

   - **If it does turn on & off/clicks and flows vacuum.**
4. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Control Module References** for ECM replacement, programming and setup
- Refer to **Evaporative Emission Canister Purge Solenoid Valve Replacement**

DTC P0446: EVAPORATIVE EMISSION (EVAP) VENT SYSTEM PERFORMANCE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P0446

Evaporative Emission (EVAP) Vent System Performance

Typical Scan Tool Data

Fuel Tank Pressure Sensor Signal Voltage	Fuel Tank Pressure
1.5 V	Atmospheric Pressure / BARO
Less than 1.5 V	Positive Pressure
More than 1.5 V	Negative Pressure / Vacuum

Circuit/System Description

This DTC tests the evaporative emission (EVAP) system for a restricted or blocked EVAP vent path that would cause excess amounts of vacuum to be developed in the EVAP system. The engine control module (ECM) commands the EVAP purge solenoid valve Open and the EVAP vent solenoid valve Closed. This allows vacuum to be applied to the EVAP system. Once a calibrated vacuum level has been reached, the ECM commands the EVAP purge solenoid valve Closed and the EVAP vent solenoid valve Open. The ECM monitors the fuel tank pressure (FTP) sensor for a decrease in vacuum. If the vacuum does not decrease to near 0 in H2O in a calibrated time, this DTC sets.

The table listed below illustrates the relationship between the ON and OFF states, and the OPEN or CLOSED states of the EVAP purge and vent solenoid valves.

ECM Command	EVAP Purge Solenoid Valve	EVAP Vent Solenoid Valve
ON	Open	Closed, Not Venting
OFF	Closed	Open, Venting

Conditions for Running the DTC

- DTC P0068, P00C8, P00C9, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0121, P0122, P0123, P0128, P0191, P0192, P0193, P0222, P0223, P0443, P0601, P0604, P0606, P16A0, P16A1, P16A2, P16F3, P2101, P2135, P2176, is not set.
- The ignition voltage is between 11-32 V.
- The start up intake air temperature (IAT) is between 4-34Â°C (39-93Â°F).
- The start up engine coolant temperature (ECT) is less than 35Â°C (95Â°F)
- The barometric pressure (BARO) is greater than 70 kPa.
- The fuel level is between 10-90%.
- This test will start and run once per cold start for no greater than 17 min.

Conditions for Setting the DTC

NOTE: **There are two stages to setting this DTC. Stage one, prep test, then stage two test.**

- If fuel tank pressure sensor reading is greater than 2.5 in H2O of pressure or less than -5 in H2O of vacuum for 60 s.

  OR

- If fuel tank pressure sensor reading is less than -12 in H2O of vacuum for 5 s before 10 L (2.6 gal) of purge volume.

- After setting the DTC for the first time, 2 L (0.5 gal) of fuel must be consumed before setting the DTC for the second time.

Action Taken When the DTC Sets

DTC P0446 is a Type B DTC.

Conditions for Clearing the DTC

DTC P0446 is a Type B DTC.

Diagnostic Aids

An intermittent condition could be caused by:

- A damaged EVAP vent housing
- A temporary blockage at the EVAP vent solenoid valve inlet
- Pinched vent hose

A blockage in the vent system may also cause a poor fuel fill problem

Reference Information

Schematic Reference

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Connector End View Reference

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- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

- CH 41415-30 Fuel Tank Cap Adapter
- GE 41413-A Evaporative Emissions System Tester (EEST)

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** **Special Tools (Service Tools)** .

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0449, P0498 or P0499 is not set.
    - **If any DTC is set**

      Refer to **DTC P0449, P0498, or P0499**.

    - **If the DTC is not set**
3. Ignition OFF, remove the fuel tank filler cap. Ignition ON.
4. Verify the scan tool Fuel Tank Pressure Sensor voltage parameter is between 1.3-1.7 V.
    - **If not between the 1.3-1.7 V**

      Refer to P0452, P0453 within **DTC P0451-P0454**.

    - **If between the 1.3-1.7 V**

5. Install the fuel tank filler cap. Engine idling at operating temperature for 5 min,
6. Verify the scan tool Fuel Tank Pressure Sensor parameter does not increase to greater than 2.5 V when commanding the EVAP Purge Solenoid Valve to 50%.
   - **If greater than 2.5 V**

     Refer to Circuit System Testing.

   - **If 2.5 V or less**
7. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
   - **If the DTC sets**

     Refer to Circuit System Testing.

   - **If the DTC does not set**
8. All OK.

Circuit/System Testing

NOTE: **Perform the Circuit/System Verification before proceeding with the Circuit/System Testing.**

1. Test for a blockage or restrictions in the EVAP system components listed below and repair as necessary.
   - Evaporative Emission Vent System Hoses
   - Evaporative Emission Canister
   - Q13 Evaporative Emission Vent Solenoid Valve
   - Evaporative Emission Vent Filter
2. Reconnect all previously disconnected EVAP hardware.

   NOTE: **Refer to the GE-41413-A operation manual for detailed instructions in Evaporative Emission System Diagnosis .**

3. Remove the fuel fill cap and connect the CH 41415-30 to the fuel tank filler neck. Connect the GE 41413-A to the CH 41415-30.
4. Command the EVAP Purge/Seal function to Not Venting with a scan tool to seal the EVAP system.
5. Turn the nitrogen/smoke valve on the GE 41413-A to nitrogen.

NOTE: **DO NOT exceed the specified value in this step. Exceeding the specified value may produce incorrect test results.**

6. Use the remote switch to activate the GE 41413-A and pressurize the fuel tank to 5.0 in H20.
7. Verify the scan tool Fuel Tank Pressure Sensor parameter is 0 in H20 when commanding the EVAP Vent Solenoid Valve to OFF.
   - **If not 0 in H20**

     Test for a blockage or a restriction in the EVAP vent hose or inlet. If the inlet or hose test normal, replace the Q13 Evaporative Emission Vent Solenoid Valve.

   - **If 0 in H20**
8. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
   - **If the DTC sets**

     Refer to step 1 above.

   - **If the DTC does not set**
9. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Evaporative Emission Canister Replacement**
- Refer to **Evaporative Emission Canister Solenoid Replacement** for EVAP Vent Solenoid Valve replacement.
- Refer to **Fuel Tank Pressure Sensor Replacement (SWB)** **Fuel Tank Pressure Sensor Replacement (LWB)**

DTC P0449, P0498, OR P0499: EVAPORATIVE EMISSION (EVAP) VENT SOLENOID VALVE CONTROL CIRCUIT

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0449

Evaporative Emission (EVAP) Vent Solenoid Valve Control Circuit

DTC P0498

Evaporative Emission (EVAP) Vent Solenoid Valve Control Circuit Low Voltage

DTC P0499

Evaporative Emission (EVAP) Vent Solenoid Valve Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
B+	P0498	P0449	-	-
Control	P0498	P0449	P0499, P0690	-

Circuit/System Description

Battery voltage is supplied to the evaporative emission (EVAP) vent solenoid valve through a fuse. The engine control module (ECM) grounds the EVAP vent solenoid valve control circuit through an internal switch called a driver. The ECM monitors the status of the driver. A scan tool will display the commanded state of the EVAP Vent Solenoid Valve as Not Venting (On) or Venting (Off).

Conditions for Running the DTC

The DTCs run continuously once the above conditions are met.

Conditions for Setting the DTC

P0449

The ECM detects the EVAP vent solenoid valve control circuit is open within 0.25 s.

P0498

The ECM detects the EVAP vent solenoid valve control circuit is shorted to ground within 0.25 s.

P0499

The ECM detects the EVAP vent solenoid valve control circuit is shorted to voltage within 0.25 s.

Action Taken When the DTC Sets

DTC P0449, P0498 and P0499 are Type B DTCs.

Conditions for Clearing the DTC

DTC P0449, P0498 and P0499 are Type B DTCs.

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- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

NOTE: **An audible click may be heard when performing step 2 below.**

1. Ignition ON.
2. Verify the following control circuit status parameters while command the EVAP Vent Solenoid Valve to Not Venting and Venting with a scan tool:
   - EVAP Vent Solenoid Valve Control Circuit Open Test Status
   - EVAP Vent Solenoid Valve Control Circuit Low Voltage Test Status
   - EVAP Vent Solenoid Valve Control Circuit High Voltage Test Status
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing.

   - **If Malfunction is not displayed**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
5. All OK.

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the Q13 Evaporative Emission Vent Solenoid Valve, Ignition ON.

2. Verify that a test lamp illuminates between the B+ circuit terminal A or 2 and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition OFF, remove the test lamp.
   2. Test for less than 2 Ω in the B+ circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**
   1. Ignition OFF, remove the test lamp.
   2. Test for infinite resistance between the B+ circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, test all components connected to the B+ circuit for a short and replace as necessary.
   - **If the test lamp illuminates**
3. Verify that a test lamp does not illuminate between the B+ circuit terminal A or 2 and the control circuit terminal B or 1.
   - **If the test lamp illuminates**
   1. Ignition OFF, remove the test lamp, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the control circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.
   - **If the test lamp does not illuminate**
4. Remove the test lamp.
5. Verify the scan tool EVAP Vent Solenoid Valve Control Circuit High Voltage Test Status parameter is OK when commanding the EVAP Vent Solenoid Valve to Not Venting with a scan tool.
   - **If OK is not displayed**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, Ignition ON.
   2. Test for less than 1 V between the control circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If OK is displayed**
6. Install a 3 A fused jumper wire between the control circuit terminal B or 1 and the B+ circuit terminal A or 2.

7. Verify the scan tool EVAP Vent Solenoid Valve Control Circuit High Voltage Test Status parameter is Malfunction when commanding the EVAP Vent Solenoid Valve to Not Venting with a scan tool.
   - **If Malfunction is not displayed**
   1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the control circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω replace the K20 Engine Control Module.
   - **If Malfunction is displayed**
8. Test or replace the Q13 Evaporative Emission Vent Solenoid Valve.

Component Testing

1. Ignition OFF, disconnect the harness connector at the Q13 Evaporative Emission Vent Solenoid Valve.
2. Test for 10-30 Ω between the control terminal B or 1 and the B+ circuit terminal A or 2.
   - **If not between 10-30 Ω**

     Replace the Q13 Evaporative Emission Vent Solenoid Valve.

   - **If between 10-30 Ω**
3. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Control Module References** for ECM replacement, programming and setup
- Refer to **Evaporative Emission Canister Solenoid Replacement** for EVAP Vent Solenoid Valve replacement.

DTC P0451-P0454: FUEL TANK PRESSURE SENSOR

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0451

Fuel Tank Pressure Sensor Performance

DTC P0452

Fuel Tank Pressure Sensor Circuit Low Voltage

DTC P0453

Fuel Tank Pressure Sensor Circuit High Voltage

DTC P0454

Fuel Tank Pressure Sensor Circuit Intermittent

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
5 V Reference	P018C, P0192, P0452, P0522, P0532, P0641, P127C, P2227, P2228	P0451	P0446, P0452	P018D, P0193, P0453, P0523, P0533, P0641, P127D, P2227	-
Signal	P0192, P0452, P0641, P2230	P0451	P0452, P0453	P0453	P0451, P0454
Low Reference	-	P0446, P0451	P0446, P0453, P0463	-	P0451

Typical Scan Tool Data

Fuel Tank Pressure Sensor Voltage

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Ignition ON, Engine OFF **Parameter Normal Range:** 1.3-1.7 V			

Circuit	Short to Ground	Open	Short to Voltage
5 V Reference	0 V	0 V	4.2-5 V
Signal	0 V	0 V	5 V
Low Reference	-	4.5 V	-

Circuit/System Description

The fuel tank pressure sensor measures vapor pressure or vacuum in the evaporative emission (EVAP) system. The engine control module (ECM) supplies a 5 V reference and a low reference circuit to the fuel tank pressure sensor. The fuel tank pressure sensor signal voltage varies depending on EVAP system pressure or vacuum. The control module also uses this fuel tank pressure signal to determine atmospheric pressure for use in the engine-off small leak test, DTC P0442. Before using this signal as an atmospheric reference it must first be re-zeroed.

Conditions for Running the DTC

P0451

- DTC P0451 runs only when the engine-off natural vacuum small leak test, P0442, executes.
- The number of times this test runs can range from 0-2 per engine-off period.
- The length of the test can be up to 10 min.

P0452 and P0453

DTC P0452 and P0453 run continuously when the ignition is ON.

P0454

- DTC P0454 runs only when the engine-off natural vacuum small leak test, P0442, executes.
- This test can run once per engine-off period. The length of the test can be up to 10 min.
- A refueling event is not detected. A refueling event is confirmed if the fuel level has a persistent change of 10% for 30 s during a 10 min refueling rationality test.

Conditions for Setting the DTC

P0451

- This DTC will set if the controller is unable to re-zero the fuel tank pressure sensor voltage within a calibrated range during the engine-off small leak test, P0442.

- The ECM must complete several engine off natural vacuum test tests before the diagnostic can turn the MIL ON or OFF.

P0452

The fuel tank pressure sensor voltage is less than 0.15 V for greater than 10 s.

P0453

The fuel tank pressure sensor voltage is more than 4.85 V for greater than 10 s.

P0454

- If, during the engine-off natural vacuum small leak test, P0442, the ECM detects an abrupt fuel tank pressure signal change, other than a refueling event, this DTC will set. An abrupt change is defined as a change of greater than 0.45 in H2O in the span of 1 s but less than 1 in H2O in 12.5 ms.
- This test must fail twice in three samples to set this DTC.

Action Taken When the DTC Sets

- DTCs P0451 and P0454 are Type A DTCs.
- DTCs P0452 and P0453 are Type B DTCs.

Conditions for Clearing the MIL/DTC

- DTCs P0451 and P0454 are Type A DTCs.
- DTCs P0452 and P0453 are Type B DTCs.

Diagnostic Aids

P0451 and P0454

- A restriction in the EVAP canister or vent lines could prevent fuel vapor pressure from bleeding off fast enough. If the vent system cannot bleed off pressure fast enough, the re-zero procedure may not complete successfully, which could cause this code to set.
- Ensure that the reference port on the fuel tank pressure sensor is unobstructed.
- An fuel tank pressure sensor that is skewed or does not have a linear transition from low to high may cause this DTC to set. Scan tool Control Functions, snapshot, and plot functions can help detect erratic sensor response. To test the sensor signal under vacuum conditions, use the Quick Snapshot and the Purge/Seal functions to capture data while commanding purge to 20%, then plot the data to look for erratic sensor

operation. A similar test can be done for the pressure side of the sensor operation by applying pressure with the **GE 41413-A** while taking a snapshot.

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- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

GE 41413-A Evaporative Emission System Tester (EEST)

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** **Special Tools (Service Tools)**

Circuit/System Verification

1. Remove the fuel cap.
2. Ignition ON, engine OFF.
3. Verify the scan tool Fuel Tank Pressure Sensor parameter is between 1.3 and 1.7 V.
   - **If not between 1.3-1.7 V**

     Refer to Circuit/System Testing

   - **If between 1.3-1.7 V**
4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
5. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
6. All OK.

Circuit/System Testing

1. Ignition OFF, all vehicle systems OFF, this may take up to 2 min, for all vehicle systems to power down. Disconnect the harness connector at the B150 Fuel Tank Pressure Sensor.
2. Test for less than 5 Ω of resistance between the low reference circuit terminal 2 and ground.
   - **If 5 Ω or greater**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.

- **If less than 5 Ω**

3. Ignition ON.
4. Test for 4.8-5.2 V between the 5 V reference circuit terminal 3 and ground.
    - **If less than 4.8 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the 5 V reference circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 Ω in the 5 V reference circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If greater than 5.2 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the 5 V reference circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If between 4.8-5.2 V**
5. Verify the scan tool Fuel Tank Pressure parameter is less than 0.2 V.
    - **If 0.2 V or greater**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON
    2. Test for less than 1 V between the signal circuit terminal 1 and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.
    - **If less than 0.2 V**
6. Install a 3 A fused jumper wire between the signal circuit terminal 1 and the 5 V reference circuit terminal 3.
7. Verify the scan tool Fuel Tank Pressure Sensor parameter is greater than 4.7 V.
    - **If 4.7 V or less**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit terminal 1 and ground.

- If less than infinite resistance, repair the short to ground on the circuit.
- If infinite resistance

3. Test for less than 2 Ω in the signal circuit end to end.

- If 2 Ω or greater, repair the open/high resistance in the circuit.
- If less than 2 Ω, replace the K20 Engine Control Module.
- **If greater than 4.7 V**

8. Test or replace the B150 Fuel Tank Pressure Sensor.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Control Module References** for ECM replacement, programming and setup
- Refer to **Fuel Tank Pressure Sensor Replacement (SWB)** **Fuel Tank Pressure Sensor Replacement (LWB)**

DTC P0455: EVAPORATIVE EMISSION (EVAP) SYSTEM LARGE LEAK DETECTED

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P0455

Evaporative Emission (EVAP) System Large Leak Detected

Circuit/System Description

The engine control module (ECM) tests the evaporative emission (EVAP) system for a large leak or restrictions to the purge path in the EVAP system. When the enabling criteria has been met the ECM commands the EVAP vent solenoid valve and purge solenoid valve ON, allowing vacuum into the EVAP system. The ECM monitors the fuel tank pressure (FTP) sensor voltage to verify that the system is able to reach a predetermined level of vacuum before a calibrated amount of purge volume has passed through the system.

Conditions for Running the DTC

- DTCs P0068, P00C8, P00C9, P00CA, P0090, P0091, P0092, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114 P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0128, P012B, P012C, P012D, P017B, P017C, P017D, P0191, P0192, P0193, P0222, P0223, P06A3, P06DB, P06DE, P0A1D, P0443, P0449, P0452, P0454, P0453, P0458, P0459, P0498, P0499, P0502, P0503, P0601, P0604, P0606, P0697, P0722, P0723, P111E, P117B, P117C, P117D, P117E, P117F, P160D, P160E, P1682, P16A0, P16A1, P16A2, P16F3, P1104, P127A, P127C, P127D, P15F2, P1221, P2100, P2101, P2102, P2103, P2122, P2123, P2127, P2128, P2135, P2138, P215B, P2176, P2227, P2228, P2229, P2230, P228C, P228D, U0073, U0074, U0293, U1817 is not set.
- The ignition voltage is greater than 11 V
- The barometric pressure (BARO) is greater than 70 kPa
- The fuel level is between 10-90%
- The cold startup engine coolant temperature (ECT) and the startup intake air temperature (IAT) are within 8Â°C (14Â°F)
- The engine coolant temperature (ECT) at start-up is less than 35Â°C (95Â°F)
- The intake air temperature (IAT) is between 4-34Â°C (39-93Â°F)
- DTC P0455 runs once per cold start shortly after purge is enabled followed by vent system performance test P0446

Conditions for Setting the DTC

- The EVAP system is not able to achieve or maintain a calibrated level of vacuum less than 2.74 kPa (11 in H2O) before a calibrated amount of purge volume has passed through the system.
- After setting the DTC for the first time, 2 L (0.5 gal) of fuel must be consumed before setting this DTC a second time.

Action Taken When the DTC Sets

DTC P0455 is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P0455 is a Type B DTC.

Diagnostic Aids

- Inspect for a loose, missing or damaged, capless fuel fill flappers.
- A blockage or restriction in the EVAP purge solenoid valve, purge pipe, canister, or vapor pipe, can cause this DTC to set.
- The EVAP system can be filled with smoke more quickly and completely by opening the system opposite the end where the smoke is injected. For example, when injecting smoke at the service port open the fuel fill flapper valves with **CH-44284-2** , or temporarily leave the vent open, until smoke is observed, then close the system and continue testing. If using the capless fuel fill adapter at the filler neck, use the **J-41413-VLV**

at the service port to allow the system to fill faster.

- To help locate intermittent leaks using the **GE-41413-A** , move all EVAP components while observing smoke with the **GE-41413-SPT** .
- Individual components can be isolated and tested using adapters in the **GE-41413-300** .
- When servicing the EVAP system, test pressure must not exceed 13 in H20 (0.5 PSI) as pressure in excess of this could cause system components to perform inaccurately.
- A condition may exist where a leak in the EVAP system only exists under a vacuum condition. This type of leak may be detected by using the scan tool Purge/Seal function to create a vacuum in the EVAP system and then observe the Fuel Tank Pressure Sensor parameter for vacuum decay.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Powertrain Component View

Powertrain Component Views

Description and Operation

Evaporative Emission Control System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

- **CH-44284-2** Fuel Flapper Door Holder
- **CH-48096** Evaporative Emissions Service Access Port Tool
- **GE-41415-60** Capless Fuel Fill Adapter
- **GE-41413-A** Evaporative Emissions System Tester (EEST)
- **GE-41413-SPT** High Intensity White Light
- **GE-41413-300** Evaporative Emissions Cap and Plug Kit
- **J-41413-VLV** Evaporative Emissions Service Port Vent Tool

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** **Special Tools (Service Tools)** .

Circuit/System Verification

1. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
2. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
3. All OK.

Circuit/System Testing

NOTE:

- **Larger volume fuel tanks and/or those with lower fuel levels may require several minutes for the floating indicator to stabilize.**
- **Refer to the GE-41413-A operation manual for detailed instructions in Evaporative Emission System Diagnosis .**

NOTE: **This vehicle has a capless fuel fill design that requires the use of CH-44284-2 to hold the two flapper valves open.**

- **Install this tool so that the raised rib nests just inside the flapper door outer lip. The flappers will hold it in place.**
- **Be careful the force of the flapper doesn't push the tool back out.**
- **Do not insert tool any further into the fuel neck or it may get stuck or fall into the lower fill tube.**

NOTE: **The GE-41415-60 is a dual purpose tool used for EVAP testing and diesel induction leak testing. It has two positions for the rubber stopper, identified on the tube by a letter A and B. Slide the stopper to just above either line depending on the test performed.**

- **Letter A position line is for diesel induction leak testing**
- **Letter B position line is for EVAP testing**

1. Disconnect the purge tube at the quick connector on the EVAP canister side of the Q12 Evaporative Emission Purge Solenoid Valve. Install the **CH-48096** between the disconnected purge tube and the purge solenoid valve.
2. Connect the **GE-41413-A** to the **CH-48096** .
3. Command the EVAP Purge/Seal function to Not Venting with a scan tool to seal the EVAP system.
4. Verify that there is no leak in the EVAP system using the flow meter on the **GE-41413-A** , calibrated to 0.51 mm (0.020 in).
   - **If a leak is detected**
   1. Apply smoke to the **CH-48096** with the **GE-41413-A** .
   2. Locate the leak using the **GE-41413-SPT** .
      - When the leak is located, repair or replace the affected component as necessary.
   - **If no leak detected**

     NOTE: **The steps below test for a restriction in the purge path.**

     NOTE: **Install the GE-41415-60 , with the tube pointing toward the ground, into the capless fuel fill opening. Wedge the stopper into the opening with just enough force to retain this tools threaded end pointing out, parallel within the opening.**

5. Install the **GE-41415-60** into the capless fuel fill opening.
6. Connect the **GE-41413-A** nitrogen/smoke hose to the **GE-41415-60** .
7. Engine idling, command the Purge/Seal function to Not Venting with a scan tool to seal the system.
8. Command the EVAP Purge Solenoid Valve to 30% with a scan tool.
9. Verify the vacuum/pressure gauge on the **GE-41413-A** and the scan tool Fuel Tank Pressure Sensor parameter both show vacuum.
    - **If the vacuum/pressure gauge shows vacuum but the Fuel Tank Pressure Sensor parameter does not show vacuum**

      Replace the B150 Fuel Tank Pressure Sensor.

    - **If both do not show vacuum**

      Repair the restriction in the purge path.

    - **If both show vacuum**
10. Verify that the Fuel Tank Pressure Sensor parameter increases to greater than 3.2 V, and the pressure values are similar between the scan tool Fuel Tank Pressure Sensor and the vacuum/pressure gauge on the **GE-41413-A** .
    - **If not within the specified range**

      Replace the B150 Fuel Tank Pressure Sensor.

    - **If within the specified range**
11. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

Refer to **Fuel Tank Pressure Sensor Replacement (SWB)** **Fuel Tank Pressure Sensor Replacement (LWB)**

DTC P0496: EVAPORATIVE EMISSION (EVAP) SYSTEM FLOW DURING NON-PURGE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P0496

Evaporative Emission (EVAP) System Flow During Non-Purge

Circuit/System Description

This DTC tests for undesired intake manifold vacuum flow to the evaporative emission (EVAP) system. The engine control module (ECM) seals the EVAP system by commanding the EVAP purge solenoid valve OFF and the vent solenoid valve ON. The ECM monitors the fuel tank pressure (FTP) sensor to determine if a vacuum is being drawn on the EVAP system. If vacuum in the EVAP system is more than a predetermined value within a predetermined time, this DTC sets.

The table listed below illustrates the relationship between the ON and OFF states, and the Open or Closed states of the EVAP purge and vent solenoid valves.

ECM Command	EVAP Purge Solenoid Valve	EVAP Vent Solenoid Valve
ON	Open	Closed
OFF	Closed	Open

Conditions for Running the DTC

- DTCs P0068, P00C8, P00C9, P00CA, P0090, P0091, P0092, P0106, P0107, P0108, P0111, P0112, P0113, P0114 P0116, P0117, P0118, P0122, P0123, P0128, P0191, P0192, P0193, P0222, P0223, P06A3, P06DB, P06DE, P0A1D, P160D, P160E, P1682, P16A0, P16A1, P16A2, P16F3, P1104, P127A, P127C, P127D, P15F2, P0443, P0449, P0452, P0453, P0454, P0502, P0503, P0601, P0604, P0606, P0697, P2100, P2101, P2102, P2103, P2122, P2123, P2127, P2128, P2135, P2138, P215B, P2176, P228C, P228D, U0073, U0074, U0293, U1817 are not set.
- The ignition voltage is between 11-32 V.
- The engine OFF time is greater than 48 min,
- The barometric pressure (BARO) is greater than 70 kPa.
- The fuel level is between 10-90%.
- The startup engine coolant temperature (ECT) is less than 35Â°C (95Â°F).
- The startup intake air temperature (IAT) is between 4-34Â°C (39-93Â°F).
- DTC P0496 runs once per cold start, for up to 17 min, when the above conditions are met. This test will run with the purge valve and the vent valve closed.

Conditions for Setting the DTC

The ECM detects greater than 10 in H2O vacuum for 5 s during a non-purge condition.

Action Taken When the DTC Sets

DTC P0496 is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P0496 is a Type B DTC.

Diagnostic Aids

An intermittent condition could be caused by an improperly installed or damaged EVAP Purge Solenoid Valve or by a temporary blockage or restriction in the EVAP Purge Solenoid Valve.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Evaporative Emission Control System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
2. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
3. All OK.

Circuit/System Testing

NOTE:

- **Vehicle and service department temperature and fuel level (vapor pressure) can affect the fuel tank pressure sensor parameter. Ensure the vehicle temperature has stabilized to service department temperature to ensure greatest accuracy.**
- **Be sure the EVAP Purge Solenoid Valve command is 0% or this test will not work.**

1. Ignition ON.
2. Command the EVAP Purge/Seal function to Not Venting with a scan tool.
3. Engine Running.
4. Verify the Fuel Tank Pressure Sensor parameter is less than 1.9 V for greater than 90 s.
   - **If greater than 1.9 V**

     Replace the Q12 Evaporative Emission Purge Solenoid Valve

   - **If less than 1.9 V**
5. All OK

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

Refer to **Evaporative Emission Canister Purge Solenoid Valve Replacement**

DTC P0506 OR P0507: IDLE SPEED

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** provide an overview of each diagnostic category.

DTC Descriptors

DTC P0506

Idle Speed Low

DTC P0507

Idle Speed High

Circuit/System Description

The throttle actuator control (TAC) motor is controlled by the engine control module (ECM). The DC motor located in the throttle body drives the throttle blade. In order to decrease idle speed, along with spark and fuel delivery changes the ECM commands the throttle closed reducing air flow into the engine and the idle speed decreases. In order to increase idle speed, the ECM commands the throttle plate open allowing more air to pass the throttle plate.

Conditions for Running the DTC

- DTCs P0068, P0101, P0102, P0103, P0112, P0113, P0116, P0117, P0118, P0121, P0122, P0123, P0128, P0171, P0172, P0174, P0175, P0201-P0208, P0222, P0223, P0300-P0308, P0351-P0358, P0461-P0463, P0496, P0502, P0503, P0606, P0722, P0723, P0806-P0808, P1101, P1516, P2066-P2068, P2101, and P2135 are not set.
- The engine is operating for 60 s or greater.
- The engine is idling for greater than 5 s.
- The barometric pressure (BARO) is greater than 70 kPa (11 psi).

- The engine coolant temperature (ECT) is warmer than 60Â°C (140Â°F).
- The intake air temperature (IAT) is warmer than -20Â°C (-4Â°F).
- The vehicle speed is less than 1.6 km/h (1 mph).
- The commanded engine speed is steady within 25 RPM.
- The transmission is not changing gears.
- The torque converter clutch (TCC) is not changing states.
- The manual transmission clutch pedal position is less than 25 percent or greater than 88 percent - If equipped.
- The manual transmission clutch is not depressed - If equipped.
- The power take-off (PTO) is not active - If equipped.
- The transfer case is not in 4WD Low - If equipped.
- A scan tool output control is not active.
- The system voltage is between 11-32 V.
- DTCs P0506 and P0507 run continuously when the above conditions are met for greater than 10 s.

Conditions for Setting the DTC

P0506

The actual idle speed is approximately 94 RPM lower than the desired idle speed.

P0507

The actual idle speed is approximately 188 RPM greater than the desired idle speed.

Action Taken When the DTC Sets

DTCs P0506 and P0507 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P0506 and P0507 are Type B DTCs.

Diagnostic Aids

- A stalling condition can cause DTC P0506 to set.

- An intermittent vehicle speed sensor (VSS) signal can cause DTC P0507 to set.
- An intermittent clutch pedal position sensor signal, if equipped, can cause DTC P0506 to set.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Throttle Actuator Control (TAC) System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify there are no other DTCs set.
    - **If any other DTCs are set**

Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** for further diagnosis.

- **If no other DTCs are set**

3. Verify the scan tool Throttle Body Idle Airflow Compensation parameter is less than 90%.
   - **If 90% or greater**

     Refer to **Throttle Body Cleaning** .

   - **If less than 90%**
4. Engine Idling at the normal operating temperature.

NOTE: **The engine must run for greater than 60 s, then idle at a steady state for an additional 10 s before comparing the actual and desired engine speed parameters.**

5. Verify the actual Engine Speed is not 100 RPM less than the Desired Idle Speed.
   - **If 100 RPM less than the Desired Idle Speed**

     Refer to Circuit/System Testing.

   - **If 100 RPM greater than the Desired Idle Speed**
6. Verify the actual Engine Speed is not 200 RPM greater than the Desired Idle Speed.
   - **If 200 RPM or greater than the Desired Idle Speed**

     Refer to Circuit/System Testing.

   - **If within 200 RPM of the Desired Idle Speed**
7. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
8. Verify a DTC does not set.
   - **If a DTC sets**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** for further diagnosis.

   - **If no DTC sets**
9. All OK

Circuit/System Testing

P0506

1. Verify the conditions listed below do not exist.
   - Restricted exhaust
   - Mechanical conditions that limits engine speed
   - Parasitic load on the engine - For example, a transmission condition, a belt driven accessory condition.
   - **If a condition is found**

     Repair as necessary.

   - **If a condition is not found**
2. All OK.

P0507

1. Verify the conditions listed below do not exist.
   - Vacuum leaks
   - A throttle valve that does not close correctly
   - Verify the correct operation of the crankcase ventilation system. Inspect for the conditions listed below:
     - Improper routing of the positive crankcase ventilation (PCV) system
     - Vacuum leaks in the PCV system - Refer to **Crankcase Ventilation System Inspection/Diagnosis** .
   - **If a condition is found**

     Repair as necessary.

   - **If a condition is not found**
2. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

Refer to **Throttle Body Assembly Replacement**

DTC P050D: COLD START ROUGH IDLE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P050D

Cold Start Rough Idle

Circuit/System Description

During a cold start, the engine control module (ECM) commands dual-pulse mode during Open Loop operation to improve cold start emissions. In dual-pulse mode, the fuel injectors are energized twice during each injection event. As with misfire diagnosis, in dual-pulse mode the ECM monitors the crankshaft position sensor and the camshaft position sensor to calculate crankshaft rotation speed. In normal operation, optimum fuel delivery during dual-pulse mode produces a steady crankshaft rotation speed. If the variations exceed a calibrated value, the code will be set.

Conditions for Running the DTC

- DTCs P0010, P0011, P0016, P0089, P0090-P0092, P00C6, P00C8, P00C9, P00CA, P0101-P0103, P0106-P0108, P0112-P0114, P0116-P0118, P0121-P0123, P0128, P0192, P0193, P0201-P0206, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0315, P0335, P0336, P0351-P0356, P0628, P069E, P1248, P1249, P124A, P124B, P124C, P124D, P1258, P135A, P135B, P150C, P163A, P1762, P2122, P2123, P2127, P2128, P2135, P2138, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F, P228C, P228D, U0109 are not set.
- The catalyst temperature is less than 300Â°C (572Â°F).
- The engine coolant temperature is between 17-43Â°C (62-110Â°F).
- The barometric pressure is greater than 75 kPa.
- The engine speed is between 550-2000 RPM.
- The engine is running less than 100 seconds.
- Accelerator position is less than 1%.
- DTC P050D runs once per cold start.

Conditions for Setting the DTC

This DTC will set if the engine control module detects variations in crankshaft rotation speed caused by the lack of adequate fuel delivery during dual-pulse mode.

Action Taken When the DTC Sets

- DTC P050D is a Type B DTC.
- The engine control module disables dual pulse mode and energizes the fuel injector as it would for a warm engine.

Conditions for Clearing the DTC

DTC P050D is a Type B DTC.

Diagnostic Aids

- This DTC may be set with a misfire DTC, however the existence of this DTC is a higher priority and indicates the condition to diagnose is related to fuel and/or injectors, not the ignition/spark system.
- A restricted fuel injector may cause this DTC to set.
- High resistance in the circuits of the fuel injectors could set this DTC without setting an injector DTC. Test the fuel injector circuits of the affected cylinders for a high resistance if you suspect a condition. Refer to **Fuel Injector Diagnosis** .
- A drop in system voltage during cold start may set this DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Testing

NOTE: **Circuit/System Testing requires cold start. Do not start vehicle prior to connecting scan tool and preparing to evaluate the condition during engine crank.**

1. Start the engine and observe the Cylinder 1-8 Current Misfire Counters during the first 500 engine cycles. The Cylinder 1-8 Current Misfire Counters should not be incrementing.
    - **If the misfire counters are incrementing on one or more cylinders**
    1. Ignition OFF.
    2. Verify that the following conditions do not exist:
    - Fuel pressure that is too low or too high - Refer to Fuel System Diagnosis .
    - Contaminated fuel - Refer to Alcohol/Contaminants-in-Fuel Diagnosis .
        - If a condition exist, repair as necessary.
        - If none of the conditions exist, replace the Q17 Fuel Injector(s) as indicated by high misfire counts.
    - **If the misfire counters are not incrementing**
2. All OK.

Repair Instructions

Refer to Fuel Injector Replacement

Repair Verification

NOTE: **Repair Verification requires cold start.**

1. Ignition ON, engine OFF, clear the DTCs with a scan tool.
2. Start the engine.
3. Verify the DTC does not reset.

DTC P05CC: COLD START INTAKE CAMSHAFT POSITION SYSTEM PERFORMANCE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P05CC

Cold Start Intake Camshaft Position System Performance

Circuit/System Description

The camshaft position (CMP) actuator system enables the engine control module (ECM) to change the timing of the camshaft while the engine is operating. The ECM controls the camshaft position actuator magnet duty cycle by controlling the amount of On time. The magnet controls the amount of engine oil flow to the CMP actuator by extending a pintle within the solenoid. The pintle acts against a spool valve in the CMP actuator mechanism which is attached to the front of the camshaft. As the spool valve is moved, oil is directed to the CMP actuator, which rotates the camshaft. The ECM can only command the camshaft position actuator to retard the valve timing from the camshaft park position, or advance the valve timing back to the park position.

The ECM controls the camshaft position actuator magnet by supplying a 12 V pulse width modulated (PWM) signal. The ECM supplies a ground to the low reference circuit.

Conditions for Running the DTC

- DTC P0010, P0016, P0335, P0336, P0340, P0341, P0345, P0346, P0365, P0366, P0390 or P0391, is not set.
- The ignition voltage is greater than 11 V.
- The engine is running.

- The desired camshaft position is greater than 0 degrees.
- The desired camshaft position is not changing greater than 4.5 degrees for at least 1 s.
- Both of the desired and actual camshaft position actuator values cannot be greater than 20 degrees or less than 5 degrees.
- DTCs P05CC, runs continuously once the above conditions are met.

Conditions for Setting the DTC

The ECM detects the difference between the desired camshaft position angle and the actual camshaft position angle is greater than 8 degrees for greater than 20 s

Action Taken When the DTC Sets

DTCs P05CC is a type B DTC.

Conditions for Clearing the DTC

DTCs P05CC is a type B DTC.

Diagnostic Aids

- The engine oil condition has a major impact on the camshaft actuator system.
- A low oil level condition may set this DTC. The engine may require an oil change. Inquire with the customer when the last oil change was performed. You may also monitor the scan tool Engine Oil Life parameter. Advise the customer an oil change may be required.
- Inspect the engine for any recent engine mechanical repairs. An incorrectly installed camshaft, camshaft actuator, or timing chain can cause this DTC to set.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Description and Operation

Camshaft Actuator System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

J 35616-200 Test Lamp Kit

Circuit/System Verification

NOTE:

- **The engine oil level and the oil pressure are critical to the correct operation of the camshaft position (CMP) actuator system. Verify that the engine has the correct oil level and the correct oil pressure before continuing with this diagnostic.**
- **The engine oil condition has a major impact on the camshaft actuator system. Debris in the oil can interfere with the camshaft position actuator solenoid and the mechanical camshaft actuator operation. Inspect for dirty or degraded crankcase oil. The engine may require an oil change. Inquire with the customer when the last oil change was performed. You may also monitor the scan tool Engine Oil Life Remaining parameter. Advise the customer an oil change may be required.**

1. Verify the engine has the correct oil pressure. Refer to **Oil Pressure Diagnosis and Testing** .

NOTE: **If a crankshaft or camshaft position sensor DTC is set, the scan tool Camshaft Position Actuator output control will not function.**

2. Ignition On.
3. Verify DTC P0010, P0016, P0335, P0336, P0340, P0341, P0345, P0346, P0365, P0366, P0390 or P0391, is not set.
   - **If any of the DTCs are set**

     If any of the DTCs are set, refer to **Diagnostic Trouble Code (DTC) List - Vehicle** for further diagnosis.

   - **If none of the DTCs are set**
4. Engine idling at normal operating temperature.
5. Verify the Desired Camshaft Position parameter matches the Camshaft Position Angle parameter when commanding the Camshaft Position Actuator to 20 degrees with a scan tool.
   - **If the parameter does not match**

     Refer to Circuit/System Testing.

   - **If the parameter does match**
6. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
7. All OK.

Circuit/System Testing

1. Ignition Off and all vehicle systems Off, disconnect the harness connector at the Q6 Camshaft Position Actuator Solenoid Valve. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal 1 and ground.
   - **If 5 Ω or greater**

     1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.

2. Test for less than 2 Ω in the low reference circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.
- **If less than 5 Ω**

NOTE: **A test lamp must be used for this test. The control circuit is pulled-up to a low current voltage. The current is too low to illuminate a test lamp. A voltage on the control circuit is normal.**

3. Ignition On.
4. Verify that a test lamp does not illuminate between the control circuit terminal 2 and ground.
    - **If the test lamp illuminates**
    1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module, ignition On.
    2. Test for less than 1 V between the control circuit and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.
    - **If the test lamp does not illuminate**
5. Remove the test lamp.
6. Connect the DMM negative lead to the control circuit terminal 2. Connect the DMM positive lead to B+. Set the DMM on the diode setting. Command the Camshaft Position Actuator Solenoid On and Off with a scan tool. The DMM should transition from OL when commanded Off to less than 1 V when commanded On.
    - **If the parameter does not correspond to the specified values**
    1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for less than 2 Ω in the control circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance or short to ground in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If the parameter corresponds to the specified values**
7. Test or replace the Q6 Camshaft Position Actuator Solenoid Valve and magnet.

Component Testing

Static Test

1. Ignition Off, disconnect the harness connector at the appropriate Q6 Camshaft Position Actuator Solenoid Valve.
2. Test for 5-12 Ω between the control terminal 1 and the low reference terminal 2.
   - **If not between 5-12 Ω**

     Replace the Q6 Camshaft Position Actuator Solenoid Valve.

   - **If between 5-12 Ω**
3. Test for infinite resistance between each terminal and the Q6 Camshaft Position Actuator Solenoid Valve housing.
   - **If not infinite resistance**

     Replace the Q6 Camshaft Position Actuator Solenoid Valve.

   - **If infinite resistance**
4. Ignition Off, remove the camshaft position actuator magnet.
5. Test for 5.0-9.0 Ω between the solenoid control terminal 2 and the low reference terminal 1 at the camshaft position actuator magnet.
   - **If not within the specified range**

     Replace the camshaft position actuator magnet

   - **If within the specified range**
6. Test for infinite resistance between each terminal of the magnet and the magnet housing.
   - **If not within the specified value**

     Replace the camshaft position actuator magnet

   - **If within the specified value**
7. All OK.

Dynamic Test

1. Remove the camshaft position actuator magnet.

NOTE:

- **The camshaft position actuator magnet pintle should be facing downward for this test.**
- **Do not allow electrical current to flow through the camshaft position actuator magnet for greater than 1-2 s.**

2. Install a 20 A fused jumper wire between the control circuit terminal 2 and 12 V. Momentarily install a jumper wire between the low reference terminal 1 and ground. The pintle should extend.
   - **If the function does not perform as specified**

     Replace the camshaft position actuator magnet

   - **If the function does perform as specified**
3. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Camshaft Position Actuator Cleaning and Inspection**
- Refer to **Camshaft Position Actuator Magnet Replacement** for camshaft position actuator magnet
- Refer to **Control Module References** for K20 Engine Control Module replacement, programming, and setup.

DTC P057B-P057D: BRAKE PEDAL POSITION SENSOR

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P057B

Brake Pedal Position Sensor Performance

DTC P057C

Brake Pedal Position Sensor Circuit Low Voltage

DTC P057D

Brake Pedal Position Sensor Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	P057C	P057C	P057D	P057B
5 V Reference	P057C P0651	P057C	P0335, P0506, P057D, P0651	-
Low Reference	-	P057D	P057D	-

Typical Scan Tool Data

Brake Pedal Position Sensor

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Ignition ON. **Normal Range:** 0.25-4.75 V			
5 V Reference	0 V	0 V	-
Signal	0 V	0 V	5 V
Low Reference	-	5 V	-

Circuit/System Description

The brake pedal position (BPP) sensor is part of the engine brake pedal override feature. The engine control module (ECM) continuously monitors the vehicle speed and the position of the brake pedal. These two main inputs, along with other ECM inputs are used to determine if the vehicle is decelerating at the proper speed and rate with the brake pedal applied. When the engine brake pedal override system is active, the ECM reduces engine torque to assist in reducing vehicle speed.

The BPP sensor is a six wire sensor, and is part of a dual brake position sensor. One BPP Sensor is used for the stop lamps and the other BPP Sensor is used for the engine brake pedal override feature. The BPP Sensor for engine brake pedal override communicates with the ECM. The ECM supplies a 5 V reference circuit, low reference circuit, and signal circuit to the BPP sensor. The BPP sensor sends a voltage signal to the ECM on the signal circuit. The voltage on the signal circuit will vary from a voltage greater than 0.25 V when the brake pedal is released to a voltage less than 4.75 V when the brake pedal is fully applied.

For information on the Stop Lamps side of the BPP Sensor, refer to **Exterior Lighting Systems Description and Operation** .

Conditions for Running the DTC

P057B

- DTCs P057C, or P057D are not set.
- Ignition voltage is greater than 10 V.
- Shift lever has been in Park at least once during key ON.
- Shift lever is not in Park.
- Vehicle speed is 8 km/h (5 MPH) or greater.
- Accelerator Pedal Position is less than 5%.
- DTC runs continuously when above condition is met.

P057C or P057D

- Ignition voltage is greater than 10 V.
- DTC runs continuously when above condition is met.

Conditions for Setting the DTC

P057B

ECM detects the brake pedal position sensor signal is stuck in a range.

P057C

ECM detects the brake pedal position sensor is less than 0.25 V for 1 s.

P057D

ECM detects the brake pedal position sensor voltage is greater than 4.75 V for 1 s.

Action Taken When the DTC Sets

- P057B, P057C, and P057D are Type A DTCs.
- Brake Pedal Position Sensor parameter defaults to 0%.

Conditions for Clearing the DTC

P057B, P057C, and P057D are Type A DTCs

Reference Information

Schematic Reference

- **Engine Controls Schematics**
- **Exterior Lights Schematics**

Connector End View Reference

- **COMPONENT CONNECTOR END VIEWS - INDEX**
- **INLINE HARNESS CONNECTOR END VIEWS - INDEX**

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

NOTE: **The Brake Pedal Position sensor scan tool data is located in the ECM automatic transmission data list.**

1. Ignition ON.
2. Verify DTC P0641, P0651, P0697, or P06A3 is not set.
    - **If any of the DTCs are set**

      Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .

    - **If none of the DTCs are set**

3. Transmission in Park, and service brake pedal released.
4. Verify the scan tool Brake Pedal Position Sensor parameter in the ECM displays greater than 0.25 V.
   - **If 0.25 V or less**

     Refer to Circuit/System Testing.

   - **If greater than 0.25 V**
5. Verify the scan tool Brake Pedal Position Sensor parameter voltage changes as the brake pedal is applied and displays less than 4.75 V when the brake pedal is fully applied.
   - **If the voltage does not change, or is greater than 4.74 V**

     Refer to Circuit/System Testing.

   - **If the voltage changes and less than 4.75 V**
6. Verify the scan tool Brake Pedal Position Sensor Learned Release Position parameter is within 0.1 V of the Brake Pedal Position Sensor parameter when the brake pedal is fully released.
   - **If difference is greater than 0.1 V**

     Perform the **Brake Pedal Position Sensor Learn** .

   - **If difference is 0.1 V or less**
7. Verify the Brake Pedal Position Sensor parameter transitions smoothly without any spikes or dropouts when slowly applying and releasing the brake pedal.
   - **If parameter does not transition smoothly or has spikes or dropouts**

     Refer to Circuit/System Testing.

   - **If parameter transitions smoothly and there are no spikes or dropouts**
8. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
9. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

- **If the DTC does not set**

10. All OK.

Circuit/System Testing

NOTE: **You must perform the Circuit/System Verification first.**

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B22 Brake Pedal Position Sensor. It may take up to 2 minutes for all vehicle systems to power down.

NOTE: **All terminal references are for the vehicle harness brake pedal position sensor connector.**

2. Test for less than 10 Ω between the low reference circuit terminal 5 and ground.
   - **If 10 Ω or greater**
   1. Disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If less than 10 Ω**
3. Ignition ON.
4. Test for 4.8-5.2 V between the 5 V reference circuit terminal 6 and ground.
   - **If less than 4.8 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the 5 V reference circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance.
   3. Test for less than 2 Ω in the 5 V reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If greater than 5.2 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

2. Test for less than 1 V between the 5 V reference circuit and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.
- **If between 4.8-5.2 V**

5. Verify the scan tool Brake Pedal Position Sensor parameter is less than 0.25 V.
    - **If 0.25 V or greater**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 0.25 V between the signal circuit terminal 4 and ground.
        - If 0.25 V or greater, repair the short to voltage on the circuit.
        - If less than 0.25 V, replace the K20 Engine Control Module.
    - **If less than 0.25 V**
6. Install a 3 A fused jumper wire between the signal circuit terminal 4 and the 5 V reference circuit terminal 6.
7. Verify the scan tool Brake Pedal Position Sensor parameter is greater than 4.8 V.
    - **If 4.8 V or less**
    1. Ignition OFF, remove the jumper wire, and disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit terminal 4 and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance.
    3. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If greater than 4.8 V**
8. Replace the B22 Brake Pedal Position Sensor.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Brake Pedal Position Sensor Replacement**
- Perform the **Brake Pedal Position Sensor Learn** following the replacement of the ECM or BPP sensor, or any repair that effects the BPP sensor alignment.

- Refer to **Control Module References** for Engine Control Module replacement, programming and setup.

DTC P0601-P0604, P0606, P062B, P062F, P0630, P16F3, OR P262B: CONTROL MODULE/VIN NOT PROGRAMMED OR MISMATCHED (ECM)

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each of the diagnostic category.

DTC Descriptors

DTC P0601

Control Module Read Only Memory Performance

DTC P0602

Control Module Not Programmed

DTC P0603

Control Module Long Term Memory Reset

DTC P0604

Control Module Random Access Memory Performance

DTC P0606

Control Module Processor Performance

DTC P062B

Control Module Fuel Injector Control Performance

DTC P062F

Control Module Long Term Memory Performance

DTC P0630

VIN Not Programmed or Mismatched - Engine Control Module (ECM)

DTC P16F3

Control Module Redundant Memory Performance

DTC P262B

Control Module Power Off Timer Performance

Circuit/System Description

This diagnostic applies to internal microprocessor integrity conditions within the engine control module (ECM). This diagnostic also addresses if the ECM is not programmed.

Conditions for Running the DTCs

P0601, P0602, P0630

These DTCs run continuously when the ignition is ON.

P0603, P062F

These DTCs run during ECM power up.

P0604

DTC P0604 runs continuously when the ignition is ON for greater than 30 s.

P0606, P062B

- The ignition is ON.
- The system voltage is greater than 11 V.
- These DTCs run continuously when the above conditions are met.

P16F3

- The engine speed is greater than 520 RPM.
- DTCs P0101, P0102, P0103, P0106, P0107, P0108, P2227, P2228, P2229, or P2230 are not set.
- DTC P16F3 runs continuously when the above conditions are met.

P262B

DTC P262B runs during ECM power down.

Conditions for Setting the DTCs

The ECM detects an internal failure or incomplete programming for more than 10 s.

Actions Taken When the DTC Sets

- DTCs P0601, P0602, P0603, P0604, P0606, P062B, P0630, and P16F3 are Type A DTCs.
- DTCs P062F and P262B are Type B DTCs.

Conditions for Clearing the MIL/DTC

- DTCs P0601, P0602, P0603, P0604, P0606, P062B, P0630, and P16F3 are Type A DTCs.
- DTCs P062F and P262B are Type B DTCs.

Diagnostic Aids

Low voltage or a momentary loss of power or ground to the ECM may cause a DTC to set. Verify the following:

- The battery cables are clean and tight, and the battery is fully charged. Refer to **Battery Inspection/Test** .
- The ECM ground circuits do not have an open or high resistance.
- The ECM power circuits do not have an open, short to ground, or high resistance.

Low voltage or a momentary loss of power or ground to the ECM may cause a DTC to set. Verify the following:

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON, clear the DTC information with a scan tool.

   NOTE: **DTC P0601-P0604, P0606, P062B, P062F, P0630, P16F3, or P262B could be set as a default action taken from another DTC.**

2. Verify no other DTCs are set.
   - **If any other DTCs are set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** for further diagnosis.

   - **If no other DTCs are set**

3. Observe the DTC information with a scan tool. Verify DTC P0602 or P0630 is not set.
    - **If any of the DTCs are set**
    1. Program the K20 Engine Control Module. Refer to **Control Module References** .
    2. Verify DTC P0602 or P0630 is not set.
        - If any of the DTCs are set, replace the K20 Engine Control Module.
        - If none of the DTCs are set
    3. All OK.
    - **If none of the DTCs are set**
4. Verify DTC P0601, P0603, P0604, P0606, P062B, P062F, P16F3, or P262B is not set.
    - **If any of the DTCs are set**

      Replace the K20 Engine Control Module.

    - **If none of the DTCs are set**
5. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

Refer to **Control Module References** for engine control module replacement, programming and setup.

DTC P0628: FUEL PUMP ENABLE CIRCUIT LOW VOLTAGE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P0628

Fuel Pump Enable Circuit Low Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control	P0171, P0506, P0628, P12A6	P0171, P0506, P12A6	-	P12A6

Circuit/System Description

The engine control module (ECM) provides ignition voltage to the fuel pump driver control module whenever the engine is cranking or running. The ECM enables the fuel pump driver control module as long as the engine is cranking or running, and ignition system reference pulses are received. While this enable voltage is being received, the fuel pump driver control module supplies a varying voltage to the fuel tank fuel pump module in order to maintain the desired fuel line pressure.

Conditions for Running the DTC

- The engine speed is greater than 0 RPM.
- The ignition voltage is greater than 11 V.
- The DTC runs continuously when the conditions above are met.

Conditions for Setting the DTC

The engine control module detects that the commanded state of the driver and the actual state of the control circuit do not match for greater than 2.5 s.

Action Taken When the DTC Sets

DTC P0628 is a Type B DTC.

Conditions for Clearing the DTC

DTC P0628 is a Type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC P0628 is not set.
    - **If the DTC is set**

      Refer to Circuit/System Testing.

    - **If the DTC is not set**
3. Verify the parameters listed below do not display Malfunction when commanding the Fuel Pump Enable On and Off with a scan tool.
    - Fuel Pump Enable Circuit Low Voltage Test Status
    - Fuel Pump Enable Circuit Open Test Status
    - Fuel Pump Enable Circuit High Voltage Test Status

- **If Malfunction is displayed**

  Refer to Circuit/System Testing.

- **If Malfunction is not displayed**

4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
5. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
6. All OK.

Circuit/System Testing

1. Ignition OFF, disconnect the K111 Fuel Pump Driver Control Module harness connector.
2. Ignition ON for 10 s.
3. Verify that a test lamp does not illuminate between the control circuit terminal 2 and ground.
   - **If the test lamp illuminates**
   1. Ignition OFF, remove the test lamp, disconnect the X1 harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the control circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If the test lamp does not illuminate**
4. Remove the test lamp.
5. Verify the scan tool Fuel Pump Enable Circuit Low Voltage Test Status parameter is OK when commanding the Fuel Pump Enable On with a scan tool.
   - **If OK is not displayed**
   1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the control circuit and ground.

- If less than infinite resistance, repair the short to ground on the circuit.
- If infinite resistance, replace the K20 Engine Control Module.

- **If OK is displayed**

6. Install a 3 A fused jumper wire between the control circuit terminal 2 and ground.
7. Verify the scan tool Fuel Pump Enable Circuit Low Voltage Test Status parameter is Malfunction when commanding the Fuel Pump Enable On with a scan tool.
   - **If Malfunction is not displayed**
   1. Ignition OFF, remove the jumper wire, disconnect the X1 harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the control circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If Malfunction is displayed**
8. Replace the K111 Fuel Pump Driver Control Module.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Fuel Pump Power Control Module Replacement** for K111 Fuel Pump Driver Control Module replacement
- Refer to **Control Module References** for K20 Engine Control Module replacement, programming, and setup

DTC P0641, P0651, P0697, OR P06A3: 5V REFERENCE CIRCUITS (1-4)

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0641

5V Reference 1 Circuit

DTC P0651

5V Reference 2 Circuit

DTC P0697

5V Reference 3 Circuit

DTC P06A3

5V Reference 4 Circuit

Circuit/System Description

The engine control module (ECM) has 4 internal 5V reference circuits. Each internal reference circuit provides external 5V reference circuits for more than one sensor. A short to ground or short to voltage on one external 5V reference circuit can affect all the components connected to the same internal 5V reference circuit.

Conditions for Running the DTC

These DTCs run continuously when the ignition voltage is greater than 6.4 V.

Conditions for Setting the DTC

The ECM detects a short to voltage or ground on any of the 5V reference circuits for greater than 0.5 s.

Action Taken When the DTC Sets

DTCs P0641, P0651, P0697, and P06A3 are Type A DTCs.

Conditions for Clearing the DTC

DTCs P0641, P0651, P0697, and P06A3 are Type A DTCs.

Diagnostic Aids

The 5V reference 1 circuit provides 5 V to the following sensors:

- Air conditioning (A/C) refrigerant pressure sensor
- Camshaft position sensor

- Engine oil pressure sensor
- Fuel pressure sensor
- Fuel rail pressure sensor
- Fuel tank pressure sensor
- Multifunction intake air sensor

The 5V reference 2 circuit provides 5 V to the following sensors:

- Brake pedal position sensor
- Crankshaft position sensor

The 5V reference 3 circuit provides 5 V to the following sensors:

- Accelerator pedal position sensor 2
- Manifold absolute pressure sensor

The 5V reference 4 circuit provides 5 V to the following sensors:

- Accelerator pedal position sensor 1
- Throttle position sensor

Disconnecting one component at a time from the affected 5V reference circuit while observing the scan tool 5V Reference Circuit Status parameter may help locate the fault. The scan tool parameter will change from Malfunction to OK when the source of the fault is disconnected. If all 5V reference components have been disconnected and a fault is still indicated, the fault may exist in the wiring harness.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify all scan tool 5V Reference Circuit Status parameters do not display Malfunction.
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing.

   - **If Malfunction is not displayed**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
5. All OK.

Circuit/System Testing

NOTE: **Additional DTCs will set when disconnecting the components.**

1. Ignition OFF, disconnect the harness connector at all appropriate sensors for the applicable DTC. Refer to Diagnostic Aids.
2. Ignition ON.
3. Test for 4.8-5.2 V between one of the 5V reference circuits and ground.

NOTE: **You may have to operate the vehicle within the Conditions for Running the DTC or the conditions that you observed from the Freeze Frame/Failure Records data to duplicate the malfunction.**

- **If less than 4.8 V**

1. Ignition OFF, disconnect the harness connectors at the K20 Engine Control Module.
2. Test for infinite resistance between the 5V reference circuit for each applicable component and ground.
   - If less than infinite resistance, repair the short to ground on the circuit.
   - If infinite resistance, replace the K20 Engine Control Module.

- **If greater than 5.2 V**

1. Ignition OFF, disconnect the harness connectors at the K20 Engine Control Module.
2. Test for less than 1 V between the 5V reference circuit for each applicable component and ground.
   - If 1 V or greater, repair the short to voltage on the circuit.
   - If less than 1 V, replace the K20 Engine Control Module.

- **If between 4.8-5.2 V**

NOTE: **A short to voltage or ground on the signal circuit of certain components may cause this DTC to set.**

4. Verify the appropriate scan tool 5V Reference 1, 2, 3, or 4 Circuit Status parameter displays OK while connecting each component associated with the 5V reference circuit one at a time.
   - **If OK is not displayed when a component is connected**

     Test the signal circuit of that component for a short to ground or voltage. If the circuit tests normal, replace the component.

   - **If OK is displayed after all components have been connected**
5. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Accelerator Pedal Position Sensor Replacement**
- Refer to **Air Conditioning (A/C) Refrigerant Pressure Sensor Replacement (L83 L86)**
- Refer to **Brake Pedal Position Sensor Replacement**
- Refer to **Camshaft Position Sensor Replacement**
- Refer to **Crankshaft Position Sensor Replacement**
- Refer to **Engine Oil Pressure Sensor Replacement**
- Refer to **Fuel Pressure Sensor Replacement (Fuel Pipe)**
- Refer to **Fuel Injection Fuel Rail Fuel Pressure Sensor Replacement**
- Refer to **Fuel Tank Pressure Sensor Replacement (SWB)** **Fuel Tank Pressure Sensor Replacement (LWB)**
- Refer to **Manifold Absolute Pressure Sensor Replacement**
- Refer to **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement** for multifunction intake air sensor replacement
- Refer to **Throttle Body Assembly Replacement**
- Refer to **Control Module References** for engine control module replacement, programming, and setup

DTC P0650, P263A, OR P263B: MALFUNCTION INDICATOR LAMP (MIL) CONTROL CIRCUIT

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P0650

Malfunction Indicator Lamp (MIL) Control Circuit

DTC P263A

Malfunction Indicator Lamp (MIL) Control Circuit Low Voltage

DTC P263B

Malfunction Indicator Lamp (MIL) Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0650	P0650	-	-
Control	P0650, P263A*	P0650, P263A	P263B	-
* The MIL remains ON				

Circuit/System Description

The malfunction indicator lamp (MIL) illuminates to inform the driver that an emission system fault has occurred and the powertrain control system requires service. Ignition voltage is supplied directly to the MIL. The engine control module (ECM) turns the MIL ON by grounding the MIL control circuit when the emission system fault occurs. Under normal operating conditions, the MIL should be ON only when the ignition is ON and the engine is OFF.

Conditions for Running the DTC

- The ignition voltage is between 11-32 V.
- Remote vehicle start is not active
- The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

DTC P0650 or DTC P263A

The ECM detects low voltage during the MIL control circuit driver OFF state. This indicates either a shorted to ground or an open MIL control circuit.

DTC P263B

The ECM detects high voltage on the MIL control circuit during the driver ON state. This indicates a shorted to voltage MIL control circuit.

Action Taken When the DTC Sets

DTC P0650, P263A, and P263B are Type B DTCs.

Conditions for Clearing the DTC

DTC P0650, P263A, and P263B are Type B DTCs.

Diagnostic Aids

- If the condition is intermittent, move the related harnesses and connectors while monitoring the scan tool MIL control circuit status parameters. Perform this test with the ignition ON and the engine OFF, and with the engine running. The MIL control circuit status parameters change from OK or Not Run to Malfunction if there is a condition with a circuit or a connection.
- If the ECM detects low voltage on the MIL control circuit during the control circuit driver OFF state, DTCs P0650 and DTC P263A may set simultaneously.

Reference Information

Schematic Reference

- **Engine Controls Schematics**
- **Instrument Cluster Schematics**

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify the parameters listed below do not display Malfunction when commanding the Malfunction Indicator Lamp On and Off with a scan tool.
   - The MIL Control Circuit Low Voltage Test Status
   - The MIL Control Circuit Open Test Status
   - The MIL Control Circuit High Voltage Test Status
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing.

   - **If Malfunction is not displayed**
3. Engine running.
4. Verify the parameters listed below do not display Malfunction when commanding the Malfunction Indicator Lamp On and Off with a scan tool.
   - The MIL Control Circuit Low Voltage Test Status
   - The MIL Control Circuit Open Test Status
   - The MIL Control Circuit High Voltage Test Status
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing.

   - **If Malfunction is not displayed**
5. Verify the malfunction indicator lamp turns ON and OFF when commanding the Malfunction Indicator Lamp On and Off with a scan tool.
   - **If the malfunction indicator lamp does not turn ON and OFF**

     Refer to Circuit/System Testing.

   - **If the malfunction indicator lamp turns ON and OFF**
6. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
   - **If the DTC sets**

Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** for further diagnosis.

- **If the DTC does not set**

7. All OK.

Circuit/System Testing

1. Ignition OFF.
2. Disconnect the X1 harness connector at the K20 Engine Control Module.
3. Ignition ON, verify the malfunction indicator lamp does not illuminate.
   - **If the malfunction indicator lamp illuminates**
   1. Test for infinite resistance between the control circuit terminal X1 46 and ground.
      - If less than infinite resistance, repair the short to ground in the circuit.
      - If infinite resistance, replace the P16 Instrument Cluster.
   - **If the malfunction indicator lamp does not illuminate**
4. Connect a 3 A fused jumper wire between the control circuit terminal X1 46 and ground.
5. Verify the malfunction indicator lamp illuminates.
   - **If the malfunction indicator lamp illuminates**

     Replace the K20 Engine Control Module.

   - **If the malfunction indicator lamp does not illuminate**
   1. Test for less than 1 V between the control circuit terminal X1 46 and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V
   2. Ignition OFF.
   3. Test for less than 2 Ω in the control circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω.
6. Ignition OFF, disconnect the harness connector at the instrument cluster.
7. Ignition ON, verify a test lamp illuminates between the ignition voltage circuit terminal 8 and ground.

- **If the test lamp does not illuminate and the circuit fuse is open**

1. Ignition OFF.
2. Test for infinite resistance between the ignition voltage circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.

- **If the test lamp does not illuminate and the circuit fuse is good**

1. Ignition OFF.
2. Test for less than 2 Ω in the ignition voltage circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.

- **If the test lamp illuminates**

8. Replace the P16 Instrument Cluster.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Instrument Cluster Replacement (Chevrolet / GMC)** **Instrument Cluster Replacement (Cadillac)**
- Refer to **Control Module References** for control module replacement, programming, and setup

DTC P0685-P0687, P0689, P0690, OR P1682: ENGINE CONTROLS IGNITION RELAY/IGNITION 1 SWITCH CIRCUIT 2

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P0685

Engine Controls Ignition Relay Control Circuit

DTC P0686

Engine Controls Ignition Relay Control Circuit Low Voltage

DTC P0687

Engine Controls Ignition Relay Control Circuit High Voltage

DTC P0689

Engine Controls Ignition Relay Feedback Circuit Low Voltage

DTC P0690

Engine Controls Ignition Relay Feedback Circuit High Voltage

DTC P1682

Ignition 1 Switch Circuit 2

Diagnostic Fault Information

Engine Controls Ignition Relay

Circuit	Short to Ground	Open/High Resistance	Short to Voltage
Relay Coil Supply Voltage	P0689, P1682	P0685, P0689, P1682	-
Relay Control Circuit	P0686, P0690	P0685, P0689, P1682	P0685, P0687, P0689, P1682
Relay Feedback Circuit	P0689, P1682	P0689, P1682	P0690

Typical Scan Tool Data

Engine Controls Ignition Relay Control Circuit Low Voltage, Open, and High Voltage Test Status - Component Commanded OFF

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Component commanded OFF **Parameter Normal Range:** The following illustrates the normal parameter state with no circuit conditions: • Component OFF - OK for Open/Low Voltage Test Status and Not Run for High Voltage Test Status • Component ON - Not Run for Open/Low Voltage Test Status and OK for High Voltage Test Status			
B+	Malfunction	Malfunction	-
Control	Malfunction	Malfunction	Not Run

Engine Controls Ignition Relay Control Circuit Low Voltage, Open, and High Voltage Test Status - Component Commanded ON

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Component commanded ON **Parameter Normal Range:** The following illustrates the normal parameter state with no circuit conditions: • Component OFF - OK for Open/Low Voltage Test Status and Not Run for High Voltage Test Status • Component ON - Not Run for Open/Low Voltage Test Status and OK for High Voltage Test Status			
B+	Not Run	Not Run	-
Control	Not Run	Not Run	Malfunction

Circuit/System Description

There are 2 ignition voltage circuits supplied to the engine control module (ECM). One is supplied by the engine controls ignition relay, and the other is supplied by the ignition main relay. The ECM monitors and compares the ignition voltage supplied by the 2 relays.

Conditions for Running the DTC

P0685, P0686, P0687

These DTCs run when Ignition 1 signal voltage is greater than 11 V.

P0689

- DTCs P0685, P0686, or P0687 are not set.
- The engine controls ignition relay is commanded ON.
- Ignition 1 signal voltage is greater than 11 V.
- The DTC runs continuously when the above conditions are met.

P0690

- DTCs P0685, P0686, or P0687 are not set.
- The engine controls ignition relay is commanded OFF.
- The DTC runs continuously when the above conditions are met.

P1682

- The engine controls ignition relay is commanded ON.
- Ignition voltage is greater than 5.5 V.
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

P0685

The ECM detects that the commanded state of the driver and the actual state of the control circuit do not match for greater than 2 s.

P0686

The ECM detects a short to ground on the control circuit for greater than 2 s.

P0687

The ECM detects a short to voltage on the control circuit for greater than 2 s.

P0689

The ECM detects the engine controls ignition relay feedback circuit is less than 5 V.

P0690

The ECM detects the engine controls ignition relay feedback circuit is greater than 4 V for greater than 5 s.

P1682

The ECM detects that the voltage level difference is greater than 3 V between the 2 ignition voltage circuits for greater than 1 s.

Action Taken When the DTC Sets

- DTCs P0685, P0686, P0687, and P0690 are Type B DTCs.
- DTC P0689 is a Type C DTC.
- DTC P1682 is a Type A DTC.
- The ECM commands the throttle actuator control (TAC) system to operate in a Reduced Engine Power mode.
- A message center or an indicator displays Reduced Engine Power.

Conditions for Clearing the DTC

- DTCs P0685, P0686, P0687, and P0690 are Type B DTCs.
- DTC P0689 is a Type C DTC.
- DTC P1682 is a Type A DTC.

Diagnostic Aids

The engine controls ignition relay may also be labeled the powertrain relay, the engine control module relay, or the main relay. The ignition main relay may also be labeled the run/crank relay, the ignition run relay, the ignition 1 relay, or the ignition relay.

Reference Information

Schematic Reference

- **Engine Controls Schematics**
- **Power Distribution Schematics**

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Electrical Center Identification Views** **Electrical Center Identification Views**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

NOTE:

- **A short to voltage on other components may cause DTC P0690 to set. If any other DTC is set, diagnose that DTC first.**
- **If you were sent here from Engine Cranks But Does Not Run, proceed to Circuit/System Testing.**

1. Ignition ON, observe the scan tool DTC information. Verify DTC P0685, P0686, P0687, P0689, P0690, or P1682 is not set.
   - **If any of the DTCs are set**

     Refer to Circuit/System Testing.

   - **If none of the DTCs are set**
2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
3. All OK.

Circuit/System Testing

NOTE: **You must perform the Circuit/System Verification before proceeding with Circuit/System Testing unless sent here from Engine Cranks But Does Not Run.**

1. Ignition OFF, disconnect the KR75 Engine Controls Ignition Relay.
2. Verify a test lamp illuminates between ground and the B+ terminals listed below:
   - Terminal 86
   - Terminal 30
   - **If the test lamp does not illuminate**

Replace the front compartment fuse block.

- **If the test lamp illuminates**

NOTE:

- **High resistance in the circuit/underhood fuse block for either the KR75 Engine Controls Ignition Relay or the KR73 Ignition Main Relay can cause DTC P1682 to set.**
- **A short to voltage on any of the circuits supplied by the engine controls ignition relay can cause DTC P0690 to set.**

3. Ignition ON.
4. Verify that a test lamp does not illuminate between the ignition voltage circuit terminal 87 and ground.
   - **If the test lamp illuminates**
   1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.
   2. Ignition ON.
   3. Test for less than 1 V between ground and connector terminal 73.
      - If 1 V or greater, repair the short to voltage in the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If the test lamp does not illuminate**
5. Ignition OFF, connect a 20 A fused jumper wire between the B+ circuit terminal 30 and the ignition voltage circuit terminal 87.
6. Ignition ON.
7. Verify the scan tool Engine Controls Ignition Relay Feedback Signal parameter displays B+.
   - **If B+ is not displayed**
   1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module
   2. Test for less than 2 Ω in the relay switch ignition voltage circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω
   3. Test for infinite resistance between the relay switch ignition voltage circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.
   - **If B+ is displayed**

8. Ignition OFF, connect a DMM, set to the diode setting, between control circuit terminal 86 and ground.
9. Verify the DMM displays OL.
    - **If OL is not displayed**
    1. Disconnect the X1 harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between ground and the relay control circuit.
        - If less than infinite resistance, repair the short to ground in the circuit.
        - If infinite resistance, replace the K20 Engine Control Module.
    - **If OL is displayed**
10. Ignition ON.
11. Verify the DMM displays less than 1 V.
    - **If 1 V or greater**
    1. Ignition OFF, disconnect the X1 connector at the K20 Engine Control Module.
    2. Ignition ON.
    3. Test for less than 1 V on the relay control circuit.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V
    4. Test for less than 2 Ω in the control circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - if less than 2 Ω, replace the K20 Engine Control Module.
    - **If less than 1 V**
12. Test or replace the KR75 Engine Controls Ignition Relay.

Component Testing

Relay Test

1. Ignition OFF, disconnect the KR75 Engine Controls Ignition Relay.
2. Test for 70-110 Ω between terminals 85 and 86:
    - **If less than 70 Ω or greater than 110 Ω**

      Replace the relay.

- **If between 70-110 Ω**

3. Test for infinite resistance between the terminals listed below:
   - 30 and 86
   - 30 and 87
   - 30 and 85
   - 85 and 87
   - **If less than infinite resistance**

     Replace the relay.

   - **If infinite resistance**
4. Install a 20 A fused jumper wire between relay terminal 85 and 12 V. Install a jumper wire between relay terminal 86 and ground.
5. Test for less than 2 Ω between terminals 30 and 87.
   - **If 2 Ω or greater**

     Replace the relay.

   - **If less than 2 Ω**
6. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Underhood Electrical Center or Junction Block Replacement** for front compartment fuse block replacement.
- Refer to **Relay Replacement (Attached to Wire Harness)** **Relay Replacement (Within an Electrical Center)**
- Refer to **Control Module References** for engine control module replacement, programming, and setup.

DTC P0700: TRANSMISSION CONTROL MODULE REQUESTED MIL ILLUMINATION

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.

- Refer to **Diagnostic Procedure Instructions** to provide an overview of each of the diagnostic category.

DTC Descriptor

DTC P0700

Transmission Control Module Requested MIL Illumination

Circuit/System Description

The Transmission Control Module (TCM) constantly monitors the transmission system for any condition which may adversely affect vehicle emissions. If a condition is detected, the TCM sets a DTC and sends a serial data message to the ECM. The ECM sets DTC P0700 to inform the technician that the TCM has set the emission related DTC. The serial data message sent by the TCM also contains a request for the ECM to illuminate the Malfunction Indicator Lamp (MIL)

The technician can observe the DTC that was set by the TCM by reviewing the ECM Freeze Frame records on the scan tool. The ECM Freeze Frame records also contain the engine operating conditions present when the transmission DTC set.

Conditions for Running the DTC

- The ignition is ON or the engine is running.
- DTC P0700 runs continuously.

Conditions for Setting the DTC

The ECM receives a serial data message from the TCM indicating that an emission related DTC has set in the TCM.

Action Taken When the DTC Sets

DTC P0700 is a Type A DTC.

Conditions for Clearing the MIL/DTC

DTC P0700 is a Type A DTC.

Diagnostic Aids

Communication codes, U-codes, as well as powertrain codes, P-codes, set in the TCM can cause the TCM to request DTC P0700 to be set in the ECM.

Reference Information

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

NOTE:

- **Do not replace the engine control module for this DTC. DTC P0700 is an informational DTC.**
- **Correct any engine control and communication DTCs before diagnosing transmission control module DTCs.**

1. Verify there are no engine control or communication DTCs set.
   - **If a DTC is set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .

   - **If a DTC is not set**
2. Verify there are no transmission control module DTCs set.
   - **If a DTC is set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .

   - **If a DTC is not set**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .

   - **If the DTC does not set**

5. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

DTC P1248-P124F: CYLINDERS (1-8) INJECTOR HIGH CONTROL CIRCUIT SHORTED TO CONTROL CIRCUIT

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P1248

Cylinder 1 Injector High Control Circuit Shorted to Control Circuit

DTC P1249

Cylinder 2 Injector High Control Circuit Shorted to Control Circuit

DTC P124A

Cylinder 3 Injector High Control Circuit Shorted to Control Circuit

DTC P124B

Cylinder 4 Injector High Control Circuit Shorted to Control Circuit

DTC P124C

Cylinder 5 Injector High Control Circuit Shorted to Control Circuit

DTC P124D

Cylinder 6 Injector High Control Circuit Shorted to Control Circuit

DTC P124E

Cylinder 7 Injector High Control Circuit Shorted to Control Circuit

DTC P124F

Cylinder 8 Injector High Control Circuit Shorted to Control Circuit

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Low Control Cylinder 1	P0261	P0201	P0262	P1248
High Control Cylinder 1	P2147	P0201	P2148	P1248
Low Control Cylinder 2	P0264	P0202	P0265	P1249
High Control Cylinder 2	P2150	P0202	P2151	P1249
Low Control Cylinder 3	P0267	P0203	P0268	P124A
High Control Cylinder 3	P2153	P0203	P2154	P124A
Low Control Cylinder 4	P0270	P0204	P0271	P124B
High Control Cylinder 4	P2156	P0204	P2157	P124B
Low Control Cylinder 5	P0273	P0205	P0274	P124C
High Control Cylinder 5	P216B	P0205	P216C	P124C
Low Control Cylinder 6	P0276	P0206	P0277	P124D
High Control Cylinder 6	P216E	P0206	P216F	P124D
Low Control Cylinder 7	P0279	P0207	P0280	P124E
High Control Cylinder 7	P217B	P0207	P217C	P124E
Low Control Cylinder 8	P0282	P0208	P0283	P124F
High Control Cylinder 8	P217E	P0208	P217F	P124F
DTC P0300 may also be present for all fault conditions				

Circuit/System Description

The engine control module (ECM) supplies voltage to each fuel injector on the high control circuits. The ECM energizes each fuel injector by grounding the low control circuit of the fuel injector. The ECM monitors the status of the fuel injector circuits. When a fuel injector circuit condition is detected by the ECM, the affected fuel injector(s) is disabled.

Conditions for Running the DTC

- DTC P062B is not present.
- Engine is running.
- Ignition voltage is greater than 11 V.
- The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

The engine control module detects greater than 25 A on the low side driver. This indicates the high side driver is shorted to the low side driver.

Action Taken When the DTC Sets

DTCs P1248, P1249, P124A, P124B, P124C, P124D, P124E and P124F are Type A DTCs.

Conditions for Clearing the DTC

DTCs P1248, P1249, P124A, P124B, P124C, P124D, P124E and P124F are Type A DTCs.

Diagnostic Aids

- Performing the fuel injector coil test may help isolate an intermittent condition. Refer to **Fuel Injector Diagnosis** .
- If the condition is intermittent, move the related harnesses and connectors, with the engine operating, while monitoring the scan tool Injector Control Circuit Status parameters. An Injector Control Circuit Status parameter will change from OK or Not Run to Malfunction if there is a condition with the circuit or a connection.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

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DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P062B is not set.
   - **If the DTC is set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle**

   - **If the DTC is not set**

NOTE: **The engine must be running for the injector circuit status parameters to function.**

3. Engine idling.
4. Verify with a scan tool parameters listed below display OK or Not Run.
   - Cylinder 1 Injector Control Circuit Status
   - Cylinder 2 Injector Control Circuit Status
   - Cylinder 3 Injector Control Circuit Status
   - Cylinder 4 Injector Control Circuit Status
   - Cylinder 5 Injector Control Circuit Status
   - Cylinder 6 Injector Control Circuit Status

- Cylinder 7 Injector Control Circuit Status
- Cylinder 8 Injector Control Circuit Status
- **If OK or Not Run is not displayed**

  Refer to Circuit/System Testing.

- **If OK or Not Run is displayed**

5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify the DTC does not set
   - **If the DTC set**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
7. All OK.

Circuit/System Testing

1. Ignition OFF, all vehicle systems OFF, disconnect the X3 harness connector at the K20 Engine Control Module. It may take up to 2 min for all vehicle systems to power down.
2. Test for greater than 3 Ω between the appropriate fuel injector high control circuit and direct low control circuit at the engine control module connector.
   - **If 3 Ω or less**
   1. Disconnect the Q17 Fuel Injector.
   2. Test for infinite resistance between the fuel injector high control circuit and low control circuit.
      - If less than infinite, repair the short in the circuit.
      - If infinite, test or replace the Q17 Fuel Injector.
   - **If greater than 3 Ω**
3. Test or Replace the K20 Engine Control Module.

Component Testing

NOTE: **The engine coolant temperature (ECT) sensor must be between 10-32Â°C (50-90Â°F) for an accurate**

measurement.

1. Ignition OFF, disconnect the harness connector at the appropriate Q17 Fuel Injector.
2. Test for 1.06 Ω +/- 10% @ 20Â°C (68Â°F) between the terminals of the fuel injector.
   - **If not within the specified range**

     Replace the Q17 Fuel Injector.

   - **If within the specified range**
3. Test for infinite resistance between each terminal and the fuel injector housing/case.
   - **If less than infinite resistance**

     Replace the Q17 Fuel Injector.

   - **If infinite resistance**
4. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Fuel Injector Replacement**
- Refer to **Control Module References** for K20 Engine Control Module replacement, programming, and setup

DTC P1255: FUEL PUMP CONTROL MODULE DRIVER HIGH TEMPERATURE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P1255

Fuel Pump Control Module Driver High Temperature

Circuit/System Description

The engine control module (ECM) supplies voltage to the fuel pump driver control module when the ECM detects that the ignition is on. The voltage from the ECM to the fuel pump driver control module remains active for 2 s, unless the engine is in crank or run. While this voltage is being received, the fuel pump driver control module supplies a varying voltage to the fuel tank fuel pump module in order to maintain the desired fuel pressure.

Conditions for Running the DTC

- The ignition voltage is greater than 7 V.
- The engine is cranking or running.
- The fuel pump enable circuit is commanded ON.
- The DTC runs continuously when the conditions above are met.

Conditions for Setting the DTC

The fuel pump driver control module detects a driver temperature greater than 150Â°C (302Â°F) for less than 0.5 s.

Action Taken When the DTC Sets

DTC P1255 is a Type A DTC.

Conditions for Clearing the DTC

DTC P1255 is a Type A DTC.

Diagnostic Aids

Using the Failure Records data may help locate an intermittent condition. If you cannot duplicate the DTC, the information in the Failure Records can help determine how many miles since the DTC set. The Fail Counter and Pass Counter can help determine how many ignition cycles that the diagnostic test reported a pass and/or a fail.

Reference Information

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Engine Controls Schematics

Connector End View Reference

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- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0231, P0232, or P023F is not set.
   - **If any of the DTCs are set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .

   - **If none of the DTCs are set**
3. Verify that the area where the K111 Fuel Pump Driver Control Module is located is free of debris, clutter, or any insulating material that would cause the fuel pump driver control module to overheat.
   - **If any debris, clutter, or other material is found**
   1. Clear the area where the K111 Fuel Pump Driver Control Module is located.
   2. Clear the DTC and test drive the vehicle.
   3. Verify the DTC does not set.

- If the DTC sets, replace the K111 Fuel Pump Driver Control Module.
- If the DTC is not set

4. All OK.

- **If no debris, clutter, or other material is found**

4. Clear the DTC and test drive the vehicle.
5. Verify the DTC does not set.
   - **If the DTC sets**

     Replace the K111 Fuel Pump Driver Control Module.

   - **If the DTC does not set**
6. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

Refer to **Fuel Pump Power Control Module Replacement** for K111 Fuel Pump Driver Control Module replacement

DTC P127C OR P127D: FUEL RAIL PRESSURE SENSOR 2 CIRCUIT VOLTAGE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P127C

Fuel Rail Pressure Sensor 2 Circuit Low Voltage

DTC P127D

Fuel Rail Pressure Sensor 2 Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference Voltage	P0192, P0193, P0340, P0345, P0365, P0390, P0506, P0641, P2227	P0192	P0193, P0641, P2227, P2229	P0191
Fuel Rail Pressure Sensor Signal 1	P0192	P0192, P0193	P0193	P0191
Fuel Rail Pressure Sensor Signal 2	P127C	P127C, P127D	P127D	P0191
Low Reference	-	P0193	P0193	P0191

Circuit/System Description

The fuel rail pressure sensor is a dual analog sensor that provides two fuel rail pressure signals to the engine control module (ECM). The ECM provides a 5 V reference voltage on the 5 V reference circuit and ground on the low reference circuit. The ECM receives a varying signal voltage on both the fuel rail pressure sensor 1 and fuel rail pressure sensor 2 signal circuits. The ECM monitors the voltage on both of the fuel rail pressure sensor circuits and compares the values to determine if the sensors are accurate. When the fuel pressure is high, the signal voltage is high. When the fuel pressure is low, the signal voltage is low.

Conditions for Running the DTC

- The engine is running.
- Battery voltage is greater than 11 V.
- The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

P127C

The engine control module detects that the fuel rail pressure sensor 2 signal voltage is less than 0.25 V for greater than 2.5 s.

P127D

The engine control module detects that the fuel rail pressure sensor 2 signal voltage is greater than 4.75 V for greater than 2.5 s.

Action Taken When the DTC Sets

- DTCs P127C and P127D are Type A DTCs.
- A message center or an indicator may display Reduced Engine Power.

Conditions for Clearing the DTC

DTCs P127C and P127D are Type A DTCs.

Reference Information

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DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0641 is not set.
   - **If the DTC is set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle**

   - **If the DTC is not set**
3. Engine at idle.
4. Verify the DTC does not set.
   - **If any of the DTCs are set**

     Refer to Circuit/System Testing.

   - **If none of the DTCs are set**
5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify the DTC does not set
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
7. All OK.

Circuit/System Testing

1. Ignition OFF, and all vehicle systems OFF, disconnect the harness connector at the B47B Fuel Rail Pressure Sensor. It may take up to 2 min for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal 3 and ground.
   - **If 5 Ω or greater**
   1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.

- **If less than 5 Ω**

3. Ignition ON.
4. Test for 4.8-5.2 V between the 5 V reference circuit terminal 1 and ground.
    - **If less than 4.8 V**
    1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the 5 V reference circuit and ground.
        - If less than infinite resistance, repair the short to ground in the circuit.
        - If infinite resistance
    3. Test for less than 2 Ω in the 5 V reference circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If greater than 5.2 V**
    1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the 5 V reference circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If between 4.8-5.2 V**
5. Verify the scan tool Fuel Rail Pressure Sensor 2 parameter is less than 0.25 V.
    - **If 0.25 V or greater**
    1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit terminal 2 and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If less than 0.25 V**
6. Install a 3 A fused jumper wire between the signal circuit terminal 2 and the 5 V reference circuit terminal 1.
7. Verify the scan tool Fuel Rail Pressure Sensor 2 parameter is greater than 4.75 V.
    - **If 4.75 V or less**
    1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit terminal 2 and ground.

- If less than infinite resistance, repair the short to ground on the circuit.
- If infinite resistance

3. Test for less than 2 Ω in the signal circuit end to end.
   - If 2 Ω or greater, repair the open/high resistance in the circuit.
   - If less than 2 Ω, replace the K20 Engine Control Module.

- **If greater than 4.75 V**

8. Test or replace the B47B Fuel Rail Pressure Sensor.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Fuel Injection Fuel Rail Fuel Pressure Sensor Replacement** for B47B Fuel Rail Pressure Sensor replacement
- Refer to **Control Module References** for K20 Engine Control Module replacement, programming, and setup

DTC P129B OR P129C: FUEL PUMP DRIVER CONTROL MODULE SYSTEM VOLTAGE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P129B

Fuel Pump Driver Control Module System Voltage Low Voltage

DTC P129C

Fuel Pump Driver Control Module System Voltage High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High	Short to Voltage	Signal Performance

		Resistance		
B+	P018B, P0506, P129B, P2635, U18A2	P018B, P0506, P129B, P2635, U18A2	P129C	-

Circuit/System Description

The fuel pump driver control module monitors the battery positive voltage circuit to verify the voltage is between the normal operating range. The DTC can set for a circuit or system voltage out of range.

Conditions for Running the DTC

P129B

- The engine is running.
- The ignition voltage is greater than 7 V.
- The fuel pump enable circuit is commanded ON.
- The DTC runs continuously when the conditions above are met.

P129C

- The engine is not running.
- The ignition voltage is greater than 7 V.
- The fuel pump enable circuit is commanded ON.
- The DTC runs continuously when the conditions above are met.

Conditions for Setting the DTC

P129B

The fuel pump driver control module detects the battery positive voltage is less than 7 V for 1 s.

P129C

The fuel pump driver control module detects the battery positive voltage is greater than 18 V for 1 s.

Action Taken When the DTC Sets

DTC P129B and P129C are Type C DTCs.

Conditions for Clearing the DTC

DTC P129B and P129C are Type C DTCs.

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Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition OFF.

2. Test for 12.4-12.8 V at the battery terminals and record the reading. The battery voltage should stabilize after a few minutes of turning the ignition OFF.
   - **If not between 12.4 V-12.8 V**

     Refer to **Battery Inspection/Test** .

   - **If between 12.4 V-12.8 V**
3. Engine running, accessories OFF.
4. Test for 13.4-15 V at the battery terminals and record the reading.
   - **If not between 13.4-15 V**

     Refer to **Charging System Test** .

   - **If between 13.4-15 V**
5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
7. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the K111 Fuel Pump Driver Control Module. It may take up to 2 min for all vehicle systems to power down.
2. Test for less than 5 Ω between the ground circuit terminal 9 and ground.
   - **If 5 Ω or greater**

     1. Ignition OFF.
     2. Test for less than 2 Ω in the ground circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, repair the open/high resistance in the ground connection.

- **If less than 5 Ω**

3. Verify a test lamp illuminates between the B+ circuit terminal 1 and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition OFF, remove the test lamp.
   2. Test for less than 2 Ω in the B+ circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**
   1. Ignition OFF, remove the test lamp.
   2. Test for infinite resistance between the B+ circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the K111 Fuel Pump Driver Control Module.
   - **If the test lamp illuminates**
4. Replace the K111 Fuel Pump Driver Control Module.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

Refer to **Fuel Pump Power Control Module Replacement** for K111 Fuel Pump Driver Control Module replacement.

DTC P129D: FUEL PUMP DRIVER CONTROL MODULE IGNITION ON/START SWITCH CIRCUIT LOW VOLTAGE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P129D

Fuel Pump Driver Control Module Ignition On/Start Switch Circuit Low Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition	P129D	P129D	P129D	-

Circuit/System Description

The fuel pump driver control module monitors the ignition voltage circuit in order to determine if the voltage is within the normal operating range.

Conditions for Running the DTC

The DTC runs continuously when the modules are awake.

Conditions for Setting the DTC

The fuel pump driver control module Power Mode does not agree with the engine control module (ECM) Power Mode for 1 s.

Action Taken When the DTC Sets

DTC P129D is a Type A DTC.

Conditions for Clearing the DTC

DTC P129D is a Type A DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

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DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Verify the engine cranks.
    - **If the engine does not crank**

      Refer to **Starter Solenoid Does Not Click** .

    - **If the engine cranks**
2. Ignition ON.
3. Verify DTC P0562 is not set.
    - **If the DTC sets**

      Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .

    - **If the DTC does not set**
4. Verify DTC P129D is not set.
    - **If the DTC sets**

      Refer to Circuit/System Testing.

    - **If the DTC does not set**

5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify DTC P129D is not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
7. All OK.

Circuit/System Testing

NOTE: **Circuit/System Verification must be performed first or misdiagnosis may result.**

1. Ignition OFF, all vehicle systems OFF, disconnect the harness connector at the K111 Fuel Pump Driver Control Module. It may take up to 2 min for all vehicle systems to power down.
2. Ignition ON.
3. Verify a test lamp illuminates between the ignition circuit terminal 6 and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition OFF, remove the test lamp.
   2. Test for less than 2 Ω in the ignition circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**
   1. Ignition OFF, remove the test lamp.
   2. Test for infinite resistance between the ignition circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the K111 Fuel Pump Driver Control Module.
   - **If the test lamp illuminates**
4. Ignition OFF, and all vehicle systems OFF, it may take up to 2 minutes for all vehicle systems to power down.
5. Verify a test lamp does not between the ignition circuit terminal 6 and ground.
   - **If the test lamp illuminates**

Repair the short to voltage on the circuit.

- **If the test lamp does not illuminate**

6. Replace the K111 Fuel Pump Driver Control Module.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

Refer to **Fuel Pump Power Control Module Replacement** for K111 Fuel Pump Driver Control Module replacement

DTC P129E OR P12A8: FUEL PUMP DRIVER CONTROL MODULE SIGNAL MESSAGE COUNTER INCORRECT/FUEL PUMP CONTROL SIGNAL MESSAGE COUNTER INCORRECT

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for a overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P129E

Fuel Pump Driver Control Module Signal Message Counter Incorrect

DTC P12A8

Fuel Pump Control Signal Message Counter Incorrect

Circuit/System Description

The fuel pump power control module is in constant communication with the engine control module (ECM) regarding the operating state of the fuel pump power control system. Serial data messages are sent in a continuously repeating series of rolling counts with associated password protect samples. Each count/sample is assigned a value. When the ECM determines that too many of the counts/samples contain an error value, the ECM sets DTC P129E or P12A8.

Conditions for Running the DTC

- The ignition voltage is greater than 7 V.
- The DTC runs continuously when the above condition is met.

Conditions for Setting the DTC

The ECM detects an error value for over 1 s.

Action Taken When the DTC Sets

DTC P129E and P12A8 are Type A DTCs.

Conditions for Clearing the DTC

DTC P129E and P12A8 are Type A DTCs.

Diagnostic Aids

An intermittent fault in the CAN circuits will cause the ECM to set DTC P129E or P12A8.

Reference Information

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

NOTE:

- **DTC P129E and P12A8 are informational DTCs.**
- **Diagnose all other engine control module DTCs prior to DTC P129E or P12A8.**

1. Verify that no other DTCs are set except for DTC P129E or P12A8.
   - **If any other DTCs are set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .

- **If only DTC P129E or P12A8 is set**

2. Replace the K111 Fuel Pump Power Control Module.
3. Verify the DTC does not set while operating the vehicle within the Conditions for Running the DTC.
   - **If DTC sets**

     Replace the K20 Engine Control Module.

   - **If DTC does not set**
4. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Fuel Pump Power Control Module Replacement** for K111 Fuel Pump Power Control Module Replacement
- Refer to **Control Module References** for K20 Engine Control Module replacement, programming, and setup

DTC P12A6: FUEL PUMP DRIVER CONTROL MODULE ENABLE CIRCUIT PERFORMANCE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P12A6

Fuel Pump Driver Control Module Enable Circuit Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control	P0171, P0506, P0628, P12A6	P0171, P0506, P12A6	-	P12A6

Circuit/System Description

The engine control module (ECM) provides ignition voltage to the fuel pump driver control module whenever the engine is cranking or running. The ECM enables the fuel pump driver control module as long as the engine is cranking or running, and ignition system reference pulses are received. While this enable voltage is being received, the fuel pump driver control module supplies a varying voltage to the fuel tank fuel pump module in order to maintain the desired fuel line pressure.

Conditions for Running the DTC

- The ignition voltage is greater than 7 V.
- The DTC runs continuously when the above condition is met.

Conditions for Setting the DTC

The engine control module state of the fuel pump enable circuit does not match the state of the fuel pump enable circuit sensed by the fuel pump driver control module for 0.5 s.

Action Taken When the DTC Sets

DTC P12A6 is a Type A DTC.

Conditions for Clearing the DTC

DTC P12A6 is a Type A DTC.

Reference Information

Schematic Reference

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- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC P12A6 is not set.
   - **If the DTC is set**

     Refer to Circuit/System Testing.

   - **If the DTC is not set**
3. Verify the parameters listed below do not display Malfunction when commanding the Fuel Pump Enable On and Off with a scan tool.
   - Fuel Pump Enable Circuit Low Voltage Test Status
   - Fuel Pump Enable Circuit Open Test Status
   - Fuel Pump Enable Circuit High Voltage Test Status
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing.

   - **If Malfunction is not displayed**
4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
5. Verify the DTC does not set.

- **If the DTC sets**

  Refer to Circuit/System Testing.

- **If the DTC does not set**

6. All OK.

Circuit/System Testing

1. Ignition OFF, all vehicle systems OFF, disconnect the harness connector at the K111 Fuel Pump Driver Control Module. It may take up to 2 min for all vehicle systems to power down.
2. Ignition ON for 10 s.
3. Verify that a test lamp does not illuminate between the control circuit terminal 2 and ground.
   - **If the test lamp illuminates**
   1. Ignition OFF, remove the test lamp, disconnect the harness connector X1 at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the control circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If the test lamp does not illuminate**
4. Remove the test lamp.
5. Verify the scan tool Fuel Pump Enable Circuit Low Voltage Test Status parameter is OK when commanding the Fuel Pump Enable On with a scan tool.
   - **If OK is not displayed**
   1. Ignition OFF, disconnect the harness connector X1 at the K20 Engine Control Module.
   2. Test for infinite resistance between the control circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.
   - **If OK is displayed**
6. Install a 3 A fused jumper wire between the control circuit terminal 2 and ground.
7. Verify the scan tool Fuel Pump Enable Circuit Low Voltage Test Status parameter is Malfunction when commanding the Fuel Pump Enable On with a scan tool.

- **If Malfunction is not displayed**

1. Ignition OFF, remove the jumper wire, disconnect the harness connector X1 at the K20 Engine Control Module.
2. Test for less than 2 Ω in the control circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If Malfunction is displayed**

8. Replace the K111 Fuel Pump Driver Control Module.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Fuel Pump Power Control Module Replacement** for K111 Fuel Pump Driver Control Module replacement.
- Refer to **Control Module References** for K20 Engine Control Module replacement, programming, and setup.

DTC P135A OR P135B: IGNITION COIL SUPPLY VOLTAGE CIRCUIT BANK 1/IGNITION COIL SUPPLY VOLTAGE CIRCUIT BANK 2

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P135A

Ignition Coil Supply Voltage Circuit Bank 1

DTC P135B

Ignition Coil Supply Voltage Circuit Bank 2

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P135A, P135B, *	P0300, P135A, P135B, **	P0690	-
* The engine cranks but does not run and opens the fuse that supplies voltage to the ignition coils. ** The engine cranks but does not run or will misfire on the affected cylinder.				

Circuit/System Description

The ignition system uses an individual ignition coil for each cylinder. The engine control module (ECM) monitors the ignition voltage from the fuse to the individual coils.

Conditions for Running the DTC

- The engine does not start after 5 engine revolutions.
- Ignition Run/Crank and PT relay voltages are greater than 11 V.

The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

The ECM detects less than 2.5 V on the ignition coil supply voltage circuit.

Action Taken When the DTC Sets

DTC P135A and P135B are Type A DTCs.

Conditions for Clearing the DTC

DTC P135A and P135B are Type A DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Electronic Ignition System Description

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

Scan Tool Reference

Control Module References

Circuit/System Verification

1. Ignition ON.
2. Verify the appropriate scan tool Ignition Coil Supply Voltage parameter displays On.
   - **If On is not displayed**

     Refer to Circuit/System Testing.

   - **If On is displayed**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
5. All OK.

Circuit/System Testing

1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.
2. Connect a 3 A fused jumper wire between the control circuit terminal 72 and ground, ignition ON.
3. Verify a test lamp illuminates between the appropriate ignition circuit terminal listed below and ground.
   - Terminal 62
   - Terminal 67
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition OFF, remove the test lamp.
   2. Test for less than 2 Ω in the ignition circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**

     NOTE: **The ignition circuit may supply voltage to other components. Make sure to test all circuits and components for a short to ground that share the ignition circuit.**

   1. Ignition OFF, remove the test lamp, and disconnect all components on the circuit.
   2. Test for infinite resistance between the ignition circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Replace the fuse, ignition ON.
   4. Verify the fuse is good after connecting each of the components one at a time.
      - If the fuse opens, replace the component that opens the fuse when connected.
      - If the fuse is good, all OK.
   - **If the test lamp illuminates**
4. Replace the K20 Engine Control Module.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Ignition Coil Replacement**
- Refer to **Control Module References** for engine control module replacement, programming, and setup

DTC P1400: COLD START EMISSION REDUCTION CONTROL SYSTEM

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** provide an overview of each diagnostic category.

DTC Descriptor

DTC P1400

Cold Start Emission Reduction Control System

Circuit/System Description

The catalyst must be warmed to efficiently reduce the emissions. The cold start strategy is to reduce the amount of time it takes to warm the catalyst. During a cold start, the engine spark timing is altered to allow the catalyst to warm quickly. This diagnostic monitors the following to build an exhaust energy model:

- Spark advance
- Engine airflow
- Engine coolant temperature
- Engine run time
- Engine idle speed
- Catalyst temperature

The actual model is then compared to the expected exhaust energy model.

Conditions for Running the DTC

- DTCs P0101, P0102, P0103, P0106, P0107, P0108, P0112, P0113, P0114, P0116, P0117, P0118, P0121, P0122, P0123, P0125, P0128, P0201-P0208, P0222, P0223, P0261, P0262, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0279, P0280, P0282, P0283, P0300-P0308, P0335, P0336, P0351-P0358, P0502, P0503, P0506, P0507, P0641, P0651, P0697, P06A3, P0722, P0723, P182E, P1915, P2122,

P2123, P2127, P2128, P2135, P2138, P2300, P2301, P2303, P2304, P2306, P2307, P2309, P2310, P2313, P2315, P2316, P2318, P2319, P2321, and P2322 are not set.

- The engine coolant temperature (ECT) is between -17-43Â°C (63-109Â°F).
- The calculated 3-way catalyst temperature is colder than 300Â°C (572Â°F).
- The barometric (BARO) pressure is greater than 75 kPa.
- The engine control module (ECM) will exit the diagnostic if the calculated 3-way catalyst temperature is greater than 800Â°C (1472Â°F) when the engine run time is greater than 1 s.
- Vehicle speed is less than 1.6 km/h (1 mph).
- The accelerator pedal is not depressed.
- The ECM will exit the diagnostic if the engine run time is greater than a calibrated value.
- This DTC runs within the first 10 s of start-up. This diagnostic runs once per trip when a cold start has been determined.

Conditions for Setting the DTC

The actual exhaust energy model does not match the expected exhaust energy model.

Action Taken When the DTC Sets

DTC P1400 is a Type A DTC.

Conditions for Clearing the DTC

DTC P1400 is a Type A DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

- **Circuit Testing**

- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Vehicle OFF, allow the engine to cool to be within the temperatures listed in the Conditions for Running the DTC.
2. Engine running.
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.
    - **If the DTC sets**
    1. Verify that none of the conditions listed below exists with the air intake system:
        - Damage, restriction, or modification
        - Dirty or deteriorating air filter element
        - Crankcase ventilation system for correct operation
        - Water intrusion
        - Vacuum leak and other unmetered air downstream of the mass air flow (MAF) sensor
        - Intake manifold leak
        - If any of the conditions exist

          Repair as necessary.

        - If none of the conditions exist
    2. Verify that none of the conditions listed below exists with the exhaust system:

- Exhaust leak
- Damaged, restricted, or modified exhaust system - Refer to **Symptoms - Engine Exhaust** .
- If any of the above conditions exist

  Repair as necessary.

- If none of the conditions exist

3. If all of the above conditions test normal, inspect for an engine mechanical condition that could alter the air flow into the combustion chamber. Refer to **Symptoms - Engine Mechanical** .

- **If the DTC does not set**

5. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

DTC P150C: TRANSMISSION CONTROL MODULE ENGINE SPEED REQUEST SIGNAL MESSAGE COUNTER INCORRECT

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P150C

Transmission Control Module Engine Speed Request Signal Message Counter Incorrect

Circuit/System Description

To improve vehicle shift feel, the transmission control module (TCM) is constantly sending the ECM serial data messages with requests to modify engine speed or torque. These serial data messages are sent through two circuits which are part of a communication network called the controller area network (CAN). The ECM sets DTC P150C when it detects a discrepancy in the structure of this message causing its integrity to be questioned.

An intermittent fault in the controller area network (CAN) circuits will cause DTC P150C to set.

Conditions for Running the DTC

- DTCs P0506, P0507, or U0101 are not set.
- The engine is running for greater than 0.5 s.
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

The ECM detects that the TCM engine speed request does not match the expected engine speed request.

Action Taken When the DTC Sets

DTC P150C is a Type B DTC.

Conditions for Clearing the DTC

DTC P150C is a Type B DTC.

Reference Information

Description and Operation

Data Link Communications Description and Operation

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

NOTE:

- **DTC P150C is an informational DTC.**
- **Diagnose all other engine control module DTCs prior to DTC P150C.**

1. Verify that no other DTCs are set except for DTC P150C.

- **If any other DTCs are set**

  Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .

- **If only DTC P150C is set**

2. Replace the K71 Transmission Control Module.
3. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
4. Verify the DTC does not set.
   - **If the DTC sets**

     Replace the K20 Engine Control Module.

   - **If the DTC does not set**
5. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

Refer to **Control Module References** for ECM or TCM replacement, programming, and setup

DTC P1516, P2101, P2119, OR P2176: THROTTLE ACTUATOR CONTROL (TAC) MODULE THROTTLE ACTUATOR POSITION PERFORMANCE/MINIMUM THROTTLE POSITION NOT LEARNED

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P1516

Throttle Actuator Control (TAC) Module Throttle Actuator Position Performance

DTC P2101

Throttle Actuator Position Performance

DTC P2119

Throttle Closed Position Performance

DTC P2176

Minimum Throttle Position Not Learned

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control Closed	P2101	P2101	P0690, P2101	P1516, P2101, P2176
Control Open	P2119	P2101	P2101	P1516, P2101, P2176

Circuit/System Description

The throttle body assembly contains a contact-less inductive throttle position sensing element that is managed by a customized integrated circuit. The throttle position (TP) sensor is mounted within the throttle body assembly and is not serviceable. The engine control module (ECM) supplies the throttle body with a 5 V reference circuit, a low reference circuit, an H-bridge motor directional control circuit, and an asynchronous signal/serial data circuit. The asynchronous signal means communication is only going from the throttle body to the ECM. The throttle body cannot receive data from the ECM over the signal/serial data circuit. The TP sensor provides a signal voltage that changes relative to throttle blade angle. The customized integrated circuit translates the voltage based position information into serial data using the Society of Automotive Engineers (SAE) J2716 Single Edge Nibble Transmission (SENT) protocol. The TP sensor information is transmitted between the throttle body and the ECM on the signal/serial data circuit. The ECM decodes the serial data signal into separate voltages which are displayed on a scan tool as the voltage inputs from TP sensors 1 and 2.

The ECM controls the throttle valve by applying a varying voltage to the control circuits of the throttle actuator control (TAC) motor. The ECM monitors the duty cycle that is required to actuate the throttle valve. The ECM monitors the TP sensor signal/serial data circuit to determine the actual throttle valve position.

Conditions for Running the DTC

P1516

- DTC P1682 is not set.
- The run/crank or powertrain relay voltage is greater than 6.41 V and reduced power is not active.
- DTC P1516 runs continuously when the above conditions are met.

P2101

- DTC P1682 is not set.
- The run/crank or powertrain relay voltage is greater than 6.41 V and reduced power is not active.
- The engine is running or the following conditions are met:
  - The engine is not running.
  - The ignition voltage is greater than 11 V.
  - The TAC system is not in the Battery Saver mode.
  - The ECM is commanding the throttle.
  - The ECM has learned the minimum throttle position.
- DTC P2101 runs continuously when the above conditions are met.

P2119

- DTCs P0122, P0123, P0222, P0223, or P06A3 is not set.
- The run/crank or powertrain relay voltage is greater than 6.41 V and reduced power is not active.
- The system is not in the Battery Save mode.
- The ECM is not commanding the throttle.
- DTC P2119 runs continuously when the above conditions are met.

P2176

- The run/crank or powertrain relay voltage is greater than 6.41 V and reduced power is not active.
- The throttle minimum learn is active.
- DTC P2176 runs continuously when the above conditions are met.

Conditions for Setting the DTC

P1516

The ECM detects an unstable throttle position for greater than 1 s.

P2101

- The ECM detects the actual throttle position does not match the predicted throttle position for greater than 1 s.

  OR

- The ECM detects the throttle control is driving the throttle in the incorrect direction or exceed the reduced power limit.

P2119

The ECM determines that the throttle blade did not return to the rest position within 1 s.

P2176

The ECM detects that both throttle position (TP) sensors were greater than a predetermined voltage during the minimum throttle learn procedure for greater than 2 s.

Action Taken When the DTC Sets

- DTCs P1516, P2101, and P2176 are type A DTCs.
- DTC P2119 is a type C DTC.
- The ECM commands the TAC system to operate in the Reduced Engine Power mode.
- A message center or an indicator displays Reduced Engine Power.
- Under certain conditions, the control module commands the engine OFF.

Conditions for Clearing the MIL/DTC

- DTCs P1516, P2101, and P2176 are type A DTCs.
- DTC P2119 is a type C DTC.

Diagnostic Aids

- Depending on the scan tool Start-Up ECT parameter, the Desired Throttle Position percentage maybe greater or less than the Throttle Position with the TAC motor at rest. When the ignition is initially turned ON, or when the engine is cranking or running the scan tool Desired and Actual Throttle positions should closely match.

- Inspect for a condition in which the throttle valve may have been held open. For example, ice may have formed in the throttle bore causing the throttle valve not to close.
- A high resistance condition on the throttle position and throttle actuator control circuits could cause a DTC to set.
- A low battery condition may cause a DTC to set.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Throttle Actuator Control (TAC) System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.

NOTE: **A low battery voltage or charging system condition may cause a DTC to set.**

2. Verify DTC P0121, P0122, P0123, P0222, P0223, P0562, P0621, P0622, or P2135 is not set.
   - **If any of the DTCs are set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** for further diagnosis.

   - **If none of the DTCs are set**
3. Verify the scan tool Throttle Body Idle Air flow Compensation parameter is less than 90%.
   - **If 90% or greater**

     Refer to **Throttle Body Cleaning** .

   - **If less than 90%**
4. Clear the DTCs with a scan tool.
5. Ignition OFF and all vehicle systems OFF. It may take up to 2 minutes for all vehicle systems to power down.
6. Ignition ON.
7. Verify the scan tool TAC Motor parameter displays Enabled while slowly depressing the accelerator pedal.
   - **If Enabled is not displayed**

     Refer to Circuit/System Testing.

   - **If Enabled is displayed**
8. Verify DTC P1516, P2101, P2119, or P2176 is not set.
   - **If any of the DTCs are set**

     Refer to Circuit/System Testing.

   - **If none of the DTCs are set**

NOTE: **If there is a condition with the throttle body, the TAC Motor Command parameter will go to 99% for a predetermined amount of time and then a DTC sets. Once a DTC is set, the TAC Motor Command parameter will go to 0% and the TAC Motor parameter will display Disabled.**

9. Verify the scan tool TAC Motor parameter displays Enabled while performing the Throttle Sweep Test with a scan tool.

- **If Enabled is not displayed**

  Replace the Q38 Throttle Body.

- **If Enabled is displayed**

10. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
11. Verify the DTC does not set.
    - **If the DTC sets**

      Refer to Circuit/System Testing.

    - **If the DTC does not set**
12. All OK.

Circuit/System Testing

1. Ignition OFF.

   WARNING: Turn OFF the ignition before inserting fingers into the throttle bore. Unexpected movement of the throttle blade could cause personal injury.

2. Verify the conditions listed below do not exist with the Q38 Throttle Body Assembly:

   NOTE:
   - **The rest position is defined as the actual Throttle Position percentage when the ignition is OFF or with the ignition ON for greater than 30 seconds.**
   - **When the ignition is OFF, spring tension should hold the throttle plate in the rest position. You should be able to open the throttle plate to wide open throttle (WOT) or push the throttle plate to the fully closed position. In each case, the throttle plate should return to the rest position without assistance.**

   - A throttle blade that is not in the rest position
   - A throttle blade that is binding open or closed
   - A throttle blade that is free to move open or closed without spring pressure
   - **If a condition is found**

Replace the Q38 Throttle Body.

- **If a condition is not found**

NOTE: **Disconnecting the throttle body harness connector may cause additional DTCs to set.**

3. Ignition OFF, disconnect the harness connector at the Q38 Throttle Body.

NOTE:
- **Before testing each circuit, the ignition must be OFF and the ECM completely powered down.**
- **The test lamp must be connected to the circuit before turning the ignition ON, or incorrect diagnosis may occur.**

4. Connect a test lamp between a motor control circuit listed below and ground.
   - TAC Motor Control Open circuit terminal 1
   - TAC Motor Control Closed circuit terminal 2

NOTE:
- **The test lamp should illuminate then immediately turn OFF as the ignition is switched to the ON position.**
- **Be prepared to observe the test lamp as the ignition is switched ON.**

5. Ignition ON, verify that a test lamp does not illuminate continuously after the ignition is switched to ON.
   - **If the test lamp illuminates continuously**
   1. Ignition OFF, disconnect the appropriate harness connector at the K20 Engine Control Module and remove the test lamp, ignition ON.
   2. Test for less than 1 V between the control circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If the test lamp is always OFF**
   1. Ignition OFF, disconnect the appropriate harness connector at the K20 Engine Control Module and remove the test lamp.
   2. Test for infinite resistance between the control circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance.

3. Test for less than 2 Ω in the control circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.
- **If the test lamp illuminates then turns OFF with ignition ON.**

6. Ignition OFF, remove the test lamp. Set the DMM to the 40 V scale or higher, select the Min/Max Recording Mode, and set the Peak Min/Max response time to 1 ms or faster.

NOTE:

- **The DMM Min/Max Recording Mode and the response time of 1 ms or faster must be reset after testing each circuit or a lower voltage will be recorded.**
- **The ignition must be OFF and the ECM completely powered down before testing each circuit or a lower voltage will be recorded.**

7. Verify the Max voltage is within 3 V of B+, while using DMM Min/Max Recording Mode function on each control circuit listed below and ground, as the ignition is turned ON.
    - TAC Motor Control Open circuit terminal 1
    - TAC Motor Control Closed circuit terminal 2
    - **If not within 3 V of B+**
    1. Ignition OFF, disconnect the appropriate harness connector at the K20 Engine Control Module.
    2. Test for less than 2 Ω in the control circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If within 3 V of B+**
8. Replace the Q38 Throttle Body.

Repair Instructions

- Refer to **Throttle Body Assembly Replacement**
- Refer to **Control Module References** for ECM replacement, programming, and setup

Repair Verification

1. Install any components that have been removed or replaced during diagnosis.

2. Perform any adjustments, programming or setup procedures that are required when a component is removed or replaced.
3. Clear the DTCs with a scan tool.
4. Ignition OFF and all vehicle systems OFF. It may take up to 2 minutes for all vehicle systems to power down.
5. Ignition ON.
6. Verify the scan tool TAC Motor parameter displays Enabled while performing the Throttle Sweep Test with a scan tool.
   - **If Enabled is not displayed**

     Test or replace the Q38 Throttle Body.

   - **If Enabled is displayed**
7. If the repair was related to a DTC, duplicate the Conditions for Running the DTC and use the Freeze Frame/Failure Records, if applicable, in order to verify the DTC does not set.
   - **If DTC sets**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** for further diagnosis.

   - **If DTC does not set**
8. All OK.

DTC P163A: CONTROL MODULE FUEL PRESSURE REGULATOR 1 CONTROL SYSTEM CIRCUITRY PERFORMANCE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P163A

Control Module Fuel Pressure Regulator 1 Control System Circuitry Performance

Circuit/System Description

This diagnostic applies to internal microprocessor integrity conditions within the engine control module (ECM). The ECM monitors the current

required to control fuel pressure regulator 1 and compares the current value to calibrated low and high thresholds.

Conditions for Running the DTC

- DTCs P0010, P0011, P0016, P0089, P0090, P0091, P0092, P0096, P0097, P0098, P0099, P00C8, P00C9, P00CA, P0117, P0118, P0178, P0179, P018B, P018C, P018D, P0192, P0193, P0231, P0232, P023F, P0335, P0336, P0340, P0341, or P1692 are not present.
- Fuel rail pressure is greater than 0.275 MPa (40 PSI).
- Battery voltage is greater than 11 V.
- Fuel temperature is between -10Â°C (14Â°F) and 100Â°C (212Â°F).
- Intake air temperature is greater than -10Â°C (14Â°F).
- The engine has been running for greater than 2 m.
- Barometric pressure is greater than 70 kPa.
- Vehicle is not in a low fuel state.
- DTC P163A runs continuously when the above conditions are met.

Conditions for Setting the DTC

The engine control module detects a condition with the integrated circuits of the high pressure fuel pump actuator driver module or the engine control module detects that the current used to drive the high pressure fuel pump actuator is out of range for greater than 1 s.

Action Taken When the DTC Sets

DTC P163A is a Type B DTC.

Conditions for Clearing the DTC

DTC P163A is a Type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTCs P0010, P0011, P0016, P0089, P0090, P0091, P0092, P0096, P0097, P0098, P0099, P00C8, P00C9, P00CA, P0117, P0118, P0178, P0179, P018B, P018C, P018D, P0192, P0193, P0231, P0232, P023F, P0335, P0336, P0340, P0341, or P1682 is not set.
   - **If any of the DTCs are set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle**

   - **If none of the DTCs are set**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

- **If the DTC does not set**

5. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the G18 High Pressure Fuel Pump. It may take up to 2 min for all vehicle systems to power down.
2. Ignition ON.
3. Verify that a test lamp does not illuminate between the high control circuit terminal 1 and ground.
   - **If the test lamp illuminates**
   1. Ignition OFF, remove the test lamp, disconnect the X3 harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the high control circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If the test lamp does not illuminate**
4. Verify that a test lamp does not illuminate between the low control circuit terminal 2 and ground.
   - **If the test lamp illuminates**
   1. Ignition OFF, remove the test lamp, disconnect the X3 harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the low control circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If the test lamp does not illuminate**
5. Verify that a test lamp does not illuminate between the high control circuit terminal 1 and B+.
   - **If the test lamp illuminates**
   1. Ignition OFF, remove the test lamp, disconnect the X3 harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the high control circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.
   - **If the test lamp does not illuminate**
6. Verify that a test lamp does not illuminate between the low control circuit terminal 2 and B+.

- **If the test lamp illuminates**

1. Ignition OFF, remove the test lamp, disconnect the X3 harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the low control circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance, replace the K20 Engine Control Module.

- **If the test lamp does not illuminate**

7. Remove the test lamp, connect a 3 A fused jumper wire between the high control circuit terminal 1 and ground.
8. Verify the Fuel Pressure Regulator 1 High Control Circuit Low Voltage Test Status transitions from OK to Malfunction.

- **If Malfunction is not displayed**

1. Ignition OFF, remove the fused jumper, disconnect the harness connector X3 at the K20 Engine Control Module.
2. Test for less than 2 Ω in the high control circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If Malfunction is displayed**

9. Connect a 3 A fused jumper wire between the low control circuit terminal 2 and B+.
10. Verify the Fuel Pressure Regulator 1 Control Circuit High Voltage Test Status transitions from OK to Malfunction.

- **If Malfunction is not displayed**

1. Ignition OFF, remove the fused jumper, disconnect the X3 harness connector at the K20 Engine Control Module.
2. Test for less than 2 Ω in the low control circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If Malfunction is displayed**

11. Test or replace the G18 High Pressure Fuel Pump.

Component Testing

1. Ignition OFF, disconnect the harness connector at the G18 High Pressure Fuel Pump.

NOTE: **The DMM and test leads must be calibrated to 0 Ω in order to prevent misdiagnosis.**

2. Test for 0.34 - 0.44 Ω at 20Â°C (68Â°F) between the low control circuit terminal 2 and the high control circuit terminal 1.

- **If not within the specified range**

  Replace the G18 High Pressure Fuel Pump.

- **If within the specified range**

3. Test for infinite resistance between each terminal and the G18 High Pressure Fuel Pump housing.
   - **If less than infinite resistance**

     Replace the G18 High Pressure Fuel Pump.

   - **If infinite resistance**
4. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Fuel Pump Replacement** for G18 High Pressure Fuel Pump replacement
- Refer to **Control Module References** for K20 Engine Control Module replacement, programming, and setup

NOTE: **Some vehicles do not support the Fuel Rail Pressure Relief Valve Reset procedure. Applications not supporting this procedure will return an error message stating "Parameter ID not supported. Check for proper vehicle selection."**

- Perform the Fuel Rail Pressure Relief Valve Reset procedure.

DTC P2096-P2099: POST CATALYST FUEL TRIM SYSTEM

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P2096

Post Catalyst Fuel Trim System Low Limit Bank 1

DTC P2097

Post Catalyst Fuel Trim System High Limit Bank 1

DTC P2098

Post Catalyst Fuel Trim System Low Limit Bank 2

DTC P2099

Post Catalyst Fuel Trim System High Limit Bank 2

Circuit Description

Fuel trim bias is used to keep the post catalyst air/fuel ratio within a predetermined range. This allows optimal catalyst efficiency under various operating conditions. The engine control module (ECM) constantly monitors how lean or rich the fuel trim bias is commanded, to determine if the fuel trim bias is greater than a calibrated amount.

Conditions for Running the DTC

- DTC P0016, P0030, P0036, P0053, P0054, P0056, P0059, P0060, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0128, P0131-P0135, P0137, P0138, P013A, P013B, P013C, P013D, P013E, P013F, P0140, P0141, P0151- P0155, P0157, P0158, P015A, P015B, P015C, P015D, P0160, P0161, P0178, P0179, P0201-P0208, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282, P0283, P0300-P0308, P0340, P0341, P0442, P0443, P0446, P0449, P0452, P0453, P0455, P0458, P0459, P0496, P0498, P0499, P1248, P1249, P124A, P124B, P124C, P124D, P124E, P124F, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F, P217B, P217C, P217E, P217F, P219A, P219B, P2227, P2228, P2229, P2269, P2270, P2271, P2272, or P2273 is not set.
- The barometric pressure is greater than 70 kPa (10.2 PSI).
- The manifold absolute pressure is between 0-200 kPa (0-29 PSI).
- The intake air temperature is between -20Â°C and +200Â°C (-4 and +392Â°F).
- The start up engine coolant temperature is warmer than -20Â°C (-4Â°F).
- The fuel control intrusive diagnostics are not active.
- The power take-off is not active, if equipped.
- The engine is operating under light acceleration, heavy acceleration, or cruise conditions.

- DTCs P2096, P2097, P2098, and P2099 run continuously when the conditions above have been met.

Conditions for Setting the DTC

The correction limit for a condition causing a rich or lean air/fuel ratio has been exceeded.

Action Taken when the DTC Sets

DTCs P2096, P2097, P2098, and P2099 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P2096, P2097, P2098, and P2099 are Type B DTCs.

Diagnostic Aids

- The post catalyst fuel trim diagnostic is very sensitive to heated oxygen sensor (HO2S) design. A non-OE sensor or an incorrect part number may cause a DTC to set.
- Certain aftermarket air filters may cause a DTC to set.
- Certain aftermarket air induction systems or modifications to the air induction system may cause a DTC to set.
- Certain aftermarket exhaust system components may cause a DTC to set.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Electrical Information Reference

- **Circuit Testing**

- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify no other HO2S or fuel trim DTC is set.
   - **If any other HO2S or fuel trim DTC is set**

     Refer to Diagnostic Trouble Code (DTC) List - Vehicle for further diagnosis.

   - **If no other HO2S or fuel trim DTC is set**
3. Verify DTC P2096, P2097, P2098, or P2099 is not set.
   - **If a DTC is set**

     Refer to Circuit/System Testing.

   - **If no DTC is set**
4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed in the Freeze Frame/Failure Records data.
5. Verify DTC P2096, P2097, P2098, or P2099 is not set.
   - **If a DTC is set**

     Refer to Circuit/System Testing.

   - **If no DTC is set**
6. All OK.

Circuit/System Testing

Verify none of the conditions listed below exist:

P2096 or P2098

- Air intake duct collapsed or restricted.
- Air filter dirty or restricted.
- Contamination of the mass air flow sensor with oil or other foreign material
- Objects blocking the throttle body.
- Excessive fuel in the crankcase. Change engine oil as necessary.
- Rich fuel injectors. Refer to **Fuel Injector Diagnosis** .
- Excessive fuel system pressure. Refer to **Fuel System Diagnosis** .
- Fuel contamination. Refer to **Alcohol/Contaminants-in-Fuel Diagnosis** .
- Fuel saturation of the evaporative emissions (EVAP) canister.
- Stuck open or leaking EVAP purge valve.
- Restricted exhaust. Refer to **Symptoms - Engine Exhaust** .
- Improper operation of the crankcase ventilation system.

P2097 or P2099

- Exhaust system leaks. Refer to **Symptoms - Engine Exhaust** .
- Split, kinked or improperly connected vacuum hoses.
- Contamination of the mass air flow sensor with oil or other foreign material
- Insufficient fuel in the tank.
- Leaks in the air induction system and air intake ducts.
- Missing air filter element.
- Cracked evaporative canister.
- Evaporative pipes plugged, obstructed, or leaking.
- Crankcase ventilation system leaking.
- Engine vacuum leaks.

- Low fuel system pressure. Refer to **Fuel System Diagnosis** .
- Contaminated fuel. Refer to **Alcohol/Contaminants-in-Fuel Diagnosis** .
- Lean fuel injectors. Refer to **Fuel Injector Diagnosis** .

- **If a condition is found**

Repair as necessary.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

Perform the scan tool Fuel Trim Reset after completing the repair.

DTC P2122, P2123, P2127, P2128, OR P2138: ACCELERATOR PEDAL POSITION SENSOR 1 CIRCUIT VOLTAGE/ACCELERATOR PEDAL POSITION SENSOR 2 CIRCUIT VOLTAGE/ACCELERATOR PEDAL POSITION SENSORS 1-2 NOT PLAUSIBLE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P2122

Accelerator Pedal Position (APP) Sensor 1 Circuit Low Voltage

DTC P2123

Accelerator Pedal Position (APP) Sensor 1 Circuit High Voltage

DTC P2127

Accelerator Pedal Position (APP) Sensor 2 Circuit Low Voltage

DTC P2128

Accelerator Pedal Position (APP) Sensor 2 Circuit High Voltage

DTC P2138

Accelerator Pedal Position (APP) Sensors 1-2 Not Plausible

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
Accelerator Pedal Position (APP) Sensor 1 5 V Reference Circuit	P06A3	P2138	P2122	P06A3	P2138
Accelerator Pedal Position (APP) Sensor 2 5 V Reference Circuit	P0106, P0108, P0107, P0697	P2138	P2127	P0106, P0108, P0697	P2138
Accelerator Pedal Position (APP) Sensor 1 Signal	P2122	P2138	P2122	P2123, P2138	P2138
Accelerator Pedal Position (APP) Sensor 2 Signal	P2127	P2138	P2127	P2128, P2138	P2138
Accelerator Pedal Position (APP) Sensor 1 Low Reference	-	P2138	P2123	-	P2138
Accelerator Pedal Position (APP) Sensor 2 Low Reference	-	P2138	P2128	-	P2138

Typical Scan Tool Data

APP Sensor 1

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: The engine is operating at idle. **Parameter Normal Range:** APP Sensor 1 0.88-1.08 V			
5 V Reference	0.00 V	0.00 V	2-3 V
Signal	0.00 V	0.00 V	4-5 V
Low Reference	-	4-5 V	-

APP Sensor 2

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: The engine is operating at idle.			

Circuit	Short to Ground	Open	Short to Voltage
Parameter Normal Range: APP Sensor 2 0.39-0.59 V			
5 V Reference	0.00 V	0.00 V	1-3 V
Signal	0.00 V	0.00 V	2-5 V
Low Reference	-	4-5 V	-

Circuit/System Description

The accelerator pedal assembly contains 2 accelerator pedal position (APP) sensors. The APP sensors are mounted to the accelerator pedal assembly and are not serviceable. The APP sensors provide a signal voltage that change relative to pedal position. The engine control module (ECM) supplies each APP sensor with a 5 V reference circuit, a low reference circuit, and a signal circuit.

Both the APP sensors 1 and 2 signal percentages increase as the pedal is depressed, from approximately 0 percent at rest to above 95 percent when fully depressed.

Vehicles equipped with a M5U-8L90 transmission utilize a 2 stage APP sensor that contains an electro-mechanical switch. The switch signals the TCM to request a full detent downshift at or near wide open throttle (WOT).

Conditions for Running the DTC

P2122, P2123, P2127, or P2128

- DTC P06A3 or P0697 are not set.
- The ignition is ON or the engine is operating.
- The ignition voltage is greater than 6.41 V.
- The DTCs run continuously when the above conditions are met.

P2138

- DTCs P06A3, P0697, P2122, P2123, P2127, or P2128 are not set.
- The ignition is ON or the engine is operating.
- The ignition voltage is greater than 6.41 V.
- The ECM is not commanding reduced power.
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

P2122

The ECM detects that the APP sensor 1 voltage is less than 0.46 V for less than 1 s.

P2123

The ECM detects that the APP sensor 1 voltage is greater than 4.75 V for less than 1 s.

P2127

The ECM detects that the APP sensor 2 voltage is less than 0.32 V for less than 1 s.

P2128

The ECM detects that the APP sensor 2 voltage is greater than 2.6 V for less than 1 s.

P2138

The ECM detects that APP sensor 1 and APP sensor 2 disagree greater than 10 percent for less than 1 s.

OR

The ECM detects that both APP sensor 1 and APP sensor 2 are 5 percent greater than the learned minimum position for less than 1 s.

Action Taken When the DTC Sets

- DTCs P2122, P2123, P2127, P2128, and P2138 are Type A DTCs.
- The ECM commands the TAC system to operate in a Reduced Engine Power mode.

Conditions for Clearing the DTC

DTCs P2122, P2123, P2127, P2128, and P2138 are Type A DTCs.

Diagnostic Aids

- A high resistance condition on the accelerator pedal position circuits could cause a DTC to set.
- Ensure that the in-line harness connector seals are installed correctly. Improper installation could result in water intrusion into the connector

and cause a DTC to set.

- Vehicles equipped with a M5U-8L90 transmission utilize a 2 stage APP sensor that contains an electro-mechanical switch. Additional effort is required to depress the pedal to WOT in order overcome the additional spring tension at or near 100% throttle.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Throttle Actuator Control (TAC) System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0697 or P06A3 is not set.

- **If any of the DTCs are set**

  Refer to **DTC P0641, P0651, P0697, or P06A3** for further diagnosis.

- **If none of the DTCs are set**

3. Verify the APP Sensor 1 Circuit Status and APP Sensor 2 Circuit Status displays OK.
   - **If OK is not displayed**

     Refer to Circuit/System Testing.

   - **If OK is displayed**
4. Verify the scan tool APP Sensor 1 and 2 Agree/Disagree parameter displays Agree while performing the tests listed below:
   - Rapidly depress the accelerator pedal from the rest position to the wide open throttle position (WOT) and release pedal. Repeat the procedure several times.
   - Slowly depress the accelerator pedal to WOT and then slowly return the pedal to closed throttle. Repeat the procedure several times.
   - **If Agree is not displayed**

     Refer to Circuit/System Testing.

   - **If Agree is displayed**
5. Verify that DTC P2122, P2123, P2127, P2128, or P2138 is not set.
   - **If any of the DTCs are set**

     Refer to Circuit/System Testing.

   - **If none of the DTCs set**
6. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
7. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing

   - **If the DTC does not set**
8. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B107 Accelerator Pedal Position Sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between each low reference circuit terminal listed below and ground.
    - Low reference circuit terminal F
    - Low reference circuit terminal A
    - **If 5 Ω or greater**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for less than 2 Ω in the low reference circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If less than 5 Ω**
3. Ignition ON.
4. Test for 4.8-5.2 V between each 5 V reference circuit terminal listed below and ground.
    - 5 V reference circuit terminal D
    - 5 V reference circuit terminal C
    - **If less than 4.8 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the 5 V reference circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 Ω in the 5 V reference circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If greater than 5.2 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the 5 V reference circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.

    - If less than 1 V, replace the K20 Engine Control Module.
  - **If between 4.8-5.2 V**
5. Verify each APP sensor voltage parameter is less than 0.2 V.
  - **If 0.2 V or greater**
  1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
  2. Test for less than 1 V between the signal circuit terminal listed below and ground.
  - APP sensor 1 signal circuit terminal E
  - APP sensor 2 signal circuit terminal B
  - If 1 V or greater, repair the short to voltage on the circuit.
  - If less than 1 V, replace the K20 Engine Control Module.
  - **If less than 0.2 V**
6. Install a 3 A fused jumper wire between the appropriate signal circuit terminal listed below and a 5 V reference circuit terminal D or C.
  - APP sensor 1 signal circuit terminal E
  - APP sensor 2 signal circuit terminal B
7. Verify the scan tool APP Sensor 1 or 2 voltage parameter is greater than 4.8 V.
  - **If 4.8 V or less**
  1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
  2. Test for infinite resistance between the signal circuit terminal and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance
  3. Test for less than 2 Ω in the signal circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.
  - **If greater than 4.8 V**
8. Test or replace the B107 Accelerator Pedal Position Sensor.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Accelerator Pedal Position Sensor Replacement**
- Refer to **Control Module References** for ECM replacement, programming, and setup

DTC P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F, P217B, P217C, P217E, OR P217F: CYLINDERS (1-8) INJECTOR HIGH CONTROL CIRCUIT VOLTAGE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P2147

Cylinder 1 Injector High Control Circuit Low Voltage

DTC P2148

Cylinder 1 Injector High Control Circuit High Voltage

DTC P2150

Cylinder 2 Injector High Control Circuit Low Voltage

DTC P2151

Cylinder 2 Injector High Control Circuit High Voltage

DTC P2153

Cylinder 3 Injector High Control Circuit Low Voltage

DTC P2154

Cylinder 3 Injector High Control Circuit High Voltage

DTC P2156

Cylinder 4 Injector High Control Circuit Low Voltage

DTC P2157

Cylinder 4 Injector High Control Circuit High Voltage

DTC P216B

Cylinder 5 Injector High Control Circuit Low Voltage

DTC P216C

Cylinder 5 Injector High Control Circuit High Voltage

DTC P216E

Cylinder 6 Injector High Control Circuit Low Voltage

DTC P216F

Cylinder 6 Injector High Control Circuit High Voltage

DTC P217B

Cylinder 7 Injector High Control Circuit Low Voltage

DTC P217C

Cylinder 7 Injector High Control Circuit High Voltage

DTC P217E

Cylinder 8 Injector High Control Circuit Low Voltage

DTC P217F

Cylinder 8 Injector High Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Low Control Cylinder 1	P0261	P0201	P0262	P1248
High Control Cylinder 1	P2147	P0201	P2148	P1248
Low Control Cylinder 2	P0264	P0202	P0265	P1249
High Control Cylinder 2	P2150	P0202	P2151	P1249
Low Control Cylinder 3	P0267	P0203	P0268	P124A
High Control Cylinder 3	P2153	P0203	P2154	P124A
Low Control Cylinder 4	P0270	P0204	P0271	P124B
High Control Cylinder 4	P2156	P0204	P2157	P124B
Low Control Cylinder 5	P0273	P0205	P0274	P124C
High Control Cylinder 5	P216B	P0205	P216C	P124C
Low Control Cylinder 6	P0276	P0206	P0277	P124D
High Control Cylinder 6	P216E	P0206	P216F	P124D
Low Control Cylinder 7	P0279	P0207	P0280	P124E
High Control Cylinder 7	P217B	P0207	P217C	P124E
Low Control Cylinder 8	P0282	P0208	P0283	P124F
High Control Cylinder 8	P217E	P0208	P217F	P124F
DTC P0300 may also be present for all fault conditions				

Circuit/System Description

The engine control module (ECM) supplies voltage to each fuel injector on the high control circuits. The ECM energizes each fuel injector by grounding the low control circuit of the fuel injector. The ECM monitors the status of the fuel injector circuits. When a fuel injector circuit condition is detected by the ECM, the affected fuel injector(s) is disabled.

Conditions for Running the DTC

- DTC P062B is not present.
- Engine is running.
- Ignition voltage is greater than 11 V.
- The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

P2147, P2150, P2153, P2156, P216B, P216E, P217B, or P217E

The engine control module detects the fuel injector high voltage supply circuit is shorted to ground for greater than 2 s.

P2148, P2151, P2154, P2157, P216C, P216F, P217C, or P217F

The engine control module detects the fuel injector high voltage supply circuit is shorted to voltage for greater than 2 s.

Action Taken When the DTC Sets

DTCs P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F, P217B, P217C, P217E, and P217F are Type A DTCs.

Conditions for Clearing the DTC

DTCs P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F, P217B, P217C, P217E, and P217F are Type A DTCs.

Diagnostic Aids

- The MIL indicator flashes when there is an engine misfire.
- High resistance in the circuits of the fuel injectors may set a misfire DTC without setting an injector DTC. Test the fuel injector circuits of the affected cylinder(s) for a high resistance if you suspect a condition.
- Performing the fuel injector coil test may help isolate an intermittent condition. Refer to **Fuel Injector Diagnosis** .
- If the condition is intermittent, move the related harnesses and connectors, with the engine operating, while monitoring the scan tool Injector Control Circuit Status parameters. An Injector Control Circuit Status parameter will change from OK or Not Run to Malfunction if there is a condition with the circuit or a connection.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P062B is not set.
   - **If the DTC is set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle**

   - **If the DTC is not set**

NOTE: **The engine must be running for the injector circuit status parameters to function.**

3. Engine idling.
4. Verify with a scan tool parameters listed below display OK or Not Run.
   - Cylinder 1 Injector Control Circuit Status
   - Cylinder 2 Injector Control Circuit Status
   - Cylinder 3 Injector Control Circuit Status

- Cylinder 4 Injector Control Circuit Status
- Cylinder 5 Injector Control Circuit Status
- Cylinder 6 Injector Control Circuit Status
- Cylinder 7 Injector Control Circuit Status
- Cylinder 8 Injector Control Circuit Status
- **If OK or Not Run is not displayed**

  Refer to Circuit/System Testing.

- **If OK or Not Run is displayed**

5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify the DTC does not set
   - **If the DTC set**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
7. All OK.

Circuit/System Testing

1. Ignition OFF, all vehicle systems OFF, disconnect the X3 harness connector at the K20 Engine Control Module. It may take up to 2 min for all vehicle systems to power down.
2. Test for infinite resistance between the appropriate Q17 Fuel Injector high control circuit and ground.
   - **If less than infinite resistance**
   1. Disconnect the harness connector of the Q17 Fuel Injector.
   2. Test for infinite resistance between the Q17 Fuel Injector high control circuit and ground.
      - If less than infinite, repair the short to ground in the circuit.
      - If infinite, test or replace the Q17 Fuel Injector.
   - **If infinite resistance**
3. Ignition ON.

4. Test for less than 1 V between the Q17 Fuel Injector high control circuit and ground.
    - **If 1 V or greater**
    1. Disconnect the harness connector of the Q17 Fuel Injector, ignition ON.
    2. Test for less than 1 V between the Q17 Fuel Injector high control circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, repair the short to voltage on the low control circuit.
    - **If less than 1 V**
5. Test or replace the K20 Engine Control Module.

Component Testing

- Refer to **Fuel Injector Diagnosis**
- Refer to **Fuel Injector Balance Test**

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Fuel Injector Replacement**
- Refer to **Control Module References** for K20 Engine Control Module replacement, programming, and setup

DTC P2199: INTAKE AIR TEMPERATURE (IAT) SENSORS 1-2 NOT PLAUSIBLE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P2199

Intake Air Temperature (IAT) Sensors 1-2 Not Plausible

Diagnostic Fault Information

IAT 1 Sensor

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	P0112, P0114, P2199	P0111, P0113, P0114, P2199	P0113, P0114, P2199*	P0111, P2199
Low Reference	-	P0111, P0113, P0114, P2199, P2227, P2228, P2229	P0113, P0114, P2199, P2227, P2229*	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

IAT Sensor 2

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0096, P0097, P00F4, P0102, P0178, P2199	P0096, P0097, P00F4, P0101, P0102, P2199, P2230	P0690	P0096, P0101, P0103
Signal	P0096, P0097, P00F5, P2199	P0096, P0097, P00F4, P2199	P0096, P0097, P00F4, P2199*	P0096
Ground	-	P0096, P0097, P00F4, P0102, P2199, P2230	-	P0096, P0102
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

IAT 1 Sensor

Circuit	Short to Ground	Open or High Resistance	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** Varies with ambient temperature; and engine bay conditions			
Signal	150Â°C (302Â°F)	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
Low Reference	-	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
*Internal ECM or sensor damage may occur if the circuit is shorted to B+			

IAT Sensor 2

Circuit	Short to Ground	Open or High Resistance	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** Varies with ambient temperature			
Ignition Voltage	-40Â°C (-40Â°F) 10 Hz	-40Â°C (-40Â°F) 10 Hz	-
Signal	-40Â°C (-40Â°F) 10 Hz	-40Â°C (-40Â°F) 10 Hz	-40Â°C (-40Â°F)* 10 Hz
Ground	-	-40Â°C (-40Â°F) 10 Hz	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

Circuit/System Description

The sensors listed below are integrated within the mass air flow/multifunction intake air sensor:

- IAT sensor 1
- IAT sensor 2
- Humidity sensor
- MAF sensor
- BARO pressure sensor

The intake air temperature (IAT) sensor 1 is a variable resistor that changes the voltage on the engine control module (ECM) supplied 5 V signal circuit. The signal varies with inlet air temperature in the sensor bore and is displayed by the scan tool as Â°C (Â°F). The IAT sensor 2 and the humidity sensor share the same circuit. The IAT sensor 2 signal is displayed by the scan tool as Hertz (Hz) and Â°C (Â°F).

The sensors listed below share an ECM supplied 5 V reference circuit:

- IAT sensor 2
- Humidity sensor
- Barometric pressure (BARO) sensor

The sensors listed below share an ECM supplied low reference circuit:

- IAT sensor 1

- IAT sensor 2
- Humidity sensor
- Barometric pressure (BARO) sensor

IAT Sensor 1 - Temperature, Resistance, Voltage Table

IAT Sensor 1	IAT Sensor 1 Resistance	IAT Sensor 1 Signal Voltage
Cold	High	High
Warm	Low	Low

IAT Sensor 2 - Temperature, Frequency Table

IAT Sensor 2	IAT Sensor 2 Frequency	IAT Sensor 2 Temperature
Cold	45 Hz	-40Â°C (-40Â°F)
Warm	302 Hz	104Â°C (219Â°F)

Conditions for Running the DTC

- DTC P1682 is not set.
- The ignition is ON.
- Ignition voltage is at least 11 V.
- This DTC runs continuously within the enabling conditions.

Conditions for Setting the DTC

The ECM detects that the absolute difference between the IAT sensor 1 and the IAT sensor 2 temperatures is greater than 55Â°C (99Â°F) for longer than 5 s.

Action Taken When the DTC Sets

DTC P2199 is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P2199 is a Type B DTC.

Diagnostic Aids

- With the ignition ON, the engine OFF and the engine is cold, a properly functioning IAT sensor 2 will gradually increase the scan tool IAT Sensor 2 parameter. This is due to the heat that is generated by the multifunction intake air sensor heating elements.
- The humidity sensor and the IAT sensor 2 signals are sent to the ECM on the same circuit. If the IAT Sensor 2 parameter displays the values: 10 Hz; -40Â°C (-40Â°F), and there are Humidity Sensor DTCs, check for a circuit problem.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

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Component View Reference

Powertrain Component Views

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL-38522-A Variable Signal Generator

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** **Special Tools (Service Tools)** .

Circuit/System Verification

NOTE: **To minimize the effects of residual engine heat and sensor internal heating elements, perform Steps 1 and 2 of this verification procedure only if the ignition has been OFF for 8 hours or more.**

1. Ignition ON.
2. Verify the following scan tool parameters are within 25Â°C (45Â°F) of each other.
   - Start-Up IAT Sensor 1
   - Start-Up IAT Sensor 2
   - Start-Up ECT
   - **If not within 25Â°C (45Â°F)**

     Refer to Circuit/System Testing.

   - **If within 25Â°C (45Â°F)**
3. Engine idling, verify the following scan tool parameters are between -38 to +149Â°C (-36 to +300Â°F).
   - IAT Sensor 1
   - IAT Sensor 2
   - ECT Sensor
   - **If not between -38 to +149Â°C (-36 to +300Â°F)**

     Refer to Circuit System Testing.

   - **If between -38 to +149Â°C (-36 to +300Â°F)**
4. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
5. Verify the DTC does not set.
   - **If any DTC sets**

     Refer to Circuit/System Testing.

   - **If no DTC sets**

6. All OK

Circuit/System Testing

NOTE: **You must perform the Circuit/System Verification before proceeding with Circuit/System Testing.**

1. Verify none of the conditions listed below exist:
   - A restricted or collapsed air intake duct
   - A misaligned or damaged air intake duct
   - Any water intrusion in the induction system
   - An intake manifold resonator with a leaking seal, or a cracked or broken housing
   - **If a condition exists**

     Repair or replace component as appropriate.

   - **If no condition exists**
2. Ignition OFF and all systems OFF, it may take up to for 2 min for all vehicle systems to power down. Disconnect the harness connector at the B75C Multifunction Intake Air Sensor.
3. Test for less than 2 Ω between the low reference circuit terminal 3 and ground.
   - **If 2 Ω or greater**
   1. Disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open or high resistance in the circuit.
      - If less than 2 Ω replace the K20 Engine Control Module.
   - **If less than 2 Ω**
4. Test for less than 2 Ω between the ground circuit terminal 7 and ground.
   - **If 2 Ω or greater**
   1. Disconnect the sensor chassis ground.
   2. Test for less than 2 Ω in the ground circuit end to end.
      - If 2 Ω or greater, repair the open or high resistance in the circuit.
      - If less than 2 Ω, repair the open/high resistance in the ground connection.

- **If less than 2 Ω**

5. Ignition ON.
6. Verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.
    - **If the test lamp does not illuminate and the circuit fuse is good**
    1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
    2. Test for less than 2 Ω in the ignition voltage circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.
    - **If the test lamp does not illuminate and the circuit fuse is open**
    1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
    2. Test for infinite resistance between the ignition voltage circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance, test all components connected to the ignition circuit, replace as necessary.
    - **If a test lamp illuminates**
7. Ignition ON.
8. Verify the scan tool IAT Sensor 1 parameter is colder than -39Â°C (-38Â°F).
    - **If warmer than -39Â°C (-38Â°F).**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit terminal 1 and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If colder than -39Â°C (-38Â°F).**
9. Ignition OFF, install a 3 A fused jumper wire between the signal circuit terminal 1 and the low reference circuit terminal 3, ignition ON.
10. Verify the scan tool IAT Sensor 1 parameter is warmer than 149Â°C (300Â°F).
    - **If colder than 149Â°C (300Â°F).**
    1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

2. Test for less than 1 V between the signal circuit and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V
3. Ignition OFF.
4. Test for less than 2 Ω in the signal circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If warmer than 149Â°C (300Â°F).**

11. Ignition ON.
12. Test for 4.8-5.2 V between the intake air temperature signal 2 circuit terminal 8 and ground.
    - **If less than 4.8 V**

    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.

    - **If greater than 5.2 V**

    NOTE: **If the signal circuit is shorted to a voltage the engine control module or the sensor may be damaged.**

    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.

    - **If between 4.8-5.2 V**

13. Determine if **EL-38522-A** Variable Signal Generator or equivalent is available.
    - **EL-38522-A, Variable Signal Generator; or equivalent is not available**

1. Test or replace the B75C Multifunction Intake Air Sensor.
2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
3. Verify the DTC does not set.
   - **If the DTC sets**

     Replace the K20 Engine Control Module.

   - **If no DTCs set**
4. All OK.

- **EL-38522-A, Variable Signal Generator; or equivalent is available**

14. Ignition OFF, connect the leads of the **EL-38522-A** Variable Signal Generator as listed below:
    - Red lead to the signal circuit terminal 8 at the harness connector
    - Black leads to ground
    - Battery voltage supply lead to B+
15. Set the **EL-38522-A** Variable Signal Generator to the specifications listed below:
    - Signal switch to 5 V
    - Duty Cycle switch to 50% (Normal)
    - Frequency switch to 30 Hz
16. Ignition ON.
17. Verify the scan tool IAT Sensor 2 parameter is between 28-32 Hz.
    - **If not between 28-32 Hz**

      Replace the K20 Engine Control Module.

    - **If between 28-32 Hz**
18. Test or replace the B75C Multifunction Intake Air Sensor.

Component Testing

Multifunction Intake Air Sensor - IAT Sensor 1

1. Ignition OFF, disconnect the harness connector at the B75C Multifunction Intake Air sensor.

NOTE: **A thermometer can be used to test the sensor off the vehicle.**

2. Test the IAT sensor 1 by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the **Temperature Versus Resistance - Intake Air Temperature Sensor** table for Hitachi Sensors. The resistance values should be in range of the table values.
   - **If not within the table values.**

     Replace the B75C Multifunction Intake Air sensor.

   - **If within the table values.**
3. All OK

Multifunction Intake Air Sensor - IAT Sensor 2

1. Test the IAT Sensor 2 by varying the sensor temperature while monitoring the air temperature with a thermometer. Compare the readings with the scan tool IAT Sensor 2 parameter. The values should be within 5%.
   - **If not within 5%**

     Replace the B75C Multifunction Intake Air sensor.

   - **If within 5%**
2. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement** for multifunction intake air sensor replacement.
- Refer to **Control Module References** for engine control module replacement, programming, and setup.

DTC P219A OR P219B: FUEL TRIM CYLINDER BALANCE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P219A

Fuel Trim Cylinder Balance Bank 1

DTC P219B

Fuel Trim Cylinder Balance Bank 2

Circuit/System Description

The Fuel Trim Cylinder Balance diagnostic detects a rich or lean cylinder to cylinder air/fuel ratio imbalance. The diagnostic monitors the pre-catalyst heated oxygen sensor (HO2S) signal's frequency and amplitude characteristics by calculating an accumulated voltage over a predetermined sample period. An imbalance is indicated when multiple samples of the accumulated voltage are consistently higher than the desired value.

Conditions for Running the DTC

- DTCs P0016, P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0116, P0117, P0118, P0122, P0123, P0128, P0201-P0208, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282, P0283, P0300, P0301-P0308, P0340, P0341, P0442, P0455, P0458, P0496, P1248, P1249, P124A, P124B, P124C, P124D, P124E, P124F, P16F3, P2101, P2135, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F, P217B, P217C, P217E, or P217F are not set.
- The evaporative emission system device control and intrusive diagnostics are not active.
- The engine overspeed protection is not active.
- The power take-off is not active, if equipped.
- The engine is in closed loop status.
- The system voltage is greater than 10 V.
- The engine coolant temperature is warmer than -20Â°C (-4Â°F).
- The engine speed is between 800-3,750 RPM.
- The mass air flow is between 5-1,000 g/s.
- Engine run time is greater than 25 s.
- Fuel level is greater than 10% and no fuel level sensor fault is present.
- The DTC runs continuously when the above conditions have been met.

Conditions for Setting the DTC

Multiple samples of the pre-catalyst HO2S accumulated voltage are consistently greater than the desired value.

Action Taken When the DTC Sets

DTCs P219A and P219B are Type A DTCs.

Conditions for Clearing the MIL/DTC

DTCs P219A and P219B are Type A DTCs.

Diagnostic Aids

- The fuel trim cylinder balance diagnostic is very sensitive to heated oxygen sensor (HO2S) design. A non-OE sensor or an incorrect part number may cause a DTC to set.
- Monitoring the misfire current counters, or misfire graph, may help to isolate the cylinder that is causing the condition.
- Certain aftermarket air filters may cause a DTC to set.
- Certain aftermarket air induction systems or modifications to the air induction system may cause a DTC to set.
- Certain aftermarket exhaust system components may cause a DTC to set.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

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- **Circuit Testing**
- **Troubleshooting with a Test Lamp**
- **Testing for Intermittent Conditions and Poor Connections**

- **Wiring Repairs**
- **Connector Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify no other DTCs are set.
   - **If any other DTCs are set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** for further diagnosis.

   - **If no other DTCs are set**
3. Verify DTC P219A or P219B is not set.
   - **If a DTC is set**

     Refer to Circuit/System Testing.

   - **If no DTC is set**
4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed in the Freeze Frame/Failure Records data.
5. Verify DTC P219A or P219B is not set.
   - **If a DTC is set**

     Refer to Circuit/System Testing.

   - **If no DTC is set**
6. All OK.

Circuit/System Testing

1. Engine idling, transmission in Park or Neutral, verify the manifold absolute pressure (MAP) sensor parameter is between 19-42 kPa (2.7-6 PSI).
   - **If not within the specified range** .

     Refer to **DTC P0106** .

   - **If within the specified range, inspect for the conditions listed below:**
   - Modified, damaged, leaking, or restricted air induction system components.
   - Improper operation of the crankcase ventilation system. Refer to **Crankcase Ventilation System Inspection/Diagnosis** .
   - Split, kinked, or improperly connected vacuum hoses.
   - Restricted, damaged, leaking, or modified exhaust system from the catalytic converter forward. Refer to **Symptoms - Engine Exhaust** .
   - Malfunctioning fuel injectors. Refer to **Fuel Injector Diagnosis** .
   - Fuel contamination. Refer to **Alcohol/Contaminants-in-Fuel Diagnosis** .
   - Excessive fuel in the crankcase due to leaking injectors. Change engine oil as necessary.
   - Malfunctioning ignition system. Refer to **Electronic Ignition System Diagnosis** .
   - **If a condition is found**

     Repair as necessary.

   - **If no condition is found**
2. Test the engine for any mechanical conditions such as sticking valves, lifters, etc., which could alter the flow into the combustion chamber. Refer to **Symptoms - Engine Mechanical** .

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

Perform the scan tool Fuel Trim Reset after completing the repair.

DTC P2227-P2230: BAROMETRIC PRESSURE (BARO) SENSOR

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.

- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P2227

Barometric Pressure (BARO) Sensor Performance

DTC P2228

Barometric Pressure (BARO) Sensor Circuit Low Voltage

DTC P2229

Barometric Pressure (BARO) Sensor Circuit High Voltage

DTC P2230

Barometric Pressure (BARO) Sensor Circuit Erratic

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P018C, P0192, P0340, P0452, P0532, P0641, P127C, P2227, P2228	P2227, P2228	P018D, P0193, P0453, P0523, P0533, P0641, P127D, P2227, P2229	P2227
Signal	P2227, P2228	P2227, P2228	P2227, P2229	P2227
Low Reference	-	P0113, P2199, P2227, P2229	-	P2227

Typical Scan Tool Data

BARO

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Ignition ON, Engine OFF **Parameter Normal Range:** 56-105 kPa (8.1-15.2 psi), varies with altitude			
5 V Reference	0 kPa (0 psi)	0 kPa (0 psi)	64 kPa (9.3 psi)
Signal	0 kPa (0 psi)	0 kPa (0 psi)	128 kPa (18.6 psi)
Low Reference	-	127 kPa (18.4 psi)	-

Circuit/System Description

The barometric pressure (BARO) sensor is integral to the multifunction intake air sensor and responds to changes in altitude and atmospheric conditions. This gives the engine control module (ECM) an indication of barometric pressure. The ECM uses this information to calculate fuel delivery. The BARO sensor provides a voltage signal to the ECM relative to the atmospheric pressure changes. The ECM monitors the BARO sensor signal for a voltage outside of the normal range.

Conditions for Running the DTC

P2227

- DTC P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0128, P0222, P0223, P1516, P2101, P2135, P2228, or P2229 is not set.
- Engine is running for greater than 30 s.

OR

- DTC P0106, P0107, P0108, P0697, P06A3, P2122, P2123, P2127, P2128, P2138, P2228, P2229, P2230, or P2610 is not active.
- DTC P0107, P0108, P0697, P06A3, P2122, P2123, P2127, P2128, P2138, P2228, or P2229 is not pending.
- Engine is OFF for at least 5 s.
- Ignition is ON
- DTC P2227 runs continuously when the above conditions are met.

P2228 or P2229

- Engine is running for greater than 30 s.
- The DTCs run continuously when the above condition is met.

P2230

- DTC P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0121, P0122, P0123, P0222, P0223, P1516, P2101, P2135, P2228, or P2229 is not set.
- Ignition is ON
- DTC P2230 runs continuously when the above conditions are met.

Conditions for Setting the DTC

P2227

- Engine running
- The ECM detects that the difference between the actual BARO and the calculated BARO is greater than 15 kPa when distance since last estimated BARO update is at most 0.1 km (0.6 mi).

  OR

- The ECM detects that the difference between the actual BARO and the calculated BARO is greater than 20 kPa when distance since last estimated BARO update is greater than 0.1 km (0.6 mi).

  OR

- Ignition ON, engine OFF
- The ECM detects that the BARO pressure is less than 50 kPa (7.3 psi) or greater than 115 kPa (16.7 psi).

P2228

The ECM detects that the BARO sensor voltage is less than 2 V for greater than 5 s.

P2229

The ECM detects that the BARO sensor voltage is greater than 4.5 V for greater than 5 s.

P2230

The ECM detects that the cumulative difference between BARO sensor readings, over a specific length of time, is greater than a calibrated threshold.

Action Taken When the DTC Sets

DTCs P2227, P2228, P2229, and P2230 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P2227, P2228, P2229, and P2230 are Type B DTCs.

Reference Information

Schematic Reference

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- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify the scan tool BARO pressure parameter is within the range specified in the **Altitude Versus Barometric Pressure** table.
    - **If the BARO is not within the specified range**

      Refer to Circuit/System Testing.

    - **If the BARO is within the specified range**

3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed in the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
5. All OK.

Circuit/System Testing

1. Verify the conditions listed below do not exist with the B75C Multifunction Intake Air Sensor:
   - Damage
   - Restrictions in the inlet port
   - **If a condition exists**

     Repair or replace the B75C Multifunction Intake Air Sensor as necessary.

   - **If none of the conditions exist**
2. Ignition OFF, and all vehicle systems OFF, it may take up to 2 minutes for all vehicle systems to power down. Disconnect the harness connector at the B75C Multifunction Intake Air Sensor.
3. Test for less than 5 Ω between the low reference circuit terminal 3 and ground.
   - **If 5 Ω or greater**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If greater than the specified value, repair the open or high resistance in the circuit.
      - If 2 Ω or less replace the K20 Engine Control Module.
   - **If less than 5 Ω**
4. Ignition ON.
5. Test for 4.8-5.2 V between the 5 V reference circuit terminal 2 and ground.
   - **If less than 4.8 V**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the 5 V reference circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance
3. Test for less than 2 Ω in the 5 V reference circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If greater than 5.2 V**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the 5 V reference circuit and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.

- **If between 4.8-5.2 V**

6. Verify the scan tool BARO Sensor parameter is less than 0.2 V.

- **If 0.2 V or greater**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the signal circuit terminal 4 and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.

- **If less than 0.2 V**

7. Install a 3 A fused jumper wire between the signal circuit terminal 4 and the 5 V reference circuit terminal 2.
8. Verify the scan tool BARO Sensor parameter is greater than 4.5 V.

- **If 4.5 V or less**

1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the signal circuit terminal 4 and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance
3. Test for less than 2 Ω in the signal circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.

- If less than 2 Ω, replace the K20 Engine Control Module.
- **If greater than 4.5 V**

9. Test or replace the B75C Multifunction Intake Air Sensor.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement** for multifunction intake air sensor replacement
- Refer to **Control Module References** for engine control module replacement, programming and setup.

DTC P2269: WATER IN FUEL

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P2269

Water in Fuel

Circuit/System Description

Alcohol content information is supplied to the engine control module (ECM) from the fuel composition sensor. The fuel composition sensor has a battery positive circuit, a signal circuit, and a ground circuit. The fuel composition sensor uses a microprocessor inside the sensor to measure the ethanol percentage and changes the output signal accordingly. The signal circuit carries the ethanol percentage via the frequency signal. The ECM provides an internal pull up to 5 V on the signal circuit, and the fuel composition sensor pulls the 5 V to ground in pulses. The normal range of operating frequency is between 50-150 Hz. The microprocessor inside the fuel composition sensor is capable of a certain amount of self-diagnosis. An output frequency between 180 Hz and 190 Hz indicates that the fuel is contaminated.

Conditions for Running the DTC

- The ignition voltage is greater than 11 V.
- The DTC runs continuously when the above condition is met.

Conditions for Setting the DTC

The engine control module detects that the fuel composition sensor output frequency is greater than 185 Hz for greater than 6 s.

Action Taken When the DTC Sets

DTC P2269 is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P2269 is a Type B DTC.

Diagnostic Aids

A momentary slug of water in the fuel system may set this DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

- **J 38522-A** Variable Signal Generator
- **J 44175-A** Fuel Composition Tester

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** **Special Tools (Service Tools)** .

Circuit/System Verification

1. Engine running.
2. Verify the scan tool Fuel Composition Sensor parameter is between 50-150 Hz.
   - **If not between 50-150 Hz**

     Refer to Circuit/System Testing.

   - **If between 50-150 Hz**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
   - **If DTC is set**

     Refer to Circuit/System Testing.

   - **If DTC is not set**
4. All OK.

Circuit/System Testing

1. Verify that there are no contaminants, water, or too high of a concentration of ethanol in the fuel. Refer to **Alcohol/Contaminants-in-Fuel Diagnosis** and the J 44175-A Instruction Manual.
   - **If the fuel tested is not within acceptable levels**

Refer to **Fuel System Cleaning** .

- **If the fuel tested within acceptable levels**

2. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B198 Fuel Composition Sensor. It may take up to 2 min for all vehicle systems to power down.
3. Test for less than 5 Ω between the ground circuit terminal 2 and ground.
   - **If 5 Ω or greater**
   1. Ignition OFF.
   2. Test for less than 2 Ω in the ground circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, repair the ground connection.
   - **If less than 5 Ω**
4. Ignition ON.
5. Verify that a test lamp illuminates between the B+ circuit terminal 1 and ground.
   - **If the test lamp does not illuminate and the fuse is not opened**
   1. Ignition OFF, remove the test lamp.
   2. Test for less than 2 Ω in the B+ circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, verify the fuse is good and voltage is supplied to the fuse.
   - **If the test lamp does not illuminate and the fuse is opened**
   1. Ignition OFF, remove the test lamp.
   2. Test for infinite resistance between the B+ circuit and ground
      - If less than infinite, repair the short to ground in the circuit.
      - If infinite, test all the components connected to the circuit, and repair or replace as necessary.
   - **If the test lamp illuminates**
6. Remove the test lamp.
7. Ignition ON, test for 4.8-5.2 V between the signal circuit terminal 3 and ground.
   - **If less than 4.8 V**
   1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

2. Test for less than 2 Ω in the signal circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, test or replace the K20 Engine Control Module.
- **If greater than 5.2 V**

1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the signal circuit and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, test or replace the K20 Engine Control Module.
- **If between 4.8-5.2 V**

8. Ignition OFF, connect the **J 38522-A** Variable Signal Generator as instructed below:
    1. Connect the red lead to the signal circuit terminal 3 at the B198 Fuel Composition Sensor harness connector.
    2. Connect the battery voltage supply lead to B+.
    3. Connect the black lead to ground.
    4. Set the signal to 5 V.
    5. Set the frequency to 60 Hz.
    6. Set the Duty Cycle to Normal.
    7. Ignition ON.
9. Verify the scan tool Fuel Composition Sensor parameter is at 60 Hz.
    - **If not 60 Hz**

      Test or replace the K20 Engine Control Module.

    - **If 60 Hz**
10. Test or replace the B198 Fuel Composition Sensor.

Component Testing

1. Test the fuel composition using the **J 44175-A** Fuel Composition Tester and the J 44175-A Instruction Manual. Record the frequency.
2. Compare the special tool test frequency and the scan tool Fuel Composition Sensor frequency parameter.
3. Verify the difference between the tool and the sensor is 12 Hz or less.
    - **If greater then 12 Hz**

Replace the B198 Fuel Composition Sensor.

- **If 12 Hz or less**

4. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Flexible Fuel Sensor Replacement** for B198 Fuel Composition Sensor replacement
- Refer to **Fuel System Cleaning**
- Perform the scan tool Fuel Composition Reset after completing the repair
- Refer to **Control Module References** for K20 Engine Control Module replacement, programming, and setup

DTC P2544: TRANSMISSION TORQUE REQUEST CIRCUIT MESSAGE COUNTER INCORRECT

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for a overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P2544

Transmission Torque Request Circuit Message Counter Incorrect

Circuit/System Description

To improve shift feel, the transmission control module (TCM) is constantly sending the engine control module (ECM) serial data messages with requests to modify engine speed or torque. These serial data messages are sent through two circuits which are part of a communication network called the controller area network (CAN). The ECM sets DTC P2544 when it detects a discrepancy in the structure of the message causing the integrity of the message to be questioned.

Conditions for Running the DTC

- The engine run time is greater than 0.5 s.

- No other CAN errors are present.

Conditions for Setting the DTC

The ECM detects that the engine speed and torque modification messages from the TCM are either corrupted or intermittently missing for greater than 4 s.

Action Taken When the DTC Sets

- DTC P2544 is a Type B DTC.
- The TCM commands maximum line pressure during shifts, which results in harsh shifts.
- The TCM freezes adaptive functions.

Conditions for Clearing the DTC

DTC P2544 is a Type B DTC.

Diagnostic Aids

An intermittent fault in the CAN circuits will cause the ECM to set DTC P2544.

Reference Information

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Circuit/System Verification

NOTE:

- **DTC P2544 is an informational DTC.**
- **Diagnose all other engine control module DTCs prior to DTC P2544.**

1. Verify that no other DTCs are set except for DTC P2544.
   - **If any other DTCs are set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .

- **If only DTC P2544 is set**

2. Replace the K71 Transmission Control Module.
3. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
4. Verify the DTC does not set.
   - **If DTC sets**

     Replace the K20 Engine Control Module.

   - **If DTC does not set**
5. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

Refer to **Control Module References** for ECM or TCM replacement, programming, and setup

DTC P2618 OR P2619: CRANKSHAFT POSITION SIGNAL OUTPUT CIRCUIT VOLTAGE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P2618

Crankshaft Position Signal Output Circuit Low Voltage

DTC P2619

Crankshaft Position Signal Output Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	B0560 08, P2618	B0560 08	B0560 08, P2619	-

Circuit/System Description

The engine control module (ECM) has a dedicated crankshaft position sensor signal circuit to the audio amplifier which controls the active noise cancellation feature. This output is used for active noise cancellation control based on engine speed.

Conditions for Running the DTC

P2618

- Ignition ON.
- Engine not running.
- ECM crankshaft position sensor signal circuit is commanded high.

P2619

- Ignition ON.
- Engine not running.
- ECM crankshaft position sensor signal circuit is commanded low.

The DTCs run continuously once the above conditions are met.

Conditions for Setting the DTC

P2618

The ECM detects a short to ground in the dedicated crankshaft position sensor signal circuit to the audio amplifier.

P2619

The ECM detects a short to voltage in the dedicated crankshaft position sensor signal circuit to the audio amplifier.

Action Taken When the DTC Sets

DTCs P2618 and P2619 are Type C DTCs.

Conditions for Clearing the DTC

DTCs P2618 and P2619 are Type C DTCs.

Reference Information

Schematic Reference

Active Noise Cancellation Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Active Noise Cancellation Description and Operation

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Engine Running.
2. Verify the scan tool parameters listed below do not display Malfunction:
    - Crankshaft Position Signal Output Circuit Low Voltage Test Status

- Crankshaft Position Signal Output Circuit Open Test Status
- Crankshaft Position Signal Output Circuit High Voltage Test Status
- **If Malfunction is displayed**

  Refer to Circuit/System Testing.

- **If Malfunction is not displayed**

3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
5. All OK.

Circuit/System Testing

1. Ignition OFF, disconnect the X3 harness connector at the T3 Audio Amplifier.
2. Engine Running at 600-700 RPM.
3. Test for 550-750 Hz AC between the signal circuit terminal 2 and ground.
   - **If not between 550-750 Hz AC**

   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 1 V between the signal circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V
   3. Test for infinite resistance between the signal circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance.
   4. Test for less than 2 Ω in the signal circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.

- If less than 2 Ω, replace the K20 Engine Control Module.
- **If between 550-750 Hz AC**

4. Replace the T3 Audio Amplifier.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

Refer to **Control Module References** for engine control module (ECM) or audio amplifier replacement, programming, and setup

DTC P2635: FUEL PUMP FLOW PERFORMANCE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P2635

Fuel Pump Flow Performance

Circuit/System Description

The engine control module (ECM) supplies voltage to the fuel pump driver control module when the ECM detects that the ignition is on. The voltage from the ECM to the fuel pump driver control module remains active for 2 s, unless the engine is in crank or run. While this voltage is being received, the fuel pump driver control module closes the ground switch of the fuel pump. The fuel pump driver control module maintains correct fuel pressure based on the information from the fuel pressure sensor and varying the pulse width modulated controlled current to the fuel pump.

Conditions for Running the DTC

- DTC P018B, P018C, P018D, P0231, P0232, P023F, P0641, P0606, P1255, P129E, or P12A6 are not active.
- Fuel pump control is enabled and the fuel pump control state is normal.
- The ignition voltage is between 11-32 V.
- The engine has been running for greater than 30 s.

- The engine fuel flow is not 0.
- Low fuel level warning not present.
- The DTC runs continuously when the conditions above are met.

Conditions for Setting the DTC

The fuel pump driver control module detects a difference of Â± 60 kPa (8.7 PSI) at 400 kPa (58 PSI) request or Â±45 kPa (6.5 PSI) at 300 kPa (43.5 PSI) request between the desired fuel pressure and the actual fuel pressure for approximately 10 s.

Action Taken When the DTC Sets

DTC P2635 is a Type B DTC.

Conditions for Clearing the DTC

DTC P2635 is a Type B DTC.

Diagnostic Aids

Using the Failure Records data may help locate an intermittent condition. If you cannot duplicate the DTC, the information in the Failure Records can help determine how many miles since the DTC set. The Fail Counter and Pass Counter can help determine how many ignition cycles that the diagnostic test reported a pass and/or a fail.

On vehicles equipped with a high pressure mechanical pump on Direct Fuel Injection engines, the vehicle may continue to run even though the pump in the fuel tank is not operating.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC U18A2 is not set or stored in history.
   - **If DTC U18A2 is set or stored in history**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .

   - **If DTC U18A2 is not set or stored in history**
3. Verify that DTC P018B, P018C, P018D, P0231, P0232, P023F, P0641, P0606, P1255, P129E, or P12A6 is not set.
   - **If any of the DTCs are set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .

   - **If none of the DTCs are set**
4. Verify the scan tool Short Term Fuel Pump Trim and the Long Term Fuel Pump Trim when multiplied together are less than 1.5.
   - **If greater than 1.5**

     Refer to Circuit/System Testing.

   - **If less than 1.5**

WARNING: Road test a vehicle under safe conditions and while obeying all traffic laws. Do not attempt any maneuvers that could jeopardize vehicle control. Failure to adhere to these precautions could lead to serious personal injury and vehicle damage.

5. Verify the scan tool Fuel Pressure Sensor and the Desired Fuel Pressure are within 45 kPa (6.5 PSI) at 300 kPa (43.5 PSI) request or 60 kPa (8.7 PSI) at 400 kPa (58 PSI) request of each other while operating the vehicle through varying loads.
   - **If greater than 45 kPa (6.5 PSI)/60 kPa (8.7 PSI)**

     Refer to Circuit/System Testing.

   - **If less than 45 kPa (6.5 PSI)/60 kPa (8.7 PSI)**
6. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
7. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
8. All OK.

Circuit/System Testing

NOTE: Do not replace the Fuel Pump Driver Control Module based on a history DTC P2635. DTC P2635 may be stored but that does not indicate a failure of the Fuel Pump Driver Control Module. Refer to Strategy Based Diagnosis for further history DTC diagnostics.

1. Verify the proper fuel system pressure. Refer to **Fuel System Diagnosis** .
   - **If the fuel pressure is not normal**

     Repair the fuel system as necessary.

   - **If the fuel pressure is normal**
2. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Fuel Feed Hose Replacement**
- Refer to **Fuel Injector Replacement**
- Refer to **Fuel Pump Replacement**
- Refer to **Fuel Tank Fuel Pump Module Replacement (SWB)** **Fuel Tank Fuel Pump Module Replacement (LWB)**
- Perform the Fuel Pump Trim Reset procedure with a scan tool after the repair.

Repair Verification

1. Install any components that have been removed or replaced during diagnosis.
2. Perform any adjustments, programming or setup procedures that are required when a component is removed or replaced.
3. Clear the DTCs with a scan tool.
4. Turn OFF the ignition for 60 s.
5. Operate the vehicle within the Conditions for Running the DTC.
6. Verify the scan tool Short Term Fuel Pump Trim and the Long Term Fuel Pump Trim when multiplied together are less than 1.5.
   - **If greater than 1.5**

     Refer to Circuit/System Testing.

   - **If less than 1.5**

WARNING: Road test a vehicle under safe conditions and while obeying all traffic laws. Do not attempt any maneuvers that could jeopardize vehicle control. Failure to adhere to these precautions could lead to serious personal injury and vehicle damage.

7. Verify the scan tool Fuel Pressure Sensor and the Desired Fuel Pressure are within 45 kPa (6.5 PSI) at 300 kPa (43.5 PSI) request or 60 kPa (8.7 PSI) at 400 kPa (58 PSI) request of each other while operating the vehicle through varying loads.
   - **If greater than 45 kPa (6.5 PSI)/60 kPa (8.7 PSI)**

     Refer to Circuit/System Testing.

   - **If less than 45 kPa (6.5 PSI)/60 kPa (8.7 PSI)**
8. All OK.

DTC P3400: CYLINDER DEACTIVATION SYSTEM

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptor

DTC P3400

Cylinder Deactivation System

Circuit/System Description

The cylinder deactivation system is used to deactivate 4 cylinders of the engine under light load driving conditions. The Engine Control Module (ECM) commands the cylinder deactivation solenoid valves ON to deactivate engine cylinders 1, 7, 6, and 4, switching to 4 cylinders or V4 mode. The cylinder deactivation solenoid valves control the oil flow to the appropriate valve lifters. The engine operates on 8 cylinders or V8 mode, during engine starting, engine idling, and medium to heavy throttle conditions.

Ignition voltage is supplied directly to the cylinder deactivation solenoid valves. The ECM controls the cylinder deactivation solenoid valves by grounding the control circuit with a solid state device called a driver.

The Cylinder Deactivation System Performance diagnostic is a test of the internal mechanical condition of the engine, during operation in V4 mode. The ECM determines the internal mechanical condition of the engine through the actual measured values of the Mass Air Flow (MAF) sensor, the intake Manifold Absolute Pressure (MAP) sensor, and the Throttle Position Sensor (TPS). The actual measured values of the 3 sensors are then compared to the calculated values for V4 mode and stored in the ECM. If the measured values are incorrect for V4 mode, the ECM may set this code and return to V8 mode operation.

Conditions for Running the DTC

- DTCs P0102, P0103, P0107, P0108, P0112, P0113, P0117, P0119, P0335, and P0336 are not set.
- The engine speed is between 450-5,600 RPM.
- The Engine Coolant Temperature (ECT) Sensor parameter is between -7 to +129Â°C (19 to 264Â°F).
- The Intake Air Temperature (IAT) Sensor is between -20 to 129Â°C (-4 to 264Â°F).
- Time in V8 mode is greater than 2 s.

- Time in V4 mode is greater than 2 s.
- This DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

The engine control module detects that the actual measured values from the MAF sensor, MAP sensor, and throttle position sensor, are not within the range of the calculated values for V4 mode.

Action Taken When the DTC Sets

- DTC P3400 is a Type B DTC.
- The engine will return to V8 mode.

Conditions for Clearing the DTC

DTC P3400 is a Type B DTC.

Diagnostic Aids

- This DTC will not set during engine idling conditions. The vehicle will need to be driven for the DTC to set.
- A restricted valve lifter oil filter may cause DTC P3400 to set. Inspect the valve lifter oil filter for a restriction or blockage. Refer to **Valve Lifter Oil Filter Replacement** .

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Cylinder Deactivation (Active Fuel Management) System Description

Electrical Information Reference

- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0201-P0208, P0351-P0358, P3401, P3403, P3404, P3425, P3427, P3428, P3441, P3443, P3444, P3449, P3451, or P3452 is not set.
    - **If a DTC is set**

      Refer to Diagnostic Trouble Code (DTC) List - Vehicle for further diagnosis.

    - **If a DTC is not set**
3. Engine idling at the normal operating temperature.
4. Verify there is no abnormal engine noise.
    - **If there is an abnormal engine noise**

      Refer to Symptoms - Engine Mechanical for further diagnosis.

    - **If no abnormal engine noise**
5. Clear all DTCs using scan tool. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify the DTC does not set.
    - **If the DTC sets**

Refer to Circuit/System Testing.

- **If the DTC is not set**

7. All OK.

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the Q43 Valve Lifter Oil Manifold Assembly.
2. Disconnect the X3 harness connector at the K20 Engine Control Module.
3. Test each cylinder deactivation solenoid valve control circuit for less than 5 Ω end to end.
   - **If 5 Ω or greater**

     Repair the open/high resistance in the circuit.

   - **If less than 5 Ω**

     NOTE: **Cylinder Deactivation System command control function will not operate if any DTCs are set.**

     Refer to **Cylinder Deactivation (Active Fuel Management) System Diagnosis** for further diagnosis.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Control Module References** for K20 Engine Control Module replacement, programming, and setup

DTC P3401, P3403, P3404, P3425, P3427, P3428, P3441, P3443, P3444, P3449, P3451, OR P3452: CYLINDERS (1, 4, 6, 7) DEACTIVATION SOLENOID VALVE CONTROL CIRCUITS

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** to provide an overview of each diagnostic category.

DTC Descriptors

DTC P3401

Cylinder 1 Deactivation Solenoid Valve Control Circuit Open

DTC P3403

Cylinder 1 Deactivation Solenoid Valve Control Circuit Low Voltage

DTC P3404

Cylinder 1 Deactivation Solenoid Valve Control Circuit High Voltage

DTC P3425

Cylinder 4 Deactivation Solenoid Valve Control Circuit Open

DTC P3427

Cylinder 4 Deactivation Solenoid Valve Control Circuit Low Voltage

DTC P3428

Cylinder 4 Deactivation Solenoid Valve Control Circuit High Voltage

DTC P3441

Cylinder 6 Deactivation Solenoid Valve Control Circuit Open

DTC P3443

Cylinder 6 Deactivation Solenoid Valve Control Circuit Low Voltage

DTC P3444

Cylinder 6 Deactivation Solenoid Valve Control Circuit High Voltage

DTC P3449

Cylinder 7 Deactivation Solenoid Valve Control Circuit Open

DTC P3451

Cylinder 7 Deactivation Solenoid Valve Control Circuit Low Voltage

DTC P3452

Cylinder 7 Deactivation Solenoid Valve Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition 1 Voltage	P3400, P3403, P3427, P3443, P3451	P3400, P3401, P3425, P3441, P3449	-	P3400
Cylinder 1 Deactivation Solenoid Valve Control	P3403	P3401	P3404	P3400
Cylinder 4 Deactivation Solenoid Valve Control	P3427	P3425	P3428	P3400
Cylinder 6 Deactivation Solenoid Valve Control	P3443	P3441	P3444	P3400
Cylinder 7 Deactivation Solenoid Valve Control	P3451	P3449	P3452	P3400

Typical Scan Tool Data

Cylinder 1, 4, 6, or 7 Deactivation Solenoid Valve Control Circuit Test Status - Component Commanded OFF

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Component Commanded OFF **Parameter Normal Range:** The following illustrates the normal parameter state with no circuit conditions: • Component OFF - OK for Open/Short to Gnd Test and Not Run for Short to Volts Test • Component ON - Not Run for Open/Short to Gnd Test and OK for Short to Volts Test			
Ignition Voltage	Malfunction	Malfunction	-
Cylinder 1, 4, 6, or 7 Deactivation Solenoid Control	Malfunction	Malfunction	Not Run

Cylinder 1, 4, 6, or 7 Deactivation Solenoid Valve Control Circuit Test Status - Component Commanded ON

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Component Commanded ON **Parameter Normal Range:** The following illustrates the normal parameter state with no circuit conditions:			

Circuit	Short to Ground	Open	Short to Voltage
• Component OFF - OK for Open/Short to Gnd Test and Not Run for Short to Volts Test • Component ON - Not Run for Open/Short to Gnd Test and OK for Short to Volts Test			
Ignition Voltage	Not Run	Not Run	-
Cylinder 1, 4, 6, or 7 Deactivation Solenoid Control	Not Run	Not Run	Malfunction

Circuit/System Description

The cylinder deactivation system is used to deactivate 4 cylinders of the engine under light load driving conditions. The engine control module (ECM) commands the cylinder deactivation solenoid valves ON to deactivate engine cylinders 1, 4, 6, and 7, switching to 4 cylinders or V4 mode. The cylinder deactivation solenoid valves control the oil flow to the appropriate valve lifters. The engine operates on 8 cylinders or V8 mode, during engine starting, engine idling in gear, and medium to heavy throttle conditions.

Ignition voltage is supplied directly to the cylinder deactivation solenoid valves. The ECM controls the cylinder deactivation solenoid valves by grounding the control circuit with a solid state device called a driver.

Conditions for Running the DTC

- Engine speed is greater than 400 RPM.
- Ignition voltage is greater than 11 V.
- DTC P3401, P3403, P3404, P3425, P3427, P3428, P3441, P3443, P3444, P3449, P3451, and P3452 run continuously when the above conditions are met.

Conditions for Setting the DTC

DTC P3401, P3425, P3441, and P3449

The engine control module detects an open in the appropriate cylinder deactivation solenoid valve control circuit for greater than 5 s.

DTC P3403, P3427, P3443, and P3451

The engine control module detects an short to ground in the appropriate cylinder deactivation solenoid valve control circuit for greater than 5 s.

DTC P3404, P3428, P3444, and P3452

The engine control module detects an short to voltage in the appropriate cylinder deactivation solenoid valve control circuit for greater than 5 s.

Action Taken When the DTC Sets

- DTCs P3401, P3403, P3404, P3425, P3427, P3428, P3441, P3443, P3444, P3449, P3451, and P3452 are Type B DTCs.
- The engine will return to V8 mode.

Conditions for Clearing the DTC

DTCs P3401, P3403, P3404, P3425, P3427, P3428, P3441, P3443, P3444, P3449, P3451, and P3452 are Type B DTCs.

Diagnostic Aids

The valve lifter oil manifold solenoid valves are assigned to the following engine cylinders:

- Cylinder Deactivation Solenoid Valve #1 = Cylinder #1
- Cylinder Deactivation Solenoid Valve #2 = Cylinder #4
- Cylinder Deactivation Solenoid Valve #3 = Cylinder #6
- Cylinder Deactivation Solenoid Valve #4 = Cylinder #7

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Cylinder Deactivation (Active Fuel Management) System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**

- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

- **EN-46999** Displacement On Demand Tester
- **EN-46999-20** Active Fuel Management Tester Harness-Small Block V8

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** **Special Tools (Service Tools)** .

Circuit/System Verification

NOTE: **DTC P3401, P3425, P3441, and P3449 set with an open ignition circuit fuse.**

1. Engine running.
2. Verify the follow parameters display OK or Not Run during each command.
   - Cylinder 1, 4, 6, or 7 Deactivation Solenoid Valve Control Circuit High Voltage Test Status
   - Cylinder 1, 4, 6, or 7 Deactivation Solenoid Valve Control Circuit Open Test Status
   - Cylinder 1, 4, 6, or 7 Deactivation Solenoid Valve Control Circuit Low Voltage Test Status
   - **If any parameter displays Malfunction**

     Refer to Circuit/System Testing.

   - **If each parameter displays OK or Not Run**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC P3401, P3403, P3404, P3425, P3427, P3428, P3441, P3443, P3444, P3449, P3451, or P3452 does not set.
   - **If a DTC set**

Refer to Circuit/System Testing.

- **If a DTC does not set**

5. All OK.

Circuit/System Testing

NOTE: **If any of the scan tool circuit status parameters displayed "Malfunction" during the Circuit/System Verification, inspect the wiring harness for signs of binding, chaffing or pinching before intake manifold removal.**

1. Ignition OFF, disconnect the harness connector at the Q43 Valve Lifter Oil Manifold Assembly, ignition ON.
2. Verify that a test lamp illuminates between the ignition circuit terminal 4 and ground.
   - **If the test lamp does not illuminate and the fuse is good.**
   1. Ignition OFF, remove the test lamp.
   2. Test for less than 5 Ω between the ignition circuit terminal 4 and the fuse.
      - If 5 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 5 Ω, verify there is voltage at the fuse and the fuse is good.
   - **If the test lamp does not illuminate and the fuse is open**
   1. Ignition OFF, remove the test lamp.
   2. Disconnect all components on the circuit.
   3. Test for infinite resistance between the ignition circuit terminal 4 and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, test all the components connected to the ignition circuit and repair or replace as necessary.
   - **If the test lamp illuminates**
3. Verify that a test lamp does not illuminate between the ignition circuit terminal 4 and the appropriate cylinder deactivation solenoid valve control circuit terminal listed below.
   - Cylinder 1 Deactivation Solenoid Valve 1 terminal 3
   - Cylinder 4 Deactivation Solenoid Valve 2 terminal 1
   - Cylinder 6 Deactivation Solenoid Valve 3 terminal 2
   - Cylinder 7 Deactivation Solenoid Valve 4 terminal 5

- **If the test lamp illuminates**

1. Ignition OFF, remove the test lamp, disconnect the harness connector X3 at the K20 Engine Control Module.
2. Test for infinite resistance between the appropriate cylinder deactivation solenoid valve control circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance, replace the K20 Engine Control Module.

- **If the test lamp does not illuminate**

4. Verify that a test lamp does not illuminate between ground and the appropriate cylinder deactivation solenoid valve control circuit terminal listed below.
    - Cylinder 1 Deactivation Solenoid Valve 1 terminal 3
    - Cylinder 4 Deactivation Solenoid Valve 2 terminal 1
    - Cylinder 6 Deactivation Solenoid Valve 3 terminal 2
    - Cylinder 7 Deactivation Solenoid Valve 4 terminal 5
    - **If the test lamp illuminates**

1. Ignition OFF, remove the test lamp, disconnect the harness connector X3 at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the appropriate cylinder deactivation solenoid valve control circuit and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.

- **If the test lamp does not illuminates**

5. Ignition OFF, remove the test lamp, disconnect the X3 harness connector at the K20 Engine Control Module.
6. Test the appropriate cylinder deactivation solenoid valve control circuit for less than 5 Ω end to end.
    - **If 5 Ω or greater**

      Repair the open/high resistance in the circuit.

    - **If less than 5 Ω**
7. Connect the **EN-46999** Displacement On Demand (DOD) Tester to the Q43 Valve Lifter Oil Manifold Assembly using **EN-46999-20** Active Fuel Management Tester Harness.
8. Connect the power leads from the DOD tester to B+ and ground.
9. With a DMM connected to the DOD tester, test for 10-24 Ω on each cylinder deactivation solenoid valve.
    - **If not between 10-24 Ω for each solenoid valve**

Replace the Q43 Valve Lifter Oil Manifold Assembly.

- **If between 10-24 Ω for each solenoid valve**

10. Test for infinite resistance between each valve lifter oil manifold circuit terminal and the valve lifter oil manifold housing.
    - **If less than infinite resistance**

      Replace the Q43 Valve Lifter Oil Manifold Assembly.

    - **If infinite resistance**
11. Replace the K20 Engine Control Module.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

- Refer to **Valve Lifter Oil Manifold Replacement**
- Refer to **Control Module References** for K20 Engine Control Module replacement, programming, and setup.

SYMPTOMS - ENGINE CONTROLS

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- Refer to **Diagnostic Procedure Instructions** provide an overview of each diagnostic category.

Symptoms Description

Symptoms cover conditions that are not covered DTCs. Certain conditions can cause multiple symptoms. These conditions are listed together under Symptoms Testing. Conditions that may only cause certain symptoms are listed separately under Additional Symptoms Test. Perform the Symptoms Testing before using the Additional Symptoms Tests.

Symptoms Definition

Backfire

Fuel ignites in the intake manifold or in the exhaust system, making a loud popping noise.

Cuts Out, Misses

A steady pulsation or jerking that follows engine speed, which is usually more pronounced as the engine load increases. This condition is not normally felt above 1500 RPM or 48 km/h (30 mph). The exhaust has a steady spitting sound at idle or at low speed.

Engine Control Module (ECM) Reduced Engine Power

The ECM illuminates the Reduced engine Power lamp and will limit engine power under potential engine/vehicle damaging or emissions related conditions. A DTC may not be set.

Detonation/Spark Knock

A mild to severe ping which usually occurs worse while under acceleration. The engine makes sharp metallic knocks that change with throttle opening.

Dieseling, Run-On

The engine continues to run after the key is turned OFF, but runs very rough.

Hard Start

Engine cranks OK, but does not start for a long time. The vehicle does eventually run, or may start but immediately stalls.

Hesitation, Sag, Stumble

Momentary lack of response as the accelerator is pushed down. This condition can occur at any vehicle speed. This condition is usually more pronounced when first trying to make the vehicle move, as from a stop. This condition may cause the engine to stall in severe conditions.

Lack of Power, Sluggishness, or Sponginess

The engine delivers less than expected power. Little or no increase in speed when the accelerator pedal is pushed down part way.

Poor Fuel Economy

Fuel economy, as measured by an actual road test, is noticeably lower than expected. Also, the fuel economy is noticeably lower than it was on this vehicle at one time, as previously shown by an actual road test.

Rough, Unstable, or Incorrect Idle and Stalling

The engine runs unevenly at idle. If severe, the engine or the vehicle may shake. Engine idle may vary in speed. Either condition may be severe enough to stall the engine.

Surges/Chuggles

Engine power variation under steady throttle or cruise. Feels like the vehicle speeds up and slows down with no change in the accelerator pedal position.

Symptoms Verification

Before using the Symptom tables, perform the following inspections:

- Verify the engine control module (ECM) and malfunction indicator lamp (MIL) are operating correctly.
- Verify there are no DTCs that are stored.
- Verify the scan tool data is within a normal operating range. Refer to **Control Module References** for scan tool information.
- Verify the customer concern.
- Perform the Visual/Physical Inspection in this section. The visual/physical inspection is extremely important, and can lead to correcting a condition without additional testing. It may also help reveal the cause of an intermittent condition.

Identifying Intermittent Conditions

Many intermittent conditions occur with harness or connector movement due to engine torque, rough pavement, vibration or physical movements of a component. Refer to the following for a list of issues that may cause an intermittent condition:

- Moisture and water intrusion in connectors, terminals, and components
- Incomplete connector mating
- Poor terminal contact
- High circuit or component resistance-High resistance can include any resistance, regardless of the amount, which can interrupt the operation of the component.
- Harness that is too short or tight
- Wire insulation that is chaffed or cut
- High or low ambient temperature
- High or low engine coolant temperatures
- High underhood temperatures

- Heat build up in component or circuit due to circuit resistance, poor terminal contact, or high electrical load
- High or low system voltage
- High vehicle load conditions
- Rough road surfaces
- Electro-magnetic interference (EMI)/circuit interference from relays, solenoids or other electrical surge
- Incorrect installation of aftermarket, add on accessories

Visual/Physical Check

- Verify the control module grounds are clean, tight, and correctly located.
- Verify the vacuum hoses are not split or kinked, and are properly connected, as shown on the Vehicle Emission Control Information label.
- Verify the air filter is clean and free from restrictions.
- Verify there is no water intrusion in connectors terminals and components.
- Inspect the air intake ducts for the conditions listed below:
  - Collapsed
  - Damaged areas
  - Looseness
  - Incorrect installation
  - Leaking

    If any condition listed above has allowed non-metered air to enter the air induction system, the **Throttle or Idle Learn** procedure must be performed after the repair is complete.

- Inspect for air leaks at the throttle body mounting area, the mass air flow (MAF) sensor and intake manifold sealing surfaces.
- Inspect the wiring harness for the following conditions:
  - Poor connections
  - Pinches
  - Cuts
- Inspect for loose, damaged, unseated, or missing sensors/components.
- Inspect the terminals for corrosion and correct contact.

Symptoms Testing

Backfire, Cuts Out/Misses, Detonation/Spark Knock, Dieseling/Run-On, Engine Control Module (ECM) Commanded Reduced Engine Power, Fuel Odor, Hard Start, Hesitation/Sag/Stumble, Lack of Power/Sluggishness/Sponginess, Poor Fuel Economy, Rough, Unstable, or Incorrect Idle and Stalling, or Surges/Chuggles

- Test/inspect the fuel system for the conditions listed below:
  - Incorrect system operation or fuel pressure - Refer to **Fuel System Diagnosis**
  - Fuel injectors leaking due to split or torn O-rings. With this condition, the engine may need to be cranked for an extended period of time before it will start. The smell of unburned fuel may also be present. Look for evidence of fuel injector leakage on the engine cylinder head and nearby components. Refer to **Fuel Rail and Injectors Cleaning and Inspection** if a leak is suspected.
  - Incorrectly operating fuel injectors - Refer to **Fuel Injector Diagnosis** .
  - Contaminated or poor quality fuel - Refer to **Alcohol/Contaminants-in-Fuel Diagnosis** .
- Test/inspect the ignition system for the conditions listed below:
  - Spark plugs with incorrect heat range or an abnormal condition - Refer to **Spark Plug Inspection** , and **Ignition System Specifications** .
  - Coolant or oil fouled spark plugs - For diagnosis, refer to **Coolant in Combustion Chamber** , or **Oil Consumption Diagnosis** .
  - Secondary ignition system susceptible to moisture. Wet down the secondary ignition system with water from a spray bottle to help locate damaged or deteriorated components. Look/listen for arcing or misfiring as the water is applied.
  - Weak spark using the **J-26792** Spark Tester - Refer to **Electronic Ignition System Diagnosis** .
- Test/inspect for the conditions listed below:
  - Non-metered air flow into the air induction system. If a leak is found, repair as necessary. The **Throttle or Idle Learn** procedure must be performed when the repair is complete.
  - Incorrectly operating transmission torque converter clutch (TCC) - The scan tool should indicate an engine speed drop when the TCC is commanded ON.
  - Incorrectly operating A/C compressor
  - Items that can cause an engine to run rich or lean - Refer to **DTC P0171, P0172, P0174, or P0175** for more information.
  - Slow responding heated oxygen sensors (HO2S). The HO2S should respond quickly to different throttle positions - Refer to **DTC P0133, P013A-P013F, P014A, P014B, P0153, P015A-P015D, or P2270-P2273** for more information.

    CAUTION: Refer to Heated Oxygen and Oxygen Sensor Caution .

  - Water intrusion in the HO2S connector
  - Incorrectly operating cylinder deactivation system, if equipped. Refer to **Cylinder Deactivation (Active Fuel Management) System Description** , and **Cylinder Deactivation (Active Fuel Management) System Diagnosis** .

NOTE: **The embossed arrows on the mass airflow (MAF) sensor indicate the direction of the intake air flow. The arrows must point toward the engine.**

- Incorrect MAF sensor installation. A MAF sensor that is incorrectly installed may cause a hard start. Install the MAF in the proper direction. Refer to **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement** .
- Incorrect MAF sensor connections.
- Engine oil contaminated by fuel
- Split, kinked, or incorrectly connected vacuum hoses.
- Excessive knock sensor (KS) system spark retard activity - Observe the Knock Retard parameter on the scan tool for activity more than 0Â°. For additional information, refer to **DTC P0324, P0326, P0331, P06B6, or P06B7** , and **DTC P0325, P0327, P0328, P0330, P0332, or P0333** .
- Electromagnetic interference (EMI) on the reference circuit, which can cause a misfire condition. You can usually detect EMI with a scan tool by monitoring the engine speed parameter. A sudden increase in the engine speed parameter with little change in actual engine speed indicates that EMI is present. Inspect the high voltage components near the ignition control circuit if a condition exists.
- Incorrectly operating crankcase ventilation valve - Refer to **Crankcase Ventilation System Inspection/Diagnosis** .
- A stuck open evaporative emission (EVAP) canister purge solenoid.
- A crankshaft position sensor with an intermittent condition - Observe the scan tool Crankshaft Position Resync Counter parameter. The Resync Counter parameter should remain at 0 during all operating conditions, and when moving the related harnesses and connectors between the crankshaft position sensor and the ECM.

- Test/inspect the engine cooling system for the conditions listed below:
  - A thermostat with incorrect heat range. Refer to **Thermostat Diagnosis** .
  - Incorrect engine coolant level - Refer to **Cooling System Draining and Filling (Vac N Fill L83 L86)** **Cooling System Draining and Filling (Static Fill L83 L86)** .

    For additional information, refer to **Symptoms - Engine Cooling** .

- Test/inspect the exhaust system components for the conditions listed below:
  - Physical damage or possible internal failure
  - Restricted three-way catalytic converters.

    For additional information, refer to **Symptoms - Engine Exhaust** .

- Test/inspect the engine for the mechanical conditions listed below:

- Excessive oil in the combustion chamber or leaking valve seals
- Incorrect cylinder compression
- Sticking or leaking valves
- Worn camshaft lobes
- Incorrect valve timing
- Worn rocker arms
- Broken valve springs
- Excessive carbon buildup in the combustion chambers-Clean the chambers with Top Engine Cleaner, if necessary. Follow the instructions on the can.
- Incorrect engine parts

  For additional information, refer to **Symptoms - Engine Mechanical** .

- If the above conditions do not address the symptom, refer to the additional symptoms tests.

Additional Symptoms Tests

Detonation/Spark Knock

- Test the engine for an overheating condition. Refer to **Symptoms - Engine Cooling** .
- Inspect for excessive carbon buildup in the combustion chambers. Clean the chambers with Top Engine Cleaner, if necessary. Follow the instructions on the can.
- If there are no engine mechanical faults, fill the fuel tank with a known high quality fuel that meets the vehicle minimum octane requirements.

Engine Control Module (ECM) Commanded Reduced Engine Power

Under certain conditions the ECM may limit engine power by reducing engine torque and, for some vehicles, fuel pressure as well. For most, but not all of the conditions, the ECM will illuminate the reduced engine power lamp on the instrument panel cluster, however a DTC may not be set.

A repair may not be necessary. Observe the scan tool Reduced Engine Power History parameter or refer to **K20 Engine Control Module: Scan Tool Information** to determine the reason for the reduced engine power event.

Verify or inspect for the following:

- Vehicle being driven inappropriately. Towing heavy loads up an incline for an extended period of time or operating the vehicle at sustained,

excessively high engine speeds may cause the engine oil or coolant to overheat. Inspect the airflow passageways in front of the engine for obstructions and clear away any debris or foreign material that is found. If no obstructions or conditions are found, review approved driving habits with the customer. The customer may need to operate the vehicle at a higher engine speed to improve cooling system performance, or, at a slower engine speed to reduce engine load.

- A cooling fan condition which may cause the ECM to reduce engine power. Refer to **Cooling Fan Description and Operation** , and **Cooling System Description and Operation** to verify correct operation of the cooling fan.
- Temporary reduced engine power. Under extremely cold ambient temperatures some SIDI equipped vehicles may experience ECM commanded reduced engine power for a few minutes during engine warm-up. This would be a normal condition, noticeable only at wide open throttle, and the reduced engine power lamp would not be illuminated.
- Fuel temperature out of range too high.
- High pressure fuel system condition. Refer to **Fuel System Diagnosis** , and **Fuel System Description** to verify high pressure fuel system pressure and operation.
- Reduced engine power due to OnStarÂ® remote command. Verify the vehicle is not in the OnStarÂ® initiated Stolen Vehicle Slowdown mode. Refer to **OnStar Stolen Vehicle Slowdown Active** , and **Remote Vehicle Speed Limiting Description and Operation** for additional information.
- Intake air temperature out of range too high. Engine running, observe the scan tool IAT sensor parameter. The readings should be between -40Â° C and +149Â° C (-40Â° F and +300Â° F. Refer to **DTC P0112, P0113, or P0114** for additional information.
- An incorrect learned brake pedal position (BPP) sensor. Verify the following actions have not occurred:
  - An engine control module has been replaced
  - A BPP sensor that has been replaced
  - A BPP sensor is misaligned or incorrectly installed

  If any of the above actions have occurred, the **Brake Pedal Position Sensor Learn** procedure must be performed.

Fuel Odor

- Inspect for leaking, damaged, or deteriorated fuel lines and components.
- Inspect for a saturated EVAP canister - Refer to **Evaporative Emission Control System Description** .
- Inspect for a condition with the internal components of the fuel tank assembly - Refer to **Fuel System Description** .

Hard Start

- Observe the TB Idle Airflow Compensation parameter with a scan tool. A value greater than 90% may indicate an excessive accumulation of deposits in the throttle bore. Inspect the throttle body and bore and clean, if necessary. Refer to **Throttle Body Cleaning** .

- Test the engine coolant temperature (ECT) sensor. Compare the ECT sensor value to the intake air temperature (IAT) sensor value on a cold engine. The ECT and IAT sensor values should be within Â± 3Â°C (5Â°F). If the ECT sensor is out of range with the IAT sensor, test the resistance of the ECT sensor. Refer to **Temperature Versus Resistance (ECT)** , for resistance specifications. Replace the ECT sensor if the resistance is not within specification. Refer to **Engine Coolant Temperature Sensor Replacement** . If the sensor is within the specification, test the ECT circuits for a high resistance.
- Verify that the fuel pump operates and provides adequate pressure for engine startup. The fuel pump should turn ON for 2 s when the ignition is turned to ON. Refer to **Fuel System Diagnosis** for fuel pressure specifications and testing procedures.

Hesitation, Sag, Stumble

- Test the fuel pressure. Refer to **Fuel System Diagnosis** for fuel pressure specifications and testing procedures..
- Test the generator. Refer to **Symptoms - Engine Electrical** . Repair the charging system if the generator output voltage is less than 9 volts or more than 16 volts.
- Test the manifold absolute pressure (MAP) sensor. Refer to **DTC P0106** .

Poor Fuel Economy

- Observe the TB Idle Airflow Compensation parameter with a scan tool. A value greater than 90% may indicate an excessive accumulation of deposits in the throttle bore. Inspect the throttle body and bore and clean, if necessary. Refer to **Throttle Body Cleaning** .
- Inspect for heavy loads being carried or towed.
- Inspect for acceleration rate too much or too often.
- Inspect the brake system for brake drag.
- Inspect for incorrect operation of the speedometer.

Rough, Unstable, or Incorrect Idle and Stalling

- An excessively high idle may be due to the floor mat interfering with the accelerator pedal. With this condition present, it may not be possible to shift the transmission into gear. Inspect the accelerator pedal for binding and verify that the floor mat is not interfering with the accelerator pedal movement.
- Engine idle speed may be unstable or the engine may stall if the ECM has learned an incorrect idle/airflow compensation value. A DTC may also set. Observe the scan tool Throttle Body Idle Airflow Compensation parameter. A value greater than 90% may indicate an excessive accumulation of deposits in the throttle bore. If the throttle body needs cleaning, refer to **Throttle Body Cleaning** .

  The actions listed below may also cause the ECM to learn an incorrect idle value.

- The engine control module has been replaced
- The throttle body has been replaced
- The throttle body has been cleaned but the idle learn procedure was not performed after completing the cleaning
- The air induction system was leaking, allowing non-metered air to enter the combustion chamber. The leak was repaired but the idle learn procedure was not performed after repairing the leak

  If any of the actions listed above have occurred, the **Throttle or Idle Learn** procedure must be performed.

- Inspect the engine mounts for looseness, wear, and damage - Refer to **Engine Mount Inspection** .

Surges/Chuggles

- Inspect the mass air flow (MAF) sensor for obstruction, contamination, and damage - Refer to **DTC P0101** , and **DTC P0102 or P0103** for more information.
- Fuel injectors incorrectly connected. Verify each injector is connected to the correct fuel injector harness connector.
- Inspect for slow responding heated oxygen sensors (HO2S). The HO2S should respond quickly to a change in throttle position. If the HO2S do not respond to different throttle positions, inspect for contamination from fuel, silicon, or the incorrect use of RTV sealant. The sensors may have a white powdery coating and result in a high, but false, signal voltage, which gives a rich exhaust indication. The ECM reduces the amount of fuel delivered to the engine, causing a driveability condition - Refer to **DTC P0133, P013A-P013F, P014A, P014B, P0153, P015A-P015D, or P2270-P2273** for more information.

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ENGINE

Engine Controls and Fuel - 5.3L (L83) or 6.2L (L86) - Repair Instructions - Engine Oil Pressure Sensor Replacement - Escalade, Suburban, Tahoe, Yukon

REPAIR INSTRUCTIONS

ENGINE OIL PRESSURE SENSOR REPLACEMENT

Fig. 1: Engine Oil Pressure Sensor
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure	

Callout	Component Name
Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)** **Air Cleaner Outlet Duct Replacement (Cadillac)** .	
1	Engine Oil Pressure Sensor **CAUTION:** **Refer to Component Fastener Tightening Caution .** **Procedure** Disconnect the engine oil pressure sensor electrical wiring harness connector. **Tighten** 35 N.m (26 lb ft)

ENGINE PERFORMANCE

Engine Controls and Fuel - 5.3L (L83) or 6.2L (L86) - Repair Instructions - Escalade, Suburban, Tahoe, Yukon

REPAIR INSTRUCTIONS

WIRE TO WIRE REPAIR - ENGINE CONTROLS AND FUEL

Special Tools

- **EL-38125-10** Splice Sleeve Crimping Tool (non GMNA)
- **J-38125-5A** Ultra Torch Special Tool
- **J-38125-8** Splice Sleeve Crimping Tool (GMNA)

For equivalent regional tools, refer to **Special Tools** .

WARNING: **In order to reduce the risk of personal injury, loss of high voltage isolation to ground and higher system impedance, do not attempt to repair any HV wiring, connector, or terminal that is damaged. High voltage coaxial type cables are not repairable. Never attempt to repair a coaxial type cable. The entire cable/harness or component must be replaced. In order to maintain system integrity and personal safety, never attempt to repair any high voltage wiring, cables, or terminals. Performing this procedure on high voltage circuits may result in serious injury or death.**

NOTE: **If the wiring harness internal to the transmission is damaged, the wiring harness must be replaced. The use of splice sleeves in an attempt to repair the internal transmission wires, connectors, or terminals could result in performance issues.**

NOTE: **Do not splice wires in Door Harness Grommets.**

NOTE: **The DuraSeal splice sleeves have the following 2 critical features:**

- **A special heat shrink sleeve environmentally seals the splice. The heat shrink sleeve contains a sealing adhesive inside.**
- **A cross hatched (knurled) core crimp provides the necessary low resistance contact integrity for these sensitive, low energy circuits.**

Use only DuraSeal splice sleeves to form a one-to-one splice on all types of insulation except high voltage and specialty cables. Use DuraSeal splice sleeves where there are special requirements such as moisture sealing. Follow the instructions below in order to splice copper wire using DuraSeal splice sleeves.

Splice Sleeve Selection

Splice Sleeve Color	Crimp Tool Nest Color		Wire Gauge mm^2 / (AWG)
	3 Crimp Nests	4 Crimp Nests	
Salmon (Yellow-Pink) 19300089	Red (1) or Red/Green (1)	Red (2)	0.22-0.8/(18-26)
Blue 19168447	Blue (2)	Blue (3)	1.0-2.0/(14-16)
Yellow 19168448	Yellow (3)	Yellow (4)	3.0-5.0/(10-12)

NOTE: **You must perform the following procedures in the listed order. Repeat the procedure if any wire strands are damaged. You must obtain a clean strip with all of the wire strands intact.**

1. Open the harness by removing any tape:
   - Use a sewing seam ripper, available from sewing supply stores, in order to cut open the harness in order to avoid wire insulation damage.
   - Use the DuraSeal splice sleeves on all types of insulation except Tefzel and coaxial.
   - Do not use the crimp and DuraSeal splice sleeve to form a splice with more than 2 wires coming together.
2. Cut as little wire off the harness as possible. You may need the extra length of wire in order to change the location of a splice.

   Adjust splice locations so that each splice is at least 40 mm (1.5 in) away from the other splices, harness branches, or connectors.

3. Strip the insulation:
   - When adding a length of wire to the existing harness, use the same size wire as the original wire.
   - Perform one of the following items in order to find the correct wire size:
     - Find the wire on the schematic and convert to regional wiring gauge size.
     - If you are unsure of the wire size, begin with the largest opening in the wire stripper and work down until achieving a clean strip of the insulation.
   - Strip approximately 5.0 mm (0.20 in) of insulation from each wire to be spliced.
   - Do not nick or cut any of the strands. Inspect the stripped wire for nicks or cut strands.

- If the wire is damaged, repeat this procedure after removing the damaged section.

4. For high temperature wiring, slide a section of high temperature SCT1 shrink tubing down the length of wire to be spliced. Ensure that the shrink tubing will not interfere with the splice procedure.
5. Select the proper DuraSeal splice sleeve according to the wire size. Refer to the above table at the beginning of the repair procedure for the color coding of the DuraSeal splice sleeves and the crimp tool nests.

Fig. 1: Splice Sleeve Crimping Tool With 4 Crimp Nests

Courtesy of GENERAL MOTORS COMPANY

6. The **EL-38125-10** splice sleeve crimping tool has four crimp nests. The largest crimp nest (4) is used for crimping 10 and 12 gauge wires. The second largest crimp nest (3) is used for crimping 14 and 16 gauge wires. The third largest crimp nest (2) is used for crimping 18 and 20 gauge wires. The smallest crimp nest (1) is used for crimping 22 to 26 gauge wires. The crimp nests are referenced in the table (farther above) under the crimp tool nest color.

Fig. 2: Splice Sleeve Crimping Tool With 3 Crimp Nests

Courtesy of GENERAL MOTORS COMPANY

7. The **J-38125-8** splice sleeve crimping tool has three crimp nests. The largest crimp nest (3) is used for crimping 10 and 12 gauge wires. The second largest crimp nest (2) is used for crimping 14 and 16 gauge wires. The smallest crimp nest (1) is used for crimping 18 to 20 gauge wires. The crimp nests are referenced in the table (farther above) under the crimp tool nest color.
8. Use the splice sleeve crimp tool in order to position the DuraSeal splice sleeve in the proper color nest of the splice sleeve crimp tool. For the four crimp nest tool, use the three largest crimp nests to crimp the splice sleeves. For the three crimp nest tool, use all three crimp nests to crimp the splice sleeves. Use the four and three crimp tool diagrams (above) and the table (farther above) to match the splice sleeve with the correct crimp nest. The crimp tool diagram callout numbers match the numbers in the table (under crimp tool nest color).

Fig. 3: Identifying Duraseal Splice Sleeve
Courtesy of GENERAL MOTORS COMPANY

9. Place the DuraSeal splice sleeve in the nest. Ensure that the crimp falls midway between the end of the barrel and the stop. The sleeve has a stop (3) in the middle of the barrel (2) in order to prevent the wire (1) from going further. Close the hand crimper handles slightly in order to firmly hold the DuraSeal splice sleeve in the proper nest.

Fig. 4: Crimped Duraseal Splice Sleeve
Courtesy of GENERAL MOTORS COMPANY

10. Insert the wire into the splice sleeve barrel until the wire hits the barrel stop. Refer to **Folded-Over Wire Repair** for splicing wires of 0.35 mm or less (22, 24, 26 gauge sizes) and for splicing wires of different gauges.

11. Tightly close the handles of the crimp tool until the crimper handles open when released.

    The crimper handles will not open until you apply the proper amount of pressure to the DuraSeal splice sleeve. Repeat steps 4 and 6 for the opposite end of the splice.

Fig. 5: Crimped Duraseal Splice Sleeve
Courtesy of GENERAL MOTORS COMPANY

12. Using the heat torch, apply heat to the crimped area of the barrel.
13. Start in the middle and gradually move the heat barrel to the open ends of the tubing:
    - The tubing will shrink completely as the heat is moved along the insulation.
    - A small amount of sealant will come out of the end of the tubing when sufficient shrinkage is achieved.

Weatherpack™ Wiring Repair

NOTE: **Some replacement pigtail connectors may be delivered without the terminated leads installed into the connector. For Weatherpack™ connectors, all terminated leads included in the package should to be installed into the connector. If the connector end view shows that a terminal is not occupied, the extra terminated lead(s) need to be installed and the end(s) sealed using a DuraSeal splice sleeve and taped back into the harness.**

1. Insert the wire into the splice sleeve barrel until the wire hits the barrel stop. Refer to **Folded-Over Wire Repair** for splicing wires of 0.35 mm or less (22, 24, 26 gauge sizes) and for splicing wires of different gauges.

Fig. 6: Tightly Close Handles Of Crimp Tool
Courtesy of GENERAL MOTORS COMPANY

2. Tightly close the handles of the crimp tool until the crimper handles open when released.

   The crimper handles will not open until you apply the proper amount of pressure to the DuraSeal splice sleeve. Holding the DuraSEAL with

one hand gently tug on the wire to ensure it is crimped in the DuraSeal.

3. Using the heat torch, apply heat to the crimped area of the barrel.

Fig. 7: Applying Heat To Crimped Area Of Barrel
Courtesy of GENERAL MOTORS COMPANY

4. Start in the middle and gradually move the heat barrel to the open ends of the tubing:
    - The tubing will shrink completely as the heat is moved along the insulation.
    - A small amount of sealant will come out of the end of the tubing when sufficient shrinkage is achieved.

Fig. 8: Taping Extra Terminated Leads Back Into Harness
Courtesy of GENERAL MOTORS COMPANY

5. Tape the extra terminated lead(s) back into the harness.

High Temperature Wiring Repairs

Use the following procedures to perform high temperature wiring repairs:

1. Center the high temperature SCT1 shrink tube over the DuraSeal splice sleeve.
2. Using the heat torch, apply heat to the high temperature heat shrink tubing.
3. Gradually move the heat from the center to the open end of the tubing:
    - The tubing will shrink completely as the heat is moved along the insulation.
    - A small amount of sealant will come out of the end of the tubing when sufficient shrinkage is achieved.
4. Replace any reflective tape and clips that may have been removed during the repair.

CONNECTOR RECONNECTION - ENGINE CONTROLS AND FUEL

Special Tools

EL-35616 Terminal Test Probe Kit

For equivalent regional tools, refer to **Special Tools** .

When the condition is not currently present, but is indicated in DTC history, the cause may be intermittent. An intermittent may also be the cause when there is a customer complaint, but the symptom cannot be duplicated. Refer to the Symptom Table of the system that is suspect of causing the condition before trying to locate an intermittent condition.

Most intermittent conditions are caused by faulty electrical connections or wiring. Inspect for the following items:

- Wiring broken inside the insulation
- Poor connection between the male and female terminal at a connector
- A terminal not seated all the way into the connector body
- Poor terminal to wire connection - Some conditions which fall under this description are poor crimps, poor solder joints, crimping over the wire insulation rather than the wire itself, and corrosion in the wire to terminal contact area, etc.
- Pierced or damaged insulation can allow moisture to enter the wiring causing corrosion. The conductor can corrode inside the insulation, with little visible evidence. Look for swollen and stiff sections of wire in the suspect circuits.
- Wiring which has been pinched, cut, or its insulation rubbed through may cause an intermittent open or short as the bare area touches other

wiring or parts of the vehicle.

- Wiring that comes in contact with hot or exhaust components
- Refer to **Inducing Intermittent Fault Conditions** in order to duplicate the conditions required, in order to verify the customer concern.
- Refer to **Testing for Electrical Intermittents** for test procedures to detect intermittent open, high resistance, short to ground, and short to voltage conditions.
- Refer to **Scan Tool Snapshot Procedure** for advanced intermittent diagnosis and Vehicle Data Recorder operation.

Testing for Terminal Fretting

Some intermittent conditions can be caused by wire terminal fretting corrosion. Fretting corrosion is a build-up of insulating, oxidized wear debris that can form when there is a small motion between electrical contacts. The oxidized wear debris can pile up enough at the electrical contact spots that the electrical resistance across the connection increases. Movement between the contacting surfaces as small as 10 to 100 microns can cause fretting. To put this in perspective, a sheet of paper is about 100 microns thick, so fretting motion is small and hard to see. Vibration and thermal expansion/contraction are the main sources that create fretting motion. Since vehicles vibrate and can experience large temperature swings, they are a good source for fretting motion. Tin, copper, nickel, and iron surfaces are all susceptible to fretting corrosion. Fretting corrosion can be difficult to see but it looks like small, dark smudges on the terminals contact surface.

To correct a fretting condition disconnect the suspect connector and add dielectric grease / lubricant (Nyogel 760G or equivalent, meeting GM specification 9986087) to both sides of the connector terminals. Then reconnect the connector and wipe away any excess lubricant. This will correct the additional terminal contact resistance due to the terminal fretting corrosion.

Testing for Proper Terminal Contact

It is important to test terminal contact at the component and any inline connectors before replacing a suspect component. Mating terminals must be inspected to ensure good terminal contact. A poor connection between the male and female terminal at a connector may be the result of contamination or deformation.

Contamination may be caused by the connector halves being improperly connected. A missing or damaged connector seal, damage to the connector itself, or exposing the terminals to moisture and dirt can also cause contamination. Contamination, usually in the underhood or underbody connectors, leads to terminal corrosion, causing an open circuit or intermittently open circuit.

Deformation is caused by probing the mating side of a connector terminal without the proper adapter. Always use the **EL-35616** kit when probing connectors. Other causes of terminal deformation are improperly joining the connector halves, or repeatedly separating and joining the connector halves. Deformation, usually to the female terminal contact tang, can result in poor terminal contact causing an open or intermittently open circuit.

Testing for Proper Terminal Contact in Bussed Electrical Centers

It is very important to use the correct test adapter when testing for proper terminal contact of fuses and relays in a bussed electrical center. Use the **EL-35616** kit to test for proper terminal contact. Failure to use the **EL-35616** kit can result in improper diagnosis of the bussed electrical center.

Follow the procedure below in order to test terminal contact:

1. Separate the connector halves.
2. Visually inspect the connector halves for contamination. Contamination may result in a white or green build-up within the connector body or between terminals. This causes high terminal resistance, intermittent contact, or an open circuit. An underhood or underbody connector that shows signs of contamination should be replaced in its entirety: terminals, seals, and connector body.
3. Using an equivalent male terminal/terminated lead, verify that the retention force is significantly different between a known good terminal and the suspect terminal. Replace the female terminal in question.

Flat Wire Connectors

There are no serviceable parts for flat wire connectors on the harness side or the component side.

Follow the procedure below in order to test terminal contact:

1. Remove the component in question.
2. Visually inspect each side of the connector for signs of contamination. Avoid touching either side of the connector as oil from your skin may be a source of contamination as well.
3. Visually inspect the terminal bearing surfaces of the flat wire circuits for splits, cracks, or other imperfections that could cause poor terminal contact. Visually inspect the component side connector to ensure that all of the terminals are uniform and free of damage or deformation.
4. Insert the appropriate adapter into the flat wire harness connector in order to test the circuit in question.

Control Module/Component Voltage and Grounds

Poor voltage or ground connections can cause widely varying symptoms.

- Test all control module voltage supply circuits. Many vehicles have multiple circuits supplying voltage to a control module. Other components in the system may have separate voltage supply circuits that may also need to be tested. Inspect connections at the module/component connectors, fuses, and any intermediate connections between the voltage source and the module/component. A test lamp or a DMM may indicate that voltage is present, but neither tests the ability of the circuit to carry sufficient current. Operate the component to test the ability of the circuit to carry sufficient current. Refer to **Circuit Testing** , and **Power Distribution Schematics** .
- Test all control module ground and system ground circuits. The control module may have multiple ground circuits. Other components in the system may have separate grounds that may also need to be tested. Inspect grounds for clean and tight connections at the grounding point.

Inspect the connections at the component and in splice packs, where applicable. Operate the component to test the ability of the circuit to carry sufficient current. Refer to **Circuit Testing** , and **Ground Distribution Schematics** .

Temperature Sensitivity

- An intermittent condition may occur when a component/connection reaches normal operating temperature. The condition may occur only when the component/connection is cold, or only when the component/connection is hot.
- Freeze Frame, Failure Records, Snapshot, or Vehicle Data Recorder data may help with this type of intermittent condition, where applicable.
- If the intermittent is related to heat, review the data for a relationship with the following:
  - High ambient temperatures
  - Underhood/engine generated heat
  - Circuit generated heat due to a poor connection, or high electrical load
  - Higher than normal load conditions, towing, etc.
- If the intermittent is related to cold, review the data for the following:
  - Low ambient temperatures - In extremely low temperatures, ice may form in a connection or component. Inspect for water intrusion.
  - The condition only occurs on a cold start.
  - The condition goes away when the vehicle warms up.
- Information from the customer may help to determine if the trouble follows a pattern that is temperature related.
- If temperature is suspected of causing an intermittent fault condition, attempt to duplicate the condition. Refer to **Inducing Intermittent Fault Conditions** in order to duplicate the conditions required.

Electromagnetic Interference and Electrical Noise

Some electrical components/circuits are sensitive to electromagnetic interference or other types of electrical noise. Inspect for the following conditions:

- A mis-routed harness that is too close to high voltage/high current devices such as secondary ignition components, motors, generator etc. - These components may induce electrical noise on a circuit that could interfere with normal circuit operation.
- Electrical system interference caused by a malfunctioning relay, or a control module driven solenoid or switch - These conditions can cause a sharp electrical surge. Normally, the condition will occur when the malfunctioning component is operating.
- Installation of non-factory or aftermarket add on accessories such as lights, 2-way radios, amplifiers, electric motors, remote starters, alarm systems, cell phones, etc. - These accessories may create interference in other circuits while operating and the interference would disappear when the accessory is not operating. Refer to **Checking Aftermarket Accessories** .

- Test for an open diode across the A/C compressor clutch and for other open diodes. Some relays may contain a clamping diode.
- The generator may be allowing AC noise into the electrical system.

Incorrect Control Module

- There are only a few situations where reprogramming a control module is appropriate:
  - A new service control module is installed.
  - A control module from another vehicle is installed.
  - Revised software/calibration files have been released for this vehicle.

NOTE: **DO NOT re-program the control module with the SAME software/calibration files that are already present in the control module. This is not an effective repair for any type of concern.**

- Verify that the control module contains the correct software/calibration. If incorrect programming is found, reprogram the control module with the most current software/calibration. Refer to **Control Module References** for replacement, setup, and programming.

BRAKE PEDAL POSITION SENSOR LEARN

Calibration Criteria

NOTE: **Do not apply the brake pedal during the brake pedal position sensor calibration procedure. Any movement of the brake pedal during this procedure will cause the calibration procedure to fail. If this occurs, the brake pedal position sensor calibration must be repeated.**

Brake pedal position sensor calibration must be performed after the brake pedal position sensor, body control module (BCM), or engine control module (ECM) have been serviced. The calibration procedure will set the brake pedal position sensor home value. This value is used by the BCM and ECM to determine the action of the driver applying the brake system and to provide this information to the vehicle subsystems via serial data.

Calibration Procedure

1. Apply the parking brake.
2. Ignition ON, engine OFF, place the transmission in the PARK position for automatic transmission or NEUTRAL position for manual transmission.
3. Install a scan tool.
4. Clear all DTCs before proceeding.
5. Navigate to the Configuration/Reset Functions menu of the BCM.

6. Select the Brake Pedal Position Sensor Learn procedure and follow the directions displayed on the screen.
7. Navigate to the Configuration/Reset Functions menu of the ECM.
8. Select the Learn Functions menu.
9. Select the Brake Pedal Position Sensor Learn procedure and follow the directions displayed on the screen.

ENGINE CONTROL MODULE REPLACEMENT

Fig. 9: Engine Control Module
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection (Dual Battery)** **Battery Negative Cable Disconnection and Connection (Single Battery)** .	

Callout	Component Name
1	Electronic Control Module **WARNING:** **Refer to Safety Glasses Warning .** **CAUTION:** • **Turn the ignition OFF when installing or removing the control module connectors and disconnecting or reconnecting the power to the control module (battery cable, powertrain control module (PCM)/engine control module (ECM)/transaxle control module (TCM) pigtail, control module fuse, jumper cables, etc.) in order to prevent internal control module**

Callout	Component Name
	damage. • Control module damage may result when the metal case contacts battery voltage. DO NOT contact the control module metal case with battery voltage when servicing a control module, using battery booster cables, or when charging the vehicle battery. • In order to prevent any possible electrostatic discharge damage to the control module, do no touch the connector pins or the soldered components on the circuit board. • Remove any debris from

Callout	Component Name
	around the control module connector surfaces before servicing the control module. Inspect the control module connector gaskets when diagnosing or replacing the control module. Ensure that the gaskets are installed correctly. The gaskets prevent contaminant intrusion into the control module. • **The replacement control module must be programmed.** **Procedure** 1. Disconnect the electrical connectors. 2. Release the retaining tabs. 3. If replacing, program the ECM. Refer to **Control Module References** .

Callout	Component Name
	NOTE: **Before removing the engine control module (ECM), record the Engine Oil Life percentage remaining. Use the scan tool to reset the Engine Oil Life remaining back to the original percentage recorded.**

CHASSIS CONTROL MODULE REPLACEMENT (WITH ACTIVE AIR SHUTTER)

Fig. 10: Chassis Control Module (With Active Air Shutter)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the spare tire. Refer to **Spare Wheel Hoist Replacement** .	
1	Chassis Control Module Fastener **CAUTION:** **Refer to Fastener Caution .**

Callout	Component Name
	Tighten 9 N.m (80 lb in)
2	Chassis Control Module **Procedure** 1. Disconnect the electrical connector. 2. If replacing, reprogram the module. Refer to **Control Module References** .

CHASSIS CONTROL MODULE REPLACEMENT (WITHOUT ACTIVE AIR SHUTTER)

Fig. 11: Chassis Control Module (Without Active Air Shutter)

Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the spare tire. Refer to **Spare Wheel Hoist Replacement** .	
1	Chassis Control Module Fastener (Qty: 3) **CAUTION:** **Refer to** **Fastener Caution** . **Tighten** 9 N.m (80 lb in)
2	Chassis Power Control Module **Procedure** 1. Disconnect the electrical connector. 2. If replacing, reprogram the module. Refer to **Control Module References** .

CRANKSHAFT POSITION VARIATION LEARN

The Crankshaft Position Variation Learn procedure is required when the following service procedures have been performed, regardless of whether DTC P0315 is set:

- An engine replacement.
- A engine control module (ECM) replacement.
- A crankshaft balancer replacement.
- A crankshaft replacement.
- A crankshaft position sensor replacement.
- Any engine repairs which disturb the crankshaft to crankshaft position sensor relationship.

The ECM monitors certain component signals to determine if all the conditions are met to continue with the Crankshaft Position Variation Learn procedure. The scan tool only displays the condition that inhibits the procedure. The scan tool displays the signals of the components listed below:

- Crankshaft position sensors activity: If there is a crankshaft position sensor condition, refer to the applicable DTC set.
- Camshaft position sensor signal activity: If there is a camshaft position sensor signal condition, refer to the applicable DTC set.
- Engine coolant temperature (ECT): If the engine coolant temperature is not warm enough, idle the engine until the engine coolant temperature reaches the correct temperature.

1. Verify no DTCs are set.
   - **If any DTCs other than P0300-P0308, or P0315 are set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .

   - **If DTC P0300-P0308, P0315, or no DTCs are set**

NOTE: **The Crankshaft Position Variation Learn may have to be repeated up to 5 times before the procedure is successful.**

2. Engine Running at normal operating temperature, perform the scan tool Crankshaft Position Variation Learn procedure and follow the on screen instructions.
3. Verify the scan tool displays Test Passed Successfully when completed.
   - **If Test Passed Successfully is not displayed**

     Verify that none of the conditions listed below exist:

   - The ignition switch is in the ON position until there is insufficient system voltage.
   - An ECM power disconnect with the ignition ON that may have erased the crankshaft position system variation values and set DTC P0315.
   - Interference in the signal circuit of the crankshaft position sensor.
   - Debris between the crankshaft position sensor and the reluctor wheel.
   - A damaged or misaligned reluctor wheel.
   - Worn crankshaft main bearings.
   - Excessive crankshaft runout.
   - A damaged crankshaft.

- If a condition is exists, repair or replace as necessary.
- If no conditions exist, replace the K20 Engine Control Module.
- **If Test Passed Successfully is displayed**

4. Clear all DTCs.
5. Engine Running.
6. Verify a DTC is not set.
   - **If a DTC is set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .

   - **If a DTC is not set**
7. All OK.

Repair Instructions

Perform the **Diagnostic Repair Verification** after completing the repair.

Control Module References for engine control module replacement, programming, and setup.

THROTTLE OR IDLE LEARN

Description

The engine control module (ECM) learns the airflow through the throttle body to ensure the correct idle. The learned airflow values are stored within the ECM. These values are learned to adjust for production variation and will continuously learn during the life of the vehicle to compensate for reduced airflow due to throttle body coking. Anytime the throttle body airflow rate changes, for example due to cleaning or replacing, the values must be relearned.

An engine that had a heavily coked throttle body that has been cleaned or replaced may take several drive cycles to unlearn the coking. To accelerate the process, the scan tool has the ability to reset all learned values back to zero. A new ECM will also have values set to zero.

The idle may be unstable or a DTC may set if the learned values do not match the actual airflow.

Conditions for Running the Throttle Learn Procedure

Scan tool Idle Learn or Idle Learn Reset Procedure

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0116, P0117, P0118, P0120, P0122, P0123, P0128, P0171, P0172, P0174, P0175, P0201-P0208, P0220, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282, P0283, P0300-P0308, P0351-P0358, P0496, P0601, P0604, P0606, P060D, P0641, P0651, P0697, P06A3, P06D2, P1248, P1249, P124A, P124B, P1516, P16A0-P16A2, P2101, P2119, P2120, P2122, P2123, P2125, P2127, P2128, P2135, P2138, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F, P217B, P217C, P217E, P217F, P2176, P2300, P2301, P2303, P2304, P2306, P2307, P2309, P2310, P2312, P2313, P2315, P2316, P2318, P2319, P2321, or P2322 are not set.
- Ignition ON, engine OFF.
- The vehicle speed sensor (VSS) is 0 km/h (0 mph).

Service Bay/On Road Learn Procedure

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0116, P0117, P0118, P0120, P0122, P0123, P0128, P0171, P0172, P0174, P0175, P0201-P0208, P0220, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282, P0283, P0300-P0308, P0351-P0358, P0496, P0601, P0604, P0606, P060D, P0641, P0651, P0697, P06A3, P06D2, P1248, P1249, P124A, P124B, P1516, P16A0-P16A2, P2101, P2119, P2120, P2122, P2123, P2125, P2127, P2128, P2135, P2138, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F, P217B, P217C, P217E, P217F, P2176, P2300, P2301, P2303, P2304, P2306, P2307, P2309, P2310, P2312, P2313, P2315, P2316, P2318, P2319, P2321, or P2322 are not set.
- The engine speed is between 450-4, 000 RPM.
- The manifold absolute pressure (MAP) is greater than 5 kPa.
- The mass air flow (MAF) is greater than 2 g/s.
- The ignition voltage is greater than 10 volts.

Diagnostic Aids

A un-metered air leak in the induction system or a small vacuum leak may not set a DTC. If the condition goes undetected, the ECM may learn an incorrect Throttle Body Idle Airflow Compensation value over time. The incorrectly learned value may cause various symptoms to occur such as rough or unstable idle speeds, and/or engine stall. If this condition is detected and repaired it will be necessary perform the Idle Learn procedure to ensure any symptoms are corrected.

Throttle Learn

Scan Tool Idle Learn or Idle Learn Reset Procedure - Performed after the throttle body is cleaned or replaced

1. Ignition ON, engine OFF, perform the Idle Learn or Idle Learn Reset in Configuration/Reset or Module Setup.
2. Engine idling, verify the scan tool Throttle Body Idle Airflow Compensation value is equal 0% and the engine is idling at a normal idle speed.

3. Clear the DTCs and return to the diagnostic that referred you here.

Service Bay/On Road Idle Learn Procedure - Performed after the ECM is programmed or replaced

NOTE: **Do NOT perform this procedure if any DTCs are set. Refer to Diagnostic Trouble Code (DTC) List - Vehicle .**

1. Engine idling for 3 m.
2. The ECM will start to learn the new idle cells and the scan tool Desired Idle Speed should start to decrease.
3. Ignition OFF for 60 s.
4. Start and idle the engine for 3 m.
5. Verify the engine is idling normally.
   - **If the engine idle is not correct**

     NOTE: **During the drive cycle the check engine light may come on with idle speed DTCs. If idle speed codes are set, clear codes so the ECM can continue to learn.**

     1. Operate the vehicle at speeds above 70 km/h (44 mph) with several decelerations and extended idles.
     2. Verify the engine is idling normally.
        - If the engine idle is not correct.

          Ignition OFF for 60 s, repeat step 5.1.

        - If the engine idle is correct.
     3. Clear any DTCs and return to the diagnostic that referred you here.
   - **If the engine idle is correct**
6. Clear any DTCs and return to the diagnostic that referred you here.

ENGINE COOLANT TEMPERATURE SENSOR REPLACEMENT

Fig. 12: Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Partially drain the cooling system. Refer to **Cooling System Draining and Filling (Static Fill L96)** **Cooling System Draining and Filling (Vac N Fill L96)** **Cooling System Draining and Filling (Vac N Fill L83 L86)** **Cooling System Draining and Filling (Static Fill L83 L86)** . Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)Air Cleaner Outlet Duct Replacement (Cadillac)**	
1	Engine Coolant Temperature Sensor **CAUTION:**

Callout	Component Name
	Refer to **Component Fastener Tightening Caution .** **Procedure** Disconnect the engine coolant temperature sensor electrical wiring harness connector. **Tighten** 20 N.m (15 lb ft)

MASS AIRFLOW SENSOR WITH INTAKE AIR TEMPERATURE SENSOR REPLACEMENT

Fig. 13: Mass Airflow Sensor with Intake Air Temperature Sensor
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Mass Airflow Sensor Screw (Qty: 2) **CAUTION:** **Refer to** **Fastener Caution .** **Tighten** 1.5 N.m (13 lb in)
2	Mass Airflow Sensor **Procedure** Disconnect the electrical connector.

MANIFOLD ABSOLUTE PRESSURE SENSOR REPLACEMENT

Fig. 14: Manifold Absolute Pressure Sensor
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure If equipped **Intake Manifold Cover Replacement**	
1	Manifold Absolute Pressure Sensor Fastener **CAUTION:** **Refer to** **Fastener Caution .**

Callout	Component Name
	Tighten 4.5 N.m (40 lb in)
2	Manifold Absolute Pressure Sensor **Procedure** Disconnect the manifold absolute pressure sensor electrical wiring harness connector.

HEATED OXYGEN SENSOR REPLACEMENT - BANK 1 SENSOR 1

Fig. 15: Heated Oxygen Sensor - Bank 1 Sensor 1
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure	

Callout	Component Name
Lifting and Jacking the Vehicle	
1	Heated Oxygen Sensor **CAUTION:** **Refer to Heated Oxygen and Oxygen Sensor Caution .** **CAUTION:** **Refer to Component Fastener Tightening Caution .** **Procedure** 1. Disconnect the heated oxygen sensor electrical connector. **NOTE:** **A special anti-seize compound is used in the HO2S threads. The compound consists of liquid graphite and glass beads.**

Callout	Component Name
	The graphite tends to burn away, but the glass beads remain, making the sensor easier to remove. New, or service replacement sensors already have the compound applied to the threads. If the sensor is removed from an exhaust component and if for any reason the sensor is to be reinstalled, the threads must have anti-seize compound applied before reinstallation.

Callout	Component Name
	2. If reinstalling the old sensor, coat the threads with anti-seize compound. **Tighten** 42 N.m (31 lb ft)

HEATED OXYGEN SENSOR REPLACEMENT - BANK 1 SENSOR 2

Fig. 16: Heated Oxygen Sensor - Bank 2 Sensor 2
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure	

Callout	Component Name
Raise and properly support the vehicle. Refer to **Lifting and Jacking the Vehicle** .	
1	Heated Oxygen Sensor **CAUTION:** **Refer to Heated Oxygen and Oxygen Sensor Caution .** **CAUTION:** **Refer to Component Fastener Tightening Caution .** **Procedure** 1. Disconnect the heated oxygen sensor harness connector. 2. If reinstalling the old sensor, coat the threads with anti-seize compound. **NOTE:** **A special anti-seize compound is used in the HO2S threads. The compound consists of liquid graphite and**

Callout	Component Name
	glass beads. The graphite tends to burn away, but the glass beads remain, making the sensor easier to remove. New, or service replacement sensors already have the compound applied to the threads. If the sensor is removed from an exhaust component and if for any reason the sensor is to be reinstalled, the threads must have anti-seize compound applied before reinstallation.

Callout	Component Name
	Tighten 42 N.m (31 lb ft)

HEATED OXYGEN SENSOR REPLACEMENT - BANK 2 SENSOR 1

Fig. 17: Heated Oxygen Sensor - Bank 2 Sensor 1
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the right front wheelhouse liner. **Front Wheelhouse Liner Replacement - Right Side (Cadillac)** **Front Wheelhouse Liner Replacement - Right Side (Chevrolet)** **Front Wheelhouse Liner Replacement - Right Side (GMC)** .	

Callout	Component Name
1	Heated Oxygen Sensor **CAUTION:** **Refer to Heated Oxygen and Oxygen Sensor Caution .** **CAUTION:** **Refer to Component Fastener Tightening Caution .** **Procedure** 1. Disconnect the heated oxygen sensor harness connector. 2. If reinstalling the old sensor, coat the threads with anti-seize compound. **NOTE:** **A special anti-seize compound is used in the HO2S threads. The compound consists of liquid graphite and glass beads.**

Callout	Component Name
	The graphite tends to burn away, but the glass beads remain, making the sensor easier to remove. New, or service replacement sensors already have the compound applied to the threads. If the sensor is removed from an exhaust component and if for any reason the sensor is to be reinstalled, the threads must have anti-seize compound applied before reinstallation.

Callout	Component Name
	Tighten 42 N.m (31 lb ft)

HEATED OXYGEN SENSOR REPLACEMENT - BANK 2 SENSOR 2

Fig. 18: Heated Oxygen Sensor - Bank 2 Sensor 2
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Raise and properly support the vehicle. Refer to **Lifting and Jacking the Vehicle** .	

Callout	Component Name
1	Heated Oxygen Sensor **CAUTION:** **Refer to Heated Oxygen and Oxygen Sensor Caution .** **CAUTION:** **Refer to Component Fastener Tightening Caution .** **Procedure** 1. Disconnect the heated oxygen sensor harness connector. 2. If reinstalling the old sensor, coat the threads with anti-seize compound. **NOTE:** **A special anti-seize compound is used in the HO2S threads. The compound consists of liquid graphite and glass beads.**

Callout	Component Name
	The graphite tends to burn away, but the glass beads remain, making the sensor easier to remove. New, or service replacement sensors already have the compound applied to the threads. If the sensor is removed from an exhaust component and if for any reason the sensor is to be reinstalled, the threads must have anti-seize compound applied before reinstallation.

Callout	Component Name
	Tighten 42 N.m (31 lb ft)

ACCELERATOR PEDAL POSITION SENSOR REPLACEMENT

Removal Procedure

CAUTION: **Handle the electronic throttle control components carefully. Use cleanliness in order to prevent damage. Do not drop the electronic throttle control components. Do not roughly handle the electronic throttle control components. Do not immerse the electronic throttle control components in cleaning solvents of any type.**

Fig. 19: View Of APP Sensor Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

1. Push down the small tab and disconnect the accelerator pedal position (APP) sensor electrical connector (1).

Fig. 20: View Of Accelerator Pedal Position Sensor Assembly
Courtesy of GENERAL MOTORS COMPANY

2. Remove the accelerator pedal bolts.
3. Remove the accelerator pedal.

Installation Procedure

Fig. 21: View Of Accelerator Pedal Position Sensor Assembly
Courtesy of GENERAL MOTORS COMPANY

1. Position the accelerator pedal to the accelerator pedal bracket.

CAUTION: Refer to Fastener Caution .

2. Install the accelerator pedal bolts and tighten to 9 N.m (80 lb in).

Fig. 22: View Of APP Sensor Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

3. Connect the APP sensor electrical connector (1).
4. Connect a scan tool to the diagnostic port in order to test for proper throttle-opening and throttle-closing range.
5. Operate the accelerator pedal and monitor the throttle angles. The accelerator pedal should operate freely, without binding, between a closed throttle, and a wide open throttle (WOT).

6. Verify that the vehicle meets the following conditions:
    - The vehicle is not in a reduced engine power mode.
    - The ignition is ON.
    - The engine is OFF.

THROTTLE BODY ASSEMBLY REPLACEMENT

Fig. 23: Throttle Body Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures	
Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)Air Cleaner Outlet Duct Replacement (Cadillac)**.	

Callout	Component Name
1	Throttle Body Assembly Fastener (Qty: 4) **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
2	Throttle Body Assembly **Procedure** 1. Disconnect the electrical connectors. 2. Install a NEW throttle body seal. 3. Perform the throttle idle learn procedure. Refer to **Throttle or Idle Learn**.

THROTTLE BODY CLEANING

WARNING: Refer to Safety Glasses Warning .

1. Remove the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)Air Cleaner Outlet Duct Replacement (Cadillac)**.
2. Fully open the throttle valve in order to Inspect the throttle body bore and the throttle valve plate for any deposits.

CAUTION: Do not subject a throttle body assembly which contains the following components to an immersion cleaner or a strong solvent:

- **Throttle position (TP) sensor**
- **Idle air control (IAC) valve**
- **Sealed throttle shaft bearings**

The cleaners will damage the electric components or sensors.

The cleaners will damage some of these components that contain seals or O-rings.

Solvents can wash away or break down the grease used on non-serviceable throttle shaft bearings.

Never use a wire brush or scraper to clean the throttle body. A wire brush or sharp tools may damage the throttle body components.

Do not use a cleaner that contains methyl ethyl ketone. This extremely strong solvent may damage components and is not necessary for this type of cleaning.

3. Use a clean shop towel and an approved GM engine cleaner. Clean the throttle body bore and the throttle valve plate.

   If necessary, use a parts cleaning brush in order to remove heavy deposits.

4. Install the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)Air Cleaner Outlet Duct Replacement (Cadillac)**.
5. Perform the throttle idle learn procedure. Refer to **Throttle or Idle Learn**.

FUEL PRESSURE GAUGE INSTALLATION AND REMOVAL

Special Tools

- **CH-47831** Fuel Line Disconnect Tool
- **J 34730-1A** Fuel Pressure Gauge
- **J 42982** Fuel Pressure Gauge Adapter

Installation Procedure

WARNING: Gasoline or gasoline vapors are highly flammable. A fire could occur if an ignition source is present. Never drain or store gasoline or diesel fuel in an open container, due to the possibility of fire or explosion. Have a dry chemical (Class B) fire extinguisher nearby.

WARNING: Wrap a shop towel around the fuel pressure connection in order to reduce the risk of fire and personal injury. The towel will absorb any fuel leakage that occurs during the connection of the fuel pressure gauge. Place the towel in an approved container when the connection of the fuel pressure gauge is complete.

CAUTION: Clean all of the following areas before performing any disconnections in order to avoid possible contamination in the system:

- **The fuel pipe connections**
- **The hose connections**
- **The areas surrounding the connections**

1. Relieve the fuel pressure. Refer to **Fuel Pressure Relief**.
2. Disconnect the quick connect coupling of the fuel feed hose from the fuel feed pipe of the fuel rail. Use a shop towel in order to catch any remaining fuel that may leak.
3. Install the **J 42982** adapter between the fuel feed pipe of the fuel rail and of the fuel feed hose.

Fig. 24: Fuel Pressure Gage
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

4. Install the **J 34730-1A** gauge to the **J 42982** adapter, and tighten securely.
5. Turn ON the ignition in order to pressurize the fuel system.

6. Turn OFF the ignition.
7. Check for any fuel leaks.

Removal Procedure

Fig. 25: Fuel Pressure Gage
Courtesy of GENERAL MOTORS COMPANY

1. Relieve the fuel pressure. Refer to the **Fuel Pressure Relief**.
2. Remove the **J 34730-1A** gauge from the **J 42982** adapter.
3. Using the **CH-47831** tool, disconnect the quick connect coupling of the **J 42982** adapter from the fuel feed pipe of the fuel rail. Use a shop towel in order to catch any remaining fuel that may leak.
4. Disconnect the quick connect coupling of the fuel feed hose (3) from the **J 42982** adapter, and remove the adapter. Use a shop towel in order to catch any remaining fuel that may leak.
5. Connect the quick-connect fitting of the fuel feed hose (3) to the fuel feed pipe of the fuel rail.
6. Turn ON the ignition in order to pressurize the fuel system.
7. Turn OFF the ignition.
8. Check for any fuel leaks.

FUEL PRESSURE RELIEF

WARNING: Fuel that flows out at high pressure can cause serious injury to the skin and eyes. ALWAYS depressurize the fuel system before removing components that are under high fuel pressure.

WARNING: Remove the fuel tank cap and relieve the fuel system pressure before servicing the fuel system in order to reduce the risk of personal injury. After you relieve the fuel system pressure, a small amount of fuel may be released when servicing the fuel lines, the fuel injection pump, or the connections. In order to reduce the risk of personal injury, cover the fuel system components with a shop towel before disconnection. This will catch any fuel that may leak out. Place the towel in an approved container when the disconnection is complete.

Scan Tool Method - Preferred

1. Install a scan tool and turn the ignition ON.
2. Using the scan tool, command the fuel pump OFF allowing the low pressure fuel pump to shut off.
3. Start the vehicle and allow the engine to idle until the engine stops. The engine will stop in approximately 5-20 seconds.
4. Repeat step 3. Using the scan tool, verify pressure has dropped to a minimal level.
5. Turn the ignition OFF.

Alternate Method - If a scan tool is not available

1. Disable the fuel pump by removing the B+ fuel pump control module fuse. Refer to **Electrical Center Identification Views** **Electrical Center Identification Views** .

2. Start the vehicle and allow the engine to idle until the engine stops. The engine will stop in approximately 5-20 seconds.
3. Attempt to restart the vehicle to ensure pressure has dropped to a minimal level.
4. Turn the ignition OFF.

METAL COLLAR QUICK CONNECT FITTING SERVICE

Special Tools

CH-41769 Fuel Line Quick Disconnect Tool

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** **Special Tools (Service Tools)** .

Disconnect Procedure

Fig. 26: Fuel Feed Line To Engine Quick-Connect Fitting Retainer
Courtesy of GENERAL MOTORS COMPANY

1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief**.
2. Remove the fuel line retainer.

Fig. 27: Blowing Dirt Out Of Fitting (Metal Collar)
Courtesy of GENERAL MOTORS COMPANY

WARNING: Wear safety glasses when using compressed air, as flying dirt particles may cause eye injury.

3. Using compressed air, blow any dirt or debris from around the connection.

Fig. 28: View Of Quick Connect Locking Tabs (Metal Collar)
Courtesy of GENERAL MOTORS COMPANY

4. Using the correct tool from the **CH-41769** disconnect tool, insert the tool into the female connector end, then push inward in order to release the quick connect locking tabs.

Fig. 29: View Of Quick Connect Locking Tabs (Metal Collar)
Courtesy of GENERAL MOTORS COMPANY

5. Pull the fuel line connection apart.

CAUTION: **If necessary, remove rust or burrs from the fuel pipes with an emery cloth. Use a radial motion with the fuel pipe end in order to prevent damage to the O-ring sealing surface. Use a clean shop towel in order to wipe off the male tube ends. Inspect all the connections for dirt and burrs. Clean or replace the components and assemblies as required.**

6. Use a clean shop towel in order to wipe off the male connection end.
7. Inspect both ends of the fitting for dirt and burrs. Clean or replace the components as required.

Connect Procedure

Fig. 30: Oiling Male Pipe Ends (Metal Collar)
Courtesy of GENERAL MOTORS COMPANY

WARNING: **In order to reduce the risk of fire and personal injury, before connecting fuel pipe fittings, always apply a few drops of clean engine oil to the male pipe ends.**

This will ensure proper reconnection and prevent a possible fuel leak.

During normal operation, the O-rings located in the female connector will swell and may prevent proper reconnection if not lubricated.

1. Apply a few drops of clean engine oil to the male connection end.

Fig. 31: View Of Connectors (Metal Collar)
Courtesy of GENERAL MOTORS COMPANY

2. Push both sides of the fitting together in order to engage the retaining tabs.

Fig. 32: Ensuring Connection (Metal Collar) Is Secure
Courtesy of GENERAL MOTORS COMPANY

3. Once installed, pull on both sides of the connection in order to ensure the connection is secure.

Fig. 33: Fuel Feed Line To Engine Quick-Connect Fitting Retainer
Courtesy of GENERAL MOTORS COMPANY

4. Install the fuel line retainer.

PLASTIC COLLAR QUICK CONNECT FITTING SERVICE

Disconnect Procedure

WARNING: **Refer to Gasoline/Gasoline Vapors Warning .**

Fig. 34: Identifying Plastic Collar Fuel & Evaporative Emission Quick Connect Fittings
Courtesy of GENERAL MOTORS COMPANY

NOTE: **There are several types of Plastic Collar Fuel and Evaporative Emission Quick Connect Fittings used on this vehicle.**

- **Bartholomew (1)**
- **Q Release (2)**
- **Squeeze to Release (3)**
- **Sliding Retainer (4)**
- **Push Down TI (5)**

The following instructions apply to all of these types of Plastic Collar Quick Connect Fittings except where indicated.

1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief**.

Fig. 35: Blowing Dirt Out Of Fitting (Plastic Collar)
Courtesy of GENERAL MOTORS COMPANY

WARNING: Refer to Safety Glasses Warning .

CAUTION: Refer to Fuel and Evaporative Emission Hose/Pipe Connection Cleaning Caution .

2. Using compressed air, blow any dirt or debris from around the connection.

Fig. 36: View Of Quick Connect Fitting Release Tabs (Plastic Collar)
Courtesy of GENERAL MOTORS COMPANY

3. This step applies to Bartholomew style connector ONLY. Squeeze the plastic quick connect fitting release tabs.

Fig. 37: Releasing Q Release Style Connectors (Plastic Collar)
Courtesy of GENERAL MOTORS COMPANY

4. This step applies to Release Tab style connector ONLY. Release the fitting by pushing the tab toward the other side of the slot in the fitting.

Fig. 38: Disengaging Quick Connect Fitting (Plastic Collar)
Courtesy of GENERAL MOTORS COMPANY

5. This step applies to the Squeeze to Release style connector ONLY. Squeeze where indicated by the arrows shown above on both sides of the plastic ring surrounding the quick connect fitting.

Fig. 39: View Of Sliding Retainer Style Connector
Courtesy of GENERAL MOTORS COMPANY

6. This step applies to the Sliding Retainer style connector ONLY. Release the fitting by pressing on one side of the release tab causing it to push in slightly. If the tab does not move try pressing the tab in from the opposite side. The tab will only move in one direction.

Fig. 40: View Of Push Down TI Style Connector
Courtesy of GENERAL MOTORS COMPANY

7. This step applies to the Push Down TI style connector ONLY. Release the fitting by pressing on the tab indicated by the arrow.

Fig. 41: View Of Pulling Connection Apart (Plastic Collar)
Courtesy of GENERAL MOTORS COMPANY

WARNING: Refer to Relieving Fuel Pressure Warning .

8. Pull the connection apart.

Connect Procedure

Fig. 42: Lubricating Male Pipe End
Courtesy of GENERAL MOTORS COMPANY

WARNING: Refer to Fuel Pipe Fitting Warning

1. Apply a few drops of clean engine oil to the male connection end.

Fig. 43: Connecting Quick-Connect Fittings
Courtesy of GENERAL MOTORS COMPANY

2. Push both sides of the quick-connect fitting together in order to cause the retaining feature to snap into place.

Fig. 44: View Of Quick-Connect Fitting
Courtesy of GENERAL MOTORS COMPANY

3. Once installed, pull on both sides of the connection in order to make sure the connection is secure.

FUEL TANK DRAINING

Fig. 45: Fuel Tank Vent Line Quick Connect Fitting, Hose Clamp, Bracket Bolts & Fill Hose
Courtesy of GENERAL MOTORS COMPANY

WARNING: Refer to Gasoline/Gasoline Vapors Warning .

1. Loosen the fuel fill cap in order to relieve the fuel tank vapor pressure.
2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

3. Loosen the fuel fill hose clamp (6).
4. Remove the fuel fill hose from the fuel tank.
5. Insert the hose from the pump devise into the fuel tank.
6. Using a hand or air operated pump device, drain as much fuel from the tank as possible.

FUEL TANK FILLER HOSE REPLACEMENT

Fig. 46: Fuel Tank Filler Hose
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
WARNING:	

Callout	Component Name
Refer to Gasoline/Gasoline Vapors Warning . **WARNING:** **Refer to Safety Glasses Warning .** **Preliminary Procedure** Lifting and Jacking the Vehicle	
1	Fuel Tank Filler Hose Clamp (Qty: 2) **CAUTION:** **Refer to Fastener Caution .** **Tighten** 4 N.m (35 lb in)
2	Fuel Tank Filler Hose **Procedure** If screen is in old hose, screen must be removed from old hose and installed in new hose if screen is not present in new hose.

FUEL TANK FILLER PIPE REPLACEMENT

Removal Procedure

NOTE: **Clean the fuel connections and surrounding areas prior to disconnecting the lines in order to avoid possible contamination.**

1. Remove Fuel Tank Filler Pipe Housing **Fuel Tank Filler Pipe Housing Replacement**

2. Remove the fuel fill cap, if necessary.

Fig. 47: Fuel Tank Filler Pipe Bracket Bolt
Courtesy of GENERAL MOTORS COMPANY

3. Remove Fuel Tank Filler Pipe Bracket Bolt (2)
4. Remove the spare tire, if necessary.
5. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

Fig. 48: View Of Rear Axle Vent Hose Clip
Courtesy of GENERAL MOTORS COMPANY

6. Remove the rear axle vent hose clip (1) from the fill pipe.
7. Remove Automatic Level Control Air Compressor Inlet Tube **Automatic Level Control Air Compressor Inlet Tube Replacement** .

Fig. 49: Fuel Tank Vent Line Quick Connect Fitting, Hose Clamp, Bracket Bolts & Fill Hose
Courtesy of GENERAL MOTORS COMPANY

8. Disconnect the fuel tank vent line quick connect fitting (5) from the fill pipe line. Refer to **Plastic Collar Quick Connect Fitting Service**.
9. Disconnect the fuel fill hose vent line quick connect fitting (3) from the EVAP canister vent solenoid valve. Refer to **Plastic Collar Quick Connect Fitting Service**.
10. Loosen the fuel fill hose clamp (6).

11. Remove the fuel fill pipe bracket bolts (2, 4).
12. Remove the fuel fill hose (1) from the fuel tank.

Installation Procedure

Fig. 50: Fuel Tank Vent Line Quick Connect Fitting, Hose Clamp, Bracket Bolts & Fill Hose
Courtesy of GENERAL MOTORS COMPANY

1. Install the fuel fill hose (1) to the fuel tank. Ensure that the notch in the hose is aligned with the notch on the fuel tank.

CAUTION: Refer to Fastener Caution .

2. Tighten the fuel fill hose clamp (6). 4 N.m (35 lb in).
3. Install the fuel fill pipe bracket bolts (2, 4). Tighten to 12 N.m (106 lb in).
4. Connect the fuel fill hose vent line quick connect fitting (3) to the EVAP canister vent solenoid valve. Refer to **Plastic Collar Quick Connect Fitting Service**.
5. Connect the fuel fill pipe vent line to the fuel tank quick connect fitting (5). Refer to **Plastic Collar Quick Connect Fitting Service**.
6. Install Automatic Level Control Air Compressor Inlet Tube **Automatic Level Control Air Compressor Inlet Tube Replacement**

Fig. 51: View Of Rear Axle Vent Hose Clip
Courtesy of GENERAL MOTORS COMPANY

7. Install the rear axle vent hose clip (1) to the fill pipe.
8. Lower the vehicle.

Fig. 52: Fuel Tank Filler Pipe Bracket Bolt
Courtesy of GENERAL MOTORS COMPANY

9. Install Fuel Tank Filler Pipe Bracket Bolt (2) Tighten to 10 N.m (89 lb in).
10. Install the spare tire, if necessary.
11. Install the fuel fill cap, if necessary.
12. Install Fuel Tank Filler Pipe Housing **Fuel Tank Filler Pipe Housing Replacement**

FUEL TANK REPLACEMENT

Special Tools

J-45722 Fuel Sender Lock Ring Wrench

Removal Procedure

NOTE: **Clean the fuel and evaporative emission (EVAP) connections and surrounding areas prior to disconnecting the lines in order to avoid possible system contamination.**

Fig. 53: Fuel Tank Vent Line Quick Connect Fitting, Hose Clamp, Bracket Bolts & Fill Hose
Courtesy of GENERAL MOTORS COMPANY

1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief**.
2. Drain the fuel tank. Refer to **Fuel Tank Draining**.
3. Disconnect the fuel tank vent line quick connect fitting (5) from the fuel fill pipe vent line. Refer to **Plastic Collar Quick Connect Fitting Service**.

Fig. 54: View Of EVAP Lines, Fuel Feed Lines & Fittings
Courtesy of GENERAL MOTORS COMPANY

4. Disconnect the chassis EVAP line quick connect fitting (4) from the fuel tank line. Refer to **Plastic Collar Quick Connect Fitting Service**.
5. Disconnect the fuel tank fuel feed line quick connect fitting (5) from the chassis line. Refer to **Plastic Collar Quick Connect Fitting Service**.
6. Cap the fuel and EVAP lines in order to prevent possible fuel and/or EVAP system contamination.

Fig. 55: View Of Fuel Tank EVAP Lines & Canister
Courtesy of GENERAL MOTORS COMPANY

7. Disconnect the fuel tank EVAP lines (1) from the EVAP canister. Refer to **Plastic Collar Quick Connect Fitting Service**.
8. Cap the EVAP lines in order to prevent possible EVAP system contamination.
9. Using an adjustable jack, support the fuel tank.

Fig. 56: View Of Fuel Tank & Straps (Single Tank)
Courtesy of GENERAL MOTORS COMPANY

10. Remove the fuel tank strap bolts.

CAUTION: Refer to Damage to Fuel Tank Straps Caution .

11. Remove the fuel tank straps.

NOTE: **Carefully lower the fuel tank until the EVAP line can be repositioned.**

12. With the aid of an assistant, carefully lower the rear of the fuel tank.

Fig. 57: Fuel Tank EVAP Line Quick Connect Fitting
Courtesy of GENERAL MOTORS COMPANY

13. Disconnect the fuel tank EVAP line quick connect fitting (1) at the fuel tank vent valve. Refer to **Plastic Collar Quick Connect Fitting**

Service.

14. Slide the front of the tank away from the frame.
15. Lower the fuel tank slightly until the chassis wiring harness electrical connectors can be accessed.

Fig. 58: View Of Chassis Wiring Harness Electrical Connectors & Module
Courtesy of GENERAL MOTORS COMPANY

16. Disengage the chassis wiring harness electrical connector, connector position assurance (CPA) retainer at the module.

17. Disconnect the chassis wiring harness electrical connectors (1) from the module and the fuel pressure sensor.

Fig. 59: View Of Fuel Tank & Straps (Single Tank)
Courtesy of GENERAL MOTORS COMPANY

18. Completely lower the fuel tank.
19. With the aid of an assistant, place the fuel tank in a suitable work area.
20. If replacing the fuel tank proceed to the next step, otherwise proceed to step 18 in the installation procedure.

Fig. 60: View Of EVAP Line Clip & Retainer
Courtesy of GENERAL MOTORS COMPANY

21. Remove the fuel feed line from the retaining feature (2) in the fuel tank.
22. Open the fuel/EVAP line clip (1) and remove the fuel feed line from the clip.
23. Disconnect the fuel feed line quick connect fitting at the fuel tank module. Refer to **Plastic Collar Quick Connect Fitting Service**.

Fig. 61: View Of Fuel Feed Line
Courtesy of GENERAL MOTORS COMPANY

24. Remove the fuel feed line from the fuel tank.

Fig. 62: View Of Fuel Tank Shields & Retainers
Courtesy of GENERAL MOTORS COMPANY

25. Remove the fuel tank shield retainers (2 and 3) and shields (1 and 4).

Fig. 63: View Of Fuel Tank Clips
Courtesy of GENERAL MOTORS COMPANY

26. Remove the EVAP line from the fuel tank clips (1, 2, 4, and 8).
27. Open the fuel tank clips (3, 5, 6, and 7) and remove the EVAP lines from the clips.
28. Disconnect the EVAP line quick connect fitting at the fuel tank module. Refer to **Plastic Collar Quick Connect Fitting Service**.

Fig. 64: View Of EVAP Lines
Courtesy of GENERAL MOTORS COMPANY

29. Remove the EVAP lines from the fuel tank.

Fig. 65: View of Special Tool & Lock Ring
Courtesy of GENERAL MOTORS COMPANY

30. Using the **J-45722** wrench, remove the lock ring.

Fig. 66: View Of Fuel Tank Module & Quick Connect Fitting
Courtesy of GENERAL MOTORS COMPANY

31. Carefully lift the module from the fuel tank, enough to access the quick connect fitting (1) under the module cover. Disconnect the quick connect fitting. Refer to **Plastic Collar Quick Connect Fitting Service**.
32. Remove the fuel tank module.
33. Remove and discard the fuel tank module seal.

Fig. 67: Checking Lock Ring For Flatness
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Inspect the lock ring for damage due to improper removal or installation procedures. If damage is found, install a NEW lock ring.**
- **Check the lock ring for flatness.**

34. Place the lock ring on a flat surface. Measure the clearance between the lock ring and the flat surface using a feeler gauge at 7 points.
35. If warpage is less than 0.41 mm (0.016 in), the lock ring does not require replacement.
36. If warpage is greater than 0.41 mm (0.016 in), the lock ring must be replaced.

Installation Procedure

Fig. 68: View Of Fuel Tank Module & Quick Connect Fitting
Courtesy of GENERAL MOTORS COMPANY

1. If the fuel tank was replaced perform the following steps, otherwise proceed to step 18.
2. Install a NEW fuel tank module seal onto the fuel tank.
3. Pull the vent line in the fuel tank up as far as possible for ease of installation.
4. Position the fuel tank module part way into the fuel tank.
5. Connect the quick connect fitting (1) to the module cover. Refer to **Plastic Collar Quick Connect Fitting Service**.
6. Install the fuel tank module into the fuel tank.
7. Place the lock ring into position.

Fig. 69: Identifying Lock Ring
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Always replace the fuel module seal when installing the fuel module. Replace the lock ring if necessary. DO NOT apply any type of lubrication in the seal groove.**

Ensure the lock ring is installed with the correct side facing upward. A correctly installed lock ring will only turn in a clockwise direction.

8. Rotate the lock ring counterclockwise using the **J-45722** wrench.

Fig. 70: View Of EVAP Lines
Courtesy of GENERAL MOTORS COMPANY

9. Install the EVAP lines to the fuel tank.

Fig. 71: View Of Fuel Tank Clips
Courtesy of GENERAL MOTORS COMPANY

10. Connect the EVAP line quick connect fitting at the fuel tank module. Refer to **Plastic Collar Quick Connect Fitting Service**.
11. Install the EVAP lines to the fuel tank clips (3, 5, 6, and 7) and close the clips.
12. Install the EVAP line to the fuel tank clips (1, 2, 4, and 8).

Fig. 72: View Of Fuel Tank Shields & Retainers
Courtesy of GENERAL MOTORS COMPANY

13. Install the fuel tank shields (1 and 4) and retainers (2 and 3).

Fig. 73: View Of Fuel Feed Line
Courtesy of GENERAL MOTORS COMPANY

14. Install the fuel feed line to the fuel tank.

Fig. 74: View Of EVAP Line Clip & Retainer
Courtesy of GENERAL MOTORS COMPANY

15. Connect the fuel feed line quick connect fitting at the fuel tank module. Refer to **Plastic Collar Quick Connect Fitting Service**.
16. Install the fuel feed line to the clip (1) and close the clip.
17. Install the fuel feed line to the retaining feature (2) in the fuel tank.

Fig. 75: View Of Chassis Wiring Harness Electrical Connectors & Module
Courtesy of GENERAL MOTORS COMPANY

18. Place the fuel tank onto a suitable jack.
19. With the aid of an assistant, partially raise the fuel tank until the electrical connections can be made.
20. Connect the chassis wiring harness electrical connectors (1) to the fuel tank module and fuel pressure sensor.
21. Engage the chassis harness electrical connector CPA retainer at the module electrical connector.

Fig. 76: View Of Fuel Tank & Straps (Single Tank)
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Carefully raise the fuel tank until the EVAP line can be positioned.**

22. Completely raise the fuel tank.

Fig. 77: Fuel Tank EVAP Line Quick Connect Fitting
Courtesy of GENERAL MOTORS COMPANY

23. Connect the fuel tank EVAP line quick connect fitting (1) at the fuel tank vent valve. Refer to **Plastic Collar Quick Connect Fitting Service**.
24. Install the fuel tank straps.

CAUTION: Refer to Fastener Caution .

25. Install the fuel tank strap bolts.

    Tighten

    Tighten the bolts to 40 N.m (30 lb ft).

26. Remove the adjustable jack from the fuel tank.

Fig. 78: View Of Fuel Tank EVAP Lines & Canister
Courtesy of GENERAL MOTORS COMPANY

27. Remove the caps from the EVAP lines.
28. Connect the fuel tank EVAP lines (1) to the EVAP canister. Refer to **Plastic Collar Quick Connect Fitting Service**.

Fig. 79: View Of EVAP Lines, Fuel Feed Lines & Fittings
Courtesy of GENERAL MOTORS COMPANY

29. Remove the caps from the fuel and EVAP lines.
30. Connect the chassis EVAP line quick connect fitting (4) to the fuel tank line. Refer to **Plastic Collar Quick Connect Fitting Service**.
31. Connect the fuel tank fuel feed line quick connect fitting (5) to the chassis line. Refer to **Plastic Collar Quick Connect Fitting Service**.

Fig. 80: Fuel Tank Vent Line Quick Connect Fitting, Hose Clamp, Bracket Bolts & Fill Hose
Courtesy of GENERAL MOTORS COMPANY

32. Connect the fuel tank vent line quick connect fitting (5) to the fuel fill pipe line. Refer to **Plastic Collar Quick Connect Fitting Service**.

33. Install the fuel fill hose to the fuel tank. Ensure that the notch in the hose is aligned with the notch on the fuel tank.
34. Tighten the fuel fill hose clamp (6).

    Tighten

    Tighten the clamp to 4 N.m (35 lb in).

35. Lower the vehicle.
36. Refill the fuel tank.
37. Install the fuel fill cap.
38. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection (Dual Battery)** **Battery Negative Cable Disconnection and Connection (Single Battery)** .
39. Use the following procedure in order to inspect for leaks:
    1. Turn the ignition ON, with the engine OFF, for 2 seconds.
    2. Turn the ignition OFF for 10 seconds.
    3. Turn the ignition ON, with the engine OFF.
    4. Inspect for fuel leaks.

FUEL TANK PRESSURE SENSOR REPLACEMENT (SWB)

Removal Procedure

Fig. 81: View Of Fuel Tank Pressure Sensor
Courtesy of GENERAL MOTORS COMPANY

1. Remove the fuel tank. Refer to **Fuel Tank Replacement**.
2. Using a slight rocking motion while pulling straight up, remove the fuel tank pressure sensor (1).

Installation Procedure

1. Transfer the fuel tank pressure sensor cover.

Fig. 82: View Of Fuel Tank Pressure Sensor
Courtesy of GENERAL MOTORS COMPANY

2. Install the fuel tank pressure sensor (1).
3. Install the fuel tank. Refer to **Fuel Tank Replacement**.

FUEL TANK PRESSURE SENSOR REPLACEMENT (LWB)

Removal Procedure

Fig. 83: View Of Fuel Tank Pressure Sensor
Courtesy of GENERAL MOTORS COMPANY

1. Remove the fuel tank. Refer to **Fuel Tank Replacement**.

2. Using a slight rocking motion while pulling straight up, remove the fuel tank pressure sensor (1).

Installation Procedure

Fig. 84: View Of Fuel Tank Pressure Sensor
Courtesy of GENERAL MOTORS COMPANY

1. Install the fuel tank pressure sensor (1).

2. Install the fuel tank. Refer to **Fuel Tank Replacement**.

FUEL TANK FUEL PUMP MODULE REPLACEMENT (SWB)

Special Tools

J-45722 Fuel Sender Lock Ring Wrench Fuel Sender Lock Ring Wrench

Removal Procedure

Fig. 85: Fuel Tank
Courtesy of GENERAL MOTORS COMPANY

1. Remove the fuel tank. Refer to **Fuel Tank Replacement**.
2. Disconnect fuel and evaporative emission (EVAP) lines (1) from the fuel tank module. Refer to **Plastic Collar Quick Connect Fitting Service**.

3. Disconnect the EVAP vent valve line quick connect fitting at the vent valve and reposition the line out of the way. Refer to **Plastic Collar Quick Connect Fitting Service**.

CAUTION: **Avoid damaging the lock ring. Use only J-45722 to prevent damage to the lock ring.**

CAUTION: **Do Not handle the fuel sender assembly by the fuel pipes. The amount of leverage generated by handling the fuel pipes could damage the joints.**

NOTE: **Do NOT use impact tools. Significant force will be required to release the lock ring. The use of a hammer and screwdriver is not recommended. Secure the fuel tank in order to prevent fuel tank rotation.**

4. Using the **J-45722** wrench and a long breaker bar, rotate the ring clockwise unlocking the fuel tank module lock ring.
5. Remove the lock ring.

Fig. 86: View Of Fuel Tank Module & Quick Connect Fitting
Courtesy of GENERAL MOTORS COMPANY

6. Carefully lift the module from the fuel tank enough to access the quick connect fitting (1) under the module cover. Disconnect the quick connect fitting. Refer to **Plastic Collar Quick Connect Fitting Service**.
7. Remove the fuel tank module.
8. Remove and discard the fuel tank module seal.

Fig. 87: Checking Lock Ring For Flatness
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Inspect the lock ring for damage due to improper removal or installation procedures. If damage is found, install a NEW lock ring.**
- **Check the lock ring for flatness.**

9. Place the lock ring on a flat surface. Measure the clearance between the lock ring and the flat surface using a feeler gauge at 7 points.
10. If warpage is less than 0.41 mm (0.016 in), the lock ring does not require replacement.
11. If warpage is greater than 0.41 mm (0.016 in), the lock ring must be replaced.

Installation Procedure

Fig. 88: View Of Fuel Tank Module & Quick Connect Fitting
Courtesy of GENERAL MOTORS COMPANY

1. Install the NEW fuel tank module seal onto the fuel tank.
2. Pull the vent line in the fuel tank up as far as possible for ease of installation.
3. Position the fuel tank module part way into the fuel tank.
4. Connect the quick connect fitting (1) to the module cover. Refer to **Plastic Collar Quick Connect Fitting Service**.
5. Install the fuel tank module into the fuel tank.
6. Place the lock ring into position.

Fig. 89: Identifying Lock Ring
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Always replace the fuel module seal when installing the fuel module. Replace the lock ring if necessary. DO NOT apply any type of lubrication in the seal groove.**

Ensure the lock ring is installed with the correct side facing upward. A correctly installed lock ring will only turn in a clockwise direction.

7. Rotate the lock ring counterclockwise using the **J-45722** wrench until fully seated.
8. Position the EVAP vent valve line and connect the EVAP vent valve line quick connect fitting to the vent valve. Refer to **Plastic Collar Quick Connect Fitting Service**.
9. Connect the fuel and EVAP lines to the fuel tank module. Refer to **Plastic Collar Quick Connect Fitting Service**.
10. Install the fuel tank. Refer to **Fuel Tank Replacement**.

FUEL TANK FUEL PUMP MODULE REPLACEMENT (LWB)

Special Tools

J-45722 Fuel Sender Lock Ring Wrench

Removal Procedure

Fig. 90: Fuel Tank
Courtesy of GENERAL MOTORS COMPANY

1. Remove the fuel tank. Refer to **Fuel Tank Replacement**.
2. Disconnect fuel and evaporative emission (EVAP) lines (1) from the fuel tank module. Refer to **Plastic Collar Quick Connect Fitting Service**.

CAUTION: **Avoid damaging the lock ring. Use only J-45722 to prevent damage to the lock ring.**

CAUTION: **Do Not handle the fuel sender assembly by the fuel pipes. The amount of leverage generated by handling the fuel pipes could damage the joints.**

NOTE: **Do NOT use impact tools. Significant force will be required to release the lock ring. The use of a hammer and screwdriver is not recommended. Secure the fuel tank in order to prevent fuel tank rotation.**

3. Using the **J-45722** wrench and a long breaker bar, rotate the ring clockwise unlocking the fuel tank module lock ring.
4. Remove the lock ring.

Fig. 91: View Of Fuel Tank Module & Quick Connect Fitting
Courtesy of GENERAL MOTORS COMPANY

5. Carefully lift the module from the fuel tank, enough to access the quick connect fitting (1) under the module cover. Disconnect the quick connect fitting. Refer to **Plastic Collar Quick Connect Fitting Service**.
6. Remove the fuel tank module.
7. Remove and discard the fuel tank module seal.

Fig. 92: Checking Lock Ring For Flatness
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **Inspect the lock ring for damage due to improper removal or installation procedures. If damage is found, install a NEW lock ring.**
- **Check the lock ring for flatness.**

8. Place the lock ring on a flat surface. Measure the clearance between the lock ring and the flat surface using a feeler gauge at 7 points.
9. If warpage is less than 0.41 mm (0.016 in), the lock ring does not require replacement.
10. If warpage is greater than 0.41 mm (0.016 in), the lock ring must be replaced.

Installation Procedure

Fig. 93: View Of Fuel Tank Module & Quick Connect Fitting
Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW fuel tank module seal onto the fuel tank.
2. Pull the vent line in the fuel tank up as far as possible for ease of installation.
3. Position the fuel tank module part way into the fuel tank.
4. Connect the quick connect fitting (1) to the module cover. Refer to **Plastic Collar Quick Connect Fitting Service**.
5. Install the fuel tank module into the fuel tank.
6. Place the lock ring into position.

Fig. 94: Identifying Lock Ring
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Always replace the fuel module seal when installing the fuel module. Replace the lock ring if necessary. DO NOT apply any type of lubrication in the seal groove.**

Ensure the lock ring is installed with the correct side facing upward. A correctly installed lock ring will only turn in a clockwise direction.

7. Rotate the lock ring counterclockwise using the **J-45722** wrench until fully seated.
8. Connect the fuel and EVAP lines to the fuel tank module. Refer to **Plastic Collar Quick Connect Fitting Service**.
9. Install the fuel tank. Refer to **Fuel Tank Replacement**.

FUEL FEED PIPE REPLACEMENT (AT ENGINE)

Fig. 95: Fuel Feed Pipe
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief**. 2. Remove the fuel pump insulator. Refer to **Fuel Pump Insulator Replacement**.	
1	Fuel Feed Pipe Bracket Fastener **CAUTION:** **Refer to** **Fastener** **Caution** . **Tighten** 10 N.m (89 lb in)
2	Fuel Feed Pipe **Procedure** Disconnect the fuel feed pipe quick connects. Refer to **Metal Collar Quick Connect Fitting Service**.

FUEL FEED PIPE REPLACEMENT (AT TANK)

Fig. 96: Fuel Feed Pipe (At Tank)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Callout	Component Name
WARNING: **Refer to Gasoline/Gasoline Vapors Warning .** **WARNING:** **Refer to Safety Glasses Warning .** **Preliminary Procedure Fuel Tank Replacement**	
1	Fuel Feed Pipe **Procedure** Disconnect the fuel feed pipe from the fuel tank fuel pump module and remove from retainers. **Plastic Collar Quick Connect Fitting Service**

FUEL PUMP REPLACEMENT

Special Tools

EN-51092 Fuel Pump Installation Gauge

For equivalent regional tools, refer to **Special Tools** .

Removal Procedure

1. Relieve the fuel pressure. Refer to **Fuel Pressure Relief**.

Fig. 97: Fuel Pump Insulator
Courtesy of GENERAL MOTORS COMPANY

2. Remove the fuel pump insulator (1). Refer to **Fuel Pump Insulator Replacement**.

Fig. 98: Low Pressure Fuel Feed Pipe To LH Rocker Cover Bolt
Courtesy of GENERAL MOTORS COMPANY

3. Remove the fuel feed pipe fastener (4) then remove the low pressure fuel feed pipe (1) from the fuel pump (2). Refer to **Plastic Collar Quick Connect Fitting Service**.

Fig. 99: Crossover Pipe And Fuel Feed Pipe Fittings
Courtesy of GENERAL MOTORS COMPANY

4. Remove and DISCARD the high pressure fuel feed pipe (1) that connects the fuel pump to the crossover pipe (3).
5. Disconnect and reposition the fuel pump and injector harness as needed.

Fig. 100: NEW High Pressure Fuel Pump Gasket
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Alternately loosen the fuel pump bolts one turn at a time until the pump is fully disengaged from fuel pump lifter follower. Trying to remove the pump bolts without even side-to-side loosening may result in pump plunger damage

6. Remove the fuel pump fasteners (5) then remove the fuel pump cover (4) and the plastic fastener retainers (3).

7. Remove the fuel pump (2) and fuel pump gasket (1) from the engine.
8. DISCARD the fuel pump gasket.

Installation Procedure

Fig. 101: Lifter Oil Manifold Assembly
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The camshaft must be in the base circle position before the high pressure fuel pump is installed.**

1. Use the **EN-51092** alignment gauge (2) to ensure that the camshaft lobe is in the base circle position. At base circle position, the tool will be flush with the top surface of the lifter oil manifold assembly (1).

Fig. 102: NEW High Pressure Fuel Pump Gasket
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Ensure that the high pressure fuel pump roller lifter is oriented properly, the camshaft is at base circle and the number 1 piston is at top dead center (TDC) on the exhaust stroke.**

NOTE: **Ensure the plastic fastener retainers (3) are installed in the high pressure fuel pump mounting holes before installing.**

2. Install a NEW high pressure fuel pump gasket (1).
3. Install the high pressure fuel pump (2) and high pressure fuel pump cover (4).

CAUTION: **Refer to Fastener Caution .**

CAUTION: **Alternately hand-tighten the fuel pump bolts one turn at a time until the pump is fully seated. Trying to draw down the pump without even side-to-side tightening may result in pump plunger damage.**

4. Start and hand-tighten the high pressure fuel pump fasteners (5) evenly and tighten the high pressure fuel pump fasteners to 25 N.m (18 lb ft).

Fig. 103: Crossover Pipe And Fuel Feed Pipe Fittings
Courtesy of GENERAL MOTORS COMPANY

5. Install the NEW high pressure fuel feed pipe (1) that connects the fuel pump to the crossover pipe (3). Finger-tighten both fuel pipe fitting nuts (2).
6. Tighten the high pressure fuel feed pipe fittings to 28 N.m (21 lb ft) in the following order: at the fuel pump (1) then at the crossover (2).

Fig. 104: Low Pressure Fuel Feed Pipe To LH Rocker Cover Bolt
Courtesy of GENERAL MOTORS COMPANY

7. Install low pressure fuel feed pipe (1) to the fuel pump (2). Press fuel pipe until an audible click is heard. Install redundant clip (3). Refer to **Plastic Collar Quick Connect Fitting Service**.
8. Install the low pressure fuel feed pipe to LH rocker cover. Tighten fuel feed fasteners (4) to 10 N.m (89 lb in).

Fig. 105: Fuel Pump Insulator
Courtesy of GENERAL MOTORS COMPANY

9. Install the fuel pump insulator (1). Refer to **Fuel Pump Insulator Replacement**.

FUEL PUMP COVER REPLACEMENT

Fig. 106: Fuel Pump Cover
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the fuel pump insulator. Refer to **Fuel Pump Insulator Replacement**.	
1	Fuel Pump Fasteners (Qty: 2) **CAUTION:** **Alternately loosen the fuel pump bolts one turn at a**

Callout	Component Name
	time until the pump is fully disengaged from fuel pump lifter follower. Trying to remove the pump bolts without even side-to-side loosening may result in pump plunger damage **CAUTION:** **Refer to Fastener Caution .** **Tighten** 25 N.m (18 lb ft)
2	Fuel Pump Cover **Procedure** Slide the fuel pump cover rearward to remove it from the fuel pump.

FUEL PUMP INSULATOR REPLACEMENT

Fig. 107: Fuel Pump Insulator
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the intake manifold. Refer to **Intake Manifold Replacement** .	
1	Fuel Pump Insulator **WARNING:** **The noise cancelling foam component MUST be**

Callout	Component Name
	replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.

FUEL LEVEL SENSOR REPLACEMENT

Removal Procedure

Fig. 108: Locating Fuel Level Sensor Tangs & Retainer
Courtesy of GENERAL MOTORS COMPANY

1. Remove the fuel tank module. Refer to **Fuel Tank Fuel Pump Module Replacement (SWB)Fuel Tank Fuel Pump Module Replacement (LWB)**.
2. Using a small pick like tool, push in the retainer (1) in order to disengage the electrical connector.
3. Remove the fuel level sensor electrical connector from the module cover.

4. Pull the level sensor locking tangs (2) out towards the outside of the module bucket.

Fig. 109: Fuel Level Sensor
Courtesy of GENERAL MOTORS COMPANY

5. Slide the fuel level sensor (1) up.

Fig. 110: Fuel Level Sensor
Courtesy of GENERAL MOTORS COMPANY

6. Remove the fuel level sensor (1) from the module.

Installation Procedure

Fig. 111: Fuel Level Sensor
Courtesy of GENERAL MOTORS COMPANY

1. Install the fuel level sensor (1) to the module.

Fig. 112: Fuel Level Sensor
Courtesy of GENERAL MOTORS COMPANY

2. Position and slide the fuel level sensor (1) down.

Fig. 113: Locating Fuel Level Sensor Tangs & Retainer
Courtesy of GENERAL MOTORS COMPANY

3. Ensure that the level sensor tangs (2) are engaged at the bucket.
4. Install the fuel level sensor electrical connector to the module cover.
5. Ensure that the retainer (1) engaged the module cover.
6. Install the fuel tank module. Refer to **Fuel Tank Fuel Pump Module Replacement (SWB)Fuel Tank Fuel Pump Module Replacement**

(LWB).

FUEL FEED AND EVAPORATIVE EMISSION HOSE REPLACEMENT

Removal Procedure

NOTE: **Clean all fuel and evaporative emission (EVAP) line connections and surrounding areas prior to disconnecting the lines in order to avoid possible fuel and/or EVAP system contamination.**

1. Lower the transmission enough to access the upper line fasteners and retainers. **Transmission Replacement** , for the 6L80 or **Transmission Replacement** for the 8L90.

Fig. 114: Fuel Feed And EVAP Hose Nut
Courtesy of GENERAL MOTORS COMPANY

2. Remove the fuel feed and EVAP hose nut (1).
3. Disconnect the fuel hose (2) from the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service**.
4. Disconnect the EVAP hose (3) from the EVAP canister purge tube. Refer to **Plastic Collar Quick Connect Fitting Service**.
5. Remove the fuel feed and EVAP hose (4) from the retainers.

Fig. 115: EVAP hose
Courtesy of GENERAL MOTORS COMPANY

6. Disconnect the EVAP hose (1) from the EVAP pipe. Refer to **Plastic Collar Quick Connect Fitting Service**.
7. Disconnect the fuel hose (2) from the fuel pipe. Refer to **Plastic Collar Quick Connect Fitting Service**.
8. Disconnect the fuel pressure sensor electrical connector.

9. Remove the fuel feed and EVAP hose (3) from the retainers and remove from vehicle.

Installation Procedure

Fig. 116: EVAP hose
Courtesy of GENERAL MOTORS COMPANY

1. Install the fuel feed and EVAP hose (3) to the vehicle and retainers.
2. Connect the fuel pressure sensor electrical connector.
3. Connect the fuel hose (2) to the fuel pipe. Refer to **Plastic Collar Quick Connect Fitting Service**.
4. Connect the EVAP hose (1) to the EVAP pipe. Refer to **Plastic Collar Quick Connect Fitting Service**.

Fig. 117: Fuel Feed And EVAP Hose Nut
Courtesy of GENERAL MOTORS COMPANY

5. Install the fuel feed and EVAP hose (4) to the retainers.
6. Connect the EVAP hose (3) to the EVAP canister purge tube. Refer to **Plastic Collar Quick Connect Fitting Service**.
7. Connect the fuel hose (2) to the fuel rail. Refer to **Metal Collar Quick Connect Fitting Service**.

CAUTION: Refer to Fastener Caution .

8. Install the fuel feed and EVAP hose nut (1) and torque to 25 N.m (18 lb ft).
9. Raise the transmission back to it original position. **Transmission Replacement** , for the 6L80 or **Transmission Replacement** for the 8L90.

FLEXIBLE FUEL SENSOR REPLACEMENT

Fig. 118: Flexible Fuel Sensor
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief** 2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle**	
1	Flexible Fuel Sensor **Procedure** 1. Disconnect the electrical connector. 2. Disconnect the fuel lines. Refer to **Plastic Collar Quick Connect Fitting Service**. 3. Depress the release tab to remove sensor from bracket.

FUEL PRESSURE SENSOR REPLACEMENT (FUEL PIPE)

Fig. 119: Fuel Pressure Sensor (Fuel Pipe)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief**. 2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .	
1	Fuel Pressure Sensor **CAUTION:** **Refer to** **Component**

Callout	Component Name
	Fastener Tightening Caution . **Procedure** 1. Disconnect the electrical connector. 2. Remove and discard the fuel pressure sensor O-ring seal. **Tighten** 15 N.m (11 lb ft)

FUEL SYSTEM CLEANING

NOTE: **Only use oil free compressed air to blow out the fuel pipes.**

1. Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection (Dual Battery)** **Battery Negative Cable Disconnection and Connection (Single Battery)** .
2. Remove the fuel tank module. Refer to **Fuel Tank Fuel Pump Module Replacement (SWB)Fuel Tank Fuel Pump Module Replacement (LWB)**.
3. Inspect the fuel tank module strainer, if equipped. If the strainer is contaminated replace the fuel tank module.
4. Inspect the fuel tank module inlet for dirt and debris. Replace the fuel tank module if you find dirt or debris in the fuel pump inlet.

NOTE: **When flushing the fuel tank, handle the fuel and water mixture as a hazardous material. Handle the fuel and water mixture in accordance with all applicable local, state, and federal laws and regulations.**

5. Flush the fuel tank with hot water.
6. Pour the water out of the fuel module opening. Rock the tank to be sure that removal of the water from the tank is complete.
7. Remove the fuel rail. Refer to **Fuel Injection Fuel Rail Assembly Replacement - Bank 1**, and **Fuel Injection Fuel Rail Assembly Replacement - Bank 2**.
8. Drain the fuel from the fuel rail. It will be necessary to remove the fuel injectors from the fuel rail to properly clear all debris from the fuel rail and fuel injectors. Refer to **Fuel Injector Replacement**.

9. Use light shop air to remove any debris from the fuel rail and injectors.
10. Use light shop air in the opposite direction of the fuel flow in order to remove any debris from the fuel lines. Catch any fuel from the fuel lines with an approved gasoline container.
11. Install the fuel injectors to the fuel rail. Refer to **Fuel Injector Replacement**.
12. Install the fuel rail. Refer to **Fuel Injection Fuel Rail Assembly Replacement - Bank 1**, and **Fuel Injection Fuel Rail Assembly Replacement - Bank 2**.
13. Install the fuel tank module. Refer to **Fuel Tank Fuel Pump Module Replacement (SWB)Fuel Tank Fuel Pump Module Replacement (LWB)**.
14. Refill the fuel tank.
15. Install the fuel fill cap.
16. Connect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection (Dual Battery)** **Battery Negative Cable Disconnection and Connection (Single Battery)** .

NOTE: **If the fuel pump or sender assembly was not replaced, purge the fuel sender assembly.**

17. Purge the fuel tank module.
    1. Disconnect the fuel feed line quick connect fitting from the fuel tank to the chassis line. Refer to **Plastic Collar Quick Connect Fitting Service**.
    2. Connect a length of hose to the fuel feed pipe.
    3. Insert the other end of the hose into an empty 3.8 liter (1 gallon) approved gasoline container.
    4. Add 23 liters (6 gallons) of clean fuel into the fuel tank.
    5. Turn on the fuel pump using the scan tool until 2 liters (1/2 gallon) of fuel flows into the fuel container.
18. Inspect for leaks.
    1. Turn the ignition switch ON for 2 seconds.
    2. Turn the ignition switch OFF for 10 seconds.
    3. Turn the ignition switch ON.
    4. Inspect for fuel leaks.

FUEL INJECTION FUEL RAIL ASSEMBLY REPLACEMENT - BANK 1

Removal Procedure

Special Tools

- EN-49245-3 Fuel injection seal Installer Sizer
- EN-49245-4 Fuel injection seal Installer Sizer
- EN-49248 Injector Rail Assembly Remover
- EN-51105 Injector Seal Installer Adapters

Equivalent regional tools:**Special Tools**

WARNING: The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.

1. Remove the fuel pump insulator. **Fuel Pump Insulator Replacement**
2. Remove the fuel injector intermediate pipe position 1. **Fuel Feed Intermediate Pipe Replacement - Position 1**
3. Clean the cylinder head pocket around the injectors of any dirt or buildup.
4. Disconnect the electrical wiring harness connectors from the fuel rail.
5. If replacing the fuel injection fuel rail assembly, remove the fuel injection fuel rail pressure sensor. **Fuel Injection Fuel Rail Fuel Pressure Sensor Replacement**

Fig. 120: Fuel Rail Fasteners
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The fuel rail fasteners are retained in the fuel rail by keepers and may be difficult to remove.**

6. Remove the fuel rail fasteners (1) securing the injector rail (2).

Fig. 121: Two Sets Of Remover
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **In some cases, the fuel injectors may be difficult to remove because of heavy carbon build-up or other factors. Excessive force with the removal tool can damage the fuel rail, injectors or both. If injectors are difficult to remove, apply solvent to the base of the injector bores, and allow adequate soaking time, to loosen the fuel injectors.**

- **Pull the fuel rail and injectors as an assembly.**
- **To prevent material from entering the combustions chambers make sure the area around each injector is clean and free of debris before the injectors are removed from the injector bores.**

7. Install two sets of EN-49248 remover (3).
    1. Install one remover in each of the fuel rail fastener bores.
    2. Remove by turning each section of the EN-49248 remover an even amount to pull the fuel rail and injectors out evenly.

CAUTION:

- **Remove the fuel rail assembly carefully in order to prevent damage to the injector electrical connector terminals and the injector spray tips. Support the fuel rail after the fuel rail is removed in order to avoid damaging the fuel rail components.**
- **Cap the fittings and plug the holes when servicing the fuel system in order to prevent dirt and other contaminants from entering open pipes and passages.**

    3. Simultaneously lift both ends of the fuel rail (2) and remove the fuel rail assembly from the cylinder head.
8. Remove and DISCARD the fuel injector seals.

Fig. 122: Fuel Injector Dust Seal
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Some vehicles were not originally equipped with fuel injector dust seals. A NEW seal must be installed when the injectors are removed.**

9. Remove and DISCARD the fuel injector dust seal (1).

NOTE: **Whenever the fuel injectors are removed from the cylinder head or fuel rail, they will need to be rebuilt. Fuel Rail and Injectors Cleaning and Inspection**

10. If replacing the fuel injection fuel rail, remove the fuel injectors. **Fuel Injector Replacement**

Installation Procedure

NOTE: **The injector seals should be clean and free of debris prior to installation.**

1. Inspect the fuel injection fuel rail insulators and replace if necessary.

2. If replacing the fuel injection fuel rail, install the fuel injectors. **Fuel Injector Replacement**

Fig. 123: Identifying Fuel Injector Tip & Seals
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do NOT use any type of lubricant when installing the NEW seals (2) on the fuel injector.**

3. Install EN-51105-1 long protector (3) onto the fuel injector tip, covering the first recessed area closest to the tip. Place a new seal (2) on the

EN-51105-1 long protector.

1. Using EN-49245-3 pusher (1), install the seal onto the second recessed area (4) of the fuel injector.

NOTE: **The EN-49245-4 is two sided, and either direction will size the seal correctly.**

2. Compress the seal with your fingers, then resize the seal using the EN-49245-4 sizer (5).

Fig. 124: Identifying Fuel Injector Tip & Seals

Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do NOT use any type of lubricant when installing NEW seals (2) on the injector.**

4. Install EN-51105-2 short protector (3) onto the fuel injector tip. Place a NEW seal (2) on EN-51105-2 short protector.
   1. Using EN-49245-3 pusher (1), install the seal onto the first recessed area (4) of the fuel injector.

      NOTE: **The EN-49245-4 is two sided, and either direction will size the seal correctly.**

   2. Compress the seal with your fingers, then resize the seal using the EN-49245-4 sizer (5).

Fig. 125: Fuel Injector Dust Seal
Courtesy of GENERAL MOTORS COMPANY

5. Install the NEW fuel injector dust seal (1).

Fig. 126: Fuel Rail Fasteners
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The fuel rail fasteners are retained into the rails using keepers. Care should be taken to ensure that the threadlock is installed after the fasteners are installed in their bore.**

6. Install the fuel rail fasteners (1) into the fuel rail (2).
    1. Apply a 0.5 mm (0.02 in) band of GM approved threadlock to the threads of the fuel rail fasteners (1).

    NOTE: **Start the fuel rail fasteners by hand then draw the injector rail down evenly prior to tightening.**

    2. Install the fuel injection fuel rail assembly (2) to the cylinder head.

    CAUTION: **Refer to Fastener Caution .**

3. Tighten to the fuel rail fasteners to 25 N.m (18 lb ft).

7. If removed, install the fuel injection fuel rail pressure sensor. **Fuel Injection Fuel Rail Fuel Pressure Sensor Replacement**
8. Connect the electrical wiring harness connectors to the fuel rail.
9. Install the NEW fuel injector intermediate pipe position 1. **Fuel Feed Intermediate Pipe Replacement - Position 1**
10. Install the fuel pump insulator. **Fuel Pump Insulator Replacement**

FUEL INJECTION FUEL RAIL ASSEMBLY REPLACEMENT - BANK 2

Special Tools

- EN-49245-3 Fuel injection seal Installer Sizer
- EN-49245-4 Fuel injection seal Installer Sizer
- EN-49248 Injector Rail Assembly Remover
- EN-51105 Injector Seal Installer Adapters

For equivalent regional tools, refer to **Special Tools** .

Removal Procedure

1. Relieve the fuel pressure. Refer to **Fuel Pressure Relief**.

WARNING: The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage, and possible injury or death.

2. Remove the fuel pump insulator. Refer to **Fuel Pump Insulator Replacement**.
3. Remove the fuel injector intermediate pipe position 1. Refer to **Fuel Feed Intermediate Pipe Replacement - Position 1**.
4. Clean the cylinder head pocket around the injectors of any dirt or buildup.
5. Disconnect the electrical wiring harness connectors from the fuel rail.

Fig. 127: Fuel Rail Fasteners
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The fuel rail fasteners are retained in the fuel rail by keepers and may be difficult to remove.**

6. Remove the fuel rail fasteners (1) securing the injector rail (2).

Fig. 128: Two Sets Of Remover
Courtesy of GENERAL MOTORS COMPANY

NOTE:

- **In some cases, the fuel injectors may be difficult to remove because of heavy carbon build-up or other factors. Excessive force with the removal tool can damage the fuel rail, injectors or both. If injectors are difficult to remove, apply solvent to the base of the injector bores, and allow adequate soaking time, to loosen the fuel injectors.**

- **Pull the fuel rail and injectors as an assembly.**
- **To prevent material from entering the combustions chambers make sure the area around each injector is clean and free of debris before the injectors are removed from the injector bores.**

7. Install two sets of EN-49248 remover (3).
    1. Install one remover in each of the fuel rail fastener bores.
    2. Remove by turning each section of the EN-49248 remover an even amount to pull the fuel rail and injectors out evenly.

CAUTION:

- **Remove the fuel rail assembly carefully in order to prevent damage to the injector electrical connector terminals and the injector spray tips. Support the fuel rail after the fuel rail is removed in order to avoid damaging the fuel rail components.**
- **Cap the fittings and plug the holes when servicing the fuel system in order to prevent dirt and other contaminants from entering open pipes and passages.**

    3. Simultaneously lift both ends of the fuel rail (2) and remove the fuel rail assembly from the cylinder head.
8. Remove and DISCARD the fuel injector seals.

Fig. 129: Fuel Injector Dust Seal
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Some vehicles were not originally equipped with fuel injector dust seals. A NEW seal must be installed when the injectors are removed.**

9. Remove and DISCARD the fuel injector dust seal (1).

NOTE: **Whenever the fuel injectors are removed from the cylinder head or fuel rail, they will need to be rebuilt. Refer to Fuel Rail and Injectors Cleaning and Inspection .**

10. If replacing the fuel injection fuel rail, remove the fuel injectors. Refer to **Fuel Injector Replacement**.

Installation Procedure

NOTE: **The injector seals should be clean and free of debris prior to installation.**

1. Inspect the fuel injection fuel rail insulators and replace if necessary.

2. If replacing the fuel injection fuel rail, install the fuel injectors. Refer to **Fuel Injector Replacement**.

Fig. 130: Identifying Fuel Injector Tip & Seals
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do NOT use any type of lubricant when installing the NEW seals (2) on the fuel injector.**

3. Install EN-51105-1 long protector (3) onto the fuel injector tip, covering the first recessed area closest to the tip. Place a new seal (2) on the

EN-51105-1 long protector.

1. Using EN-49245-3 pusher (1), install the seal onto the second recessed area (4) of the fuel injector.

NOTE: **The EN-49245-4 is two sided, and either direction will size the seal correctly.**

2. Compress the seal with your fingers, then resize the seal using the EN-49245-4 sizer (5).

Fig. 131: Identifying Fuel Injector Tip & Seals

Courtesy of GENERAL MOTORS COMPANY

NOTE: **Do NOT use any type of lubricant when installing NEW seals (2) on the injector.**

4. Install EN-51105-2 short protector (3) onto the fuel injector tip. Place a NEW seal (2) on EN-51105-2 short protector.
   1. Using EN-49245-3 pusher (1), install the seal onto the first recessed area (4) of the fuel injector.

      NOTE: **The EN-49245-4 is two sided, and either direction will size the seal correctly.**

   2. Compress the seal with your fingers, then resize the seal using the EN-49245-4 sizer (5).

Fig. 132: Fuel Injector Dust Seal
Courtesy of GENERAL MOTORS COMPANY

5. Install the NEW fuel injector dust seal (1).

Fig. 133: Fuel Rail Fasteners
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The fuel rail fasteners are retained into the rails using keepers. Care should be taken to ensure that the threadlock is installed after the fasteners are installed in their bore.**

6. Install the fuel rail fasteners (1) into the fuel rail (2).
    1. Apply a 0.5 mm (0.02 in) band of GM approved threadlock to the threads of the fuel rail fasteners (1).
    2. Install the fuel injection fuel rail assembly (2) to the cylinder head.

    NOTE: **Start the fuel rail fasteners by hand then draw the injector rail down evenly prior to tightening.**

    CAUTION: **Refer to Fastener Caution .**

    3. Tighten to the fuel rail fasteners to 25 N.m (18 lb ft).
7. Connect the electrical wiring harness connectors to the fuel rail.

8. Install the NEW fuel injector intermediate pipe position 1. Refer to **Fuel Feed Intermediate Pipe Replacement - Position 1**.
9. Install the fuel pump insulator. Refer to **Fuel Pump Insulator Replacement**.

FUEL INJECTION FUEL RAIL FUEL PRESSURE SENSOR REPLACEMENT

Removal Procedure

1. Relieve the fuel system pressure **Fuel Pressure Relief**.
2. Remove Fuel Pump Insulator **Fuel Pump Insulator Replacement**

Fig. 134: Fuel Rail Pressure Sensor
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Fuel and Evaporative Emission Hose/Pipe Connection Cleaning Caution .**

NOTE: **Applying force to the plastic housing of the sensor may damage the sensor. To tighten or loosen, apply force only to the attached hexagon.**

3. Disconnect Electrical Connector (1) @Fuel Injection Fuel Rail Fuel Pressure Sensor (2)

NOTE: **Some fuel may leak from the fuel injection fuel rail fuel pressure sensor orifice after the sensor is**

removed. Dry the area around this orifice after the removal of the sensor using a lint free cloth and inspect the fuel injection fuel rail fuel pressure sensor sealing surface. The surface should be free of fuel, debris, and burrs.

4. Remove Fuel Injection Fuel Rail Fuel Pressure Sensor (2) @Fuel Injection Fuel Rail (3) and DISCARD

Installation Procedure

Fig. 135: Fuel Rail Pressure Sensor
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Applying force to the plastic housing of the sensor may damage the sensor. To tighten or loosen, apply force only to the attached hexagon.**

NOTE: **Ensure the fuel rail threads are clean and free of any excess fuel, or the fuel injection fuel rail fuel pressure sensor will NOT seal properly.**

1. Lubricate the threads and sealing surface of the NEW fuel injection fuel rail fuel pressure sensor with one drop of clean engine oil.
2. Install the NEW fuel injection fuel rail fuel pressure sensor (2) and hand tighten.
3. Remove Fuel Injection Fuel Rail Fuel Pressure Sensor (2) @Fuel Injection Fuel Rail (3) and re-lubricate with one drop of clean engine oil.

CAUTION: Refer to Component Fastener Tightening Caution .

4. Install Fuel Injection Fuel Rail Fuel Pressure Sensor (2) @Fuel Injection Fuel Rail (3) and tighten 33 N.m (24 lb ft)
5. Connect Electrical Connector (1) @Fuel Injection Fuel Rail Fuel Pressure Sensor (2).

NOTE: If a fuel leak occurs at the fuel rail, the fuel rail will need to be replaced.

6. Pressurize the fuel system and inspect for leaks.
7. Install Fuel Pump Insulator **Fuel Pump Insulator Replacement**

FUEL FEED INTERMEDIATE PIPE REPLACEMENT - POSITION 1

Fig. 136: Fuel Feed Intermediate Pipe - Position 1
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief**. 2. Remove the fuel pump insulator. Refer to **Fuel Pump Insulator Replacement**. 3. Remove the fuel feed intermediate pipe position 2. Refer to **Fuel Feed Intermediate Pipe Replacement - Position 2**.	
1	Fuel Feed Intermediate Pipe Fitting (Qty:2) **CAUTION:** **Refer to Component Fastener Tightening Caution .** **Tighten** 28 N.m (21 lb ft)
2	Fuel Feed Intermediate Pipe Fastener **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
3	Fuel Feed Intermediate Pipe Position 1 **Procedure** 1. DISCARD the old fuel feed pipe and install a NEW fuel feed pipe. 2. Ensure that the high pressure fuel pipe, and fuel rail fittings are clean and dry prior to assembly.

Callout	Component Name
	3. Pressure up the fuel system and check for leaks.

FUEL FEED INTERMEDIATE PIPE REPLACEMENT - POSITION 2

Fig. 137: Fuel Feed Intermediate Pipe - Position 2
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures	
1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief**.	
2. Remove the fuel pump insulator. Refer to **Fuel Pump Insulator Replacement**.	

Callout	Component Name
1	Fuel Feed Intermediate Pipe Fitting (Qty:2) **CAUTION:** **Refer to Component Fastener Tightening Caution .** **Tighten** 28 N.m (21 lb ft)
2	Fuel Feed Intermediate Pipe Position 2 **Procedure** 1. DISCARD the old fuel feed pipe and install a NEW fuel feed pipe. 2. Ensure that the high pressure fuel pipe, and fuel pump fittings are clean and dry prior to assembly. 3. Pressure up the fuel system and check for leaks.

FUEL INJECTOR REPLACEMENT

Fig. 138: Fuel Injector
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the fuel rail. Refer to **Fuel Injection Fuel Rail Assembly Replacement - Bank 1**, and/or **Fuel Injection Fuel Rail Assembly Replacement - Bank 2**. **Special Tools** **EN-51097** Injector Retaining Clip Installer For equivalent regional tools. Refer to **Special Tools** .	
1	Fuel Injector Retainer **Procedure** Remove and discard the fuel injector retainer clips by installing EN-51097 injector retaining clip installer and spreading both sides of the clip evenly.

Callout	Component Name
2	Fuel Injector Collars **NOTE:** **Always use NEW fuel injector collars supplied with injector when installing the new injector. If reinstalling the injector, it is not necessary to remove the collars unless the collars are being replaced.**
3	Fuel Injector **Procedure** Replace the injector seals as needed. Refer to **Fuel Rail and Injectors Cleaning and Inspection** . **NOTE:** **Inspect the injectors to be sure that they are clean and free of debris prior**

Callout	Component Name
	to installation. Do NOT lubricate the injector seals. Rebuild the fuel injectors whenever the injector has been removed from the fuel injector rail.

EVAPORATIVE EMISSION CANISTER PURGE SOLENOID VALVE REPLACEMENT

Fig. 139: Evaporative Emission Canister Purge Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure **Remove the air cleaner outlet duct. Refer to Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)Air Cleaner Outlet Duct Replacement (Cadillac).**	
1	Evaporative Emission Canister Purge Solenoid Valve Hose

Callout	Component Name
Preliminary Procedure **Remove the air cleaner outlet duct. Refer to Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)Air Cleaner Outlet Duct Replacement (Cadillac).**	
2	Evaporative Emission Canister Purge Solenoid Valve Fastener **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
3	Evaporative Emission Canister Purge Solenoid Valve **Procedure** Disconnect the electrical wiring harness connector from the evaporative emission canister purge solenoid valve.

EVAPORATIVE EMISSION CANISTER PURGE TUBE REPLACEMENT

Removal Procedure

NOTE: **Clean all fuel and evaporative emission (EVAP) line connections and surrounding areas prior to disconnecting the lines in order to avoid possible fuel and/or EVAP system contamination.**

Fig. 140: EVAP Canister Purge Tube
Courtesy of GENERAL MOTORS COMPANY

1. Disconnect the EVAP canister purge tube (1) from the EVAP canister solenoid. Refer to **Plastic Collar Quick Connect Fitting Service**.

Fig. 141: EVAP Canister Purge Tube
Courtesy of GENERAL MOTORS COMPANY

2. Disconnect the EVAP canister purge tube (1) from the EVAP pipe. Refer to **Plastic Collar Quick Connect Fitting Service**.
3. Remove the EVAP canister purge tube (1) from the vehicle.

Installation Procedure

Fig. 142: EVAP Canister Purge Tube
Courtesy of GENERAL MOTORS COMPANY

1. Install the EVAP canister purge tube (1) to the vehicle.
2. Connect the EVAP canister purge tube (1) to the EVAP pipe. Refer to **Plastic Collar Quick Connect Fitting Service**.

Fig. 143: EVAP Canister Purge Tube
Courtesy of GENERAL MOTORS COMPANY

3. Connect the EVAP canister purge tube (1) to the EVAP canister solenoid. Refer to **Plastic Collar Quick Connect Fitting Service**.

EVAPORATIVE EMISSION CANISTER SOLENOID REPLACEMENT

Removal Procedure

NOTE: **Clean the evaporative emission (EVAP) connections and surrounding areas prior to disconnecting the fittings in order to avoid possible system contamination.**

1. Remove the spare tire and wheel assembly.

Fig. 144: View Of EVAP Canister Vent Solenoid Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
3. Disconnect the chassis wiring harness electrical connector from the EVAP canister vent solenoid.

Fig. 145: EVAP Canister Vent Solenoid Quick Connect Fitting
Courtesy of GENERAL MOTORS COMPANY

4. Disconnect the EVAP canister vent solenoid quick connect fitting (1) from the EVAP canister. Refer to **Plastic Collar Quick Connect Fitting Service**.

Fig. 146: Push Pin
Courtesy of GENERAL MOTORS COMPANY

5. Disconnect the solenoid vent filter from the filler pipe by removing the push pin (1).

Fig. 147: 2 Tie Straps
Courtesy of GENERAL MOTORS COMPANY

6. Remove the 2 tie straps (1) that hold the solenoid vent line to the fuel fill pipe hose.

Fig. 148: EVAP Canister Vent Solenoid Retainer
Courtesy of GENERAL MOTORS COMPANY

7. Disengage the retainer (1) securing the EVAP canister vent solenoid to the bracket.
8. Remove the EVAP canister vent solenoid assembly.

Installation Procedure

Fig. 149: EVAP Canister Vent Solenoid Retainer
Courtesy of GENERAL MOTORS COMPANY

1. Install the EVAP canister vent solenoid.
2. Slide the EVAP canister vent solenoid onto the bracket until the retainer (1) engages the clip.

Fig. 150: EVAP Canister Vent Solenoid Quick Connect Fitting
Courtesy of GENERAL MOTORS COMPANY

3. Connect the EVAP canister vent solenoid quick connect fitting (1) to the EVAP canister. Refer to **Plastic Collar Quick Connect Fitting Service**.

Fig. 151: Push Pin
Courtesy of GENERAL MOTORS COMPANY

4. Connect the solenoid vent filter to the filler pipe with a new push pin (1).

Fig. 152: 2 Tie Straps
Courtesy of GENERAL MOTORS COMPANY

5. Install 2 tie straps (1) to hold the solenoid vent line to the fuel fill pipe hose.

Fig. 153: View Of EVAP Canister Vent Solenoid Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

6. Connect the chassis wiring harness electrical connector (1) to the EVAP canister vent solenoid.
7. Lower the vehicle.
8. Install the spare tire and wheel assembly.

EVAPORATIVE EMISSION CANISTER REPLACEMENT

Removal Procedure

NOTE: **Clean all evaporative emission (EVAP) line connections and surrounding areas prior to disconnecting, in order to avoid possible EVAP system contamination.**

Fig. 154: View Of Fuel Tank EVAP Lines & Canister
Courtesy of GENERAL MOTORS COMPANY

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Remove the EVAP canister bracket bolts and lower the EVAP canister.
3. Disconnect the fuel tank EVAP line quick connect fittings (1) from the EVAP canister. Refer to **Plastic Collar Quick Connect Fitting Service**.

Fig. 155: View Of Quick Connect Fittings
Courtesy of GENERAL MOTORS COMPANY

4. Disconnect the EVAP canister vent solenoid quick connecting fitting (1) from the EVAP canister. Refer to **Plastic Collar Quick Connect**

Fitting Service.

Fig. 156: View Of EVAP Canister, Bracket & Bolts
Courtesy of GENERAL MOTORS COMPANY

5. Remove the EVAP canister.
6. If necessary, remove the EVAP canister to bracket bolt.
7. If necessary, remove the EVAP canister from the bracket.

Installation Procedure

Fig. 157: View Of EVAP Canister, Bracket & Bolts
Courtesy of GENERAL MOTORS COMPANY

1. If necessary, install the EVAP canister to the bracket.

CAUTION: Refer to Fastener Caution .

2. If necessary, install the EVAP canister to bracket bolt.

   Tighten

   Tighten the bolt to 25 N.m (18 lb ft).

3. Position the EVAP canister.

Fig. 158: View Of Quick Connect Fittings
Courtesy of GENERAL MOTORS COMPANY

4. Connect the EVAP canister vent solenoid quick connecting fitting (1) to the EVAP canister. Refer to **Plastic Collar Quick Connect Fitting Service**.

Fig. 159: View Of Fuel Tank EVAP Lines & Canister
Courtesy of GENERAL MOTORS COMPANY

5. Connect the fuel tank EVAP line quick connect fittings (1) to the EVAP canister. Refer to **Plastic Collar Quick Connect Fitting Service**.
6. Install the EVAP canister bracket bolts.

   Tighten

   Tighten the bolts to 25 N.m (18 lb ft).

7. Lower the vehicle.

IGNITION COIL REPLACEMENT

Fig. 160: Ignition Coil
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Callout	Component Name
Preliminary Procedure 1. Remove the valve rocker arm cover insulator. Refer to **Valve Rocker Arm Cover Insulator Replacement - Left Side** , and/or **Valve Rocker Arm Cover Insulator Replacement - Right Side** . 2. Remove the spark plug wires. Refer to **Spark Plug Wire Replacement**.	
1	Ignition Coil Fasteners (Qty: 2) **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
2	Ignition Coil **Procedure** 1. Relocate wiring harnesses and hoses as necessary. 2. Disconnect the electrical wiring harness connector from the ignition coil.

SPARK PLUG WIRE INSPECTION

IMPORTANT: Spark plug wire integrity is vital for proper engine operation. A thorough inspection will be necessary to accurately identify conditions that may affect engine operation. Inspect for the following conditions:

1. Correct routing of the spark plug wires. Incorrect routing may cause cross-firing.
2. Inspect for any signs of cracks or splits in the wires.
3. Inspect each boot for the following conditions:
   - Tearing
   - Piercing

- Arcing
- Carbon tracking
- Corroded terminals

4. If corrosion, carbon tracking or arcing are indicated on a spark plug wire boot or on a terminal, replace the wire and the component connected to the wire.

SPARK PLUG WIRE REPLACEMENT

Fig. 161: Spark Plug Wire
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure	
Remove the valve rocker arm cover insulator. Refer to **Valve Rocker Arm Cover Insulator Replacement - Left Side** , and/or **Valve**	

Callout	Component Name
Rocker Arm Cover Insulator Replacement - Right Side .	
1	Spark Plug Wire **Procedure** **NOTE:** **Pull only on the spark plug wire boot to remove the wire.** 1. Twist the spark plug wire boot 1/2 turn and remove the spark plug wire. 2. Inspect the spark plug wire for damage and replace if necessary. 3. Inspect the inside of the ignition coil rubber boot for a thin, even coat of grease. If there is no grease present or additional grease is necessary, apply a thin coating of dielectric grease evenly to the inside of the ignition coil rubber boot up to a depth of 15 mm from the end of the boot. Refer to Adhesives, Fluids, Lubricants, and Sealers .

SPARK PLUG INSPECTION

Spark Plug Usage

Ensure that the correct spark plug is installed. An incorrect spark plug causes driveability conditions. Refer to the Electronic Parts Catalog.

Spark Plug Inspection

Fig. 162: Cross Sectional View Of Spark Plug
Courtesy of GENERAL MOTORS COMPANY

- Inspect the terminal post (1) for damage.
  - Inspect for a bent or broken terminal post (1).
  - Test for a loose terminal post (1) by twisting and pulling the post. The terminal post (1) should NOT move.

- Inspect the insulator (2) for flashover or carbon tracking, soot. This condition is often mistakenly identified as a cracked insulator. This is caused by the electrical charge traveling across the insulator (2) between the terminal post (1) and ground. Inspect for the following conditions:
  - Inspect the spark plug boot for damage.
  - Inspect the spark plug recess area of the cylinder head for moisture, such as oil, coolant, or water. A spark plug boot that is saturated causes arcing to ground.
- Inspect the insulator (2) for cracks. All or part of the electrical charge may arc through the crack instead of the electrodes (3, 4).
- Inspect for evidence of improper arcing.

NOTE: **To avoid damage to the iridium tip on the center electrode, DO NOT attempt to adjust spark plug gap. If the spark plug gap does not meet specifications, replace the spark plug.**

  - Measure the gap between the center electrode (4) and the side electrode (3) terminals. This must be done carefully in order to avoid damaging the small diameter Iridium center electrode. Refer to **Ignition System Specifications** . An excessively wide electrode gap can prevent correct spark plug operation.
  - Inspect for the correct spark plug torque. Refer to **Ignition System Specifications** . Insufficient torque can prevent correct spark plug operation. An over torqued spark plug, causes the insulator (2) to crack.
  - Inspect for signs of tracking that occurred near the insulator tip instead of the center electrode (4).
  - Inspect for a broken or worn side electrode (3).
  - Inspect for a broken, worn, or loose center electrode (4) by shaking the spark plug.
    - A rattling sound indicates internal damage.
    - A loose center electrode (4) reduces the spark intensity.
  - Inspect for bridged electrodes (3, 4). Deposits on the electrodes (3, 4) reduce or eliminates the gap.
  - Inspect for worn or missing platinum pads on the electrodes (3, 4) If equipped.
  - Inspect for excessive fouling.
- Inspect the spark plug recess area of the cylinder head for debris. Dirty or damaged threads can cause the spark plug not to seat correctly during installation.

Spark Plug Visual Inspection

- Normal operation-Brown to grayish-tan with small amounts of white powdery deposits are normal combustion by-products from fuels with additives. Reddish orange deposits can indicate MMT fuel additive which is still used in some markets around the world (will cause misfire and cannot be burned off). MMT fuel additive use should be avoided.

- Carbon Fouled-Dry, fluffy black carbon, or soot caused by the following conditions:
  - Rich fuel mixtures
    - Leaking fuel injectors
    - Excessive fuel pressure
    - Restricted air filter element
    - Incorrect combustion
  - Reduced ignition system voltage output
    - Weak coils
    - Worn ignition wires
    - Incorrect spark plug gap
  - Excessive idling or slow speeds under light loads can keep spark plug temperatures so low that normal combustion deposits may not burn off.
- Deposit Fouling-Oil, coolant, or additives that include substances such as silicone, very white coating, reduces the spark intensity. Most powdery deposits will not effect spark intensity unless they form into a glazing over the electrode.

Fig. 163: Carbon On Spark Plug Tower
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Carbon on spark plug tower means carbon will also be on inside of spark plug wire boot or coil boot and will cause both new spark plug and spark plug wire or coil boot to fail again.**

-
- If carbon tracking occurs on spark plug tower (1), replace spark plug and spark plug wire or coil boot.

SPARK PLUG REPLACEMENT

Removal Procedure

1. Remove the spark plug wires from the spark plugs.

Fig. 164: Locating Spark Plug Gap

Courtesy of GENERAL MOTORS COMPANY

2. Loosen each spark plug 1 or 2 turns.
3. Use a brush, or use compressed air in order to remove any dirt from the spark plugs.
4. Remove the spark plugs one at a time and place each plug in a tray marked with the corresponding cylinder numbers.

Installation Procedure

Fig. 165: Locating Spark Plug Gap
Courtesy of GENERAL MOTORS COMPANY

1. Hand start the spark plugs in the corresponding cylinders.

CAUTION: Refer to Component Fastener Tightening Caution .

2. Tighten the spark plugs to 20 N.m (15 lb ft).
3. Install the spark plug wires onto the spark plugs.

CRANKSHAFT POSITION SENSOR REPLACEMENT

Fig. 166: Crankshaft Position Sensor
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Remove the starter. Refer to **Starter Replacement (L83, L86)** **Starter Replacement (L96)** .	
1	Crankshaft Position Sensor Fastener **CAUTION:**

Callout	Component Name
	Refer to **Fastener Caution** . **Tighten** 25 N.m (18 lb ft)
2	Crankshaft Position Sensor **Procedure** Disconnect the crankshaft position sensor electrical wiring harness connector.

CAMSHAFT POSITION SENSOR REPLACEMENT

Removal Procedure

WARNING: Refer to Eye Protection Warning .

1. Disconnect the battery ground cable from the battery. Refer to **Battery Negative Cable Disconnection and Connection (Dual Battery)** **Battery Negative Cable Disconnection and Connection (Single Battery)** .
2. Remove Drive Belt Tensioner - Accessory **Drive Belt Tensioner Replacement - Accessory** .

Fig. 167: Camshaft Position Sensor Bracket Fasteners And Engine Block
Courtesy of GENERAL MOTORS COMPANY

3. Remove the camshaft position sensor bracket fasteners (1) from the engine block.
4. Carefully reposition the bracket aside and remove the camshaft position sensor from the engine front cover with the harness attached.

Fig. 168: Camshaft Position Sensor And Engine Front Cover
Courtesy of GENERAL MOTORS COMPANY

5. Disconnect the camshaft position sensor electrical connector (3) from the camshaft position sensor (1).

Installation Procedure

Fig. 169: Camshaft Position Sensor And Engine Front Cover
Courtesy of GENERAL MOTORS COMPANY

NOTE: **If a new sensor is not being installed, a new camshaft sensor seal MUST be installed to prevent leaks.**

1. Connect the camshaft position sensor electrical connector (3) to the camshaft position sensor (1).
2. Install the camshaft position sensor (1) into the engine front cover (2).

Fig. 170: Camshaft Position Sensor Bracket Fasteners And Engine Block
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

3. Position the camshaft position sensor bracket (2) in place then install the camshaft position sensor bracket fasteners (1) and tighten to 25 N.m (18 lb ft).
4. Install **Drive Belt Tensioner Replacement - Accessory** .

5. Connect the battery ground cable to the battery. Refer to **Battery Negative Cable Disconnection and Connection (Dual Battery)** **Battery Negative Cable Disconnection and Connection (Single Battery)** .
6. If re-programming is required, refer to **Control Module References** .

CAMSHAFT POSITION ACTUATOR MAGNET REPLACEMENT

Fig. 171: Camshaft Position Actuator (Magnet)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Camshaft Position Actuator Fasteners (Qty: 3) **CAUTION:**

Callout	Component Name
	Refer to Fastener Caution . **Tighten** 10 N.m (89 lb in)
2	Camshaft Position Actuator **Procedure** 1. Unplug the camshaft position actuator electrical connector. 2. Remove the camshaft position actuator seal from the engine front cover.

CAMSHAFT POSITION ACTUATOR MAGNET CLEANING AND INSPECTION

1. Remove the camshaft position sensor. Refer to **Camshaft Position Sensor Replacement**.
2. Clean the camshaft position sensor using a clean shop towel with an appropriate cleaner.
3. Inspect the camshaft position sensor and replace if evidence of damage or wear exists.

KNOCK SENSOR 1 REPLACEMENT

Fig. 172: Knock Sensor 1
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. **Lifting and Jacking the Vehicle** 2. If equipped **Front Axle Propeller Shaft Replacement (NPO)** **Front Axle Propeller Shaft Replacement (NQH)** **Front Axle Propeller Shaft Replacement (Heavy Duty)**	
1	Knock Sensor Shield Fastener **CAUTION:**

Callout	Component Name
	Refer to **Fastener Caution** . **Tighten** 25 N.m (18 lb ft)
2	Knock Sensor Shield
3	Knock Sensor Fastener **Tighten** 25 N.m (18 lb ft)
4	Knock Sensor **Procedure** Disconnect the electrical wiring harness connector from the knock sensor.

KNOCK SENSOR 2 REPLACEMENT

Fig. 173: Knock Sensor 2
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Starter Replacement (L83, L86) Starter Replacement (L96)	
1	Knock Sensor Fastener **CAUTION:** **Refer to** **Fastener Caution .**

Callout	Component Name
	Tighten 25 N.m (18 lb ft)
2	Knock Sensor **Procedure** Disconnect the electrical wiring harness connector from the knock sensor.

VACUUM PUMP REPLACEMENT

Removal Procedure

WARNING: To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

WARNING: Refer to Eye Protection Warning .

1. Disconnect the battery ground cable from the battery. Refer to **Battery Negative Cable Disconnection and Connection (Dual Battery)** **Battery Negative Cable Disconnection and Connection (Single Battery)** .
2. Remove the vacuum pump belt. Refer to **Vacuum Pump Belt Replacement** .

Fig. 174: Tie Straps And Vacuum Boost Pipe Sleeve
Courtesy of GENERAL MOTORS COMPANY

3. Cut the tie straps (2) off the vacuum boost pipe sleeve and remove the vacuum boost pipe sleeve (3) from the vacuum boost pipe.
4. Remove the vacuum boost pipe retainer (1) from its bracket.

Fig. 175: Vacuum Boost Pipe
Courtesy of GENERAL MOTORS COMPANY

5. Remove the vacuum boost pipe (1) from the vacuum pump and reposition it away from the pump. Refer to **Plastic Collar Quick Connect Fitting Service**.
6. Remove the steering gear skid shield. Refer to **Steering Gear Skid Shield Replacement** .

Fig. 176: Engine Electrical Wiring Harness Retainers And Reposition Harness
Courtesy of GENERAL MOTORS COMPANY

7. Remove the engine electrical wiring harness retainers (1) and reposition the harness (2) away from the vacuum pump.
8. Remove Intermediate Steering Shaft **Intermediate Steering Shaft Replacement**

Fig. 177: Vacuum Pump
Courtesy of GENERAL MOTORS COMPANY

9. Remove Vacuum Pump Fastener (1) @Vacuum Pump (2)

Fig. 178: Vacuum Pump And Vacuum Pump Gasket
Courtesy of GENERAL MOTORS COMPANY

10. Remove the vacuum pump (1) and the vacuum pump gasket (2) from the engine block.

Installation Procedure

NOTE: **A new vacuum pump gasket should be installed when the vacuum pump is installed to prevent leaks.**

Fig. 179: Vacuum Pump And Vacuum Pump Gasket
Courtesy of GENERAL MOTORS COMPANY

1. Install the vacuum pump gasket (2) and vacuum pump (1) onto the engine block.

Fig. 180: Vacuum Pump
Courtesy of GENERAL MOTORS COMPANY

2. Install Vacuum Pump Fastener (1) @Vacuum Pump (2) and tighten 25 N.m (18 lb ft)
3. Install Intermediate Steering Shaft **Intermediate Steering Shaft Replacement**

Fig. 181: Engine Electrical Wiring Harness Retainers And Reposition Harness
Courtesy of GENERAL MOTORS COMPANY

4. Reposition the engine wiring harness (2) and install the wiring harness retainers (1).
5. Install the steering gear skid shield. Refer to **Steering Gear Skid Shield Replacement** .

Fig. 182: Vacuum Boost Pipe
Courtesy of GENERAL MOTORS COMPANY

6. Reposition and install the vacuum boost pipe (1) onto the vacuum pump. Refer to **Plastic Collar Quick Connect Fitting Service**.
7. Install the vacuum boost pipe (1) into its retainer.

Fig. 183: Tie Straps And Vacuum Boost Pipe Sleeve
Courtesy of GENERAL MOTORS COMPANY

8. Position the vacuum boost pipe sleeve (3) in place and install zip ties (2) to secure it to the vacuum boost pipe.
9. Install the vacuum pump belt. Refer to **Vacuum Pump Belt Replacement** .
10. Connect the battery ground cable to the battery. Refer to **Battery Negative Cable Disconnection and Connection (Dual Battery)** **Battery Negative Cable Disconnection and Connection (Single Battery)** .

AIR CLEANER ELEMENT REPLACEMENT

Fig. 184: View Of Air Cleaner Element
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure 1. Disconnect the air cleaner outlet duct from the air cleaner housing. Refer to **Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)Air Cleaner Outlet Duct Replacement (Cadillac)**. 2. Disconnect and unclip the MAF harness from the air cleaner housing.	
1	Air Cleaner Housing Cover Screw (Qty: 4)

Callout	Component Name
	CAUTION: **Refer to Fastener Caution .** **Tighten** 3 N.m (27 lb in)
2	Air Cleaner Housing
3	Air Cleaner Element

AIR CLEANER ASSEMBLY REPLACEMENT

Fig. 185: Air Cleaner Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. If replacing, remove the mass airflow sensor, otherwise disconnect the mass airflow sensor electrical connector. Refer to **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement**. 2. Disconnect the air cleaner outlet duct from the air cleaner assembly. Refer to **Air Cleaner Outlet Duct Replacement (Chevrolet and GMC)Air Cleaner Outlet Duct Replacement (Cadillac)**.	
1	Air Cleaner Assembly **Procedure** Unclip the MAF harness retainer from the air cleaner housing. Pull upward in a jerking manner in order to disengage the air cleaner housing from the insulators.

AIR CLEANER BRACKET REPLACEMENT

Fig. 186: Air Cleaner Bracket
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures Remove the air cleaner assembly. Refer to **Air Cleaner Assembly Replacement**.	
1	Air Cleaner Bracket Bolts (Qty: 4) **CAUTION:** **Refer to** **Fastener Caution .** **Tighten** 9 N.m (80 lb in)
2	Air Cleaner Bracket

AIR CLEANER OUTLET DUCT REPLACEMENT (CHEVROLET AND GMC)

Fig. 187: Air Cleaner Outlet Duct
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Air Cleaner Outlet Duct Clamps (Qty: 2) **NOTE:** **Ensure the outlet duct is fully seated to the mating surfaces before**

Callout	Component Name
	clamping. Verify that the cuff is not rolled under.
2	PCV Tube Quick Connect Fitting
3	Air Cleaner Outlet Duct

AIR CLEANER OUTLET DUCT REPLACEMENT (CADILLAC)

Fig. 188: Air Cleaner Outlet Duct
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure **Intake Manifold Cover Replacement**	
1	Air Cleaner Outlet Duct Clamp (Qty: 2) **NOTE:** **Ensure the outlet duct is fully seated to the mating surfaces before clamping. Verify that the cuff is not rolled under.**
2	PCV Tube Quick Connect Fitting
3	Air Cleaner Outlet Duct

FUEL PUMP POWER CONTROL MODULE REPLACEMENT

Fig. 189: Fuel Pump Power Control Module
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .	
1	Fuel Pump Power Control Module Fastener (Qty: 2) **CAUTION:** **Refer to Fastener Caution .**

Callout	Component Name
	Tighten 9 N.m (80 lb in)
2	Fuel Pump Power Control Module **Procedure** 1. Disconnect the electrical connector. 2. If replacing, reprogram the module. Refer to **Control Module References** .

FUEL FEED HOSE REPLACEMENT

Fig. 190: Fuel Feed Hose
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle**	
1	Fuel Feed Hose **Procedure** Disconnect the fuel feed hose quick connects. Refer to **Plastic Collar Quick Connect Fitting Service**.

ENGINE PERFORMANCE

Engine Controls and Fuel - 5.3L (L83) or 6.2L (L86) - Schematic and Routing Diagrams - Engine Controls Schematics - Escalade, Suburban, Tahoe, Yukon

SCHEMATIC WIRING DIAGRAMS

ENGINE CONTROLS WIRING SCHEMATICS

Module Power, Ground, Serial Data and MIL

Fig. 1: Module Power, Ground, Serial Data and MIL

Courtesy of GENERAL MOTORS COMPANY

5V and Low Reference Busses

Fig. 2: 5V and Low Reference Busses
Courtesy of GENERAL MOTORS COMPANY

Engine Data Sensors - Pressure, Temperature and Throttle Controls

Fig. 3: Engine Data Sensors - Pressure, Temperature and Throttle Controls
Courtesy of GENERAL MOTORS COMPANY

Engine Data Sensors - Oxygen Sensors

Fig. 4: Engine Data Sensors - Oxygen Sensors
Courtesy of GENERAL MOTORS COMPANY

Ignition Controls - Ignition Coils Bank 1

Fig. 5: Ignition Controls - Ignition Coils Bank 1
Courtesy of GENERAL MOTORS COMPANY

Ignition Controls - Ignition Coils Bank 2

Fig. 6: Ignition Controls - Ignition Coils Bank 2
Courtesy of GENERAL MOTORS COMPANY

Ignition Controls - Crankshaft Position, Camshaft Position and Knock Sensors, and Camshaft Position Actuator Solenoid

Fig. 7: Ignition Controls - Crankshaft Position, Camshaft Position and Knock Sensors, and Camshaft Position Actuator Solenoid
Courtesy of GENERAL MOTORS COMPANY

Valve Lifter Oil Manifold Assembly

Fig. 8: Valve Lifter Oil Manifold Assembly
Courtesy of GENERAL MOTORS COMPANY

Fuel Controls - Fuel Injectors and Fuel Pressure

Fig. 9: Fuel Controls - Fuel Injectors and Fuel Pressure
Courtesy of GENERAL MOTORS COMPANY

Fuel Controls - Fuel Pump Control

Fig. 10: Fuel Controls - Fuel Pump Control
Courtesy of GENERAL MOTORS COMPANY

Fuel Controls - Evaporative Emissions Controls

Fig. 11: Fuel Controls - Evaporative Emissions Controls
Courtesy of GENERAL MOTORS COMPANY

Controlled/Monitored Subsystem References

Fig. 12: Controlled/Monitored Subsystem References
Courtesy of GENERAL MOTORS COMPANY

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