Engine Controls/Fuel - 1.4L (LUV)

Specifications

Temperature Versus Resistance (ECT)

°C	°F	Sensor Resistance
Temperature vs Resistance Values (Approximate)		
100	212	155
90	194	208
80	176	283
70	158	392
60	140	552
50	122	793
45	113	958
40	104	1165
35	95	1425
30	86	1755
25	77	2176
20	68	2717
15	59	3428
10	50	4356
5	41	5578
0	32	7198
−5	23	9362
−10	14	12278
−15	5	16229
−20	−4	21653
−30	−22	39631
−40	−40	75529

Temperature Versus Resistance - Intake Air Temperature Sensor (Bosch Sensor)

Temperature C°/F°	Resistance Minimum Ohms	Resistance Maximum Ohms
Bosch Intake Air Temperature (IAT) Sensor		
−40/−40	36,595	42,717
−20/−4	12,947	14,744
−10/14	8,082	9,105
0/32	5,191	5,789
20/68	2,309	2,530
25/77	1,913	2,088
40/104	1,122	1,210
60/140	587	625
80/176	328	345
100/212	193	201

Temperature Versus Resistance - Intake Air Temperature Sensor (Bosch Sensor) (cont'd)

Temperature C°/F°	Resistance Minimum Ohms	Resistance Maximum Ohms
Bosch Intake Air Temperature (IAT) Sensor		
120/248	119	125
140/284	76	81

Temperature Versus Resistance - Intake Air Temperature Sensor (Delco Sensor)

Temperature C°/F°	Resistance Minimum Ohms	Resistance Maximum Ohms
Delco Intake Air Temperature (IAT) Sensor		
−40/−40	42,661	54,224
−20/−4	14,039	17,333
−10/14	8,529	10,399
0/32	5,358	6,458
20/68	2,308	2,727
25/77	1,904	2,236
40/104	1,113	1,292
60/140	571	655
80/176	309	351
100/212	175	197
120/248	103	116
140/284	67	73
150/302	54	59

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
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

Altitude Versus Barometric Pressure (cont'd)

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)
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

Altitude Versus Barometric Pressure (cont'd)

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)
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

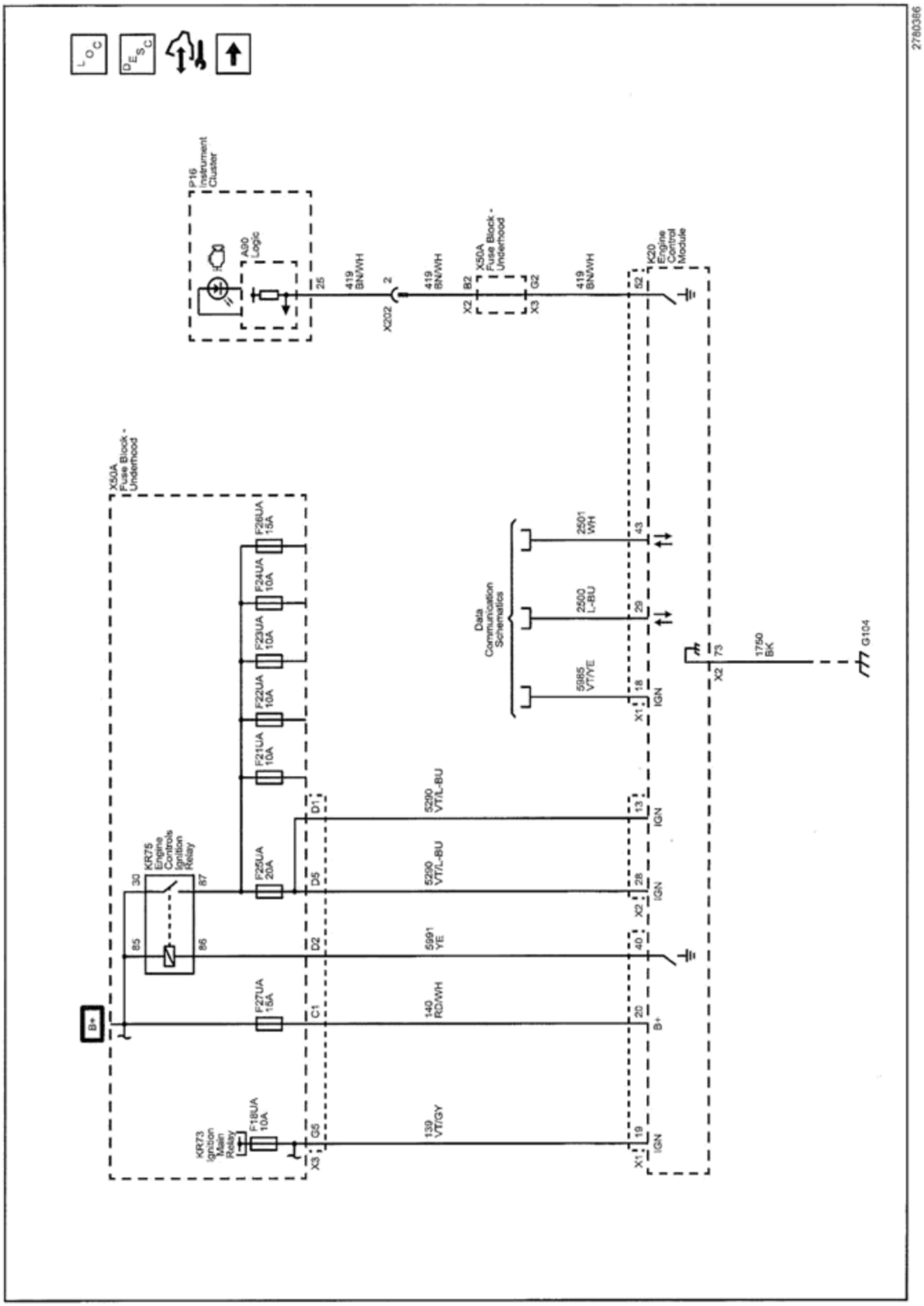
Application	Specification
Ignition Type	Ignition Coil Module
Firing Order	1–3–4–2
Spark Plug Torque	Refer to *Fastener Tightening Specifications on page 9-755*
Spark Plug Gap	0.70 mm (0.028 in)
Spark Plug Type	Refer to Electronic Parts Catalogue

Fastener Tightening Specifications

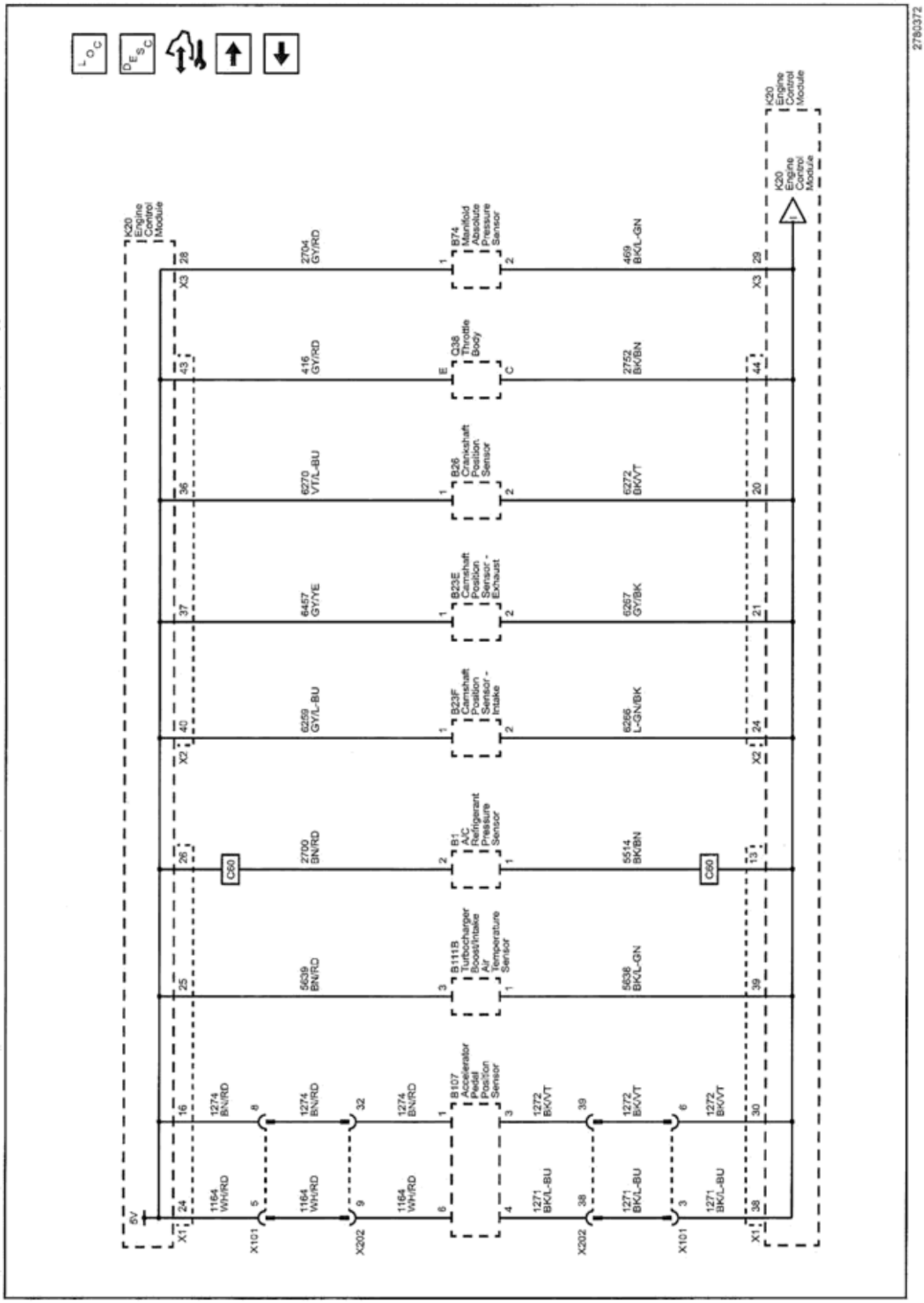
Application	Specification	
	Metric	English
Accelerator Pedal Position Sensor Bolt	10 N•m	89 lb in
Camshaft Position Actuator Solenoid Valve Bolts	8 N•m	71 lb in
Camshaft Position Sensor Bolts	8 N•m	71 lb in
Charge Air Cooler Outlet Air Hose Bolt	8 N•m	71 lb in
Crankshaft Position Sensor Bolt	8 N•m	71 lb in
Engine Control Module Bracket Nuts	9 N•m	80 lb in
Engine Oil Pressure Indicator Switch	20 N•m	15 lb ft
Fuel Injection Fuel Rail Bolt	7 N•m	62 lb in
Fuel Pressure Sensor	19 N•m	14 lb ft
Fuel Tank Filler Pipe Bracket Bolt	9 N•m	80 lb in
Fuel Tank Filler Pipe Ground Bolt	9 N•m	80 lb in
Fuel Tank Strap Bolts	23 N•m	17 lb ft
Heated Oxygen Sensor 1 and 2	40 N•m	30 lb ft
Ignition Coil Bolts	8 N•m	71 lb in
Knock Sensor	20 N•m	15 lb ft
Spark Plugs	25 N•m	18 lb ft
Throttle Body Bolts	9 N•m	80 lb in

Schematic and Routing Diagrams

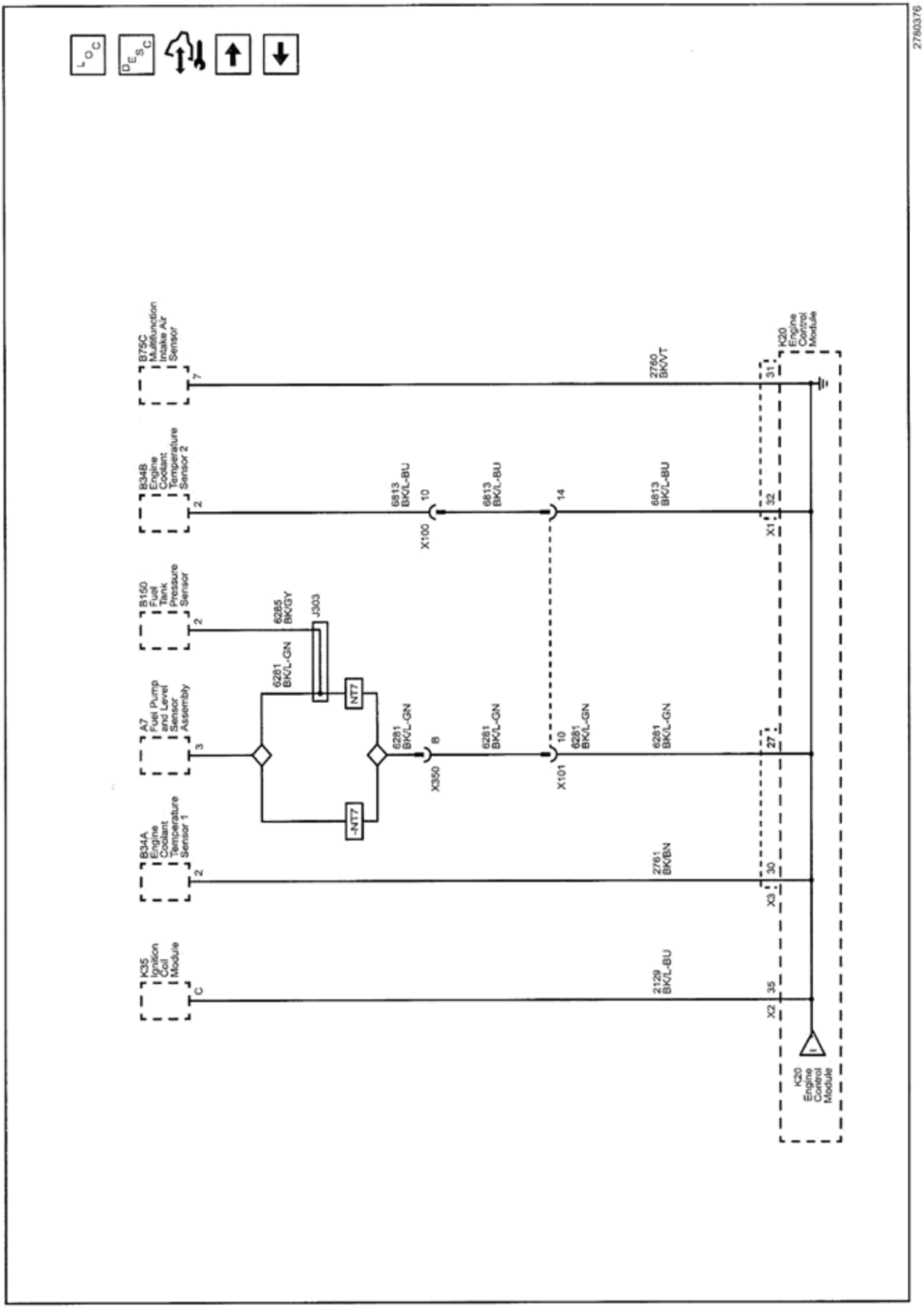
Engine Controls Schematics (Module Power, Ground, Serial Data, and MIL)



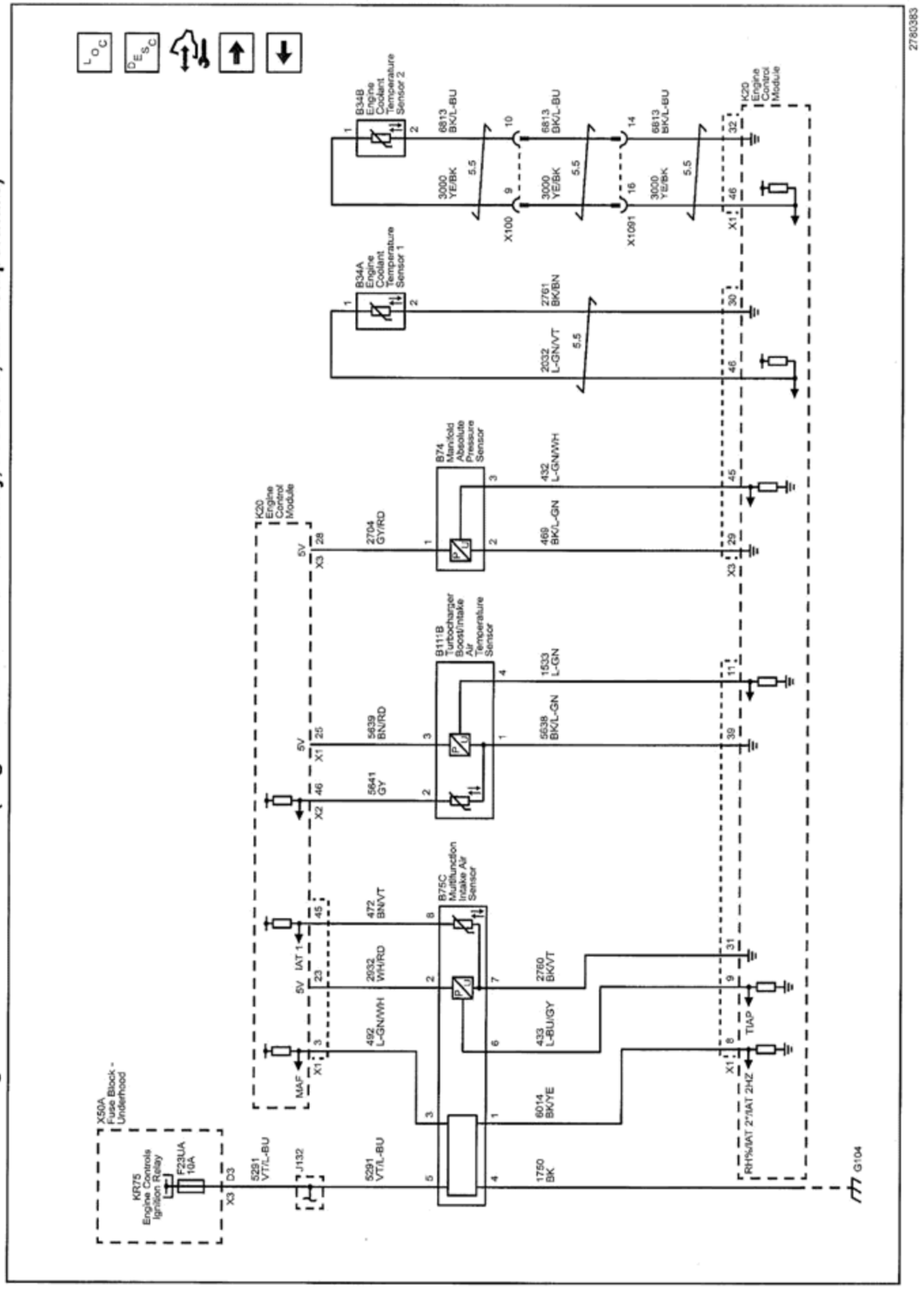
Engine Controls Schematics (5V and Low Reference Bus (1 of 2))



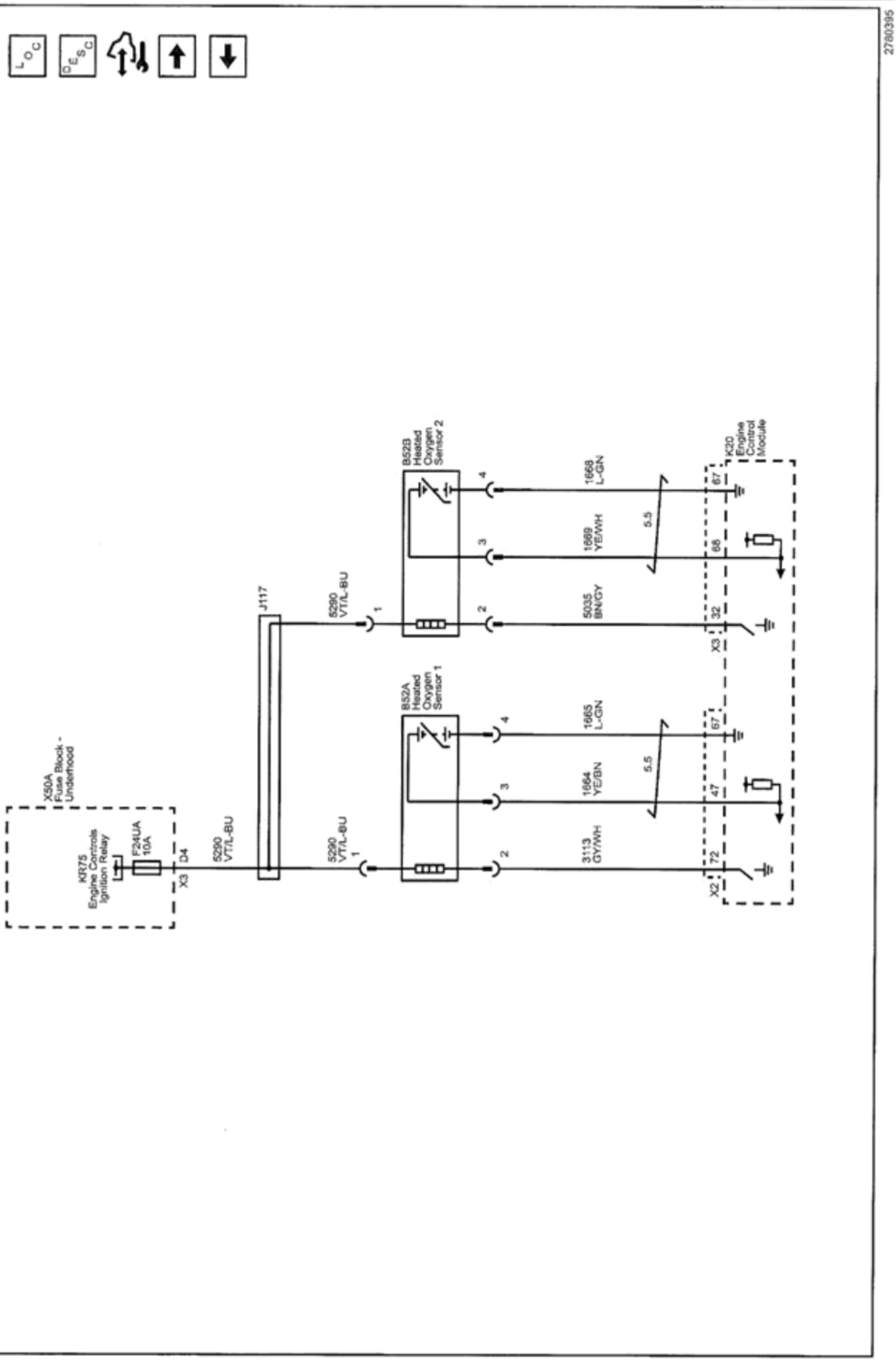
Engine Controls Schematics (Low Reference Bus (2 of 2))



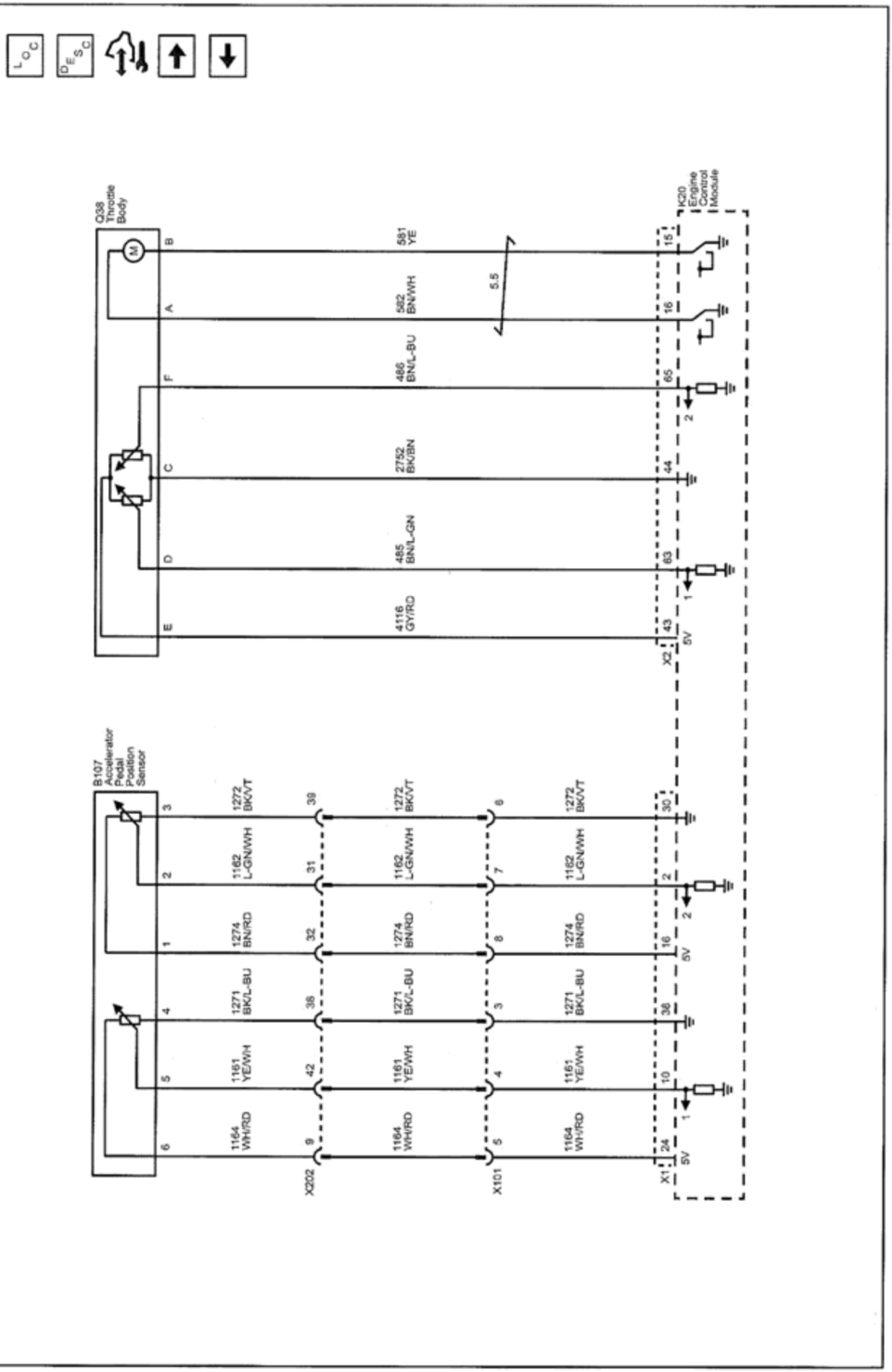
Engine Controls Schematics (Engine Data Sensors - Humidity, Pressure, and Temperature)



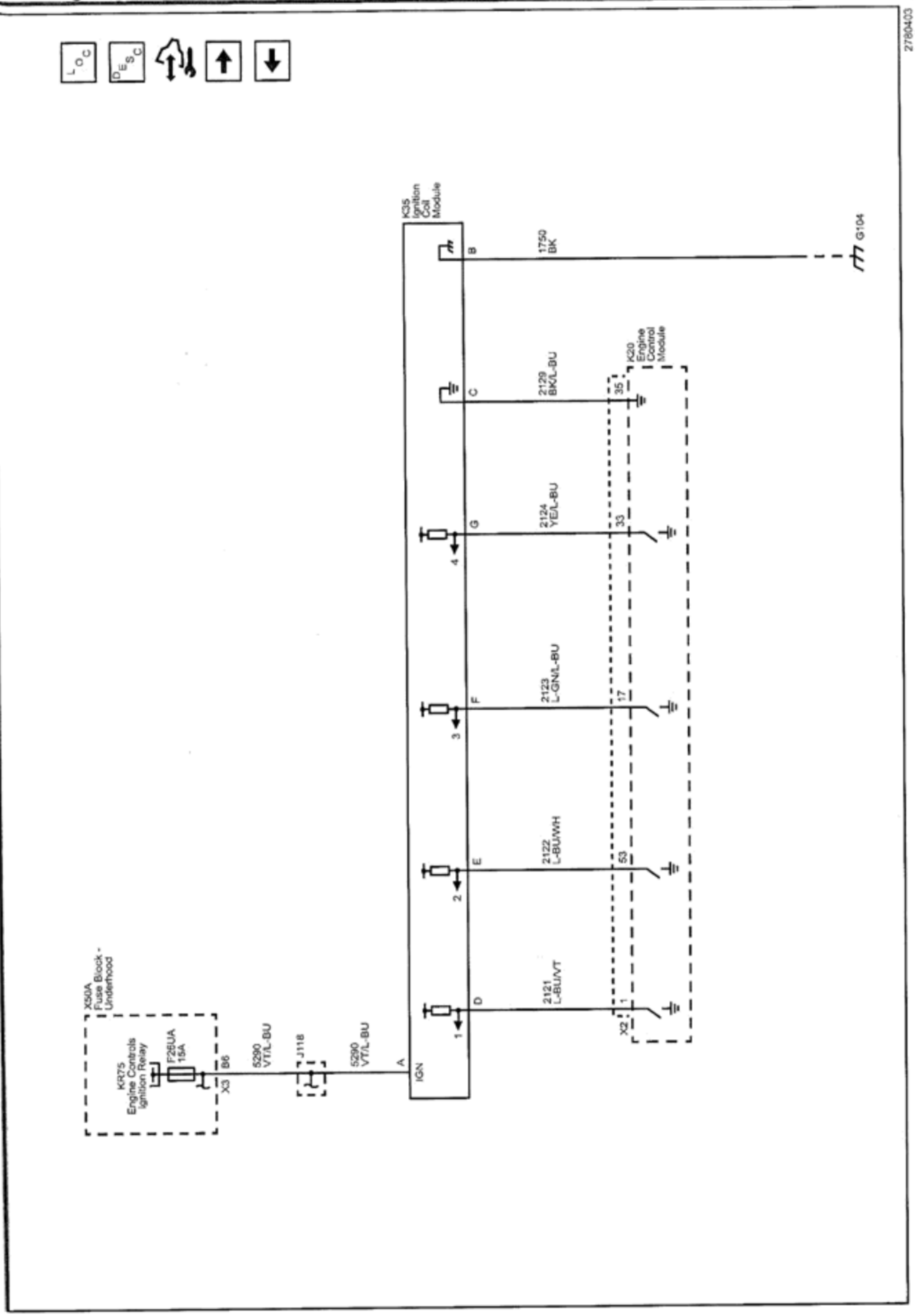
Engine Controls Schematics (Engine Data Sensors - Oxygen Sensors)



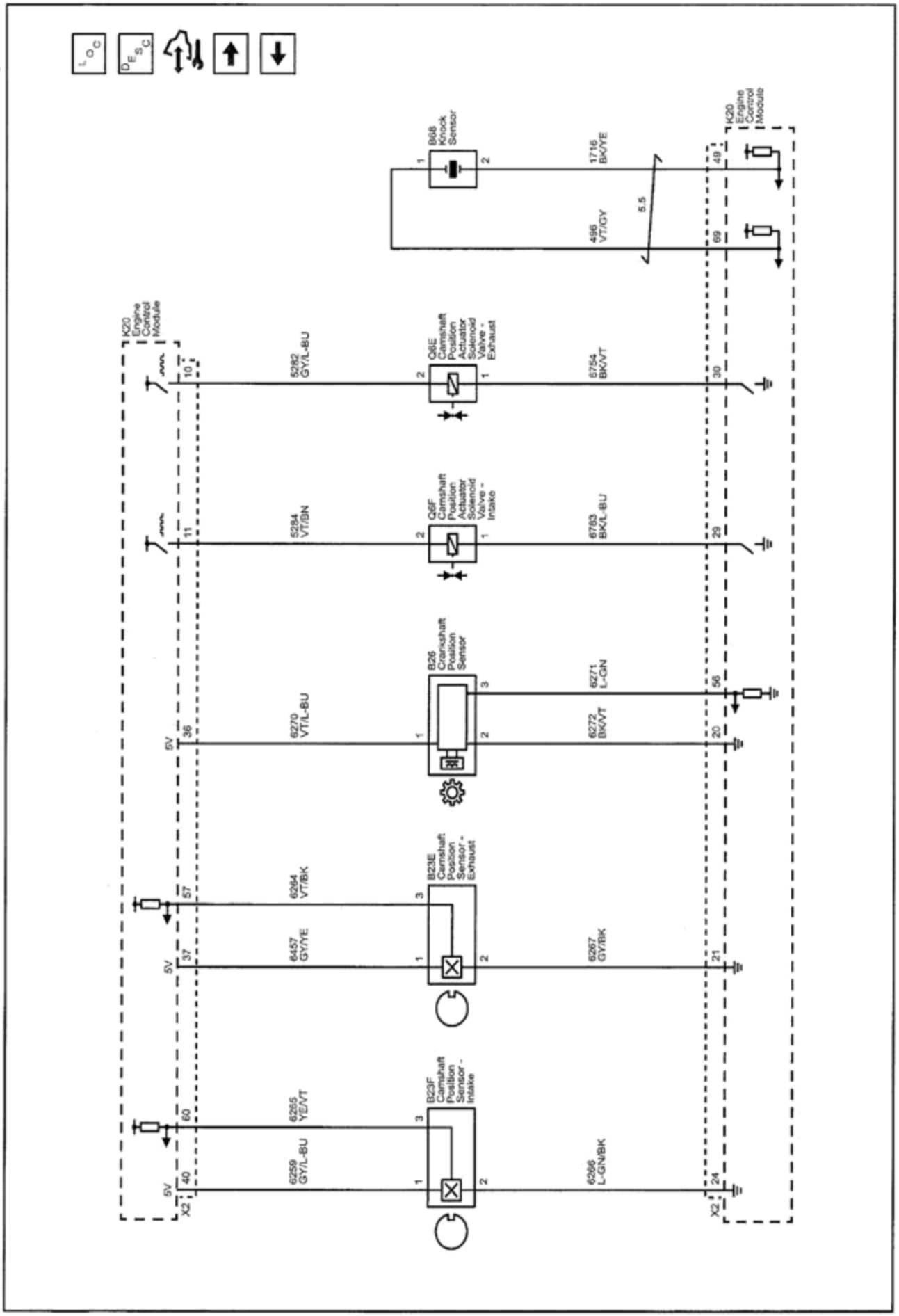
Engine Controls Schematics (Engine Data Sensors - Throttle Controls)



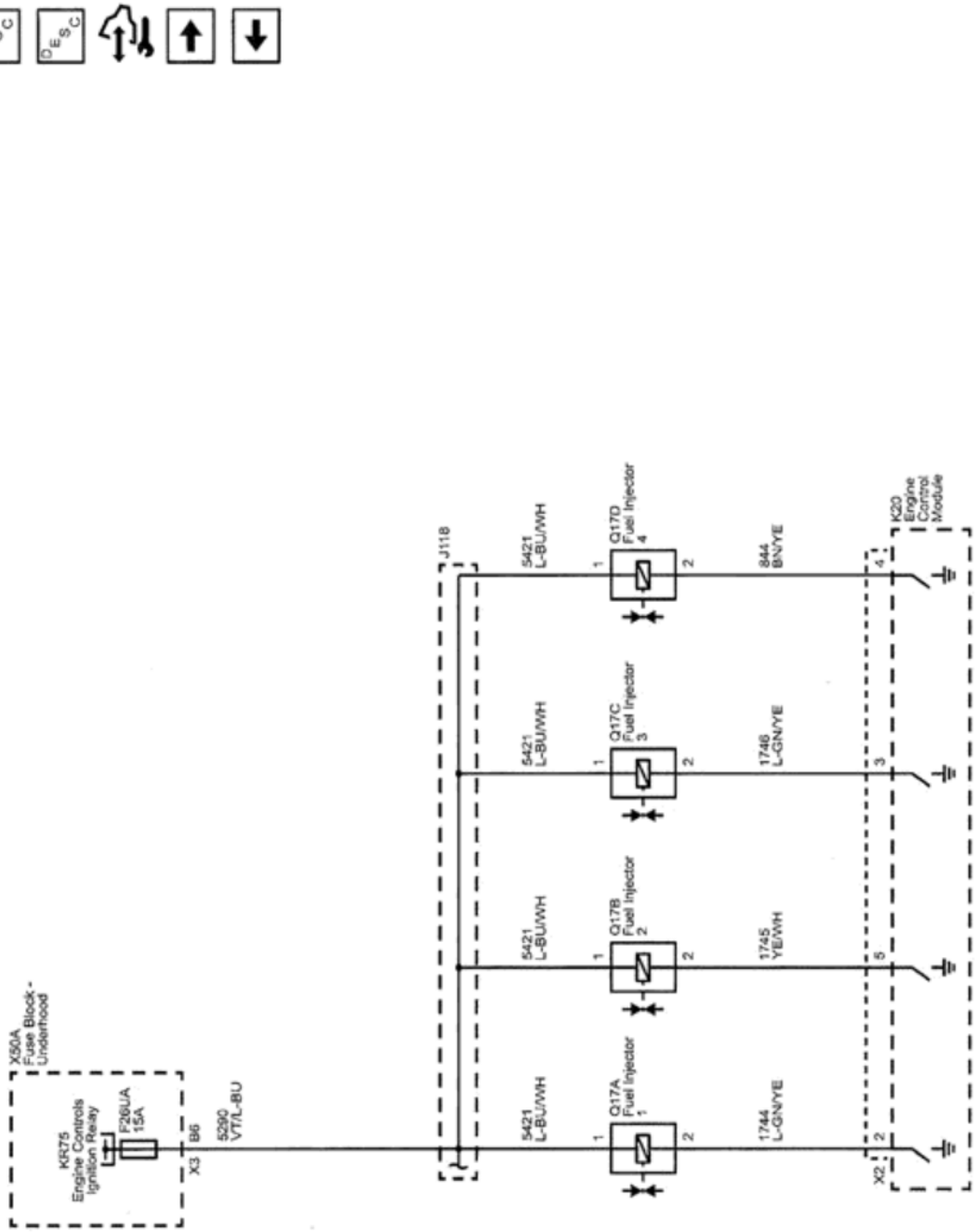
Engine Controls Schematics (Ignition Controls - Ignition System)



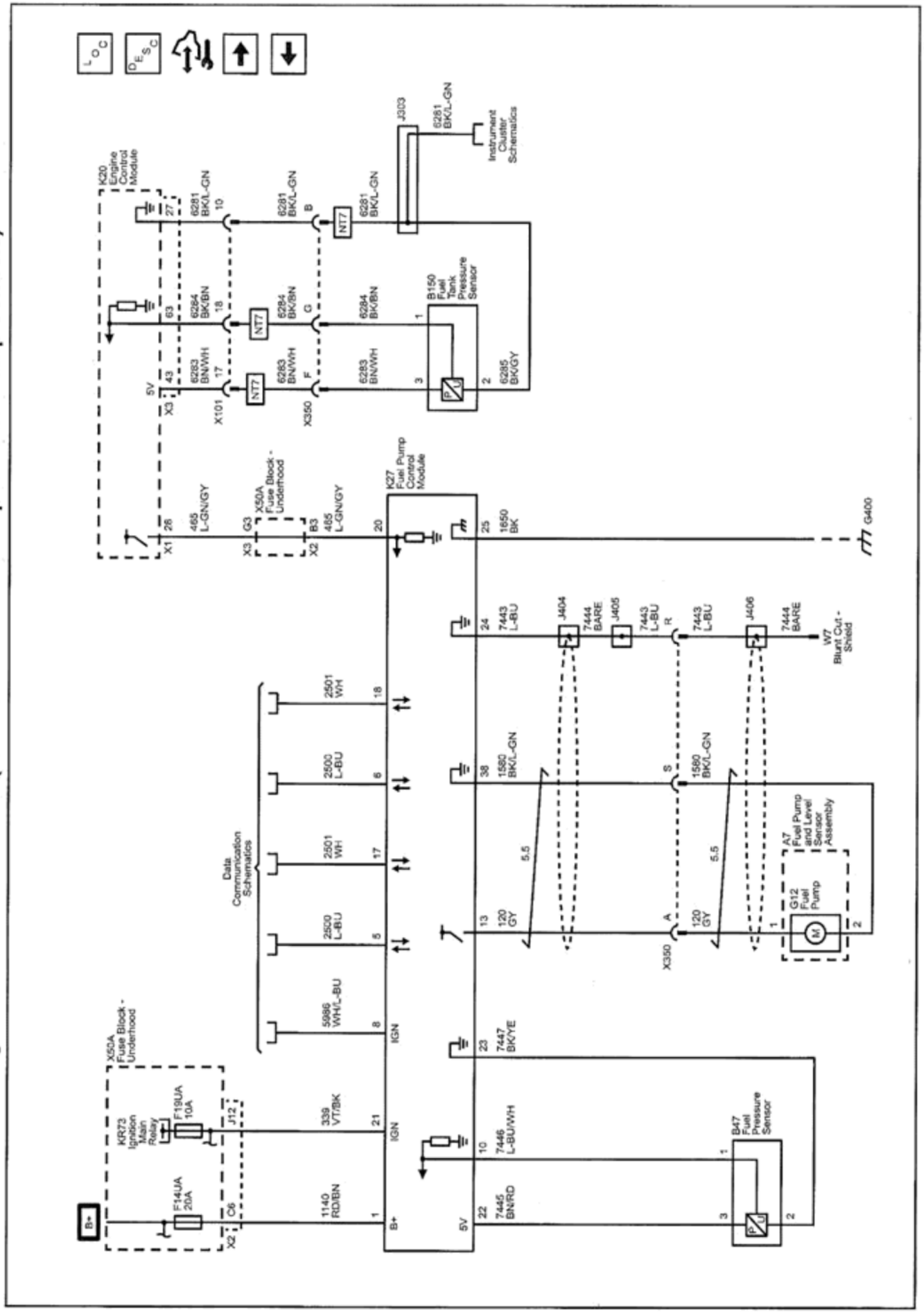
Engine Controls Schematics (Ignition Controls - Camshaft, Crankshaft, and Knock Sensors, Camshaft Actuators)



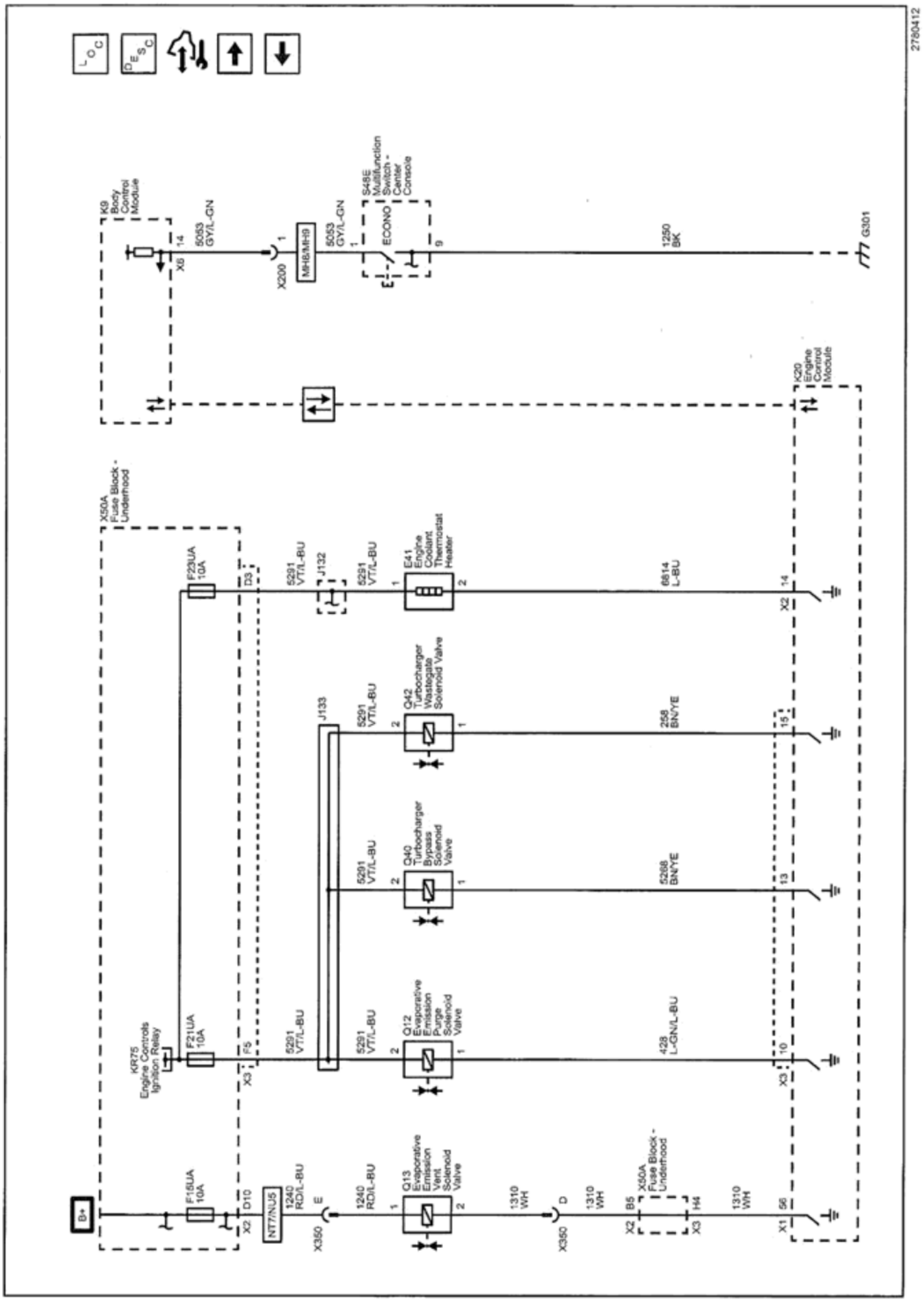
Engine Controls Schematics (Fuel Controls - Fuel Injectors)



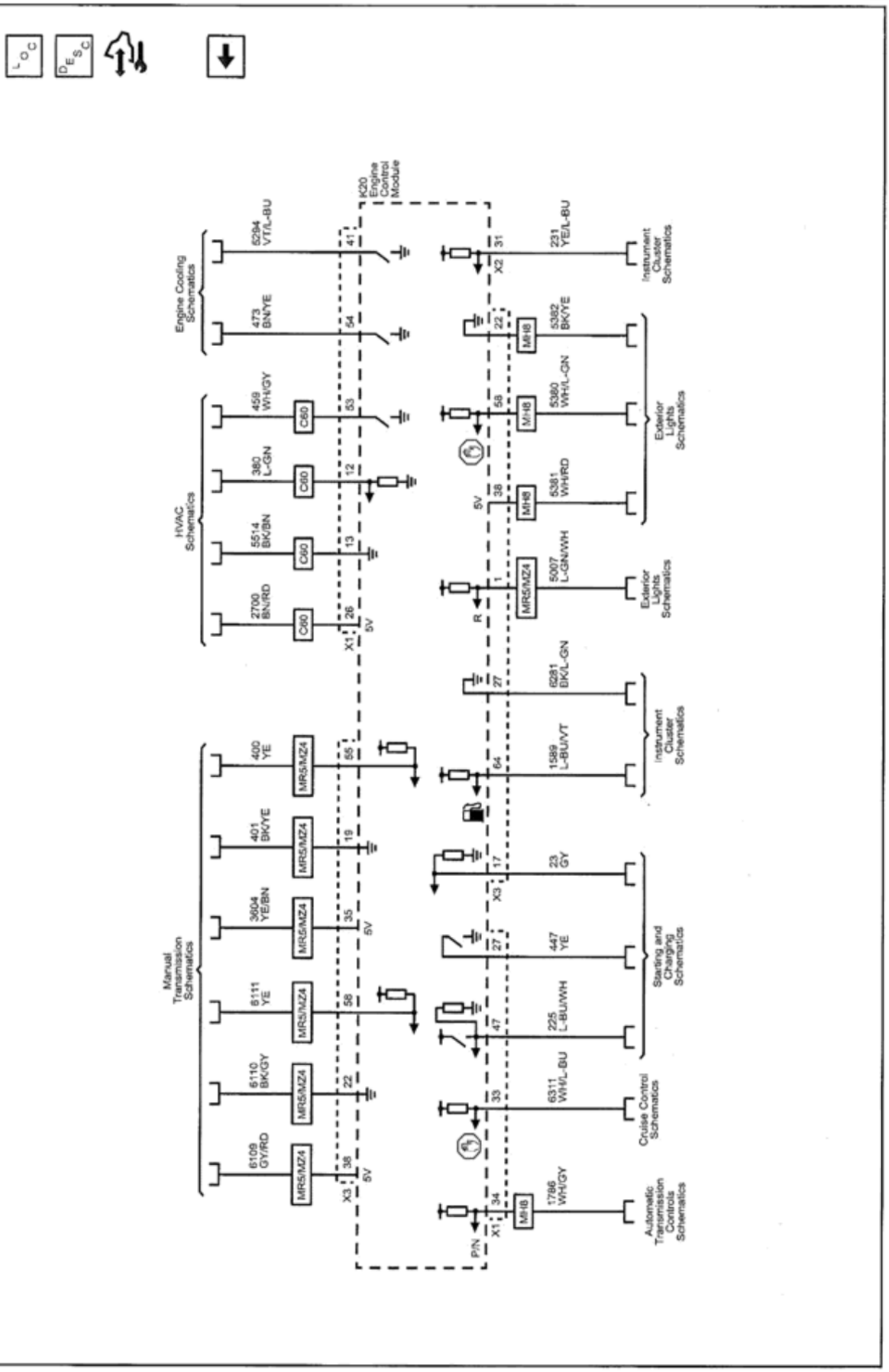
Engine Controls Schematics (Fuel Controls - Fuel Pump and Fuel Pump Controls)



Engine Controls Schematics (Fuel Controls - Evaporative Emission, Economy, and Device Controls)



Engine Controls Schematics (Controlled/Monitored Subsystem References)



Diagnostic Information and Procedures

DTC P0010, P0013, or P2088-P2091

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptors

DTC P0010: Intake Camshaft Position Actuator Solenoid Valve Control Circuit
DTC P0013: Exhaust Camshaft Position Actuator Solenoid Valve Control Circuit
DTC P2088: Intake Camshaft Position Actuator Solenoid Control Circuit Low Voltage
DTC P2089: Intake Camshaft Position Actuator Solenoid Control Circuit High Voltage
DTC P2090: Exhaust Camshaft Position Actuator Solenoid Control Circuit Low Voltage
DTC P2091: Exhaust Camshaft Position Actuator Solenoid Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
Camshaft Position Actuator Solenoid Valve High Control	P0010, P0013, P2088, P2090	P0010, P0013	P0010, P0013	P0010, P0013, P2089, P2091	P0011, P0014
Camshaft Position Actuator Solenoid Valve Low Reference	—	P0010, P0013	P0010, P0013	—	—

Circuit/System Description

The camshaft position actuator system enables the Engine Control Module (ECM) to change the timing of the camshafts while the engine is operating. The Camshaft Position Actuator Solenoid Valve signal from the ECM is pulse width modulated (PWM). The ECM controls the Camshaft Position Actuator Solenoid Valve duty cycle by controlling the amount of solenoid valve ON time. The Camshaft Position Actuator Solenoid Valve controls the advance or the retard of each camshaft. The Camshaft Position Actuator Solenoid Valve controls the oil flow that applies the pressure to advance or retard the camshafts.

The ECM controls the Camshaft Position Actuator Solenoid Valve by suppling 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 voltage is greater than 11 V
- The ignition switch is in the crank or run position.
- The ECM has commanded the Camshaft Position Actuator Solenoid Valve ON.
- The DTCs 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 P0010, P0013, P2088, P2089, P2090 and P2091 are type B DTCs.

Conditions for Clearing the DTC

DTCs P0010, P0013, P2088, P2089, P2090 and P2091 are type B DTCs.

Diagnostic Aids

If the condition is intermittent, move the related harnesses and connectors, with the engine operating, while monitoring the scan tool Circuit Test Status parameters for the component. The Circuit Test Status parameters 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 on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Camshaft Actuator System Description on page 9-296

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

Note: If a crankshaft or camshaft position sensor DTC is set, the Camshaft Position Actuator output control will not function.

1. Ignition ON.
2. Verify DTC P0335, P0336, P0340, and P0341 is not set.

⇒ **If any of the DTCs are set**

Refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69* for further diagnosis.

⇓ **If none of the DTCs are set**

3. 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 High Voltage test status
   - Camshaft Position Actuator Solenoid Valve Control Circuit Low Voltage test status

⇒ **If Malfunction is displayed**

Refer to Circuit/System Testing.

⇓ **If Malfunction is not displayed**

4. Engine idling at normal operating temperature.
5. Verify the scan tool parameters listed below do not display Malfunction when commanding the appropriate scan tool Camshaft Position Actuator from 0–10° and back to 0° with a scan tool:
   - Camshaft Position Actuator Solenoid Valve Control Circuit Open test status
   - Camshaft Position Actuator Solenoid Valve Control Circuit High Voltage test status
   - Camshaft Position Actuator Solenoid Valve Control Circuit Low Voltage test status

⇒ **If Malfunction is displayed**

Refer to Circuit/System Testing.

⇓ **If Malfunction is not displayed**

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 appropriate 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 1and ground.

⇒ **If 5 Ω or greater**

2.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

2.2. 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.

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.

4. Verify that a test lamp does not illuminate between the control circuit terminal 2and ground.

⇒ **If the test lamp illuminates**

4.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

4.2. 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. Verify the scan tool parameters listed below do not display Malfunction when commanding the Camshaft Position Actuator Solenoid Valve ON with a scan tool:
   - Intake Camshaft Position Actuator Solenoid Valve Control Circuit Low Voltage Test Status
   - Exhaust Camshaft Position Actuator Solenoid Valve Control Circuit Low Voltage Test Status

- Intake Camshaft Position Actuator Solenoid Valve Control Circuit High Voltage Test Status
- Exhaust Camshaft Position Actuator Solenoid Valve Control Circuit High Voltage Test Status

⇒ **If Malfunction is displayed**

6.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

6.2. 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 Malfunction is not displayed**

7. Test or replace the Q6 Camshaft Position Actuator Solenoid Valve.

Component Testing

1. Ignition OFF, disconnect the harness connector at the Q6 Camshaft Position Actuator Solenoid Valve.
2. Test for 7–12 Ω between the control terminal 2 and the low reference terminal 1.

⇒ **If not between 7–12 Ω**

Replace the Q6 Camshaft Position Actuator Solenoid Valve.

⇓ **If between 7–12 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. All OK.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Camshaft Position Actuator Solenoid Valve Replacement on page 9-1061*
- *Control Module References on page 6-3* for Engine Control Module replacement, programming and setup.

DTC P0011 or P0014

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptors

DTC P0011: Intake Camshaft Position System Performance

DTC P0014: Exhaust Camshaft Position System Performance

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
Camshaft Position Actuator Solenoid Valve High Control	P0010, P0013, P2088, P2090	P0010, P0013	P0010, P0013	P0010, P0013, P2089, P2091	P0011, P0014
Camshaft Position Actuator Solenoid Valve Low Reference	—	P0010, P0013	P0010, P0013	—	—

Circuit/System Description

The camshaft position (CMP) actuator system enables the engine control module (ECM) to change the timing of the camshafts while the engine is operating. The camshaft position actuator solenoid valves are operated hydraulically in order to change the angle of the camshaft relative to crankshaft position. The camshaft position actuator solenoid valves are controlled by the engine control module (ECM). The ECM sends a pulse width modulated signal to the camshaft position actuator solenoid valves. The camshaft position actuator solenoid valves control the amount of engine oil flow that applies the pressure to advance or retard the camshafts.

Conditions for Running the DTC

- DTC P0010, P0013, P0016, P0017, P0335, P0340, P0341, P0365, or P0366 is not set.
- The engine is running.
- The ignition voltage is between 11–32 V.
- The camshaft position actuator is enabled.
- The rate of change in the camshaft position is less than 3° for 4 s.
- DTCs P0011 and P0014 runs continuously once the above conditions are met for greater than 0.1 s.

Conditions for Setting the DTC

The ECM detects a difference between the camshaft position angle and the desired camshaft position angle is greater than 6 to 10° based on engine coolant temperature and engine speed.

Action Taken When the DTC Sets

DTCs P0011 and P0014 are Type B DTCs.

Conditions for Clearing the DTC

DTCs P0011 and P0014 are Type B DTCs.

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 Remaining 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 belt can cause this DTC to set.
- A resistance greater than 8 Ω on the camshaft position actuator solenoid valve control circuit may set this DTC. If you suspect high resistance, ground the control circuit while the engine is idling. The scan tool Intake or Exhaust Camshaft Position Actuator Solenoid Valve Control Circuit Low Voltage Test Status should display Malfunction. If the parameter displays OK, test the control circuit for high resistance.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-314

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Camshaft Actuator System Description on page 9-296

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 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 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 correct engine oil pressure. Refer to *Oil Pressure Diagnosis and Testing on page 9-954*

⇒ **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 DTC P0010, P0013, P0016, P0017, P0335, P0336, P0340, P0341, P0365, P0366, P2088, P2089, P2090 or P2091 is not set.

⇒ **If any of the DTCs are set**

Refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69* for further diagnosis.

⇓ **If none of the DTCs are set**

4. Engine idling.
5. Verify the scan tool parameters are less than 2° in each of the commanded states when commanding the Camshaft Position Actuator from 0–20° and back to 0° with the scan tool.
   - Intake Camshaft Position Variance
   - Exhaust Camshaft Position Variance

⇒ **If 2° or greater**

Refer to Circuit/System Testing.

⇓ **If less than 2°**

6. Verify that DTC P0011 or P0014 is not set.

⇒ **If any of the DTCs are set**

Refer to Circuit/System Testing.

⇓ **If none of the DTCs set**

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 the DTC does not set.

⇒ **If the DTC sets**

Refer to Circuit/System Testing.

⇓ **If the DTC does not set**

9. All OK.

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the appropriate 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**

2.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

2.2. 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.

Note: A test lamp must be used for this test. The control circuit is pulled-up to a low current voltage, 1.5–4.5 V on the control circuit is normal.

4. Verify that a test lamp does not illuminate between the control circuit terminal 2 and ground.

⇒ **If the test lamp illuminates**

4.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

4.2. 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. Verify the scan tool parameters listed below do not display Malfunction when commanding the appropriate Camshaft Position Actuator Solenoid Valve ON with a scan tool.
   - Intake Camshaft Position Actuator Solenoid Valve Control Circuit Low Voltage Test Status
   - Exhaust Camshaft Position Actuator Solenoid Valve Control Circuit Low Voltage Test Status
   - Intake Camshaft Position Actuator Solenoid Valve Control Circuit High Voltage Test Status
   - Exhaust Camshaft Position Actuator Solenoid Valve Control Circuit High Voltage Test Status

⇒ **If Malfunction is displayed**

6.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

6.2. 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 Malfunction is not displayed**

7. Ignition OFF, remove the Q6 Camshaft Position Actuator Solenoid Valve.
8. Verify the conditions listed below do not exist with the Q6 Camshaft Position Actuator Solenoid Valve:

8.1. Torn, restricted, mis-positioned, or missing screens.

8.2. Engine oil leak between the oil sealing lands of the solenoid. Inspect the lands of the solenoid for nicks.

8.3. Oil seepage at the solenoid connector.

⇒ **If a condition is found**

Replace the Q6 Camshaft Position Actuator Solenoid Valve.

⇓ **If a condition is not found**

Note: After swapping toe solenoids, install jumper wires to the appropriate terminals of the harness connectors and the solenoids.

9. Ignition OFF, swap the Q6 Camshaft Position Actuator Solenoid Valve with the Q6 Camshaft Position Actuator Solenoid Valve that is operating correctly.
10. Engine idling.
11. Verify the scan tool Camshaft Position Variance parameter is less than 2° in each of the commanded states when commanding the Camshaft Position Actuator from 0–20° and back to 0° with a scan tool.

⇒ **If 2° or greater**

Replace the mechanical camshaft position actuator.

⇓ **If less than 2°**

12. Test or replace the Q6 Camshaft Position Actuator Solenoid Valve.

Component Testing

1. Ignition OFF, disconnect the harness connector at the Q6 Camshaft Position Actuator Solenoid Valve.
2. Test for 7-12 Ω between the control terminal 2 and the low reference circuit terminal 1.

⇒ **If not between 7-12 Ω**

Replace the Q6 Camshaft Position Actuator Solenoid Valve.

⇓ **If between 7-12 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. All OK

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Camshaft Position Actuator Solenoid Valve Replacement on page 9-1061*
- *Control Module References on page 6-3* for ECM replacement, programming and setup

DTC P0016 or P0017

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptors

DTC P0016: Crankshaft Position – Intake Camshaft Position Not Plausible

DTC P0017: Crankshaft Position – Exhaust Camshaft Position Not Plausible

Circuit/System Description

The engine control module (ECM) uses the crankshaft position sensor, intake camshaft position sensor, and the exhaust camshaft position sensor information to monitor the correlation between the crankshaft, intake camshaft, and exhaust camshaft position.

Conditions for Running the DTC

- DTCs P0335, P0336, P0340, P0341, P0365, P0366, P0641, or P0651 is not set
- The engine is running.
- The camshaft position actuator solenoid valves are in the parked position.

The DTCs run continuously once the above conditions are met.

Conditions for Setting the DTC

The ECM detects a camshaft to crankshaft misalignment. The DTC sets if the crankshaft position sensor signal is 10 degrees before or after the normal position in relation to the crankshaft angle while the engine is running.

Action Taken When the DTC Sets

DTCs P0016 and P0017 are Type B DTCs.

Conditions for Clearing the DTC

DTCs P0016 and P0017 are Type B DTCs.

Diagnostic Aids

The following conditions can also set the DTCs:

- A short to ground in a camshaft position actuator solenoid valve control circuit.
- Crankshaft end play out of specification.
- A crankshaft reluctor wheel that has moved in relationship to top dead center (TDC).

Reference Information

Description and Operation

Camshaft Actuator System Description on page 9-296

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0335, P0336, P0340, P0341, P0365, P0366, P0641 or P0651 is not set.

⇒ **If any of the DTCs are set**

Refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69*.

⇓ **If none of the DTCs are set**

3. Engine Running at normal operating temperature.
4. Verify DTC P0016 or P0017 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.
- The correct installation of the Q6 Camshaft Position Actuator Solenoid Valves.
- The correct installation of the B23 Camshaft Position Sensors.
- 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.
- A crankshaft reluctor wheel that has moved in relationship to top dead center (TDC) on the crankshaft.

⇓ **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 on page 6-92* after completing the repair.

- *Camshaft Position Actuator Solenoid Valve Replacement on page 9-282*
- *Camshaft Position Sensor Replacement on page 9-285*
- *Crankshaft Position Sensor Replacement on page 9-284*
- *Timing Chain Tensioner Replacement on page 9-797*

DTC P0030-P0032, P0036-P0038, P0053, P0054, P0135, or P0141

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provide an overview of each diagnostic category.

DTC Descriptors

DTC P0030: HO2S Heater Control Circuit Sensor 1
DTC P0031: HO2S Heater Control Circuit Low Voltage Sensor 1
DTC P0032: HO2S Heater Control Circuit High Voltage Sensor 1
DTC P0036: HO2S Heater Control Circuit Sensor 2
DTC P0037: HO2S Heater Control Circuit Low Voltage Sensor 2
DTC P0038: HO2S Heater Control Circuit High Voltage Sensor 2
DTC P0053: HO2S Heater Resistance Sensor 1
DTC P0054: HO2S Heater Resistance Sensor 2
DTC P0135: HO2S Heater Performance Sensor 1
DTC P0141: HO2S Heater Performance Sensor 2

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
HO2S Heater Voltage Supply	P0030, P0036, P0102, P0132, P0134, P0135, P0138, P0141, P0443, *	P0030, P0036, P0132, P0134, P0135, P0138, P0140, P0141, P0154, P0155, P0158, P0160, P0161	P0030, P0036, P0132, P0134, P0135, P0138, P0140, P0141	P0690	P0135, P0141
HO2S Heater Control	P0030, P0031, P0036, P0037, P0053, P0054, P0135, P0141	P0030, P0036, P0053, P0132, P0135, P0138, P0140, P0141	P0030, P0036, P0132, P0134, P0135, P0138, P0140, P0141	P0030, P0032, P0036, P0038, P0132, P0134, P0135, P0138, P0140, P0141, P0690	P0135, P0141
*Opens Fuse					

Typical Scan Tool Data

HO2S Sensor 1 Current/HO2S Sensor 2 Current

Circuit	Short to Ground	Open	Short to Voltage
Parameter Normal Range: 0.2–1.5 A			
HO2S Heater Low Control	0 A	0 A	0 A
HO2S Heater Voltage Supply	0 A	0 A	0.2–2 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. Each HO2S must reach operating temperature to provide an accurate voltage signal. A heating element inside each of the HO2S minimizes the time required for the sensor 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, P0031, P0032, P0036, P0037 and P0038

- The system voltage is between 11–32 V.
- The engine speed is greater than 400 RPM.
- The DTCs run continuously when the above conditions are met for greater than 5 s.

P0053 and P0054

- DTCs P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119 or P2610 are not set.
- The system voltage is less than 32 V.
- The ignition is OFF for greater than 8 h.
- The engine is running.
- The ECT is between −30 to +45°C (−22 to +113°F).
- The engine coolant temperature (ECT) and the intake air temperature (IAT) are within 8°C (14°F).
- The DTCs run once per valid cold start-up when the above conditions are met.

P0135 and P0141

- DTCs P0116, P0117, P0118, P0119 or P0128 are not set.
- The system voltage is between 10–32 V.
- The HO2S heaters are at operating temperature.
- The scan tool HO2S Heater device control is not active.
- The commanded HO2S heater duty cycle is greater than 0%.
- The DTCs run twice per drive cycle when the above conditions are met for greater than 30 s.

Conditions for Setting the DTC

P0030, P0031, P0032, P0036, P0037 and P0038

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.

P0053 and P0054

The ECM detects the HO2S heater is not within 7.5-13 Ω at engine start-up.

P0135 and P0141

The ECM detects the HO2S heater current is less than 0.30 A or greater than 2.5 A for greater than 8 s.

Action Taken When the DTC Sets

DTC P0030, P0031, P0032, P0036, P0037, P0038, P0053, P0054, P0135, and P0141 are Type B DTCs.

Conditions for Clearing the DTC

DTC P0030, P0031, P0032, P0036, P0037, P0038, P0053, P0054, P0135, and P0141 are Type B DTCs.

Diagnostic Aids

- If the condition is intermittent, move the related harnesses and connectors, with the engine operating, while monitoring the scan tool circuit status parameters for the component. The circuit status parameters will change from OK or Not Run to Malfunction if there is a condition with the circuit or a connection.
- An open fuse in the HO2S heater circuit may be caused by the heater element in one of the sensors. The condition may not be present until the sensor operates for a period of time. If no fault is present in the heater circuit, monitor the amperage of each heater with a scan tool to determine if one of the heater elements is the cause of the open fuse. Inspect the sensor pigtail or the harness for contacting the exhaust system.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Engine idling.
2. Verify the parameters listed below do not display Malfunction.
   - HO2S 1 or 2 Heater Control Circuit Low Voltage Test Status
   - HO2S 1 or 2 Heater Control Circuit Open Test Status
   - HO2S 1 or 2 Heater 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 appropriate B52 Heated Oxygen Sensor. Ignition ON.
2. Verify that a test lamp illuminates between the ignition voltage circuit terminal 1 and ground.

⇒ **If the test lamp does not illuminate and the circuit fuse is good**

2.1. Ignition OFF.

2.2. 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

2.1. Ignition OFF, remove the test lamp.

2.2. 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 1 and the control circuit terminal 2.

⇒ **If the test lamp illuminates**

3.1. Ignition OFF, remove the test lamp, disconnect the harness connector at the K20 Engine Control Module.

3.2. 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 HO2S 1 or 2 Heater Control Circuit High Voltage Test Status parameter is OK when commanding the HO2S Heater Sensor 1 or 2 ON with a scan tool.

⇒ **If OK is not displayed**

5.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

5.2. 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**

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.

6. Install a 10 A fused jumper wire between the control circuit terminal 2 and the ignition voltage circuit terminal 1.

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.

7. Verify the scan tool HO2S 1 or 2 Heater Control Circuit High Voltage Test Status parameter is Malfunction when commanding the HO2S Heater Sensor 1 or 2 ON with a scan tool.

⇒ **If Malfunction is not displayed**

7.1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module.

7.2. 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 B52 Heated Oxygen Sensor.

Component Testing

1. Ignition OFF, disconnect the harness connector at the appropriate B52 Heated Oxygen Sensor.
2. Test for 8–20 Ω between the ignition voltage circuit terminal 1 and the control circuit terminal 2.

⇒ **If not within the specified range, replace the B52 Heated Oxygen Sensor.**

⇓ **If within the specified range**

3. All OK.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Heated Oxygen Sensor Replacement - Sensor 1 on page 9-249*
- *Heated Oxygen Sensor Replacement - Sensor 2 on page 9-250*
- Perform the scan tool Heated Oxygen Sensor Resistance Learn Reset after replacing a HO2S.
- *Control Module References on page 6-3* for ECM replacement, programming and setup.

DTC P0033-P0035

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptors

DTC P0033: Turbocharger Bypass Solenoid Valve Control Circuit
DTC P0034: Turbocharger Bypass Solenoid Valve Control Circuit Low Voltage
DTC P0035: Turbocharger Bypass Solenoid Valve Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage Circuit	P0030, P0034, P0036, P0134, P0135, P0245, P0443, P0598*	P0030, P0033, P0034, P0036, P0134, P0135, P0140, P0141, P0243, P0245, P0443, P0597	—	—
Control Circuit	P0034	P0033	P0010, P0013, P0035, P0443, P0690	—
* Ignition fuse opens.				

Circuit/System Description

The turbocharger incorporates a wastegate that is controlled by a pressure differential, that is determined by the engine control module (ECM) by means of a PWM solenoid valve, in order to regulate the pressure ratio of the turbocharger. A turbocharger bypass valve also controlled by the ECM by utilizing a remotely mounted solenoid valve is integrated into the bypass valve to prevent turbocharger surging and damage from vibrations by opening during abrupt closed throttle conditions. When the valve is open during closed throttle deceleration conditions, the bypass valve allows the air to recirculate in the turbocharger and maintain turbocharger speed. Within a calibrated range during the closed throttle event, or upon a wide open throttle command the valve will then close to optimize turbo response. The bypass solenoid valve has the following circuits:

- Ignition voltage
- Turbocharger bypass solenoid valve control

As engine load and engine speed increases, the turbocharger bypass solenoid valve remains commanded ON by the ECM. As soon as the throttle closes the turbocharger bypass solenoid valve is commanded OFF by the ECM, in order to allow the turbocharger bypass valve to open and allow the turbocharger air to recirculate, there by preventing turbocharger surging.

Conditions for Running the DTC

- The engine is not cranking.
- The powertrain relay voltage is greater than 11 V.
- The run/crank voltage is greater than 6 V.
- The DTC run continuously when the above conditions are met.

Conditions for Setting the DTC

The ECM detects an open, a short to ground, or a short to voltage on the turbocharger bypass solenoid valve control circuit for greater than 1 s.

Action Taken When the DTC Sets

DTC P0033, P0034, P0035 are Type B DTCs.

Conditions for Clearing the DTC

DTC P0033, P0034, P0035 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Turbocharger System Description on page 9-306

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Ignition ON, Verify the parameters listed below do not display Malfunction when commanding the Turbocharger Bypass Solenoid Valve ON and OFF with a scan tool:
   - Turbocharger Bypass Solenoid Valve Control Circuit Low Voltage Test Status
   - Turbocharger Bypass Solenoid Valve Control Circuit Open Test Status
   - Turbocharger Bypass Solenoid Valve Control Circuit High Voltage Test Status

⇒ **If Malfunction is displayed**

Refer to Circuit/System Testing.

⇓ **If Malfunction is not displayed**

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 a DTC does not set.

⇒ **If a DTC sets**

Refer to Circuit/System Testing

⇓ **If a DTC does not set**

4. All OK

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the Q40 Turbocharger Bypass Solenoid Valve. Ignition ON.
2. Verify a test lamp illuminates between the ignition circuit terminal 2 and ground.

⇒ **If the test lamp does not illuminate and the circuit fuse is good**

2.1. Ignition OFF, remove the test lamp.

2.2. 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**

2.1. 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.

2.2. 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 control circuit terminal 1 and the ignition circuit terminal 2.

⇒ **If the test lamp illuminates**

3.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module. Remove the test lamp.

3.2. 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 Turbocharger Bypass Solenoid Valve Control Circuit High Voltage Test Status parameter is OK when commanding the Turbocharger Bypass Solenoid Valve Active with a scan tool.

⇒ **If OK is not displayed**

5.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

5.2. 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 1 and the ignition circuit terminal 2.

7. Verify the scan tool Turbocharger Bypass Solenoid Valve Control Circuit High Voltage Test Status parameter is Malfunction when commanding the Turbocharger Bypass Solenoid Valve Active with a scan tool.

⇒ **If Malfunction is not displayed**

7.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

7.2. 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 Q40 Turbocharger Bypass Solenoid Valve.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Charge Air Bypass Regulator Solenoid Valve Replacement on page 9-295*
- *Control Module References on page 6-3* for ECM replacement, programming and setup

DTC P0068 or P1101

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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 airflow based on throttle position (TP) to a calculated airflow based on manifold absolute pressure (MAP) sensor, and mass air flow (MAF).

Conditions for Running the DTC

DTC P0068

- The engine speed is at least 800 RPM.
- The ignition voltage is at least 6.4 V.
- The DTC runs continuously when the above conditions are met.

DTC P1101

- DTC P0102, P0103, P0107, P0111, P0112, P0113, P0116, P0117, P0118, P0335,or P0336 is not set
- The engine speed is between 400–7,000 RPM
- The engine coolant temperature (ECT) is between −7 to +125°C (+19 to +257°F).
- The intake air temperature (IAT) is between −20 to +125°C (−4 to +257°F).
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTCs

The ECM detects that the actual airflow rate is greater than the calculated airflow.

Action Taken When the DTCs Set

- DTC P0068 is a type A DTC.
- DTC P1101 is a type B DTC.

Conditions for Clearing the DTCs

- DTC P0068 is a type A DTC.
- DTC P1101 is a type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC DTC P0641, P0651, P0697, or P06A3 is not set.

⇒ **If any of the DTCs are set**

Refer to *DTC P0641, P0651, P0697, or P06A3 (ECM) on page 9-182* for further diagnosis.

⇓ **If none of the DTCs are set**

3. Ignition ON.
4. Verify the scan tool Throttle Body Idle Airflow Compensation parameter is less than 90 %.

⇒ **If 90 % or greater**

Refer to *Throttle Body Inspection and Cleaning on page 9-253.*

⇓ **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 Test with a scan tool.

⇒ **If Disagree**

Refer to *DTC P0121-P0123, P0222, P0223, or P2135 (LUV) on page 9-102* for further diagnosis.

⇓ **If Agree**

6. Determine the current vehicle testing altitude.

7. Verify the scan tool MAP Sensor pressure parameter is within the range specified in the *Altitude Versus Barometric Pressure on page 9-26* table.

⇒ **If the MAP Sensor parameter is not in range**

Refer to *DTC P0106 on page 9-84* for further diagnosis.

⇓ **If the MAP Sensor parameter is within range**

8. Verify the engine is equipped with a turbocharger.

⇒ **If not equipped with a turbocharger**

Refer to Step 11.

⇓ **If equipped with a turbocharger**

9. Verify the scan tool Boost Pressure Sensor parameter is within the range specified in the *Altitude Versus Barometric Pressure on page 9-26* table.

⇒ **If the Boost Pressure Sensor parameter is not in range**

Refer to *DTC P0236 on page 9-128* for further diagnosis.

⇓ **If the Boost Pressure Sensor parameter is within range**

10. Verify the scan tool Boost Pressure Sensor parameter decreases after starting the engine.

⇒ **If the Boost Pressure Sensor parameter does not decrease**

Refer to *DTC P0236 on page 9-128* for further diagnosis.

⇓ **If the Boost Pressure Sensor parameter is within range**

11. Engine idling, 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 between 26–52 kPa (3.8–7.5 psi) or does not change**

Refer to *DTC P0106 on page 9-84* for further diagnosis.

⇓ **If between 26–52 kPa (3.8–7.5 psi) 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.
    12.1. Engine idling
    12.2. Perform the scan tool snapshot function.
    12.3. Increase the engine speed slowly to 3,000 RPM and then back to idle.
    12.4. Exit from the scan tool snapshot and review the data.
    12.5. 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 on page 9-77* for further diagnosis.

⇓ **If the MAF Sensor 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 a DTC does not set.

⇒ **If any DTC sets**

Refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69* for further diagnosis.

⇓ **If no DTCs set**

15. All OK

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

Control Module References on page 6-3 for engine control module replacement, programming, and setup

DTC P0096 or P0111

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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
Sensor	P0112, P0114, P2199	P0113, P0114, P2199	P0113, P0114, P2199*	P0111, P0114
Low Reference	—	P0097, P0113, P11C2, 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
5 V Reference	P0097, P0651, P11C2, P2199, P2227, P2228	P0096, P0097, P11C2, P2199, P2227, P2228	P0097, P0651, P11C2, P2199, P2227, P2228	—
Sensor	P0097, P11C3, P2199	P0097, P11C2, P2199	P0097, P11C2, P2199*	—
Low Reference	—	P0097, P0113, P11C2, 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 or High Resistance	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** Varies with ambient temperature			
Sensor	150°C (302°F)	-40°C (-40°F)	-40°C (-40°F)*
Low Reference	—	-40°C (-40°F)	-40°C (-40°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			
5 V Reference	−40°C (−40°F) 10 Hz	−40°C (−40°F) 10 Hz	—
Signal	−40°C (−40°F)	−40°C (−40°F)	−40°C (−40°F)* 10 Hz*
Ground	—	−40°C (−40°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 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 °C (°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 °C (°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	−40°C (−40°F)
Warm	302 Hz	104°C (219°F)

Conditions for Running the DTCs

P0096 and P0111

- DTCs P0097, P0098, P0111, P0112, P0113, P0117, P0118, P00EA, P00EB, or P1682 are not set.
- The ignition 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 25°C (45°F).

  AND

- The ECM determines the absolute difference between IAT sensor 2 start-up temperature and the IAT sensor 3 start-up temperature is greater than 25°C (45°F).

  AND

- The ECM determines the absolute difference between IAT sensor 1 start-up temperature and the IAT sensor 3 start-up temperature is less than or equal to 25°C (45°F).
- This DTC runs once per ignition cycle when the enabling conditions are met.

Note: P0111 Can fail under any of the following 3 sets of conditions.

P0111 – Condition 1

- The ECM determines the absolute difference between IAT sensor 1 start-up temperature and the IAT sensor 2 start-up temperature is greater than 25°C (45°F).

  AND

- The ECM determines the absolute difference between IAT sensor 1 start-up temperature and the IAT sensor 3 start-up temperature is greater than 25°C (45°F).

AND

- The ECM determines the absolute difference between IAT sensor 2 start-up temperature and the IAT sensor 3 start-up temperature is less than or equal to 25°C (45°F).

P0111 – Condition 2

- The ECM determines the IAT sensor 2 start-up temperature is between the IAT sensor 1 and IAT sensor 3 start-up temperatures.

AND

- The ECM determines the absolute difference between IAT sensor 1 start-up temperature and the IAT sensor 3 start-up temperature is greater than 25°C (45°F).

AND

- The ECM determines the absolute difference between IAT sensor 2 and the IAT sensor 1 start-up temperatures is greater than absolute difference between IAT sensor 2 and the IAT sensor 3 start-up temperatures.

P0111 – Condition 3

- The ECM determines the IAT sensor 3 start-up temperature is between the IAT sensor 1 and IAT sensor 2 start-up temperatures.

AND

- The ECM determines the absolute difference between IAT sensor 1 start-up temperature and the IAT sensor 2 start-up temperature is greater than 25°C (45°F).

AND

- The ECM determines the absolute difference between IAT sensor 3 and the IAT sensor 1 start-up temperatures is greater than absolute difference between IAT sensor 3 and the IAT sensor 2 start-up temperatures.

DTC P0111 runs once an ignition cycle when the any one, of the above 3 enabling sets of conditions is 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 is 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; −40°C (−40°F), and there are also Humidity Sensor DTCs, check for a circuit problem.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Special Tools

EN-38522 Variable Signal Generator

For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308.*

Circuit/System Verification

1. Ignition ON, verify that DTC DTC P0641, P0651, P0697, or P06A3 is not set.

⇒ **If any of the DTCs are set**

Refer to *DTC P0641, P0651, P0697, or P06A3 (ECM) on page 9-182* for further diagnosis.

⇓ **If none of the DTCs are set**

Note: To minimize the effects of residual engine heat and sensor internal heating elements, perform Steps 2 and 3 of this verification procedure only if the ignition has been OFF for 8 hours or more.

2. Ignition ON.
3. Verify the following scan tool parameters are within 25°C (45°F) of each other.
   - Start-Up IAT Sensor 1
   - IAT Sensor 2
   - IAT Sensor 3, where equipped

⇒ **If not within 25°C (45°F)**

Refer to Circuit/System Testing.

⇓ **If within 25°C (45°F)**

4. Engine idling, verify the following scan tool parameters are between: −38 and +149°C (−36 and +300°F).
   - IAT Sensor 1
   - IAT Sensor 2
   - IAT Sensor 3, where equipped

⇒ **If not between: −38 and +149°C (−36 and +300°F)**

Refer to Circuit System Testing.

⇓ **If between: −38 and +149°C (−36 and +300°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 DTCs do not set.

⇒ **If any of the DTCs set**

Refer to Circuit/System Testing.

⇓ **If none of the DTCs set**

7. All OK

Circuit/System Testing

Note: You must perform the Circuit/System Verification before proceeding with Circuit/System Testing.

1. Check the integrity of the entire air induction system and verify that none of the following conditions exist:
   - A loose or disconnected charge air cooler hose or pipe, where equipped
   - A blocked or obstructed charge air cooler, including: after-market grill covers, where equipped
   - Any snow or ice build-up at the charge air cooler in cold climates, where equipped
   - Any mud or dirt build-up at the charge air cooler, where equipped
   - A restricted or collapsed air intake duct
   - An intake manifold leak
   - A MAP sensor seal that is leaking, missing, or damaged
   - 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 vehicle systems OFF, disconnect the B75C Multifunction Intake Air sensor. It may take up to 2 minutes for all vehicle systems to power down.
3. Test for less than 2 Ω between the low reference circuit terminal 7 and ground.

⇒ **If 2 Ω or greater**

3.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

3.2. 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 ON, test for 4.8–5.2 V between the 5 V reference circuit terminal 2 and ground.

⇒ **If less than 4.8 V**

4.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

4.2. 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

4.3. 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 5 V reference circuit is shorted to a voltage the engine control module or the sensor may be damaged.

4.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

4.2. 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. Ignition ON, test for 4.8–5.2 V between the signal circuit terminal 8 and ground.

⇒ **If less than 4.8 V**

5.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

5.2. 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

5.3. 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.

5.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

5.2. Ignition ON, 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 ON, test for 4.8–5.2 V between the signal terminal 1 and ground.

⇒ **If less than 4.8 V**

6.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

6.2. 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

6.3. 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.

6.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

6.2. Ignition ON, 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. Ignition OFF, connect the leads of the *EN-38522* Variable Signal Generator as follows:
   - Red lead to the signal circuit terminal 1 at the harness connector
   - Black leads to ground
   - Battery voltage supply lead to B+
8. Set the *EN-38522* Variable Signal Generator to the following specifications.
   - Signal switch to 5 V
   - Duty Cycle switch to 50 % (Normal)
   - Frequency switch to 30 Hz
9. Ignition ON, 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**

10. Ignition OFF and all vehicle systems OFF, disconnect the B111B Turbocharger Boost/Intake Air Temperature sensor. It may take up to 2 minutes for all vehicle systems to power down.
11. Test for less than 2 Ω between the low reference circuit terminal 1 and ground.

⇒ **If 2 Ω or greater**

11.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

11.2. 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**

12. Ignition ON, test for 4.8–5.2 V between the signal circuit terminal 2 and ground.

⇒ **If less than 4.8 V**

12.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.

12.2. 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

12.3. 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.

12.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.

12.2. Ignition ON, 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. Test or replace the appropriate temperature 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 (Bosch Sensor) on page 9-26* or *Temperature Versus Resistance - Intake Air Temperature Sensor (Delco Sensor) on page 9-26* table for Bosch Sensors. The resistance values should be in range of the table values.

⇒ **If not within the specified range.**

Replace the B75C Multifunction Intake Air sensor.

⇓ **If within the specified range.**

3. All OK

Multifunction Intake Air Sensor

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

Turbocharger Boost/Intake Air Temperature sensor

1. Ignition OFF, disconnect the harness connector at the B111B Turbocharger Boost/Intake Air Temperature sensor.

Note: A thermometer can be used to test the sensor off the vehicle.

2. Test the IAT sensor 3 by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the *Temperature Versus Resistance - Intake Air Temperature Sensor (Bosch Sensor) on page 9-26* or *Temperature Versus Resistance - Intake Air Temperature Sensor (Delco Sensor) on page 9-26* table for Delco sensors. The resistance values should be in range of the table values.

⇒ **If not within the specified range.**

Replace the B111B Turbocharger Boost/Intake Air Temperature sensor.

⇓ **If within the specified range.**

3. All OK

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Mass Airflow Sensor Replacement on page 9-246* for multifunction intake air sensor replacement.
- *Intake Air Pressure and Temperature Sensor Replacement on page 9-247* for turbocharger boost/intake air temperature sensor replacement.
- *Control Module References on page 6-3* for Engine Control Module replacement, programming, and setup.

DTC P0097 or P0098

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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

Diagnostic Fault Information

IAT Sensor 2

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P0097, P0651, P11C2, P2199, P2227, P2228	P0096, P0097, P11C2, P2199, P2227, P2228	P0097, P0651, P11C2, P2199, P2227, P2228	—
Sensor	P0097, P11C3, P2199	P0097, P11C2, P2199	P0097, P11C2, P2199*	—
Low Reference	—	P0097, P0113, P11C2, P2227, P2229	*	—
*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			
5 V Reference	−40°C (−40°F) 10 Hz	−40°C (−40°F) 10 Hz	—
Signal	−40°C (−40°F)	−40°C (−40°F)	−40°C (−40°F)* 10 Hz*
Ground	—	−40°C (−40°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 multifunction intake air sensor:

- Intake Air Temperature (IAT) sensor 1
- IAT sensor 2
- Humidity sensor
- Mass Air Flow (MAF) sensor
- Barometric (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 °C (°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 2 — Temperature, Frequency Table

IAT Sensor 2	IAT Sensor 2 Frequency	IAT Sensor 2 Temperature
Cold	45 Hz	−40°C (−40°F)
Warm	302 Hz	104°C (219°F)

Conditions for Running the DTCs

P0097 and P0098

- 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 and +150°C (−40 and +302°F).

The ECM detects that the IAT sensor 2 signal is less than 10 Hz, colder than −60°C (−76°F), for greater than 5 s.

P0098

The ECM detects that the IAT sensor 2 signal is greater than 390 Hz, warmer than 150°C (302°F), for greater than 5 s.

Action Taken When the DTC Sets

- DTCs P0097 and P0098 are Type B DTCs.
- The ECM commands the cooling fans ON.

Conditions for Clearing the MIL/DTCs

DTCs P0097 and P0098 are Type B DTCs.

Diagnostic Aids

- With the ignition ON, when the engine is cold and not running, properly functioning IAT sensor 2 will gradually increase the scan tool IAT Sensor 2 parameters. 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; −40°C (-40°F), and there are also Humidity Sensor DTCs, check for a circuit problem.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 Control Module References for scan tool information

Special Tools

EN-38522 Variable Signal Generator

For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308.*

Circuit/System Verification

1. Ignition ON, verify that DTC DTC P0641, P0651, P0697, or P06A3 is not set.

⇒ **If any of the DTCs are set**

Refer to *DTC P0641, P0651, P0697, or P06A3 (ECM) on page 9-182* for further diagnosis.

⇓ **If none of the DTCs are set**

Note: To minimize the effects of residual engine heat and sensor internal heating elements, perform Steps 2 and 3 of this verification procedure only if the ignition has been OFF for 8 hours or more.

2. Ignition ON.
3. Verify the following scan tool parameters are within 25°C (45°F) of each other.
   - Start-Up IAT Sensor 1
   - IAT Sensor 2
   - IAT Sensor 3, where equipped

⇒ **If not within 25°C (45°F)**

Refer to Circuit/System Testing.

⇓ **If within 25°C (45°F)**

4. Engine idling, verify the following scan tool parameters are between: −38 and +149°C (−36 and +300°F).
   - IAT Sensor 1
   - IAT Sensor 2
   - IAT Sensor 3, where equipped

⇒ **If not between: −38 and +149°C (−36 and +300°F)**

Refer to Circuit System Testing.

⇓ **If between: −38 and +149°C (−36 and +300°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 DTCs do not set.

⇒ **If any of the DTCs set**

Refer to Circuit/System Testing.

⇓ **If none of the DTCs set**

7. All OK

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the B75C Multifunction Intake Air sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 2 Ω between the low reference circuit terminal 7 and ground.

⇒ **If 2 Ω or greater**

2.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

2.2. 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, test for 4.8–5.2 V between the 5 V reference circuit terminal 2 and ground.

⇒ **If less than 4.8 V**

3.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

3.2. 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

3.3. 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 5 V reference circuit is shorted to a voltage the engine control module or the sensor may be damaged.

3.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

3.2. 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**

4. Ignition ON, test for 4.8–5.2 V between the signal circuit terminal 1 and ground.

⇒ **If less than 4.8 V**

4.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

4.2. 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

4.3. 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.

4.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

4.2. Ignition ON, 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. Ignition OFF, connect the leads of the *EN-38522* Variable Signal Generator as follows:
   - Red lead to the signal circuit terminal 1 at the harness connector
   - Black lead to ground
   - Battery voltage supply lead to B+
6. Set the *EN-38522* Variable Signal Generator to the following specifications.
   - Signal switch to 5 V
   - Duty Cycle switch to 50 % (Normal)
   - Frequency switch to 30 Hz
7. Ignition ON, 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**

8. Test or replace the B75C Multifunction Intake Air sensor.

Component Testing

Multifunction Intake Air Sensor

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%.**

All OK

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Mass Airflow Sensor Replacement on page 9-246* for multifunction intake air sensor replacement.
- *Control Module References on page 6-3* for Engine Control Module replacement, programming, and setup.

DTC P00B6

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC P00B6: Radiator Coolant Temperature (RCT) – Engine Coolant Temperature (ECT) Not Plausible

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
RCT Sensor Signal	—	—	—	P00B6
Low Reference	—	—	—	P00B6

Circuit/System Description

The radiator coolant temperature (RCT) sensor is a variable resistor that measures the temperature of the radiator coolant. The ECM supplies 5 V to the RCT sensor signal circuit and supplies a ground for the low reference circuit.

The following table illustrates the difference between temperature, resistance, and voltage:

RCT	RCT Resistance	RCT Signal Voltage
Cold	High	High
Warm	Low	Low

Conditions for Running the DTC

- DTCs P0112, P0113, P0117, or P0118 are not set.
- The ignition has been off for greater than 8 h before vehicle is started.
- The ignition is ON, or the engine is running.
- The intake air temperature (IAT) is greater than −7°C (19°F).
- The fuel level is greater than 10%.
- The DTC runs once per ignition cycle when the above conditions are met.

Conditions for Setting the DTC

This DTC sets if one of the following conditions occurs for less than 1 s:

- The ECM detects the RCT sensor and the ECT sensor are greater than a predetermined intake air temperature at engine start-up.
- The ECM detects the RCT sensor is 20°C (68°F) warmer than the ECT sensor at engine start-up and the block heater has not been detected.
- The ECM detects the RCT sensor is 20°C (68°F) warmer than the ECT sensor at engine start-up and the engine has been cranking for greater than 10 s without a fuel level sensor DTC.

Action Taken When the DTC Sets

DTC P00B6 is a Type B DTC.

Conditions for Clearing the DTC

DTC P00B6 is a Type B DTC.

Diagnostic Aids

- If the vehicle has sat overnight, the RCT sensor and the ECT sensor values should display within 3°C (5°F).
- As the thermostat opens, the RCT sensor temperature should rise steadily, then stabilize once the thermostat opens completely.
- Test the RCT sensor at various temperature levels in order to evaluate the possibility of a skewed sensor.
- Inspect for the correct operation of the engine cooling system and verify the correct coolant level.
- If the condition is intermittent, allowing the vehicle to sit for greater than 8 h with the ignition OFF, may help isolate the condition. Compare the scan tool RCT and ECT temperature sensor values at Ignition ON. The RCT sensor and the ECT sensor values should display within 3°C (5°F).

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Cooling System Description and Operation on page 9-680

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*

- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Ignition ON, observe the DTC information with a scan tool. DTC P0117, P0118, P0597, P0598, or P0599 should not be set.
   ⇒ If a DTC is set, refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69* for further diagnosis.
2. Verify the coolant in the radiator surge tank is at the correct level and there are no engine coolant leaks. Refer to *Cooling System Draining and Filling on page 9-628* and *Loss of Coolant on page 9-625*.
3. Engine idling for 15 min with the A/C OFF.

Note: Depending on ambient temperature, it may take up to 4 min for the temperatures to equalize.

4. Command the engine coolant thermostat heater to 100% with a scan tool. Increase the engine speed to 3 000 RPM. Observe the scan tool RCT and the ECT sensor parameters. The RCT and the ECT sensor parameters should be within 20°C (68°F).
5. Operate the vehicle within the conditions for running the DTC to verify the DTC does not reset. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the B34B Engine Coolant Temperature Sensor 2.
2. Ignition OFF for 1 min, test for less than 5 Ω between the low reference circuit terminal 1 and ground.
   ⇒ If greater than the specified range, test the low reference circuit for an open/high resistance. If the circuit tests normal, replace the K20 Engine Control Module.
3. Ignition ON, verify the scan tool Radiator Coolant Temperature Sensor parameter is −40°C (−40°F).
   ⇒ If greater than the specified range, test the signal circuit terminal 2 for a short to ground. If the circuit tests normal, replace K20 Engine Control Module.

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.

4. Install a 1 A fused jumper wire between the signal circuit terminal 2 and the low reference circuit terminal 1. Verify the scan tool Radiator Coolant Temperature Sensor parameter is at 140°C (284°F).
   ⇒ If less than specified range, test the signal circuit for a short to voltage or an open/high resistance. If the circuit tests normal, replace the K20 Engine Control Module.
5. If all circuits test normal, test or replace the B34B Engine Coolant Temperature Sensor 2.

Component Testing

Static Test

1. Ignition OFF, disconnect the harness connector at the B34B Engine Coolant Temperature Sensor 2.

Note: A thermometer can be used to the used to test the sensor off the vehicle.

2. Test the B34B Engine Coolant Temperature Sensor 2 by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the table *Temperature Versus Resistance (ECT) on page 9-26* and verify that the resistance is within 5% of the specification.
   ⇒ If not within the specified range, replace the B34B Engine Coolant Temperature Sensor 2.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

- *Control Module References on page 6-3* for ECM replacement, programming and setup
- *Engine Coolant Temperature Sensor Replacement (Water Outlet) on page 9-244* or *Engine Coolant Temperature Sensor Replacement (Thermostat) on page 9-246* or *Engine Coolant Temperature Sensor Replacement (Radiator) on page 9-245*

DTC P00C7

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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 3 sensors, the barometric pressure (BARO) sensor, the manifold absolute pressure (MAP) sensor, and the turbo boost sensor.

Conditions for Running the DTC

- DTCs P0106, P0107, P0108, P2122, P2123, P2127, P2128, P2138 or P2610 are not set.
- The engine is running.
- Time between current ignition cycle and the last time the engine was running is greater than 10 s.
- Manifold pressure between 50–115 kPa (7.25–16.68 PSI).
- BARO pressure between 50–115 kPa (7.25–16.68 PSI).
- Turbocharger boost pressure between 50–115 kPa (7.25–16.68 PSI).
- This DTC runs continuously within the enabling conditions.

Conditions for Setting the DTC

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 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 on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Ignition ON, observe the DTC information with a scan tool. Verify that DTCs P0106, P0107, P0236, P0237, P0238, P2227, P2228, P2229, or P2230, are not set.

⇒ **If any of the DTCs are set**

If a DTC is set, refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69* for further diagnosis.

⇓ **If none of the DTCs is set**

2. Ignition ON, verify the following scan tool parameters are within range of the Altitude vs. Barometric Pressure table. Refer to: *Altitude Versus Barometric Pressure on page 9-26* table.
   - BARO Sensor
   - MAP Sensor
   - Turbo Boost Sensor

⇒ **If a sensor parameter is not within range**

Refer to the appropriate diagnostic below for further diagnosis.

- Barometric Pressure (BARO) Sensor. Refer to: *DTC P2227-P2230 on page 9-214*
- Manifold Absolute Pressure (MAP) Sensor. Refer to: *DTC P0106 on page 9-84*
- Turbocharger Boost Pressure Sensor. Refer to: *DTC P0236 on page 9-128*

⇓ **If all sensor parameters are within range**

3. All OK

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

Control Module References on page 6-3 for Engine Control Module replacement, programming and setup

DTC P00EA or P00EB

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptors

DTC P00EA: Intake Air Temperature (IAT) Sensor 3 Circuit Low Voltage
DTC P00EB: Intake Air Temperature (IAT) Sensor 3 Circuit High Voltage

Diagnostic Fault Information

IAT Sensor 3

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Sensor	P00EA, P00EB	P00E9, P00EB	P00EB*	P00E9
Low Reference	—	P00E9, P00EB	P00EB*	—
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

IAT Sensor 3

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			
Sensor	150°C (302°F)	−40°C (−40°F)	−40°C (−40°F)*
Low Reference	—	−40°C (−40°F)	−40°C (−40°F)*
*Internal ECM or sensor damage may occur if the circuit is shorted to B+			

Circuit/System Description

The intake air temperature (IAT) sensor 3 is a variable resistor that changes an engine control module (ECM) supplied 5 V signal. The signal varies with inlet air temperature and is displayed by the scan tool as °C (° F). The IAT sensor 3 is integrated with the throttle inlet absolute pressure sensor in the sensor bore, which is located before the throttle body. The ECM provides a ground for the IAT sensor 3 low reference circuit.

Conditions for Running the DTCs

P00EA and P00EB

- The ignition is ON, or the engine is running.
- The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

P00EA

The ECM detects that the IAT sensor 3 signal is warmer than 149°C (300°F) for at least 5 s.

P00EB

Note: The scan tool display range is between −40 and +150°C (−40 and +302°F).

The ECM detects that the IAT sensor 3 signal is colder than −60°C (−76°F) for at least 5 s.

Action Taken When the DTCs Set

- DTCs P00EA and P00EB are Type B DTCs.
- The ECM commands the cooling fans ON.

Conditions for Clearing the DTCs

DTCs P00EA and P00EB are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

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 25°C (45°F) of each other.
   - Start-Up IAT Sensor 1
   - IAT Sensor 2
   - IAT Sensor 3

⇒ **If not within 25°C (45°F)**

Refer to Circuit/System Testing.

⇓ **If within 25°C (45°F)**

3. Engine idling, verify the IAT Sensor 3 scan tool parameter is between: −38 and +149°C (−36 and +300°F).

⇒ **If not between: −38 and +149°C (−36 and +300°F)**

Refer to Circuit System Testing.

⇓ **If between: −38 and +149°C (−36 and +300°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 of the DTCs set**

Refer to Circuit/System Testing.

⇓ **If none of the DTCs set**

6. All OK

Circuit/System Testing

Note: You must perform the Circuit/System Verification before proceeding with Circuit/System Testing.

1. Ignition OFF and all vehicle systems OFF, disconnect the B111B Turbocharger Boost/Intake Air Temperature sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 2 Ω between the low reference circuit terminal 1 and ground.

⇒ **If 2 Ω or greater**

2.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

2.2. 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, test for 4.8–5.2 V between the signal circuit terminal 2 and ground.

⇒ **If less than 4.8 V**

3.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.

3.2. 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

3.3. 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.

3.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.

3.2. Ignition ON, 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**

4. Test or replace the B111B Turbocharger Boost/ Intake Air Temperature sensor.

Component Testing

Turbocharger Boost/Intake Air Temperature sensor

1. Ignition OFF, disconnect the harness connector at the B111B Turbocharger Boost/Intake Air Temperature sensor.

Note: A thermometer can be used to test the sensor off the vehicle.

2. Test the IAT sensor 3 by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the *Temperature Versus Resistance - Intake Air Temperature Sensor (Bosch Sensor) on page 9-26* or *Temperature Versus Resistance - Intake Air Temperature Sensor (Delco Sensor) on page 9-26* table for Delco sensors. The resistance values should be in range of the table values.

⇒ **If not within the specified range.**

Replace the B111B Turbocharger Boost/Intake Air Temperature sensor.

⇓ **If within the specified range.**

3. All OK

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Intake Air Pressure and Temperature Sensor Replacement on page 9-247* for turbocharger boost/intake air temperature replacement.
- *Control Module References on page 6-3* for Engine Control Module replacement, programming, and setup.

DTC P00E9

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC P00E9: Intake Air Temperature (IAT) Sensor 3 Circuit Performance

Diagnostic Fault Information

IAT Sensor 3

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Sensor	P00EA, P00EB	P00E9, P00EB	P00EB*	P00E9
Low Reference	—	P00E9, P00EB	P00EB*	—
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

IAT Sensor 3

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			
Sensor	150°C (302°F)	−40°C (−40°F)	−40°C (−40°F)*
Low Reference	—	−40°C (−40°F)	−40°C (−40°F)*
*Internal ECM or sensor damage may occur if the circuit is shorted to B+			

Circuit/System Description

The intake air temperature (IAT) sensor 3 is a variable resistor that changes an engine control module (ECM) supplied 5 V signal. The signal varies with inlet air temperature and is displayed by the scan tool as °C (° F). The IAT sensor 3 is integrated with the turbocharger boost pressure sensor in the sensor bore, which is located before the throttle body. The ECM supplies a ground for the IAT sensor 3 low reference circuit.

IAT Sensor 3 — Temperature, Resistance, Voltage Table

IAT Sensor 3	IAT Sensor 3 Resistance	IAT Sensor 3 Signal Voltage
Cold	High	High
Warm	Low	Low

Conditions for Running the DTC

P00E9

- DTCs P0097, P0098, P00EA, P00EB, P0111, P0112, P0113, P0117, P0118, or P1682 are not set.
- The vehicle has been OFF at least 8 hours.
- Ignition voltage is at least 11 V.
- This DTC runs once per ignition cycle when the enabling conditions are met.

Conditions for Setting the DTC

Note: P00E9 Can fail under any of the following 3 sets of conditions.

P00E9–Condition 1

- The ECM determines the absolute difference between IAT sensor 1 start-up temperature and the IAT sensor 2 start-up temperature is less or equal to 25°C (45°F).

  AND

- The ECM determines the absolute difference between IAT sensor 3 start-up temperature and the IAT sensor 1 start-up temperature is greater than 25°C (45°F).

  AND

- The ECM determines the absolute difference between IAT sensor 3 start-up temperature and the IAT sensor 2 start-up temperature is greater than 25°C (45°F).

P00E9–Condition 2

- The ECM determines the IAT sensor 1 start-up temperature is between the IAT sensor 3 and the IAT sensor 2 start-up temperatures

  AND

- The ECM determines the absolute difference between IAT sensor 3 start-up temperature and the IAT sensor 2 start-up temperature is greater than 25°C (45°F).

  AND

- The ECM determines the absolute difference between IAT sensor 3 and the IAT sensor 1 start-up temperatures is greater than the absolute difference between IAT sensor 2 and the IAT sensor 1 start-up temperatures.

P00E9–Condition 3

- The ECM determines the IAT sensor 2 start-up temperature is between the IAT sensor 3 and the IAT sensor 1 start-up temperatures

  AND

- The ECM determines the absolute difference between IAT sensor 3 and the IAT sensor 1 start-up temperatures is greater than 25°C (45°F).

  AND

- The absolute difference between IAT sensor 3 and the IAT sensor 2 start-up temperatures is greater than the absolute difference between IAT sensor 2 and the IAT sensor 1 start-up temperatures.

DTC P00E9 runs once an ignition cycle when one of the above 3 enabling sets of conditions are met.

Action Taken When the DTC Sets

DTC P00E9 is a Type B DTC.

Conditions for Clearing the DTCs

DTC P00E9 is a Type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Special Tools

EN-38522 Variable Signal Generator

For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308.*

Circuit/System Verification

1. Ignition ON, verify that DTC DTC P0641, P0651, P0697, or P06A3 is not set.

⇒ **If any of the DTCs are set**

Refer to *DTC P0641, P0651, P0697, or P06A3 (ECM) on page 9-182* for further diagnosis.

⇓ **If none of the DTCs are set**

Note: To minimize the effects of residual engine heat and sensor internal heating elements, perform Steps 2 and 3 of this verification procedure only if the ignition has been OFF for 8 hours or more.

2. Ignition ON.
3. Verify the following scan tool parameters are within 25°C (45°F) of each other.
   - Start-Up IAT Sensor 1
   - IAT Sensor 2
   - IAT Sensor 3

⇒ **If not within 25°C (45°F)**

Refer to Circuit/System Testing.

⇓ **If within 25°C (45°F)**

4. Engine idling, verify the following scan tool parameters are between: −38 and +149°C (−36 and +300°F).
   - IAT Sensor 1
   - IAT Sensor 2
   - IAT Sensor 3

⇒ **If not between: −38 and +149°C (−36 and +300°F)**

Refer to Circuit System Testing.

⇓ **If between: −38 and +149°C (−36 and +300°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 DTCs do not set.

⇒ **If any of the DTCs set**

Refer to Circuit/System Testing.

⇓ **If none of the DTCs set**

7. All OK

Circuit/System Testing

Note: You must perform the Circuit/System Verification before proceeding with Circuit/System Testing.

1. Check the integrity of the entire air induction system and verify that none of the following conditions exist:
   - A loose or disconnected charge air cooler hose or pipe
   - A blocked or obstructed charge air cooler, including: after-market grill covers
   - Any snow or ice build-up at the charge air cooler in cold climates
   - Any mud or dirt build-up at the charge air cooler
   - A restricted or collapsed air intake duct
   - An intake manifold leak
   - A MAP sensor seal that is leaking, missing, or damaged
   - 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 vehicle systems OFF, disconnect the B75C Multifunction Intake Air sensor. It may take up to 2 minutes for all vehicle systems to power down.
3. Test for less than 2 Ω between the low reference circuit terminal 7 and ground.

⇒ **If 2 Ω or greater**

3.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

3.2. 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 ON, test for 4.8–5.2 V between the 5 V reference circuit terminal 2 and ground.

⇒ **If less than 4.8 V**

4.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

4.2. 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

4.3. 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 5 V reference circuit is shorted to a voltage the engine control module or the sensor may be damaged.

4.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

4.2. 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. Ignition ON, test for 4.8–5.2 V between the signal terminal 8 and ground.

⇒ **If less than 4.8 V**

5.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

5.2. 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

5.3. 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.

5.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

5.2. Ignition ON, 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 ON, test for 4.8–5.2 V between the signal terminal 1 and ground.

⇒ **If less than 4.8 V**

6.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

6.2. 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

6.3. 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.

6.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

6.2. Ignition ON, 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. Ignition OFF, connect the leads of the *EN-38522* Variable Signal Generator as follows:
   - Red lead to the signal circuit terminal 1 at the harness connector
   - Black leads to ground
   - Battery voltage supply lead to B+
8. Set the *EN-38522* Variable Signal Generator to the following specifications.
   - Signal switch to 5 V
   - Duty Cycle switch to 50 % (Normal)
   - Frequency switch to 30 Hz
9. Ignition ON, 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**

10. Ignition OFF and all vehicle systems OFF, disconnect the B111B Turbocharger Boost/Intake Air Temperature sensor. It may take up to 2 minutes for all vehicle systems to power down.
11. Test for less than 2 Ω between the low reference circuit terminal 1 and ground.

⇒ **If 2 Ω or greater**

11.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

11.2. 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**

12. Ignition ON, test for 4.8–5.2 V between the signal terminal 2 and ground.

⇒ **If less than 4.8 V**

12.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.

12.2. 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

12.3. 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.

12.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.

12.2. Ignition ON, 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. Test or replace the appropriate temperature 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 (Bosch Sensor) on page 9-26* or *Temperature Versus Resistance - Intake Air Temperature Sensor (Delco Sensor) on page 9-26* table for Bosch Sensors. The resistance values should be in range of the table values.

⇒ **If not within the specified range.**

Replace the B75C Multifunction Intake Air sensor.

⇓ **If within the specified range.**

3. All OK

Multifunction Intake Air Sensor

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

Turbocharger Boost/Intake Air Temperature sensor

1. Ignition OFF, disconnect the harness connector at the B111B Turbocharger Boost/Intake Air Temperature sensor.

Note: A thermometer can be used to test the sensor off the vehicle.

2. Test the IAT sensor 3 by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the *Temperature Versus Resistance - Intake Air Temperature Sensor (Bosch Sensor) on page 9-26* or *Temperature Versus Resistance - Intake Air Temperature Sensor (Delco Sensor) on page 9-26* table for Delco sensors. The resistance values should be in range of the table values.

⇒ **If not within the specified range.**

Replace the B111B Turbocharger Boost/Intake Air Temperature sensor.

⇓ **If within the specified range.**

3. All OK

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Intake Air Pressure and Temperature Sensor Replacement on page 9-247* for turbocharger boost/intake air temperature sensor replacement.
- *Mass Airflow Sensor Replacement on page 9-246* for multifunction intake air sensor replacement.
- *Control Module References on page 6-3* for Engine Control Module replacement, programming, and setup.

DTC P0101

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC P0101: Mass Air Flow (MAF) Sensor Performance

Diagnostic Fault Information

MAF Sensor

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0102	P0102, P01101	P0690	P0101
Sensor	P0102, P1101	P0102, P1101	P0102*	P0101, P1101
Ground	—	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	—
Sensor	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 sensors listed below are integrated within the multifunction intake air sensor:

- Intake Air Temperature (IAT) sensor 1
- IAT sensor 2
- Humidity sensor
- Mass Air Flow (MAF) sensor
- Barometric (BARO) pressure sensor

The MAF sensor is an air flow meter that measures the amount of air flowing 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 signal circuit. The sensor produces 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). Vehicle ignition voltage and ground circuits are also supplied to the MAF sensor.

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.

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

Conditions for Running the DTCs

- DTCs P0096, P0097, P0098, P0102, P0103, P0107, P0111, P0112, P0113, P0116, P0117, P0118, P0119, P0237, P0238, P0335, P0336, P2227, P2228, P2229, or P2230 are not set.
- The engine speed is between 400–6,000 RPM.
- The engine coolant temperature (ECT) is between −7 and +125°C (+19 and +257°F).
- The intake air temperature (IAT) is between −20 and +100°C (−4 and +212°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 airflow from the MAF, MAP, and throttle position sensors is not within range of the calculated airflow 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

- 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.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Special Tools

EN-38522 Variable Signal Generator

For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308*.

Circuit/System Verification

1. Ignition ON, verify that DTC DTC P0641, P0651, P0697, or P06A3 is not set.

⇒ **If any of the DTCs are set**

Refer to *DTC P0641, P0651, P0697, or P06A3 (ECM) on page 9-182* for further diagnosis.

⇓ **If none of the DTCs are set**

2. If you were sent here from DTC P0068, P0106, P0121, P0236, or P1101; refer to Circuit/System Testing.
3. Ignition ON.
4. Verify the scan tool Throttle Body Idle Airflow Compensation parameter is less than 90 %.

⇒ **If 90 % or greater**

Refer to *Throttle Body Inspection and Cleaning on page 9-253*.

⇓ **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 Test with a scan tool.

⇒ **If Disagree**

Refer to *DTC P0121-P0123, P0222, P0223, or P2135 (LUV) on page 9-102* for further diagnosis.

⇓ **If Agree**

6. Determine the current vehicle testing altitude.
7. Verify the scan tool MAP Sensor pressure parameter is within the range specified in the *Altitude Versus Barometric Pressure on page 9-26* table.

⇒ **If the MAP Sensor parameter is not in range**

Refer to *DTC P0106 on page 9-84* for further diagnosis.

⇓ **If the MAP Sensor parameter is within range**

8. Verify the engine is equipped with a turbocharger.

⇒ **If not equipped with a turbocharger**

Refer to Step 11.

⇓ **If equipped with a turbocharger**

9. Verify the scan tool Boost Pressure Sensor parameter is within the range specified in the *Altitude Versus Barometric Pressure on page 9-26* table.

⇒ **If the Boost Pressure Sensor parameter is not in range**

Refer to *DTC P0236 on page 9-128* for further diagnosis.

⇓ **If the Boost Pressure Sensor parameter is within range**

10. Verify the scan tool Boost Pressure Sensor parameter decreases after starting the engine.

⇒ **If the Boost Pressure Sensor parameter does not decrease**

Refer to *DTC P0236 on page 9-128* for further diagnosis.

⇓ **If the Boost Pressure Sensor parameter does decrease**

11. Engine idling, 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 between 26–52 kPa (3.8–7.5 psi) or does not change**

Refer to *DTC P0106 on page 9-84* for further diagnosis.

⇓ **If between 26–52 kPa (3.8–7.5 psi) 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.
    - 12.1. Engine idling
    - 12.2. Perform the scan tool snapshot function.
    - 12.3. Increase the engine speed slowly to 3,000 RPM and then back to idle.
    - 12.4. Exit from the scan tool snapshot and review the data.
    - 12.5. 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 Circuit/System Testing.

⇓ **If the MAF Sensor 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 a DTC does not set.

⇒ **If any DTC sets**

Refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69* for further diagnosis.

⇓ **If no DTCs set**

15. All OK

Circuit/System Testing

Note: You must perform the Circuit/System Verification before proceeding with Circuit/System Testing.

1. Check the integrity of the entire air induction system by verifying that none of the following conditions exist:
    - Any damaged components
    - Improper operation of turbocharger wastegate actuator or bypass valve, where equipped
    - 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 4 and ground.

⇒ **If 2 Ω or greater**

- 3.1. Ignition OFF.
- 3.2. 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.
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**

- 5.1. Ignition OFF, remove the test lamp and remove the fuse for the ignition circuit.
- 5.2. 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**

5.1. Ignition OFF, remove the test lamp and remove the fuse for the ignition circuit.

5.2. 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

5.3. Test for greater than 2 Ω between the ignition circuit terminal 5 and ground.

⇒ If less than 2 Ω, repair the short to ground on the circuit.

⇒ If greater than 2 Ω, test all the components connected to the circuit and repair or replace as necessary.

⇓ **If a test lamp illuminates**

6. Ignition ON, test for 4.8–5.2 volts between the signal circuit terminal 3 and ground.

⇒ **If less than 4.8 V**

6.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

6.2. 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

6.3. 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**

6.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

6.2. Ignition ON, 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. Ignition OFF, connect the leads of the *EN-38522* Variable Signal Generator as follows:
   - Red lead to the signal circuit terminal 3 at the harness connector
   - Black lead to ground
   - Battery voltage supply lead to B+
8. Set the *EN-38522* Variable Signal Generator to the following specifications.
   - Signal switch to 5 V
   - Frequency switch to 5 kHz
   - Duty Cycle switch to 50 % (Normal)
9. Engine idling, verify the scan tool MAF Sensor parameter is 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.**

10. Test or replace the B75C Multifunction Intake Air sensor.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Mass Airflow Sensor Replacement on page 9-246* for multifunction intake air sensor replacement.
- *Control Module References on page 6-3* for Engine Control Module replacement, programming, and setup.

DTC P0102 or P0103

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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

MAF Sensor

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0102	P0102, P01101	P0690	P0101
Sensor	P0102, P1101	P0102, P1101	P0102*	P0101, P1101
Ground	—	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	—
Sensor	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 sensors listed below are integrated within the multifunction intake air sensor:

- Intake Air Temperature (IAT) sensor 1
- IAT sensor 2
- Humidity sensor
- Mass Air Flow (MAF) sensor
- Barometric (BARO) pressure sensor

The MAF sensor is an air flow meter that measures the amount of air flowing 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 signal circuit. The sensor produces 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). Vehicle ignition voltage and ground circuits are also supplied to the MAF sensor.

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

Conditions for Running the DTCs

- The engine is running for at least 1 s.
- The engine speed is at least 300 RPM.
- The ignition signal is at least 10 V.

- The above conditions are met for at least 1 s.
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTCs

P0102

The ECM detects that the MAF Sensor signal parameter is less than 1,837 Hz (about 0.39 g/s) for at least 250 cylinder firing events.

P0103

The ECM detects that the MAF Sensor signal parameter is at least 13,200 Hz (about 810 g/s) for at least 250 cylinder firing events.

Action Taken When the DTCs Set

DTCs P0102 and P0103 are Type B DTCs.

Conditions for Clearing the MIL/DTCs

DTCs P0102 and P0103 are Type B DTCs.

Diagnostic Aids

Verify that any electrical aftermarket devices are properly connected and grounded. Refer to *Checking Aftermarket Accessories on page 11-525*.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Special Tools

EN-38522 Variable Signal Generator

For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308*.

Circuit/System Verification

1. Engine idling, verify the scan tool MAF Sensor parameter is between 1.75–5.5 g/s.

⇒ **If not between 1.75–5.5 g/s**

Refer to Circuit/System Testing.

⇓ **If between 1.75–5.5 g/s**

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.
   2.1. Engine idling
   2.2. Perform the scan tool snapshot function.
   2.3. Increase the engine speed slowly to 3,000 RPM and then back to idle.
   2.4. Exit from the scan tool snapshot and review the data.
   2.5. 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 Circuit/System Testing.

⇓ **If 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 a DTC does not set.

⇒ **If any DTC sets**

Refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69* for further diagnosis.

⇓ **If no DTCs set**

5. All OK

Circuit/System Testing

Note: You must perform the Circuit/System Verification before proceeding with Circuit/System Testing.

1. Ignition OFF, disconnect the harness connector at the B75C Multifunction Intake Air sensor.
2. Test for less than 2 Ω between the ground circuit terminal 4 and ground.

⇒ **If 2 Ω or greater**

   2.1. Ignition OFF. Disconnect the sensor chassis ground.
   2.2. 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**

   4.1. Ignition OFF, remove the test lamp and remove the fuse for the ignition circuit.
   4.2. 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**

4.1. Ignition OFF, remove the test lamp and remove the fuse for the ignition circuit.

4.2. 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

4.3. Test for greater than 2 Ω between the ignition circuit terminal 5 and ground.

⇒ If less than 2 Ω, repair the short to ground on the circuit.

⇒ If greater than 2 Ω, test all the components connected to the circuit and repair or replace as necessary.

⇓ **If a test lamp illuminates**

5. Ignition ON, test for 4.8–5.2 volts between the signal circuit terminal 3 and ground.

⇒ **If less than 4.8 V**

5.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

5.2. 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

5.3. 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**

5.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

5.2. Ignition ON, 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 the leads of the *EN-38522* Variable Signal Generator as follows:
   - Red lead to the signal circuit terminal 3 at the harness connector
   - Black lead to ground
   - Battery voltage supply lead to B+
7. Set the *EN-38522* Variable Signal Generator to the following specifications.
   - Signal switch to 5 V
   - Frequency switch to 5 kHz
   - Duty Cycle switch to 50 % (Normal)
8. Engine idling, verify the scan tool MAF Sensor parameter is 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.**

9. Test or replace the B75C Multifunction Intake Air sensor.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Mass Airflow Sensor Replacement on page 9-246* for multifunction intake air sensor replacement.
- *Control Module References on page 6-3* for Engine Control Module replacement, programming, and setup.

DTC P0106

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC P0106: Manifold Absolute Pressure (MAP) Sensor Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P0107, P0697	P0106, P0107	P0108, P0697	P0106
Signal	P0107	P0106, P0107	P0108	P0106
Low Reference	—	P0106, P0108	—	P0106

Typical Scan Tool Data

MAP Sensor

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running at various operating conditions **Parameter Normal Range:** 12–103 kPa (1.7–14.9 psi)			
5 V Reference	0 kPa (0 psi)	0 kPa (0 psi)	104 kPa (15.1 psi)
Signal	0 kPa (0 psi)	0 kPa (0 psi)	104 kPa (15.1 psi)*
Low Reference	—	80–103 kPa (11.6–14.9 psi)	—
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

MAP Sensor, when equipped with Turbocharger

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running at various operating conditions **Parameter Normal Range:** 12–225 kPa (1.7–32.6 psi)			
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 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 where 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. Where 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 are not set.
- The engine speed is between 400–6 500 RPM.
- The engine coolant temperature (ECT) sensor is between −7 to +125°C (19.4–257°F).
- The intake air temperature (IAT) sensor is between −20 to +125°C (−4 to +257°F).
- This DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

The ECM detects that the MAP sensor pressure is not within range of the calculated pressure that is derived from the system of models for more than 0.5 s.

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 on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Turbocharger System Description on page 9-306

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Special Tools

EN-23738-A Vacuum Pump

For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308.*

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 (ECM) on page 9-182* for further diagnosis.

⇓ **If none of the DTC are set**

3. If you were sent here from DTC P0068, P0101, P0121, P0236, or P1101; refer to Circuit/System Testing.
4. Ignition ON.
5. Verify the scan tool Throttle Body Idle Airflow Compensation parameter is less than 90 %.

⇒ **If 90% or greater**

Refer to *Throttle Body Inspection and Cleaning on page 9-253.*

⇓ **If less than 90%**

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 Disagree**

Refer to *DTC P0121-P0123, P0222, P0223, or P2135 (LUV) on page 9-102* for further diagnosis.

⇓ **If Agree**

7. Determine the current vehicle testing altitude.
8. Verify the scan tool MAP Sensor pressure parameter is within the range specified in the *Altitude Versus Barometric Pressure on page 9-26* table.

⇒ **If the MAP Sensor parameter is not in range**

Refer to Circuit/System Testing.

⇓ **If the MAP Sensor parameter is in range**

9. Verify the engine is equipped with a turbocharger.

⇒ **If not equipped with a turbocharger**

Refer to Step 12.

⇓ **If equipped with a turbocharger**

10. Verify the scan tool Boost Pressure Sensor parameter is within the range specified in the *Altitude Versus Barometric Pressure on page 9-26* table.

⇒ **If the Boost Pressure Sensor parameter is not in range**

Refer to *DTC P0236 on page 9-128* for further diagnosis.

⇓ **If the Boost Pressure Sensor parameter is in range**

11. Verify the scan tool Boost Pressure Sensor parameter decreases after starting the engine.

⇒ **If the Boost Pressure Sensor parameter does not decrease**

Refer to *DTC P0236 on page 9-128* for further diagnosis.

⇓ **If the Boost Pressure Sensor parameter is within range**

12. Engine idling, 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 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**

13. 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.
    13.1. Engine idling
    13.2. Perform the scan tool snapshot function.
    13.3. Increase the engine speed slowly to 3,000 RPM and then back to idle.
    13.4. Exit from the scan tool snapshot and review the data.
    13.5. 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 on page 9-77*.

⇓ **If the MAF Sensor parameter does change smoothly and gradually**

14. 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.
15. Verify a DTC does not set.

⇒ **If the DTC sets**

Refer to Circuit/System Testing.

⇓ **If the DTC does not set**

16. All OK.

Circuit/System Testing

1. Check 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, where equipped
   - Loose or improper installation of the turbocharger and the charge air cooler, including the flexible ductwork, where 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, where equipped
   - A restriction in the MAP sensor port or the BARO port
   - Proper operation of the Positive Crankcase Ventilation (PCV) system
   - Missing, restricted or leaking exhaust components. Refer to *Symptoms - Engine Exhaust on page 9-734*.
   - Engine mechanical condition; for example: low compression or incorrect timing chain installation. Refer to *Symptoms - Engine Mechanical on page 9-770*.

⇒ **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, disconnect the B74 Manifold Absolute Pressure sensor. It may take up to 2 minutes for all vehicle systems to power down.
3. Test for less than 2 Ω between the low reference circuit terminal 2 and ground.

⇒ **If 2 Ω or greater**

3.1. Ignition OFF, disconnect the K20 Engine Control Module, listed below:
   - X2 harness connector, ECM with 2 face mounted connectors
   - X3 harness connector, ECM with 3 face mounted connectors

3.2. 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**

5.1. Ignition OFF, disconnect the K20 Engine Control Module, listed below:
   - X2 harness connector, ECM with 2 face mounted connectors
   - X3 harness connector, ECM with 3 face mounted connectors

5.2. 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

5.3. 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 engine control module or the sensor may be damaged.

⇒ **If greater than 5.2 V**

5.1. Ignition OFF, disconnect the K20 Engine Control Module, listed below:
- X2 harness connector, ECM with 2 face mounted connectors
- X3 harness connector, ECM with 3 face mounted connectors

5.2. 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. Ignition ON, verify the scan tool MAP Sensor parameter is less than 0.5 V.

⇒ **If 0.5 V or greater**

6.1. Ignition OFF, disconnect the K20 Engine Control Module, listed below:
- X2 harness connector, ECM with 2 face mounted connectors
- X3 harness connector, ECM with 3 face mounted connectors

6.2. Ignition ON, 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. Ignition OFF, install a 3 A fused jumper wire between the signal circuit terminal 3 and the 5 V reference circuit terminal 1.
8. Ignition ON, verify the scan tool MAP voltage parameter is greater than 4.5 V.

⇒ **If 4.5 V or less**

8.1. Ignition OFF, disconnect the K20 Engine Control Module, listed below:
- X2 harness connector, ECM with 2 face mounted connectors
- X3 harness connector, ECM with 3 face mounted connectors

8.2. Remove the jumper wire, 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

8.3. 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**

9. Test or replace the B74 Manifold Absolute Pressure sensor.

Component Testing

Note: You must perform the Circuit/System Testing in order to Check 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, apply –17 kPa (5.0 inHg) of vacuum to the B74 Manifold Absolute Pressure sensor, with the *EN-23738-A* Vacuum Pump. Verify the scan tool MAP 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).**

3. Apply –34 kPa (10.0 inHg) of vacuum to the B74 Manifold Absolute Pressure sensor, with the *EN-23738-A* Vacuum Pump. Verify the scan tool MAP 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).**

4. 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 0-15kPa of vacuum to the sensor with the *EN-23738-A* Vacuum Pump. Verify the voltage changes, without any spikes or dropouts, between 4.9–0.2 V.

⇒ **If not between 4.9–0.2 V or has spikes or dropouts**

Replace the B74 Manifold Absolute Pressure sensor.

⇓ **If between 4.9–0.2 V and there are no spikes or dropouts**

7. All OK.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

- *Manifold Absolute Pressure Sensor Replacement on page 9-248*
- *Control Module References on page 6-3* for Engine Control Module replacement, programming and setup

DTC P0107 or P0108

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P0107, P0697	P0106, P0107	P0108, P0697	P0106
Signal	P0107	P0106, P0107	P0108	P0106
Low Reference	—	P0106, P0108	—	P0106

Typical Scan Tool Data

MAP Sensor

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running at various operating conditions **Parameter Normal Range:** 12–103 kPa (1.7–14.9 psi)			
5 V Reference	0 kPa (0 psi)	0 kPa (0 psi)	104 kPa (15.1 psi)
Signal	0 kPa (0 psi)	0 kPa (0 psi)	104 kPa (15.1 psi)*
Low Reference	—	80–103 kPa (11.6–14.9 psi)	—
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

MAP Sensor, when equipped with Turbocharger

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running at various operating conditions **Parameter Normal Range:** 12–225 kPa (1.7–32.6 psi)			
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 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 where 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. Where 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

P0107

- DTCs P0120, P0121, P0122, P0123, P0220, P0221, P0222, P0223 or P0641 are not set
- The engine speed is between 400–6 500 RPM.
- The throttle position is greater than or equal to 0% when the engine speed is less than or equal to 1 000 RPM

  or
- The throttle position is greater than or equal to 12.5% when the engine speed is greater than 1 000 RPM.
- This DTC runs continuously when the above conditions are met.

P0108

- The engine has been running for a length of time that is determined by the start up coolant temperature. The length of time ranges from 5.5 minutes at colder than −30°C (−22°F) to 10 s at greater than 30°C (+86°F).
- DTCs P0120, P0121, P0122, P0123, P0220, P0221, P0222, P0223 or P0641 are not set
- The throttle position is less than or equal to 1% when the engine speed is less than or equal to 1 200 RPM.

  or
- The throttle position is less than or equal to 20% when the engine speed is greater than 1 200 RPM.
- This DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

P0107

The ECM detects that the MAP sensor voltage is less than 0.05 V for greater than 5 s.

P0108

The ECM detects that the MAP sensor voltage is more than 4.9 V for greater than 5 s.

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 on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Special Tools

EN-23738-A Vacuum Pump

For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308.*

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 (ECM) on page 9-182* for further diagnosis.

⇓ **If none of the DTCs are set**

3. Engine idling, verify the scan tool MAP voltage parameter is between 0.3–4.8 V and changes with accelerator pedal input.

⇒ **If not between 0.3–4.8 V or does not change**

Refer to Circuit/System Testing.

⇓ **If between 0.3–4.8 V and changes**

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 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 B74 Manifold Absolute Pressure sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 2 Ω between the low reference circuit terminal 2 and ground.

⇒ **If 2 Ω or greater**

2.1. Ignition OFF, disconnect the K20 Engine Control Module, listed below:
- X2 harness connector, ECM with 2 face mounted connectors
- X3 harness connector, ECM with 3 face mounted connectors

2.2. 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**

4.1. Ignition OFF, disconnect the K20 Engine Control Module, listed below:
- X2 harness connector, ECM with 2 face mounted connectors
- X3 harness connector, ECM with 3 face mounted connectors

4.2. 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

4.3. 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 engine control module or the sensor may be damaged.

⇒ **If greater than 5.2 V**

4.1. Ignition OFF, disconnect the K20 Engine Control Module, listed below:
- X2 harness connector, ECM with 2 face mounted connectors
- X3 harness connector, ECM with 3 face mounted connectors

4.2. 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. Ignition ON, verify the scan tool MAP Sensor parameter is less than 0.5 V.

⇒ **If 0.5 V or greater**

5.1. Ignition OFF, disconnect the K20 Engine Control Module, listed below:
- X2 harness connector, ECM with 2 face mounted connectors
- X3 harness connector, ECM with 3 face mounted connectors

⇒ 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. Ignition OFF, install a 3 A fused jumper wire between the signal circuit terminal 3 and the 5 V reference circuit terminal 1.
7. Ignition ON, verify the scan tool MAP voltage parameter is greater than 4.5 V.

⇒ **If 4.5 V or less**

7.1. Ignition OFF, disconnect the K20 Engine Control Module, listed below:
- X2 harness connector, ECM with 2 face mounted connectors
- X3 harness connector, ECM with 3 face mounted connectors

7.2. Remove the jumper wire, 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

7.3. 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 Check 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, apply –17 kPa (5.0 inHg) of vacuum to the B74 Manifold Absolute Pressure sensor, with the *EN-23738-A* Vacuum Pump. Verify the scan tool MAP 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).**

3. Apply –34 kPa (10.0 inHg) of vacuum to the B74 Manifold Absolute Pressure sensor, with the *EN-23738-A* Vacuum Pump. Verify the scan tool MAP 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).**

4. 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 0-15kPa of vacuum to the sensor with the *EN-23738-A* Vacuum Pump. Verify the voltage changes, without any spikes or dropouts, between 4.9–0.2 V.

⇒ **If not between 4.9–0.2 V or has spikes or dropouts**

Replace the B74 Manifold Absolute Pressure sensor.

⇓ **If between 4.9–0.2 V and there are no spikes or dropouts**

7. All OK.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

- *Manifold Absolute Pressure Sensor Replacement on page 9-248*
- *Control Module References on page 6-3* for Engine Control Module replacement, programming and setup

DTC P0112, P0113, or P0114

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptors

DTC P0112: Intake Air Temperature (IAT) Sensor Circuit Low Voltage
DTC P0113: Intake Air Temperature (IAT) Sensor Circuit High Voltage
DTC P0114: Intake Air Temperature (IAT) Sensor Circuit Intermittent

Diagnostic Fault Information

IAT Sensor 1

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Sensor	P0112, P0114, P2199	P0113, P0114, P2199	P0113, P0114, P2199*	P0111, P0114
Low Reference	—	P0097, P0113, P11C2, 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 or High Resistance	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** Varies with ambient temperature			
Sensor	150°C (302°F)	-40°C (-40°F)	-40°C (-40°F)*
Low Reference	—	-40°C (-40°F)	-40°C (-40°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 °C (°F).

The sensors listed below share an ECM supplied 5 V reference circuit:

- IAT sensor 2
- Humidity sensor
- BARO pressure 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

Conditions for Running the DTCs

P0112, P0113, and P0114

- The ignition is ON, or the engine is running.
- The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTCs

P0112

The ECM detects that the IAT sensor signal is warmer than 149°C (300°F) for at least 5 s.

P0113

Note: The scan tool display range is between −40 and +150°C (−40 and +302°F).

The ECM detects that the IAT sensor signal is colder than −60°C (−76°F) for at least 5 s.

P0114

The ECM detects that the IAT sensor signal is intermittent or has abruptly changed for at least 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, when the engine is cold and not running, 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 multifunction intake air sensor internal heating elements.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

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, verify the following scan tool parameters are within 25°C (45°F) of each other.
   - Start-Up IAT Sensor 1
   - IAT Sensor 2
   - IAT Sensor 3, where equipped

⇒ **If not within 25°C (45°F)**

Refer to Circuit/System Testing.

⇓ **If within 25°C (45°F)**

2. Engine idling, verify the following scan tool parameters are between: −38 and +149°C (−36 and +300°F).
   - IAT Sensor 1
   - IAT Sensor 2
   - IAT Sensor 3, where equipped

⇒ **If not between: −38 and +149°C (−36 and +300°F)**

Refer to Circuit System Testing.

⇓ **If between: −38 and +149°C (−36 and +300°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 DTCs do not set.

⇒ **If any of the DTCs set**

Refer to Circuit/System Testing.

⇓ **If none of the DTCs set**

5. All OK

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the B75C Multifunction Intake Air sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 2 Ω between the low reference circuit terminal 7 and ground.

⇒ **If 2 Ω or greater**

2.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

2.2. 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, test for 4.8–5.2 V between signal circuit terminal 8 and ground.

⇒ **If less than 4.8 V**

3.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

3.2. 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

3.3. 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.

3.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

3.2. Ignition ON, 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**

4. 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 (Bosch Sensor) on page 9-26* or *Temperature Versus Resistance - Intake Air Temperature Sensor (Delco Sensor) on page 9-26* table for Bosch Sensors. The resistance values should be in range of the table values.

⇒ **If not within the specified range.**

Replace the B75C Multifunction Intake Air sensor.

⇓ **If within the specified range.**

3. All OK

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Mass Airflow Sensor Replacement on page 9-246* for multifunction intake air sensor replacement.
- *Control Module References on page 6-3* for Engine Control Module replacement, programming, and setup.

DTC P0116

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC P0116: Engine Coolant Temperature (ECT) Sensor Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal Circuit	P0117	P0118	P0118*	P0116, P0119, P0128
Low Reference	—	P0118	P0118*	P0116, 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 operating in closed loop **Parameter Normal Range:** Varies with coolant temperature			
Signal	140°C (284°F)	−40°C (−40°F)	−40°C (−40°F)
Low Reference	—	−40°C (−40°F)	−40°C (−40°F)

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 purpose of this diagnostic is 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 engine is OFF. If the required engine OFF time is met at start-up, the ECM will compare the temperature difference between the actual measured ECT and a calibrated ECT model. The information for this model is derived from the previous drive cycle and includes the accumulated mass air flow (MAF), the engine run time, the ambient air temperature and the ECT at the end of the drive cycle.

If the ECM detects that the temperature difference between the measured and modeled ECT is not within an acceptable operating range of each other, then the ECM will continue to run this diagnostic to determine if a block heater was active during the engine OFF time.

Conditions for Running the DTC

- The ignition is ON, or the engine is running.
- DTCs P0111, P0112, P0113, P0117, P0118, P0722, P0723 or P2610 are not set.
- The ignition has been off for greater than 8 h before the engine is started.
- This DTC runs continuously within the enabling conditions.

Conditions for Setting the DTC

P0116 Engine Running, Sensor Signal Stuck Test

- The ECM detects that the ECT sensor signal has abruptly changed a minimum of 20°C (68°F) warmer than intake air temperature (IAT) at engine start.
- The measured ECT is greater than measured IAT at engine start, is not within range of the calibrated model.

P0116 Engine Running, Sensor Within Range Test

- The ECT at engine start is not within range of the calibrated model.
- The ECT is greater than measured IAT at engine start, is not within range of the calibrated model.

Action Taken When the DTC Sets

- DTC P0116 is a Type B DTC.
- The cooling fans will be commanded ON.
- The A/C compressor will be commanded OFF.

Conditions for Clearing the DTC

DTC P0116 is a Type B DTC.

Diagnostic Aids

- Inspect the ECT sensor terminals for corrosion and for engine coolant leaking through the sensor. 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 intake air temperature (IAT) sensor that is biased colder at various ambient temperatures due to greater resistance than is normal will increase the range between these 2 sensors. Measure and record the resistance of the IAT sensor at various ambient temperatures, then compare those measurements to the Temperature vs. Resistance table. Refer to *Temperature Versus Resistance (ECT) on page 9-26*.
- Test the ECT sensor at various temperature levels in order to evaluate the possibility of a biased sensor. A sensor that is biased warmer can result in a driveability condition. Refer to *Temperature Versus Resistance (ECT) on page 9-26*.
- 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.
- If the condition is intermittent, allow the vehicle to sit for greater than 8 h with the ignition OFF, may help isolate the condition. Compare the scan tool and ECT Sensor temperature sensor values at ignition on. The Radiator Coolant Temperature Sensor and the ECT Sensor values should display within 3°C (5°F).

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Ignition ON, observe the DTC information with a scan tool. Verify that DTC P0112, P0113, P0117, or P0118 are not set.
   ⇒ If any of the DTCs are set, refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69*.
2. Ignition OFF, inspect the cooling system surge tank for the proper coolant level. Refer to *Loss of Coolant on page 9-625* and *Cooling System Draining and Filling on page 9-628*.
3. If the ignition has been OFF for 8 h or greater, observe the scan tool parameters list below. The temperatures should be within 20°C (68°F).
   - ECT Sensor
   - IAT Sensor
4. Engine running, observe the ECT Sensor parameter. The reading should be between −39 to +120°C (−38 to +148°F) depending on the current ambient temperature and the vehicle operating conditions.
5. Operate the vehicle within the conditions for running the DTC to verify the DTC does not reset. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the B34 Engine Coolant Temperature Sensor.
2. Inspect the B34 Engine Coolant Temperature Sensor terminals for corrosion and for engine coolant leaking through the sensor.
3. Ignition OFF for 1 min, test for less than 5 Ω between the low reference circuit terminal 2 and ground.
   ⇒ If greater than the specified range, test the low reference circuit for an open/high resistance. If the circuit tests normal, replace the K20 Engine Control Module.
4. Ignition ON, verify the scan tool ECT Sensor parameter is colder than −39°C (−38°F).
   ⇒ If greater than the specified range, test the signal circuit terminal 1 for a short to ground. If the circuit tests normal, replace the K20 Engine Control Module.
5. Install a 3 A fused jumper wire between the signal circuit terminal 1 and the low reference circuit terminal 2. Verify the scan tool ECT Sensor parameter is greater than 130°C (266°F).
   ⇒ If less than the specified range, test the signal circuit for a short to voltage or an open/high resistance. If the circuit tests normal, replace the K20 Engine Control Module.
6. If all circuits test normal, test or replace the B34 Engine Coolant Temperature Sensor.

Component Testing

Static Test

1. Ignition off, disconnect the harness connector at the B34 Engine Coolant Temperature Sensor.

Note: A thermometer can be used to test the sensor off vehicle.

2. Test the B34 Engine Coolant Temperature Sensor by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the *Temperature Versus Resistance (ECT) on page 9-26* table and verify that the resistance is within 5% of the specification.
   ⇒ If not within the specified range, replace the B34 Engine Coolant Temperature Sensor.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

- *Engine Coolant Temperature Sensor Replacement (Water Outlet) on page 9-244* or *Engine Coolant Temperature Sensor Replacement (Thermostat) on page 9-246* or *Engine Coolant Temperature Sensor Replacement (Radiator) on page 9-245*
- *Control Module References on page 6-3* for ECM replacement, programming and setup

DTC P0117, P0118, or P0119

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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	Open/High Resistance	Short to Voltage	Signal Performance
Signal	P0117	P0118, P0119	P0118*,P0119	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 at various operating conditions **Parameter Normal Range:** Varies with engine coolant temperature			
Signal	140°C (284°F)	−40°C (−40°F)	−40°C (−40°F)
Low Reference	—	−40°C (−40°F)	—

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 for greater than 10 s.
  OR
- The engine run time is less than 10 s when the intake air temperature (IAT) is colder than 50°C (122°F).
- 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 the IAT is warmer than 0°C (32°F).
- This DTC runs continuously within the enabling conditions.

P0119

- This DTC runs continuously within the enabling conditions.

Conditions for Setting the DTC

P0117

The ECM detects that the ECT is warmer than 149°C (300°F) for greater than 5 s.

P0118

The ECM detects that the ECT is colder than −39°C (−38°F) for greater than 5 s.

P0119

The ECM detects that the ECT is intermittent or has abruptly changed for greater than 4 seconds.

Action Taken When the DTC Sets

- DTC P0117, P0118 or P0119 are a Type B DTC.
- The cooling fans will be commanded ON.
- The Engine Coolant Temperature Gauge is inoperative.
- The AC compressor will be commanded OFF.

Conditions for Clearing the DTC

DTC P0117, P0118 or P0119 are a Type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify the scan tool ECT Sensor parameter is between −39 to + 120°C (−38 to +248°F) and changes with engine run time.

⇒ **If not between −39 to + 120°C (−38 to +248°F) or does not change**

Refer to Circuit/System Testing.

⇓ **If between −39 to + 120°C (−38 to +248°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 circuit terminal 2 and ground.

⇒ **If 5 Ω or greater**

2.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

2.2. 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 −39°C (−38°F).

⇒ **If warmer than −39°C (−38°F)**

4.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

4.2. 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, replace the K20 Engine Control Module.

⇓ **If colder than -39°C (-38°F)**

5. Install a 3 A fused jumper wire between the signal circuit terminal 1 and the low reference circuit terminal 2.
6. Verify the scan tool ECT sensor parameter is warmer than 137°C (280°F).

⇒ **If colder than 137°C (280°F)**

6.1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

6.2. 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

6.3. Ignition OFF.

6.4. 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 137°C (280°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) on page 9-26* 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 on page 6-92* after completing the repair.

- *Engine Coolant Temperature Sensor Replacement (Water Outlet) on page 9-244* or *Engine Coolant Temperature Sensor Replacement (Thermostat) on page 9-246* or *Engine Coolant Temperature Sensor Replacement (Radiator) on page 9-245*
- *Engine Control Module Replacement on page 9-242* engine control module replacement, programming, and setup

DTC P0121-P0123, P0222, P0223, or P2135 (LUV)

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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 P2135: Throttle Position Sensors 1-2 Not Plausible

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
5 V Reference	P06A3	P2135	P0122, P0222	P06A3, P2135	P0068, P0121
Throttle Position Sensor 1 Signal	P0122	P2135	P0122	P0123	P0068, P0121
Throttle Position Sensor 2 Signal	P0222	P2135	P0223	P0223	P0068, P0121
Low Reference	—	P2135	P0123, P0223	—	P0068, P0121

Typical Scan Tool Data

Throttle Position Sensor 1

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running at various operating conditions **Normal Range:** 4.75–0.35 V			
5 V Reference	0 V	0 V	5 V
Throttle Position Sensor 1 Signal	0 V	0 V	5 V
Low Reference	—	4–5 V	—

Throttle Position Sensor 2

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running at various operating conditions **Parameter Normal Range:** 0.35–4.65 V			
5 V Reference	0 V	0 V	5 V
Throttle Position Sensor 2 Signal	0 V	5 V	5 V
Low Reference	—	5 V	—

Circuit/System Description

The throttle body assembly contains 2 throttle position sensors. The throttle position sensors are mounted to the throttle body assembly and are not serviceable. The throttle position sensors provide a signal voltage that changes relative to throttle blade angle. The engine control module (ECM) supplies the throttle position sensors with a common 5 V reference circuit, a common low reference circuit, and two independent signal circuits.

The throttle position sensors have opposite functionality. throttle position sensor 1 signal voltage decreases and throttle position sensor 2 signal voltage increases as the accelerator pedal increases to wide open throttle (WOT).

Conditions for Running the DTC

P0122, P0123, P0222, and P0223

- DTC P06A3 is not set.
- The run/crank or powertrain relay voltage is greater than 6 V and reduced power is not active.
- The ignition is ON or the engine is operating.
- DTC P0122, P0123, P0222, P0223 run continuously when the above conditions are met.

P0121

- No Active or Pending DTCs.
- The engine speed is between 400–7,000 RPM.
- The engine coolant temperature (ECT) is between −7 to +125°C (19–257°F).
- The intake air temperature (IAT) is between −20 to +125°C (−4 to +257°F).
- DTC P0121 runs continuously when the above conditions are met.

P2135

- DTC P0122, P0123, P0222, P0223, or P06A3 is not set.
- The run/crank or powertrain relay voltage is greater than 6 V and reduced power is not active.
- The ignition is ON or the engine is operating.
- DTC P2135 runs continuously when the above conditions are met.

Conditions for Setting the DTC

P0121

The ECM detects the throttle position sensor is stuck within range for greater than 1 s.

P0122

The ECM detects the throttle position sensor 1 voltage is less than 0.325 V for greater than 1 s.

P0123

The ECM detects the throttle position sensor 1 voltage is greater than 4.75 V for greater than 1 s.

P0222

The ECM detects that the throttle position sensor 2 voltage is less than 0.25 V for greater than 1 s.

P0223

The ECM detects the throttle position sensor 2 voltage is greater than 4.59 V for greater than 1 s.

P2135

The ECM detects the difference between the throttle position sensor 1 and throttle position sensor 2 exceeds a predetermined value for greater than 1 s.

Action Taken When the DTC Sets

- DTC P0122, P0123, P0222, P0223, and P2135 are Type A DTCs.
- DTC P0121 is a Type B 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 P0122, P0123, P0222, P0223, and P2135 are Type A DTCs.
- DTC P0121 is a Type B DTC.

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 on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Throttle Actuator Control (TAC) System Description on page 9-305

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 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 P0641, P0651, P0697, or P06A3 is not set.

⇒ **If any of the DTCs are set**

Refer to *DTC P0641, P0651, P0697, or P06A3 (ECM) on page 9-182* 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 %.

⇒ **90 % or greater**

Refer to *Throttle Body Inspection and Cleaning on page 9-253*.

⇓ **If less than 90 %**

5. Verify the scan tool Throttle Position Sensor 1 and Throttle Position Sensor 2 voltage parameters are between 1.0–4.0 V and change with accelerator pedal input.

⇒ **If not between 1.0–4.0 V or does not change**

Refer to Circuit/System Testing

⇓ **If between 1.0–4.0 V and changes**

6. Verify the scan tool Throttle Position Sensor 1 and 2 Agree/Disagree parameter displays Agree while performing the Throttle Sweep Test with a scan tool.

⇒ **If Disagree**

Refer to Circuit/System Testing

⇓ **If Agree**

7. Determine the current vehicle testing altitude.
8. Verify the scan tool MAP Sensor pressure parameter is within range specified in the *Altitude Versus Barometric Pressure on page 9-26* table.

⇒ **The MAP Sensor pressure is not in range**

Refer to *DTC P0106 on page 9-84*.

⇓ **The MAP Sensor pressure is within range**

9. Engine idling.
10. 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 between 26–52 kPa (3.8–7.5 psi) or does not change**

Refer to *DTC P0106 on page 9-84*.

⇓ **If between 26–52 kPa (3.8–7.5 psi) and changes**

11. 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.
    - 11.1. Engine idling
    - 11.2. Perform the scan tool snapshot function.
    - 11.3. Increase the engine speed slowly to 3,000 RPM and then back to idle.
    - 11.4. Exit from the scan tool snapshot and review the data.
    - 11.5. 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 on page 9-77*.

⇓ **The MAF Sensor parameter changes smoothly and gradually**

12. Verify the scan tool Boost Pressure Sensor pressure and BARO parameters are within 3 kPa (0.4 psi).

⇒ **The parameters are not within 3 kPa (0.4 psi)**

Refer to *DTC P0236 on page 9-128*.

⇓ **The parameters are within 3 kPa (0.4 psi)**

13. Verify the scan tool MAP Sensor parameter and the Boost Pressure Sensor parameter are within 20 kPa (2.9 psi) during a WOT acceleration at the time of the 1–2 shift.

⇒ **The parameters are not within 20 kPa (2.9 psi)**

Refer to *DTC P0236 on page 9-128*.

⇓ **The parameters are within 20 kPa (2.9 psi)**

14. 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.
15. Verify the DTC does not set.

⇒ **If the DTC sets**

Refer to Circuit/System Testing

⇓ **If the DTC does not set**

16. 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. 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 C and ground.

⇒ **If 5 Ω or greater**

- 2.1. Ignition OFF, disconnect the harness connector at the K20 engine control module.
- 2.2. 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 E and ground.

⇒ **If less than 4.8 V**

4.1. Ignition OFF, disconnect the harness connector at the K20 engine control module.

4.2. 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

4.3. 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**

4.1. Ignition OFF, disconnect the harness connector at the K20 engine control module, ignition ON.

4.2. 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. Ignition ON.
6. Test for less than 1 V between the throttle position sensor 1 signal circuit terminal D and ground.

⇒ **If 1.0 V or greater**

6.1. Ignition OFF, disconnect the harness connector at the K20 engine control module, ignition ON.

6.2. 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 1.0 V or less**

7. Install a 3 A fused jumper wire between throttle position sensor 1 signal circuit terminal D and the 5 V reference circuit terminal E.
8. Verify the scan tool throttle position sensor 1 voltage parameter is greater than 4.8 V.

⇒ **If 4.8 V or less**

8.1. Ignition OFF, disconnect the harness connector at the K20 engine control module.

8.2. 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

8.3. 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 or greater**

9. Test for 4.8–5.2 V between the throttle position sensor 2 signal circuit terminal F and ground.

⇒ **If less than 4.8 V**

9.1. Ignition OFF, disconnect the harness connector at the K20 engine control module.

9.2. 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

9.3. 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**

9.1. Ignition OFF, disconnect the harness connector at the K20 engine control module, ignition ON.

9.2. 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**

10. Test or replace the Q38 throttle body.

Repair Instructions

- *Throttle Body Assembly Replacement on page 9-253*
- *Control Module References on page 6-3* 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 Disagree**

Test or replace the Q38 throttle body assembly.

⇓ **If Agree**

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 on page 6-69* for further diagnosis.

⇓ **If DTC does not set**

8. All OK

DTC P0128 (LUJ)

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC P0128: Engine Coolant Temperature (ECT) Below Thermostat Regulating Temperature

Circuit/System Description

The engine control module (ECM) monitors the temperature of the engine coolant for engine control and enabling criteria for some diagnostics. The amount of air flow into an engine is proportional to the amount of heat an engine generates. The ECM monitors the amount of air flow into the engine to calculate engine coolant temperature (ECT). The ECM uses the calculated temperature to determine if the engine has warmed up to the thermostat regulating temperature. If the ECT does not increase normally or does not reach the thermostat regulating temperature, diagnostics that use the ECT as enabling criteria, may not run when expected. If the ECT fails to reach the thermostat regulating temperature, before a predetermined amount of air flow enters the engine, the DTC sets.

Conditions for Running the DTC

- DTCs P00B3, P00B6, P0101, P0102, P0103, P0111, P0112, P0113, P0116, P0117 or P0118 are not set.
- Average Airflow is greater than 11 g/s.
- Thermostat Heater duty commanded cycle 10%.
- Engine not run time 30 min
- Engine run time between 22 s and 30 min
- The DTC runs once per ignition key cycle.

Conditions for Setting the DTC

The ECM detects that the actual engine coolant temperature is 26°C (78.8°F) colder than the commanded engine coolant temperature while the IAT is between 10–65°C (50–149°F)

or

The ECM detects that the actual engine coolant temperature is 46°C (114.8°F) colder than the commanded engine coolant temperature while the IAT is between −7°C to +10°C (−19.4 to+50°F)

Action Taken When the DTC Sets

DTC P0128 is a Type B DTC.

Conditions for Clearing the DTC

DTC P0128 is a Type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Verify the cooling system is filled to the correct coolant level. Refer to *Loss of Coolant on page 9-625* and *Cooling System Draining and Filling on page 9-628.*

⇒ **If the coolant level is not correct**

Repair as necessary

⇓ **If the coolant level is correct**

2. Verify the DTC P00B7, P0116, P0117, P0118, P0597, P0598, or P0599 is not set.

⇒ **If a DTC is set**

Refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69*

⇓ **If a DTC is not set**

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 79°C (174°F) when commanding the Engine Coolant Thermostat Heater to 0%.

⇒ **If less than 79°C (174°F)**

Replace the E41 Engine Coolant Thermostat Heater.

⇓ **If greater than 79°C (174°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 Step 1.

⇓ **If the DTC does not set**

7. All OK.

Component Testing

1. Ignition OFF, disconnect the B34 Engine Coolant Temperature Sensor harness connector at the sensor.
2. Test for refer to *Temperature Versus Resistance (ECT) on page 9-26* Temperature Versus Resistance between the signal circuit terminal 1 and the low reference terminal 2.

⇒ **If the temperature versus resistance are not within the specified ranges**

Replace the B34 Engine Coolant Temperature Sensor.

⇓ **If the temperature versus resistance are within the specified ranges**

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 on page 6-92* after completing the repair.

- *Engine Coolant Temperature Sensor Replacement (Water Outlet) on page 9-244* or *Engine Coolant Temperature Sensor Replacement (Thermostat) on page 9-246* or *Engine Coolant Temperature Sensor Replacement (Radiator) on page 9-245*
- *Engine Coolant Thermostat Housing Removal on page 9-863*
- *Control Module References on page 6-3* for engine control module replacement, programming and setup.

DTC P0131, P0132, P0134, P0137, P0138, or P0140

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptors

DTC P0131: HO2S Circuit Low Voltage Sensor 1
DTC P0132: HO2S Circuit High Voltage Sensor 1
DTC P0134: HO2S Circuit Insufficient Activity Sensor 1
DTC P0137: HO2S Circuit Low Voltage Sensor 2
DTC P0138: HO2S Circuit High Voltage Sensor 2
DTC P0140: HO2S Circuit Insufficient Activity Sensor 2

Diagnostic Fault Information

HO2S 1

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
HO2S 1 High Signal	P0131	P0132, P0134	P0132, P0134	P0133, P1133
HO2S 1 Low Signal	—	P0132, P0134	—	P0133, P1133

HO2S 2

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
HO2S 2 High Signal	P0137	P0138, P0140	P0138, P0140	—
HO2S 2 Low Signal	P0137	P0138, P0140	P0138, P0140	—

Typical Scan Tool Data

HO2S 1 or 2

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine operating in Closed Loop **Parameter Normal Range:** 50–1 050 mV			
High Signal	0 mV	1,100–2,100 mV	1,100–2,100 mV
Low Signal	—	1,700–2,100 mV	—

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 0–1 275 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

DTC P0131 or P0137

- DTCs P0068, P0106, P0107, P0108, P0121, P0122, P0123, P0222, P0223, P0442, P0443, P0446, P0449, P0451, P0452, P0453, P0454, P0455, P0496, P1101, P1516, P2101, P2119, P2135 and P2176 are not set.
- The ignition voltage is between 10–32 V.
- The fuel level is greater than 10%.
- The mass air flow (MAF) sensor parameter is between 2–60 g/s.
- The fuel composition is less than 87% ethanol.
- The fuel system is in Closed Loop.
- The vehicle is not decelerating.
- The DTC P0131 runs continuously when the above conditions are met for greater than 3 s.
- The DTC P0137 runs continuously when the above conditions are met for greater than 5 s.

DTC P0132 or P0138

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0121, P0122, P0123, P0222, P0223, P0442, P0443, P0446, P0449, P0451, P0452, P0453, P0454, P0455, P0496, P1101, P1516, P2101, P2119, P2135 and P2176 are not set.
- The ignition voltage is between 10–32 V.
- The fuel level is greater than 10%.
- The fuel composition is less than 87% ethanol.
- The fuel system is in Closed Loop.
- Engine run time is greater than 5 s.
- The vehicle is not decelerating.
- The DTC P0132 and P0138 run continuously when the above conditions are met for greater than 3 s.

DTC P0134 or P0140

- DTCs P0068, P0101, P0102, P0103, P0121, P0122, P0123, P0222, P0223, P1516, P2101, P2119, P2135 and P2176 are not set.
- The ignition voltage is between 10–32 V.
- HO2S heater warm up is finished.
- Engine run time is greater than 5 s.
- The engine has been operating for greater than 50 s.
- The fuel composition is less than 87% ethanol.

Conditions for Setting the DTC

P0131

The engine control module (ECM) detects that the heated oxygen sensor (HO2S) voltage is less than 20 mV for greater than 38 s.

P0137

The engine control module (ECM) detects that the heated oxygen sensor (HO2S) is shorted to ground for greater than 38 s.

P0132 or P0138

The ECM detects that the heated oxygen sensor (HO2S) voltage is greater than 1 050 mV for greater than 10 s.

P0134 or P0140

The ECM detects that the heated oxygen sensor (HO2S) voltage is greater than 1 700 mV for greater than 10 s.

Action Taken When the DTC Sets

DTCs P0131, P0132, P0134, P0137, P0138 and P0140 are Type B DTCs.

Conditions for Clearing the DTC

DTCs P0131, P0132, P0134, P0137, P0138 and P0140 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Ignition ON, observe the DTC information with a scan tool. Verify no HO2S heater DTCs are set.
   ⇒ If a HO2S heater DTC is set, refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69*.
2. Engine running, observe the scan tool heated oxygen sensor voltage parameters. The reading should fluctuate above and below the range of 20–1 050 mV.
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.

Circuit/System Testing

Note: All modules must be powered down or misdiagnosis may result.

1. Ignition OFF, disconnect the scan tool and wait 60 s to ensure all modules are powered down.
2. Disconnect the appropriate B52 Heated Oxygen Sensor harness connector.

3. Measure for less than 5 Ω between the low signal circuit terminal 3 and ground.
   ⇒ If greater than the specified range, test the low signal circuit for an open/high resistance. If the circuit tests normal, replace the K20 Engine Control Module.
4. Ignition ON, test for 1.5–3.0 V between the signal circuit terminal 4 and ground.
   ⇒ If less than the specified range, test the signal circuit for a short to ground or an open/high resistance. If the circuit tests normal, replace the K20 Engine Control Module.
   ⇒ If greater than the specified range, test the signal circuit for a short to voltage. If the circuit tests normal, replace the K20 Engine Control Module.
5. Install a 3 A fused jumper wire between the signal circuit terminal 4 and the low reference circuit terminal 3 of the affected B52 Heated Oxygen Sensor. Engine running, verify the scan tool HO2S 1 or HO2S 2 parameter is less than 60 mV.
   ⇒ If greater than the specified value, replace the K20 Engine Control Module.
6. Verify none of the following conditions exist:
   - Water intrusion in the HO2S harness connector
   - Low or high fuel system pressure—Refer to *Fuel System Description on page 9-302*.
   - Fuel that is contaminated—Refer to *Alcohol/ Contaminants-in-Fuel Diagnosis on page 9-235*.
   - Fuel saturation of the evaporative emission (EVAP) canister
   - Exhaust leaks near the HO2S
   - Engine vacuum leaks

   ⇒ If you find any of the above conditions, repair as necessary.
7. If all circuits test normal, replace the appropriate B52 Heated Oxygen Sensor.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

- *Heated Oxygen Sensor Replacement - Sensor 1 on page 9-249*
- *Heated Oxygen Sensor Replacement - Sensor 2 on page 9-250*
- Perform the scan tool Heated Oxygen Sensor Resistance Learn Reset after replacing an HO2S.
- *Control Module References on page 6-3* for ECM replacement, programming and setup

DTC P0133, P013A, P013B, P013E, P013F, P015A, P015B, P2270, or P2271

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provide an overview of each diagnostic category.

DTC Descriptors

DTC P0133: HO2S Slow Response Sensor 1
DTC P013A: HO2S Slow Response Rich to Lean Sensor 2
DTC P013B: HO2S Slow Response Lean to Rich Sensor 2
DTC P013E: HO2S Delayed Response Rich to Lean Sensor 2
DTC P013F: HO2S Delayed Response Lean to Rich Sensor 2
DTC P015A: HO2S Delayed Response Rich to Lean Sensor 1
DTC P015B: HO2S Delayed Response Lean to Rich Sensor 1
DTC P2270: HO2S Signal Stuck Lean Sensor 2
DTC P2271: HO2S Signal Stuck Rich Sensor 2

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0030, P0033, P0034, P0036, P0134, P0135, P0140, P0141, P0243, P0245, P0443, P0597	P0030, P0036,	—	—
HO2S Heater Control	P0030, P0135, P0036, P0141	P0030, P0132, P0135, P0137, P0036, P0138, P0140, P0141	P0030, P0135, P0137, P0036, P0141	P0135, P0141
HO2S High Signal	P0131, P0137	P0132, P0134, P0138, P0140	P0132, P0134, P0138, P0140	P0133
HO2S Low Signal	P0137	P0132, P0134, P0138, P0140	P0132, P0134, P0138, P0140	P0133

Typical Scan Tool Data

HO2S 1

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine operating in Closed Loop **Parameter Normal Range:** 200–800 mV			
HO2S 1 or 2 Signal	0 mV	1 275 mV	1 275 mV
HO2S 1 or 2 Low Signal	—	1 275 mV	—

HO2S 2

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine operating in Closed Loop **Parameter Normal Range:** 200–800 mV			
HO2S 2 High Signal	0 mV	1 890 mV	2 040 mV
HO2S 2 Low Signal	0 mV	1 890 mV	2 040 mV

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 0–1 275 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

DTC P0133

- DTCs P0068, P0096, P0097, P0098, P00B3, P00B4, P00B6, P00C7, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0128, P0131, P0132, P0134, P0201, P0202, P0203, P0204, P0222, P0223, P0300, P0442, P0443, P0446, P0449, P0451, P0452, P0453, P0454, P0455, P0496, P1101, P1516, P2101, P2119, P2135, P2176 and P2450 are not set.
- The ignition signal parameter is between 10–32 V.
- The engine speed parameter is between 1 300–3 500 RPM.
- The Engine coolant temperature (ECT) is greater than 65°C (149°F).
- The intake air temperature (IAT) is greater than −40°C (−40°F).
- The engine has been operating for greater than 100 s.
- The calculated airflow is between 10–35 g/s.
- The fuel system is in Closed Loop.
- The vehicle is not decelerating.
- The DTCs run continuously when the above conditions are met for greater than 1 s.

P013A

- DTCs P0068, P0096, P0097, P0098, P00B6, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0171, P0172, P0201, P0202, P0203, P0204, P0222, P0223, P0300, P1101, P1516, P2096, P2097, P2101, P2119, P2135, P2176 are not set.
- The system voltage is between 10–32 V.
- The fuel level is greater than 10%.
- DTC P013B, P013E, P013F, P2270 and P2271 have run.
- DTC P013E and P2270 have passed.
- DTC P013A runs once per trip.

P013B

- DTCs P0068, P0096, P0097, P0098, P00B6, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0171, P0172, P0201, P0202, P0203, P0204, P0222, P0223, P0300, P1101, P1516, P2096, P2097, P2101, P2119, P2135, P2176 are not set.
- The system voltage is between 10–32 V.
- The fuel level is greater than 10%.
- DTC P013A, P013E, P013F, P2270 and P2271 have run.
- DTC P013F and P2271 have passed.
- DTC P013B runs once per trip.

P013E

- DTCs P0068, P0096, P0097, P0098, P00B6, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0171, P0172, P0201, P0202, P0203, P0204, P0222, P0223, P0300, P1101, P1516, P2096, P2097, P2101, P2119, P2135, P2176 are not set.
- The system voltage is between 10–32 V.
- The fuel level is greater than 10%.
- DTC P013A, P013B, P013F, P2270 and P2271 have run.
- DTC P2270 have passed.
- DTC P013E runs once per trip.

P013F

- DTCs P0068, P0096, P0097, P0098, P00B6, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0171, P0172, P0201, P0202, P0203, P0204, P0222, P0223, P0300, P1101, P1516, P2096, P2097, P2101, P2119, P2135, P2176 are not set.
- The system voltage is between 10–32 V.
- The fuel level is greater than 10%.
- DTC P013A, P013B, P013E, P2270 and P2271 have run.
- DTC P2270 and P2271 have passed.
- DTC P013F runs once per trip.

P015A and P015B

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0128, P0131, P0132, P0134, P0171, P0172, P0201, P0202, P0203, P0204, P0222, P0223, P0300, P0442, P0443, P0446, P0449, P0452, P0453, P0455, P0496, P016F3, P2101 or P2135 are not set.
- The ignition signal parameter is between 10–32 V.
- The device controls are not active.
- The fuel level is more than 10%.
- The HO2S heater is commanded ON for greater than 40 s.

- The Engine coolant temperature (ECT) is greater than 60°C (140°F).
- The intake air temperature (IAT) is greater than −40°C (−40°F).
- The engine has been operating for greater than 150 s.
- The engine speed is between 1 550–3 500 RPM to initially enable the test.
- The vehicle speed is between 70–125 km/h (44–78 mph) to initially enable the test.
- The engine speed is between 1 350–3 650 RPM to keep the test enabled.
- The vehicle speed is between 65–130 km/h (41–81 mph) to keep the test enabled.
- The mass air flow (MAF) sensor parameter is between 2–20 g/s.
- The fuel system is in Closed Loop.
- The evaporative emission (EVAP) diagnostics are not in control of purge.
- The predicted catalytic converter temperature is between 550–900°C (1 022–1 652°F).
- DTC P015A runs once per trip, during the deceleration fuel cut-off (DFCO) mode, when the above conditions are met.
- DTC P015B runs once per trip, during the fuel enrich mode, when the above conditions are met.

P0140

- DTCs P0068, P0101, P0102, P0103, P0121, P0122, P0123, P0222, P0223, P1516, P2101, P2119, P2135, P2176 are not set.
- The ignition signal parameter is between 10–32 V.
- The ignition signal parameter is between 10–32 V.
- The fuel level is more than 10%.
- Engine run time is equal to or greater than 5 s.
- The mass air flow (MAF) sensor parameter is between 2–60 g/s.
- The fuel composition is less than 87% ethanol.
- DTC P0140 runs once per drive cycle when the above conditions are met for 3 s.

P2270

- DTCs P0068, P0096, P0097, P0098, P00B6, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0171, P0172, P0201, P0202, P0203, P0204, P0222, P0223, P0300, P1101, P1516, P2096, P2097, P2101, P2119, P2135, P2176 are not set.
- The ignition signal parameter is between 10–32 V.
- The fuel level is greater than 10%.
- The engine speed parameter is between 1 100–3 500 RPM.
- The mass air flow (MAF) sensor parameter is between 1–30 g/s.
- The fuel composition is less than 87% ethanol.
- The fuel system is in Closed Loop.
- DTC P013A, P013B, P013E, P013F, P2270 and P2271 have run.
- DTC P2270 and P2271 have passed.
- DTC P2270 runs once per drive cycle when the above conditions are met for 5 s.

P2271

- DTCs P0068, P0096, P0097, P0098, P00B6, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0171, P0172, P0201, P0202, P0203, P0204, P0222, P0223, P0300, P1101, P1516, P2096, P2097, P2101, P2119, P2135, P2176 are not set.
- The ignition signal parameter is between 10–32 V.
- The fuel level is greater than 10%.
- The engine speed parameter is between 1 100–3 500 RPM.
- The mass air flow (MAF) sensor parameter is between 1–30 g/s.
- The fuel composition is less than 87% ethanol.
- The fuel system is in Closed Loop.
- DTC P013A, P013B, P013E, P013F and P2270 have run.
- DTC P013A, P013E and P2270 have passed.
- DTC P2270 runs once per drive cycle when the above conditions are met for 5 s.

Conditions for Setting the DTC

P0133

- The ECM detects that the HO2S 1 average response time is more than a calculated value.
- DTC P0133 sets within 60 s when the above condition is met.

P013A

The ECM detects that the accumulated mass air flow monitored during rich to lean transitions between 150–450 mV is more than 6 g.

P013B

The ECM detects that the accumulated mass air flow monitored during rich to lean transitions between 335–650 mV is more than 25 g.

P013E

The ECM detects that the Post O2 sensor voltage is greater than 450 mV and the accumulated mass air flow monitored during the delayed Response Test is greater than 20 g.

P013F

The ECM detects that the Post O2 sensor voltage is less than 350 mV and the accumulated mass air flow monitored during the delayed Response Test is greater than 70 g.

P0140

The ECM detects that the heated oxygen sensor (HO2S) 2 parameter is greater than 1 700 mV.

P2270

- The ECM detects that the heated oxygen sensor (HO2S) 2 sensor cannot achieve voltage equal to or less than 775 mV.

  and

- The ECM detects that the accumulated mass air flow monitored during the Stuck Lean Voltage Test is more than 38 g.

P2271

- The ECM detects that the heated oxygen sensor (HO2S) 2 sensor cannot achieve voltage equal to or less than 100 mV.

  and

- The ECM detects that the accumulated mass air flow monitored during the stuck rich voltage test is more than 25 g.

Action Taken When the DTC Sets

- DTCs P0133, P0134, P013E, P013F, P0140, P2270 are P2271 Type B DTCs.
- DTCs P013A and P013B are Type A DTCs.

Conditions for Clearing the DTC

- DTCs P0133, P0134, P013E, P013F, P0140, P2270 are P2271 Type B DTCs.
- DTCs P013A and P013B are Type A DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. If any heated oxygen sensor (HO2S) heater DTCs are set, perform those diagnostics first.
2. Allow the engine to reach operating temperature.
3. Verify none of the following conditions exist:
   - Lean or rich fuel injectors
   - Water intrusion in the HO2S harness connector
   - Low or high fuel system pressure, refer to *Fuel System Diagnosis on page 9-230*
   - Fuel that is contaminated, refer to *Alcohol/ Contaminants-in-Fuel Diagnosis on page 9-235*
   - Fuel saturation of the evaporative emission (EVAP) canister
   - Exhaust leaks near the HO2S
   - Engine vacuum leaks
   - Engine oil consumptions *Oil Consumption Diagnosis on page 9-773*
   - Engine coolant consumption, refer to *Symptoms - Engine Cooling on page 9-617*

   ⇒ If you find any of the above conditions, repair as necessary.
4. If all conditions test normal, test or replace the appropriate HO2S.
5. Operate the vehicle within the conditions for running the DTC. Or operate the vehicle within the conditions that you observed from the freeze frame/failure records data.

Repair Instructions

Caution: Refer to *Heated Oxygen Sensor Resistance Learn Reset Caution on page 0-9*.

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

- *Heated Oxygen Sensor Replacement - Sensor 1 on page 9-249*
- *Heated Oxygen Sensor Replacement - Sensor 2 on page 9-250*
- *Control Module References on page 6-3* for ECM replacement, programming and setup

DTC P0171 or P0172

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptors

DTC P0171: Fuel Trim System Lean

DTC P0172: Fuel Trim System Rich

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, P0053, P0101, P0102, P0103, P0106, P0107, P0108, P0131–P0135, P0201–P0204, P0300–P0304, P0411, P0442, P0455, P0458, P0496, P0506, P0507, P1248, P1249, P124A, P124B, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P2227, P2228, P2229, P2230, P2440, or P2444 are not set.
- The engine is in Closed Loop status.
- The catalyst monitor diagnostic intrusive test, post 02 diagnostic intrusive test, and EVAP diagnostic test are not active.
- The engine coolant temperature (ECT) is between −20°C and +150°C (−4°F and +302°F).
- The intake air temperature (IAT) is between −20°C and +150°C (−4°F and +302°F).
- The manifold absolute pressure (MAP) is between 10–255 kPa (1.5–37 psi).
- The engine speed is between 400–7,000 RPM.
- The mass air flow (MAF) is between 1–512 g/s.
- The barometric pressure (BARO) is greater than 70 kPa (10.2 psi).
- The fuel level is greater than 10 % and no fuel sensor fault is present.
- 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 and P0172 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P0171 and P0172 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.
- It is very unlikely that an HO2S will cause this DTC to set without the occurrence of the circuit related HO2S DTCs. Do not replace an HO2S to address this DTC without first performing all the steps in Circuit/System Verification.
- 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

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 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 on page 6-69* for further diagnosis.

⇓ **If no other DTCs are set**

3. Verify DTC P0171 or P0172 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 or P0172 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 manifold absolute pressure sensor is within the range specified for your altitude. Refer to *Altitude Versus Barometric Pressure on page 9-26*

⇒ **If not within the specified range**

Refer to *DTC P0106 on page 9-84*

⇓ **If within the specified range**

3. Engine running, allow the engine to reach operating temperature.
4. Verify the Long Term Fuel Trim parameter is between –30 % and +30 %.

⇒ **If not within the specified range, verify that none of the conditions listed below exist:**

P0171

- Mass air flow (MAF) sensor signal skewed. If the Short Term Fuel Trim parameter changes greater than 20 % when the MAF sensor is disconnected, refer to *DTC P0101 on page 9-77*.
- Fuel contamination. Refer to *Alcohol/ Contaminants-in-Fuel Diagnosis on page 9-235*.
- Missing, restricted, or leaking exhaust components. Refer to *Symptoms - Engine Exhaust on page 9-734*.
- Malfunctioning fuel injectors. Refer to *Fuel Injector Diagnosis on page 9-232*.
- Split, kinked, or improperly connected vacuum hoses
- Insufficient fuel in the tank
- Low fuel pressure. Refer to *Fuel System Diagnosis on page 9-230*.
- 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
- Leaks in the crankcase ventilation system

P0172

- 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 on page 9-77*.
- Fuel contamination. Refer to *Alcohol/ Contaminants-in-Fuel Diagnosis on page 9-235*.
- Missing, restricted, or leaking exhaust components. Refer to *Symptoms - Engine Exhaust on page 9-734*.
- Malfunctioning fuel injectors. Refer to *Fuel Injector Diagnosis on page 9-232*
- Collapsed or restricted air intake duct
- Excessive fuel pressure. Refer to *Fuel System Diagnosis on page 9-230*
- 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**

5. Test the engine for a mechanical condition. Refer to *Symptoms - Engine Mechanical on page 9-770*.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

DTC P018B-P018D

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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, P0641, P06A6	P018C	P018D	P06A6
Signal	P018C	P018C	P018D	P018B
Low Reference	—	P018D	—	P06A6

Circuit/System Description

The fuel pressure sensor is located on the fuel line. The fuel pressure sensor monitors the fuel pressure in the fuel line. The fuel pump control module monitors the voltage signal from the fuel pressure sensor.

Conditions for Running the DTC

- The engine is running.
- DTCs P018C, P018D, P0231, P0232, P023F, P064A, P1255 or P06A6 are not active.
- DTC P0641 has not failed this ignition cycle.
- Fuel pump control is enabled and the fuel pump control state is normal.
- The engine has been running for at least 5 seconds.

Conditions for Setting the DTC

The fuel pump 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 provides a means to detect fuel pressure sensor output that is stuck within the normal operating range of the sensor.

Action Taken When the DTC Sets

DTCs P018B, P018C and P018D are Type A DTCs.

Conditions for Clearing the DTC

DTCs 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.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Fuel System Description on page 9-302

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Connector Repairs on page 11-548*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Engine running.
2. Verify the scan tool Fuel Pressure Sensor Voltage 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**

3. All OK.

Circuit/System Testing

Note: Verify that the fuel tank is not empty. Only perform this diagnostic if there is at least 2 gallons of fuel in the fuel tank. Clear the DTC, and start and run the engine. Verify that the DTC resets before proceeding with the circuit system testing. If the DTC does not reset, refer to diagnostic aids.

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B47 Fuel Pressure Sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 10 Ω between the low reference circuit terminal 2 and ground.

⇒ **If 10 Ω or greater**

2.1. Ignition OFF, disconnect the harness connector at the K27 Fuel Pump Control Module.

2.2. 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 K27 Fuel Pump 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 3 and ground.

⇒ **If less than 4.8 V**

4.1. Ignition OFF, disconnect the harness connector at the K27 Fuel Pump Control Module.

4.2. 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

4.3. 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 K27 Fuel Pump Control Module.

⇒ **If greater than 5.2 V**

4.1. Ignition OFF, disconnect the harness connector at the K27 Fuel Pump Control Module, ignition ON.

4.2. 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 K27 Fuel Pump Control Module.

⇓ **If between 4.8–5.2 V**

5. Verify the scan tool Fuel Pressure Sensor Voltage parameter is less than 1 V.

⇒ **If 1 V or greater**

5.1. Ignition OFF, disconnect the harness connector at the K27 Fuel Pump Control Module, ignition ON.

5.2. 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 K27 Fuel Pump 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 seconds.
7. Verify the scan tool Fuel Pressure Sensor Voltage parameter is greater than 4.8 V.

⇒ **If 4.8 V or less**

7.1. Ignition OFF, disconnect the harness connector at the K27 Fuel Pump Control Module.

7.2. 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

7.3. 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 K27 Fuel Pump Control Module.

⇓ **If greater than 4.8 V**

8. Test or replace the B47 Fuel Pressure Sensor.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

Control Module References on page 6-3 for fuel pump control module replacement, programming and setup

DTC P0201, P0202, P0203, P0204, P0261, P0262, P0264, P0265, P0267, P0268, P0270, or P0271

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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 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

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0201*, P0202*, P0203*, P0204*, P0261*, P0264*, P0267*, P0270*	P0201**, P0202**, P0203**, P0204**, P0261**, P0264**, P0267**, P0270**	—	—
Injector 1 Control	P0201, P0261	P0201, P0300	P0262, P0300	—
Injector 2 Control	P0202, P0264	P0202, P0300	P0265, P0300	—
Injector 3 Control	P0203, P0267	P0203, P0300	P0268, P0300	—
Injector 4 Control	P0204, P0270	P0204, P0300	P0271, P0300	—

* Open fuse, cranks no start.
** Cranks no start if the condition is between the fuse and the splice.

Circuit/System Description

The engine control module (ECM) enables the appropriate fuel injector pulse for each cylinder. Ignition voltage is supplied to the fuel injectors. The ECM controls each fuel injector by grounding the control circuit via a solid state device called a driver. The ECM monitors the status of each driver. If the ECM detects an incorrect voltage for the commanded state of the driver, a fuel injector control circuit DTC sets.

Conditions for Running the DTC

- The engine is running for greater than 1 s.
- The ignition voltage is greater than 11 V.
- The DTCs run continuously when the above conditions are met for greater than 5 s.

Conditions for Setting the DTC

The control module detects an incorrect voltage on the fuel injector control circuit for greater than 5 s.

Action Taken When the DTC Sets

DTCs P0201, P0202, P0203, P0204, P0261, P0262, P0264, P0265, P0267, P0268, P0270, and P0271 are Type B DTCs.

Conditions for Clearing the DTC

DTCs P0201, P0202, P0203, P0204, P0261, P0262, P0264, P0265, P0267, P0268, P0270, and P0271 are Type B DTCs.

Diagnostic Aids

Performing the Fuel Injector Diagnosis may help isolate an intermittent condition. Refer to *Fuel Injector Diagnosis on page 9-232*.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Special Tool

CH 34730-2C Noid Light, if available

Circuit/System Verification

1. Engine cranking or running.
2. Verify the scan tool parameters listed below do not display Malfunction.
   - Cylinder 1–4 Injector Control Circuit Low Voltage Test Status
   - Cylinder 1–4 Injector Control Circuit Open Test Status
   - Cylinder 1–4 Injector 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 appropriate Q17 Fuel Injector, ignition ON.
2. Verify a test lamp illuminates between the ignition circuit terminal 1 and ground.

⇒ **If the test lamp does not illuminate and the circuit fuse is good**

2.1. Ignition OFF, remove the test lamp.

2.2. 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**

2.1. Ignition OFF, remove the test lamp, and disconnect all components on the circuit.

2.2. 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

2.3. Replace the fuse, ignition ON.

2.4. 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**

3. Ignition OFF, connect the test lamp to the affected fuel injector connector.
4. Engine cranking.
5. Verify the test lamp turns ON and OFF.

⇒ **If the test lamp is always OFF**

5.1. Ignition OFF, remove the test lamp, disconnect the X2 harness connector at the K20 Engine Control Module, ignition ON.

5.2. 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

5.3. Ignition OFF.

5.4. 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 the test lamp is always ON**

5.1. Ignition OFF, remove the test lamp, disconnect the X2 harness connector at the K20 Engine Control Module.

5.2. 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 turns ON and OFF**

6. Test or replace the appropriate Q17 Fuel Injector.

Component Testing

Fuel Injector Diagnosis on page 9-232

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Fuel Injector Replacement on page 9-269*
- *Control Module References on page 6-3* for Engine Control Module replacement, programming, and setup

DTC P0231, P0232, or P023F

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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	P0231	P023F	P0232	P023F, P2635
Low Reference	—	P023F	—	P023F, P2635

Circuit/System Description

The engine control module (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 seconds, unless the engine is in crank or run. While this voltage is being received, the fuel pump control module supplies a varying voltage to the fuel tank pump module in order to maintain the desired fuel line pressure.

Conditions for Running the DTC

P0231, P023F

The ignition voltage is between 9–18 V.

P0232

The control enable voltage signal supplied for the ECM to fuel pump control module is inactive for 4 seconds after engine has been shut off.

Conditions for Setting the DTC

The fuel pump control module detects a fault on the fuel pump voltage circuit that is less than 11 V or greater than 18 V.

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.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Fuel System Description on page 9-302

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the A7 Fuel Pump and Level Sensor Assembly. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 10 Ω between the low reference circuit terminal 2 and ground.

⇒ **If 10 Ω or greater**

2.1. Ignition OFF, disconnect the harness connector at the K27 fuel pump control module.

2.2. 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 K27 fuel pump control module.

⇩ **If less than 10 Ω**

3. Connect a test lamp between the control circuit terminal 1 and the low reference circuit terminal 2.
4. Ignition ON.
5. Verify the test lamp turns ON and OFF when commanding the fuel pump ON and OFF using the scan tool ECM fuel pump enable control function.

⇒ **If the test lamp is always OFF**

5.1. Ignition OFF, disconnect the harness connector at the K27 fuel pump control module.

5.2. 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

5.3. 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 K27 fuel pump control module.

⇒ **If the test lamp is always ON**

5.1. Ignition OFF, disconnect the harness connector at the K27 fuel pump control module, ignition ON.

5.2. 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 K27 fuel pump control module.

⇩ **If the test lamp turns ON and OFF**

6. Replace the A7 Fuel Pump and Level Sensor Assembly.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Fuel Tank Fuel Pump Module Replacement on page 9-261*
- *Control Module References on page 6-3* for fuel pump control module replacement, programming and setup

DTC P0234 or P0299

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptors

DTC P0234: Engine Overboost

DTC P0299: Engine Underboost

Circuit Description

The boost pressure sensor is integrated with the turbocharger boost/intake air temperature sensor. The boost pressure sensor measures the range of pressures between the turbocharger and the throttle body. The sensor used on this engine is a three atmosphere sensor. Pressure in this portion of the induction system is affected by engine speed, throttle opening, turbocharger boost pressure, Intake air temperature (IAT), barometric pressure (BARO), and the efficiency of the charge air cooler.

The sensor provides a signal voltage to the engine control module (ECM), relative to the pressure changes. Under normal operation the greatest pressure that can exist in this portion of the induction system at ignition ON, engine OFF is equal to the BARO. When the engine is operated at wide-open throttle (WOT) the turbocharger can increase the pressure to near 240 kPa (34.8 psi). The pressure is equal to the BARO when the engine is idling or decelerating.

Conditions for Running the DTC

P0234 or P0299

- DTCs P0010, P0011, P0013, P0014, P0033, P0034, P0035, P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0128, P0222, P0223, P0234, P0236, P0237, P0238, P0243, P0245, P0246, P0299, P16F3, P2101, P2227, P2228, P2229 or P2230 are not set.
- Engine speed between 2,400–6,000 RPM.
- Desired boost pressure between 135–220 kPa (19.58–31.90 PSI).
- Ambient pressure between 60–120 kPa (8.70–17.40 PSI).
- Coolant temperature between −40 to +120°C (−40 to +248°F)
- Intake air temperature between −40 to +80°C (−40 to +176°F)

Conditions for Setting the DTC

P0234

The ECM detects that the actual boost pressure is greater than the desired boost pressure for greater than 1 s.

P0299

The ECM detects that the actual boost pressure is less than the desired boost pressure for greater than 2.2 s.

Action Taken When the DTC Sets

DTCs P0234 and P0299 are Type B DTCs.

The ECM will disable boost control and limit the system to mechanical boost only, resulting in a substantial decrease in engine power.

Conditions for Clearing the DTC

DTCs P0234 and P0299 are Type B DTCs.

Diagnostic Aids

- The charged air cooler is connected to the turbocharger and to the throttle body by flexible duct work that requires the use of special high torque fastening clamps. These clamps cannot be substituted. In order to prevent any type of air leak when servicing the duct work, the tightening specifications and proper positioning of the clamps is critical, and must be strictly adhered to.
- An excessively worn wastegate pivot pin may allow the wastegate to open slightly when commanded closed, which may result in P0299 being set.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Turbocharger System Description on page 9-306

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0033, P0034, P0035, P0236, P0237, P0238, P0243, P0245, or P0246 is not set.

⇒ **If any of the DTCs are set**

Refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69*.

⇓ **If none of the DTCs are set**

3. Verify the scan tool BARO Sensor parameter is within the range specified in the *Altitude Versus Barometric Pressure on page 9-26* table for the current testing altitude.

⇒ **If the parameter is not within the range specified in the table.**

Refer to *DTC P2227-P2230 on page 9-214*.

⇓ **If the parameter is within the range specified in the table.**

4. Verify the scan tool MAP Sensor and BARO Sensor parameters are within 3 kPa (0.4 psi) .

⇒ **If the parameters are not within 3 kPa (0.4 psi).**

Refer to *DTC P0106 on page 9-84*.

⇓ **If the parameters are within 3 kPa (0.4 psi).**

5. Verify the scan tool Boost Pressure Sensor and BARO Sensor parameters are within 3 kPa (0.4 psi) .

⇒ **If the parameters are not within 3 kPa (0.4 psi).**

Refer to *DTC P0236 on page 9-128*.

⇓ **If the parameters are within 3 kPa (0.4 psi).**

6. Verify a click is heard or felt from the Q40 turbocharger bypass valve solenoid when commanding the Turbocharger Bypass Solenoid Valve between Active and Inactive with a scan tool.

⇒ **If a click is not heard or felt**

Refer to Circuit/System Testing.

⇓ **If a click is heard or felt**

7. Verify a series of clicks, which increase in frequency, are heard or felt from the Q42 turbocharger wastegate solenoid valve when commanding the Turbocharger Wastegate Solenoid Valve between 15–100 % with a scan tool.

⇒ **If a series of clicks in increasing frequency are not heard or felt**

Refer to Circuit/System Testing.

⇓ **If a series of clicks in increasing frequency is heard or felt**

8. Verify the scan tool MAP Sensor parameter and the Boost Pressure Sensor parameter are within 20 kPa (2.9 psi) during a WOT acceleration at the time of the 1-2 shift.

⇒ **If the parameters are not within 20 kPa (2.9 psi)**

Refer to Circuit/System Testing.

⇓ **If the parameter are within 20 kPa (2.9 psi)**

9. 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.
10. Verify a DTC does not set.

⇒ **If a DTC sets**

Refer to Circuit/System Testing

⇓ **If a DTC does not set**

11. All OK

Circuit/System Testing

1. Verify the conditions listed below do not exist:
   - Loose clamps, cracks or other damage in the air intake duct system
   - Collapsed or restricted intake duct system
   - Restricted air filter
   - Any air flow restriction
   - Any air leak between the turbocharger and the throttle body, including the charge air cooler assembly
   - Splits, kinks or improper connections at the vacuum hoses
   - Any vacuum leak
   - Restricted, leaking or incorrect routing of hoses going to the components listed below:
     - Turbocharger wastegate solenoid valve
     - Turbocharger bypass solenoid valve
     - Intake manifold and turbocharger vacuum reservoir on the bottom of intake manifold
     - Turbocharger
     - Turbocharger wastegate
     - Turbocharger bypass valve
   - Missing, restricted or leaking exhaust components. Refer to *Restricted Exhaust on page 9-734*
   - Exhaust leak between the turbocharger and the exhaust manifold
   - Restricted turbocharger oil supply line
   - Loose or incorrect installation of any components

   ⇒ **If a condition exists**

   Repair or replace the affected component as necessary.

   ⇓ **If none of the conditions exist**

2. Ignition OFF, disconnect the turbocharger wastegate solenoid valve supply hose at the turbocharger and apply 51 kPa (15 inches Hg) of vacuum to the hose with the *GE 23738-A* . Ignition ON.

3. Verify the pressure decreases to 0 kPa (0 inches Hg) when commanding the Turbocharger Wastegate Solenoid Valve to 15 % with a scan tool.

⇒ **The pressure does not decrease to 0 kPa (0 inches Hg)**

Replace the Q42 turbocharger wastegate solenoid valve

⇓ **The pressure decreases to 0 kPa (0 inches Hg)**

4. Connect the turbocharger wastegate solenoid valve supply hose to the turbocharger.
5. Disconnect the hose from the turbocharger wastegate actuator and connect the exhaust/ pressure port of the *GE 23738-A* , or a suitable hand pressure pump, to the actuator.
6. Verify the wastegate actuator rod moves when applying pressure to the actuator.

⇒ **If the actuator does not move**

6.1. Disconnect the wastegate actuator arm from the wastegate.

6.2. Verify the wastegate actuator rod moves when applying pressure to the actuator.

⇒ If the actuator does not move, replace the turbocharger wastegate actuator

⇒ If the actuator moves, replace the turbocharger

7. Disconnect the vacuum hose at the turbocharger bypass valve.
8. Install a vacuum gauge to the hose.
9. Engine Idling, verify the vacuum gauge displays between 51–67 kPa (15–20 inches Hq) of vacuum.

⇒ **The gauge does not display between 51–67 kPa (15–20 inches Hq) of vacuum.**

Inspect and repair the leaking vacuum hose in the areas listed below:

- Between the turbocharger bypass valve and the turbocharger bypass solenoid valve
- Between the intake manifold and the turbocharger bypass solenoid valve

⇓ **The gauge displays between 51–67 kPa (15–20 inches Hq) of vacuum.**

10. Disconnect the vacuum hose at the turbocharger vacuum reservoir on the bottom of intake manifold.
11. Connect the *GE 23738-A* to the vacuum reservoir and apply 34 kPa (10 inches Hg) of vacuum.
12. Verify the reservoir holds vacuum for at least 10 s.

⇒ **The reservoir does not hold vacuum for at least 10 s**

Replace the intake manifold

⇓ **The reservoir holds vacuum for at least 10 s**

13. Engine idling, vacuum gauge still installed from step 8, command the Turbocharger Bypass Solenoid Valve ON and OFF with the scan tool.
14. Verify the vacuum toggles between 0 kPa (0 inches Hg) when OFF to greater than 51 kPa (15 inches Hg) when ON.

⇒ **The vacuum does not toggle between 0–51 kPa (0–15 psi)**

Replace the Q40 turbocharger bypass solenoid valve

⇓ **The vacuum toggles between 0–51 kPa (0–15 psi)**

15. Verify the conditions listed below do not exist with the turbocharger assembly. Refer to *Turbocharger Cleaning and Inspection on page 9-895*
    - Worn or damaged wastegate pivot pin
    - Cracked, damaged or worn turbine blades
    - Restricted wastegate, turbine, ports or passages
    - Foreign material

⇒ **A condition exists**

Repair or replace the turbocharger as necessary

⇓ **None of the conditions exist**

16. Replace the turbocharger.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Charge Air Bypass Regulator Solenoid Valve Replacement on page 9-295*
- *Turbocharger Replacement on page 9-843*
- *Control Module References on page 6-3* for ECM replacement, programming and setup

DTC P0236

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC P0236: Turbocharger Boost Sensor Performance

Circuit Description

The boost pressure sensor is integrated with the turbocharger boost/intake air temperature sensor. The boost pressure sensor measures the range of pressures between the turbocharger and the throttle body. The sensor used on this engine is a three atmosphere sensor. Pressure in this portion of the induction system is affected by engine speed, throttle opening, turbocharger boost pressure, Intake air temperature (IAT), barometric pressure (BARO), and the efficiency of the charge air cooler.

The sensor provides a signal voltage to the engine control module (ECM), relative to the pressure changes. Under normal operation the greatest pressure that can exist in this portion of the induction system at ignition ON, engine OFF is equal to the BARO. When the engine is operated at wide-open throttle (WOT) the turbocharger can increase the pressure to near 240 kPa (34.8 psi). The pressure is equal to the BARO when the engine is idling or decelerating.

Conditions for Running the DTC

- DTC P0096, P0097, P0098, P0102, P0103, P0107, P0108, P0111, P0112, P0113, P0116, P0117, P0118, P0119, P0128, P0237, P0238, P0335, P0336, P2227, P2228, P2229, or P2230 is not active.
- Engine speed is between 400–7,000 RPM.
- Engine Coolant Temperature (ECT) is between -7 to +125°C (19.4–257°F).
- Intake Air Temperature (IAT) is between -20 to +125°C (-4 to +257°F).
- The DTC runs continuously when the above conditions have been met.

  OR
- DTC P0106, P0107, P0108, P0237, P0238, P2227, P2228, P2229, P2230, or P2610 s not active.
- DTC P0107, P0108, P0237, P0238, P2228, or P2229 is not pending.
- Ignition is ON.
- Engine is OFF
- The time between current ignition cycle and the last time the engine was running is greater than 6 s.
- The DTC runs continuously when the above conditions have been met.

Conditions for Setting the DTC

- The ECM detects that various combinations of Turbocharger Intake Flow Rationality Diagnostic Failure models, derived from engine speed, the BARO sensor, the MAF sensor, the MAP sensor, the throttle position sensor and the turbocharger boost pressure sensor have failed when the engine is running.

  OR
- The ECM detects that the boost pressure sensor signal is less than 50 kPa (7.3 psi) or greater than 115 kPa (16.7 psi) when the ignition is ON and the engine is NOT rotating.

Action Taken When the DTC Sets

- DTC P0236 is a Type B DTC.
- The ECM will disable boost control and limit the system to mechanical boost only, resulting in a substantial decrease in engine power.

Conditions for Clearing the MIL/DTC

DTC P0236 is a Type B DTC.

Diagnostic Aids

- The charge air cooler is connected to the turbocharger and to the throttle body by flexible duct work that requires the use of special high torque fastening clamps. These clamps cannot be substituted. In order to prevent any type of air leak when servicing the duct work, the tightening specifications and proper positioning of the clamps is critical, and must be strictly adhered to.
- Use a smoke generating device or a solution of dish soap and water in a spray bottle to pinpoint any suspected air leaks in the induction system and in the charge air cooler assembly.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Turbocharger System Description on page 9-306

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Verify that DTC P0641 is not set.

⇒ **If the DTC is set**

Refer to *DTC P0641, P0651, P0697, or P06A3 (ECM) on page 9-182.*

⇓ **If the DTC is not set**

2. If you were sent here from DTC P0068, P0101, P0106, P0121, or P1101, refer to Circuit/System Testing.
3. Ignition ON.
4. Verify the scan tool Throttle Body Idle Airflow Compensation parameter is less than 90%.

⇒ **90% or greater**

Refer to *Throttle Body Inspection and Cleaning on page 9-253.*

⇓ **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 Test with a scan tool.

⇒ **If Disagree**

Refer to *DTC P0121-P0123, P0222, P0223, or P2135 (LUV) on page 9-102.*

⇓ **If Agree**

6. Verify the scan tool BARO parameter is within the range specified in the *Altitude Versus Barometric Pressure on page 9-26* table, for the current vehicle testing altitude.

⇒ **BARO is not in range**

Refer to *DTC P2227-P2230 on page 9-214.*

⇓ **BARO is within range**

7. Verify the scan tool MAP Sensor pressure and BARO parameters are within 3 kPa (0.4 psi) .

⇒ **The parameters are not within 3 kPa (0.4 psi).**

Refer to *DTC P0106 on page 9-84.*

⇓ **The parameters are within 3 kPa (0.4 psi).**

8. Engine idling.
9. 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 between 26–52 kPa (3.8–7.5 psi) or does not change**

Refer to *DTC P0106 on page 9-84.*

⇓ **If between 26–52 kPa (3.8–7.5 psi) and changes**

10. 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.
    - 10.1. Engine idling
    - 10.2. Perform the scan tool snapshot function.
    - 10.3. Increase the engine speed slowly to 3,000 RPM and then back to idle.
    - 10.4. Exit from the scan tool snapshot and review the data.
    - 10.5. 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 on page 9-77.*

⇓ **The MAF Sensor parameter changes smoothly and gradually**

11. Verify the scan tool Boost Pressure Sensor pressure and BARO parameters are within 3 kPa (0.4 psi) .

⇒ **The parameters are not within 3 kPa (0.4 psi).**

Refer to Circuit/System Testing

⇓ **The parameters are within 3 kPa (0.4 psi).**

12. Verify the scan tool MAP Sensor parameter and the Boost Pressure Sensor parameter are within 20 kPa (2.9 psi) during a WOT acceleration at the time of the 1-2 shift.

⇒ **The parameters are not within 20 kPa (2.9 psi)**

Refer to Circuit/System Testing.

⇓ **The parameters are within 20 kPa (2.9 psi)**

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 a DTC does not set.

⇒ **If a DTC sets**

Refer to Circuit/System Testing.

⇓ **If a DTC does not set**

15. All OK.

Circuit/System Testing

1. Verify that DTC P0237 or P0238 is not set.

⇒ **If a DTC is set**

Refer to *DTC P0237 or P0238 on page 9-131.*

⇓ **If none of the DTCs are set**

2. Verify the conditions listed below do not exist:
   - Loose clamps, cracks, or other damage in the air intake duct system
   - Collapsed or restricted air intake duct system

- Restricted air filter
- Splits, kinks or improper connections at the vacuum hoses
- Missing, restricted or leaking exhaust components — Refer to *Symptoms - Engine Exhaust on page 9-734*.
- Vacuum leaks at the intake manifold and throttle body

⇒ **If a condition exists**

Repair as necessary.

⇓ **If none of the conditions exist**

3. Replace the B111B turbocharger boost/intake air temperature sensor.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Intake Air Pressure and Temperature Sensor Replacement on page 9-247* for turbocharger boost/intake air temperature sensor replacement.
- *Control Module References on page 6-3* for engine control module replacement, programming, and setup

DTC P0237 or P0238

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptors

DTC P0237: Turbocharger Boost Sensor Circuit Low Voltage
DTC P0238: Turbocharger Boost Sensor Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P0236, P0237, P0340, P0365, P0452, P0532, P0641, P2227	P0236, P0237, P2227	P0236, P0238, P0453, P0641, P2227	P0236
Intake Air Pressure Signal	P0236, P0237, P2227	P0236, P0237, P2227	P0236, P0238, P2227	P0236
Low Reference	—	P0098, P0236, P0238, P2227	—	—

Typical Scan Tool Data

Boost Pressure Sensor

Circuit	Short to Ground	Open	Short to Voltage
Parameter Normal Range: BARO to 240 kPa (34.8 psi) **Operating Conditions:** Engine running			
5 V Reference	0 kPa (0 psi)	0 kPa (0 psi)	269 kPa (39 psi)
Boost Pressure Signal	0 kPa (0 psi)	0 kPa (0 psi)	269 kPa (39 psi)
Low Reference	—	267 kPa (38.7 psi)	—

Circuit Description

The boost pressure sensor is integrated with the turbocharger boost/intake air temperature sensor. The boost pressure sensor measures the range of pressures between the turbocharger and the throttle body. The sensor used on this engine is a three atmosphere sensor. Pressure in this portion of the induction system is affected by engine speed, throttle opening, turbocharger boost pressure, intake air temperature (IAT), barometric pressure (BARO), and the efficiency of the charge air cooler.

The sensor provides a signal voltage to the engine control module (ECM), relative to the pressure changes. Under normal operation the greatest pressure that can exist in this portion of the induction system at ignition ON, engine OFF is equal to the BARO. When the engine is operated at wide-open throttle (WOT) the turbocharger can increase the pressure to near 240 kPa (34.8 psi). The pressure is equal to the BARO when the engine is idling or decelerating.

Conditions for Running the DTC

- Ignition is ON or the engine is running.
- The DTCs run continuously when the above conditions have been met.

Conditions for Setting the DTC

P0237

The ECM detects that the boost pressure sensor voltage is less than 1.0 V for greater than 5 s.

P0238

The ECM detects that the boost pressure sensor voltage is greater than 4.7 V for greater than 5 s.

Action Taken When the DTC Sets

- DTCs P0237 and P0238 are Type B DTCs.
- The ECM will disable boost control and limit the system to mechanical boost only, resulting in a substantial decrease in engine power.

Conditions for Clearing the MIL/DTC

DTCs P0237 and P0238 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Turbocharger System Description on page 9-306

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Verify that DTC P0641 is not set.

⇒ **If the DTC is set**

Refer to *DTC P0641, P0651, P0697, or P06A3 (ECM) on page 9-182*.

⇓ **If the DTC is not set**

2. Verify the scan tool BARO parameter is within the range specified in the *Altitude Versus Barometric Pressure on page 9-26* table, for the current vehicle testing altitude.

⇒ **BARO is not in range.**

Refer to *DTC P2227-P2230 on page 9-214*.

⇓ **BARO is within range.**

3. Verify the scan tool Boost Pressure Sensor pressure and BARO parameters are within 3 kPa (0.4 psi).

⇒ **The parameters are not within 3 kPa (0.4 psi).**

Refer to Circuit/System Testing.

⇓ **The parameters are within 3 kPa (0.4 psi).**

4. Verify the scan tool MAP Sensor parameter and the Boost Pressure Sensor parameter are within 20 kPa (2.9 psi) during a WOT acceleration at the time of the 1-2 shift.

⇒ **The parameters are not within 20 kPa (2.9 psi).**

Refer to Circuit/System Testing.

⇓ **The parameters are within 20 kPa (2.9 psi).**

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 a 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 B111B turbocharger boost/intake air 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 circuit terminal 1 and ground.

⇒ **If 5 Ω or greater**

2.1. Ignition OFF, disconnect the X1 harness connector at the K20 engine control module.

2.2. 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**

4.1. Ignition OFF, disconnect the X1 harness connector at the K20 engine control module.

4.2. 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

4.3. 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 engine control module or the sensor may be damaged.

⇒ **If greater than 5.2 V**

4.1. Ignition OFF, disconnect the X1 harness connector at the K20 engine control module, ignition ON.

4.2. 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 Boost Pressure Sensor voltage parameter is less than 0.2 V.

⇒ **If 0.2 V or greater**

5.1. Ignition OFF, disconnect the X1 harness connector at the K20 engine control module, ignition ON.

5.2. 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**

6. Install a 3 A fused jumper wire between the signal circuit terminal 4 and the 5 V reference circuit terminal 3.

7. Verify the scan tool Boost Pressure Sensor voltage parameter is greater than 4.5 V.

⇒ **If 4.5 V or less**

7.1. Ignition OFF, remove the jumper wire, disconnect the X1 harness connector at the K20 engine control module.

7.2. 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

7.3. 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 B111B turbocharger boost/intake air temperature sensor.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Intake Air Pressure and Temperature Sensor Replacement on page 9-247* for turbocharger boost/intake air temperature sensor replacement
- *Control Module References on page 6-3* for ECM replacement, programming, and setup

DTC P0243, P0245, or P0246

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptors

DTC P0243: Turbocharger Wastegate Solenoid Valve Control Circuit
DTC P0245: Turbocharger Wastegate Solenoid Valve Control Circuit Low Voltage
DTC P0246: Turbocharger Wastegate Solenoid Valve Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage Circuit	P0030, P0034, P0036, P0134, P0135, P0245, P0443, P0598*	P0030, P0033, P0034, P0036, P0134, P0135, P0140, P0141, P0243, P0245, P0443, P0597	—	—
Control Circuit	P0245	P0243	P0010, P0013, P0246, P0443, P0690	P0243

* Ignition fuse opens.

Circuit/System Description

The BorgWarner™ dual scroll turbocharger incorporates a wastegate that is controlled by a pressure differential, that is determined by the engine control module (ECM) by means of a pulse width modulation (PWM) solenoid, in order to regulate the pressure ratio of the compressor. A charge air bypass valve also controlled by the ECM by utilizing a remotely mounted solenoid is integrated into the bypass valve to prevent compressor surging and damage from vibrations by opening during abrupt closed throttle conditions. When the bypass valve is open during closed throttle deceleration conditions, the bypass valve allows the air to recirculate in the turbocharger and maintain compressor speed. Within a calibrated range during the closed throttle event, or upon a wide open throttle command the bypass valve will then close to optimize turbo response. The turbocharger wastegate actuator has the following circuits:

- Ignition voltage
- Turbocharger wastegate solenoid control

At idle the turbocharger wastegate solenoid parameter is commanded to 0% by the ECM. When the engine load and RPM first increases under a wide open throttle, the turbocharger wastegate solenoid parameter should briefly be commanded as great as 90–100%. When the proper level of boost pressure is attained, the ECM will decrease the PWM of the solenoid to a range of 65–85%. As soon as the throttle closes the ECM will command the turbocharger wastegate solenoid parameter back to 0%, in order to allow the turbocharger waste gate to open from the air pressure ratio differential, there by reducing the speed of the turbine.

Conditions for Running the DTC

- Ignition ON or engine running.
- The battery voltage is between 11–32 V.
- This DTC runs continuously within the enabling conditions.

Conditions for Setting the DTC

The ECM detects an open, a short to ground, or a short to voltage on the turbocharger wastegate solenoid control circuit for greater than 0.5 s.

Action Taken When the DTC Sets

DTCs P0243, P0245 and P0246 are Type B DTCs.

Conditions for Clearing the DTC

DTCs P0243, P0245 and P0246 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Turbocharger System Description on page 9-306

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Ignition ON
2. Verify a series of clicks, which increase in frequency, are heard or felt from the Q42 Turbocharger Wastegate Solenoid Valve when commanding the Turbocharger Wastegate Solenoid Valve between 15–100 % with a scan tool.

⇒ **If a series of clicks in increasing frequency are not heard or felt**

Refer to Circuit/System Testing.

⇓ **If a series of clicks in increasing frequency is heard or felt**

3. Verify the parameters listed below do not display Malfunction when commanding the Turbocharger Wastegate Solenoid Valve between 15–100 % with a scan tool.
   - Turbocharger Wastegate Solenoid Valve Control Circuit High Voltage Test Status
   - Turbocharger Wastegate Solenoid Valve Control Circuit Open Test Status
   - Turbocharger Wastegate Solenoid Valve Control Circuit Low 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 a DTC does not set.

⇒ **If a DTC sets**

Refer to Circuit/System Testing

⇓ **If a DTC does not set**

6. All OK

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the Q42 Turbocharger Wastegate Solenoid Valve. Ignition ON.
2. Verify a test lamp illuminates between the ignition circuit terminal 2 and ground.

⇒ **If the test lamp does not illuminate and the circuit fuse is good**

2.1. Ignition OFF, remove the test lamp.

2.2. 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**

2.1. 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.

2.2. 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. Remove the test lamp.
4. Verify the scan tool Turbocharger Wastegate Solenoid Valve Control Circuit Low Voltage Test Status parameter is OK.

⇒ **If OK is not displayed**

4.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

4.2. 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**

5. Verify the scan tool Turbocharger Wastegate Solenoid Valve Control Circuit High Voltage Test Status parameter is OK.

⇒ **If OK is not displayed**

5.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

5.2. 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 1 and the ignition circuit terminal 2.
7. Verify the scan tool Turbocharger Wastegate Solenoid Valve Control Circuit High Voltage Test Status parameter is Malfunction.

⇒ **If Malfunction is not displayed**

7.1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module.

7.2. 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 Q42 Turbocharger Wastegate Solenoid Valve.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

Control Module References on page 6-3 for ECM replacement, programming and setup

DTC P025A

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC P025A: Fuel Pump Control Module Enable Circuit

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control	P025A	P025A	—	P025A

Circuit/System Description

The engine control module (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 seconds, unless the engine is in crank or run. While this voltage is being received, the fuel pump control module supplies a varying voltage to the fuel tank pump module in order to maintain the desired fuel line pressure.

Conditions for Running the DTC

The ignition is ON.

Conditions for Setting the DTC

The serial data message from the ECM to the fuel pump control module does not agree with the state of the control enable voltage signal supplied from the ECM to the fuel pump control module for more than 2 seconds.

Action Taken When the DTC Sets

DTC P025A is a Type A DTC.

Conditions for Clearing the DTC

DTC P025A is a Type A DTC.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Fuel System Description on page 9-302

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Testing

Note: Verify that the fuel tank is not empty. Only perform this diagnostic if there is at least 2 gallons of fuel in the fuel tank. Clear the DTC, and start and run the engine. Verify that the DTC resets before proceeding with the circuit system testing. If the DTC does not reset, refer to diagnostic aids.

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the K27 fuel pump control module, ignition ON.
2. Connect a test lamp between the control circuit terminal 20 and ground.
3. Verify the test lamp turns ON and OFF when commanding the fuel pump ON and OFF using the scan tool ECM fuel pump enable control function.

⇒ **If the test lamp is always OFF**

3.1. Ignition OFF, disconnect the harness connector at the K20 engine control module.

3.2. 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

3.3. 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 is always ON**

3.1. Ignition OFF, disconnect the harness connector at the K20 engine control module, ignition ON.

3.2. 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 turns ON and OFF**

4. Test or replace the K27 fuel pump control module.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

Control Module References on page 6-3 for ECM or fuel pump control module replacement, programming and setup

DTC P0300-P0304

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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

Circuit/System Description

The engine control module (ECM) uses information from the crankshaft position sensor and the camshaft position sensors in order to determine when an engine misfire is occurring. By monitoring variations in the crankshaft rotation speed for each cylinder, the ECM is able to detect individual misfire events. A misfire rate that is high enough can cause 3-way catalytic converter damage. The malfunction indicator lamp (MIL) will flash ON and OFF when the conditions for catalytic converter damage are present. DTCs P0301 through P0304 correspond to cylinders 1 through 4. If the ECM is able to determine that a specific cylinder is misfiring, the DTC for that cylinder will set, and the corresponding fuel injector is disabled and/or add fuel. The ECM will re-enable the fuel injector after 3 crankshaft revolutions (6 for manual transmission vehicles) to determine if a misfire is still present and either disable for 3 crankshaft revolutions (6 for manual transmission vehicles) again or stay enabled, depending on whether the misfire is still present.

Conditions for Running the DTC

- DTC 0010, P0011, P0013, P0014, P0016, P0017, P0018, P0019, P0020, P0021, P0023, P0024, P0068, 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, P0601, P0604, P0606, P0651, P16A0, P16A1, P16A2, P16F3, P2101, P2135, P2227, P2228, P2229, or P2230 is not set.
- The engine speed is between 600–6 528 RPM.
- The ignition voltage is between 11–18 V.
- The engine coolant temperature (ECT) sensor is between −7 to +125°C (+19 to +257°F).
- The A/C compressor clutch is not changing states.
- The fuel tank level is greater than 15%.
- The ECM is not in fuel cut-off or deceleration fuel cut-off mode.
- The ECM is not receiving a rough road signal.
- The throttle angle is steady within 5%.
- The throttle angle is greater than 3% when the vehicle speed is greater than 5 km/h (3 MPH).
- The transmission is not changing gears.
- The antilock brake system (ABS) and the traction control system, if equipped, is not active.
- DTCs P0300 00, P0301 00, P0302 00, P0303 00, and P0304 00 run continuously when the above conditions are met.

Conditions for Setting the DTC

The ECM is detecting a crankshaft rotation speed variation indicating a misfire sufficient to cause emission or catalyst damaging levels to exceed mandated standards.

Action Taken When the DTC Sets

- DTCs P0300–P0304 are Type B DTCs.
- The ECM may disable up to two fuel injector's of the misfiring cylinder's when a catalyst damaging level of misfire is present. And will flash the malfunction indicator lamp (MIL).

Conditions for Clearing the DTC

DTCs P0300–P0304 are Type B DTCs.

Diagnostic Aids

- A misfire may only occur when the engine is under a load or when the engine is cold.
- A misfire DTC may be caused by an excessive vibration from sources other than the engine. Inspect for the following possible sources:
  - A tire or wheel that is out of round or out of balance
  - Variable thickness brake rotors
  - Certain rough road conditions
  - A damaged accessory drive component or belt
  - A damaged reluctor wheel
- 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.
- The MIL indicator flashes when there is an engine misfire.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Special Tools

- *EL 26792* HEI Spark Tester
- *EN 36012–A* Ignition System Diagnostic Harness

For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308.*

Circuit/System Verification

Note: Before starting vehicle, review freeze frame data to determine if misfire sets during cold start or warmed up operation. If the vehicle has a cold start problem and the vehicle is started, the vehicle will require to be not started for many hours before next attempt to operate the vehicle within the fail conditions.

1. Engine idling at the normal operating temperature, verify there is no abnormal engine noise.
2. Verify there is no abnormal engine noise.

⇒ **If abnormal engine noises are present**

Refer to *Symptoms - Engine Mechanical on page 9-770.*

⇓ **If there are no abnormal engine noises**

3. Verify no DTCs other than P0300–P0304 are set.

⇒ **If any DTCs other than P0300–P0304 are set**

Refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69.*

⇒ **If only DTCs P0300–P0304 are set**

Refer to Circuit/System Testing.

⇓ **If no DTCs are set**

4. Verify the scan tool Cylinder 1–4 Current Misfire Counter Misfire parameters do not increment.

⇒ **If Misfire Current Counters are incrementing**

Refer to Circuit/System Testing

⇓ **If Misfire Current Counters are not incrementing**

5. Engine idling.
6. Verify the engine speed changes when performing the Cylinder Power Balance Test with a scan tool.

⇒ **If engine speed does not change**

Refer to Circuit/System Testing.

⇓ **If engine speed does change**

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 the DTCs are not set.

⇒ **If any of the DTCs set**

Refer to Circuit/System Testing.

⇓ **If none of the DTCs set**

9. All OK.

Circuit/System Testing

1. Perform the *Crankshaft Position System Variation Learn on page 9-243* procedure. Verify the scan tool displays Learned Successful.

⇒ **If the scan tool did not display Learned Successful**

Inspect for the following conditions and repair as necessary:

- Worn crankshaft main bearings
- A damaged or misaligned reluctor wheel
- Excessive crankshaft runout
- Interference in the signal circuit of the crankshaft position sensor
- 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
- Debris between the crankshaft position sensor and the reluctor wheel

⇒ If the engine control module is still unable to complete the learn procedure, replace the K20 Engine Control Module..

⇓ **If the scan tool displays Learned Successful**

2. Verify that the following conditions do not exist:
   - 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 on page 9-230.*
   - Contaminated fuel—Refer to *Alcohol/ Contaminants-in-Fuel Diagnosis on page 9-235.*
   - Exhaust system restrictions

⇒ **If a condition exist**

Repair or replace as necessary.

⇓ **If no conditions exist**

3. Ignition OFF, remove the K35 Ignition Coil Module and connect the *(EL 26792)* HEI Spark Tester to the coil of the misfiring cylinder.

4. Verify none of the conditions listed below exist with the boot of the K35 Ignition Coil Module:
   - Holes
   - Tears
   - Carbon tracking
   - Oil contamination
   - Water intrusion

⇒ **If a condition exist**

Repair or replace as necessary.

⇓ **If no conditions exist**

Note: An erratic or weak spark is considered a no spark condition.

5. Verify the*(EL 26792)* HEI Spark Tester sparks while cranking or starting the engine.

⇒ **If there is no spark**

Refer to *Electronic Ignition System Diagnosis on page 9-238* for diagnosis of the ignition coil.

⇓ **If there is spark**

6. Ignition OFF, remove the spark plug from the misfiring cylinder.
7. Exchange the suspected spark plug with another cylinder that is operating correctly.
8. Engine idling.
9. Verify the scan tool Cylinder 1–4 Current Misfire Counter parameter does not increment on the spark plug coil it was removed from.

⇒ **If the misfire does follow the spark plug exchange**

Replace the spark plug.

⇓ **If the misfire does not follow the spark plug exchange**

10. Test or inspect for the following:
    - A lean or rich Q17 Fuel Injector—Refer to *Fuel System Diagnosis on page 9-230*.
    - An engine mechanical condition—Refer to *Symptoms - Engine Mechanical on page 9-770*.

Repair Instructions

- *Ignition Coil Replacement on page 9-277*
- *Spark Plug Replacement on page 9-281*

Repair Verification

1. If the customer concern was a flashing MIL, operate the vehicle within the conditions for running DTC P0420 00. Refer to *DTC P0420 on page 9-155*.
2. Clear the DTCs with a scan tool.
3. Turn OFF the ignition for 60 s.
4. Start the engine.
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.
6. If the DTC fails this ignition, a misfire still exists.

DTC P0315

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC P0315: Crankshaft Position System Variation Not Learned

Circuit/System Description

The crankshaft position sensor system 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.

The crankshaft position sensor system variation compensating values are stored in ECM memory after a learn procedure has been performed. If the actual crankshaft position sensor variation is not within the crankshaft position sensor system variation compensating values stored in the ECM, DTC P0300 may set.

If the crankshaft position sensor system variation values are not stored in the ECM memory, DTC P0315 sets.

Conditions for Running the DTC

- The engine is running.
- The DTC runs continuously.

Conditions for Setting the DTC

The crankshaft position sensor system variation values are not stored in the ECM memory.

Action Taken When the DTC Sets

DTC P0315 is a Type A code.

Conditions for Clearing the DTC

DTC P0315 is a Type A code.

Diagnostic Aids

This test procedure requires that the vehicle battery has passed a load test and is completely charged. Refer to *Battery Inspection/Test on page 9-702*.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Testing

Note: The crankshaft position sensor system variation learn procedure may have to be repeated up to 5 times before the procedure is learned.

1. Perform the crankshaft position variation learn procedure. Refer to *Crankshaft Position System Variation Learn on page 9-243*.
2. If the crankshaft position variation learn procedure cannot be performed successfully, inspect for the following conditions:
   - Any worn crankshaft main bearings
   - A damaged or misaligned reluctor wheel
   - Excessive crankshaft runout
   - Interference in the signal circuit of the B26 Crankshaft Position Sensor
   - The ignition switch is left in the ON position, until the battery is discharged
   - An ECM power disconnect, with the ignition ON, that may have erased the crankshaft position sensor system variation values and set DTC P0315
   - Any debris between the crankshaft position sensor and the reluctor wheel

   ⇒ If the ECM is still unable to complete the learn procedure, replace the K20 Engine Control Module.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

Control Module References on page 6-3 for ECM replacement, programming and setup

DTC P0324, P0326, or P06B6

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC P0324: Knock Sensor Module Performance

DTC P0326: Knock Sensor Performance

DTC P06B6: Control Module Knock Sensor Processor Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	P0327	P0325	P0328	P0326
Low Reference	P0327	—	P0325, P0328	—

Circuit/System Description

The knock sensor 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. The knock sensor produces 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 knock sensor signal. The ECM receives the knock sensor signal through a signal circuit. The ECM supplies a ground circuit to the knock sensor through a low reference circuit. The ECM also supplies a shielded ground circuit to the knock sensor. The ECM learns a knock sensor noise level at idle and uses calibrated values for the rest of the engine speed range. The ECM should monitor a normal knock sensor signal within the noise channel.

Conditions for Running the DTC

P0324, and P0326 Excessive Knock Detection Mode

- Engine speed is between 580–8 500 RPM.
- The ECT is greater than −40°C (−40°F).
- The IAT is greater than −40°C (−40°F).
- The DTCs run continuously when the above conditions are met.

P0324 and P0326 Abnormal Noise Detection Mode, Improperly Bolted Knock Sensor

- Engine speed is between 2 500–8 500 RPM.
- The ECT is greater than −40°C (−40°F).
- The IAT is greater than −40°C (−40°F).
- The DTCs run continuously when the above conditions are met.

P06B6

- Engine speed is greater than 580 RPM.
- The ECT is greater than −40°C (−40°F).
- The IAT is greater than −40°C (−40°F).
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

P0324

The knock sensor signal indicates an excessive engine knock is present for greater than 10 s for at least 1 single cylinder.

P0326

- The signal indicates the sensor harness is connected, but the sensor is not properly bolted to the engine.
- The above condition exist for greater than 10 s.

or

- The knock sensor signal indicates an excessive engine knock is present.
- The above condition exist for greater than 10 s.

P06B6

The ECM has detected an internal knock sensor processor fault.

Action Taken When the DTC Sets

- DTCs P0324, P0326 and P06B6 are Type B DTCs.
- The ignition timing is retarded to reduce the potential of engine damaging spark knock.

Conditions for Clearing the DTC

DTCs P0324, P0326 and P06B6 are Type B DTCs.

Diagnostic Aids

- Inspect the knock sensor for physical damage and proper installation. A knock sensor that is dropped or damaged may cause a DTC to set.
- Inspect the knock sensor for proper installation. A knock sensor that is loose or over torqued may cause a DTC to set. The knock sensor should be free of thread sealant.
- The knock sensor mounting surface should be free of burrs, casting flash, and foreign material.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Knock Sensor System Description on page 9-304

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Engine running, observe the DTC information with a scan tool.
3. Verify DTC P0325, P0327, P0328 and P06B6 is not set.

⇒ **IF DTC P0325, P0327, or P0328 is set with P06B6**

Refer to *DTC P0325, P0327, or P0328 on page 9-145* for further diagnosis.

⇒ **If only DTC P06B6 is set**

Verify that no external knock sensor circuit issues exist, then; replace the K20 engine control module.

⇓ **If none of the DTCs is set**

4. Vehicle OFF, inspect for the following:
   - The affected B68 knock sensor for physical damage. A sensor that is dropped or damaged may cause a DTC to set
   - The sensor for proper installation. A sensor that is loose or not at the correct torque may cause a DTC to set. Refer to *Fastener Tightening Specifications on page 9-27*.
   - The sensor mounting surface for burrs, casting flash, and foreign material
   - The sensor must be clear of hoses, brackets, and engine electrical wiring
   - Loose brackets
   - Loose or broken accessory drive belts, brackets, components
   - An engine mechanical condition—Refer to *Symptoms - Engine Mechanical on page 9-770*

⇒ **If a condition is found**

Repair or replace component as appropriate.

⇓ **If no condition is found**

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 any of the DTCs set**

Test or replace the B68 knock sensor.

⇓ **If none of the DTCs set**

6. All OK

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

- *Knock Sensor Replacement on page 9-286*
- *Control Module References on page 6-3* for ECM replacement, programming and setup

DTC P0325, P0327, or P0328

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	P0327	P0325	P0328	P0326
Low Reference	P0327	P0325, P06B6	P0328	P0326

Circuit/System Description

The knock sensor 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 sensor produces 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 knock sensor signals. The ECM receives the two knock sensor signals through 2 isolated circuits. The ECM learns a minimum knock sensor noise level for all of the engine speed ranges. The ECM monitors for a normal knock sensor signal. The ECM monitors the two internal knock sensor processor by verifying a 20 KHz signal generated on the signal circuits is detected on the sensor low reference circuit.

Conditions for Running the DTCs

P0325

- Engine speed is between 500 and 7,000 RPM.
- The number of engine revolutions above the minimum engine speed is least 67 revolutions.
- Engine is running at least 2 s.
- The ECT is warmer than −40°C (−40°F).
- The IAT sensor is warmer than −40°C (−40°F).
- The DTCs run continuously when the above conditions are met.

P0327 or P0328

- Engine speed is less than 8,500 RPM.
- The DTCs run continuously when the above condition is met.

Conditions for Setting the DTCs

P0325

The ECM detects that a knock sensor signal circuit is open for longer than 6 s.

P0327

The ECM detects that a knock sensor signal circuit is shorted to ground for longer than 6 s.

P0328

The ECM detects that a knock sensor signal circuit is shorted to voltage for longer than 6 s.

Action Taken When the DTCs Set

- DTCs P0325, P0327 and P0328 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 and P0328 are Type B DTCs.

Diagnostic Aids

- Inspect the affected knock sensor for physical damage. A sensor that is dropped or damaged may cause a DTC to set.
- The sensor mounting surface must be free of burrs, casting flash, and foreign material.
- The sensor must be clear of hoses, brackets, and engine electrical wiring.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Circuit Testing on page 11-526*
- *Wiring Repairs on page 11-537*
- *Connector Repairs on page 11-548*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Engine Running.
2. Verify DTC P0325, P0327 or P0328 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 is properly tightened. Refer to *Fastener Tightening Specifications on page 9-755.*
4. Verify the scan tool parameters below display NO while moving the related harnesses and connectors for the appropriate B68 Knock Sensor.
   - Cylinder 1 Knock Detected
   - Cylinder 2 Knock Detected
   - Cylinder 3 Knock Detected
   - Cylinder 4 Knock Detected

   ⇒ **If NO is not displayed**

   Refer to Circuit/System Testing.

   ⇓ **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.

⇒ **If the DTC is set**

Refer to Circuit/System Testing.

⇓ **If the DTC is not set**

6. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the appropriate B68 Knock Sensor. It may take up to 2 min for all vehicle systems to power down.
2. Test for less than 10 Ω between the low reference circuit terminal 2 and ground.

⇒ **If 10 Ω or greater**

2.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.

2.2. 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. Test for 1–4 V between the signal circuit terminal 1 and ground.

⇒ **If greater than 4 V**

3.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module, ignition ON.

3.2. 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.

4. **If less than 1 V**

4.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.

4.2. 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

4.3. 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 between 1–4 V**

5. Replace the B68 Knock Sensor.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Knock Sensor Replacement on page 9-286*
- *Control Module References on page 6-3* for engine control module replacement, programming, and setup.

DTC P0335 or P0336

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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, P0335, P0651	P0335	P0651	P0336
Signal	P0335, P0506	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 (CMP) sensor pulses.

  OR
- DTCs P0101, P0102 and P0103 are not set.

  AND
- The airflow into the engine is greater than 2 g/s.

Condition 2

- The engine is running and the starter is not engaged.
- DTC P0651 is not set.

Condition 3

- The engine is running or the starter is engaged.
- DTCs P0365, P0366, P0641, or P0651 are not set.

P0336 Condition 1

- The airflow into the engine is greater than 2 g/s.
- Engine speed is greater than 450 RPM.
- DTCs P0335 or P0651 are not set.

Condition 2

- The engine is running and the starter is not engaged.
- DTC P0651 is not set.

Condition 3

- The starter is engaged and the engine control module detects camshaft position (CMP) sensor pulses.

  OR
- DTCs P0101, P0102, and P0103 are not set.
- The airflow into the engine is greater than 2 g/s.

Condition 4

- The engine is running or the starter is engaged.
- DTCs P0365, P0366, P0641, or P0651 are not set.

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 0.1 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 resynchronization have occurred within 10 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 greater than 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 on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Electronic Ignition System Description on page 9-297

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 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 (ECM) on page 9-182.*

⇓ **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**

2.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.

2.2. 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**

4.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.

4.2. 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

4.3. 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**

4.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module, ignition ON.

4.2. 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 3 and ground.

⇒ **If less than 4.8 V**

5.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.

5.2. 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.

5.3. 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**

5.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module, ignition ON.

5.2. 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 3, 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 on page 6-92* after completing the repair.

- *Crankshaft Position Sensor Replacement on page 9-284*
- *Control Module References on page 6-3* for engine control module replacement, programming, and setup

DTC P0340, P0341, P0365, or P0366

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptors

DTC P0340: Intake Camshaft Position Sensor Circuit
DTC P0341: Intake Camshaft Position Sensor Performance
DTC P0365: Exhaust Camshaft Position Sensor Circuit
DTC P0366: Exhaust Camshaft Position Sensor Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P0107, P0452, P0532, P0641	P0340, P0365	P0641	—
Signal	P0340, P0365	P0340, P0365	P0340, P0365	P0341, P0366
Low Reference	—	P0340, P0365	P0340, P0365	—

Circuit/System Description

The camshaft position sensors each have 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 exhaust camshaft position sensor to determine injector and ignition system synchronization. The intake and exhaust camshaft position sensors are also used to determine camshaft to crankshaft relationship. The ECM also 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 or P0365 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.
- The airflow into the engine is greater than 2 g/s.

Condition 2

- The engine is running and the starter is not engaged.
- DTC P0651 is not set.

Condition 3

- The crankshaft is synchronized.
- The starter is engaged.
- DTC P0335, P0336, P0641, or P0651 are not set.

Condition 4

- The crankshaft is synchronized.
- DTC P0335, P0336, P0641, or P0651 are not set.

P0341 or P0366 Condition 1

- The crankshaft is synchronized.
- The starter is engaged.
- DTC P0335, P0336, P0641, or P0651 are not set.

Condition 2

- The crankshaft is synchronized.
- DTC P0335, P0336, P0641, or P0651 are not set.

The DTCs run continuously once the above conditions are met.

Conditions for Setting the DTC

P0340 or P0365 Condition 1

The ECM does not detect a camshaft position sensor pulse for greater than 5.5 s or greater than 4.0 s since the time the starter has been engaged.

Condition 2

The ECM detects less than 4 camshaft position sensor pulses 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 or P0366 Condition 1

The ECM detects less than 4 or greater than 6 camshaft position sensor pulses during the first 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, P0341, P0365, and P0366 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, P0341, P0365, and P0366 are Type B DTCs.

Diagnostic Aids

- With a DTC set, the engine may crank for an extended period of time at start-up
- The exhaust camshaft position sensor is used for injector and ignition system synchronization. A stalling condition will occur if the camshaft positionsensor signal is intermittent and a DTC may not set. Inspect the intake and exhaust camshaft position sensor circuits for poor connections.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Electronic Ignition System Description on page 9-297

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0641 or P0651 is not set.

⇒ **If any of the DTCs are set**

Refer to *DTC P0641, P0651, P0697, or P06A3 (ECM) on page 9-182*.

⇓ **If none of the DTCs are set**

3. Engine Running.
4. Verify the scan tool parameters listed below increment:
   - Exhaust Camshaft Position Active Counter
   - Intake Camshaft Position Active Counter

⇒ **If any counter does not increment**

Refer to Circuit/System Testing.

⇓ **If all counters increment**

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 appropriate 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**

2.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.

2.2. 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**

4.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.

4.2. 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.

4.3. 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**

4.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module, ignition ON.

4.2. 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**

5.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.

5.2. 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.

5.3. 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**

5.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module, ignition ON.

5.2. 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 or P0366 is not set.

⇒ **If any of the DTCs are 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 none of the DTCs are set**

7. Test or replace the B23 Camshaft Position Sensor.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Camshaft Position Sensor Replacement on page 9-285*
- *Control Module References on page 6-3* for engine control module replacement, programming, and setup

DTC P0351-P0354

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	1	2	—	—
Ignition Coil 1 Control	P0300, P0351	P0300, P0351	P0300, P0351	P0300, P0351
Ignition Coil 2 Control	P0300, P0352	P0300, P0352	P0300, P0352	P0300, P0352
Ignition Coil 3 Control	P0300, P0353	P0300, P0353	P0300, P0353	P0300, P0353
Ignition Coil 4 Control	P0300, P0354	P0300, P0354	P0300, P0354	P0300, P0354
Low Reference	—	—	—	—
Ground	—	3	—	—

1. The engine cranks but does not run and opens the fuse that supplies voltage to the ignition coils.
2. The engine cranks but does not run
3. The engine may still run

Circuit/System Description

The ignition system on this engine uses an ignition coil module. The engine control module (ECM) controls the spark event for each cylinder through the individual ignition coil 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 running.
- Ignition voltage is greater than 5 V.

The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

The engine control module detects that the voltage command 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, and P0354 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P0351, P0352, P0353, and P0354 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Electronic Ignition System Description on page 9-297

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*

- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Engine Running.
2. Verify the scan tool parameters listed below do not display Malfunction:
   - Ignition Coil 1–4 Control Circuit High Voltage Test Status
   - Ignition Coil 1–4 Control Circuit Low Voltage Test Status
   - Ignition Coil 1–4 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 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 K35 Ignition Coil Module.
2. Remove the fuel injector fuse.
3. Connect a DMM between the appropriate K35 Ignition Coil Module control circuit listed below and ground. Set the DMM to the DC Hz scale and utilize the Min-Max function:
   - Ignition Coil 1 terminal D
   - Ignition Coil 2 terminal E
   - Ignition Coil 3 terminal F
   - Ignition Coil 4 terminal G
4. Verify the DMM displays greater than 1.5 Hz while cranking the engine.

⇒ **If less than 1.5 Hz**

4.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.

4.2. 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

4.3. 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

4.4. Ignition ON.

4.5. 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 greater than 1.5 Hz**

5. Replace the K35 Ignition Coil Module.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Ignition Coil Replacement on page 9-277*
- *Control Module References on page 6-3* for engine control module replacement, programming, and setup

DTC P0420

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC P0420: Catalyst System Low Efficiency

Circuit/System Description

Note: A new converter with less than 160 km (100 mi) on it may set DTC P0420 due to outgassing of the internal matting. Operating the vehicle at highway speeds for approximately 1 h may correct the condition.

A 3-way catalyst controls emissions of hydrocarbons, carbon monoxide (CO), and oxides of nitrogen (NOX). The catalyst within the converter promotes a chemical reaction, which oxidizes the hydrocarbon(s) and the CO that are present in the exhaust gas. This process converts the hydrocarbon(s) 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 a heated oxygen sensor (HO2S) that is in the exhaust stream after the three way catalyst. The HO2S 2 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 allowing the catalyst to heat, then wait for a stabilization period while the engine is idling. The ECM then adds and removes fuel while monitoring the HO2S 2. When the catalyst is functioning properly, the HO2S 2 response to the extra fuel is slow compared to the response of the HO2S 1, which is located before the three way catalyst. When the HO2S 2 response is near that of the HO2S 1, the oxygen storage capability and efficiency of the catalyst may be degraded below an acceptable threshold.

Conditions for Running the DTC

- DTCs P000A, P000B, P0010, P0013, P0016, P0017, P0030, P0031, P0032, P0036, P0038, P0117, P0118, P0119, P0121, P0122, P0123, P0131, P0132, P0133, P0134, P0135, P0136, P0137, P0138, P0139, P0140, P0141, P0171, P0201, P0202, P0203, P0204, P0221, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0301, P0302, P0303, P0304, P0335, P0336, P0340, P0365, P0366, P0443, P0446, P0458, P0459, P0496, P0562, P0563, P0642, P0643, P0652, P0653, P0661, P0662, P2088, P2089, P2090, P2091, P2096, P2097, P2100, P2101, P2122, P2123, P2127, P2128, P2176, P2297, P2301, P2303, P2304, P2306, P2307, P2309, P2310, P2A00, P2A0 are not set.
- The engine speed is greater than 1 200 RPM for a minimum of 2 s.
- The vehicle speed is less than 1.24 MPH.
- The intake mass air flow (MAF) is between 2.00–7.00 g/s.
- The vehicle is in closed loop.
- The calculated exhaust mass gas flow is between 5–55.56 g/s, and stable.
- The calculated catalyst temperature is between 480–800°C (896–1 472°F).
- The rear heated oxygen sensor (HO2S) has exceeded the dew point for more than 60 s.
- This diagnostic attempts one test during each period when the above conditions have been met. This diagnostic attempts up to 4 tests during each drive cycle.

Conditions for Setting the DTC

- The ECM has determined the catalyst efficiency has degraded below a calibrated threshold.
- This diagnostic may conclude in 6 test attempts which will require at least 2 drive cycles. However, this diagnostic may require as many as 8 test attempts. Depending on driving conditions, more than 2 drive cycles may be required. Each test attempt may conclude within approximately 1 min.

Action Taken When the DTC Sets

DTC P0420 is a Type A DTC.

Conditions for Clearing the DTC

DTC P0420 is a Type A DTC.

Diagnostic Aids

Inspect for the following conditions, which may cause a catalyst to degrade:

- An engine misfire
- High engine oil or high coolant consumption
- Retarded spark timing
- A weak or poor spark
- A lean fuel mixture
- A rich fuel mixture
- A damaged oxygen sensor or wiring harness

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Testing

1. Engine idling, observe the DTC information with a scan tool. Verify there are no HO2S or misfire DTCs set.
   ⇒ If any of the DTCs are set, refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69*.
2. Verify the following conditions do not exist with the catalyst:
   - Dents
   - A severe discoloration caused by excessive temperatures
   - Road damage
   - An internal rattle caused by damaged catalyst subset
   - Restrictions

   ⇒ If a condition is found, replace the catalyst
3. Verify the following conditions do not exist with the exhaust system:
   - Leaks
   - Physical damage
   - Loose or missing hardware
   - Properly torqued B52A Heated Oxygen Sensor 1 or B52B Heated Oxygen Sensor 2

   ⇒ If a condition is found, repair the exhaust system.

   ⇒ If the DTC fails this key cycle, continue with this procedure.
4. Verify the following conditions do not exist with the B52B Heated Oxygen Sensor 2.
   - A grounded B52B Heated Oxygen Sensor 2 wiring harness
   - Damage

   ⇒ If a condition is found, replace the B52B Heated Oxygen Sensor 2.
5. If no physical condition is detected and the B52B Heated Oxygen Sensor 2 is as active as the B52A Heated Oxygen Sensor 1 after operating the engine at 1 500 RPM for 1 min and then returning to a stabilized idle, then replace the catalyst.

Repair Instructions

Note: A new converter with less than 160 km (100 mi) on it may set DTC P0420 due to outgassing of the internal matting. Operating the vehicle at highway speeds for approximately 1 h may correct the condition.

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

- *Heated Oxygen Sensor Replacement - Sensor 1 on page 9-249*
- *Heated Oxygen Sensor Replacement - Sensor 2 on page 9-250*
- *Catalytic Converter Replacement (LUV) on page 9-742*
- *Exhaust Leakage on page 9-736*
- *Symptoms - Engine Exhaust on page 9-734*

DTC P0442

Diagnostic Instructions

- Perform the*Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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 (EONV) test is the small leak detection diagnostic for the evaporative emission (EVAP) system. This diagnostic tests the 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. 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 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 P010C, P010D, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0125, P0128, P0443, P0446, P0449, P0452, P0453, P0455, P0496, P0461, P0462, P0463, P0464, P0496, P0502, P0503, P0722, P0723, P2227, P2228, P2229, P2230, P2610. are not set.
- The barometric pressure (BARO) is greater than 70 kPa.
- The engine coolant sensor (ECT) is greater than 70°C (158°F)
- No fuel filling during the EONV test period.
- The fuel level is between 10–90 %.
- The start-up engine coolant temperature (ECT) and the start-up intake air temperature (IAT) are within 8°C (46°F).
- The engine run time before shut-off was greater than 10 min.
- The drive distance before engine shut-off was more than 8 km (5 mi).
- The ambient air temperature at the end of the drive cycle is between 0–34°C (32–93°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 controller will not make more than 2 test attempts per day. The time since the last completed EONV test must be at least 17 h.

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 EONV 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 temporarily leave the EVAP vent solenoid valve open until smoke is observed then close the system and continue testing.
- To help locate intermittent leaks using the *GE 41413-A* Evaporative Emissions System Tester (EEST), move all EVAP components while observing smoke with the *GE 41413-SPT* High Intensity White Light.
- Individual components can be isolated and tested using adapters in the *GE 41413-300* EVAP Cap and Plug Kit.
- 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 parameter for vacuum decay.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Evaporative Emission Control System Description on page 9-300

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*

- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Special Tools

- *CH 48096* EVAP Service Port Access Tool
- *GE 41413–A* Evaporative Emissions System Tester (EEST)
- *GE 41413–300* EVAP Cap and Plug Kit
- *GE 41413–SPT* High Intensity White Light

For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308*.

Circuit/System Testing

Note:

- Refer to the *GE 41413-A* Evaporative Emissions System Tester (EEST) operation manual for detailed instructions in *Evaporative Emission Control System Diagnosis on page 9-236*
- Larger volume fuel tanks and/or those with lower fuel levels may require several minutes for the floating indicator to stabilize or produce smoke from a leak.
- 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* EVAP Service Port Access Tool.
2. Connect the *GE 41413-A* Evaporative Emissions System Tester (EEST) to the *CH 48096* EVAP Service Port Access Tool.
3. Using a scan tool close the EVAP vent solenoid valve to seal the EVAP system.
4. Use the flow meter on the *GE 41413-A* Evaporative Emissions System Tester (EEST), calibrated to 0.51 mm (0.020 in) to determine if there is a leak.

⇒ **If a leak is detected**

4.1. Use the *GE 41413-A* Evaporative Emissions System Tester (EEST) to apply smoke to the EVAP system at the purge tube until the leak is located using the *GE 41413-SPT* High Intensity White Light

⇓ **No leak in the EVAP system**

5. All OK.

Repair Verification

1. Seal the EVAP system and use the flow meter on the *GE 41413-A* Evaporative Emissions System Tester (EEST), calibrated to 0.51 mm (0.020 in) to determine that there is no leak in the EVAP system.
2. Clear DTCs.

DTC P0443

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC P0443: Evaporative Emission (EVAP) Purge Solenoid Valve Control Circuit

Diagnostic Fault Information

Circuit	Short to Ground	Open / High Resistance	Short to Voltage
Ignition – Purge Supply	P0031, P0033, P0034, P0037, P0132, P0134, P0135, P0138, P0140, P0245, P0443, P0597, P0507, P0598	P0443	P0690
EVAP Purge Solenoid Valve Control	P0443	P0443	P0443, P0690

Circuit/System Description

An ignition voltage is supplied directly to the evaporative emission (EVAP) purge solenoid valve. The engine control module (ECM) grounds the EVAP purge solenoid valve control circuit through an internal switch called a driver. The ECM monitors the status of the driver. The EVAP purge solenoid valve is pulse width modulated (PWM). A scan tool will display the amount of ON time as a percentage. If the ECM detects an incorrect voltage for the commanded state of the driver this DTC sets.

Conditions for Running the DTC

- The system voltage is greater than 11 V.
- DTC P0443 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 P0443 is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P0443 is a Type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Evaporative Emission Control System Description on page 9-300

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify the parameters listed below do not display malfunction when commanding the EVAP purge solenoid valve from 0 to 50 % and back to 0 % with a scan tool.
   - EVAP Purge Solenoid Valve Control Circuit Low Voltage Test Status
   - EVAP Purge Solenoid Valve Control Circuit Open 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 display**

3. 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 circuit terminal 2 and ground.

⇒ **If the test lamp does not illuminate and the circuit fuse is good**

2.1. Ignition OFF, remove the test lamp.

2.2. 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**

2.1. Ignition OFF, remove the test lamp.

2.2. 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 the Q12 Evaporative Emission Purge Solenoid Valve and replace as necessary.

⇓ **If the test lamp illuminates**

3. Verify that a test lamp does not illuminate between the ignition circuit terminal 2 and the control circuit terminal 1.

⇒ **If the test lamp illuminates**

3.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

3.2. 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 Purge Solenoid Valve Control Circuit High Voltage Test Status parameter is OK when commanding the EVAP purge solenoid valve ON with a scan tool.

⇒ **If the Parameter is not OK**

5.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

5.2. 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**

6. Install a 3 A fused jumper wire between the control circuit terminal 1 and the ignition circuit terminal 2.
7. Verify the scan tool EVAP Purge Solenoid Valve Control Circuit High Voltage Test Status parameter is Malfunction when commanding the EVAP Purge Solenoid Valve ON with a scan tool.

⇒ **If the Parameter is not Malfunction.**

7.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

7.2. 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**

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 10.0–30.0 Ω between the control circuit terminal 1 and the ignition circuit terminal 2 of the Q12 Evaporative Emission Purge Solenoid Valve.

⇒ **If not between 10.0–30.0 Ω**

Replace the Q12 Evaporative Emission Purge Solenoid Valve

⇓ **If between 10.0–30.0 Ω**

3. All OK.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Evaporative Emission Canister Purge Solenoid Valve Replacement on page 9-276*
- *Control Module References on page 6-3* for ECM replacement, setup, and programming

DTC P0446

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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) uses the fuel tank pressure (FTP) sensor to monitor EVAP system vacuum. With the purge valve and vent valve open, if the EVAP system vacuum goes above a calibrated threshold, P0446 will set.

The following table 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 P00C8, P00C9, P010C, P010D, P0068, P16F3, P0102, P0103, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0122, P0123, P0125, P0128, P160E, P160D, P0191, P0192, P0193, P0222, P0223, P0443, P0449, P0452, P0453, P0454, P0502, P0503, P0606, P0722, P0723, P1104, P2100, P2101, P2102, P2103, P2135, P2227, P2228, P2229, or P2230 is not set
- The ignition voltage is between 11–32 V.
- The barometric pressure (BARO) is more than 70 kPa.
- The fuel level is between 10–90 %.
- The startup engine coolant temperature (ECT) is less than 35°C (95°F).
- The startup intake air temperature (IAT) is between 4–30°C (39–86°F).
- DTC P0446 runs once per cold start, for up to 17 min, when the above conditions are met, .

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 liters (0.5 gallons) 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 MIL/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, or a pinched vent hose. A blockage in the vent system may also cause a poor fuel fill condition.
- An EVAP canister filter that is restricted can cause this DTC to set.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Evaporative Emission Control System Description on page 9-300

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 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 on page 9-593*

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0443 is not set.

⇒ **If the DTC is set**

Refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69*

⇓ **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 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 on page 9-433*

⇓ **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 Control System Diagnosis on page 9-524*.

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 System Seal 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 H2O.
7. Verify the scan tool Fuel Tank Pressure Sensor parameter is 0 in H2O 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 H2O**

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 on page 6-92* after completing the repair.

- *Evaporative Emission Canister Vent Solenoid Valve Replacement on page 9-270*
- *Evaporative Emission Canister Replacement (Steel Tank) on page 9-567*
- *Fuel Tank Pressure Sensor Replacement on page 9-263*

DTC P0449

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptors

DTC P0449: Evaporative Emission (EVAP) Vent Solenoid Valve Control Circuit

Diagnostic Fault Information

Circuit	Short to Ground	Open / High Resistance	Short to Voltage
Battery – Vent Supply	P0449	P0449	—
EVAP Vent Solenoid Valve Control	P0449	P0449	P0449

Circuit/System Description

Battery voltage is supplied to the evaporative emissions (EVAP) vent solenoid valve. 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 for the control circuit. A scan tool will display the commanded state of the EVAP vent solenoid valve as OFF – Venting or ON – Not Venting .

Conditions for Running the DTC

DTC P0449 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 P0449 is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P0449 is a Type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Evaporative Emission Control System Description on page 9-300

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Ignition ON, engine OFF,
2. Command the EVAP Vent Solenoid Valve ON – Not Venting and OFF – Venting with a scan tool.
3. You should hear the solenoid click when commanded ON and OFF.

⇒ **No clicking heard**

Refer to Circuit/System Testing

⇓ **Clicking is heard**

4. Engine idling, command the EVAP Vent Solenoid Valve ON – Not Venting and OFF – Venting with a scan tool while observing the following control circuit status parameters:
   - EVAP Vent Solenoid Valve Control Circuit Low Voltage Test Status
   - EVAP Vent Solenoid Valve Control Circuit Open Test Status
   - EVAP Vent Solenoid Valve Control Circuit High Voltage Test Status

⇒ **If the Parameters display Malfunction**

Refer to Circuit/System Testing

⇓ **If the Parameters display OK or Not Run**

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 Q13 Evaporative Emissions Vent Solenoid Valve, ignition ON.
2. Verify that a test lamp illuminates between the B+ circuit terminal 2 and ground.

⇒ **If the test lamp does not illuminate and the circuit fuse is good**

2.1. Ignition OFF, remove the test lamp.

2.2. 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**

2.1. Ignition OFF, remove the test lamp.

2.2. Test for infinite resistance between the B+ circuit and ground.

⇒ If less than infinite resistance, repair the short to ground in the circuit.

⇒ If infinite resistance, test the Q13 Evaporative Emissions Vent Solenoid Valve 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 2 and the control circuit terminal 1.

⇒ **If the test lamp illuminates**

3.1. Ignition OFF, disconnect the harness connector at the Q13 Evaporative Emissions Vent Solenoid Valve.

3.2. 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 ON with a scan tool.

⇒ **If the Parameter is not OK**

5.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

5.2. Test for less than 1 V between the control 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 the Parameter is OK**

6. Install a 3 A fused jumper wire between the control circuit terminal 1 and the B+ circuit terminal 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 ON with a scan tool.

⇒ **If the Parameter is not Malfunction**

7.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

7.2. 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**

8. Test or replace the Q13 Evaporative Emission Vent Solenoid Valve.

Component Testing

Static Test

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 1 and the B+ voltage terminal 2.

⇒ **If not between 10.0–30.0 Ω**

Replace the Q13 Evaporative Emission Vent Solenoid Valve.

⇓ **If between 10.0–30.0 Ω**

3. All OK.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Evaporative Emission Canister Vent Solenoid Valve Replacement on page 9-270*
- *Control Module References on page 6-3* for ECM replacement, setup, and programming.

DTC P0451-P0454

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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	P0236, P0237, P0452, P0532, P0641	P0451	P0452	P0236, P0238, P0453, P0641, P1101,P2227	—
Signal	P0452	P0451	P0452	P0453	P0451, P0454
Low Reference	—	P0446, P0451	P0453, P0463	—	P0451

Typical Scan Tool Data

FTP Sensor Voltage

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Ignition ON, Engine OFF **Parameter Normal Range:** 1.3–1.7 V			
FTP Sensor 5 V Reference	0 V	0 V	4.2–5 V
FTP Sensor Signal	0 V	0 V	5 V
FTP Sensor Low Reference	—	4.5 V	—

Circuit/System Description

The Fuel Tank Pressure (FTP) sensor measures 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 FTP sensor. The FTP sensor signal voltage varies depending on EVAP system pressure or vacuum. The controller also uses this FTP 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 and the EVAP Vent Solenoid Valve is closed.
- 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.

Conditions for Setting the DTC

P0451

This DTC will set if the controller is unable to re-zero the FTP sensor voltage within a calibrated range during the engine-off small leak test, P0442.

P0452

The FTP sensor voltage is less than 0.15 V for more than 10 s.

P0453

The FTP sensor voltage is more than 4.9 V for more than 10 s.

P0454

If, during the engine-off natural vacuum small leak test, P0442, the ECM detects an abrupt FTP signal change, other than a refueling event, this DTC will set. An abrupt change is defined as a change of 0.45 in H2O in the span of 1 s but less than 1 in H2O in 12.5 ms.

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 FTP sensor is unobstructed.
- An FTP sensor that is skewed or does not have a linear transition from low to high may cause this code to set. Scan tool output controls, 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.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Evaporative Emission Control System Description on page 9-300

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Special Tools

GE 41413-A Evaporative Emission System Tester (EEST)

For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308*

Circuit/System Verification

1. Remove the fuel cap.
2. Ignition ON, engine OFF.
3. Verify the scan tool FTP 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. 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**

2.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

2.2. 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**

4.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

4.2. 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

4.3. 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**

4.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

4.2. 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 FTP parameter is less than 0.2 V.

⇒ **If 0.2 V or greater**

5.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON

5.2. 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 FTP sensor parameter is greater than 4.7 V.

⇓ **If 4.7 V or less**

7.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

7.2. 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

7.3. 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 on page 6-92* after completing the repair.

- *Fuel Tank Pressure Sensor Replacement on page 9-263*
- *Control Module References on page 6-3* for ECM replacement, setup, and programming.

DTC P0455

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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 within a set amount of time.

Conditions for Running the DTC

- DTCs P00C8, P00C9, P010C, P010D, P16A0, P16A1, P16A2, P160E, P160D, P16F3, P0068, P0101, P0102, P0103, P0111, P0112, P0113, P0114 P0116, P0117, P0118, P0122, P0123, P0125, P0128, P0191, P0192, P0193, P0222, P0223, P0443, P0449, P0452, P0453, P0454, P0502, P0503, P0601, P0604, P0606, P0722, P0723, P1104, P1682, P2100, P2101, P2102, P2103, P2135, P2176, P2227, P2228, P2229, P2230 are not set.
- The ignition voltage is between 11–32 V.
- The barometric pressure (BARO) is greater than 70 kPa.
- The fuel level is between 10–90 %.
- The EVAP purge flow is greater than 2.80 %
- The cold startup engine coolant temperature (ECT) and the startup intake air temperature (IAT) are within 8°C (46°F).
- The startup engine coolant temperature (ECT) is less than 35°C (95°F).
- The startup intake air temperature (IAT) is between 4–30°C (39–86°F).
- DTC P0455 runs once per cold start, for up to 17 min, when the above conditions are met.

Conditions for Setting the DTC

- The EVAP system is not able to achieve or maintain a calibrated level of vacuum within a set amount of time.
- 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.
- With a DTC P0455 detected a weak vacuum follow-up test (fuel cap replacement test) will run and passes if tank vacuum is greater than 2.74 kPa (11 in H20). This test will run for a maximum of 22 min. This test runs until it passes.

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, damaged, or incorrect fuel fill cap.
- Inspect for a damaged fuel filler neck seal surface.
- A blockage or restriction in the EVAP purge solenoid valve, purge pipe, EVAP 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 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 *J 41413-VLV* EVAP Service Port Vent Fitting at the service port to allow the system to fill faster.
- To help locate intermittent leaks using the *GE 41413-A* Evaporative Emissions System Tester (EEST), move all EVAP components while observing smoke with the *GE 41413-SPT* High Intensity White Light.
- Individual components can be isolated and tested using adapters in the *J 41413-300* EVAP Cap and Plug Kit.
- 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 parameter for vacuum decay.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Evaporative Emission Control System Description on page 9-300

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Special Tools

- *CH 48096* EVAP Service Access Port Tool
- *GE 41415-30* Fuel Tank Cap Adapter
- *GE 41413-A* Evaporative Emissions System Tester (EEST)
- *J 41413-300* EVAP Cap and Plug Kit
- *GE 41413-SPT* High Intensity White Light
- *J 41413-311* EVAP Plug
- *J 41413-VLV* EVAP Service Port Vent Fitting

For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308*

Circuit/System Testing

Important:

- Larger volume fuel tanks and/or those with lower fuel levels may require several minutes for the floating indicator to stabilize or produce smoke from a leak.
- Refer to the *GE 41413-A* Evaporative Emissions System Tester (EEST) operation manual for detailed instructions in *Evaporative Emission Control System Diagnosis on page 9-236*

1. Disconnect the purge tube at the quick connector on the EVAP canister side of the purge solenoid valve and install the *CH 48096* EVAP Service Access Port Tool.
2. Connect the *GE 41413-A* Evaporative Emissions System Tester (EEST) to the vehicle EVAP service port adapter.
3. Use a scan tool to seal the EVAP system.
4. Use the flow meter on the *GE 41413-A* Evaporative Emissions System Tester (EEST), calibrated to 0.51 mm (0.020 in) to determine that there is no leak in the EVAP system.

⇒ **If a leak is detected**

4.1. Use the *GE 41413-A* Evaporative Emissions System Tester (EEST) to apply smoke to the EVAP system at the service access port adapter.

4.2. Locate the leak using the *GE 41413-SPT* High Intensity White Light.

⇓ **No leak detected**

5. Refer to step 10.
6. To test for a restriction in the purge path.

6.1. Connect the *GE 41413-A* Evaporative Emissions System Tester (EEST) nitrogen/smoke hose to the *J 41413-311* EVAP Plug brass cone adapter.

6.2. Disconnect the hose at the fuel cap end of the *GE 41415-30* Fuel Tank Cap Adapter.

6.3. Connect the *J 41413-311* EVAP Plug to the disconnected hose on the *GE 41415-30* Fuel Tank Cap Adapter.

6.4. Install the *GE 41415-30* Fuel Tank Cap Adapter, filler neck end only, to the vehicle.

7. Engine idling, command the Purge/Seal function to seal the system with a scan tool.
8. Command the EVAP purge solenoid valve to 30 %.
9. The vacuum/pressure gauge on the *GE 41413-A* Evaporative Emissions System Tester (EEST) and the FTP parameter on the scan tool should both show vacuum.

⇒ **If the vacuum/pressure gauge shows vacuum, but the FTP parameter does not show vacuum**

Replace the B150 Fuel Tank Pressure Sensor.

⇒ **If neither the FTP parameter nor the vacuum/pressure gauge shows vacuum**

Repair the restriction in the purge path.

10. Verify that the vacuum increases to the abort limit on the scan tool or greater than 3.2 V, and the values are similar between the scan tool and the vacuum/pressure gauge on the *GE 41413-A* Evaporative Emissions System Tester (EEST).

⇒ **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 on page 6-92* after completing the diagnostic procedure.

- *Fuel Tank Pressure Sensor Replacement on page 9-263*
- *Control Module References on page 6-3* for ECM replacement, setup, and programming.

DTC P0496

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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 following table 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 P00C8, P00C9, P010C, P010D, P16A0, P16A1, P16A2, P160E, P160D, P16F3, P0068, P0101, P0102, P0103, P0111, P0112, P0113, P0114 P0116, P0117, P0118, P0122, P0123, P0125, P0128, P0191, P0192, P0193, P0222, P0223, P0443, P0449, P0452, P0453, P0454, P0502, P0503, P0601, P0604, P0606, P0722, P0723, P1104, P1682, P2100, P2101, P2102, P2103, P2135, P2176, P2227, P2228, P2229, P2230 are not set.
- The ignition voltage is between 11–32 V.
- The engine OFF time is greater than 8 h,
- 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 35°C (95°F).
- The startup intake air temperature (IAT) is between 4–30°C (39–86°F).
- DTC P0496 runs once per cold start, for up to 17 min, when the above conditions are met.

Conditions for Setting the DTC

- The ECM detects more than 10 in H2O vacuum for 5 s during a non-purge condition.
- This test will run with the purge valve closed and the vent valve closed.

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 or system tubing.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Evaporative Emission Control System Description on page 9-300

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 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

1. Ignition ON, engine OFF.
2. Seal the EVAP system using the Purge/Seal function with a scan tool.
3. Start the engine.
4. Observe the FTP sensor with a scan tool. The FTP sensor parameter should be less than 1.7 V after 90 s.

⇒ **If not within specifications**

Replace the Q12 Evaporative Emission Purge Solenoid Valve

⇓ **Within Specifications**

5. All OK

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

Evaporative Emission Canister Purge Solenoid Valve Replacement on page 9-276

DTC P0506 or P0507 (LUV)

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* 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, P0120, P0121, P0122, P0123, P0128, P0171, P0172, P0201–P0204, P0220, P0222, P0223, P0300–P0304, P0351–P0354, P0461– P0463, P0496, P0606, P0722, P0723, P1516, P2066–P2068, P2101, P2135 are not set.
- The engine is operating for at least 60 s.
- The barometric pressure (BARO) is greater than 70 kPa (11 psi).
- The engine coolant temperature (ECT) is greater than 60°C (140°F).
- The system voltage is between 11–32 V.
- The transmission is not changing gears.
- The torque converter clutch (TCC) is not changing states.
- The intake air temperature (IAT) is warmer than −20°C (−4°F).
- The vehicle speed is less than 3 km/h (2 mph).
- The commanded engine speed is steady within 25 RPM.
- The engine is idling for greater than 5 s.
- A scan tool output control is not active.
- DTC 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 91 RPM lower than the desired idle speed.

P0507

The actual idle speed is approximately 182 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 on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Throttle Actuator Control (TAC) System Description on page 9-305

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify no other DTCs set.

⇒ **If any other DTC is set**

Refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69* for further diagnosis.

⇓ **If no other DTC is set**

3. Verify the scan tool Throttle Body Idle Airflow Compensation parameter is less than 90 %.

⇒ **90 % or greater**

Refer to *Throttle Body Inspection and Cleaning on page 9-253*.

⇓ **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 greater than the Desired Idle Speed**

Refer to Circuit/System Testing

⇓ **If 200 RPM less than 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 the DTC does not set.

⇒ **If the DTC sets**

Refer to Circuit/System Testing

⇓ **If the DTC does not set**

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.

⇒ **If a condition is found**

Repair as necessary.

⇓ **If a condition is not found**

2. All OK.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

Throttle Body Assembly Replacement on page 9-253

DTC P0601-P0604, P0606, or P062F (Fuel Pump Control Module)

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each 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 P062F: Control Module Long Term Memory Performance

Circuit/System Description

The internal fault detection is handled inside the fuel pump control module. No external circuits are involved.

Conditions for Running the DTC

The fuel pump control module runs the program to detect an internal fault when power up is commanded. The only requirements are voltage and ground. This program runs even if the voltage is out of the valid operating range.

Conditions for Setting the DTC

The fuel pump control module has detected an internal malfunction.

Action Taken When the DTC Sets

DTC P0601, P0602, P0603, P0604, P0606 and P062F are type A DTCs.

Conditions for Clearing the DTC

DTC P0601, P0602, P0603, P0604, P0606 and P062F are type A DTCs.

Reference Information

Description and Operation

Engine Controls Schematics on page 9-28

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Circuit/System Verification

Note: This DTC may be stored as a history DTC without affecting the operation of the module. If stored only as a history DTC and not retrieved as a current DTC, do not replace the module.

1. Ignition ON.
2. Verify DTC P0602 is not set.

⇒ **If DTC P0602 is set**

2.1. Program the K27 fuel pump control module.
2.2. Verify the DTC does not set.
⇒ If the DTC sets, replace the K27 fuel pump control module.
⇓ If the DTC does not set.
2.3. All OK.

⇓ **If DTC P0602 is not set**

3. Verify DTCs P0601, P0603, P0604, P0606, and P062F are not set.

⇒ **If any of the DTCs are set**

3.1. Program the K27 fuel pump control module.
3.2. Verify the DTC does not set.
⇒ If the DTC sets, replace the K27 fuel pump control module.
⇓ If the DTC does not set.
3.3. All OK.

⇓ **If none of the DTCs are set**

4. All OK

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

Control Module References on page 6-3 for fuel pump control module replacement, programming and setup

DTC P0601-P0604, P0606, P062B, P062F, P0630, P16F3, or P262B (ECM)

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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 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 in ON.

P0603, P062F

These DTCs run once per ignition cycle.

P0604

DTC P0604 runs continuously when the ignition is ON for greater than 30 s.

P0606

DTC P0606 runs continuously when Ignition 1 Signal voltage is greater than 11 V.

P16F3

- The engine speed is greater than 500 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 on 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, P062F, P0630, and P16F3 are Type A DTCs.
- DTC P262B is a Type B DTC.

Conditions for Clearing the MIL/DTC

- DTCs P0601, P0602, P0603, P0604, P0606, P062F, P0630, and P16F3 are Type A DTCs.
- DTC P262B is a Type B DTC.

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 on page 9-702*.
- 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.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Ignition ON, clear the DTC information with a scan tool. Observe the DTC information with a scan tool.
2. Verify that DTC P0641, P0651, P0697, or P06A3 does not set.

⇒ **If a DTC is set**

Refer to *DTC P0641, P0651, P0697, or P06A3 (ECM) on page 9-182* for further diagnosis.

⇓ **If DTC P0641, P0651, P0697, or P06A3 does not set**

3. Observe the DTC information with a scan tool. Verify DTC P0602 or P0630 is not set.

⇒ **If DTC P0602 or P0630 is set**

3.1. Program the K20 Engine Control Module. Refer to *Control Module References on page 6-3*.

3.2. Verify DTC P0602 or P0630 is not set.

⇒ If DTC P0602 or P0630 sets, replace the K20 Engine Control Module.

⇓ If DTC P0602 or P0630 does not set

3.3. All OK.

⇓ **If DTC P0602 or P0630 is not set**

4. Verify DTC P0601, P0603, P0604, P0606, P062F, P16F3, or P262B is not set.

⇒ **If DTC P0601, P0603, P0604, P0606, P062F, P16F3, or P262B is set**

Replace the K20 Engine Control Module.

⇓ **If DTC P0601, P0603, P0604, P0606, P062F, P16F3, or P262B is not set**

5. All OK.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

Control Module References on page 6-3 for Engine Control Module replacement, programming and setup

DTC P0627-P0629

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptors

DTC P0627: Fuel Pump Enable Circuit
DTC P0628: Fuel Pump Enable Circuit Low Voltage
DTC P0629: Fuel Pump Enable Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control	P0628	P0627, P0628	P0629	—

Circuit/System Description

The engine control module (ECM) provides ignition voltage to the fuel pump flow control module whenever the engine is cranking or running. The control module enables the fuel pump flow 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 flow control module supplies a varying voltage to the in-tank fuel pump module in order to maintain the desired fuel line pressure.

Conditions for Running the DTC

P0627 and P0629

- The ignition voltage is between 11–32 V.
- The ECM has commanded the fuel pump OFF.
- The DTCs run continuously when the above conditions are met for greater than 1 s.

P0628

- The ignition voltage is between 11–32 V.
- The ECM has commanded the fuel pump ON.
- The DTC runs continuously when the above conditions are met for greater than 1 s.

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 2.5 s.

Action Taken When the DTC Sets

DTCs P0627, P0628, and P0629 are Type B DTCs.

Conditions for Clearing the DTC

DTCs P0627, P0628, and P0629 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC P0627, P0628, or P0629 is not set.

⇒ **If a DTC is set**

Refer to Circuit/System Testing

⇓ **If a 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 harness connector at the K27 Fuel Pump Control Module.
2. Install two 3 A fused jumper wires at the harness connector between the following terminals:
   - Terminal 5 and terminal 6
   - Terminal 17 and terminal 18
3. Ignition ON for 10 s.
4. Verify that a test lamp does not illuminate between the control circuit terminal 20 and ground.

⇒ **If the test lamp illuminates**

4.1. Ignition OFF, remove the test lamp, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

4.2. 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. 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**

6.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

6.2. 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**

7. Install a 3 A fused jumper wire between the control circuit terminal 20 and ground.
8. 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**

8.1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module.

8.2. 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. Replace the K27 Fuel Pump Control Module.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

Control Module References on page 6-3 for Engine Control Module or Fuel Pump Flow Control Module replacement, programming, and setup

DTC P0630

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC P0630: VIN Not Programmed or Mismatched – Engine Control Module (ECM)

Circuit/System Description

This DTC sets when the engine control module (ECM) has determined that the vehicle identification number (VIN) is not stored in the ECM memory. When the control module is replaced, the VIN must be programmed into the control module memory.

Conditions for Running the DTC

- The control module is ON or awake.
- The DTC runs continuously when the above condition is met.

Conditions for Setting the DTC

The ECM detects that no VIN is stored in memory.

Action Taken When the DTC Sets

DTCs P0630 is a Type C DTC.

Conditions for Clearing the DTC

DTCs P0630 is a Type C DTC.

Reference Information

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

Note: The ECM cannot determine if the VIN programmed into the control module is valid. Always verify that the VIN displayed on the scan tool is correct for that vehicle.

1. Ignition ON, observe the Vehicle Information under ID System Information on the scan tool. The VIN information should match the vehicles VIN.
   ⇒ If a VIN is not displayed, program the VIN with a scan tool.
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.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

DTC P0641 or P06A6 (Fuel Pump Control Module)

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptors

DTC P0641: 5 V Reference Circuit
DTC P06A6: 5 V Reference 1 Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P018C, P0641, P06A6	P018C	P018D, P0641, P06A6	P06A6
Signal	P018C	P018B, P018C	P018D	P018B
Low Reference	—	P0641, P06A6	—	P06A6

Circuit/System Description

The fuel pressure sensor is located on the fuel line. The fuel pressure sensor monitors the fuel pressure in the fuel line. The fuel pump control module monitors the voltage signal from the fuel pressure sensor.

Conditions for Running the DTC

The ignition is ON.

Conditions for Setting the DTC

The fuel pump control module detects that the fuel pressure 5 V reference is above or below a predetermined voltage threshold.

Action Taken When the DTC Sets

DTCs P0641 and P06A6 are Type A DTCs.

Conditions for Clearing the DTC

DTCs P0641 and P06A6 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.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Fuel System Description on page 9-302

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

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 minutes for all vehicle systems to power down.
2. Test for less than 10 Ω between the low reference circuit terminal 2 and ground.

⇒ **If 10 Ω or greater**

2.1. Ignition OFF, disconnect the harness connector at the K27 Fuel Pump Control Module.

2.2. 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 K27 Fuel Pump 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 3 and ground.

⇒ **If less than 4.8 V**

4.1. Ignition OFF, disconnect the harness connector at the K27 Fuel Pump Control Module.

4.2. 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

4.3. 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 K27 Fuel Pump Control Module.

⇒ **If greater than 5.2 V**

4.1. Ignition OFF, disconnect the harness connector at the K27 Fuel Pump Control Module, ignition ON.

4.2. 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 K27 Fuel Pump Control Module.

⇓ **If between 4.8–5.2 V**

5. Verify the scan tool Fuel Pressure Sensor Voltage parameter is less than 1 V.

⇒ **If 1 V or greater**

5.1. Ignition OFF, disconnect the harness connector at the K27 Fuel Pump Control Module, ignition ON.

5.2. 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 K27 Fuel Pump 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 seconds.
7. Verify the scan tool Fuel Pressure Sensor Voltage parameter is greater than 4.8 V.

⇒ **If 4.8 V or less**

7.1. Ignition OFF, disconnect the harness connector at the K27 Fuel Pump Control Module.

7.2. 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

7.3. 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 K27 Fuel Pump Control Module.

⇓ **If greater than 4.8 V**

8. Test or replace the B47 Fuel Pressure Sensor.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

Control Module References on page 6-3 for fuel pump control module replacement, programming and setup

DTC P0641, P0651, P0697, or P06A3 (ECM)

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptors

DTC P0641: 5 V Reference 1 Circuit
DTC P0651: 5 V Reference 2 Circuit
DTC P0697: 5 V Reference 3 Circuit
DTC P06A3: 5 V Reference 4 Circuit

Circuit/System Description

The engine control module (ECM) has 4 internal 5 V reference circuits. Each internal reference circuit provides external 5 V reference circuits for more than one sensor. A short to ground or short to voltage on one external 5 V reference circuit can affect all the components connected to the same internal 5 V 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 voltage out of range condition on any of the 5 V 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

P0641

The 5 V reference 1 circuit provides 5 V circuits to the following sensors:

- Air conditioning (A/C) refrigerant pressure sensor
- Exhaust and intake camshaft position sensors
- Fuel tank pressure sensor
- Intake manifold pressure and air temperature sensor

P0651

The 5 V reference 2 circuit provides 5 V circuits to the following sensors:

- Brake pedal position sensor (automatic transmission)
- Clutch pedal position sensor (manual transmission)
- Crankshaft position sensor
- Multifunction intake air sensor
- Vehicle speed sensor (manual transmission)

P0697

The 5 V reference 3 circuit provides 5 V circuits to the following sensors:

- Accelerator pedal position sensor 2
- Manifold absolute pressure sensor

P06A3

The 5 V reference 4 circuit provides 5 V circuits to the following sensors:

- Accelerator pedal position sensor 1
- Throttle position sensor 1 and 2

It may be possible to locate the fault by disconnecting one component at a time from the affected 5 V reference circuit while viewing the 5 V Reference Circuit Status parameter on the scan tool. The scan tool parameter will change from Malfunction to OK when the source of the fault is disconnected. If all 5 V 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 on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify all scan tool 5 V Reference Circuit Status parameters do not display Malfunction.

⇒ **If any of the parameters display Malfunction**

Refer to Circuit/System Testing

⇓ **If none of the parameters display Malfunction**

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 5 V reference circuits and ground.

⇒ **If less than 4.8 V**

3.1. Ignition OFF, disconnect the harness connectors at the K20 Engine Control Module.

3.2. Test for infinite resistance between the 5 V 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**

3.1. Ignition OFF, disconnect the harness connectors at the K20 Engine Control Module.

3.2. Test for less than 1 V between the 5 V 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 5 V Reference 1, 2, 3, or 4 Circuit Status parameter displays OK while connecting each component associated with the 5 V reference circuit one at a time.

⇒ **If the parameter does not display OK when a component is connected**

Replace the component

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Accelerator Pedal Position Sensor Replacement on page 9-252*
- *Air Conditioning (A/C) Refrigerant Pressure Sensor Replacement (1.4L) on page 10-30* or *Air Conditioning (A/C) Refrigerant Pressure Sensor Replacement (LUV) on page 10-31* or *Air Conditioning (A/C) Refrigerant Pressure Sensor Replacement (LDE/LUW/LWE) on page 10-32*
- *Brake Pedal Position Sensor Replacement on page 4-186*
- *Camshaft Position Sensor Replacement on page 9-285*
- *Clutch Pedal Position Sensor Replacement on page 17-415*
- *Crankshaft Position Sensor Replacement on page 9-284*
- *Fuel Tank Pressure Sensor Replacement on page 9-263*
- *Intake Air Pressure and Temperature Sensor Replacement on page 9-247*
- *Manifold Absolute Pressure Sensor Replacement on page 9-248*
- *Mass Airflow Sensor Replacement on page 9-246*
- *Throttle Body Assembly Replacement on page 9-253*
- *Vehicle Speed Sensor Replacement on page 17-461*
- *Control Module References on page 6-3* for engine control module replacement, programming, and setup

DTC P0650

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC P0650: Malfunction Indicator Lamp (MIL) Control Circuit

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0650	P0650	—	—
MIL Control	* P0650	P0650	P0650	—
* 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 engine 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 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

- DTCs P0601, P0604, P0605, P0606, P0607, and P2610 are not set
- The DTC runs continuously when the above conditions are met .

Conditions for Setting the DTC

- The ECM detects that the commanded state of the MIL driver and the actual state of the control circuit do not match for more than 1 s.
- Should a short circuit to B+ or an open circuit occur on the MIL control circuit, the MIL must be commanded ON for the DTC to set. A short circuit to ground on the MIL control circuit can be detected immediately by the ECM in the commanded OFF state.

Action Taken When the DTC Sets

DTC P0650 is a Type B DTC, with no MIL request.

Conditions for Clearing the DTC

DTC P0650 is a Type B DTC, with no MIL request.

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 Fault if there is a condition with a circuit or a connection.

Reference Information

Schematic Reference

- *Engine Controls Schematics on page 9-28*
- *Instrument Cluster Schematics on page 8-78*

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Command the malfunction indicator lamp ON and OFF with a scan tool.

3. Verify that the malfunction indicator lamp turns ON and OFF as commanded.

⇒ **If the malfunction indicator lamp does not turn ON and OFF as commanded**

Refer to Circuit/System Testing

⇓ **If the malfunction indicator lamp turns ON and OFF as commanded**

4. Ignition ON.
5. Command the malfunction indicator lamp ON and OFF with a scan tool and verify that the control circuit status parameters listed below display OK or Not Run .
   - 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 OK or Not Run is displayed**

6. Engine running.
7. Command the malfunction indicator lamp ON and OFF with a scan tool and verify that the control circuit status parameters listed below display OK or Not Run .
   - 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 OK or Not Run is 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.

⇒ **If the DTC sets**

Refer to Circuit/System Testing

⇓ **If the DTC does not set**

9. All OK.

Circuit/System Testing

1. Ignition OFF.
2. Disconnect the X1 harness connector at the K20 Engine Control Module.
3. Ignition ON.
4. Verify the malfunction indicator lamp does not illuminate.

⇒ **If the malfunction indicator lamp illuminates**

4.1. Test for infinite resistance between the malfunction indicator lamp control circuit terminal X1 52 and ground.

⇒ If less than infinite resistance, repair the short to ground in the circuit.

⇒ If resistance is infinite, replace the P16 instrument cluster.

⇓ **If the malfunction indicator lamp does not illuminate**

5. Connect a 3 A fused jumper wire between the malfunction indicator lamp control circuit terminal X1 52 and ground.
6. Verify the malfunction indicator lamp illuminates.

⇒ **If the malfunction indicator lamp does not illuminate**

6.1. Test the malfunction indicator lamp control circuit terminal X1 52 for a short to voltage or an open/high resistance.

⇒ If the malfunction indicator lamp control circuit terminal X1 52 is shorted to voltage or has an open/high resistance, repair as necessary.

⇓ If the malfunction indicator lamp control circuit terminal X1 52 tests normal

6.2. Test the instrument cluster ignition voltage circuit for a short to ground or an open/high resistance.

⇒ If the instrument cluster ignition voltage circuit is shorted to ground or has an open/high resistance, repair as necessary.

⇒ If the instrument cluster ignition voltage circuit tests normal, replace the P16 instrument panel cluster/bulb.

⇓ **If the malfunction indicator lamp illuminates**

7. Replace the K20 Engine Control Module.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Instrument Cluster Replacement on page 8-104*
- *Control Module References on page 6-3* for ECM replacement, programming and setup

DTC P0685, P0686, P0687, P0689, P0690, or P1682

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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
DTCP0689: 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

Ignition Run Relay

Circuit	Short to Ground	Open/High Resistance	Short to Voltage
Ignition 1 Signal	1	1	2
1. No Crank condition. 2. Engine continues to operate with ignition OFF.			

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			
Battery Voltage	Malfunction	Malfunction	—
Engine Controls Ignition Relay Control Circuit	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			

Engine Controls Ignition Relay Control Circuit Low Voltage, Open, and High Voltage Test Status—Component Commanded ON (cont'd)

Circuit	Short to Ground	Open	Short to Voltage
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			
Battery Voltage	Not Run	Not Run	—
Engine Controls Ignition Relay Control Circuit	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 run relay. The ECM monitors and compares the ignition voltage supplied by the 2 relays.

Conditions for Running the DTC

P0685, P0686, P0687

The DTC runs when ignition 1 signal voltage is greater than 11 V.

P0689

- DTC P0685 is 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

- P0685 is 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 when the engine controls ignition relay is commanded ON.

P0690

- The ECM detects the engine controls ignition relay feedback circuit is greater than 4 V when the engine controls ignition relay is commanded OFF.
- The condition is present 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 less than 1 s.

Action Taken When the DTC Sets

- DTCs P0685, P0686, P0687, P0689, and P0690 are Type B DTCs.
- DTC P1682 is a Type A DTC.

Conditions for Clearing the DTC

- DTCs P0685, P0686, P0687, P0689, and P0690 are Type B DTCs.
- 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 run relay may also be labeled the run/crank relay, the ignition main relay, the ignition 1 relay, or the ignition relay.

Reference Information

Schematic Reference

- *Engine Controls Schematics on page 9-28*
- *Power Distribution Schematics on page 11-128*

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Electrical Center Identification Views on page 11-240*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 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 any of the DTCs are set**

Refer to Circuit/System Testing.

⇓ **If none of the DTCs are 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 relay circuit terminals listed below:
   - Terminal 85
   - Terminal 30

⇒ **If the test lamp does not illuminate**

Replace the front compartment fuse block. Refer to *Front Compartment Fuse Block Replacement on page 11-609*.

⇓ **If the test lamp illuminates**

Note:

- High resistance in the circuit/underhood fuse block for either the engine controls ignition relay or the ignition run 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**

4.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.

4.2. Ignition ON.

4.3. Test for less than 1 V between ground and connector terminal 28.

⇒ 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 relay switch B+ circuit terminal 30 and the relay switch ignition voltage circuit terminal 87.
6. Ignition ON.
7. Observe the scan tool Engine Controls Ignition Relay Feedback Signal parameter. The K20 Engine Control Module should communicate, and the parameter should display B+.

⇒ **If the parameter does not display B+ or the K20 Engine Control Module does not communicate**

7.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.

7.2. 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

7.3. 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 the parameter displays B+**

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 the DMM does not display OL**

9.1. Disconnect the X1 harness connector at the K20 Engine Control Module.

9.2. 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 the DMM displays OL**

10. Ignition ON.

11. Verify the DMM displays less than 1 V.

⇒ **If the DMM does not display less than 1 V**

11.1. Ignition OFF, disconnect the X1 connector at the K20 Engine Control Module.

11.2. Ignition ON.

11.3. 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

11.4. 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 the DMM displays 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 on page 6-92* after completing the diagnostic procedure.

- *Relay Replacement (Within an Electrical Center) on page 11-607* or *Relay Replacement (Attached to Wire Harness) on page 11-607*
- *Control Module References on page 6-3* for engine control module replacement, programming, and setup

DTC P069E

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC P069E: Fuel Pump Control Module Requested MIL Illumination

Circuit/System Description

The fuel pump control module uses the serial data network to signal the engine control module (ECM) that the fuel pump control module is requesting malfunction indicator lamp (MIL) illumination. A DTC is set in the fuel pump control module, and the request for MIL illumination is sent when the fuel pump control module determines that a failure that affects emissions has occurred in the fuel pump control system. When the ECM receives the message from the fuel pump control module, DTC P069E will set in the ECM.

Conditions for Running the DTC

The ignition is ON, or the engine is running for more than 3 s without interruption.

Conditions for Setting the DTC

A fuel pump control module related DTC is set.

Action Taken When the DTC Sets

- DTC P069E is a Type A DTC.
- DTC P069E will continue to be current or active as long as the fuel pump control module is requesting MIL illumination.

Conditions for Clearing the DTC

DTC P069E is a Type A DTC.

Diagnostic Aids

Communication codes, U-codes, as well as powertrain codes, P-codes, set in the fuel pump control module will cause the fuel pump control module to request DTC P069E to be set in the ECM.

Reference Information

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3

Circuit/System Verification

Note: Correct any engine controls and communication DTCs before diagnosing fuel pump control module DTCs.

1. DTC P069E is an informational DTC. If there are no engine controls or communication DTCs, refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69* for diagnosis of fuel pump control module DTCs.
2. Operate the vehicle within the Conditions for Running the DTC to verify the DTC does not reset. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

DTC P11C2 or P11C3

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptors

DTC P11C2: Intake Air Humidity Sensor Circuit Low Voltage
DTC P11C3: Intake Air Humidity Sensor Circuit High Voltage

Diagnostic Fault Information

Intake Air Humidity Sensor

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P0097, P0651, P11C2, P2199, P2227, P2228	P0096, P0097, P11C2, P2199, P2227, P2228	P0097, P0651, P11C2, P2199, P2227, P2228	—
Signal	P0097, P11C3, P2199	P0097, P11C2, P2199	P0097, P11C2, P2199*	—
Low Reference	—	P0097, P0113, P11C2, P2227, P2229	*	—
*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			
5 V Reference	0 %	0 %	—
Signal	100 %	0 %	0 %*
Low Reference	—	0 %	*
*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 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 engine control module (ECM) applies 5 V to the signal circuit. The humidity sensor and the IAT sensor 2 share the same circuit.

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

Conditions for Running the DTCs

P11C2 and P11C3

- 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

P11C2

The ECM detects that the humidity sensor signal is less than or equal to 5 % for greater than 5 s.

P11C3

The ECM detects that the humidity sensor signal is greater than or equal to 95 % for greater than 5 s.

Action Taken When the DTC Sets

DTCs P11C2 and P11C3 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P11C2 and P11C3 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.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Special Tools

EN-38522 Variable Signal Generator

For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308.*

Circuit/System Verification

1. Ignition ON, verify that DTC DTC P0641, P0651, P0697, or P06A3 is not set.

⇒ **If any of the DTCs are set**

Refer to *DTC P0641, P0651, P0697, or P06A3 (ECM) on page 9-182* for further diagnosis.

⇓ **If none of the DTCs are set**

Note: To minimize the effects of residual engine heat and sensor internal heating elements, perform Steps 2 and 3 of this verification procedure only if the ignition has been OFF for 8 hours or more.

2. Ignition ON.
3. Verify the following scan tool parameters are within 25°C (45°F) of each other.
   - Start-Up IAT Sensor 1
   - IAT Sensor 2
   - IAT Sensor 3, where equipped

⇒ **If not within 25°C (45°F)**

Refer to Circuit/System Testing.

⇓ **If within 25°C (45°F)**

4. 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 %**

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 DTCs do not set.

⇒ **If any of the DTCs set**

Refer to Circuit/System Testing.

⇓ **If none of the DTCs set**

7. All OK

Circuit/System Testing

Note: You must perform the Circuit/System Verification before proceeding with Circuit/System Testing.

1. Ignition OFF and all vehicle systems OFF, disconnect the B75C Multifunction Intake Air sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 2 Ω between the low reference circuit terminal 7 and ground.

⇒ **If 2 Ω or greater**

2.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

2.2. 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 OFF, all vehicle systems OFF, test for less than 2 Ω between the ground circuit terminal 4 and ground.

⇒ **If 2 Ω or greater**

3.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

3.2. 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, test for 4.8–5.2 V between the 5 V reference circuit terminal 2 and ground.

⇒ **If less than 4.8 V**

4.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

4.2. 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

4.3. 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 5 V reference circuit is shorted to a voltage the engine control module or the sensor may be damaged.

4.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

4.2. 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. Ignition ON, test for 4.8–5.2 V between the humidity signal circuit terminal 1 and ground.

⇒ **If less than 4.8 V**

5.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

5.2. 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

5.3. 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.

5.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

5.2. Ignition ON, 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 the leads of the *EN-38522* Variable Signal Generator as follows:
   - Red lead to the signal circuit terminal 1 at the harness connector
   - Black lead to ground
   - Battery voltage supply lead to B+
7. Set the *EN-38522* Variable Signal Generator to the following specifications.
   - Signal switch to 5 V
   - Frequency switch to 250 Hz
   - Duty Cycle switch to 50 % (Normal)
8. Ignition ON, verify the scan tool Intake Air Humidity parameter is between 45–55 %.

⇒ **If not between 45–55 %**

Replace the K20 Engine Control Module.

⇓ **If between 45–55 %**

9. 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%.**

Replace the B75C Multifunction Intake Air sensor.

⇓ **If within 5–95%.**

2. All OK

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Mass Airflow Sensor Replacement on page 9-246* for multifunction intake air sensor replacement.
- *Control Module References on page 6-3* for Engine Control Module replacement, programming, and setup.

DTC P1255 or P064A

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptors

DTC P064A: Fuel Pump Control Module Performance

DTC P1255: Fuel Pump Control Module Driver High Temperature

Circuit/System Description

The engine control module (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 seconds, unless the engine is in crank or run. While this voltage is being received, the fuel pump control module supplies a varying voltage to the fuel tank pump module in order to maintain the desired fuel pressure.

Conditions for Running the DTC

The engine is running.

Conditions for Setting the DTC

The fuel pump control module detects an over-temperature fault.

Action Taken When the DTC Sets

DTCs P064A and P1255 are Type A DTCs.

Conditions for Clearing the DTC

DTCs P064A and P1255 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.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Fuel System Description on page 9-302

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 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 on page 6-69*.

⇓ **If none of the DTCs are set**

3. Verify that the area where the K27 fuel pump control module is located is free of debris, clutter, or any insulating material that would cause the K27 fuel pump control module to overheat.

⇒ **If any debris, clutter, or other material is found**

3.1. Clear the area where the K27 fuel pump control module is located.

3.2. Clear the DTC and test drive the vehicle.

3.3. Verify DTC P1255 or P064A is not set.

⇒ If DTC P1255 or P064A is set, replace the K27 fuel pump control module.

⇓ If DTC P1255 or P064A is not set

3.4. All OK.

⇓ **If no debris, clutter, or other material is found**

4. Clear the DTC and test drive the vehicle.
5. Verify DTC P1255 or P064A is not set.

⇒ **If DTC P1255 or P064A is set**

Replace the K27 fuel pump control module.

⇓ **If DTC P1255 or P064A is not set.**

6. All OK.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

Control Module References on page 6-3 for fuel pump control module replacement, programming and setup

DTC P1400

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* 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 idle speed is elevated and spark timing is retarded to allow the catalyst to warm quickly. This diagnostic monitors the following to build an exhaust energy model:

- Engine speed
- Spark advance
- Throttle position
- Engine airflow
- Engine coolant temperature
- Engine run time
- Park/neutral position
- Vehicle speed

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, P0222, P0223, P0201, P0202, P0203, P0204, P0300, P0301, P0302, P0303, P0304, P0335, P0336, P0351, P0352, P0353, P0354, P0502, P0503, P0506, P0507, P0641, P0651, P0697, P06A3, P0806, P0807, P080A, P2122, P2123, P2125, P2127, P2128, P2135, P2138, and P2544 are not set.
- The engine is idling less than 30 s.
- The engine coolant temperature (ECT) sensor is greater than −10°C (14°F).
- The calculated 3-way catalyst temperature is less than 350°C (662°F).
- The ECM will exit the diagnostic if the calculated 3-way catalyst temperature is greater than 420°C (788°F) when the engine run time is greater than 30 s.
- The ECM will exit the diagnostic if the engine run time is greater than 90 s.
- The vehicle speed is less than 2 km/h (1 MPH).
- The engine is at idle with no input from the accelerator pedal.

This DTC runs within the first 90 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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Ignition OFF, allow the engine to cool.
2. Engine idling for at least 2 min, observe the scan tool DTC information. DTC P1400 should run and pass.
3. Operate the vehicle within the Conditions for Running the DTC to verify the DTC does not reset. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

Circuit/System Testing

1. Inspect the air intake system for the following:
   - 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

2. Inspect the exhaust system for the following:
   - Water intrusion
   - Exhaust leak
   - Damaged, restricted, or modified exhaust system. Refer to *Symptoms - Engine Exhaust on page 9-734*.
3. Inspect for an engine mechanical condition that could alter the air flow into the combustion chamber. Refer to *Symptoms - Engine Mechanical on page 9-770*.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

DTC P1516, P2101, P2119, or P2176 (LUV)

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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
TAC Motor Control Closed	P1516, P2101, P2176	P1516, P2101, P2176	P1516, P2101, P2176	P1516, P2101, P2176
TAC Motor Control Open	P1516, P2101, P2176	P1516, P2101, P2176	P1516, P2101, P2176	P1516, P2101, P2176

Circuit/System Description

The Engine Control Module (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 throttle position (TP) sensors 1 and 2 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 5.5 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

- The ignition is ON.
- DTC P0121, P0122, P0123, P0222, P0223, P0697, P06A3, or P2135 is not set.
- The run/crank or powertrain relay voltage is greater than 6.41 V and reduced power is not active.
- DTC P2119 runs continuously when the above conditions are met.

P2176

- The ignition is ON.
- The run/crank or powertrain relay voltage is greater than 6.41 V and reduced power is not active.
- The ECM enable the minimum throttle learn procedure.
- DTC P2176 run 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.

P2119

The ECM detects the throttle blade did not return to the default position when the TAC motor is de-energized for greater than 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

P1516, P2101, and P2176

- DTCs P1516, P2101, and P2176 are Type A DTCs.
- The control module 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.

P2119

DTC P2119 is a Type C DTC.

Conditions for Clearing the MIL/DTC

- DTCs P1516, P2101, and P2176 are Type A DTCs.
- DTC P2119 is a Type C DTC.

Diagnostic Aids

- 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 on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Throttle Actuator Control (TAC) System Description on page 9-305

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 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 on page 6-69* 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 Inspection and Cleaning on page 9-253*.

⇓ **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**

Note: Before replacing the Throttle Body Assembly, make sure the TAC motor control circuits are not shorted to B+.

Test or replace the Q38 Throttle Body Assembly.

⇓ **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:
   - 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**

Test or replace the Q38 Throttle Body Assembly.

⇓ **If a condition is not found**

3. Ignition OFF.

Note:

- Disconnecting the throttle body harness connector may cause additional DTCs to set.
- The Test Lamp must be connected to circuit before turning ignition on or incorrect diagnosis may occur.

4. Disconnect the harness connector at the Q38 Throttle Body Assembly.
5. Cycle the Ignition ON and OFF and then ON again.
6. Verify that a test lamp illuminates between each motor control circuit listed below and ground.
   - TAC Motor Control Closed circuit terminal A
   - TAC Motor Control Open circuit terminal B

⇒ **If the test lamp does not illuminate**

6.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

6.2. Test for infinite resistance between the appropriate control circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

6.3. Test for less than 2 Ω on the control circuit from end to end.

⇒ If greater than 2 Ω, repair the open or high resistance on the circuit.

⇒ If less than 2 Ω, replace the K20 Engine Control Module.

⇓ **If the test lamp illuminates**

7. Disconnect the harness connector at the K20 Engine Control Module.
8. Test for less than 1 V between each motor control circuit listed below and ground.
   - TAC Motor Control Closed circuit terminal A
   - TAC Motor Control Open circuit terminal B

⇒ **If greater than 1 V**

Repair the short to voltage on the circuit.

⇓ **If less than 1 V**

9. Test or replace the Q38 Throttle Body Assembly.

Repair Instructions

- *Throttle Body Assembly Replacement on page 9-253*
- *Control Module References on page 6-3* for Engine Control Module replacement, programming, and setup

Repair Verification

1. Ignition OFF.
2. Install any components that have been removed or replaced during diagnosis.
3. Perform any adjustments, programming or setup procedures that are required when a component is removed or replaced.
4. Ignition ON.
5. Clear the DTCs with a scan tool.
6. Turn the ignition OFF for 60 s.
7. Ignition ON.
8. 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 Assembly.

⇓ **If Enabled is displayed**

9. 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 on page 6-69* for further diagnosis.

⇓ **If DTC does not set**

10. All OK.

DTC P2096

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC P2096: Post Catalyst Fuel Trim System Low Limit

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, P0017, P0030, P0036, P0053, P0054, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0128, P0131, P0132, P0133, P0134, P0135, P0137, P0138, P013A, P013B, P013E, P013F, P0140, P0141, P015A, P015B, P0201, P0202, P0203, P0204, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0300, P0301, P0302, P0303, P0304, P0340, P0341, P0365, P0366, P0411, P0442, P0443, P0446, P0449, P0452, P0453, P0455, P0496, P1248, P1249, P124A, P124B, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P219A, P2227, P2228, P2229, P2230, P2270, P2271, P2440, or P2444 is not set.
- The barometric pressure (BARO) is greater than 70 kPa (10.2 PSI).
- The mass air flow (MAF) is between 0–100 g/s.
- The manifold absolute pressure (MAP) is between 0–200 kPa (0–29 PSI).
- The intake air temperature (IAT) is between –20°C and +200°C (-4 and +392°F).
- The start up engine coolant temperature is warmer than –20°C (–4°F).
- The fuel control intrusive diagnostics are not active.
- The engine is operating under cruise conditions.
- DTC P2096 runs continuously when the conditions above have been met.

Conditions for Setting the DTC

The lean correction limit for a condition causing a rich air/fuel ratio has been exceeded.

Action Taken when the DTC Sets

- DTCs P2096 is a Type B DTC.
- The ECM records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the ECM stores this information in the Failure records. If the diagnostic reports a failure on the second ignition cycle, the ECM records the operating conditions at the time of the failure. The ECM writes the operating conditions to the Freeze Frame and updates the Failure records. The ECM illuminates the malfunction indicator lamp (MIL) when one of the following occurs:
  - The ECM detects the same fuel trim failure during 2 consecutive trips.
  - The ECM detects any fuel trim failure during any subsequent trip if the conditions at the time of failure meet the following criteria:
    - The engine load is within 20 percent of the previous test that failed.
    - The engine speed is within 375 RPM of the previous test that failed.
    - The engine coolant temperature is in the same range of the previous test that failed.

Conditions for Clearing the MIL/DTC

- DTCs P2096 is a Type B DTC.
- The ECM turns OFF the malfunction indicator lamp (MIL) at the beginning of the fourth ignition cycle, after 3 ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.

Diagnostic Aids

- It is very unlikely that an HO2S will cause this DTC to set without the occurrence of circuit related HO2S DTCs. Do not replace an HO2S to address this DTC without first performing all the steps in Circuit/System Verification and Circuit/System Testing.
- 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 on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 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 on page 6-69* for further diagnosis.

⇓ **If no other HO2S or fuel trim DTC is set**

3. Verify DTC P2096 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 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:

- Air intake duct collapsed or restricted.
- Air filter dirty or restricted.
- Objects blocking the throttle body.
- Excessive fuel in the crankcase. Change engine oil as necessary.
- Rich fuel injectors. Refer to *Fuel Injector Diagnosis on page 9-232.*
- Excessive fuel system pressure. Refer to *Fuel System Diagnosis on page 9-230.*
- Fuel contamination. Refer to *Alcohol/ Contaminants-in-Fuel Diagnosis on page 9-235.*
- Fuel saturation of the evaporative emissions (EVAP) canister
- Stuck open or leaking EVAP purge valve
- Restricted exhaust. Refer to *Symptoms - Engine Exhaust on page 9-734.*
- Improper operation of the crankcase ventilation system.

⇒ If a condition is found

Repair as necessary.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

DTC P2097

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC P2097: Post Catalyst Fuel Trim System High Limit

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, P0017, P0030, P0036, P0053, P0054, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0128, P0131, P0132, P0133, P0134, P0135, P0137, P0138, P013A, P013B, P013E, P013F, P0140, P0141, P015A, P015B, P0201, P0202, P0203, P0204, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0300, P0301, P0302, P0303, P0304, P0340, P0341, P0365, P0366, P0411, P0442, P0443, P0446, P0449, P0452, P0453, P0455, P0496, P1248, P1249, P124A, P124B, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P219A, P2227, P2228, P2229, P2230, P2270, P2271, P2440, or P2444 is not set.
- The barometric pressure (BARO) is greater than 70 kPa (10.2 PSI).
- The mass air flow (MAF) is between 0–100 g/s.
- The manifold absolute pressure (MAP) is between 0–200 kPa (0–29 PSI).
- The intake air temperature (IAT) is between –20°C and +200°C (-4 and +392°F).
- The start up engine coolant temperature is warmer than –20°C (–4°F).
- The fuel control intrusive diagnostics are not active.
- The engine is operating under cruise conditions.
- DTC P2097 runs continuously when the conditions above have been met.

Conditions for Setting the DTC

The rich correction limit for a condition causing a lean air/fuel ratio has been exceeded.

Action Taken when the DTC Sets

- DTCs P2097 is a Type B DTC.
- The ECM records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the ECM stores this information in the Failure records. If the diagnostic reports a failure on the second ignition cycle, the ECM records the operating conditions at the time of the failure. The ECM writes the operating conditions to the Freeze Frame and updates the Failure records. The ECM illuminates the malfunction indicator lamp (MIL) when one of the following occurs:
  - The ECM detects the same fuel trim failure during 2 consecutive trips.
  - The ECM detects any fuel trim failure during any subsequent trip if the conditions at the time of failure meet the following criteria:
    - The engine load is within 20 percent of the previous test that failed.
    - The engine speed is within 375 RPM of the previous test that failed.
    - The engine coolant temperature is in the same range of the previous test that failed.

Conditions for Clearing the MIL/DTC

- DTCs P2097 is a Type B DTC.
- The ECM turns OFF the malfunction indicator lamp (MIL) at the beginning of the fourth ignition cycle, after 3 ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.

Diagnostic Aids

- It is very unlikely that an HO2S will cause this DTC to set without the occurrence of circuit related HO2S DTCs. Do not replace an HO2S to address this DTC without first performing all the steps in Circuit/System Verification and Circuit/System Testing.
- 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 on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 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 on page 6-69* for further diagnosis.

⇓ **If no other HO2S or fuel trim DTC is set**

3. Verify DTC P2097 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 P2097 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:

- Exhaust system leaks. Refer to *Symptoms - Engine Exhaust on page 9-734*.
- Vacuum hoses for splits, kinks, and proper connections
- Insufficient fuel in the tank
- Air induction system and air intake ducts for leaks
- 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 on page 9-230*.
- Contaminated fuel. Refer to *Alcohol/ Contaminants-in-Fuel Diagnosis on page 9-235*.
- Lean fuel injectors. Refer to *Fuel Injector Diagnosis on page 9-232*.

⇒ If a condition is found

Repair as necessary.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

DTC P2122, P2123, P2127, P2128, or P2138

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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	Open/High Resistance	Short to Voltage	Signal Performance
APP Sensor 1 5V Reference	P2122	P2122	P2123	—
APP Sensor 1 Signal	P2122	P2122	P2123	P2138
APP Sensor 1 Low Reference	—	P2123	—	—
APP Sensor 2 5V Reference	P2127	P2127	P2128	—
APP Sensor 2 Signal	P2127	P2127	P2128	P2138
APP Sensor 2 Low Reference	—	P2128	—	—

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:** 0.13–4.88 V			
APP Sensor 1 5V Reference	0 V	0 V	5 V
APP Sensor 1 Signal	0 V	0 V	5 V
APP Sensor 1 Low Reference	—	4.96 V	—

APP Sensor 2

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: The engine is operating at idle **Parameter Normal Range:** 0.12–2.64 V			
APP Sensor 2 5V Reference	0 V	0 V	5 V
APP Sensor 2 Signal	0 V	0 V	5 V
APP Sensor 2 Low Reference	—	4.92 V	—

Circuit/System Description

The throttle actuator control (TAC) system uses two accelerator pedal position (APP) sensors to monitor the accelerator pedal position. The APP sensors 1 and 2 are located within the pedal assembly. Each sensor has a 5 V reference circuit, a low reference circuit, and a signal circuit.

Two processors are also used to monitor the TAC motor system data. Both processors are located within the ECM. Each signal circuit provides both processors with a signal voltage proportional to pedal movement. The processors share and monitor data to verify that the indicated APP sensor calculation is correct.

Conditions for Running the DTC

P2122 and P2123

- DTC P0642, or P0643 is not set.
- The ignition is ON.
- The DTCs run continuously when the above conditions are met.

P2127 and P2128

- DTC P0652, or P0653 is not set.
- The ignition is ON.
- The DTCs run continuously when the above conditions are met.

P2138

- DTCs P0642, P0643, P0652, or P0653 is not set.
- The ignition is ON.
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

P2122

The ECM detects that APP sensor 1 voltage is less than 0.61 V for greater than 0.5 s.

P2123

The ECM detects that APP sensor 1 voltage is greater than 4.59 V for greater than 0.5 s.

P2127

The ECM detects that APP sensor 2 voltage is less than 0.10 V for greater than 0.5 s.

P2128

The ECM detects that APP sensor 2 voltage is greater than 2.5 V for greater than 0.5 s.

P2138

The ECM detects that the difference between APP sensor 1 and APP sensor 2 exceeds a predetermined value for greater than 2 s.

Action Taken When the DTC Sets

- DTCs P2122, P2123, P2127, P2128 and P2138 are Type A DTCs.
- The ECM commands the TAC motor system to operate in reduced engine power mode.

Conditions for Clearing the DTC

DTCs P2122, P2123, P2127, P2128, and P2138 are Type A DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Throttle Actuator Control (TAC) System Description on page 9-305

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC P0697, or P06A3 is not set.

⇒ **If any of the DTCs are set**

Refer to *DTC P0641, P0651, P0697, or P06A3 (ECM) on page 9-182.*

⇓ **If none of the DTCs are set**

3. Verify the scan tool APP Sensor 1 parameter. The reading should be between 0.32–4.87 V, and change with the accelerator pedal input.
4. Verify the scan tool APP Sensor 2 parameter. The reading should be between 0.16–2.30 V, and change with the accelerator pedal input.

⇒ **If the reading does not change**

Refer to Circuit/System Testing.

⇓ **If the reading does change**

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 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 4
   - Low reference circuit terminal 5

⇒ **If 5 Ω or greater**

2.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

2.2. 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 1
   - 5 V reference circuit terminal 2

⇒ **If less than 4.8 V**

4.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

4.2. 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

4.3. 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**

4.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

4.2. 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 APP sensor 1 and 2 voltage parameter is less than 0.1 V.

⇒ **If 0.1 V or greater**

5.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

5.2. Test for less than 1 V between the signal circuit terminal listed below and ground.
   - APP sensor 1 signal circuit terminal 3
   - APP sensor 2 signal circuit terminal 6

⇒ 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 0.1 V**

6. Install a 3 A fused jumper wire between each signal circuit terminal listed below and the 5 V reference circuit terminal 1.
   - APP sensor 1 signal circuit terminal 3
   - APP sensor 2 signal circuit terminal 6
7. Verify the scan tool APP sensor 1 and 2 voltage parameter is greater than 4.8 V.

⇒ **If 4.8 V or less**

7.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

7.2. 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

7.3. 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 on page 6-92* after completing the repair.

- *Accelerator Pedal Position Sensor Replacement on page 9-252*
- *Control Module References on page 6-3* for ECM replacement, programming, and setup.

DTC P2199

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC P2199: Intake Air Temperature (IAT) Sensors 1-2 Not Plausible

Diagnostic Fault Information

IAT Sensor 1

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Sensor	P0112, P0114, P2199	P0113, P0114, P2199	P0113, P0114, P2199*	P0111, P0114
Low Reference	—	P0097, P0113, P11C2, 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
5 V Reference	P0097, P0651, P11C2, P2199, P2227, P2228	P0096, P0097, P11C2, P2199, P2227, P2228	P0097, P0651, P11C2, P2199, P2227, P2228	—
Sensor	P0097, P11C3, P2199	P0097, P11C2, P2199	P0097, P11C2, P2199*	—
Low Reference	—	P0097, P0113, P11C2, 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 or High Resistance	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** Varies with ambient temperature			
Sensor	150°C (302°F)	−40°C (−40°F)	−40°C (−40°F)*
Low Reference	—	−40°C (−40°F)	−40°C (−40°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			
5 V Reference	−40°C (−40°F) 10 Hz	−40°C (−40°F) 10 Hz	—
Signal	−40°C (−40°F)	−40°C (−40°F)	−40°C (−40°F)* 10 Hz*
Ground	—	−40°C (−40°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 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 °C (°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 °C (°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	−40°C (−40°F)
Warm	302 Hz	104°C (219°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 55°C (99°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, when the engine is OFF and is 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; −40°C (−40°F), and there are also Humidity Sensor DTCs, check for a circuit problem.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Special Tools

EN-38522 Variable Signal Generator

For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308.*

Circuit/System Verification

1. Ignition ON, verify that DTC DTC P0641, P0651, P0697, or P06A3 is not set.

⇒ **If any of the DTCs are set**

Refer to *DTC P0641, P0651, P0697, or P06A3 (ECM) on page 9-182* for further diagnosis.

⇓ **If none of the DTCs are set**

Note: To minimize the effects of residual engine heat and sensor internal heating elements, perform Steps 2 and 3 of this verification procedure only if the ignition has been OFF for 8 hours or more.

2. Ignition ON.
3. Verify the following scan tool parameters are within 25°C (45°F) of each other.
   - Start-Up IAT Sensor 1
   - IAT Sensor 2
   - IAT Sensor 3, where equipped

⇒ **If not within 25°C (45°F)**

Refer to Circuit/System Testing.

⇓ **If within 25°C (45°F)**

4. Engine idling, verify the following scan tool parameters are between: −38 and +149°C (−36 and +300°F).
   - IAT Sensor 1
   - IAT Sensor 2
   - IAT Sensor 3, where equipped

⇒ **If not between: −38 and +149°C (−36 and +300°F)**

Refer to Circuit System Testing.

⇓ **If between: −38 and +149°C (−36 and +300°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 DTCs do not set.

⇒ **If any of the DTCs set**

Refer to Circuit/System Testing.

⇓ **If none of the DTCs set**

7. All OK

Circuit/System Testing

Note: You must perform the Circuit/System Verification before proceeding with Circuit/System Testing.

1. Check the integrity of the entire air induction system by verifying that none of the following conditions exist:
   - A restricted or collapsed air intake duct
   - An intake manifold leak
   - A MAP sensor seal that is leaking, missing, or damaged
   - 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 the component as appropriate.

⇓ **If no condition exists**

2. Ignition OFF and all vehicle systems OFF, disconnect the B75C Multifunction Intake Air sensor. It may take up to 2 minutes for all vehicle systems to power down.
3. Test for less than 2 Ω between the low reference circuit terminal 7 and ground.

⇒ **If 2 Ω or greater**

3.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

3.2. 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 ON, test for 4.8–5.2 V between the 5 V reference circuit terminal 2 and ground.

⇒ **If less than 4.8 V**

4.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

4.2. 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

4.3. 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 5 V reference circuit is shorted to a voltage the engine control module or the sensor may be damaged.

4.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

4.2. 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. Ignition ON, test for 4.8–5.2 V between the signal terminal 8 and ground.

⇒ **If less than 4.8 V**

5.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

5.2. 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

5.3. 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.

5.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

5.2. Ignition ON, 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 ON, test for 4.8–5.2 V between the signal terminal 1 and ground.

⇒ **If less than 4.8 V**

6.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

6.2. 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

6.3. 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.

6.1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.

6.2. Ignition ON, 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. Ignition OFF, connect the leads of the *EN-38522* Variable Signal Generator as follows:
   - Red lead to the signal circuit terminal 1 at the harness connector
   - Black leads to ground
   - Battery voltage supply lead to B+
8. Set the *EN-38522* Variable Signal Generator to the following specifications.
   - Signal switch to 5 V
   - Duty Cycle switch to 50 % (Normal)
   - Frequency switch to 30 Hz
9. Ignition ON, 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**

10. 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 (Bosch Sensor) on page 9-26* or *Temperature Versus Resistance - Intake Air Temperature Sensor (Delco Sensor) on page 9-26* table for Bosch Sensors. The resistance values should be in range of the table values.

⇒ **If not within the specified range.**

Replace the B75C Multifunction Intake Air sensor.

⇓ **If within the specified range.**

3. All OK

Multifunction Intake Air Sensor

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 on page 6-92* after completing the repair.

- *Mass Airflow Sensor Replacement on page 9-246* for multifunction intake air sensor replacement.
- *Control Module References on page 6-3* for Engine Control Module replacement, programming, and setup.

DTC P219A

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC P219A: Fuel Trim Cylinder Balance

Circuit/System Description

The Air Fuel Imbalance 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, P0017, P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0116, P0117, P0118, P0122, P0123, P0128, P0201–P0204, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0300, P0301–P0304, P0340, P0341, P0365, P0366, P0411, P0442, P0455, P0496, P1248, P1249, P124A, P124B, P2101, P2135, P2147, P2148, P2150. P2151, P2153, P2154, P2156, P2157, P2440, P2444 are not set.
- The EVAP device control and intrusive diagnostics are not active.
- The engine overspeed protection is not active.
- The engine is in closed loop status.
- The system voltage is greater than 11 V.
- The engine coolant temperature (ECT) is warmer than −20°C (−4°F).
- The engine speed is between 1,200–3,200 RPM.
- The mass air flow is between 10–100 g/s.
- The AIR pump is not ON.
- Engine run time is greater than 30 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

DTC P219A is a Type A DTC.

Conditions for Clearing the MIL/DTC

DTC P219A is a Type A DTC.

Diagnostic Aids

- The air fuel imbalance 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 on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Troubleshooting with a Test Lamp on page 11-528*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*
- *Connector Repairs on page 11-548*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 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 on page 6-69* for further diagnosis.

⇓ **If no other DTCs are set**

3. Verify DTC P219A 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 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, verify the manifold absolute pressure (MAP) sensor parameter is between 20–48 kPa.

⇒ **If not within the specified range.**

Refer to *DTC P0106 on page 9-84* or *DTC P0107 or P0108 on page 9-89*

⇓ **If within the specified range, verify that none of the conditions listed below exist:**

- Modified, damaged, leaking, or restricted air induction system components.
- Improper operation of the crankcase ventilation system.
- Split, kinked, or improperly connected vacuum hoses.
- Restricted, damaged, leaking, or modified exhaust system from the catalytic converter forward. Refer to *Symptoms - Engine Exhaust on page 9-734*.
- Improperly operating fuel injectors. Refer to *Fuel Injector Diagnosis on page 9-232*.
- Contaminated fuel. Refer to *Alcohol/ Contaminants-in-Fuel Diagnosis on page 9-235*.
- Excessive fuel in the crankcase due to leaking injectors. Change engine oil as necessary.
- Improper ignition system operation. Refer to *Electronic Ignition System Diagnosis on page 9-238*.

⇒ **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 on page 9-770*.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

DTC P2227-P2230

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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 - (If used)

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5V Reference	P0641, P2228	P2228	P0641, P2229	P2227
Signal	P2228	P2228	P2229	P2227
Low Reference	—	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, varies with altitude			
5V Reference	0 kPa	0 kPa	127 kPa
Signal	0 kPa	0 kPa	127 kPa
Low Reference	—	127 kPa	—

Circuit/System Description

The barometric pressure (BARO) sensor 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

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0112, P0113, P0117, P0118, P0121, P0122, P0123, P0222, P0223, P1516, P2135, P2228 and P2229 are not set.
- Engine is running.

  OR
- DTCs P0106, P0107, P0108, P2228, P2229 and P2230 are not set and are not pending.
- Ignition ON, engine OFF.
- DTC P2227 runs continuously when the above conditions are met.

P2228 or P2229

- The engine is running.
- The DTCs run continuously when the above condition is met .

P2230

- The engine is running.
- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0112, P0113, P0117, P0118, P0121, P0122, P0123, P0222, P0223, P1516, P2135, P2228 and P2229 are not set.
- 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 BARO signal and the calculated BARO is greater than 15 kPa (2.17 PSI) when the vehicle has traveled no more than 0.1 km (0.06 mi) since the last calculated BARO update, or if the difference is greater than 25 kPa (3.62 PSI) when the vehicle has traveled greater than 0.1 km (0.06 mi) since the last calculated BARO update.
- Ignition ON, engine OFF, the ECM detects that the BARO pressure is less than 50 kPa (7.25 PSI) or greater than 115 kPa (16.76 PSI).

P2228

The ECM detects that the BARO sensor voltage is less than 2 V.

P2229

The ECM detects that the BARO sensor voltage is greater than 4.5 V.

P2230

The ECM detects that the difference between the current BARO sensor reading and the previous BARO sensor reading is greater than 10 kPa (1.45 PSI).

Action Taken When the DTC Sets

DTCs P2227, P2228, P2229, and P2230 are Type B DTCs.

Conditions for Clearing the DTC

DTCs P2227, P2228, P2229, and P2230 are Type B DTCs.

Diagnostic Aids

Inspect the inlet port on the Barometric Pressure Sensor for moisture or debris and attempt to dry or clean the inlet, if contaminated.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 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 on page 9-26* 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 7 and ground.

⇒ **If 5 Ω or greater**

3.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

3.2. 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**

5.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

5.2. 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

5.3. 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**

5.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

5.2. 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**

6.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

6.2. Test for less than 1 V between the signal circuit terminal 6 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 6 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**

8.1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module.

8.2. Test for infinite resistance between the signal circuit terminal 6 and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

8.3. 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 on page 6-92* after completing the repair.

- *Mass Airflow Sensor Replacement on page 9-246* for multifunction intake air sensor replacement
- *Control Module References on page 6-3* for engine control module replacement, programming and setup

DTC P2261

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC P2261: Turbocharger Bypass Valve Stuck

Circuit/System Description

The turbocharger incorporates a bypass valve which is controlled by the Engine Control Module (ECM), by utilizing a remotely mounted solenoid valve, to prevent turbocharger surging and damage from vibrations by opening during abrupt closed throttle conditions. When the valve is open during closed throttle deceleration conditions, it allows the air to recirculate in the turbocharger and maintain turbocharger speed. Within a calibrated range during the closed throttle event, or upon a wide open throttle command the valve will then close to optimize turbo response. The bypass solenoid valve has the following circuits:

- Ignition voltage
- Turbocharger bypass solenoid valve control

As engine load and engine speed increases, the turbocharger bypass solenoid valve remains commanded ON by the ECM. As soon as the throttle closes the turbocharger bypass solenoid valve is commanded OFF by the ECM, in order to allow the turbocharger bypass valve to open and allow the turbocharger air to recirculate, there by preventing turbocharger surging.

Conditions for Running the DTC

- DTCs P0033, P0034, P0035, P0097, P0098, P0100, P0101, P0102, P0103, P0121, P0122, P0123, P0221, P0222, P0223, P0234, P0237, P0238, P0299, P2228, or P2229, are not set.
- The boost pressure versus the barometric pressure (BARO) ratio is between 1.1–3.3.
- The charge air bypass valve has been commanded ON for greater than 1 s immediately after an abrupt closed throttle has occurred and the resulting pressure ratio across the compressor exceeds the calibrated pressure ratio limit.
- The engine speed is greater than 1,800 RPM.
- This DTC runs continuously within the enabling conditions.

Conditions for Setting the DTC

The ECM has detected a series of pulsations in the induction system that exceed a calibrated threshold.

Action Taken When the DTC Sets

DTC P2261 is a Type B DTC.

Conditions for Clearing the DTC

DTC P2261 is a Type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Turbocharger System Description on page 9-306

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0033, P0034, or P0035 is not set.

⇒ **If any of the DTCs are set**

Refer to *DTC P0033-P0035 on page 9-51*.

⇓ **If none of the DTCs are set**

3. Verify the scan tool BARO Sensor parameter is within the range specified in the *Altitude Versus Barometric Pressure on page 9-26* table for the current testing altitude.

⇒ **If the parameter is not within the range specified in the table**

Refer to *DTC P2227-P2230 on page 9-214*.

⇓ **If the parameter is within the range specified in the table**

4. Verify the scan tool Boost Pressure Sensor and BARO Sensor parameters are within 3 kPa (0.4 psi).

⇒ **If the parameters are not within 3 kPa (0.4 psi)**

Refer to *DTC P0236 on page 9-128*.

⇓ **If the parameters are within 3 kPa (0.4 psi)**

5. Verify a click is heard or felt from the Q40 Turbocharger Bypass Solenoid Valve when commanding the Turbocharger Bypass Solenoid Valve ON and OFF with a scan tool.

⇒ **If a click is not heard or felt**

Refer to Circuit/System Testing.

⇓ **If a click is heard or felt**

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 a DTC does not set.

⇒ **If a DTC sets**

Refer to Circuit/System Testing.

⇓ **If a DTC does not set**

8. All OK

Circuit/System Testing

1. Verify the conditions listed below do not exist:
   - Vacuum leaks
   - Vacuum line restrictions
   - Improper routing or connecting of the vacuum hoses on the Q40 Turbocharger Bypass Solenoid Valve, the bypass valve, and the bypass valve vacuum tank

⇒ **If a condition exists**

Repair or replace the component as necessary.

⇓ **If none of the conditions exist**

2. Disconnect the vacuum hose at the Q40 Turbocharger Bypass Solenoid Valve.
3. Install a vacuum gauge to the hose.
4. Engine Idling, verify the vacuum gauge displays between 51–67 kPa (15–20 inches Hq) of vacuum.

⇒ **The gauge does not display between 51–67 kPa (15–20 inches Hq) of vacuum.**

Inspect and repair the leaking vacuum hose in the areas listed below:

- Between the turbocharger bypass valve and the turbocharger bypass solenoid valve
- Between the intake manifold and the turbocharger bypass solenoid valve

⇓ **The gauge displays between 51–67 kPa (15–20 inches Hq) of vacuum.**

5. Disconnect the vacuum hose at the turbocharger vacuum reservoir on the bottom of intake manifold.
6. Connect the *GE 23738-A* to the vacuum reservoir and apply 34 kPa (10 inches Hg) of vacuum.
7. Verify the reservoir holds vacuum for at least 10 s.

⇒ **The reservoir does not hold vacuum for at least 10 s.**

Replace the intake manifold.

⇓ **The reservoir holds vacuum for at least 10 s.**

8. Engine idling, vacuum gauge still installed from step 3, command the Turbocharger Bypass Solenoid Valve ON and OFF with a scan tool.
9. Verify the vacuum toggles between 0 kPa (0 inches Hg) when OFF to greater than 51 kPa (15 inches Hg) when ON.

⇒ **The vacuum does not toggle between 0–51 kPa (0–15 psi).**

Replace the Q40 Turbocharger Bypass Solenoid Valve.

⇓ **The vacuum toggles between 0–51 kPa (0–15 psi).**

10. Verify damage to the turbocharger bypass valve assembly does not exist. Refer to *Turbocharger Cleaning and Inspection on page 9-895*.

⇒ **If the turbocharger bypass valve assembly is damaged**

Repair or replace the turbocharger bypass valve assembly as necessary.

⇓ **If the turbocharger bypass valve assembly is not damaged**

11. Replace the turbocharger.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Charge Air Bypass Regulator Solenoid Valve Replacement on page 9-295* for turbocharger bypass solenoid valve replacement
- *Intake Manifold Replacement on page 9-790*
- *Turbocharger Replacement on page 9-843*
- *Control Module References on page 6-3* for ECM replacement, programming and setup

DTC P2534 (Fuel Pump Control Module)

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC P2534: Ignition On/Start Switch Circuit Low Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition	P2534	P2534	—	—

Circuit/System Description

The fuel pump 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 engine is running.

Conditions for Setting the DTC

The fuel pump control module detects that the ignition voltage is less than 6.0 V.

Action Taken When the DTC Sets

DTC P2534 is a Type A DTC.

Conditions for Clearing the DTC

DTC P2534 is a Type A DTC.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Fuel System Description on page 9-302

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Testing

1. Ignition ON.
2. Verify DTC P0562 is not set.

⇒ **If the DTC is set**

Refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69*.

⇓ **If the DTC is not set**

3. Ignition OFF, disconnect the harness connector at the K27 fuel pump control module, ignition ON.
4. Verify a test lamp illuminates between the ignition circuit terminal 21 and ground.

⇒ **If the test lamp does not illuminate and the circuit fuse is good**

4.1. Ignition OFF.

4.2. 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**

4.1. Ignition OFF.

4.2. 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 K27 fuel pump control module.

⇓ **If the test lamp illuminates**

5. Replace the K27 fuel pump control module.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair .

Control Module References on page 6-3 for fuel pump control module replacement, programming and setup.

DTC P2544

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptors

DTC P2544 72: Transmission Torque Request Circuit Message Counter Incorrect

DTC P2544 74: Transmission Torque Request Circuit Bus Signal Checksum Error

Circuit/System Description

To improve shift feel, the transmission control module (TCM) may request that the engine control module (ECM) reduce engine torque during shift events. When such a request is received, the ECM responds by retarding the injection timing and notifying the TCM that the request has succeeded. If the ECM is unable to comply with the request, the ECM sends the TCM a message that the request has failed.

The torque reduction request is sent to the ECM through GMLAN.

Conditions for Running the DTC

- The ignition is ON.
- The DTCs run continuously once the above condition is met.

Conditions for Setting the DTC

The ECM detects an invalid signal from the TCM.

Action Taken When the DTC Sets

DTC P2544 is a Type C DTC.

Conditions for Clearing the DTC

DTC P2544 is a Type C DTC.

Reference Information

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Circuit/System Testing

1. Observe the Freeze Frame/Failure Records with a scan tool.
2. Clear the DTCs with a scan tool.
3. Ignition OFF for 30 s.
4. Operate the vehicle within the Conditions for Running the DTC to verify the DTC does not reset. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
   - ⇒ If any other DTC is set, refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69*
   - ⇒ Verify DTC P2544 is not set. If DTC P2544 resets, replace K71 Transmission Control Module.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

Control Module References on page 6-3 for TCM replacement, setup, and programming

DTC P2635 (Fuel Pump Control Module)

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

DTC Descriptor

DTC P2635: Fuel Pump Flow Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control	P0231	P023F	P0232	P023F, P2635
Low Reference	—	P023F	—	P023F, P2635

Circuit/System Description

The engine control module (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 seconds, 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 pump and also supplies a varying voltage to the fuel tank pump module in order to maintain the desired fuel line pressure.

Conditions for Running the DTC

- DTC P018B, P018C, P018D, P0231, P0232, P023F, P064A, P1255 or P06A6 are not active.
- DTC P0641 has not failed this ignition cycle.
- Fuel pump control is enabled and the fuel pump control state is normal.
- The system voltage is greater than 11 V.
- The engine has been running for more than 30 seconds.
- Low fuel level warning not present.

Conditions for Setting the DTC

This DTC sets when the fuel pump control module detects a predetermined fuel pressure performance degradation between the desired fuel pressure and the current fuel pressure.

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 on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Fuel System Description on page 9-302

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions on page 6-68

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Testing

Note: Do not replace the fuel pump control module based on a history DTC P2635. The DTC P2635 may be stored but that does not indicate a failure of the fuel

pump control module. Refer to *Strategy Based Diagnosis on page 6-58* for further history DTC diagnostics.

1. Ignition ON.
2. Verify DTCs P018B, P018C, P018D, P0231, P0232 or P023F are not set.

⇒ **If any of the DTCs are set**

Refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69*.

⇓ **If none of the DTCs are set**

3. Verify the proper fuel system pressure. Perform the fuel system pressure test, refer to *Fuel System Diagnosis on page 9-230*.

⇒ **If the fuel system pressure test is not normal**

Replace the G12 Fuel Pump.

⇓ **If the fuel system pressure test is normal**

4. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the G12 Fuel Pump. It may take up to 2 minutes for all vehicle systems to power down.
5. Test for less than 10 Ω between the low reference circuit terminal 2 and ground.

⇒ **If 10 Ω or greater**

5.1. Ignition OFF, disconnect the harness connector at the K27 Fuel Pump Control Module.

5.2. 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 K27 Fuel Pump Control Module.

⇓ **If less than 10 Ω**

6. Connect a test lamp between the control circuit terminal 1 and the low reference circuit terminal 2.
7. Ignition ON.
8. Verify the test lamp turns ON and OFF when commanding the fuel pump ON and OFF with a scan tool.

⇒ **If the test lamp is always OFF**

8.1. Ignition OFF, disconnect the harness connector at the K27 Fuel Pump Control Module.

8.2. 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

8.3. 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 K27 Fuel Pump Control Module.

⇒ **If the test lamp is always ON**

8.1. Ignition OFF, disconnect the harness connector at the K27 Fuel Pump Control Module, ignition ON.

8.2. 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 K27 Fuel Pump Control Module.

⇓ **If the test lamp turns ON and OFF**

9. All OK.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Fuel Tank Fuel Pump Module Replacement on page 9-261*
- *Control Module References on page 6-3* for fuel pump control module replacement, programming and setup

Symptoms - Engine Controls

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

Symptoms Description

Symptoms cover conditions that are not covered by DTCs. Certain conditions can cause multiple symptoms. These conditions are listed together under Symptoms Testing. Conditions that may only cause specific symptoms are listed separately under additional symptoms testing. Perform the symptoms testing before using the additional symptoms testing.

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 1 500 RPM or 48 km/h (30 MPH). The exhaust has a steady spitting sound at idle or at low speed.

Detonation/Spark Knock: A mild to severe ping which usually gets worse while under acceleration. The engine makes sharp metallic knocks that change with throttle opening.

Dieseling, Run-On: Fuel ignites in the intake manifold or in the exhaust system, making a loud popping noise.

Engine Control Module (ECM) Commanded 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.

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.

Poor Fuel Fill Quality: Difficulty when refueling the vehicle.

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 that the malfunction indicator lamp (MIL) is operating correctly. Use the scan tool to command the lamp ON and OFF.
- Verify that there are no DTCs stored.
- Verify that the scan tool data is within the normal operating range. Refer to *Control Module References on page 6-3* for scan tool information.
- Verify that there are no Bulletins concerning the current symptom.
- Verify that the vehicle tires are correctly inflated and meet original equipment specifications.
- 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 that the control module grounds are clean, tight, and correctly located.
- Verify that the vacuum hoses are not split or kinked, and are properly connected, as shown on the Vehicle Emission Control Information label.
- Verify that the air filter is clean and free from restrictions.
- Verify that there is no water intrusion in connectors terminals and components.
- Inspect the air intake ducts for the following conditions:
  - Collapsed
  - Damaged areas
  - Looseness
  - Incorrect installation
  - Leaking
- 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, Hard Start, Hesitation/Sag/Stumble, Lack of Power/ Sluggishness/Sponginess, Poor Fuel Economy, Rough, Unstable, or Incorrect Idle and Stalling, or Surges/Chuggles

1. Test for the following conditions:
   - An incorrectly operating fuel system. Test for the following:
     - Correct operation and pressure—Refer to *Fuel System Diagnosis on page 9-230*.
     - Leaking or improperly operating fuel injectors – Refer to *Fuel Injector Diagnosis on page 9-232*.
     - Contaminated or a poor quality fuel – Refer to *Alcohol/Contaminants-in-Fuel Diagnosis on page 9-235*.
   - An incorrectly operating ignition system. Test for the following:
     - Spark plugs with an incorrect heat range or an abnormal condition – Refer to *Spark Plug Inspection on page 9-279* and *Ignition System Specifications on page 9-27*.
     - Coolant or oil fouled spark plugs.
     - Secondary ignition system susceptible to moisture. Engine running, 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 *EL 26792* HEI spark tester. For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308*. Refer to *Electronic Ignition System Diagnosis on page 9-238*.
   - An incorrectly operating turbocharger system. Refer to *Turbocharger System Description on page 9-306* and *Turbocharger Cleaning and Inspection on page 9-895*.
   - Incorrect operation of the transmission torque converter clutch (TCC) – The scan tool should indicate an engine speed drop when the TCC is commanded ON.
   - Incorrect operation of the A/C compressor
   - Items that can cause an engine to run lean or rich – Refer to *DTC P0171 or P0172 on page 9-116*.
   - An incorrectly installed Mass Air Flow (MAF) / Intake Air Temperature (IAT) Sensor
   - Engine oil contaminated by fuel
   - Split or kinked vacuum hoses – Verify that the routing and connections are as shown on the vehicle emission control information label.
   - Excessive knock sensor spark retard activity – Refer to *Knock Sensor Replacement on page 9-286* and *DTC P0324, P0326, or P06B6 on page 9-143*.
   - Fuel octane switch setting – Verify the fuel octane switch is set to the proper fuel octane rating for the fuel being used in the vehicle.
   - Electromagnetic interference on the reference circuit, which can cause a misfire condition. You can usually detect electromagnetic interference 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 electromagnetic interference is present. Inspect the high voltage components near the ignition control circuit if a condition exists.
   - A crankshaft position sensor with an incorrect resistance – The crankshaft position sensor resistance may be out of range after a hot soak. The resistance should be between 700–1 200 Ω.
   - A stuck open evaporative emission (EVAP) canister purge solenoid valve.
   - Incorrect operation of the positive crankcase ventilation system – check all connections for leaks or restrictions.
   - An exhaust system condition. Test for the following:
     - Physical damage or possible internal failure
     - Restricted 3-way catalytic converters

     For more information, refer to *Symptoms - Engine Exhaust on page 9-734*.
   - An engine cooling system condition. Test for the following:
     - A thermostat with incorrect heat range. Refer to *Thermostat Diagnosis on page 9-626*.
     - Incorrect engine coolant level – Refer to *Cooling System Draining and Filling on page 9-628*.
     - An incorrectly operating engine coolant thermostat heater – Refer to *DTC P0597-P0599 on page 9-614*.
   - An engine mechanical condition. Test for the following mechanical conditions – Refer to *Symptoms - Engine Mechanical on page 9-770*.
     - Excessive oil in the combustion chamber or leaking valve seals
     - Oil Consumption
     - Incorrect cylinder compression
     - Sticking or leaking valves
     - Worn camshaft lobes
     - Incorrect valve timing
     - 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

2. 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 on page 9-617*.
- 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.

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. Observe the scan tool Reduced Engine Power History parameter, if applicable, or refer to *Engine Control Module Scan Tool Information on page 6-33* to determine the reason for the reduced engine power event.

Verify or inspect for the following:

- Vehicle being operated at sustained high engine speeds, or, towing heavy loads up an incline for an extended period of time, which may cause the engine oil or coolant to overheat. A repair may not be necessary. 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 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 (LUV) on page 9-679* or *Cooling Fan Description and Operation (LWE, LUW) on page 9-680* and *Cooling System Description and Operation on page 9-680* to verify correct operation of the cooling fan.
- If equipped with the OnStar® feature, reduced engine power may be due to OnStar® remote command. Verify the vehicle is not in the OnStar® initiated Stolen Vehicle Slowdown mode.
- Excessively high fuel pressure condition. Refer to *Fuel System Description on page 9-302* and *Fuel System Diagnosis on page 9-230* to verify fuel system operation.
- Maximum recommended engine oil life exceeded. Refer to the Owners Manual for scheduled maintenance recommendations.
- Turbocharger boost pressure out of range. Refer to *DTC P0234 or P0299 on page 9-125*.
- Intake air temperature out of range too high. Observe the scan tool IAT Sensor 1 and IAT Sensor 2 parameters. The readings should be within 9°C (16°F) of a each other. Refer to *DTC P0096 or P0111 on page 9-56* for more information.
- If equipped with automatic transmission, an incorrect learned brake pedal position (BPP) sensor. Verify the following actions have not occurred:
  - An engine control module (ECM) has been replaced
  - A BPP sensor 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 on page 17-164* procedure must be performed.

Fuel Odor

- Inspect for leaking, damaged, or deteriorated fuel lines.
- Inspect for a saturated EVAP canister – Refer to *Evaporative Emission Control System Description on page 9-300*.
- Inspect for a condition with the internal components of the fuel tank assembly—Refer to *Fuel System Description on page 9-302*.

Hard Start

- 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. Inspect the throttle body and bore and clean, if necessary. Refer to *Throttle Body Inspection and Cleaning on page 9-253*.
- 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 approximately 3°C (5°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) on page 9-26* for resistance specifications. Replace the ECT sensor if the resistance is not within specification. If the sensor is within the specification, test the ECT circuits for a high resistance.
- Verify that the fuel pump turns ON for 2 s when the ignition is turned ON. Refer to *Fuel System Diagnosis on page 9-230* for additional information.

Hesitation, Sag, Stumble

- Test the fuel pressure. Refer to *Fuel System Diagnosis on page 9-230*.
- Test the manifold absolute pressure (MAP) sensor. Refer to *DTC P0106 on page 9-84*.
- Test the generator. Refer to *Symptoms - Engine Electrical on page 9-701*. Repair the charging system if the generator output voltage is less than 9 V or more than 16 V.

Note: The following actions may need to be repeated in order to verify an intermittent intake or exhaust camshaft actuator condition.

- Engine warm and idling, verify the correct operation of the camshaft actuator system. Command the intake and exhaust camshaft actuators from 0 degrees to 25 degrees and back to zero while observing the scan tool Intake Camshaft Position Variance and Exhaust Camshaft Position Variance parameters. Each parameter should be less than 2 degrees in each of the commanded states.
  - ⇒ If any of the parameters is greater than 2 degrees, inspect the suspect camshaft actuator and camshaft actuator solenoid valve and valve bore for contamination, obstruction, and damage. Refer to *Camshaft Actuator System Description on page 9-296* and *Camshaft Position Actuator Solenoid Valve Replacement on page 9-282*.

Lack of Power, Sluggishness, or Sponginess

- Inspect the engine electrical system for correct operation. Refer to *Symptoms - Engine Electrical on page 9-701*.
- Verify that each injector harness is connected to the correct injector.
- Inspect the mass air flow (MAF) sensor for obstruction, contamination, and damage. Refer to *Mass Airflow Sensor Replacement on page 9-246*.

Note: The following actions may need to be repeated in order to verify an intermittent intake or exhaust camshaft actuator condition.

- Engine warm and idling, verify the correct operation of the camshaft actuator system. Command the intake and exhaust camshaft actuators from 0 degrees to 25 degrees and back to zero while observing the scan tool Intake Camshaft Position Variance and Exhaust Camshaft Position Variance parameters. Each parameter should be less than 2 degrees in each of the commanded states.
  - ⇒ If any of the parameters is greater than 2 degrees, inspect the suspect camshaft actuator and camshaft actuator solenoid valve and valve bore for contamination, obstruction, and damage. Refer to *Camshaft Actuator System Description on page 9-296* and *Camshaft Position Actuator Solenoid Valve Replacement on page 9-282*.
- Verify the correct operation of the turbocharger system. Perform the following:
  - – Inspect the turbocharger moving components for looseness, binding, wear, and damage.
  - – Verify that the turbocharger air inlet ducts and outlet ducts are tightly sealed and that the air passages are not obstructed. Engine running, use a solution of dish soap and water in a spray bottle to pinpoint any air leaks.
  - – Inspect the turbocharger system components for external fluid leaks. Inspect the gaskets and sealing surfaces and look for cracks in the turbocharger components.
  - – Inspect for a loss of turbocharger pressure. Ignition ON, verify the scan tool Turbo Boost Sensor parameter is within the range specified in the *Altitude Versus Barometric Pressure on page 9-26*.
  - ⇒ If not within the range specified, refer to *DTC P0236 on page 9-128*
  - – For additional information, refer to *Turbocharger System Description on page 9-306* and *Turbocharger Cleaning and Inspection on page 9-895*.

Poor Fuel Economy

- Inspect for heavy loads being carried or towed
- Inspect for acceleration rate too much or too often
- Inspect for incorrect operation of the speedometer.
- 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. Inspect the throttle body and bore and clean, if necessary. Refer to *Throttle Body Inspection and Cleaning on page 9-253*.
- Inspect the brake system for brake drag.

Poor Fuel Fill Quality

- Inspect for restricted vent lines
- Inspect for high fuel temperature
- Inspect for a condition with the internal components of the fuel tank assembly

  For more information, refer to *Fuel System Description on page 9-302* and *Evaporative Emission Control System Description on page 9-300*.

Rough, Unstable, or Incorrect Idle and Stalling

- 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. Inspect the throttle body and bore and clean, if necessary. Refer to *Throttle Body Inspection and Cleaning on page 9-253*.
- Inspect the engine mounts for looseness, wear, and damage.
- Inspect the intake and exhaust manifolds for casting flash.
- 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 aceclerator pedal movement.

Surges/Chuggles

- Verify that each injector harness is connected to the correct injector.
- Inspect the mass air flow (MAF) sensor for obstruction, contamination, and damage. Refer to *Mass Airflow Sensor Replacement on page 9-246*.
- Inspect for slow responding heated oxygen sensors (HO2S). The heated oxygen sensors should respond quickly to a change in throttle

position. If the heated oxygen sensors do not respond to different throttle positions, inspect for contamination from fuel, silicon, or the incorrect use of room temperature vulcanizing 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.

Malfunction Indicator Lamp (MIL) Diagnosis

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides 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 engine 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 Fault if there is a condition with a circuit or a connection.

Reference Information

Schematic Reference

- *Engine Controls Schematics on page 9-28*
- *Instrument Cluster Schematics on page 8-78*

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Circuit/System Verification

Note: Any MIL requesting DTCs that may be set should be diagnosed first.

1. Ignition ON.
2. Command the malfunction indicator lamp ON and OFF with a scan tool.
3. Verify that the malfunction indicator lamp turns ON and OFF as commanded.

⇒ **If the malfunction indicator lamp does not turn ON and OFF as commanded**

Refer to Circuit/System Testing.

⇓ **If the malfunction indicator lamp turns ON and OFF as commanded**

4. Command the malfunction indicator lamp ON and OFF with a scan tool.
5. Verify that the control circuit status parameters listed below display OK or Not Run
   - 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 OK or Not Run is displayed**

6. Engine running.
7. Command the malfunction indicator lamp ON and OFF with a scan tool.
8. Verify that the control circuit status parameters listed below display OK or Not Run
   - 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 OK or Not Run is displayed**

9. All OK.

Circuit/System Testing

1. Ignition OFF.
2. Disconnect the X1 harness connector at the K20 Engine Control Module.
3. Ignition ON.
4. Verify the malfunction indicator lamp does not illuminate.

⇒ **If the malfunction indicator lamp illuminates**

4.1. Test for infinite resistance between the malfunction indicator lamp control circuit terminal X1 52 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**

5. Connect a 3 A fused jumper wire between the malfunction indicator lamp control circuit terminal X1 52 and ground.
6. Verify the malfunction indicator lamp illuminates.

⇒ **If the malfunction indicator lamp does not illuminate**

6.1. Test the malfunction indicator lamp control circuit terminal X1 52 for a short to voltage or an open/high resistance.

⇒ If the malfunction indicator lamp control circuit terminal X1 52 is shorted to voltage or has an open/high resistance, repair as necessary.

⇓ If the malfunction indicator lamp control circuit terminal X1 52 tests normal

6.2. Test the instrument cluster ignition voltage circuit for a short to ground or open/high resistance.

⇒ If the instrument cluster ignition voltage circuit is shorted to ground or has an open/high resistance, repair as necessary.

⇒ If the instrument cluster ignition voltage circuit tests normal, replace the P16 instrument panel cluster/bulb.

⇓ **If the malfunction indicator lamp illuminates**

7. Replace the K20 Engine Control Module.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Instrument Cluster Replacement on page 8-104*
- *Control Module References on page 6-3* for replacement, programming, and setup.

Engine Cranks But Does Not Run

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

Circuit/System Description

The engine cranks but does not run is an organized approach to identify a condition which causes the engine to crank but not start. This diagnostic directs the technician to the appropriate system diagnosis.

This diagnostic assumes the system voltage levels are adequate for starter motor operation. Fuel level and fuel quality must be determined for correct 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. Refer to *Fuel Injector Diagnosis on page 9-232*.
- 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. Check all the engine data parameters with a scan tool and compare the values indicated with the expected values or the values from a known vehicle in good condition.
- Check the crankshaft position sensor engine reference signal with a scan tool. 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, check for an open in the ground circuits of the crankshaft position sensor and the camshaft position sensor – intake or camshaft position sensor – exhaust.
- 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 min 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 in order to check for an engine starting or will not stay running concern.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Special Tools

- *CH 48027* Digital Pressure Gauge
- *EL 26792* HEI Spark Tester
- *EN 36012-A* Ignition System Diagnostic Harness

For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308.*

Circuit/System Verification

Note: This diagnostic assumes the following:

- The battery is completely charged. Refer to *Battery Inspection/Test on page 9-702.*
- The engine cranking speed is acceptable. Refer to *Engine Cranks Slowly on page 9-711.*
- There is adequate fuel in the fuel tank.

Circuit/System Testing

1. Crank the engine for up to 15 s.
2. Verify that DTC P0117, P0118, P0122, P0123, P0222, P0223, P0335, P0336, P0513, P0562, P0563, P0601, P0602, P0603, P0604, P0606, P062F, P0633, P0685, P0689, P0690, P1516, P1631, P1682, P16F3, P2101, P2119, or P2610 is not set.

⇒ **If any of the DTCs are set**

Refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69.*

⇓ **If none of the DTCs are set**

3. Ignition ON
4. Verify the Theft Deterrent LED located in the driver information center illuminates momentarily.

⇒ **If the LED stays ON or is flashing**

Review the *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69* for Immobilizer system DTCs. Refer to *Immobilizer Description and Operation on page 13-31* for additional information.

⇓ **If the LED 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 on page 9-147.*

⇓ **If greater than 0 RPM**

6. Ignition OFF.

Note: It may be necessary to secure the *EN 36012-A* ignition system diagnostic harness to the spark plug boots with electrical tape.

7. Install the *EN 36012-A* ignition system diagnostic harness to the spark plug boots.
8. Connect the *EL 26792* HEI spark tester between the boot of a spark plug wire and ground.
9. Connect the remaining wires to the appropriate cylinders.

Note: An erratic or weak spark is considered a no spark condition.

10. Verify the spark tester sparks while cranking the engine.

⇒ **If the spark tester does not spark**

Refer to *Electronic Ignition System Diagnosis on page 9-238.*

⇓ **If the spark tester sparks**

11. Ignition ON.
12. Verify the fuel pump turns ON while commanding the scan tool Fuel Pump Enable ON.

⇒ **If the fuel pump does not turn ON**

Refer to *Fuel System Diagnosis on page 9-230.*

⇓ **If the fuel pump turns ON**

13. Ignition OFF.
14. Disconnect the harness connector at a Q17 Fuel Injector.
15. Connect a test lamp between the control circuit and the ignition voltage circuit of the harness connector.
16. Verify the injector test lamp flashes while cranking the engine.

⇒ **If the injector test lamp does not flash**

Refer to *DTC P0201, P0202, P0203, P0204, P0261, P0262, P0264, P0265, P0267, P0268, P0270, or P0271 on page 9-120.*

⇓ **If the injector test lamp flashes**

17. Ignition OFF.
18. Install the *CH 48027* digital pressure gauge.
19. Ignition ON.

Note:

- The Fuel Pump Enable may need to be commanded ON a few times, in order to obtain the highest possible fuel pressure.
- Do NOT start the engine for this test.

20. Command the Fuel Pump Enable ON several times with a scan tool.
21. Verify the fuel pressure is between 345–650 kPa (50–94 PSI) while the fuel pump is running.

⇒ **If not within the specified range**

Refer to *Fuel System Diagnosis on page 9-230.*

⇓ **If within the specified range**

22. Verify none of the conditions listed below exist:
    - Collapsed air intake duct to the throttle body
    - Air filter and air intake system for restrictions and obstructions
    - Spark plugs for being gas or coolant fouled
    - A skewed manifold absolute pressure (MAP) sensor

- A skewed engine coolant temperature (ECT) sensor
- Test the exhaust system for restrictions. Refer to *Restricted Exhaust on page 9-734*.
- Test the fuel for contamination. Refer to *Alcohol/Contaminants-in-Fuel Diagnosis on page 9-235*.
- Engine mechanical condition, for example, worn timing belt or low compression—Refer to *Symptoms - Engine Mechanical on page 9-770*.

⇒ **If a condition exists**

Repair as necessary.

⇓ **If no conditions exist**

23. All OK.

Repair Verification

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

Spark Plug Replacement on page 9-281

Fuel System Diagnosis

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

Circuit/System Description

The engine control module (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 pump 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.

The fuel tank stores the fuel supply. An electric turbine style fuel pump attaches to the fuel tank fuel pump module inside the fuel tank. The fuel pump supplies high pressure fuel through the fuel feed pipe to the fuel injection system. The fuel pump also supplies fuel to a venturi pump located on the bottom of the fuel tank fuel pump module. The function of the venturi pump is to fill the fuel tank fuel pump module reservoir. The fuel tank fuel pump module contains a reverse flow check valve. The check valve maintains fuel pressure in the fuel feed pipe and the fuel rail in order to prevent long cranking times.

Diagnostic Aids

Observe the Misfire Counters or perform the Fuel Injector Balance Test to help identify a leaking fuel injector.

Reference Information

Description and Operation

Fuel System Description on page 9-302

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

Scan Tool Reference

Control Module References on page 6-3 for scan tool information

Special Tools

- *CH 48027* Digital Pressure Gauge
- *EN 37287* Fuel Line Shut-off Adapter

For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308*.

Circuit/System Verification

Note:

- Repair all fuel system related DTCs, except P2635, 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.
- Before proceeding with this test review the User Manual CH 48027–5 for Safety Information and Instructions.

1. Ignition OFF, all accessories OFF, install a *CH 48027* Gauge.

Note: DO NOT perform the Fuel System Diagnosis if the engine coolant temperature is above 60°C (150°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) ± 5 percent.

2. Ignition ON, engine OFF, command the Fuel Pump Enable On several times with a scan tool.
3. Verify the fuel pressure is between 345–650 kPa (50–94 psi) with the fuel pump running.

⇒ **If less than 345 kPa (50 psi)**

Refer to Circuit/System Testing - Fuel Pressure Low.

⇒ **If greater than 650 kPa (94 psi)**

Replace the G12 Fuel Pump.

⇓ **If between 345–650 kPa (50–94 psi)**

4. Verify that the fuel pressure decreases to less than 600 kPa (87 psi) after the fuel pump is turned off.

⇒ **If greater than 600 kPa (87 psi)**

Replace the G12 Fuel Pump.

⇓ **If less than 600 kPa (87 psi)**

5. Verify that the fuel pressure does not decrease more than 34 kPa (5 psi) in 1 minute.

⇒ **If greater than 34 kPa (5 psi)**

Refer to Circuit/System Testing - Fuel Pressure Leaks Down.

⇓ **If less than 34 kPa (5 psi)**

6. Relieve the fuel pressure to 69 kPa (10 psi).
7. Verify that the fuel pressure does not decrease more than 14 kPa (2 psi) in 5 min.

⇒ **If greater than 14 kPa (2 psi)**

Replace the G12 Fuel Pump.

⇓ **If less than 14 kPa (2 psi)**

8. Engine idling at normal operating temperature.
9. Verify the Fuel Pump Control Module Fuel Pressure Sensor parameter is between 300–400 kPa (43–58 psi).

⇒ **If less than 300 kPa (43 psi)**

Refer to Circuit/System Testing - Fuel Pressure Low.

⇒ **If greater than 400 kPa (58 psi)**

Replace the G12 Fuel Pump.

⇓ **If between 300–400 kPa (43–58 psi)**

10. 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 - Fuel Pressure Low.

⇓ **If less than 1.5**

11. 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 - Fuel Pressure Drops Off.

⇓ **If less than 45 kPa (6.5 psi)/60 kPa (8.7 psi)**

12. If the fuel system components test normal, refer to *Symptoms - Engine Controls on page 9-222* and *Fuel Injector Diagnosis on page 9-232*.

Circuit/System Testing

Fuel Pressure Low

1. Verify none of the conditions listed below exist:
   - Restricted fuel feed pipe
   - Inspect the harness connectors and the ground circuits of the fuel pump for poor connections.

⇒ **If a condition exists**

Repair as necessary.

⇓ **If none of the conditions exist**

Replace the G12 Fuel Pump.

Fuel Pressure Leaks Down

1. Ignition OFF, relieve the fuel pressure. Refer to *Fuel Pressure Relief on page 9-253*.
2. Install the *EN 37287* Adapter between the chassis fuel feed hose and the engine compartment fuel feed pipe.
3. Open the valve on the *EN 37287* Adapter.
4. Ignition ON, command the Fuel Pump Enable On with a scan tool and bleed the air from the *CH 48027* Gauge.
5. Command the Fuel Pump Enable On and then Off with a scan tool.
6. Close the valve on the *EN 37287* Adapter.
7. Verify that the fuel pressure does not decrease more than 34 kPa (5 psi) in 1 min.

⇒ **If greater than 34 kPa (5 psi)**

Locate and replace the leaking Q17 Fuel Injector.

⇓ **If less than 34 kPa (5 psi)**

Replace the G12 Fuel Pump.

Fuel Pressure Drops Off

1. Verify none of the conditions listed below exist:
   - Restricted fuel feed pipe
   - Inspect the harness connectors and the ground circuits of the fuel pump for poor connections.

⇒ **If a condition exists**

Repair as necessary.

⇓ **If none of the conditions exist**

Replace the G12 Fuel Pump.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

- *Fuel Feed Pipe Replacement on page 9-258*
- *Fuel Injector Replacement on page 9-269*
- *Fuel Tank Fuel Pump Module Replacement on page 9-261*

Fuel Injector Diagnosis

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

Circuit/System Description

The engine control module (ECM) enables the appropriate fuel injector pulse for each cylinder. The ignition voltage is supplied directly to the fuel injectors. The ECM controls each fuel injector by grounding the control circuit via a solid state device called a driver. A fuel injector coil winding resistance that is too high or too low will affect the engine driveability. A fuel injector control circuit DTC may not set, but a misfire may be apparent. 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.

When performing the fuel injector balance test with the fuel injector tester or the scan tool, the scan tool is first used to enable the fuel pump. The fuel injector tester or the scan tool is then used to pulse each injector for a precise amount of time, allowing a measured amount of fuel to be injected. This causes a drop in the system fuel pressure that can be recorded and used to compare each injector.

Diagnostic Aids

- Operating the vehicle over a wide temperature range may help isolate the fuel injector that is causing the condition.
- Perform the fuel injector coil test within the conditions of the concern from the customer. A fuel injector condition may only be apparent at a certain temperature, or under certain conditions.
- Monitoring the Current Misfire Counters, or misfire graph, may help to isolate the fuel injector that is causing the condition.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Fuel System Description on page 9-302

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

Special Tools

- *CH 48027* Digital Pressure Gauge
- *EL 39021* Fuel Injector Coil and Balance Tester

For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308*.

Fuel Injector Coil Test

Verify the resistance of each Q17 Fuel Injector with one of the following methods:

- If the engine coolant temperature (ECT) sensor is between 10–32°C (50–90°F), the resistance of each fuel injector should be 11–14 Ω. If the injectors measure OK, perform the Fuel Injector Balance Test.
  - ⇒ If not within the specified range, replace the Q17 Fuel Injector.
- If the ECT sensor is not between 10–32°C (50–90° F), measure and record the resistance of each fuel injector. Subtract the lowest resistance value from the highest resistance value. The difference between the lowest value and the highest value should be equal to or less than 3 Ω. If the injectors measure OK, perform the Fuel Injector Balance Test.
  - ⇒ If not within the specified range, add all of the fuel injector resistance values to obtain a total resistance value. Divide the total resistance value by the number of fuel injectors to obtain an average resistance value. Subtract the lowest individual fuel injector resistance value from the average resistance value. Compute the difference between the highest individual fuel injector resistance value and the average resistance value. Replace the Q17 Fuel Injector that displays the greatest difference above or below the average.

Fuel Injector Balance Test with Special Tool

Note:

- DO NOT perform this test if the engine coolant temperature (ECT) is above 94°C (201°F). Irregular fuel pressure readings may result due to hot soak fuel boiling.
- Verify that adequate fuel is in the fuel tank before proceeding with this diagnostic.
- Before proceeding with this test review the User Manual CH 48027-5 for Safety Information and Instructions.

1. Verify the correct fuel system pressure. Refer to *Fuel System Diagnosis on page 9-230*.
2. Set the amperage supply selector switch on the fuel injector tester to the Balance Test 0.5–2.5 A position.
3. Connect the *EL 39021* fuel injector coil and balance tester to a Q17 Fuel Injector.
4. Command the Fuel Pump Enable On and then Off three times with a scan tool. On the last command, as the fuel pressure begins to slowly degrade and stabilize, select a fuel pressure within 34 kPa

(5 psi) of the maximum pump pressure. Record this fuel pressure. This is the starting pressure at which you will pulse each injector.

5. Command the Fuel Pump Enable On one more time and energize the fuel injector by depressing the Push to Start Test button on the *EL 39021* fuel injector coil and balance tester at the previously selected pressure.
6. After the injector stops pulsing, select Min from the Display Mode on the *CH 48027* gauge and record the Min pressure.

Note: New test results will not be recorded if the Min/Max results are not cleared after each injector is tested.

7. Clear the Min/Max results on the *CH 48027* gauge.
8. Select Normal from the Display Mode on the *CH 48027* gauge.
9. Repeat steps 3 and 5 through 8 for each fuel injector.
10. Subtract the minimum pressure from the starting pressure for one fuel injector. The result is the pressure drop value.
11. Obtain a pressure drop value for each fuel injector.
12. Add all of the individual pressure drop values except for the injector suspected of being faulty. This is the total pressure drop.
13. Divide the total pressure drop by the number of fuel injectors that were added together. This is the average pressure drop. The difference between any individual pressure drop and the average pressure drop should not be more than 20 kPa (3 psi).
    - ⇒ If the difference between any individual pressure drop and the average pressure drop is more than 20 kPa (3 psi), replace the Q17 Fuel Injector.

Fuel Injector Balance Test with Scan Tool

1. Verify the correct fuel system pressure. Refer to *Fuel System Diagnosis on page 9-230*.
2. Command the Fuel Pump Enable On and then Off three times with a scan tool. On the last command, as the fuel pressure begins to slowly degrade and stabilize, select a fuel pressure within 34 kPa (5 psi) of the maximum pump pressure. Record this fuel pressure. This is the starting pressure at which you will pulse each injector.
3. With a scan tool, select the Fuel Injector Balance Test function within the Special Functions menu.
4. Select an injector to be tested.
5. Press Enter to prime the fuel system.
6. Energize the fuel injector by depressing the Pulse Injector button on the scan tool at the previously selected pressure.
7. After the injector stops pulsing, select Min from the Display Mode on the *CH 48027* gauge and record the Min pressure.

Note: New test results will not be recorded if the Min/Max results are not cleared after each injector is tested.

8. Clear the Min/Max results on the *CH 48027* gauge.
9. Select Normal from the Display Mode on the *CH 48027* gauge.
10. Press Enter on the scan tool to bring you back to the Select Injector screen.
11. Repeat steps 4 through 10 for each fuel injector.
12. Subtract the minimum pressure from the starting pressure for one fuel injector. The result is the pressure drop value.
13. Obtain a pressure drop value for each fuel injector.
14. Add all of the individual pressure drop values except for the injector suspected of being faulty. This is the total pressure drop.
15. Divide the total pressure drop by the number of fuel injectors that were added together. This is the average pressure drop. The difference between any individual pressure drop and the average pressure drop should not be more than 20 kPa (3 psi).
    - ⇒ If the difference between any individual pressure drop and the average pressure drop is more than 20 kPa (3 psi), replace the Q17 Fuel Injector.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

Fuel Injector Replacement on page 9-269

Fuel Injector Circuit Diagnosis

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0201*, P0202*, P0203*, P0204*, P0261*, P0264*, P0267*, P0270*	P0201**, P0202**, P0203**, P0204**, P0261**, P0264**, P0267**, P0270**	—	—
Injector 1 Control	P0201, P0261	P0201, P0300	P0262, P0300	—
Injector 2 Control	P0202, P0264	P0202, P0300	P0265, P0300	—
Injector 3 Control	P0203, P0267	P0203, P0300	P0268, P0300	—
Injector 4 Control	P0204, P0270	P0204, P0300	P0271, P0300	—

* Open fuse, cranks no start.

** Cranks no start if the condition is between the fuse and the splice.

Circuit/System Description

The engine control module (ECM) enables the appropriate fuel injector pulse for each cylinder. Ignition voltage is supplied to the fuel injectors. The ECM controls each fuel injector by grounding the control circuit via a solid state device called a driver.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

Scan Tool Reference

Control Module References on page 6-3

Special Tool

CH 34730-2C Noid Light

Circuit/System Verification

1. Engine cranking or running.
2. Verify the scan tool parameters listed below do not display Malfunction.
   - Cylinder 1–4 Injector Control Circuit Low Voltage Test Status
   - Cylinder 1–4 Injector Control Circuit Open Test Status
   - Cylinder 1–4 Injector Control Circuit High Voltage Test Status

⇒ **If Malfunction is displayed**

Refer to Circuit/System Testing.

⇓ **If Malfunction is not displayed**

3. All OK.

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at a Q17 Fuel Injector, ignition ON.
2. Verify a test lamp illuminates between the ignition circuit terminal 1 and ground.

⇒ **If the test lamp does not illuminate and the circuit fuse is good**

2.1. Ignition OFF, remove the test lamp.

2.2. 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**

2.1. Ignition OFF, remove the test lamp.

2.2. 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 1 and the control circuit 2.

⇒ **If the test lamp illuminates**

3.1. Ignition OFF, remove the test lamp, disconnect the harness connector at the K20 Engine Control Module.

3.2. 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. Ignition OFF, connect the *CH 34730-2C* Noid Light to a fuel injector connector.
5. Engine cranking.
6. Verify the *CH 34730-2C* Noid Light turns ON and OFF for each fuel injector connector.

⇒ **If the CH 34730-2C is always OFF**

6.1. Ignition OFF, remove the *CH 34730-2C* Noid Light, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

6.2. 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

6.3. Ignition OFF.

6.4. 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 the CH 34730-2C is always ON**

6.1. Ignition OFF, remove the *CH 34730-2C* Noid Light, disconnect the harness connector at the K20 Engine Control Module.

6.2. 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 CH 34730-2C turns ON and OFF**

7. Test or replace the Q17 Fuel Injector.

Component Testing

Fuel Injector Diagnosis on page 9-232

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Fuel Injector Replacement on page 9-269*
- *Control Module References on page 6-3* for Engine Control Module replacement, programming, and setup.

Alcohol/Contaminants-in-Fuel Diagnosis

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

Test 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 percent can cause driveability conditions and fuel system deterioration. Fuel with more than 10 percent ethanol could result in 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 Tool

CH 44175-A Fuel Composition Tester, if available

For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308*.

System Verification

The fuel sample should be drawn from the bottom of the tank so that any water present in the tank will be detected. The sample should be bright and clear.

⇒ If the sample appears cloudy, or contaminated with water, as indicated by a water layer at the bottom of the sample, perform the Particulate Contaminants in Fuel Testing Procedure.

⇒ If alcohol contamination is suspected, perform the Alcohol in Fuel Testing procedure.

Alcohol in Fuel Testing with Special Tool, If Available

1. Test the fuel composition using the *CH 44175-A* Fuel Composition Tester and the Instruction Manual.
2. If water appears in the fuel sample, clean the fuel system.
3. Subtract 50 from the reading on the DMM in order to obtain the percentage of alcohol in the fuel sample.
4. If the fuel sample contains more than 15 percent ethanol, add fresh, regular gasoline to the vehicle's fuel tank.
5. Test the fuel composition.
6. If testing shows the ethanol percentage is still more than 15 percent, replace the fuel in the vehicle.

Alcohol in Fuel Testing without Special Tool

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 seconds.
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 seconds.
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 percent 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.

Particulate Contaminants in Fuel Testing Procedure

1. Using an approved fuel container, draw approximately 0.5 liter (0.53 qt) of fuel.
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. Observe the fuel sample. If any physical contaminants or water are present, clean the fuel system.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the diagnostic procedure.

- *Fuel System Cleaning on page 9-266*
- *Fuel Tank Draining on page 9-254*

Evaporative Emission Control System Diagnosis

Special Tools

EN 41413-VLV EVAP Service Port Vent Fitting

Operating Instructions for the Evaporative Emission System Tester (EEST)

Vehicle Setup

Warning: Refer to Fuel and Evaporative Emission Pipe Warning on page 0-4.

Caution: Refer to *Clean, Dry, Low Pressure Gas Source Caution on page 0-8*.

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 on page 0-8*.

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 evaporative emission (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 ORVR pipe and orifice.

7. Press and release the remote switch to activate the nitrogen flow and fill the system.
8. Compare the stable floating indicator position to the red flag.
   - Below the red flag, the result is acceptable, Pass. Test complete
   - Above the red flag, the result is unacceptable, Fail. Go to the Smoke Procedure
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. Consult the service procedures for DTCs that relate to evaporative emission (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. 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 EVAP Service Port Vent Fitting, until smoke is observed then remove the vent fitting tool and close the system to continue with the test.

Note: 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.
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. Introduce smoke at 15 s intervals, as needed, until leak source is identified.

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 EEST is stored indoors, approximately 21°C (70°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 3.2 kPa, 13 in. H2O (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.

Electronic Ignition System Diagnosis

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

Circuit/System Description

This ignition system uses an ignition coil module. The engine control module (ECM) controls the spark events by transmitting the timing pulses on the ignition control (IC) circuits to the cylinder ignition coils in firing order sequence.

Diagnostic Aids

- 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 on page 9-28

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Electronic Ignition System Description on page 9-297

Electrical Information Reference

- *Circuit Testing on page 11-526*
- *Connector Repairs on page 11-548*
- *Testing for Intermittent Conditions and Poor Connections on page 11-531*
- *Wiring Repairs on page 11-537*

Scan Tool Reference

Control Module References on page 6-3

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 K35 Ignition Coil 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 B and ground.

⇒ **If 5 Ω or greater**

2.1. Ignition OFF.

2.2. 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 C and ground.

⇒ **If 5 Ω or greater**

3.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.

3.2. 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 A and ground.

⇒ **If the test lamp does not illuminate and the circuit fuse is good**

5.1. Ignition OFF, remove the test lamp.

5.2. 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.

5.1. Ignition OFF, remove the test lamp, and disconnect all components on the circuit.

5.2. 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

5.3. Replace the fuse, ignition ON.

5.4. 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**

6. Replace the K35 Ignition Coil Module.

Repair Instructions

Perform the *Diagnostic Repair Verification on page 6-92* after completing the repair.

- *Ignition Coil Replacement on page 9-277*
- *Control Module References on page 6-3* for engine control module replacement, programming, and setup.

Inspection/Maintenance System Check

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Diagnostic System Check - Vehicle on page 6-66* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

Circuit/System Description

Several states require for a vehicle to pass on-board diagnostic (OBD) system tests and the inspection/maintenance emission inspection in order to renew license plates. This is accomplished by viewing the inspection/maintenance system status display on a scan tool. Using a scan tool, the technician can observe the inspection/maintenance system status in order to verify that the vehicle meets the criteria that comply with the local area requirements.

Condition for Updating the Inspection/Maintenance Emission System Status

Each system monitor requires at least one, and sometimes several, diagnostic tests. The result of each test is reported by a diagnostic trouble code (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 inspection/maintenance 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 two heated oxygen sensors, either both heater circuit tests have passed or one of the heater circuit tests has illuminated the MIL. The inspection/maintenance 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 may set the inspection/maintenance 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 engine control module (ECM) power or ground has been interrupted.
- The ECM has been reprogrammed.
- The ECM 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 catalyst 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 (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 on page 9-241*. 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 inspection/maintenance system status indicator.

Circuit/System Verification

Review the inspection/maintenance system DTC Table System Status indicators. All inspection/maintenance system DTC Table system status indicators should report YES.

Circuit/System Testing

Note: Many DTC related repairs will instruct the technician to clear the DTC information. Clearing the DTC will reset the inspection/maintenance system DTC Table system status indicators to NO. Performing the inspection/maintenance complete system set procedure will set each of the inspection/maintenance system status indicators to YES.

1. Observe the Engine DTC information with a scan tool.
   ⇒ If a DTC is set that may prevent the inspection/maintenance system status tests from completing, diagnose that DTC before continuing. Refer to *Inspection/Maintenance (I/M) System DTC Table on page 9-241*.
2. Review applicable service bulletins for software updates that may prevent the inspection/maintenance system status tests from completing.
   ⇒ If a control module reprogram or other repair is required, perform the . *Inspection/Maintenance Complete System Set Procedure on page 9-240*
3. Observe the inspection/maintenance system status indicators.
   ⇒ If any inspection/maintenance system status indicators report NO, perform the *Inspection/Maintenance Complete System Set Procedure on page 9-240*.

Inspection/Maintenance Complete System Set Procedure

Diagnostic Instructions

- Perform the *Diagnostic System Check - Vehicle on page 6-66* prior to using this diagnostic procedure.
- Review *Strategy Based Diagnosis on page 6-58* for an overview of the diagnostic approach.
- *Diagnostic Procedure Instructions on page 6-59* provides an overview of each diagnostic category.

Circuit/System Description

The purpose of the inspection/maintenance complete system set procedure is to satisfy the enable criteria necessary to execute all of the inspection/maintenance readiness diagnostics and complete the trips for those particular diagnostics. When all inspection/maintenance monitored diagnostic tests are completed, the inspection/maintenance system status indicators are set to yes. Perform the inspection/maintenance complete system set procedure if any inspection/maintenance system status indicators are set to NO.

Condition for Meeting a Cold Start

- The ignition voltage between 10–18 V.
- The barometric pressure (BARO) is more than 75 kPa (10.15 PSI).
- The engine coolant temperature (ECT) at start-up is greater than −5°C (23°F).
- The intake air temperature (IAT) at start-up is less than 40°C (104°F).
- The difference between the start-up IAT and ECT are within 3°C (5°F).
- The engine is OFF for greater than 6 h or the following conditions must be met:
  - The start-up IAT minus start-up ECT 1 are within 12°C (22°F).
  - The start-up ECT minus start-up IAT are within 50°C (90°F).
- Fuel level is between 25–75%.

Circuit/System Verification

Review the inspection/maintenance system status indicators. All inspection/maintenance system status indicators should report yes.

Inspection/Maintenance 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.
   ⇒ If the Evaporative Emission (EVAP) inspection/maintenance system status indicator displays NO, perform the EVAP Service Bay test if applicable.
2. Turn OFF all accessories; HVAC system, other electrical loads, including aftermarket/add-on equipment, etc., and open the hood.
3. Set the vehicle parking brake and ensure the vehicle is in park for automatic transmission or neutral for manual transmission.
4. Turn the ignition ON for 1 min.
5. Start and idle the engine for 5 min.
6. Run the engine for 6 min within the following conditions:
   - Calculated air flow is between 9–30 g/s
   - Engine speed is steady between 1 300–3 000 RPM
7. Apply and hold brake pedal, and shift to Drive for automatic, or apply clutch pedal for manual and operate the vehicle within the following conditions for 2 min:
   - Manifold Absolute Pressure (MAP) signal is greater than 12 g/s
   - Engine speed is greater than 1 000 RPM

Note: Do NOT touch the accelerator pedal until told to do so. A change in throttle position sensor angle or an increase in engine speed may invalidate this portion of the test.

8. Release the accelerator pedal and shift the vehicle to Park for automatic, or Neutral and release clutch pedal for manual, and allow the engine to idle for 2 min.
9. Close the hood, release the parking brake and drive vehicle at 90 km/h (55 MPH) for 2 min.
10. Release the accelerator pedal for at least 10 s. This will allow the vehicle to enter the deceleration fuel cut off.
11. Safely stop the vehicle, with the engine in drive for automatic or neutral with the clutch pedal depressed and parking brake applied for manual. Allow the vehicle to idle for 2 min.

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.

12. Shift the vehicle to park for automatic and neutral for manual. Turn OFF the ignition and exit the vehicle. Do NOT disturb the vehicle for 45 min.

13. Observe the Inspection/Maintenance System Status with a scan tool. All of the inspection/maintenance System Status indicators should display YES.
    - ⇒ If the EVAP inspection/maintenance system status indicator displays NO, turn OFF the ignition, ensure that the vehicle meets the conditions for a cold start, and repeat steps 6 through 11 three more times, or until the EVAP inspection/maintenance system status indicator transitions to yes. If the indicator continues to display NO, refer to the *Inspection/Maintenance (I/M) System DTC Table on page 9-241* to identify the DTCs that did not run.
    - ⇒ If any of the inspection/maintenance system status indicators display NO, refer to the *Inspection/Maintenance (I/M) System DTC Table on page 9-241* for the indicator which did not display yes. The inspection/maintenance system DTC table identifies the DTCs associated with each inspection/maintenance system status Indicator.

Inspection/Maintenance (I/M) System DTC Table

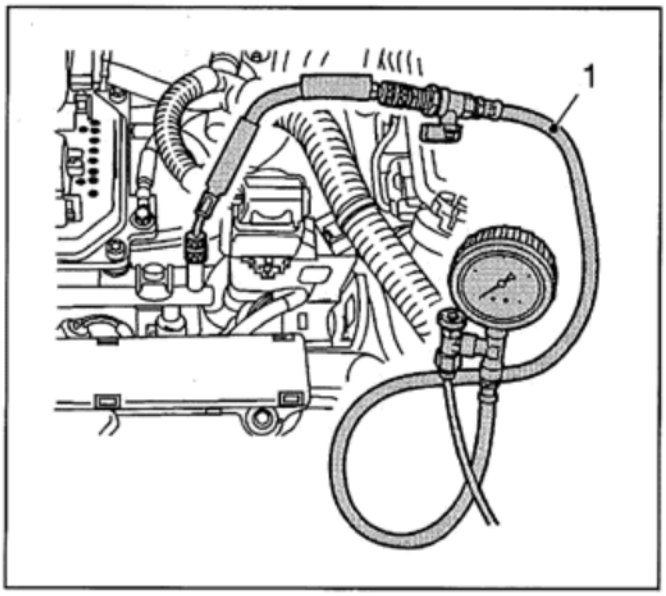
System	DTCs Required to Set System Status to YES
If an inspection/maintenance system status indicator did not update to yes during the *Inspection/Maintenance Complete System Set Procedure on page 9-240* , review each indicator and reference this table to determine each DTC associated with the inspection/maintenance 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 inspection/maintenance system status indicators to transition to yes.	
Catalyst monitor	DTC P0420. Refer to *DTC P0420 on page 9-155*.
Evaporative emission (EVAP)	• DTC P0442. Refer to *DTC P0442 on page 9-157* • DTC P0443. Refer to *DTC P0443 on page 9-159* • DTC P0446. Refer to *DTC P0446 on page 9-161* • DTC P0449. Refer to *DTC P0449 on page 9-163* • DTC P0455. Refer to *DTC P0455 on page 9-168* • DTC P0496. Refer to *DTC P0496 on page 9-170*
Oxygen sensor	• DTC P0131, P0132, P0134, P0137, P0138, or P0140. Refer to *DTC P0131, P0132, P0134, P0137, P0138, or P0140 on page 9-109*. • DTC P0133, P013A, P013B, P013E, P013F, P015A, P015B, P2270, or P2271. Refer to *DTC P0133, P013A, P013B, P013E, P013F, P015A, P015B, P2270, or P2271 on page 9-112*.
Oxygen sensor heater	DTC P0030–P0032, P0036–P0038, P0053, P0054, P0135, or P0141. Refer to *DTC P0030-P0032, P0036-P0038, P0053, P0054, P0135, or P0141 on page 9-48*.

Fuel Pressure Measurement

Special Tools

EN 34730–91 Pressure Tester

For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308*



1945805

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: 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.

1. Remove the protective cap from the test connection.
2. Attach the *EN 34730–91* tester (1) to the test connection.
3. Start the engine.
   - Bleed the pressure tester at idling speed.
   - Collect the exiting fuel in a suitable container.
   - Read the fuel pressure from the pressure gauge.

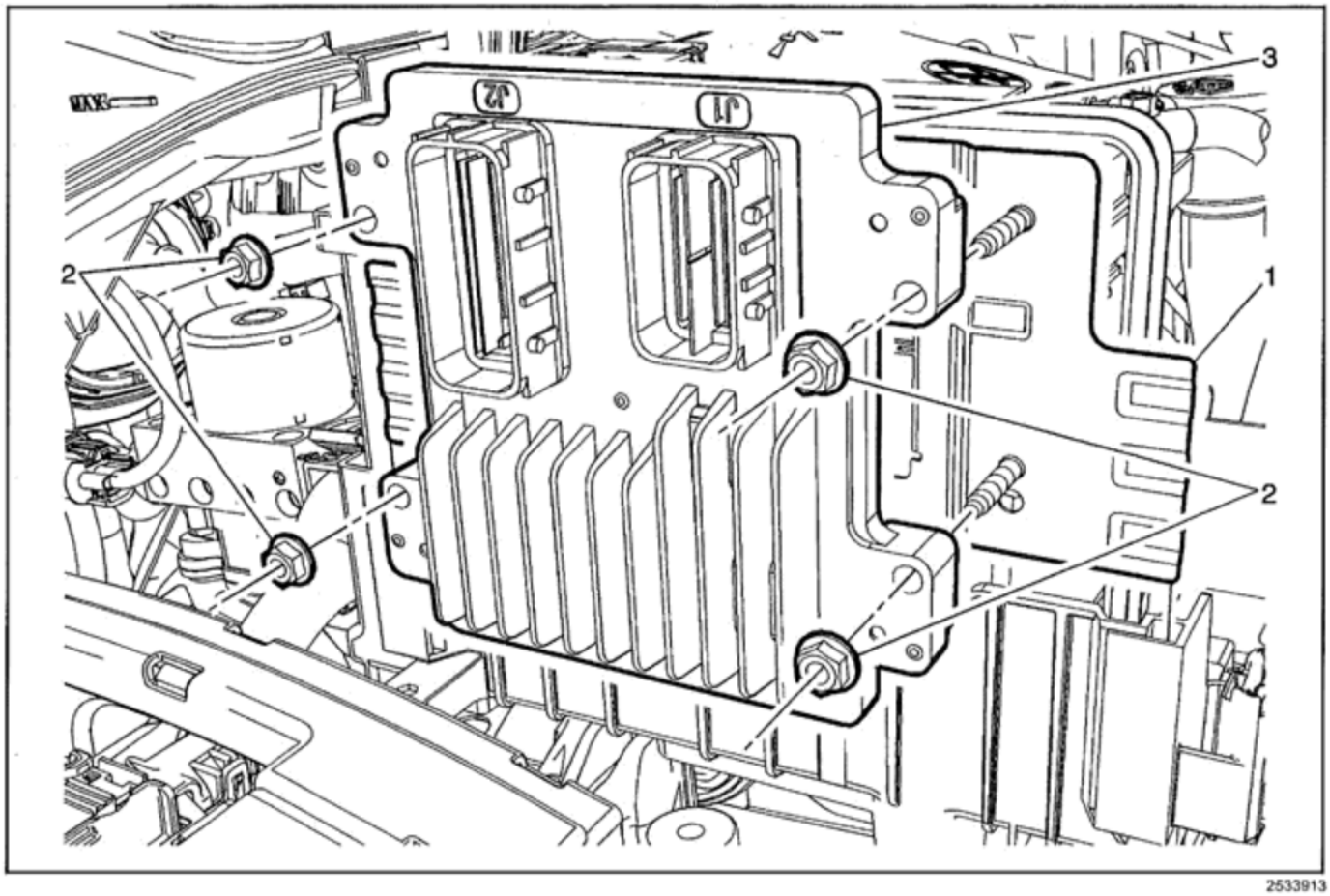
Caution: Clean all of the following areas before performing any disconnections in order to avoid possible contamination in the system:

- The fuel pipe connections
- The hose connections
- The areas surrounding the connections

4. Detach the pressure gauge *EN 34730–91* tester from the test connection.

Repair Instructions

Engine Control Module Replacement



2533913

Engine Control Module Replacement

Callout	Component Name
Note: If the ECM is to be replaced, the ECM must be RESET (prepared for removal) prior to removal from the vehicle. Failing to reset the ECM will result in the following: • Inability to test the ECM for warranty purposes • Inability to use the ECM in other vehicles. **Preliminary Procedures** 1. Prepare the ECM for replacement. Refer to *Control Module References on page 6-3*. 2. Using a scan tool, retrieve the percentage of remaining engine oil. Record the remaining engine oil life. 3. Disconnect the battery negative cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*	
1	Engine Control Module Mounting Bracket **Procedure** 1. Disconnect the electrical wiring harness connectors from the engine control module. 2. Unclip the engine control module bracket from the battery tray.
2	Engine Control Module Fasteners (Qty: 4) **Caution:** Refer to *Fastener Caution on page 0-8*. **Tighten** 10 N•m(89 lb in)
3	Engine Control Module **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 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 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. Remove the engine control module from the engine control module bracket. 2. If replacing the ECM, refer to *Control Module References on page 6-3* for programming and setup. **Note:** Before removing the engine control module (ECM), record the oil life percentage remaining. Use the scan tool to reset the Engine Oil Life remaining back to the original percentage recorded.

Crankshaft Position System Variation Learn

Note: The crankshaft position sensor system variation learn procedure is required when the following service procedures have been performed, regardless of whether DTC P0315 00 is set:

- Engine replacement
- Engine control module (ECM) replacement
- Crankshaft damper replacement
- Crankshaft replacement
- Crankshaft Position Sensor Replacement
- Any engine repairs which disturb the crankshaft to crankshaft position sensor relationship.

Note: The scan tool monitors certain component signals to determine if all the conditions are met to continue with the crankshaft position sensor system variation learn procedure. The scan tool only displays the condition that inhibits the procedure. The scan tool monitors the following components:

- Crankshaft Position Sensor activity – If there is a crankshaft position sensor condition, refer to the applicable DTC that set.
- Camshaft position signal activity – If there is a camshaft position sensor signal condition, refer to the applicable DTC that 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. Install a scan tool.
2. Monitor the ECM for DTCs with a scan tool. If other DTCs are set, except DTC P0315 00, refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69* for the applicable DTC that set.

3. With a scan tool, select the Crankshaft Position System Variation Learn procedure and perform the following:
   3.1. Observe the fuel cut-off for the applicable engine.
   3.2. Block the drive wheels.
   3.3. Set the parking brake.
   3.4. Place the vehicles transmission in Park or Neutral.
   3.5. Turn the air conditioning (A/C) OFF.
   3.6. Cycle the ignition from OFF to ON.
   3.7. Apply and hold the brake pedal for the duration of the procedure.
   3.8. Start and idle the engine.
   3.9. Accelerate to wide open throttle (WOT). The engine should not accelerate beyond the calibrated fuel cut-off RPM value noted in step 3.1. Release the throttle immediately if the value is exceeded.

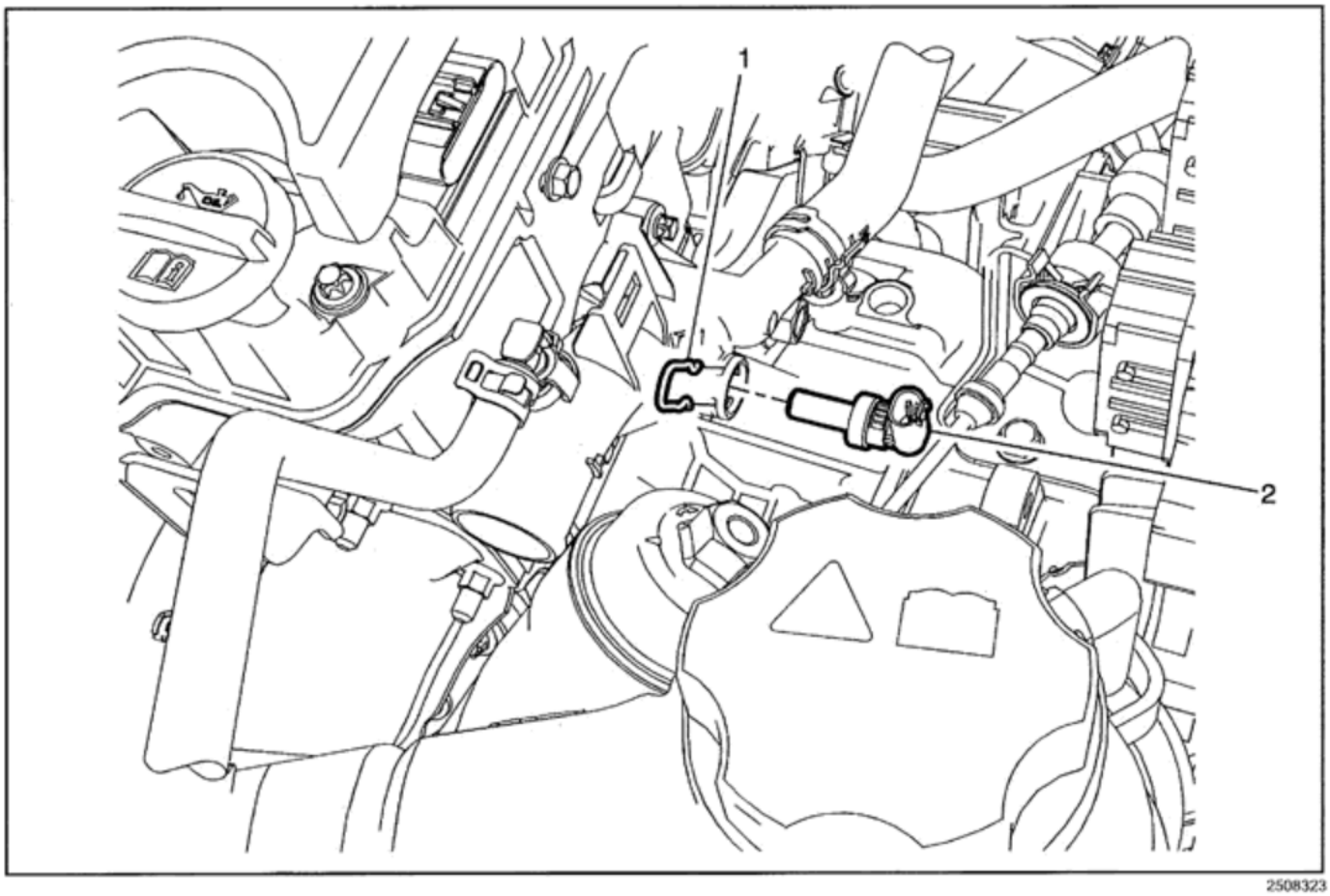
Note: While the learn procedure is in progress, release the throttle immediately when the engine starts to decelerate. The engine control is returned to the operator and the engine responds to throttle position after the learn procedure is complete.

   3.10. Release the throttle when fuel cut-off occurs.
   3.11. Accelerate to wide open throttle (WOT). The engine should not accelerate beyond the calibrated fuel cut-off RPM value noted in step 3.1. Release the throttle immediately if the value is exceeded.

Note: While the learn procedure is in progress, release the throttle immediately when the engine starts to decelerate. The engine control is returned to the operator and the engine responds to throttle position after the learn procedure is complete.

4. The scan tool displays Learn Status: Learned this Ignition. If the scan tool indicates that DTC P0315 00 ran and passed, the crankshaft position sensor variation learn procedure is complete. If the scan tool indicates DTC P0315 00 failed or did not run, refer to *DTC P0315 on page 9-142*. If any other DTCs set, refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69* for the applicable DTC that set.
5. Turn OFF the ignition for 30 s after the learn procedure is completed successfully.

Engine Coolant Temperature Sensor Replacement (Water Outlet)

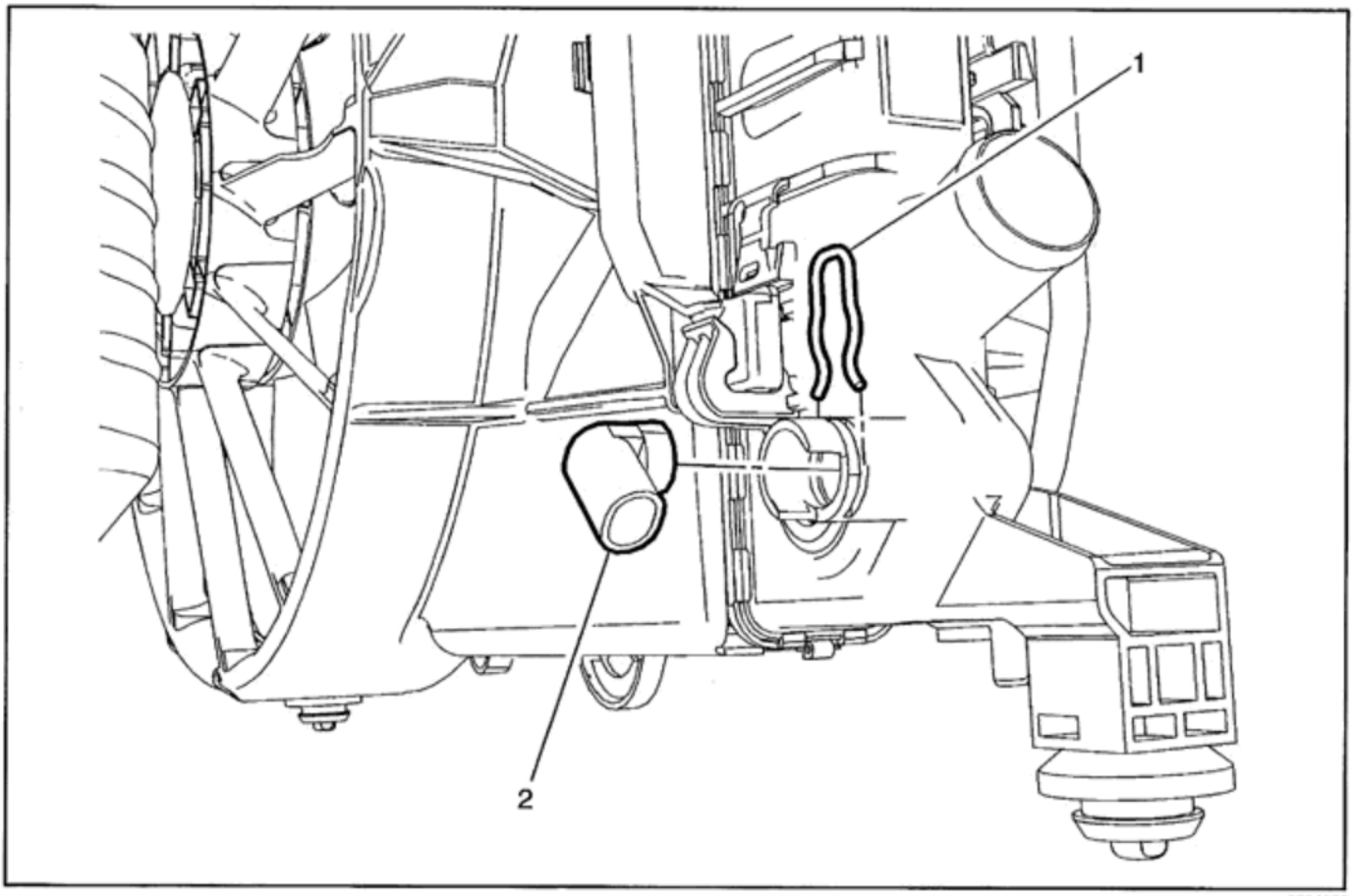


2508323

Engine Coolant Temperature Sensor Replacement (Water Outlet)

Callout	Component Name
Preliminary Procedure 1. Disconnect the negative battery cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713.* 2. Drain the cooling system. Refer to *Cooling System Draining and Filling on page 9-628.*	
1	Engine Coolant Temperature Sensor Fastener
2	Engine Coolant Temperature Sensor **Procedure** Disconnect the electrical wiring harness connector from the engine coolant temperature sensor.

Engine Coolant Temperature Sensor Replacement (Radiator)



2594856

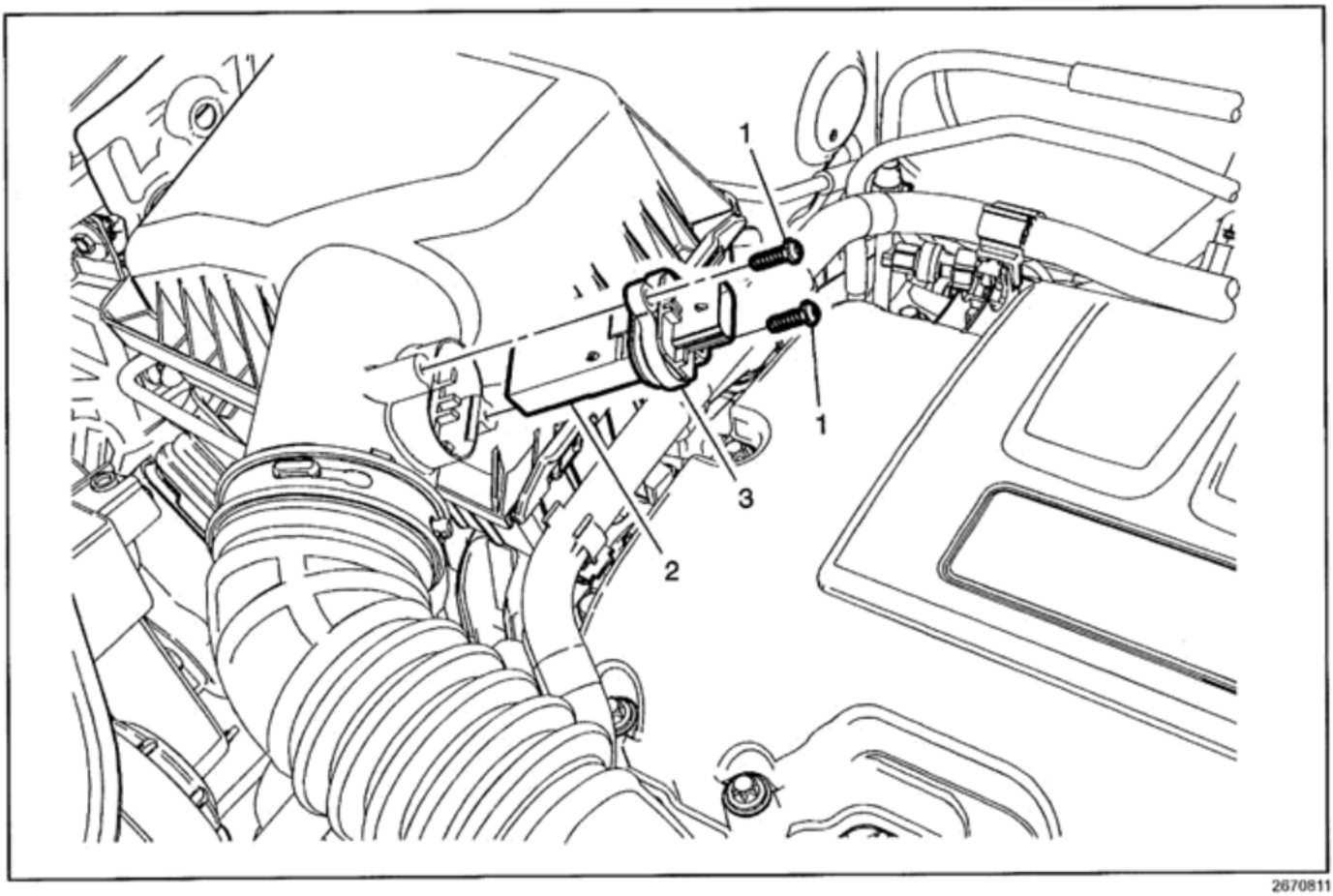
Engine Coolant Temperature Sensor Replacement (Radiator)

Callout	Component Name
Preliminary Procedures Drain the cooling system. Refer to *Cooling System Draining and Filling on page 9-628.*	
1	Retaining Clamp
2	Engine Coolant Temperature Sensor **Procedure** Disconnect the electrical connector.

Engine Coolant Temperature Sensor Replacement (Thermostat)

The engine coolant temperature sensor is integrated in the engine coolant thermostat housing. Refer to *Engine Coolant Thermostat Housing Replacement (LUW) on page 9-659*.

Mass Airflow Sensor Replacement

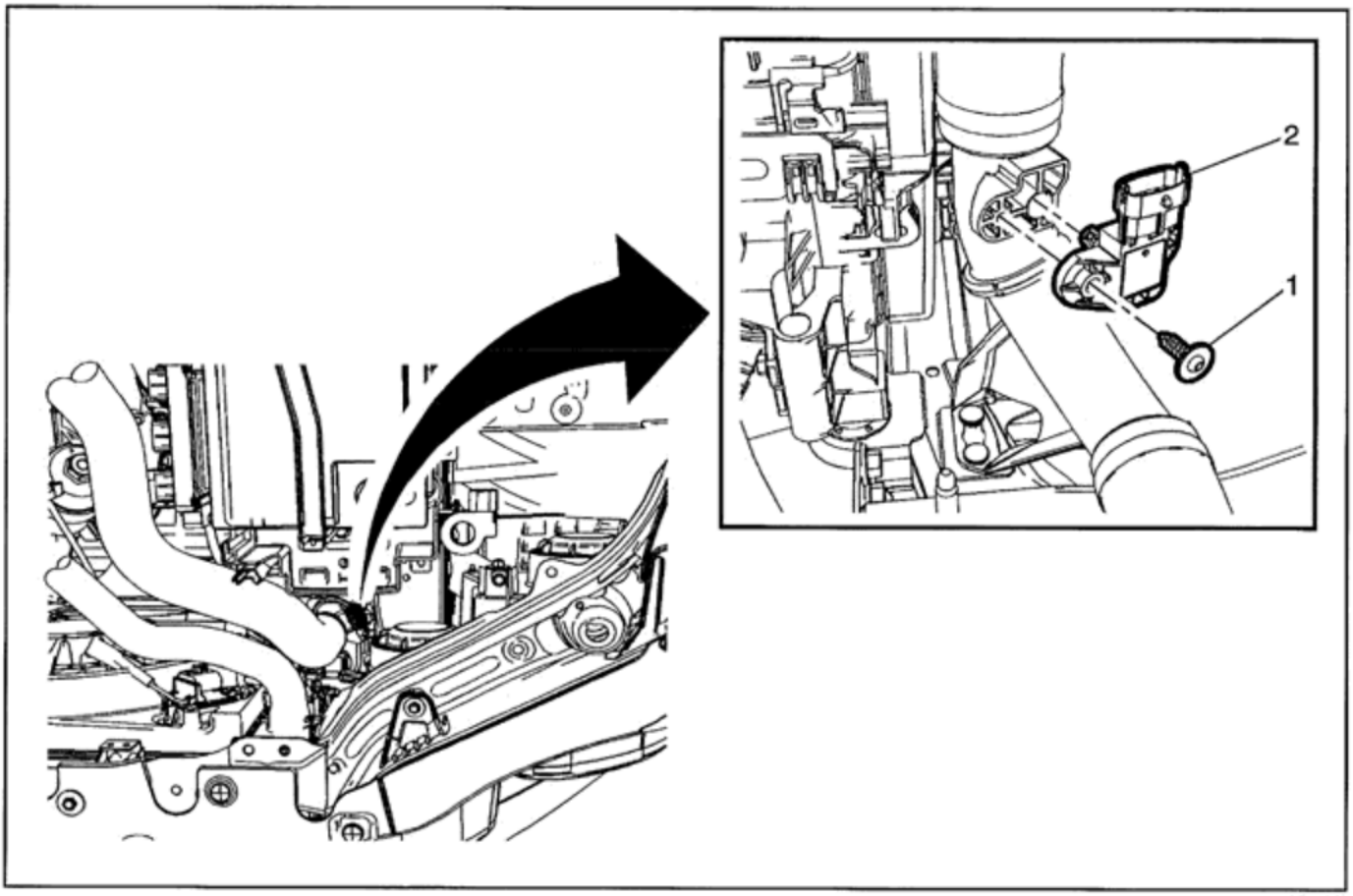


2670811

Mass Airflow Sensor Replacement

Callout	Component Name
1	Mass Air Flow Sensor Fasteners (Qty: 2)
2	Mass Air Flow Sensor **Procedure** 1. Disconnect electrical connector 2. After replacement of mass air flow sensor, use a scan tool to perform the learn functions. Refer to *Engine Control Module Programming and Setup on page 6-7*.
3	Mass Air Flow Sensor Seal Ring

Intake Air Pressure and Temperature Sensor Replacement

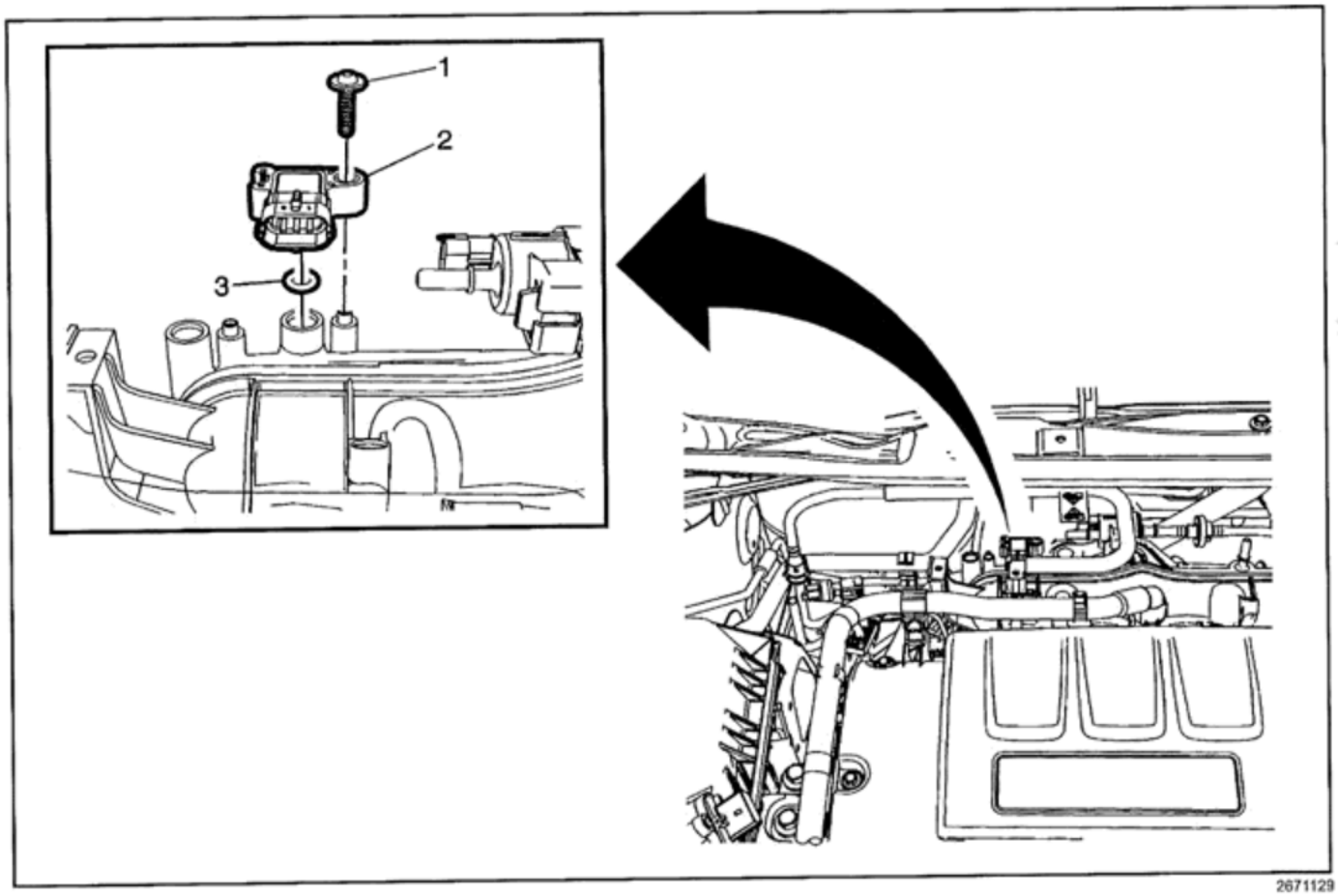


2671064

Intake Air Pressure and Temperature Sensor Replacement

Callout	Component Name
Preliminary Procedure Remove the left front wheelhouse liner. Refer to *Front Wheelhouse Liner Replacement (Rear) on page 3-151* or *Front Wheelhouse Liner Replacement (Front) on page 3-150*.	
1	Intake Air Temperature and Pressure Sensor Fasteners (Qty 2) **Caution:** Refer to *Fastener Caution on page 0-8*.
2	Intake Air Temperature and Pressure Sensor **Procedure** Disconnect the electrical connector.

Manifold Absolute Pressure Sensor Replacement

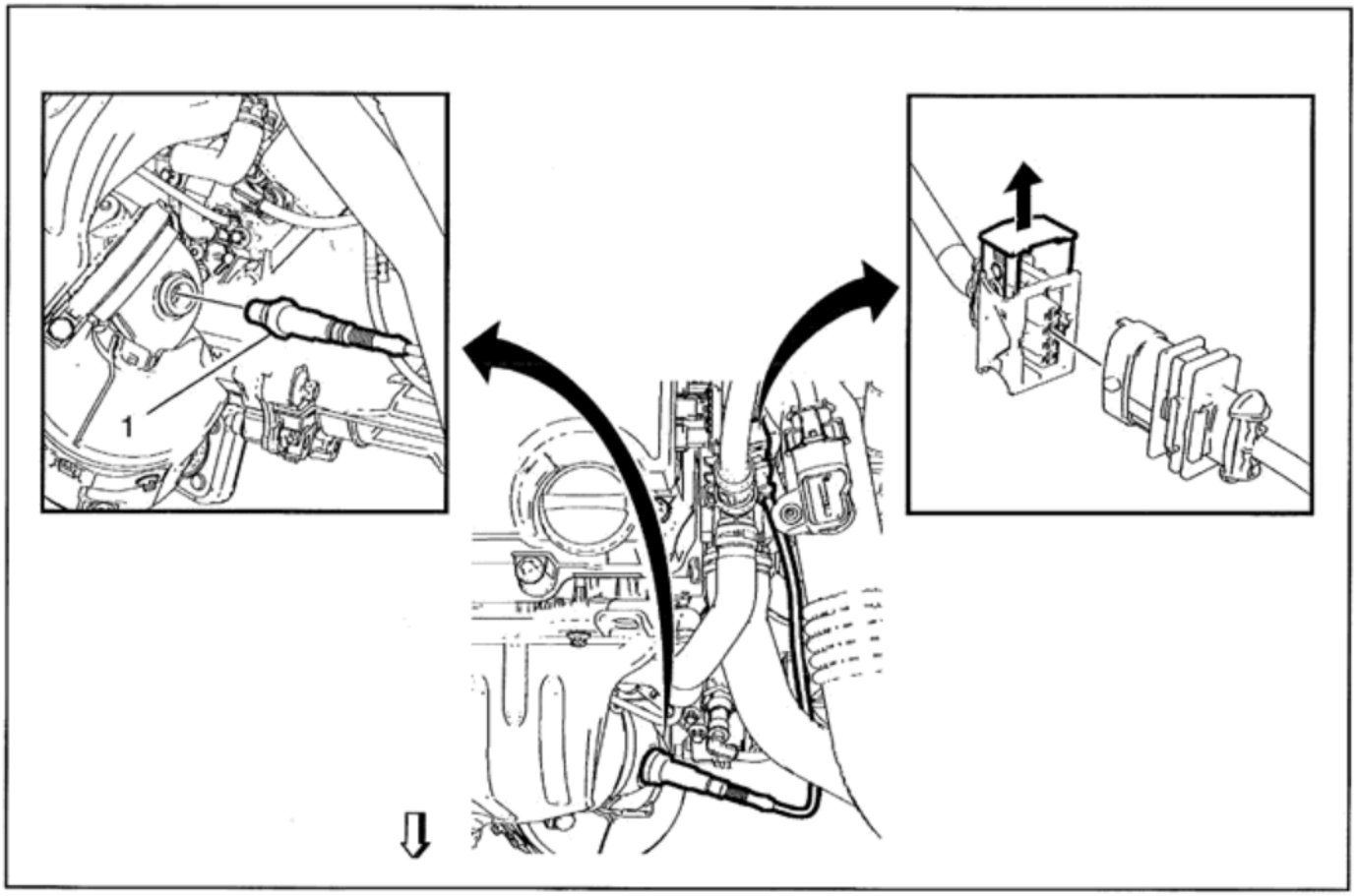


2671129

Manifold Absolute Pressure Sensor Replacement

Callout	Component Name
1	Manifold Absolute Pressure Sensor Fastener
2	Manifold Absolute Pressure Sensor **Procedure** 1. Disconnect the electrical connector. 2. After replacement of the manifold absolute pressure sensor use a scan tool to speed up the learn process. Refer to *Engine Control Module Programming and Setup on page 6-7*.
3	O-ring Seal

Heated Oxygen Sensor Replacement - Sensor 1

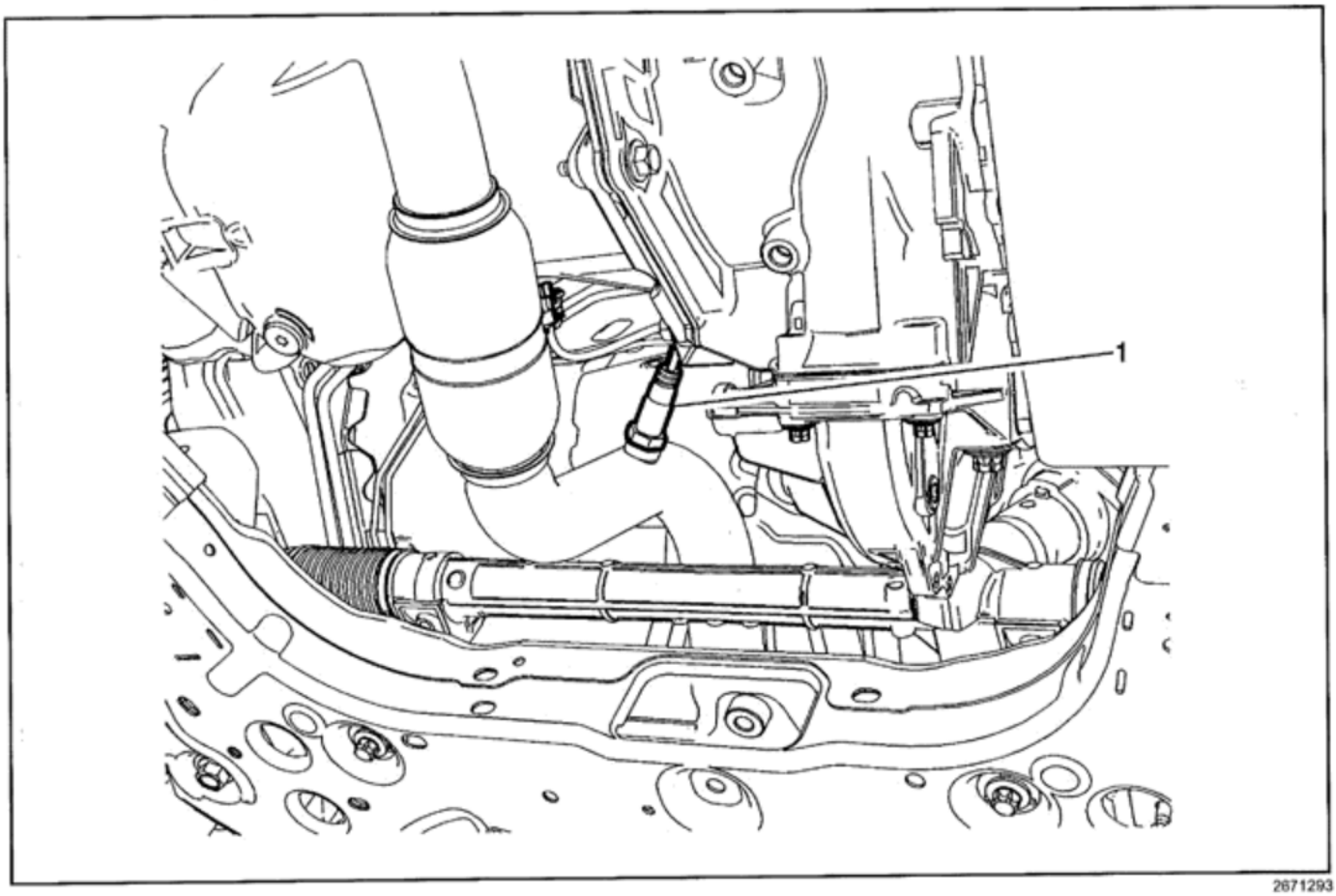


2192003

Heated Oxygen Sensor Replacement - Sensor 1

Callout	Component Name
Warning: In order to avoid being burned, do not service the exhaust system while it is still hot. Service the system when it is cool.	
Preliminary Procedure Disconnect battery negative cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.	
1	Heated Oxygen Sensor 1 **Caution:** Refer to *Fastener Caution on page 0-8*. **Procedure** 1. Remove the wiring harness from retainer clip. 2. Disconnect electrical connector. 3. After replacement of the heated oxygen sensor, use a scan tool to speed up learn functions. Refer to *Engine Control Module Programming and Setup on page 6-7*. 4. If reusing the heated oxygen sensor, coat the thread with assembly paste. **Tighten** 42 N•m(31 lb ft) **Special Tools** *EN-48259* Installer/Remover For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308*

Heated Oxygen Sensor Replacement - Sensor 2

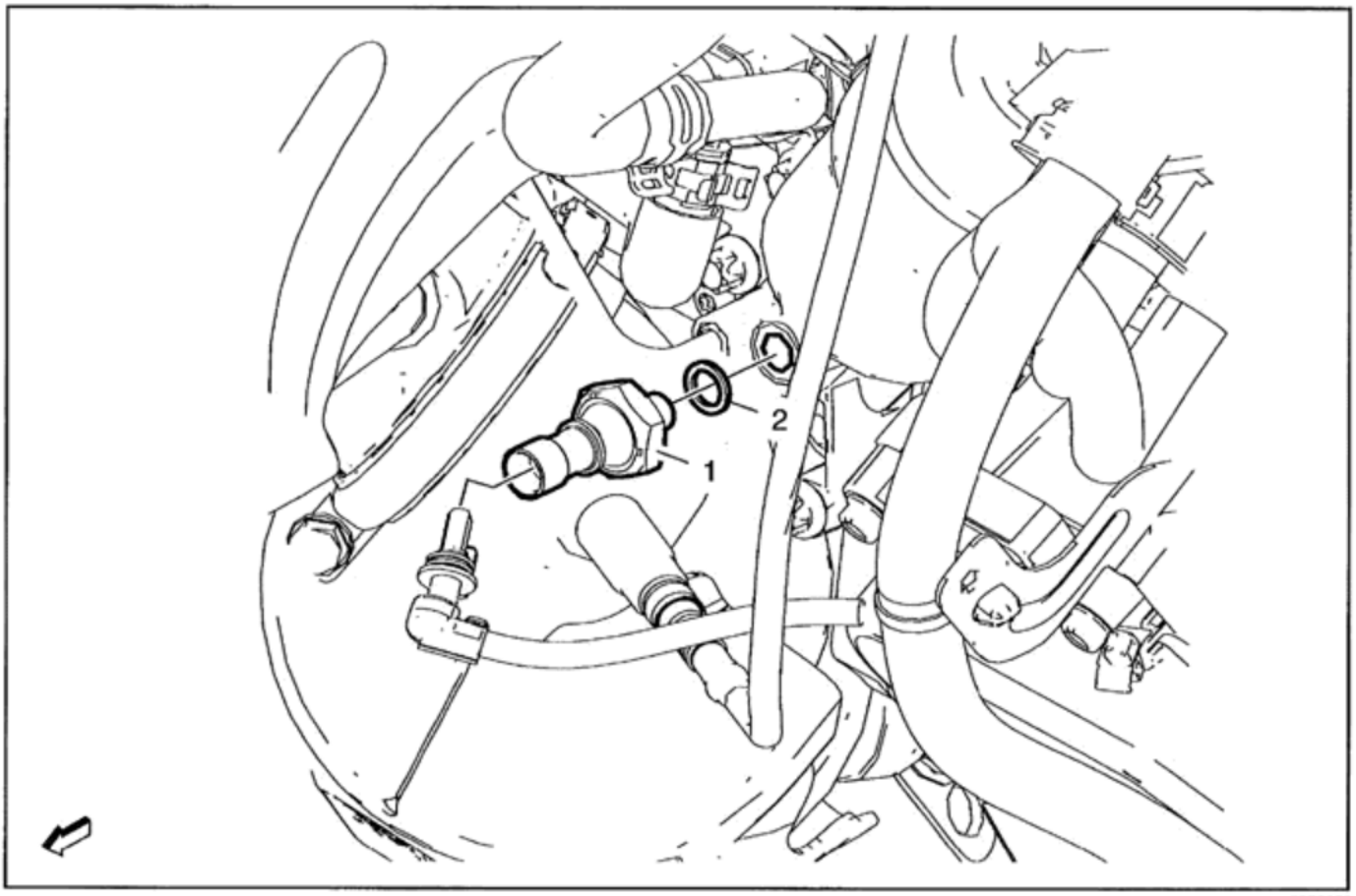


2671293

Heated Oxygen Sensor Replacement - Sensor 2

Callout	Component Name
Warning: In order to avoid being burned, do not service the exhaust system while it is still hot. Service the system when it is cool.	
Preliminary Procedure Raise and support the vehicle. Refer to *Lifting and Jacking the Vehicle on page 1-31*.	
1	Heated Oxygen Sensor 2 **Caution:** Refer to *Fastener Caution on page 0-8*. **Procedure** 1. Disconnect electrical connector. 2. After replacement of the heated oxygen sensor, use a scan tool to speed up learn functions. Refer to *Engine Control Module Programming and Setup on page 6-7*. 3. If reusing the heated oxygen sensor, coat the thread with assembly paste. **Tighten** 42 N•m(31 lb ft) **Special Tools** *EN-48259* Installer/Remover For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308*

Engine Oil Pressure Indicator Switch Replacement

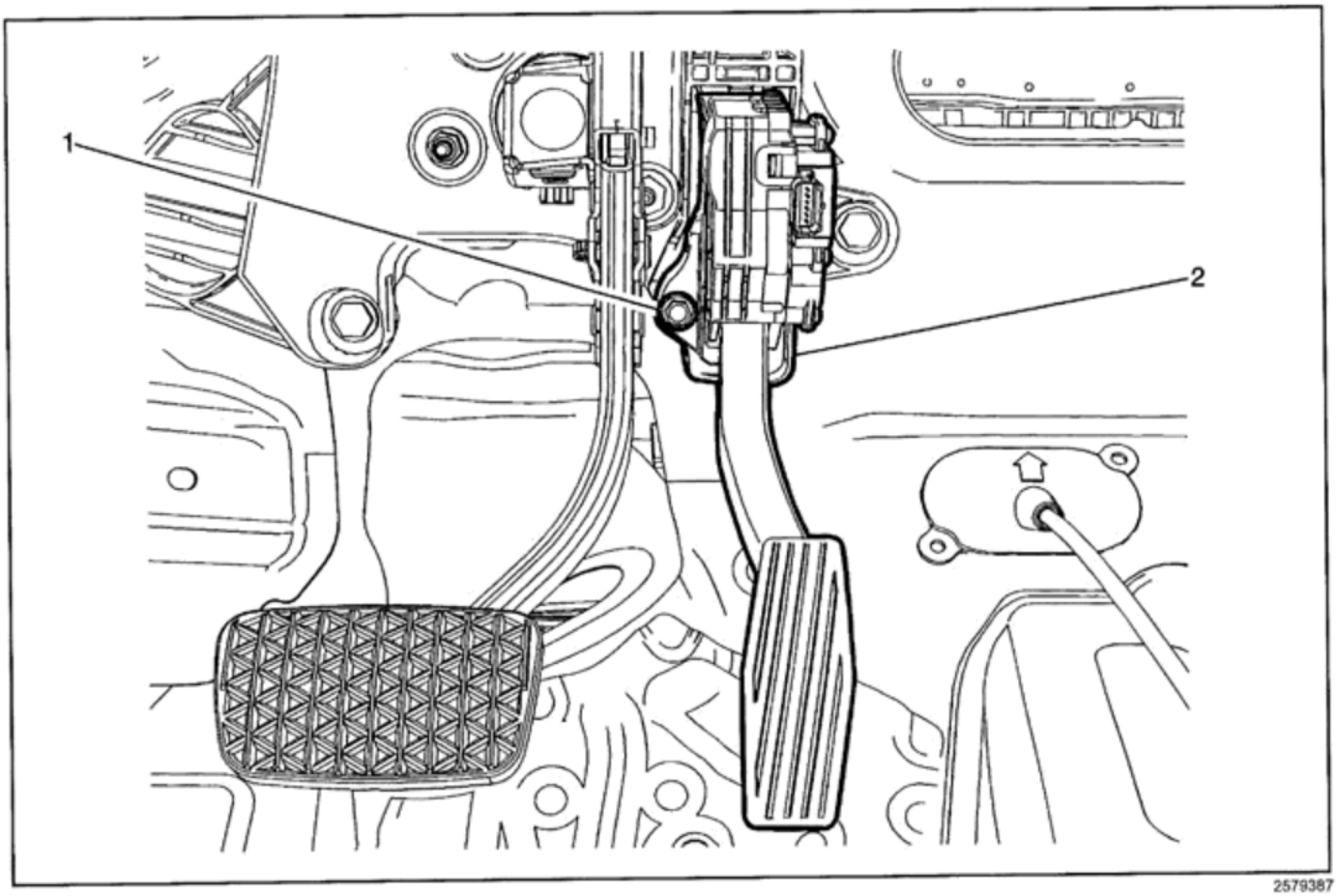


2373053

Engine Oil Pressure Indicator Switch Replacement

Callout	Component Name
1	Engine Oil Pressure Indicator Switch **Caution:** Refer to *Fastener Caution on page 0-8.* **Procedure** 1. Place collecting basin underneath. 2. Disconnect the electrical connector. 3. Check engine oil level after replacement. **Tighten** 20 N•m (15 lb ft)
2	Engine Oil Pressure Indicator Switch Seal Ring

Accelerator Pedal Position Sensor Replacement



2579387

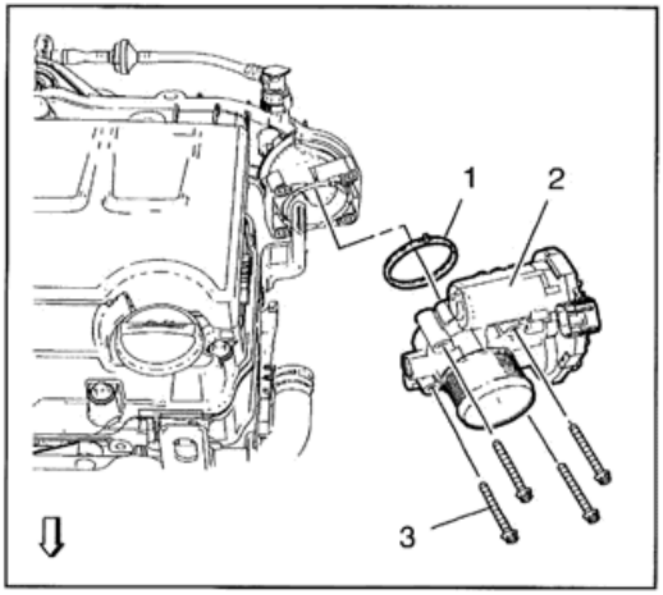
Accelerator Pedal Position Sensor Replacement

Callout	Component Name
Preliminary Procedure Disconnect the battery negative cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713.*	
1	Accelerator Pedal Position Sensor Fastener **Caution:** Refer to *Fastener Caution on page 0-8.* **Tighten** 10 N•m (89 lb in)
2	Accelerator Pedal Position Sensor **Procedure** 1. Disconnect the electrical wiring harness connector from accelerator pedal position Sensor. 2. After replacement of the accelerator pedal position sensor, use a scan tool to speed up the learn process. Refer to *Engine Control Module Programming and Setup on page 6-7.*

Throttle Body Assembly Replacement

Removal Procedure

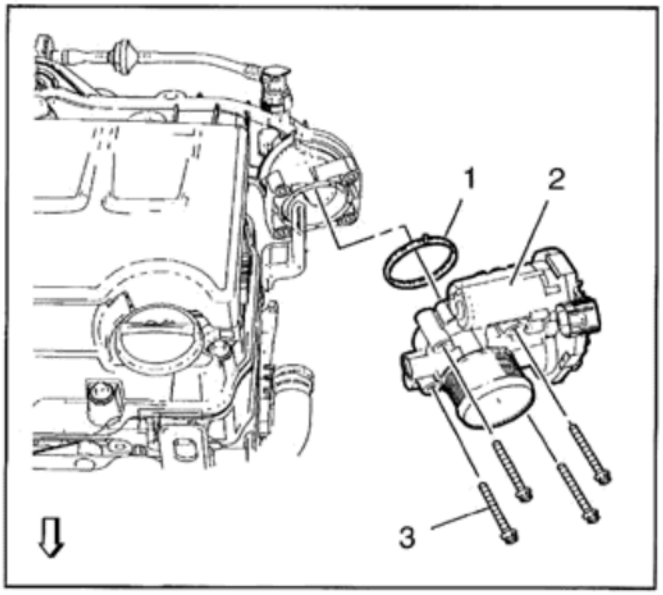
1. Disconnect the throttle body wiring harness connector.
2. Remove the charge air cooler outlet air hose from the throttle body. Refer to *Charge Air Cooler Outlet Air Hose Replacement on page 9-293*.



2191968

3. Remove the 4 throttle body fasteners (3).
4. Remove the throttle body (2) along with the throttle body seal ring (1).

Installation Procedure



2191968

1. Install the throttle fasteners (2) along with a NEW throttle body seal ring (1).

Caution: Refer to *Fastener Caution on page 0-8*.

2. Install the 4 throttle body fastener (3) and tighten to **8 N•m (71 lb in)**.
3. Install the charge air cooler outlet air hose to the throttle body. Refer to *Charge Air Cooler Outlet Air Hose Replacement on page 9-293*.
4. Connect the throttle body wiring harness connector.

Throttle Body Inspection and Cleaning

Note: Over extended time and mileage, deposits may accumulate on the back of the throttle valve plate. The source of the deposit is exhaust gas. Typically these deposits pose no problem. Occasionally the deposit may accumulate to a point where perceived pedal effort or throttle valve movement is effected. This procedure should not be performed on vehicles with mileage under 80,450 km (50,000 mi).

1. Remove the air cleaner outlet duct. Refer to *Air Cleaner Outlet Duct Replacement on page 9-288*.

Warning: Turn OFF the ignition before inserting fingers into the throttle bore. Unexpected movement of the throttle blade could cause personal injury.

Caution: Do not insert any tools into the throttle body bore in order to avoid damage to the throttle valve plate.

2. Inspect the throttle body bore and the throttle valve plate for deposits. You will need to open the throttle valve in order to inspect all surfaces.

Caution: Do not use any solvent that contains Methyl Ethyl Ketone (MEK). This solvent may damage fuel system components.

3. Clean the throttle body bore and the throttle valve plate using a clean shop towel with an appropriate cleaner.
4. Install the air cleaner outlet duct. Refer to *Air Cleaner Outlet Duct Replacement on page 9-288*.
5. Perform the Throttle/Idle Learn procedure. Refer to *Throttle/Idle Learn on page 9-278*.

Fuel Pressure Relief

Special Tools

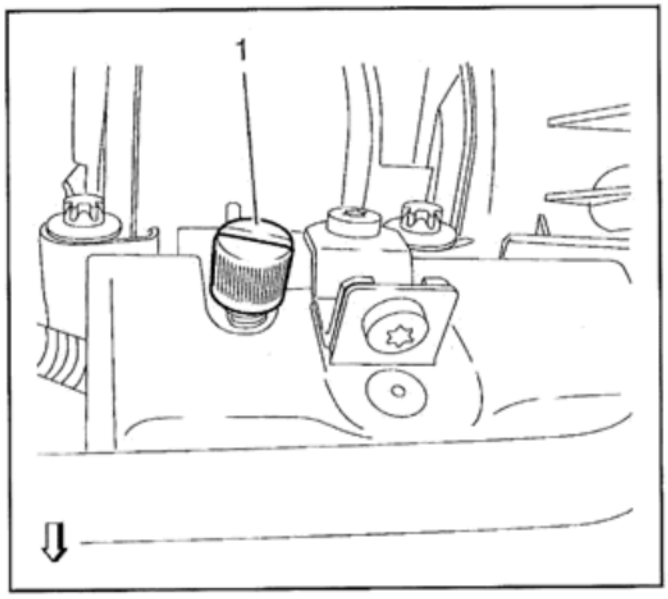
EN-34730-91 Pressure Tester

For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308*.

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.

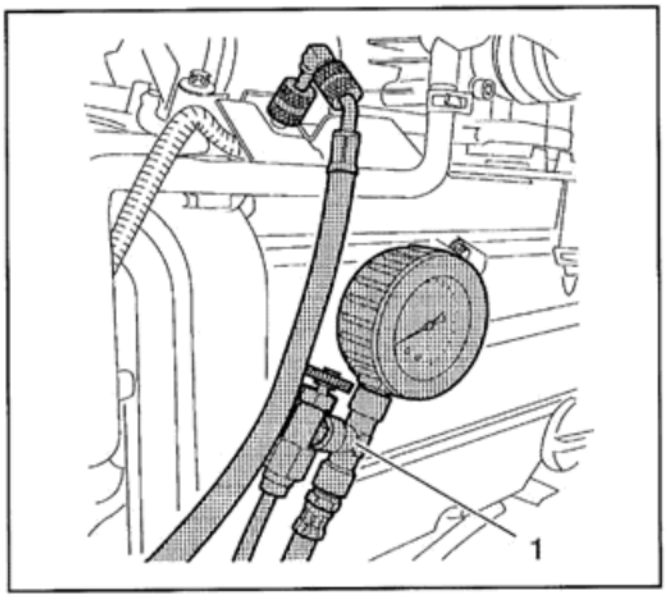
Warning: Relieve the fuel system pressure before servicing fuel system components in order to reduce the risk of fire and personal injury.

After relieving the system pressure, a small amount of fuel may be released when servicing the fuel lines or connections. In order to reduce the chance of personal injury, cover the regulator and the fuel line fittings with a shop towel before disconnecting. This will catch any fuel that may leak out. Place the towel in an approved container when the disconnection is complete.



2191389

1. Remove the fuel injector rail cap (1).



2191388

2. Relieve the fuel pressure. Use *EN-34730-91* pressure tester (1).

Fuel Tank Draining

Warning: Refer to Gasoline/Gasoline Vapors Warning on page 0-5.

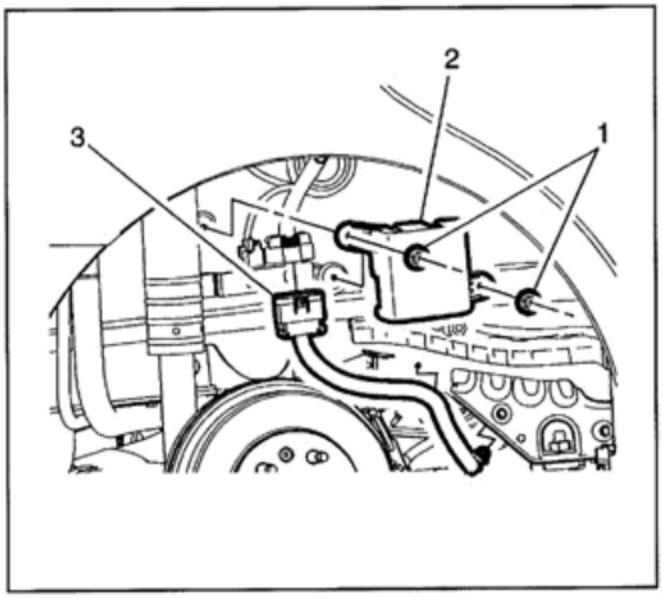
Note: The fuel tank must be drained with a suitable, commercially-available fuel removal unit and suction hose - follow safety regulations and national legislation. The fuel tank is fitted with a refill limit float valve. This is located on the filler neck in the fuel tank. To prevent damaging the refill limit float valve, a suitable suction hose must be used. In the presence of fuel vapors or escaping fuel - observe safety regulations and national legislation. Store drained fuel in a suitable, sealable container.

1. Disconnect the negative battery cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.
2. Remove the fuel tank filler cap.
3. Insert a suitable suction hose into the fuel tank filler pipe.
4. Attach a suitable suction hose to the hose used with the hand or air operated pump devise.
5. Using a hand or air operated pump drain as much fuel from the tank as possible.

Fuel Tank Replacement

Removal Procedure

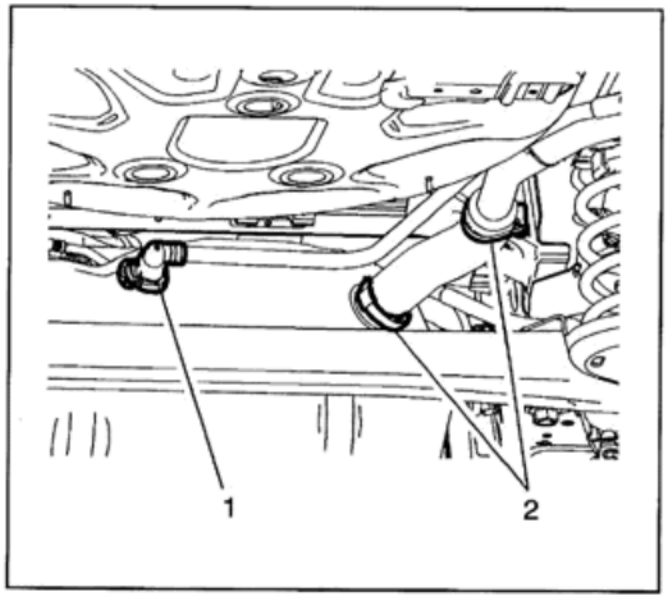
1. Disconnect the battery negative cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.
2. Relieve the fuel pressure. Refer to *Fuel Pressure Relief on page 9-547*.
3. Drain the fuel Tank. Refer to *Fuel Tank Draining on page 9-551*.
4. Lift and support the vehicle. Refer to *Lifting and Jacking the Vehicle on page 1-31*.



2495376

5. Remove the harness cover fastener (1) and harness cover (2).

6. Disconnect the fuel pump harness electrical connector (3).



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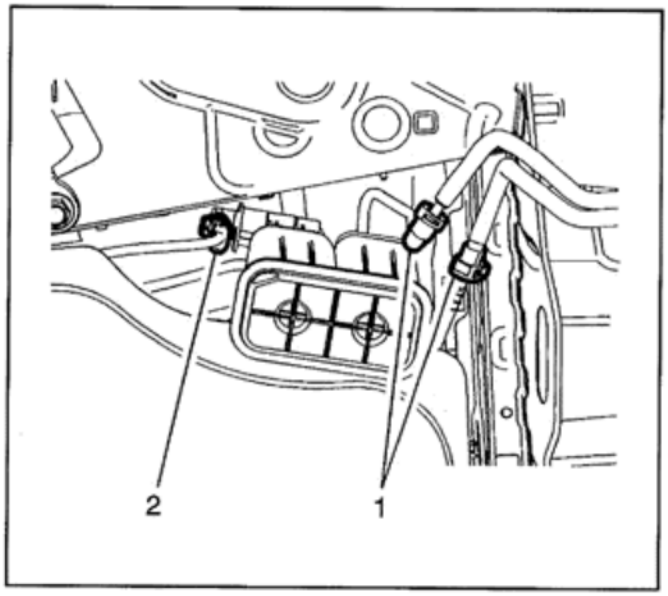
7. Disconnect the vent hose (1)
8. Loosen the hose clamps (2) and slide the filler hose off the fuel tank.



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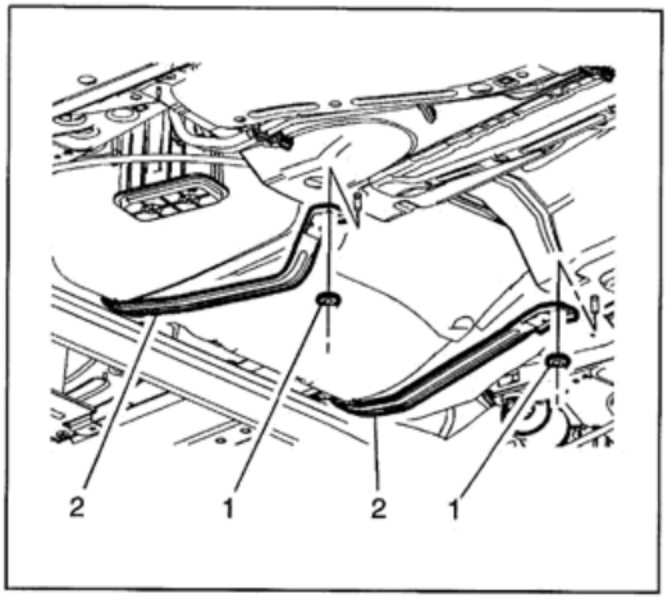
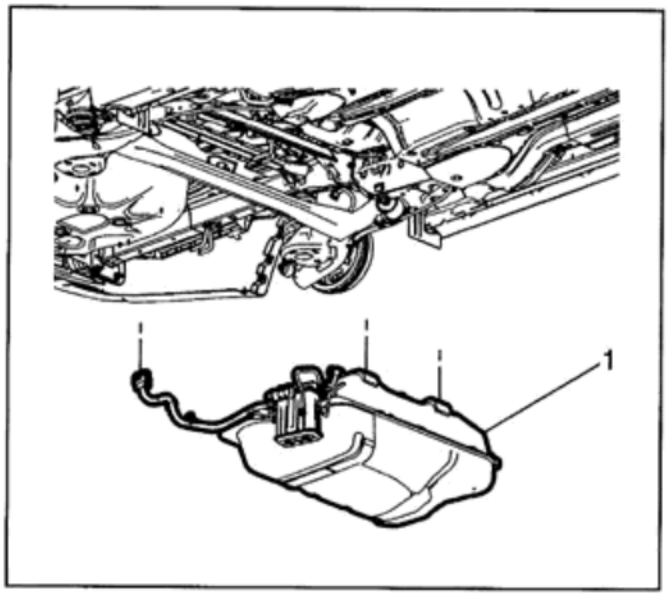
9. Disconnect the fuel and evaporative emission connectors (1). Refer to *Plastic Collar Quick Connect Fitting Service on page 9-547*.



2495382

10. Support the fuel tank with a suitable stand.
11. Remove the fuel tank strap fasteners (1).
12. Reposition the fuel tank straps (2) toward the back of the vehicle.



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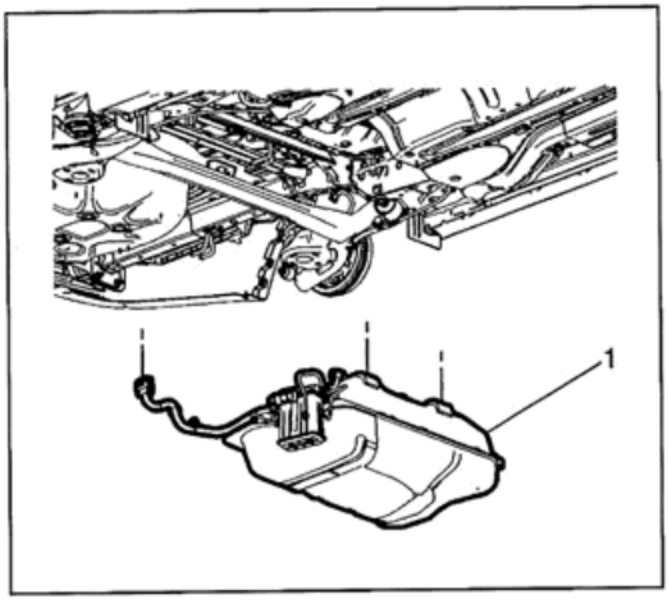
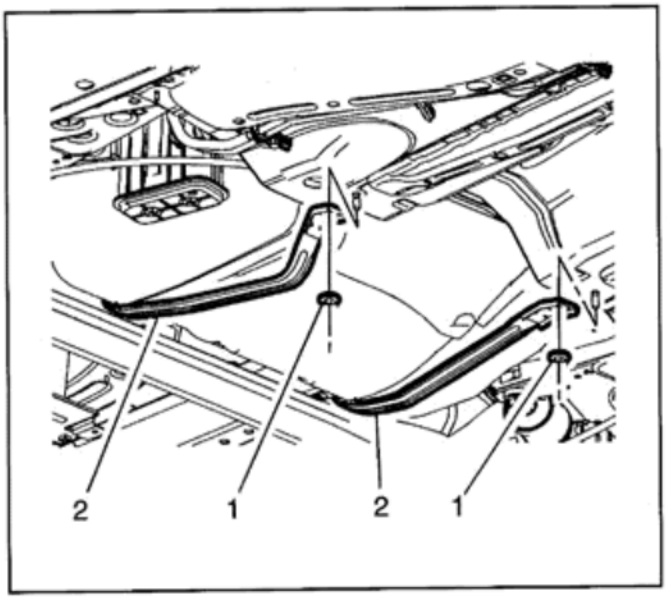
13. Lower the fuel tank (1).

Installation Procedure



2495385

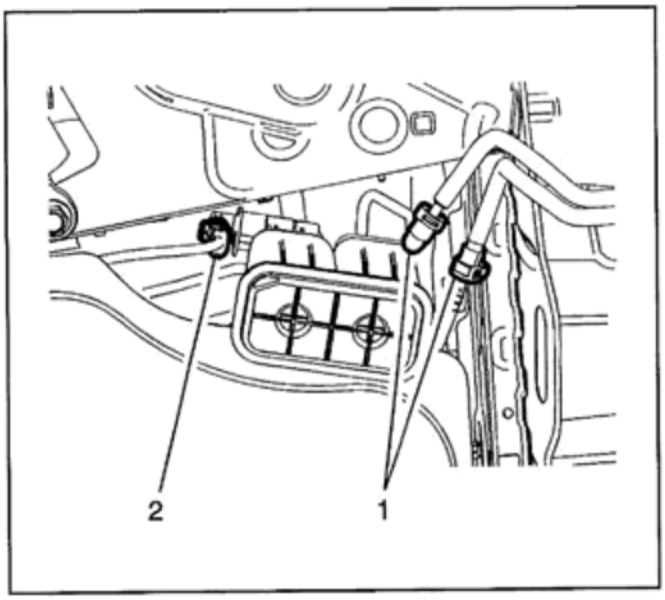
1. If replacing the tank, remove the fuel pump module and the evaporative emission canister. Refer to *Fuel Tank Fuel Pump Module Replacement (Steel Tank) on page 9-559* and *Evaporative Emission Canister Replacement (Steel Tank) on page 9-567*.
2. Transfer parts as necessary.
3. Raise the fuel tank (1).



2495382

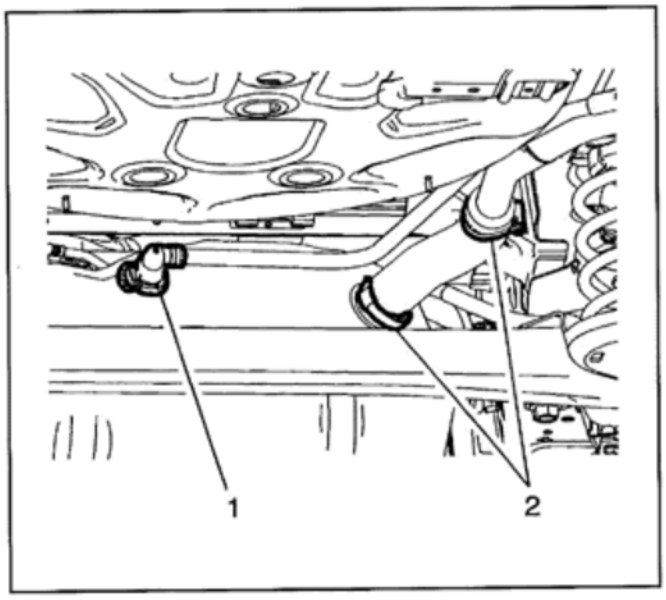
Caution: Refer to *Fastener Caution on page 0-8*.

4. Support the fuel tank with a suitable stand.
5. Position the fuel tank straps (2) onto the fuel tank.
6. Install the fuel tank strap fasteners (1) and tighten to **22 N•m (16 lb ft)**.



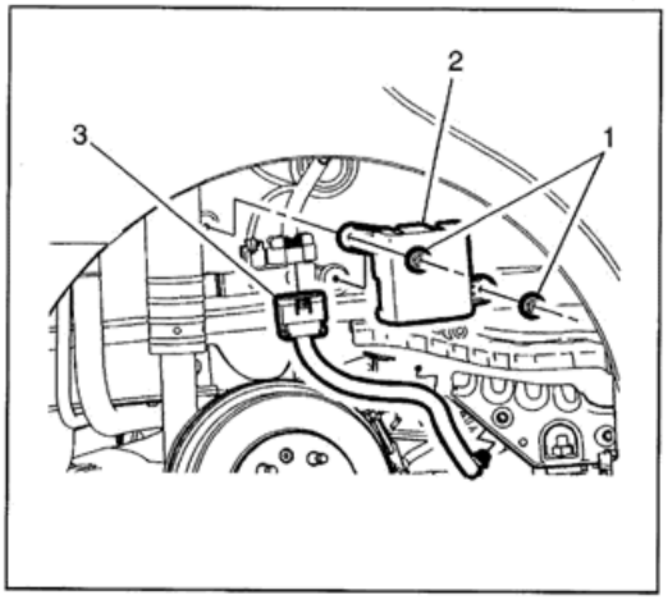
2495381

7. Connect the fuel and evaporative emission connectors (1). Refer to *Plastic Collar Quick Connect Fitting Service on page 9-547*.



2495378

8. Connect the vent hose (1) .
9. Tighten the hose clamps (2) to **4.5 N•m (40 lb in).** and slide the filler hose off the fuel tank.

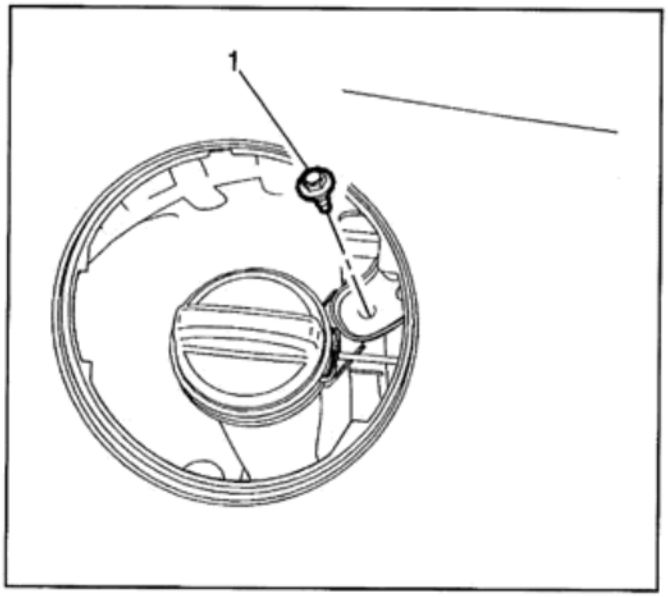


2495376

10. Connect the fuel pump harness electrical connector (3).
11. Install the harness cover (2) and tighten the cover fasteners (1).
12. Connect the battery negative cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.

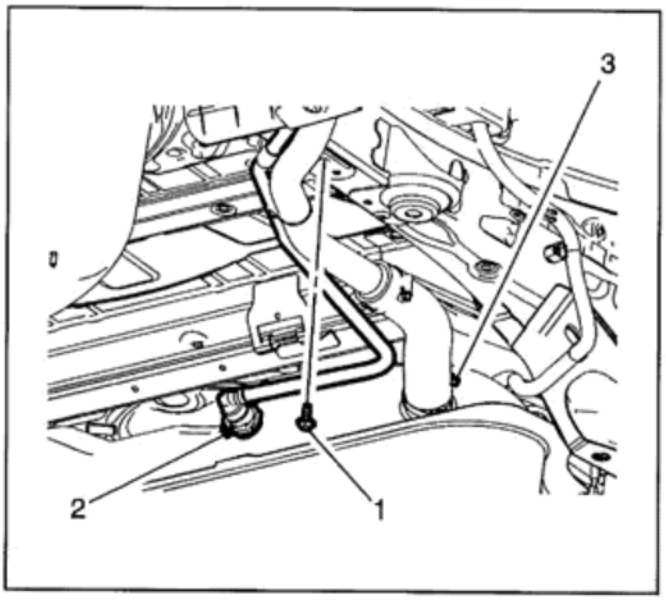
Fuel Tank Filler Pipe Replacement

Removal Procedure



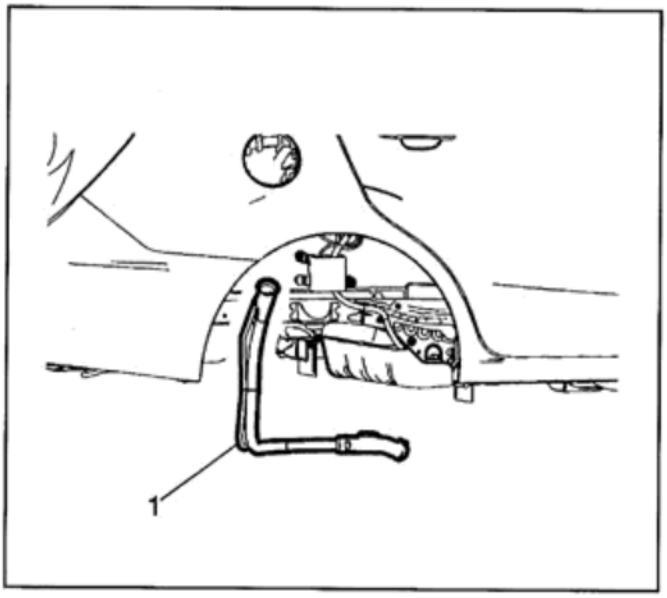
2498413

1. Remove the bracket fastener (1).



2498415

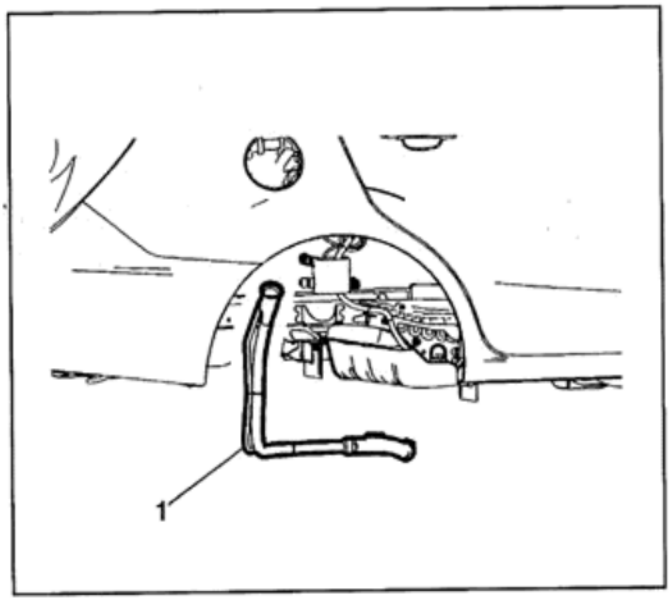
2. Lift and support the vehicle. Refer to *Lifting and Jacking the Vehicle on page 1-31*.
3. Remove the fuel tank filler pipe bracket fastener (1).
4. Disconnect the vent hose (2). Refer to *Plastic Collar Quick Connect Fitting Service on page 9-264*.
5. Loosen the filler pipe hose clamp (3).



2498418

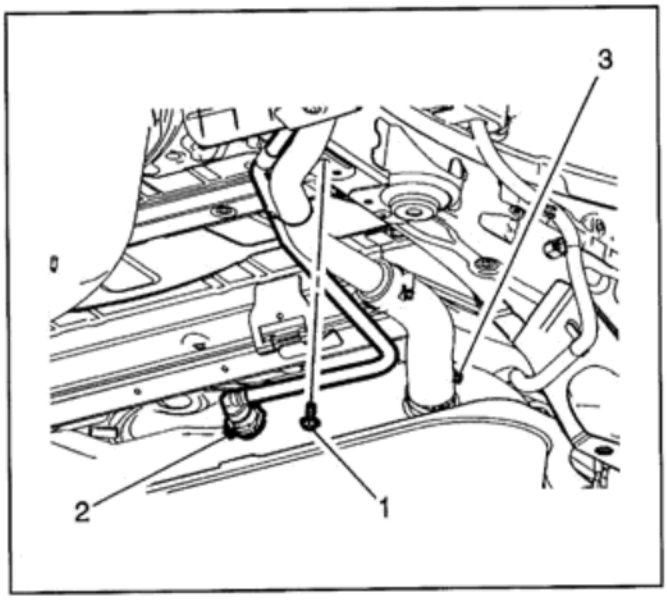
6. Remove the fuel tank filler pipe (1).

Installation Procedure



2498418

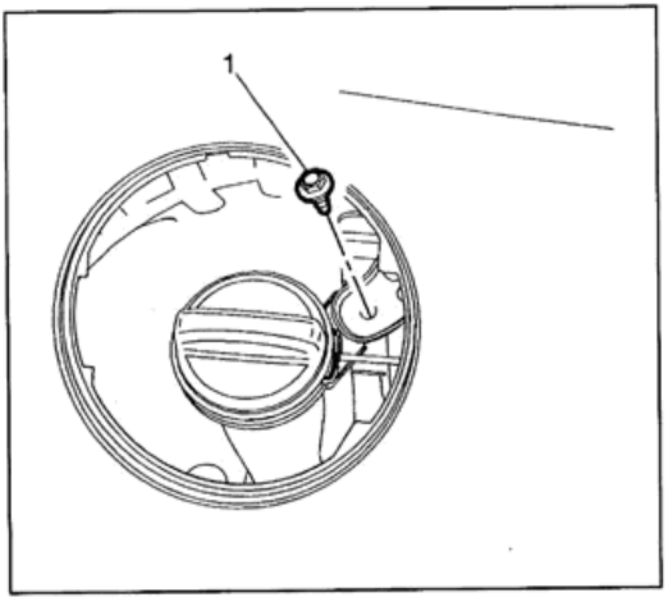
1. Install the fuel tank filler pipe (1).



2498415

Caution: Refer to *Fastener Caution on page 0-8*.

2. Tighten hose clamp (3) to **4 N•m(35 lb in)**.
3. Connect the vent hose (2). Refer to *Plastic Collar Quick Connect Fitting Service on page 9-264*.
4. Tighten the filler pipe bracket fastener (1) to **9 N•m(89 lb in)**.



2498413

5. Install the bracket fastener (1) and tighten to **9 N•m(89 lb in)**.

Fuel Feed Pipe Replacement

Special Tools

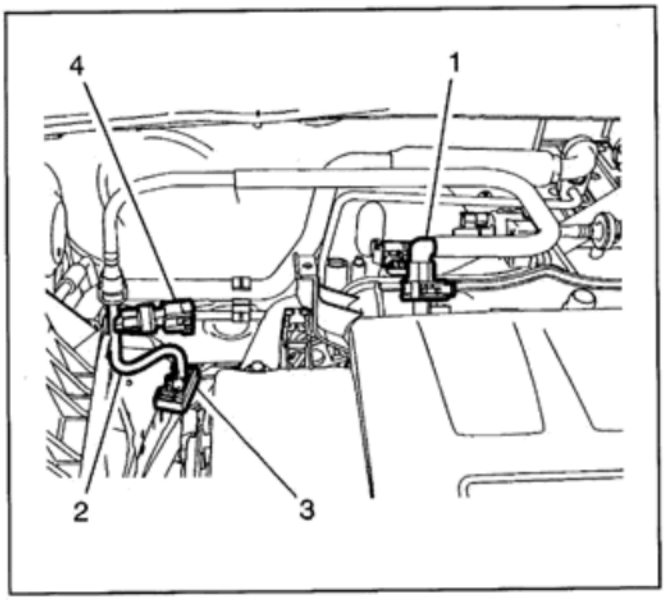
- *CH-807* Closure Plugs
- *CH-6015* Closure Plugs

For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308*.

Removal Procedure

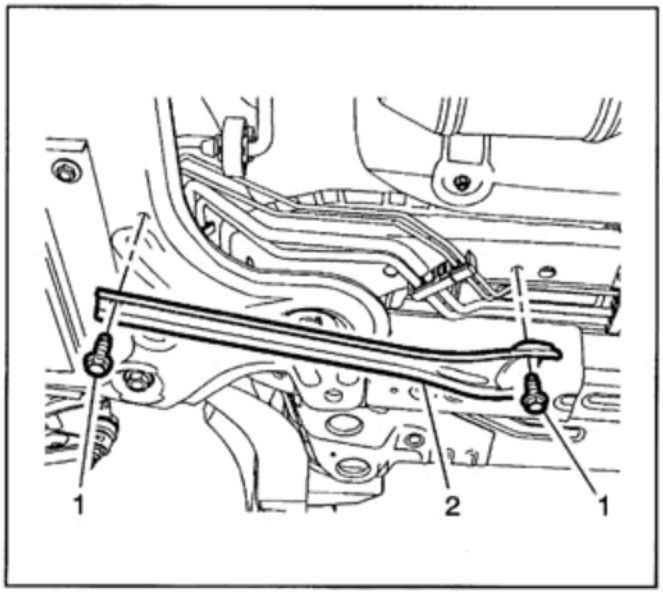
Warning: Refer to Gasoline/Gasoline Vapors Warning on page 0-5.

1. Disconnect the battery negative cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.
2. Relief the fuel pressure. Refer to *Fuel Pressure Relief on page 9-253*.



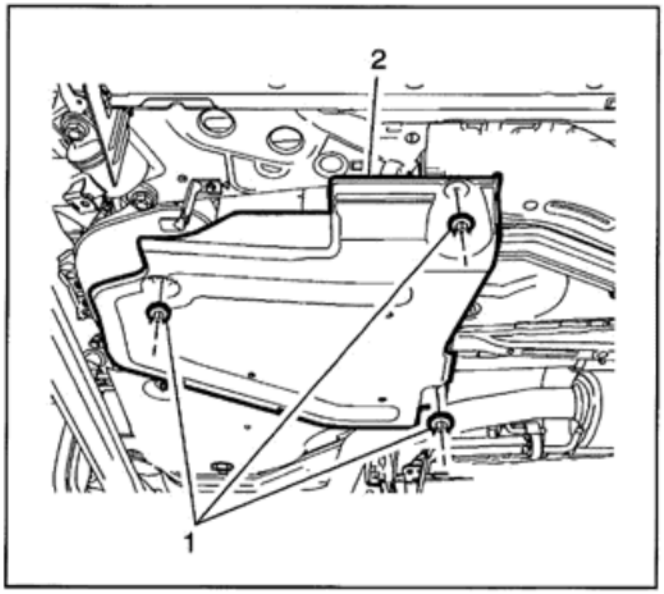
2672203

3. Disconnect the front fuel feed pipe connector (1) from the fuel injector rail and the fuel feed pipe(2) and remove the front fuel feed pipe. Refer to *Plastic Collar Quick Connect Fitting Service on page 9-264*.
4. Close the fuel feed pipe connectors with *CH-807* plugs.
5. Unclip the fuel feed pipe (2) from the retainer clip (3).
6. Disconnect the electrical wiring harness connector from the fuel pressure sensor (4).
7. Raise and support the vehicle. Refer to *Lifting and Jacking the Vehicle on page 1-31*.



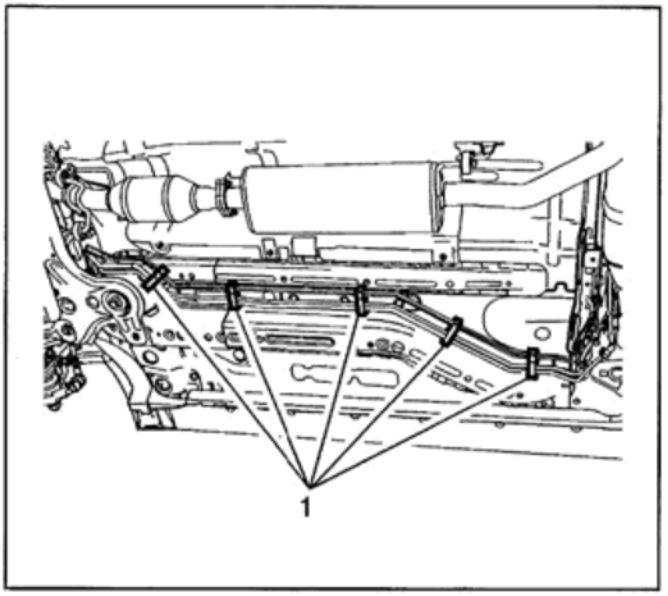
2672339

8. Remove the frame reinforcement fasteners (1) and remove the frame reinforcement(2).



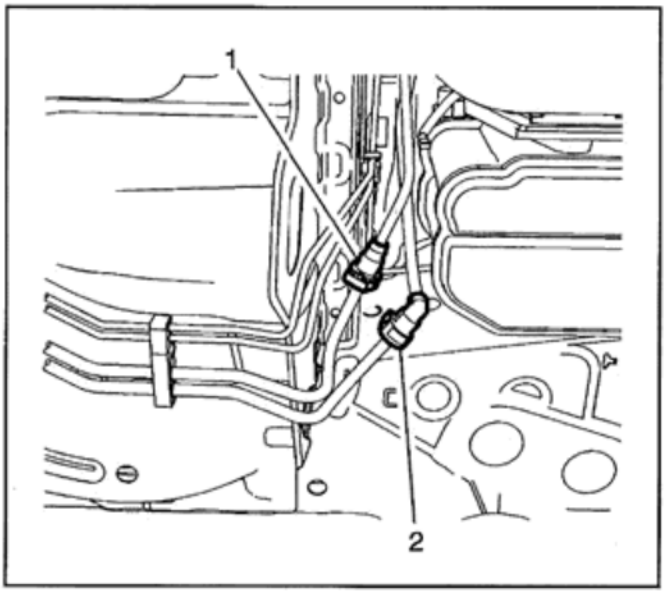
2672350

9. Remove the EVAP canister cover fasteners (1) and cover (2).



2672361

10. Open the 5 fuel pipe clips (1).

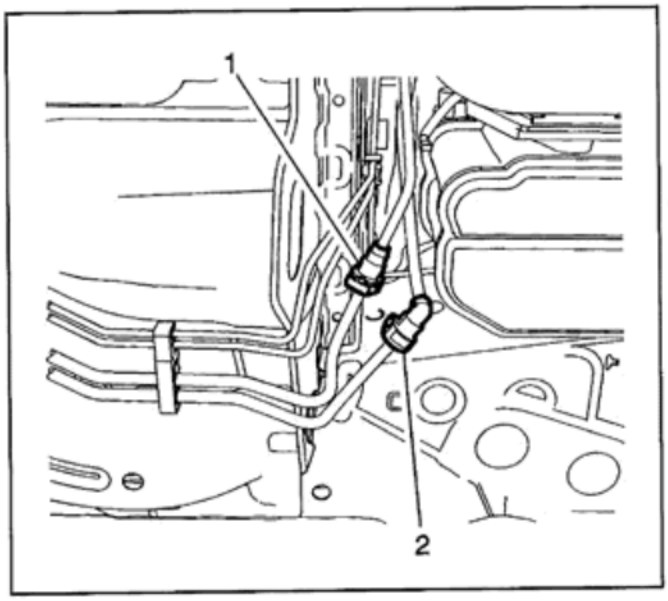


2672365

11. Disconnect the fuel tank feed pipe connector (1) from fuel feed pipe. Refer to *Plastic Collar Quick Connect Fitting Service on page 9-264*.
12. Close the fuel feed pipe and fuel tank feed pipe with *CH-6015* plugs.
13. Remove the fuel feed pipe.

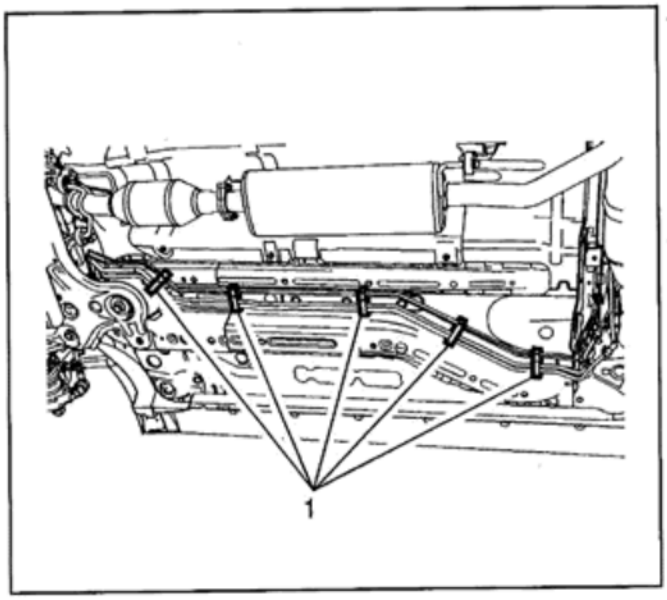
Installation Procedure

1. Remove the *CH-6015* plugs from fuel feed tank pipe and fuel feed pipe.



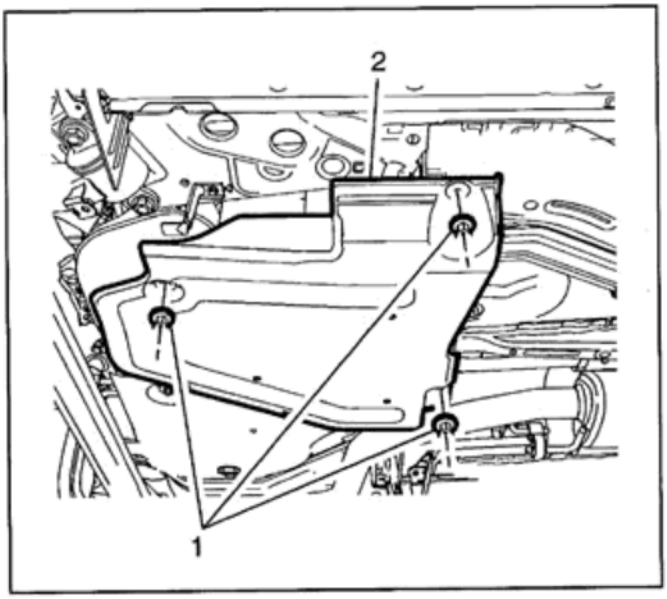
2672365

2. Install the fuel feed pipe and secure with the rear fuel pipe clip.
3. Connect the fuel tank feed pipe connector (1) to the fuel feed pipe. Refer to *Plastic Collar Quick Connect Fitting Service on page 9-264*.



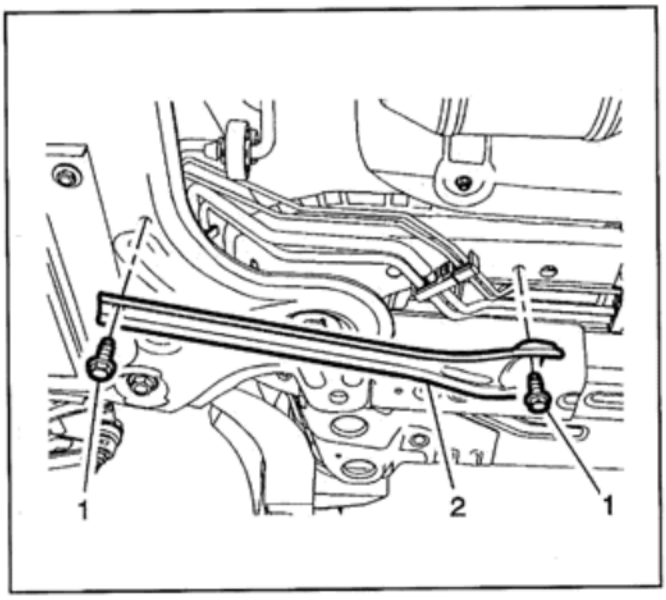
2672361

4. Close the 5 fuel pipe clips (1).



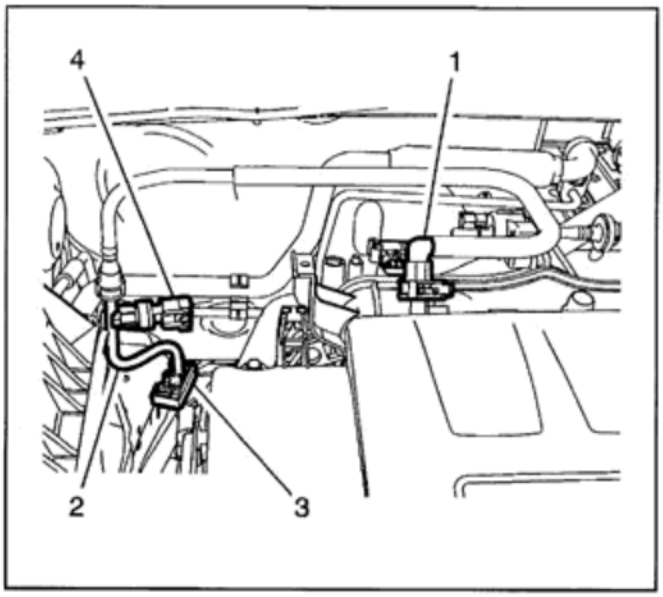
2672350

5. Install the EVAP canister cover (2) and tighten the EVAP canister cover fasteners (1) to **9 N•m (71 lb in)**.



2672339

6. Install the frame reinforcement (2) and tighten the frame reinforcement fasteners (1) to **60 N•m (44 lb ft)**.
7. Lower the vehicle.



2672203

8. Connect the electrical wiring harness connector to the fuel pressure sensor (4).
9. Clip the fuel feed pipe (2) into the retainer clip (3).
10. Remove the *CH-807* plugs from the fuel feed pipe connectors.
11. Connect the front fuel feed pipe connector (1) to the fuel injector rail and the fuel feed pipe(2). Refer to *Plastic Collar Quick Connect Fitting Service on page 9-264*.
12. Connect the battery negative cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.

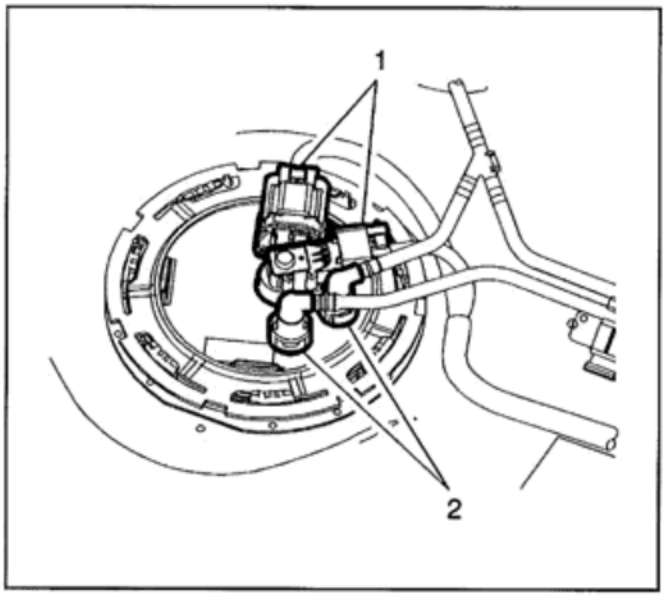
Fuel Tank Fuel Pump Module Replacement

Special Tools

CH 45722 Fuel Sender Lock Ring Wrench

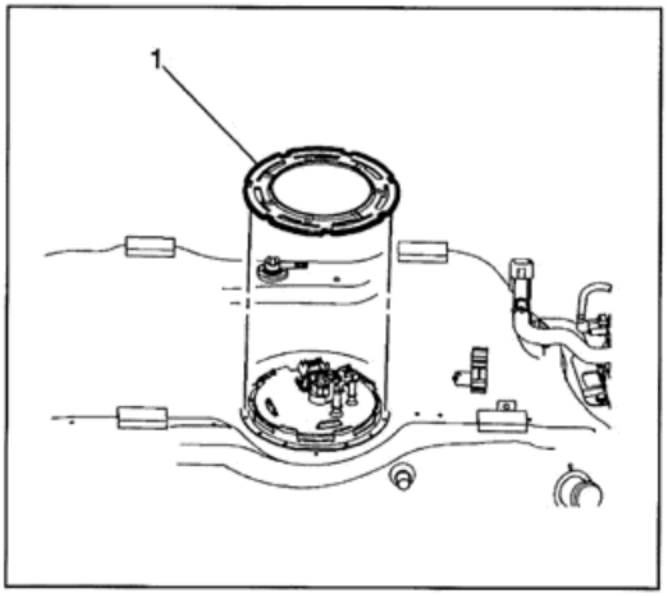
For equivalent regional tools, refer *Special Tools (Diagnostic Tools) on page 9-308*.

Removal Procedure



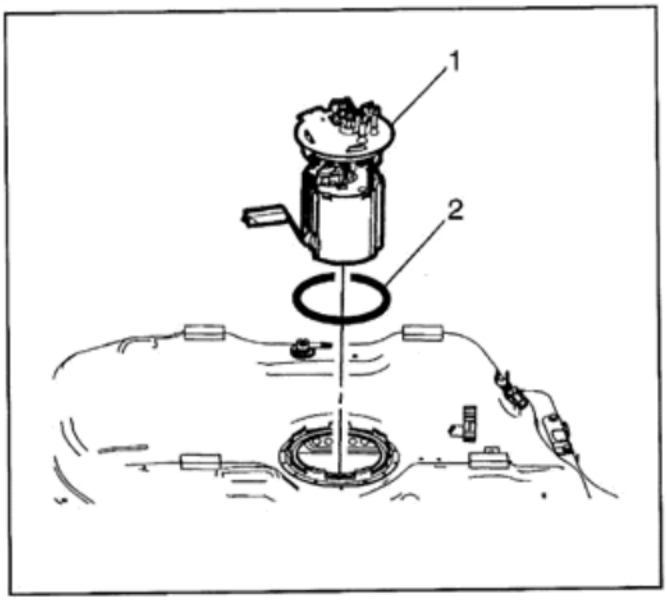
2495427

1. Relieve the fuel system pressure. Refer to *Fuel Pressure Relief on page 9-253*
2. Remove the fuel tank. Refer to *Fuel Tank Replacement on page 9-254*.
3. Disconnect the electrical connectors (1).
4. Disconnect the evaporative emission and fuel lines (2). Refer to *Plastic Collar Quick Connect Fitting Service on page 9-264*.



2495431

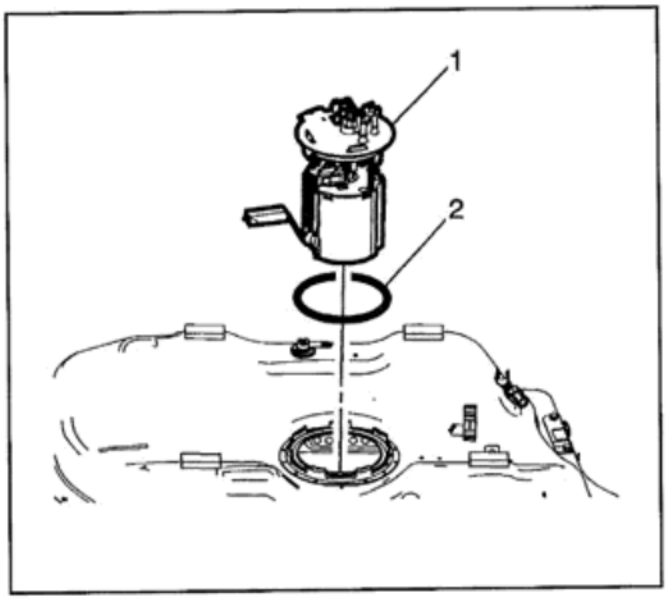
5. Using the *CH 45722* wrench, remove the lock ring (1) by turning counter-clockwise.



2495432

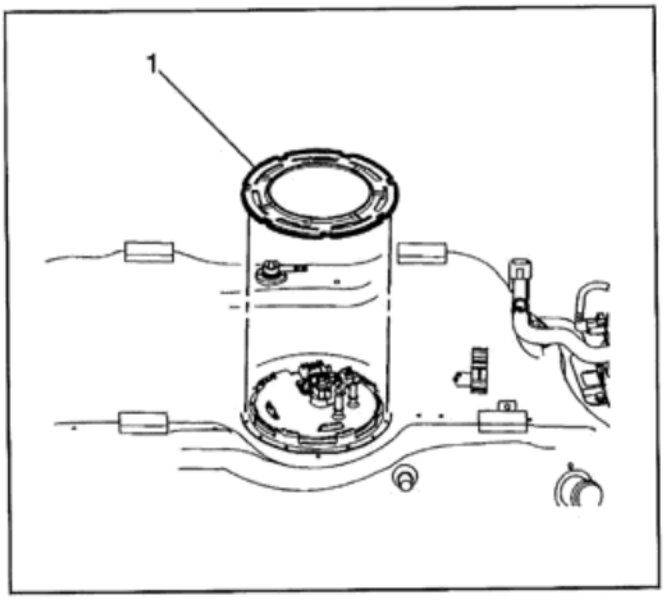
6. Remove the fuel pump module (1) and O-ring (2).

Installation Procedure



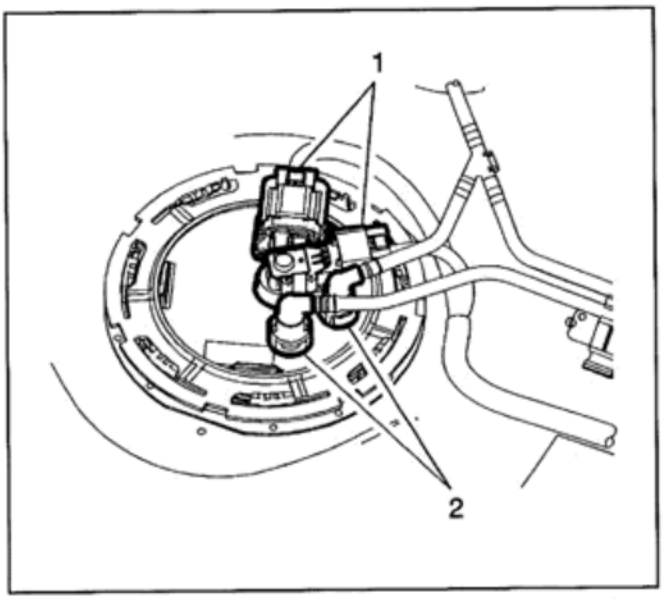
2495432

1. Install a NEW O-ring (2) and the fuel pump module (1).



2495431

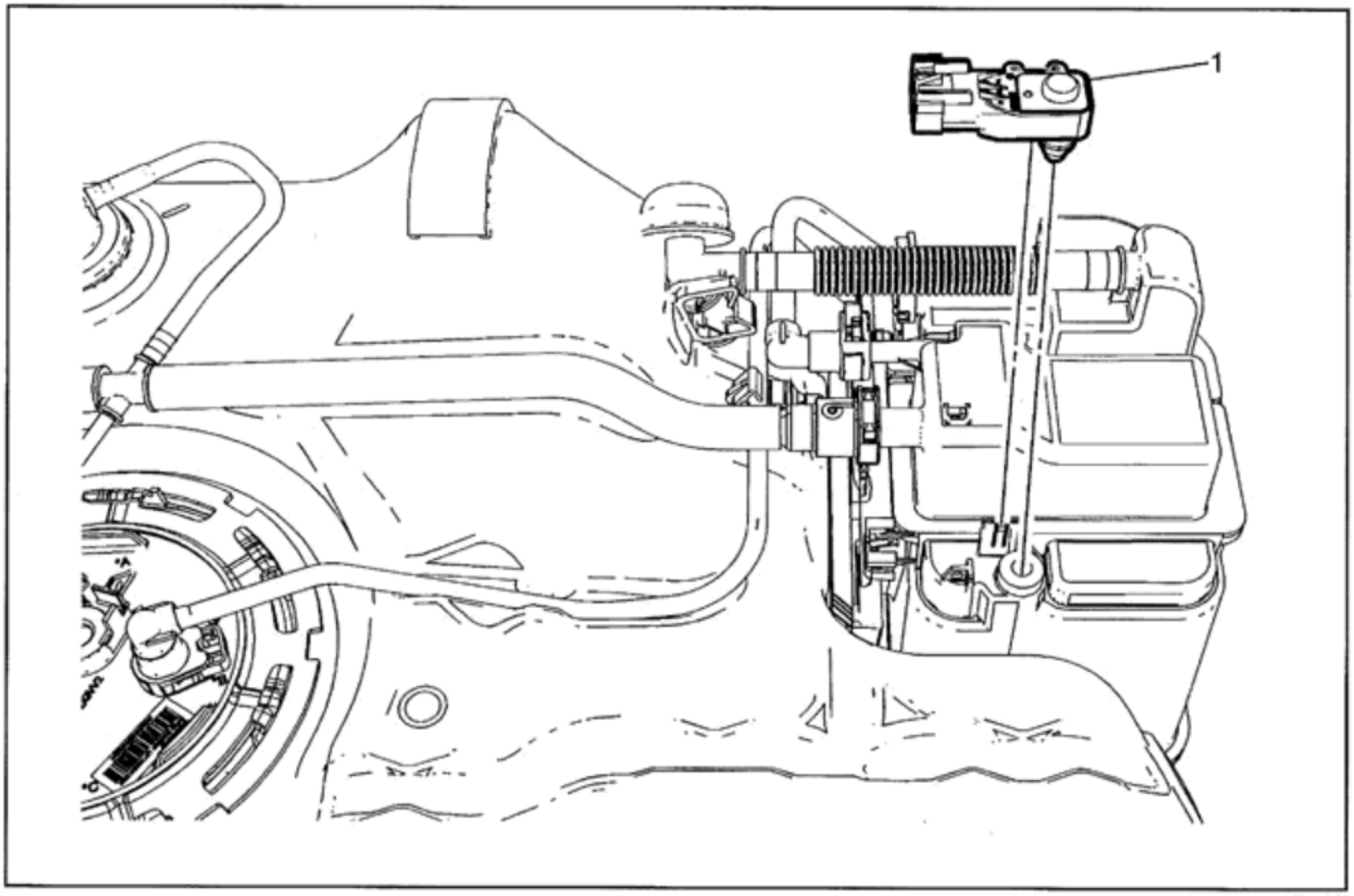
2. Using the *CH 45722* wrench, install the lock ring (1) by turning clockwise.



2495427

3. Connect the electrical connectors (1).
4. Connect the evaporative emission and fuel lines (2). Refer to *Plastic Collar Quick Connect Fitting Service on page 9-264*.
5. Install the fuel tank. Refer to *Fuel Tank Replacement on page 9-254*.

Fuel Tank Pressure Sensor Replacement



2866445

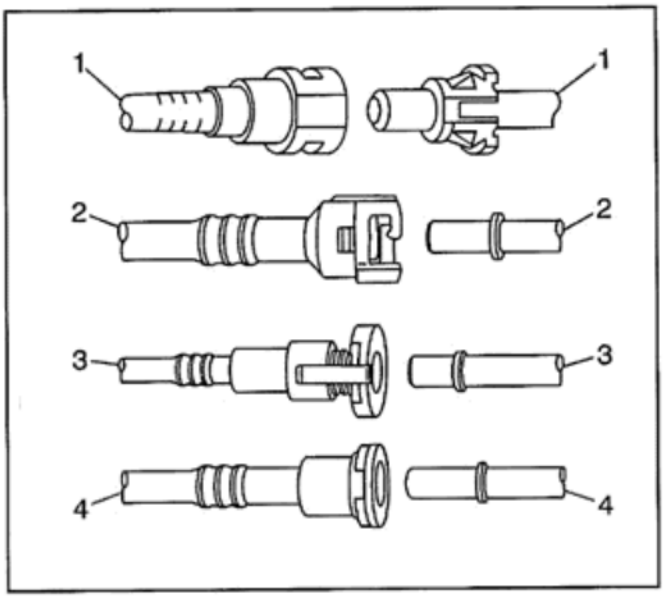
Fuel Tank Pressure Sensor Replacement

Callout	Component Name
Preliminary Procedure Remove the fuel tank. Refer to *Fuel Tank Replacement on page 9-254*.	
1	Fuel Tank Pressure Sensor **Procedure** Disconnect the FTP sensor electrical connector.

Plastic Collar Quick Connect Fitting Service

Removal Procedure

Warning: Refer to Gasoline/Gasoline Vapors Warning on page 0-5.

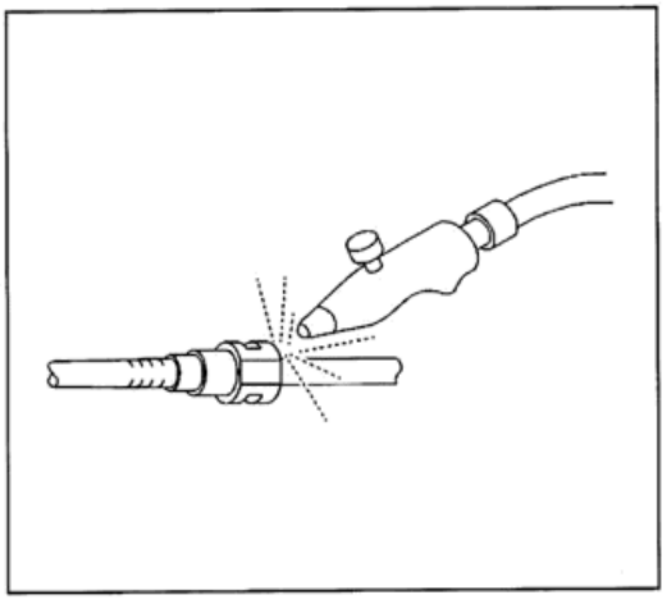


1210508

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)

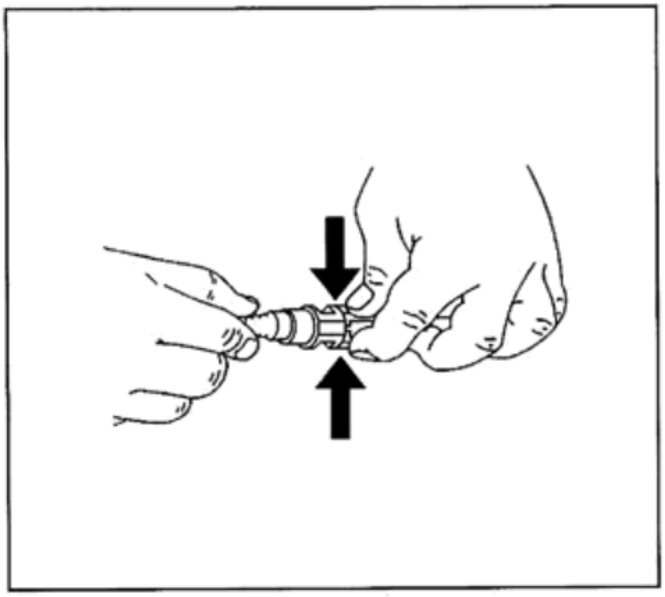
1. Relieve the fuel system pressure. Refer to *Fuel Pressure Relief on page 9-547*.



155410

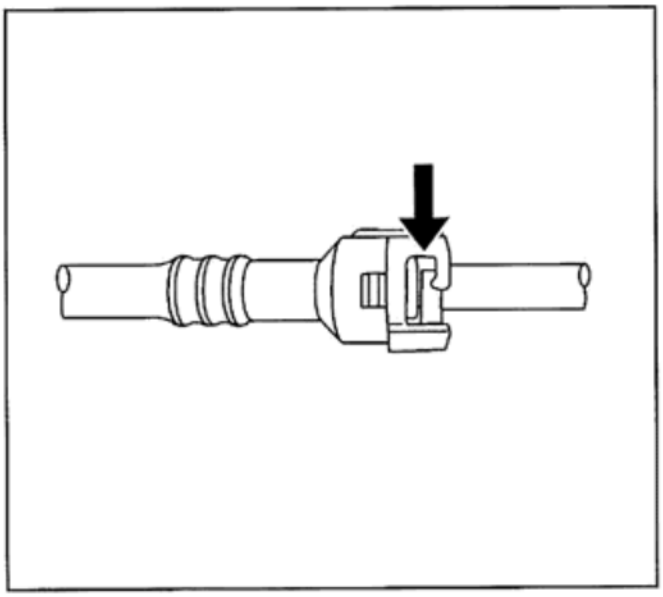
Warning: Refer to Safety Glasses Warning on page 0-5.

2. Using compressed air, blow any dirt out of the quick-connect fitting.



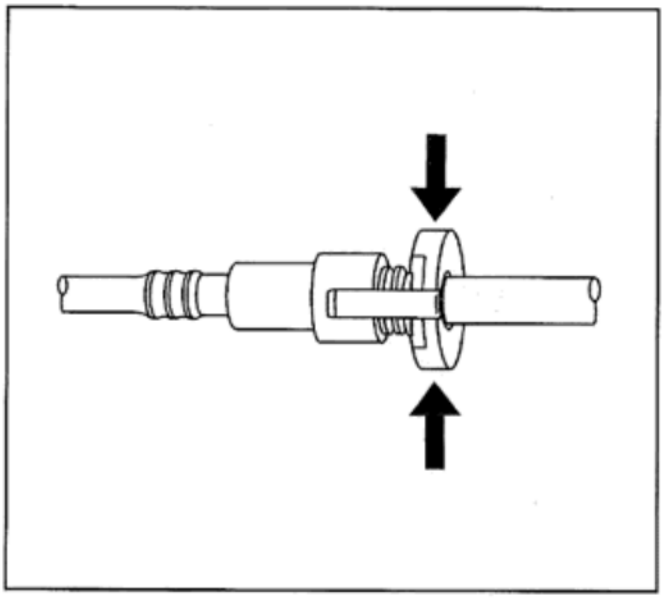
12777

3. This step applies to Bartholomew style connectors ONLY. Squeeze the plastic quick connect fitting release tabs.



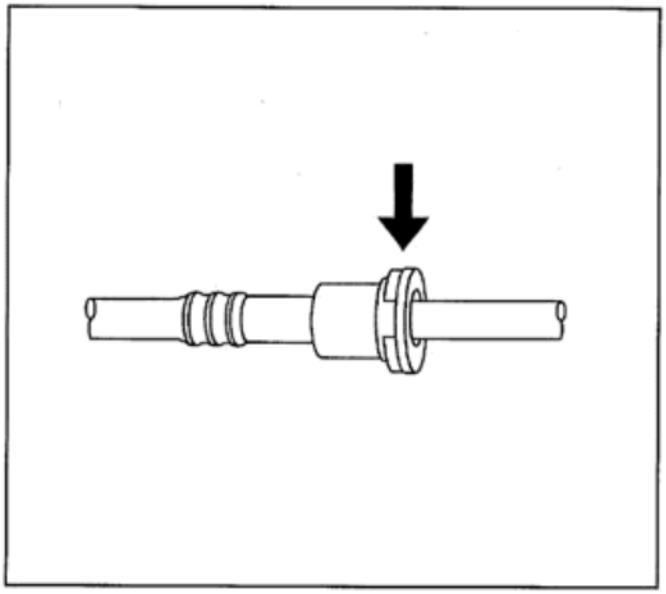
1205667

4. This step applies to Q Release style connectors ONLY. Release the fitting by pushing the tab toward the other side of the slot in the fitting.



1205675

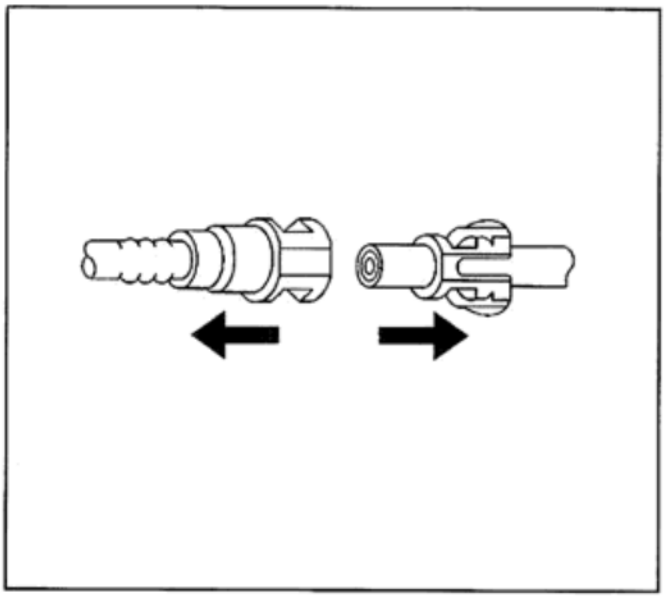
5. This step applies to Squeeze to Release style connectors ONLY. Squeeze where indicated by arrows on both sides of the plastic ring surrounding the quick connect fitting.



1205683

Warning: Refer to Relieving Fuel Pressure Warning on page 0-5.

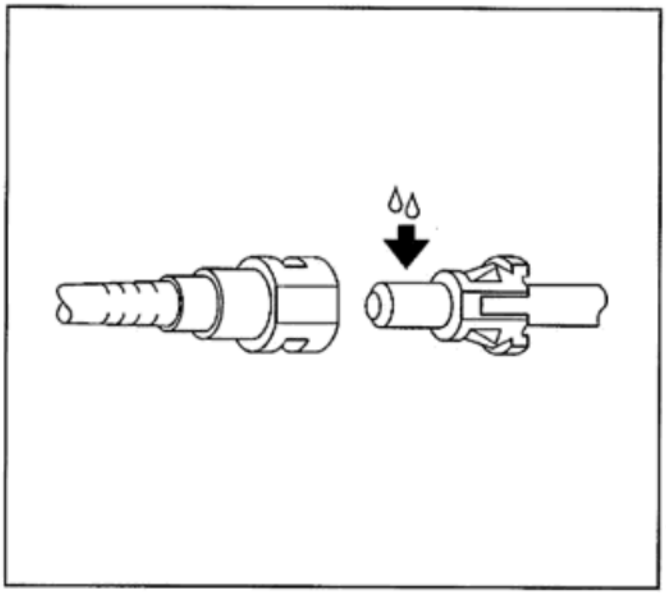
6. This step applies to Sliding Retainer style connectors ONLY. Release the fitting by pressing on one side of the release tab causing it to push in slightly. If the tab doesn't move try pressing the tab in from the opposite side. The tab will only move in one direction.



12778

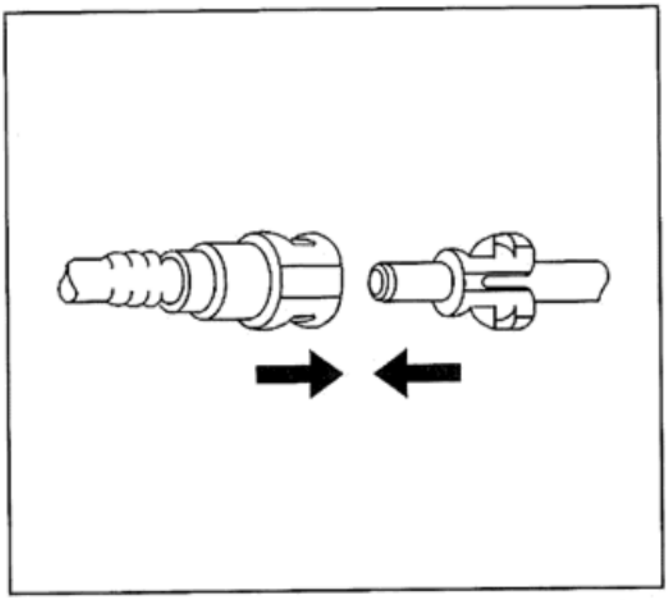
7. Pull the connection apart.

Installation Procedure



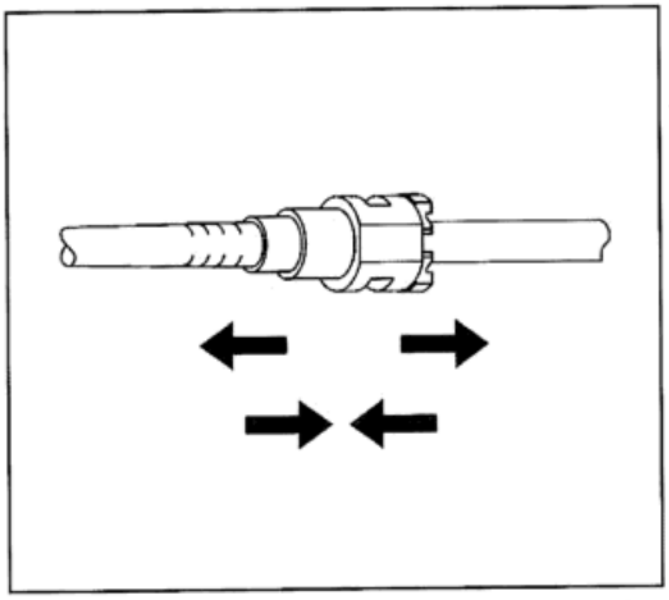
155425

1. Apply a few drops of clean engine oil to the male connection end.



21855

2. Push both sides of the quick-connect fitting together in order to cause the retaining feature to snap into place.



155399

3. Once installed, pull on both sides of the quick-connect fitting in order to make sure the connection is secure.

Fuel System Cleaning

Note: If the fuel filter is plugged, the fuel tank should be inspected internally and cleaned if necessary.

1. Drain the fuel tank. Refer to *Fuel Tank Draining on page 9-254*.
2. Remove the fuel pump module assembly. Refer to *Fuel Tank Fuel Pump Module Replacement on page 9-261*.
3. Inspect the fuel pump module strainer. Replace the pump module assembly if the fuel strainer is contaminated.

Note: When flushing the fuel tank, handle the fuel and water mixture as a hazardous material. Handle the fuel and water in accordance with all applicable local, state, and federal laws and regulations.

4. Flush the fuel tank with hot water.
5. Pour the water out of the fuel sender assembly opening in the fuel tank. Rock the fuel tank in order to be sure that the removal of the water from the fuel tank is complete.
6. Allow the tank to dry completely before reassembly.
7. Disconnect the fuel feed pipe at the engine fuel rail. Refer to *Plastic Collar Quick Connect Fitting Service on page 9-264*.

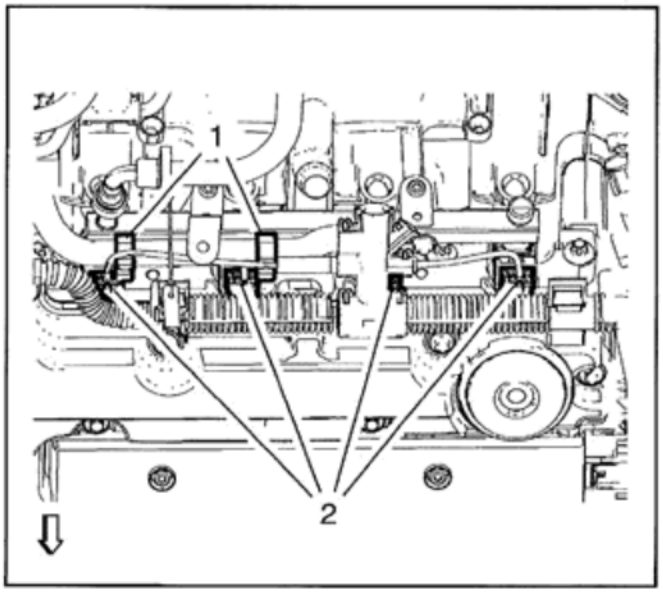
Note: Only use oil-free compressed air to blow out the fuel pipes.

8. Clean the fuel pipes by applying air pressure in the opposite direction of the fuel flow.
9. Connect the fuel feed pipe to the engine fuel rail. Refer to *Plastic Collar Quick Connect Fitting Service on page 9-264*.
10. Install the fuel pump module assembly. Refer to *Fuel Tank Fuel Pump Module Replacement on page 9-261*.

Fuel Injection Fuel Rail Assembly Replacement

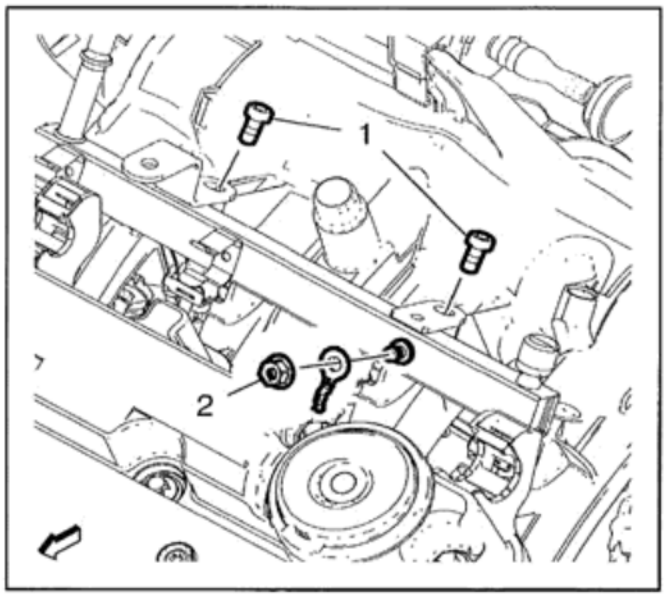
Removal Procedure

1. Disconnect battery negative cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.
2. Remove engine cover. Refer to *Engine Cover Replacement on page 9-790*.
3. Remove the fuel feed pipe from fuel injection fuel rail. Refer to *Fuel Feed Pipe Replacement on page 9-258*.
4. Remove the positive crankcase ventilation pipe from the intake manifold. Refer to *Positive Crankcase Ventilation Pipe Removal on page 9-860*.



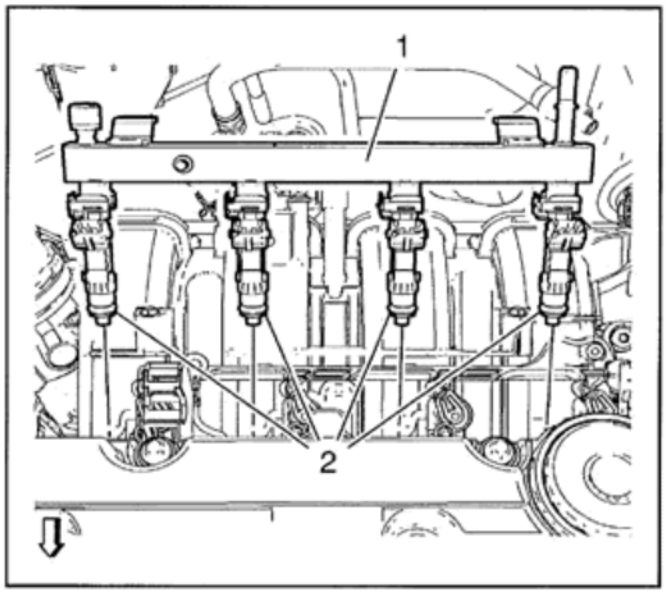
2373064

5. Disconnect the 4 fuel injector wiring harness plugs (2).
6. Unclip the ECM wiring harness from retainer clips (1) and the camshaft cover.



2373065

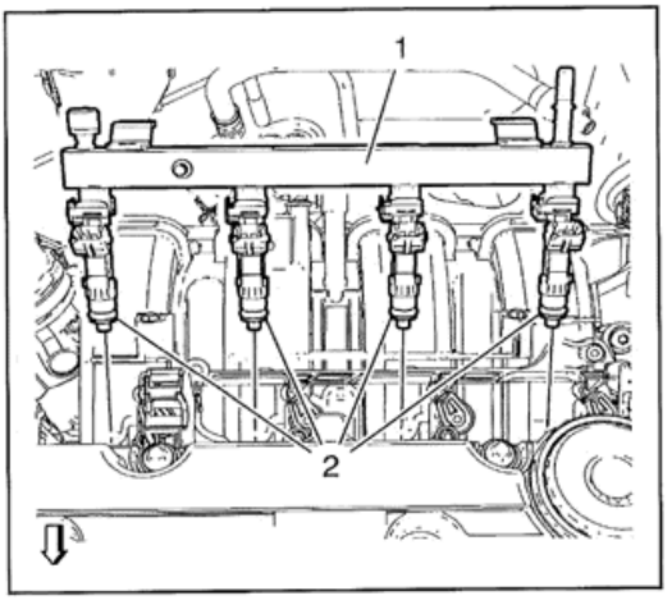
7. Remove the ground cable nut (2) and the ground cable.
8. Remove the 2 fuel injection fuel rail bolts (1).



2191817

9. Remove the fuel injection fuel rail assembly (1) and the 4 fuel injector seal rings (2).

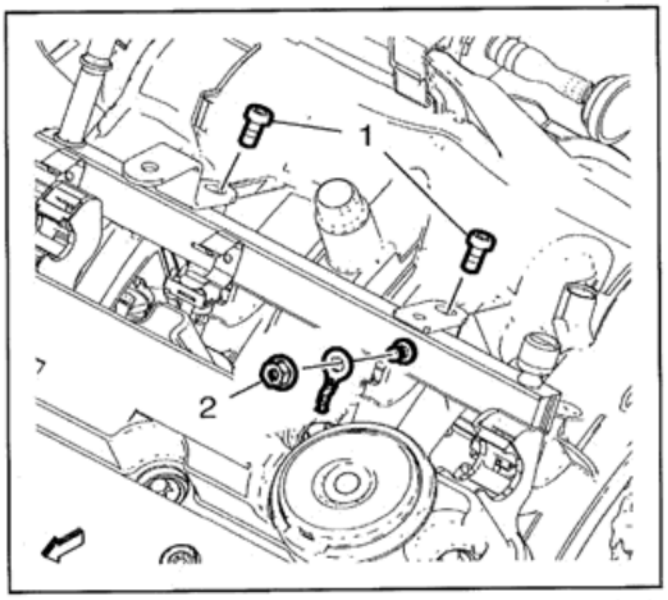
Installation Procedure



2191817

Note: Lubricate the 4 fuel injector seal rings (2) with clean engine oil.

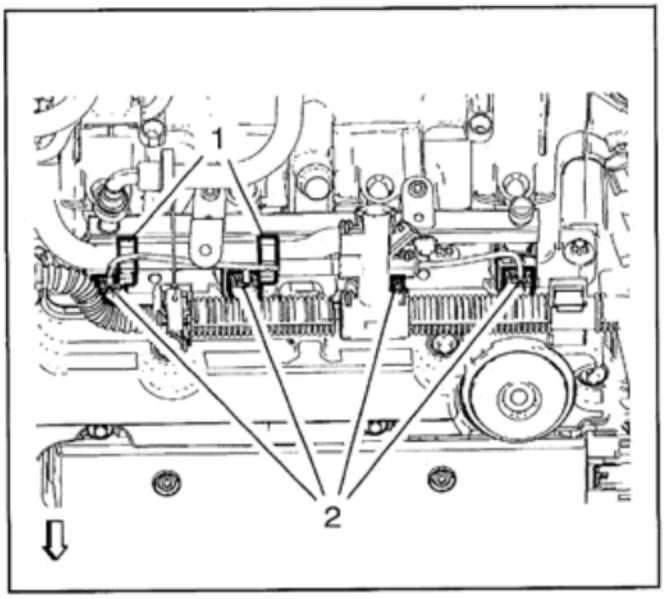
1. Install the fuel injection fuel rail assembly (1) to the intake manifold. Use NEW fuel injector seal rings (2).



2373065

Caution: Refer to *Fastener Caution on page 0-8.*

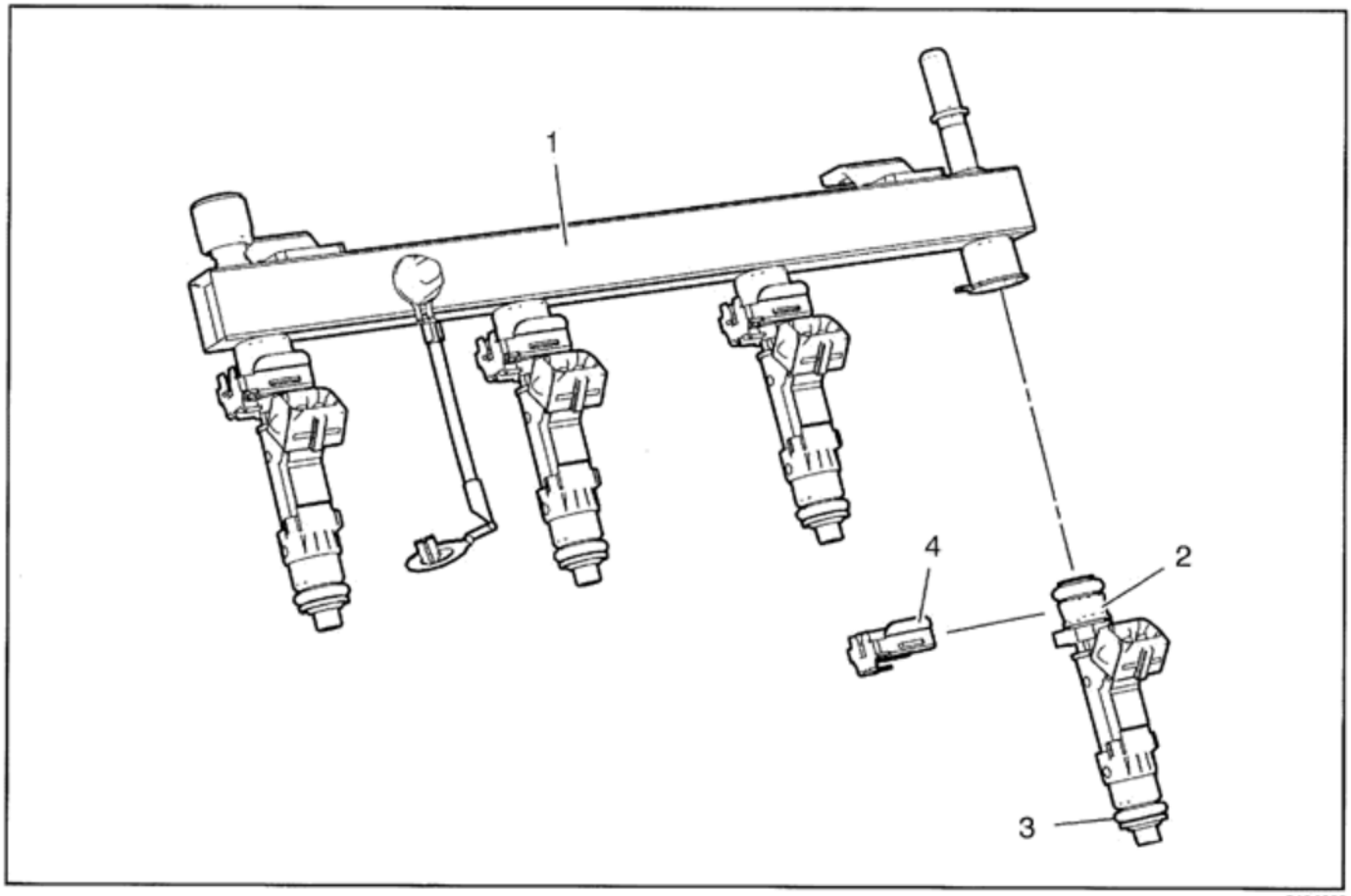
2. Install the 2 fuel injection fuel rail bolts (1) and tighten to **7 N•m (62 lb in)**.
3. Install the ground cable and the ground cable nut (2) and tighten.



2373064

4. Connect the 4 fuel injector wiring harness plugs (2).
5. Clip the ECM wiring harness to the retainer clip (1) and the camshaft cover.
6. Remove the positive crankcase ventilation pipe from the intake manifold. Refer to *Positive Crankcase Ventilation Pipe Removal on page 9-860.*
7. Install the fuel feed pipe to the fuel injection fuel rail. Refer to *Fuel Feed Pipe Replacement on page 9-258.*
8. Install the engine sight shield. Refer to *Engine Cover Replacement on page 9-790.*
9. Connect battery negative cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713.*

Fuel Injector Replacement

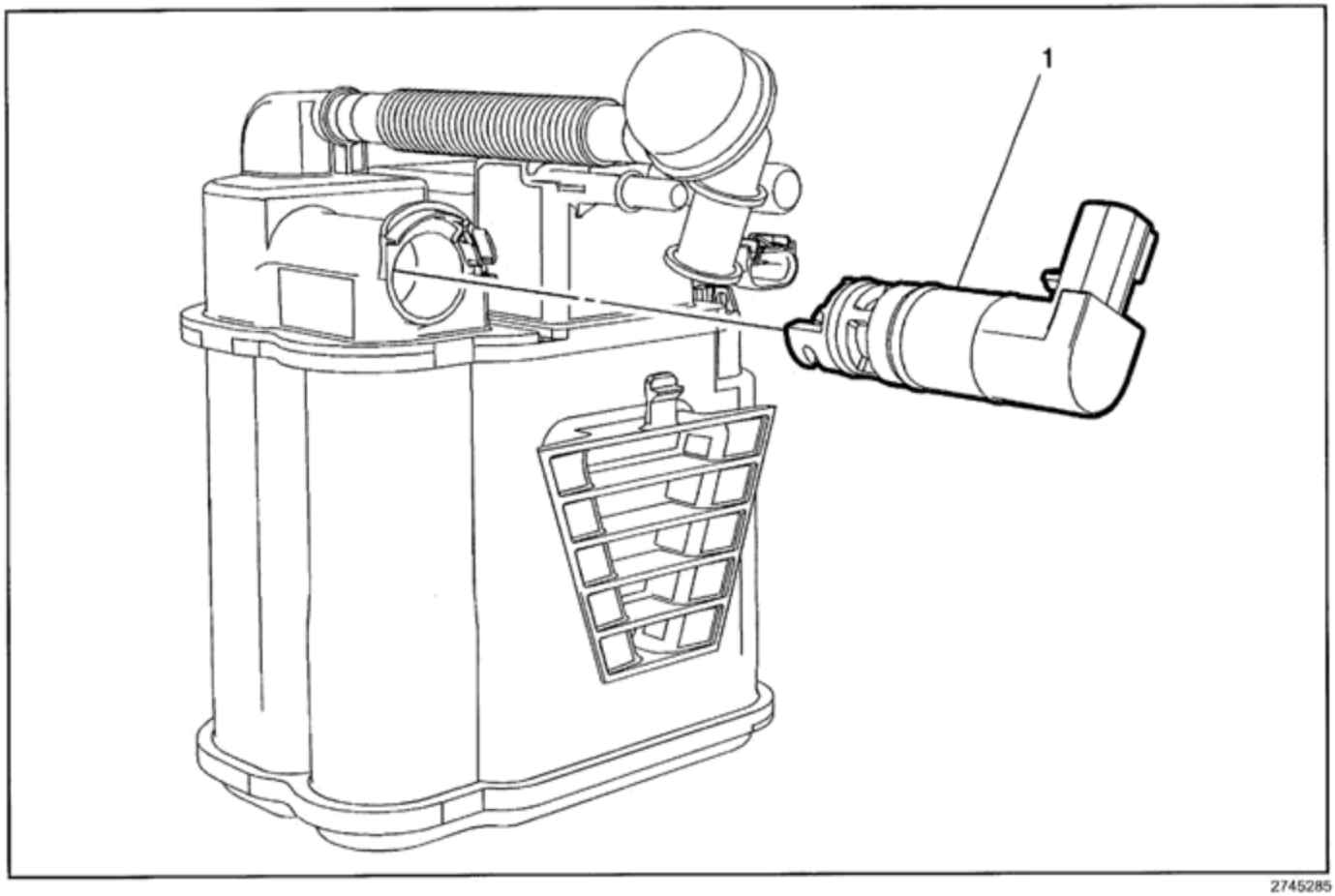


2191822

Fuel Injector Replacement

Callout	Component Name
Preliminary Procedure 1. Disconnect battery negative cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713.* 2. Remove the fuel injection fuel rail assembly. Refer to *Fuel Injection Fuel Rail Assembly Replacement on page 9-267.*	
1	Fuel Rail
2	Fuel Injector
3	Fuel Injector Seal Ring
4	Fuel Injector Retainer Clamp

Evaporative Emission Canister Vent Solenoid Valve Replacement



2745285

Evaporative Emission Canister Vent Solenoid Valve Replacement

Callout	Component Name
Preliminary Procedures 1. Disconnect the battery negative cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713.* 2. Remove the evaporative emissions canister. Refer to *Evaporative Emission Canister Replacement on page 9-273.*	
1	Evaporative Emissions Canister Vent Solenoid Valve **Procedure** Turn the evaporative emission canister vent solenoid valve counter clockwise 45 degrees and remove the solenoid from the evaporative emissions canister.

Evaporative Emission System Hose/ Pipe Replacement

Special Tools

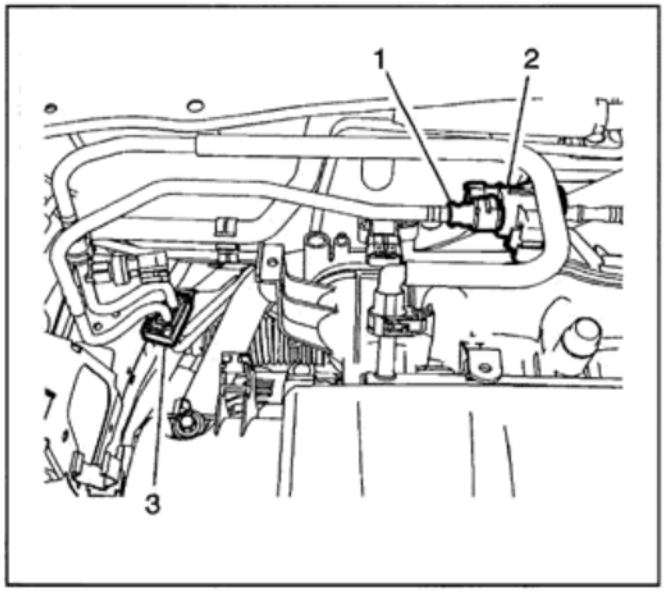
- *CH-807* Closure Plugs
- *CH-6015* Closure Plugs

For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308.*

Removal Procedure

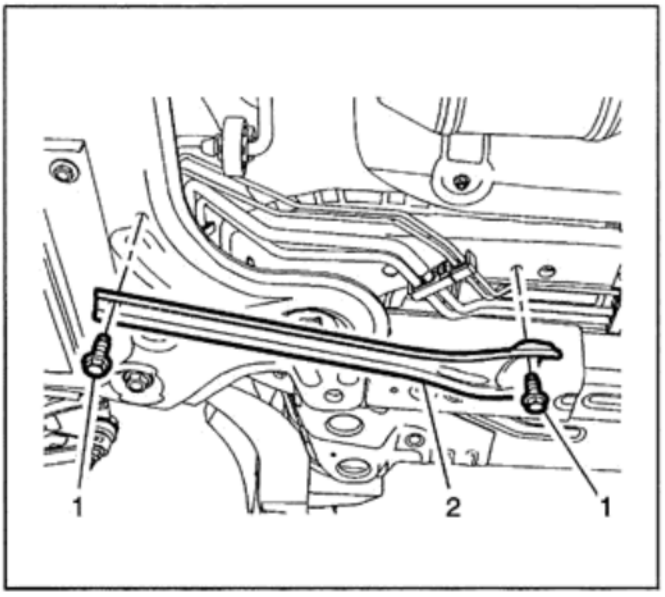
Warning: Refer to Gasoline/Gasoline Vapors Warning on page 0-5.

1. Disconnect the battery negative cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713.*
2. Relief the fuel pressure. Refer to *Fuel Pressure Relief on page 9-253.*



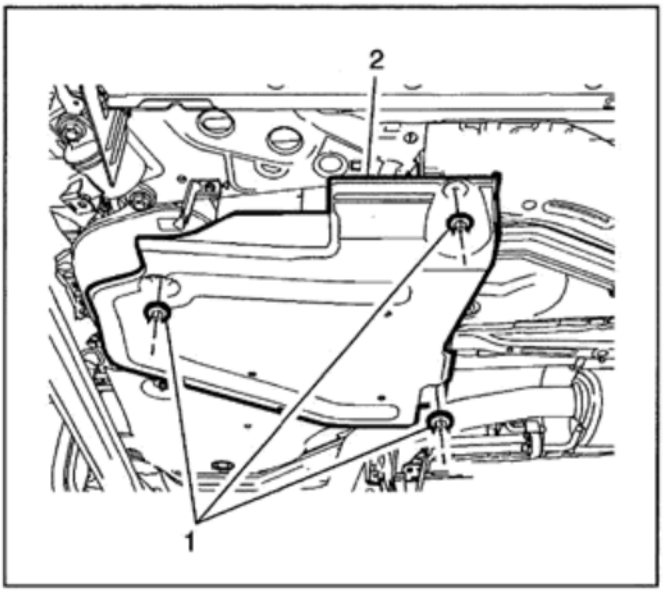
2672609

3. Disconnect the evaporative emissions front pipe (1) from the evaporative emissions purge valve (2). Refer to *Plastic Collar Quick Connect Fitting Service on page 9-264.*
4. Close the evaporative emissions pipe connections with the *CH-807* plugs.
5. Unclip the evaporative emissions pipe (1) from the retainer clip (3).
6. Raise and support the vehicle. Refer to *Lifting and Jacking the Vehicle on page 1-31.*



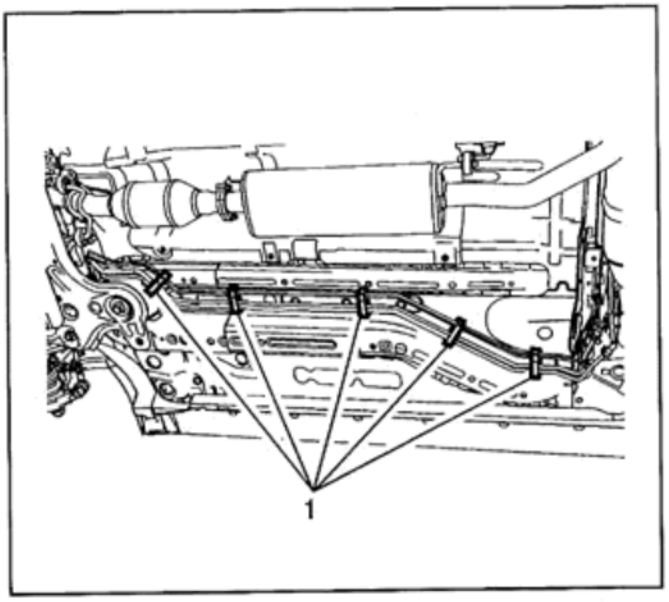
2672339

7. Remove the frame reinforcement fasteners (1) and remove the frame reinforcement(2).



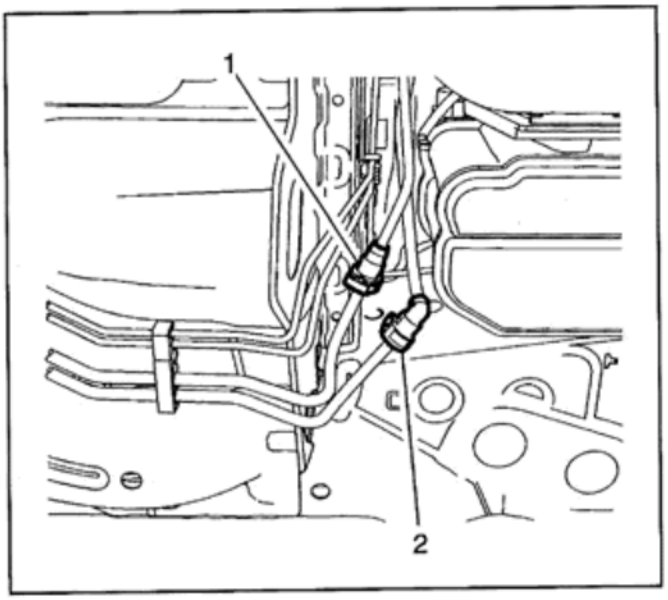
2672350

8. Remove the EVAP canister cover fasteners (1) and cover (2).



2672361

9. Open the 5 fuel pipe clips (1).

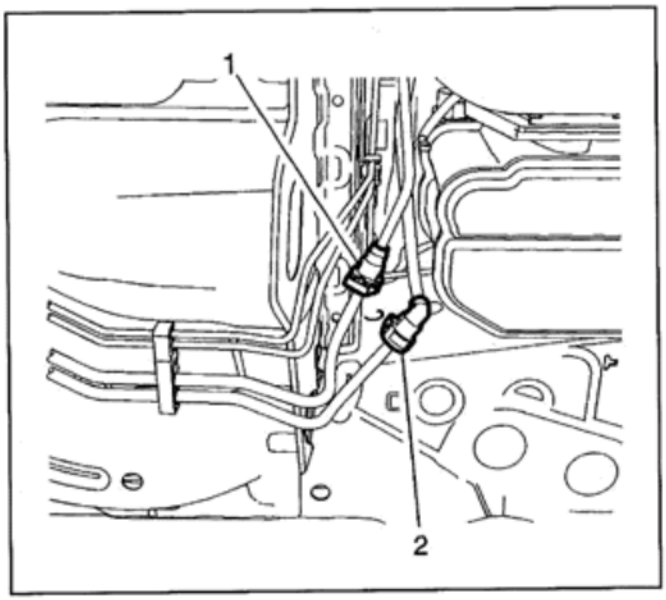


2672365

10. Disconnect the fuel tank evaporative emissions connector (2) from evaporative emissions pipe. Refer to *Plastic Collar Quick Connect Fitting Service on page 9-264*.
11. Close the evaporative emissions pipe and evaporative emissions fuel tank feed pipe with the *CH-6015* plugs.
12. Remove the evaporative emissions pipe.

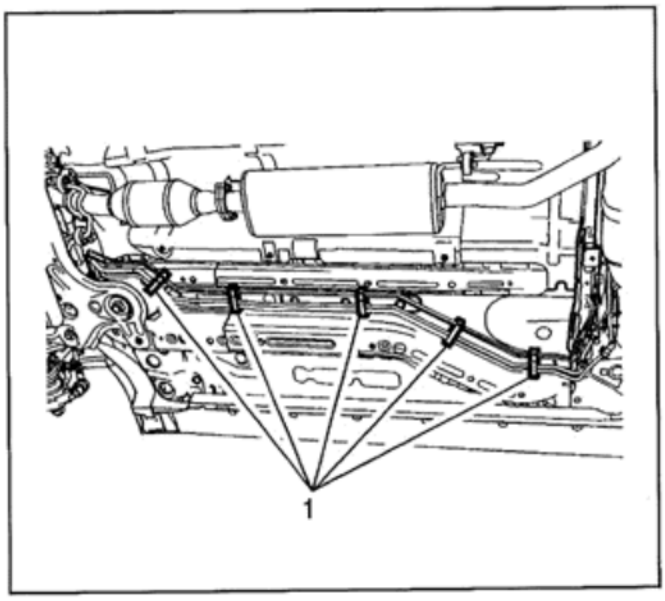
Installation Procedure

1. Remove the *CH-6015* plugs from evaporative emissions fuel tank pipe and evaporative emissions pipe.



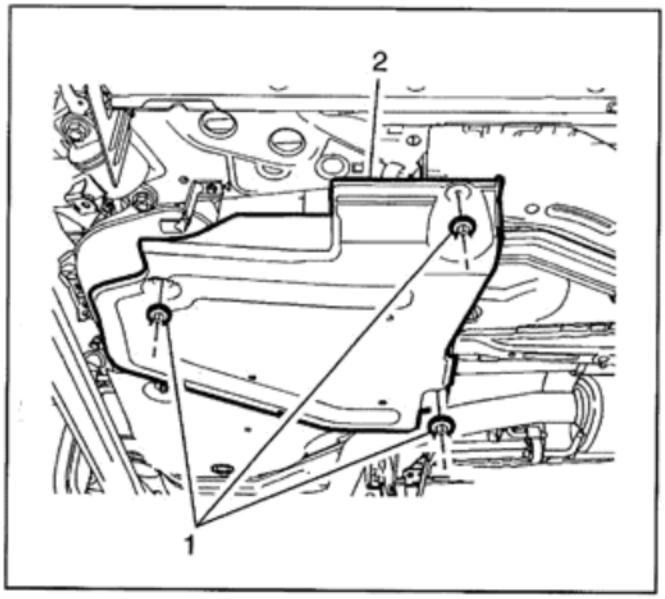
2672365

2. Install the evaporative emissions pipe and secure with the rear fuel pipe clip.
3. Connect the fuel tank feed pipe connector (2) to the evaporative emissions pipe. Refer to *Plastic Collar Quick Connect Fitting Service on page 9-264*.



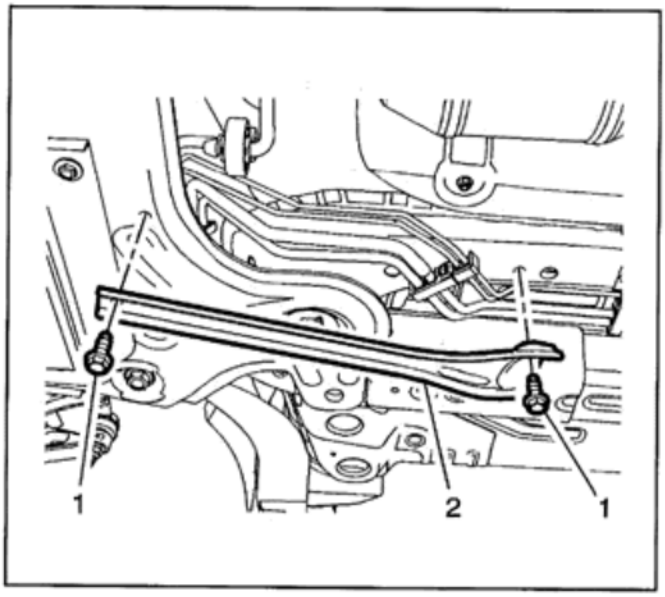
2672361

4. Close the 5 fuel pipe clips (1).



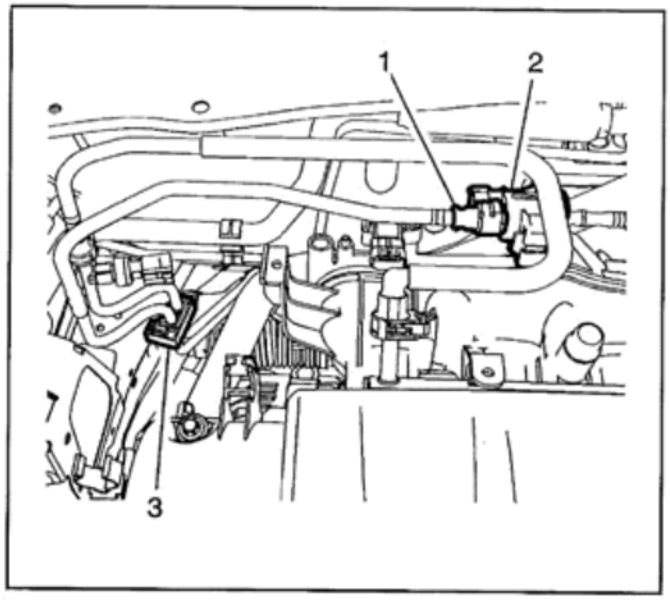
2672350

5. Install the EVAP canister cover (2) and tighten the EVAP canister cover fasteners (1) to **9 N•m (71 lb in)**.



2672339

6. Install the frame reinforcement (2) and tighten the frame reinforcement fasteners (1) to **60 N•m (44 lb ft)**.
7. Lower the vehicle.



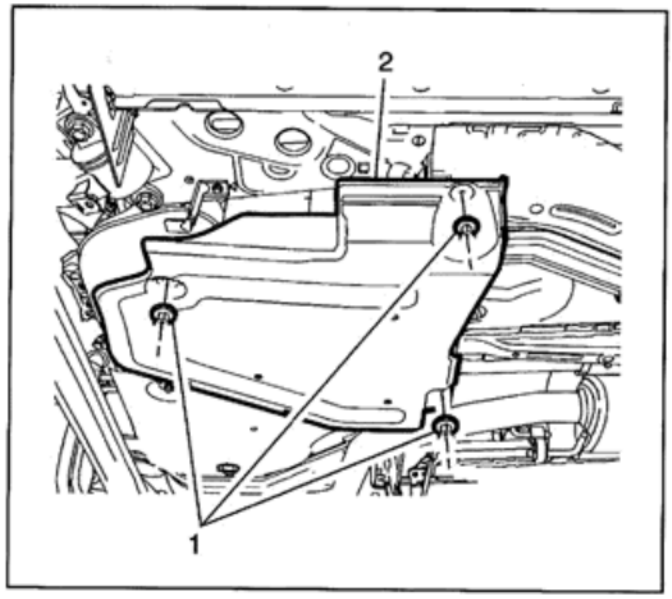
2672609

8. Clip the evaporative emissions pipe (2) into the retainer clip (3).
9. Remove the *CH-807* plugs from the evaporative emissions pipe connectors.
10. Connect the front evaporative emissions pipe connector (1) to the evaporative emissions purge valve (2). Refer to *Plastic Collar Quick Connect Fitting Service on page 9-264*.
11. Connect the battery negative cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.

Evaporative Emission Canister Replacement

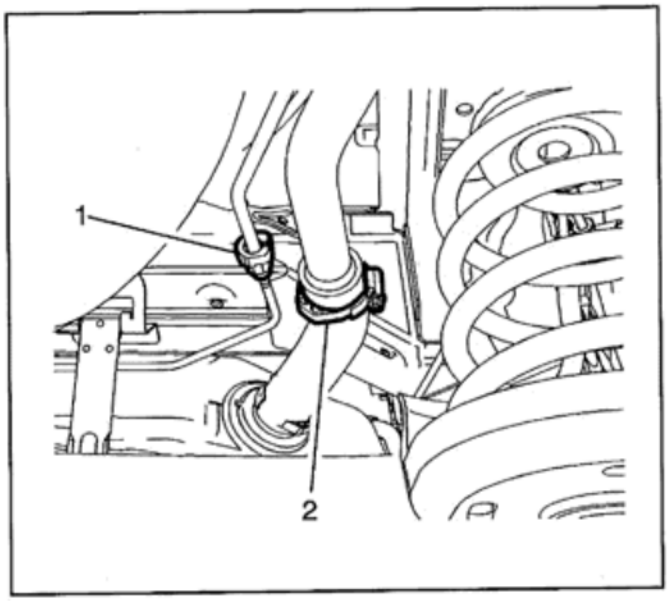
Removal Procedure

1. Raise and support the vehicle. Refer to *Lifting and Jacking the Vehicle on page 1-31*.



2672350

2. Remove the EVAP canister cover fasteners (1) and cover (2).



2672640

Warning: Do not breathe the air through the EVAP component tubes or hoses. The fuel vapors inside the EVAP components may cause personal injury.

Note: Do not remove the fuel tank filler hose when the fuel tank is over half filled with fuel.

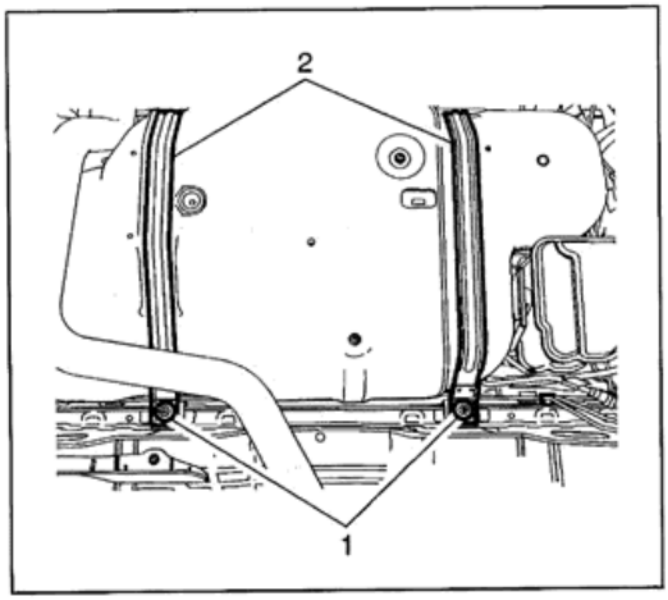
3. Remove the evaporative emissions fill vent pipe connector(1) and loosen the fuel filler hose clamp (2).

   If the fuel level is over half filled, refer to *Fuel Tank Draining on page 9-254*.

Warning: To help avoid personal injury, always use jack stands when you are working on or under any vehicle that is supported only by a jack.

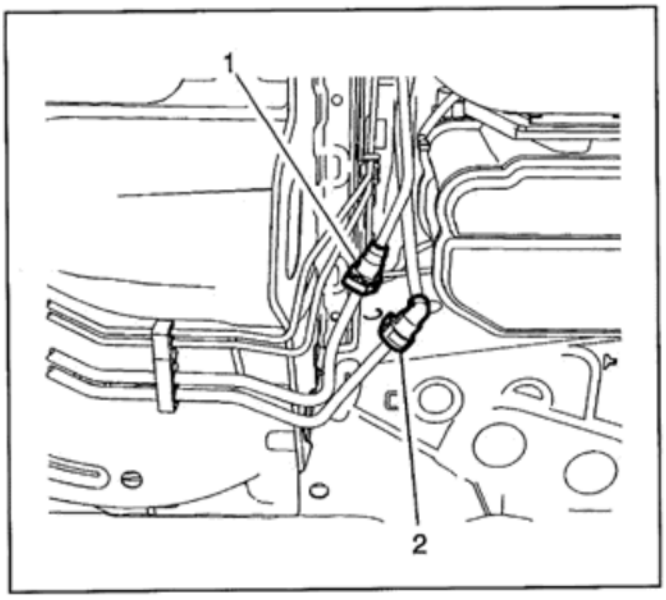
Caution: When you are jacking or lifting a vehicle at the frame side rails or other prescribed lift points, be certain that the lift pads do not contact the catalytic converter, the brake pipes or the fuel lines. If such contact occurs, vehicle damage or unsatisfactory vehicle performance may result.

4. Place a suitable adjustable jack under the fuel tank.



2672641

5. Remove the 2 fuel tank strap bolts (1).
6. Remove the 2 fuel tank straps (2).

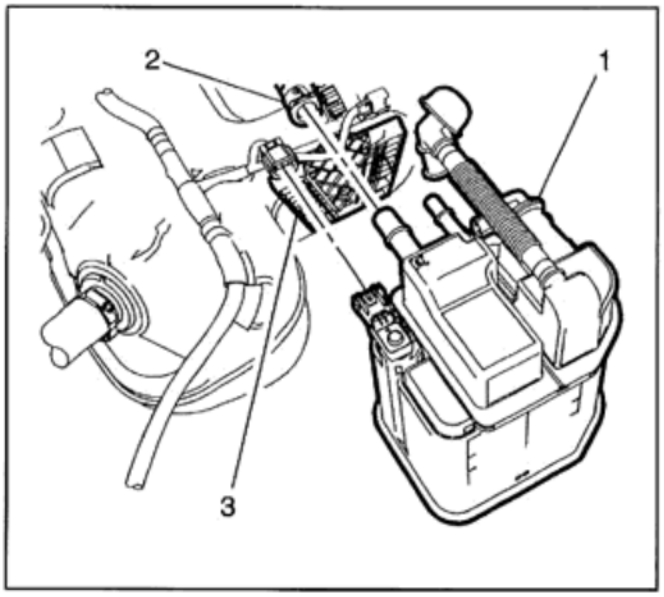


2672365

7. Disconnect the fuel feed (1) and the evaporative emissions pipe (2).

Note: Closely watch parts like pipes or hoses that are still installed to the fuel tank. If lowering the fuel tank slightly does not provide enough access to remove the fuel tank, refer to *Fuel Tank Replacement on page 9-254*.

8. Lower the fuel tank to a height where the evaporative emission canister is easily accessible.

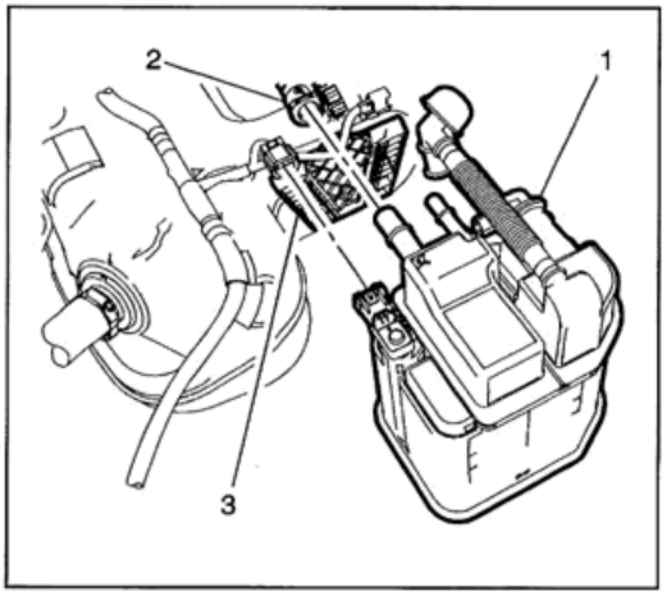


2672645

Warning: Always wear safety goggles when working with fuel in order to protect the eyes from fuel splash.

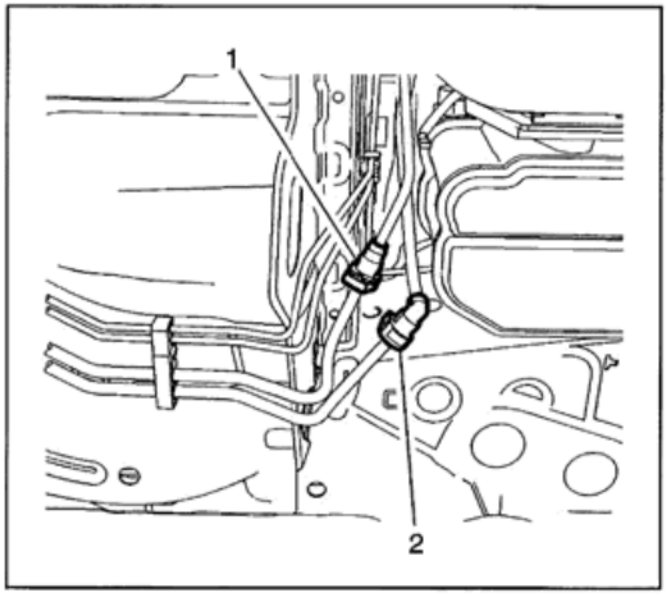
9. Disconnect the fuel tank vent pipe (2).
10. Disconnect the evaporative emission canister wiring harness connectors.
11. Disconnect the evaporative emission canister purge pipe (4).
12. Remove the evaporative emission canister (1) from the evaporative emission canister bracket (3).

Installation Procedure



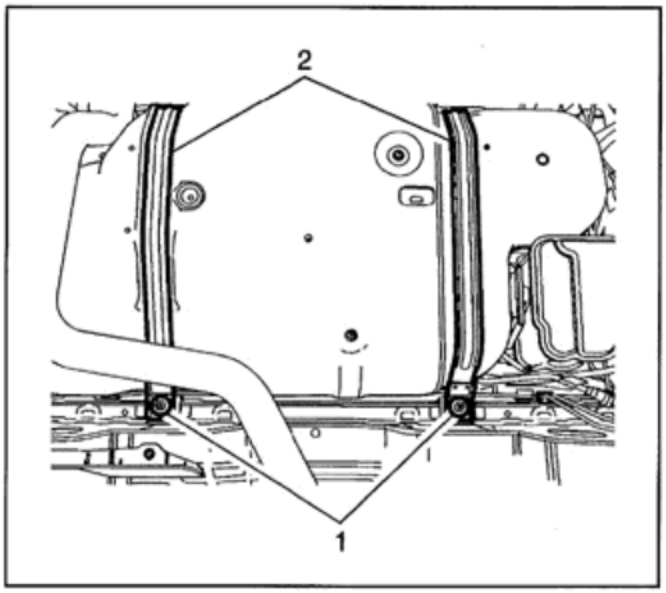
2672645

1. Install the evaporative emission canister (1) to the evaporative emission canister bracket (3).
2. Connect the evaporative emission canister purge pipe (4).
3. Connect the evaporative emission canister wiring harness plug.
4. Connect the fuel tank vent pipe (2).
5. Raise the fuel tank to its original position.



2672365

6. Connect the fuel feed (1) and the evaporative emissions pipes (2).

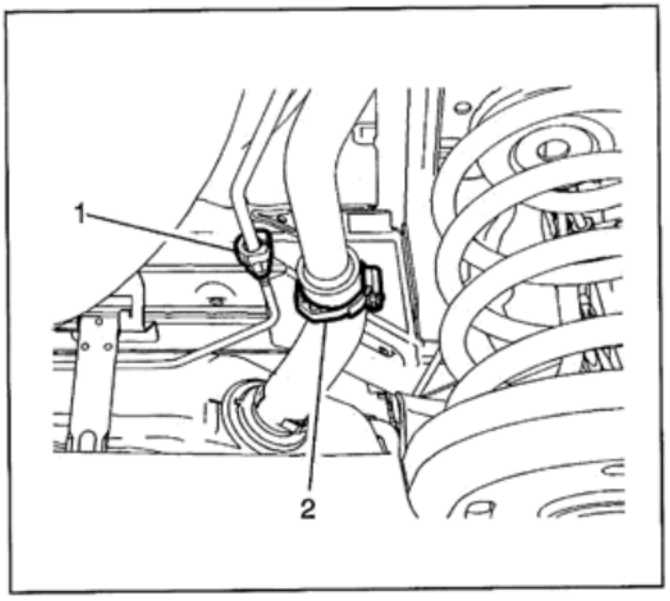


2672641

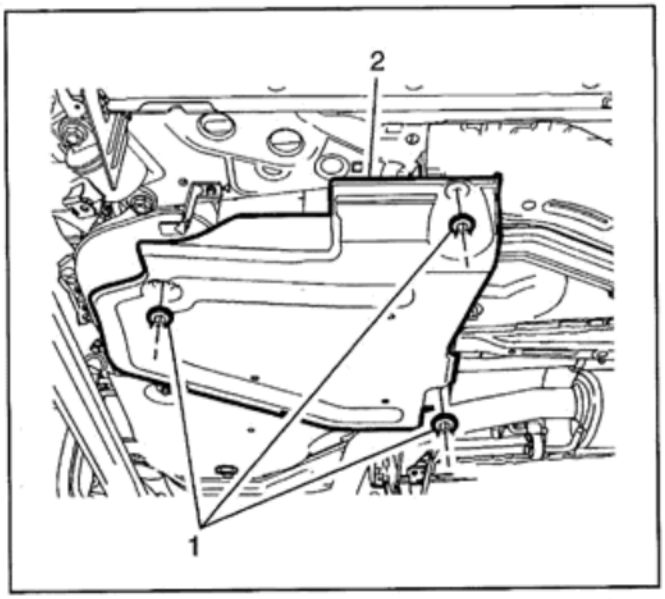
7. Install the 2 fuel tank straps (1).

Caution: Refer to *Fastener Caution on page 0-8.*

8. Install the 2 fuel tank strap bolts (2) and tighten to **23 N•m (17 lb ft)**.
9. Remove the adjustable jack.



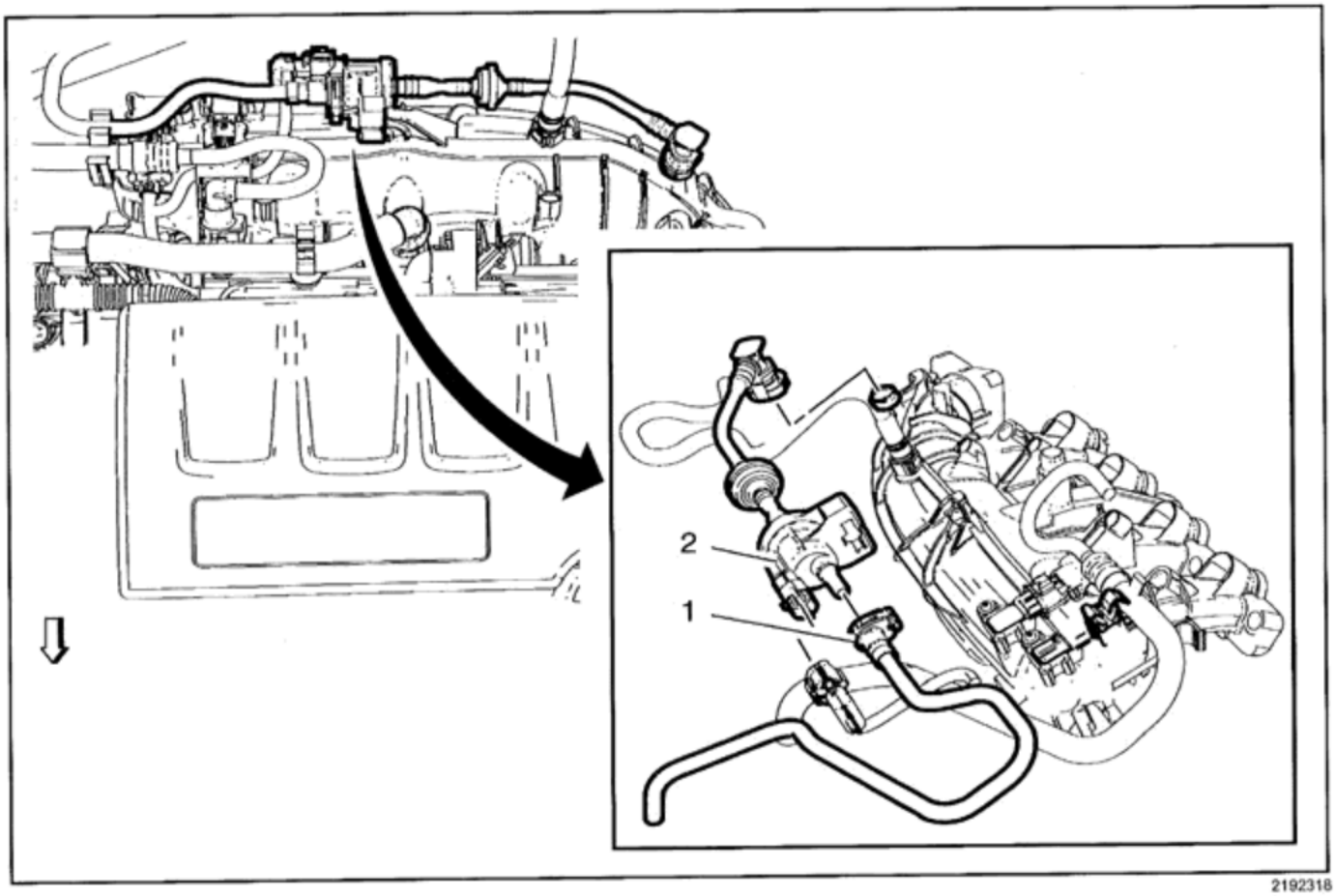
2672640



2672350

10. Connect the evaporative emissions fill vent pipe connector(1).
11. Install the clamp (2) and tighten to **3 N•m (27 lb in)**.
12. Install the EVAP canister cover (2).
13. Lower the vehicle.

Evaporative Emission Canister Purge Solenoid Valve Replacement



2192318

Evaporative Emission Canister Purge Solenoid Valve Replacement

Callout	Component Name
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. **Preliminary Procedure** Disconnect battery negative cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.	
1	Fuel Ventilation Pipe
2	Evaporative Emission Canister Purge Solenoid Valve **Procedure** Disconnect the electrical connector.

Ignition Coil Replacement

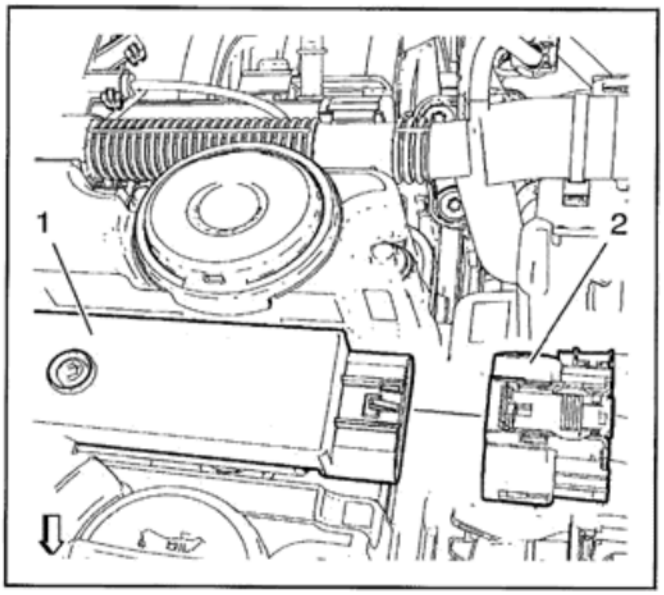
Special Tools

EN-6009 Remover and Installer Ignition Module

For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308*.

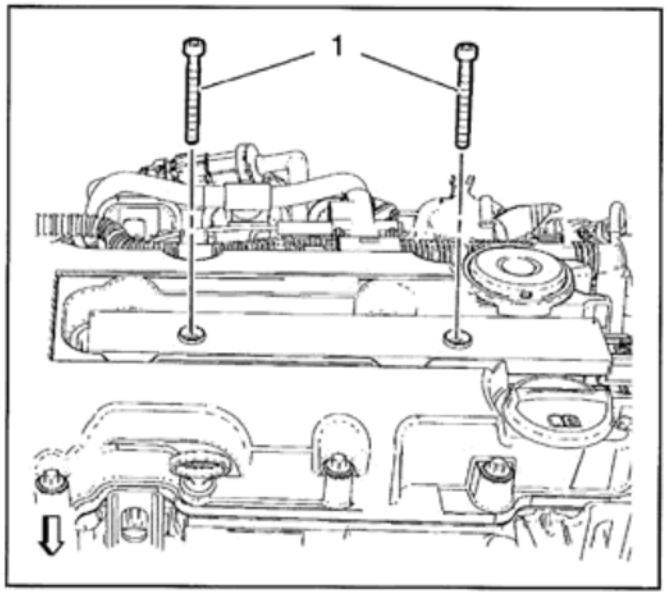
Removal Procedure

1. Remove engine cover. Refer to *Engine Cover Replacement on page 9-790*.



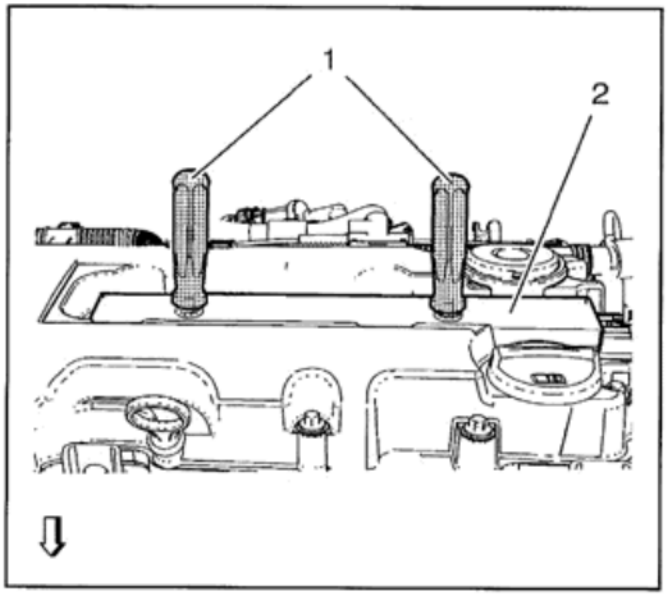
2191363

2. Disconnect ignition coil wiring harness plug (2) from ignition coil (1).



2191364

3. Remove the 2 ignition coil bolts (1).

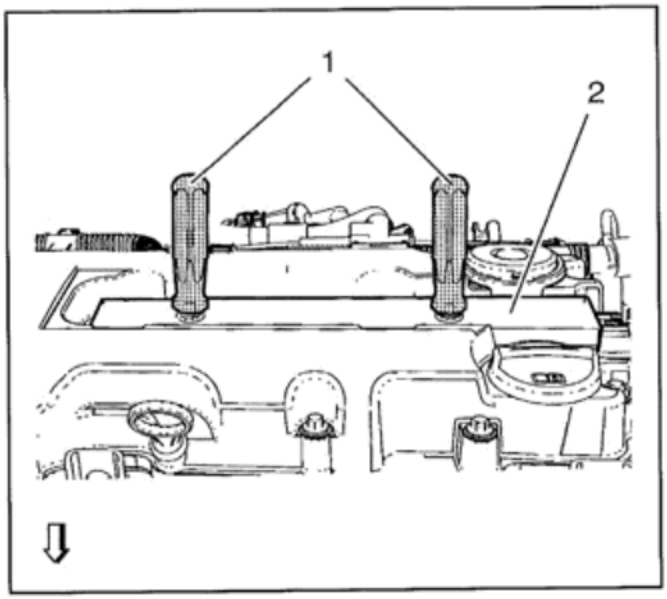


2191365

4. Install *EN-6009* remover/installer (1) to ignition coil (2).
5. Remove the ignition coil.

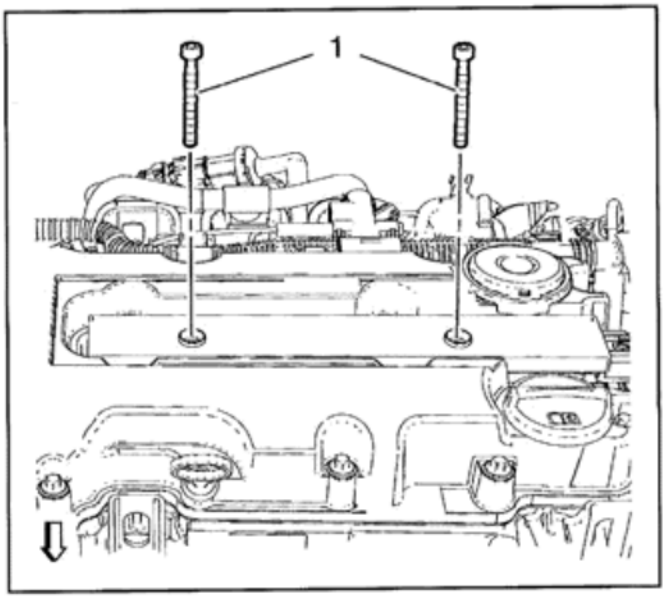
Installation Procedure

1. Install the ignition coil.



2191365

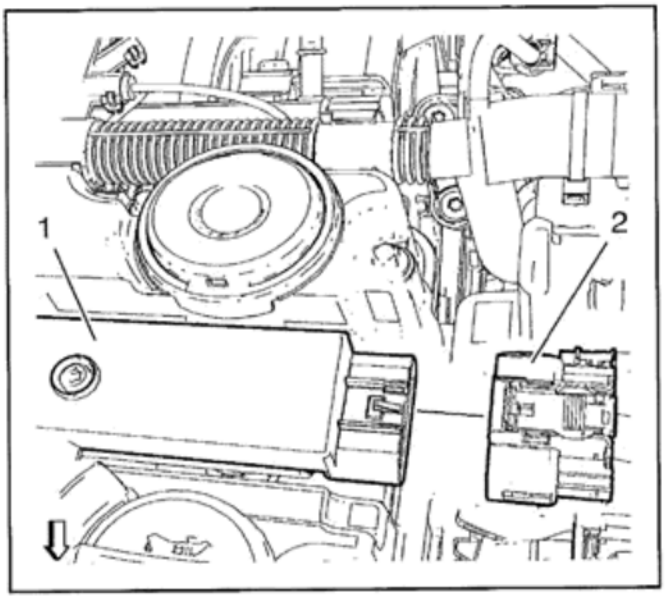
2. Remove *EN-6009* remover (1) from ignition coil (2).



2191364

Caution: Refer to *Fastener Caution on page 0-8*.

3. Install the 2 ignition coil bolts (1) and tighten to **8 N•m (71 lb in)**.



2191363

4. Connect ignition coil wiring harness plug (2) to ignition coil (1).
5. Install engine cover. Refer to *Engine Cover Replacement on page 9-790*.

Throttle/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 learn out 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

Reset Procedure

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0116, P0117, P0118, P0120, P0122, P0123, P0128, P0171, P0172, P0174, P0175, P0201, P0202, P0203, P0204, P0205, P0206, P0220, P0222, P0223, P0300, P0351, P0352, P0353, P0496, P0601, P0604, P0606, P060D, P0641, P0651, P1516, P2101, P2119, P2120, P2122, P2123, P2125, P2127, P2128, P2135, P2138, or P2176 are not set.
- Ignition ON, engine OFF.
- The vehicle speed sensor (VSS) is 0 km/h (0 mph).

Learn Procedure

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0116, P0117, P0118, P0120, P0122, P0123, P0128, P0171, P0172, P0174, P0175, P0201, P0202, P0203, P0204, P0205, P0206, P0220, P0222, P0223, P0300, P0351, P0352, P0353, P0496, P0601, P0604, P0606, P060D, P0641, P0651, P1516, P2101, P2119, P2120, P2122, P2123, P2125, P2127, P2128, P2135, P2138, or P2176 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.

Throttle Learn

Reset Procedure (Performed after the throttle body is cleaned or replaced)

1. Ignition ON, engine OFF, perform the Idle Learn Reset in Module Setup with a scan tool.
2. Start the engine and monitor the TB Idle Airflow Compensation parameter. The TB Idle Airflow Compensation value should equal 0 percent and the engine should be idling at a normal idle speed.
3. Clear the DTCs and return to the diagnostic that referred you here.

Learn Procedure (Performed after the ECM is flashed or replaced)

Note: Do NOT perform this procedure if DTCs are set. Refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69.*

1. Start and idle the engine for 3 minutes.
2. With a scan tool, monitor the Desired Idle Speed and the actual Engine Speed.
3. The ECM will start to learn the new idle cells and Desired Idle Speed should start to decrease.
4. Ignition OFF for 60 seconds.
5. Start and idle the engine for 3 minutes.
6. After the 3 minute run time the engine should be idling normal.

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.

⇒ If the engine idle speed has not been learned the vehicle will need to be driven at speeds above 70 km/h (44 mph) with several decelerations and extended idles.

7. After the drive cycle, the engine should be idling normally.

⇒ If the engine idle speed has not been learned, turn OFF the ignition for 60 seconds and repeat step 6.

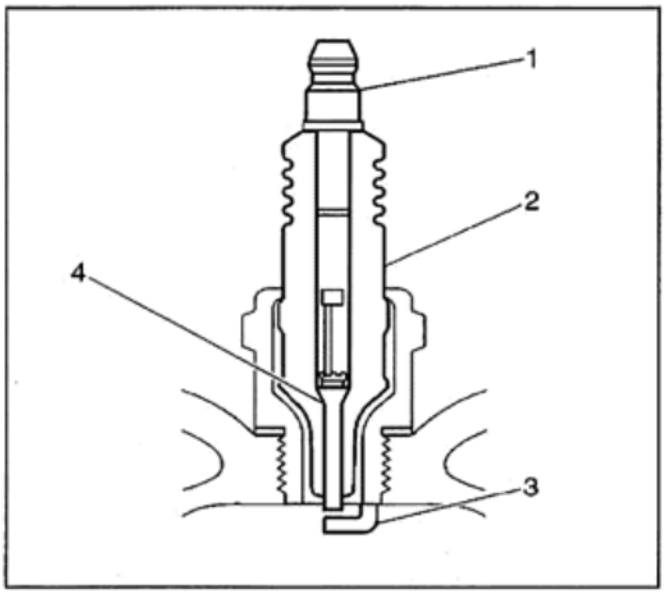
8. Once the engine speed has returned to normal, clear DTCs and return to the diagnostic that referred you here.

Spark Plug Inspection

Spark Plug Usage

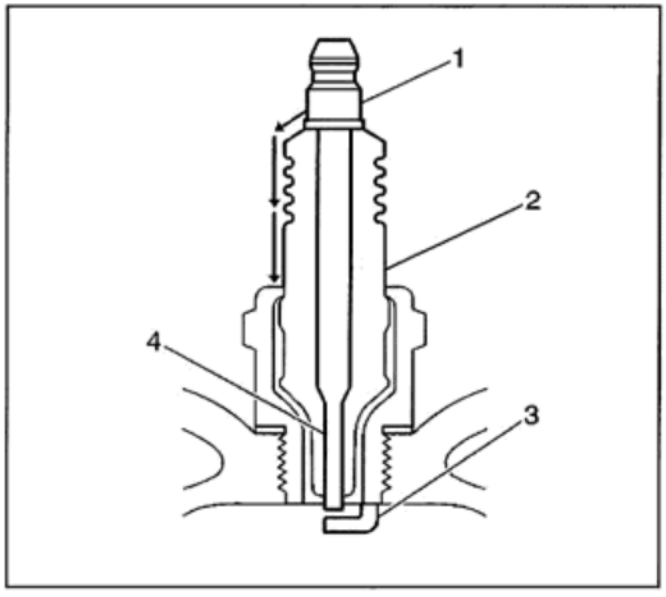
1. Ensure that the correct spark plug is installed. An incorrect spark plug causes driveability conditions.
2. Ensure that the spark plug has the correct heat range. An incorrect heat range causes the following conditions:
   - Spark plug fouling—Colder plug
   - Pre-ignition causing spark plug and/or engine damage—Hotter plug

Spark Plug Inspection



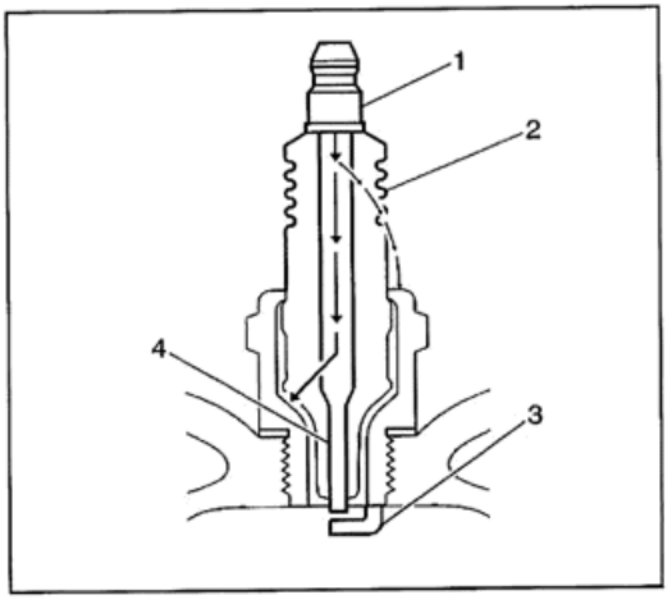
622530

1. 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.



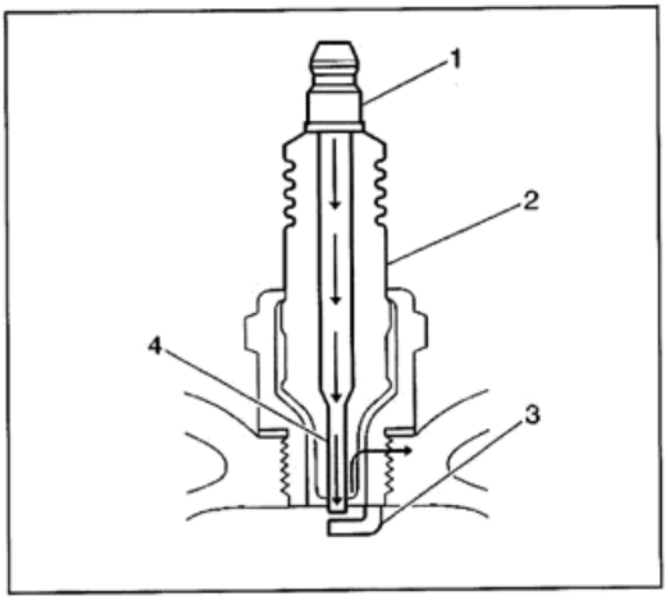
622529

2. Inspect the insulator (2) for flashover or carbon tracking, soot. 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.



622528

3. Inspect the insulator (2) for cracks. All or part of the electrical charge may arc through the crack instead of the electrodes (3, 4).



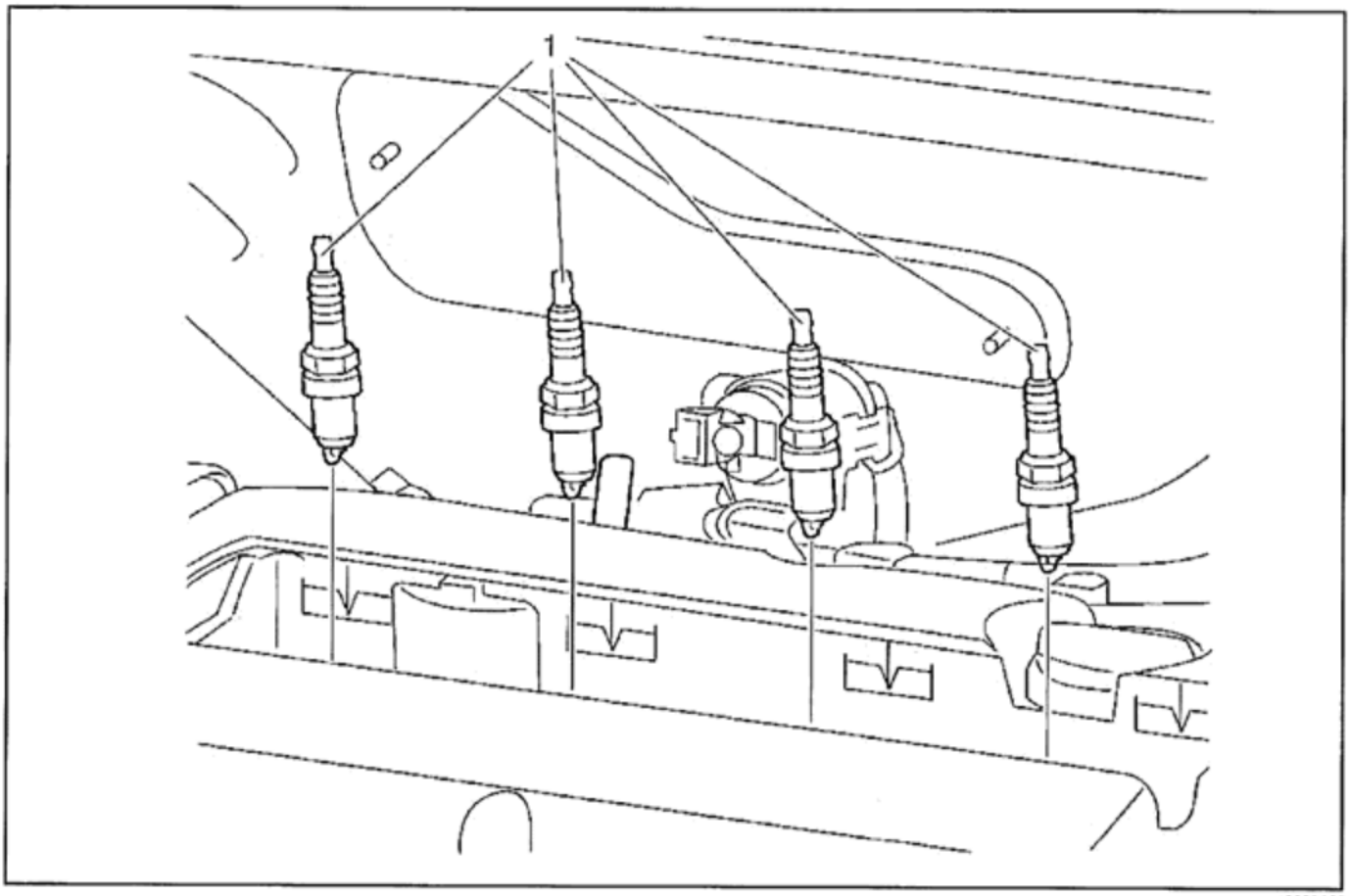
622527

4. Inspect for evidence of improper arcing.
   - Measure the gap between the center electrode (4) and the side electrode (3) terminals. An excessively wide electrode gap can prevent correct spark plug operation.
   - Inspect for the correct spark plug torque. 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.
5. A rattling sound indicates internal damage.
6. 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

1. Normal operation—Brown to grayish-tan with small amounts of white powdery deposits are normal combustion by-products from fuels with additives.
2. 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.

Spark Plug Replacement



2020163

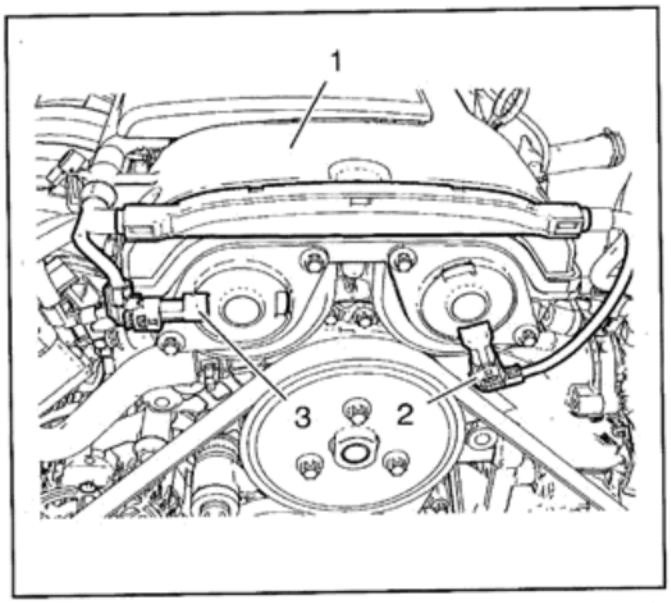
Spark Plug Replacement

Callout	Component Name
Preliminary Procedure 1. Open the hood. 2. Remove the engine sight shield. 3. Remove the ignition coil. Refer to *Ignition Coil Replacement on page 9-277*.	
1	Spark Plugs **Caution:** Refer to *Fastener Caution on page 0-8*. **Tighten** 25 N•m (18 lb ft) **Special Tools** *EN-194-E* Spark Plug Remover For equivalent regional tools, refer to *Special Tools (Diagnostic Tools) on page 9-308*.

Camshaft Position Actuator Solenoid Valve Replacement

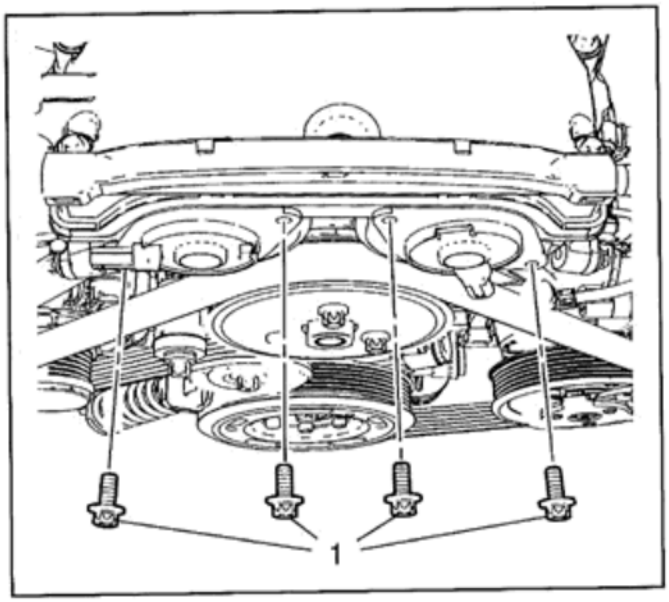
Removal Procedure

1. Remove the air cleaner assembly. Refer to *Air Cleaner Assembly Replacement on page 9-290*.



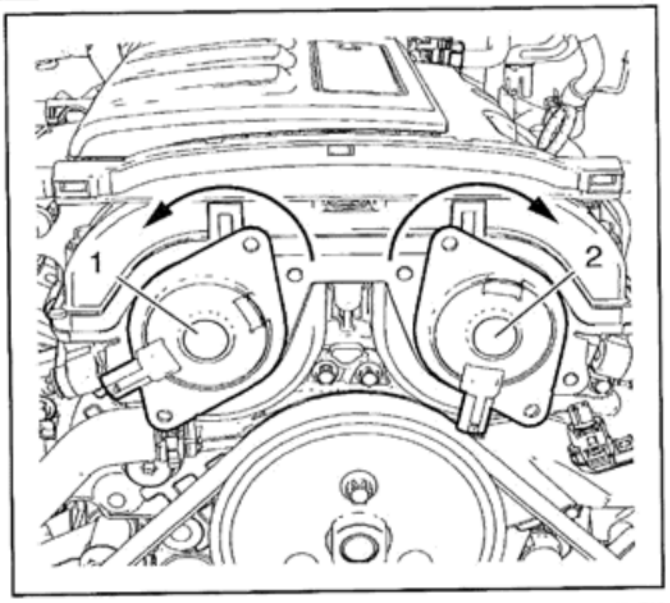
2191792

2. Disconnect the intake camshaft position actuator solenoid valve wiring harness plug (3).
3. Disconnect the exhaust camshaft position actuator solenoid valve wiring harness plug (2).
4. Unclip ECM wiring harness (1) from camshaft cover.



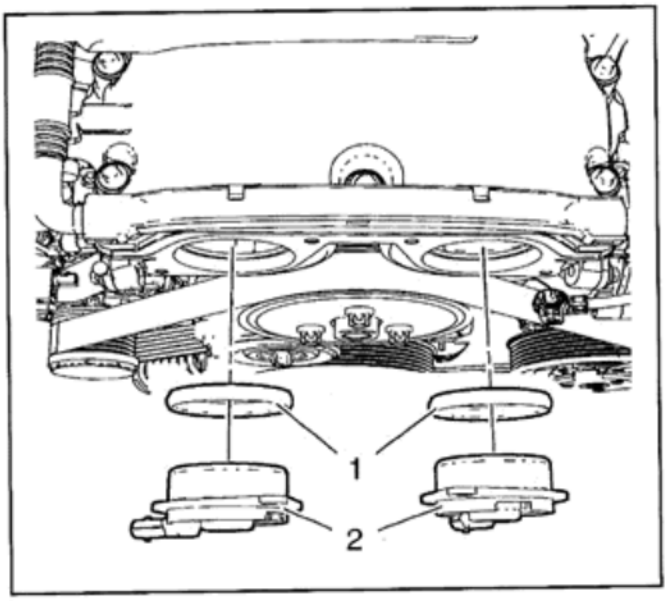
2191794

5. Remove the 4 camshaft position actuator solenoid valve bolts (1).



2191798

6. Carefully rotate the intake camshaft position actuator solenoid valve (1) counter clockwise as shown.
7. Carefully rotate the exhaust camshaft position actuator solenoid valve (2) clockwise as shown.

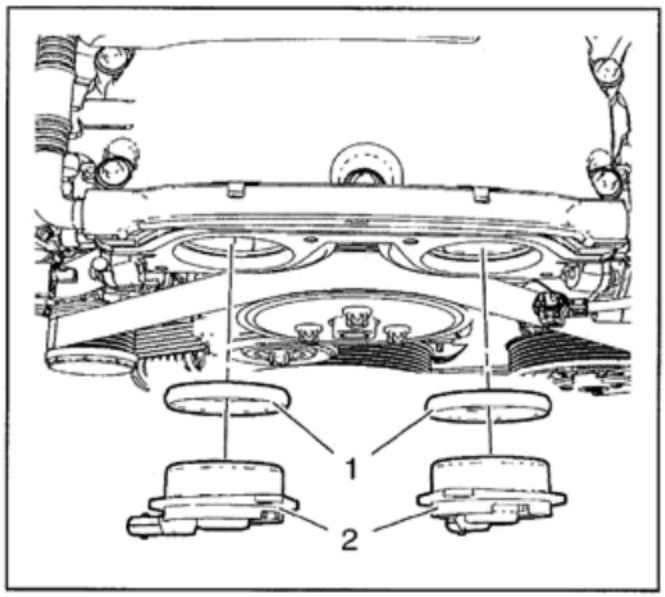


2191796

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.

8. Carefully remove the 2 camshaft position actuator solenoid valves (2) and the seal rings (1).

Installation Procedure

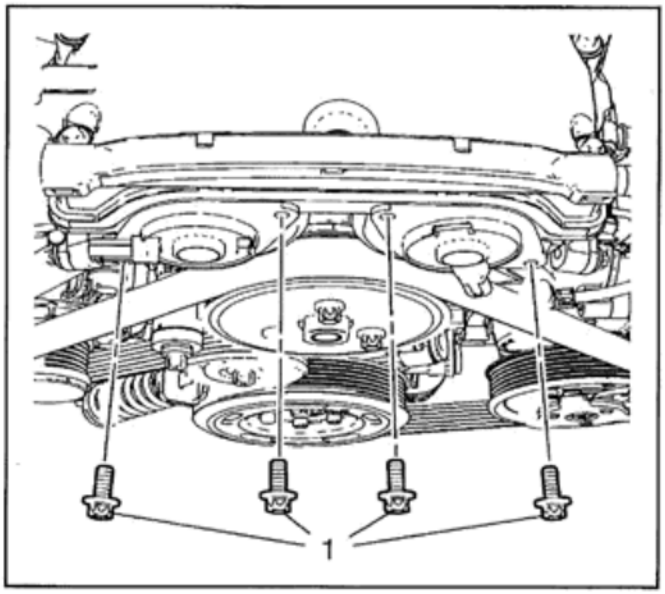


2191796

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: Lubricate the seal rings with oil in order to make the installation easier.

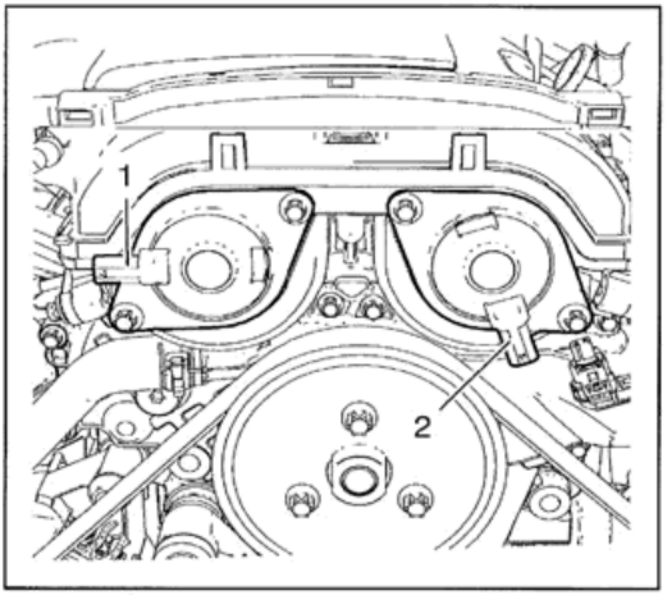
1. Carefully install the 2 camshaft position actuator solenoid valves (2) and the 2 seal rings (1) by gently pressing into position.



2191794

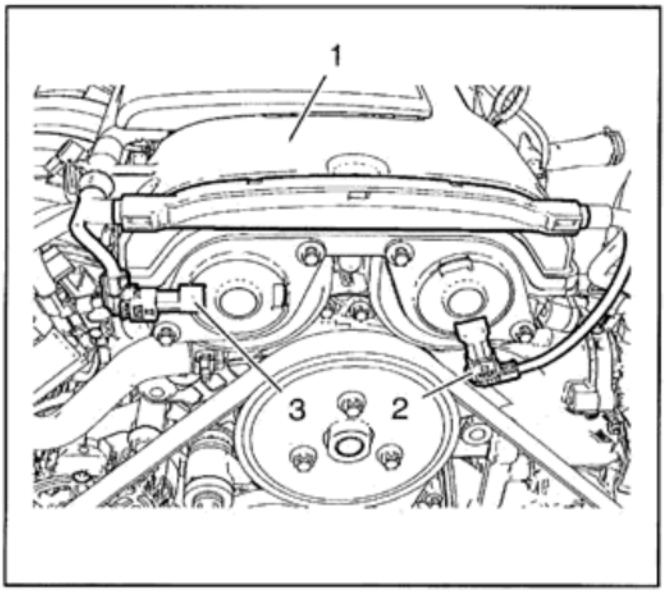
Caution: Refer to *Fastener Caution on page 0-8*.

2. Install the 4 camshaft position actuator solenoid valve bolts (1) and tighten to **8 N·m (71 lb in)**.



2191797

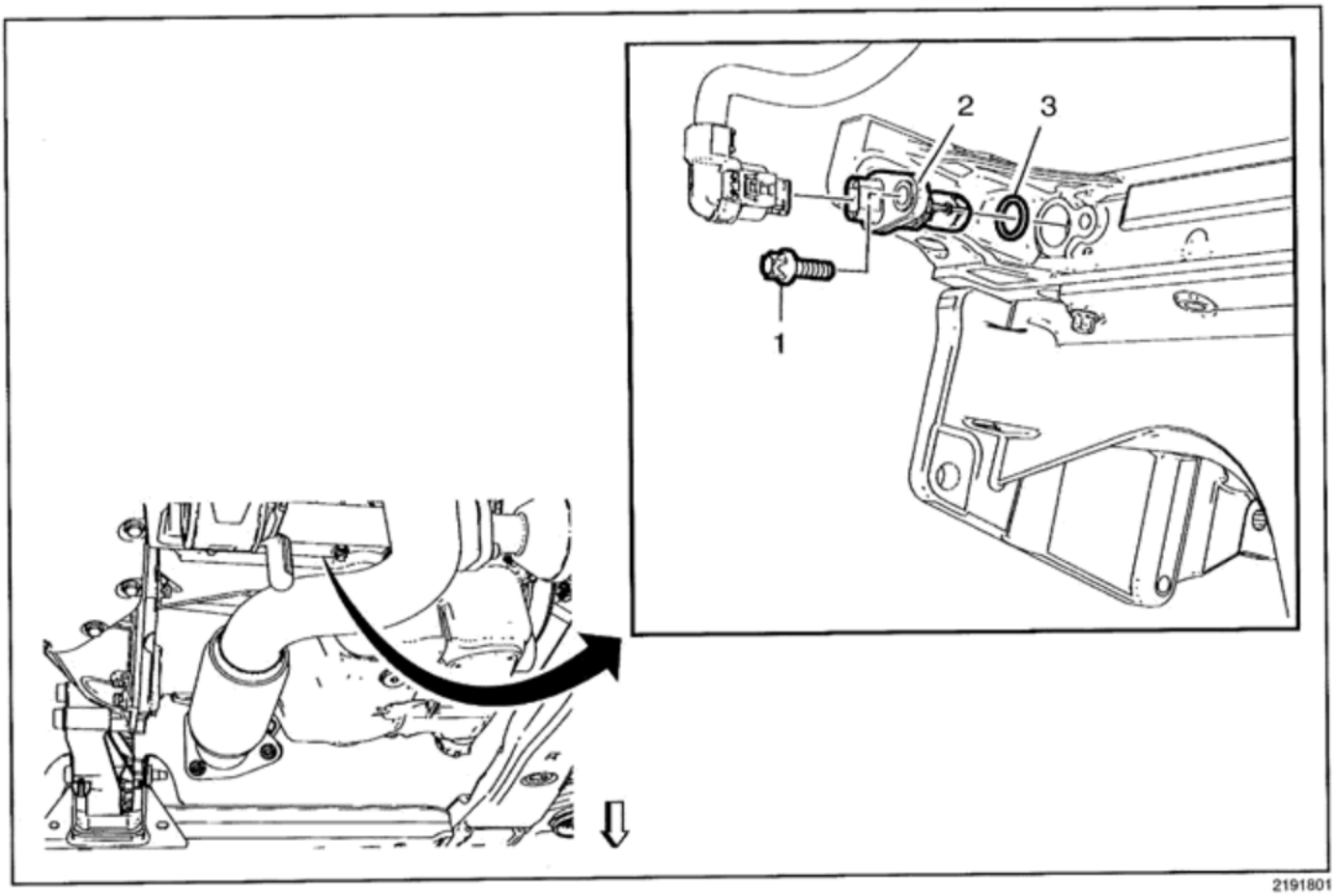
3. The 2 camshaft position actuator solenoid valves should be installed in the position as shown (1) and (2).



2191792

4. Clip ECM wiring harness (1) to camshaft cover.
5. Connect the exhaust camshaft position actuator solenoid valve wiring harness plug (2).
6. Connect the intake camshaft position actuator solenoid valve wiring harness plug (3).
7. Install the air cleaner assembly. Refer to *Air Cleaner Assembly Replacement on page 9-290*.

Crankshaft Position Sensor Replacement



2191801

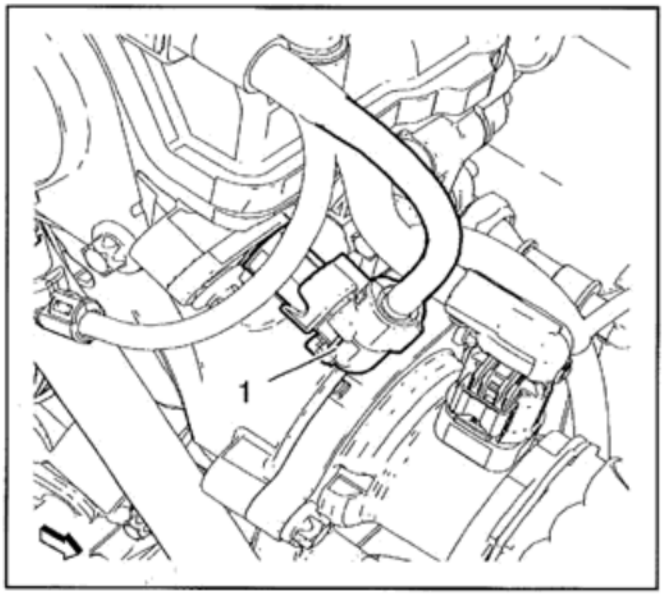
Crankshaft Position Sensor Replacement

Callout	Component Name
Preliminary Procedures Raise and support the vehicle. Refer to *Lifting and Jacking the Vehicle on page 1-31*	
1	Crankshaft Position Sensor Bolt **Caution:** Refer to *Fastener Caution on page 0-8*. **Tighten** 8 N•m (71 lb in)
2	Crankshaft Position Sensor **Procedure** 1. Disconnect the electrical connector. 2. After replacement of crankshaft position sensor, use a scan tool to speed up learn function. Refer to *Engine Control Module Programming and Setup on page 6-7*.
3	Crankshaft Position Sensor Seal Ring

Camshaft Position Sensor Replacement

Removal Procedure

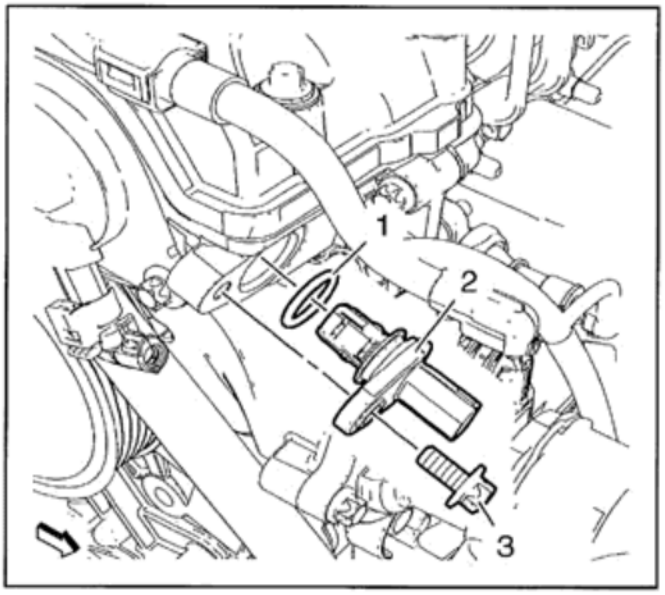
1. Remove the air cleaner assembly. Refer to *Air Cleaner Assembly Replacement on page 9-290*.



2191800

Note: Graphic shows exhaust camshaft position sensor. Use same procedure for Intake camshaft position sensor.

2. Disconnect the camshaft position sensor wiring harness plug (1).

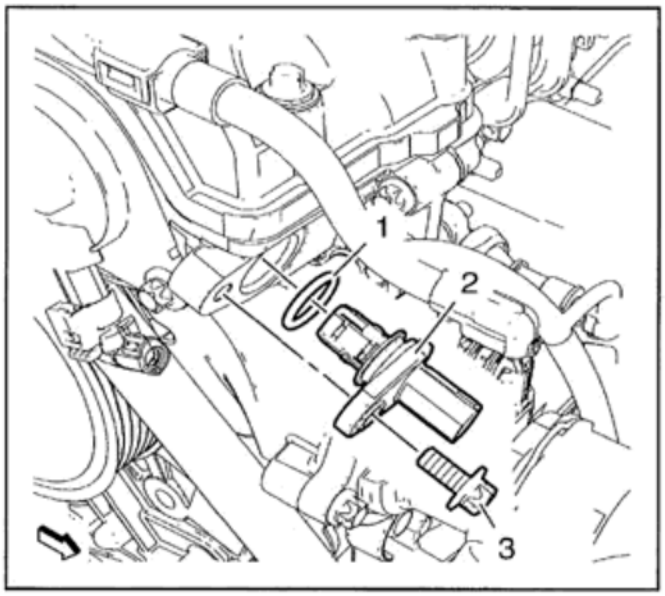


2191799

Note: Graphic shows exhaust camshaft position sensor. Use same procedure for Intake camshaft position sensor.

3. Remove the camshaft position sensor bolt (3).
4. Remove the camshaft position sensor (2) and the seal ring (1).

Installation Procedure



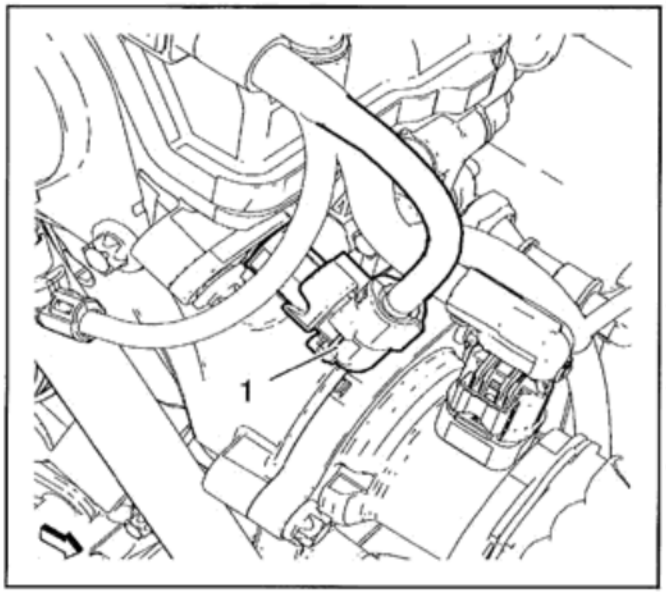
2191799

Note: Graphic shows exhaust camshaft position sensor. Use same procedure for Intake camshaft position sensor.

1. Install the camshaft position sensor (2) and the seal ring (1).

Caution: Refer to *Fastener Caution on page 0-8*

2. Install the camshaft position sensor bolt (3) and tighten to **8 N•m (71 lb in)**.



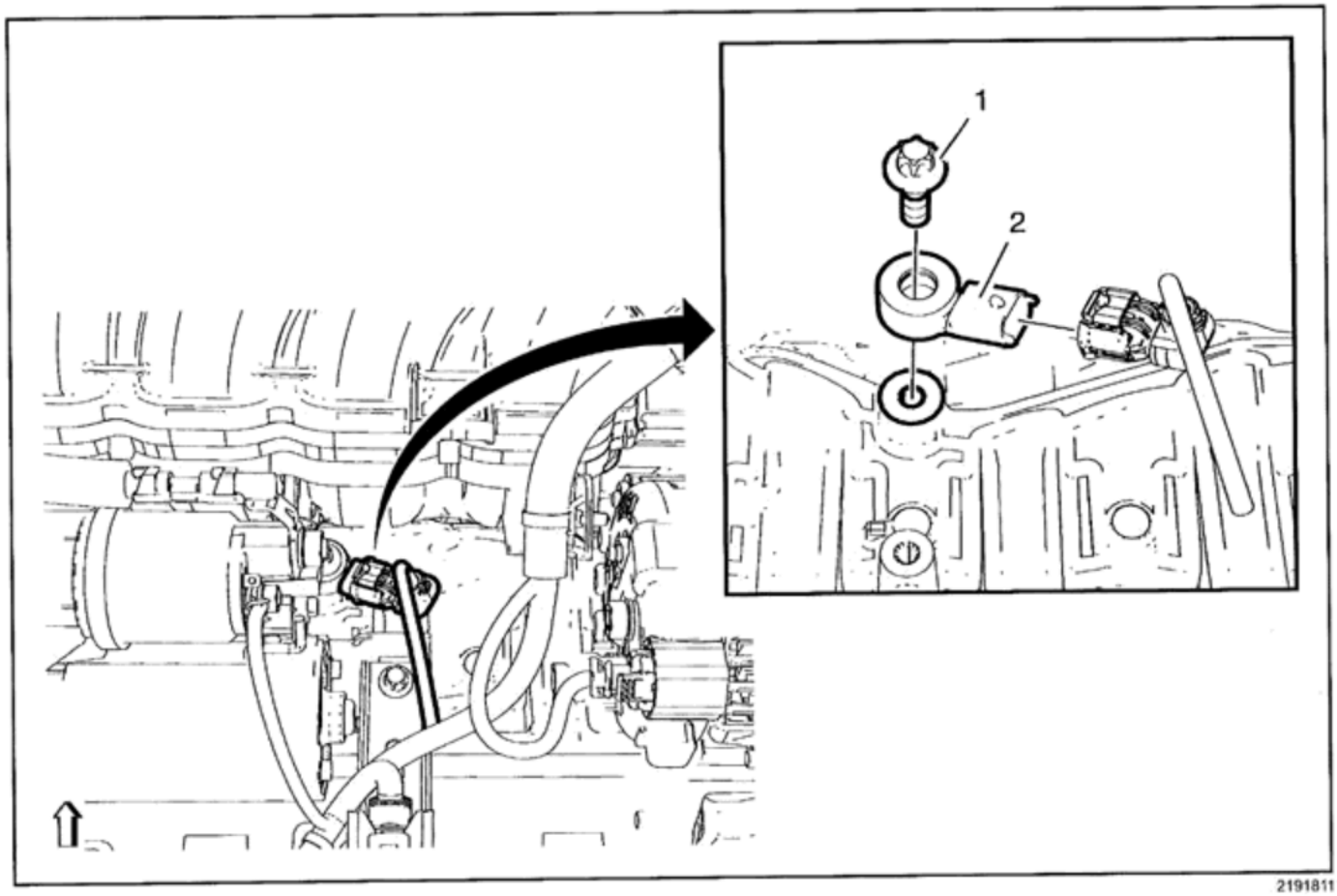
2191800

Note: Graphic shows exhaust camshaft position sensor. Use same procedure for Intake camshaft position sensor.

3. Connect the camshaft position sensor wiring harness plug (1).
4. Install the air cleaner assembly. Refer to *Air Cleaner Assembly Replacement on page 9-290*.

5. After replacement of an camshaft position sensor, use a scan tool to speed up learn function. Refer to *Engine Control Module Programming and Setup on page 6-7*

Knock Sensor Replacement



2191811

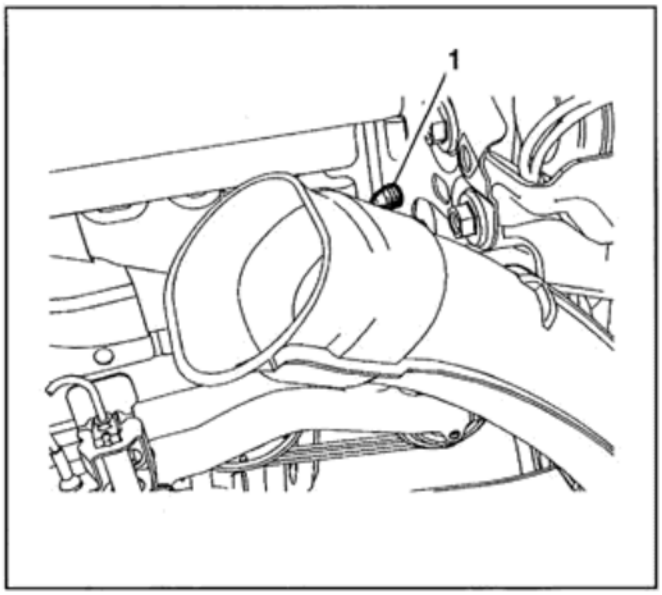
Knock Sensor Replacement

Callout	Component Name
Preliminary Procedures 1. Disconnect battery negative cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713.* 2. Raise and support the vehicle. Refer to *Lifting and Jacking the Vehicle on page 1-31*	
1	Knock Sensor Bolt **Caution:** Refer to *Fastener Caution on page 0-8.* **Procedure** 1. Disconnect the electrical connector. 2. DO NOT mistake the knock sensor electrical connector with the generator electrical connector. **Tighten** 25 N•m (18 lb ft)
2	Knock Sensor

Air Cleaner Inlet Duct Replacement

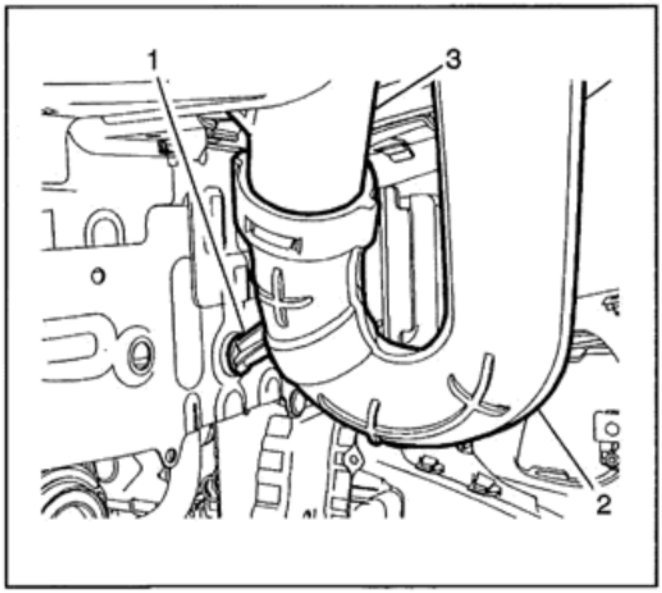
Removal Procedure

1. Remove the right front wheelhouse liner. Refer to *Front Wheelhouse Liner Replacement (Rear) on page 3-151* or *Front Wheelhouse Liner Replacement (Front) on page 3-150*.



2498132

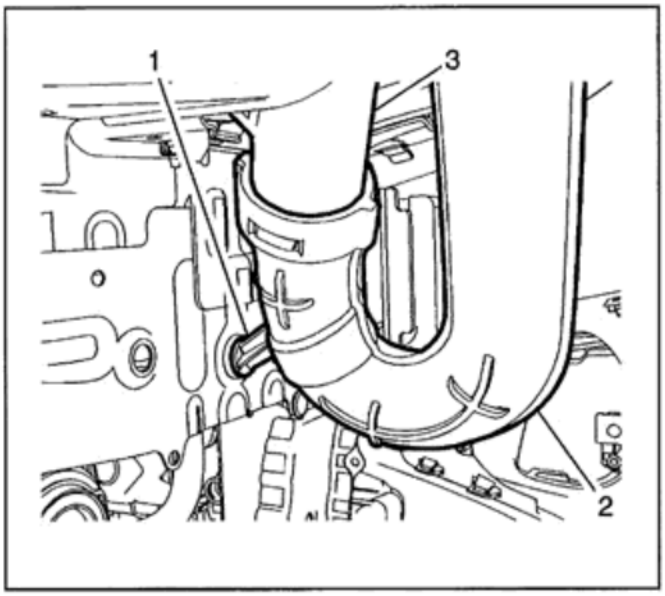
2. Remove the upper intake air duct plastic fastener (1).



2498133

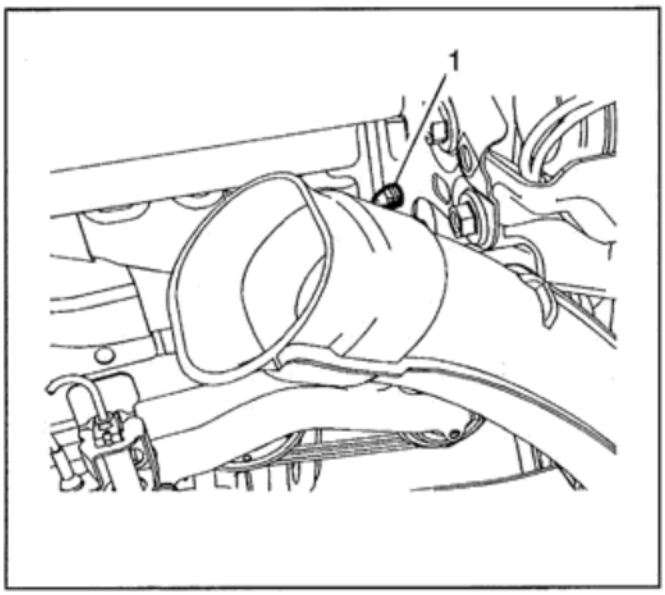
3. Pull the lower portion of the intake air duct outward to release the duct from the rubber mounting grommet (1).
4. Pull downward to separate the lower portion of the intake air duct (2) from the upper duct (3).

Installation Procedure



2498133

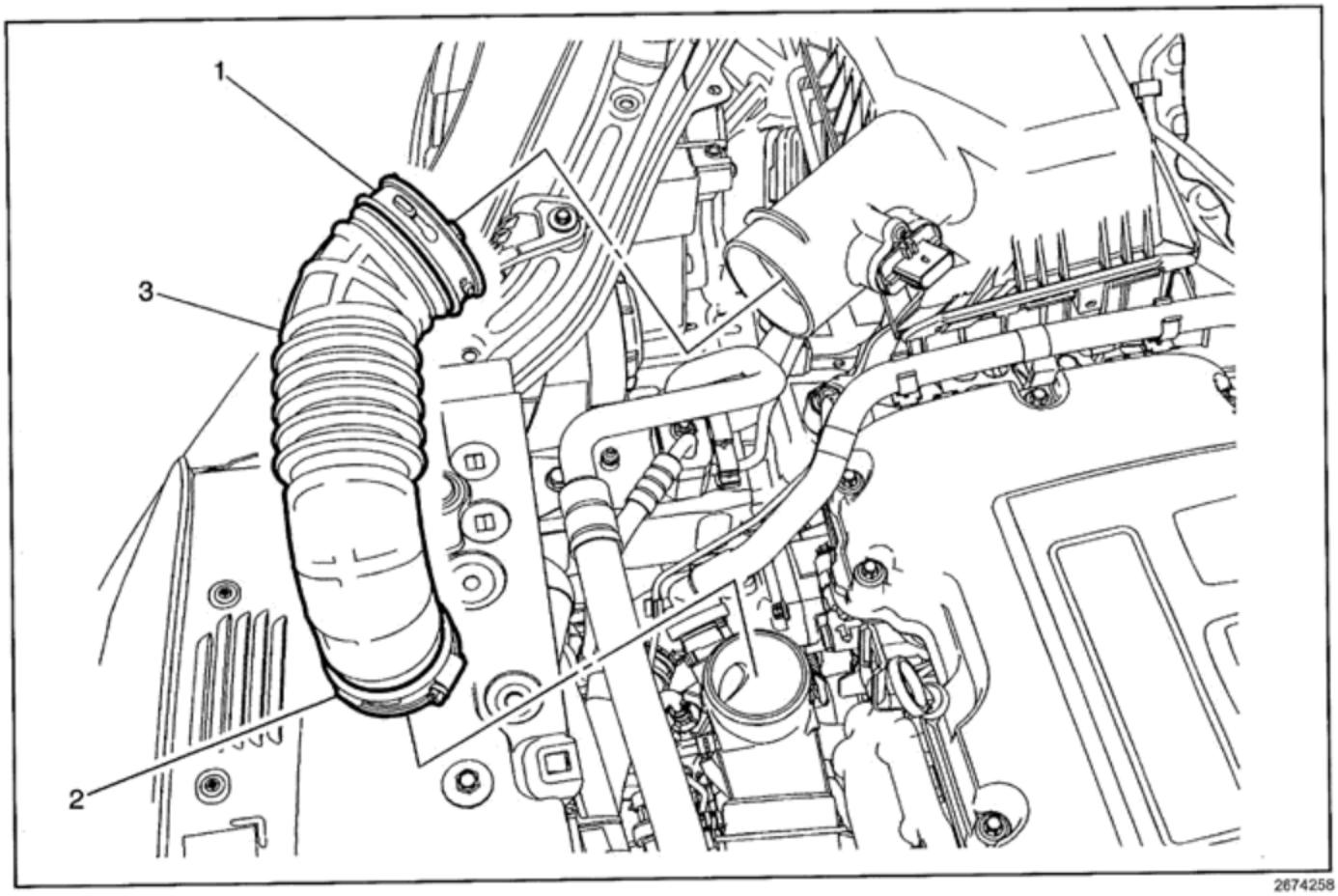
1. Attach the lower portion of the intake air duct (2) to the upper duct (3).
2. Attach the lower portion of the intake air duct to the rubber mounting grommet (1).



2498132

3. Install the upper intake air duct plastic fastener (1) to the body bracket.
4. Install the right front wheelhouse liner. Refer to *Front Wheelhouse Liner Replacement (Rear) on page 3-151* or *Front Wheelhouse Liner Replacement (Front) on page 3-150*.

Air Cleaner Outlet Duct Replacement



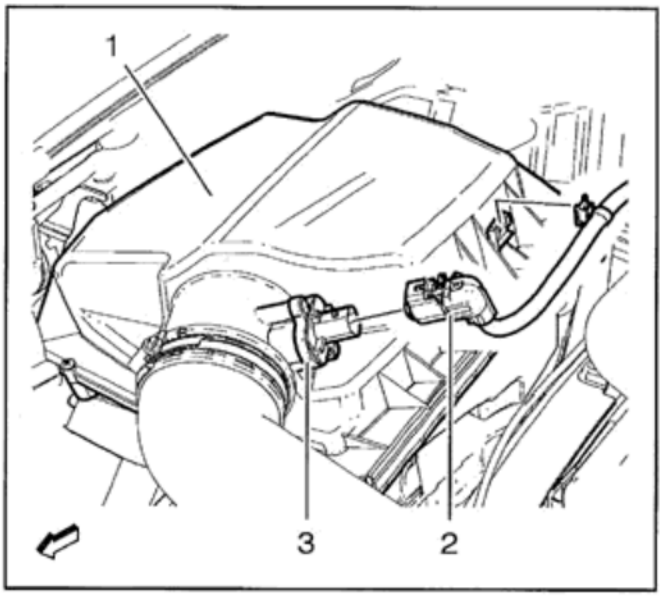
2674258

Air Cleaner Outlet Duct Replacement

Callout	Component Name
1	Air Cleaner Outlet Duct Clamp
2	Air Cleaner Outlet Duct Clamp
3	Air Cleaner Outlet Duct **Tip:** Air cleaner outlet front duct and air cleaner outlet rear duct are one part.

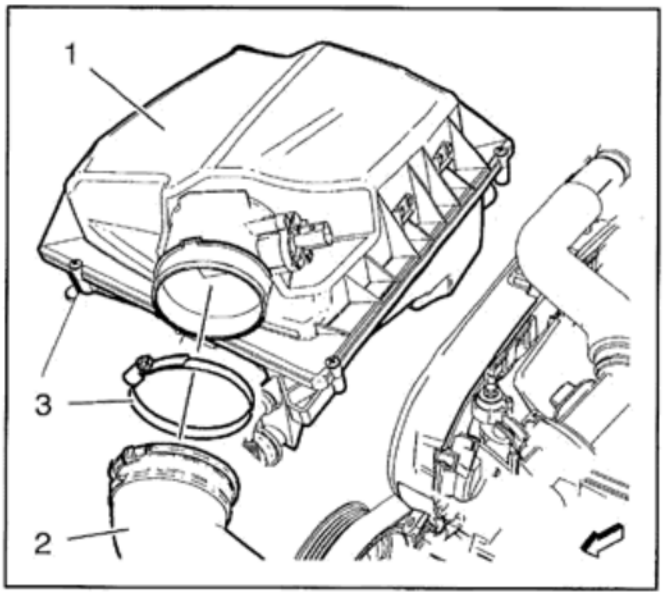
Air Cleaner Element Replacement

Removal Procedure



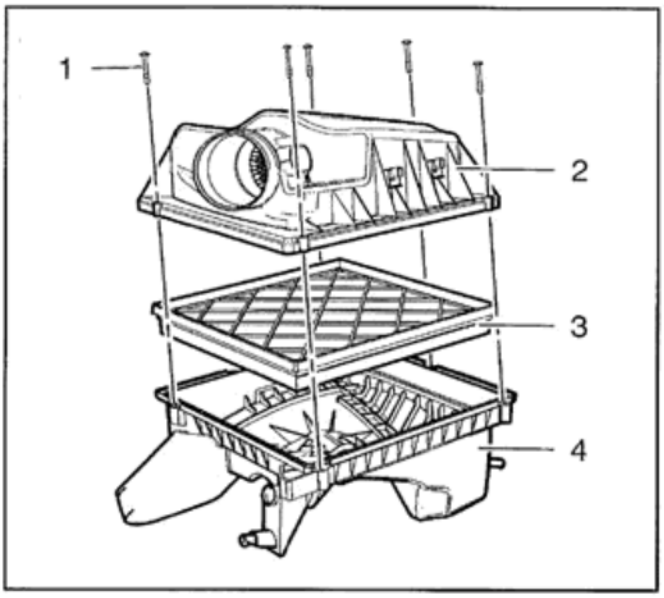
2191533

1. Disconnect mass air flow sensor wiring harness plug (2) from mass air flow sensor (3).
2. Unclip mass air flow sensor wiring harness retainer clip from air cleaner housing (1).



2191547

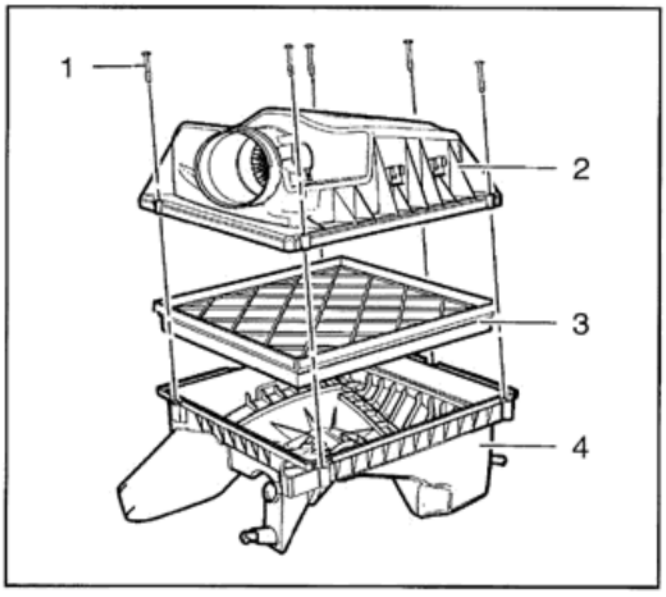
3. Remove the air cleaner outlet duct clamp (3).
4. Remove the air cleaner outlet duct (2) from air cleaner housing (1).



2191545

5. Remove the 5 air cleaner housing bolts (1).
6. Remove the air cleaner upper housing (2) from the air cleaner lower housing (4).
7. Remove the air cleaner element (3).

Installation Procedure

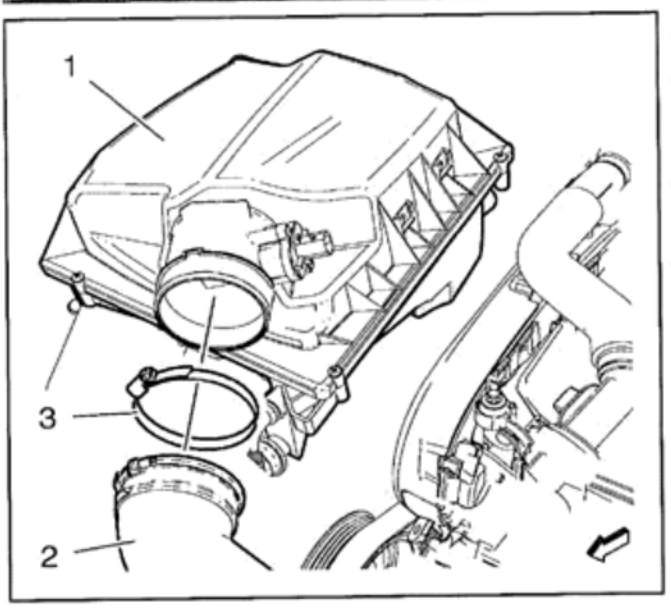


2191545

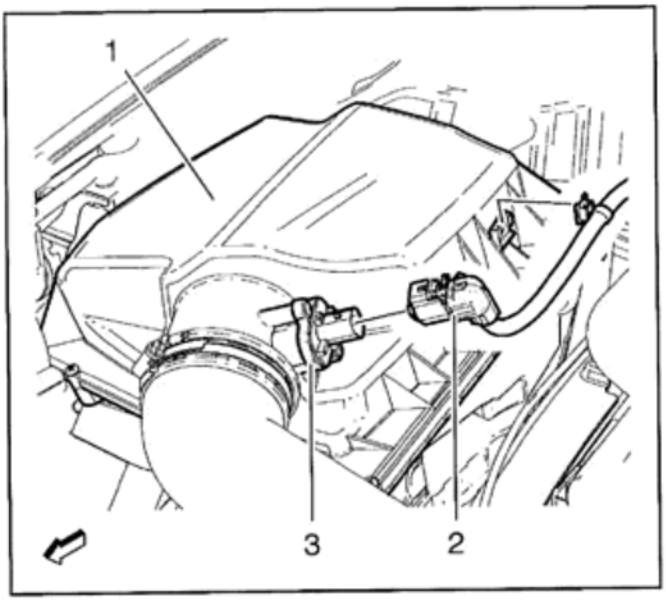
1. Install the air cleaner element (3).
2. Install the air cleaner upper housing (2) to the air cleaner lower housing (4).

Caution: Refer to *Fastener Caution on page 0-8.*

3. Install the 5 air cleaner housing bolts (1).



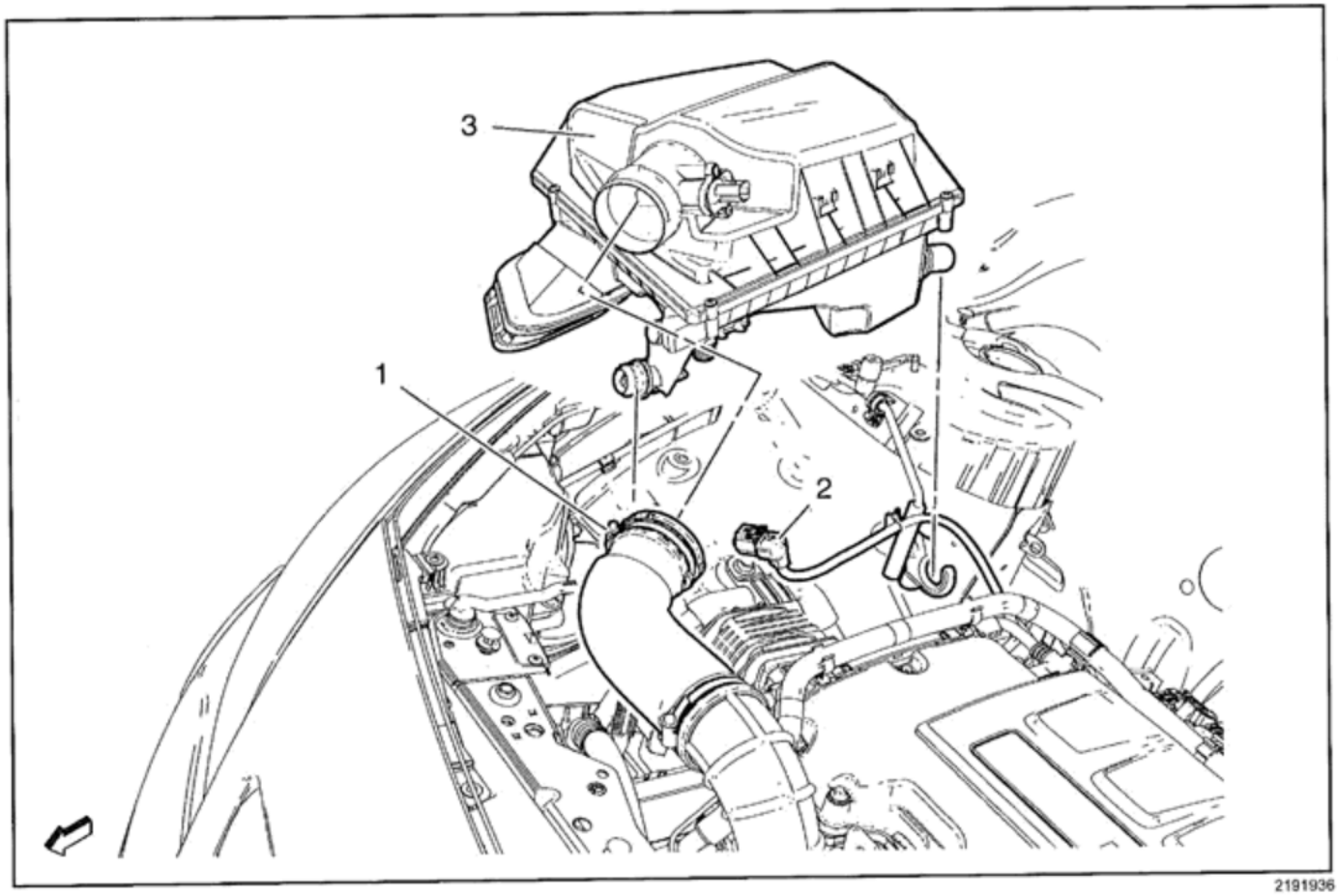
2191547



2191533

4. Install the air cleaner outlet duct (2) to the air cleaner housing (1).
5. Install the air cleaner outlet duct clamp (3).
6. Clip in mass air flow sensor wiring harness retainer clip to air cleaner housing (1).
7. Connect the mass air flow sensor wiring harness plug 2) to the mass air flow sensor (3).

Air Cleaner Assembly Replacement

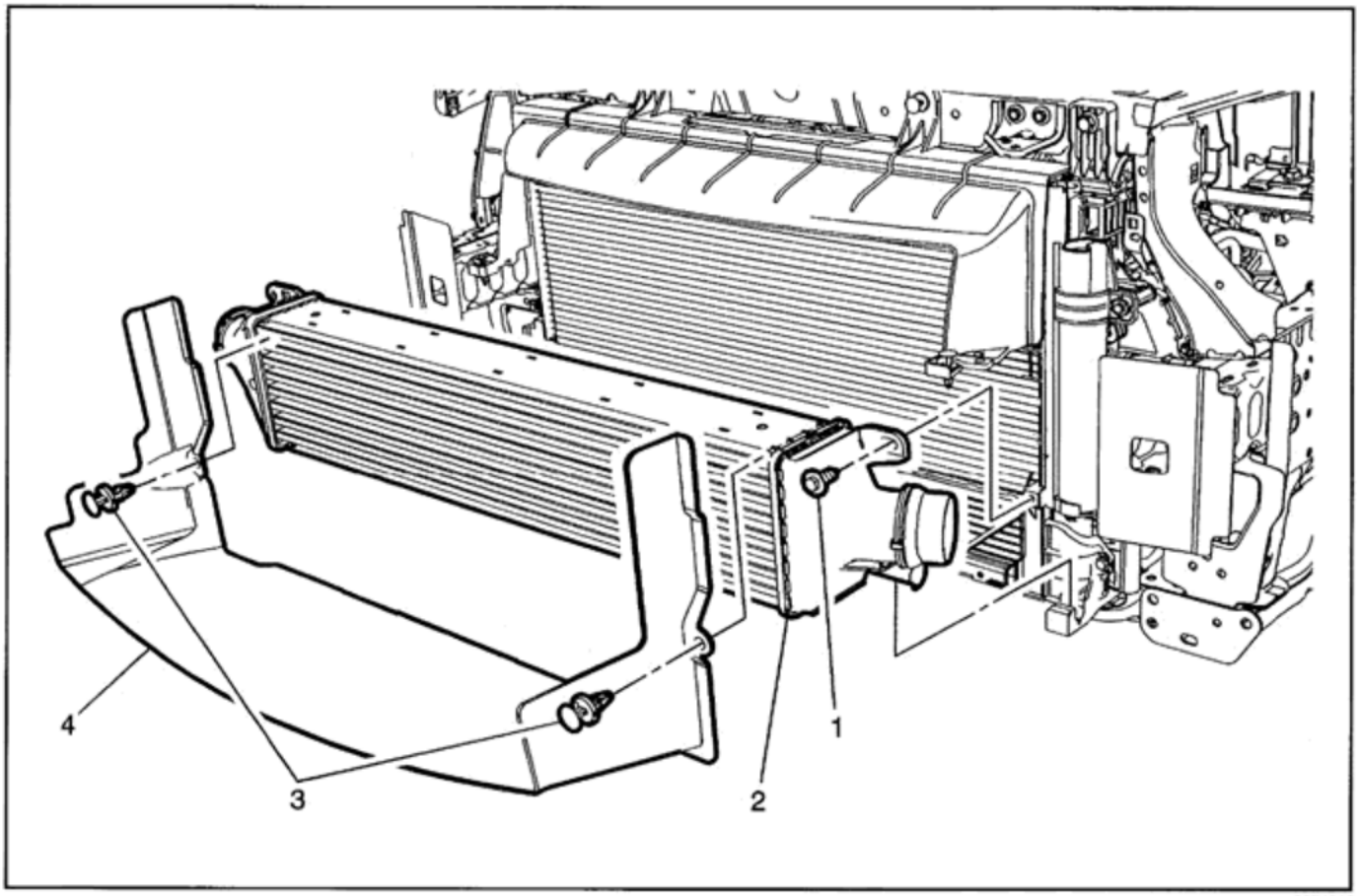


2191936

Air Cleaner Assembly Replacement

Callout	Component Name
1	Air Cleaner Outlet Duct Clamp. **Procedure** Loosen clamp and remove air cleaner outlet duct from air cleaner assembly.
2	Mass Flow Sensor **Procedure** Disconnect mass air flow sensor wiring harness plug from mass air flow sensor and unclip from retainer clip.
3	Air Cleaner Assembly

Charge Air Cooler Replacement



2674916

Charge Air Cooler Replacement

Callout	Component Name
Preliminary Procedures 1. Disconnect the negative battery cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713.* 2. Raise and properly support the vehicle. Refer to *Lifting and Jacking the Vehicle on page 1-31.* 3. Remove the front fascia. Refer to *Front Bumper Fascia Replacement on page 3-55.* 4. Disconnect the charge air cooler inlet duct from the charge air cooler. Refer to *Charge Air Cooler Inlet Air Hose Replacement on page 9-292.* 5. Disconnect the charge air cooler outlet front duct from the charge air cooler. Refer to *Charge Air Cooler Outlet Air Hose Replacement on page 9-293.*	
1	Charge Air Cooler Fastener (Qty 2) **Caution:** Refer to *Fastener Caution on page 0-8.* **Tighten** 10 N•m (89 lb in)

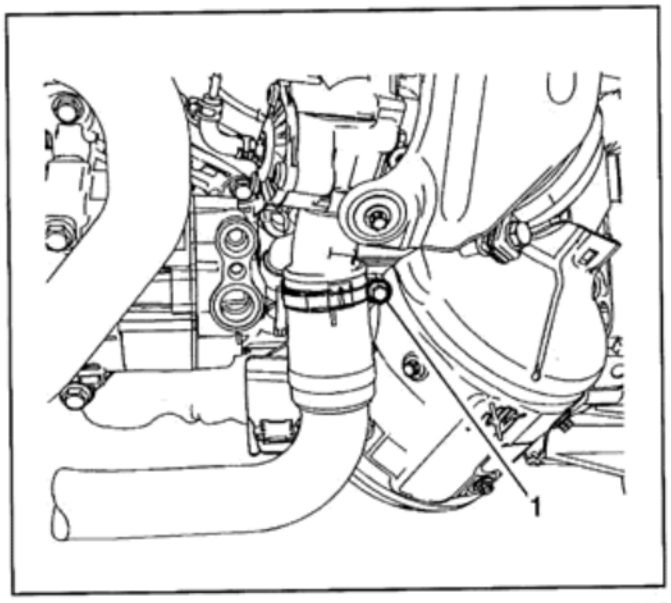
Charge Air Cooler Replacement (cont'd)

Callout	Component Name
2	Charge Air Cooler **Procedure** Pull the charge air cooler upward to release the cooler from the rubber grommets.
3	Charge Air Cooler Air Deflector Fasteners (Qty 2) **Procedure** Remove the charge air cooler air deflector fasteners.
4	Charge Air Cooler Air Deflector

Charge Air Cooler Inlet Air Hose Replacement

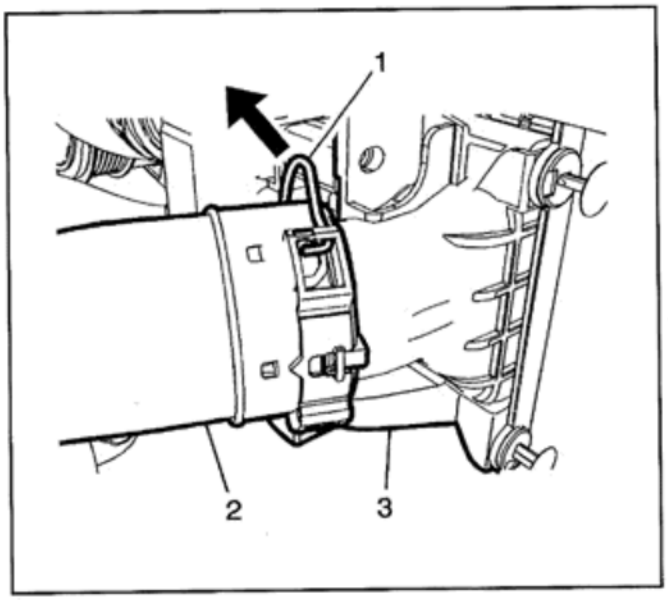
Removal Procedure

1. Disconnect the battery negative cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.
2. Remove the front bumper fascia. Refer to *Front Bumper Fascia Replacement on page 3-55*.



2675417

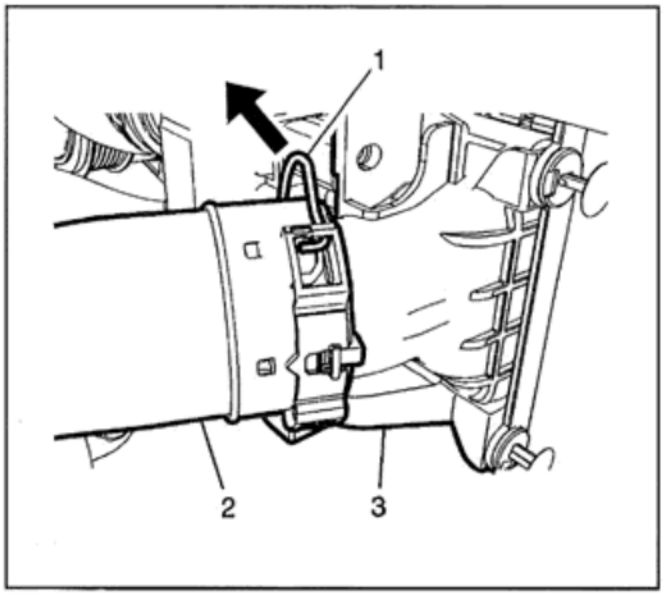
3. Loosen the charge air cooler inlet air pipe clamp (1) at the turbocharger outlet.



2552463

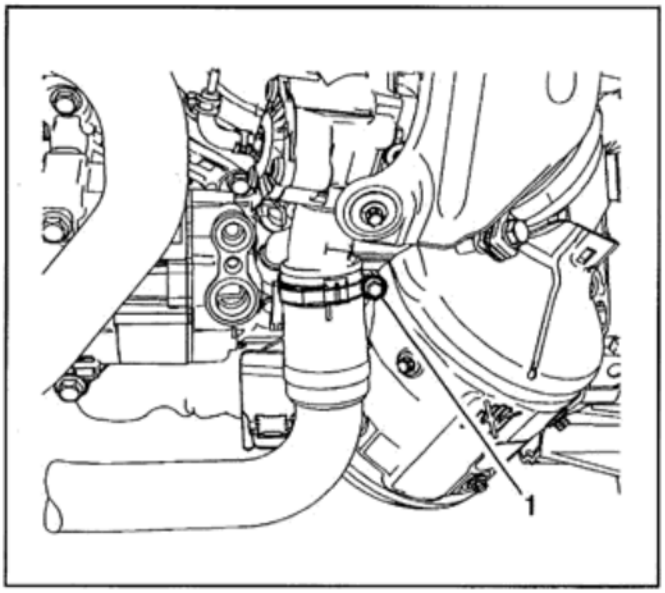
4. Unclip the retainer spring (1) at the charge air cooler inlet.
5. Remove the charge air cooler inlet air hose (2) from the charge air cooler (3) and remove the hose from the vehicle.

Installation Procedure



2552463

1. Install the charge air cooler inlet air hose (2) to charge air cooler (3).
2. Clip the in retainer spring (1).



2675417

3. Install the charge air cooler inlet air pipe to the turbocharger outlet.

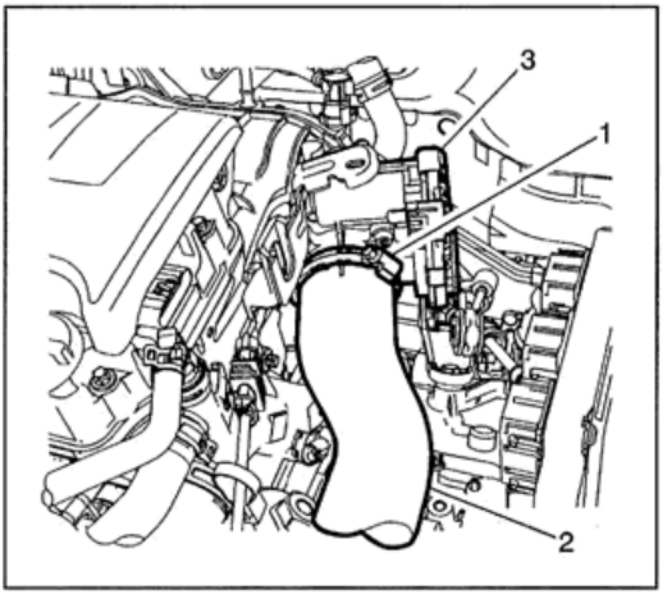
Caution: Refer to *Fastener Caution on page 0-8.*

4. Tighten the clamp (1).
5. Install the front bumper fascia. Refer to *Front Bumper Fascia Replacement on page 3-55.*
6. Connect the battery negative cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713.*

Charge Air Cooler Outlet Air Hose Replacement

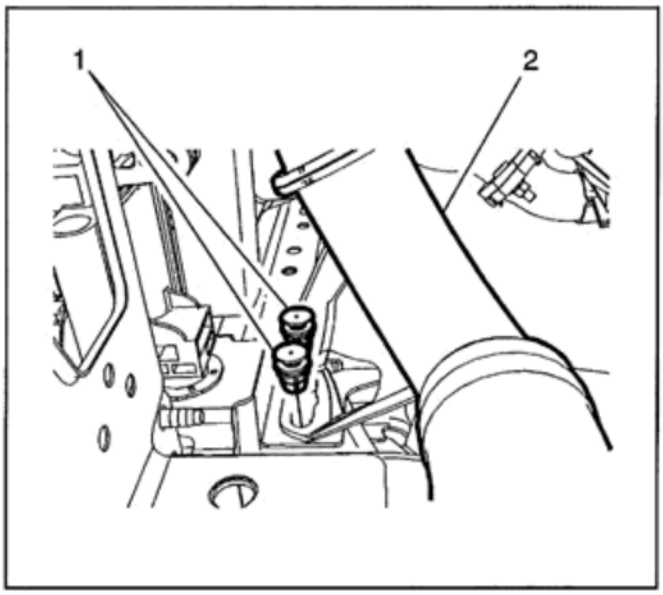
Removal Procedure

1. Remove the front bumper fascia. Refer to *Front Bumper Fascia Replacement on page 3-55.*



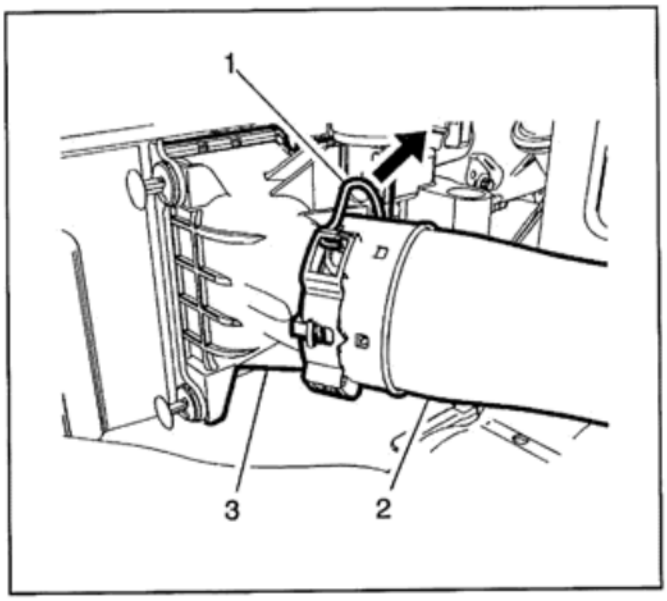
2675424

2. Loosen the clamp (1) at the charge air cooler outlet pipe (2) to throttle body (3).
3. Disconnect the intake air pressure and temperature sensor harness connector.



2552516

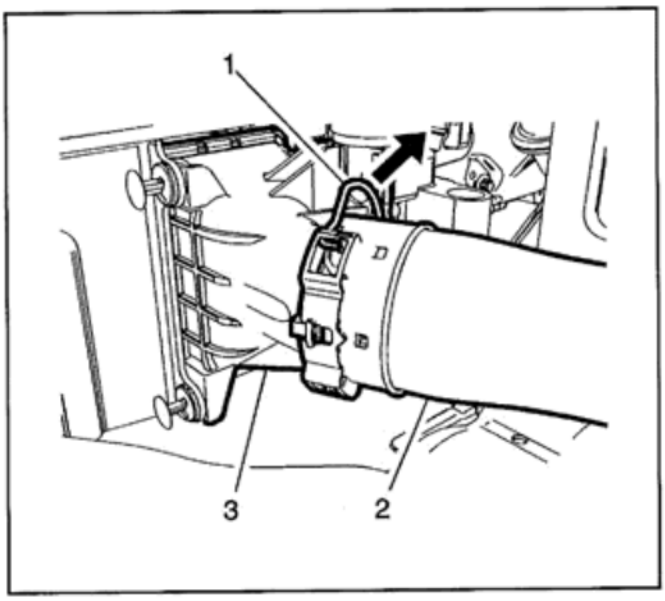
4. Remove the plastic fasteners (1) from the charge air cooler outlet air pipe to frame bracket (2).



2552472

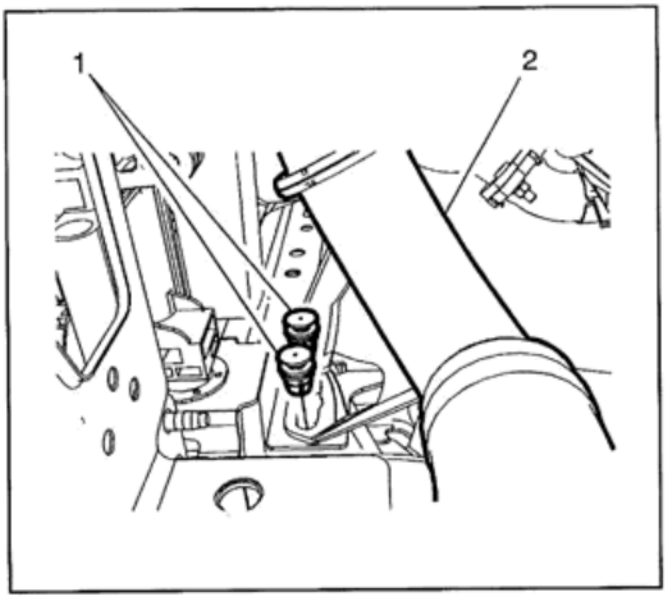
5. Unclip the retainer spring (1).
6. Remove the charge air cooler outlet air hose (2) from the charge air cooler (3).
7. Transfer parts as necessary.

Installation Procedure



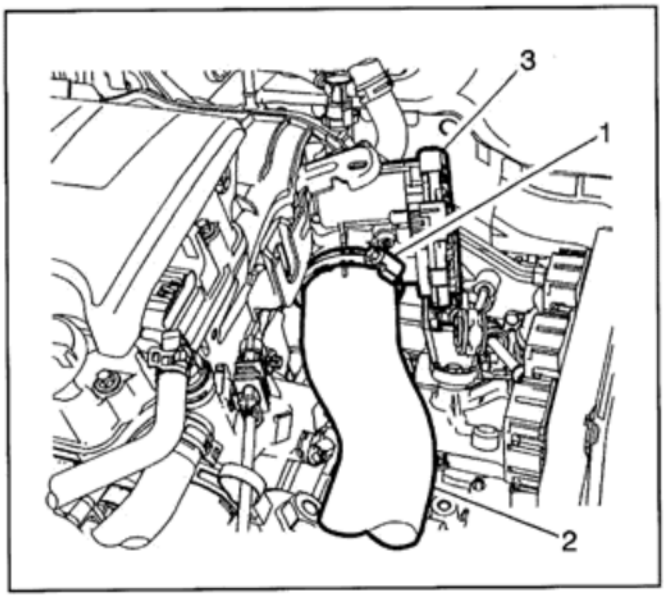
2552472

1. Install the charge air cooler outlet air hose (2) to charge air cooler (3).
2. Clip the in retainer spring (1).
3. Connect the intake air pressure and temperature sensor harness connector.



2552516

4. Install the plastic fasteners (1) to the charge air cooler outlet air pipe to frame bracket (2).



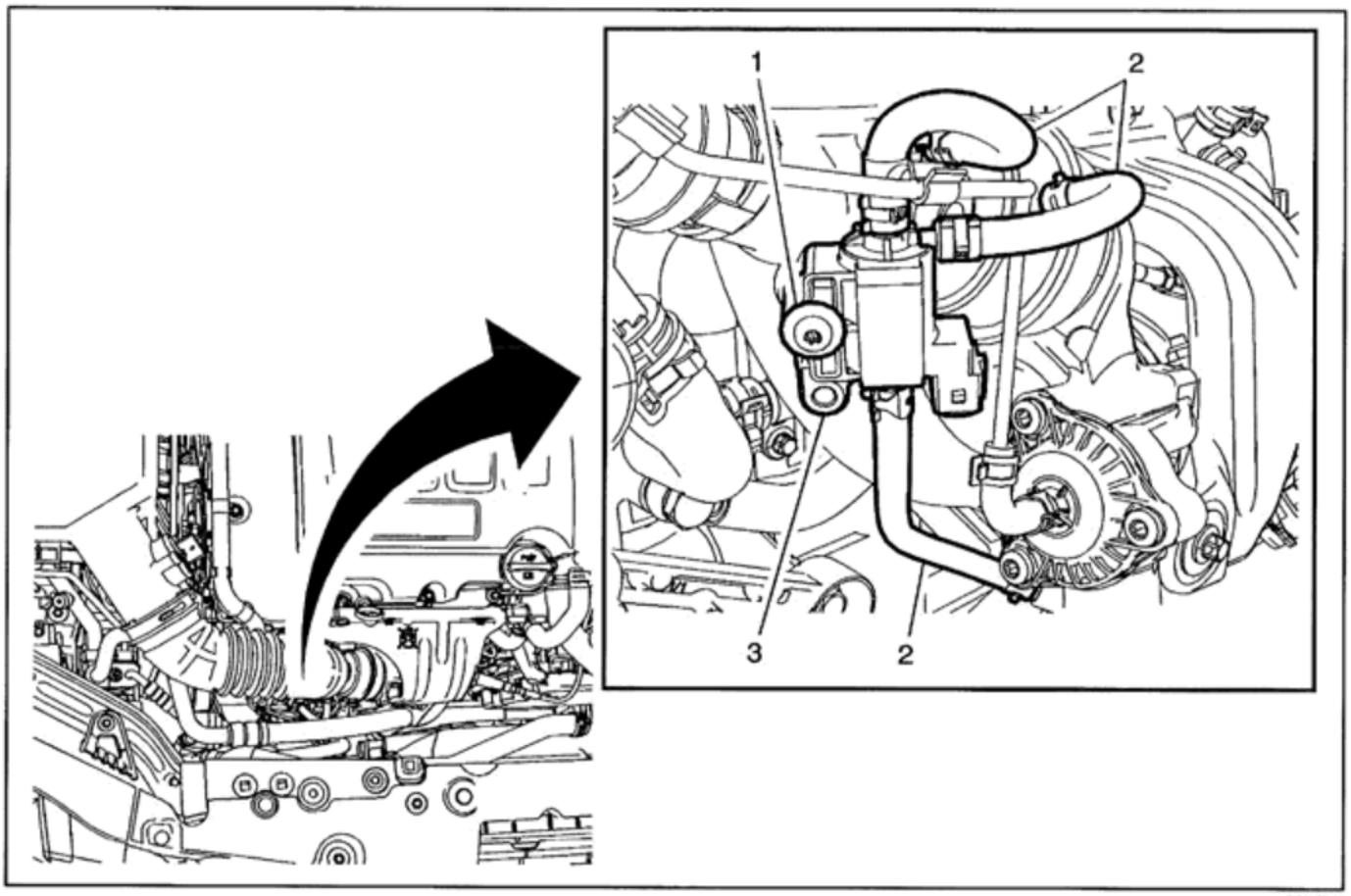
2675424

5. Install the charge air cooler inlet air pipe to the turbocharger.

Caution: Refer to *Fastener Caution on page 0-8*.

6. Tighten the clamp (1).
7. Install the front bumper fascia. Refer to *Front Bumper Fascia Replacement on page 3-55*.

Charge Air Bypass Regulator Solenoid Valve Replacement



2675517

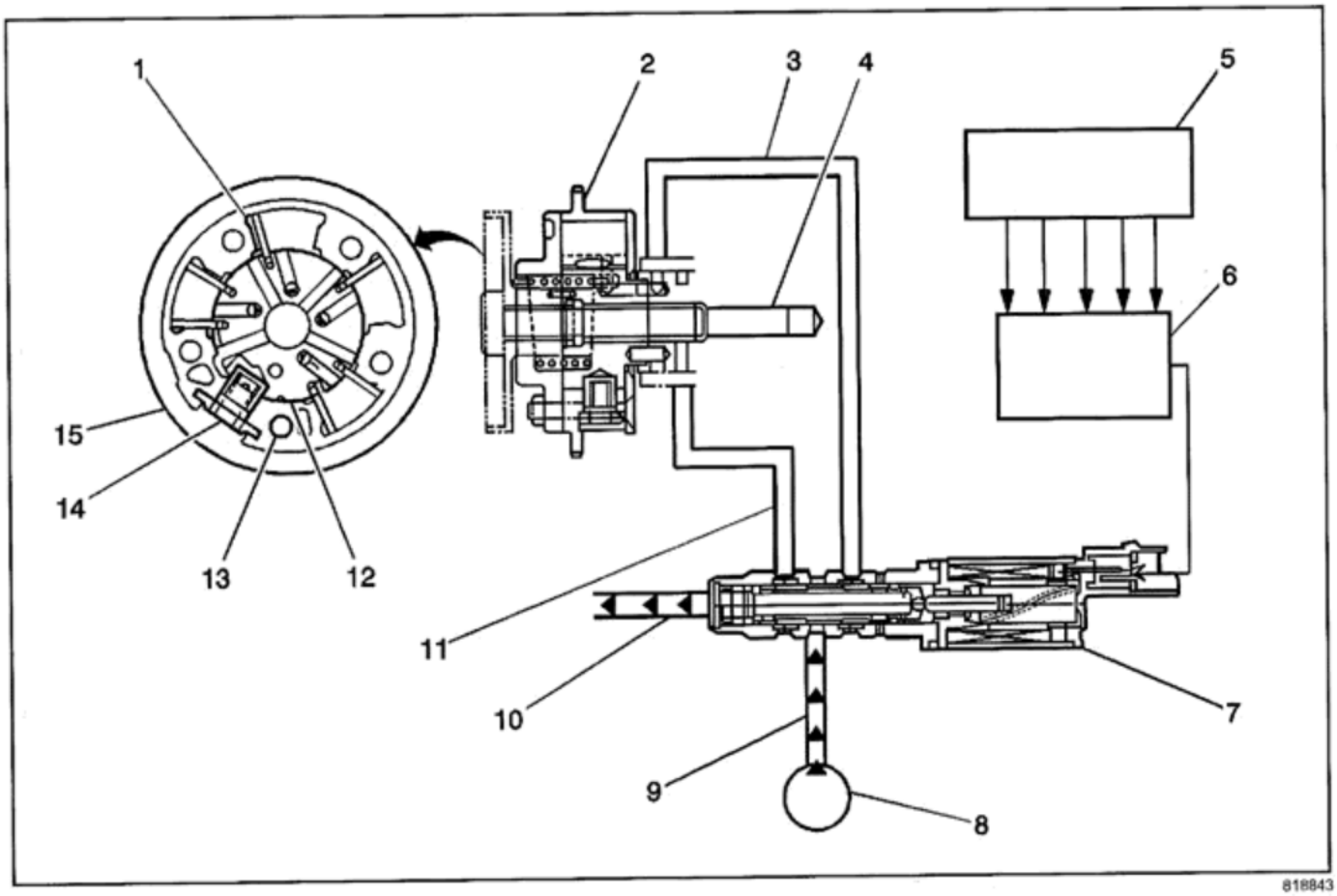
Charge Air Bypass Regulator Solenoid Valve Replacement

Callout	Component Name
Preliminary Procedure Disconnect the radiator outlet hose from the water inlet. Refer to *Water Inlet Replacement (LUW) on page 9-668* or *Water Inlet Replacement (LUV) on page 9-669*.	
1	Charge Air Bypass Regulator Solenoid Valve Fastener **Caution:** Refer to *Fastener Caution on page 0-8*. **Tighten** 8 N•m (71 lb in)
2	Charge Air Bypass Regulator Solenoid Valve Hose (Qty: 3)
3	Charge Air Bypass Regulator Solenoid Valve **Procedure** Disconnect the electrical connector.

Description and Operation

Camshaft Actuator System Description

Camshaft Actuator System Overview



Legend

(1) Camshaft Actuator Vane
(2) Timing Chain Sprocket
(3) Engine Oil Pressure-For retarding the camshaft
(4) Camshaft
(5) Input Signals from Engine Sensors
(6) Engine Control Module (ECM)
(7) Camshaft Actuator Solenoid
(8) Engine Oil Pump
(9) Engine Oil Pressure Supply
(10) Engine Oil Drain
(11) Engine Oil Pressure-For advancing the camshaft
(12) Camshaft Actuator Rotor
(13) Camshaft Position Sensor Reluctor
(14) Camshaft Actuator Lock Pin
(15) Camshaft Actuator Housing

The camshaft actuator system enables the engine control module (ECM) to change camshaft timing of all 4 camshafts while the engine is operating. The camshaft position (CMP) actuator assembly (15) varies the camshaft position in response to directional changes in oil pressure. The CMP actuator solenoid valve controls the oil pressure that is applied to advance or retard a camshaft. Modifying camshaft timing under changing engine demand provides better balance between the following performance concerns:

- Engine power output
- Fuel economy
- Tailpipe emissions

The CMP actuator solenoid valve (7) is controlled by the ECM. The crankshaft position (CKP) sensor and the CMP sensors are used to monitor changes in camshaft positions. The ECM uses the following information in order to calculate the desired camshaft positions:

- Engine coolant temperature
- Calculated engine oil temperature (EOT)
- Mass air flow (MAF)
- Throttle position (TP)
- Vehicle speed
- Volumetric efficiency

Operation

The CMP actuator assembly has an outer housing that is driven by an engine timing chain. Inside the assembly is a rotor with fixed vanes that is attached to the camshaft. Oil pressure that is applied to the fixed vanes will rotate a specific camshaft in relationship to the crankshaft. The movement of the intake camshafts will advance the intake valve timing. The movement of the exhaust camshafts will retard the exhaust valve timing. When oil pressure is applied to the return side of the vanes, the camshafts will return to 0 crankshaft degrees, or top dead center (TDC). The CMP actuator solenoid valve directs the oil flow that controls the camshaft movement. The ECM commands the CMP solenoid to move the solenoid plunger and spool valve until oil flows from the advance passage (11). Oil flowing thru the CMP actuator assembly from the CMP solenoid advance passage applies pressure to the advance side of the vanes in the CMP actuator assembly. When the camshaft position is retarded, the CMP actuator solenoid valve directs oil to flow into the CMP actuator assembly from the retard passage (3). The ECM can also command the CMP actuator solenoid valve to stop oil flow from both passages in order to hold the current camshaft position.

The ECM operates the CMP actuator solenoid valve by pulse width modulation (PWM) of the solenoid coil. The higher the PWM duty cycle, the larger the change in camshaft timing. The CMP actuator assembly also contains a lock pin (14) that prevents movement between the outer housing and the rotor vane assembly. The lock pin is released by oil pressure before any movement in the CMP actuator assembly takes place. The ECM is continuously comparing CMP sensor inputs with CKP sensor input in order to monitor camshaft position and detect any system malfunctions. If a condition exists in either the intake or exhaust camshaft actuator system, the opposite bank, intake or exhaust, camshaft actuator will default to 0 crankshaft degrees.

CMP Actuator System Operation

Driving Condition	Change in Camshaft Position	Objective	Result
Idle	No Change	Minimize Valve Overlap	Stabilized Idle Speed
Light Engine Load	Retarded Valve Timing	Decrease Valve Overlap	Stabled Engine Output
Medium Engine Load	Advanced Valve Timing	Increase Valve Overlap	Better Fuel Economy with Lower Emissions
Low to Medium RPM with Heavy Load	Advanced Valve Timing	Advance Intake Valve Closing	Improved Low to Mid-range Torque
High RPM with Heavy Load	Retarded Valve Timing	Retard Intake Valve Closing	Improved Engine Output

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) collects information from the crankshaft position sensor and the intake/exhaust camshaft position sensors to determine the sequence, dwell, and timing of the spark for each cylinder. The ECM transmits a frequency signal to the ignition coil module on the individual ignition control circuits to fire the spark plugs.

Crankshaft Position Sensor

The crankshaft position sensor is an externally magnetically biased digital output integrated circuit sensing device. The sensor provides a pulse for each magnetic pole of the encoder wheel on the crankshaft. The sensor produces an ON/OFF DC voltage of varying frequency, with 58 output pulses per crankshaft revolution. The frequency of the sensor output depends on the velocity of the crankshaft. The ECM uses sensor signal pulse to determine crankshaft speed and position to calculate the best timing for ignition and fuel injection. The ECM also uses the crankshaft position sensor information 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.

The crankshaft position sensor is connected to the engine control module by the circuits listed below:

- A 5 V reference circuit
- A low reference circuit
- A signal circuit

Crankshaft Encoder Wheel

The crankshaft encoder wheel is part of the crankshaft. The encoder wheel consists of 58 tooth and a reference gap. Each tooth on the encoder wheel is spaced 6° apart with a 12° space for the reference gap. The pulse from the reference gap is known as the sync pulse. The sync pulse is used to synchronize the ignition coil module firing sequence with the crankshaft position while the other tooth provides cylinder location during a revolution.

Camshaft Position Sensors

The intake and exhaust camshaft position sensors are each triggered by a notched reluctor wheel built onto the camshaft sprockets. The four signal pulses occur every camshaft revolution. Each notch is a different size which is used to identify the compression stroke of

each cylinder and to enable sequential fuel injection. The camshaft position sensors are connected to the ECM by the circuits listed below:

- A 5 V reference circuit
- A low reference circuit
- A signal circuit

Ignition Coil Module

The ignition coil module integrates the 4 coils and the ignition control module within a single sealed component.

The ignition coil module has the following circuits:

- An ignition voltage circuit
- A ground
- A low reference circuit
- 4 ignition coil control circuits

The ECM controls the individual coils by transmitting timing pulses on the ignition coil control circuit to each ignition coil to enable a spark event.

The spark plugs are connected to each coil by a short boot. The boot contains a spring that conducts the spark energy from the coil to the spark plug. The spark plug electrode is coated with platinum for long wear and higher efficiency.

Engine Control Module (ECM)

The ECM controls all ignition system functions and constantly adjusts the spark timing. The ECM monitors information from various sensor inputs that include the following:

- The crankshaft position sensor
- The accelerator pedal position (APP)
- The manifold absolute pressure (MAP) sensor
- The intake air temperature (IAT) sensor
- The vehicle speed sensor (VSS)
- The engine knock sensor
- The engine coolant temperature (ECT) sensor
- The mass airflow (MAF) sensor
- The camshaft position sensors

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.

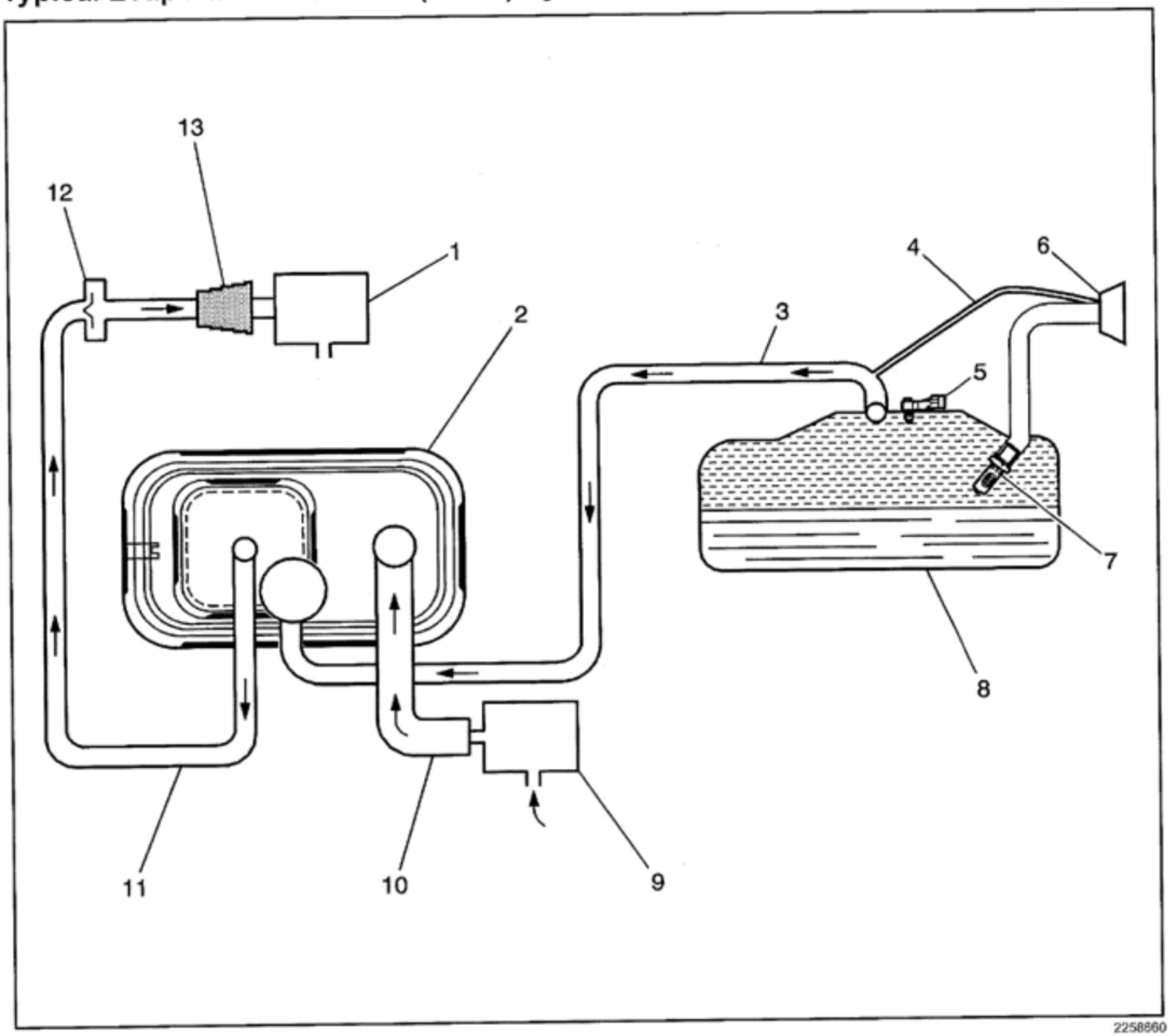
Emissions Control Information Label

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).

Evaporative Emission Control System Description

Typical Evaporative Emission (EVAP) System Hose Routing Diagram



Legend

(1) Evaporative Emissions (EVAP) Purge Solenoid Valve
(2) EVAP Canister
(3) EVAP Vapor Tube
(4) Vapor Recirculation Tube
(5) Fuel Tank Pressure Sensor
(6) Fuel Filler Cap (Some Vehicles May Have A Capless Design)
(7) Fuel Fill Pipe Inlet Check Valve
(8) Fuel Tank
(9) EVAP Canister Vent Solenoid Valve
(10) Vent hose
(11) EVAP Purge Tube
(12) Purge Tube Check Valve, Turbo-Charged Applications Only
(13) EVAP Canister Purge Tube Connector

EVAP System Operation

The evaporative emission (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 (FTP) sensor for an increase in vacuum. The ECM will log a fault 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 FTP 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 log a fault 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 FTP 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

Turbocharged vehicles have a check valve in the purge tube between the EVAP purge solenoid valve and the EVAP canister to prevent pressurization of the EVAP system under boost conditions. Note that the presence of this one-way check valve prevents pressure testing the EVAP system for leaks at the EVAP canister purge tube connector.

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.

Fuel Tank Pressure Sensor

The FTP sensor measures the difference between the pressure or vacuum in the fuel tank and outside air pressure. The ECM provides a 5 V reference and a ground to the FTP sensor. 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. The FTP sensor provides a signal voltage back to the ECM that can vary between 0.1–4.9 V. A high FTP sensor voltage indicates a low fuel tank pressure or vacuum. A low FTP 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.

Fuel Fill Cap

The fuel fill cap is equipped with a seal and a vacuum relief valve.

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.

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.

The fuel tank stores the fuel supply. 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 fuel injection system. The fuel tank fuel pump module contains a reverse flow check valve. The check valve maintains fuel pressure in the fuel feed pipe and the fuel rail in order to prevent long cranking times.

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. A 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 flow control module via a GMLAN serial data message. A liquid fuel pressure sensor provides the feedback the fuel pump flow control module requires for Closed Loop fuel pressure control.

Fuel Pump Flow Control Module

The fuel pump flow control module is a serviceable GMLAN module. The fuel pump flow 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 flow 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 15 A. A liquid fuel pressure sensor provides fuel pressure feedback to the fuel pump flow control module.

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 fuel pump flow control module through a vehicle wiring harness. The sensor provides a fuel pressure signal to the fuel pump flow control module, which is used to provide Closed Loop fuel pressure control.

Fuel Tank

The fuel tank stores the fuel supply. The fuel tank is located in the rear of the vehicle. The fuel tank is held in place by 2 metal straps that are attached to the underbody. The fuel tank is molded from high-density polyethylene.

Fuel Filler Cap

The fuel fill pipe has a tethered fuel filler cap.
A torque-limiting device prevents the cap from being overtightened. To install the cap, turn the cap clockwise until the cap clicks audibly. This indicates that the cap is correctly torqued and fully seated.

Fuel Tank Fuel Pump Module

The fuel tank fuel pump module consists of the following components:

- The fuel level sensor
- The fuel pump
- The fuel strainer
- The pressure relief regulator valve
- The 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 ECM sends the fuel level signal via a High Speed CAN-Bus signal to the body control module (BCM). The BCM then sends the information via a Low Speed CAN-Bus signal to the instrument cluster to display the fuel level. When the fuel level falls below 11% the instrument cluster illuminates the low fuel level indicator. The ECM also monitors the fuel level input for various diagnostics.

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 fuel injection system 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.

Fuel Strainer

The fuel strainer is attached to the lower end of the fuel tank fuel pump module. The fuel strainer is made of woven plastic. The functions of the fuel strainer are to filter contaminants and to wick away fuel. Normally, the fuel strainer does not require maintenance. Fuel stoppage at this point indicates that the fuel tank contains an abnormal amount of sediment or contamination.

Jet Pump

The 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

jet pump through a restrictive orifice located on the pump cover. The jet pump fills the reservoir of the fuel tank fuel pump module.

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 flow 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.

Nylon Fuel Pipes

Warning: Refer to Fuel and Evaporative Emission Pipe Warning on page 0-4.

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 shaped around gradual turns under the vehicle. However, if nylon fuel pipes are forced into sharp bends, the pipes may kink and restrict the flow of fuel. Also, once exposed to fuel, nylon pipes may become stiffer and are more likely to kink if bent too far. Exercise special care when working on a vehicle with nylon fuel pipes.

Quick-Connect Fittings

Nylon fuel pipes are somewhat flexible and can be shaped around gradual turns under the vehicle. However, if nylon fuel pipes are forced into sharp bends, the pipes may kink and restrict the flow of fuel. Also, once exposed to fuel, nylon pipes may become stiffer and are more likely to kink if bent too far. Exercise special care when working on a vehicle with nylon fuel pipes.

Fuel Rail Assembly

The fuel rail assembly is attached to the engine intake manifold. The fuel rail assembly performs the following functions:

- Positions the injectors in the intake manifold
- Distributes fuel evenly to the injectors

Fuel Injectors

The fuel injector assembly is a solenoid device controlled by the ECM that meters pressurized fuel to a single engine cylinder. The ECM energizes the high-impedance, 12 Ω, injector solenoid to open a ball valve, normally closed. This allows fuel to flow into the top of the injector, past the ball valve, and through a director plate at the injector outlet. The director plate has machined holes that control the flow of fuel, generating a spray of finely atomized fuel at the injector tip. Fuel from the injector tip is directed at the intake valve, causing the fuel to become further atomized and vaporized before entering the combustion chamber. This fine atomization improves fuel economy and emissions.

Fuel Metering Modes of Operation

The ECM monitors voltages from several sensors in order to determine how much fuel to feed to 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.

Clear Flood Mode

If the engine is flooded with fuel during starting and will not start, the clear flood mode can be manually enabled. To enable Clear Flood Mode, press the accelerator to wide open throttle (WOT). The ECM will completely turn OFF the fuel injectors and will maintain this mode as long as the ECM detects a WOT condition with engine speed below a predetermined value.

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).

Knock Sensor System Description

Circuit/System Description

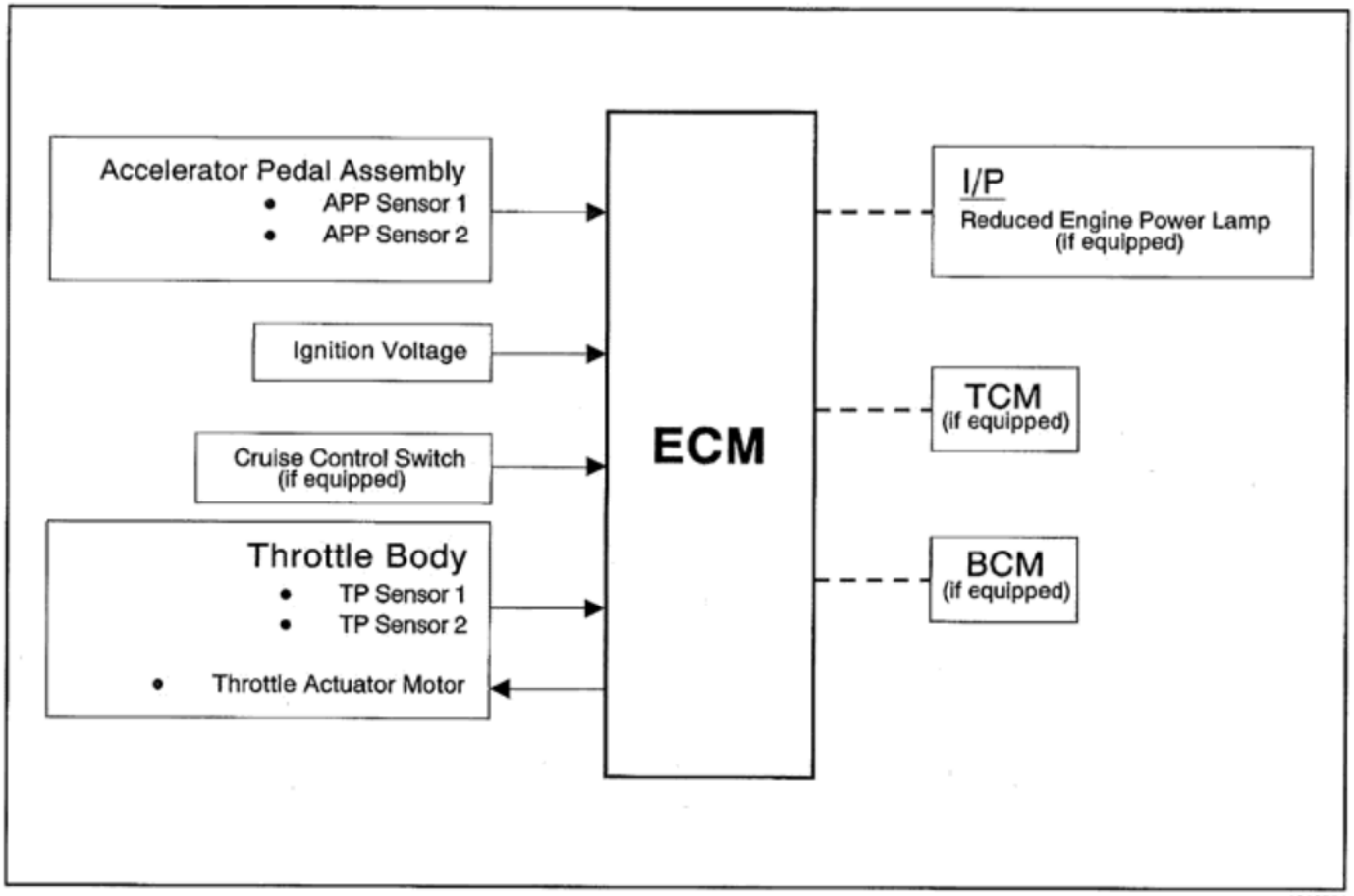
The knock sensor system enables the engine control module (ECM) to control the ignition timing for the best possible performance while protecting the engine from potentially damaging levels of detonation. The ECM uses the knock sensor system to test for abnormal engine noise that may indicate detonation, also known as spark knock.

Sensor Description

This knock sensor system uses one or two flat response dual-wire sensors. The sensor uses piezo-electric crystal technology that produces an alternating current (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 2 isolated signal circuits.

If the ECM has determined that knock is present, it will retard the ignition timing to attempt to reduce the knock. The ECM is capable of controlling spark retard on an individual cylinder basis. The ECM will always try to work back to a zero compensation level, or no spark retard. knock sensor diagnostics are calibrated to detect faults with the knock sensor circuitry inside the ECM, 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 mechanical engine noise.

Throttle Actuator Control (TAC) System Description



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.
- Minimum pedal value—At key-up, the ECM updates the learned minimum pedal value.
- Battery saver mode—After a predetermined time without engine RPM, 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.

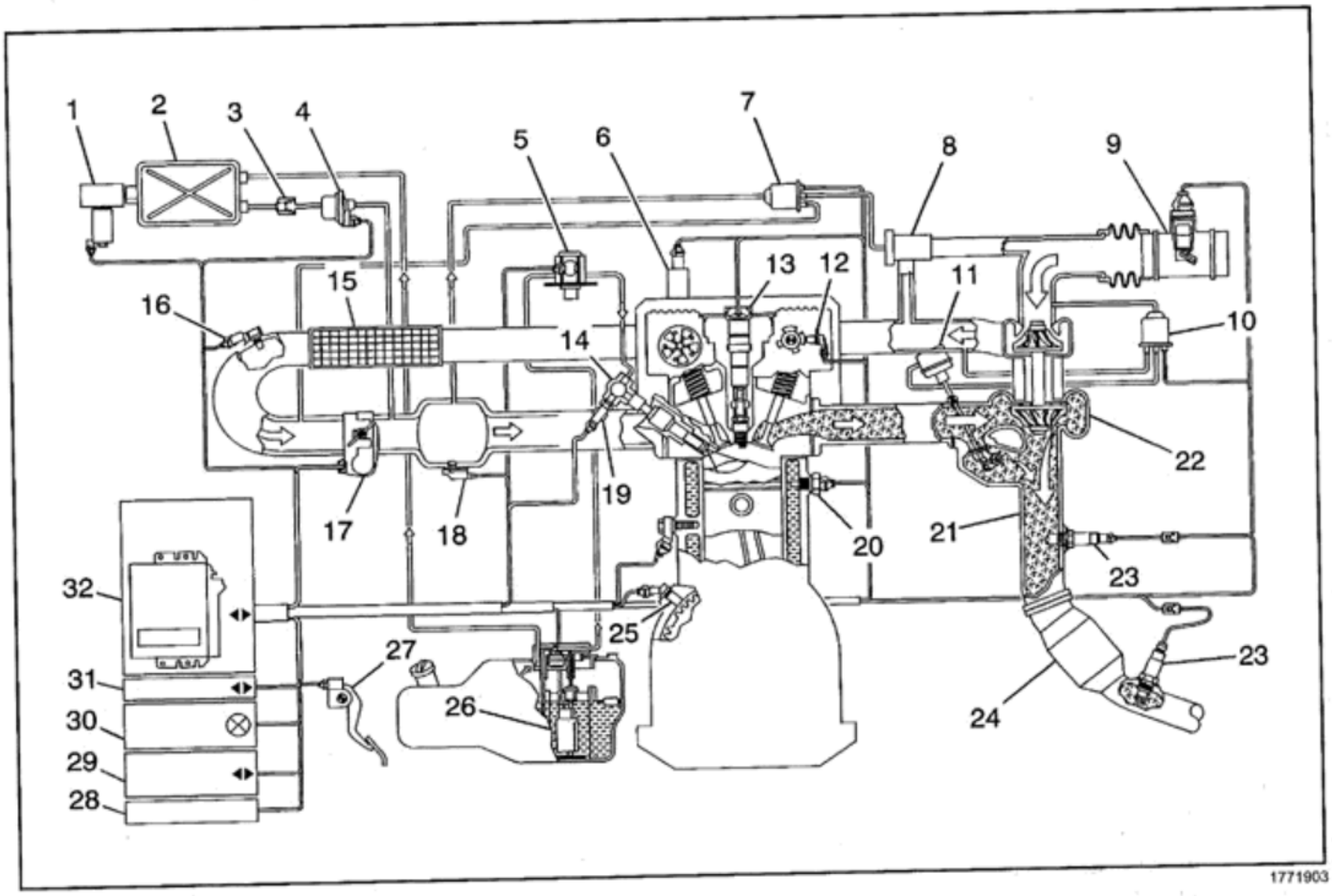
Reduced Engine Power Mode

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 idle positioning the throttle position, or by controlling the fuel and spark if the throttle is turned OFF.
  - Ignore the accelerator pedal input.
- Engine shutdown mode—The ECM will disable fuel and de-energize the throttle actuator.

Turbocharger System Description



Legend

(1) Evaporative Emission (EVAP) Canister Vent Solenoid Valve
(2) EVAP Canister
(3) Non-Return Valve
(4) EVAP Canister Purge Solenoid Valve
(5) High Pressure Fuel Pump
(6) Camshaft Position Actuator Solenoid
(7) Turbocharger Bypass Solenoid Valve
(8) Turbocharger Bypass Valve
(9) Mass Air Flow (MAF)/Intake Air Temperature (IAT) Sensor
(10) Turbocharger Wastegate Regulator Solenoid Valve
(11) Turbocharger Wastegate Diaphragm Valve
(12) Camshaft Position Sensor
(13) Ignition Coil/Module and Spark Plug
(14) Fuel Injector
(15) Charge Air Cooler
(16) Intake Air Pressure and Temperature Sensor
(17) Throttle Body
(18) Manifold Absolute Pressure (MAP) Sensor
(19) Fuel Rail Pressure Sensor
(20) Engine Coolant Temperature (ECT) Sensor
(21) Engine Exhaust Manifold
(22) Turbocharger
(23) Heated Oxygen Sensor (HO2S) 1 and 2
(24) Catalyst
(25) Crankshaft Position Sensor
(26) Fuel Pump Module
(27) Accelerator Pedal
(28) Theft Deterrent
(29) Data Link Connector (DLC)
(30) Malfunction Indicator Lamp (MIL)
(31) GMLAN Serial Data
(32) Engine Control Module (ECM)

Turbocharger Description and Operation

A turbocharger is a compressor that is used to increase the power output of an engine by increasing the mass of the oxygen and therefore the fuel entering the engine. The BorgWarner™ dual-scroll turbocharger is mounted on the exhaust manifold and the lightweight turbine is driven by the waste energy generated by the flow of the exhaust gases. The turbine is connected by a shaft to the compressor which is mounted in the induction system of the engine. The compressor vanes compress the intake air above atmospheric pressure, thereby greatly increasing the density of the air entering the engine.

The turbocharger incorporates a wastegate that is controlled by the ECM, by means of a PWM solenoid, to regulate the pressure ratio of the compressor. An integral turbocharger bypass valve, controlled by the ECM through a remotely mounted solenoid, is used to prevent compressor surging and damage by opening during abrupt closed throttle conditions. The bypass valve opens during closed throttle deceleration conditions, which allows the air to recirculate in the turbocharger and maintain compressor speed. During a wide open throttle command, the bypass valve closes to optimize turbo response.

The turbocharger is connected to the engine oiling system by a supply and drain tube and synthetic oil is installed at the factory. Synthetic oil is required for its friction-reducing capabilities and high-temperature performance. There is a cooling system circuit in the turbocharger that utilizes the engine coolant to further reduce operating temperatures.

Turbocharger Wastegate Solenoid Valve

The wastegate valve opens and closes a bypass passage beside the turbine wheel. A spiral spring works in the closing direction while the pressure in the diaphragm works in the opening direction. The ECM supplies a PWM signal to the solenoid valve, which then allows pressure from the turbo to come through. When the pressure overcomes the spring force the actuator rod begins to move, opening the wastegate valve to a corresponding degree. The ECM changes wastegate valve opening by varying the PWM signal, which regulates the turbine speed.

At low loads, the wastegate valve is closed. All the exhaust gas then passes through the turbine. At high loads, the volume of exhaust gas is greater, which makes the turbine wheel rotate faster. This delivers a greater air displacement to the engine.

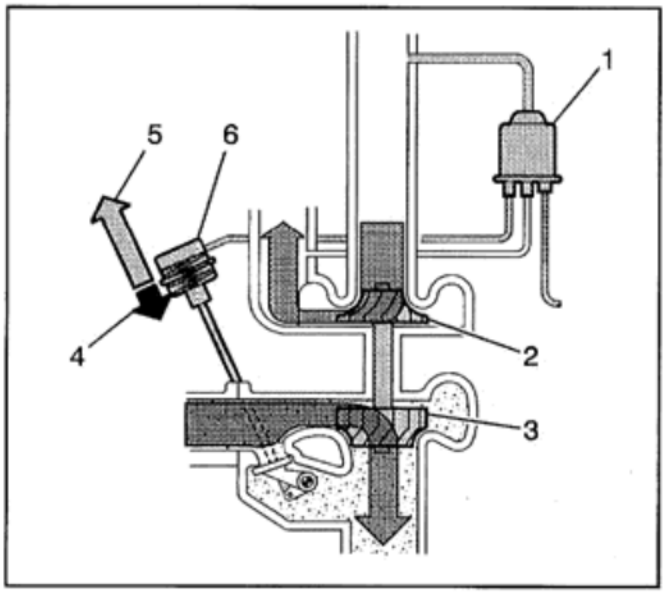
When the air displacement becomes so large that the current air mass per combustion cannot be controlled with the throttle alone, the turbo must be regulated. This is done by opening the wastegate valve so that some of the exhaust gas passes through the wastegate. Consequently, this gas does not contribute to driving the turbine and the turbine speed will be regulated so that the turbo air displacement will be correct.

When certain DTCs are set the ECM will limit the amount of available boost pressure. Limiting boost pressure is accomplished by the ECM controlling the wastegate actuator solenoid valve and maintaining the duty cycle at 0 %. This means that the ECM will not actively close the wastegate during greater engine loads. The system at this point is limited to mechanical boost. Mechanical boost means that the wastegate will still move, but the amount of motion is limited by the mechanical properties of the return spring within the diaphragm valve, the pneumatic properties of the actuator, and the physics of the exhaust gas flow in the exhaust system.

The turbocharger wastegate diaphragm valve assembly has a threaded rod and nut that connects the diaphragm of the valve to the wastegate. This rod is adjusted to BorgWarner™ factory specifications and is not adjustable.

The following diagrams illustrate the turbocharger wastegate closed and open conditions:

Turbocharger Wastegate Closed

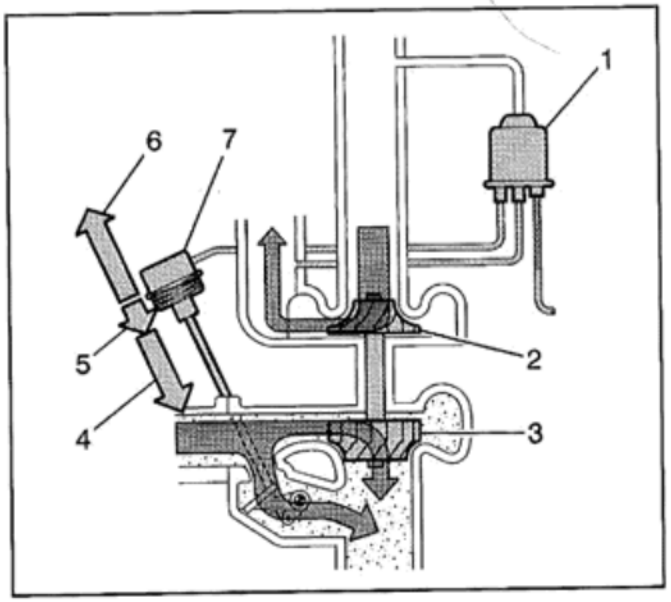


1964698

Legend

(1) Turbocharger Wastegate Actuator Solenoid Valve with Duty Cycle at 100 percent
(2) Compressor
(3) Turbine
(4) Exhaust Gas Pressure
(5) Spring Force
(6) Turbocharger Wastegate Diaphragm Valve

Turbocharger Wastegate Open



1964696

Legend

(1) Turbocharger Wastegate Actuator Solenoid Valve with Duty Cycle at 0 percent
(2) Compressor
(3) Turbine
(4) Regulating Pressure
(5) Exhaust Gas Pressure
(6) Spring Force
(7) Turbocharger Wastegate Diaphragm Valve

The wastegate is completely closed at idle. All of the exhaust energy is passing through the turbine.

During normal operation, when wide open throttle is requested at lower engine speeds, the ECM commands the wastegate solenoid with a duty cycle of 100 % to minimize any turbo lag. During engine loads in the middle and upper RPM ranges, the ECM commands the solenoid with a duty cycle of 65–80 %.

Turbocharger Bypass Solenoid Valve

The turbocharger bypass valve prevents the turbo from exceeding the pump limit at low flow and high pressure. This occurs when the engine is running with a load and the throttle suddenly closes. In this case, flow is almost null and pressure is very high. This not only is damaging to the turbocharger, but also generates noise and decelerates turbine speed. The ECM supplies a voltage signal to the solenoid valve output driver, which regulates the open or closed valve position.

Accelerator Pedal Depressed

The bypass valve is closed. The force in the return spring integrated in the valve presses the valve cone against its seat in the turbo housing. The valve is turned OFF.

Accelerator Pedal Released

In order to avoid pressure spikes in the intake manifold and unloading or overrunning the turbo, the ECM sends a voltage signal to the bypass valve, which will then open. The compressed air on the pressure side of the turbo is led to the intake via the open valve. When the pressure drops, the turbine speed can be kept relatively high and the turbocharger is prevented from exceeding the pump limit.

Charge Air Cooler

The turbocharger is supported by an air-to-air charge air cooler system, which uses fresh air drawn through a heat exchanger to reduce the temperature of the warmer compressed air forced through the intake system. Inlet air temperature can be reduced by up to 100°C (180°F), which enhances performance. This is due to the higher density of oxygen in the cooled air, which promotes optimal combustion. The charge air cooler is connected to the turbocharger and to the throttle body by flexible ductwork that requires the use of special high torque fastening clamps. In order to prevent any type of air leak when servicing the ductwork, the tightening specifications and proper positioning of the clamps is critical, and must be strictly adhered to.

Special Tools and Equipment

Special Tools (Diagnostic Tools)

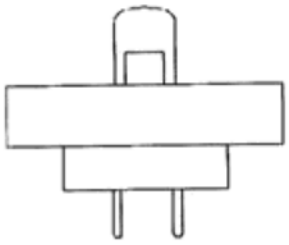
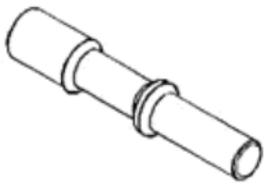
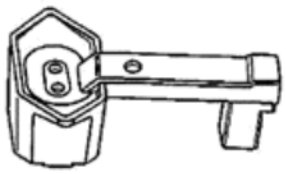
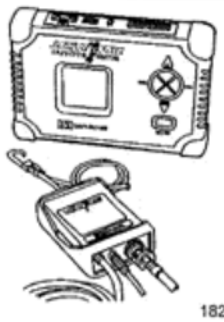
Illustration	Tool Number/Description
 5390	CH-34730-2C J-34730-2C Injector Test Lamp
1633271	CH-39021-460 J-39021-460 Fuel Injector Test Adapter

Illustration	Tool Number/Description
845593	CH-41415-30 GE-41415-30 J-41415-30 Fuel Tank Cap Adapter South America – Use Local Equivalent
 382677	CH-42960-2 J-42960-2 Fuel Flapper Door Holder
 677554	CH-44175-A J-44175-A Fuel Composition Tester South America – Use Local Equivalent
793709	CH-45004 J-45004 Fuel Tank Drain Hose South America – Use Local Equivalent
 1825929	CH-47976 Active Fuel Injector Tester (AFIT)

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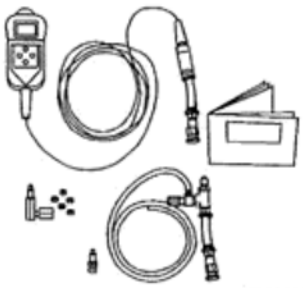
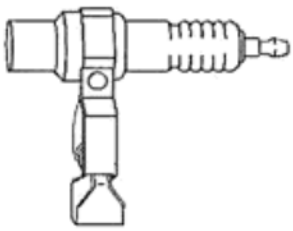
2088700	CH-47976-75 Fuel Injector Harness Adapter
 1738990	CH-48027 Fuel Pressure Gauge South America – Use Local Equivalent
1755444	CH-48096 EVAP Service Access Port Tool
 5381	EL-26792 J-26792 HEI Spark Tester South America – Use Local Equivalent
2239948	EL-38522-A J-38522-A Variable Signal Generator

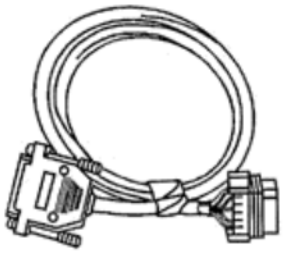
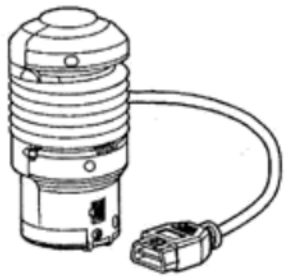
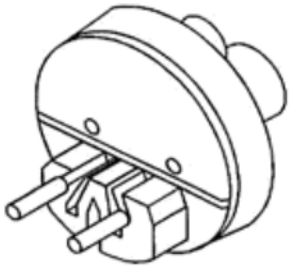
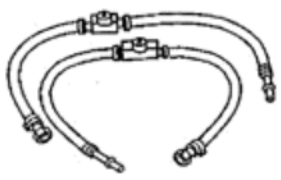
Illustration	Tool Number/Description
5380	EL-39021 J-39021 Fuel Injector Coil Balance Tester
 1346201	EL-39021-460 J-39021-460 Fuel Injector Test Adapter
 1463375	EL-42598-B J-42598-B Vehicle Data Recorder
 1161158	EL-44603 J-44603 Injector Test Lamp
 13541	EN-37287 J-37287 Fuel Line Shut-off Adapters

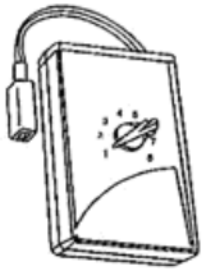
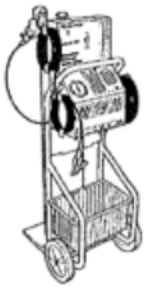
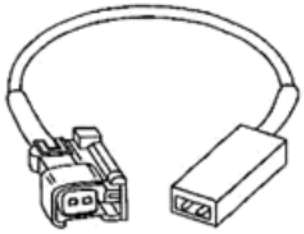
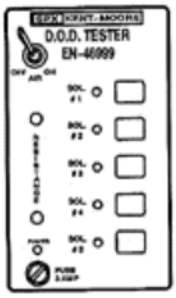
Illustration	Tool Number/Description
 16875	EN-39021-210 J-39021-210 Injector Tester Adapter Box
 2657852	GE-41413-A EN-41413-A J-41413-A Evaporative Emissions System Tester (EEST) South America – Use Local Equivalent
829198	EN-41413-VLV J-41413-VLV EVAP Service Port Vent Fitting South America – Use Local Equivalent
 649345	EN-44602 J-44602 Injector Test Adapter
 1402244	EN-46999 Displacement On Demand Electric Tool

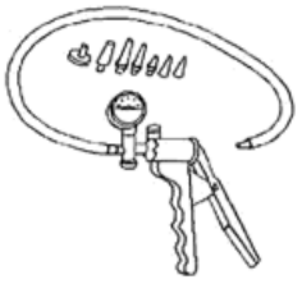
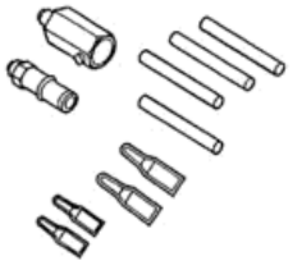
Illustration	Tool Number/Description
 5386	GE-23738-A J-23738-A Vacuum Pump
 2490507	GE-41413-300 EN-41413-300 J-41413-300 EVAP Cap and Plug Kit South America – Use Local Equivalent

Illustration	Tool Number/Description
829182	GE-41413-SPT J-41413-SPT High Intensity White Light South America – Use Local Equivalent