Engine Controls/Fuel - 1.8L (LUW, LWE)

Specifications

Temperature Versus Resistance (ECT)

°C	°F	Ohms
Temperature vs. Resistance Values (Approximate)		
140	284	50
126	258	75
116	240	100
108	226	120
99	210	160
92	197	200
84	183	250
78	172	300
69	156	400
63	145	500
58	136	600
51	123	750
47	116	900
39	102	1200
33	91	1500
29	84	1800
24	75	2250
19	66	2800
15	59	3500
9	48	4500
5	41	5500
1	33	7000
−6	+22	9500
−9	+16	12000
−14	+7	16000
−19	−2	21500
−24	−11	28500
−24	−11	31000
−27	−16	33000
−27	−16	35000
−28	−18	39000
−30	−22	49000
−33	−27	60000
−37	−34	70000
−40	−40	93000

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
120/248	119	125
140/284	76	81

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
1,829	6,000	77–85	11.2–12.3
1,524	5,000	80–88	11.6–12.8
1,219	4,000	83–91	12.0–13.2
914	3,000	87–95	12.6–13.8
610	2,000	90–98	13.1–14.2
305	1,000	94–102	13.6–14.8
0	0 Sea Level	96–104	13.9–15.1
−305	−1,000	101–105	14.6–15.2

Ignition System Specifications

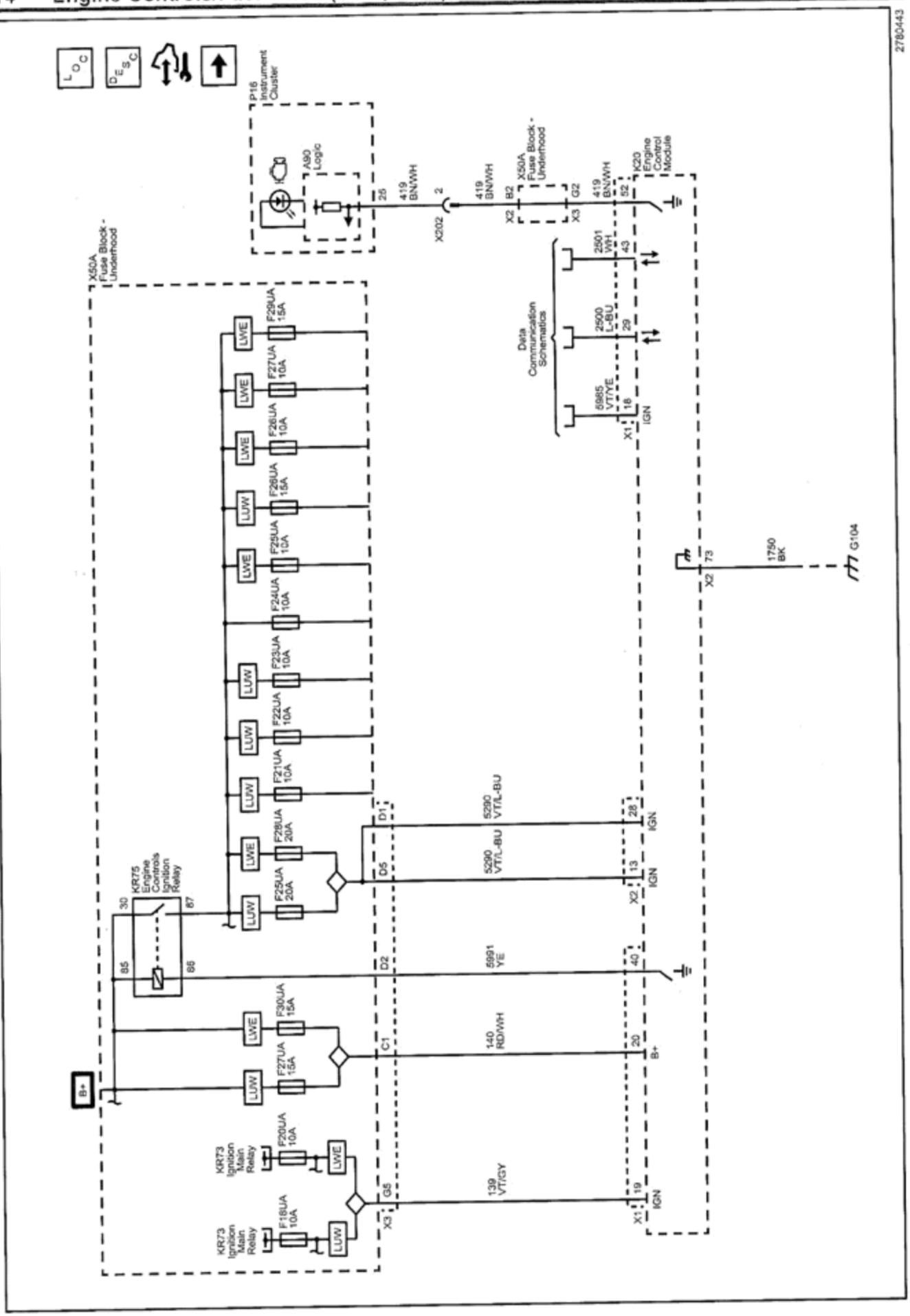
Application	Specification
Ignition Type	Ignition Coil Module
Firing Order	1–3–4–2
Spark Plug Torque	Refer to *Fastener Tightening Specifications (1.8L LUW and LWE) on page 9-944* or *Fastener Tightening Specifications (1.6L LDE) on page 9-941*
Spark Plug Gap – All (Except LFH, LUW, and LWE)	0.8–0.9 mm (0.031–0.035 in)
Spark Plug Gap – LFH, LUW, and LWE	0.6–0.7 mm (0.024–0.028 in)
Spark Plug Type	Refer to Electronic Parts Catalogue

Fastener Tightening Specifications

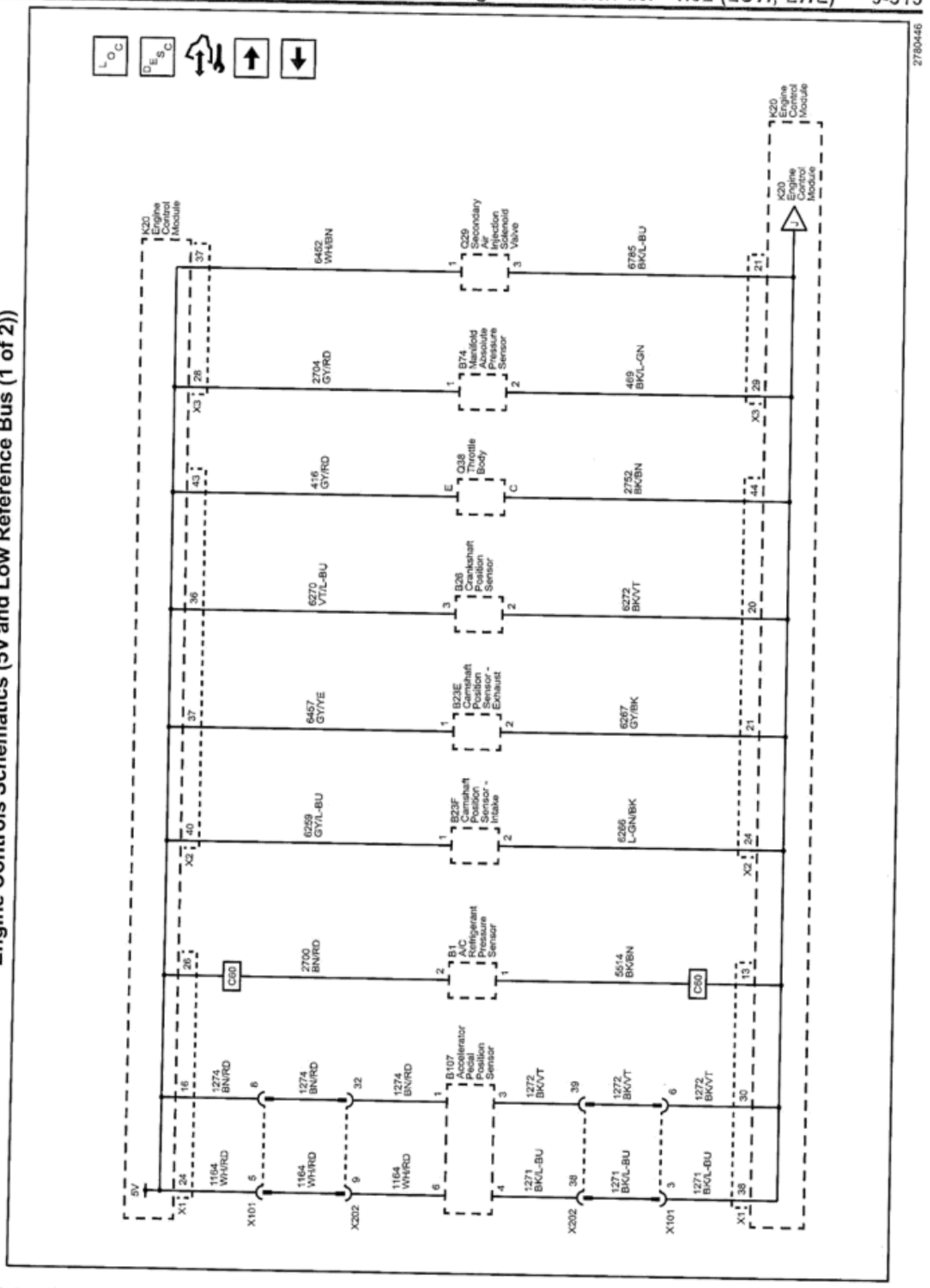
Application	Specification	
	Metric	English
Camshaft Position Sensor Fastener	6 N•m	54 lb in
Crankshaft Position Sensor Retaining Bolt	5 N•m	44 lb in
Ignition Coil Fasteners	9 N•m	80 lb in
Engine Control Module Fasteners	10 N•m	89 lb in
Engine Coolant Temperature Sensor	20 N•m	15 lb ft
Evaporative Emission Canister Bracket Fasteners	10 N•m	89 lb in
Evaporative Emission Canister Purge Solenoid Fastener	5 N•m	44 lb in
Exhaust Gas Recirculation Valve Fasteners	10 N•m	89 lb in
Exhaust Gas Recirculation Valve Pipe Fasteners	6 N•m	59 lb in
Fuel Tank Filler Pipe Bracket Fasteners	9 N•m	89 lb in
Fuel Rail Retaining Fasteners	10 N•m	89 lb in
Fuel Tank Strap Fasteners	22 N•m	16 lb ft
Hose Clamps	4 N•m	35 lb in
Knock Sensor Fastener	20 N•m	15 lb ft
Manifold Absolute Pressure Sensor Fastener	10 N•m	89 lb in
Heated Oxygen Sensor Fastener	42 N•m	31 lb ft
Spark Plugs	25 N•m	18 lb in
Throttle Body Fasteners	9 N•m	80 lb in

Schematic and Routing Diagrams

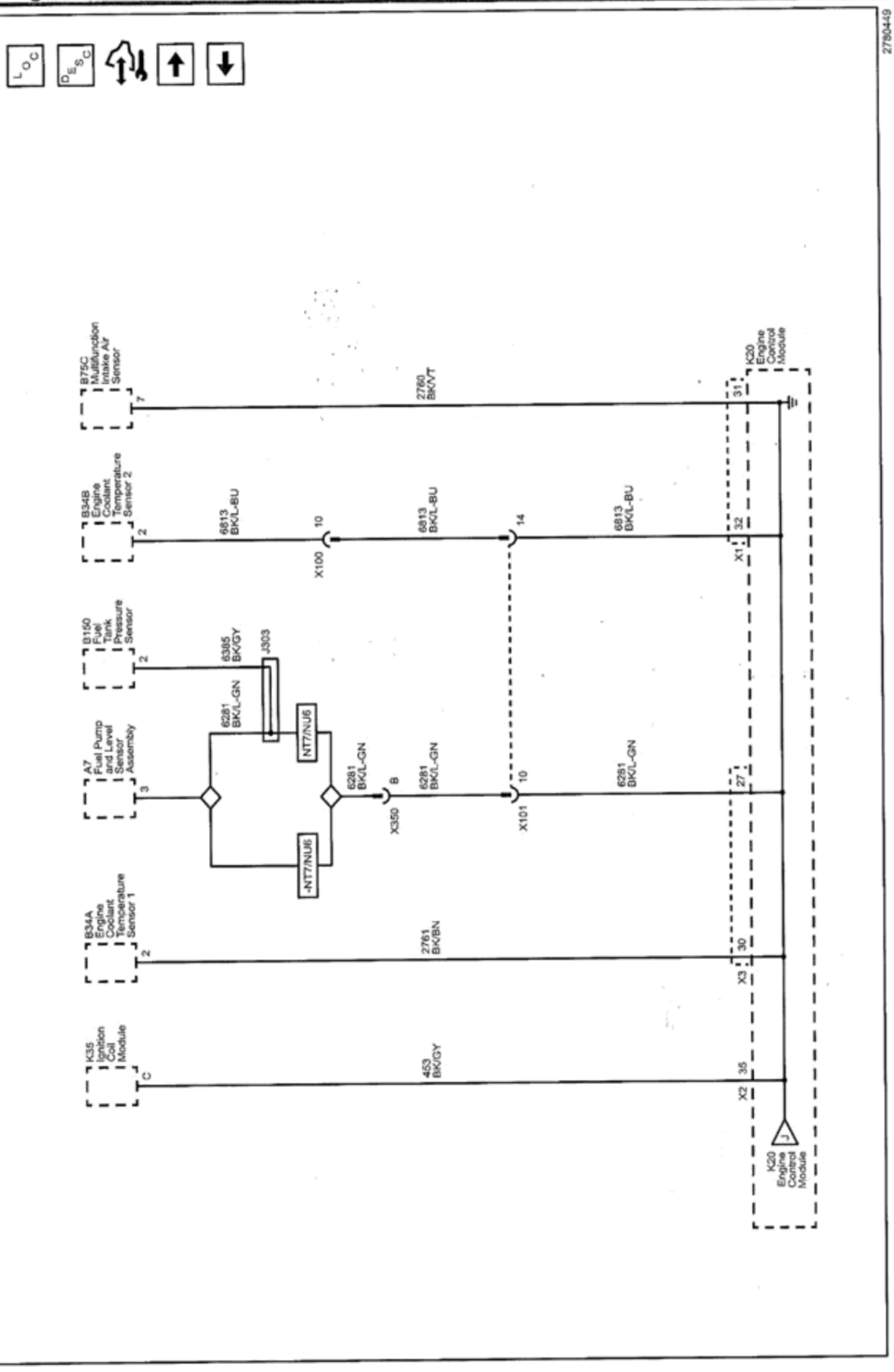
Engine Controls Schematics (Module Power, Ground, Serial Data, and MIL)



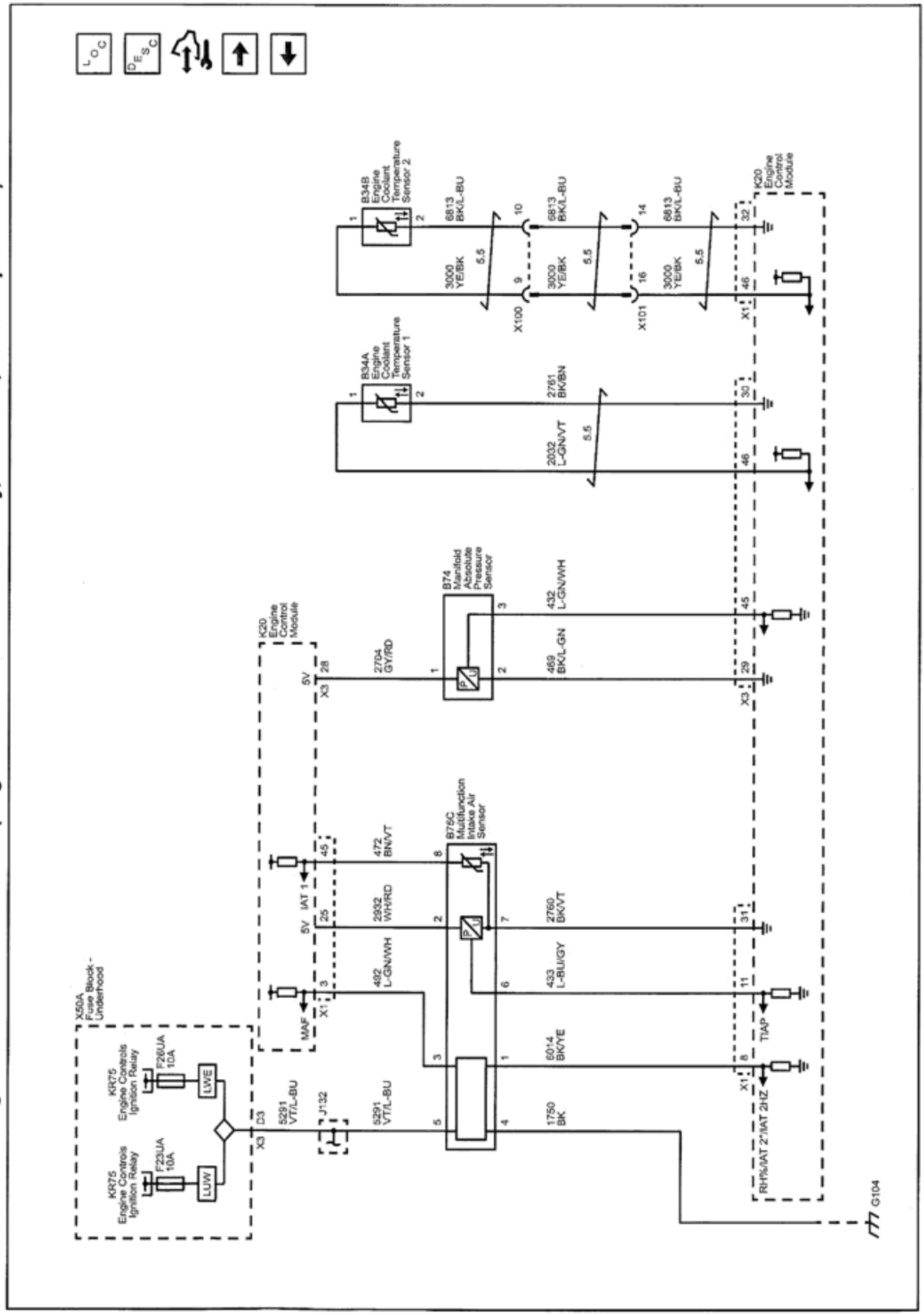
Engine Controls Schematics (5V and Low Reference Bus (1 of 2))



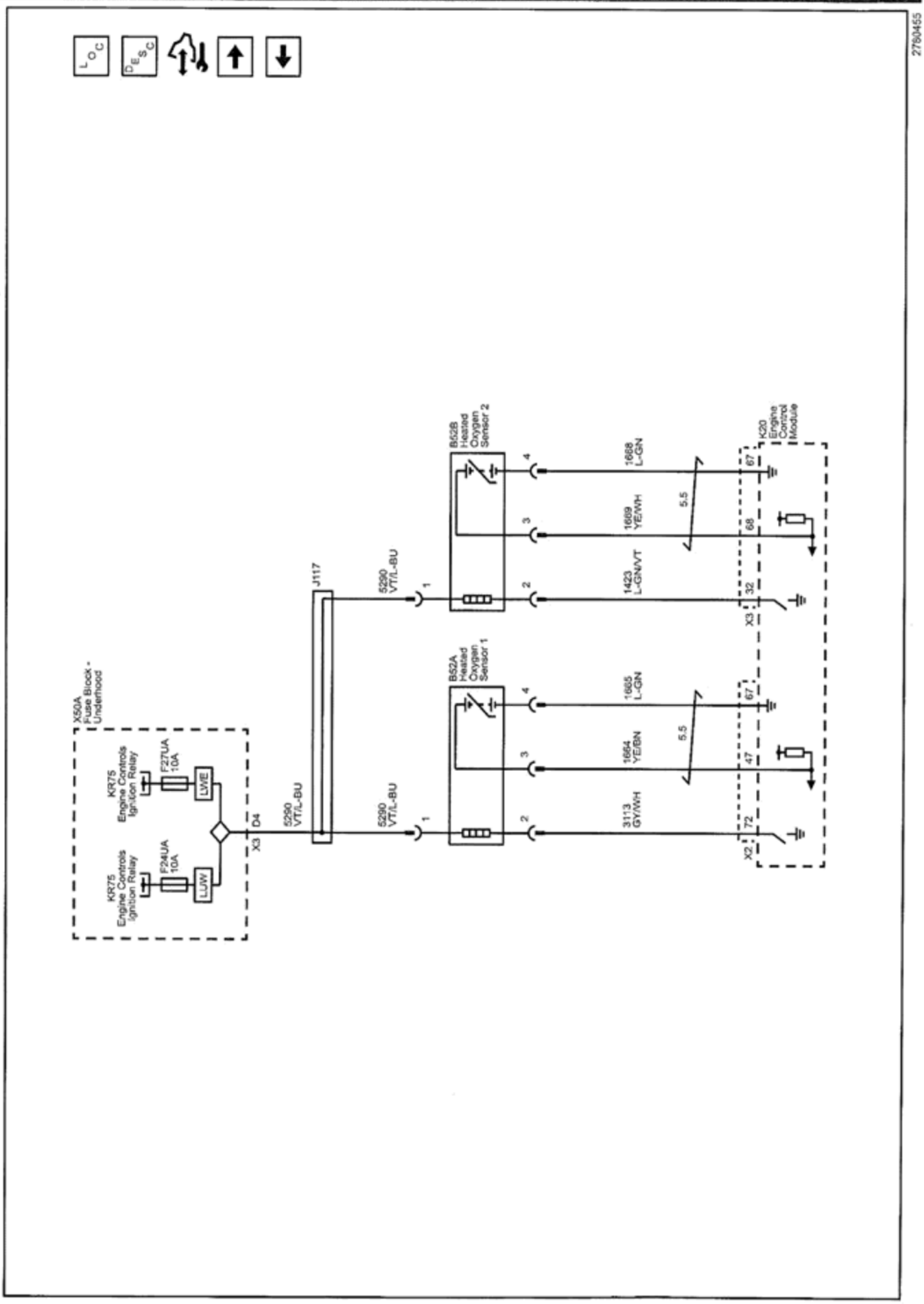
Engine Controls Schematics (Low Reference Bus (2 of 2))



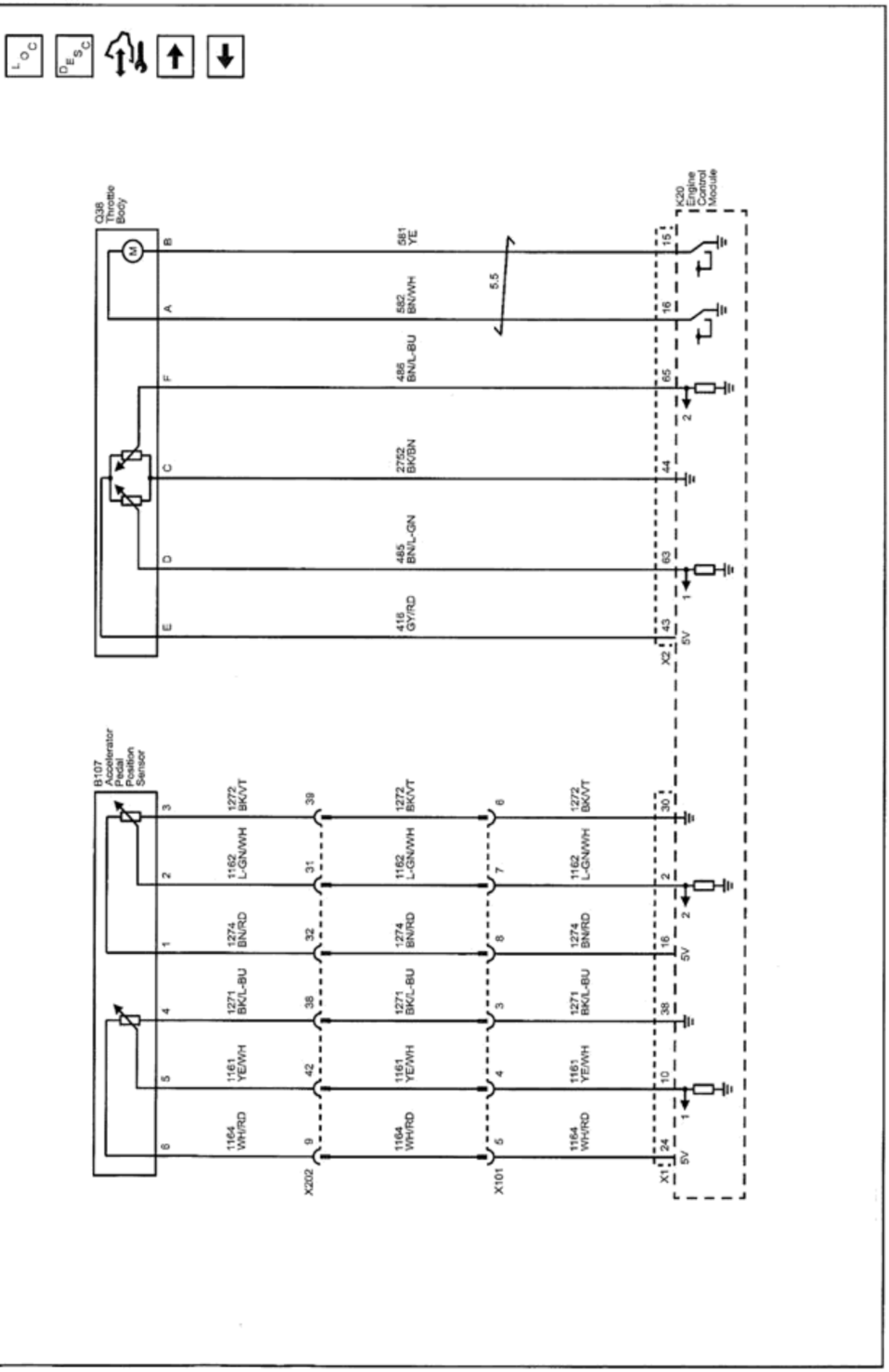
Engine Controls Schematics (Engine Data Sensors - Humidity, Pressure, and Temperature)



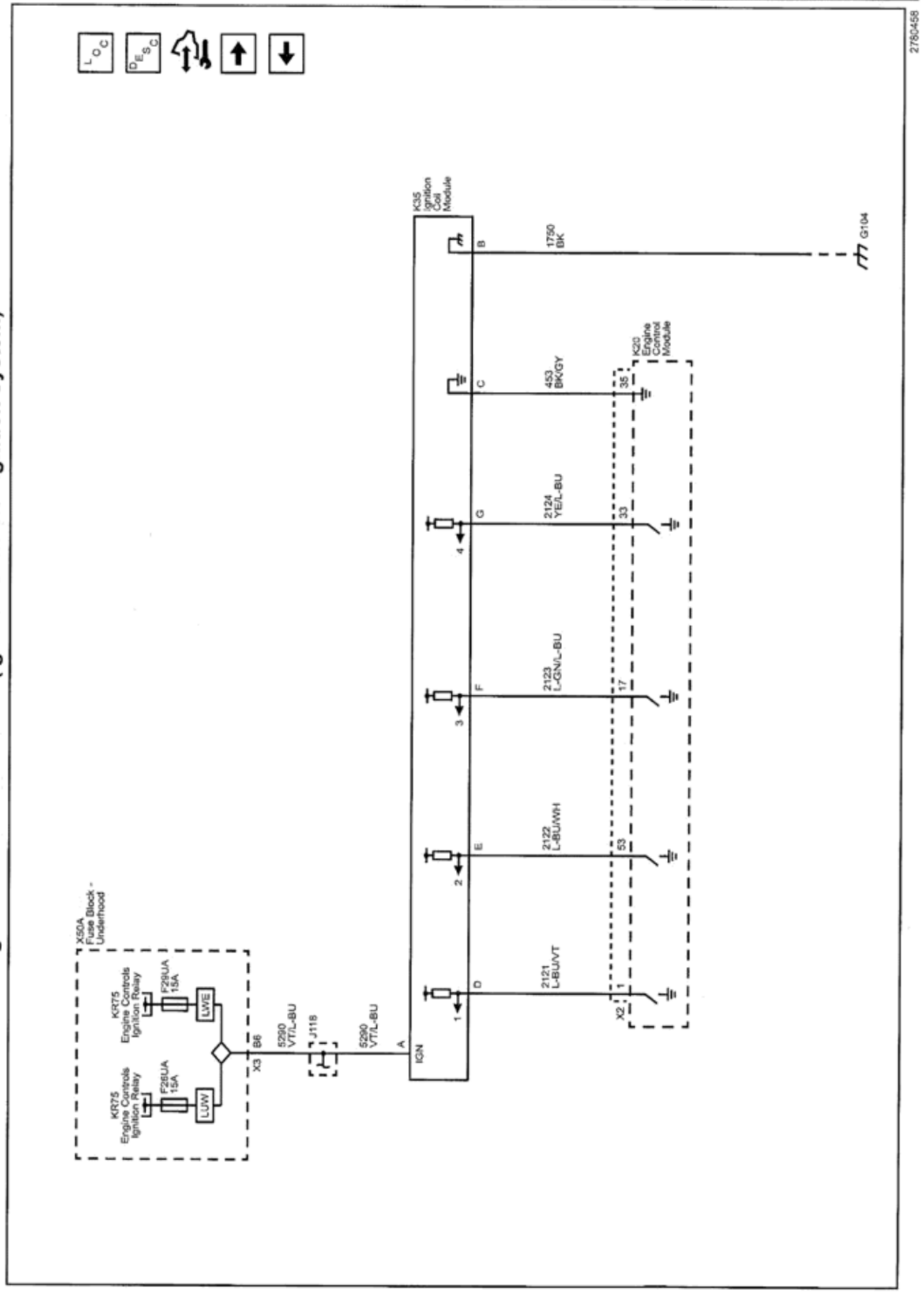
Engine Controls Schematics (Engine Data Sensors - Oxygen Sensors)



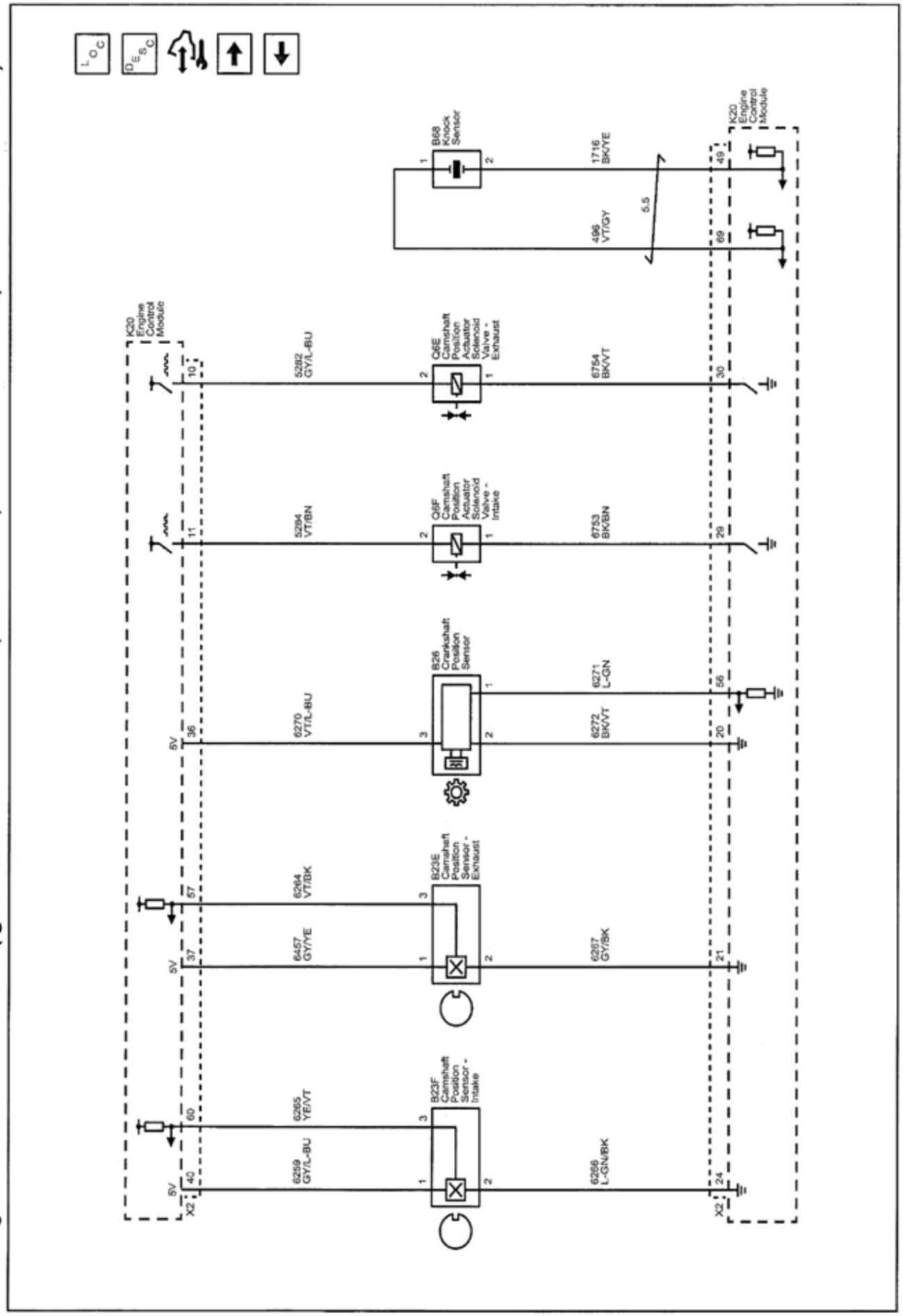
Engine Controls Schematics (Engine Data Sensors - Throttle Controls)



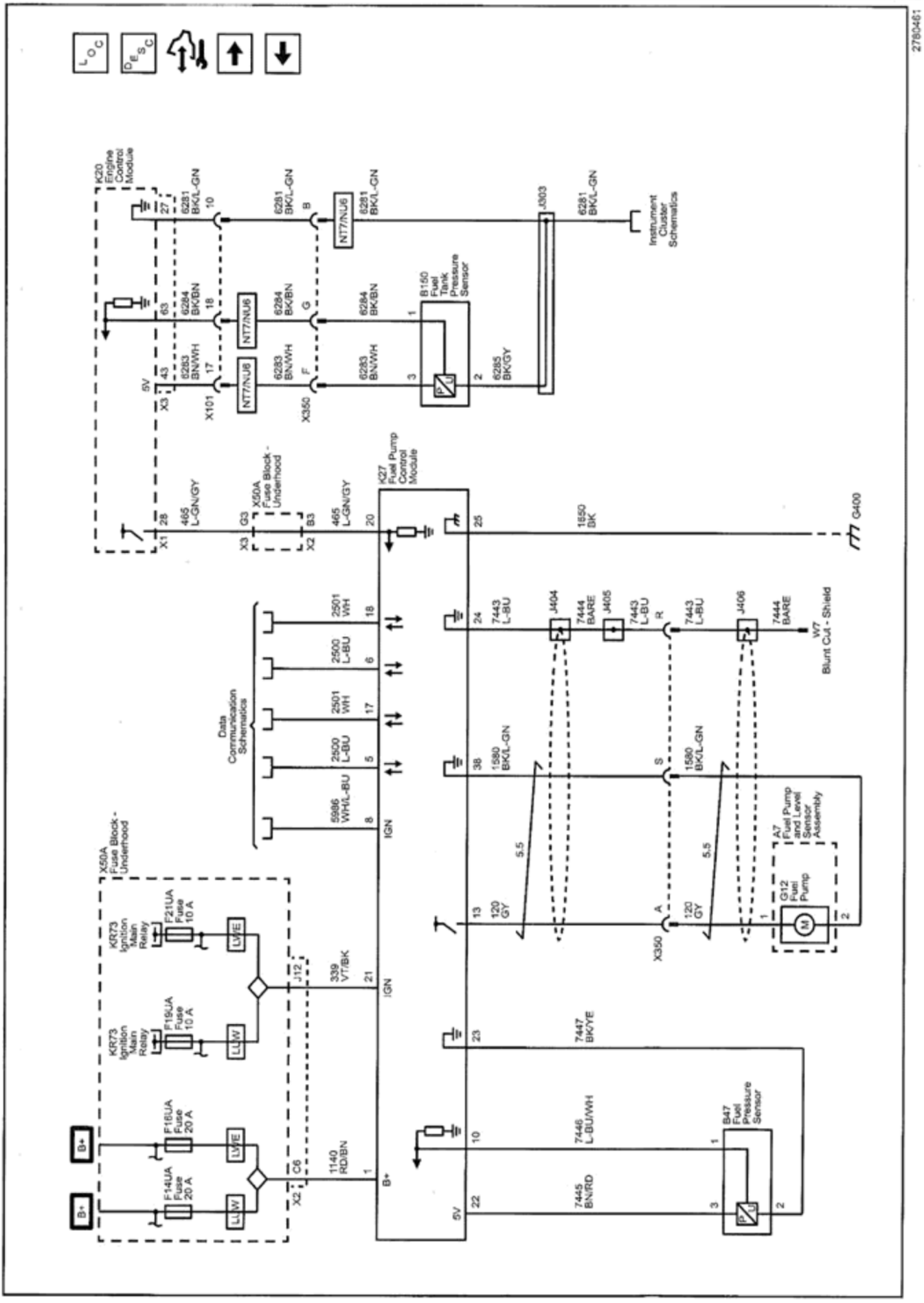
Engine Controls Schematics (Ignition Controls - Ignition System)



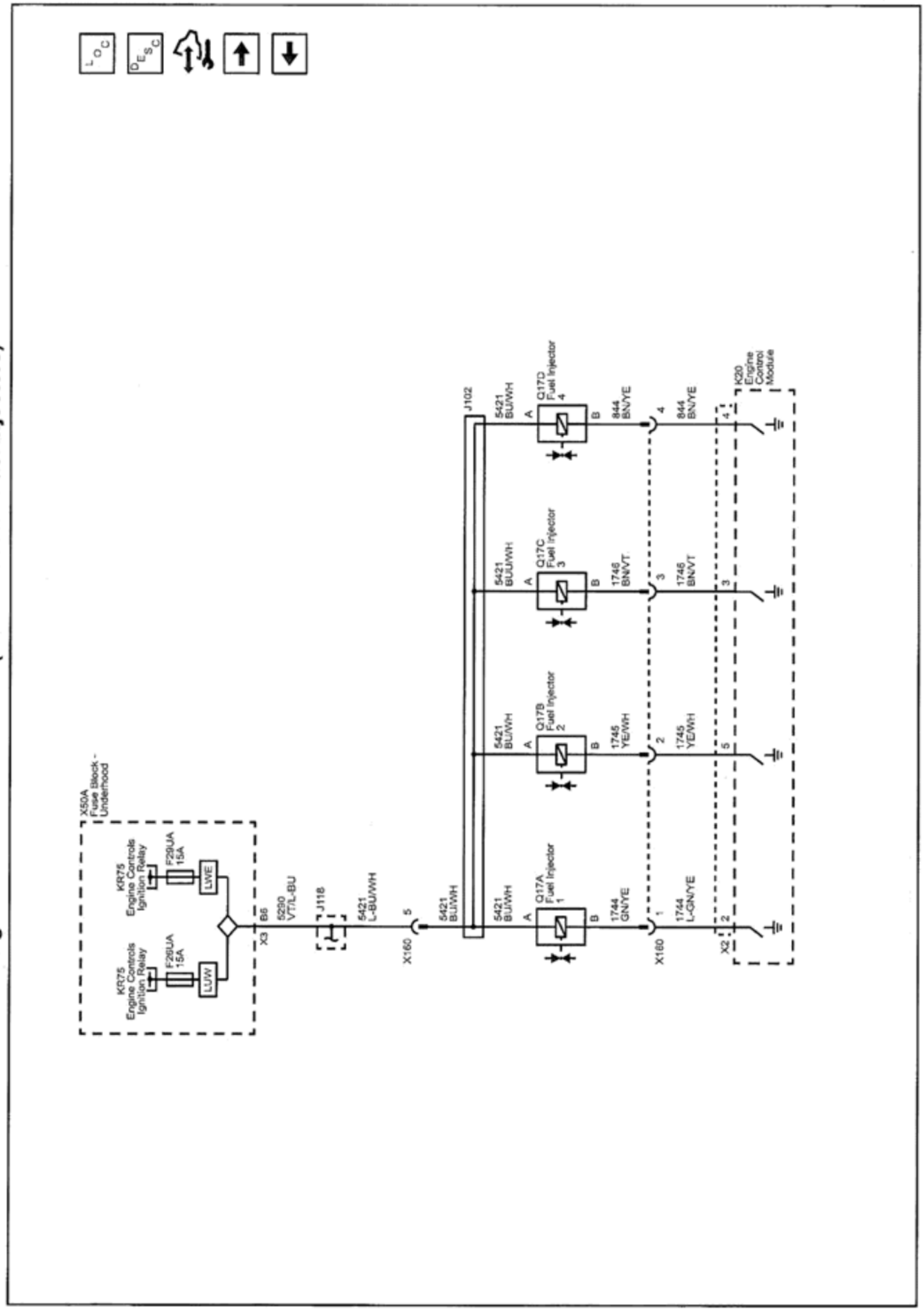
Engine Controls Schematics (Ignition Controls - Camshaft, Crankshaft, and Knock Sensors, Camshaft Actuators)



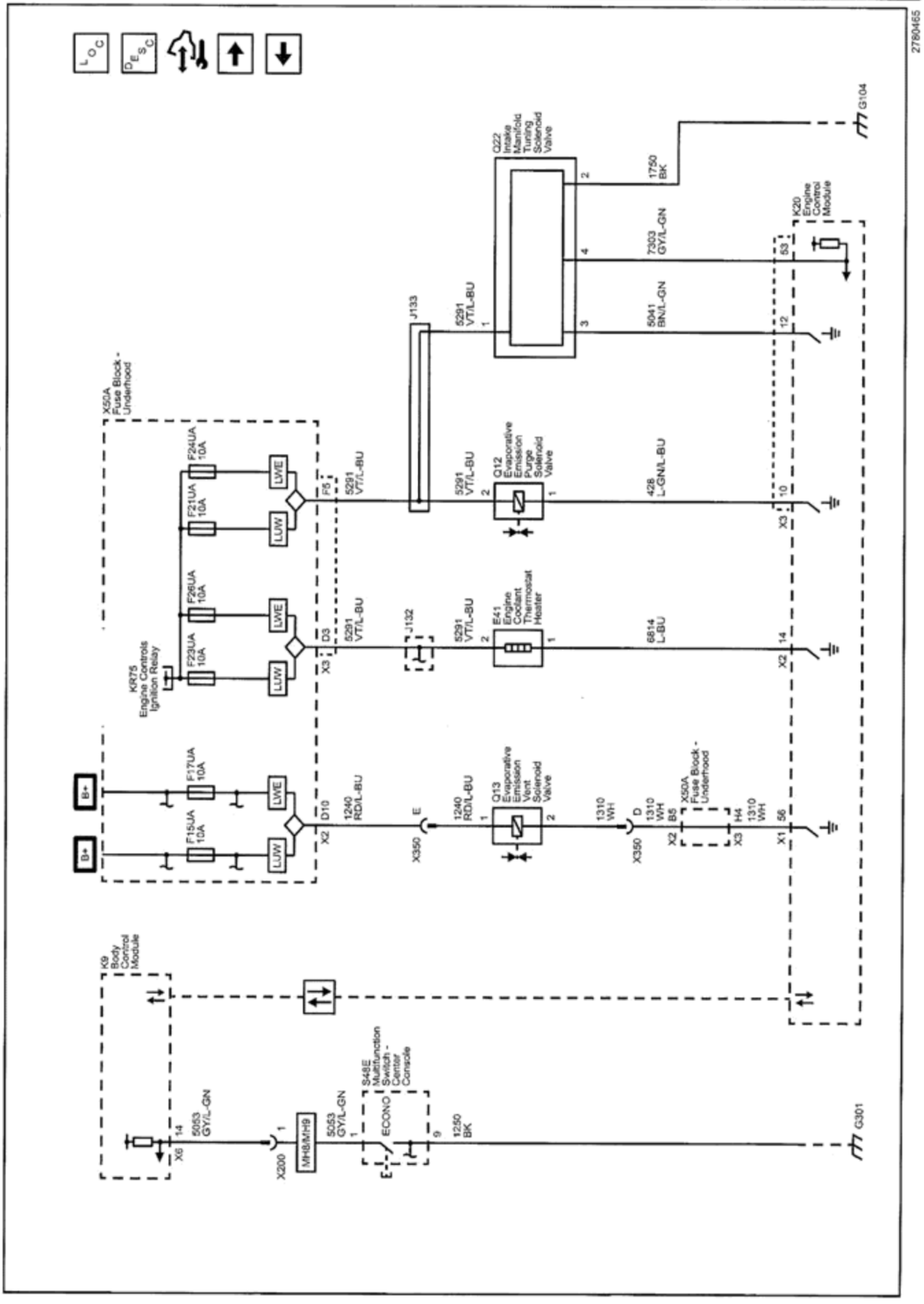
Engine Controls Schematics (Fuel Controls - Fuel Pump and Fuel Pump Controls)



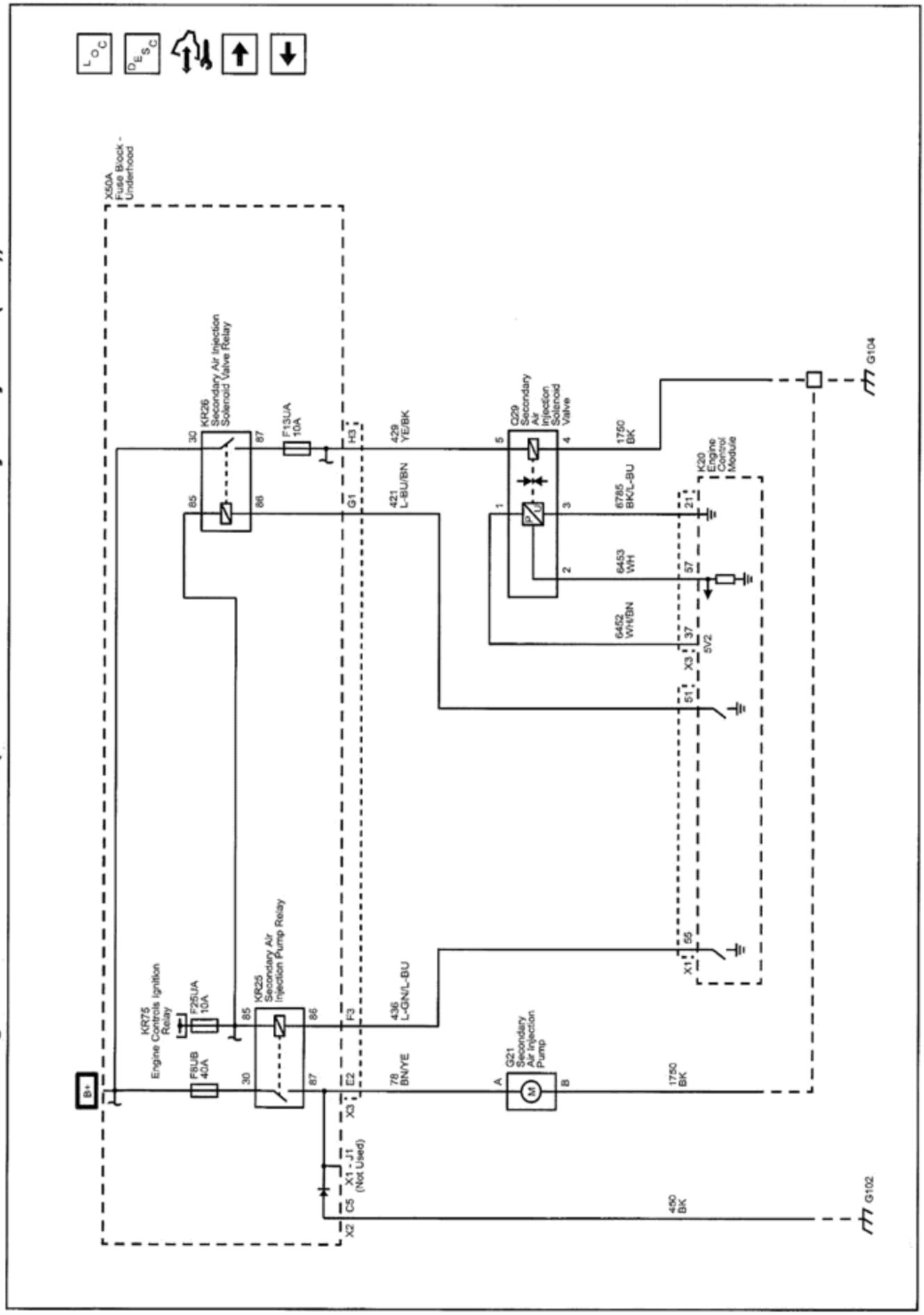
Engine Controls Schematics (Fuel Controls - Fuel Injectors)



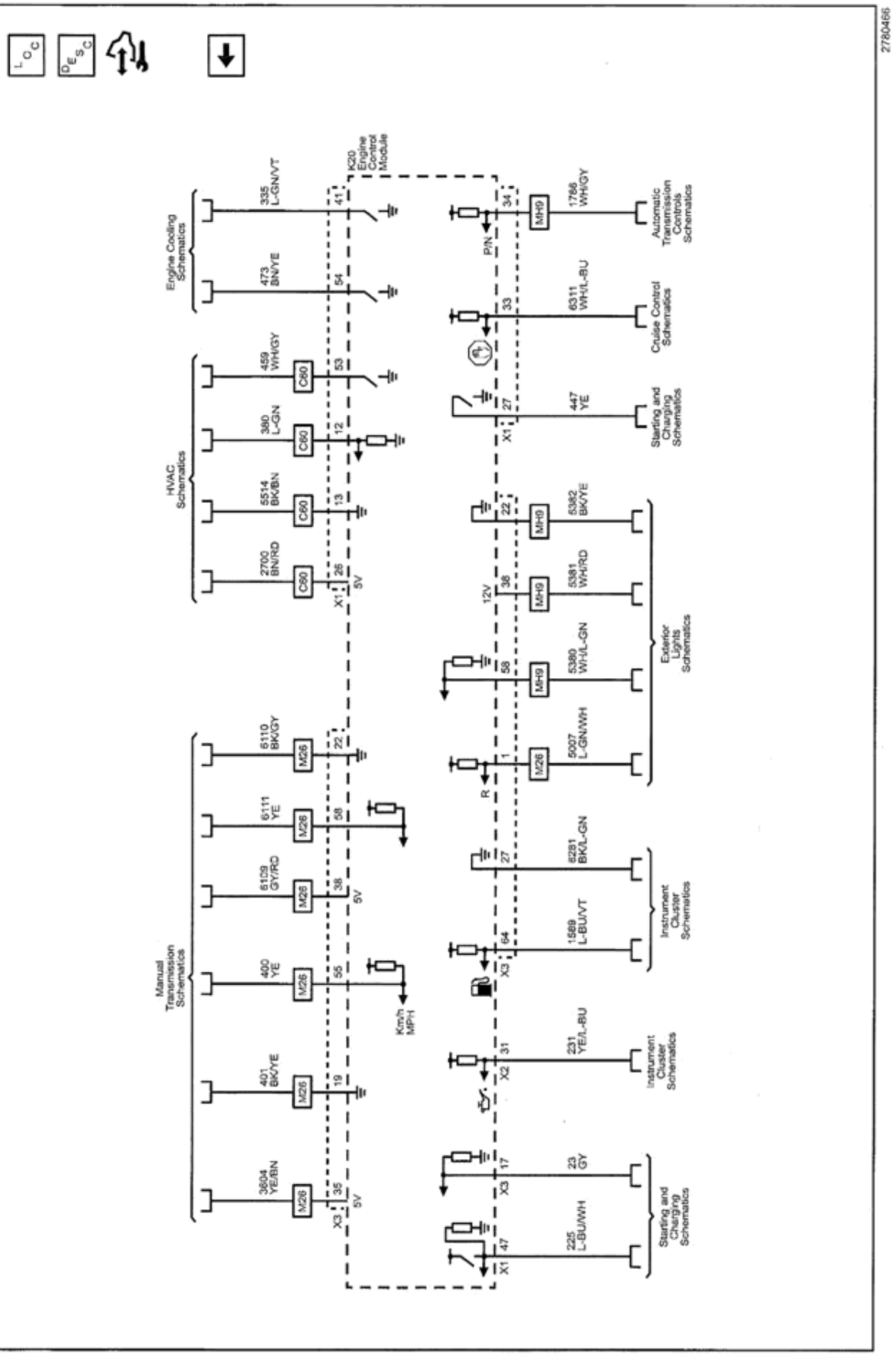
Engine Controls Schematics (Evaporative Emission, Economy, and Device Controls)



Engine Controls Schematics (Device Controls - Secondary Air Injection (NU6))



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 9-314

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Camshaft Actuator System Description on page 9-588

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 1 and ground.

⇒ **If 5 Ω or greater**

2.1. Ignition OFF.

2.2. Disconnect the harness connector at the K20 Engine Control Module.

2.3. 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, 1.5–3.5 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.

4.2. Disconnect the harness connector at the K20 Engine Control Module.

4.3. Ignition ON.

4.4. Test for less than 1 V between the control circuit and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit

⇒ If less than 1 V, replace the K20 Engine Control Module

⇓ **If the test lamp does not illuminate**

5. Remove the test lamp.
6. Connect the DMM black lead to the control circuit terminal 2. Connect the DMM red lead to B+. Set the DMM on the diode setting. Command the CMP actuator solenoid ON and OFF with a scan tool.

The DMM should transition from OL when commanded OFF to less than 1 V when commanded ON.

⇒ **If the circuit voltage does not correspond to the specified values**

6.1. Ignition OFF.

6.2. Disconnect the harness connector at the K20 Engine Control Module.

6.3. Test for less than 2 Ω in the control circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance or short to ground in the circuit

⇒ If less than 2 Ω, replace the K20 Engine Control Module

⇓ **If the circuit voltage corresponds to the specified values**

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

Component Testing

1. Ignition OFF.
2. Disconnect the harness connector at the appropriate Q6 Camshaft Position Actuator Solenoid Valve.
3. 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**

4. Test for infinite resistance between each terminal and theQ6 Camshaft Position Actuator Solenoid Valve housing.

⇒ **If not infinite resistance**

Replace the Q6 Camshaft Position Actuator Solenoid Valve.

⇓ **If infinite resistance**

5. 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, setup, and programming

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 9-588

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. Vehicle OFF
2. Disconnect the harness connector at the Q6 Camshaft Position Actuator Solenoid Valve.
3. 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**

4. 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**

5. 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, camshaft position sensor – intake, and the camshaft position sensor – exhaust 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 9-588

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 belt tensioner condition.
- An incorrectly installed timing belt.
- Excessive play in the timing belt.
- A timing belt with damaged teeth.
- 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 9-1061*
- *Camshaft Position Sensor Replacement on page 9-576*
- *Crankshaft Position Sensor Replacement on page 9-575*
- *Timing Belt Replacement on page 9-985*

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	Open/High Resistance	Short to Voltage	Signal Performance
HO2S Heater Voltage Supply	P0030, P0036, P0037, P0132, P0134, P0135, P0138, P0141, *	P0030, P0036, P0132, P0134, P0135, P0138, P0140, P0141	P0690	P0135, P0141
HO2S Heater Control	P0030, P0031, P0036, P0037, P0053, P0054, P0135, P0141	P0030, P0036, P0132, P0134, P0135, P0138, P0140, P0141	P0030, P0032, P0036, P0038, P0132, P0134, P0135, P0138, P0140, P0141, P0690	P0135, P0141
* Opens Fuse				

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 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 engine speed is greater than 400 RPM.
- The ignition voltage is between 11–32 V.
- 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 ignition is OFF for greater than 8 h.
- The engine is running.
- The engine coolant temperature (ECT) and the intake air temperature (IAT) are within 8°C (14°F).
- The ECT is between −30 to +45°C (−22 to +113°F).
- The ignition voltage is less than 32 V.
- 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 resistance is not within a specified range 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 heated oxygen sensor 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 9-314

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 running.
2. Verify that the control circuit status parameters listed below do not display Malfunction.
   - HO2S 1 or 2 Heater Control Circuit High Voltage Test Status
   - HO2S 1 or 2 Heater Control Circuit Open Voltage Test Status
   - HO2S 1 or 2 Heater Control Circuit Low Voltage Test Status

⇒ **If Malfunction is displayed**

Refer to Circuit/System Testing.

⇓ **If Malfunction is not displayed**

3. Observe the scan tool HO2S 1 Heater or HO2S 2 Heater parameter. The amperage should be between 0.3–2.4 A.

⇒ **If not between 0.3–2.4 A**

Refer to Circuit/System Testing.

⇓ **If between 0.3–2.4 A**

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

Note: You must perform the circuit/system verification before proceeding with 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, 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, replace the B52 Heated Oxygen Sensor.

⇓ **If the test lamp illuminates**

3. Connect a test lamp between the control circuit terminal 2 and the ignition circuit terminal 1.
4. Verify the test lamp turns ON and OFF when Commanding the HO2S Heater Sensor ON and OFF with a scan tool.

⇒ **If the test lamp is always OFF**

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

4.3. Ignition OFF.

4.4. 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**

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 the test lamp turns ON and OFF**

5. Test or replace the B52 Heated Oxygen Sensor.

Repair Instructions

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

- *Heated Oxygen Sensor Replacement - Sensor 1 on page 9-538*
- *Heated Oxygen Sensor Replacement - Sensor 2 on page 9-539*
- 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 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 to a calculated airflow based on manifold absolute pressure (MAP) sensor, and mass air flow (MAF).

Conditions for Running the DTC

DTC P0068

- DTC P0102, P0103, P0107, P0108, or P0651 is not set
- The engine speed is at least 800 RPM.
- The Ignition signal is at least 6.0 V.
- The throttle actuator control system is not in reduced power mode, without LUW
- The DTC runs continuously when the above conditions are met.

DTC P1101

- DTC P0102, P0103, P0107, P0108, P0117, P0118, P0128, P0335, or P0336 is not set
- The engine speed is between 400–7 000 RPM; 400–6 000 RPM with LUW
- 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 DTC

The ECM detects that the airflow rate is more than the calculated airflow for greater than 0.2 s.

Action Taken When the DTC Sets

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

Conditions for Clearing the DTC

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

Diagnostic Aids

Use a solution of dish soap and water in a spray bottle to pinpoint any suspected air leaks in the induction system. This includes vacuum lines, positive crankcase ventilation system, intake manifold, throttle body.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-314

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, 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 9-449* for further diagnosis.

⇓ **If none of the DTCs are set**

2. Ignition ON, 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 9-547*.

⇓ **If less than 90 %**

3. 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 on page 9-372* for further diagnosis.

⇓ **If Agree**

4. Determine the current vehicle testing altitude.
5. Verify the scan tool MAP Sensor pressure parameter is within the range specified in the *Altitude Versus Barometric Pressure on page 9-312* table.

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

Refer to *DTC P0106 on page 9-356* for further diagnosis.

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

6. 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 9-356* for further diagnosis.

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

7. Verify the scan tool MAF Sensor g/s parameter changes smoothly and gradually as the engine speed is increased and decreased while performing the actions listed below.
   7.1. Engine idling
   7.2. Perform the scan tool snapshot function.
   7.3. Increase the engine speed slowly to 3 000 RPM and then back to idle.
   7.4. Exit from the scan tool snapshot and review the data.
   7.5. 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 9-349* for further diagnosis.

⇓ **If the MAF Sensor parameter changes smoothly and gradually**

8. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
9. Verify 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**

10. 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 ECM 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+. **P2199 - where used.				

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+. **P2199 - where used.				

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:

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

The intake air temperature (IAT) sensor 1 is a variable resistor that measures the temperature of the air in the sensor bore. The engine control module (ECM) supplies 5 V to the IAT sensor 1 signal circuit and a ground for the IAT sensor 1 low reference circuit. The signal varies with inlet air temperature and is displayed by the scan tool as °C (°F).

The IAT sensor 2 produces a frequency signal based on the inlet air temperature very close to the humidity sensor within the sensor bore. The signal varies with inlet air temperature and is displayed by the scan tool as °C (°F) and Hertz (Hz). The signal circuit is shared by the IAT sensor 2 and the humidity 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

Ignition voltage and ground circuits are also supplied to the multifunction intake air sensor's internal circuits for the mass air flow (MAF) 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, P0112, P0113, P0117, P0118, P0119, or P1682 are not set.
- The vehicle has been OFF at least 8 hours.
- Ignition 1 voltage is at least 11 V for longer than 0.9 s.
- 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 absolute difference between ECT start-up temperature and the IAT sensor 2 start-up temperature is greater or equal to the absolute difference between ECT start-up temperature and the IAT sensor 1 start-up temperature.
- This DTC runs once per ignition cycle when the enabling conditions are met.

P0111

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

  AND

- The absolute difference between ECT start-up temperature and the IAT sensor 1 start-up temperature is greater or equal to the absolute difference between ECT start-up temperature and the IAT 2 start-up temperature.
- This DTC runs once per ignition cycle when the enabling conditions are met.

Action Taken When the DTCs Set

DTCs P0096 and P0111 are Type B DTCs.

Conditions for Clearing the DTCs

DTCs P0096 and P0111 are Type B DTCs.

Diagnostic Aids

- With the ignition ON, when the engine is OFF and 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 9-314

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 on page 9-593*.

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 9-449* 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 1 and 2 of this verification procedure only if the ignition has been OFF for 8 hours or more.

2. Verify the following scan tool parameters are within 55°C (99°F) of each other.
   - Start-Up IAT Sensor 1
   - IAT Sensor 2
   - Start-Up ECT

⇒ **If not within 55°C (99°F)**

Refer to Circuit/System Testing.

⇓ **If within 55°C (99°F)**

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

⇒ **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. Check the integrity of the entire air induction system and verify that none of the following conditions exist:
   - A restricted, collapsed, misaligned, or damaged air intake duct
   - An intake manifold leak
   - A MAP sensor seal that is leaking, missing, or damaged
   - 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 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
   - 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 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 9-312* 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 9-536* for multifunction intake air sensor replacement.
- *Control Module References on page 6-3* for Engine Control Module replacement, programming, and setup

DTC P0097, P0098, or P0099

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
DTC P0099: Intake Air Temperature (IAT) Sensor 2 Circuit Intermittent

Diagnostic Fault Information

IAT Sensor 2

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
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+. **P2199 - where used.				

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 intake air temperature (IAT) sensor 1 is a variable resistor that measures the temperature of the air in the sensor bore. The engine control module (ECM) supplies 5 V to the IAT sensor 1 signal circuit and a ground for the IAT sensor 1 low reference circuit. The signal varies with inlet air temperature and is displayed by the scan tool as °C (°F).

The IAT sensor 2 produces a frequency signal based on the inlet air temperature very close to the humidity sensor within the sensor bore. The signal varies with

inlet air temperature and is displayed by the scan tool as °C (°F) and Hertz (Hz). The signal circuit is shared by the IAT sensor 2 and the humidity 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

Ignition voltage and ground circuits are also supplied to the multifunction intake air sensor's internal circuits for the mass air flow (MAF) 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, P0098, and P0099

- The ignition is ON, or the engine is running.
- The Ignition 1 voltage is at least 11 V for longer than 0.9 s.
- 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 13 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.

P0099

The ECM monitors the IAT sensor 2 signal every 0.1 s, to determine if the signal has changed more than 100° C (212°F). The DTC fails when the condition exists for longer than 4 s.

Action Taken When the DTC Sets

- DTCs P0097, P0098, and P0099 are Type B DTCs.
- The ECM commands the cooling fans ON.

Conditions for Clearing the MIL/DTCs

DTCs P0097, P0098, and P0099 are Type B DTCs.

Diagnostic Aids

- With the ignition ON, the engine OFF, if the engine is cold, a properly functioning IAT sensor 2 will gradually increase the scan tool IAT Sensor 2 parameter. This is due to the heat that is generated by the MAF sensor heating elements.
- The humidity sensor and the IAT sensor 2 signals are sent to the ECM on the same circuit. If the IAT Sensor 2 parameter displays the values: 10 Hz; −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 9-314

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 on page 9-593.*

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 55°C (99°F) of each other.
   - Start-Up IAT Sensor 1
   - IAT Sensor 2
   - Start-Up ECT

⇒ **If not within 55°C (99°F)**

Refer to Circuit/System Testing.

⇓ **If within 55°C (99°F)**

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

⇒ **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, disconnect the harness connector at the B75C Multifunction Intake Air sensor.
2. Ignition OFF and all systems OFF. It may take up to for 2 minutes for all vehicle systems to power down. 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 intake air temperature signal 2 circuit terminal 1 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. 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+
5. 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
6. 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**

7. 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 9-312* 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 9-536* 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.

Vehicle ignition voltage and ground circuits are 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

- DTC P0102, P0103, P0107, P0108, P0111, P0112, P0113, P0114, P0117, P0118, P0128, P0335, or P0336 is 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 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 9-314

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 on page 9-593*.

Circuit/System Verification

1. Ignition ON, 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 9-449* for further diagnosis.

⇓ **If none of the DTCs are set**

2. Ignition ON, 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 9-547*.

⇓ **If less than 90 %**

3. 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 on page 9-372* for further diagnosis.

⇓ **If Agree**

4. Determine the current vehicle testing altitude.
5. Verify the scan tool MAP Sensor pressure parameter is within the range specified in the *Altitude Versus Barometric Pressure on page 9-312* table.

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

Refer to *DTC P0106 on page 9-356* for further diagnosis.

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

6. 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 9-356* for further diagnosis.

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

7. Verify the scan tool MAF Sensor g/s parameter changes smoothly and gradually as the engine speed is increased and decreased while performing the actions listed below.
   - 7.1. Engine idling
   - 7.2. Perform the scan tool snapshot function.
   - 7.3. Increase the engine speed slowly to 3,000 RPM and then back to idle.

7.4. Exit from the scan tool snapshot and review the data.

7.5. 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 for further diagnosis.

⇓ **If the MAF Sensor parameter changes smoothly and gradually**

8. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
9. Verify a DTC does not set.

⇒ **If any DTC sets**

Refer to Circuit/System Testing for further diagnosis.

⇓ **If no DTCs set**

10. 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
   - 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
   - Improper operation of the positive crankcase ventilation (PCV) system

⇒ **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 9-536* for multifunction intake air sensor replacement.
- *Control Module References on page 6-3* for ECM 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:** 1,500–10,000 Hz			
Ignition Voltage	0 Hz	0 Hz	—
Signal	0 Hz	0 Hz	0 Hz
Ground	—	0 Hz	—

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 DTC

- The engine is running for at least 1 s.
- The engine speed is at least 300 RPM.
- The ignition signal is at least 8 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 DTC

P0102

The ECM detects that the MAF Sensor signal parameter is less than 100 Hz (about 0.15 g/s) for at least 500 cylinder firing events.

P0103

The ECM detects that the MAF Sensor signal parameter is at least 14,500 Hz (about 270.2 g/s) for at least 500 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.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-314

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 on page 9-593*.

Circuit/System Verification

1. Engine idling, verify the scan tool MAF Sensor parameter is between 2.5–5.5 g/s.

⇒ **If not between 2.5–5.5 g/s**

Refer to Circuit/System Testing.

⇓ **If between 2.5–5.5 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.

⇒ **The MAF Sensor parameter does not change smoothly and gradually**

Refer to Circuit/System Testing.

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

3. Operate the vehicle within the Conditions for Running the DTC 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.
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 9-536* 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	High Resistance	Open	Short to Voltage	Signal Performance
5 V Reference	P0106, P0107, P0697	P0106, P0107	P0107	P0106, P0108, P0697	P0106
Signal	P0106, P0107	P0106, P0107	P0106, P0107	P0106, P0108*	P0106, P1101
Low Reference	—	P0106, P0108	P0106, P0108	—	P0106
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.					

Typical Scan Tool Data

MAP Sensor

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)	128 kPa (18.6 psi)
Signal	0 kPa (0 psi)	0 kPa (0 psi)	128 kPa (18.6 psi)*
Low Reference	—	80–128 kPa (11.6–18.6 psi)	—
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

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). 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 2967326 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. 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 P0102, P0103, P0107, P0108, P0111, P0112, P0113, P0116, P0117, P0118, P0119, P0335, or P0336 are not set
- The engine speed is between 400-7 000 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 determines if the MAP sensor is stuck within the normal operating range.

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 9-314

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

GE-23738-A Vacuum Pump

For equivalent regional tools, refer to *Special Tools on page 9-593*.

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 9-449* for further diagnosis.

⇓ **If none of the DTCs are set**

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

⇒ **If 90 % or greater**

Refer to *Throttle Body Inspection and Cleaning on page 9-547*.

⇓ **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 on page 9-372* 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 9-312* table.

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

Refer to Circuit/System Testing.

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

9. 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**

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.

⇒ **If the MAF Sensor parameter does not change smoothly and gradually**

Refer to *DTC P0101 on page 9-349* for further diagnosis.

⇓ **If the MAF Sensor parameter changes smoothly and gradually**

11. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
12. Verify a DTC does not set.

⇒ **If the DTC sets**

Refer to Circuit/System Testing.

⇓ **If the DTC does not set**

13. All OK

Circuit/System Testing

1. Check the integrity of the entire air induction system and verify that none of the following conditions exist:
   - Any damaged components
   - 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, where equipped
- Proper operation of the Positive Crankcase Ventilation 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 or belt installation. Refer to *Symptoms - Engine Mechanical on page 9-953*.

⇒ **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:
- X3 harness connector, ECM with 3 face mounted connectors
- X2 harness connector, ECM with 2 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 verify the integrity of the MAP sensor circuits before proceeding with the Component Testing.

Skewed Sensor Test

1. Ignition OFF, remove the B74 Manifold Absolute Pressure sensor from the engine. Connect the harness to the sensor, if disconnected.
2. Ignition ON, apply 17 kPa (5.0 inHg) of vacuum to the B74 Manifold Absolute Pressure sensor, with the *GE-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 *GE-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 0-15 kPa of vacuum to the sensor with the *GE-23738-A* Vacuum Pump. Verify the voltage changes, without any spikes or dropouts and is between 0.2–4.9 V.

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

Replace the B74 Manifold Absolute Pressure sensor.

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

7. All OK.

Repair Instructions

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

- *Manifold Absolute Pressure Sensor Replacement on page 9-537*.
- *Control Module References on page 6-3* for ECM 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	High Resistance	Open	Short to Voltage	Signal Performance
5 V Reference	P0106, P0107, P0697	P0106, P0107	P0107	P0106, P0108, P0697	P0106
Signal	P0106, P0107	P0106, P0107	P0106, P0107	P0106, P0108*	P0106, P1101
Low Reference	—	P0106, P0108	P0106, P0108	—	P0106
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.					

Typical Scan Tool Data

MAP Sensor

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)	128 kPa (18.6 psi)
Signal	0 kPa (0 psi)	0 kPa (0 psi)	128 kPa (18.6 psi)*
Low Reference	—	80–128 kPa (11.6–18.6 psi)	—
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

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). 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 V 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. The lowest manifold pressure occurs when the vehicle is idling or decelerating. The ECM monitors the MAP sensor signal for pressure outside of the normal range.

Conditions for Running the DTC

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

Conditions for Setting the DTC

P0107

The ECM detects that the MAP sensor voltage is less than 0.2 V for greater than 4 s.

P0108

The ECM detects that the MAP sensor voltage is greater than 4.5 V for greater than 4 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 9-314

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

GE-23738-A Vacuum Pump

For equivalent regional tools, refer to *Special Tools on page 9-593*.

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 9-449* for further diagnosis.

⇓ **If none of the DTCs are set**

3. Determine the current vehicle testing altitude.
4. Verify the scan tool MAP Sensor pressure parameter is within the range specified in the *Altitude Versus Barometric Pressure on page 9-312* table.

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

Refer to Circuit/System Testing for further diagnosis.

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

5. Engine idling, verify the scan tool MAP voltage parameter is between 0.2–4.5 V and changes with accelerator pedal input.

⇒ **If not between 0.2–4.5 V or does not change**

Refer to Circuit/System Testing.

⇓ **If between 0.2–4.5 V and changes**

6. 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.
7. Verify a DTC does not set.

⇒ **If any DTC sets**

Refer to Circuit/System Testing.

⇓ **If no DTC sets**

8. All OK.

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the B74 Manifold Absolute Pressure sensor.
2. Ignition OFF and all vehicle systems OFF. It may take up to 2 minutes for all vehicle systems to power down. 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

5.2. 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**

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 verify the integrity of the MAP sensor circuits before proceeding with the Component Testing.

Skewed Sensor Test

1. Ignition OFF, remove the B74 Manifold Absolute Pressure sensor from the engine. Connect the harness to the sensor, if disconnected.
2. Ignition ON, apply 17 kPa (5.0 inHg) of vacuum to the B74 Manifold Absolute Pressure sensor, with the *GE-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 *GE-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 0-15 kPa of vacuum to the sensor with the *GE-23738-A* Vacuum Pump. Verify the voltage changes, without any spikes or dropouts and is between 0.2–4.9 V.

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

Replace the B74 Manifold Absolute Pressure sensor.

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

7. All OK.

Repair Instructions

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

- *Manifold Absolute Pressure Sensor Replacement on page 9-537*
- *Control Module References on page 6-3* for ECM 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 1 Circuit Low Voltage
DTC P0113: Intake Air Temperature (IAT) Sensor 1 Circuit High Voltage
DTC P0114: Intake Air Temperature (IAT) Sensor 1 Circuit Intermittent

Diagnostic Fault Information

IAT Sensor 1

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
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+. **P2199 - where used.				

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:

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

The intake air temperature (IAT) sensor 1 is a variable resistor that measures the temperature of the air in the sensor bore. The engine control module (ECM) supplies 5 V to the IAT sensor 1 signal circuit and a ground for the IAT sensor 1 low reference circuit. The signal varies with inlet air temperature and is displayed by the scan tool as °C (°F).

The IAT sensor 2 produces a frequency signal based on the inlet air temperature very close to the humidity sensor within the sensor bore. The signal varies with inlet air temperature and is displayed by the scan tool as °C (°F) and Hertz (Hz). The signal circuit is shared by the IAT sensor 2 and the humidity 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

Ignition voltage and ground circuits are also supplied to the multifunction intake air sensor's internal circuits for the mass air flow (MAF) 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 DTC

P0112

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 warmer than 150°C (302°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 monitors the IAT sensor signal every 0.1 s, to determine if the signal has changed more than 80°C (176°F). The DTC fails when the condition exists for longer than 4 s.

Action Taken When the DTCs Set

- DTCs P0112, P0113, and P0114 are Type B DTCs.
- The ECM commands the cooling fans ON.

Conditions for Clearing the DTCs

DTCs P0112, P0113, and P0114 are Type B DTCs.

Diagnostic Aids

- With the ignition ON, the engine OFF, if the engine is cold, a properly functioning IAT sensor 1 will gradually increase the scan tool IAT Sensor 1 parameter. This is due to the heat that is generated by the MAF sensor heating elements.
- Depending on the ambient temperature, an IAT sensor 1 signal circuit or low reference circuit that is shorted to the MAF sensor signal circuit can cause a DTC P0113 and/or P0114 to set. This condition causes a rapid fluctuation in the IAT Sensor 1 parameter.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-314

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 55°C (99°F) of each other.
   - Start-Up IAT Sensor 1
   - IAT Sensor 2
   - Start-Up ECT

⇒ **If not within 55°C (99°F)**

Refer to Circuit/System Testing.

⇓ **If within 55°C (99°F)**

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

⇒ **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 a DTC sets**

Refer to Circuit/System Testing.

⇓ **If no DTC sets**

6. All OK

Circuit/System Testing

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

1. 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 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 8 and ground.

⇒ **If less than 4.8 V**

3.1. Ignition OFF, disconnect the 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 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 9-312* 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 9-536* for B75C Multifunction Intake Air sensor replacement.
- *Control Module References on page 6-3* for Engine Control Module replacement, programming, and setup.

DTC P0116 (LUW)

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 P0116: Engine Coolant Temperature (ECT) Sensor Performance

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 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

- DTCs P0111, P0112, P0113, P0117, P0118, P0502, P0503, P0722, P0723, or P2610 are not set.
- The intake air temperature (IAT) is warmer than −7°C (19°4F).
- The fuel level is greater than 10%.
- The ECM has no block heater detected.
- The ignition has been off for greater than 8 h before the engine is started.
- This DTC runs once per cold start when the above conditions are met.

Conditions for Setting the DTC

- The ECM detects a temperature difference at power-up that indicates that the ECT sensor is 30° C (86°F) warmer than the IAT sensor.

  OR
- The ECM detects a temperature difference at power-up that indicates that the ECT sensor is 20° C (68°F) warmer than the IAT sensor, and the time spent cranking the engine is greater than 10 s when the fuel level is greater than 10%

  OR
- The ECM detects a temperature difference at power-up that indicates that the ECT sensor is 20° C (68°F) warmer than the IAT sensor. Then the vehicle must be driven for greater than 6 min and 40 s at greater than 24 km/h (15 mph) . If the IAT sensor then decreases greater than 3°C (37.4°F), an engine block heater was detected and the test is aborted. If the IAT sensor does not decrease, an engine block heater was not detected and DTC P0116 will set.

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 9-312*.
- 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 9-312*.
- 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 9-314

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*

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 −40 to +140°C (−40 to +284°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 B34A Engine Coolant Temperature Sensor.
2. Ignition OFF, 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.
3. Ignition ON, verify the scan tool ECT Sensor is at −40°C (−40°F).
   ⇒ If warmer 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.

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 3 A fused jumper wire between the signal circuit terminal 1 and the low reference circuit terminal 2. Verify the scan tool ECT Sensor is at 140°C (284°F).
   ⇒ If colder 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.
5. If all circuits test normal, test or replace the B34A Engine Coolant Temperature Sensor.

Component Testing

Static Test

1. Ignition OFF, disconnect the harness connector at the B34A Engine Coolant Temperature Sensor.

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

2. Test the B34A 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 9-312* table and verify that the resistance is within 5% of the specification.
   ⇒ If not within the specified range, replace the B34A Engine Coolant Temperature Sensor.

Repair Instructions

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

- *Engine Coolant Temperature Sensor Replacement (Water Outlet) on page 9-534* or *Engine Coolant Temperature Sensor Replacement (Radiator) on page 9-535* or *Engine Coolant Temperature Sensor Replacement (Thermostat) on page 9-535*
- *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 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. 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 9-314

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 149°C (300°F).

⇒ **If colder than 149°C (300°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 149°C (300°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 on page 9-597* 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 9-534* or *Engine Coolant Temperature Sensor Replacement (Radiator) on page 9-535* or *Engine Coolant Temperature Sensor Replacement (Thermostat) on page 9-535*
- *Engine Control Module Replacement on page 9-531* engine control module replacement, programming, and setup

DTC P0121-P0123, P0222, P0223, or P2135

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	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	—	4–5 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 6.41 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

- DTCs P0102, P0103, P0107, P0108, P0112, P0113, P0114, P0116, P0117, P0118, P0128, P0315, P0335, P0336, or is not set.
- The engine speed is between 400 and 6,000 RPM.
- The engine coolant temperature (ECT) is between −7 to +125°C (19–257°F).
- The intake air temperature (IAT) is between −20 to +100°C (−4 to +212°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 6.41 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 9-314

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Throttle Actuator Control (TAC) System Description on page 9-587

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 9-449* 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 9-547*.

⇓ **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 9-312* table.

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

Refer to *DTC P0106 on page 9-356*.

⇓ **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 9-356*.

⇓ **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 9-349*.

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

12. 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.
13. Verify the DTC does not set.

⇒ **If the DTC sets**

Refer to Circuit/System Testing

⇓ **If the DTC does not set**

14. 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 9-542*
- *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 (LUW)

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 as 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 coolant temperature 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 engine coolant temperature 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

- DTC P00B3, P00B4, P00B6, P0101, P0102, P0103, P0111, P0112, P0113, P0116, P0117, or P0118 are not set.
- The decrease in ECT after engine start is within a calibrated range.
- The start-up ECT is between −40 to +80°C (−40 to +176°F).
- The start-up IAT is between −7 to +65°C (+19.4 to +149°F).
- The engine coolant thermostat heater command is equal to or greater than 10%.
- The engine average airflow is greater than 11 g/s.
- The engine has not run for greater than 30 minutes.
- The engine runtime is between 22 s and 30 min.
- The ethanol in the fuel is equal or less than 100%
- The DTC runs once per ignition cycle when the above conditions are met.

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 to +65°C (+50 to +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 to +10°C (+19.4 to +50°F).

Action Taken When the DTC Sets

- DTC P0128 is a type B DTC.
- The cooling fan will be commanded ON.
- The A/C compressor will be commanded OFF.

Conditions for Clearing the DTC

DTC P0128 is a Type B DTC.

Diagnostic Aids

The following conditions can also set the DTC:

- DTC P0128 occurring with insufficient vehicle interior heating is an indication of improper thermostat operation.
- Corrosion on the engine coolant temperature (ECT) sensor terminals or the engine coolant temperature (ECT) sensor harness connector results in a greater voltage on the engine coolant temperature (ECT) sensor signal circuit, which is interpreted by the ECM as a colder engine coolant temperature (ECT) sensor.
- A slight to moderate resistance in the engine coolant temperature (ECT) sensor signal circuit or low reference circuit will affect this diagnostic. This condition results in a greater voltage on the engine coolant temperature (ECT) sensor signal circuit, which is interpreted by the ECM as a colder engine coolant temperature (ECT) sensor.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-314

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

Circuit/System Verification

1. IgnitionOFF, 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*.
2. Ignition ON, observe the DTC information with a scan tool. DTC P00B7, P0597, P0598, P0599, or p2181 should not be set.
   ⇒ If a DTC is set, refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69*.
3. Engine idling for 15 min with the A/C OFF.
4. Command the Engine Coolant Thermostat Heater to 0% with a scan tool. Increase the engine speed to 3 000 RPM. Observe the scan tool ECT Sensor parameter. The temperature should increase to greater than 102°C (215°F).
   ⇒ If less than the specified value, replace the E41 Engine Coolant Thermostat Heater.
5. Command the Engine Coolant Thermostat Heater to 100% with a scan tool. Increase the engine speed to 3 000 RPM. Observe the scan tool Radiator Coolant Temperature Sensor and the ECT Sensor parameters. The Radiator Coolant Temperature Sensor and the ECT Sensor parameters should be within 20°C (68°F).
6. Engine idling, observe the DTC information with a scan tool. DTC P0128 should not set.
7. 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, all vehicles system OFF. It may take up to 2 min for all vehicles systems to power down. Disconnect the harness connector at the B34A Engine Coolant Temperature Sensor.
2. Test for less than 5 Ω between the low reference circuit terminal 2 and ground.
   ⇒ If greater than the specified range, test the ground circuit for an open/high resistance. If the circuit tests normal, replace the K20 Engine Control Module.
3. Ignition ON, verify the scan tool ECT Sensor parameter is at −40°C (−40°F).
   ⇒ If warmer than −40°C (−40°F), test the signal circuit terminal 1 for a short to ground. If the circuit tests normal, replace the 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 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 at 140°C (284°F).
   ⇒ If colder 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.
5. If all circuits/connections test normal, replace the B34A Engine Coolant Temperature Sensor.

Component Testing

Static Test

1. Ignition OFF, disconnect the harness connector at the B34A Engine Coolant Temperature Sensor.

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

2. Test the B34A 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 9-312* 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 repair.

- *Engine Coolant Temperature Sensor Replacement (Water Outlet) on page 9-534* or *Engine Coolant Temperature Sensor Replacement (Radiator) on page 9-535* or *Engine Coolant Temperature Sensor Replacement (Thermostat) on page 9-535*
- *Engine Coolant Thermostat Replacement (LUV) on page 9-661* or *Engine Coolant Thermostat Replacement (LUW) on page 9-662*
- *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* provide 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

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
HO2S High Signal	P0131, P0137	P0132, P0134, P0138, P0140	P0132, P0134, P0138, P0140	P0133, P1133*, P015A*, P015B*
HO2S Low Signal	P0131, P0137	P0132, P0134, P0138, P0140	P0132, P0134, P0138, P0140	P0133, P1133*, P015A*, P015B*
*If equipped				

Typical Scan Tool Data

HO2S 1 Voltage, HO2S Sensor 2 Voltage

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 High Signal	0 mV	1 800–2 100 mV	1 800–2 100 mV
HO2S 1 or 2 Low Signal	−0 mV	1 800–2 100 mV	1 800–2 100 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 0–1 000 mV. Once sufficient HO2S voltage fluctuation is observed by the control module, closed loop is entered. The control module uses the HO2S voltage to determine the air to fuel ratio. An HO2S voltage that increases toward 1 000 mV indicates a rich fuel mixture. An HO2S voltage that decreases toward 0 mV indicates a lean fuel mixture.

The heating elements inside each HO2S heat the sensor to bring the sensor up to operating conditions faster. This allows the system to enter closed loop earlier and the control module to calculate the air to fuel ratio sooner.

Conditions for Running the DTC

DTC P0131 or P0137

- DTCs P0068, P0106, P0108, P0122, P0123, P0201, P0202, P0203, P0204, P0222, P0223, P0442, P0443, P0449, P0452, P0455, P0496, P0606, P16F3 and P2101 are not set.
- The system 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.
- The engine is not decelerating.
- DTC P0131 runs continuously when the above conditions are met for greater than 3 s.
- DTC P0137 runs continuously when the above conditions are met for greater than 5 s.

DTC P0132 or P0138

- DTCs P0106, P0108, P0201, P0202, P0203, P0204, P0442, P0443, P0449, P0452, P0453, P0455 and P0496 are not set.
- The system 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.
- The engine runtime is greater than 5 s.
- The engine is not decelerating.
- 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, P0122, P0123, P0222, P0223, P0606 and P16F3 are not set.
- The ignition voltage is between 10–32 V.
- The heated oxygen sensor heater warm up is finished.
- The engine runtime is greater than 5 s.
- The fuel composition is less than 87% ethanol.
- DTC P0134 and P0140 run continuously when the above conditions are met.

Conditions for Setting the DTC

P0131 or P0137

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

P0132 or P0138

The engine control module detects that the heated oxygen sensor voltage is greater than 1 050 mV for greater than 10 s.

P0134 or P0140

The engine control module detects that the heated oxygen sensor 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 9-314

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 HO2S heater DTCs are set.

⇒ **If a HO2S heater DTC is set.**

Refer to *DTC P0030-P0032, P0036-P0038, P0053, P0054, P0135, or P0141 on page 9-335.*

⇓ **If no HO2S heater DTC is set.**

3. Allow the engine to reach operating temperature, engine running.
4. Verify the scan tool HO2S Sensor 1 or 2 voltage parameters are between 50–1 050 mV.

⇒ **If not between 50–1 050 mV.**

Refer to Circuit/System Testing.

⇓ **If between 50–1 050 mV.**

5. Operate the vehicle within the Conditions for Running 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 B52 Heated Oxygen Sensor. It may take up to 2 min for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal 3 and ground.

⇒ **If 5 Ω or greater**

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 1.5–2.5 V between the high signal circuit terminal 4 and ground.

⇒ **If less than 1.5 V**

4.1. Ignition OFF, disconnect the 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, replace the K20 Engine Control Module.

⇒ **If greater than 2.5 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 signal circuit and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇓ If less than 1 V

4.3. Ignition OFF

4.4. Test for less than 2 Ω in the signal circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, replace the K20 Engine Control Module.

⇓ **If between 1.5–2.5 V**

5. Verify none of the following conditions exist:
   - Lean or rich fuel injectors. Refer to *Fuel Injector Diagnosis on page 9-520*.
   - Water intrusion in the HO2S harness connector
   - Low or high fuel system pressure. Refer to *Fuel System Description on page 9-584*.
   - Fuel that is contaminated. Refer to *Alcohol/ Contaminants-in-Fuel Diagnosis on page 9-523*.
   - Fuel saturation of the evaporative emission (EVAP) canister
   - Exhaust leaks near the HO2S
   - Engine vacuum leaks

⇒ **If a condition is found**

Repair as necessary.

⇓ **If no condition is found**

Test or replace the appropriate B52 Heated Oxygen Sensor.

Repair Instructions

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

- *Heated Oxygen Sensor Replacement - Sensor 1 on page 9-538*
- *Heated Oxygen Sensor Replacement - Sensor 2 on page 9-539*
- 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 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

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, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0116, P0117, P0118, P0119, P0122, P0123, P0128, P0131, P0132, P0134, P0201, P0202, P0203, P0204, P0222, P0223, P0300, P0442, P0443, P0449, P0452, P0455, P0496, P16F3, P2101 or P2135 is not set.
- The ignition signal parameter is between 10–32 V.
- The device controls are not active.
- The engine speed is between 1 200–3 500 RPM.
- 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 barometric pressure (BARO) is greater than 70 kPa (10 PSI).
- The engine has been operating for greater than 150 s.
- The mass air flow (MAF) sensor parameter is between 12–30 g/s.
- The HO2S heater is commanded ON for greater than 40 s.
- The fuel system is in Closed Loop.
- The vehicle is not decelerating.
- The learned heater resistance is valid.
- The fuel composition is less than 87% ethanol.
- The DTCs run continuously when the above conditions are met for greater than 1 s.

P013A

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0116, P0117, P0118, P0119, P0122, P0123, P0128, P0171, P0172, P0201, P0202, P0203, P0204, P0222, P0223, P0300, P16F3, P2101 or P2135 is not set.
- The system voltage is between 10–32 V.
- The learned heater resistance is valid.
- The fuel level is greater than 10%.
- DTC P013B, P013E, P013F, P2270 or P2271 have failed this key cycle.
- DTC P013E and P2270 have passed.
- The DTC runs once per trip, during deceleration fuel cut-off (DFCO) mode, when the above conditions are met.

P013B

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0116, P0117, P0118, P0119, P0122, P0123, P0128, P0171, P0172, P0201, P0202, P0203, P0204, P0222, P0223, P0300, P16F3, P2101 or P2135 is not set.
- The system voltage is between 10–32 V.
- The learned heater resistance is valid.
- The fuel level is greater than 10%.
- DTC P013A, P013E, P013F, P2270 or P2271 have failed this key cycle.
- DTC P013A, P013E, P013F, P2270 and P2271 have passed.
- The DTC runs once per trip, during the fuel enrich mode, when the above conditions are met.

P013E

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0116, P0117, P0118, P0119, P0122, P0123, P0128, P0171, P0172, P0201, P0202, P0203, P0204, P0222, P0223, P0300, P16F3, P2101 or P2135 is not set.
- The system voltage is between 10–32 V.
- The learned heater resistance is valid.
- The fuel level is greater than 10%.
- DTC P013A, P013B, P013F, P2270 and P2271 have failed this key cycle.
- DTC P2270 have passed.
- The DTC runs once per trip, during deceleration fuel cut-off (DFCO) mode, when the above conditions are met.

P013F

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0116, P0117, P0118, P0119, P0122, P0123, P0128, P0171, P0172, P0201, P0202, P0203, P0204, P0222, P0223, P0300, P16F3, P2101 or P2135 is not set.
- The system voltage is between 10–32 V.
- The learned heater resistance is valid.
- The fuel level is greater than 10%.
- DTC P013A, P013B, P013E, P2270 and P2271 have failed this key cycle.
- DTC P013A, P013E, P2270 and P2271 have passed.
- The DTC runs once per trip, during the fuel enrich mode, when the above conditions are met.

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, P0204, P0222, P0223, P0300, P0442, P0443, P0446, P0449, P0452, P0453, P0455, P0496, P16F3, P2101 or P2135 is not set.
- The system voltage is between 10–32 V.
- The device controls are not active.
- The fuel level is greater than 10%.
- The HO2S heater is commanded ON for greater than 40 s.
- The learned heater resistance is valid.
- 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.

P2270

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0116, P0117, P0118, P0119, P0122, P0123, P0128, P0171, P0172, P0201, P0202, P0203, P0204, P0222, P0223, P0300, P16F3, P2101 or P2135 is not set.
- The ignition signal parameter is between 10–32 V.
- The fuel level is greater than 10%.
- The engine speed is between 1 400–3 500 RPM to initially enable the test.
- The vehicle speed is between 45–125 km/h (28–78 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 40–130 km/h (25–81 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 HO2S heater is commanded ON for greater than 40 s.
- The predicted catalytic converter temperature is between 550–900°C (1 022–1 652°F).

- DTC P013A, P013B, P013E, P013F, P2270 or P2271 have failed this key cycle.
- The DTC runs once per trip, during the fuel enrich mode, when the above conditions are met for 1.5 s.

P2271

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0116, P0117, P0118, P0119, P0122, P0123, P0128, P0171, P0172, P0201, P0202, P0203, P0204, P0222, P0223, P0300, P16F3, P2101 or P2135 is not set.
- The ignition signal parameter is between 10–32 V.
- The fuel level is greater than 10%.
- The engine speed is between 1 400–3 500 RPM.
- The vehicle speed is between 45–125 km/h (28–78 mph).
- 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 HO2S heater is commanded ON for greater than 40 s.
- The predicted catalytic converter temperature is between 550–900°C (1 022–1 652°F).
- DTC P013A, P013B, P013E, P013F or P2270 have failed this key cycle.
- DTC P013A, P013E and P2270 have passed.
- The DTC runs once per trip, during deceleration fuel cut-off (DFCO) mode, when the above conditions are met.

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 greater than 10 g.

P013B

The ECM detects that the accumulated mass air flow monitored during rich to lean transitions between 335–650 mV is greater than 140 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 260 g.

P2270

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

  and

- The ECM detects that the accumulated mass air flow monitored during the Stuck Lean Voltage Test is greater than 60 g.

P2271

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

  and

- The ECM detects that the accumulated mass air flow monitored during the stuck rich voltage test is greater than 30 g.

Action Taken When the DTC Sets

- DTCs P0133, P013E, P013F, P2270 are P2271 Type B DTCs.
- DTCs P013A, P013B, P015A and P015B are Type A DTCs.

Conditions for Clearing the DTC

- DTCs P0133, P013E, P013F, P2270 are P2271 Type B DTCs.
- DTCs P013A, P013B, P015A and P015B are Type A DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-314

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*
- *Heated Oxygen Sensor Wiring Repairs on page 11-543*

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 *DTC P0030-P0032, P0036-P0038, P0053, P0054, P0135, or P0141 on page 9-335*
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 9-518*
   - Fuel that is contaminated, refer to *Alcohol/ Contaminants-in-Fuel Diagnosis on page 9-523*
   - Fuel saturation of the evaporative emission (EVAP) canister
   - Exhaust leaks
   - Engine vacuum leaks
   - Engine oil consumptions, refer to *Oil Consumption Diagnosis on page 9-956*
   - 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 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

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

- *Heated Oxygen Sensor Replacement - Sensor 1 on page 9-538*
- *Heated Oxygen Sensor Replacement - Sensor 2 on page 9-539*
- 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 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 9-312*

⇒ **If not within the specified range**

Refer to *DTC P0106 on page 9-356*

⇓ **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 –25 % and +25 % (LWE) or –30 % and +30 % (LUW).

⇒ **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 9-349*.
- Fuel contamination. Refer to *Alcohol/ Contaminants-in-Fuel Diagnosis on page 9-523*.
- 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 9-520*.
- Split, kinked, or improperly connected vacuum hoses
- Insufficient fuel in the tank
- Low fuel pressure. Refer to *Fuel System Diagnosis on page 9-518*.
- 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. Refer to *Crankcase Ventilation System Inspection/Diagnosis on page 9-968*.

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 9-349*.
- Fuel contamination. Refer to *Alcohol/ Contaminants-in-Fuel Diagnosis on page 9-523*.
- 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 9-520*
- Collapsed or restricted air intake duct
- Excessive fuel pressure. Refer to *Fuel System Diagnosis on page 9-518*
- 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 9-953.*

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.
- DTC 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

DTC P018B, P018C and P018D are Type A DTCs.

Conditions for Clearing the DTC

DTC P018B, P018C and P018D are Type A DTCs.

Diagnostic Aids

Using the Failure Records data may help locate an intermittent condition. If you cannot duplicate the DTC, the information in the Failure Records can help determine how many miles since the DTC set. The Fail Counter and Pass Counter can help determine how many ignition cycles that the diagnostic test reported a pass and/or a fail.

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

Fuel System Description on page 9-584

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.

Conditions for Setting the DTC

The control module detects an incorrect voltage on the fuel injector control circuit for more 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 9-520*.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-314

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 9-520

Repair Instructions

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

- *Fuel Injector Replacement on page 9-562*
- *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 9-314

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Fuel System Description on page 9-584

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 G12 fuel pump. 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 G12 fuel pump.

Repair Instructions

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

- *Fuel Tank Fuel Pump Module Replacement (Steel Tank) on page 9-559*
- *Control Module References on page 6-3* for fuel pump control module 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 9-314

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Fuel System Description on page 9-584

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 (LUW)

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 in order to determine when an engine misfire is occurring and uses information from the camshaft position sensor intake and camshaft position sensor exhaust sensors in order to determine which cylinder is misfiring. By monitoring variations in the crankshaft rotation speed for each cylinder, the ECM is able to detect individual misfire events. If the ECM detects a misfire rate sufficient to cause emission levels to exceed mandated standards, DTC P0300 sets. Under certain driving conditions, a misfire rate can be high enough to cause the 3-way catalyst to overheat, possibly damaging the converter. The malfunction indicator lamp (MIL) will flash ON and OFF when converter overheating, damaging conditions are present and DTC P0300 is set. DTCs P0301-P0304 corresponds to cylinders 1–4. If the ECM is able to determine that a specific cylinder is misfiring, the DTC for that cylinder will set.

Conditions for Running the DTC

- DTCs P0010, P0011, P0013, P0014, P0016, P0017, P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0117, P0118, P0122, P0123, P0222, P0223, P0335, P0336, P0606, P0651, P0697, P06A3, P0806, P0807, P0808, P1104, P16F3, P182E, P2101, P2122, P2123, P2127, P2128, P2135 or P2138 are not set.
- The engine speed is between 500–6,500 RPM or DTC P0315 is set and the engine speed is greater than 1,000 RPM.
- The engine coolant temperature (ECT) is between −7 and +125°C (19 and 257°F).
- If the ECT is colder than −7°C (+19°F) at start–up, this diagnostic will not run until the ECT is between 21–125°C (70–257°F).
- The system voltage is between 9–32 V.
- The engine runtime is greater than 2 crankshaft revolutions.
- The throttle deltas are less than 95%.
- The fuel level is greater than 10%.
- The camshaft and crankshaft sensors are synchronized with each other.
- DTCs P0300-P0304 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.

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 —Remove the drive belt and safely operate the engine to evaluate.
  - 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.
- If the condition is intermittent, observing the scan tool IC Circuit Test and Fuel Injector Circuit Test Status parameters may help to isolate the condition. The circuit status parameters will change from OK or Not Run to Malfunction if a condition exists.
- A condition in HO2S heater control circuits may set a misfire DTC.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-314

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

- *J 34730-2C* Injector Test light
- *EL 26792* HEI Spark Tester

For equivalent regional tools, refer to *Special Tools on page 9-593*.

Circuit/System Verification

1. Engine running at normal operating temperature, verify there is no abnormal engine noise.
   ⇒ If there is an abnormal engine noise, refer to *Symptoms - Engine Mechanical on page 9-953*.
2. Observe the DTC information with a scan tool. Verify that DTC P0201–P0204, P0315, P0335, P0336, P0351–P0354 are not set.
   ⇒ If any of the DTCs are set, refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69*.

Note: A misfire may only occur when the engine is under a load. An engine load may be necessary to verify the condition.

3. Observe the scan tool Misfire Current Counter parameters. The Misfire Counters should not be incrementing.
4. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that are captured in the freeze frame/failure records lists.

Circuit/System Testing

1. Verify that the following conditions do not exist:
   - Vacuum hose splits, kinks, and incorrect connections
   - Engine vacuum leaks
   - Crankcase ventilation system for vacuum leaks, refer to *Crankcase Ventilation System Inspection/Diagnosis on page 9-968*.
   - Fuel pressure that is too low or too high, refer to *Fuel System Diagnosis on page 9-518*.
   - Contaminated fuel, refer to *Alcohol/ Contaminants-in-Fuel Diagnosis on page 9-523*.
   - Restricted exhaust system, refer to *Restricted Exhaust on page 9-734*.

   ⇒ If you find any of the above conditions, repair as necessary.
2. Ignition OFF, disconnect the harness connector at the appropriate Q17 Fuel Injector.
3. Connect a *J 34730-2C* Injector Test light between the control circuit terminal 2 and the ignition voltage circuit terminal 1.
4. Engine idling, the test lamp should flash.
   ⇒ If the test lamp does not flash, refer to *DTC P0201, P0202, P0203, P0204, P0261, P0262, P0264, P0265, P0267, P0268, P0270, or P0271 on page 9-390*.
5. Ignition OFF, connect the Q17 Fuel Injector connector. Remove the T8 Ignition Coil.
6. Inspect the ignition coil spark plug boots for the following conditions:
   - Damage
   - Carbon tracking
   - Oil contamination
   - Water intrusion

   ⇒ If you find any of the above conditions, repair as necessary.
7. Connect the harness connector to the ignition coil assembly.
8. Install the *EL 26792* HEI Spark Tester between the spark plug boot of the misfiring cylinder and ground.
9. Connect the remaining wires to the appropriate cylinders.

Note: An erratic or weak spark is considered a no spark condition.

10. Attempt to start the engine and observe the *EL 26792* HEI Spark Tester. The spark tester should spark.
    ⇒ If there is no spark, refer to *Electronic Ignition System Diagnosis on page 9-527*.
11. Ignition OFF, remove the spark plug from the misfiring cylinder. Verify the following conditions do not exist with the spark plug:
    - Gas, coolant, or oil fouled, refer to *Spark Plug Inspection on page 9-571*.
    - Cracked, worn, incorrectly gapped

    ⇒ If there is a condition with the spark plug, replace the spark plug.
12. Exchange the suspected spark plug with another cylinder that is operating correctly.

13. Engine running, observe the scan tool Cylinder 1–4 Current Misfire Counters. The misfire should not follow the spark plug exchange.
    ⇒ If the misfire follows the spark plug, replace the spark plug.
14. If all conditions test normal, test or inspect for the following:
    - A lean or rich fuel injector, refer to *Fuel Injector Diagnosis on page 9-520*.
    - An engine mechanical condition, refer to *Symptoms - Engine Mechanical on page 9-953*.

Repair Instructions

- *Ignition Coil Replacement on page 9-570*
- *Spark Plug Replacement on page 9-573*

Repair Verification

1. Install any components or connectors that have been removed or replaced during diagnosis.
2. Perform any adjustment, programming or setup procedures that are required when a component or module is removed or replaced.
3. Clear the DTCs.
4. Turn OFF the ignition for 60 s.
5. If the repair was related to a DTC, duplicate the conditions for running the DTC and use the freeze frame/failure records, if applicable, in order to verify the DTC does not reset. If the DTC resets or another DTC is present, refer to the *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69*.
6. To verify that the performance of the catalyst has not been affected by the condition that set this DTC, perform the Repair Verification for DTC P0420. Refer to *DTC P0420 on page 9-422*.

DTC P0315 (LUW)

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 build tolerance variations in the crankshaft position sensor, crankshaft, and crankshaft position sensor position. 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 wide range of engine speeds and load conditions. The ECM stores the crankshaft position system variation values after a learn procedure has been performed. If the actual crankshaft position variation is not stored within the crankshaft position sensor compensating value look up table, then DTC P0300 may set. If the crankshaft position sensor system variation values are not stored in the ECM memory, or a proper ECM power down does not occur after completing the crankshaft position sensor Learn Procedure, then 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 DTC.

Conditions for Clearing the DTC

DTC P0315 is a Type A DTC.

Diagnostic Aids

This test procedure requires that the vehicle battery has passed a load test and is completely charged. Refer to *Battery Inspection/Test on page 9-702*.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-314

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.
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
   - A damaged crankshaft. Refer to *Crankshaft and Bearing Cleaning and Inspection on page 9-1109*.
   - 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 there is a condition, repair as necessary.
3. 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 repair.

Control Module References *Control Module References on page 6-3* for engine control module 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 Descriptors

DTC P0324: Knock Sensor (KS) System Performance

DTC P0326: Knock Sensor (KS) Performance

DTC P06B6: Control Module Knock Sensor Processor 1 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, P06B6	P0328	P0326

Circuit/System Description

The knock sensors enable the engine control module (ECM) to control the ignition timing for the best possible performance while protecting the engine from potentially damaging levels of detonation. The knock sensors produce an alternating current (AC) voltage signal that varies depending on the vibration level during engine operation. The ECM adjusts the spark timing based on the amplitude and the frequency of the two knock sensor signals. The ECM receives 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 processors by verifying a 20 KHz signal generated on the signal circuits is detected on the sensors' low reference circuits.

Conditions for Running the DTCs

P0324 or P0326–Condition 1; Excessive Knock Diagnostic

- Engine speed is between 400 and 8,500 RPM.
- Engine is running for greater than 2 s.
- The number of engine revolutions above the minimum engine speed is least 200 revolutions.
- The engine coolant temperature (ECT) is warmer than −40°C (−40°F).
- The intake air temperature (IAT) sensor 1 is warmer than −40°C (−40°F).
- The DTCs run continuously when the above conditions are met.

P0324 or P0326–Condition 2; Abnormal Noise Diagnostic and Condition 3; Flat Signal Diagnostic

- Engine speed is at least 8,500 RPM.
- The number of engine revolutions above the minimum engine speed is least 200 revolutions.
- The ECT is warmer than −40°C (−40°F).
- The IAT sensor 1 is warmer than −40°C (−40°F).
- The DTCs run continuously when the above conditions are met.

P06B6

- Engine speed is between 500 and 5,500 RPM.
- The number of engine revolutions within the engine speed window is least 100 revolutions.
- Engine is running greater than 2 s.
- The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTCs

P0324

The ECM detects that the knock sensor signal's performance is out of the normal expected range due to an excessive engine knock, or abnormal noise, or a flat signal; in at least a single cylinder.

P0326

- The ECM detects that the knock sensor signal indicates the sensor harness is connected, but the sensor is not properly bolted to the engine.

  OR

- The ECM detects that the knock sensor signal indicates an excessive engine knock is present.

P06B6

The ECM has detected an internal knock sensor processor fault.

Action Taken When the DTCs Set

- 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 DTCs

DTCs P0324, P0326, and P06B6 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. 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 repair.

- *Knock Sensor Replacement on page 9-286*
- *Control Module References on page 6-3* for engine control module replacement, programming, and setup.

DTC P0325, P0327, or P0328 (LUW)

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	P0324, P0326, P06B6
Low Reference	P0327	P0325	P0328	P0324, P0326, P06B6

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 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 and a low reference circuit. The ECM learns a minimum knock sensor noise level at idle and uses calibrated values for the rest of the RPM range. The ECM should monitor a normal knock sensor signal within the noise channel.

Conditions for Running the DTC

P0325

- Engine speed is between 600-8 500 RPM.
- The ECT is greater than −40°C (−40°F).
- The IAT is greater than −40°C (−40°F).
- The engine runtime is greater than 5 s.
- The DTC runs continuously when the above conditions are met.

P0327 or P0328

- Engine speed is between 0-8 500 RPM.
- DTCs P0327 and P0328 run continuously when the above condition is met.

Conditions for Setting the DTC

P0325

The ECM detects the knock sensor signal circuit is open for greater than 5 s.

P0327

The ECM detects that the sensor input signal is less than 0.57 V or the sensor return signal is less than 0.40 V for greater than 5 s.

P0328

The ECM detects that the sensor input signal is greater than 2.76 V or the sensor return signal is greater than 1.95 V for greater than 5 s.

Action Taken When the DTC Sets

- 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 DTC

DTCs P0325, P0327, and P0328 are Type B DTCs.

Diagnostic Aids

- Inspect the knock sensor for physical damage. 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 9-314

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Electronic Ignition System Description on page 9-591

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 DTC P0325, P0327, P0328 or P06B6 is not set.

⇒ **If DTC P0325, P0327 or P0328 is set with P06B6**

Refer to Circuit/System Testing.

⇒ **If only DTC P06B6 is set**

Replace the K20 Engine Control Module.

⇓ **If none of the DTCs are set**

3. Verify the affected B68 Knock Sensor is properly tightened. Refer to *Fastener Tightening Specifications on page 9-313*.
4. Verify the scan tool parameters below display NO while moving the related harnesses and connectors for the affected 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 any of the DTCs set**

Refer to Circuit/System Testing.

⇓ **If none of the DTCs set**

6. All OK

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the B68 Knock Sensor, ignition ON.
2. Test for 1–4 V between each of the following circuits and ground:
   - Signal terminal 1
   - Low reference terminal 2

⇒ **If less than 1 V**

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

2.2. Test for infinite resistance between the affected circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

2.3. Test for less than 2 Ω in the affected circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, replace the K20 Engine Control Module.

⇒ **If greater than 4 V**

2.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module, ignition ON.

2.2. Test for less than 1 V between the affected circuit and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇒ If less than 1 V, replace the K20 Engine Control Module.

⇓ **If between 1–4 V**

3. 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 9-577*
- *Control Module References on page 6-3* for ECM 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 9-314

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Electronic Ignition System Description on page 9-591

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 9-449*.

⇓ **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 3 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 1 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 1, ignition ON.

Note: Additional DTCs may set when performing this test.

7. Verify the scan tool Crankshaft Position Sensor Active Counter parameter increments while rapidly tapping the fused jumper wire end to ground.

⇒ **If the counter does not increment**

Replace the K20 Engine Control Module.

⇓ **If the counter increments**

8. Verify DTC P0336 is not set.

⇒ **If the DTC is set**

Inspect for the conditions listed below:

- Excessive play or looseness of the B26 Crankshaft Position Sensor or the reluctor wheel
- Improper installation of the B26 Crankshaft Position Sensor
- Foreign material passing between the B26 Crankshaft Position Sensor and the reluctor wheel
- Damaged reluctor wheel
- Excessive air gap between the B26 Crankshaft Position Sensor and the reluctor wheel
- Engine oil for debris
- Timing chain, tensioner, and sprockets for wear or damage

⇒ If any of the conditions above are found, repair as necessary.

⇒ If all components test normal, test or replace the B26 Crankshaft Position Sensor.

⇓ **If the DTC is not set**

9. Test or replace the B26 Crankshaft Position Sensor.

Repair Instructions

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

- *Crankshaft Position Sensor Replacement on page 9-575*
- *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	P0340, P0365, P0532, P0641	P0340	P0641	—
Signal	P0340	P0340	P0340	P0341, P0366
Low Reference	—	P0340	—	—

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 position sensor 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 9-314

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Electronic Ignition System Description on page 9-591

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 9-449*.

⇓ **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. 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 9-576*
- *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 9-314

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Electronic Ignition System Description on page 9-591

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. Engine Cranking, test for greater than 1.5 Hz.

⇒ **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 9-570*
- *Control Module References on page 6-3* for engine control module replacement, programming, and setup

DTC P0411

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 P0411: Secondary Air Injection System Incorrect Air Flow Detected

Circuit/System Description

The secondary air injection system aids in the reduction of hydrocarbon emissions during a cold start. The electric air pump forces fresh air into the exhaust stream in order to accelerate the catalyst operation. A pressure sensor in the shutoff/check valve is used to monitor the air flow from the secondary air injection pump. The engine control module (ECM) supplies voltage to the 5-volt reference circuit and supplies a ground to the low reference circuit. The sensor provides a signal voltage to the ECM relative to the pressure changes within the secondary air injection system.

Ignition voltage is supplied to the secondary air injection pump and air injection shutoff/check valve relays. The ECM controls the relays by grounding the control circuits, which activates the relays. When the relay contacts close, voltage is supplied to the pump and the valve, which turns the pump on and opens the valve.

The diagnostic uses 3 phases to test the secondary air injection system:

- DTCs P0411 and P2430 run during Phase 1
- DTCs P2430 and P2440 run during Phase 2
- DTC P2444 runs during Phase 3

During phase 1, the secondary air injection pump and the secondary air injection shutoff and check valve are activated. Normal secondary air function occurs. Expected system pressure is 5–13 kPa (0.7–1.9 psi) above BARO.

During phase 2, only the secondary air injection pump is activated. The shutoff and check valve is closed. Pressure sensor performance and shutoff and check valve deactivation are tested. Expected system pressure is 14–25 kPa (2.0–3.6 psi) above BARO.

During phase 3, neither the secondary air injection pump nor the secondary air injection shutoff and check valve are activated. Secondary air injection pump deactivation is tested. Expected system pressure equals BARO.

Conditions for Running the DTC

- DTC P0101, P0102, P0103, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0128, P0201, P0202, P0203, P0204, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0300, P0301, P0302, P0303, P0304, P0351, P0352, P0353, P0354, P0412, P0418, P0420, P124A, P124B, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P2227, P2228, P2229, P2230, P2430, P2431, P2432, or P2433 is not set.
- Greater than 60 min has elapsed since the last cold start.
- The ignition voltage is between 10–32 V.
- The engine speed is less than 5,000 RPM.
- The intake air temperature (IAT) is greater than −10°C (14°F).
- The engine coolant temperature (ECT) is between −10 and +80°C (12.2–176°F).
- The barometric pressure (BARO) is greater than 60 kPa (8.7 psi).
- The manifold absolute pressure (MAP) sensor is greater than 20 kPa (2.9 psi).
- The mass air flow (MAF) is less than 50 g/s.
- The secondary air injection pump is commanded ON.
- DTC P0411 runs once per ignition cycle when the above conditions are met for greater than 7 s.

Conditions for Setting the DTC

- The actual system pressure at the shutoff/check valve is at least 4.5 kPa (0.7 psi) greater or 7.5 kPa (1.1 psi) less than the predicted system pressure for greater than 7 s.

  OR

- The difference between the predicted magnitude of pressure pulsations and the actual magnitude of pressure pulsations, at the shutoff/check valve over a specific length of time, exceeds a calibrated threshold.

Action Taken When the DTC Sets

DTC P0411 is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P0411 is a Type B DTC.

Diagnostic Aids

Ice buildup due to condensation/water in the air passages or pump may cause this DTC to set.

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

Secondary Air Injection System Description on page 9-592

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 36169-HD Fused Jumper

For equivalent regional tools, refer to *Special Tools on page 9-593*.

Circuit/System Verification

Note: Verify the battery is fully charged before proceeding with this diagnostic procedure. The secondary air injection pump output will vary with system voltage.

1. Ignition ON
2. Verify that DTC P0412, P0418, P2430, P2431, P2432, P2433, P2440, or P2444 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 pressure parameter is within the range specified in the *Altitude Versus Barometric Pressure on page 9-312* table.

⇒ **If not within the specified range**

Refer to *DTC P2227-P2230 on page 9-494*.

⇓ **If within the specified range**

4. Verify the scan tool Secondary Air Injection Pressure Sensor and the BARO pressure parameters are within 3 kPa (0.4 psi).

⇒ **If not within the specified range**

Replace the Q29 Secondary Air Injection Solenoid Valve

⇓ **If within the specified range**

Note: Engine coolant temperature must be greater than 5°C (41°F) to enable scan tool device control. It may be necessary to use one of the methods listed below to verify valve operation:

- Use a stethoscope to listen for valve operation.
- Disconnect the secondary air injection pipe from the secondary air injection solenoid valve and visually inspect the valve inlet port for valve stem movement.
- Disconnect the Q29 Secondary Air Injection Solenoid Valve and verify airflow through the valve when commanding the Secondary Air Injection System Active with a scan tool.

5. Verify the Q29 Secondary Air Injection Solenoid Valve opens and closes when commanding the Secondary Air Injection Solenoid Valve Open and Closed with a scan tool.

⇒ **If the valve does not open and close**

Refer to Circuit/System Testing—Secondary Air Injection Shutoff and Check Valve Malfunction

⇓ **If the valve opens and closes**

Note: To prevent the secondary air injection pump from overheating, do not operate the pump consecutively for greater than 2 minutes. The pump is provided with a thermal protector that will automatically reset when allowed to cool.

6. Verify the G21 Secondary Air Injection Pump turns ON and OFF when commanding the Secondary Air Injection Pump Relay between ON and OFF with a scan tool.

⇒ **If the pump does not turn ON and OFF**

Refer to Circuit/System Testing—Secondary Air Injection Pump Malfunction

⇓ **If the pump turns ON and OFF**

7. Engine running
8. Verify the scan tool Secondary Air Injection Pressure Sensor parameter increases between 14–25 kPa (2.0–3.6 psi) when the Secondary Air Injection Pump Relay is commanded ON with a scan tool.

⇒ **If not within the specified range**

Refer to Circuit/System Testing—Secondary Air Injection System Pressure Not In Range.

⇓ **If within the specified range**

9. Verify the scan tool Secondary Air Injection Pressure Sensor parameter increases between 5–13 kPa (0.7–1.9 psi) when the Secondary Air Injection System is commanded ON with a scan tool.

⇒ **If not within the specified range**

Refer to Circuit/System Testing—Secondary Air Injection System Pressure Not In Range.

⇓ **If within the specified range**

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

Secondary Air Injection Shutoff and Check Valve Malfunction

1. Ignition OFF, disconnect the KR26 Secondary Air Injection Solenoid Valve Relay. Ignition ON.
2. Verify a test lamp illuminates between the B+ circuit terminal 30 and ground.

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

2.1. 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

2.2. Test for infinite resistance between the B+ circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

2.3. Disconnect the harness connector at the Q29 Secondary Air Injection Solenoid Valve.

2.4. Test for infinite resistance between the control circuit terminal 5 and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

2.5. Test or replace the Q29 Secondary Air Injection Solenoid Valve.

⇓ **If the test lamp illuminates**

3. Disconnect the harness connector at the Q29 Secondary Air Injection Solenoid Valve.
4. Ignition OFF and all vehicle systems OFF, it may take up to 2 minutes for all vehicle systems to power down. Test for less than 10 Ω between the Q29 Secondary Air Injection Solenoid Valve ground circuit terminal 4 and ground.

⇒ **If 10 Ω or greater**

4.1. Ignition OFF.

4.2. 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 10 Ω**

5. Connect the harness connector at the Q29 Secondary Air Injection Solenoid Valve.
6. Connect a 10 A fused jumper wire between the B+ circuit terminal 30 and the control circuit terminal 87.
7. Verify the Q29 Secondary Air Injection Solenoid Valve is activated.

⇒ **If the valve does not activate**

7.1. Ignition OFF, disconnect the harness connector at the Q29 Secondary Air Injection Solenoid Valve.

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, test or replace the Q29 Secondary Air Injection Solenoid Valve.

⇓ **If the valve activates**

8. Test or replace the KR26 Secondary Air Injection Solenoid Valve Relay.

Secondary Air Injection Pump Malfunction

1. Ignition OFF, disconnect the KR25 Secondary Air Injection Pump Relay.
2. Verify a test lamp illuminates between the B+ circuit terminal 30 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 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

2.2. Test for infinite resistance between the B+ circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

2.3. Disconnect the harness connector at the G21 Secondary Air Injection Pump.

2.4. Test for infinite resistance between the control circuit terminal A and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

2.5. Test or replace the G21 Secondary Air Injection Pump.

⇓ **If the test lamp illuminates**

3. Disconnect the harness connector at the G21 Secondary Air Injection Pump.
4. Ignition OFF and all vehicle systems OFF, it may take up to 2 minutes for all vehicle systems to power down. Test for less than 10 Ω between the G21 Secondary Air Injection Pump ground circuit terminal B and ground.

⇒ **If 10 Ω or greater**

4.1. Ignition OFF.

4.2. 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 10 Ω**

5. Connect the harness connector at the G21 Secondary Air Injection Pump.
6. Connect a 40 A *EL 36169-HD* between the B+ circuit terminal 30 and the control circuit terminal 87.

Note: To prevent the secondary air injection pump from overheating, do not operate the pump consecutively for greater than 2 minutes. The pump is provided with a thermal protector that will automatically reset when allowed to cool.

7. Verify the G21 Secondary Air Injection Pump is activated.

⇒ **If the pump does not activate**

7.1. Ignition OFF, disconnect the harness connector at the G21 Secondary Air Injection Pump.

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,

7.3. Test or replace the G21 Secondary Air Injection Pump.

⇓ **If the pump activates**

8. Test or replace the KR25 Secondary Air Injection Pump Relay.

Secondary Air Injection System Pressure Not In Range

1. Verify the following conditions do not exist with the secondary air injection shutoff and check valve:
   - Hoses/pipes restricted or blocked
   - Hoses/pipes leaking or disconnected
   - Damaged secondary air injection shutoff and check valve
   - Restricted or blocked cylinder head secondary air injection inlet ports and passages

⇒ **If a condition is located**

Repair or replace the affected component as necessary.

⇓ **If all components test normal**

2. Disconnect the secondary air injection hoses/pipe from the Q29 Secondary Air Injection Solenoid Valve.
3. Ignition ON, command the Secondary Air Injection Pump Relay ON with a scan tool.
4. Verify airflow to the Q29 Secondary Air Injection Solenoid Valve.

⇒ **If no airflow**

Replace the G21 Secondary Air Injection Pump.

⇓ **If airflow**

5. Disconnect the appropriate Q29 Secondary Air Injection Solenoid Valve from the engine.
6. Connect the harness connector at the Q29 Secondary Air Injection Solenoid Valve.
7. Connect the secondary air injection pipe between the Q29 Secondary Air Injection Solenoid Valve and the G21 Secondary Air Injection Pump.
8. Ignition ON, command the Secondary Air Injection System Active with a scan tool. Verify there is airflow through the valve.

⇒ **If no airflow**

Replace the Q29 Secondary Air Injection Solenoid Valve

⇓ **If airflow**

9. Replace the G21 Secondary Air Injection Pump.

Component Testing

Relay Test

1. Ignition OFF, disconnect the appropriate relay.
2. Test for 70–110 Ω between terminals 85–86.

⇒ **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 15 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 repair.

- *Relay Replacement (Within an Electrical Center) on page 11-607* or *Relay Replacement (Attached to Wire Harness) on page 11-607*
- *Secondary Air Injection Pump Replacement on page 9-546*
- *Secondary Air Injection Check Valve Replacement on page 9-543* for secondary air injection solenoid valve replacement
- *Secondary Air Injection Pump Pipe Replacement on page 9-545*

DTC P0412 or P0418

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 P0412: Secondary Air Injection Valve Control Circuit
DTC P0418: Secondary Air Injection Pump Control Circuit

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Secondary Air Injection Pump Relay Coil Voltage Supply	—	P0418	P0690	—
Secondary Air Injection Pump Relay Coil Control	P0418	P0418	P0690, P2413	—
Solenoid Relay Coil Voltage Supply	P0412	P0412	P0690	—
Solenoid Relay Coil Control	P0412	P0412	P0412, P0690	—

Circuit/System Description

The secondary air injection system aids in the reduction of hydrocarbon emissions during a cold start. The electric air pump forces fresh air into the exhaust stream in order to accelerate the catalyst operation. Ignition voltage is supplied directly to the secondary air injection pump relay and secondary air solenoid valve relay. The engine control module (ECM) controls the relays by grounding the control circuit with a solid state device called a driver. The ECM monitors the control circuits for open, short to ground, or short to voltage conditions.

Conditions for Running the DTC

- The ignition voltage is between 10–32 V.
- The DTCs run continuously once the above conditions are met.

Conditions for Setting the DTC

DTC P0412 or P0418

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

Action Taken When the DTC Sets

DTC P0412 and P0418 are Type B DTCs.

Conditions for Clearing the DTC

DTC P0412 and P0418 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 Secondary Air Injection Solenoid Valve Control Circuit and Secondary Air Injection Pump Relay Control Circuit status parameters. The circuit status parameter changes 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 9-314

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Secondary Air Injection System Description on page 9-592

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

P0412

1. Ignition ON
2. Verify a click is heard or felt from the KR25 Secondary Air Injection Pump Relay and the KR26 Secondary Air Injection Solenoid Valve Relay when commanding the Secondary Air Injection System between Inactive and Active with a scan tool.

⇒ **If a click is not heard or felt at one or more of the relays**

Refer to Circuit/System Testing

⇓ **If a click is heard or felt at each of the relays**

3. Verify the circuit status parameters listed below do not display Malfunction when commanding the Secondary Air Injection System between Inactive and Active with a scan tool:
   - Secondary Air Injection Pump Relay Control Circuit Low Voltage Test Status
   - Secondary Air Injection Pump Relay Control Circuit Open Test Status
   - Secondary Air Injection Pump Relay Control Circuit High Voltage Test Status
   - Secondary Air Injection Solenoid Valve Control Circuit Low Voltage Test Status
   - Secondary Air Injection Solenoid Valve Control Circuit Open Test Status
   - Secondary Air Injection Solenoid Valve Control 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 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.
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

P0412

1. Ignition OFF, disconnect the KR26 Secondary Air Injection Solenoid Valve Relay. Ignition ON.
2. Verify a test lamp illuminates between the relay coil ignition circuit terminal 85 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 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.

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 or replace the KR26 Secondary Air Injection Solenoid Valve Relay

⇓ **If the test lamp illuminates**

3. Connect a DMM, set on the diode setting, between the control circuit terminal 86 and ground.
4. Verify the DMM reading is greater than 2.5 V or displays O.L. when commanding the Secondary Air Injection Solenoid Valve Closed with a scan tool.

⇒ **If 2.5 V or less**

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

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

4.3. Ignition OFF.

4.4. 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, test or replace the K20 Engine Control Module

⇓ **If greater than 2.5 V or displays O.L.**

5. Verify the DMM reading is less than 1 V when commanding the Secondary Air Injection Solenoid Valve Open with a scan tool.

⇒ **If 1 V or greater**

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

5.2. 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 less than 1 V**

6. Test or replace the KR26 Secondary Air Injection Solenoid Valve Relay.

P0418

1. Ignition OFF, disconnect the KR25 Secondary Air Injection Pump Relay. Ignition ON.
2. Verify a test lamp illuminates between the relay coil ignition circuit terminal 85 and ground.

⇒ **If the test lamp does not illuminate**

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 the test lamp illuminates**

3. Connect a DMM, set on the diode setting, between the control circuit terminal 86 and ground.
4. Verify the DMM reading is greater than 2.5 V or displays O.L. when commanding the Secondary Air Injection Pump Relay OFF with a scan tool.

⇒ **If 2.5 V or less**

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

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

4.3. Ignition OFF.

4.4. 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, test or replace the K20 Engine Control Module

⇓ **If greater than 2.5 V or displays O.L.**

5. Verify the DMM reading is less than 1 V when commanding the Secondary Air Injection Pump Relay ON with a scan tool.

⇒ **If 1 V or greater**

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

5.2. 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 less than 1 V**

6. Test or replace the KR25 Secondary Air Injection Pump Relay.

Component Testing

Relay Test

1. Ignition OFF, disconnect the appropriate relay.
2. Test for 70–110 Ω between terminals 85–86.

⇒ **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 15 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 repair.

- *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 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

A 3-way catalytic converter controls emissions of hydrocarbons, Carbon Monoxide (CO) and Nitrogen Oxide (NOx). The catalyst within the converter promotes a chemical reaction, which oxidizes the hydrocarbons and the CO that are present in the exhaust gas. This process converts the hydrocarbons and the CO into water vapor and Carbon Dioxide (CO2), and reduces the NOx, converting the NOx into nitrogen. The catalytic converter also stores oxygen. The ECM monitors this process by using a heated oxygen sensor (HO2S) that is in the exhaust stream after the 3-way catalytic converter. 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 3-way catalytic converter. 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

- DTC P0016, P0017, P0030, P0036, P0053, P0054, P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0128, P0131, P0132, P0133, P0134, P0135, P0137, P0138, P013A, P013B, P013E, P013F, P0140, P0141, P015A, P015B, P0171, P0172, P0222, P0223, P0300, P0301, P0302, P0303, P0304, P0335, P0336, P0340, P0341, P0365, P0366, P0443, P0506, P0507, P0606, P0697, P06A3, P16F3, P2101, P2122, P2123, P2127, P2128, P2135, P2138, P2270 or P2271 is not set.
- Before the ECM performs the idle test, the vehicle must be driven under the conditions listed below:
  - The engine speed is greater than 1,100 RPM.
  - The engine run time is greater than a calibrated value
  - Both conditions exist for at least 5 s
- The vehicle speed is less than 2 km/h (1.24 mph).
- Divers foot is off accelerator pedal
- The throttle is in the rest position.
- The run/crank voltage is greater than 11 V.
- The intake air temperature (IAT) is between −20 to +250°C (−4 to +482°F).
- The engine coolant temperature (ECT) is between 40–140°C (104–284°F).
- The engine has been idling less than 50 s.
- The short term fuel trim is between 0.8–1.3 %.
- The barometric pressure (BARO) is greater than 70 kPa.
- The intake mass air flow (MAF) is between 1.5–7.0 g/s.
- The engine is operating in closed loop.
- The calculated catalyst temperature is between 550–950°C (1,022–1,742°F).
- The Evaporative Emission (EVAP), Fueltrim, Post O2, or other intrusive tests are not active
- The transmission is not in P/N (automatic transmission only).
- This diagnostic attempts one test during each valid idle period once the above conditions have been met. This diagnostic attempts up to 8 tests during each drive cycle.

Conditions for Setting the DTC

The ECM determines that the efficiency of the catalyst has degraded below a calibrated threshold.

Action Taken When the DTC Sets

DTC P0420 is a Type A DTC.

Conditions for Clearing the DTC

DTC P0420 is a Type A DTC.

Diagnostic Aids

Inspect for the conditions listed below, which may cause a catalytic converter 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

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 there are no other DTCs 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. Operate the vehicle within the Conditions for Running the DTC.
4. Verify the scan tool Catalyst Monitor Not At Idle Test Conditions Met parameter changes to Yes.

⇒ **If Yes is not displayed**

Refer to step 3.

⇓ **If Yes is displayed**

5. When the conditions are safe, stop and idle the vehicle in gear (If equipped with automatic transmission) or neutral (If equipped with manual transmission).
6. Verify the Catalyst Monitor Test Result parameter displays Pass when performing the steps listed below:
   6.1. Apply the service brake.
   6.2. Monitor the scan tool Catalyst Monitor Test State parameter. When the parameter indicates Active, the Catalyst Monitor Test is running.

Note: When the test has completed, the Catalyst Monitor Test Counter parameter will increment by one and the Catalyst Monitor Test Result parameter will indicate Passed, Failed or No Result.

   6.3. Continue to monitor the parameter. When the parameter indicates Inactive, the Catalyst Monitor Test has completed.

⇒ **If the Catalyst Monitor Test Result parameter indicates No Result**

Repeat steps 3–6 until the Test Result parameter indicates Passed or Failed

⇒ **If the Catalyst Monitor Test Result parameter indicates Failed**

Refer to Circuit /System Testing

⇓ **If the Catalyst Monitor Test Result parameter indicates Pass**

7. All OK.

Circuit/System Testing

1. Verify the conditions listed below do not exist with the catalytic converter(s):
   - Dents
   - Severe discoloration caused by excessive temperatures
   - Road damage
   - Internal rattles caused by damaged catalyst substrate
   - Restrictions

   ⇒ **If a condition is found**

   Replace the catalytic converter(s).

   ⇓ **If no condition is found**
2. Verify the conditions listed below do not exist with the exhaust system:
   - Leaks
   - Physical damage
   - Loose or missing hardware

   ⇒ **If a condition is found**

   Repair or replace the component as necessary.

   ⇓ **If no condition is found**
3. Verify the conditions listed below do not exist with the B52B heated oxygen sensor 2:
   - Incorrect torque
   - Damage

   ⇒ **If a condition is found**

   Replace the B52B heated oxygen sensor 2 or repair the condition as necessary.

   ⇓ **If no condition is found**
4. Test or replace the catalytic converter and the exhaust front pipe.

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.

- *Exhaust Manifold with Catalytic Converter Replacement (LUW) on page 9-737* for catalytic converter replacement.
- *Exhaust Front Pipe Replacement (LUV,LUW) on page 9-738*
- *Heated Oxygen Sensor Replacement - Sensor 2 on page 9-539*

Repair Verification

1. Install any components that have been removed or replaced during diagnosis.
2. Perform any adjustments, programming or setup procedures that are required when a component is removed or replaced.
3. Clear the DTCs with a scan tool.
4. Turn OFF the ignition for 60 s

5. Operate the vehicle within the Conditions for Running the DTC.
6. Verify the scan tool Catalyst Monitor Not At Idle Test Conditions Met parameter changes to Yes.

⇒ **If Yes is not displayed**

Refer to step 5.

⇓ **If Yes is displayed**

7. When the conditions are safe, stop and idle the vehicle in gear (If equipped with automatic transmission) or neutral (If equipped with manual transmission).
8. Verify the Catalyst Monitor Test Result parameter displays Pass when performing the steps listed below:
   8.1. Apply the service brake.
   8.2. Monitor the scan tool Catalyst Monitor Test State parameter. When the parameter indicates Active, the Catalyst Monitor Test is running.

Note: When the test has completed, the Catalyst Monitor Test Counter parameter will increment by one and the Catalyst Monitor Test Result parameter will indicate Passed, Failed or No Result.

   8.3. Continue to monitor the parameter. When the parameter indicates Inactive, the Catalyst Monitor Test has completed.

⇒ **If the Catalyst Monitor Test Result parameter indicates No Result**

Repeat steps 5–8 until the Test Result parameter indicates Passed or Failed

⇒ **If the Catalyst Monitor Test Result parameter indicates Failed**

Refer to Circuit /System Testing

⇓ **If the Catalyst Monitor Test Result parameter indicates Pass**

9. All OK.

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 (LUW, LWE)

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 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, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0128, P0171, P0172, P0201, P0202, P0203, P0204, P0222, P0223, P0300, P0351, P0352, P0353, P0354, P0461, P0462, P0463, P0496, P0502, P0503, P0606, P0697, P06A3, P0806, P0807, P0808, P16F3, P2101, P2122, P2123, P2127, P2128, P2135, P2138 or P2771 are not set.
- The barometric pressure (BARO) is greater than 70 kPa.
- The engine runtime is greater than 60 s.
- The engine is idling for greater than 10 s.
- The torque converter clutch (TCC) is not changing states.
- The transmission is not changing gears.
- The intake air temperature (IAT) is greater than −20°C (−4°F).
- The engine coolant temperature (ECT) is between 60–120°C (140–248°F).
- The ignition voltage is between 11–32 V.
- The vehicle speed is less than 3.2 km/h (2 mph).
- The commanded engine speed is steady within 25 RPM.
- The DTCs run continuously when the above conditions are met for greater than 10 s.

Conditions for Setting the DTC

P0506

The ECM detects that the actual idle speed is approximately 91 RPM lower than the desired idle speed.

P0507

The ECM detects that the actual idle speed is approximately 182 RPM higher than desired idle speed.

Action Taken When the DTC Sets

DTC P0506 and P0507 are Type B DTCs.

Conditions for Clearing the DTC

DTC 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 9-314

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Throttle Actuator Control (TAC) System Description on page 9-587

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 there are no other DTCs 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 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 9-547*.

⇓ **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—Refer to *Crankcase Ventilation System Inspection/ Diagnosis on page 9-968*.

⇒ **If a condition is found**

Repair as necessary.

⇓ **If a condition is not found**

2. All OK.

Repair Verification

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

- *Throttle Body Inspection and Cleaning on page 9-547*
- *Throttle Body Assembly Replacement on page 9-542*

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 9-314

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 9-314

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 9-449* 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, P0629	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 11 V or greater.
- 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 11 V or greater.
- 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 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 9-314

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. Ignition ON for 10 s.
3. Verify that a test lamp does not illuminate between the control circuit terminal 20 and ground.

⇒ **If the test lamp illuminates**

3.1. Ignition OFF, remove the test lamp, 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 does not illuminate**

4. Remove the test lamp.
5. Verify the scan tool Fuel Pump Enable Circuit Low Voltage Test Status parameter is OK when commanding the Fuel Pump Enable On with a scan tool.

⇒ **If OK is not displayed**

5.1. Ignition OFF, disconnect the 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 OK is displayed**

6. Install a 3 A fused jumper wire between the control circuit terminal 20 and ground.
7. Verify the scan tool Fuel Pump Enable Circuit Low Voltage Test Status parameter is Malfunction when commanding the Fuel Pump Enable On with a scan tool.

⇒ **If Malfunction is not displayed**

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. 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 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 9-314

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Fuel System Description on page 9-584

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
- Multifunction intake air 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
- Secondary air injection pressure sensor, if equipped
- 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 9-314

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 9-541*
- *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 9-576*
- *Clutch Pedal Position Sensor Replacement on page 17-415*
- *Crankshaft Position Sensor Replacement on page 9-575*
- *Fuel Tank Pressure Sensor Replacement on page 9-560*
- *Manifold Absolute Pressure Sensor Replacement on page 9-537*
- *Mass Airflow Sensor Replacement on page 9-536*
- *Secondary Air Injection Check Valve Replacement on page 9-543*
- *Throttle Body Assembly Replacement on page 9-542*
- *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, P263A, or P263B

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 Open
DTC P263A: Malfunction Indicator Lamp (MIL) Control Circuit Low Voltage
DTC P263B: Malfunction Indicator Lamp (MIL) Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0650	P0650	—	—
MIL Control	P0650, P263A*	P0650, P263A	P0650, P263B	—
* The MIL remains ON				

Circuit/System Description

The malfunction indicator lamp (MIL) illuminates to inform the driver that an emission system fault has occurred and the 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.

Conditions for Running the DTC

- The engine speed is greater than 80 RPM.
- The ignition voltage is between 11–32 V.
- The DTCs run continuously when the above conditions are met .

Conditions for Setting the DTC

DTC P0650

The ECM detects low voltage during the MIL control circuit driver OFF state.

DTC P263A

The ECM detects low voltage during the MIL control circuit driver OFF state.

DTC P263B

The ECM detects high voltage on the MIL control circuit during the driver ON state.

Action Taken When the DTC Sets

DTC P0650, P263A, and P263B are Type B DTCs.

Conditions for Clearing the DTC

DTC P0650, P263A, and P263B are Type B DTCs.

Diagnostic Aids

- If the condition is intermittent, move the related harnesses and connectors while monitoring the scan tool MIL control circuit status parameters. Perform this test with the ignition ON and the engine OFF, and with the engine running. The MIL control circuit status parameters change from OK or Not Run to Fault if there is a condition with a circuit or a connection.
- If the ECM detects low voltage on the MIL control circuit during the MIL control circuit driver OFF state, DTCs P0650 and DTC P263A may set simultaneously.

Reference Information

Schematic Reference

- *Engine Controls Schematics on page 9-314*
- *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, command the malfunction indicator lamp ON and OFF with a scan tool.
2. 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**

3. Ignition ON, 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**

4. Engine running, 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**

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 sets**

Refer to Circuit/System Testing

⇓ **If the DTC does not set**

6. All OK.

Circuit/System Testing

1. Ignition OFF.
2. Disconnect the X1 harness connector at the K20 Engine Control Module.
3. Ignition ON, verify the malfunction indicator lamp does not illuminate.

⇒ **If the malfunction indicator lamp illuminates**

3.1. 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**

4. Connect a 3 A fused jumper wire between the malfunction indicator lamp control circuit terminal X1 52 and ground.
5. Verify the malfunction indicator lamp illuminates.

⇒ **If the malfunction indicator lamp does not illuminate**

5.1. 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

5.2. 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**

6. 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 engine control module replacement, programming, and setup.

DTC P0660, P0661, or P0662

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 P0660: Intake Manifold Tuning Control Valve Control Circuit
DTC P0661: Intake Manifold Tuning Control Valve Control Circuit Low Voltage
DTC P0662: Intake Manifold Tuning Control Valve Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
Ignition 1 Voltage	P0661	—	P0660, P0661	—	—
Intake Manifold Tuning Valve Solenoid Control	P0661	—	P0660, P0661	P0662	—

Circuit/System Description

The intake manifold tuning valve controls the length of the intake runners in the intake manifold. The intake manifold contains both long and short runners. The tuning valve controls only the short runners. When the valve is closed, the short runners are blocked, which forces the air through the long runners. This results in tuning effects in the manifold that increases the torque produced by the engine at lower engine speeds. When the valve is open, both the long runners and short runners are open, but the majority of the air travels through the short runners, since the air will naturally follow the shortest path into the cylinder. This allows the air to flow through the short runners, which results in increased torque at higher engine speeds.

Ignition voltage is supplied directly to the intake manifold tuning valve actuator. The engine control module (ECM) controls the valve actuator motor by grounding the control circuit with a solid state device called a driver. The driver is equipped with a feedback circuit that is pulled up to a voltage. The ECM can determine if the control circuit is open, shorted to ground, or shorted to a voltage by monitoring the feedback voltage signal.

The tuning valve actuator contains a position sensor, which outputs a pulse width modulated (PWM) signal, to detect the actual position of the tuning valve in relation to its commanded position. Variations in the duty cycle of the PWM signal enables the ECM to detect a physically broken, restricted or stuck tuning valve.

Conditions for Running the DTC

- Engine speed is at least 400 rpm.
- The battery voltage is at least 11 V.
- DTCs P0660, P0661 and P0662 run continuously when the above conditions are met.

Conditions for Setting the DTC

P0660

The ECM detects an open circuit on the intake manifold tuning valve control circuit for greater than 0.5 s.

P0661

The ECM detects a short to ground or an open circuit on the intake manifold tuning valve control circuit for greater than 0.5 s.

P0662

The ECM detects a short to voltage on the intake manifold tuning valve control circuit for greater than 0.5 s.

Action Taken When the DTC Sets

DTCs P0660, P0661 and P0662 are Type B DTCs.

Conditions for Clearing the DTC

DTCs P0660, P0661 and P0662 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-314

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 running.
2. Verify a click is heard or felt from the Q22 Intake Manifold Tuning Solenoid Valve when commanding the Intake Manifold Tuning Control Valve Open and Closed with a scan tool.

⇒ **If a click is not heard or felt**

Refer to Circuit/System Testing

⇓ **If a click is heard or felt**

3. Verify the circuit status parameters listed below do not display Malfunction when commanding the Intake Manifold Tuning Control Valve Open and Closed with a scan tool:
   - Intake Manifold Tuning Control Valve Control Circuit High Voltage Test Status
   - Intake Manifold Tuning Control Valve Control Circuit Open Test Status
   - Intake Manifold Tuning Control 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.

⇒ **If a DTC sets**

Refer to Circuit/System Testing

⇓ **If a DTC does not set**

5. All OK.

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the Q22 Intake Manifold Tuning Solenoid Valve. Ignition ON.
2. Verify that a test lamp illuminates between the ignition circuit terminal 1 and ground.

⇒ **If the test lamp does not illuminate and the circuit fuse is 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 2 and the ignition 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 Intake Manifold Tuning Control Valve Control Circuit High Voltage Test Status parameter is OK when commanding the Intake Manifold Tuning Control Valve Open 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 3 and the ignition circuit terminal 1.

7. Verify the scan tool Intake Manifold Tuning Control Valve Control Circuit High Voltage Test Status parameter is Malfunction when commanding the Intake Manifold Tuning Control Valve Open 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. Replace the Intake Manifold.

Repair Instructions

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

- *Intake Manifold Replacement (LUW) on page 9-981* or *Intake Manifold Replacement (LDE) on page 9-978*
- *Control Module References on page 6-3* for replacement, programming, and setup.

DTC P0685-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

Typical Scan Tool Data

Engine Controls Ignition Relay Control Circuit Low Voltage, Open, and High Voltage Test Status—Component Commanded OFF

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Component commanded OFF **Parameter Normal Range:** The following illustrates the normal parameter state with no circuit conditions: • Component OFF – OK for Open/Low Voltage Test Status and Not Run for High Voltage Test Status • Component ON – Not Run for Open/Low Voltage Test Status and OK for High Voltage Test Status			
B+	Malfunction	Malfunction	—
Control	Malfunction	Malfunction	Not Run

Engine Controls Ignition Relay Control Circuit Low Voltage, Open, and High Voltage Test Status—Component Commanded ON

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Component commanded ON **Parameter Normal Range:** The following illustrates the normal parameter state with no circuit conditions: • Component OFF – OK for Open/Low Voltage Test Status and Not Run for High Voltage Test Status • Component ON – Not Run for Open/Low Voltage Test Status and OK for High Voltage Test Status			
B+	Not Run	Not Run	—
Control	Not Run	Not Run	Malfunction

Circuit/System Description

There are 2 ignition voltage circuits supplied to the engine control module (ECM). One is supplied by the engine controls ignition relay, and the other is supplied by the ignition 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.

P0690

The ECM detects the engine controls ignition relay feedback circuit is greater than 4 V 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 greater 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 9-314*
- *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. Verify DTC P0685, P0686, P0687, P0689, P0690, or P1682 is not set.

⇒ **If any of the DTCs are set**

Refer to Circuit/System Testing

⇓ **If none of the DTCs are set**

2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

⇒ **If the DTC sets**

Refer to Circuit/System Testing

⇓ **If the DTC does not set**

3. All OK.

Circuit/System Testing

Note: You must perform the Circuit/System Verification before proceeding with Circuit/System Testing unless sent here from Engine Cranks But Does Not Run.

1. Ignition OFF, disconnect the KR75 Engine Controls Ignition Relay.
2. Verify a test lamp illuminates between ground and the relay circuit terminals listed below:
   - Terminal 85
   - Terminal 30

⇒ **If the test lamp does not illuminate**

Replace the front compartment fuse block.

⇓ **If the test lamp illuminates**

Note:

- High resistance in the circuit/underhood fuse block for either the KR75 Engine Controls Ignition Relay or the KR74 Ignition Run Relay can cause DTC P1682 to set.
- A short to voltage on any of the circuits supplied by the KR75 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. Verify the scan tool Engine Controls Ignition Relay Feedback Signal parameter displays B+.

⇒ **If B+ is not displayed**

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 B+ is displayed**

8. Ignition OFF, connect a DMM, set to the diode setting, between control circuit terminal 86 and ground.
9. Verify the DMM displays OL.

⇒ **If OL is not displayed**

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 OL is displayed**

10. Ignition ON.
11. Verify the DMM displays less than 1 V.

⇒ **If 1 V or greater**

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 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 repair.

- *Front Compartment Fuse Block Replacement on page 11-609*
- *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 monitors the fuel pump control system for any conditions which may adversely affect vehicle emissions. If an adverse condition is detected, the fuel pump control module sets a fuel pump control system DTC. The fuel pump control module then sends a serial data message to the engine control module (ECM) requesting malfunction indicator lamp (MIL) illumination. 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 greater than 3 s.

Conditions for Setting the DTC

The fuel pump control module requests the ECM to illuminate the MIL.

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 for scan tool information

Circuit/System Verification

Note:

- Do not replace the engine control module for this DTC. DTC P069E is an informational DTC.
- Correct any engine control and communication DTCs before diagnosing fuel pump control module DTCs.

1. Verify there are no engine control or communication DTCs set.

⇒ **If a DTC is set**

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

⇓ **If a DTC is not set**

2. Verify there are no fuel pump control module DTCs 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. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.

⇒ **If the DTC sets**

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

⇓ **If the DTC does not set**

5. All OK.

Repair Instructions

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

DTC P0700 (LUW)

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 P0700: Transmission Control Module Requested MIL Illumination

Circuit/System Description

The transmission control module (TCM) uses the controller area network (CAN) to signal the engine control module (ECM) that the TCM is requesting malfunction indicator lamp (MIL) illumination. This occurs when the TCM determines a condition that affects emissions within the transmission control system. When the ECM receives the message from the TCM, DTC P0700 will set.

Conditions for Running the DTC

- The ignition is ON for greater than 3 s.
- The DTC runs continuously when the above condition is met.

Conditions for Setting the DTC

The TCM requests the ECM to illuminate the MIL.

Action Taken When the DTC Sets

DTC P0700 is a Type A DTC.

Conditions for Clearing the DTC

DTC P0700 is a Type A DTC.

Diagnostic Aids

Communication codes, U-codes, as well as powertrain codes, P-codes, set in the transmission control module will cause the transmission control module to request DTC P0700 to be set in the ECM.

DTC P0700 cannot be cleared from the ECM until the related TCM codes have been cleared.

Reference Information

DTC Type Reference

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

Circuit/System Verification

Note: Correct any engine control module (ECM) DTCs before diagnosing TCM DTCs.

1. DTC P0700 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 transmission control module DTCs. Do not replace the ECM for this DTC.
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 repair.

DTC P11C2-P11C4

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
DTC P11C4: Intake Air Humidity Sensor Circuit Erratic

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+. **P2199 - where used.				

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, P11C3, and P11C4

- The ignition is ON.
- The Ignition 1 voltage is at least 11 V for longer than 0.9 s.
- 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.

P11C4

The ECM monitors the humidity sensor signal every 0.1 s, to determine if the signal has changed more than 80 %. The DTC fails when the condition exists for longer than 4 s.

Action Taken When the DTC Sets

DTCs P11C2, P11C3, P11C4 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P11C2, P11C3, P11C4 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 9-314

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 on page 9-593*.

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 9-449* 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 1 and 2 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 55°C (99°F) of each other.
   - Start-Up IAT Sensor 1
   - IAT Sensor 2
   - Start-Up ECT

⇒ **If not within 55°C (99°F)**

Refer to Circuit/System Testing.

⇓ **If within 55°C (99°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 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 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 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 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 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 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. Determine if *EN-38522* Variable Signal Generator or equivalent is available.

⇒ **If EN-38522, Variable Signal Generator; or equivalent is not available**

6.1. Replace the K20 Engine Control Module.

6.2. 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.

6.3. Verify the DTC does not set.

⇒ **If the DTC sets**

Refer to step 10.

⇩ **If no DTCs set**

6.4. Refer to step 11.

⇩ **If EN-38522, Variable Signal Generator; or equivalent is available**

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
   - Frequency switch to 250 Hz
   - Duty Cycle switch to 50 % (Normal)
9. 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 %**

10. Test or replace the B75C Multifunction Intake Air sensor.
11. All OK.

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 9-312* 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 9-536* for B75C 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 9-314

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Fuel System Description on page 9-584

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* provides 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, P0116, P0117, P0118, P0119, P0122, P0123, P0128, P0201, P0202, P0203, P0204, P0222, P0223, P0300, P0301, P0302, P0303, P0304, P0335, P0336, P0351, P0352, P0353, P0354, P0502, P0503, P0506, P0507, P0697, P06A3, P0722, P0723, P0806, P0807, P0808, P182E, P1915, P2122, P2123, P2127, P2128, P2135, and P2138 are not set.
- The catalyst temperature is less than 300°C (572°F).
- The engine coolant temperature (ECT) sensor is greater than −10°C (14°F).
- The vehicle speed is less than 2 km/h (1 MPH).
- The ECM will exit the diagnostic if the calculated three way catalyst temperature is greater than 700°C (1292°F) and the engine run time is greater than 30 s.
- The ECM will exit the diagnostic if the ECT is greater than 40°C (104°F) or the engine run time is greater than 80 s.
- This DTC runs within the first 10 s of start up. This diagnostic runs once per trip when a cold start has been determined.

Conditions for Setting the DTC

The actual exhaust energy model does not match the expected exhaust energy model.

Action Taken When the DTC Sets

DTC P1400 is a Type A DTC.

Conditions for Clearing the DTC

DTC P1400 is a Type A DTC.

Reference Information

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. Allow the engine to cool until the catalyst temperature is less than 300°C (572°F) and the engine coolant is between −10°C (14°F) and 40°C (104°F).
2. Engine idling for at least 2 min, observe the scan tool DTC information. DTC P1400 should not set.
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. Verify none of the conditions listed below exists with the air intake system:
   - Damage, restriction, or modification
   - Dirty or deteriorating air filter element
   - Crankcase ventilation system for correct operation. Refer to *Crankcase Ventilation System Inspection/Diagnosis on page 9-968*

- Water intrusion
- Vacuum leak and other unmetered air downstream of the mass air flow (MAF) sensor
- Intake manifold leak

⇒ If there is a condition, repair as necessary.

2. Verify none of the conditions listed below exists with the exhaust system:
   - Water intrusion
   - Exhaust leak
   - Damaged, restricted, or modified exhaust system. Refer to *Symptoms - Engine Exhaust on page 9-734*

   ⇒ If there is a condition, repair as necessary.
3. Inspect for an engine mechanical condition that could alter the air flow into the combustion chamber. Refer to *Symptoms - Engine Mechanical on page 9-953*

Repair Instructions

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

DTC P150C

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 P150C: Transmission Control Module Engine Speed Request Signal Message Counter Incorrect

Circuit/System Description

This diagnostic applies to communication integrity between the engine control module (ECM) and the transmission control module (TCM). The ECM determines that the engine speed signal counter is incorrect for the current vehicle operation.

Conditions for Running the DTC

- DTCs P0506, P0507, or U0101 are not set.
- The engine is running 0.5 s.
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

The ECM detects that the TCM engine speed request does not match the expected engine speed request.

Action Taken When the DTC Sets

DTC P150C is a Type B DTC.

Conditions for Clearing the DTC

DTC P150C is a Type B DTC.

Reference Information

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: Correct any other engine controls and communication DTCs before diagnosing transmission control module DTCs.

1. DTC P150C 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 transmission control module DTCs. Do not replace the ECM for this DTC.
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 repair.

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

DTC P1516, P2101, P2119, or P2176 (LUW, LWE)

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 5.5 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 runs continuously when the above conditions are met.

Conditions for Setting the DTC

P1516

The ECM detects an unstable throttle position for greater than 1 s.

P2101

The ECM detects the actual throttle position does not match the predicted throttle position for greater than 1 s.

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 9-314

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Throttle Actuator Control (TAC) System Description on page 9-587

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 9-547*.

⇓ **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 9-542*
- *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 P2070 or P2071

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 P2070: Intake Manifold Tuning Control Valve Stuck Open

DTC P2071: Intake Manifold Tuning Control Valve Stuck Closed

Circuit/System Description

The intake manifold tuning valve controls the length of the intake runners in the intake manifold. The intake manifold contains both long and short runners. The tuning valve controls only the short runners. When the valve is closed, the short runners are blocked, which forces the air through the long runners. This results in tuning effects in the manifold that increases the torque produced by the engine at lower engine speeds. When the valve is open, both the long runners and short runners are open, but the majority of the air travels through the short runners, since the air will naturally follow the shortest path into the cylinder. This allows the air to flow through the short runners, which results in increased torque at higher engine speeds.

Ignition voltage is supplied directly to the intake manifold tuning valve actuator. The engine control module (ECM) controls the valve actuator motor by grounding the control circuit with a solid state device called a driver. The driver is equipped with a feedback circuit that is pulled up to a voltage. The ECM can determine if the control circuit is open, shorted to ground, or shorted to a voltage by monitoring the feedback voltage signal.

The tuning valve actuator contains a position sensor, which outputs a pulse width modulated (PWM) signal, to detect the actual position of the tuning valve in relation to its commanded position. Variations in the duty cycle of the PWM signal enables the ECM to detect a physically broken, restricted or stuck tuning valve.

Conditions for Running the DTC

- DTCs P0660, P2077 or P2078 are not set.
- The DTCs run continuously when the above condition is met for greater than 4 s.

Conditions for Setting the DTC

P2070

The ECM detects the time after the close command without the intake manifold tuning valve reaching the closed position is greater than 5 s.

P2071

The ECM detects the time after the open command without the intake manifold tuning valve reaching the open position is greater than 5 s.

Action Taken When the DTC Sets

DTC P2070 and P2071 is a Type B DTC.

Conditions for Clearing the DTC

DTC P2070 and P2071 is a Type B DTC.

Diagnostic Aids

- Ignition ON, command the Intake Manifold Tuning Solenoid Valve Open and Closed with a scan tool and observe if anything interferes with the motion.
- 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. A circuit test status parameter will change from OK or Not Run to Malfunction if there is a condition with the circuit or a connection.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-314

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Air Intake System Description on page 9-592

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 P0660, P0661, P0662, P2077, or P2078 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 Q22 Intake Manifold Tuning Solenoid Valve Opens and Closes when commanding the Intake Manifold Tuning Control Valve Open and Closed with a scan tool.

⇒ **If the valve does not Open and Close**

Refer to Circuit/System Testing

⇓ **If the valve Opens and Closes**

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. Verify the following conditions do not exist with the Q22 Intake Manifold Tuning Solenoid Valve assembly:
   - Disconnected or damaged linkage
   - Linkage binding
   - Interference with hoses, wiring, or any other components

⇒ **If a condition is located**

Repair or replace the affected component as necessary.

⇓ **If all components test normal**

2. Disconnect the linkage from the Q22 Intake Manifold Tuning Solenoid Valve.
3. Verify the Q22 Intake Manifold Tuning Solenoid Valve Opens and Closes when commanding the Intake Manifold Tuning Control Valve Open and Closed with a scan tool.

⇒ **If the solenoid valve does not Open and Close**

Replace the intake manifold

⇓ **If the solenoid valve Opens and Closes**

4. Verify the following conditions do not exist with the intake manifold:
   - Carbon build-up that limits or restricts the movement of the intake manifold tuning valve vanes.
   - Casting flash that limits or restricts the movement of the intake manifold tuning valve vanes.
   - Foreign material that limits or restricts the movement of the intake manifold tuning valve vanes.

⇒ **If a condition is located**

Repair or replace the intake manifold as necessary.

⇓ **If all components test normal**

5. Replace the intake manifold.

Repair Instructions

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

- *Intake Manifold Replacement (LUW) on page 9-981* or *Intake Manifold Replacement (LDE) on page 9-978*
- *Control Module References on page 6-3* for ECM replacement, programming, and setup.

DTC P2076

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 P2076: Intake Manifold Tuning Control Valve Position Sensor Performance

Diagnostic Fault Information

DTC P2076

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	*	P0443, P0660, P2078	—	P2076
Intake Manifold Tuning Valve Control Circuit	P0660, P2071	P0660, P2070	—	P2076
Intake Manifold Tuning Valve Signal Circuit	P2077	P2078	P2076, P2077, P2078	P2076
Intake Manifold Tuning Valve Ground	—	P2078	—	P2076
*Opens the fuse that supplies voltage to the Intake Manifold Tuning Valve Solenoid.				

Circuit/System Description

The intake manifold tuning valve controls the length of the intake runners in the intake manifold. The intake manifold contains both long and short runners. The tuning valve controls only the short runners. When the valve is closed, the short runners are blocked, which forces the air through the long runners. This results in tuning effects in the manifold that increases the torque produced by the engine at lower engine speeds. When the valve is open, both the long runners and short runners are open, but the majority of the air travels through the short runners, since the air will naturally follow the shortest path into the cylinder. This allows the air to flow through the short runners, which results in increased torque at higher engine speeds.

Ignition voltage is supplied directly to the intake manifold tuning valve actuator. The engine control module (ECM) controls the valve actuator motor by grounding the control circuit with a solid state device called a driver. The driver is equipped with a feedback circuit that is pulled up to a voltage. The ECM can determine if the control circuit is open, shorted to ground, or shorted to a voltage by monitoring the feedback voltage signal.

The tuning valve actuator contains a position sensor, which outputs a pulse width modulated (PWM) signal, to detect the actual position of the tuning valve in relation to its commanded position. Variations in the duty cycle of the PWM signal enables the ECM to detect a physically broken, restricted or stuck tuning valve.

Conditions for Running the DTC

- The powertrain relay voltage is greater than 11 V.
- The engine run time is greater than 1 s.
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

- The ECM detects the intake manifold tuning valve actuator learn sequence has been initiated for greater than 5 s and the valve position is between 5–35%

  OR

- The ECM detects an intake manifold tuning valve actuator learn sequence has been initiated for greater than 0.2 s and the valve position is between 5–35% for greater than 10 times in one ignition cycle.

Action Taken When the DTC Sets

DTC P2076 is a Type B DTC.

Conditions for Clearing the DTC

DTC P2076 is a Type B DTC.

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. A circuit test status parameter will change from OK or Not Run to Malfunction if there is a condition with the circuit or a connection.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-314

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Air Intake System Description on page 9-592

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 P0660, P0661, P0662, P2070, P2071, P2077, or P2078 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 Q22 Intake Manifold Tuning Solenoid Valve Opens and Closes when commanding the Intake Manifold Tuning Control Valve Open and Closed with a scan tool.

⇒ **If the valve does not Open and Close**

Refer to Circuit/System Testing

⇓ **If the valve Opens and Closes**

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. Verify the following conditions do not exist with the Q22 Intake Manifold Tuning Solenoid Valve assembly:
   - Disconnected or damaged linkage
   - Linkage binding
   - Interference with hoses, wiring, or any other components

⇒ **If a condition is located**

Repair or replace the affected component as necessary.

⇓ **If all components test normal**

2. Disconnect the linkage from the Q22 Intake Manifold Tuning Solenoid Valve.
3. Verify the Q22 Intake Manifold Tuning Solenoid Valve Opens and Closes when commanding the Intake Manifold Tuning Control Valve Open and Closed with a scan tool.

⇒ **If the solenoid valve does not Open and Close**

Replace the intake manifold

⇓ **If the solenoid valve Opens and Closes**

4. Verify the following conditions do not exist with the intake manifold:
   - Carbon build-up that limits or restricts the movement of the intake manifold tuning valve vanes.
   - Casting flash that limits or restricts the movement of the intake manifold tuning valve vanes.
   - Foreign material that limits or restricts the movement of the intake manifold tuning valve vanes.

⇒ **If a condition is located**

Repair or replace the intake manifold as necessary.

⇓ **If all components test normal**

5. Replace the intake manifold.

Repair Instructions

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

Intake Manifold Replacement (LUW) on page 9-981 or *Intake Manifold Replacement (LDE) on page 9-978*

DTC P2077 or P2078

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 P2077: Intake Manifold Tuning Control Valve Position Sensor Circuit Low Voltage
DTC P2078: Intake Manifold Tuning Control Valve Position Sensor Circuit High Voltage

Diagnostic Fault Information

DTC P2077 or P2078

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	*	P0443, P0660, P2078	—	P2076
Intake Manifold Tuning Valve Control Circuit	P0660, P2071	P0660, P2070	—	P2076
Intake Manifold Tuning Valve Signal Circuit	P2077	P2078	P2076, P2077, P2078	P2076
Intake Manifold Tuning Valve Ground	—	P2078	—	P2076
*Opens the fuse that supplies voltage to the Intake Manifold Tuning Valve Solenoid.				

Circuit/System Description

The intake manifold tuning valve controls the length of the intake runners in the intake manifold. The intake manifold contains both long and short runners. The tuning valve controls only the short runners. When the valve is closed, the short runners are blocked, which forces the air through the long runners. This results in tuning effects in the manifold that increases the torque produced by the engine at lower engine speeds. When the valve is open, both the long runners and short runners are open, but the majority of the air travels through the short runners, since the air will naturally follow the shortest path into the cylinder. This allows the air to flow through the short runners, which results in increased torque at higher engine speeds.

Ignition voltage is supplied directly to the intake manifold tuning valve actuator. The engine control module (ECM) controls the valve actuator motor by grounding the control circuit with a solid state device called a driver. The driver is equipped with a feedback circuit that is pulled up to a voltage. The ECM can determine if the control circuit is open, shorted to ground, or shorted to a voltage by monitoring the feedback voltage signal.

The tuning valve actuator contains a position sensor, which outputs a pulse width modulated (PWM) signal, to detect the actual position of the tuning valve in relation to its commanded position. Variations in the duty cycle of the PWM signal enables the ECM to detect a physically broken, restricted or stuck tuning valve.

Conditions for Running the DTC

- The ignition is ON or the engine is operating.
- The DTCs run continuously once the above condition is met for greater than 4 s.

Conditions for Setting the DTC

P2077

The ECM detects a continuous open or short to low in the intake manifold tuning valve position sensor circuit.

P2078

The ECM detects a continuous short to high in the intake manifold tuning valve position sensor circuit.

Action Taken When the DTC Sets

DTC P2077 and P2078 are Type B DTCs.

Conditions for Clearing the DTC

DTC P2077 and P2078 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. A circuit test status parameter will change from OK or Not Run to Malfunction if there is a condition with the circuit or a connection.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-314

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Air Intake System Description on page 9-592

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 P2077, or P2078 is not set.

⇒ **If any of the DTCs are set**

Refer to Circuit/System Testing

⇓ **If none of the DTCs are set.**

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.
4. Verify a DTC does not set.

⇒ **If a DTC sets**

Refer to Circuit/System Testing

⇓ **If a DTC does not set**

5. All OK

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the Q22 Intake Manifold Tuning 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 ground circuit terminal 2 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 2 Ω**

3. Ignition ON, verify that a test lamp illuminates between the ignition circuit terminal 1 and ground.

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

3.1. Ignition OFF, remove the test lamp.

3.2. Test for less than 2 Ω in the ignition voltage circuit end to end.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

⇒ If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.

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

3.1. Ignition OFF, remove the test lamp.

3.2. Test for infinite resistance between the ignition voltage circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

Note: The vehicle may not be equipped with each circuit and component as listed below.

3.3. Test for greater than 10 Ω between each of the ignition circuits listed below and ground:

- Ignition circuit terminal 1 - B52A Heated Oxygen Sensor 1
- Ignition circuit terminal 1 - B52B Heated Oxygen Sensor 2
- Ignition circuit terminal 2 - E41 Engine Coolant Thermostat Heater
- Ignition circuit terminal 2 - Q12 Evaporative Emission Purge Solenoid

⇒ If 10 Ω or less, disconnect the appropriate component and retest to verify if the short is in the circuit or the component.

⇒ If greater than 10 Ω, replace the intake manifold

⇓ **If the test lamp illuminates**

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

4.1. Ignition OFF, disconnect the X2 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. Replace the Intake Manifold.

Repair Instructions

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

- *Intake Manifold Replacement (LUW) on page 9-981* or *Intake Manifold Replacement (LDE) on page 9-978*
- *Control Module References on page 6-3* for ECM replacement, programming, and setup .

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 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 9-314

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 9-520*.
- Excessive fuel system pressure. Refer to *Fuel System Diagnosis on page 9-518*.
- Fuel contamination. Refer to *Alcohol/ Contaminants-in-Fuel Diagnosis on page 9-523*.
- 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. Refer to *Crankcase Ventilation System Inspection/Diagnosis on page 9-968*.

⇒ 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 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 9-314

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. Refer to *Crankcase Ventilation System Inspection/ Diagnosis on page 9-968*.
- Engine vacuum leaks
- Low fuel system pressure. Refer to *Fuel System Diagnosis on page 9-518*.
- Contaminated fuel. Refer to *Alcohol/ Contaminants-in-Fuel Diagnosis on page 9-523*.
- Lean fuel injectors. Refer to *Fuel Injector Diagnosis on page 9-520*.

⇒ 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	P06A3, P2122	P2122	P06A3, P2123	—
APP Sensor 2 5V Reference	P0106, P0107, P0697, P2127	P2127	P0106, P0108, P0697, P2128	—
APP Sensor 1 Signal	P2122	P2122	P2123	P2138
APP Sensor 2 Signal	P2127	P2127	P2128	P2138
APP Sensor 1 Low Reference	—	P2123	—	—
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:** 0.46–4.75 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:** 0.32–2.6 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, P2123, P2127, P2128

- The system voltage is greater than 6.4 V.
- The ignition is in the unlock, accessory, run, or crank position.
- DTC P06A3 or P0697 are not set.
- The DTCs run continuously when the above conditions are met.

P2138

- The system voltage is greater than 6.4 V.
- The ignition is in the unlock, accessory or run position.
- DTC P06A3, P0697, P2122, P2123, P2127 or P2128 are not set.
- 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 0.5 V for greater than 0.5 s.

P2123

The ECM detects that APP sensor 1 voltage is greater than 4.75 V for greater than 0.5 s.

P2127

The ECM detects that APP sensor 2 voltage is less than 0.3 V for greater than 0.5 s.

P2128

The ECM detects that APP sensor 2 voltage is greater than 2.6 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 9-314

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Throttle Actuator Control (TAC) System Description on page 9-587

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 P0697 or P06A3 is not set.

⇒ **If any of the DTCs are set**

Refer to for *DTC P0641, P0651, P0697, or P06A3 (ECM) on page 9-449* further diagnosis.

⇓ **If none of the DTCs are set**

3. Verify the APP Sensor 1 Circuit Status and APP Sensor 2 Circuit Status displays OK.

⇒ **If Malfunction is displayed**

Refer to Circuit/System Testing

⇓ **If OK is displayed**

4. Verify the scan tool APP Sensor 1 and 2 Agree/ Disagree parameter displays Agree while performing the tests listed below:
   - Rapidly depress the accelerator pedal from the rest position to the wide open throttle position (WOT) and release pedal. Repeat the procedure several times.
   - Slowly depress the accelerator pedal to WOT and then slowly return the pedal to closed throttle. Repeat the procedure several times.

⇒ **If Disagree**

Refer to Circuit/System Testing

⇓ **If Agree**

5. Verify that DTC P2122, P2123, P2127, P2128, or P2138 is not set.

⇒ **If any of the DTCs are set**

Refer to Circuit/System Testing

⇓ **If none of the DTCs are set**

6. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

7. Verify DTC P2122, P2123, P2127, P2128, or P2138 is not set.

⇒ **If any of the DTCs are sets**

Refer to Circuit/System Testing

⇓ **If none of the DTCs are set**

8. All OK

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B107 Accelerator Pedal Position Sensor.

   It may take up to 2 min 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 3

⇒ **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 6
   - 5 V reference circuit terminal 1

⇒ **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 each APP sensor voltage 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 listed below and ground.
   - APP sensor 1 signal circuit terminal 5
   - APP sensor 2 signal circuit terminal 2

⇒ 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 each signal circuit terminal listed below and the 5 V reference circuit terminal 1.
   - APP sensor 1 signal circuit terminal 5
   - APP sensor 2 signal circuit terminal 2
7. Verify the scan tool APP 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 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 9-541*
- *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) Sensor 1-2 Correlation

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:

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

The intake air temperature (IAT) sensor 1 is a variable resistor that measures the temperature of the air in the sensor bore. The engine control module (ECM) supplies 5 V to the IAT sensor 1 signal circuit and a ground for the IAT sensor 1 low reference circuit. The signal varies with inlet air temperature and is displayed by the scan tool as °C (°F).

The IAT sensor 2 produces a frequency signal based on the inlet air temperature very close to the humidity sensor within the sensor bore. The signal varies with inlet air temperature and is displayed by the scan tool as °C (°F) and Hertz (Hz). The signal circuit is shared by the IAT sensor 2 and the humidity 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

Ignition voltage and ground circuits are also supplied to the multifunction intake air sensor's internal circuits for the mass air flow (MAF) 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

- The ignition is ON.
- Ignition 1 voltage is at least 11 V for at least 0.9 s.
- 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 9-314

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 on page 9-593*.

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 9-449* 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 1 and 2 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 55°C (99°F) of each other.
   - Start-Up IAT Sensor 1
   - IAT Sensor 2
   - Start-Up ECT

⇒ **If not within 55°C (99°F)**

Refer to Circuit/System Testing.

⇓ **If within 55°C (99°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
   - Start-Up ECT

⇒ **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 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
   - 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 9-312* 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 9-536* 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 9-314

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 9-356* or *DTC P0107 or P0108 on page 9-360*

⇓ **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. Refer to *Crankcase Ventilation System Inspection/Diagnosis on page 9-968.*
- 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 9-520.*
- Contaminated fuel. Refer to *Alcohol/ Contaminants-in-Fuel Diagnosis on page 9-523.*
- 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 9-527.*

⇒ **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 9-953.*

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

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P0641, P2227, P2228	P2228	P0641, P2229	P2227
Signal	P2227, P2228	P2227, P2228	P2227, P2229	P2227
Low Reference	—	P2227, P2229	—	P2227

Typical Scan Tool Data

BARO

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Ignition ON, Engine OFF **Parameter Normal Range:** 56–105 kPa (8.1–15.2 psi), varies with altitude			
5 V Reference	0 kPa (0 psi)	0 kPa (0 psi)	127 kPa (18.4 psi)
Signal	0 kPa (0 psi)	0 kPa (0 psi)	127 kPa (18.4 psi)
Low Reference	—	127 kPa (18.4 psi)	—

Circuit/System Description

The barometric pressure (BARO) sensor is integral to the multifunction intake air sensor and responds to changes in altitude and atmospheric conditions. This gives the ECM an indication of barometric pressure. The ECM uses this information to calculate fuel delivery. The BARO sensor provides a voltage signal to the ECM relative to the atmospheric pressure changes. The ECM monitors the BARO sensor signal for a voltage outside of the normal range.

Conditions for Running the DTC

P2227

- DTC P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0121, P0122, P0123, P0222, P0223, P1516, P2101, P2135, P2228, or P2229 is not set.
- Engine is running for greater than 30 s.

OR

- DTC P0106, P0107, P0108, P2228, P2229, P2230, or P2610 is not active .
- DTC P0107, P0108, P2228, or P2229 is not pending.
- Engine is OFF for at least 7 min.
- Ignition is ON
- DTC P2227 runs continuously when the above conditions are met.

P2228 or P2229

- Engine is running for greater than 30 s.
- The DTCs run continuously when the above condition is met .

P2230

- DTC P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0121, P0122, P0123, P0222, P0223, P1516, P2101, P2135, P2228, or P2229 is not set.
- Ignition is ON
- DTC P2230 runs continuously when the above conditions are met.

Conditions for Setting the DTC

P2227

- The engine is running.
- The ECM detects that the difference between the actual BARO and the calculated BARO is greater than a calibrated threshold.

  OR
- Ignition ON, engine OFF
- The ECM detects that the BARO pressure is less than 50 kPa (7.3 psi) or greater than 115 kPa (16.7 psi).

P2228

The ECM detects that the BARO sensor voltage is less than 2 V for greater than 5 s.

P2229

The ECM detects that the BARO sensor voltage is greater than 4.5 V for greater than 5 s.

P2230

The ECM detects that the cumulative difference between BARO sensor readings, over a specific length of time, is greater than a calibrated threshold.

Action Taken When the DTC Sets

DTCs P2227, P2228, P2229, and P2230 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P2227, P2228, P2229, and P2230 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-314

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 9-312* 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.

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 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 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 9-536* for multifunction intake air sensor replacement
- *Control Module References on page 6-3* for engine control module replacement, programming, and setup

DTC P2430 or P2431

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 P2430: Secondary Air Injection System Pressure Sensor Circuit

DTC P2431: Secondary Air Injection System Pressure Sensor Performance

Circuit/System Description

The secondary air injection system aids in the reduction of hydrocarbon emissions during a cold start. The electric air pump forces fresh air into the exhaust stream in order to accelerate the catalyst operation. A pressure sensor in the shutoff/check valve is used to monitor the air flow from the secondary air injection pump. The engine control module (ECM) supplies voltage to the 5-volt reference circuit and supplies a ground to the low reference circuit. The sensor provides a signal voltage to the ECM relative to the pressure changes within the secondary air injection system.

Ignition voltage is supplied to the secondary air injection pump and air injection shutoff/check valve relays. The ECM controls the relays by grounding the control circuits, which activates the relays. When the relay contacts close, voltage is supplied to the pump and the valve, which turns the pump on and opens the valve.

The diagnostic uses 3 phases to test the secondary air injection system:

- DTCs P0411 and P2430 run during Phase 1
- DTCs P2430 and P2440 run during Phase 2
- DTC P2444 runs during Phase 3

During phase 1, the secondary air injection pump and the secondary air injection shutoff and check valve are activated. Normal secondary air function occurs. Expected system pressure is 5–13 kPa (0.7–1.9 psi) above BARO.

During phase 2, only the secondary air injection pump is activated. The shutoff and check valve is closed. Pressure sensor performance and shutoff and check valve deactivation are tested. Expected system pressure is 14–25 kPa (2.0–3.6 psi) above BARO.

During phase 3, neither the secondary air injection pump nor the secondary air injection shutoff and check valve are activated. Secondary air injection pump deactivation is tested. Expected system pressure equals BARO.

Conditions for Running the DTC

P2430

- DTC P0412, P0418, P0606, P2431, P2432, or P2433 is not set.
- Greater than 30 min has elapsed since the last cold start.
- The ignition voltage is between 10–32 V.
- The engine speed is less than 5,000 RPM.
- The intake air temperature (IAT) is greater than -11°C (12.2°F).
- The engine coolant temperature (ECT) is between −11 and +56°C (12.2–133°F).
- The barometric pressure (BARO) is greater than 74 kPa (10.7 psi).
- The manifold absolute pressure (MAP) sensor is greater than 20 kPa (2.9 psi).
- The mass air flow (MAF) is less than 50 g/s.
- The secondary air injection pump is commanded ON.
- DTC P2430 runs once per ignition cycle when the above conditions are met for greater than 5 s.

P2431

- DTC P0101, P0102, P0103, P0300, P0301, P0302, P0303, P0304, P2430, P2432, or P2433 is not set.
- Greater than 30 min has elapsed since the last cold start.
- The ignition voltage is between 10–32 V.
- The engine speed is less than 5,000 RPM.
- The intake air temperature (IAT) is greater than -11°C (12.2°F).
- The engine coolant temperature (ECT) is between −11 and +56°C (12.2–133°F).
- The barometric pressure (BARO) is greater than 74 kPa (10.7 psi).
- The manifold absolute pressure (MAP) sensor is greater than 20 kPa (2.9 psi).
- The mass air flow (MAF) is less than 50 g/s.
- DTC P2431 runs continuously when the above conditions are met for greater than 15 s.

Conditions for Setting the DTC

P2430

The ECM determines that the pressure sensor value change at the shutoff/check valve is less than 0.5 kPa and the signal variation is less than 0.15 kPa for greater than 5 s when the secondary air injection pump is commanded ON.

P2431

- The difference between the actual system pressure at the shutoff/check valve and BARO is greater than 18 kPa (2.6 psi) or less than −10 kPa −1.5 psi) for greater than 5 s when the secondary air injection pump is commanded OFF.

  OR

- The difference between the actual system pressure at the shutoff/check valve and BARO is greater than 50 kPa (7.3 psi) for greater than 5 s when the secondary air injection pump is commanded ON.

Action Taken When the DTC Sets

DTCs P2430 and P2431 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P2430 and P2431 are Type B DTCs.

Diagnostic Aids

Ice buildup due to condensation/water in the air passages or pump may cause this DTC to set.

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

Secondary Air Injection System Description on page 9-592

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 36169-HD Fused Jumper

For equivalent regional tools, refer to *Special Tools on page 9-593*.

Circuit/System Verification

Note: Verify the battery is fully charged before proceeding with this diagnostic procedure. The secondary air injection pump output will vary with system voltage.

1. Ignition ON
2. Verify that DTC P0412, P0418, P2432, P2433, P2440, or P2444 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 pressure parameter is within the range specified in the *Altitude Versus Barometric Pressure on page 9-312* table.

⇒ **If not within the specified range**

Refer to *DTC P2227-P2230 on page 9-494*.

⇓ **If within the specified range**

4. Verify the scan tool Secondary Air Injection Pressure Sensor and the BARO pressure parameters are within 3 kPa (0.4 psi).

⇒ **If not within the specified range**

Replace the Q29 Secondary Air Injection Solenoid Valve

⇓ **If within the specified range**

Note: To prevent the secondary air injection pump from overheating, do not operate the pump consecutively for greater than 2 minutes. The pump is provided with a thermal protector that will automatically reset when allowed to cool.

5. Verify the G21 Secondary Air Injection Pump turns ON and OFF when commanding the Secondary Air Injection Pump Relay between ON and OFF with a scan tool.

⇒ **If the pump does not turn ON and OFF**

Refer to Circuit/System Testing—Secondary Air Injection Pump Malfunction

⇓ **If the pump turns ON and OFF**

6. Engine running
7. Verify the scan tool Secondary Air Injection Pressure Sensor parameter increases between 14–25 kPa (2.0–3.6 psi) when the Secondary Air Injection Pump Relay is commanded ON with a scan tool.

⇒ **If not within the specified range**

Refer to Circuit/System Testing—Secondary Air Injection System Pressure Not In Range.

⇓ **If within the specified range**

8. Verify the scan tool Secondary Air Injection Pressure Sensor parameter increases between 5–13 kPa (0.7–1.9 psi) when the Secondary Air Injection System is commanded Active with a scan tool.

⇒ **If not within the specified range**

Refer to Circuit/System Testing—Secondary Air Injection System Pressure Not In Range.

⇓ **If within the specified range**

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 the DTC does not set.

⇒ **If the DTC sets**

Refer to Circuit/System Testing

⇓ **If the DTC does not set**

11. All OK

Circuit/System Testing

Secondary Air Injection Pump Malfunction

1. Ignition OFF, disconnect the KR25 Secondary Air Injection Pump Relay. Ignition ON.
2. Verify a test lamp illuminates between the B+ circuit terminal 30 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 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

2.2. Test for infinite resistance between the B+ circuit and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

2.3. Disconnect the harness connector at the G21 Secondary Air Injection Pump.

2.4. Test for infinite resistance between the control circuit terminal A and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.

⇓ If infinite resistance

2.5. Test or replace the G21 Secondary Air Injection Pump.

⇓ **If the test lamp illuminates**

3. Disconnect the harness connector at the G21 Secondary Air Injection Pump.
4. Ignition OFF and all vehicle systems OFF, it may take up to 2 minutes for all vehicle systems to power down. Test for less than 10 Ω between the G21 Secondary Air Injection Pump ground circuit terminal B and ground.

⇒ **If 10 Ω or greater**

4.1. Ignition OFF.

4.2. 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 10 Ω**

5. Connect the harness connector at the G21 Secondary Air Injection Pump.
6. Connect a 50 A fused jumper wire between the B+ circuit terminal 30 and the control circuit terminal 87.

Note: To prevent the secondary air injection pump from overheating, do not operate the pump consecutively for greater than 2 minutes. The pump is provided with a thermal protector that will automatically reset when allowed to cool.

7. Verify the G21 Secondary Air Injection Pump is activated.

⇒ **If the pump does not activate**

7.1. Ignition OFF, disconnect the harness connector at the G21 Secondary Air Injection Pump.

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,

7.3. Test or replace the G21 Secondary Air Injection Pump.

⇓ **If the pump activates**

8. Test or replace the KR25 Secondary Air Injection Pump Relay.

Secondary Air Injection System Pressure Not In Range

1. Verify the following conditions do not exist with the secondary air injection shutoff and check valve:
   - Hoses/pipes restricted or blocked
   - Hoses/pipes leaking or disconnected
   - Damaged secondary air injection shutoff and check valve
   - Restricted or blocked cylinder head secondary air injection inlet ports and passages

⇒ **If a condition is located**

Repair or replace the affected component as necessary.

⇓ **If all components test normal**

2. Disconnect the secondary air injection hoses/pipe from the Q29 Secondary Air Injection Solenoid Valve.
3. Ignition ON, command the Secondary Air Injection Pump Relay ON with a scan tool.
4. Verify airflow to the Q29 Secondary Air Injection Solenoid Valve.

⇒ **If no airflow**

Replace the G21 Secondary Air Injection Pump.

⇓ **If airflow**

5. Disconnect the appropriate Q29 Secondary Air Injection Solenoid Valve from the engine.
6. Connect the harness connector at the Q29 Secondary Air Injection Solenoid Valve.

7. Connect the secondary air injection pipe between the Q29 Secondary Air Injection Solenoid Valve and the G21 Secondary Air Injection Pump.
8. Ignition ON, command the Secondary Air Injection System Active with a scan tool. Verify there is airflow through the valve.

⇒ **If no airflow**

Replace the Q29 Secondary Air Injection Solenoid Valve

⇓ **If airflow**

9. Replace the G21 Secondary Air Injection Pump.

Component Testing

Relay Test

1. Ignition OFF, disconnect the KR25 Secondary Air Injection Pump Relay.
2. Test for 70–110 Ω between terminals 85–86.

⇒ **If less than 70 Ω or greater than 110 Ω**

Replace the KR25 Secondary Air Injection Pump 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 KR25 Secondary Air Injection Pump Relay.

⇓ **If infinite resistance**

4. Install a 15 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 KR25 Secondary Air Injection Pump Relay.

⇓ **If less than 2 Ω**

6. All OK.

Repair Instructions

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

- *Relay Replacement (Within an Electrical Center) on page 11-607* or *Relay Replacement (Attached to Wire Harness) on page 11-607*
- *Secondary Air Injection Pump Replacement on page 9-546*
- *Secondary Air Injection Check Valve Replacement on page 9-543* for secondary air injection solenoid valve replacement
- *Secondary Air Injection Pump Pipe Replacement on page 9-545*

DTC P2432 or P2433

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 P2432: Secondary Air Injection System Pressure Sensor Circuit Low Voltage
DTC P2433: Secondary Air Injection System Pressure Sensor Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Secondary Air Injection Pressure Sensor 5 V Reference	P0335, P2432	P2432	P2433*	P2431
Secondary Air Injection Pressure Sensor Signal	P2432	P2432	P2433*	P2431
Secondary Air Injection Pressure Sensor Low Reference	—	P2433	—	P2431
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

Secondary Air Injection Pressure Sensor

Circuit	Short to Ground	Open	Short to Voltage
Parameter Normal Range: BARO **Operating Conditions:** Ignition ON, Engine OFF			
5-Volt Reference	41 kPa (6 psi)	41 kPa (6 psi)	149 kPa (21.6 psi)
Secondary Air Pressure Sensor Signal	40 kPa (5.8 psi)	40 kPa (5.8 psi)	149 kPa (21.6 psi)
Low Reference	—	149 kPa (21.6 psi)	—

Circuit/System Description

The secondary air injection system aids in the reduction of hydrocarbon emissions during a cold start. The electric air pump forces fresh air into the exhaust stream in order to accelerate the catalyst operation. The Secondary air injection pressure sensor, which is integral to the shutoff and check valve, is used to monitor the air flow from the secondary air injection pump. The engine control module (ECM) supplies voltage to the 5 V reference circuit and provides a ground for the low reference circuit. The sensor provides a signal voltage to the ECM relative to the pressure changes within the secondary air injection system.

Conditions for Running the DTC

- DTC P0606 is not set.
- The ignition is ON, or the engine is running.
- The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

P2432

The ECM detects that the secondary air injection pressure sensor signal is less than 0.3 V for greater than 6 s.

P2433

The ECM detects that the secondary air injection pressure sensor signal is greater than 4.7 V for greater than 6 s.

Action Taken When the DTC Sets

DTCs P2432 and P2433 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P2432 and P2433 are Type B DTCs.

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

Secondary Air Injection System Description on page 9-592

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 P0651 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. Verify the scan tool BARO pressure parameter is within the range specified in the *Altitude Versus Barometric Pressure on page 9-312* table.

⇒ **If not within the specified range**

Refer to *DTC P2227-P2230 on page 9-494*.

⇓ **If within the specified range**

4. Verify the scan tool Secondary Air Injection Pressure Sensor and the BARO pressure parameters are within 3 kPa (0.4 psi).

⇒ **If not within the specified range**

Refer to Circuit/System Testing

⇓ **If within the specified range**

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. It may take up to 2 min, for all vehicle systems to power down. Disconnect the harness connector at the Q29 Secondary Air Injection Solenoid Valve.
2. Test for less than 5 Ω of resistance between the low reference circuit terminal 3 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 1 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 Secondary Air Injection Pressure Sensor parameter is less than 0.5 V.

⇒ **If 0.5 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 2 and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.

⇒ If less than 1 V, replace the K20 Engine Control Module.

⇓ **If less than 0.5 V**

6. Install a 3 A fused jumper wire between the signal circuit terminal 2 and the 5 V reference circuit terminal 1.
7. Verify the scan tool Secondary Air Injection Pressure Sensor 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 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 4.8 V**

8. Test or replace the Q29 Secondary Air Injection Solenoid Valve.

Repair Instructions

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

- *Secondary Air Injection Check Valve Replacement on page 9-543* for secondary air injection solenoid valve replacement
- *Control Module References on page 6-3* for ECM replacement, programming, and setup

DTC P2440

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 P2440: Secondary Air Injection System Cut-Off Valve Stuck Open

Circuit/System Description

The secondary air injection system aids in the reduction of hydrocarbon emissions during a cold start. The electric air pump forces fresh air into the exhaust stream in order to accelerate the catalyst operation. A pressure sensor in the shutoff/check valve is used to monitor the air flow from the secondary air injection pump. The engine control module (ECM) supplies voltage to the 5-volt reference circuit and supplies a ground to the low reference circuit. The sensor provides a signal voltage to the ECM relative to the pressure changes within the secondary air injection system.

Ignition voltage is supplied to the secondary air injection pump and air injection shutoff/check valve relays. The ECM controls the relays by grounding the control circuits, which activates the relays. When the relay contacts close, voltage is supplied to the pump and the valve, which turns the pump on and opens the valve.

The diagnostic uses 3 phases to test the secondary air injection system:

- DTCs P0411 and P2430 run during Phase 1
- DTCs P2430 and P2440 run during Phase 2
- DTC P2444 runs during Phase 3

During phase 1, the secondary air injection pump and the secondary air injection shutoff and check valve are activated. Normal secondary air function occurs. Expected system pressure is 5–13 kPa (0.7–1.9 psi) above BARO.

During phase 2, only the secondary air injection pump is activated. The shutoff and check valve is closed. Pressure sensor performance and shutoff and check valve deactivation are tested. Expected system pressure is 14–25 kPa (2.0–3.6 psi) above BARO.

During phase 3, neither the secondary air injection pump nor the secondary air injection shutoff and check valve are activated. Secondary air injection pump deactivation is tested. Expected system pressure equals BARO.

Conditions for Running the DTC

- DTC P0101, P0102, P0103, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0128, P0201, P0202, P0203, P0204, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0300, P0301, P0302, P0303, P0304, P0351, P0352, P0353, P0354, P0412, P0418, P0420, P124A, P124B, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P2227, P2228, P2229, P2230, P2430, P2431, P2432, or P2433 is not set.
- Greater than 30 min has elapsed since the last cold start.
- The ignition voltage is between 10–32 V.
- The engine speed is less than 5,000 RPM.
- The intake air temperature (IAT) is greater than -11°C (12.2°F).
- The engine coolant temperature (ECT) is between −11 and +56°C (12.2–133°F).
- The barometric pressure (BARO) is greater than 60 kPa (8.7 psi).
- The manifold absolute pressure (MAP) sensor is greater than 20 kPa (2.9 psi).
- The mass air flow (MAF) is less than 50 g/s.
- The secondary air injection pump is commanded ON.
- Secondary air injection diagnostic test Phase 1 has run and passed.
- DTC P2440 runs once per ignition cycle when the above conditions are met for greater than 3 s.

Conditions for Setting the DTC

The ECM detects that the secondary air system pressure is less than a calibrated threshold for greater than 1.5 s.

Action Taken When the DTC Sets

DTC P2440 is a Type B DTC.

Conditions for Clearing the DTC

DTC P2440 is a Type B DTC.

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

Secondary Air Injection System Description on page 9-592

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 P0411, P0412, P0418, P2430, P2431, P2432, or P2433 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 pressure parameter is within the range specified in the *Altitude Versus Barometric Pressure on page 9-312* table.

⇒ **If not within the specified range**

Refer to *DTC P2227-P2230 on page 9-494*.

⇓ **If within the specified range**

4. Verify the scan tool Secondary Air Injection Pressure Sensor parameter and the BARO pressure parameter are within 3 kPa (0.4 psi).

⇒ **If not within the specified range**

Replace the Q29 Secondary Air Injection Solenoid Valve

⇓ **If within the specified range**

5. Engine running
6. Verify the scan tool Secondary Air Injection Pressure Sensor parameter increases between 14–25 kPa (2.0–3.6 psi) when the Secondary Air Injection Pump Relay is commanded ON with a scan tool.

⇒ **If not within the specified range**

Refer to Circuit/System Testing

⇓ **If within the specified range**

7. 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 the DTC sets**

Refer to Circuit/System Testing

⇓ **If the DTC does not set**

8. All OK

Circuit/System Testing

1. Ignition OFF, disconnect the KR26 Secondary Air Injection Solenoid Valve Relay. Ignition ON.
2. Verify a test lamp does not illuminate between the control circuit terminal 87 and ground.

⇒ **If the test lamp illuminates**

Repair the short to voltage on the circuit.

⇓ **If the test lamp does not illuminate**

3. Ignition OFF, connect the KR26 Secondary Air Injection Solenoid Valve Relay.
4. Disconnect the harness connector at the Q29 Secondary Air Injection Solenoid Valve. Ignition ON.
5. Verify a test lamp does not illuminate between the control circuit terminal 5 and ground.

⇒ **If the test lamp illuminates**

Test or replace the KR26 Secondary Air Injection Solenoid Valve Relay.

⇓ **If the test lamp does not illuminate**

6. Verify the conditions listed below do not exist:
   - Hoses/pipes restricted or blocked upstream of valve
   - Hoses/pipes leaking or disconnected
   - Damaged or restricted secondary air injection pump
   - Damaged secondary air injection check valve

⇒ **If a condition exists**

Repair or replace the affected component as necessary.

⇓ **If none of the conditions exist**

7. Ignition OFF, remove the Q29 Secondary Air Injection Solenoid Valve.
8. Connect the harness connector at the Q29 Secondary Air Injection Solenoid Valve.
9. Connect the secondary air injection pipe to the Q29 Secondary Air Injection Solenoid Valve.
10. Ignition ON, command the Secondary Air Injection Pump Relay ON with a scan tool. Verify there is NO airflow through the valve.

⇒ **If airflow**

Replace the Q29 Secondary Air Injection Solenoid Valve.

⇓ **If no airflow**

11. Replace the G21 Secondary Air Injection Pump.

Component Testing

Relay Test

1. Ignition OFF, disconnect the KR26 Secondary Air Injection Solenoid Valve Relay.
2. Test for 70–110 Ω between terminals 85–86.

⇒ **If less than 70 Ω or greater than 110 Ω**

Replace the KR26 Secondary Air Injection Solenoid Valve 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 KR26 Secondary Air Injection Solenoid Valve Relay.

⇓ **If infinite resistance**

4. Install a 15 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 KR26 Secondary Air Injection Solenoid Valve Relay.

⇓ **If less than 2 Ω**

6. All OK

Repair Instructions

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

- *Relay Replacement (Within an Electrical Center) on page 11-607* or *Relay Replacement (Attached to Wire Harness) on page 11-607*
- *Secondary Air Injection Pump Replacement on page 9-546*
- *Secondary Air Injection Check Valve Replacement on page 9-543* for secondary air injection solenoid valve replacement
- *Secondary Air Injection Pump Pipe Replacement on page 9-545*

DTC P2444

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 P2444: Secondary Air Injection System Pump Stuck On

Circuit/System Description

The secondary air injection system aids in the reduction of hydrocarbon emissions during a cold start. The electric air pump forces fresh air into the exhaust stream in order to accelerate the catalyst operation. A pressure sensor in the shutoff/check valve is used to monitor the air flow from the secondary air injection pump. The engine control module (ECM) supplies voltage to the 5-volt reference circuit and supplies a ground to the low reference circuit. The sensor provides a signal voltage to the ECM relative to the pressure changes within the secondary air injection system.

Ignition voltage is supplied to the secondary air injection pump and air injection shutoff/check valve relays. The ECM controls the relays by grounding the control circuits, which activates the relays. When the relay contacts close, voltage is supplied to the pump and the valve, which turns the pump on and opens the valve.

The diagnostic uses 3 phases to test the secondary air injection system:

- DTCs P0411 and P2430 run during Phase 1
- DTCs P2430 and P2440 run during Phase 2
- DTC P2444 runs during Phase 3

During phase 1, the secondary air injection pump and the secondary air injection shutoff and check valve are activated. Normal secondary air function occurs. Expected system pressure is 5–13 kPa (0.7–1.9 psi) above BARO.

During phase 2, only the secondary air injection pump is activated. The shutoff and check valve is closed. Pressure sensor performance and shutoff and check valve deactivation are tested. Expected system pressure is 14–25 kPa (2.0–3.6 psi) above BARO.

During phase 3, neither the secondary air injection pump nor the secondary air injection shutoff and check valve are activated. Secondary air injection pump deactivation is tested. Expected system pressure equals BARO.

Conditions for Running the DTC

- DTC P0101, P0102, P0103, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0128, P0201, P0202, P0203, P0204, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0300, P0301, P0302, P0303, P0304, P0351, P0352, P0353, P0354, P0412, P0418, P0420, P124A, P124B, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P2227, P2228, P2229, P2230, P2430, P2431, P2432, or P2433 is not set.
- Greater than 30 min has elapsed since the last cold start.
- The ignition voltage is between 10–32 V.
- The engine speed is less than 5,000 RPM.
- The intake air temperature (IAT) is greater than −11°C (12.2°F).
- The engine coolant temperature (ECT) is between −11 and +56°C (12.2–133°F).
- The barometric pressure (BARO) is greater than 60 kPa (8.7 psi).
- The manifold absolute pressure (MAP) sensor is greater than 20 kPa (2.9 psi).
- The mass air flow (MAF) is less than 50 g/s.
- Secondary air injection pump is commanded ON.
- Secondary air injection diagnostic test Phase 1 and Phase 2 have run and passed.
- DTC P2444 runs once per ignition cycle when the above conditions are met for greater than 3 s.

Conditions for Setting the DTC

The ECM detects that average difference between the predicted system pressure and the actual system pressure is greater than or less than calibrated thresholds for greater than 2 s.

Action Taken When the DTC Sets

DTC P2444 is a Type A DTC.

Conditions for Clearing the MIL/DTC

DTC P2444 is a Type A DTC.

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

Secondary Air Injection System Description on page 9-592

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 P0412, P0418, P2432 or P2433 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.**

Note: To prevent the secondary air injection pump from overheating, do not operate the pump consecutively for greater than 2 minutes. The pump is provided with a thermal protector that will automatically reset when allowed to cool.

3. Verify the G21 Secondary Air Injection Pump turns ON and OFF when commanding the Secondary Air Injection Pump Relay ON and OFF with a scan tool.

⇒ **If the pump does not turn ON and OFF**

Refer to Circuit/System Testing

⇓ **If the pump turns ON and OFF**

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 KR25 Secondary Air Injection Pump Relay.
2. Ignition ON, verify a test lamp does not illuminate between the control circuit terminal 87 and ground.

⇒ **If the test lamp illuminates**

Repair the short to voltage on the circuit.

⇓ **If the test lamp does not illuminate**

3. Test or replace the KR25 Secondary Air Injection Pump Relay.

Component Testing

Relay Test

1. Ignition OFF, disconnect the KR25 Secondary Air Injection Pump Relay.
2. Test for 70–110 Ω between terminals 85–86.

⇒ **If less than 70 Ω or greater than 110 Ω**

Replace the KR25 Secondary Air Injection Pump 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 KR25 Secondary Air Injection Pump Relay.

⇓ **If infinite resistance**

4. Install a 15 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 KR25 Secondary Air Injection Pump Relay.

⇓ **If less than 2 Ω**

6. All OK

Repair Instructions

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

Relay Replacement (Within an Electrical Center) on page 11-607 or *Relay Replacement (Attached to Wire Harness) on page 11-607*

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 9-314

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Fuel System Description on page 9-584

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 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 9-314

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Fuel System Description on page 9-584

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 9-518*.

⇒ **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 (Steel Tank) on page 9-559*
- *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 that are stored.
- Verify that the scan tool data is within a normal operating range. Refer to *Control Module References on page 6-3* for scan tool information.
- Verify the customer concern.
- Perform the Visual/Physical Inspection in this section. The visual/physical inspection is extremely important, and can lead to correcting a condition without additional testing. It may also help reveal the cause of an intermittent condition.

Identifying Intermittent Conditions

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

- Moisture and water intrusion in connectors, terminals, and components
- Incomplete connector mating
- Poor terminal contact
- High circuit or component resistance—High resistance can include any resistance, regardless of the amount, which can interrupt the operation of the component.
- Harness that is too short or tight
- Wire insulation that is chaffed or cut
- High or low ambient temperature
- High or low engine coolant temperatures
- High underhood temperatures
- Heat build up in component or circuit due to circuit resistance, poor terminal contact, or high electrical load
- High or low system voltage
- High vehicle load conditions
- Rough road surfaces
- Electro-magnetic interference (EMI)/circuit interference from relays, solenoids or other electrical surge
- Incorrect installation of aftermarket, add on accessories

Visual/Physical Check

- Verify 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:
   - For the correct installation of the Mass Air Flow (MAF)/Intake Air Temperature (IAT) Sensor.
   - The fuel system for the following:
     - Correct fuel pressure. Refer to *Fuel System Diagnosis on page 9-518*.
     - Leaking or incorrectly operating fuel injectors. Refer to *Fuel Injector Diagnosis on page 9-520*.
     - Contaminated or a poor fuel quality condition. Refer to *Alcohol/Contaminants-in-Fuel Diagnosis on page 9-523*.
   - The ignition system for the following:
     - Spark plugs with incorrect heat range or an abnormal condition—Refer to *Spark Plug Inspection on page 9-571* and *Ignition System Specifications on page 9-313*.
     - Coolant or oil fouled spark plugs—For diagnosis, refer to *Coolant in Combustion Chamber on page 9-957* or *Oil Consumption Diagnosis on page 9-956*.
     - 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 on page 9-593*. Refer to *Electronic Ignition System Diagnosis on page 9-527*.
   - The operation of the transmission torque converter clutch (TCC). The scan tool should indicate an engine speed drop when the TCC is commanded ON.
   - The 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 9-385*.
   - The crankshaft position sensor for the correct resistance. The crankshaft position sensor resistance may be out of range after a hot soak. The resistance should be between 700–1 200 Ω.
   - The engine for the following mechanical failures. Refer to *Symptoms - Engine Mechanical on page 9-953*.
     - Too much oil in the combustion chamber or leaking valve seals
     - Incorrect cylinder compression
     - Sticking or leaking valves
     - Worn camshaft lobes
     - Incorrect valve timing
     - Broken valve springs
     - Too much carbon buildup in the combustion chambers. Clean the chambers with top engine cleaner, if necessary. Follow the instructions on the can.
     - Incorrect engine parts

Note: The embossed arrows on the mass air flow (MAF) sensor indicate the direction of the intake air flow. The arrows must point toward the engine.

   - Improper MAF sensor installation. A mass air flow sensor that is improperly installed may cause a hard start. Install the mass air flow in the proper direction. Refer to *Mass Airflow Sensor Replacement on page 9-536*.
   - Vacuum hoses for splits or kinks. Verify that the routing and connections are as shown on the vehicle emission control information label.
   - Knock sensor system for too much spark retard activity. Refer to *Knock Sensor Replacement on page 9-577* and *DTC P0335 or P0336 on page 9-406*.
   - Fuel octane switch setting, if equipped. Verify the fuel octane switch is set to the proper fuel octane rating for the fuel being used in the vehicle.
   - The exhaust system components for the following:
     - Physical damage or possible internal malfunction
     - The 3-way catalytic converters for a restriction

     For more information, refer to *Symptoms - Engine Exhaust on page 9-734*.
   - Electromagnetic interference on the reference circuit 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.
   - Inspect the positive crankcase ventilation system and all connections for leaks or restrictions.

- Evaporative Emission (EVAP) Canister Purge Solenoid Valve that is stuck open
- The engine cooling system for the following conditions:
  - The thermostat is the correct heat range. Refer to *Thermostat Diagnosis on page 9-626*.
  - The engine coolant thermostat heater is working proper. Refer to *DTC P0597-P0599 on page 9-614*.
  - Proper engine coolant level. Refer to *Cooling System Draining and Filling on page 9-628*.

2. If the above conditions do not address the symptom, refer to the additional symptoms tests.

Additional Symptoms Tests

Detonation/Spark Knock

- Test for an engine overheating condition. Refer to *Engine Overheating on page 9-625*.
- Inspect for excessive carbon buildup in the combustion chambers. Clean the chambers with Top Engine Cleaner, if necessary. Follow the instructions on the can.
- If there are no engine mechanical faults, fill the fuel tank with a known high quality fuel that meets the vehicle minimum octane requirements.

Engine Control Module (ECM) Commanded Reduced Engine Power

Under certain conditions the engine control module 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 engine control module 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 engine control module 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 the vehicle is 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.
- High pressure fuel system out of range—Refer to *Fuel System Diagnosis on page 9-518* and *Fuel System Description on page 9-584* to verify high pressure fuel system pressure and operation.
- Maximum recommended engine oil life exceeded —Refer to the Owners Manual for scheduled maintenance recommendations.
- If equipped with manual transmission, reduced engine power may be due to overheated transmission oil. Allow the transmission oil to cool down. Refer to the Owners Manual for scheduled maintenance recommendations to determine if the transmission is due for servicing.
- Intake air temperature out of range too high—Engine running, observe the scan tool IAT Sensor parameter. The readings should be between –40° C and +149°C (–40°F and +300°F). Refer to *DTC P0112, P0113, or P0114 on page 9-364* for additional information.
- Fuel temperature out of range too high
- 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 9-589*.
- Inspect for a condition with the internal components of the fuel tank assembly. Refer to *Fuel System Description on page 9-584*.

Hard Start

- 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 9-312* 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 system operates correctly during engine start-up. The fuel pump should turn ON for 2 S when the ignition is turned to ON and fuel pressure should be as specified in *Fuel System Diagnosis on page 9-518* procedure. For additional fuel system information, refer to *Fuel System Description on page 9-584*.

Hesitation, Sag, Stumble

- Test the fuel pressure. Refer to *Fuel System Diagnosis on page 9-518*.
- Inspect the mass air flow (MAF) sensor for obstruction, contamination, and damage. Refer to *Mass Airflow Sensor Replacement on page 9-536*.
- Test the manifold absolute pressure (MAP) sensor. Refer to *DTC P0106 on page 9-356*.
- 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.

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.
- Inspect for foreign material accumulation in the throttle bore, and for carbon deposits on the throttle plate and shaft. Also inspect for throttle body tampering.
- Inspect the mass air flow (MAF) sensor for obstruction, contamination, and damage. Refer to *Mass Airflow Sensor Replacement on page 9-536*.
- 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 the following:
  - *Engine Controls Schematics on page 9-314*
  - *Fuel System Description on page 9-584*
  - *Evaporative Emission Control System Description on page 9-589*

Rough, Unstable, or Incorrect Idle and Stalling

- Inspect the engine mounts *Engine Mount Replacement on page 9-976*.
- Inspect the mass air flow (MAF) sensor for obstruction, contamination, and damage. Refer to *Mass Airflow Sensor Replacement on page 9-536*.
- Inspect the intake and exhaust manifolds for casting flash.
- Inspect the exhaust system for damaged or collapsed pipes
- Inspect for foreign material accumulation in the throttle bore, and for carbon deposits on the throttle plate and shaft. Also inspect for throttle body tampering.
- An excessively high idle may be due to the floor mat interfering with the accelerator pedal. With this condition present, it may not be possible to shift the transmission into gear. Inspect the accelerator pedal for binding and verify that the floor mat is not interfering with the accelerator pedal movement.

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 9-536*.
- Inspect for slow responding heated oxygen sensors (HO2S). The HO2S should respond quickly to a change in throttle position. If the HO2S do not respond to different throttle positions, inspect for contamination from fuel, silicon, or the incorrect use of 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.
- Inspect for foreign material accumulation in the throttle bore, and for carbon deposits on the throttle plate and shaft. Also inspect for throttle body tampering.

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) turn 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.

Reference Information

Schematic Reference

- *Engine Controls Schematics on page 9-314*
- *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

Circuit/System Verification

Note: Any MIL requesting DTCs that may be set should be diagnosed first.

1. Ignition ON.
2. Verify that the P16 Instrument Cluster warning indicators are all illuminated.

⇒ **If the warning indicators do not illuminate**

Refer to *Symptoms - Displays and Gauges on page 8-89*

⇓ **If the warning indicators illuminate**

3. Verify all the scan tool parameters listed below display OK or Not Run when commanding the MIL ON and OFF with a scan tool.
   - The MIL Control Circuit Low Voltage Test Status
   - The MIL Control Circuit Open test Status
   - The MIL Control Circuit High Voltage test Status

⇒ **If Malfunction displayed**

Refer to Circuit/System Testing.

⇓ **If OK or Not Run 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.

⇒ **If the DTC sets**

Refer to Circuit/System Testing

⇓ **If the DTC does not set**

5. All OK.

Circuit/System Testing

1. Ignition ON.
2. Ignition OFF, disconnect the harness connector at the P16 Instrument Cluster.
3. Connect a test lamp between the control circuit terminal 25 and B+ circuit terminal.
4. Verify the test lamp turns ON and OFF when commanding the ECM Malfunction Indicator Lamp (MIL) ON and OFF with a scan tool.

⇒ **If the test lamp is always OFF**

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

4.3. Ignition OFF.

4.4. 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**

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 the test lamp turns ON and OFF**

5. Test or replace the P16 Instrument Cluster.

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.

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 9-520*.
- 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 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 9-314

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
- *EN 36012–A* Ignition System Diagnostic Harness
- *EL 26792* HEI Spark Tester
- *J 34730-2C* Injector Test Lamp

For equivalent regional tools, refer to *Special Tools on page 9-593*.

Circuit/System Testing

Note: This diagnostic assumes the following:

- The battery is completely charged.
- The engine cranking speed is acceptable.
- There is adequate fuel in the fuel tank.

1. Crank the engine for up to 15 s.
2. Verify that DTC P0117, P0118, P0122, P0123, P018C, P018D, P0222, P0223, P0231, P0232, P023F, P025A, P0335, P0336, P0513, P0562, P0563, P0601, P0602, P0603, P0604, P0606, P0628, P0629, P062F, P0633, P0685, P0689, P0690, P1516, P1631, P1682, P16F3, P2101, P2119, or P2610 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. Ignition ON
4. Verify the security indicator on the instrument cluster illuminates momentarily.

⇒ **If the security indicator stays ON or is flashing**

Review the *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69* for Immobilizer system DTCs. For additional information, refer to *Immobilizer Description and Operation on page 13-31*.

⇓ **If the security indicator does not stay ON and is not flashing**

5. Verify the scan tool Engine Speed parameter displays greater than 0 rpm while cranking the engine.

⇒ **If 0 rpm**

Refer to *DTC P0325, P0327, or P0328 (LUW) on page 9-404*.

⇓ **If greater than 0 rpm**

Note: It may be necessary to secure the *EN 36012–A* to the spark plug boots with electrical tape.

6. Install the *EN 36012–A* Ignition System Diagnostic Harness to the spark plug boots.
7. Connect the *EL 26792* Spark Tester between the boot of a spark plug wire and ground.
8. Connect the remaining wires to the appropriate cylinders.

Note: An erratic or weak spark is considered a no spark condition.

9. Verify the spark tester sparks while cranking the engine.

⇒ **If the spark tester does not spark**

Refer to *Electronic Ignition System Diagnosis on page 9-527* for diagnosis of the ignition coil.

⇓ **If the spark tester sparks**

10. Ignition OFF, all accessories OFF, install the *CH 48027* Digital Pressure Gauge.
11. Ignition ON.

Note: Do not start the engine for this test.

12. Command the Fuel Pump Enable ON several times with a scan tool.
13. Verify that the fuel pressure is between 345–650 kPa (50–94 PSI) with the fuel pump running.

⇒ **If not within the specified range**

Refer to *Fuel System Diagnosis on page 9-518*.

⇓ **If within the specified range**

14. Ignition OFF, disconnect the harness connector at a Q17 Fuel Injector.
15. Connect the *J 34730-2C* Injector Test Lamp between the control circuit and the ignition voltage circuit.
16. Verify the injector test lamp flashes while cranking the engine.

⇒ **If the injector test lamp does not flash**

Refer to *Fuel Injector Diagnosis on page 9-520*.

⇓ **If the injector test lamp flashes**

17. Verify the following conditions do not exist:
    - Air intake duct to the throttle body collapsed
    - Air filter or air intake system restricted
    - Gas or coolant fouled spark plugs. Refer to *Spark Plug Inspection on page 9-571*.
    - A skewed manifold absolute pressure (MAP) sensor.
    - A skewed engine coolant temperature (ECT) sensor.
    - Exhaust system restricted. Refer to *Restricted Exhaust on page 9-734*.
    - Contaminated fuel. Refer to *Alcohol/ Contaminants-in-Fuel Diagnosis on page 9-523*.
    - An engine mechanical condition, for example, worn timing belt or low compression. Refer to *Symptoms - Engine Mechanical on page 9-953*.

⇒ **If a condition exists**

Repair as necessary.

⇓ **If no condition exists**

18. All OK.

Repair Verification

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

Spark Plug Replacement on page 9-573

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.

Reference Information

Description and Operation

Fuel System Description on page 9-584

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 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. Operate the vehicle within the conditions of the customer's concern while monitoring the fuel pressure with the *CH 48027* Gauge.
11. Verify the fuel pressure does not drop off during acceleration, cruise or hard cornering.

⇒ **If the fuel pressure drops off**

Refer to Circuit/System Testing - Fuel Pressure Drops Off.

⇓ **If the fuel pressure does not drop off**

12. If the fuel system components test normal, refer to *Symptoms - Engine Controls on page 9-511* and *Fuel Injector Diagnosis on page 9-520*.

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 9-557*
- *Fuel Injector Replacement on page 9-562*
- *Fuel Tank Fuel Pump Module Replacement (Steel Tank) on page 9-559*

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 9-314

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Fuel System Description on page 9-584

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 on page 9-593*.

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 9-518*.
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 Relay 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 Relay 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 9-518*.
2. Command the Fuel Pump Relay 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 9-562

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 9-314

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 9-520

Repair Instructions

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

- *Fuel Injector Replacement on page 9-562*
- *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 on page 9-593*.

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 9-562*
- *Fuel Tank Draining on page 9-551*

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.

Intake Manifold Runner Control 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* provide an overview of each diagnostic category.

Circuit/System Description

An intake manifold tuning solenoid valve is used to change the intake manifold plenum configuration. When the intake manifold tuning solenoid valve is open, the intake manifold is configured to one large plenum. When the intake manifold tuning solenoid valve is closed, the intake manifold is configured to 2 smaller plenums. The intake manifold tuning solenoid valve improves engine performance at low and high engine speeds.

Ignition voltage is supplied directly to the intake manifold tuning solenoid valve. The engine control module (ECM) controls the solenoid by grounding the control circuit with a solid state device called a driver. The driver is equipped with a feedback circuit that is pulled up to a voltage. The ECM can determine if the control circuit is open, shorted to ground, or shorted to a voltage by monitoring the feedback voltage.

The intake manifold tuning solenoid valve also contains a position sensor which is used to detect the actual position of the intake manifold tuning solenoid valve in relation to its commanded position. The ECM supplies the intake manifold tuning solenoid valve position sensor with a 5 V signal circuit and the position sensor uses a common ground circuit. The position sensor enables the ECM to detect a physically broken or stuck intake manifold tuning solenoid valve.

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. A circuit test status parameter will change from OK or Not Run to Malfunction if there is a condition with the circuit or a connection.

Reference Information

Schematic Reference

Engine Controls Schematics on page 9-314

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 scan tool DTC information. Verify that DTCs P0660, P2070, P2071, P2076, P2077, or P2078 are not set.
   ⇒ If any of the DTCs are set, refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69*.
2. Command the Intake Manifold Tuning Valve ON with a scan tool. The intake manifold tuning valve actuator should move to the closed position.

Circuit/System Testing

1. Inspect the linkage between the Q22 Intake Manifold Tuning Solenoid Valve and the valve at the intake manifold for the conditions listed below:
   - Linkage for being connected
   - Linkage binding
   - Interference with hoses, wiring, or any other components

   ⇒ If a condition is found, repair as necessary.
2. Remove the linkage from the Q22 Intake Manifold Tuning Solenoid Valve.
3. Ignition ON, disconnect the harness connector at the Q22 Intake Manifold Tuning Solenoid Valve and then reconnect. The Q22 Intake Manifold Tuning Solenoid Valve should move. Repeat procedure several times.
   ⇒ If the solenoid did not move, replace the intake manifold.
4. Inspect the inside of the intake manifold for the following conditions:
   - Carbon build-up that limits the movement of the Q22 Intake Manifold Tuning Solenoid Valve.
   - Casting flash that limits the movement of the Q22 Intake Manifold Tuning Solenoid Valve.
   - Foreign material that limits the movement of the Q22 Intake Manifold Tuning Solenoid Valve.

   ⇒ If a condition is found, repair as necessary.
5. If all components test normal, clean or replace the intake manifold.

Repair Instructions

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

Intake Manifold Replacement (LUW) on page 9-981 or *Intake Manifold Replacement (LDE) on page 9-978*

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 9-314

Connector End View Reference

Component Connector End Views on page 11-269

Description and Operation

Electronic Ignition System Description on page 9-591

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 9-570*
- *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 that a vehicle pass on-board diagnostic (OBD) system tests and the inspection/maintenance (I/M) emission inspection in order to renew license plates. This is accomplished by viewing the I/M System Status display on a scan tool. Using a scan tool, the technician can observe the I/M System Status in order to verify that the vehicle meets the criteria that complies with the local area requirements. While testing in the I/M System Status mode, some DTCs may occur that are called I/M Test DTCs. An I/M Test DTC is defined as a fault code that is currently commanding the MIL ON, and is stored in non-volatile memory. The intended use of this data is to prevent vehicles from passing I/M inspection without proper repair to the vehicle. These fault codes are not erasable from any scan tool command or erasable by disconnecting power to the controller. The I/M Test DTCs will be supported by all emissions related ECUs such as ECMs, TCMs, FPCMs, etc. An I/M Test DTC will not be stored or erased from the ECU except at the end of trip processing which occurs 5 s after ignition OFF.

Conditions for Updating the I/M 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 Monitor 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.

Conditions for Clearing I/M Test DTCs

1. Only the OBD II System can erase the I/M Test DTC. The OBD II system must determine that the malfunction that caused the I/M Test DTC to be stored is no longer present and is not commanding the MIL. Each of the following represents ways to clear an I/M Test DTC:
   - If the MIL goes out due to 3 passing drive cycles, scan tool code clear is not used, the I/M Test DTC is erased at power down of the last drive cycle.
   - If a scan tool code clear is used to turn OFF the MIL, the I/M Test DTC is not erased, the DTC must PASS and not FAIL. The I/M Test DTC is erased at power down of the drive cycle.
   - If the controller is reflashed/reprogrammed, all I/M Test DTCs are erased.
2. For the OBD II System to run a single drive cycle for clearing an I/M Test DTC, all of the following conditions must occur:
   - Cumulative time of engine run time is greater than 600 s.
   - Cumulative vehicle operation above 40 km/h (25 mph) for over 300 s.
   - Continuous vehicle idle for greater than 30 s.
   - Turn ignition OFF for 5 s and allow the code to clear.

Monitored Emission Control Systems

The OBD II system monitors all emission control systems that are on-board. Not all vehicles need every possible emission control system. For example, a vehicle may not be equipped with secondary air injection (AIR) or exhaust gas recirculation (EGR). The OBD II regulations require monitoring of the following; if equipped:

- 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 9-530*. 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.

Diagnostic Aids

The I/M System Status display provides an indication of when the control module has completed the required tests. This does not necessarily mean that the test has passed, only that a decision was made. If the diagnostic fails, a DTC will indicate the failure. If a failure indication is present for a DTC associated with one of the I/M regulated systems, it may prevent other required tests from running. For example, a DTC for the control circuit of the EVAP purge solenoid may not be listed in the Inspection/Maintenance System DTC Table because it is a continuous test. If this DTC is set, the Active Tests for the EVAP system may not run.

The I/M System Status information may be useful for a technician to determine if diagnostics have run when verifying repairs.

Circuit/System Verification

Review the I/M System Status indicators. All I/M System Status indicators should report YES, and no I/M Test DTCs should be present.

Circuit/System Testing

Note: Many DTC related repairs will instruct the technician to clear the DTC information. Clearing the DTC will reset the I/M System Status indicators to NO. Performing the I/M Complete System Set Procedure will set each of the I/M System Status indicators to YES.

1. Observe the Engine DTC information with a scan tool. Verify no DTCs are present.
   ⇒ If a DTC is set that would prevent the I/M System Status tests from completing, diagnose that DTC before continuing. Refer to *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69*.
2. Review applicable service bulletins for software updates that would prevent the I/M System Status tests from completing.
   ⇒ If a control module re-program or other repair is required, perform the *Inspection/Maintenance Complete System Set Procedure on page 9-529*.
3. Observe the I/M System Status indicators.
   ⇒ If any I/M System Status indicators report NO, perform the *Inspection/Maintenance Complete System Set Procedure on page 9-529*.
4. Observe the I/M Test DTC information with a scan tool. Verify there are no I/M Test DTCs present.
   ⇒ If an I/M Test DTC is set and all of the I/M System Status indicators are Yes, there is no need to perform the Complete System Set Procedure. Diagnose the DTC using the *Diagnostic Trouble Code (DTC) List - Vehicle on page 6-69* and refer to Conditions for Clearing the I/M Test DTCs.
   ⇒ If an I/M Test DTC is set and the I/M System Status indicators are NO, diagnosis the DTC and perform the *Inspection/Maintenance Complete System Set Procedure on page 9-529*.

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 m.
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 minutes:
   - 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.

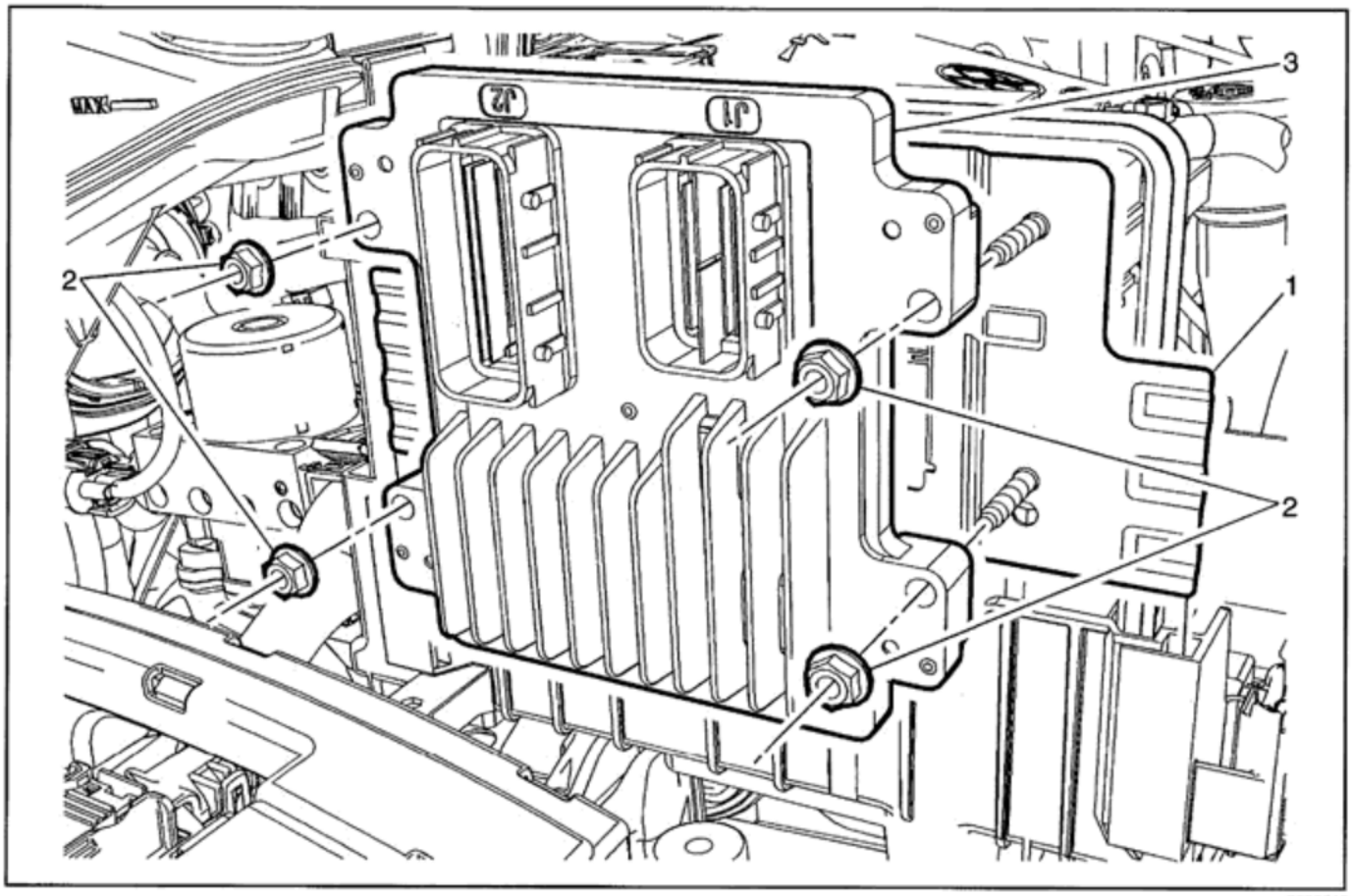
12. Shift the vehicle to park for automatic and neutral for manual. Turn OFF the ignition and exit the vehicle. Do NOT disturb the vehicle for 45 min.
13. Observe the Inspection/Maintenance System Status with a scan tool. All of the inspection/maintenance System Status indicators should display YES.
    ⇒ 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 9-530* 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 9-530* 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 System Check on page 9-528* , 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 on page 9-422.*
Evaporative emission (EVAP)	• *DTC P0442 on page 9-425.* • *DTC P0443 on page 9-427.* • *DTC P0446 on page 9-429.* • *DTC P0449 on page 9-431.* • *DTC P0455 on page 9-436.* • *DTC P0496 on page 9-438.*
Oxygen sensor	• *DTC P0131, P0132, P0134, P0137, P0138, or P0140 on page 9-378* • *DTC P0133, P013A, P013B, P013E, P013F, P015A, P015B, P2270, or P2271 on page 9-381.*
Oxygen sensor heater	*DTC P0030-P0032, P0036-P0038, P0053, P0054, P0135, or P0141 on page 9-335*
Camshaft System	*DTC P0011 or P0014 on page 9-330*

Repair Instructions

Engine Control Module Replacement



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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** 9 N•m (80 lb in)

Engine Control Module Replacement (cont'd)

Callout	Component Name
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 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, 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.

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.

   3.11. 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.

4. The scan tool displays Learn Status: Learned this Ignition. If the scan tool indicates that DTC P0315 ran and passed, the crankshaft position sensor variation learn procedure is complete. If the scan tool indicates DTC P0315 failed or did not run, refer to *DTC P0315 (LUW) on page 9-400*. 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.

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.

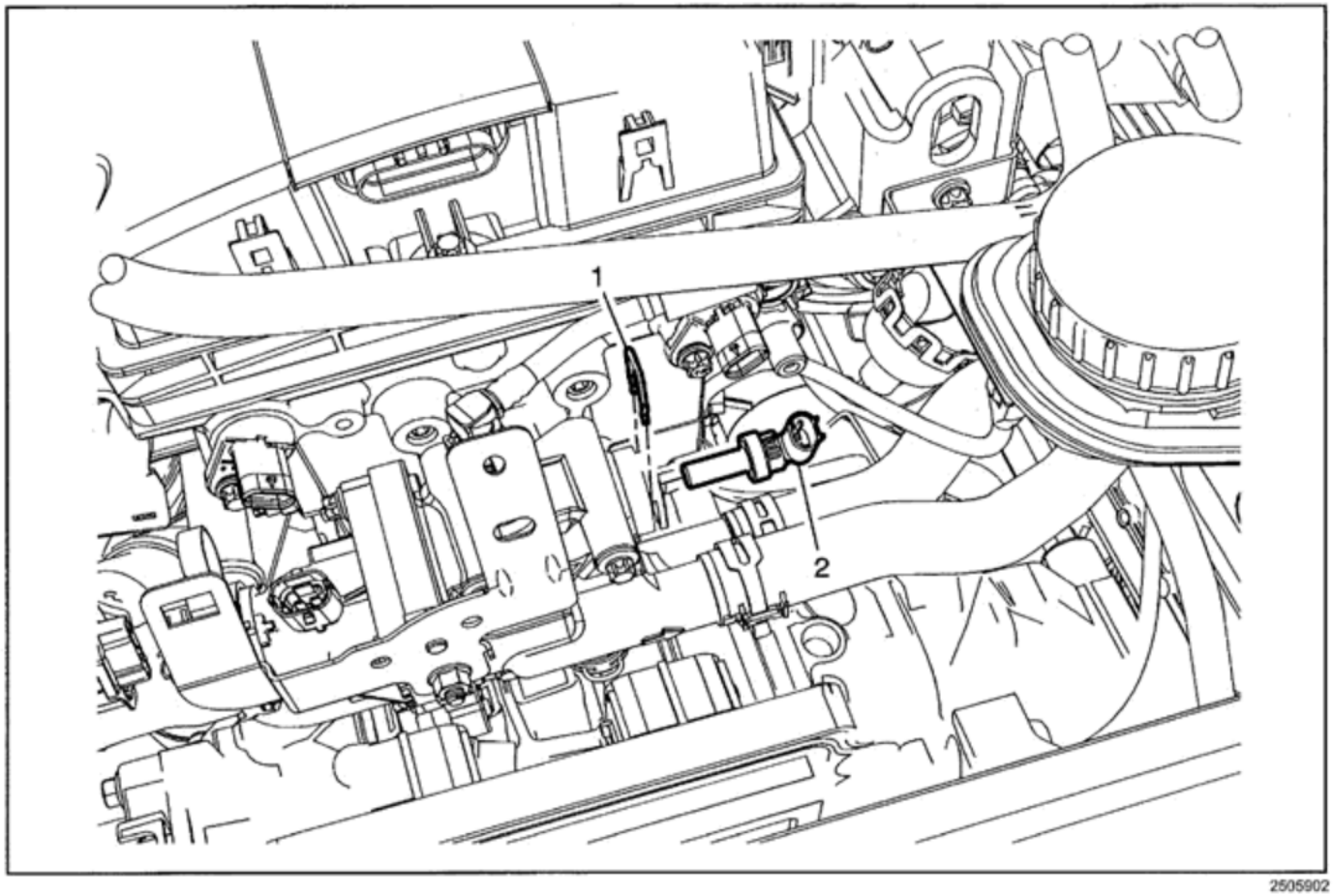
   ⇒ If the engine idle speed has not been learned the vehicle will need to be driven at speeds above 70 km/h (44 mph) with several decelerations and extended idles.

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.

Engine Coolant Temperature Sensor Replacement (Water Outlet)



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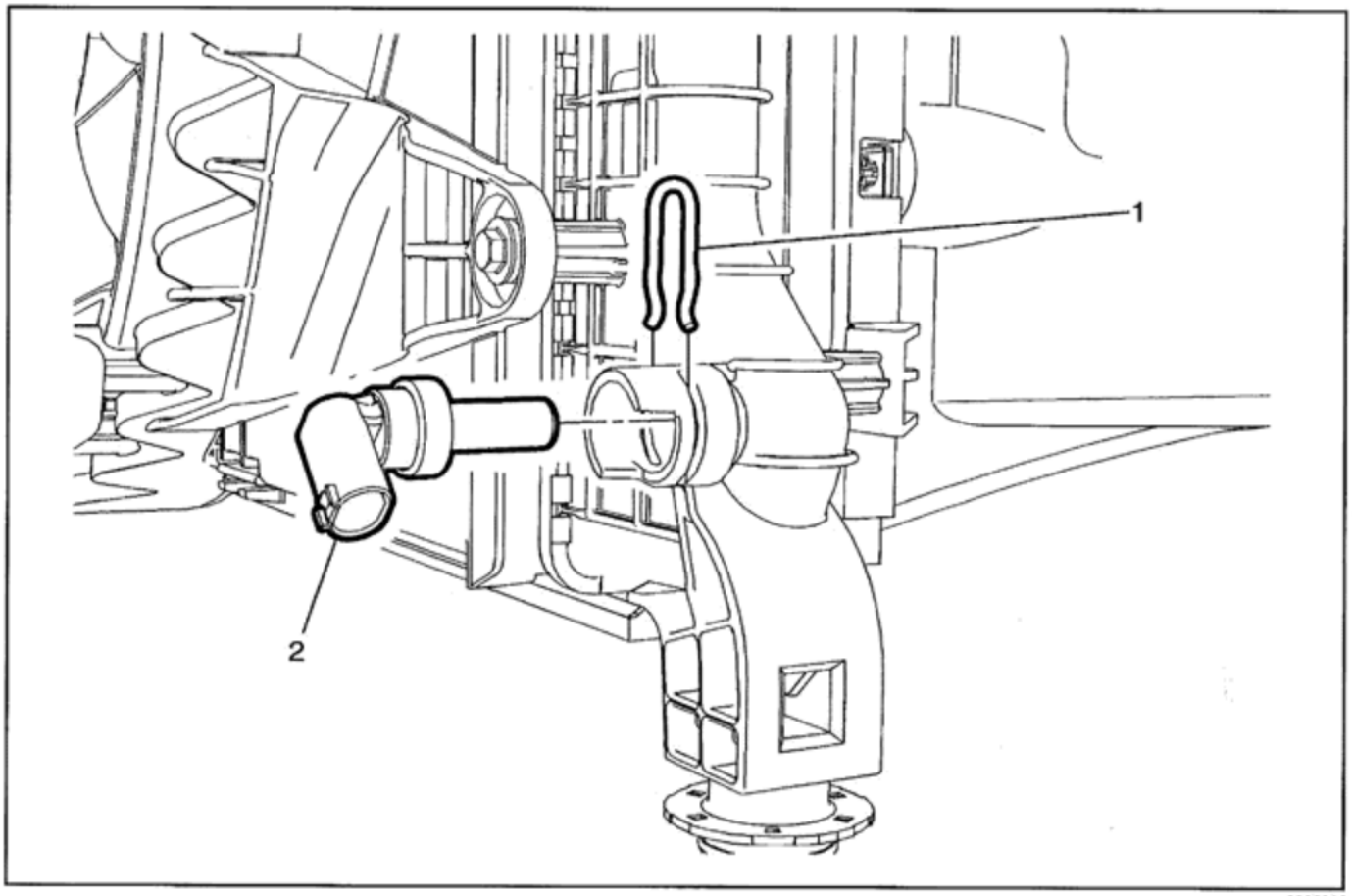
Engine Coolant Temperature Sensor Replacement (Water Outlet)

Callout	Component Name
Preliminary Procedure 1. Drain the cooling system. Refer to *Cooling System Draining and Filling on page 9-628*. 2. Disconnect the electrical wiring harness connector.	
1	Engine Coolant Temperature Sensor Fastener
2	Engine Coolant Temperature Sensor

Engine Coolant Temperature Sensor Replacement (Radiator)



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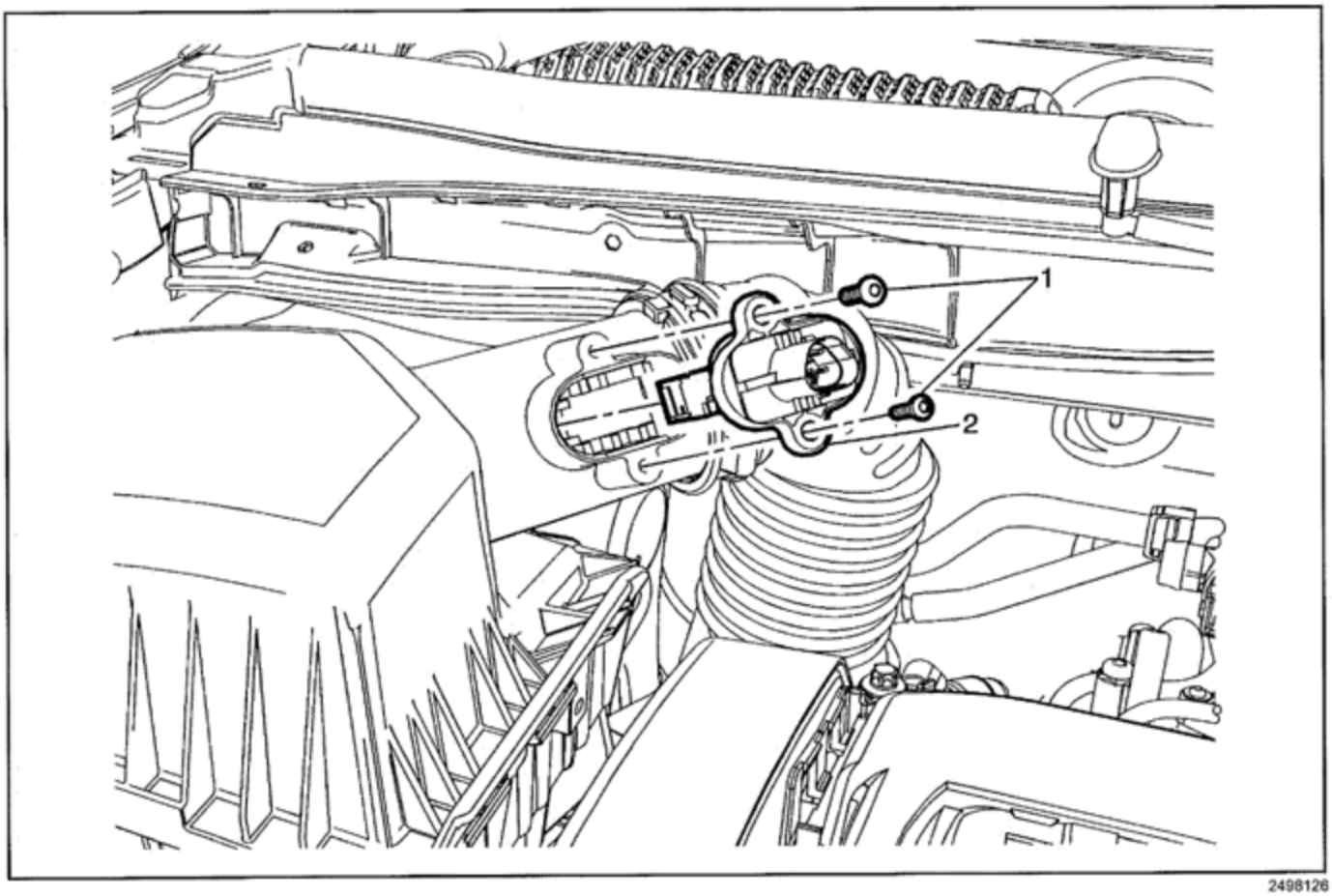
Engine Coolant Temperature Sensor Replacement (Radiator)

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



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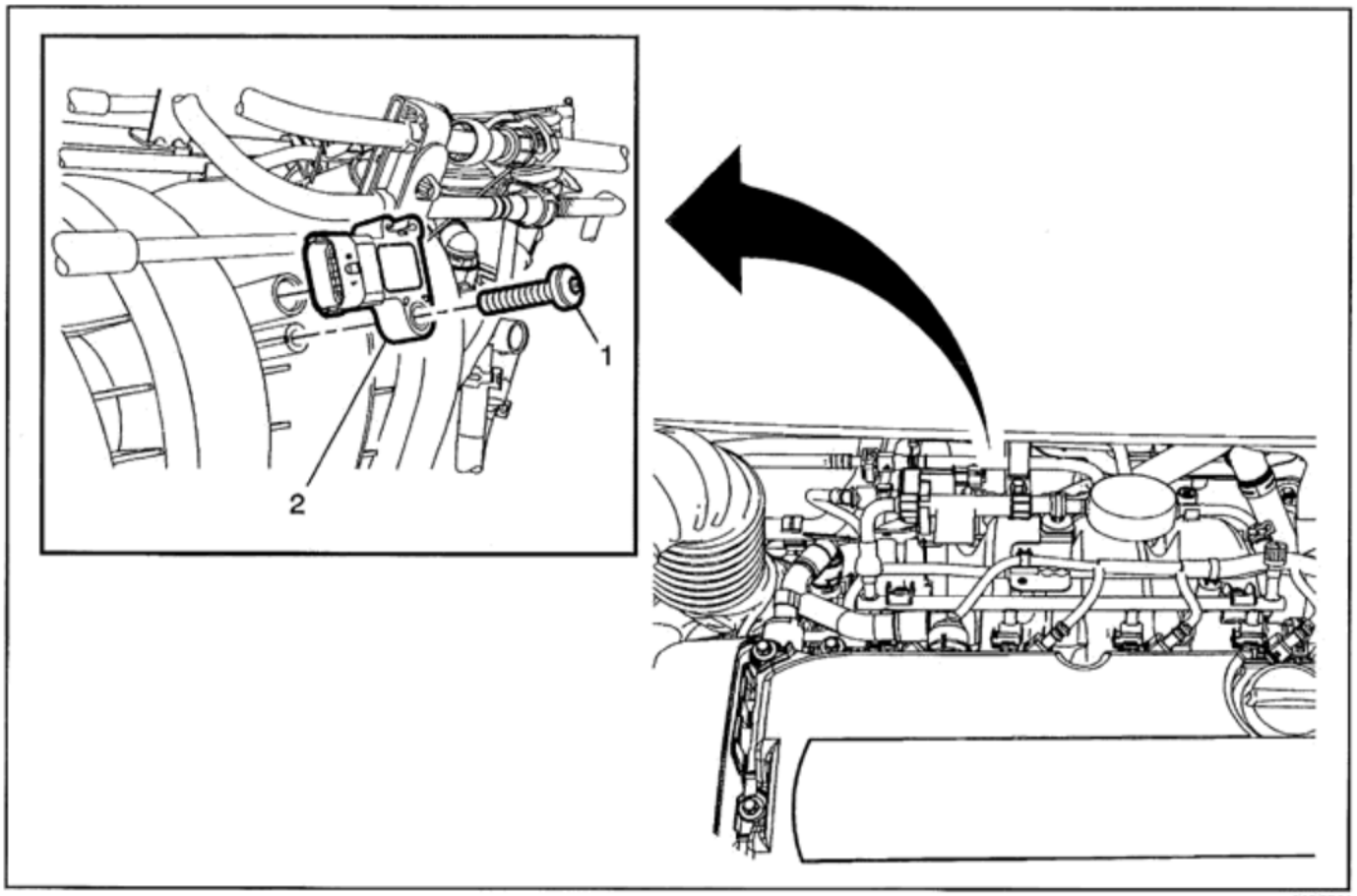
Mass Airflow Sensor Replacement

Callout	Component Name
1	Mass Airflow Sensor Fastener (Qty 2) **Caution:** Refer to *Fastener Caution on page 0-8.* **Tighten** 5 N•m (44 lb in)
2	Mass Airflow Sensor **Procedure** Disconnect the electrical wiring harness connector from the Mass Airflow Sensor.

Manifold Absolute Pressure Sensor Replacement



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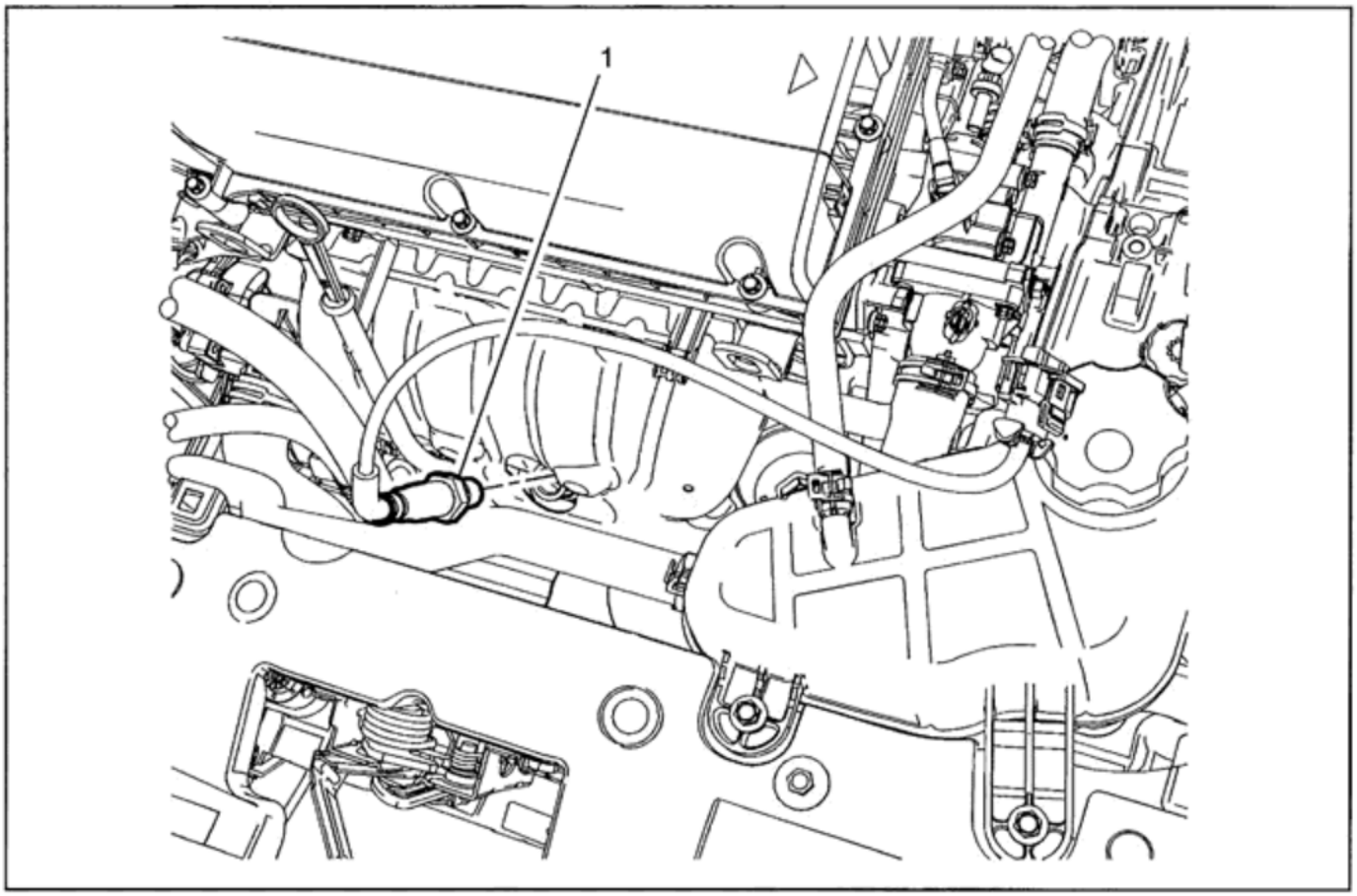
Manifold Absolute Pressure Sensor Replacement

Callout	Component Name
1	Manifold Absolute Pressure Sensor Fastener **Caution:** Refer to *Fastener Caution on page 0-8* **Tighten** 6 N•m (54 lb in)
2	Manifold Absolute Pressure Sensor **Procedure** Disconnect the electrical wiring harness connector from the Manifold Absolute Pressure Sensor.

Heated Oxygen Sensor Replacement - Sensor 1



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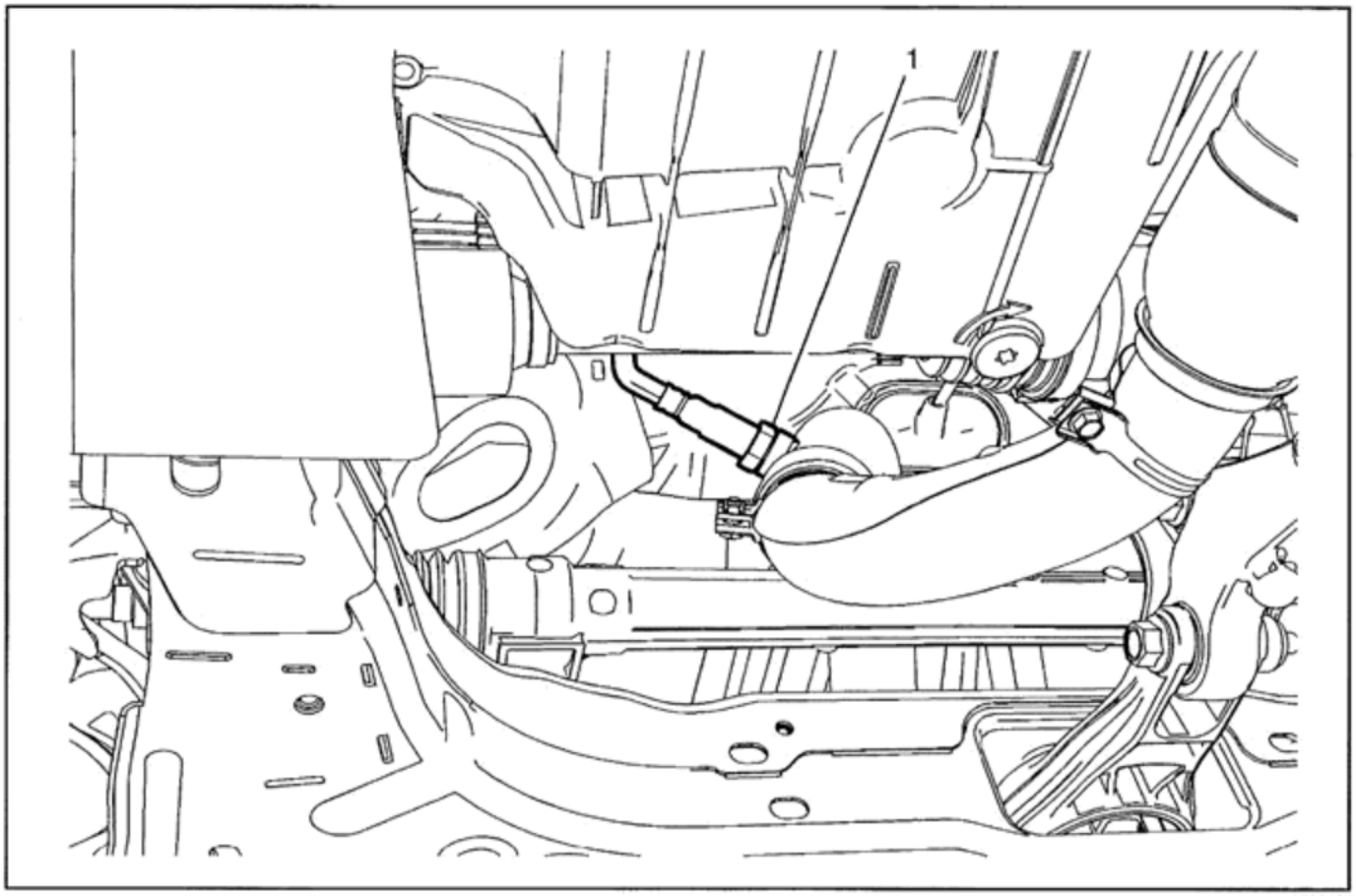
Heated Oxygen Sensor Replacement - Sensor 1

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 Procedures Disconnect the negative battery cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.	
1	Heated Oxygen Sensor **Caution:** Refer to *Fastener Caution on page 0-8*. **Procedure** 1. Disconnect the heated oxygen sensor wiring harness connector. 2. Remove the heated oxygen sensor. **Tip:** When re-using the heated oxygen sensor, coat the thread with assembly paste. **Tighten** 42 N•m (31 lb ft) **Special Tools** EN-6179 Heated Oxygen Sensor Remover / Installer For equivalent regional tools. refer to *Special Tools on page 9-593*.

Heated Oxygen Sensor Replacement - Sensor 2



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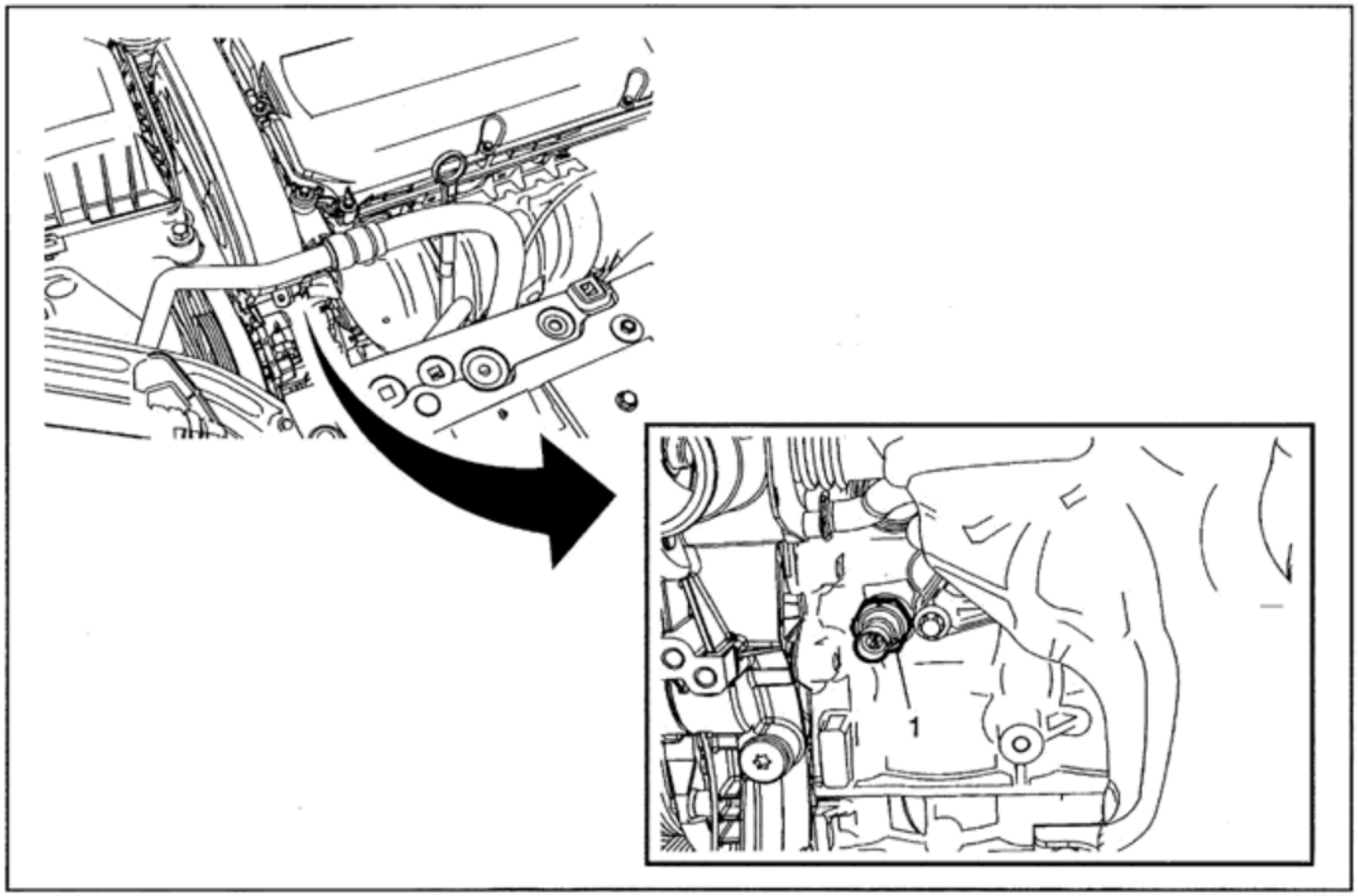
Heated Oxygen Sensor Replacement - Sensor 2

Callout	Component Name
1	Heated Oxygen Sensor 2 ***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.*** **Caution:** Refer to *Fastener Caution on page 0-8*. **Procedure** 1. Disconnect the heated oxygen sensor 2 electrical wiring harness connector. 2. Remove the heated oxygen sensor 2. **Tip:** When re-using the heated oxygen sensor, coat the thread with assembly paste. **Tighten** 42 N•m (31 lb ft) **Special Tools** EN-6179 Heated Oxygen Sensor Remover / Installer For equivalent regional tools. refer to *Special Tools on page 9-593*.

Engine Oil Pressure Indicator Switch Replacement



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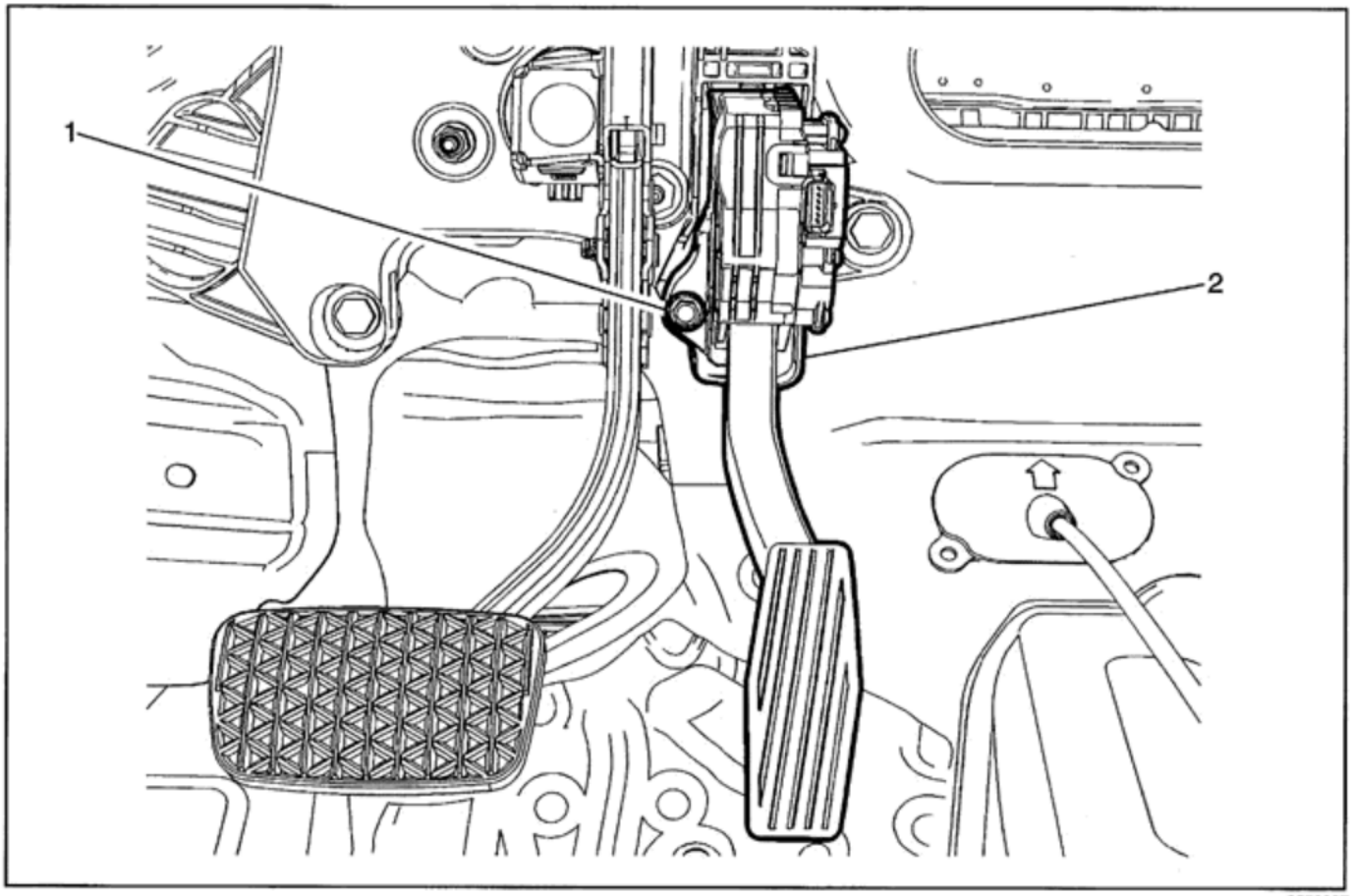
Engine Oil Pressure Indicator Switch Replacement

Callout	Component Name
Preliminary Procedure Remove the air conditioning compressor. Refer to *Air Conditioning Compressor Replacement (LDE, LUW, LWE) on page 10-16* or *Air Conditioning Compressor Replacement (LUV) on page 10-17*.	
1	Oil Pressure Switch **Caution:** Refer to *Fastener Caution on page 0-8*. **Procedure** Disconnect the oil pressure switch electrical wiring harness connector and remove the switch. **Tighten** 30 N•m (22 lb ft)

Accelerator Pedal Position Sensor Replacement



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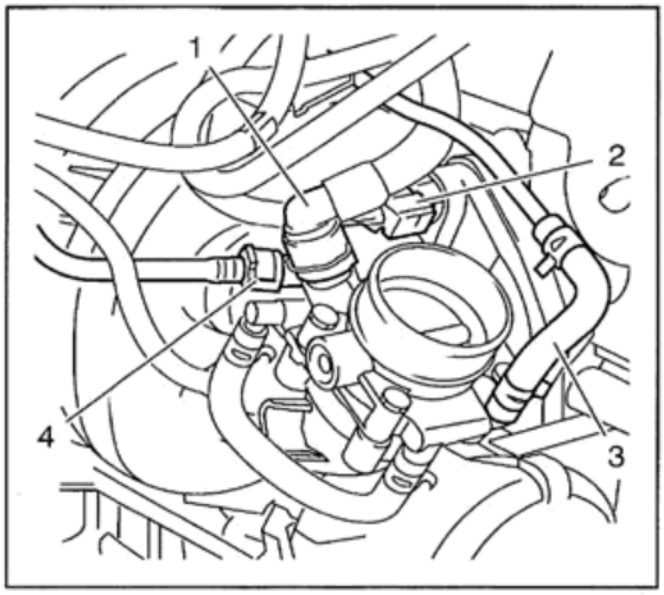
Accelerator Pedal Position Sensor Replacement

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. Remove the Air Cleaner Assembly. Refer to *Air Cleaner Assembly Replacement on page 9-582*.



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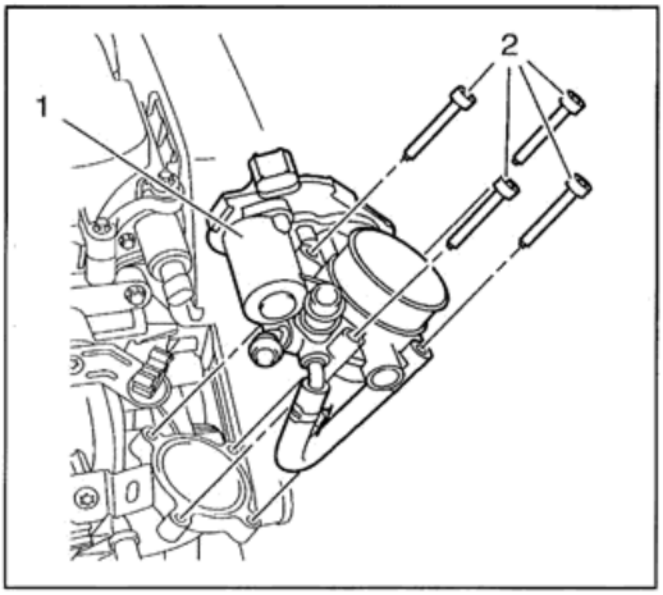
2. Disconnect the electrical wiring harness connector (2).
3. Disconnect the positive crankcase ventilation pipe (1).
4. Place collecting basin underneath.
5. Disconnect the throttle body heater outlet pipe (4).
6. Disconnect the throttle body heater inlet pipe (3).



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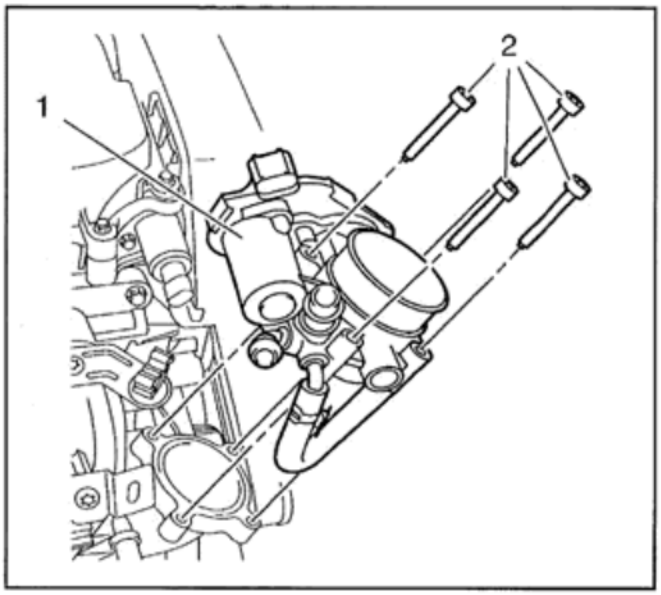
7. Remove the 4 throttle body bolts (2).
8. Remove the throttle body (1).

Installation Procedure



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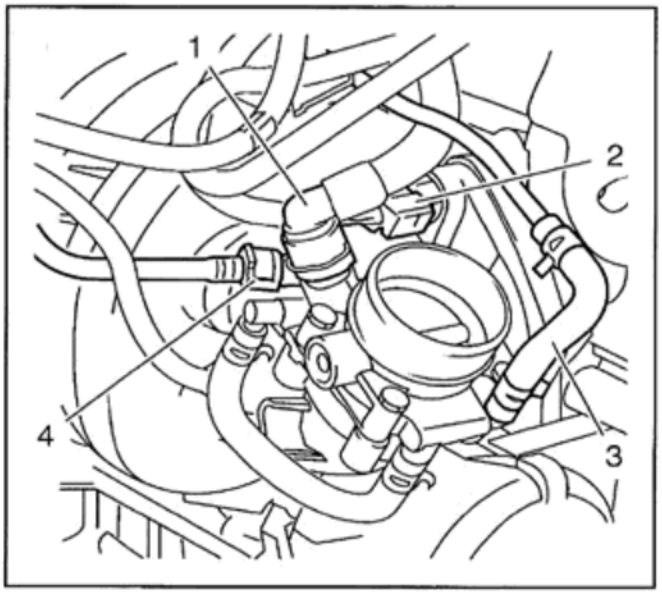
1. Install the throttle body (1).

Caution: Refer to *Fastener Caution on page 0-8*.

2. Install the 4 throttle body bolts (2) and tighten to **8 N•m (71 lb in)**.



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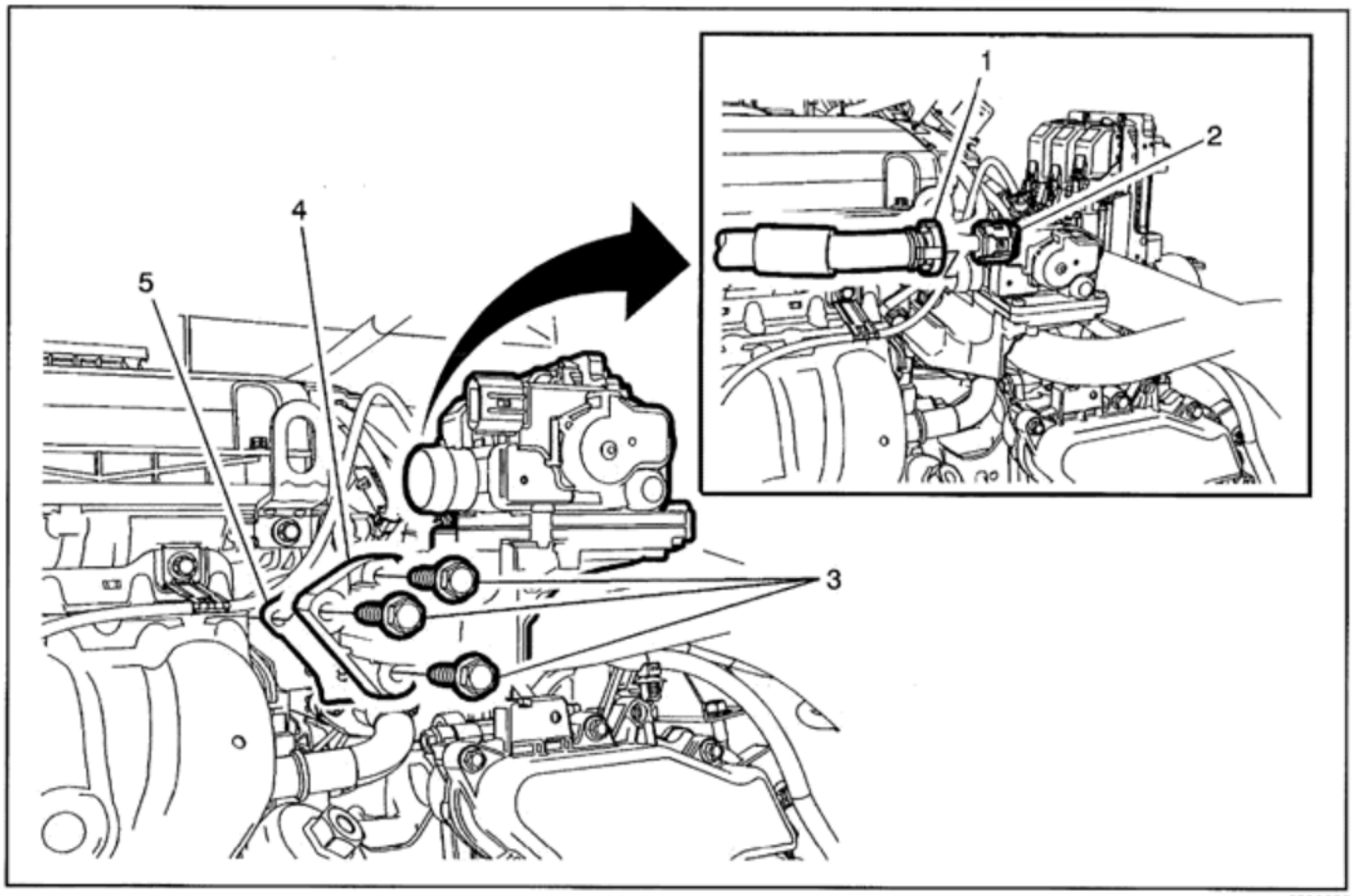
3. Connect the throttle body heater inlet pipe (3).
4. Connect the throttle body heater outlet pipe (4).
5. Connect the positive crankcase ventilation pipe (1).
6. Connect the electrical wiring harness connector (2).
7. Install the Air Cleaner Assembly. Refer to *Air Cleaner Assembly Replacement on page 9-582*.

Secondary Air Injection Check Valve Replacement



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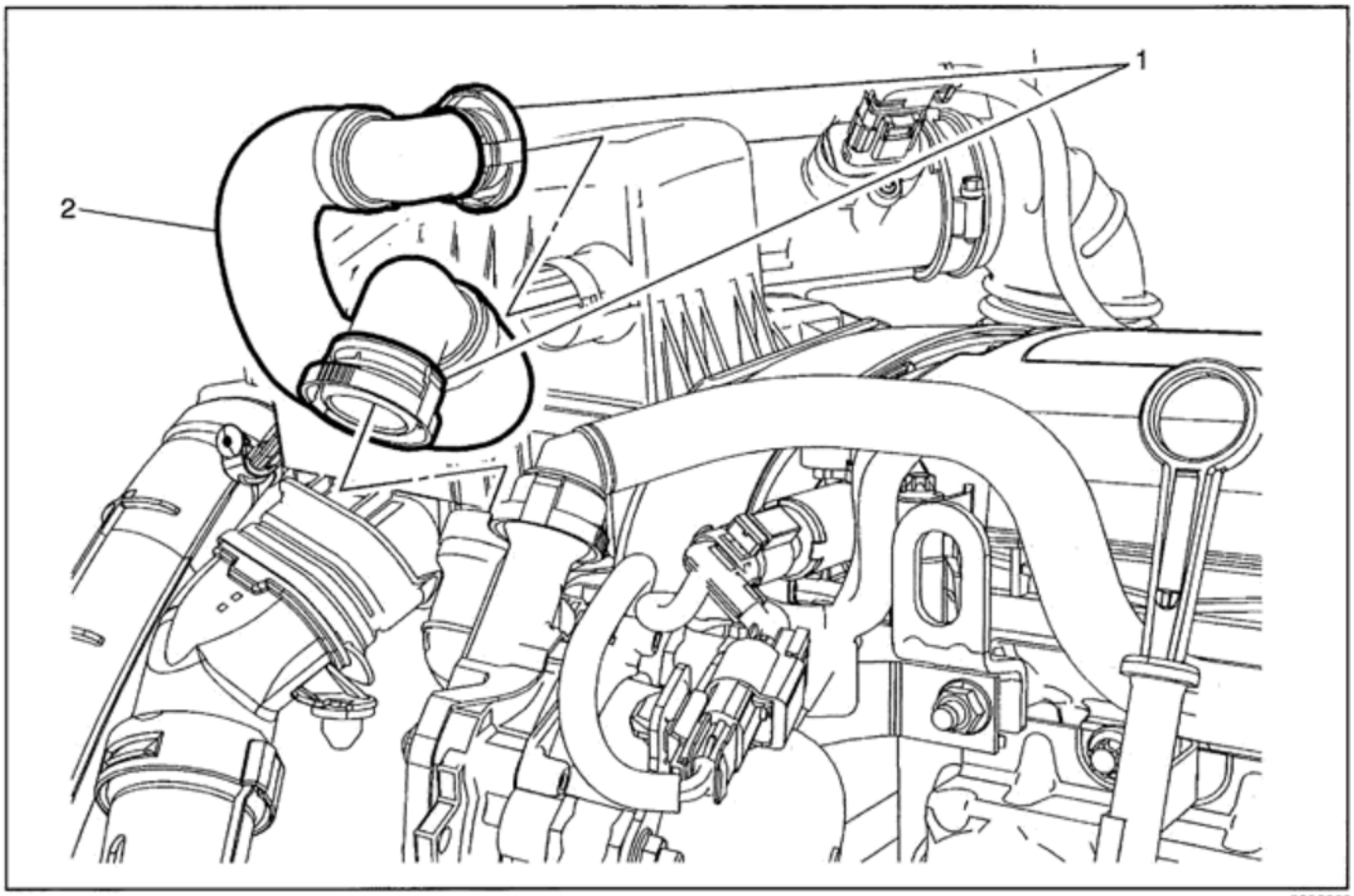
Secondary Air Injection Check Valve Replacement

Callout	Component Name
1	Secondary Air Injection Outlet Pipe **Note:** Squeeze the retainer on opposite sides to release.
2	Secondary Air Injection Check Valve Electrical Connector
3	Secondary Air Injection Check Valve Bolts (Qty: 3). **Caution:** Refer to *Fastener Caution on page 0-8.* **Tighten** 25 N•m (18 lb ft)
4	Secondary Air Injection Check Valve
5	Secondary Air Injection Check Valve Gasket

Secondary Air Injection Pump Air Cleaner Pipe Replacement



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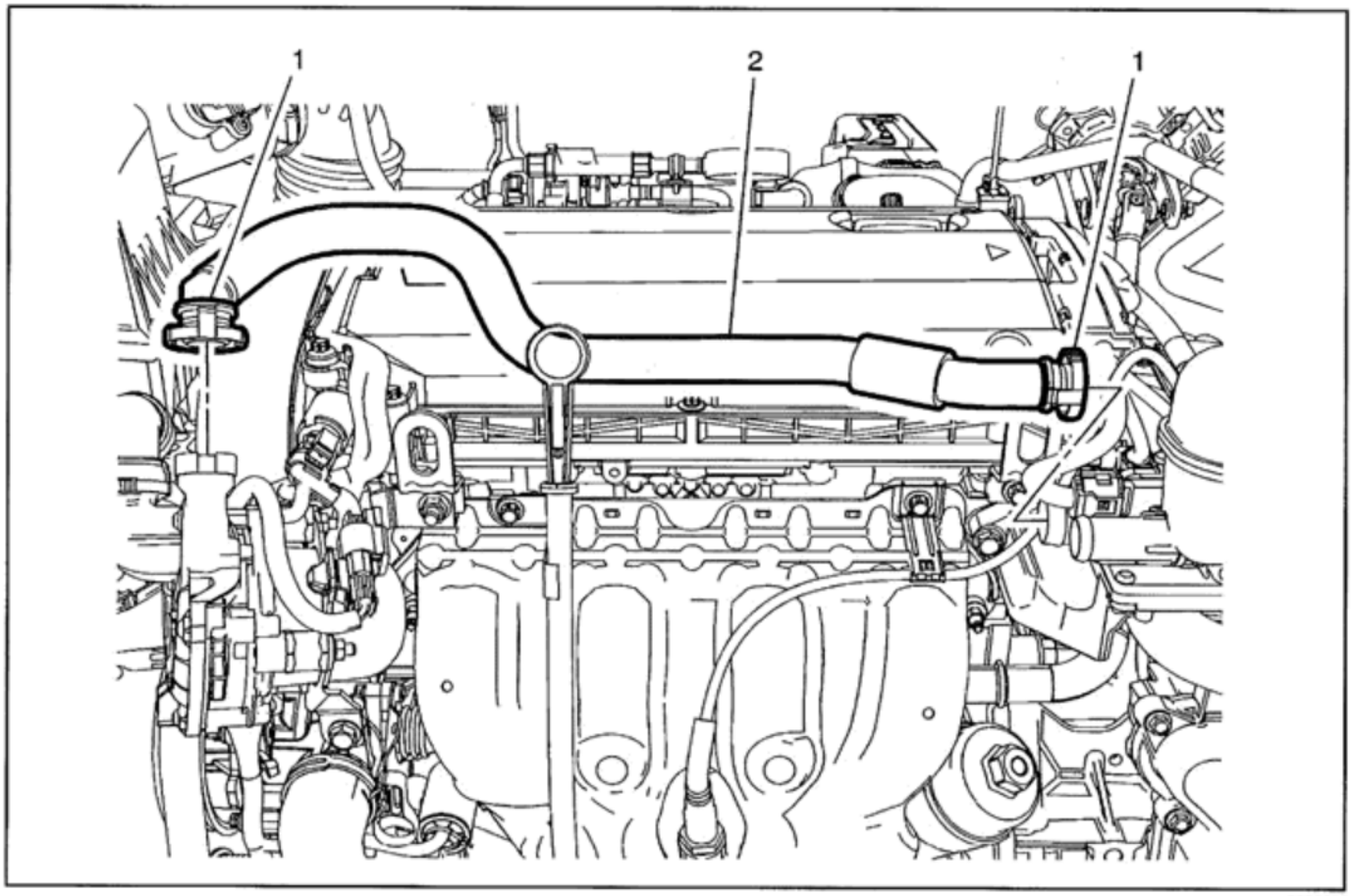
Secondary Air Injection Pump Air Cleaner Pipe Replacement

Callout	Component Name
1	Hose Retainer (QTY:2) **Note:** Squeeze the retainer on opposite sides to release.
2	Secondary Air Injection Pipe. **Procedure** Disconnect the pipe from the secondary air injection pump and the air cleaner.

Secondary Air Injection Pump Pipe Replacement



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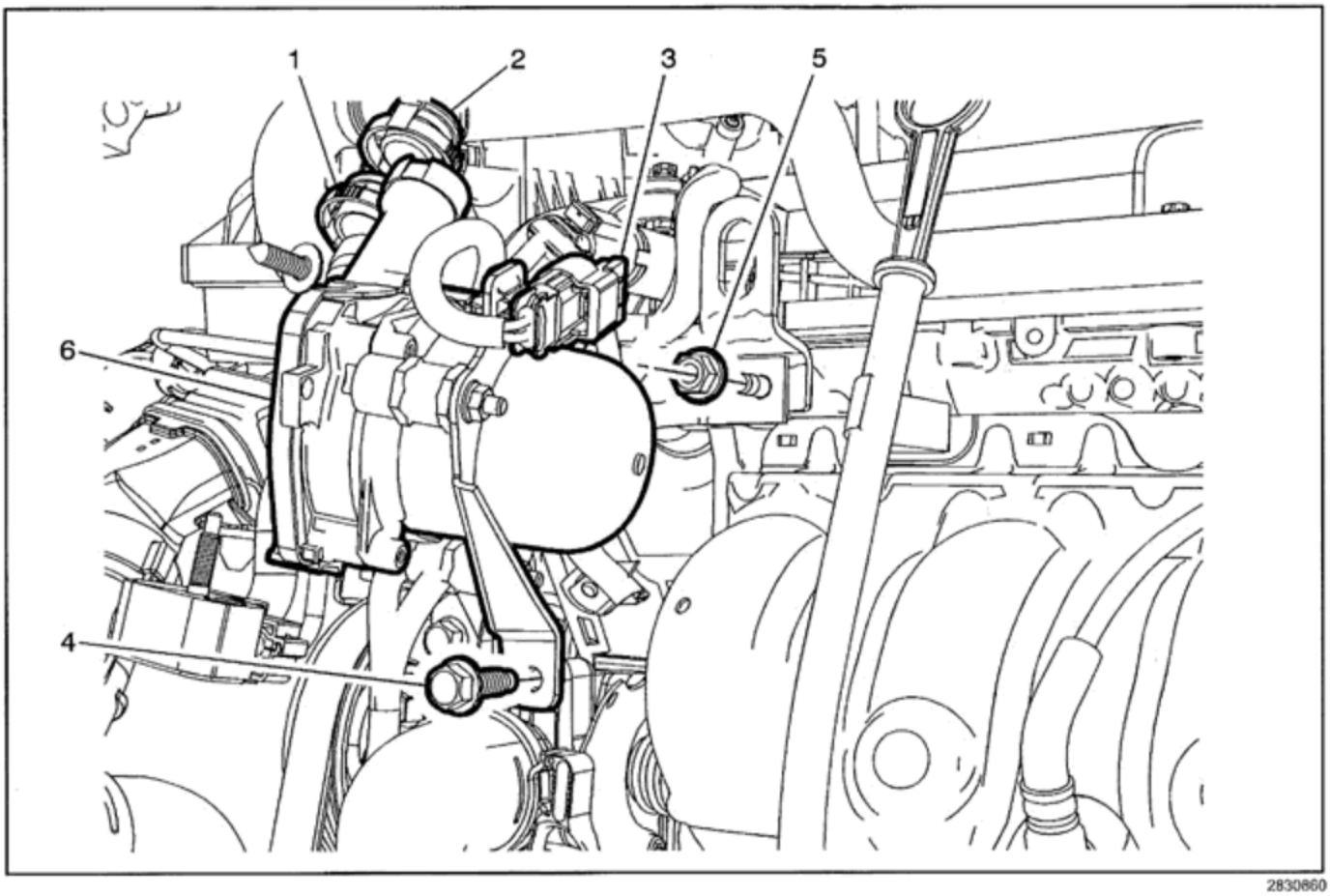
Secondary Air Injection Pump Pipe Replacement

Callout	Component Name
1	Hose Retainer (QTY:2) **Note:** Squeeze the retainer on opposite sides to release.
2	Secondary Air Injection Pipe. **Procedure** Disconnect the pipe from the secondary air injection pump and the secondary air injection check valve.

Secondary Air Injection Pump Replacement



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Secondary Air Injection Pump Replacement

Callout	Component Name
1	Secondary Air Injection Pump Inlet Pipe **Note:** Squeeze the retainer on opposite sides to release.
2	Secondary Air Injection Pump Outlet Pipe **Note:** Squeeze the retainer on opposite sides to release.
3	Secondary Air Injection Pump Electrical Connector
4	Secondary Air Injection Pump Bolt **Caution:** Refer to *Fastener Caution on page 0-8.* **Tighten** 22 N•m (16 lb ft)
5	Secondary Air Injection Pump Nut **Tighten** 22 N•m (16 lb ft)
6	Secondary Air Injection Pump

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 9-580*.
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.
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 9-580*.

Fuel Pressure Relief

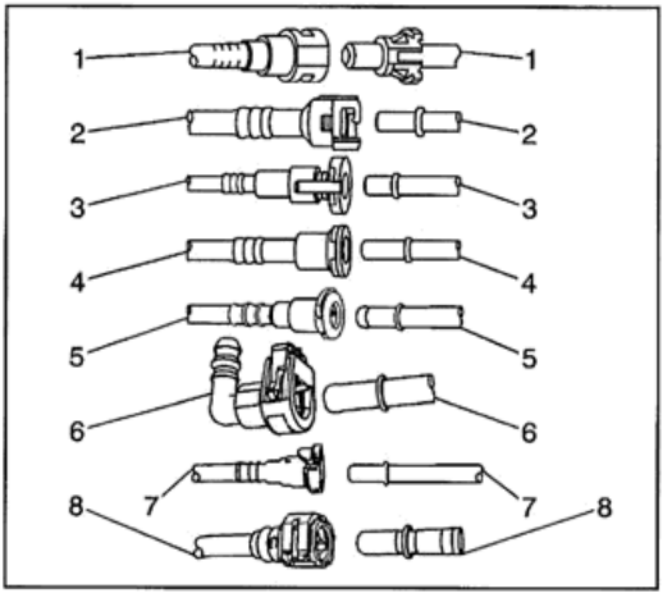
Warning: Refer to Gasoline/Gasoline Vapors Warning on page 0-5.

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. Disconnect the battery. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*
2. Loosen the fuel fill cap in order to relieve the fuel tank vapor pressure.
3. Remove the engine cover, if required.
4. Wrap a shop towel around the fuel feed pipe at the fuel rail and disconnect the pipe.
5. Remove the shop towel from around the fuel rail service port, and place in an approved gasoline container.
6. Connect the fuel feed pipe.
7. Install the engine cover, if required.
8. Tighten the fuel fill cap.

Plastic Collar Quick Connect Fitting Service

Removal Procedure



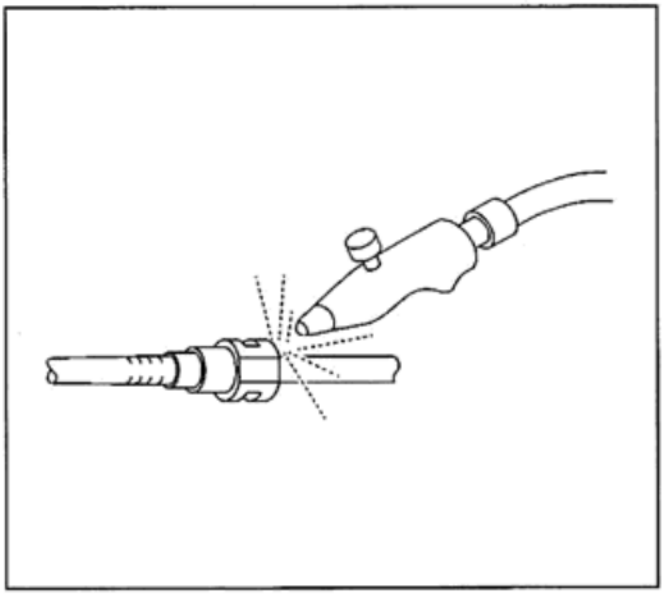
2005276

Warning: Refer to Gasoline/Gasoline Vapors Warning on page 0-5.

Note: There are several types of Plastic Collar Fuel and Evaporative Emission Quick Connect Fittings used on this vehicle.

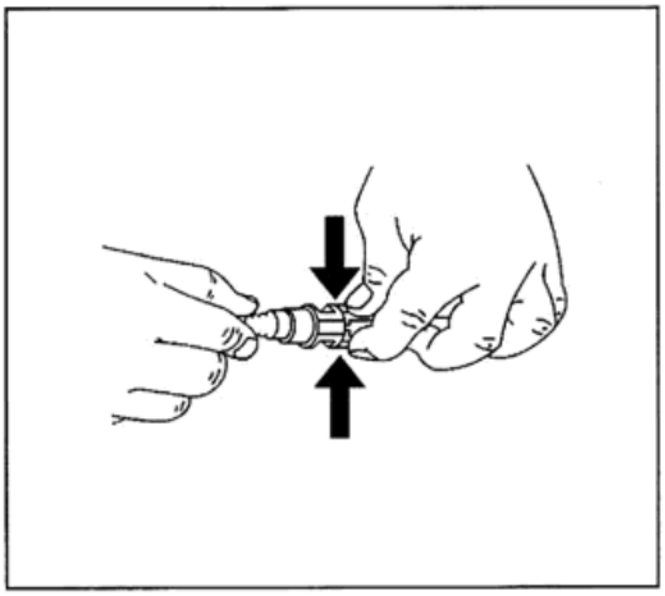
- Bartholomew (1)
- Q Release (2)
- Squeeze to Release (3)
- Sliding Retainer (4)
- Global Connect (5)
- TI Loc (6)
- Safe Lock (7)

The following instructions apply to all of these types of Plastic Collar Quick Connect Fittings except where indicated.



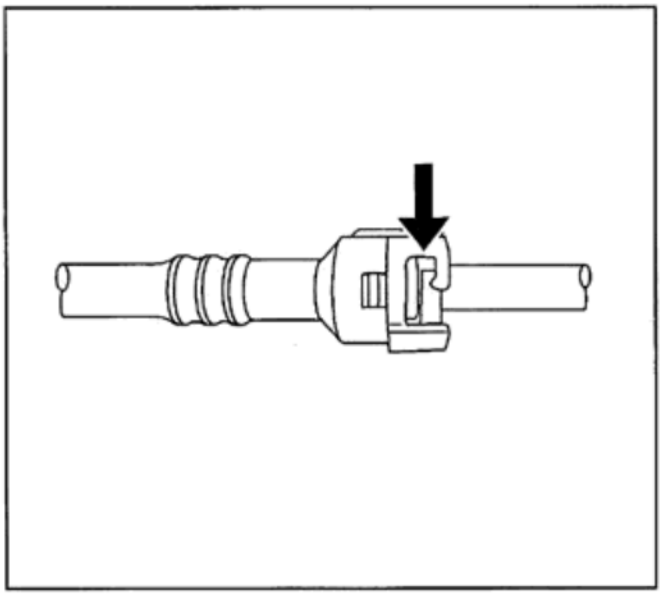
155410

1. Using compressed air, blow any dirt out of the quick-connect fitting.



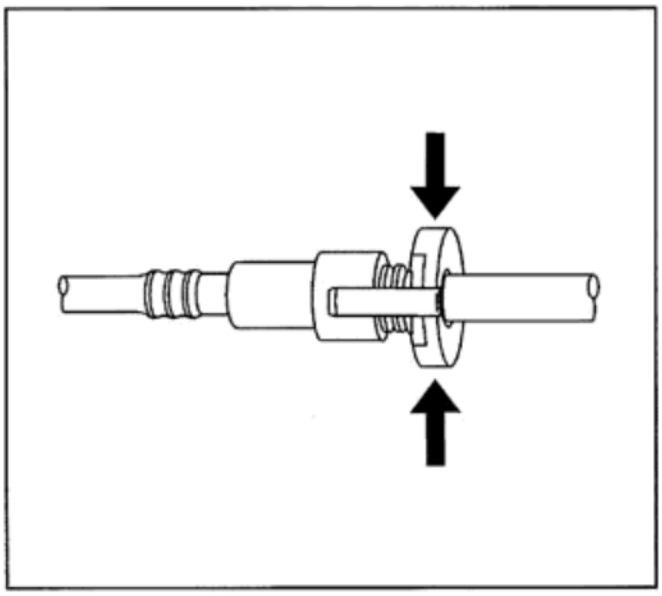
12777

2. This step applies to Bartholomew style connectors ONLY. Squeeze the plastic quick-connect fitting release tabs.



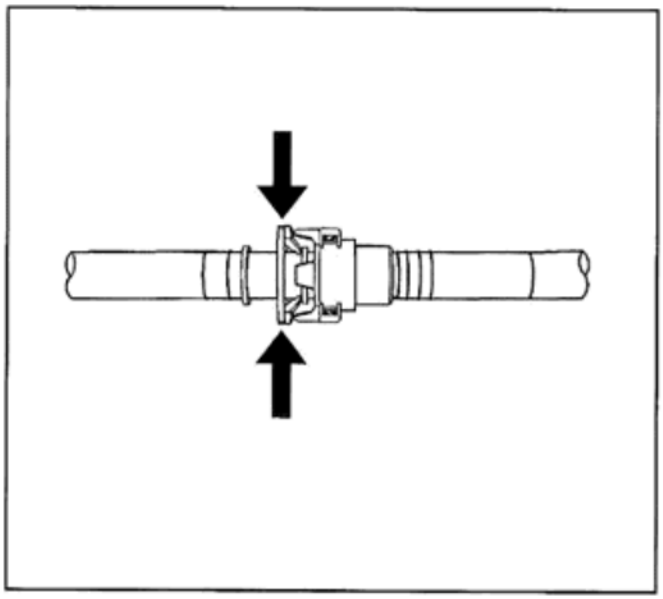
1205667

3. 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.



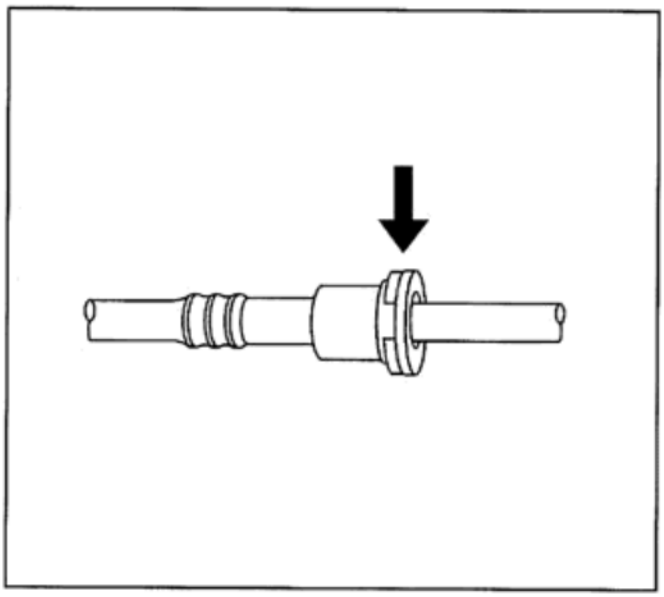
1205675

4. 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.



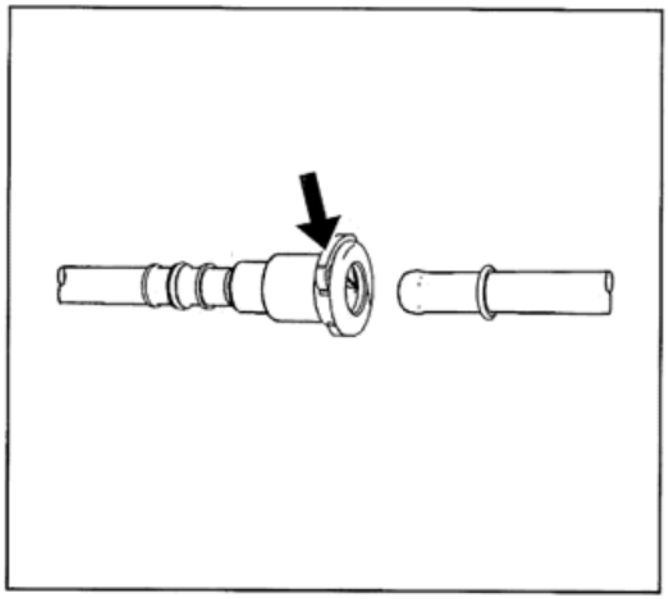
1699700

5. This step applies to Squeeze to Release style connectors ONLY. Push in the male side slightly in order to slide the retainer away from the retainers, squeeze where indicated by arrows on both sides of the plastic ring surrounding the quick-connect fitting.



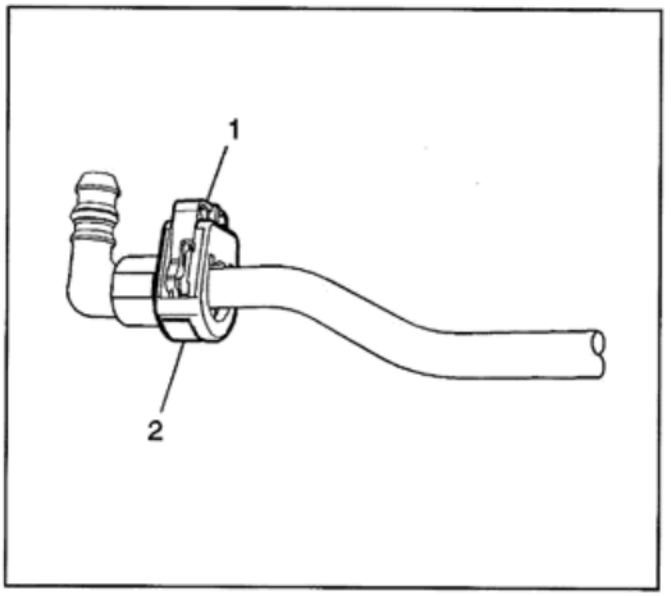
1205683

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.



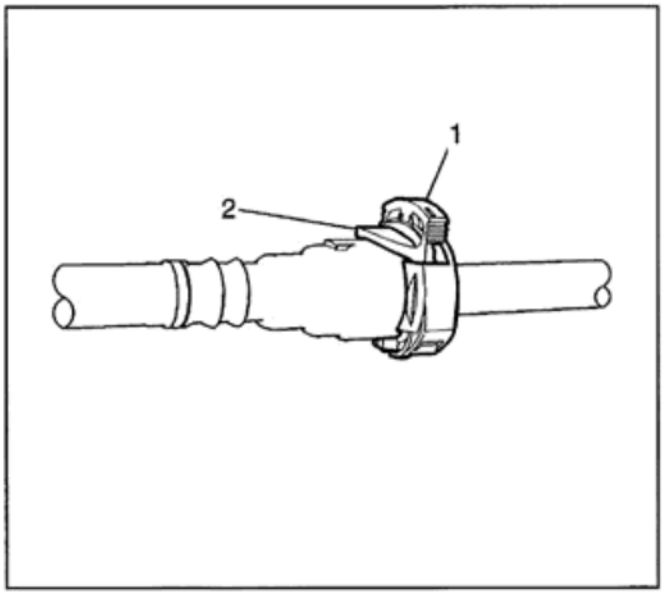
2005284

7. This step applies to the Global Connector style only. Push the connector toward the tube in order to release the pressure. Press and hold down the release mechanism, and pull the connector straight out.



2005895

8. This step applies to the TI Loc style only. Push the connector toward the tube in order to release the pressure. Release the redundant latch (1) with two fingers or a flat bladed tool. Then press and hold down the bottom release mechanism (2) and pull the connector straight out.



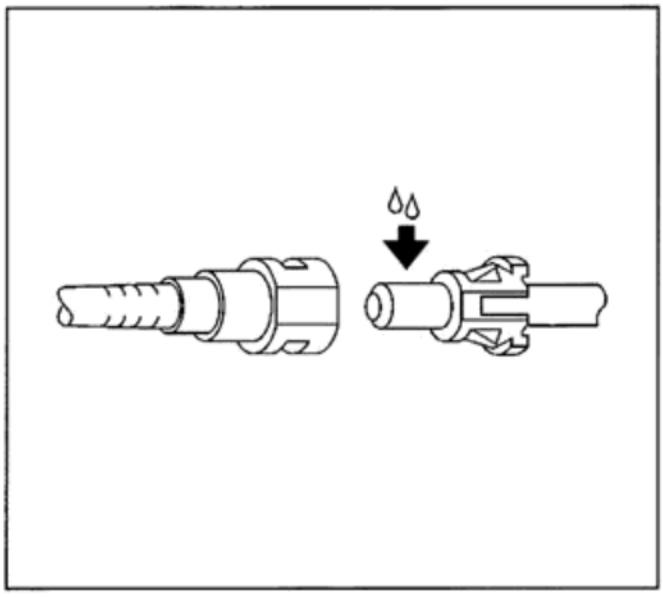
2264193

9. This step applies to the Safe Lock style only. Push the connector toward the tube in order to release the pressure. Release the second latch (1) with two fingers. Then press and hold down the bottom release mechanism (2) and pull the connector straight out.

Warning: Refer to Relieving Fuel Pressure Warning on page 0-5.

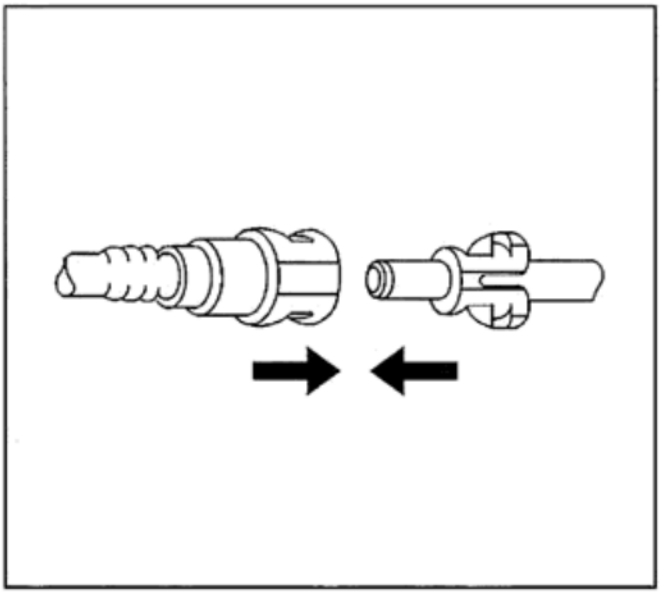
10. Using a clean shop towel, wipe off the male pipe end.
11. Inspect both ends of the fitting for dirt and burrs.
12. Clean or replace components as necessary.

Installation Procedure



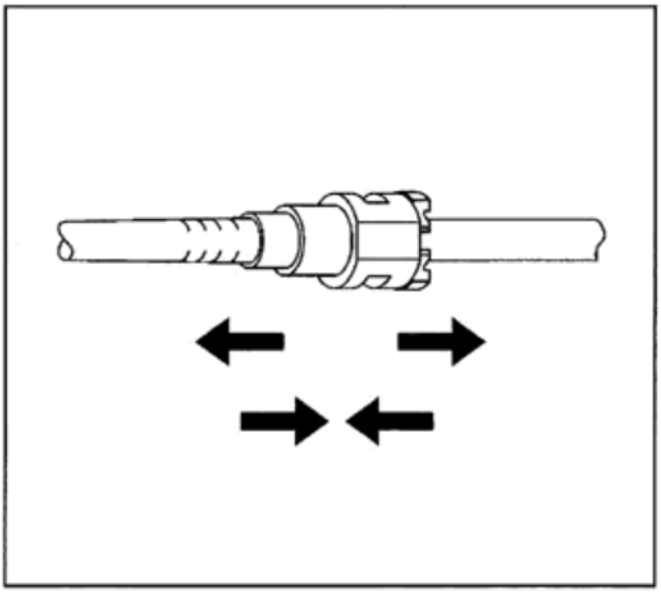
155425

1. Apply a few drops of clean engine oil to the male pipe end.



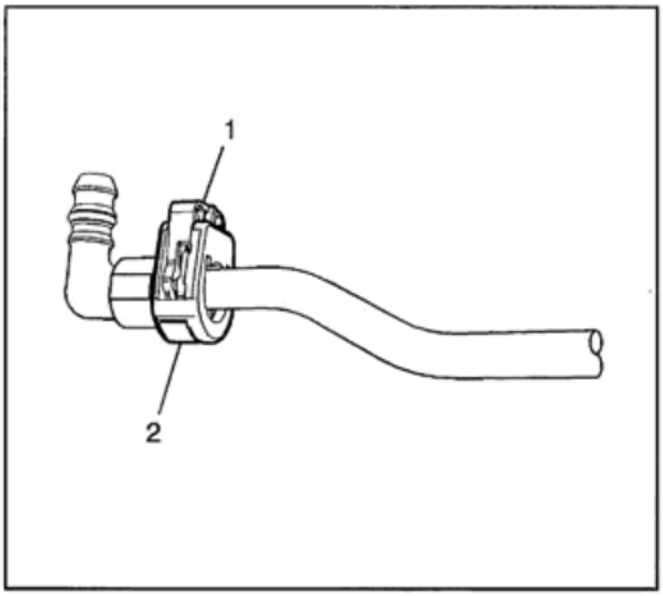
21855

2. Push both sides of the quick-connect fitting together in order to cause the retaining feature to snap into place.



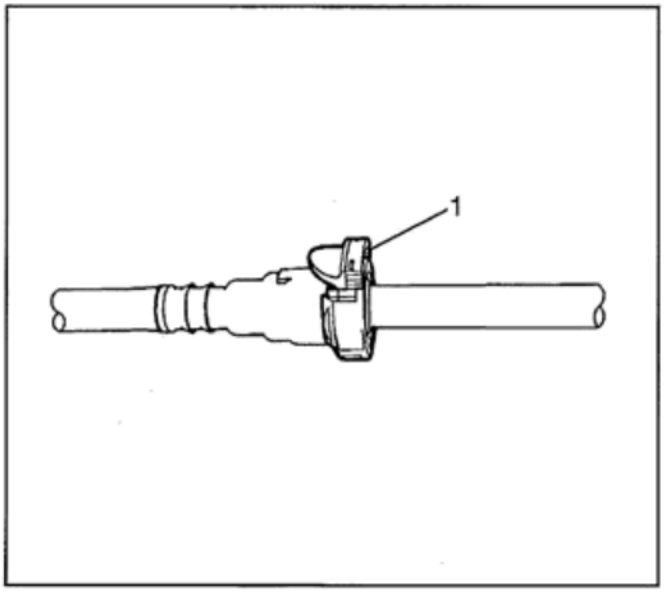
155399

3. Pull on both sides of the quick-connect fitting to make sure the connection is secure.



2005895

4. Insert the tube in the connector until the retainer snaps in place.
5. Push down on the redundant latch (1) until it is fully engaged and snapped into position.



2264192

6. Insert the tube in the connector until the retainer snaps in place.
7. Push down on the second latch (1) in order to secure the connection.
8. Inspect for leaks using the following procedure:
   8.1. Turn the ignition ON, with the engine OFF for 2 seconds.
   8.2. Turn the ignition OFF, for 10 seconds.
   8.3. Turn the ignition ON, with the engine OFF for 2 seconds.
   8.4. Turn the ignition OFF.
   8.5. Inspect for leaks.

Fuel Tank Draining

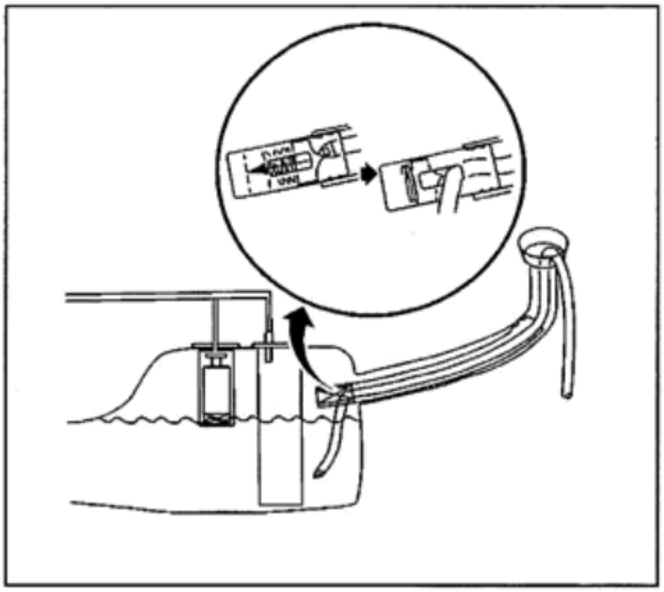
Special Tool

CH 45004 Fuel Tank Drain Hose

Warning: Never drain or store fuel in an open container. Always use an approved fuel storage container in order to reduce the chance of fire or explosion.

Warning: Place a dry chemical (Class B) fire extinguisher nearby before performing any on-vehicle service procedures. Failure to follow these precautions may result in personal injury.

1. Remove the fuel fill cap.



387061

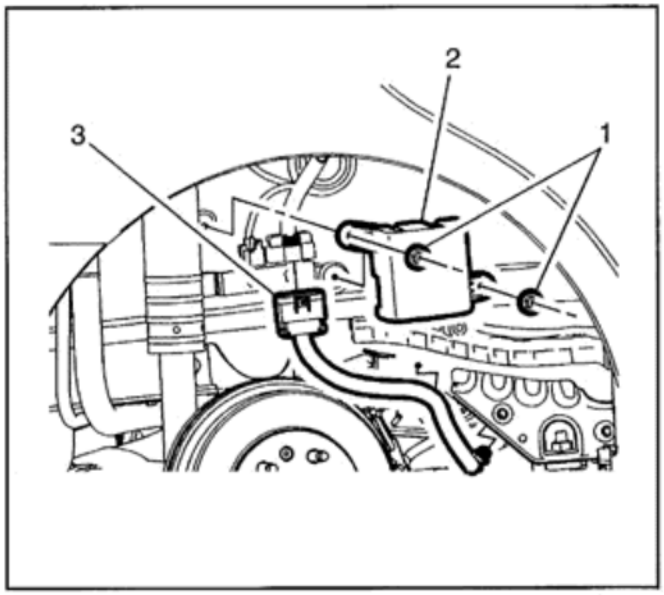
Note: Lubricate the fuel drain hose with Transjel Lubricant or equivalent to aid in hose insertion.

2. Insert the *CH 45004* hose into the fuel tank until the bottom is reached.
3. Use a hand or air operated pump device in order to drain as much fuel through the fuel fill pipe as possible.

Fuel Tank Replacement

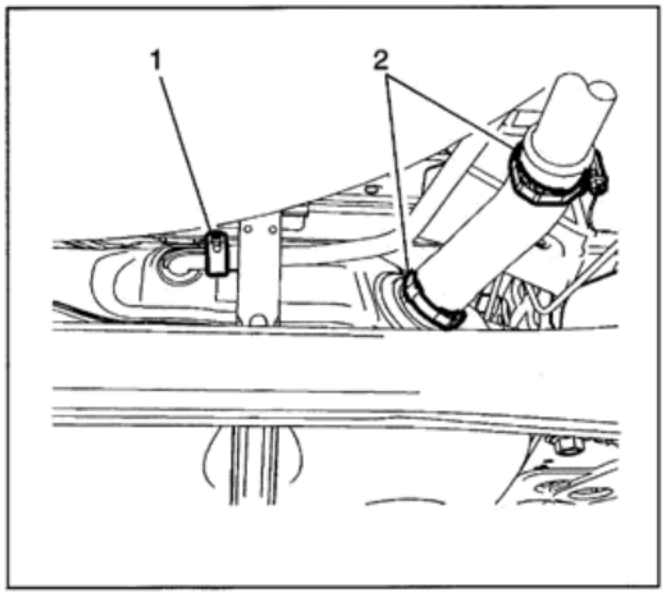
Removal Procedure

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*



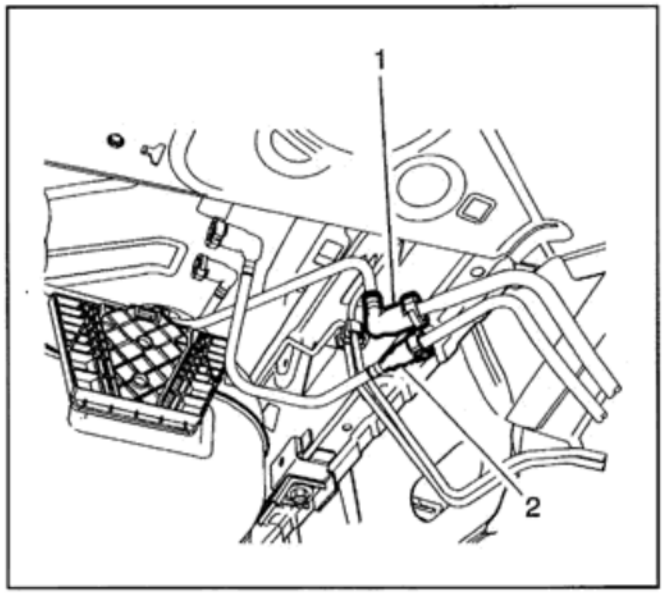
2495376

5. Remove the harness cover fastener (1) and harness cover (2).
6. Disconnect the fuel pump harness electrical connector (3).



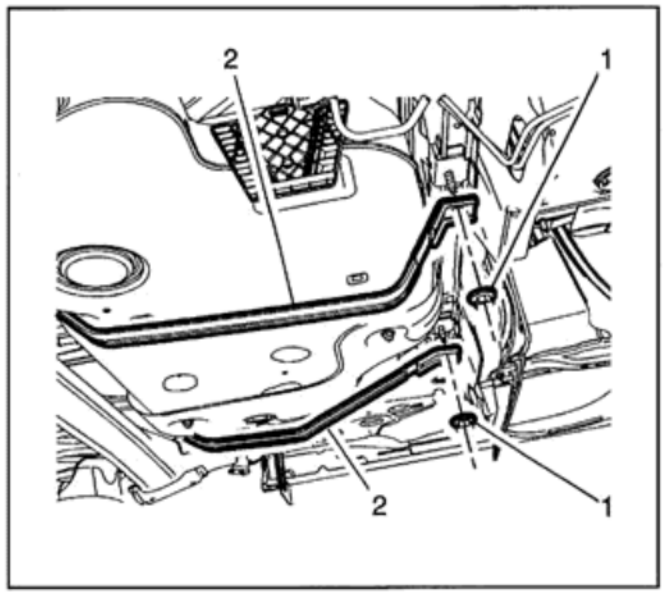
2551476

7. Collapse the vent hose spring clamp (1) and remove the vent hose.
8. Loosen the hose clamps (2) and slide the filler hose off the fuel tank.



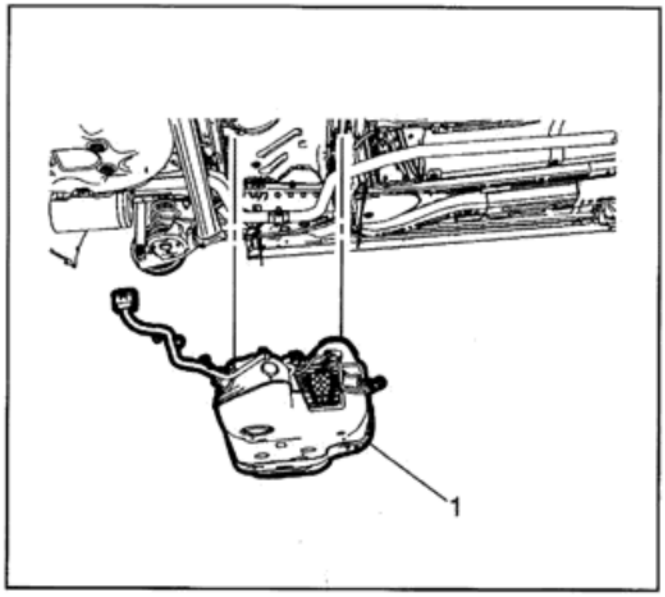
2551477

9. Disconnect the fuel feed pipe connector (1). Refer to *Plastic Collar Quick Connect Fitting Service on page 9-547*.
10. Disconnect the evaporative emission pipe connector (2). Refer to *Plastic Collar Quick Connect Fitting Service on page 9-547*.



2551478

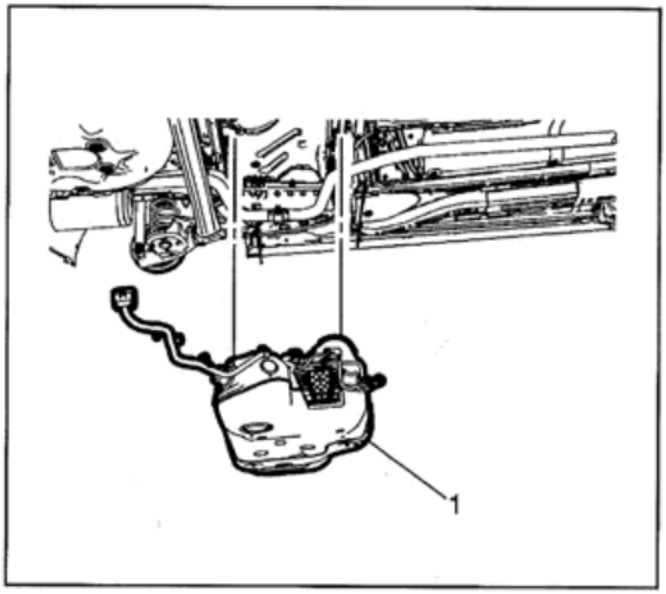
11. Support the fuel tank with a suitable stand.
12. Remove the fuel tank strap fasteners (1).
13. Reposition the fuel tank straps (2) toward the back of the vehicle.



2551479

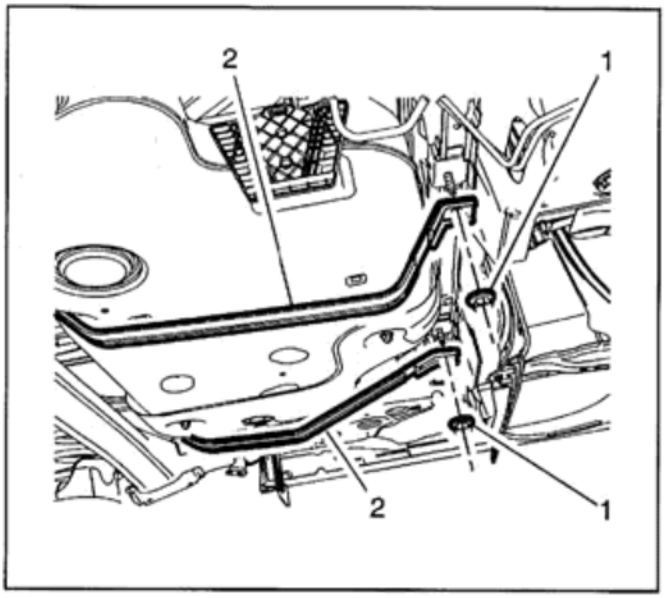
14. Lower the fuel tank (1).

Installation Procedure



2551479

1. If replacing the tank, transfer 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 any additional parts as necessary.
3. Raise the fuel tank (1).

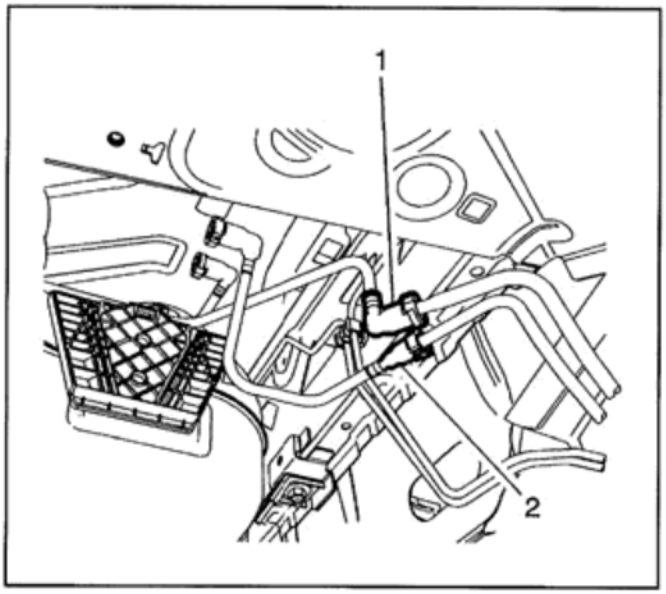


2551478

4. Support the fuel tank with a suitable stand.
5. Position the fuel tank straps (2) onto the fuel tank.

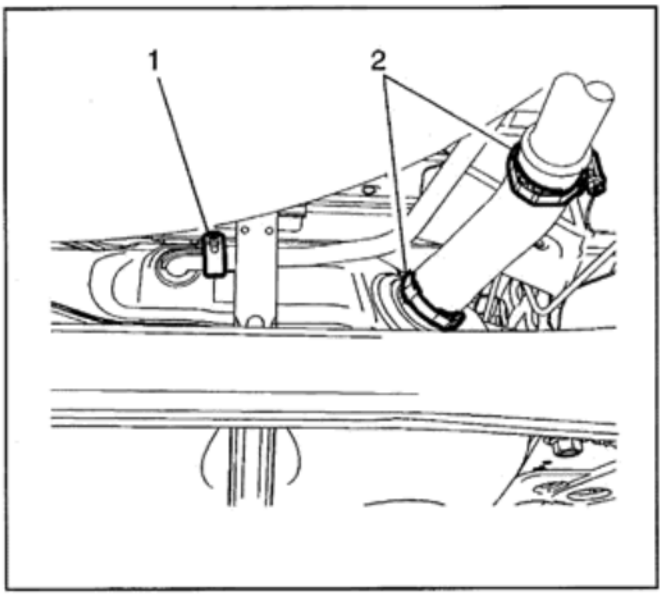
Caution: Refer to *Fastener Caution on page 0-8*.

6. Install the fuel tank strap fasteners (1) and tighten to **22 N·m(16 lb ft)**.



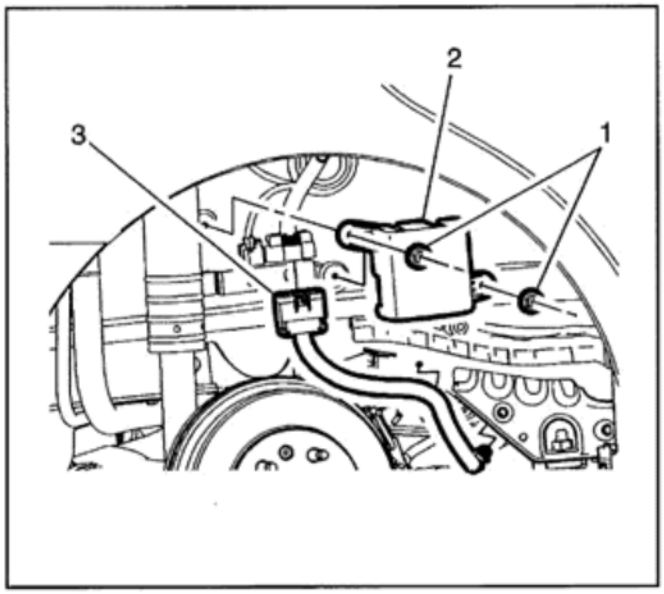
2551477

7. Connect the fuel feed pipe connector (1). Refer to *Plastic Collar Quick Connect Fitting Service on page 9-547*.
8. Connect the evaporative emission pipe connector (2). Refer to *Plastic Collar Quick Connect Fitting Service on page 9-547*.



2551476

9. Collapse the vent hose spring clamp (1) and install the vent hose.
10. Tighten the filler tube hose clamps (2).

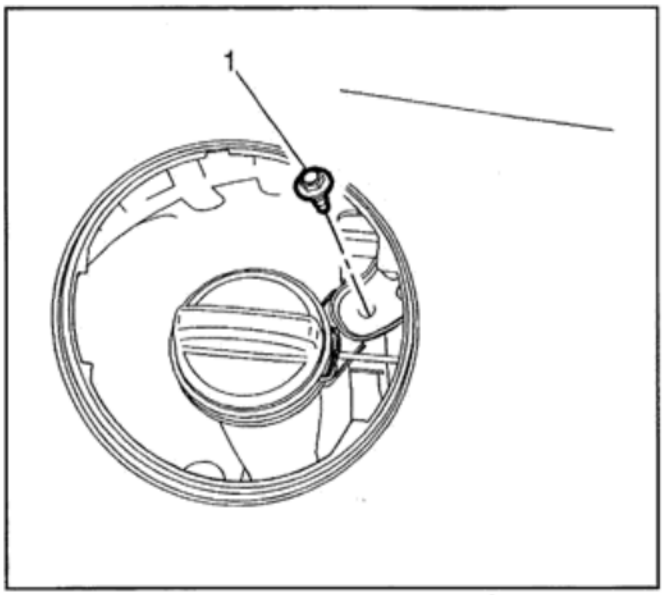


2495376

11. Connect the fuel pump harness electrical connector (3).
12. Install the harness cover (2) and tighten the cover fasteners (1).
13. Connect the battery negative cable. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.

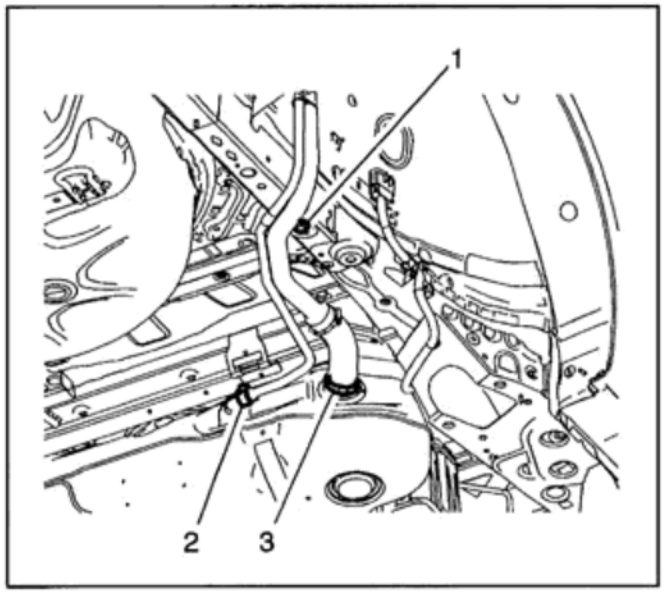
Fuel Tank Filler Pipe Replacement (Steel Tank)

Removal Procedure



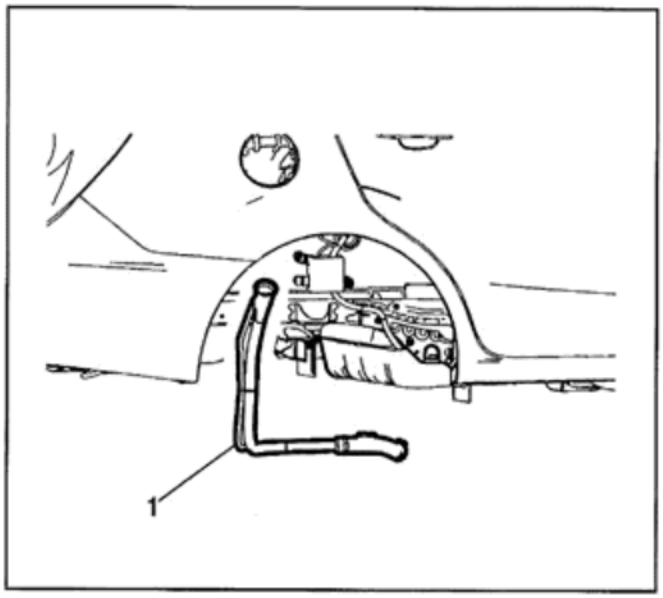
2498413

1. Remove the fuel filler door housing. Refer to *Fuel Tank Filler Door Latch Housing Replacement on page 3-33*.
2. Remove the bracket fastener (1).



2597399

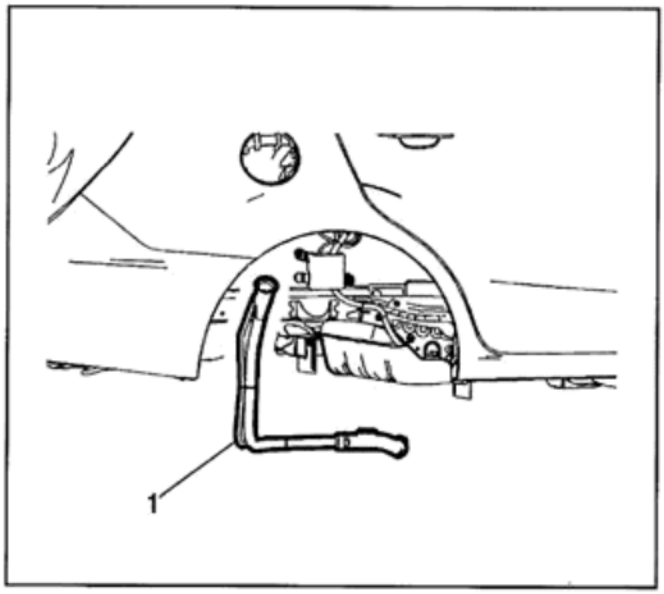
3. Lift and support the vehicle. Refer to *Lifting and Jacking the Vehicle on page 1-31*.
4. Remove the fuel tank filler pipe bracket fastener (1).
5. Remove the vent hose clamp (2) and vent hose.
6. Loosen the filler pipe hose clamp (3).



2498418

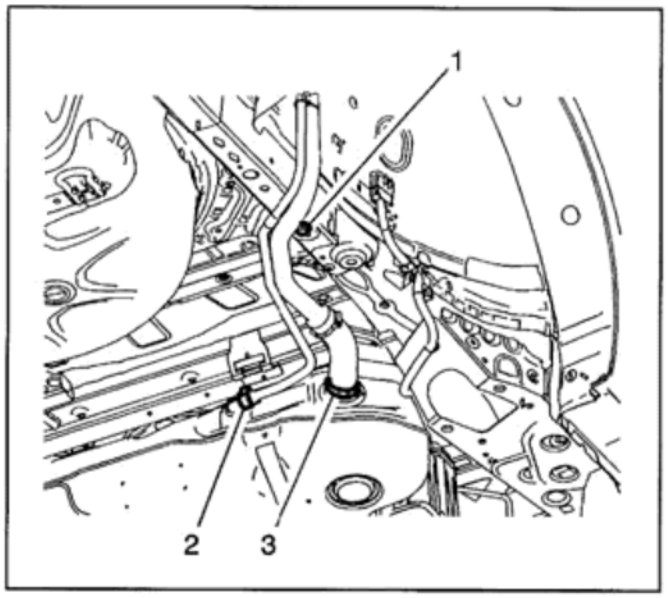
7. Remove the fuel tank filler pipe (1).

Installation Procedure



2498418

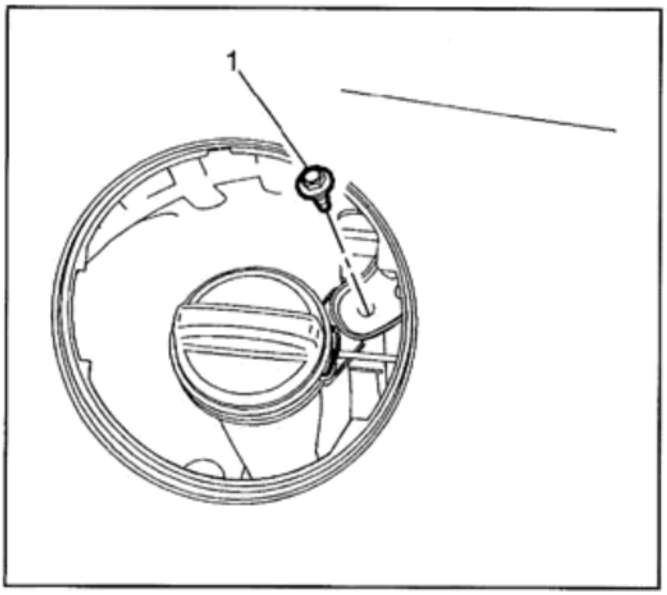
1. Install the fuel tank filler pipe (1).



2597399

Caution: Refer to *Fastener Caution on page 0-8*.

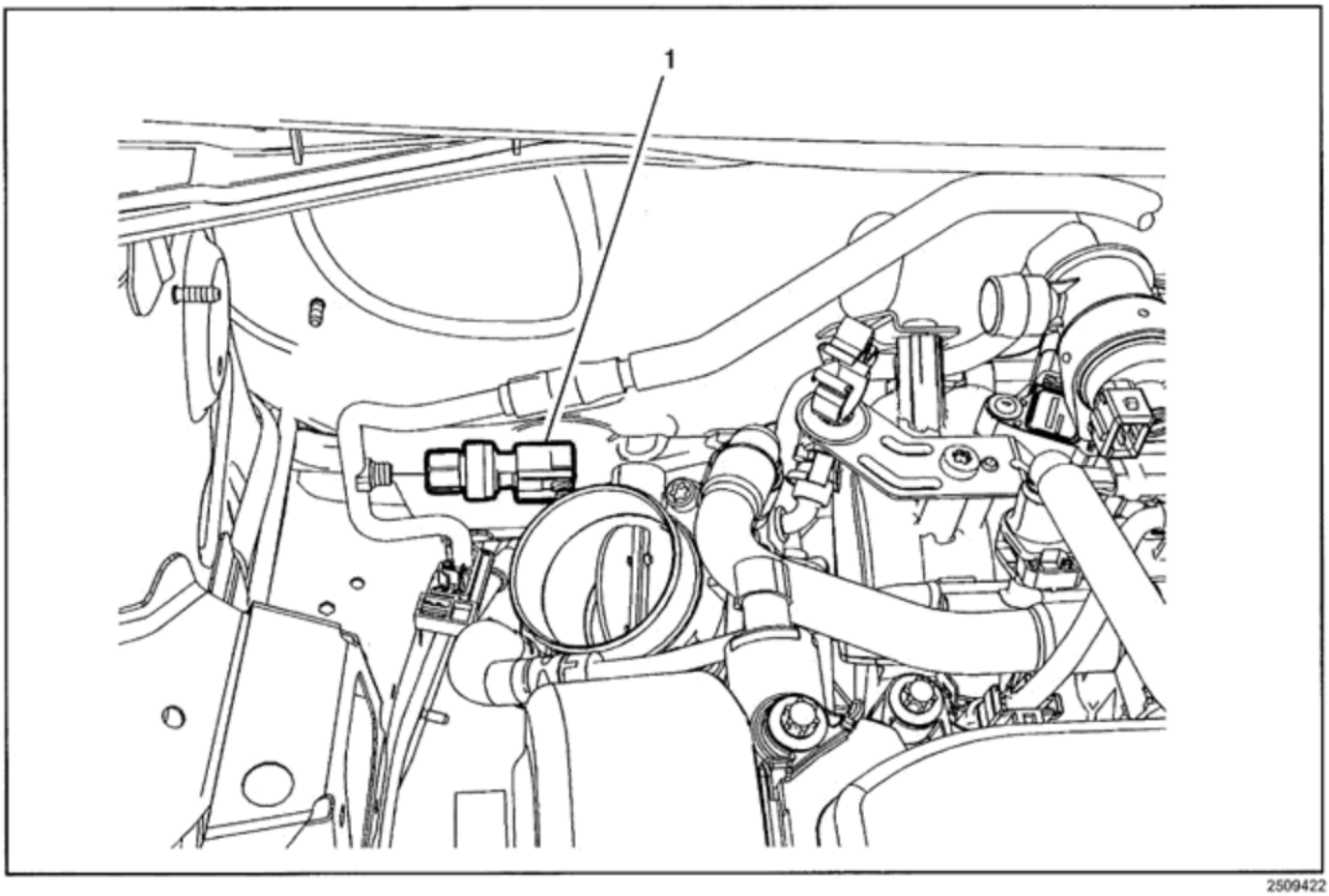
2. Tighten hose clamp (3) to **4 N•m(35 lb in)**.
3. Install the vent hose clamp (2) and vent hose.
4. Tighten the filler pipe bracket fastener (1) to **9 N•m(89 lb in)**.



2498413

5. Install the bracket fastener (1) and tighten to **9 N•m(89 lb in)**.
6. Install the fuel filler door housing. Refer to *Fuel Tank Filler Door Latch Housing Replacement on page 3-33*.

Fuel Pressure Sensor Replacement - Fuel Feed Pipe



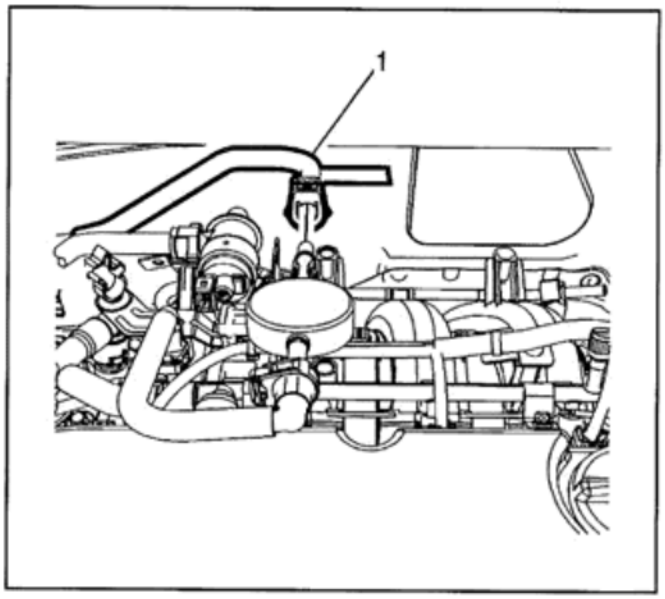
2509422

Fuel Pressure Sensor Replacement - Fuel Feed Pipe

Callout	Component Name
Preliminary Procedure 1. Relieve the fuel system pressure. Refer to *Fuel Pressure Relief on page 9-547*. 2. Remove the air cleaner assembly. Refer to *Air Cleaner Assembly Replacement on page 9-582*.	
1	Fuel Pressure Sensor **Caution:** Refer to *Fastener Caution on page 0-8*. **Tighten** 19 N•m(14 lb ft)

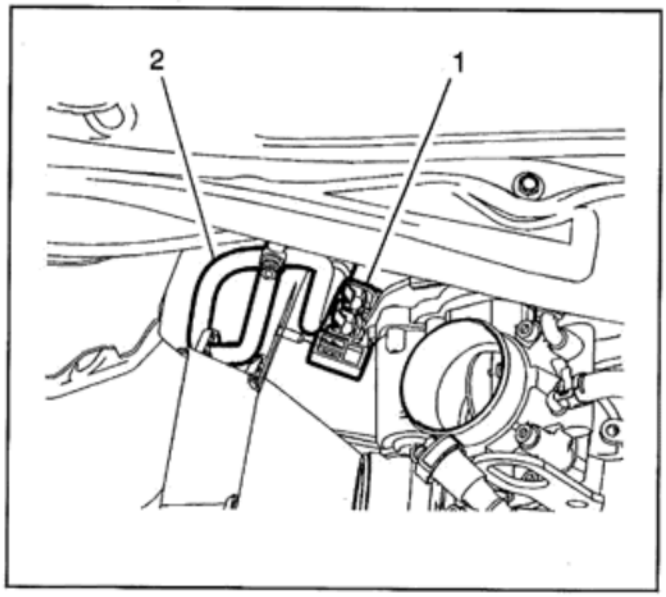
Fuel Feed Pipe Replacement

Removal Procedure



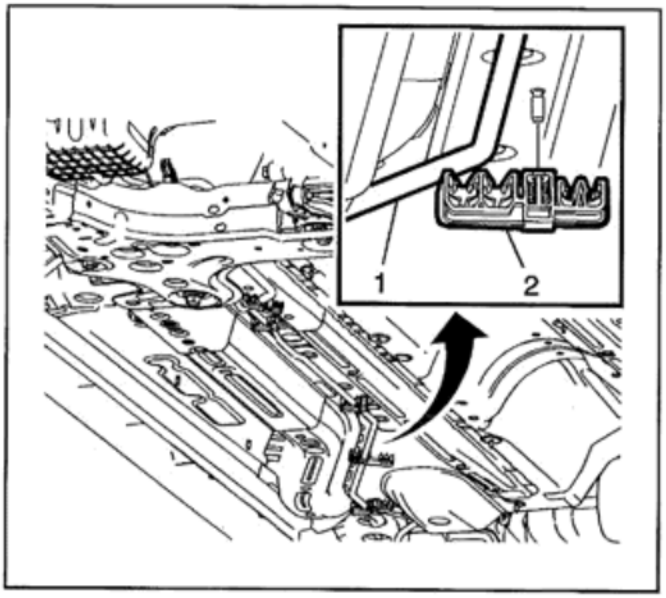
2509366

1. Remove the fuel feed pressure sensor. Refer to *Fuel Pressure Sensor Replacement - Fuel Feed Pipe on page 9-556*.
2. Disconnect the fuel feed pipe (1). Refer to *Plastic Collar Quick Connect Fitting Service on page 9-547*.



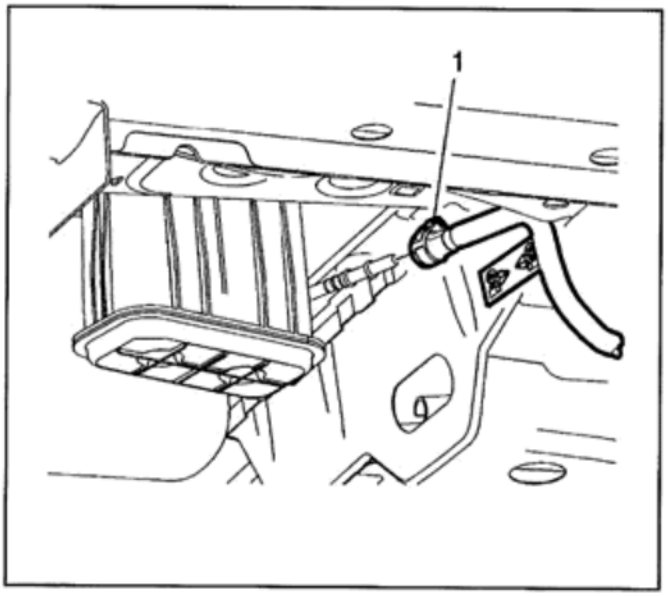
2495619

3. Remove the plastic retainer (1) and disconnect the fuel feed pipe (2).



2495620

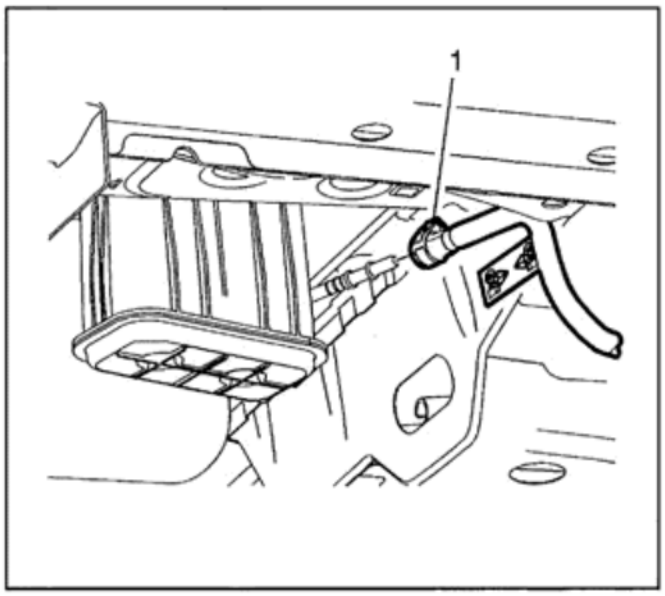
4. Lift and support the vehicle. Refer to *Lifting and Jacking the Vehicle on page 1-31*.
5. Disconnect the fuel feed pipe (1) from the plastic retainers (2).



2495623

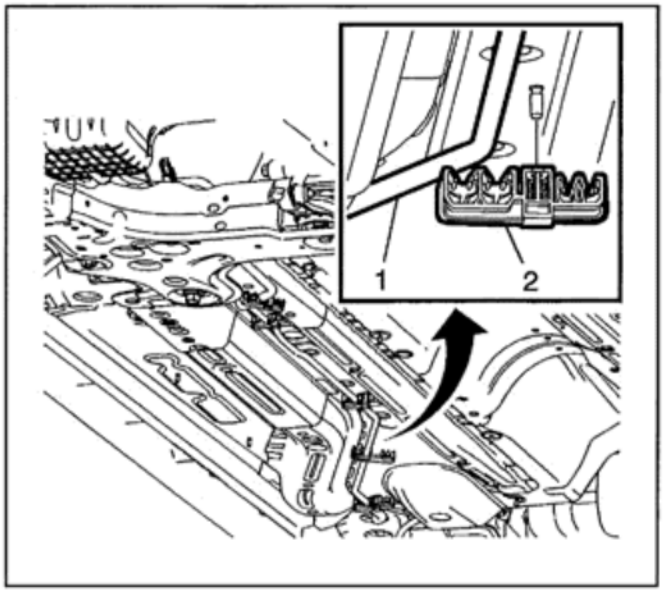
6. Disconnect the fuel feed pipe (1). Refer to *Plastic Collar Quick Connect Fitting Service on page 9-547*.
7. Remove the fuel feed pipe.

Installation Procedure



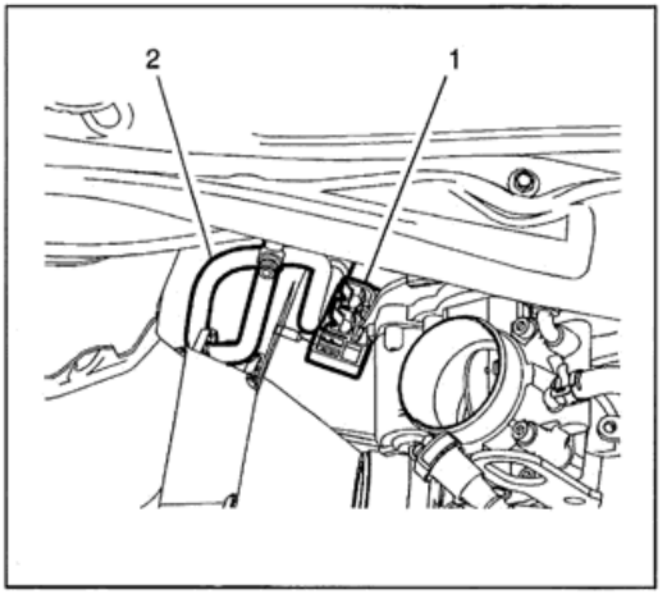
2495623

1. Install the fuel feed pipe.
2. Connect the fuel feed pipe (1). Refer to *Plastic Collar Quick Connect Fitting Service on page 9-547*.



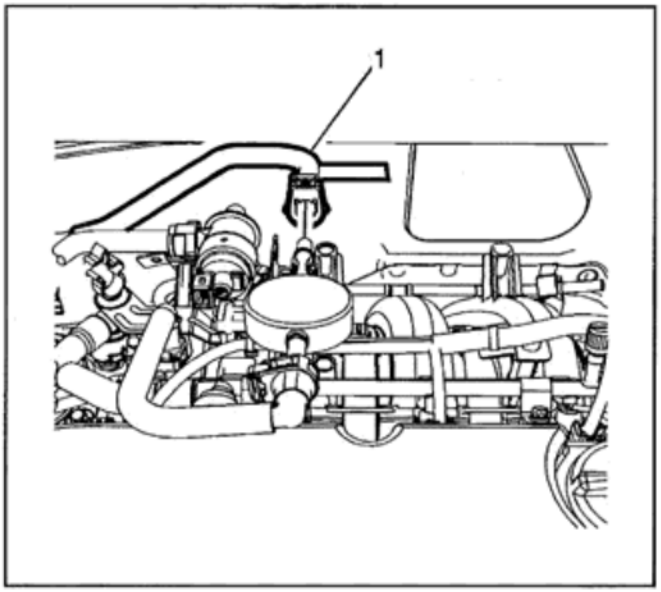
2495620

3. Connect the fuel feed pipe (2) to the plastic retainers (1).



2495619

4. Connect the fuel feed pipe (2) and install the plastic retainer (1).



2509366

5. Connect the fuel feed pipe (1). Refer to *Plastic Collar Quick Connect Fitting Service on page 9-547*.
6. Install the fuel feed pressure sensor. Refer to *Fuel Pressure Sensor Replacement - Fuel Feed Pipe on page 9-556*.

Fuel Tank Fuel Pump Module Replacement (Steel Tank)

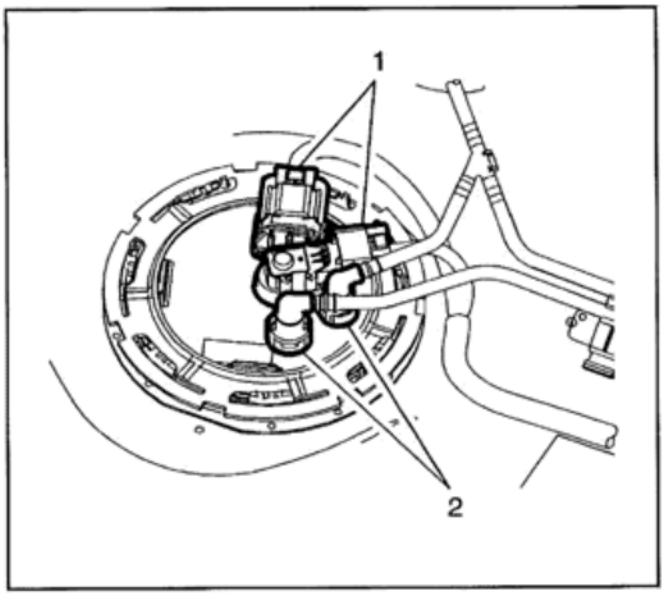
Special Tools

EN-48279 Fuel Sender Lock Ring Wrench

For equivalent regional tools, refer to *Special Tools on page 9-593*.

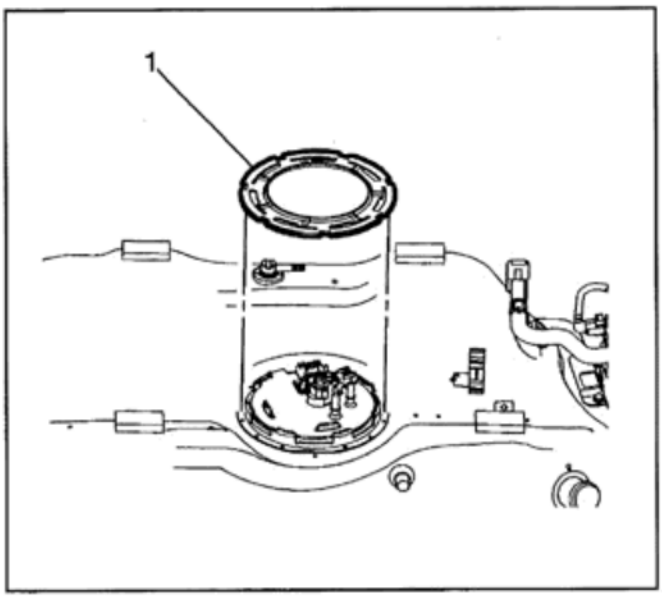
Removal Procedure

1. Relieve the fuel system pressure. Refer to *Fuel Pressure Relief on page 9-547*.
2. Remove the fuel tank. Refer to *Fuel Tank Replacement on page 9-551*.



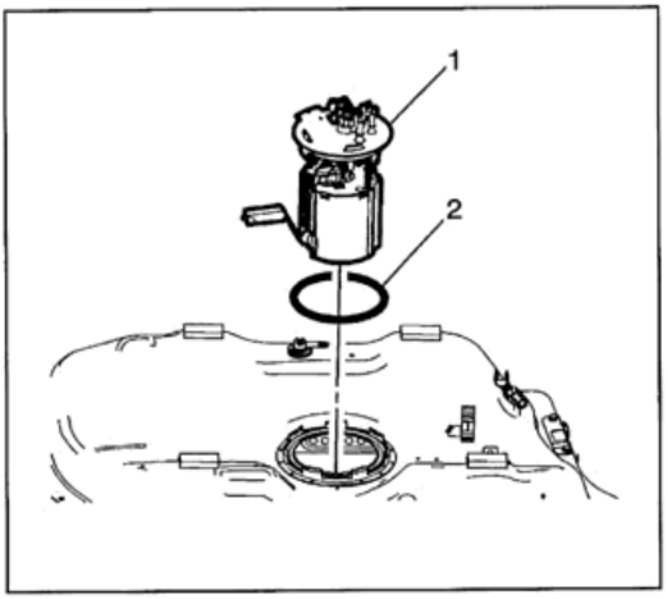
2495427

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 9-547*.



2495431

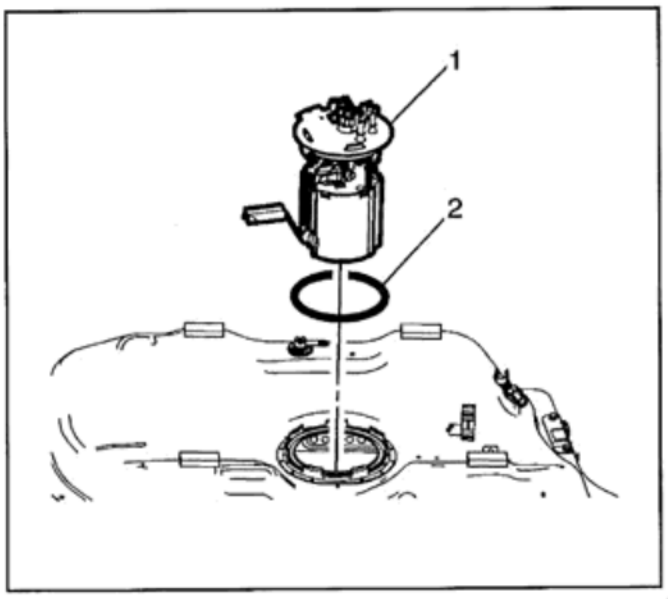
5. Using the *EN-48279* fuel sender lock ring wrench, remove the lock ring (1) by turning counter-clockwise.



2495432

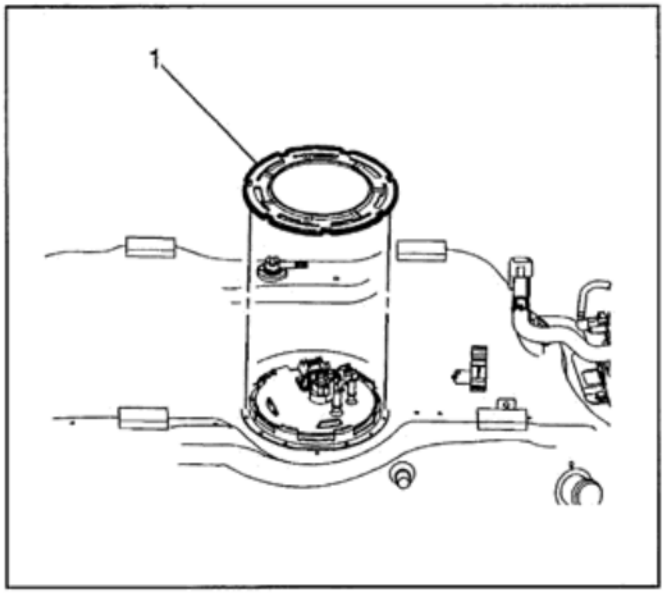
6. Remove the fuel pump module (1) and O-ring (2). Discard the seal.

Installation Procedure

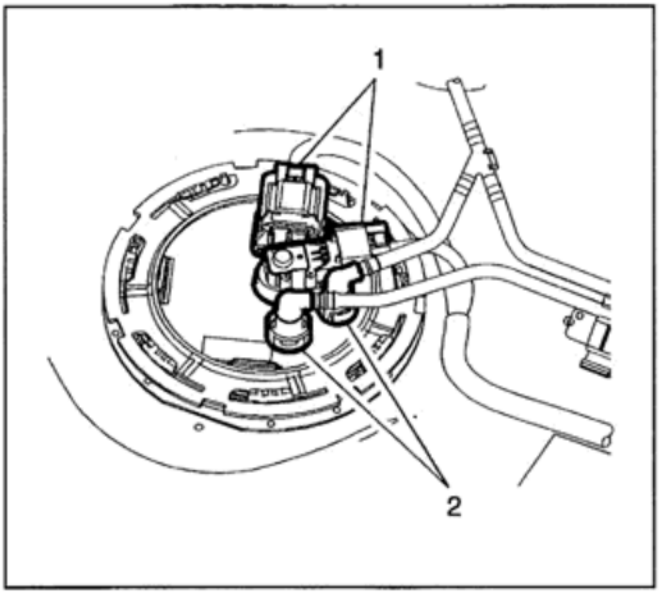


2495432

1. Install a NEW O-ring (2) and the fuel pump module (1).



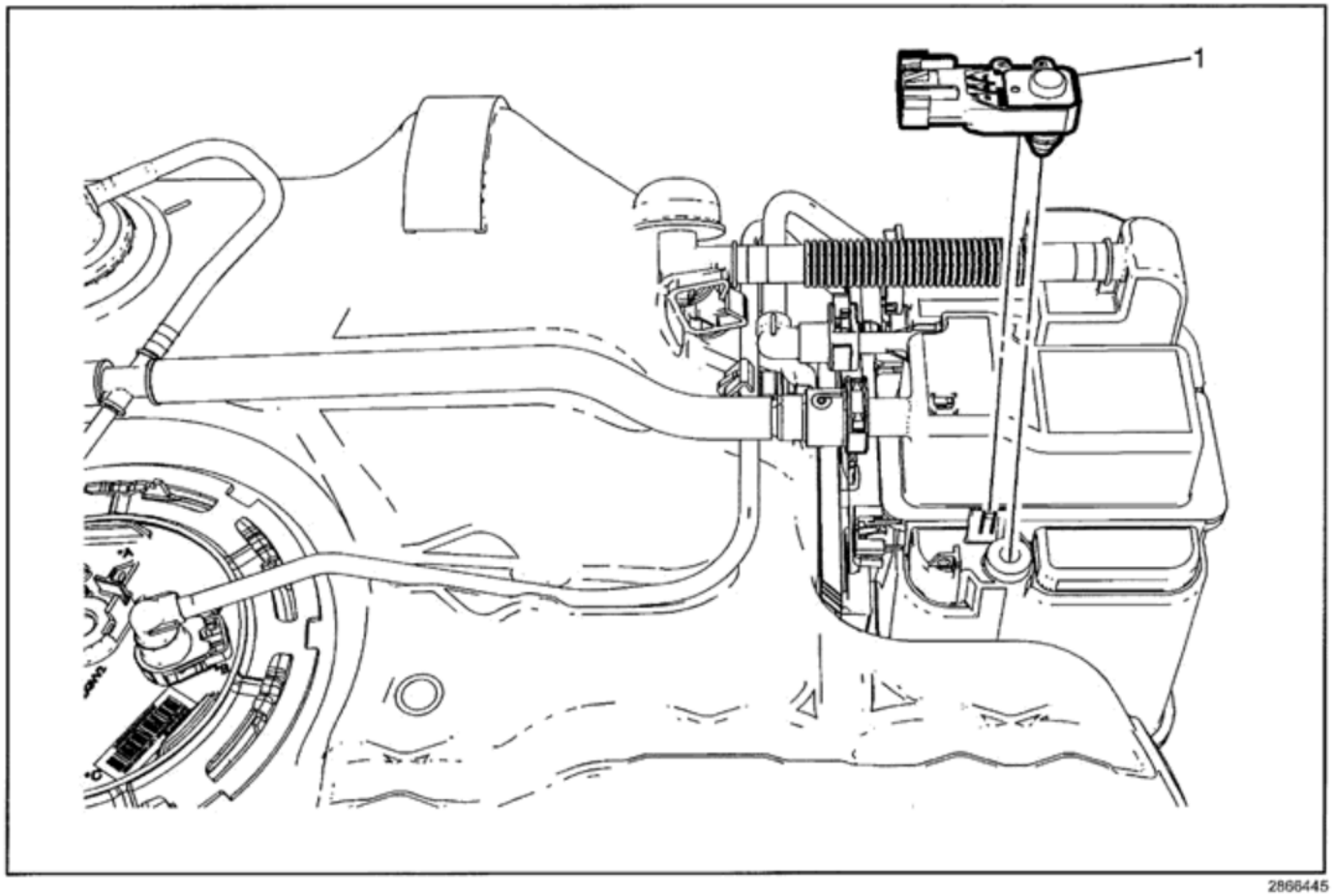
2495431



2495427

2. Using the EN 48279 wrench, install the lock ring (1) by turning clockwise.
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 9-547*.
5. Install the fuel tank. Refer to *Fuel Tank Replacement on page 9-551*.

Fuel Tank Pressure Sensor Replacement

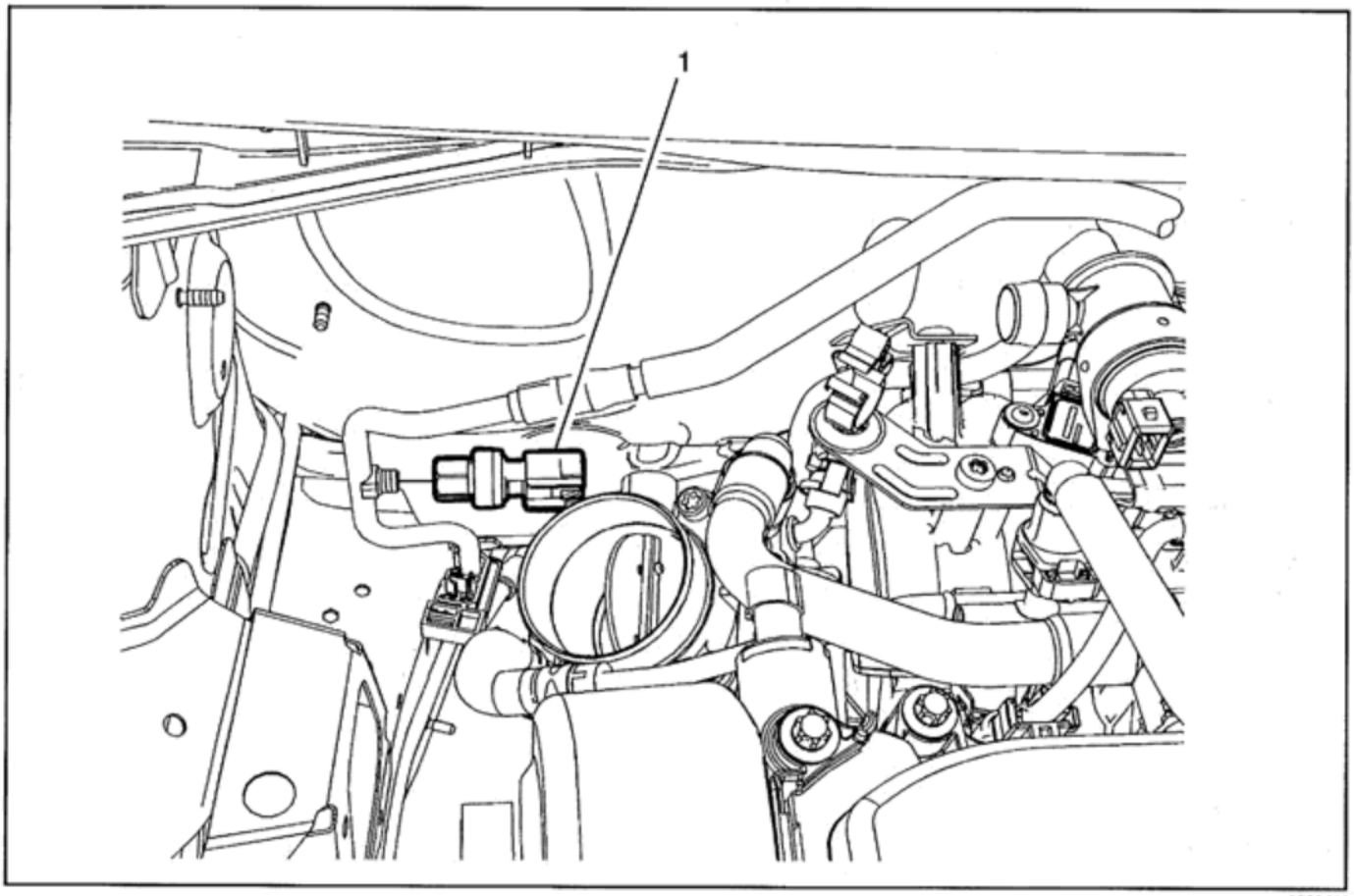


2866445

Fuel Tank Pressure Sensor Replacement

Callout	Component Name
Preliminary Procedure Remove the fuel tank. Refer to *Fuel Tank Replacement on page 9-551*.	
1	Fuel Tank Pressure Sensor **Procedure** Disconnect the FTP sensor electrical connector.

Fuel Pressure Sensor Replacement



2509422

Fuel Pressure Sensor Replacement

Callout	Component Name
Preliminary Procedure 1. Relieve the fuel system pressure. Refer to *Fuel Pressure Relief on page 9-547*. 2. Remove the air cleaner assembly. Refer to *Air Cleaner Assembly Replacement on page 9-582*.	
1	Fuel Pressure Sensor **Caution:** Refer to *Fastener Caution on page 0-8*. **Tighten** 19 N•m(14 lb ft)

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 9-551*.
2. Remove the fuel pump module assembly. Refer to *Fuel Tank Fuel Pump Module Replacement (Steel Tank) on page 9-559*.
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 *Fuel Feed Pipe Replacement on page 9-557*.

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 *Fuel Feed Pipe Replacement on page 9-557*.
10. Install the fuel pump module assembly. Refer to *Fuel Tank Fuel Pump Module Replacement (Steel Tank) on page 9-559*.

Fuel Injector Replacement

Special Tools

CH-807 Closure Plugs

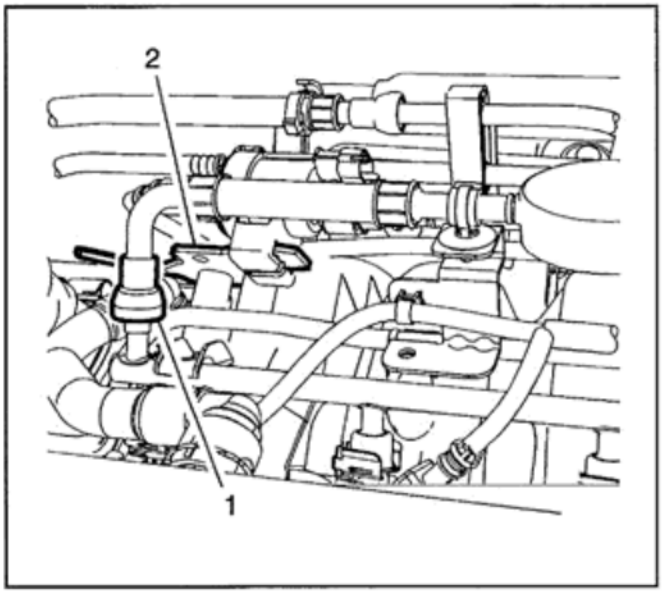
For equivalent regional tools, refer to *Special Tools on page 9-593*.

Removal Procedure

1. Disconnect the negative cable from the battery. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.
2. Remove the positive crankcase ventilation tube. Refer to *Positive Crankcase Ventilation Hose/Pipe/Tube Replacement on page 9-1019*.
3. Disconnect the wiring harness from the:
   3.1. Evaporative emission purge valve
   3.2. Fuel injectors
   3.3. Manifold absolute pressure sensor
4. Place a collecting basin underneath.

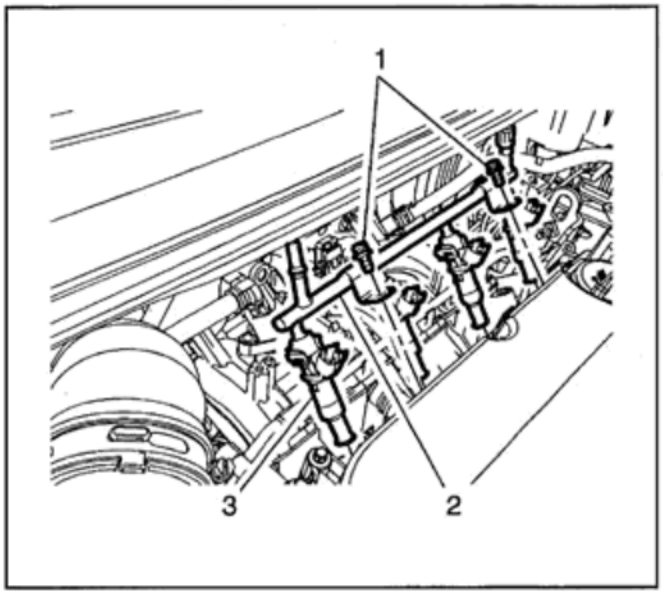
Warning: Gasoline or gasoline vapors are highly flammable. A fire could occur if an ignition source is present. Never drain or store gasoline or diesel fuel in an open container, due to the possibility of fire or explosion. Have a dry chemical (Class B) fire extinguisher nearby.

5. Release the fuel pressure. Refer to *Fuel Pressure Relief on page 9-547*.



2676363

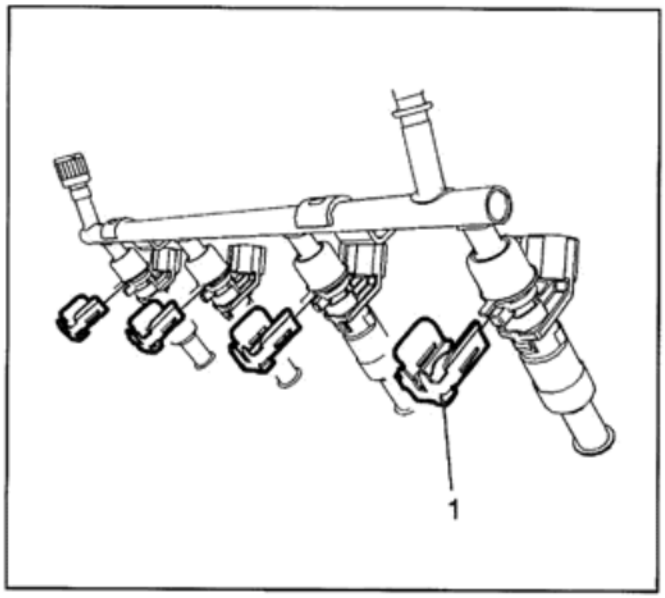
6. Disconnect the fuel feed pipe (1) . Refer to *Plastic Collar Quick Connect Fitting Service on page 9-547*.
7. Install *CH-807* plug to the fuel feed pipe.
8. Remove the 2 evaporative emission canister purge solenoid valve bracket bolts (2).
9. Relocate the evaporative emission canister purge solenoid valve and bracket.



2506162

10. Remove the 2 multiport fuel injection fuel rail bolts (1).
11. Remove the multiport fuel injection fuel rail (2) with the fuel injectors (3) from the intake manifold..

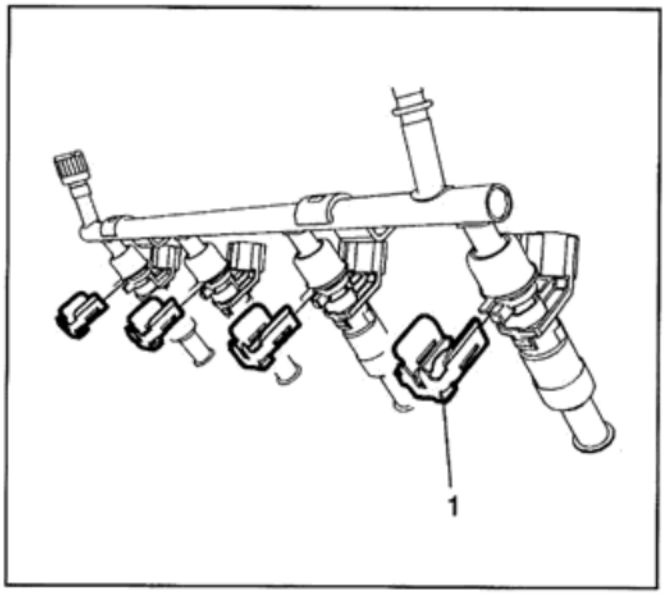
12. Remove the 4 fuel injector seals.



2506161

13. Remove the fuel injector retainer (1).
14. Remove the fuel injectors.

Installation Procedure



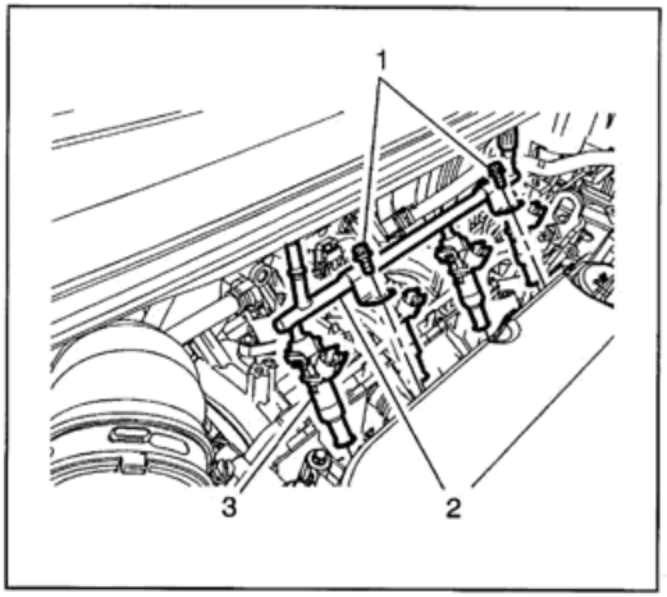
2506161

Note: Install new fuel injector seals, coat the multiport fuel injector seals with silicone grease.

1. Install the fuel injector retainer (1).

Note: Coat the fuel injector seals with silicone grease

2. Install the 4 new fuel injector seals.

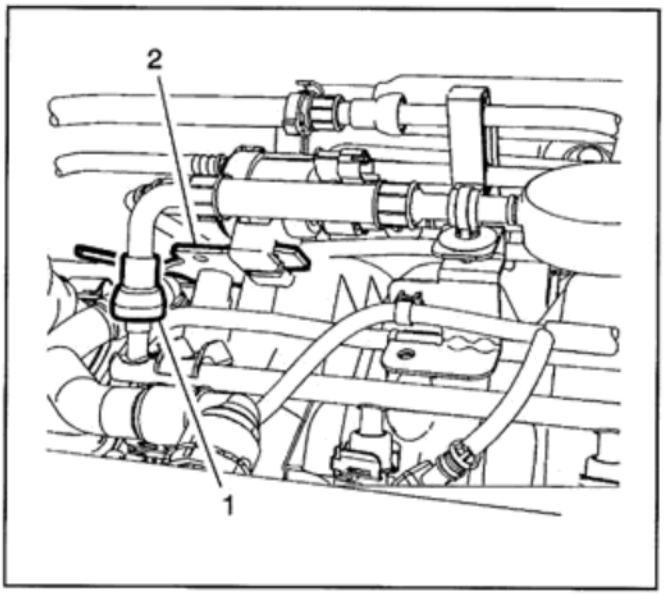


2506162

3. Install the multiport fuel injection fuel rail (2) and the fuel injectors (3) to the intake manifold.

Caution: Refer to *Fastener Caution on page 0-8.*

4. Install the 2 multiport fuel injection fuel rail bolts (1) and tighten to **8 N•m (71 lb in)**.

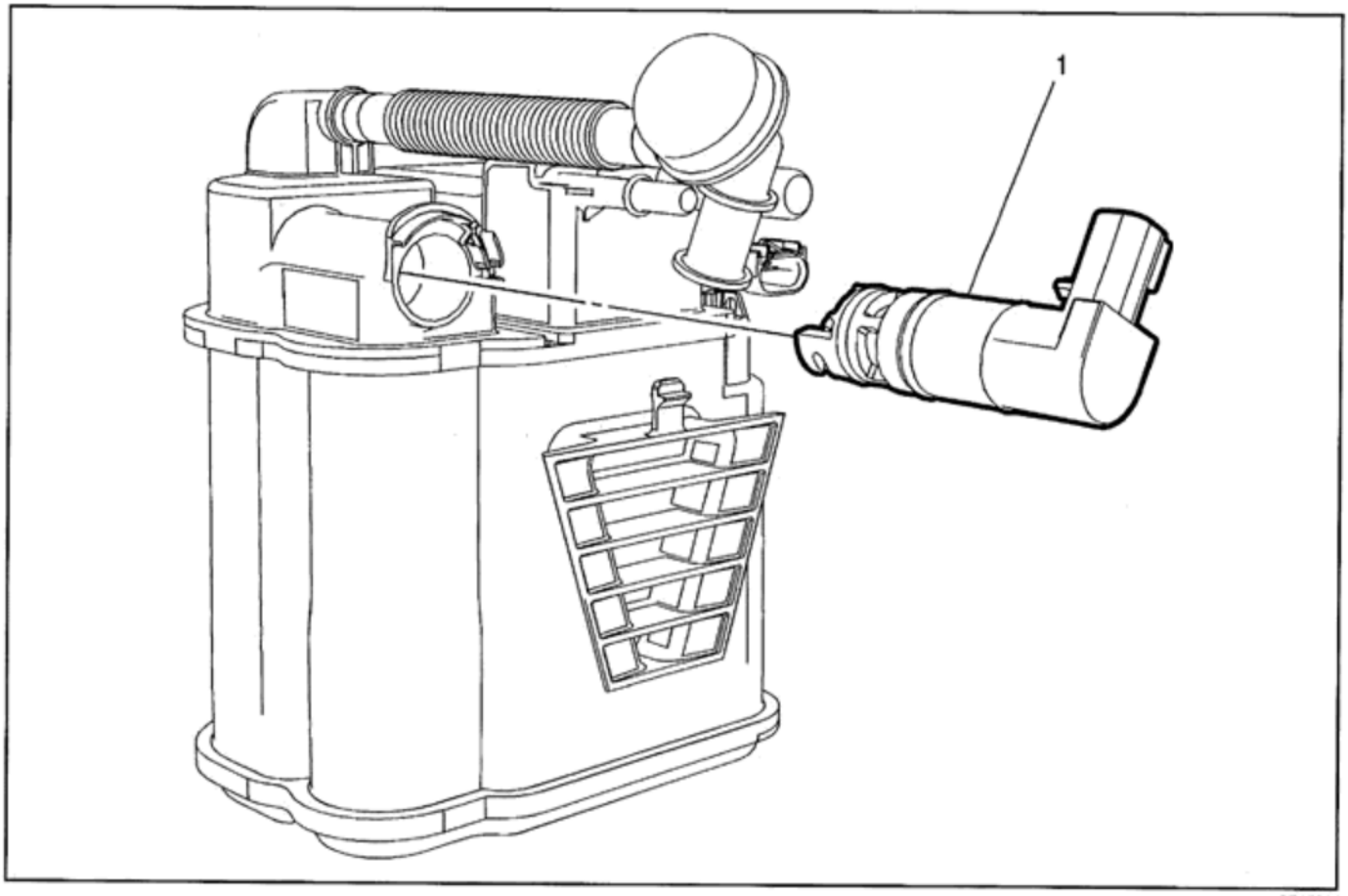


2676363

5. Install the 2 evaporative emission canister purge solenoid valve bracket bolts (2) and tighten to **8 N•m (71 lb in)**.
6. Remove the *CH-807* plug.
7. Connect the quick-release fitting of fuel feed pipe (1).
8. Connect the wiring harness to the:
   8.1. Evaporative emission purge valve
   8.2. Fuel injectors
   8.3. Manifold absolute pressure sensor

9. Install the positive crankcase ventilation tube. Refer to *Positive Crankcase Ventilation Hose/Pipe/ Tube Replacement on page 9-1019.*
10. Connect the negative cable from the battery. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713.*

Evaporative Emission Canister Vent Solenoid Valve Replacement



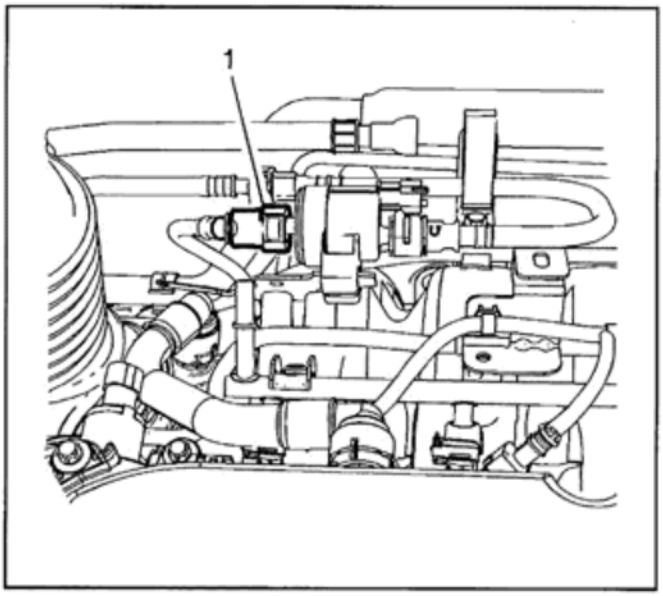
2745285

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 (Steel Tank) on page 9-567.*	
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.

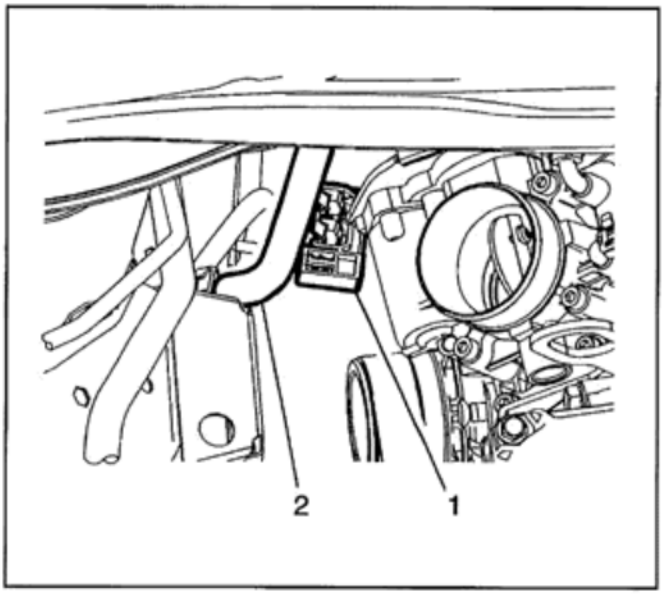
Evaporative Emission System Hose/ Pipe Replacement

Removal Procedure



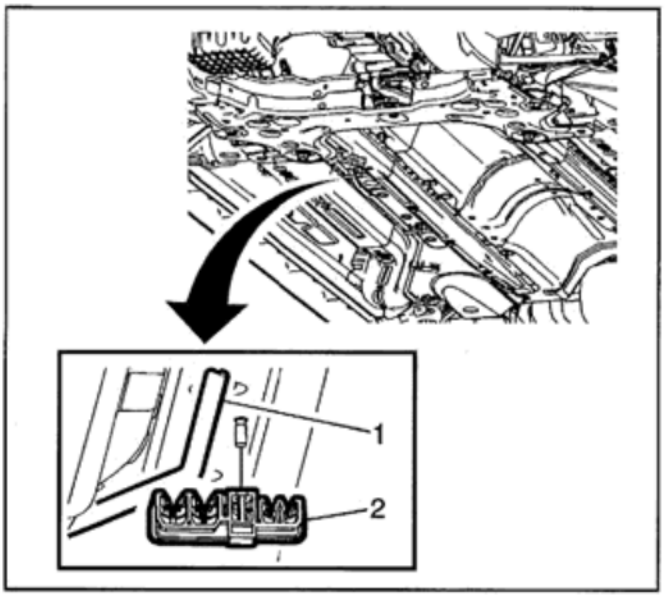
2676473

1. Disconnect the evaporative emission pipe (1). Refer to *Plastic Collar Quick Connect Fitting Service on page 9-547*.



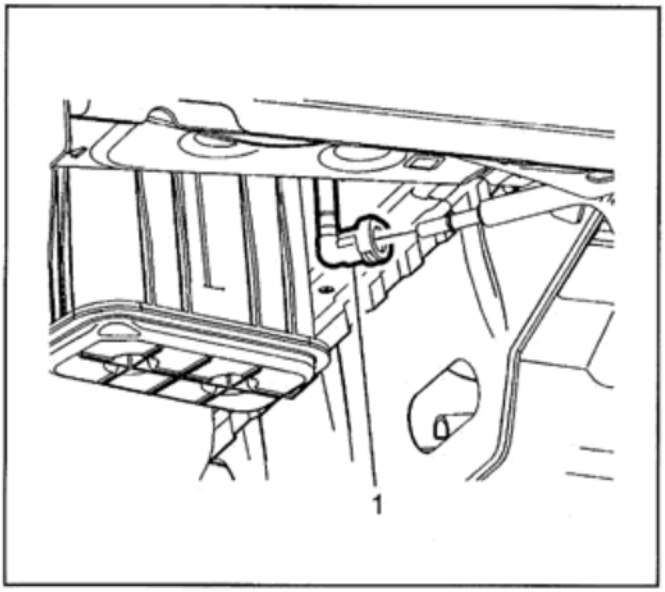
2496058

2. Remove the plastic retainer (1) and disconnect the evaporative emission pipe (2).



2496084

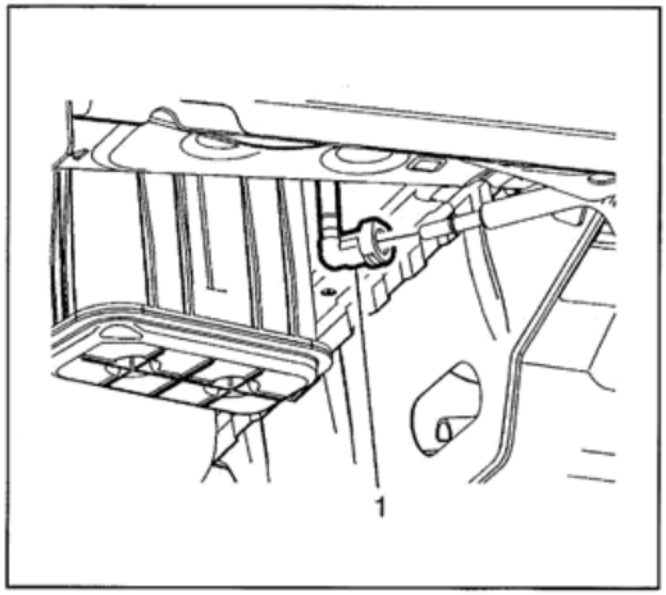
3. Lift and support the vehicle. Refer to *Lifting and Jacking the Vehicle on page 1-31*.
4. Disconnect the evaporative emission pipe (1) from the plastic retainers (2).



2496061

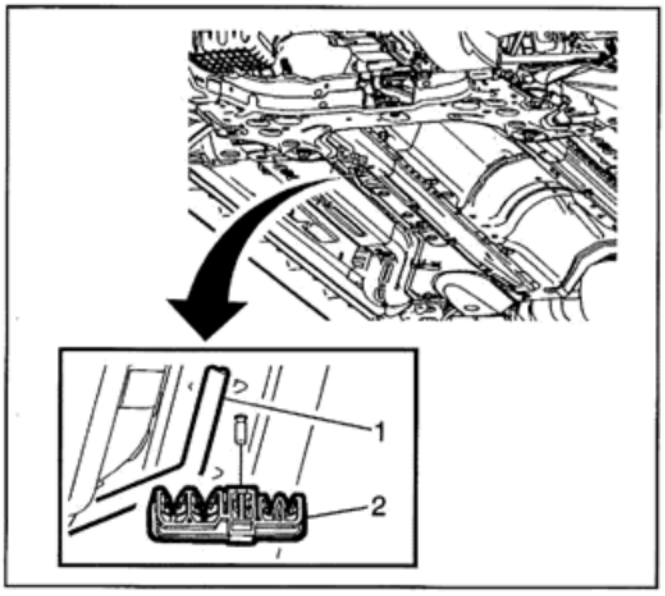
5. Disconnect the evaporative emission pipe (1). Refer to *Plastic Collar Quick Connect Fitting Service on page 9-547*.
6. Remove the evaporative emission pipe.

Installation Procedure



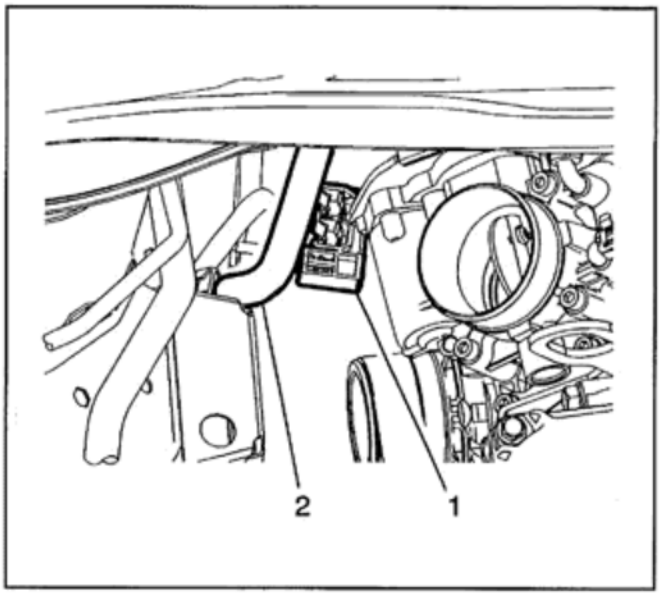
2496061

1. Install the evaporative emission pipe.
2. Connect the evaporative emission pipe (1). Refer to *Plastic Collar Quick Connect Fitting Service on page 9-547*.



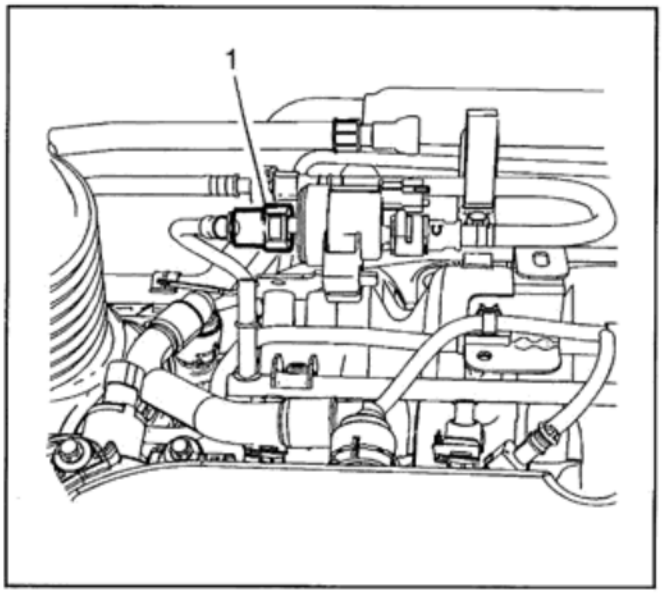
2496064

3. Connect the evaporative emission pipe (1) to the plastic retainers (2).



2496058

4. Connect the evaporative emission pipe (2) and install the plastic retainer (1).

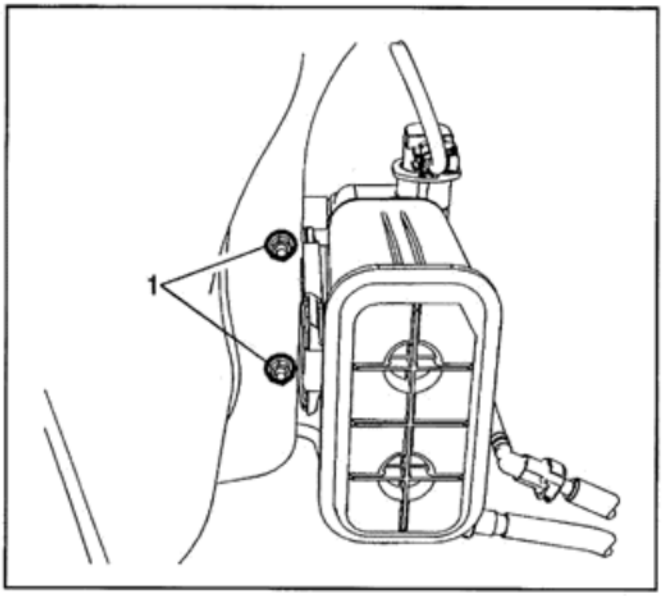


2676473

5. Connect the evaporative emission pipe (1). Refer to *Plastic Collar Quick Connect Fitting Service on page 9-547*.

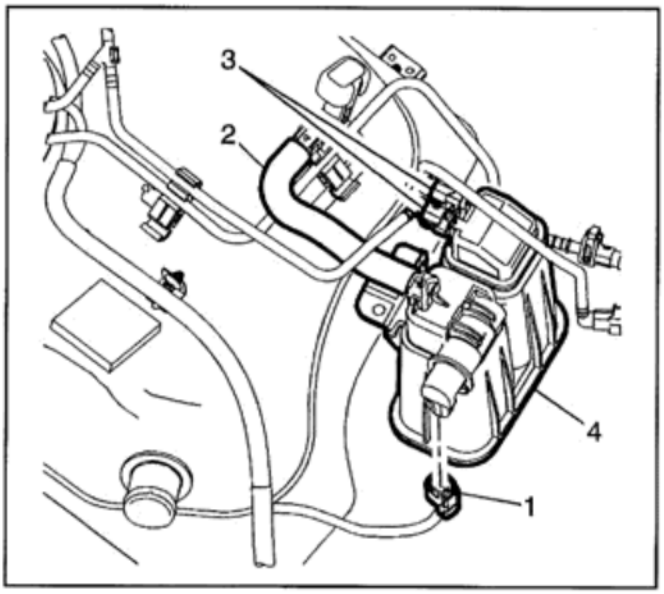
Evaporative Emission Canister Replacement (Steel Tank)

Removal Procedure



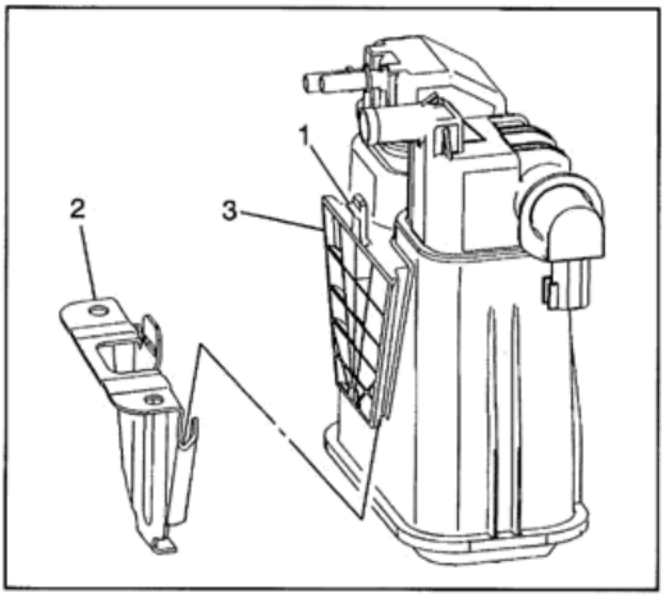
2538905

1. Remove the evaporative emission canister bracket fasteners (1).



2538906

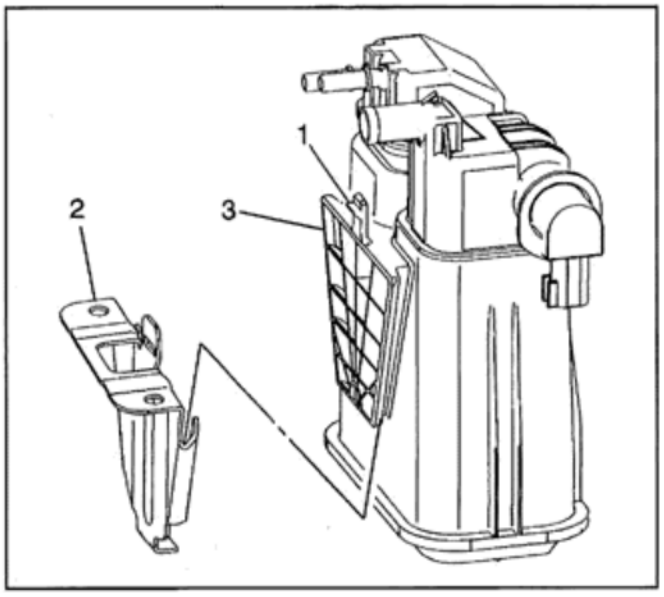
2. Disconnect the purge solenoid valve electrical connector (1).
3. Disconnect the evaporative emission canister vent hose (2).
4. Disconnect the evaporative emission canister pipes (3). Refer to *Plastic Collar Quick Connect Fitting Service on page 9-547*
5. Remove the evaporative emission canister (4).



2538907

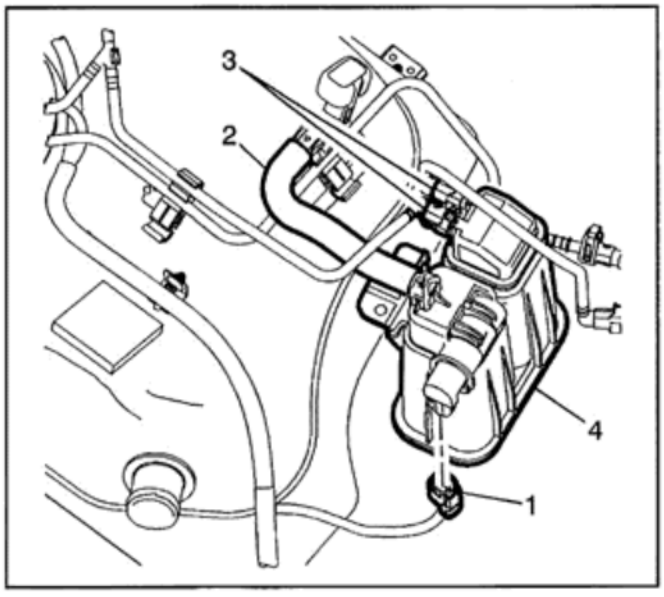
6. Release the retaining tab (1) and remove the evaporative emission canister (2).

Installation Procedure



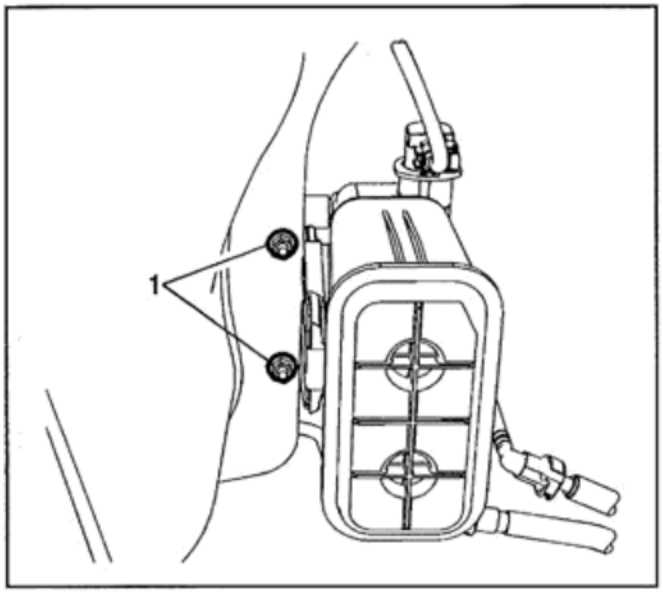
2538907

1. Slide the evaporative emission canister (3) into the evaporative emission canister bracket (2) until the retaining tab (1) snaps into position.



2538906

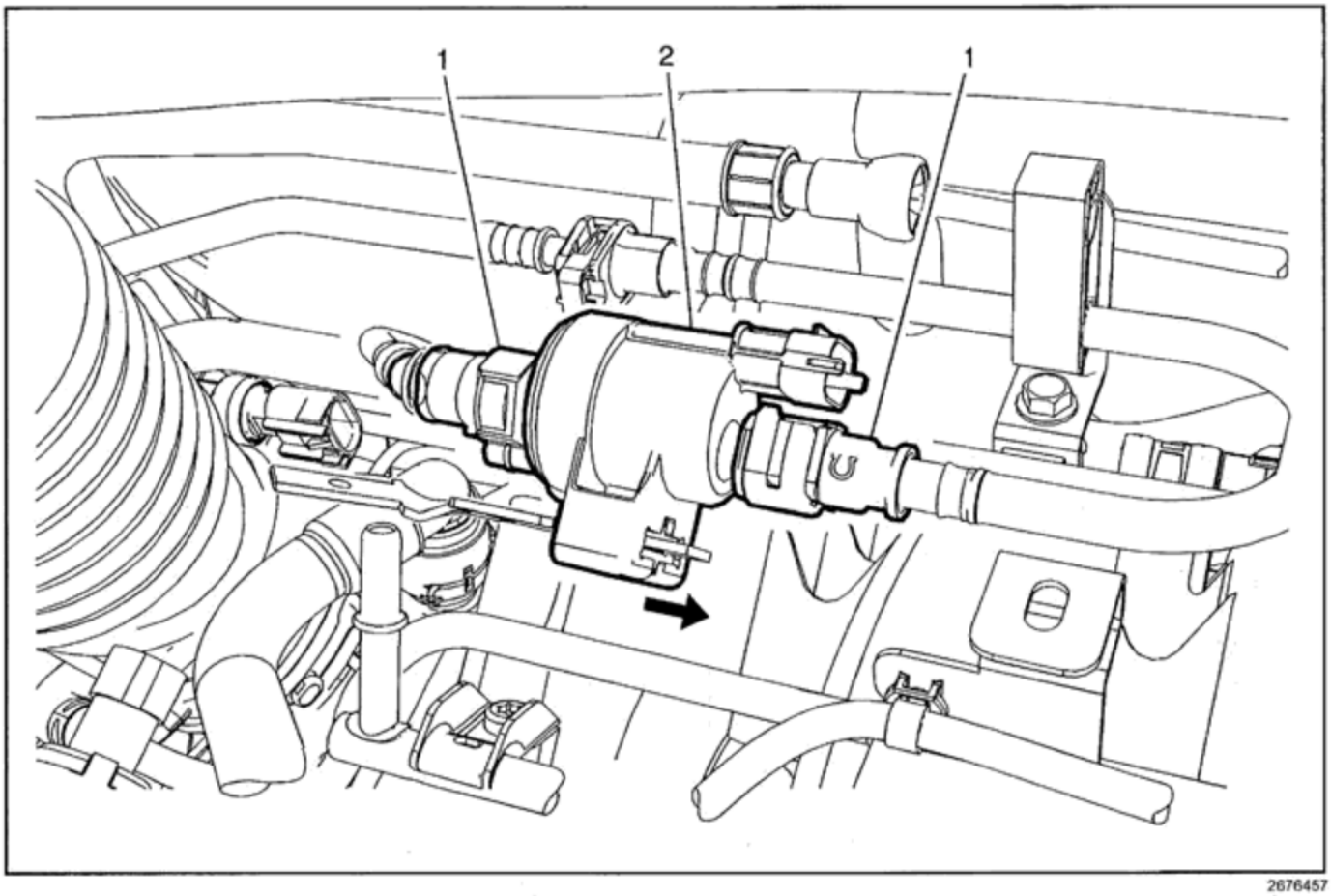
2. Install the evaporative emission canister (4) into position.
3. Connect the evaporative emission canister pipes (3). Refer to *Plastic Collar Quick Connect Fitting Service on page 9-547*
4. Connect the evaporative emission canister vent hose (2).
5. Connect the purge solenoid valve electrical connector (1).



2538905

6. Install the evaporative emission canister bracket fasteners (1) and tighten to **10 N•m (89 lb in).**

Evaporative Emission Canister Purge Solenoid Valve Replacement



2676457

Evaporative Emission Canister Purge Solenoid Valve Replacement

Callout	Component Name
1	Purge Pipe Fittings (Qty: 2) **Procedure** Disconnect the vacuum lines quick connect fitting from the evaporative emission canister purge solenoid valve. Refer to *Plastic Collar Quick Connect Fitting Service on page 9-547*.
2	Evaporative Emission Canister Purge Solenoid Valve **Procedure** 1. Disconnect the purge solenoid valve harness connector. 2. Remove the evaporative emission canister purge solenoid valve from the bracket.

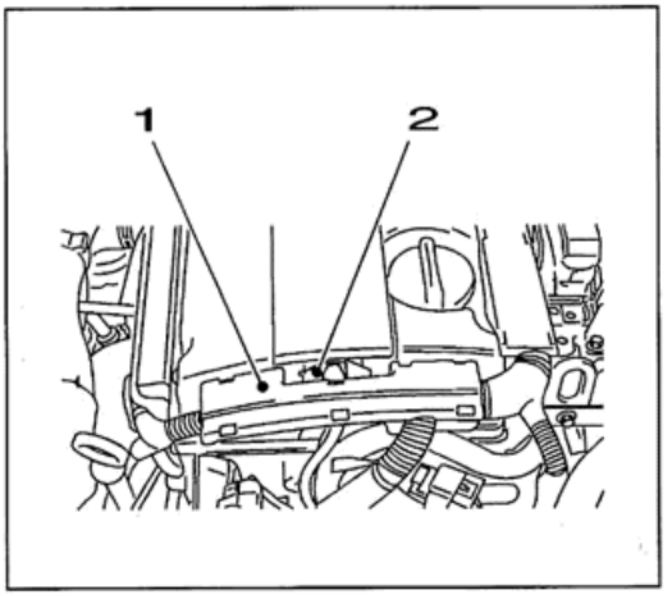
Ignition Coil Replacement

Special Tools

EN–6009 Remover and Installer Ignition Coil

For equivalent regional tools, refer to *Special Tools on page 9-593*.

Removal Procedure

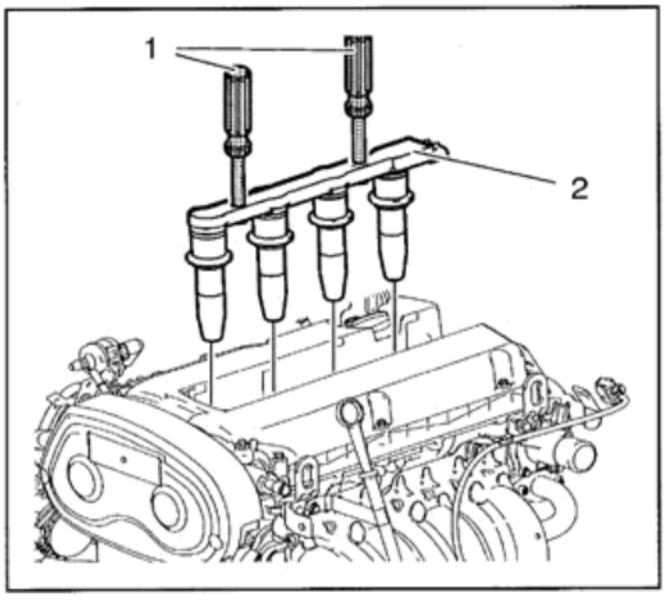


1937023

1. Remove the engine wiring harness guide (1) from the cylinder head.
2. Disconnect the ignition coil electrical connector (2).

Note: Note the arrow on the cover.

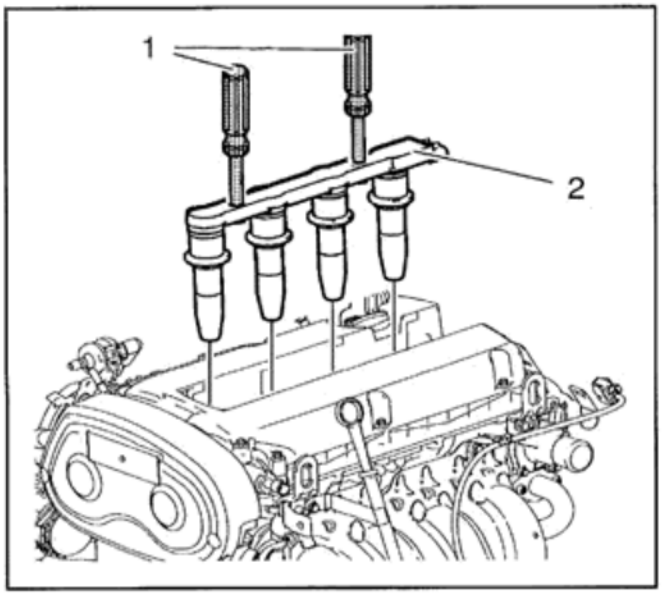
3. Remove the cover of the ignition coil in the direction of the arrow.
4. Remove the ignition coil bolts.



2026537

5. Install the *EN–6009* remover/installer (1).
6. Remove the ignition coil (2).
7. Remove the *EN–6009* remover/installer (1).

Installation Procedure

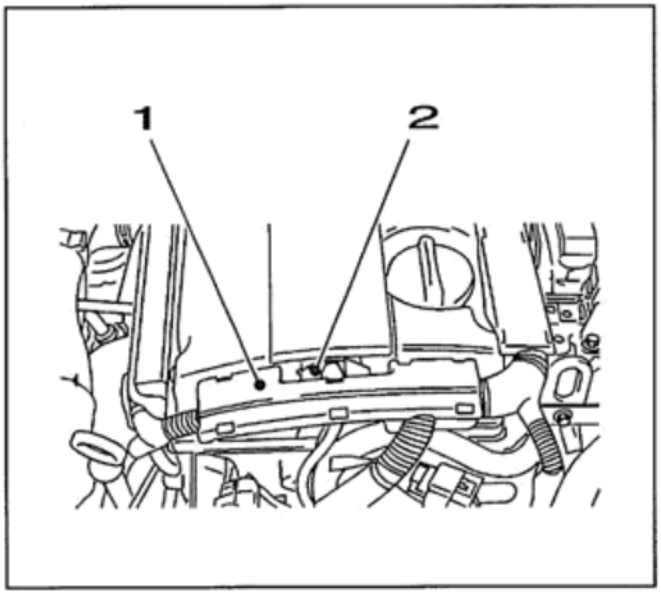


2026537

1. Install the *EN–6009* remover/installer (1).
2. Install the ignition coil (2).
3. Remove the *EN–6009* remover/installer (1).
4. Install the ignition coil fasteners an tighten to **8 N•m (71 lb in)**.

Note: Note the arrow on the cover.

5. Install the ignition coil cover in the opposite direction of the arrow.



1937023

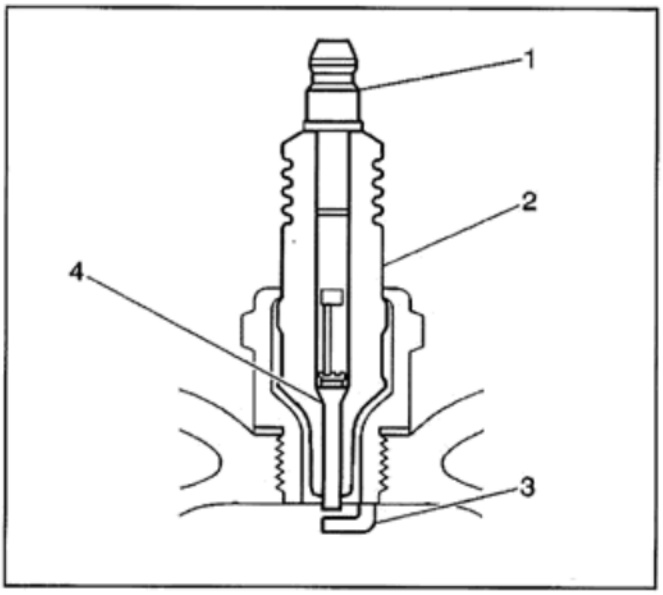
6. Connect the ignition coil electrical connector (2).
7. Install the engine wiring harness guide (1) at the cylinder head.

Spark Plug Inspection

Spark Plug Usage

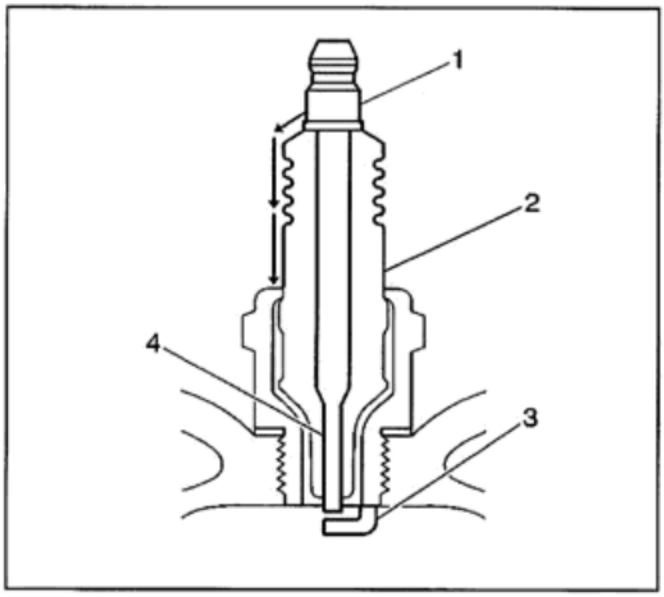
1. Ensure that the correct spark plug is installed. An incorrect spark plug causes driveability conditions. Refer to the Electronic Parts Catalog.
2. Ensure that the spark plug has the correct heat range. An incorrect heat range causes the following conditions:
   - Spark plug fouling—Colder plug
   - Pre-ignition causing spark plug and/or engine damage—Hotter plug

Spark Plug Inspection



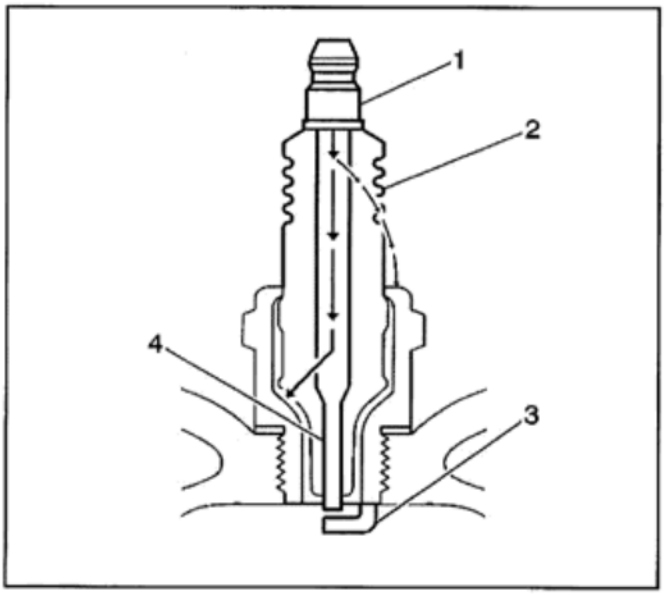
622530

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.



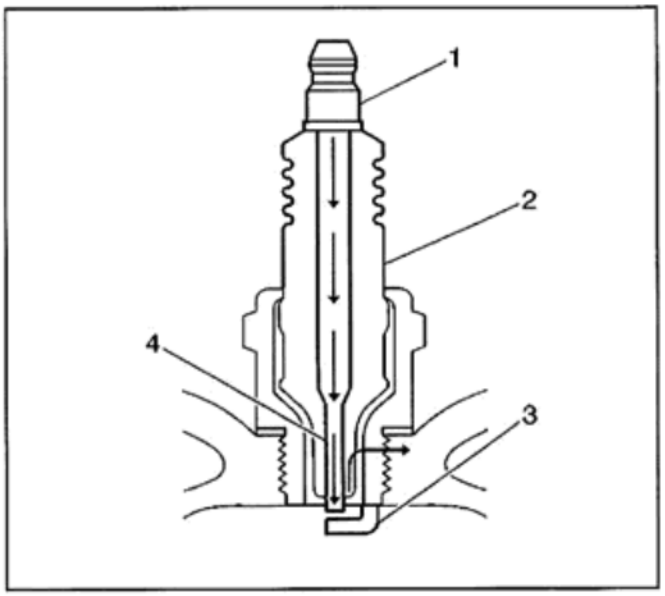
622529

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).



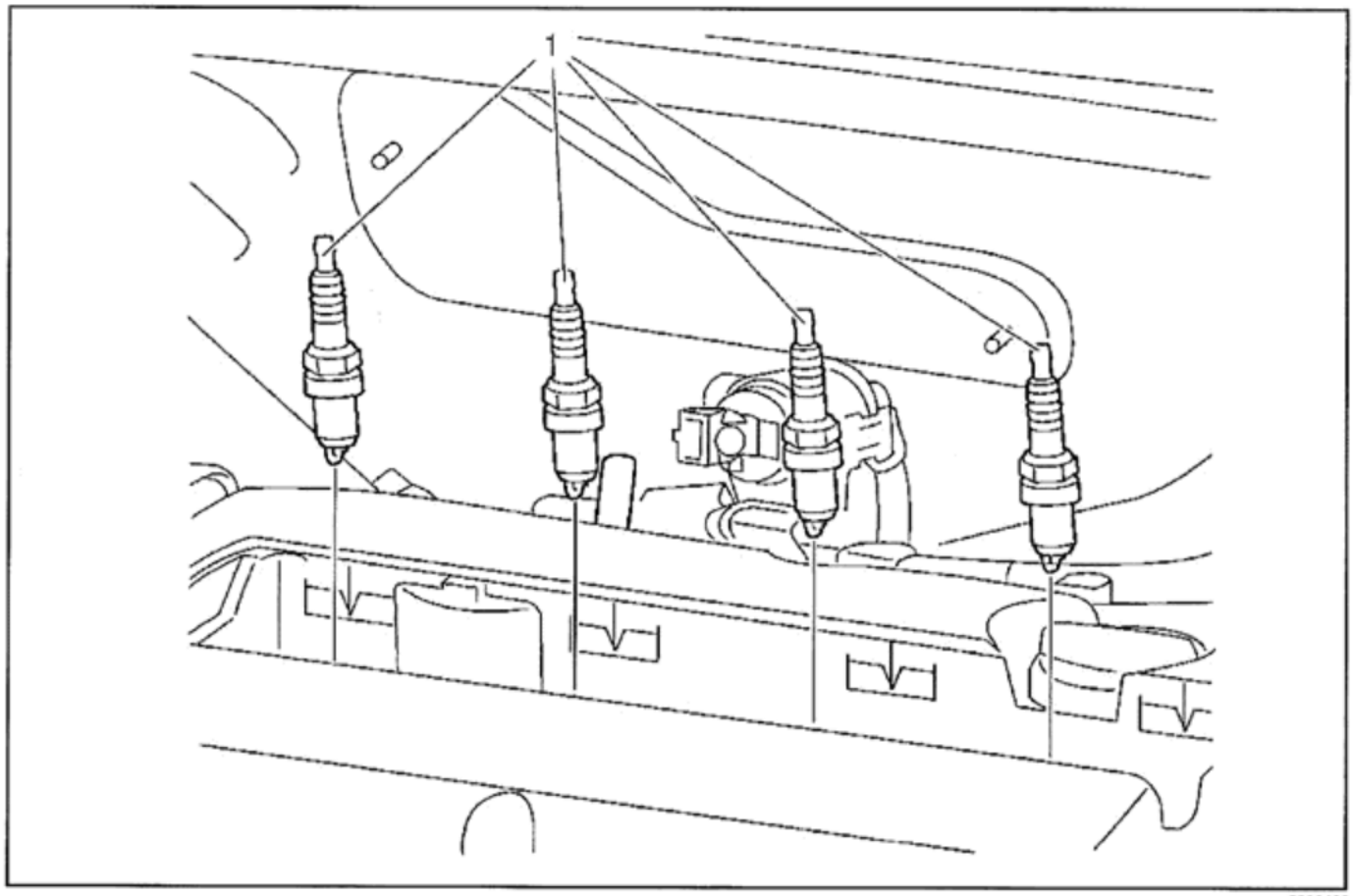
622527

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

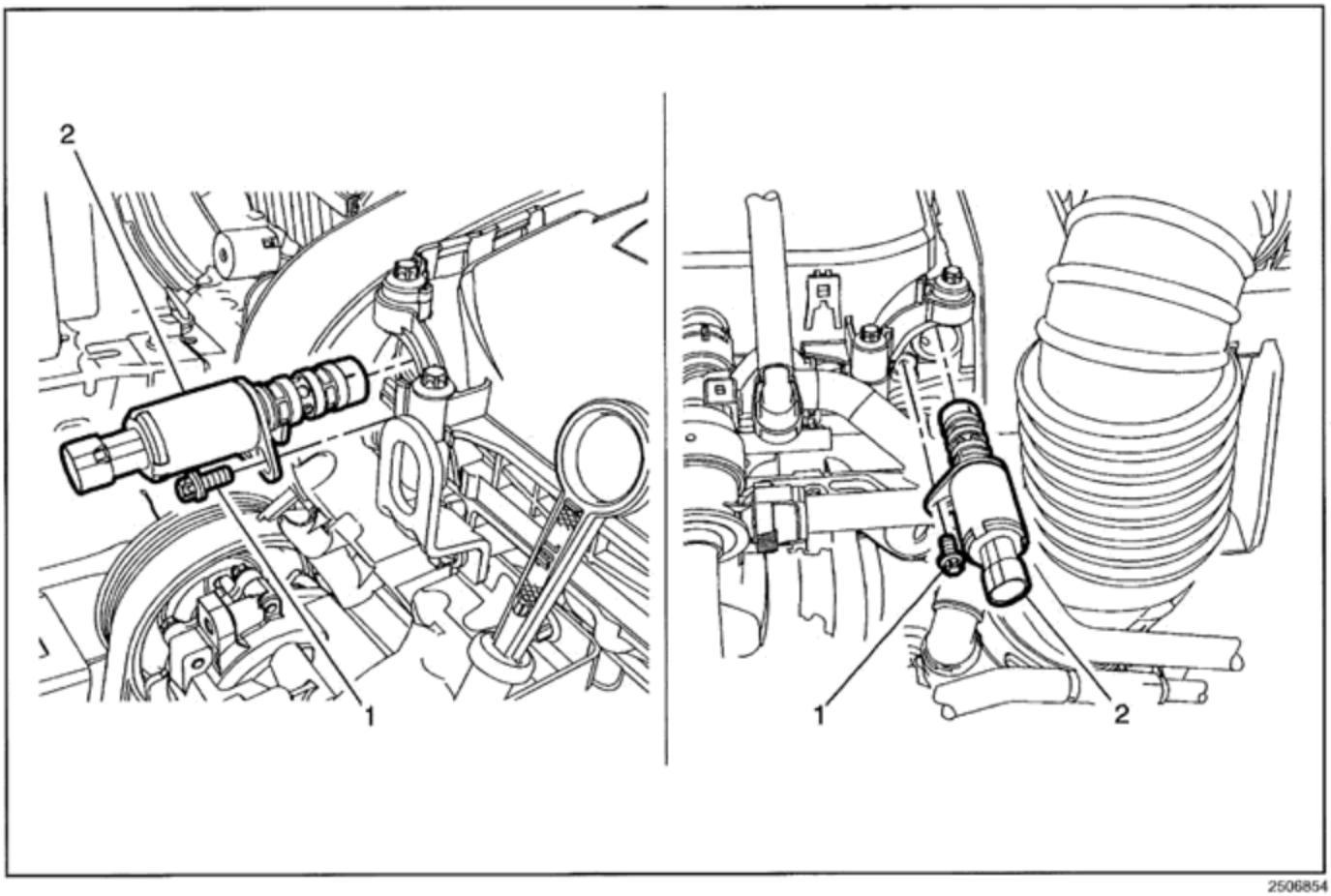


2020163

Spark Plug Replacement

Callout	Component Name
Preliminary Procedure Remove the ignition coil. Refer to *Ignition Coil Replacement on page 9-570*.	
1	Spark Plug **Caution:** Refer to *Component Fastener Tightening Caution on page 0-8*. **Tighten** 25 N•m (18 lb ft)

Camshaft Position Actuator Solenoid Valve Replacement

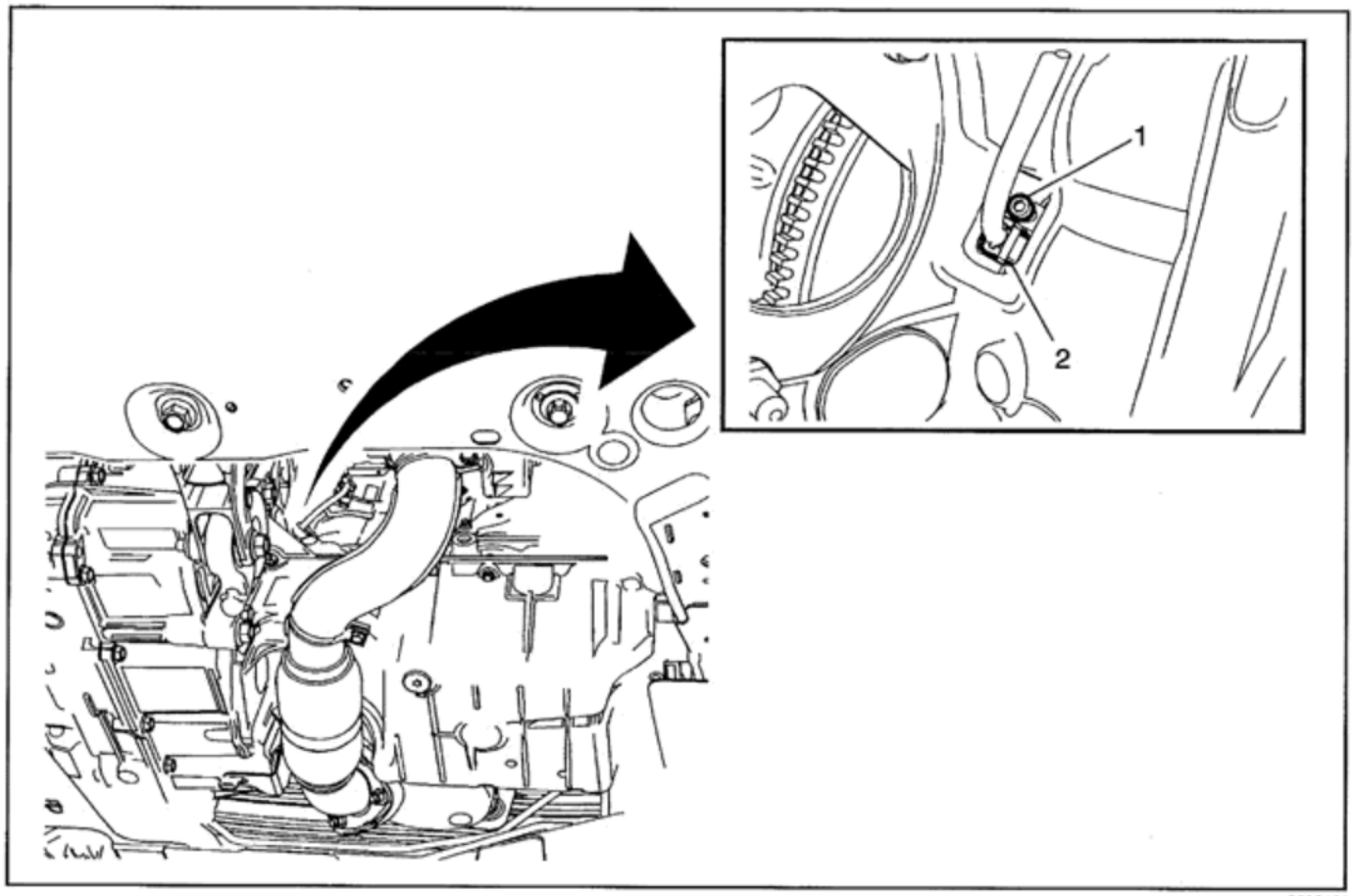


2506854

Camshaft Position Actuator Solenoid Valve Replacement

Callout	Component Name
1	Camshaft Position Actuator Solenoid Valve Fastener (Qty: 2) **Caution:** Refer to *Fastener Caution on page 0-8*. **Tighten** 6 N•m (53 lb in)
2	Camshaft Position Actuator Solenoid Valve (Qty: 2) **Procedure** Disconnect the electrical wiring harness connector from the camshaft position actuator solenoid valve. **Note:** • Coat the camshaft position actuator solenoid valve seals with NEW engine oil. • Replace only the intake or the exhaust camshaft position actuator solenoid valve if necessary.

Crankshaft Position Sensor Replacement

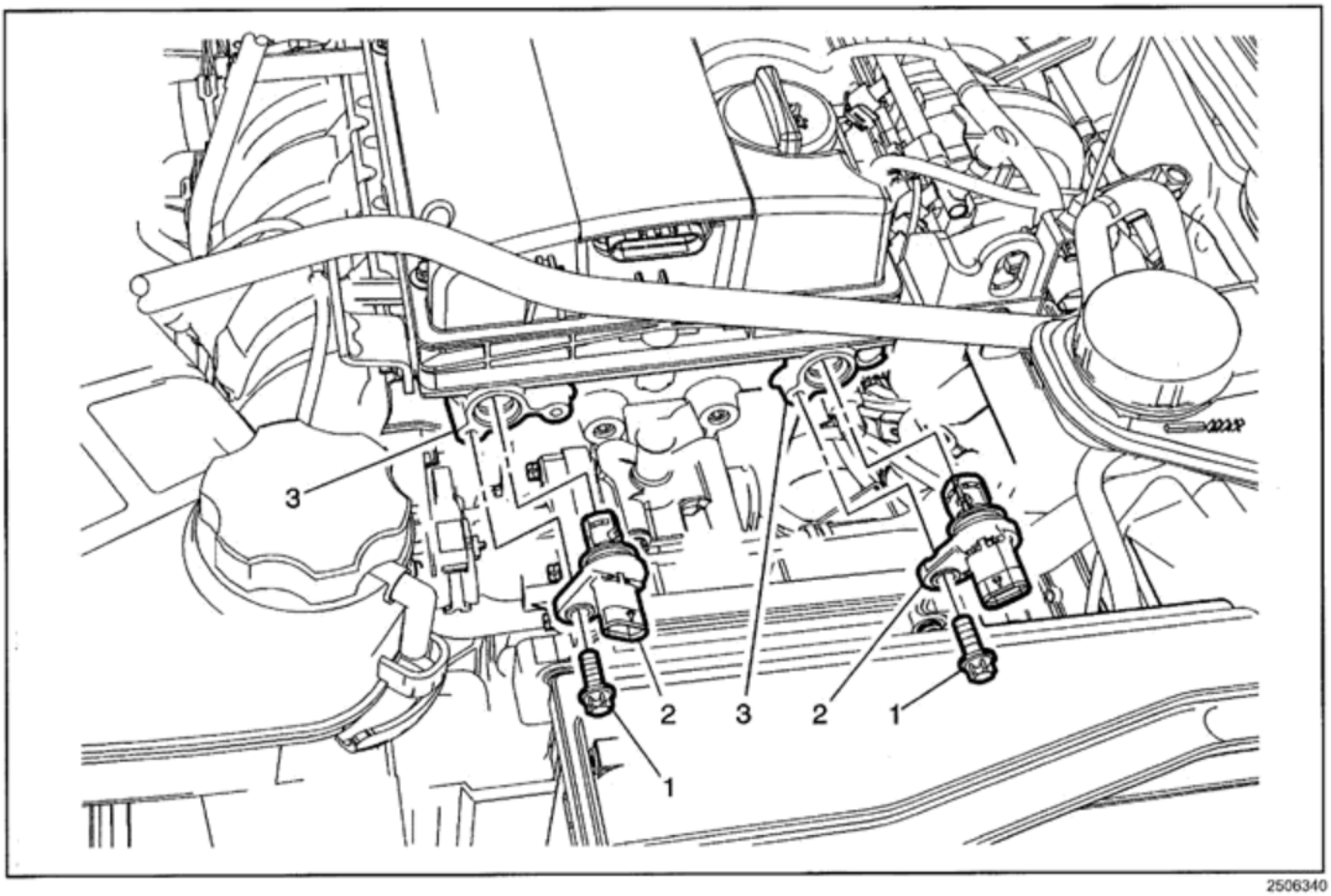


2506181

Crankshaft Position Sensor Replacement

Callout	Component Name
Preliminary Procedure Remove the starter motor. Refer to *Starter Replacement (LUW) on page 9-722* or *Starter Replacement (LUV) on page 9-724*.	
1	Crankshaft Position Sensor Fastener **Caution:** Refer to *Fastener Caution on page 0-8*. **Procedure** Remove the crankshaft position sensor bolt **Tighten** 4.5 N•m (40 lb in)
2	Crankshaft Position Sensor **Procedure** Disconnect the electrical wiring harness connector from the crankshaft position sensor.

Camshaft Position Sensor Replacement



2506340

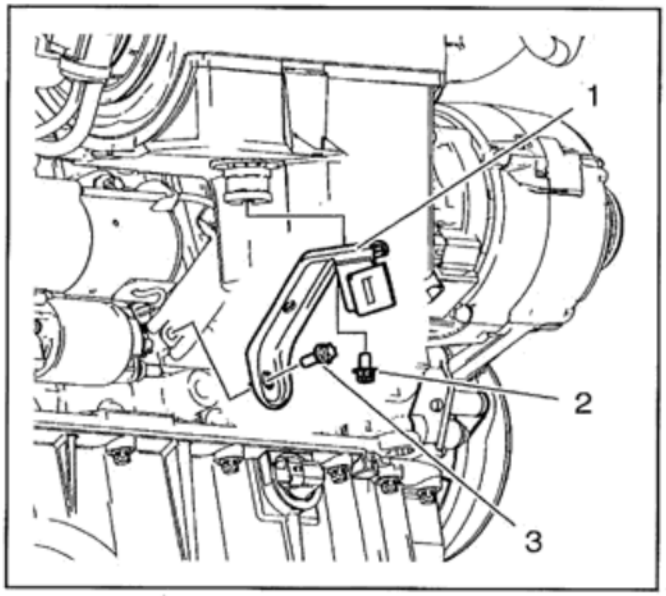
Camshaft Position Sensor Replacement

Callout	Component Name
1	Camshaft Position Sensor Fastener **Caution:** Refer to *Fastener Caution on page 0-8.* **Tighten** 6 N•m (54 lb in)
2	Camshaft Position Sensor **Procedure** Disconnect electrical wiring harness connector from the camshaft position sensor.
3	Remove the Camshaft Position Sensor Seal Ring

Knock Sensor Replacement

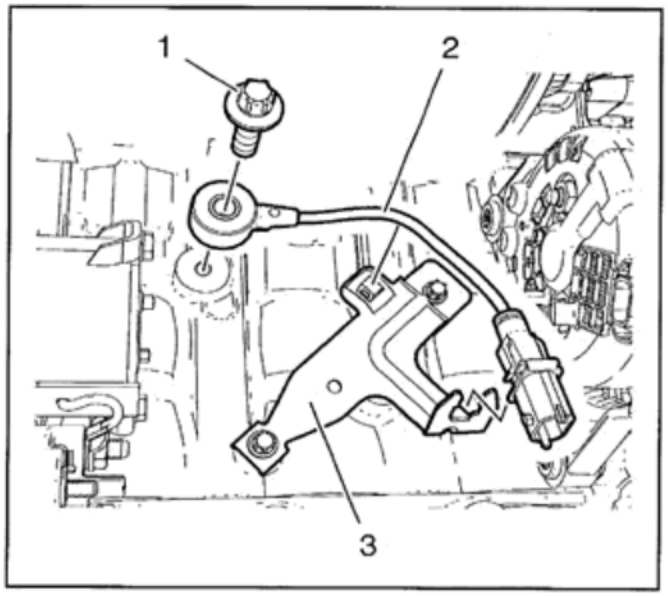
Removal Procedure

1. Disconnect the negative cable from the battery. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.



2026538

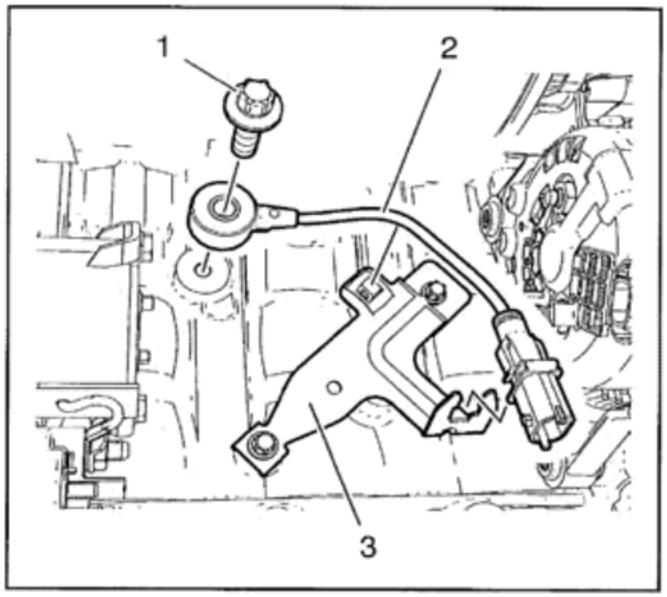
2. Remove the 2 intake manifold bracket bolts (2, 3).
3. Unclip the wiring harness.
4. Remove the intake manifold bracket (1).



2189291

5. Remove the sensor bolt (1).
6. Disconnect the electrical wiring harness connector.
7. Remove the knock sensor (2) from the bracket (3).

Installation Procedure

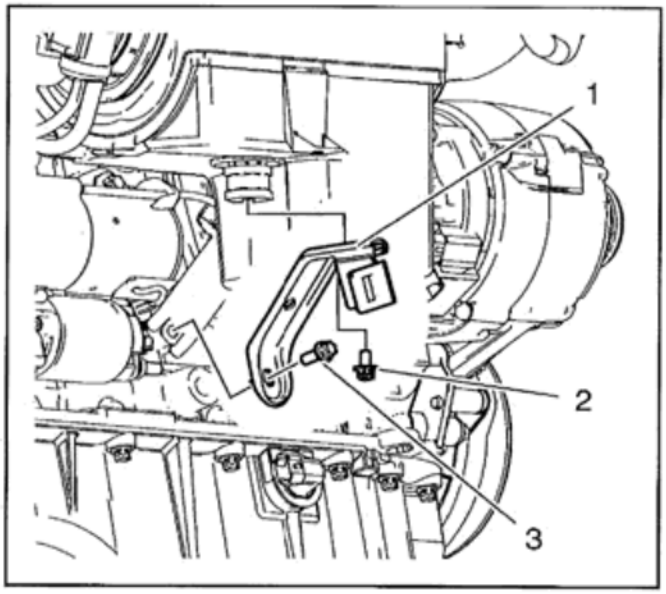


2189291

1. Install the knock sensor (2) to the bracket (3).

Caution: Refer to *Fastener Caution on page 0-8*

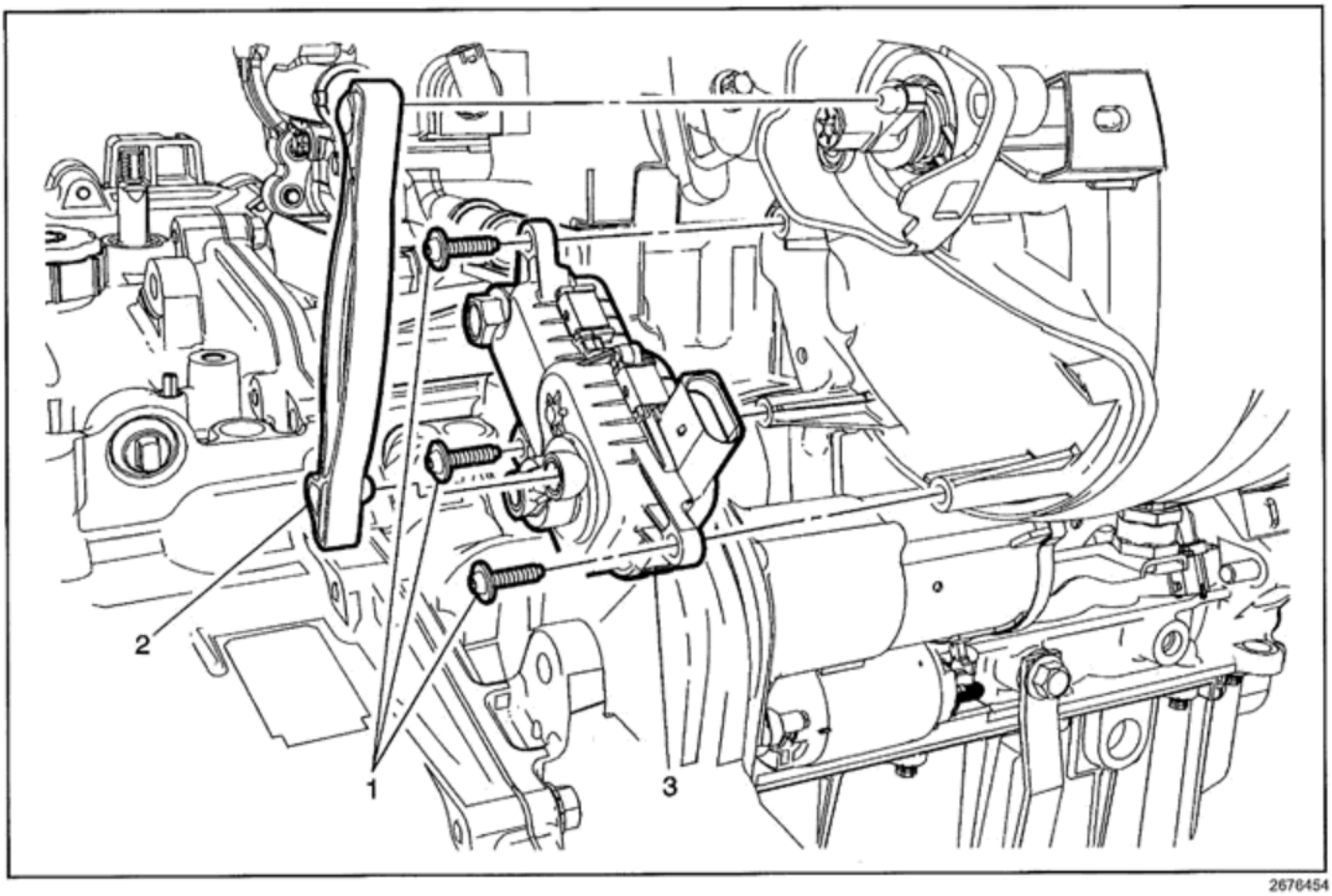
2. Install the sensor bolt (1) and tighten to **20** N•m **(15 lb ft)**.
3. Connect the electrical wiring harness connector.



2026538

4. Install the intake manifold bracket (1).
5. Clip in the wiring harness to the bracket.
6. Install the 2 intake manifold bracket bolts (2, 3) and tighten to **8** N•m **(71 lb in)**.
7. Connect the negative cable to the battery. Refer to *Battery Negative Cable Disconnection and Connection on page 9-713*.

Intake Manifold Tuning Valve Actuator Replacement



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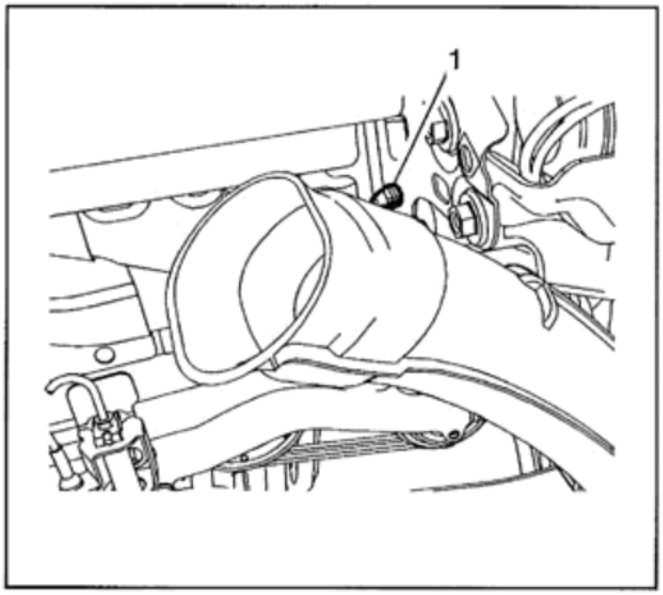
Intake Manifold Tuning Valve Actuator Replacement

Callout	Component Name
Preliminary Procedure Properly raise and support the vehicle. Refer to *Lifting and Jacking the Vehicle on page 1-31*.	
1	Intake Manifold Runner Control Valve Actuator Solenoid Valve Fastener (Qty: 3) **Caution:** Refer to *Fastener Caution on page 0-8*. **Tighten** 6 N•m (53 lb in)
2	Intake Manifold Runner Control Valve Actuator Solenoid Linkage
3	Intake Manifold Runner Control Valve Actuator Solenoid **Procedure** Disconnect the wiring harness electrical connector from the intake manifold runner control valve actuator solenoid.

Air Cleaner Inlet Duct Replacement

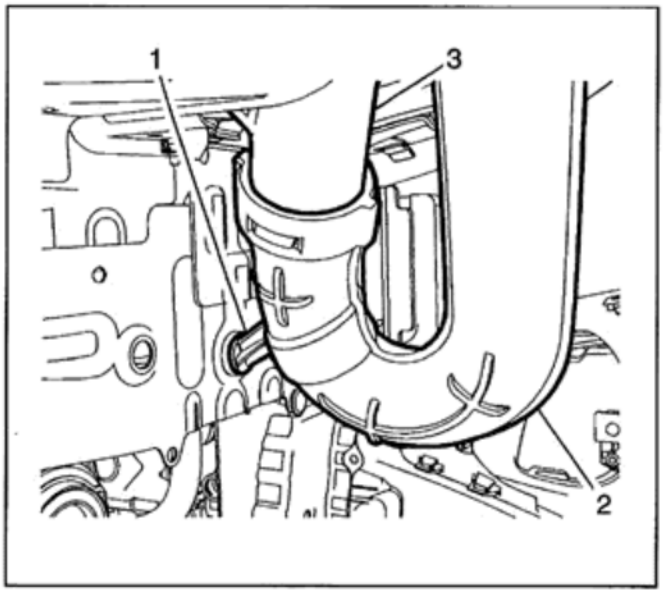
Removal Procedure

1. Remove the front bumper fascia. Refer to *Front Bumper Fascia Replacement on page 3-55.*



2498132

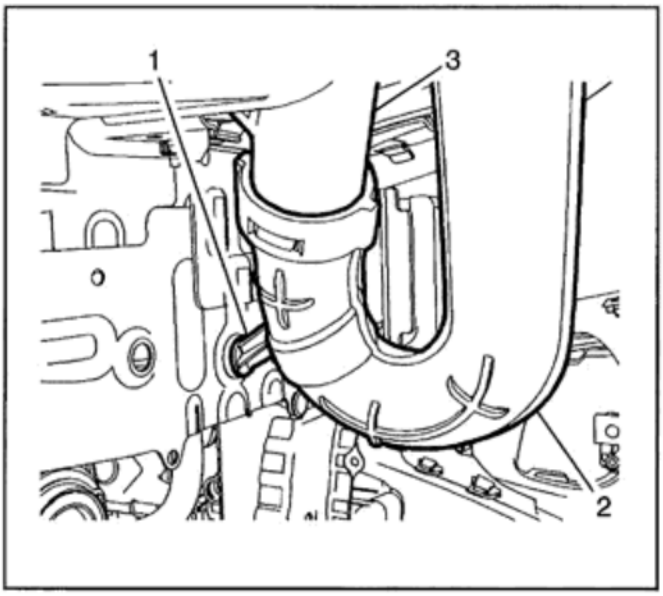
2. Remove the upper intake air duct plastic fastener (1).



2498133

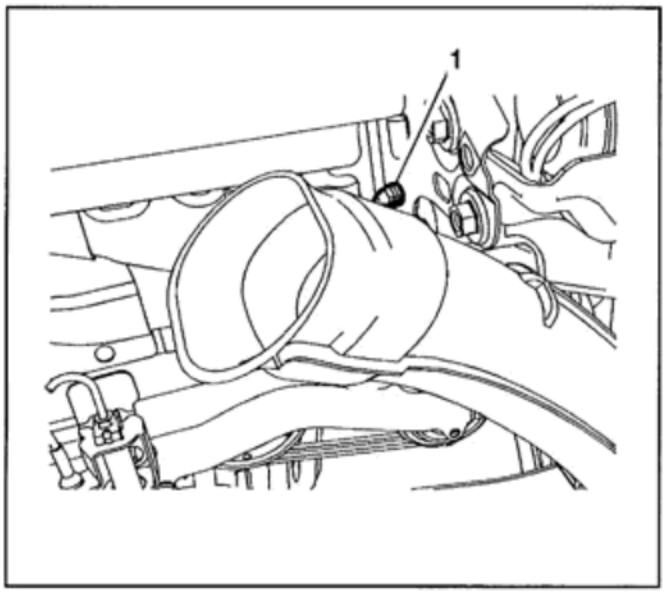
3. Pull the lower portion of the intake air duct outward to release the duct from the rubber mounting grommet (1).
4. Pull downward to separate the lower portion of the intake air duct (2) from the upper duct (3).

Installation Procedure



2498133

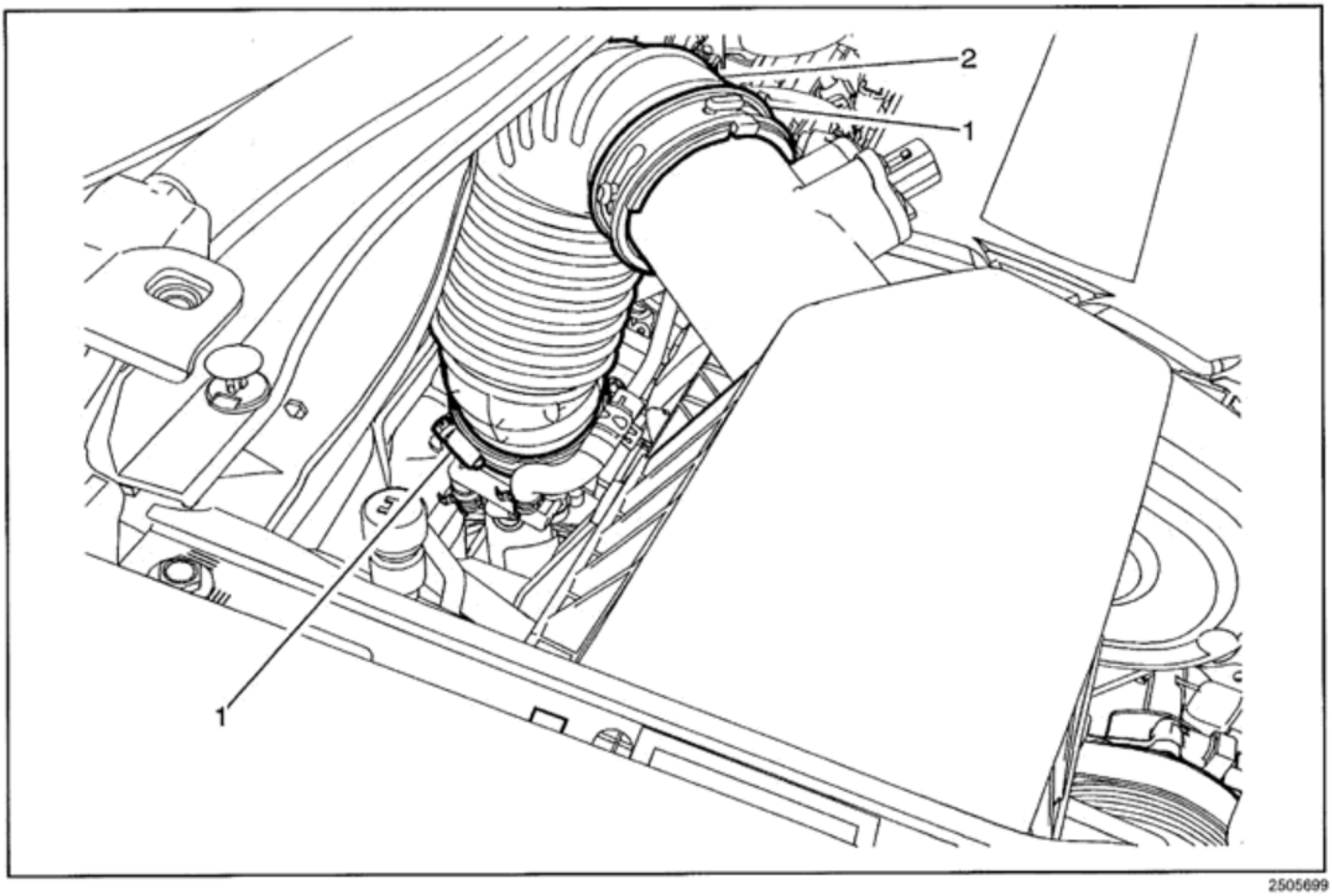
1. Attach the lower portion of the intake air duct (2) to the upper duct (3).
2. Attach the lower portion of the intake air duct to the rubber mounting grommet (1).



2498132

3. Install the upper intake air duct plastic fastener (1) to the body bracket.
4. Install the front bumper fascia. Refer to *Front Bumper Fascia Replacement on page 3-55.*

Air Cleaner Outlet Duct Replacement

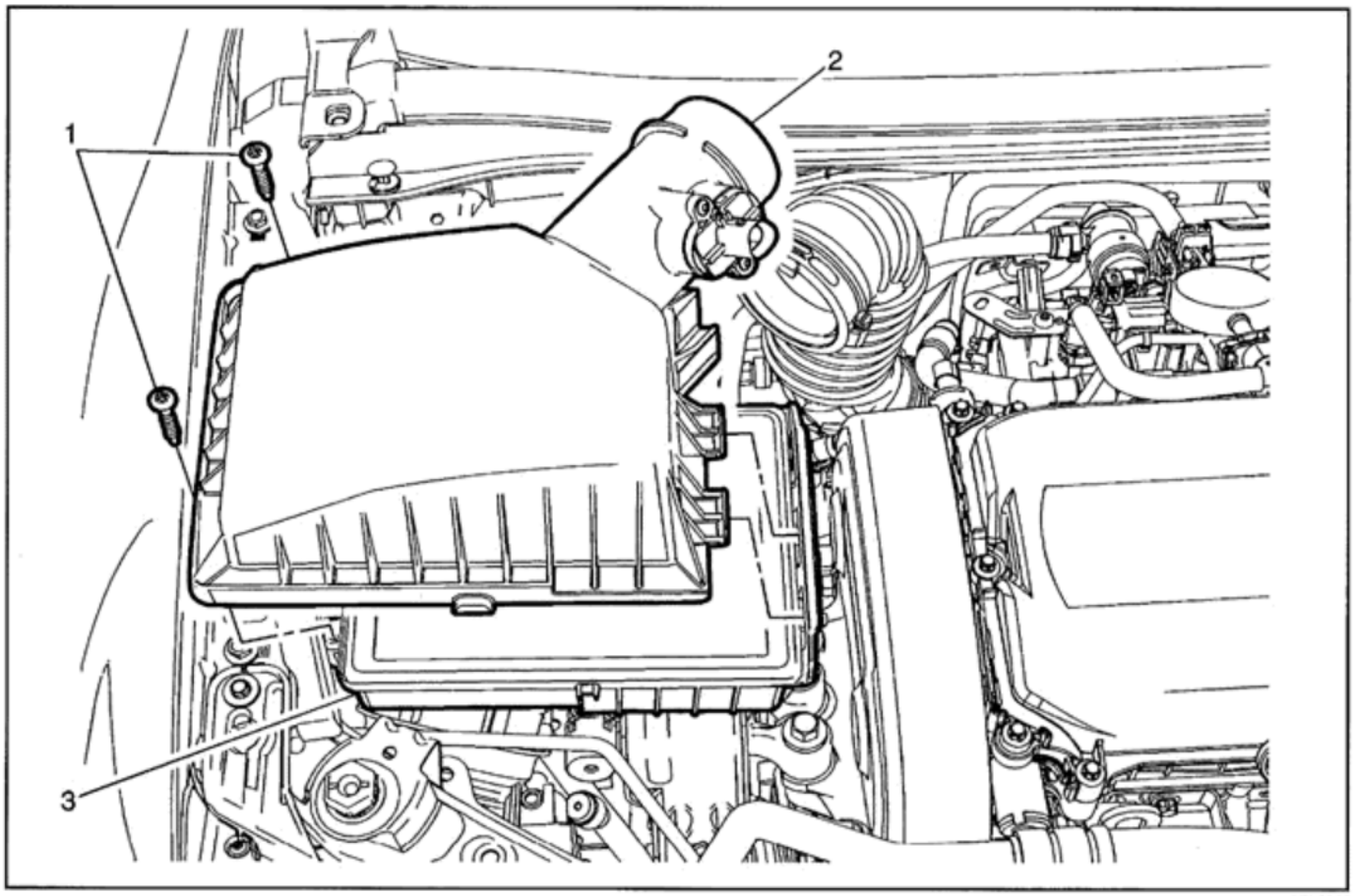


2505699

Air Cleaner Outlet Duct Replacement

Callout	Component Name
1	Air Cleaner Outlet Duct Clamps (Qty 2) **Caution:** Refer to *Fastener Caution on page 0-8.*
2	Air Cleaner Outlet Duct

Air Cleaner Element Replacement

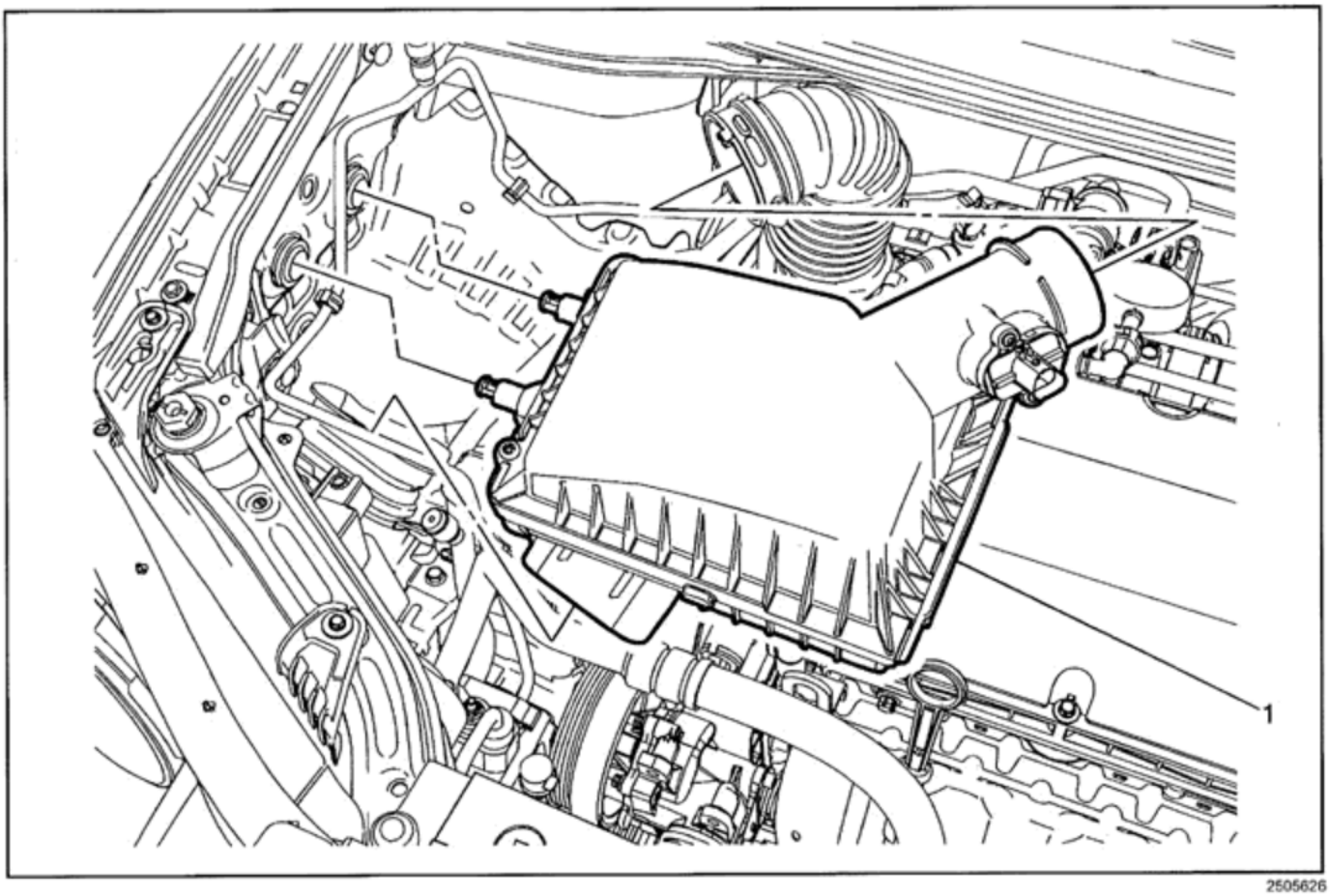


2505628

Air Cleaner Element Replacement

Callout	Component Name
Preliminary Procedure Remove the air cleaner outlet duct. Refer to *Air Cleaner Outlet Duct Replacement on page 9-580*.	
1	Air Cleaner Housing Fasteners (Qty 2) **Caution:** Refer to *Fastener Caution on page 0-8*. **Tighten** 5 N•m(44 lb in)
2	Air Cleaner Housing **Procedure** Disconnect the electrical wiring harness connector from the Mass Airflow Sensor.
3	Air Cleaner Element

Air Cleaner Assembly Replacement



2505626

Air Cleaner Assembly Replacement

Callout	Component Name
Preliminary Procedure Remove the air cleaner outlet duct. Refer to *Air Cleaner Outlet Duct Replacement on page 9-580*.	
1	Air Cleaner Assembly **Procedure** Pull the air cleaner assembly upward and away from the right inner fender to separate the assembly from the rubber grommets.

Description and Operation

Engine Control Module Description

The Engine Control Module (ECM) interacts with many emission related components and systems, and monitors emission related components and systems for deterioration. OBD II diagnostics monitor the system performance and a diagnostic trouble code (DTC) sets if the system performance degrades. The ECM is part of a network and communicates with various other vehicle control modules.

Malfunction indicator lamp (MIL) operation and DTC storage are dictated by the DTC type. A DTC is ranked as a Type A or Type B if the DTC is emissions related. Type C is a non-emissions related DTC.

The ECM is the control center of the engine controls system. Review the components and wiring diagrams in order to determine which systems are controlled by the ECM.

The ECM constantly monitors the information from various sensors and other inputs, and controls the systems that affect engine performance and emissions. The ECM also performs diagnostic tests on various parts of the system and can turn on the MIL when it recognizes an operational problem that affects emissions. When the ECM detects a malfunction, the ECM stores a DTC. The condition area is identified by the particular DTC that is set. This aids the technician in making repairs.

ECM Function

The ECM can supply 5 V or 12 V to various sensors or switches. This is done through pull-up resistors to regulated power supplies within the ECM. In some cases, even an ordinary shop voltmeter will not give an accurate reading due to low input resistance. Therefore, a digital multimeter (DMM) with at least 10 megaohms input impedance is required in order to ensure accurate voltage readings.

The ECM controls the output circuits by controlling the ground or the power feed circuit through transistors or a device called an output driver module.

EEPROM

The electronically erasable programmable read only memory (EEPROM) is an integral part of the ECM. The EEPROM contains program and calibration information that the ECM needs in order to control engine operation.

Special equipment, as well as the correct program and calibration for the vehicle, are required in order to reprogram the ECM.

Data Link Connector (DLC)

The data link connector (DLC) provides serial data communication for ECM diagnosis. This connector allows the technician to use a scan tool in order to monitor various serial data parameters, and display DTC information. The DLC is located inside the driver's compartment, underneath the instrument panel.

Malfunction Indicator Lamp (MIL)

The malfunction indicator lamp (MIL) is inside the instrument panel cluster (IPC). The MIL is controlled by the ECM and illuminates when the ECM detects a condition that affects vehicle emissions.

ECM Service Precautions

The ECM, by design, can withstand normal current draws that are associated with vehicle operations. However, care must be used in order to avoid overloading any of these circuits. When testing for opens or shorts, do not ground or apply voltage to any of the ECM circuits unless the diagnostic procedure instructs you to do so. These circuits should only be tested with a DMM unless the diagnostic procedure instructs otherwise.

Emissions Diagnosis For State I/M Programs

This OBD II equipped vehicle is designed to diagnose any conditions that could lead to excessive levels of the following emissions:

- Hydrocarbons (HC)
- Carbon monoxide (CO)
- Oxides of nitrogen (NOx)
- Evaporative emission (EVAP) system losses

Should this vehicle's on-board diagnostic system (ECM) detect a condition that could result in excessive emissions, the ECM turns ON the MIL and stores a DTC that is associated with the condition.

Aftermarket (Add-On) Electrical And Vacuum Equipment

Caution: Do not attach add-on vacuum operated equipment to this vehicle. The use of add-on vacuum equipment may result in damage to vehicle components or systems.

Caution: Connect any add-on electrically operated equipment to the vehicle's electrical system at the 12 V battery (power and ground) in order to prevent damage to the vehicle.

Aftermarket, add-on, electrical and vacuum equipment is defined as any equipment installed on a vehicle after leaving the factory that connects to the vehicle's electrical or vacuum systems. No allowances have been made in the vehicle design for this type of equipment.

Add-on electrical equipment, even when installed to these strict guidelines, may still cause the powertrain system to malfunction. This may also include equipment not connected to the vehicle electrical system, such as portable telephones and radios. Therefore, the first step in diagnosing any powertrain condition is to eliminate all of the aftermarket electrical equipment from the vehicle. After this is done, if the problem still exists, the problem may be diagnosed in the normal manner.

Electrostatic Discharge (ESD) Damage

Note: In order to prevent possible electrostatic discharge damage to the ECM, DO NOT touch the connector pins on the ECM.

The electronic components that are used in the control systems are often designed to carry very low voltage. These electronic components are susceptible to damage caused by electrostatic discharge. Less than 100 V of static electricity can cause damage to some electronic components. By comparison, it takes as much as 4,000 V for a person to even feel a static discharge.

There are several ways for a person to become statically charged. The most common methods of charging are by friction and by induction. An example of charging by friction is a person sliding across a car seat.

Charging by induction occurs when a person with well insulated shoes stands near a highly charged object and momentarily touches ground. Charges of the same polarity are drained off leaving the person highly charged with the opposite polarity. Static charges can cause damage, therefore, it is important to use care when handling and testing electronic components.

Emissions Control Information Label

The underhood Vehicle Emissions Control Information Label contains important emission specifications. This identifies the year, the displacement of the engine in liters, and the class of the vehicle.

This label is located in the engine compartment of every General Motors vehicle. If the label has been removed, it can be ordered from GM service parts operations (GMSPO).

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.

Flex Fuel Sensor (If Equipped)

The flex fuel sensor measures the ethanol-gasoline ratio of the fuel being used in a flexible fuel vehicle. Flexible fuel vehicles can be operated with a blend of ethanol and gasoline, up to 85 percent ethanol. In order to adjust the ignition timing and the fuel quantity to be injected, the engine management system requires information about the percentage of ethanol in the fuel.

The flex fuel sensor uses quick-connect style fuel connections, an incoming fuel connection, and an outgoing fuel connection. All fuel passes through the flex fuel sensor before continuing on to the fuel rail. The flex fuel sensor measures the fuel alcohol content, and sends an electrical signal to the engine control module (ECM) to indicate ethanol percentage.

The flex fuel sensor has a three-wire electrical harness connector. The three wires provide a ground circuit, a power source, and a signal output to the ECM. The power source is battery positive voltage and the ground circuit connects to an engine ground. The signal circuit carries the ethanol percentage via a frequency signal.

The flex fuel sensor uses a microprocessor inside the sensor to measure the ethanol percentage and changes the output signal accordingly. The ECM provides an internal pull-up to 5 V on the signal circuit, and the flex fuel sensor pulls the 5 V to ground in pulses. The normal range of operating frequency is between 50 and 150 Hz, with 50 Hz representing 0 percent ethanol, and 150 Hz representing 100 percent ethanol.

The microprocessor inside the sensor is capable of a certain amount of self-diagnosis. An output frequency between 180 Hz and 190 Hz indicates that the fuel is contaminated. Certain substances dissolved in the fuel can cause the fuel to be contaminated, raising the output frequency higher than the actual ethanol percentage should indicate. Examples of these substances include water, sodium chloride (salt), and methanol.

It should be noted that it is likely that the flex fuel sensor will indicate a slightly lower ethanol percentage than what is advertised at the fueling station. This is not a fault of the sensor. The reason has to do with government requirements for alcohol-based motor fuels. Government regulations require that alcohol intended for use as motor fuel be denatured. This means that 100 percent pure ethanol is first denatured with approximately 4½ percent gasoline, before being mixed with anything else. When an ethanol gasoline mixture is advertised as E85, the 85 percent ethanol was denatured before being blended with gasoline, meaning an advertised E85 fuel contains only about 81 percent ethanol. The flex fuel sensor measures the actual percentage of ethanol in the fuel.

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 fuel filter
- 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 Pulse Dampener

The fuel pulse dampener is a part of the front fuel feed pipe. The fuel pulse dampener is diaphragm-operated with fuel pump pressure on one side and with spring pressure on the other side. The function of the dampener is to dampen the fuel pump pressure pulsations.

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:

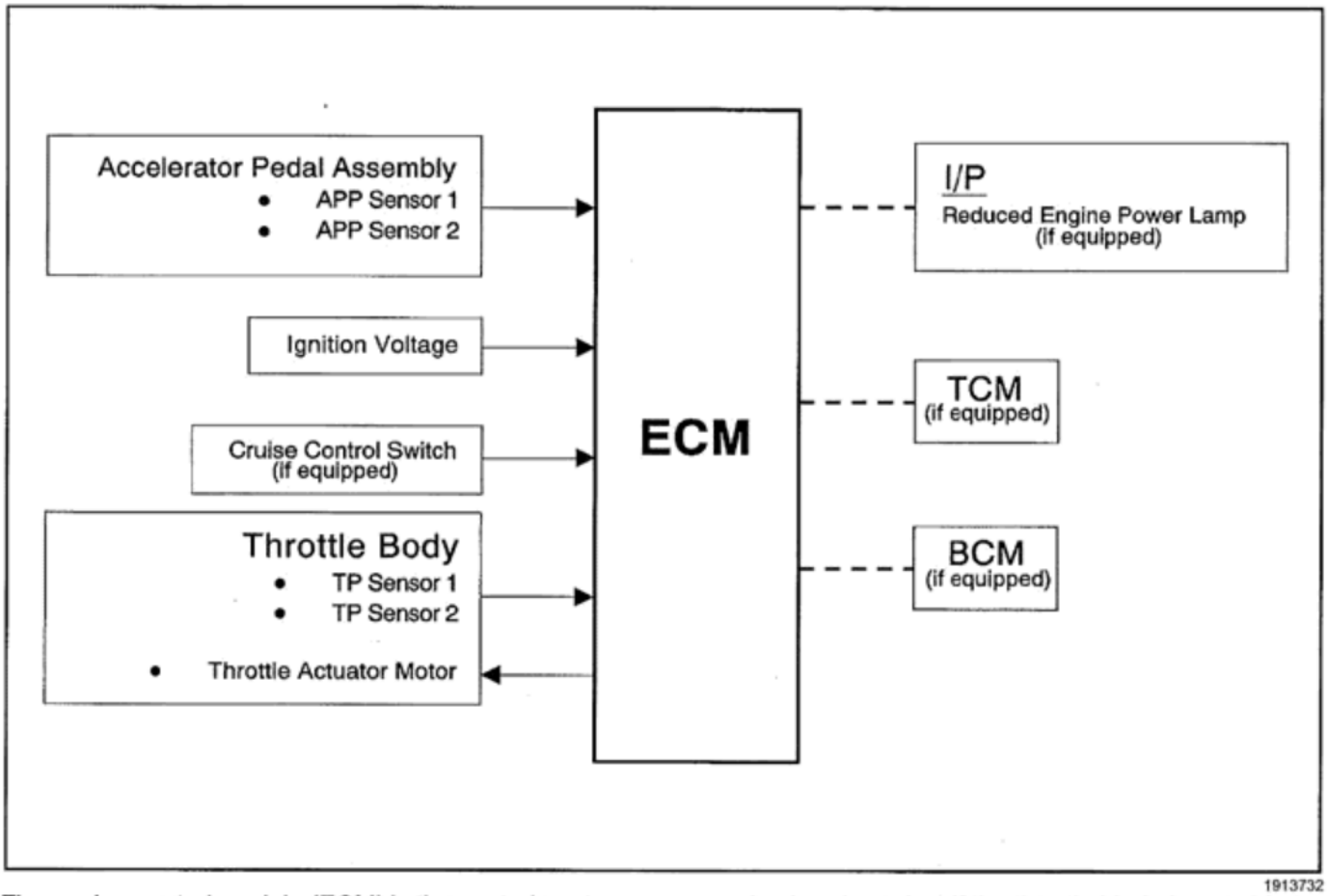
- The ignition is OFF. This prevents engine run-on.
- The ignition is ON but there is no ignition reference signal. This prevents flooding or backfiring.
- The engine speed is too high, above red line.
- The vehicle speed is too high, above rated tire speed.
- During an extended, high speed, closed throttle 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).

Throttle Actuator Control (TAC) System Description



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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.

Camshaft Actuator System Description

Circuit/System Description

The camshaft position actuator solenoid valve – intake and camshaft position actuator solenoid valve – exhaust system enables the engine control module (ECM) to change camshaft timing while the engine is running. The camshaft position actuator assembly varies camshaft position in response to directional changes in oil pressure. The camshaft position actuator solenoid valve – intake and camshaft position actuator solenoid valve – exhaust controls the oil pressure that is applied to advance or retard the camshaft. Modifying camshaft timing under changing engine demand provides better balance between the following performance concerns:

- Engine power output
- Fuel economy
- Lower exhaust emissions

The camshaft position actuator solenoid valve – intake and camshaft position actuator solenoid valve – exhaust is controlled by the ECM. The crankshaft position sensor and the camshaft position sensor – intake and camshaft position sensor – exhaust are used to monitor changes in camshaft position. The ECM uses information from the following sensors in order to calculate the desired camshaft position:

- The engine coolant temperature (ECT) sensor
- The manifold absolute pressure (MAP) sensor
- The throttle position sensor
- The vehicle speed sensor (VSS)

Camshaft Position Actuator System Operation

The ECM operates the camshaft position actuator solenoid valve – intake and camshaft position actuator solenoid valve – exhaust by pulse width modulation (PWM) of the solenoid coil. The higher the PWM duty cycle, the larger the change in camshaft timing. Oil pressure that is applied to the advance side of the fixed vanes will rotate the camshaft in a clockwise direction. The clockwise movement of the camshaft will advance the timing up to a maximum of 21°. When oil pressure is applied to the return side of the vanes, the camshaft will rotate counterclockwise until returning to 0°.

Oil flowing to the camshaft position actuator solenoid valve – intake and camshaft position actuator solenoid valve – exhaust housing from the camshaft position actuator solenoid valve – intake and camshaft position actuator solenoid valve – exhaust advance passage applies pressure to the advance side of the vane wheel in the camshaft position actuator assembly. At the same time the camshaft position actuator solenoid valve – intake and camshaft position actuator solenoid valve – exhaust retard passage is open, allowing oil pressure to decrease on the retard side of the vane wheel. These two simultaneous actions cause the vane wheel to rotate clockwise, advancing camshaft advance timing.

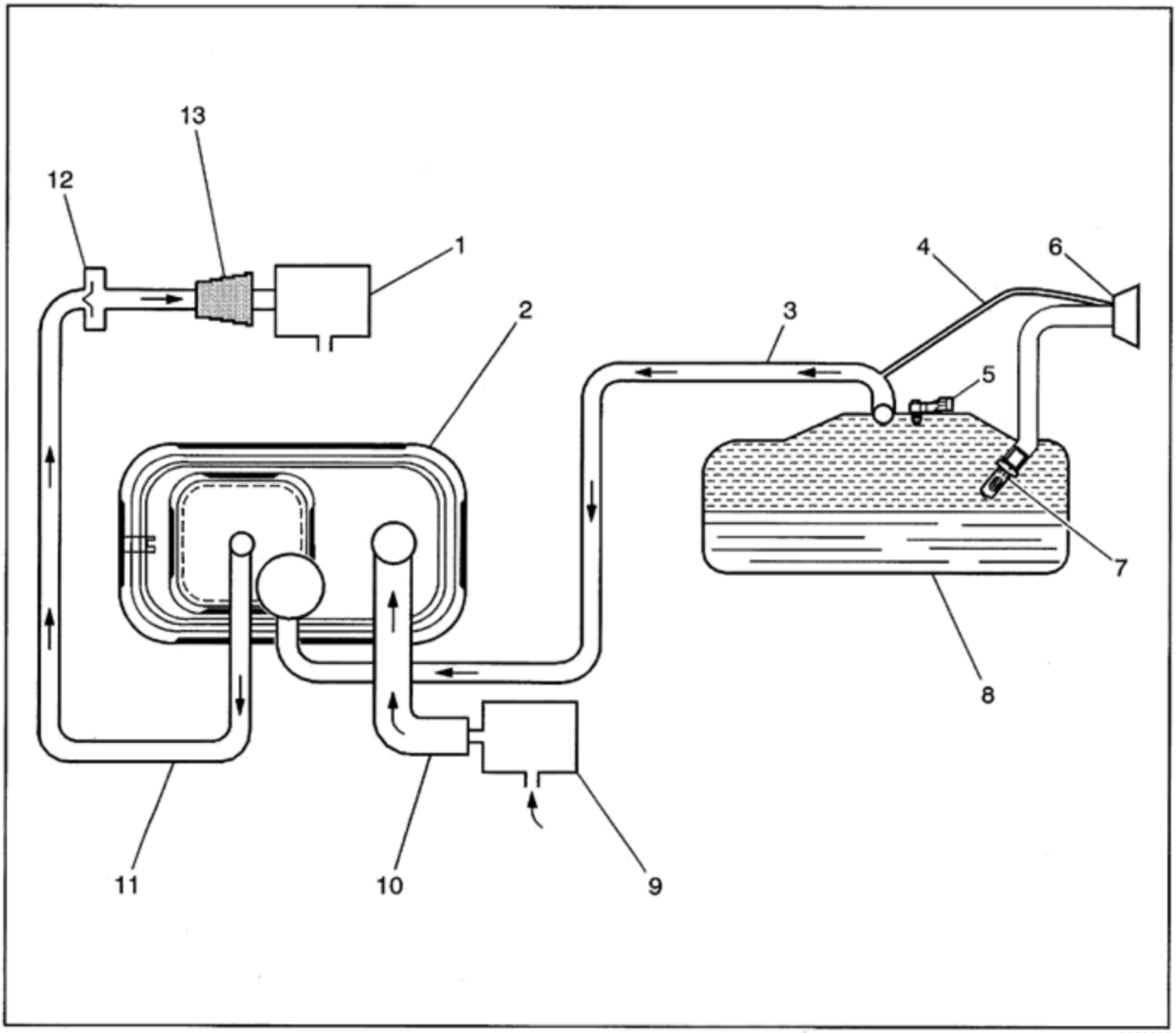
When the oil flowing to the camshaft position actuator solenoid valve – intake and camshaft position actuator solenoid valve – exhaust housing is from the camshaft position actuator solenoid valve – intake and camshaft position actuator solenoid valve – exhaust retard passage, oil pressure is applied to the retard side of the vane wheel. Because the solenoid advance passage is open, allowing oil pressure to decrease on the advance side of the vane wheel, the camshaft position retards.

The ECM can also command the camshaft position actuator solenoid valve – intake and camshaft position actuator solenoid valve – exhaust to stop oil flow from both passages in order to hold the current camshaft position. The ECM is continuously comparing camshaft position sensor – intake and camshaft position sensor – exhaust input with camshaft position actuator solenoid valve – intake and camshaft position actuator solenoid valve – exhaust input in order to monitor camshaft position and detect any system malfunctions. The following table provides camshaft phase commands for common driving conditions:

Driving Conditions	Change in Camshaft Position	Objective	Result
Idle	No change	Minimize valve overlap	Stabilize idle speed
Light engine load	Retard valve timing	Decrease valve overlap	Stable engine output
Medium engine load	Advance valve timing	Increase valve overlap	Better fuel economy with lower emissions
High engine speed with heavy load	Retard valve timing	Retard intake valve closing	Improve engine output

Evaporative Emission Control System Description

Typical Evaporative Emission (EVAP) System Hose Routing Diagram



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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.

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

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 2-wire sensors. The sensor uses piezo-electric crystal technology that produces an alternating current 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.

Air Intake System Description

Circuit/System Description

The primary function of the air intake system is to provide filtered air to the engine. The system uses a filter element mounted in a housing. The filter housing is remotely mounted and uses intake ducts to route the incoming air into the throttle body. The secondary function of the air intake system is to muffle air induction noise. This is achieved by the use of resonators attached to the air intake ducts. The resonators are tuned to the specific powertrain. The intake air temperature (IAT) sensor is used to measure the temperature of the air entering the engine.

Intake Manifold Tuning Solenoid Valve

The intake manifold tuning solenoid valve system uses variable air induction tuning in order to achieve maximum performance and efficiency over the entire operating range of the engine. The characteristic torque curve of a normally aspirated engine depends mainly on how the engines average pressure changes over the engine speed range. The average pressure is proportional to the volume of the air mass present in the cylinder when the inlet valve is closed. The design of the inlet system determines how large an air mass can be drawn into a cylinder at a given engine speed. An intake manifold tuning solenoid valve is used to change the intake manifold plenum configuration. When the intake manifold tuning solenoid valve is open, the intake manifold is configured to one large plenum. When the intake manifold tuning solenoid valve is closed, the intake manifold is configured to two smaller plenums. The two intake manifold plenum sizes result in different torque curves which improves performance at low and high engine speeds.

During low speed, high load conditions the intake manifold tuning solenoid valve is closed creating a longer runner path inside the plenum which increases torque. During higher engine speeds and loads, the intake manifold tuning solenoid valve opens creating a shorter runner path inside the plenum which increases horsepower. Ignition voltage is supplied to the intake manifold tuning solenoid valve solenoid through a fuse when the ignition key is turned ON. The intake manifold tuning solenoid valve solenoid is normally closed which will not allow vacuum to pass through it. When the engine speed and load are increased above a calibrated threshold, the ECM provides a ground to the intake manifold tuning solenoid valve, energizing the intake manifold tuning solenoid valve and allowing a vacuum from the intake manifold tuning valve vacuum tank to be applied to the intake manifold tuning actuator valve. The intake manifold tuning actuator valve then opens the intake manifold tuning valve in the intake manifold for desired performance. The variable intake manifold system consists of the following components:

- The intake manifold tuning solenoid valve
- The intake manifold tuning valve vacuum reservoir
- The intake manifold tuning vacuum actuator
- The intake manifold tuning valve
- An intake manifold

Ignition voltage is supplied directly to the intake manifold tuning solenoid valve. The engine control module (ECM) controls the intake manifold tuning solenoid valve by grounding the control circuit via an internal driver switch. The primary function of the driver is to supply ground for the intake manifold tuning solenoid valve. The ECM can determine if the control circuit is open, shorted to ground, or shorted to a voltage by monitoring the voltage on the control circuit.

Secondary Air Injection System Description

The Secondary Air Injection System aids in the reduction of hydrocarbon exhaust emissions during a cold start. This occurs when the start-up engine coolant temperature (ECT) is between −10 to +56°C (14–133° F), the intake air temperature (IAT) is greater than −10° C (14°F) and it has been more than 60 minutes since the last engine start. The secondary air injection pump operates 5–60 s after start-up.

The engine control module (ECM) activates the secondary air injection system by simultaneously completing the ground paths for the secondary air injection pump relay and the secondary air injection solenoid (shutoff and check) valve relay. This action closes the relays' internal contacts. The pump and valve are in turn energized. The pump turns ON and the valve opens.

The secondary air injection pump sends pressurized filtered fresh air into the pipe/hose, through the open valve and into the exhaust manifold. The extra air accelerates the catalyst operation, helping it to reach operating temperature faster. The secondary air injection pump remains ON for a short period of time after the valve is commanded OFF. When the pump is commanded OFF it will not run or be activated until the next vehicle cold start. When the secondary air injection system is inactive, the valve is closed to prevent air/exhaust flow in either direction.

The ECM monitors the secondary air injection system pressure by tracking voltage signal from the pressure sensor, which is integral to the solenoid (shutoff and check) valve assembly.

The ECM utilizes a 3 phase diagnostic routine to test the secondary air injection system:

During phase 1, DTCs P0411 and P2430 run and both the secondary air injection pump and the solenoid (shutoff and check) valve are activated. Normal secondary air function occurs. Expected system pressure is 5–13 kPa (0.7–1.9 psi) above BARO.

During phase 2, DTCs P2430 and P2440 run and only the secondary air injection pump is activated. The valve is closed. Pressure sensor performance and valve deactivation are tested. Expected system pressure is 14–25 kPa (2.0–3.6 psi) above BARO.

During phase 3, DTC P2444 runs and neither the secondary air injection pump nor the valve are activated. Secondary air injection pump deactivation is tested. Expected system pressure equals BARO.

The secondary air injection system includes the following components:

- The secondary air injection pump—The electric secondary air injection pump supplies pressurized, filtered air to the secondary air injection solenoid (shutoff and check) valve. The secondary air injection pump is a turbine type pump that is permanently lubricated and requires no periodic maintenance.

Note: The secondary air injection solenoid valve and the pressure sensor are serviced as an assembly.

- The secondary air injection solenoid (shutoff and check) valve assembly—The valve assembly has a direct current (DC) motor operated valve. When the valve motor is energized by the secondary air injection solenoid valve relay, the valve opens, pressurized air from the secondary air injection pump flows through the valve and is directed into the exhaust manifold.
- The secondary air injection pressure sensor—The pressure sensor is integral to the secondary air injection solenoid valve assembly. The sensor is a 3-wire sensor that measures the secondary air injection system pressure at the inlet of the valve assembly.
- The secondary air injection pump relay—The relay supplies high current and battery voltage to the secondary air injection pump. The ECM commands the relay ON by supplying a ground to the relay control circuit.
- The secondary air injection solenoid valve relay—The relay supplies high current and battery voltage to the secondary air injection solenoid valve. The ECM commands the relay ON by supplying a ground to the relay control circuit.
- The pipes and hoses—The secondary air injection pump inlet hose carries filtered air from the engine intake air cleaner to the secondary air injection pump inlet. The secondary air injection pump pipe carries the air from the pump outlet to the solenoid valve which in turn feeds the exhaust manifold.

System Fault Detection

The ECM monitors the secondary air injection system for faults during cold start operation. When the system's pressure or relay circuits operations vary too far from the expected values, a DTC will set. Diagnostics detect the following conditions:

- A partially or fully blocked or leaking secondary air injection system
- A malfunctioning secondary air injection pump
- A malfunctioning secondary air injection solenoid (shutoff and check) valve assembly
- A malfunctioning secondary air injection pressure sensor
- A restricted exhaust system
- A malfunctioning secondary air injection pump and secondary air injection valve relay

The following DTCs set when a secondary air injection system fault is detected:

- DTC P0411 – A secondary air injection system insufficient airflow fault condition has been detected.
- DTC P0412 – A secondary air injection valve relay coil circuit fault condition has been detected.
- DTC P0418 – A secondary air injection pump relay coil circuit fault condition has been detected.
- DTC P2430 – A secondary air injection pressure sensor signal stuck in range fault condition has been detected.
- DTC P2431 – A skewed air injection pressure sensor signal has been detected.
- DTC P2432 – A secondary air injection pressure sensor signal voltage below the minimum range of the sensor fault condition has been detected.
- DTC P2433 – A secondary air injection pressure sensor signal voltage is above the maximum range of the sensor fault condition has been detected.
- DTC P2440 – The solenoid (shutoff and check) valve is stuck open or a system leak between the pump and the valve has been detected.
- DTC P2444 – A secondary air injection pump stuck ON fault condition has been detected.

Special Tools and Equipment

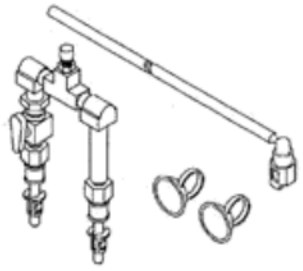
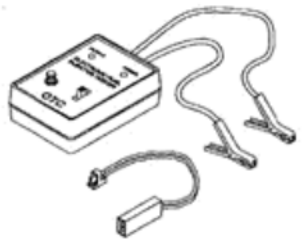
Illustration	Tool Number/Description
 878632	CH 9127-E SA 9127-E Fuel Pressure/Flow Adapter
 879925	CH 9182-E SA 9182-E Electronic Fuel Injector Tester

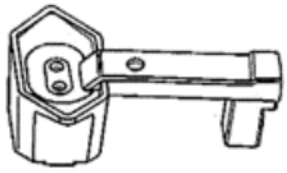
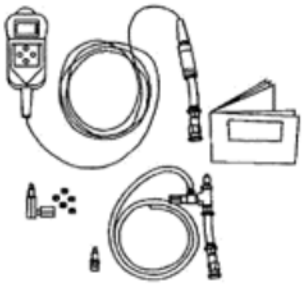
Illustration	Tool Number/Description
 677554	CH 44175 J 44175 Fuel Composition Tester
793709	CH 45004 J 45004 Fuel Tank Drain Hose
 1738992	CH 48027 Digital Pressure Gauge
1755444	CH 48096 EVAP Service Access Port Tool
696431	EL 43244 J 43244 DW 540-010 Relay Puller Pliers

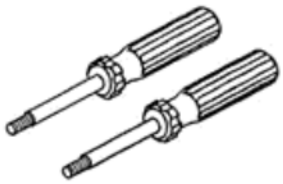
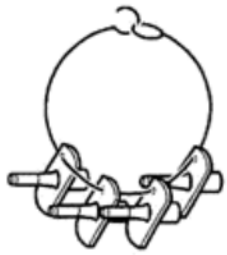
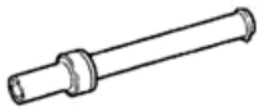
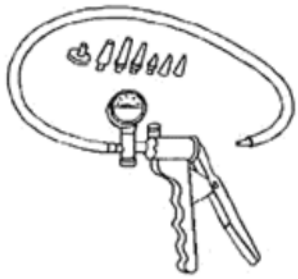
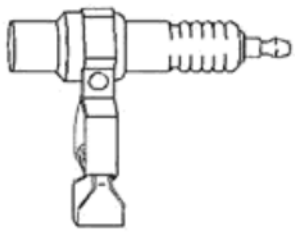
Illustration	Tool Number/Description
 1936461	EN 6009 KM 6009 83 96-335 Remover and Installer Ignition Coil
 2028332	EN 6015 KM 6015 Closure Plugs
 2028259	EN 6363 KM 6363 Spark Plug Remover/ Installer
 5386	EN 23738-A J 23738-A Mityvac
 5381	EL 26792 J 26792 HEI Spark Tester

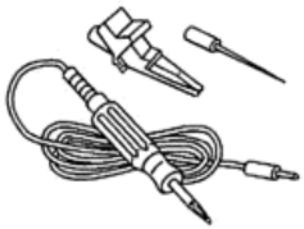
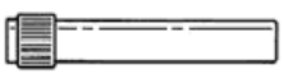
Illustration	Tool Number/Description
1936492	EN 34730-91 KM J-34730 Via Testing Port
 1338380	EL 35616-E J 35616-E GM-Approved Terminal Test Kit includes J 35616-200 Test Light – Probe Kit
378627	EN 36012-A J 36012-A Ignition System Diagnosis Harness
829182	EN 41413-SPT J 41413-SPT High Intensity White Light
 829198	EN 41413-VLV J 41413-VLV EVAP Service Port Vent Fitting

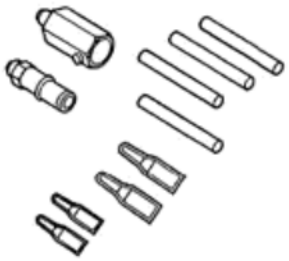
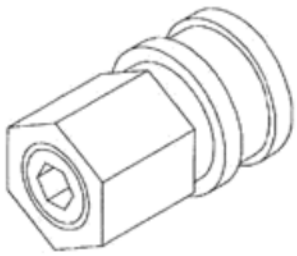
Illustration	Tool Number/Description
227620	EN 41313-100 J 41413-100 EVAP Pressure and Purge Station
825000	EN 41413-200 J 41413-200 Evaporative Emissions System Tester
 1253126	EN 41413-300 J 41413-300 EVAP Cap and Plug Kit
1174862	EN 41413-311 J 41413-311 EVAP Plug
 892655	EN 43936 J 43936 Fuel Pressure Adapter Cap

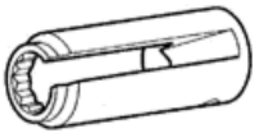
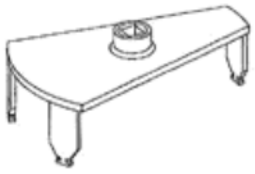
Illustration	Tool Number/Description
1207566	EN 43937 J 43937 Fuel Pressure Adapter Lines
 2191102	EN 48259 KM 6179 Heated Oxygen Sensor Remover/Installer

Illustration	Tool Number/Description
 2028359	EN 48279 Main Fuel Pump Locking Ring Remover/Installer
845593	GE 41415-30 Fuel Tank Cap Adapter