# 8. Engine/Propulsion

## 8.1. 12V Starting and Charging System

### 8.1.1. Description and Operation

#### 8.1.1.1. Battery Description and Operation

| Warning: |
|---|
| Batteries produce explosive gases, contain corrosive acid, and supply levels of electrical current high enough to cause burns. Therefore, to reduce the risk of personal injury when working near a battery:<br>• Always shield your eyes and avoid leaning over the battery whenever possible.<br>• Do not expose the battery to open flames or sparks.<br>• Do not allow the battery electrolyte to contact the eyes or the skin. Flush immediately and thoroughly any contacted areas with water and get medical help.<br>• Follow each step of the jump starting procedure in order.<br>• Treat both the booster and the discharged batteries carefully when using the jumper cables. |

Batteries that are no longer wanted must be disposed of by an approved battery recycler and must never be thrown in the trash or sent to a landfill.

Batteries that are not part of the vehicle itself, not the battery under the hood, must only be transported on public streets for business purposes via approved hazardous material transportation procedures.

Battery storage, charging and testing facilities in repair shops must meet various requirements for ventilation, safety equipment, material segregation, etc.

The maintenance free battery is standard. There are no vent plugs in the cover. The battery is completely sealed except for 2 small vent holes in the side. These vent holes allow the small amount of gas that is produced in the battery to escape.

The battery has 3 functions as a major source of energy:
- Engine cranking
- Voltage stabilizer
- Alternate source of energy with generator overload

##### 8.1.1.1.1. Battery Low Start Vehicle Message

The body control module (BCM) monitors battery positive voltage to determine battery state of charge. If one or more of the BCM battery positive voltage terminals measure less than approximately 11.6V compared to the BCM ground circuits, this message will display and four chimes may sound. Start the vehicle immediately. If the vehicle is not started and the battery continues to discharge, the climate controls, heated seats, and audio systems will shut off and the vehicle may require a jump start. These systems will function again after the vehicle is started.

##### 8.1.1.1.2. Battery Ratings

A battery has 2 ratings:
- Cold cranking amperage
- Amperage hours

When a battery is replaced use a battery with similar ratings. See battery specification label on the original battery.

#### 8.1.1.1.3. Amperage Hours

The amperage hour rating tells you how much amperage is available when discharged evenly over a 20 hour period. The amperage hour rating is cumulative, so in order to know how many constant amperage the battery will output for 20 h, you have to divide the amperage hour rating by 20. Example: If a battery has an amperage hour rating of 74, dividing by 20 = 3.75. Such a battery can carry a 3.75 A load for 20 hours before dropping to 10.5 V. (10.5 V is the fully discharged level, at which point the battery needs to be recharged.) A battery with an amperage hour rating of 55 will carry a 2.75 A load for 20 hours before dropping to 10.5 V.

#### 8.1.1.1.4. Cold Cranking Amperage

The cold cranking amperage is an indication of the ability of the battery to crank the engine at cold temperatures. The cold cranking amperage rating is the minimum amperage the battery must maintain for 30 seconds at −18°C (0°F) while maintaining at least 7.2 V. See battery label for the cold cranking amperage rating of this battery.

### 8.1.1.2. Charging System Description and Operation

#### 8.1.1.2.1. Electrical Power Management Overview

The electrical power management system is designed to monitor and control the charging system and send diagnostic messages to alert the driver of possible problems with the battery and generator. This electrical power management system primarily utilizes existing onboard computer capability to maximize the effectiveness of the generator, to manage the load, improve battery state-of-charge and life, and minimize the system's impact on fuel economy. The electrical power management system performs 3 functions:

- It monitors the battery voltage and estimates the battery condition.
- It takes corrective actions by boosting idle speeds, and adjusting the regulated voltage.
- It performs diagnostics and driver notification.

The battery condition is estimated during ignition-off and during ignition-on. During ignition-off the state-of-charge of the battery is determined by measuring the open-circuit voltage. The state-of-charge is a function of the acid concentration and the internal resistance of the battery, and is estimated by reading the battery open circuit voltage when the battery has been at rest for several hours.

The state-of-charge can be used as a diagnostic tool to tell the customer or the dealer the condition of the battery. Throughout
Ignition-on, the algorithm continuously estimates state-of-charge based on adjusted net amp hours, battery capacity, initial state-of-charge, and temperature.

While running, the battery degree of discharge is primarily determined by a battery current sensor, which is integrated to obtain net amp hours.

In addition, the electrical power management function is designed to perform regulated voltage control to improve battery state-of-charge, battery life, and fuel economy. This is accomplished by using knowledge of the battery state-of-charge and temperature to set the charging voltage to an optimum battery voltage level for recharging without detriment to battery life.

The Charging System Description and Operation is divided into 3 sections. The first section describes the charging system components and their integration into the electrical power management. The second section describes charging system operation. The third section describes the instrument panel cluster operation of the charge indicator, driver information center messages, and voltmeter operation.

### 8.1.1.2.2. Charging System Components

**Generator**
The generator is a serviceable component. If there is a diagnosed failure of the generator it must be replaced as an assembly. The engine drive belt drives the generator. When the rotor is spun it induces an alternating current (AC) into the stator windings. The AC voltage is then sent through a series of diodes for rectification. The rectified voltage has been converted into a direct current (DC) for use by the vehicles electrical system to maintain electrical loads and the battery charge. The voltage regulator integral to the generator controls the output of the generator. It is not serviceable. The voltage regulator controls the amount of current provided to the rotor. If the generator has field control circuit failure, the generator defaults to an output voltage of 13.8 V.

**Body Control Module (BCM)**
The body control module (BCM) is a LAN device. It communicates with the engine control module (ECM) and the instrument panel cluster for electrical power management (electrical power management) operation. The BCM determines the output of the generator and sends the information to the ECM for control of the generator turn on signal circuit. It monitors the generator field duty cycle signal circuit information sent from the ECM for control of the generator. It monitors a battery current sensor, the battery positive voltage circuit, and estimated battery temperature to determine battery state of charge. The BCM performs idle boost.

**Battery Current Sensor**
The battery current sensor is a serviceable component that is connected to the negative battery cable at the battery. The battery current sensor is a 3-wire hall-effect current sensor. The battery current sensor monitors the battery current. It directly inputs to the BCM. It creates a 5 volt pulse width modulation (PWM) signal of 128 Hz with a duty cycle of 0–100 percent. Normal duty cycle is between 5–95 percent. Between 0–5 percent and 95–100 percent are for diagnostic purposes.

**Engine Control Module (ECM)**
When the engine is running, the generator turn-on signal is sent to the generator from the ECM, turning on the regulator. The generator's voltage regulator controls current to the rotor, thereby controlling the output voltage. The rotor current is proportional to the electrical pulse width supplied by the regulator. When the engine is started, the regulator senses generator rotation by detecting AC voltage at the stator through an internal wire. Once the engine is running, the regulator varies the field current by controlling the pulse width. This regulates the generator output voltage for proper battery charging and electrical system operation. The generator field duty terminal is connected internally to the voltage regulator and externally to the ECM. When the voltage regulator detects a charging system problem, it grounds this circuit to signal the ECM that a problem exists. The ECM monitors the generator field duty cycle signal circuit, and receives control decisions based on information from the BCM.

**Instrument Panel Cluster**
The instrument panel cluster provides the customer notification in case a concern with the charging system through a charge indicator

### 8.1.1.2.3. Charging System Operation

The purpose of the charging system is to maintain the battery charge and vehicle loads. There are 6 modes of operation and they include:

- Battery Sulfation Mode
- Charge Mode
- Fuel Economy Mode
- Head lamp Mode
- Start Up Mode
- Voltage Reduction Mode

The engine control module (ECM) controls the generator through the generator turn ON signal circuit. The ECM monitors the generator performance though the generator field duty cycle signals circuit. The signal is a pulse width modulation (PWM) signal of 128 Hz with a duty cycle of 0–100 percent. Normal duty cycle is between 5–95 percent. Between 0–5 percent and 95–100 percent are for diagnostic purposes. The following table shows the commanded duty cycle and output voltage of the generator:

| Commanded Duty Cycle | Generator Output Voltage |
|---|---|
| 10% | 11 V |
| 20% | 11.56 V |
| 30% | 12.12 V |
| 40% | 12.68 V |
| 50% | 13.25 V |
| 60% | 13.81 V |
| 70% | 14.37 V |
| 80% | 14.94 V |
| 90% | 15.5 V |

The generator provides a feedback signal of the generator voltage output through the generator field duty cycle signal circuit to the
ECM. This information is sent to the body control module (BCM). The signal is PWM signal of 128 Hz with a duty cycle of 0–100 percent. Normal duty cycle is between 5–99 percent. Between 0–5 percent and 100 percent are for diagnostic purposes.

#### 8.1.1.2.4. Battery Sulfation Mode

The BCM will enter this mode when the interpreted generator output voltage is less than 13.2 V for 45 minutes. When this condition exists the BCM will enter Charge Mode for 2–3 minutes. The BCM will then determine which mode to enter depending on voltage requirements.

#### 8.1.1.2.5. Charge Mode

The BCM will enter Charge Mode whenever one of the following conditions is met.

- The wipers are ON for more than 3 seconds.
- LAN (Climate Control Voltage Boost Mode Request) is true, as sensed by the HVAC control head. High speed cooling fan, rear defogger and HVAC high speed blower operation can cause the BCM to enter the Charge Mode.
- The estimated battery temperature is less than 0°C (32°F).
- Battery State of Charge is less than 80 percent.
- Vehicle speed is greater than 145 km/h (90 mph)
- Current sensor fault exists.
- System voltage was determined to be below 12.56 V

When any one of these conditions is met, the system will set targeted generator output voltage to a charging voltage between 13.9– 15.5 V, depending on the battery state of charge and estimated battery temperature.

#### 8.1.1.2.6. Fuel Economy Mode

The BCM will enter Fuel Economy Mode when the estimated battery temperature is at least 0°C (32°F) but less than or equal to 80°C (176°F), the calculated battery current is less than 15 amperes and greater than −8 amperes, and the battery state-of-charge is greater than or equal to 80 percent. Its targeted generator output voltage is the open circuit voltage of the battery and can be between 12.5–13.1 V. The BCM will exit this mode and enter Charge Mode when any of the conditions described above are present.

#### 8.1.1.2.7. Head lamp Mode

The BCM will enter Head lamp Mode whenever the head lamps are ON (high or low beams). Voltage will be regulated between 13.9– 14.5 V.

#### 8.1.1.2.8. Start Up Mode

When the engine is started the BCM sets a targeted generator output voltage of 14.5 V for 30 seconds.

#### 8.1.1.2.9. Instrument Panel Cluster Operation

**Charge Indicator Operation**

The instrument panel cluster illuminates the charge indicator and displays a warning message in the driver information center if equipped, when the one or more of the following occurs:

- The engine control module (ECM) detects that the generator output is less than 11 V or greater than 16 V. The instrument panel cluster receives a GMLAN message from the ECM requesting illumination.
- The instrument panel cluster determines that the system voltage is less than 11 V or greater than 16 V for more than 30 seconds. The instrument panel cluster receives a GMLAN message from the body control module (BCM) indicating there is a system voltage range concern.
- The instrument panel cluster performs the displays test at the start of each ignition cycle. The indicator illuminates for approximately 3 seconds.

### 8.1.1.3. Electrical Power Management Description and Operation

Table 1: Idle Boost and Load Shed With Current Sensor
Table 2: Idle Boost and Load Shed Without Current Sensor (based on battery voltage)

#### 8.1.1.3.1. Electrical Power Management

The electrical power management is used to monitor and control the charging system and alert the driver of possible problems within the charging system. The electrical power management system makes the most efficient use of the generator output, improves the battery state-of-charge, extends battery life, and manages system electrical loads.

The load shed operation is a means of reducing electrical loads during a low voltage or low battery state-of-charge condition.

The idle boost operation is a means of improving generator performance during a low voltage or low battery state-of-charge condition.

Each electrical power management function, either idle boost or load shed, is activated in incremental steps. For example, idle boost 1 must be active before idle boost 2 can be active.

**Idle Boost and Load Shed With Current Sensor**

| Function | Battery Temperature Calculation | Battery Voltage Calculation | Amp-Hour Calculation | Action Taken |
|---|---|---|---|---|
| Idle Boost 1 Start | Less Than −15°C (5°F) | Less Than 13 V | - | First level Idle boost requested |
| Idle Boost 1 Start | - | - | Battery has a net loss greater than 0.6 Ah | First level Idle boost requested |
| Idle Boost 1 Start | - | Less Than 11 V | - | First level Idle boost requested |
| Idle Boost 1 End | Greater Than −10°C (14°F) | Greater Than 12 V | Battery has a net loss less than 0.2 Ah | First level Idle boost request cancelled |
| Idle Boost 2 Start | | | Battery has a net loss greater than 1.6 Ah | Second level Idle boost requested |
| Idle Boost 2 Start | | Less Than 11 V | | Second level Idle boost requested |
| Idle Boost 2 End | | Greater Than 12 V | Battery has a net loss less than 0.8 Ah | Second level Idle boost request cancelled |
| Load Shed 1 Start | | | Battery has a net loss of 4 Ah | Heated Seats, HVAC cycled OFF for 20% of their cycle |
| Load Shed 1 Start | | Less Than 11 V | | Heated Seats, HVAC cycled OFF for 20% of their cycle |

| | | | | |
|---|---|---|---|---|
| Load Shed 1 End | | Greater Than 12 V | Battery has a net loss of less than 2 Ah | Clear Load Shed 1 |
| Idle Boost 3 Start | | | Battery has a net loss of 10 Ah | Third level Idle boost requested |
| Idle Boost 3 Start | | Less Than 11 V | | Third level Idle boost requested |
| Idle Boost 3 End | | Greater Than 12 V | Battery has a net loss of less than 6.0 Ah | Third level Idle boost request cancelled |
| Load Shed 2 Start | | | Battery has a net loss greater than 12 Ah | Heated Seats, HVAC cycled OFF for 50% of their cycle. |
| Load Shed 2 Start | | Less Than 11 V | | Heated Seats, HVAC cycled OFF for 50% of their cycle. |
| Load Shed 2 End | | Greater Than 12 V | Battery has a net loss of less than 8 Ah | Clear Load Shed 2 |
| Load Shed 3 Start | | Less Than 11.9 V | Battery has a net loss greater than 20 Ah | Heated Seats, HVAC cycled OFF for 100% of their cycle. |
| Load Shed 3 Start | | Less Than 11 V | | Heated Seats, HVAC cycled OFF for 100% of their cycle. |
| Load Shed 3 End | | Greater Than 12.6 V | Battery has a net loss of less than 13 Ah | Clear Load Shed 3 |

**Idle Boost and Load Shed Without Current Sensor (based on battery voltage)**

| Function | Battery Temperature | Battery Voltage Calculation | Action Taken |
|---|---|---|---|
| Idle Boost 1 Start | Less Than −15°C (5°F) | Less Than 13 V | First level Idle boost requested |
| Idle Boost 1 Start | - | Less Than 12.6 V | First level Idle boost requested |
| Idle Boost 1 End | Greater Than −15°C (5°F) | - | First level Idle boost request cancelled |
| Idle Boost 1 End | - | Greater Than 13 V | First level Idle boost request cancelled |
| Idle Boost 2 Start | - | Less Than 12.4 V | Second level Idle boost requested |
| Idle Boost 2 End | - | Greater Than 12.5 V | Second level Idle boost request cancelled |
| Load Shed 1 Start | - | Less Than 12.3 V | Heated Seats, HVAC cycled OFF for 20% of their cycle |
| Load Shed 1 End | - | Greater Than 12.4 V | Clear Load Shed 1 |
| Idle Boost 3 Start | - | Less Than 10 V | Third level Idle boost requested |
| Idle Boost 3 End | - | Greater Than 12.3 V | Third level Idle boost request cancelled |
| Load Shed 2 Start | - | Less Than 12.1 V | Heated Seats, HVAC cycled OFF for 50% of their cycle. The BATTERY SAVER ACTIVE message will be displayed on the DIC |
| Load Shed 2 End | - | Greater Than 12.2 V | Clear Load Shed 2 |
| Load Shed 3 Start | - | Less Than 11.9 V | Heated Seats, HVAC cycled OFF for 100% of their cycle. The BATTERY SAVER ACTIVE message will be displayed on the DIC |
| Load Shed 3 End | - | Greater Than 12.0 V | Clear Load Shed 3 |

### 8.1.1.4. Starting System Description and Operation

The starter motor is non-repairable. it has pole pieces that are arranged around the armature. Both solenoid windings are energized. The pull-in winding circuit is completed to the ground through the starter motor. The windings work together magnetically to pull and hold in the plunger. The plunger moves the shift lever. This action causes the starter drive assembly to rotate on the armature shaft spline as it engages with the flywheel ring gear on the engine. Moving at the same time, the plunger also closes the solenoid switch contacts in the starter solenoid. Full battery voltage is applied directly to the starter motor and it cranks the engine.

As soon as the solenoid switch contacts close, current stops flowing thorough the pull-in winding because battery voltage is applied to both ends of the windings. The hold-in winding remains energized. Its magnetic field is strong enough to hold the plunger, shift lever, starter drive assembly, and solenoid switch contacts in place to continue cranking the engine. When the engine starts, pinion overrun protects the armature from excessive speed until the switch is opened.

When the ignition switch is released from the START position, the START relay opens and battery voltage is removed from the starter solenoid S terminal. Current flows from the motor contacts through both windings to the ground at the end of the hold-in winding. However, the direction of the current flow through the pull-in winding is now opposite the direction of the current flow when the winding was first energized.

The magnetic fields of the pull-in and hold-in windings now oppose one another. This action of the windings, along with the help of the return spring, causes the starter drive assembly to disengage and the solenoid switch contacts to open simultaneously. As soon as the contacts open, the starter circuit is turned off.

#### 8.1.1.4.1. Circuit Description (Key Start)

When the ignition switch is placed in the Start position, a discrete signal is supplied to the body control module (BCM) notifying it that the ignition is in the Start position. The BCM then sends a message to the engine control module (ECM) notifying it that CRANK has been requested. The ECM verifies that the transmission is in Park or Neutral. If it is, the ECM then supplies 12 V to the control circuit of the crank relay. When this occurs, battery positive voltage is supplied through the switch side of the crank relay to the S terminal of the starter solenoid.

### 8.1.2. Diagnostic Information and Procedures

#### 8.1.2.1. Symptoms Engine Electrical

| Note: |
|---|
| The following steps must be completed before using the symptom tables. |

Perform Diagnostic System Check Vehicle before using the Symptom Tables in order to verify that all of the following are true:

– There are no DTCs set.
– The control modules can communicate via the serial data link.

Review the system descriptions and operations in order to familiarize yourself with the system functions. Refer to one of the following system operations:

– Battery Description and Operation
– Charging System Description and Operation
– Electrical Power Management Description and Operation
– Starting System Description and Operation

**Visual/Physical Inspection**

- Inspect for aftermarket devices which could affect the operation of the starting and charging systems. Refer to Checking Aftermarket Accessories.
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.

**Intermittent**

Faulty electrical connections or wiring may be the cause of intermittent conditions. Refer to Testing for Intermittent Conditions and Poor Connections.

**Symptom List**

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

- Battery Inspection/Test
- Battery Electrical Drain/Parasitic Load Test
- Charging System Test
- Generator Noise Diagnosis
- Starter Solenoid Does Not Click
- Starter Solenoid Clicks, Engine Does Not Crank
- Engine Cranks Slowly
- Starter Noise Diagnosis

#### 8.1.2.1.1. Battery Inspection/Test

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

#### 8.1.2.1.2. Diagnostic Aids

| Note: |
|---|
| For Warranty repairs —<br>You must use regionally required battery test equipment for warranty repairs. For accurate test results the battery must be disconnected from the vehicle and the equipment connected directly to the battery posts. When setting up the equipment, select “Out of Vehicle” and then the correct battery type (Flooded, AGM or Stop/Start AGM) and rated CCA (both from the battery label) must be entered.<br>• Failure to obtain the correct connections during the test may result in a failed test on a good battery.<br>• Use the Out of Vehicle test (battery disconnected with test equipment connected directly to the posts) for each battery when testing a vehicle with dual batteries. |

#### 8.1.2.1.3. Reference Information

**Schematic Reference**

Starting and Charging Schematics

**Connector End View Reference**

Component Connector End Views

**Description and Operation**

Starting System Description and Operation

**Electrical Information Reference**

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

**Scan Tool Reference**

Control Module References for scan tool information

**Special Tools**

EL 50313 Battery Tester

#### 8.1.2.1.4. Circuit/System Testing

| Warning: |
| --- |
| Unless directed otherwise, the ignition must be OFF with the key removed, and all electrical loads must be OFF before servicing any electrical component. Disconnect the negative battery cable to prevent an electrical spark should a tool or equipment come in contact with an exposed electrical terminal. Failure to follow these precautions may result in personal injury and/or damage to the vehicle or its components. |

1. Verify the C1 Battery or C1B Battery – Auxiliary (if equipped) case is not cracked, broken, or damaged, which may be indicated by battery acid leakage.

**⇒ If there is any apparent damage**

Replace the C1 Battery or C1B Battery – Auxiliary.

**⇓ If there is no damage**

2. Verify that the battery cables are clean and tight. The battery terminal bolts should be torqued as specified in Fastener Specifications.

**⇒ If the battery cables need to be cleaned or tightened**

Clean as required and tighten as specified.

**⇓ If the battery cables are clean and tight**

3. Disconnect battery from the vehicle. There is no need to remove the battery from the vehicle.
4. Connect the EL-50313 directly to the battery terminal posts.
5. Select “Charging,” “Diagnostic” and “Out of Vehicle” when setting up the test.
6. Select the proper battery type, Flooded, AGM
7. Enter the CCA as shown on the battery label.
8. Verify the test result is not REPLACE BATTERY or BAD CELLREPLACE

| Note: |
| --- |
| Always write the test code displayed by the tester on the repair order for any warranty purposes. The number is a unique ode that describes the test data for a particular battery at a particular time. The test code may occasionally repeat when you retest the same battery. More often, each test will result in a different code. Use the test code from the Out of Vehicle test. |

**⇒ If the test result is REPLACE BATTERY or BAD CELLREPLACE**

Replace the C1 Battery or C1B Battery – Auxiliary.

**⇓ If the test result is not REPLACE BATTERY or BAD CELLREPLACE**

9. All OK.

#### 8.1.2.1.5. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.
Battery Replacement

### 8.1.2.2. Battery Charging

#### 8.1.2.2.1. Special Tools

EL 50313 Battery Tester

#### 8.1.2.2.2. Diagnostic Aids

- The charging area should be well ventilated.
- Do not charge a battery that appears to be frozen. Allow the battery to warm to room temperature and test it using the EL -50313 before charging.
- An AGM battery may be damaged if charged to more than 14.5 V.
- A Flooded Cell battery may be damaged if charged to more than 16.5 V.

#### 8.1.2.2.3. Battery State of Charge

| **Note:** |
|---|
| Using voltage to determine the batteries state of charge is only accurate after the battery has been at rest for 24 hours. This is enough time for the acid in each cell to equalize. If the battery has been charged or discharged in the past 24 hours, the battery state of charge will only be an estimate. |

The maintenance-free batteries state of charge is estimated by reading the voltage of the battery across the battery terminals. Because the voltage is affected by current flow into or out of the battery, the engine must be stopped and all electrical loads turned OFF, including parasitic loads, when checking the voltage. The voltage can also be affected if the battery has just been charged or discharged, so it is important to consider what has happened to the battery in the time just before testing. Use the following procedure to determine the battery's state of charge:

1. Be sure all electrical loads are turned OFF.
2. Determine whether the battery has been used in a vehicle or charged within the past 12 hours.
   - If the answer is no, the terminal voltage will be stabilized and no action is necessary before reading the voltage. Skip to step 3.
   - If the answer is yes, terminal voltage will not be stabilized and you should wait 12 hours since the last time the battery was used.
3. Estimate the battery temperature by determining the average temperature to which the battery has been exposed for the past 12 hours.

| **Note:** |
|---|
| The table is accurate to 10 % only after the battery has been at rest for 12 hours. |

4. Measure the battery voltage at the battery terminals. Refer to the following table to determine the state of charge according to the estimated battery temperature:

| **Battery Voltage** | **% Charge at 0°C (32°F)** | **% Charge at 25°C (75°F)** |
|---|---|---|
| 12.75 V | 100% | 100% |
| 12.7 V | 100% | 90% |
| 12.6 V | 90% | 75% |
| 12.45 V | 75% | 65% |
| 12.2 V | 65% | 45% |
| 12.0 V | 40% | 20% |

Use the state of charge information as follows:

- A battery with a state of charge that is below 65% must always be recharged before returning it to service or continuing storage.
- A battery with a state of charge that is 65% or greater is generally considered to be charged enough in order to be returned to normal service or in order to continue storage. However, if the battery is being used in slow traffic or with short drive times, or if the temperature is very hot or very cold, the battery should be fully charged, to at least 90%, before returning it to service or continuing storage.

#### 8.1.2.2.4. Charging Time Required

The time required to charge a battery will vary depending upon the following factors:

- The battery charger capacity—The higher the charger amperage, the less time it will take to charge the battery.
- The state of charge of the battery—A completely discharged battery requires more than twice as much charging time as a half charged battery. In a discharged battery with a voltage below 11 V, the battery has a very high internal resistance and may only accept a very low current at first. Later, as the charging current causes the acid content to increase in the electrolyte, the charging current will increase. Extremely discharged batteries may not activate the reversed voltage protection in some chargers. Refer to the manufacturer's instructions for operating this circuitry.
- The temperature of the battery—The colder the battery is, the more time it takes to recharge the battery. The charging current accepted by a cold battery is very low at first. As the battery warms, the charging current will increase.

#### 8.1.2.2.5. Charging Procedure

| Caution |
|---|
| Turn OFF the ignition when connecting or disconnecting the battery cables, the battery charger or the jumper cables. Failure to do so may damage the ECM/PCM or other electronic components. |

| Caution |
|---|
| Refer to Fastener Caution. |

1. Ensure that all of the battery terminal connections are clean and tight.
2. Connect the charger positive lead to the battery positive terminal on the battery or the remote jumper stud underhood.

| Caution |
|---|
| Do not connect the negative charger lead to the housings of other vehicle electrical accessories or equipment. The action of the battery charger may damage such equipment. |

3. Connect the negative charger lead to a solid engine ground or to a ground stud in the engine compartment that is connected directly to the battery negative terminal, but away from the battery. If the negative battery cable is disconnected and a terminal adapter is being used, connect directly to the adapter.
4. Select ”Charging,” “PDI” and “In Vehicle” when setting up the charger.
5. Select the proper battery type, Flooded, AGM, Spiral AGM
6. Enter the CCA as shown on the battery label.

### 8.1.2.3. Battery Electrical Drain/Parasitic Load Test

#### 8.1.2.3.1. 12 V Battery

The following procedure is for the 12 V battery only.

#### 8.1.2.3.2. Diagnostic Instructions

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

#### 8.1.2.3.3. Circuit/System Description

Components most likely to cause a parasitic draw on the vehicles battery are switches, relays, and control modules. After the ignition is turned OFF the control modules will begin to go to sleep shut OFF. All control modules do not go to sleep at the same time, some may take up to 30 min or longer after turning the ignition off before going to sleep. Other modules may periodically wake up then go back to sleep. These are all normal conditions.

#### 8.1.2.3.4. Diagnostic Aids

- Rule out any possible aftermarket equipment causing an unacceptable parasitic current drain. Aftermarket accessories installed into the courtesy lamp circuit can cause the inadvertent power timer in the body control module (BCM) to keep resetting. This may cause the BCM to remain awake and cause a current drain on the battery.

- Rule out customer driving habits such as regular short trips that do not allow enough time to properly charge the battery. Refer to Battery Description and Operation.

- Verify that the battery and charging system are in proper working order. Refer to Battery Charging and Charging System Test.

- A battery discharging for no apparent reason while the vehicle is parked can be caused by an intermittent draw, such as a module waking up, or a continuous draw, such as a stuck relay.

- Some systems and modules such as regulated voltage control, if equipped, are designed to wake up, perform a task, and go back asleep at regular intervals. Refer to Body Control System Description and Operation for the system or modules description and operation.

- An engine off natural vacuum evaporative test can occur if the engine control module (ECM) determines the drive cycle has met the appropriate criteria immediately after key off. The ECM will stay awake and the vent solenoid will stay energized for as long as 45 min. The typical current draw for this is about 1 A.

- An extremely low mA current level is consumed by the remote keyless entry receiver for monitoring purposes, actual system wake up only occurs when the fobs for the vehicle are used. When other devices on the same remote keyless entry operating frequency are activated, such as the tire pressure monitoring sensors and other vehicle FOBs in the vicinity, the remote keyless entry receiver will have a 100 mA spike. These spikes are normal and occur too briefly to have a significant effect on battery drain. Competing signals may cause remote keyless entry performance issues such as jamming but should not cause excessive battery draw.

- If an excessive current draw is not present during initial testing, continue periodic testing over a 1–2 hour period to see if the current draw increases and stays above an unacceptable level.

| Caution |
| --- |
| The battery specification listed below is a generic specification. Refer to the label on the original battery when testing the battery. |

- The battery run down time will vary depending on the batteries reserve capacity. If the reserve capacity is higher, then the battery run down time may be longer. If the reserve capacity is lower, then the battery run down time may be shorter. The graph below indicates roughly how many days a 690 cold cranking amperage battery with a 110 min reserve capacity starting at 80% state of charge will last with a constant current draw until it reaches 50% state of charge. Differences in battery reserve capacity and temperature will affect the results.

| Current Drain | Days |
|---|---|
| 25 mA | 33 |
| 5 mA | 16.5 |
| 75 mA | 11 |
| 100 mA | 8.25 |
| 250 mA | 3.3 |
| 500 mA | 1.65 |
| 750 mA | 1 |
| 1 A | 0.8 |
| 2 A | 0.4 |

#### 8.1.2.3.5. Reference Information

**Schematic Reference**

Control Module References

**Connector End View Reference**

Component Connector End Views

**Electrical Information Reference**

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

**Scan Tool Reference**

Control Module References for scan tool information

**Special Tools**

EL 38758 Parasitic Draw Test Switch

#### 8.1.2.3.6. Circuit/System Verification

| Note: |
| --- |
| • Most vehicle systems will go to sleep within 30 min but it can take up to 2 h before all systems power down allowing the parasitic draw test to pass. An occasional increase in the parasitic draw is normal as long as it returns within 1 s.<br><br>• Closing the door latches/ajar switch while leaving the doors open is recommended, this allows the vehicle systems to perform in a "doors closed" mode while allowing vehicle interior access that may be needed to complete the diagnostic steps.<br><br>• Locking doors will arm the vehicle content theft deterrent system if equipped. Failure to arm the system may cause a theft system fault to not be present during testing.<br><br>• There are many things that can prevent the vehicle from completely going to sleep and passing the parasitic draw test. Make sure all the conditions listed below are met before performing the parasitic current draw test.<br>– Ignition OFF<br>– Key out of the ignition switch – when not equipped with keyless access and start<br>– Retained Accessory Power OFF – open and close the driver door after ignition OFF<br>– Scan tool not communicating with a vehicle control module – in some cases it may need to be disconnected from the DLC<br>– All access doors closed<br>– Headlamps OFF – auto headlamps disabled<br>– Any delay lighting OFF<br>– HVAC after blow OFF<br>– Any accessory that can work with ignition OFF inactive or OFF<br>– Wait up to 2 min or longer, after all other listed conditions are met |

**Using an Inductive Pickup Probe**

1. Connect an inductive pickup probe to the negative battery cable that can read down to 1 mA.
2. Ignition OFF, as the vehicle systems shut down test for less than 30 mA of parasitic current drain.

⇒ If greater than the specified range, refer to Circuit/System Testing.

**Using the EL 38758 Parasitic Draw Test Switch**

| Warning: |
| --- |
| Refer to Battery Disconnect Warning. |

| Caution |
| --- |
| When a fused jumper wire or digital multimeter is connected to the test switch terminals, always turn the test switch ON before opening any access door, turning the ignition on, or turning any accessory on. This is to prevent damaging the jumper wire or digital multimeter fuse. |

| Note: |
| --- |
| The switch knob on the EL 38758 switch is marked ON and OFF. When the switch knob is in the ON position, the circuit is closed and electrical current will pass through the switch. When the switch knob is in the OFF position, the circuit is open and electrical current will not pass through the switch. |

1. Ignition OFF, disconnect the battery negative cable from the battery. Refer to Battery Negative Cable Disconnection and
Connection.
2. Turn the EL 38758 switch knob to the OFF position.
3. Install the male end of the EL 38758 switch to the battery ground terminal.

4. Install the battery negative cable to the female end of the EL 38758 switch.
5. Turn the EL 38758 switch knob to the ON position.
6. Road test the vehicle and activate all of the accessories such as the radio and air conditioning.
7. Ignition OFF, connect a 10 A fused jumper wire to the test switch tool terminals.
8. Turn the EL 38758 switch knob to the OFF position. The current now flows through the jumper wire.
9. Check the fuse in the jumper wire. The fuse should be OK.

⇒ Failed: If the jumper wire fuse is blown, refer to Circuit/System Testing.
⇓ Passed

10. Turn the EL 38758 switch knob to the ON position. Remove the fused jumper wire.
11. Connect a DMM set to the 10 A DC scale between the test switch tool terminals.
12. Turn the EL 38758 switch knob to the OFF position. The current now flows through the DMM.
13. As the vehicle systems shut down test for less than 30 mA of parasitic current drain.

⇒ If greater than the specified range, refer to Circuit/System Testing.

#### 8.1.2.3.7. Circuit/System Testing

| Note: |
| --- |
| • Removing or installing a fuse, relay, or connector, to determine the area causing high parasitic draw may wake up control modules. You must wait for the control modules to go back to sleep before retesting. It is best to install any removed or disconnected components after the diagnosis is completed.<br>• Fuses for power mode master components such as the BCM should be removed last to avoid misdiagnosis.<br>• If a scan tool is connected to the DLC, either disconnect it or subtract the scan tool current draw from the DMM reading to get the actual vehicle parasitic current draw. |

If the vehicle has an unacceptable amount of parasitic current draw, remove each fuse one at a time until the current draw falls to an acceptable level. A drop of more than 10–20 mA, when disabling a single system or circuit, is an indication of an overly high current draw that could be causing the battery drain. Refer to Power Distribution Schematics to diagnose exactly which circuit of the suspect system is causing the high parasitic drain. The following is a list of common components that could cause a high current draw:

- Stuck switch
- Stuck relay
- Control module

#### 8.1.2.3.8. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.
Control Module References for control module replacement, programming and setup

## 8.1.2.4. Charging System Test

### 8.1.2.4.1. Diagnostic Instructions

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

### 8.1.2.4.2. Diagnostic Fault Information

| Circuit | Short to Ground | Open/High Resistance | Short to Voltage | Signal Performance |
|---|---|---|---|---|
| B+ | - | P0621 | - | - |
| Control – L Terminal | P0621 | P0621 | P0621 | - |
| Signal – F Terminal | P0622 | P0622 | P0622 | P0622 |

### 8.1.2.4.3. Circuit/System Description

The engine control module (ECM) uses the generator turn ON control circuit to control the load of the generator on the engine. A high side driver in the ECM applies a duty cycled voltage to the voltage regulator. The duty cycle controls the voltage regulator to turn the field circuit ON and OFF. The ECM monitors the state of the generator turn ON control circuit. The ECM should detect low voltage on the generator turn on control circuit when the ignition is ON and the engine is OFF, or when the charging system malfunctions. With the engine running, the ECM should detect high voltage when the duty cycle voltage is commanded high and a low voltage when the duty cycle voltage is commanded low on the generator turn on control circuit.

The engine control module (ECM) uses the generator field duty cycle signal circuit, or F-terminal circuit, to monitor the duty cycle of the generator. The generator field duty cycle signal circuit connects to high side of the field windings in the generator. A pulse width modulated (PWM) high side driver in the voltage regulator turns the field windings on and off. The ECM uses the PWM signal input to determine the generator load on the engine. This allows the ECM to adjust the idle speed to compensate for high electrical loads. The ECM monitors the status of the generator field duty cycle signal circuit. When the ignition is ON and the engine is off, the ECM should detect a duty cycle near 0%. When the engine is running, the duty cycle should be between 5–99%.

### 8.1.2.4.4. Reference Information

**Schematic Reference**

Starting and Charging Schematics

**Connector End View Reference**

Component Connector End Views

**Description and Operation**

Charging System Description and Operation

**Electrical Information Reference**

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

#### 8.1.2.4.5. Circuit/System Verification

| Note: |
|---|
| Do not have a battery charger connected during the generator testing. |

1. Ignition ON.
2. Verify that no G13 Generator or B18 Battery Current Sensor DTCs are set that would cause a charging system concern.

**⇒ If DTCs are set**

Refer to Diagnostic Trouble Code (DTC) List Vehicle.

**⇓ If no DTCs are set**

3. Verify the scan tool Body Control Module Battery Voltage parameter is 12 V or greater.

**⇒ If less than 12 V**

Refer to Battery Inspection/Test.

**⇓ If 12 V or greater**

4. Engine running, all accessories OFF.
5. Verify the scan tool Body Control Module Battery Voltage parameter continually increases when controlling the Body Control Module Generator Regulator Setpoint from 10% to 80% with a scan tool. It may take up to 10 s for the battery voltage to stabilize between each setpoint change.

**⇒ If the battery voltage does not continually increase**

Refer to Circuit/System Testing.

**⇓ If the battery voltage continually increases**

6. All OK.

#### 8.1.2.4.6. Circuit/System Testing

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

1. Ignition OFF.
2. Test for less than 2 Ω between the G13 Generator housing and C1 Battery negative terminal.

**⇒ If 6.5 Ω or greater**

Repair the open/high resistance in the circuit.

**⇓ If less than 6.4 Ω**

3. Verify a test lamp illuminates between the G13 Generator B+ circuit terminal A X2, B X2, 1 X1 or 1 X2 and ground.

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

3.1. Remove the test lamp and disconnect the B+ cable at the G13 Generator.

3.2. 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**

3.1. Remove the test lamp, disconnect the C1 Battery negative cable, and disconnect the G13 Generator B+ cable.

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

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

**⇓ If the test lamp illuminates**

4. Test or replace the G13 Generator.

#### 8.1.2.4.7. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

Generator Replacement

### 8.1.2.5. Generator Noise Diagnosis

#### 8.1.2.5.1. Diagnostic Instructions

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

#### 8.1.2.5.2. Diagnostic Aids

Noise from a generator may be due to electrical or mechanical noise. Electrical noise or magnetic whine usually varies with the electrical load placed on the generator and is a normal operating characteristic of all generators. When diagnosing a noisy generator, it is important to remember that loose or misaligned components around the generator may transmit the noise into the passenger compartment and that replacing the generator may not solve the problem.

#### 8.1.2.5.3. Circuit/System Testing

1. Start the engine. Verify the noise can be heard. Compare the concern to a similar vehicle.
2. Perform a charging system test. Verify that the generator is charging properly.
3. Inspect the generator, generator mounting, wiring harness, heater hoses, A/C lines, or other accessory equipment that may be misrouted or be the cause of noise being transmitted into the passenger compartment.
4. Ignition OFF, remove the engine drive belt.
5. Verify the generator, A/C compressor, water pump pulley, power steering pump, idler pulley, and tensioner pulley spin freely.

**⇒ If any of the pulleys do not spin freely**

Replace the affected component.

**⇓ If all belt driven components spin freely**

6. Start the engine. Operate the engine for no longer than 30-40s.
7. Verify that the noise goes away.

**⇒ If the noise is still present**

The generator is not the cause of the noise. Refer to Symptoms Engine Mechanical

**⇓ If noise is no longer present**

8. Inspect for worn accessory drive components or abnormalities such as severe cracking, bumps, or missing areas in the accessory drive belt and/or misalignment of system components

#### 8.1.2.5.4. Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

**8.1.2.5.5. Starter Solenoid Does Not Click**

**8.1.2.5.6. Diagnostic Instructions**

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

**8.1.2.5.7. Diagnostic Fault Information**

| Circuit | Short to Ground | Open/High Resistance | Short to Voltage | Signal Performance |
|---|---|---|---|---|
| B+ | 1 | 1 | - | - |
| Control Terminal 85 | - | 1 | 2 | - |
| Control Terminal 87 | 1 | 1 | 2 | - |
| Ground Terminal 86 | - | 1 | - | - |
| 1. No Crank<br>2. Cranks All The Time | | | | |

**8.1.2.5.8. Circuit/System Description**

When the ignition switch is placed in the START position, a signal is supplied to the starter relay. Providing that the transmission is in Park/Neutral. The engine will crank.

**8.1.2.5.9. Reference Information**

Schematic Reference
Starting and Charging Schematics

Connector End View Reference
Component Connector End Views

Description and Operation
Starting System Description and Operation

Electrical Information Reference
- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

Scan Tool Reference
Control Module References for scan tool information

**8.1.2.5.10.Circuit/System Verification**

1. Transmission range selector in park, attempt to start the vehicle. The starter solenoid should click and the engine should begin cranking.
   ⇒ If the starter solenoid does not click or the engine does not crank, refer to Circuit/System Testing.
2. Ignition ON, observe the scan tool ECM Crankshaft Position Sensor Active Counter is not incrementing.
   ⇒ If the Crankshaft Position Sensor Active Counter is incrementing, replace the Crankshaft Position Sensor.

**8.1.2.5.11.Circuit/System Testing**

1. Verify DTC P0851, P0852, B1370, B1380, B1440, or B1441 are not set.
   ⇒ If either DTC is set, refer to Diagnostic Trouble Code (DTC) List Vehicle.
2. Ignition Off, disconnect the starter relay.
3. Test for less than 10 Ω between the relay ground coil terminal 86 and ground.
   ⇒ If greater than the specified range, test the ground circuit for an open/high resistance.
4. Ignition ON, verify that a test lamp illuminates between the B+ circuit terminal 30 and ground.
   ⇒ If the test lamp does not illuminate, test the B+ circuit for a short to ground or an open/high resistance. If the circuit tests normal and the fuse is open, test the relay switch control output terminal 87 for a short to ground.
5. Ensure the parking brake is applied and the transmission is in park/neutral.
6. Momentarily install a 30 A fused jumper wire between the B+ circuit terminal 30 and the relay switch output terminal 87.
7. The starter solenoid should engage and the engine should begin cranking
   ⇒ If the solenoid does not engage, test the relay switch output circuit for a short to ground or an open/high resistance. If the circuit tests normal, replace the starter motor.
8. Connect a test lamp between the starter relay coil control circuit terminal 85 and the coil ground terminal 86.
9. Transmission in park/neutral, cycle the ignition between the OFF and Crank position. The test lamp should turn ON and OFF when
changing between the Crank and OFF positions.
   ⇒ If the test lamp is always ON, test the control circuit for a short to voltage. If the circuit tests normal, replace the ECM.
   ⇒ If the test lamp is always OFF, test the control circuit for a short to ground or an open/high resistance. If the circuit tests normal, replace the ECM.
10. If all circuits tests normal, replace the starter relay.

**8.1.2.5.12.Repair Instructions**

Perform the Diagnostic Repair Verification after completing the repair.

- Crankshaft Position Sensor Replacement
- Clutch Pedal Position Sensor Replacement
- Relay Replacement
- Starter Replacement
- Control Module References for ECM replacement, setup and programming

### 8.1.2.6. Starter Solenoid Clicks, Engine Does Not Crank

#### 8.1.2.6.1. Diagnostic Instructions

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

#### 8.1.2.6.2. Reference Information

Schematic Reference

Starting and Charging Schematics

Connector End View Reference

Component Connector End Views

Description and Operation

Starting System Description and Operation

Electrical Information Reference

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

Scan Tool Reference

Control Module References for scan tool information

#### 8.1.2.6.3. Circuit/System Testing

1. Ignition OFF, measure and record the C1 Battery voltage at the terminals.
2. Verify the measured voltage is between 12–15 V.
**⇒ If voltage is less than 12 V or greater than 15 V**
    Refer to Battery Inspection/Test.
**⇓ If voltage is between 12–15V**
3. Remove the drive belts. Refer to Drive Belt Replacement
4. Verify the crankshaft rotates rotate the crankshaft by hand using the appropriate tools.
**⇒ If the crankshaft does not rotate**
    Refer to Engine Will Not Crank Crankshaft Will Not Rotate
**⇓ If the crankshaft rotates**
5. Verify the engine does not crank when attempting to start the vehicle.
**⇒ If the engine cranks**
    Inspect the engine and belt drive system for mechanical binding, seized engine, or seized generator.
**⇓ If the engine does not crank**
6. Verify that a test lamp illuminates between the M64 Starter Motor B+ terminal 1 X2 or A X2 and ground.
**⇒ If the test lamp does not illuminate and the circuit fuse is good**
    6.1. Ignition OFF.
    6.2. 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**
    6.1. Ignition OFF.
    6.2. Test for greater than 100 Ω between the B+ circuit and ground.
    ⇒ If 100 Ω or less, repair the short to ground on the circuit.
    ⇒ If greater than 100 Ω, replace the M64 Starter Motor.
**⇓ If the test lamp illuminates**
7. Test for less than 0.5 V between the positive battery cable and M64 Starter Motor B+ terminal 1 X2 or A X2 with the ignition in the START position.
**⇒ If 0.5 V or greater**
    Replace the positive battery cable.
**⇓ If less than 0.5 V**
8. Test for less than 0.5 V between the negative battery cable and the M64 Starter Motor case with the ignition in the START position.
**⇒ If 0.5 V or greater**
    Replace the negative battery cable.
**⇓ less than 0.5 V**
9. Replace the M64 Starter Motor.

#### 8.1.2.6.4. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Battery Negative Cable Replacement
- Battery Positive Cable Replacement
- Starter Replacement

### 8.1.2.7. Engine Cranks Slowly

#### 8.1.2.7.1. Diagnostic Instructions

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

#### 8.1.2.7.2. Reference Information

**Schematic Reference**
Starting and Charging Schematics

**Connector End View Reference**
Component Connector End Views

**Description and Operation**
Starting System Description and Operation

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

**Scan Tool Reference**
Control Module References for scan tool information

#### 8.1.2.7.3. Circuit/System Verification

1. Ignition OFF, measure and record the battery voltage at the C1 battery terminals. The voltage should be between 12.0–15.0 V.
   ⇒ If not within the specified range, refer to Battery Charging.
2. Test for less than 0.5 V between the positive battery cable and terminal B X2 at the M64 starter motor as the ignition is placed to the CRANK position.
   ⇒ If greater than the specified value, replace the positive battery cable.
3. Test for less than 0.5 V between the negative battery cable and the M64 starter motor case as the ignition switch is placed to the CRANK position.
   ⇒ If greater than the specified value, replace the negative battery cable.
4. Remove the drive belts. Refer to one of the following:
   - Drive Belt Replacement
   - Drive Belt Tensioner Replacement
5. Place the ignition to the CRANK position. verify the engine does not crank normal.
   ⇒ If the engine cranks normal, inspect the engine and belt drive system for mechanical binding, seized generator etc.
6. If all circuits test normal, replace the M64 starter motor.

#### 8.1.2.7.4. Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.
- Battery Negative Cable Disconnection and Connection
- Starter Replacement

## 8.1.2.8. Starter Noise Diagnosis

### 8.1.2.8.1. Diagnostic Instructions

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

### 8.1.2.8.2. Circuit/System Description

The PG starter motors are non-repairable. They have pole pieces that are arranged around the armature. Both solenoid windings are energized. The pull-in winding circuit is completed to the ground through the starter motor. The windings work together magnetically to pull and hold in the plunger. The plunger moves the shift lever. This action causes the starter drive assembly to rotate on the armature shaft spline as it engages with the flywheel ring gear on the engine. Moving at the same time, the plunger also closes the solenoid switch contacts in the starter solenoid. Full battery voltage is applied directly to the starter motor and it cranks the engine.

### 8.1.2.8.3. Reference Information

**Description and Operation**

Starting System Description and Operation

### 8.1.2.8.4. Circuit/System Verification

Start the engine. Listen to the starter noise, while the engine is cranking. Compare the concern to a similar vehicle.

### 8.1.2.8.5. Circuit/System Testing

1. Remove the flywheel inspection cover.
2. Inspect the flywheel for the following:
   - Loose flywheel bolts
   - Chipped gear teeth
   - Missing gear teeth
   - Bent flywheel
   - Debris in the bell housing

⇒ If not within specifications, remove the debris, tighten the flywheel bolts, or repair or replace the flywheel.

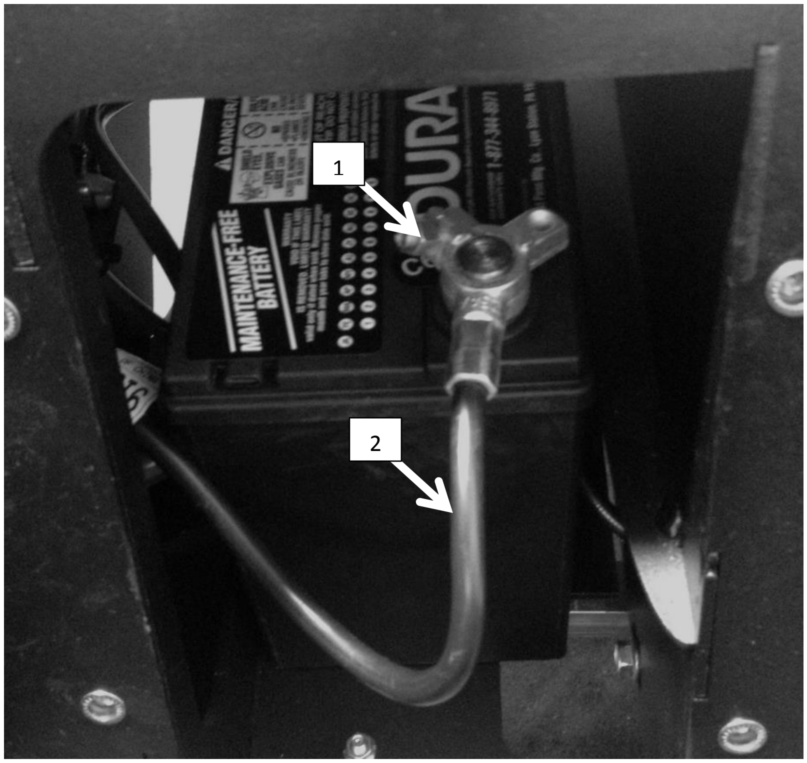
3. If all inspections were within specification, replace the starter motor.

### 8.1.2.8.6. Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

- Starter Replacement
- Engine Flywheel Replacement

### 8.1.2.9. Battery Negative Cable Disconnection and Connection (Battery to Chassis)




Battery Negative Cable Disconnection and Connection

| Callout | Component Name |
|---|---|
| **Preliminary Procedures**<br>1.Slide the Right Seat fully forward<br>2. Remove Back Carpet<br>3. Remove Battery Hatch Cover<br>4. Ensure that all lamps and accessories are turned off.<br>5. Turn the ignition OFF and remove the ignition key. | |
| 1 | Battery Negative Cable Fastener<br>Warning: Refer to Battery Disconnect Warning.<br>Caution: Refer to Fastener Caution.<br>**Tighten**<br>4.5 Nm (40 lb in) |
| 2 | Battery Negative Cable<br>Procedure<br>1. Disconnect the battery negative cable from the battery.<br>2. After connecting the battery negative cable, insert the ignition key and turn the ignition to the ON position.<br>3. Program the volatile memory. Refer to Control Module References. |

### 8.1.2.10. DTC B1325, B1327B1330, B1395, B1415, B1424, B1425, B1439, B1517, C0800, C0805, C0870, C0880, C0895, C0899, C0900, P0560, P0562, P0563, P0611, P129B, P129C, P15AE, or P15AF

#### 8.1.2.10.1.Diagnostic Instructions

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

#### 8.1.2.10.2. DTC Descriptors

**DTC B1325**
Device Power Circuit Voltage
**DTC B1327**
Device Voltage Circuit
**DTC B1328**
Device Voltage Circuit
**DTC B1330**
Device Power 2 Circuit
**DTC B1390**
Control Module Supply Circuit 1
**DTC B1395**
Control Module Voltage Reference Output 1
**DTC B1400**
Control Module Supply Circuit 2
**DTC B1410**
Control Module Supply Circuit 3
**DTC B1415**
Control Module Voltage Reference Output 3
**DTC B1424**
Control Module Power Circuit
**DTC B1425**
Control Module Power Circuit
**DTC B1439**
Intermittent Device Voltage
**DTC B1517**
Battery Voltage
**DTC C0800**
Device Power 1 Circuit Voltage
**DTC C0805**
Control Module Power 2 Circuit
**DTC C0870**
Control Module Voltage Reference
**DTC C0880**
Control Module Voltage Reference
**DTC C0895**
Device Voltage
**DTC C0899**
Device Voltage
**DTC C0900**
Device Voltage
**DTC P0560**
System Voltage Low
**DTC P0561**
System Voltage Performance
**DTC P0562**
System Voltage Low
**DTC P0563**
System Voltage High
**DTC P0611**
Fuel Injector Control Module Performance
**DTC P129B**
System Voltage Low
**DTC P129C**
System Voltage High

**DTC P15AE**

Fuel Injector Control Module System Voltage Low Voltage

**DTC P15AF**

Fuel Injector Control Module System Voltage High Voltage

For symptom byte information refer to Symptom Byte List.

**8.1.2.10.3.Circuit/System Description**

The vehicle control modules or sensors monitor the system voltage to verify the system voltage is within the normal operating range.

**8.1.2.10.4.Conditions for Running the DTC**

The engine is running.

**8.1.2.10.5.Conditions for Setting the DTC**

The control module or sensor detects a system voltage of less than approximately 9 V or greater than 15 V for approximately 5 s.

**8.1.2.10.6.Action Taken When the DTC Sets**

A driver information center message and/or warning indicator may be displayed.
The control module may be temporarily disabled.

**8.1.2.10.7.Conditions for Clearing the DTC**

The system voltage returns to normal operating range.

**8.1.2.10.8.Diagnostic Aids**

A high or low voltage DTC set or voltage value in multiple modules/sensors indicates a concern in the charging system.
A possible cause of this DTC could be overcharging with a battery charger or jump starting.

#### 8.1.2.10.9.Reference Information

**Schematic Reference**
Control Module References

**Connector End View Reference**
Component Connector End Views

**Description and Operation**
Charging System Description and Operation

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

**DTC Type Reference**
Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**
Control Module References for scan tool information

#### 8.1.2.10.10. Circuit/System Verification

1. Ignition OFF, measure and record the battery voltage at the battery terminals.
2. Verify the battery voltage stabilizes between 12.4 and 12.8 V within a few minutes of turning the ignition OFF.

**⇒ If battery voltage is less than 12.4 V or more than 12.8 V**
Refer to Battery Inspection/Test.

**⇓ If battery voltage is between 12.4 and 12.8 V**

3. Engine running, headlights ON, measure and record the battery voltage at the battery terminals.
4. Verify the voltage is at least 1 V greater than the voltage measured in step 1, but less than 15 V.

**⇒ If the voltage is not at least 1 V greater than the voltage measured in step 1 or is greater than 15 V.**
Refer to Charging System Test.

**⇓ If the voltage is at least 1 V greater than the voltage measured in step 1, but less than 15 V.**

5. Verify the appropriate control module battery voltage and ignition voltage parameters are available in the scan tool.

**⇒ If parameters are not available in the scan tool**
Refer to Circuit/System Testing

**⇓ If parameters are available in the scan tool**

6. Verify the appropriate control module scan tool battery voltage and ignition voltage parameters are within 1 V of the battery voltage.

**⇒ If not within 1 V of the battery voltage**
Refer to Circuit/System Testing

**⇓ If within 1 V of the battery voltage**

7. All OK.

**8.1.2.10.11. Circuit/System Testing**

| Note: |
|---|
| Use the schematic to identify the following:<br>• Control modules the vehicle is equipped with<br>• The control module's ground, B+, and Ignition circuit terminal IDs and connectors |

| Note: |
|---|
| Some control module ground circuits may require up to 20 min after the ignition is turned off before achieving a resistance reading of less than 5 Ω. In most cases the readings will drop below 20 Ω within 1 min indicating the control module is going to sleep. |

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connectors at the appropriate control module. It may take up to 2 min for all vehicle systems to power down.
2. Test for less than 10 Ω between each ground circuit terminal and ground.

**⇒ If 10 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 10 Ω**

3. If equipped, verify a test lamp illuminates between each B+ circuit terminal and ground.

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

3.1. Ignition OFF.
3.2. 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**

3.1. Ignition OFF.
3.2. Test for infinite resistance between the B+ circuit and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇒ If infinite resistance, replace the appropriate control module.

**⇓ If the test lamp illuminates**

4. Ignition ON.
5. If equipped, verify a test lamp illuminates between each ignition circuit terminal and ground.

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

5.1. Ignition OFF.
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.
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, replace the appropriate control module.

**⇓ If the test lamp illuminates**

6. Replace the control module.

**8.1.2.10.12. Repair Instructions**

Perform the Diagnostic Repair Verification after completing the repair.
Control Module References for control module replacement, programming and setup.

### 8.1.2.11. DTC B1516

#### 8.1.2.11.1. Diagnostic Instructions

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

#### 8.1.2.11.2. DTC Descriptors

**DTC B1516 08**
Battery Current Sensor Signal Invalid
**DTC B1516 66**
Battery Current Sensor Wrong Mounting Position

#### 8.1.2.11.3. Diagnostic Fault Information

| Circuit | Short to Ground | Open/High Resistance | Short to Voltage | Signal Performance |
|---|---|---|---|---|
| 5 V | B1516 08 | B1516 08 | - | - |
| Signal | B1516 08 | B1516 08 | B1516 08 | B1516 08, B1516 66 |
| Low Reference | - | B1516 08 | - | - |

#### 8.1.2.11.4. Circuit/System Description

The battery current sensor is a 3wire hall effect current sensor. The body control module (BCM) supplies 5 V and ground to the battery current sensor. The battery current sensor measures the amount of current flowing to or from the battery, and supplies a pulse width modulation (PWM) signal to the BCM.

#### 8.1.2.11.5. Conditions for Running the DTC

**B1516 08**
The BCM is awake.
**B1516 66**
The BCM is awake.
The engine is OFF.

#### 8.1.2.11.6. Conditions for Setting the DTC

**B1516 08**
The battery current signal is less than 4 % or greater than 96 % duty cycle for 2 min.
**B1516 66**
The battery current polarity is positive for 2 minutes.

#### 8.1.2.11.7. Action Taken When the DTC Sets

The regulated voltage control (RVC) is disabled.

#### 8.1.2.11.8. Conditions for Clearing the DTC

The DTC passes when the battery current returns to the normal range for 15 s.

#### 8.1.2.11.9. Diagnostic Aids

DTC B1516 08 could be set by overcharging with a battery charger or jump starting.

**8.1.2.11.10. Reference Information**

**Schematic Reference**

Starting and Charging Schematics

**Connector End View Reference**

Component Connector End Views

**Description and Operation**

Charging System Description and Operation

**Electrical Information Reference**

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

**Scan Tool Reference**

Control Module References for scan tool information

**8.1.2.11.11. Circuit/System Testing**

**B1516 08**

1. Ignition OFF, disconnect the harness connector at the B18 battery current sensor.
2. Ignition OFF and scan tool disconnected, open and close the driver door, and wait 1 min. Test for less than 30 Ω between the low reference circuit terminal B and ground.
   ⇒ If greater than specified range , test the low reference circuit for an open/high resistance. If the circuit tests normal, replace the K9 Body Control Module.
3. Ignition ON, test for 4.8–5.2 V between the 5 V reference circuit terminal A and ground.
   ⇒ If less than the specified range, test the 5 V reference circuit for a short to ground or an open/high resistance. If the circuit tests normal, replace the K9 Body Control Module.
   ⇒ If greater than the specified range, test the 5 V reference circuit for a short to voltage. If the circuit tests normal, replace the K9 Body Control Module.
4. Ignition ON, test for 4.8–5.2 V between the signal circuit terminal C and ground.
   ⇒ If less than the specified range, test the signal circuit for a short to ground or an open/high resistance. If the circuit tests normal, replace the K9 Body Control Module.
   ⇒ If greater than the specified range, test the signal circuit for a short to voltage. If the circuit tests normal, replace the K9 Body Control Module.
5. If all circuits test normal, test or replace the B18 Battery Current Sensor.

**B1516 66**

1. Verify that the B18 Battery Current Sensor is installed securely around the negative battery cable, with the tape tab pointing away from the negative terminal on the C1 Battery.
   ⇒ If the B18 Battery Current Sensor is not installed correctly, remove and reinstall the sensor properly.
2. Replace the B18 Battery Current Sensor.

**8.1.2.11.12. Repair Instructions**

Perform the Diagnostic Repair Verification after completing the repair.

- Battery Current Sensor Replacement
- Control Module References for BCM replacement, setup, and programming

## 8.1.2.12. DTC B151A

### 8.1.2.12.1. Diagnostic Instructions

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

### 8.1.2.12.2. DTC Descriptor

**DTC B151A 58**
Battery Capacity Performance

### 8.1.2.12.3. Circuit/System Description

The body control module (BCM) monitors the battery voltage level during an engine crank event to detect a low battery voltage condition.

### 8.1.2.12.4. Conditions for Running the DTC

The vehicle is ON

### 8.1.2.12.5. Conditions for Setting the DTC

A minimum crank battery voltage is less than the minimum crank battery voltage threshold for 16 consecutive crank events.

### 8.1.2.12.6. Action Taken When the DTC Sets

A driver information center message is displayed.

### 8.1.2.12.7. Conditions for Clearing the DTC

The DTC will clear if the minimum crank voltage is greater than the minimum crank voltage threshold during a crank event.

### 8.1.2.12.8. Reference Information

**Schematic Reference**
Starting and Charging Schematics

**Connector End View Reference**
Component Connector End Views

**Description and Operation**
Charging System Description and Operation

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

**Scan Tool Reference**
Control Module References for scan tool information

**8.1.2.12.9.Circuit/System Verification**

1. Verify DTC P0621 or P0622 is not set.

**⇒ If DTC P0621 or P0622 is set**

Refer to DTC P0621 or DTC P0622

**⇓ If DTC P0621 or P0622 is not set**

2. Perform the Battery Inspection/Test.

## 8.1.2.13. DTC B1527

### 8.1.2.13.1.Diagnostic Instructions

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

### 8.1.2.13.2.DTC Descriptor

**DTC B1527 00**
Parasitic Load

### 8.1.2.13.3.Circuit/System Description

The body control module (BCM) monitors the state of charge of the electrical system.

### 8.1.2.13.4.Conditions for Running the DTC

The ignition is in Accessory or Run mode.

### 8.1.2.13.5.Conditions for Setting the DTC

The state of charge at ignition ON is 30% lower than when the engine was running and battery drain is more than 2 A.

### 8.1.2.13.6.Action Taken When the DTC Sets

There is no battery telltale illuminated or DIC message displayed.

### 8.1.2.13.7.Conditions for Clearing the DTC

The DTC will clear if the fault does not return after 50 consecutive ignition cycles.
The DTC will clear when run state of charge is greater than or equal to 80%.

### 8.1.2.13.8.Reference Information

**Schematic Reference**
Starting and Charging Schematics

**Connector End View Reference**
Component Connector End Views

**Description and Operation**
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**Electrical Information Reference**
- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

**Scan Tool Reference**
Control Module References for scan tool information

### 8.1.2.13.9.Circuit/System Verification

Refer to Battery Electrical Drain/Parasitic Load Test.

## 8.1.2.14. DTC P0615, P0616, or P0617

### 8.1.2.14.1. Diagnostic Instructions

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

### 8.1.2.14.2. DTC Descriptors

**DTC P0615**
Starter Relay Control Circuit
**DTC P0616**
Starter Relay Control Circuit Low Voltage
**DTC P0617**
Starter Relay Control Circuit High Voltage

### 8.1.2.14.3. Diagnostic Fault Information

| Circuit | Short to Ground | Open/High Resistance | Short to Voltage | Signal Performance |
|---|---|---|---|---|
| Control | P0616 | P0615 | P0617 | - |
| Ground | - | P0615 | - | - |

### 8.1.2.14.4. Circuit/System Description

When the ignition switch is placed in the CRANK position, a discrete signal is supplied to the body control module (BCM) notifying it that the ignition is in the CRANK position. The BCM then sends a message to the engine control module (ECM) that crank has been requested. The ECM then verifies that the clutch pedal is depressed or the transmission is in Park/Neutral. If it is, the ECM then supplies 12 V to the control circuit of the starter relay. When this occurs, battery voltage is supplied through the switch of the starter relay to the starter motor.

### 8.1.2.14.5. Conditions for Running the DTC

- The ignition is in the CRANK position.
- The system voltage is between 9.5–18 V.

### 8.1.2.14.6. Conditions for Setting the DTC

The ECM detects improper voltage on the control circuit of the starter relay.

### 8.1.2.14.7. Action Taken When the DTC Sets

DTC P0615, P0616, and P0617 are C type DTCs.

### 8.1.2.14.8. Conditions for Clearing the DTC

DTC P0615, P0616, and P0617 are C type DTCs.

### 8.1.2.14.9. Reference Information

Schematic Reference
Starting and Charging Schematics

Connector End View Reference
Component Connector End Views

Description and Operation
Starting System Description and Operation

Electrical Information Reference
- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

DTC Type Reference
Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference
Control Module References for scan tool information

### 8.1.2.14.10. Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the KR27 Starter Relay. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 10 Ω between the ground circuit terminal 86 and ground.

**⇒ If 10 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 10 Ω**

3. Ignition ON.
4. 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**

4.1. Ignition OFF.
4.2. Test for less than 2 Ω in the B+ circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, verify the fuse is good and 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 B+ circuit and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇓ If infinite resistance
4.3. Test for infinite resistance between the control circuit terminal 87 and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇒ If infinite resistance, replace the KR27 Starter Relay.

**⇓ If the test lamp illuminates**

5. Connect a test lamp between the control circuit terminal 85 and the ground circuit terminal 86.
6. Verify the test lamp turns ON and OFF when activating the vehicle ignition switch.

**⇒ If the test lamp is always OFF**

6.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
6.2. Test for infinite resistance between the control circuit and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇓ If infinite resistance
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 in the circuit.
⇒ If less than 2 Ω, replace the K20 Engine Control Module.

**⇒ If the test lamp is always ON**

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 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**

7. Ignition ON, connect a 30 A fused jumper wire between the B+ circuit terminal 30 and the control circuit terminal 87.
8. Verify the M64 starter motor is activated.

**⇒ If the M64 starter motor does not activate**

8.1. Ignition OFF, disconnect the X1 harness connector at the M64 starter motor.
8.2. Test for infinite resistance between the control circuit terminal X1 A or X1 1 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 M64 starter motor.

**⇓ If the M64 starter motor activates**

9. Test or replace the KR27 Starter Relay.

### 8.1.2.14.11. Component Testing

**Relay Test**

1. Ignition OFF, disconnect the KR27 Starter Relay.
2. Test for 60–180 Ω between terminals 85 and 86.

**⇒ If less than 60 or greater than 180 Ω**

Replace the relay.

**⇓ If between 60–180 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

### 8.1.2.14.12. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Relay Replacement

- Starter Replacement
- Control Module References for ECM replacement, programming, and setup

## 8.1.2.15. DTC P0621

### 8.1.2.15.1. Diagnostic Instructions

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

### 8.1.2.15.2. DTC Descriptor

**DTC P0621**
Generator L-Terminal Circuit

### 8.1.2.15.3. Diagnostic Fault Information

| Circuit | Short to Ground | Open/High Resistance | Short to Voltage | Signal Performance |
|---|---|---|---|---|
| B+ | - | P0621 | - | - |
| Control – L Terminal | P0621 | - | P0621 | - |
| Signal – F Terminal | P0622 | - | P0622 | P0622 |

### 8.1.2.15.4. Circuit/System Description

The engine control module (ECM) uses the generator turn on control circuit to control the load of the generator on the engine. A high side driver in the ECM applies a duty cycled voltage to the voltage regulator. The duty cycle controls the voltage regulator to turn the field circuit on and off. The ECM monitors the state of the generator turn on control circuit. The ECM should detect low voltage on the generator turn on control circuit when the ignition is ON and the engine is off, or when the charging system malfunctions. With the engine running, the ECM should detect on the generator turn on control circuit, a high voltage when the duty cycle voltage is commanded high, and a low voltage when the duty cycle voltage is commanded low.

### 8.1.2.15.5. Conditions for Running the DTC

- Ignition ON, engine OFF (Prior to Ignition ON, the ignition must have been OFF for at least 5 s).
- The engine is running for the run test

### 8.1.2.15.6. Conditions for Setting the DTC

- Ignition ON, engine OFF – The ECM detects greater than 3.5 V on the generator control circuit for 5 s.
- Engine running – The ECM detects a low voltage for 15 s on the generator control circuit when the duty cycle voltage is commanded high.
- Engine running – The ECM detects a high voltage for 15 s on the generator control circuit when the duty cycle voltage is commanded low.

### 8.1.2.15.7. Action Taken When the DTC Sets

DTC P0621 is a type C DTC.

### 8.1.2.15.8. Conditions for Clearing the DTC

- Ignition ON, engine OFF– Low voltage.
- Engine running – A control signal duty cycle is detected.

#### 8.1.2.15.9.Reference Information

**Schematic Reference**
Starting and Charging Schematics

**Connector End View Reference**
Component Connector End Views

**Description and Operation**
Charging System Description and Operation

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

**DTC Type Reference**
Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**
Control Module References for scan tool information

#### 8.1.2.15.10. 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.

#### 8.1.2.15.11. Circuit/System Testing

1. Verify a test lamp illuminates between the G13 Generator B+ circuit terminal A X1, A X2, B X2 or 1 X2, and ground.
**⇒ If the test lamp does not illuminate and the circuit fuse is good**
1.1. Remove the test lamp and disconnect the B+ cable at the G13 Generator.
1.2. Test for less than 2 Ω in the B+ circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.
**⇒ If the test lamp does not illuminate and the circuit fuse is open**
1.1. Remove the test lamp, disconnect the battery negative cable, and disconnect the G13 Generator B+ cable.
1.2. Test for infinite resistance between the B+ circuit and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
**⇓ If the test lamp illuminates**
2. Disconnect the X1 harness connector at the G13 Generator, engine running.
3. Test for 1 V or greater between the control circuit terminal 1 X1 and ground.
**⇒ If less than 1 V**
3.1. Ignition OFF, disconnect the harness connectors 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 greater than 2 Ω, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, replace the K20 Engine Control Module.
**⇓ If 1V or greater**

4. Ignition OFF, disconnect the harness connectors at the K20 Engine Control Module, Ignition ON
5. Test for less than 1 V between the G13 Generator control circuit terminal 1 X1 and ground.

**⇒ If greater than 1 V**

Repair the short to voltage on the circuit.

**⇓ If 1V or less**

6. Test or replace the G13 Generator.

**8.1.2.15.12. Repair Instructions**

Perform the Diagnostic Repair Verification after completing the repair.

- Generator Replacement
- Control Module References for engine control module replacement, programming, and setup

## 8.1.2.16. DTC P0622

### 8.1.2.16.1. Diagnostic Instructions

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

### 8.1.2.16.2. DTC Descriptor

**DTC P0622**
Generator F-Terminal Circuit

Diagnostic Fault Information

| Circuit | Short to Ground | Open/High Resistance | Short to Voltage | Signal Performance |
|---|---|---|---|---|
| B+ | - | P0621 | - | - |
| Control – L Terminal | P0621 | - | P0621 | - |
| Signal – F Terminal | P0622 | - | P0622 | P0622 |

### 8.1.2.16.3. Circuit/System Description

The engine control module (ECM) uses the generator field duty cycle signal circuit, or F-terminal circuit, to monitor the duty cycle of the generator. The generator field duty cycle signal circuit connects to high side of the field windings in the generator. A pulse width modulated (PWM) high side driver in the voltage regulator turns the field windings on and off. The ECM uses the PWM signal input to determine the generator load on the engine. This allows the ECM to adjust the idle speed to compensate for high electrical loads. The ECM monitors the status of the generator field duty cycle signal circuit. When the ignition is ON and the engine is off, the ECM should detect a duty cycle near 0%. When the engine is running, the duty cycle should be between 5–99%.

### 8.1.2.16.4. Conditions for Running the DTC

- Ignition ON, engine OFF (Prior to Ignition ON, the ignition must have been OFF for at least 5 s)
- Engine running at less than 3,000 RPM

### 8.1.2.16.5. Conditions for Setting the DTC

- DTC P0621 is not set
- Ignition ON, engine OFF (Prior to Ignition ON, the ignition must have been OFF for at least 5 s), the ECM detects a PWM signal that is greater than 65% for 5 s
- Engine running at less than 3,000 RPM—The ECM detects a PWM signal that is less than 5% for 30 s

### 8.1.2.16.6. Action Taken When the DTC Sets

DTC P0622 is a type C DTC

### 8.1.2.16.7. Conditions for Clearing the DTC

- Ignition ON, Engine OFF– Low / no PWM signal detected
- Engine running – A 5–90% duty cycle is detected

#### 8.1.2.16.8.Reference Information

**Schematic Reference**
Starting and Charging Schematics

**Connector End View Reference**
Component Connector End Views

**Description and Operation**
Charging System Description and Operation

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

**DTC Type Reference**
Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**
Control Module References for scan tool information

#### 8.1.2.16.9.Circuit/System Verification

| Note: |
| --- |
| Do not have a battery charger connected during the generator testing. |

1. Engine running.
2. Verify the scan tool Engine Control Module Generator F-Terminal Signal parameter is between 5–90%.

**⇒ If not between 5–90%**
Refer to Circuit/System Testing.
**⇓ If between 5–90%**

3. Verify the scan tool Generator F-Terminal Signal parameter changes when commanding the headlamps ON and OFF.

**⇒ If the parameter does not change**
Refer to Circuit/System Testing.
**⇓ If the parameter changes**

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

**⇒ If the DTC sets**
Refer to Circuit/System Testing.
**⇓ If the DTC does not set**

6. All OK.

#### 8.1.2.16.10. Circuit/System Testing

1. Verify a test lamp illuminates between the G13 Generator B+ circuit terminal A X1, A X2, B X2 or 1 X2, and ground.

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

1.1. Remove the test lamp and disconnect the B+ cable at the G13 Generator.
1.2. Test for less than 2 Ω in the B+ circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.

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

1.1. Remove the test lamp, disconnect the battery negative cable, and disconnect the G13 Generator B+ cable.
1.2. Test for infinite resistance between the B+ circuit and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇒ If infinite resistance, test or replace the G13 Generator.

**⇓ If the test lamp illuminates**

2. Disconnect the X1 harness connector at the G13 Generator, engine running.
3. Verify the scan tool Engine Control Module Generator F-Terminal Signal parameter is less than 5%.

**⇒ If 5% or greater**

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 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 5%**

4. Install a 3 A fused jumper wire between the signal circuit terminal 2 and B+, engine running.
5. Verify the scan tool Engine Control Module Generator F-Terminal Signal parameter is greater than 95%.

**⇒ If 95% or less**

5.1. Ignition OFF, remove the jumper wire, 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 95%**

6. Test or replace the G13 Generator.

#### 8.1.2.16.11. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

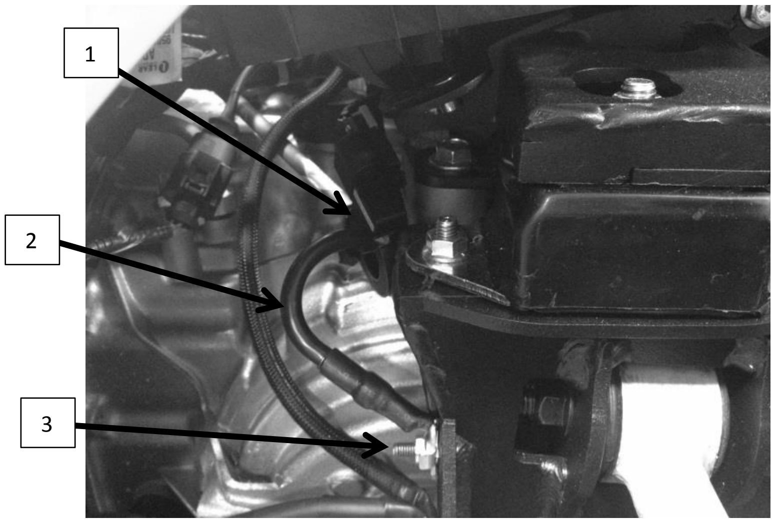
- Generator Replacement
- Control Module References for engine control module replacement, programming, and setup

### 8.1.3. Repair instructions

#### 8.1.3.1. Battery Current Sensor Replacement

##### 8.1.3.1.1. Removal Procedure

1. Remove the Hood, Refer to Hood in Body Repair




2. Remove the chassis ground nut (3)
3. Disconnect the battery current sensor from the body harness connector (1).
4. Cut any wire ties on the battery current sensor (1).

| Note: |
|---|
| Observe the position of the battery current sensor when removing. |

5. Slide the battery current sensor from the ground wire

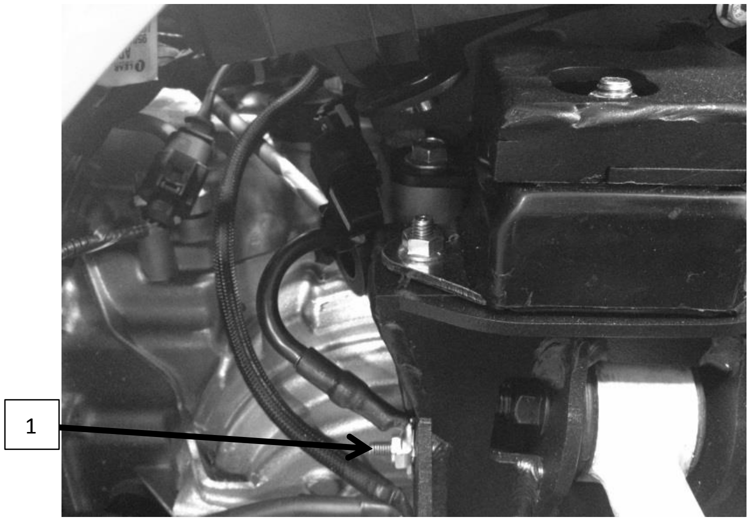
##### 8.1.3.1.2. Installation Procedure

1. Install the battery current sensor onto the battery negative cable.
2. Attach the battery current sensor to the battery negative cable with wire ties
3. Install the battery negative cable (2) frame ground terminal and bolt (3) . Tighten to 22 Nm (16 lb ft).
4. Install the Hood, Refer to Hood in Body Repair

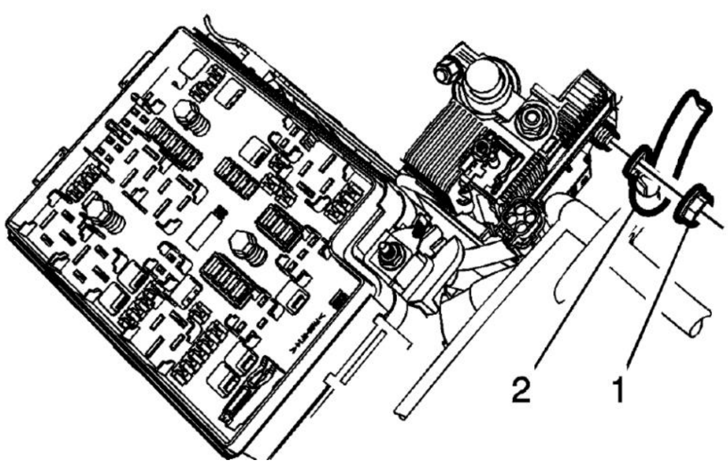
### 8.1.3.2. Battery Positive and Negative Cable Replacement

#### 8.1.3.2.1. Removal Procedure

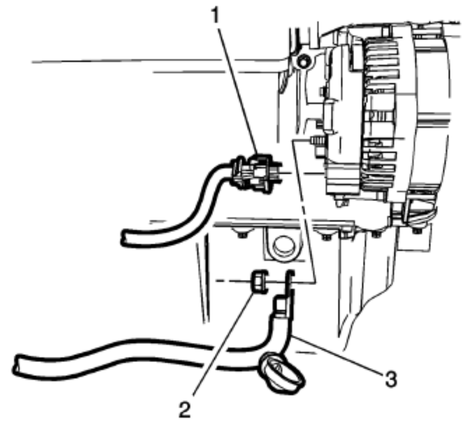
1. Remove the Hood., Refer to Hood in Body Repair
2. Disconnect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection (Battery to Chassis).



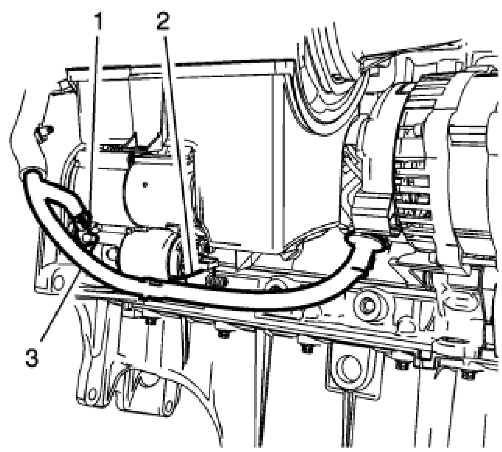

3. Remove the chassis ground nut(1)
4. Remove the fuse block and jump post cable covers.




5. Remove the battery positive nut (1) and the battery positive cable (2), from the battery positive cable junction block.

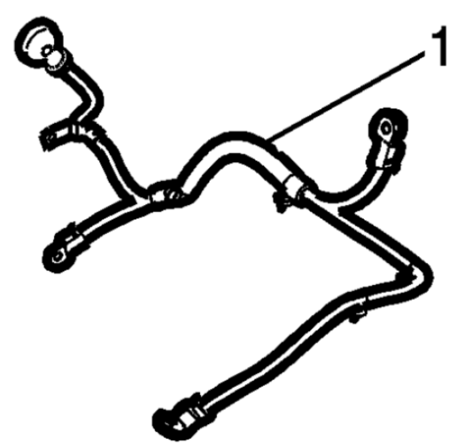



6. Remove the battery positive cable nut (2) and the battery positive cable (3), from the back of the generator.



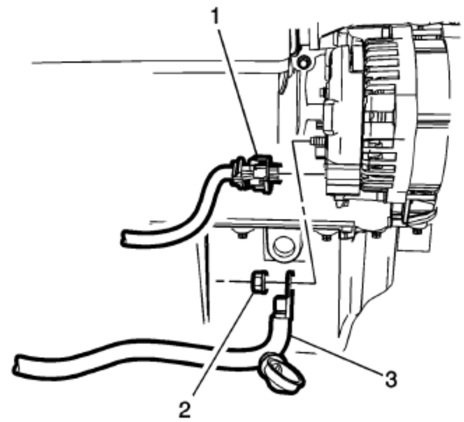

7. Remove the battery negative cable stud/nut (1) and the starter solenoid nut (2).

| Note: |
|---|
| Visualize the routing of the battery positive and negative cable within the engine compartment. |



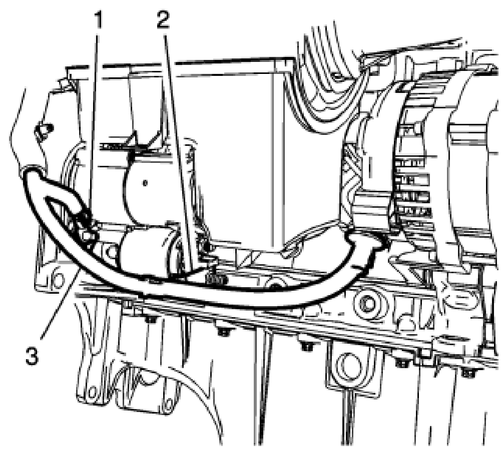

8. Remove the battery positive and negative cable (1) from the engine compartment.

**8.1.3.2.2. Installation Procedure**

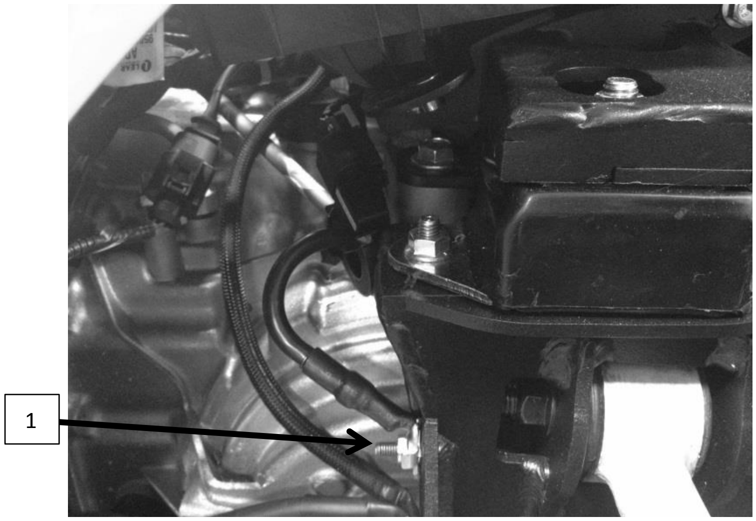



| Caution: |
|---|
| Refer to Fastener Caution. |

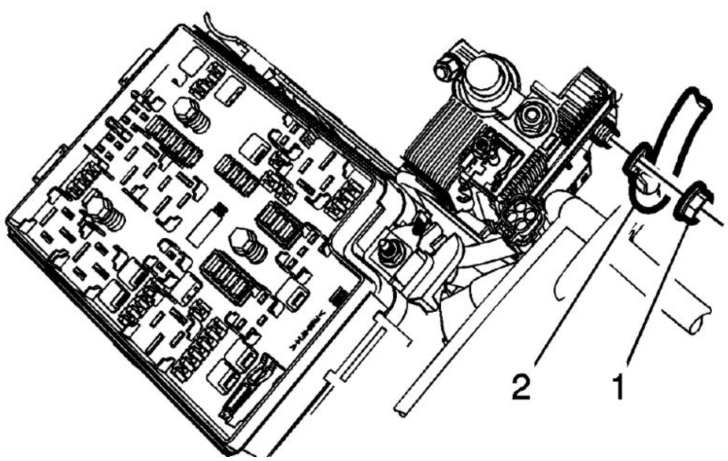
1. Install the battery positive cable (3) to the back of the generator and tighten nut (2) to 20 Nm (15 lb ft).




2. Install the battery positive cable (3) to the starter solenoid and tighten nut (2) to 12 Nm (9 lb ft).
3. Install the battery negative cable to the starter and tighten the stud/nut (1) to 25 Nm (18 lb ft).

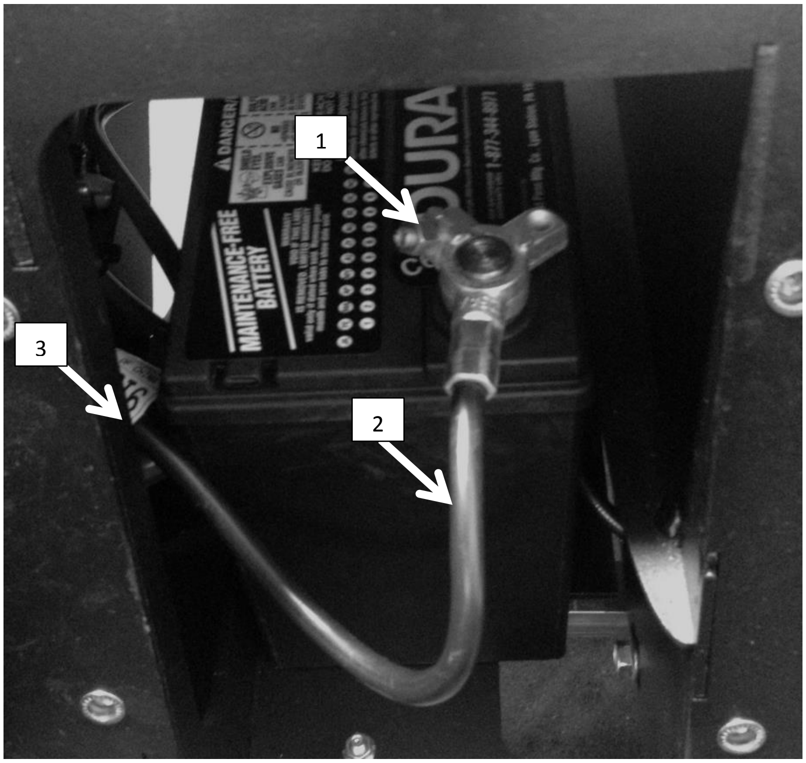



4. Install the battery negative cable nut (1) and the battery negative cable (2), to the chassis frame stud and tighten to 22 Nm (16 lb ft).




5. Install the battery positive cable (2) to the battery positive cable extension cable junction block and tighten nut (1) to 12 Nm (9 lb ft).
6. Connect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection (Battery to Chassis).
7. Install the fuse block and battery positive cable cover.
8. Install the Hood, Refer to Hood in Body Repair

### 8.1.3.3. Battery Negative Cable Replacement

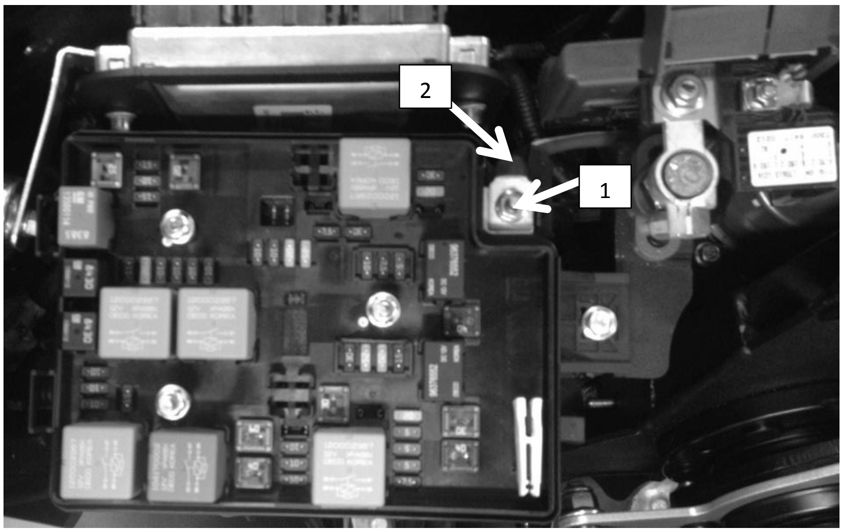



| Callout | Component Name |
|---|---|
| **Preliminary Procedures**<br>1.Slide the Right Seat fully forward<br>2. Remove Battery Hatch Cover<br>3. Ensure that all lamps and accessories are turned off.<br>4. Turn the ignition OFF and remove the ignition key. | |
| 1 | Battery Negative Cable Fastener<br>Warning: Refer to Battery Disconnect Warning.<br>Caution: Refer to Fastener Caution.<br>**Tighten**<br>4.5 Nm (40 lb in) |
| 2 | Battery Negative Cable<br>Procedure<br>1. Disconnect the battery negative cable from the battery.<br>2. After connecting the battery negative cable, insert the ignition key and turn the ignition to the ON position.<br>3. Program the volatile memory. Refer to Control Module References. |
| 3 | Battery Negative Frame Ground Nut<br>**Tighten**<br>22 Nm (16 lb ft) |

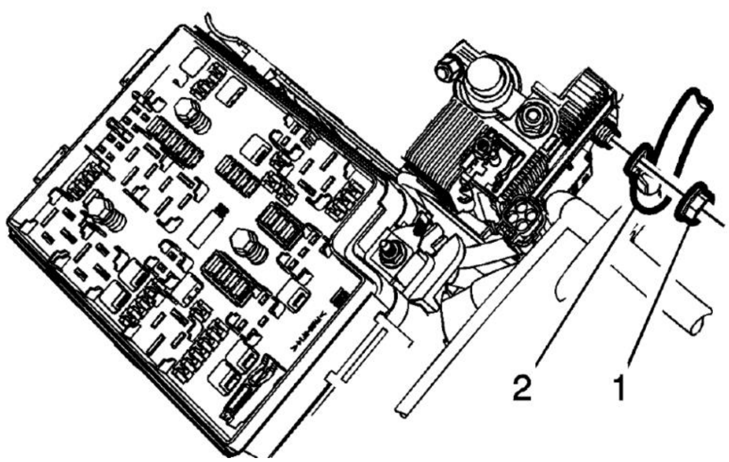
### 8.1.3.4. Battery Positive Cable Replacement (Fuse Block to Jump Post)

#### 8.1.3.4.1. Removal Procedure

1. Remove the Hood, Refer to Hood in Body Repair
2. Disconnect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection (Battery to Chassis).
3. Remove the under hood fuse block cover.



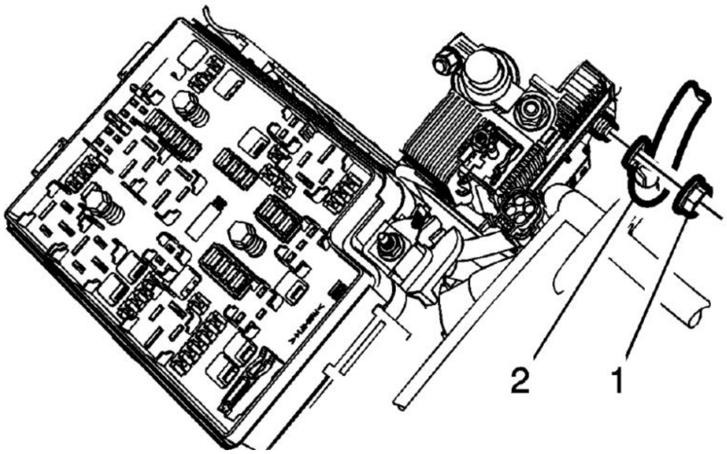

4. Remove the battery positive nut (1) and the battery positive cable (2), from the Junction Block



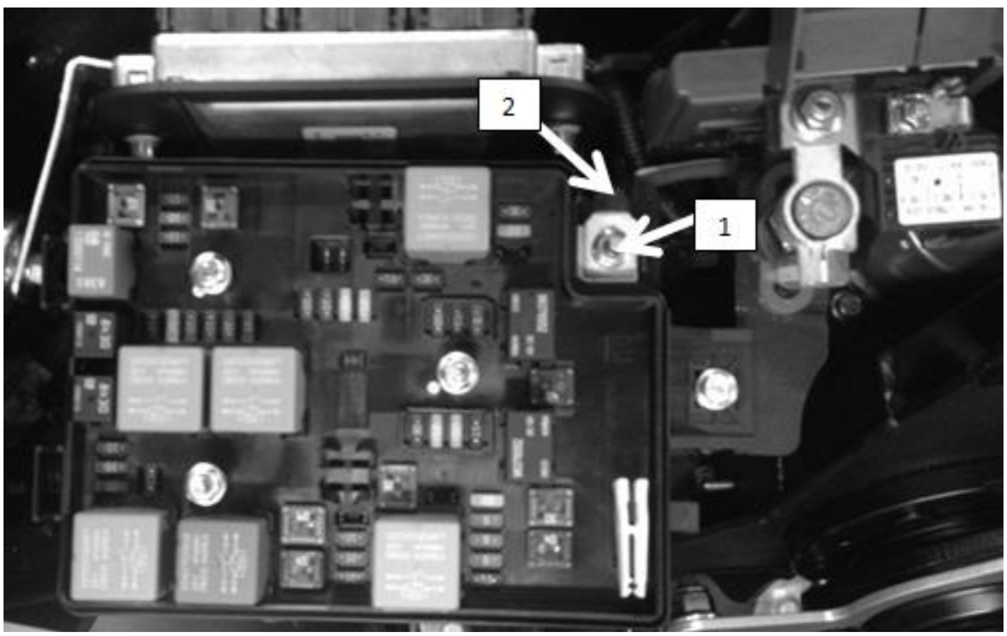

5. Remove the battery positive cable nut (1) from the battery positive cable junction block.
6. Remove the battery positive cable (2) from the vehicle.

#### 8.1.3.4.2. Installation Procedure

| Note: |
|---|
| Refer to Fastener Caution. |




1. Install the battery positive cable (2) to the battery positive cable junction block and tighten nut (1) to 7 Nm (62 lb in).

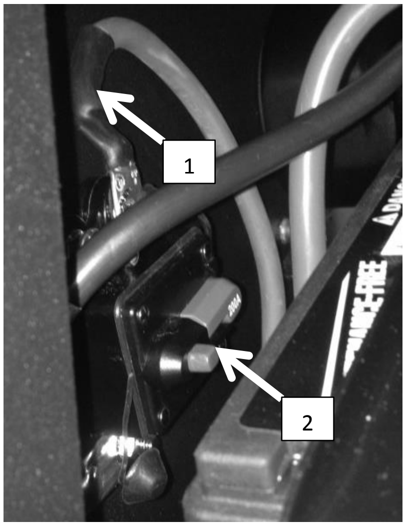



2. Install the battery positive cable (2) to the under hood fuse block and tighten nut (1) to 7 Nm (62 lb in).
3. Install the under hood fuse block cover.
4. Connect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection (Battery to Chassis).
5. Install the Hood, Refer to Hood in Body Repair

### 8.1.3.5. Battery Positive Cable Replacement (Main Breaker to Jump Post )

#### 8.1.3.5.1. Removal Procedure

1. Disconnect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection (Battery to Chassis).
2. Remove Battery Refer to Battery Replacement



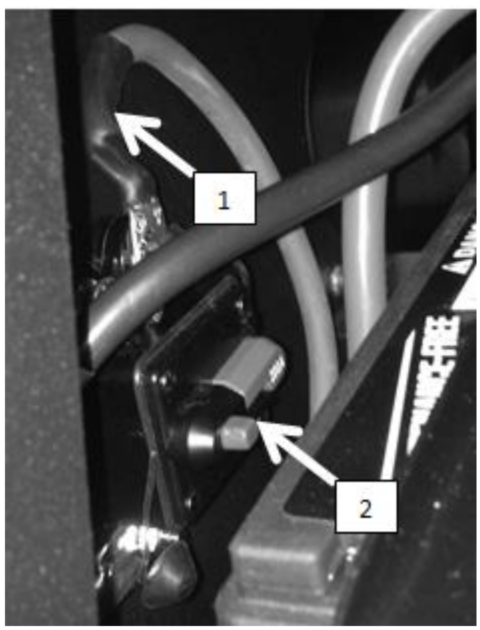

3. Disconnect the Positive battery cable (Main Breaker to Jump Post) (1) from the Main Breaker (2)
4. Remove the Hood, Refer to Hood in Body Repair
5. Remove the Cowl , Refer to Cowl in Body Repair
6. Remove the Right (Passenger) Rocker Panel, Refer to Rocker Panel in Body Repair


7. Remove the battery positive cable junction (1)
8. Unscrew the battery jump post
9. Remove positive the battery cable from the jump post
10. Remove the positive battery cable from chassis

#### 8.1.3.5.2. Installation Procedure

1. Feed the battery cable through the chassis


2. Connect the battery cable to the jump post and tighten jump post to 4.5 Nm (40 lb in)
3. Connect the battery positive cable junction to the battery jump post and tighten to 4.5 Nm (40 lb in)
4. Install the Right (Passenger) Rocker Panel, Refer to Rocker in Body Repair
5. Install the Cowl, Refer to Cowl in Body Repair
6. Install the Hood , Refer to Hood in Body Repair

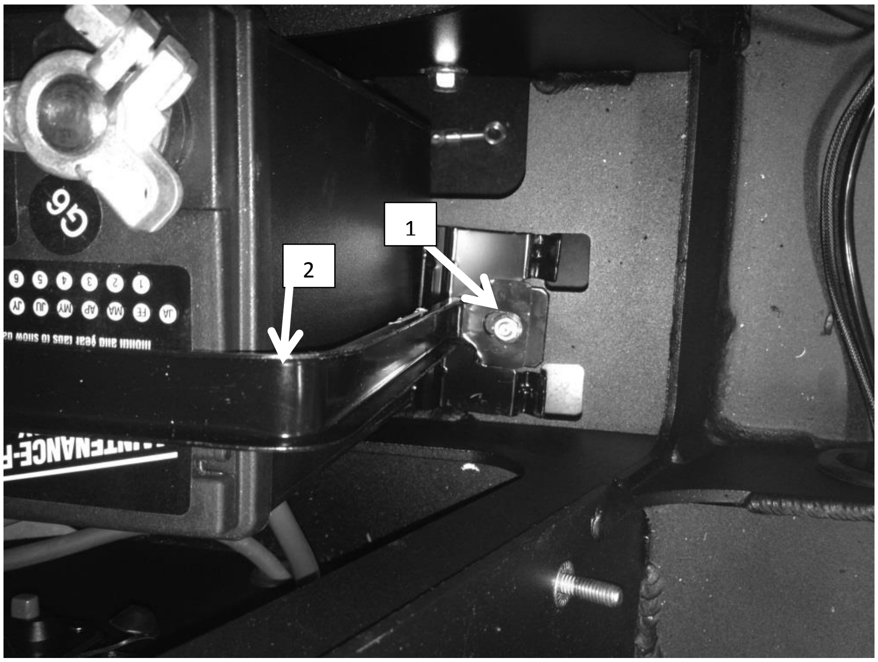



7. Connect the Positive battery cable (Main Breaker to Jump Post) (1) from the Main Breaker (2)
8. Connect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection (Battery to Chassis).

### 8.1.3.6. Battery Replacement

#### 8.1.3.6.1. Removal Procedure

1. Slide the Right Seat fully forward
2. Remove Battery Hatch Cover
3. Disconnect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection.




4. Remove the battery retainer nut (1) and the battery retainer (2).
5. Slide battery forward until the positive battery cable can be accessed
6. Remove positive battery cable
7. Remove battery

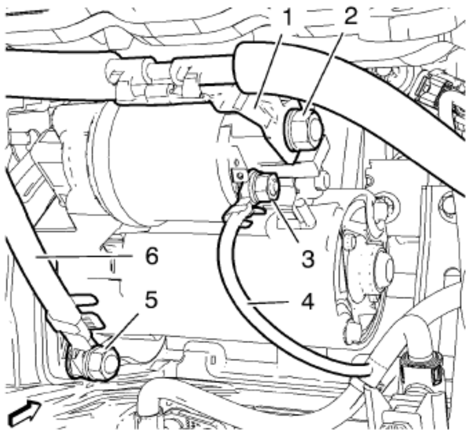
#### 8.1.3.6.2. Installation Procedure

1. Insert the battery in to the battery tray about one third of the way.
2. Connect the positive battery cable and tighten to 4.5 Nm (40 lb in)
3. Slide battery fully in to battery tray
4. Connect negative battery cable and tighten 4.5 Nm (40 lb in)
5. Tighten the battery retainer bolt (1) to 22 Nm (16 lb ft).
6. Install Battery Hatch cover
7. Slide the passenger seat back

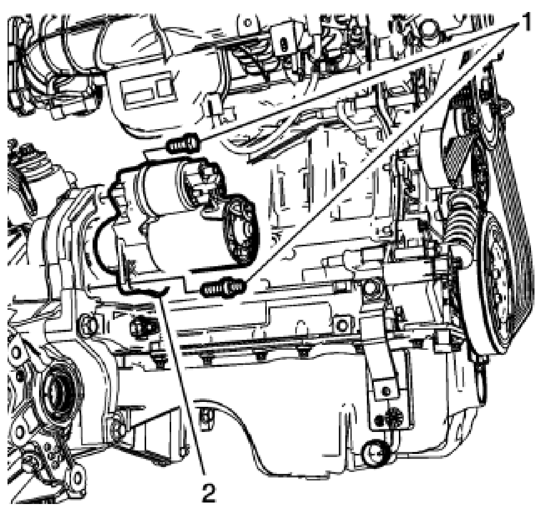
## 8.1.3.7. Starter Replacement

### 8.1.3.7.1. Removal Procedure

1. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.

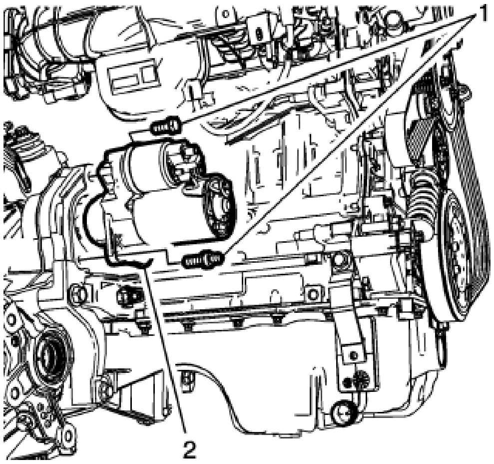



3. Remove the battery positive cable fastener (2) and the battery positive cable terminal (1), from the starter solenoid.
4. Remove the starter battery positive fastener (3) and the positive terminal (4), from the starter solenoid.
5. Remove the battery negative cable fastener (5) and the battery negative ground terminal (6), from the starter mounting stud.




6. Remove the starter mounting fasteners (1) and remove the starter from the vehicle.

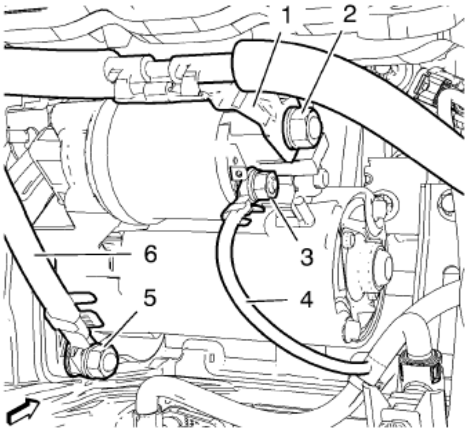
**8.1.3.7.2. Installation Procedure**




1. Install the starter (2).

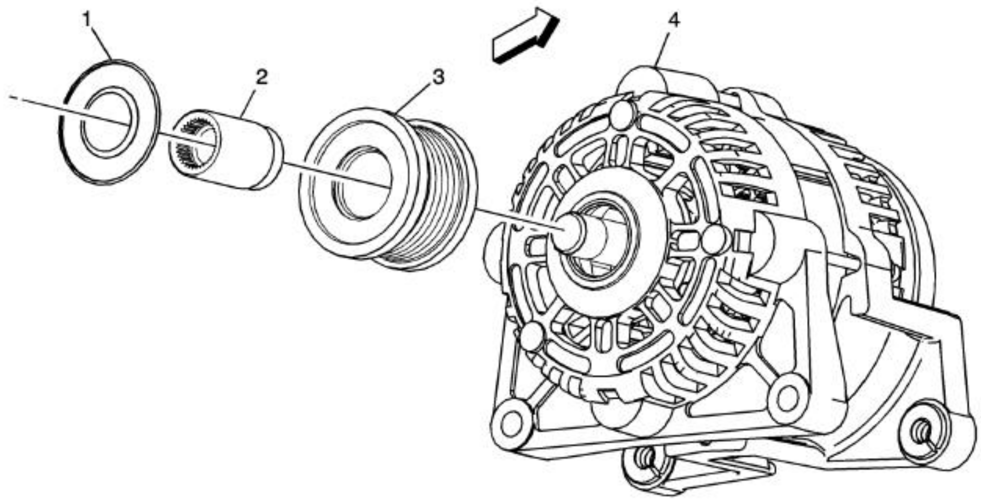
| Caution: |
|---|
| Refer to Fastener Caution. |

2. Install the starter fasteners (1) and tighten to 25 Nm (18 lb ft).




3. Install the ground cable (6).
4. Install the ground cable fastener (5) and tighten to 12.5 Nm (111 lb in).
5. Install the starter positive cable (4) to starter.
6. Install the starter positive cable fastener (3) and tighten to 12.5 Nm (111 lb in).
7. Install the battery positive cable terminal (1).
8. Install the battery positive cable fastener (2) and tighten to 12.5 Nm (111 lb in).
9. Lower the vehicle.
10. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

### 8.1.3.8. Generator Pulley Replacement



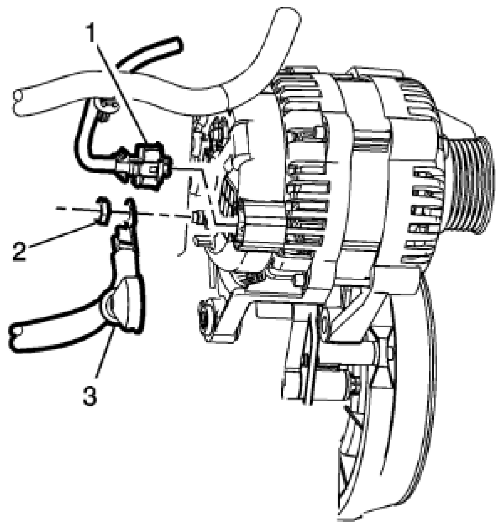

**Generator Pulley Replacement**

| Callout | Component Name |
|---|---|
| Preliminary Procedure<br>Remove the generator. Refer to Generator Replacement. | |
| 1 | Generator Pulley Nut Cap |
| 2 | Generator Pulley Nut<br>Caution: Refer to Fastener Caution.<br><br>**Procedure**<br>Remove the generator pulley nut by using EN-6372 counterhold .<br><br>**Tighten**<br>90 Nm (66 lb ft)<br><br>**Special Tools**<br>EN-6372 Counterhold<br>For equivalent regional |
| 3 | Generator Pulley |
| 4 | Generator |

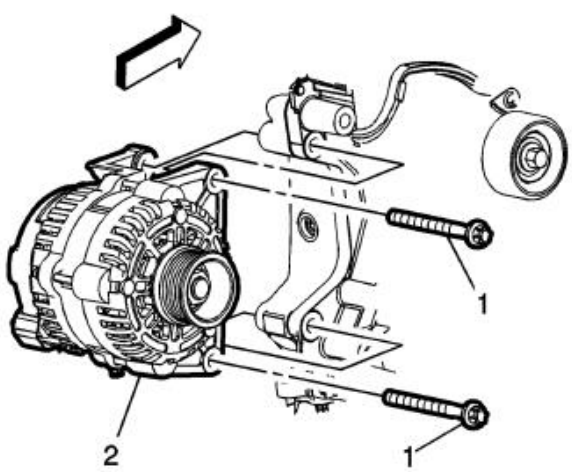
### 8.1.3.9. Generator Replacement

#### 8.1.3.9.1. Removal Procedure

1. Remove the Hood, Refer to Hood in Body Repair
2. Disconnect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection.
3. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
4. Remove the drive belt. Refer to Drive Belt Replacement.
5. Remove the drive belt tensioner. Refer to Drive Belt Tensioner Replacement.

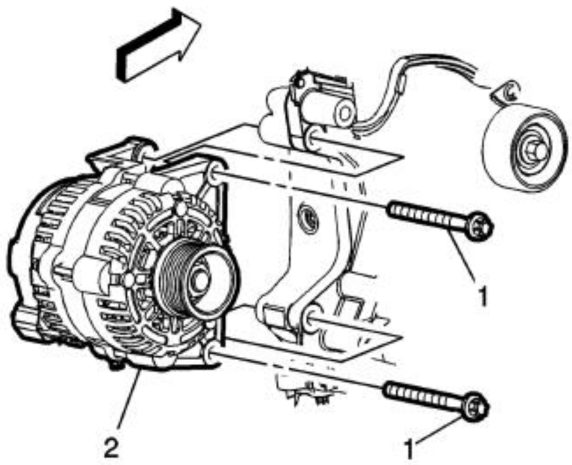



6. Remove the engine harness connector (1) and the battery positive cable generator fastener (2).
7. Remove the battery positive cable (3) from the back of the generator.



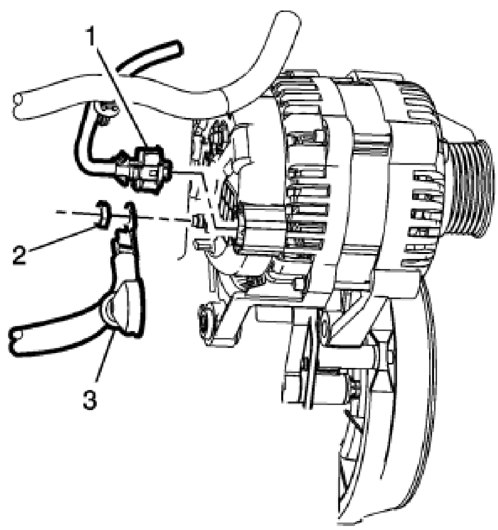

8. Remove the generator mounting fasteners (1) and remove the generator (2) from the engine.

#### 8.1.3.9.2. Installation Procedure




| Caution: |
|---|
| Refer to Fastener Caution. |

1. Install the generator (2) with the mounting fasteners (1) and tighten to 35 Nm (26 lb ft).




2. Install the battery positive cable (3) and the engine harness connector (1) to the back of the generator. Tighten fastener (2) to 9 Nm (80 lb in).
3. Install the drive belt tensioner. Refer to Drive Belt Tensioner Replacement.
4. Install the drive belt. Refer to Drive Belt Replacement.
5. Connect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection.
6. Install the Hood, Refer to Hood in Body Repair

### 8.1.4. Specifications

#### 8.1.4.1. Fastener Specifications

**Fastener Specifications**

| Application | Specification | |
|---|---|---|
| | Metric | English |
| Battery Ground Cable Fastener | 9 Nm | 80 lb ft |
| Battery Ground Cable to Battery Negative Cable Fastener | 9 Nm | 80 lb ft |
| Battery Hold Down Retainer Fastener | 22 Nm | 16 lb ft |
| Battery Negative Cable Ground Fastener (Engine Block) | 22 Nm | 16 lb ft |
| Battery Negative Cable Ground Fastener (Frame) | 22 Nm | 16 lb ft |
| Battery Negative Cable Fastener | 4.5 Nm | 40 lb ft |
| Battery Positive Cable Fastener | 4.5 Nm | 40 lb ft |
| Battery Positive Cable to Battery Junction Block Fastener | 7 Nm | 62 lb in |
| Battery Positive Cable to Under-hood Fuse Block | 7 Nm | 62 lb in |
| Generator Mounting Fastener | 35 Nm | 26 lb ft |
| Generator Positive Cable Fastener | 20 Nm | 15 lb ft |
| Generator Pulley Fastener | 90 Nm | 66 lb ft |
| Starter Mounting Fastener | 25 Nm | 18 lb ft |
| Starter Stud | 25 Nm | 18 lb ft |
| Starter Ground Cable Fastener | 12.5 Nm | 111 lb in |
| Starter Positive Cable Fastener | 9 Nm | 80 lb in |

## 8.2. Engine Controls/Fuel 1.4L

### 8.2.1. Description and Operation

#### 8.2.1.1. 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.

**8.2.1.1.1. ECM Function**

The ECM can supply 5 V or 12 V to various sensors or switches. This is done through pullup 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.

**8.2.1.1.2. 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.

**8.2.1.1.3. 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.

**8.2.1.1.4. 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.

**8.2.1.1.5. 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.

**8.2.1.1.6. 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 onboard 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.

**8.2.1.1.7. 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.

**8.2.1.1.8. Electrostatic Discharge (ESD) Damage**

| **Caution:** |
|---|
| 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.

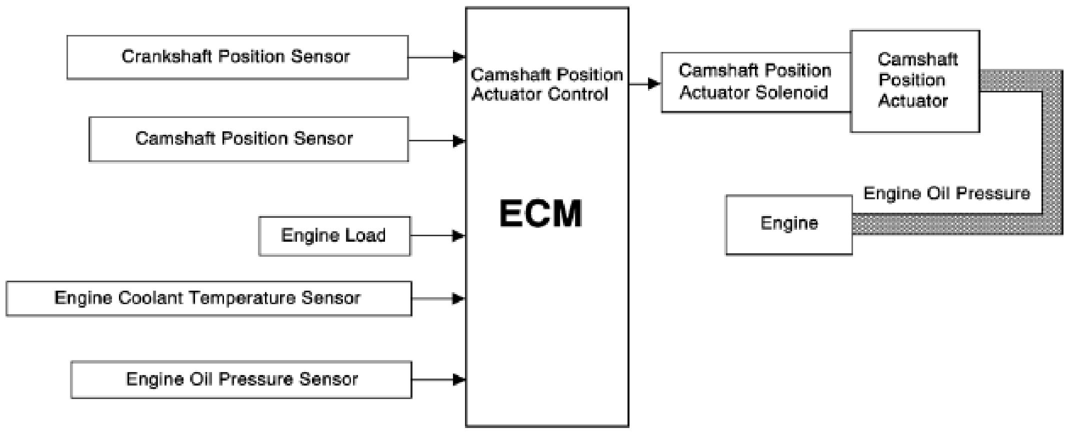
There are several ways for a person to become statically charged. The most common methods of charging are by friction and by induction. An example of charging by friction is a person sliding across a car seat.

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.

#### 8.2.1.1.9. 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.

### 8.2.1.2. Camshaft Actuator System Description




#### 8.2.1.2.1. Camshaft Position (CMP) Actuator System

The camshaft position (CMP) actuator system is an electrohydraulic operated device used for a variety of engine performance and operational enhancements. These enhancements include lower emission output through exhaust gas dilution of the intake charge in the combustion chamber, a broader engine torque range, and improved fuel economy. The CMP actuator system accomplishes this by changing the angle or timing of the camshaft relative to the crankshaft position. The CMP actuator simply allows earlier or later intake and exhaust valve opening during the four stroke engine cycle. The CMP actuator cannot vary the duration of valve opening, or the valve lift.

During engine Off, engine idling conditions, and engine shutdown, the camshaft actuator is held in the Park position. Internal to the CMP actuator assembly is a return spring and a locking pin. During non-phasing modes of the camshaft, the return spring rotates the camshaft back to the Park position, and the locking pin retains the CMP actuator sprocket to the camshaft.

#### 8.2.1.2.2. CMP Actuator System Operation

The CMP actuator system is controlled by the engine control module (ECM). The ECM sends a signal to a CMP actuator solenoid in order to control the amount of engine oil flow to a Cam Actuator passage. The pressurized engine oil is sent to unseat the locking pin, and to the vane and rotor assembly of the CMP actuator. There are 2 different passages for oil to flow through, a passage for cam advance and a passage for cam retard. The Cam Actuator is attached to a camshaft and is hydraulically operated in order to change the angle of the camshaft relative to crankshaft position (CKP). Engine oil pressure (EOP), viscosity, temperature and engine oil level can have an adverse effect on Cam Actuator performance.

## 8.2.1.3. Electronic Ignition System Description

### 8.2.1.3.1. 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.

### 8.2.1.3.2. 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

### 8.2.1.3.3. 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.

### 8.2.1.3.4. 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

### 8.2.1.3.5. Knock Sensor

The knock sensor system enables the control module to control the ignition timing for the best possible performance while protecting the engine from potentially damaging levels of detonation, also known as spark knock. The knock sensor system uses 1 or 2 flat response 2wire sensors. The sensor uses piezoelectric crystal technology that produces an AC voltage signal of varying amplitude and frequency based on the engine vibration or noise level. The amplitude and frequency depend upon the level of knock that the knock sensor detects. The control module receives the knock sensor signal through the high and low signal circuits.

The control module learns a minimum noise level, or background noise, at idle from the knock sensor and uses calibrated values for the rest of the RPM range. The control module uses the minimum noise level to calculate a noise channel. A normal knock sensor signal will ride within the noise channel. As engine speed and load change, the noise channel upper and lower parameters will change to accommodate the normal knock sensor signal, keeping the signal within the channel. In order to determine which cylinders are knocking, the control module only uses knock sensor signal information when each cylinder is near top dead center (TDC) of the firing stroke. If knock is present, the signal will range outside of the noise channel.

If the control module has determined that knock is present, it will retard the ignition timing to attempt to eliminate the knock. The control module will always try to work back to a zero compensation level, or no spark retard. An abnormal knock sensor signal will stay outside of the noise channel or will not be present. Knock sensor diagnostics are calibrated to detect faults with the knock sensor circuitry inside the control module, the knock sensor wiring, or the knock sensor voltage output. Some diagnostics are also calibrated to detect constant noise from an outside influence such as a loose/damaged component or excessive engine mechanical noise.

#### 8.2.1.3.6. 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

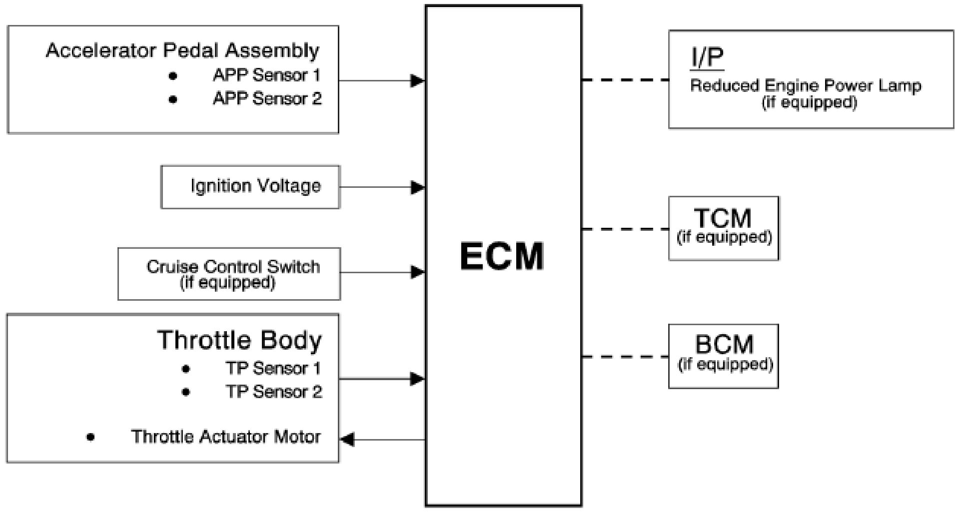
The ECM controls the individual coils by transmitting timing pulses on the ignition coil control circuit to each ignition coil to enable a spark event.
The spark plugs are connected to each coil by a short boot. The boot contains a spring that conducts the spark energy from the coil to the spark plug. The spark plug electrode is coated with platinum for long wear and higher efficiency.

#### 8.2.1.3.7. 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

### 8.2.1.4. Throttle Actuator Control (TAC) System Description




The engine control module (ECM) is the control center for the throttle actuator control (TAC) system. The ECM determines the driver's intent based on input from the accelerator pedal position sensors, then calculates the appropriate throttle response based on the throttle position sensors. The ECM achieves throttle positioning by providing a pulse width modulated voltage to the throttle actuator motor. The throttle blade is spring loaded in both directions, and the default position is slightly open.

#### 8.2.1.4.1. Modes Of Operation

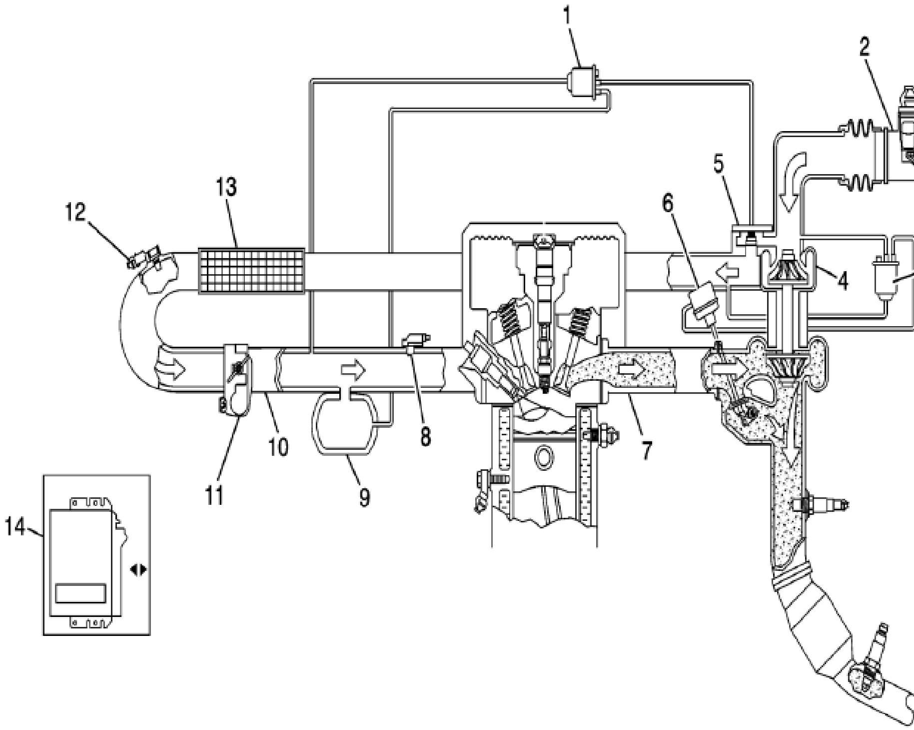
**Normal Mode**
During the operation of the TAC system, several modes, or functions, are considered normal. The following modes may be entered during normal operations:

- 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.

**8.2.1.4.2. Turbocharger System Description**




(1) Turbocharger Bypass Solenoid Valve
(2) Multifunction Intake Air Sensor
(3) Turbocharger Wastegate Regulator Solenoid Valve
(4) Turbocharger
(5) Turbocharger Bypass Valve
(6) Turbocharger Wastegate Actuator
(7) Engine Exhaust Manifold
(8) Manifold Absolute Pressure (MAP) Sensor
(9) Vacuum Tank (Integral to Intake Manifold)
(10) Intake Manifold
(11) Throttle Body
(12) Intake Air (Boost) Pressure and Temperature Sensor
(13) Charge Air Cooler
(14) Engine Control Module (ECM)

#### 8.2.1.4.3. Turbocharger Description and Operation

A turbocharger is a forced induction device used for increasing power output of an internal combustion engine. By using the exhaust gas forces to compress intake air, a turbocharged engine is more powerful and efficient than a naturally aspirated engine with the same displacement. The dual-scroll turbocharger is mounted on the exhaust manifold and the lightweight turbine is driven by the waste energy generated by the flow of the exhaust gases. The turbine is connected by a shaft to the compressor which is mounted in the induction system of the engine. The compressor vanes compress the intake air above atmospheric pressure, thereby greatly increasing the density of the air entering the engine.

The turbocharger incorporates a wastegate that is controlled by the ECM, by means of a pulse width modulated (PWM) solenoid, to regulate the pressure ratio of the compressor. An integral turbocharger bypass valve, controlled by the ECM through a remotely mounted solenoid, is used to prevent compressor surging and damage by opening during abrupt closed throttle conditions. The bypass valve opens during closed throttle deceleration conditions, which allows the air to recirculate in the turbocharger and maintain compressor speed. During a wide open throttle command, the bypass valve closes to optimize turbo response.

The turbocharger is connected to the engine oiling system by a supply and drain tube and synthetic oil is installed at the factory. Synthetic oil is required for its friction-reducing capabilities and high-temperature performance. There is a cooling system circuit in the turbocharger that utilizes the engine coolant to further reduce operating temperatures.

#### 8.2.1.4.4. Turbocharger Wastegate Solenoid Valve

The wastegate valve opens and closes a bypass passage beside the turbine wheel. A spiral spring works in the closing direction while the pressure in the diaphragm works in the opening direction. The ECM supplies a PWM signal to the solenoid valve, which then allows pressure from the turbo to come through. When the pressure overcomes the spring force the actuator rod begins to move, opening the wastegate valve to a corresponding degree. The ECM changes wastegate valve opening by varying the PWM signal, which regulates the turbine speed.

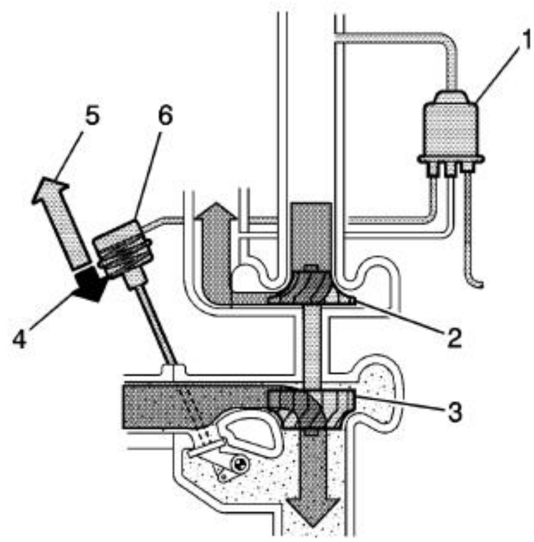
At low loads, the wastegate valve is closed. All the exhaust gas then passes through the turbine. At high loads, the volume of exhaust gas is greater, which makes the turbine wheel rotate faster. This delivers a greater air displacement to the engine.

When the air displacement becomes so large that the current air mass per combustion cannot be controlled with the throttle alone, the turbo must be regulated. This is done by opening the wastegate valve so that some of the exhaust gas passes through the air displacement will be correct.

When certain DTCs are set the ECM will limit the amount of available boost pressure. Limiting boost pressure is accomplished by the ECM controlling the wastegate actuator solenoid valve and maintaining the duty cycle at 0 %. This means that the ECM will not actively close the wastegate during greater engine loads. The system at this point is limited to mechanical boost. Mechanical boost means that the wastegate will still move, but the amount of motion is limited by the mechanical properties of the return spring within the diaphragm valve, the pneumatic properties of the actuator, and the physics of the exhaust gas flow in the exhaust system.

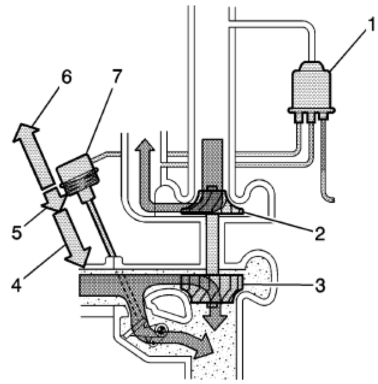
The turbocharger wastegate diaphragm valve assembly has a threaded rod and nut that connects the diaphragm of the valve to the wastegate. This rod is adjusted to factory specifications and is not adjustable. The following diagrams illustrate the turbocharger wastegate closed and open conditions:

**Turbocharger Wastegate Closed**




(1) Turbocharger Wastegate Actuator Solenoid Valve with Duty Cycle at 100 percent
(2) Compressor
(3) Turbine
(4) Exhaust Gas Pressure
(5) Spring Force
(6) Turbocharger Wastegate Diaphragm Valve

**Turbocharger Wastegate Open**




(1) Turbocharger Wastegate Actuator Solenoid Valve with Duty Cycle at 0 percent
(2) Compressor
(3) Turbine
(4) Regulating Pressure
(5) Exhaust Gas Pressure
(6) Spring Force
(7) Turbocharger Wastegate Diaphragm Valve

The wastegate is completely closed at idle. All of the exhaust energy is passing through the turbine.

During normal operation, when wide open throttle is requested at lower engine speeds, the ECM commands the wastegate solenoid with a duty cycle of 100 % to minimize any turbo lag. During engine loads in the middle and upper RPM ranges, the ECM commands the solenoid with a duty cycle of about 65 %.

### 8.2.1.4.5. Turbocharger Bypass Solenoid Valve

The turbocharger bypass valve prevents the turbo from exceeding the pump limit at low flow and high pressure. This occurs when the engine is running with a load and the throttle suddenly closes. In this case, flow is almost null and pressure is very high. This not only is damaging to the turbocharger, but also generates noise and decelerates turbine speed. The ECM supplies a voltage signal to the solenoid valve output driver, which regulates the open or closed valve position.

**Accelerator Pedal Depressed**
The bypass valve is closed. The force in the return spring integrated in the valve presses the valve cone against its seat in the turbo housing. The valve is turned OFF.

**Accelerator Pedal Released**
To avoid pressure spikes in the intake manifold and unloading or overrunning the turbo, the ECM sends a voltage signal to the bypass valve, which will then open. The compressed air on the pressure side of the turbo is led to the intake via the open valve. When the pressure drops, the turbine speed can be kept relatively high and the turbocharger is prevented from exceeding the pump limit.

### 8.2.1.4.6. Charge Air Cooler

The turbocharger is supported by an air-to-air charge air cooler system, which uses fresh air drawn through a heat exchanger to reduce the temperature of the warmer compressed air forced through the intake system. Inlet air temperature can be reduced by up to 100°C (180°F), which enhances performance. This is due to the higher density of oxygen in the cooled air, which promotes optimal combustion. The charge air cooler is connected to the turbocharger and to the throttle body by flexible ductwork that requires the use of special high torque fastening clamps. In order to prevent any type of air leak when servicing the ductwork, the tightening specifications and proper positioning of the clamps is critical, and must be strictly adhered to.

### 8.2.1.5. Engine Component Description

#### 8.2.1.5.1. Cylinder Block

The cylinder hollow frame structured in–line 4 cylinder. The block has 5 crankshaft bearings with the thrust bearing located on the third bearing from the front of the engine.

#### 8.2.1.5.2. Crankshaft

The crankshaft is a steel crankshaft. It is supported in 5 main journals with main bearings which have oil clearance for lubrication. The 3rd bearing is the thrust bearing which controls the proper axial end play of the crankshaft. A harmonic damper is used to control torsional vibration.

#### 8.2.1.5.3. Oil Pump

The engine is equipped with a variable oil pump. The oil pump is integrated into the engine front cover and provides different oil pressure values depending on the engine speed.

#### 8.2.1.5.4. Oil Pan

The oil pan is a structural aluminum oil pan with transmission attachment points. The oil suction gallery for the oil pump is integrated into the oil pan.

#### 8.2.1.5.5. Piston and Connecting Rod

The pistons are aluminum pistons. The connecting rods are made of fractured steel. The piston pin is floating in piston bore and shrinked in connecting rod.

#### 8.2.1.5.6. Cylinder Head

This cylinder head is a double over head camshaft (DOHC) type and has 2 camshafts that open 4 valves per cylinder with hydraulic valve lash adjusters and hydraulic valve lash adjuster arms. The cylinder head is made of cast aluminum alloy for better strength and hardness while remaining light weight. The combustion chamber of the cylinder head is designed for increasing of squish and swirl efficiency to help maximize gasoline combustion efficiency.

#### 8.2.1.5.7. Camshaft Drive with Variable Camshaft Timing

A timing chain is used for camshaft drive. There is a tensioner to control the tension of the chain. The engine is equipped with a variable camshaft timing system. The camshaft adjuster will readjust itself depending on the engine speed. The valve timing readjusts to reduce fuel consumption and provide optimal power and torque.

#### 8.2.1.5.8. Intake Manifold

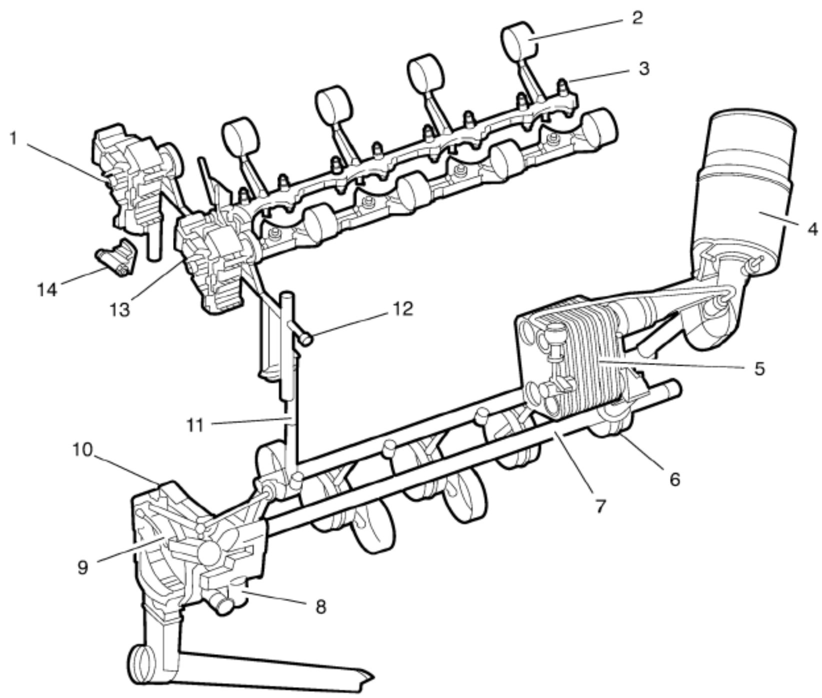
The intake manifold provides the air flow passage to the combustion chambers through the throttle body. The intake manifold along with the throttle body have an effect on engine torque, power, noise, driveability, emission, fuel economy and performance. The intake manifold is made of plastic for better strength with maintaining a light weight.

#### 8.2.1.5.9. Turbocharger

The turbocharger consists of turbine and compressor on a common shaft. The shaft bearing is constructed to higher rotation speed and lubricated by engine oil. The turbocharger is water cooled for improved durability. The turbine wheel is driven by exhaust emissions. The compressor wheel compresses the intake air. A bypass valve (Wastegate) regulates the charging pressure for generating a high pressure at low speed as well. At a defined charging pressure it regulates the way of the exhaust emission on bypassing the turbine wheel. The Wastegate valve is controlled pneumatic and electric from the pressure in the intake manifold. The pressure of exhaust emission is reduced by opening the Wastegate thereby reducing the intake pressure.

### 8.2.1.6. Lubrication Description

#### 8.2.1.6.1. General Lubrication Description




Oil is applied under pressure to the crankshaft bearings (6), connecting rod bearings (7), camshaft bearings (2) and hydraulic lash adjusters (3). In addition the variable oil pump (9), variable camshaft phaser (1), and hydraulic chain tensioner (14) are supplied with pressurized oil. Oil is sucked from the oil pan through the fixed screen into the variable vane type oil pump. The. pump is integrated in the front cover and directly driven by the crankshaft. Also integrated into the front cover is a pressure relieve valve (8) that opens when the oil pressure is too high at a cold start. When that valve is open some oil flows directly into the oil pan. Normally the pressurized oil passes into the engine oil gallery leading through the oil cooler (5) to the oil filter assembly (4). The oil is cleaned by passing the filter from the outer to the inner side of the filter. Then the oil flows into the main oil gallery. A filter bypass valve in the oil filter ensures continues oil flow in case the oil filter should be restricted by more than 1.7 bar. From the oil filter the oil is distributed to the crankshaft bearings, oil pump displacement control chamber (10) and cylinder head feed (11). The connecting rod bearings are supplied by oil flow passages through the crankshaft connecting the main journals to the rod journals. A groove around each upper main bearing furnishes oil to the drilled crankshaft passages. In the cylinder head the oil is distributed to the variable camshaft phasers, chain tensioner, oil pressure switch (12) and through the restrictor orifice (13) into the camshaft feed oil gallery. From there the hydraulic valve lifters and camshaft bearings are supplied with oil.

#### 8.2.1.6.2. Variable Oil Pump Description

The engine is equipped with a variable displacement vane oil pump. It is indirect regulated by the oil pressure out of the main oil gallery. The purpose of this indirect regulation is to keep a defined maximum pressure in the main oil gallery independent of the individual pressure drop between the pump outlet, the main gallery inlet, and the various engine components. The purpose of the variable displacement is to reduce the power consumption of the pump to reduce the overall fuel consumption of the engine. The oil flow of a static displacement oil pump is linear to the speed of the pump. This would lead to a too high oil pressure after a certain engine speed (ca. 1000 rpm at cold oil temperature, ca. 3000 rpm at hot oil temperatures). To reduce that high oil pressure normal pumps have a relieve valve: a portion of the pressurized, already pumped oil is fed back to the intake of the pump. This is waste of power. The oil flow of a Variable Displacement Vane Pump (VDVP) as used in Fam 0 Gen 3 is linear to the speed and to the eccentricity of the rotor to the slide. The slide is moveable, so it is possible to reduce the oil flow for a given speed by reducing the eccentricity. With a lower flow the oil pressure is reduced; pump oil flow equals now engine oil flow.

### 8.2.1.7. Cleanliness and Care

An automobile engine is a combination of many of the following surfaces:

- Machined
- Honed
- Polished
- Lapped

The tolerances of these surfaces are measured in the ten-thousandths of an inch. When you service any internal engine part, cleanliness and care are important. Apply a liberal coating of engine oil to the friction areas during assembly in order to protect and lubricate the surfaces on initial operation. Throughout this section, practice proper cleaning and protection procedures to the machined surfaces and to the friction areas.

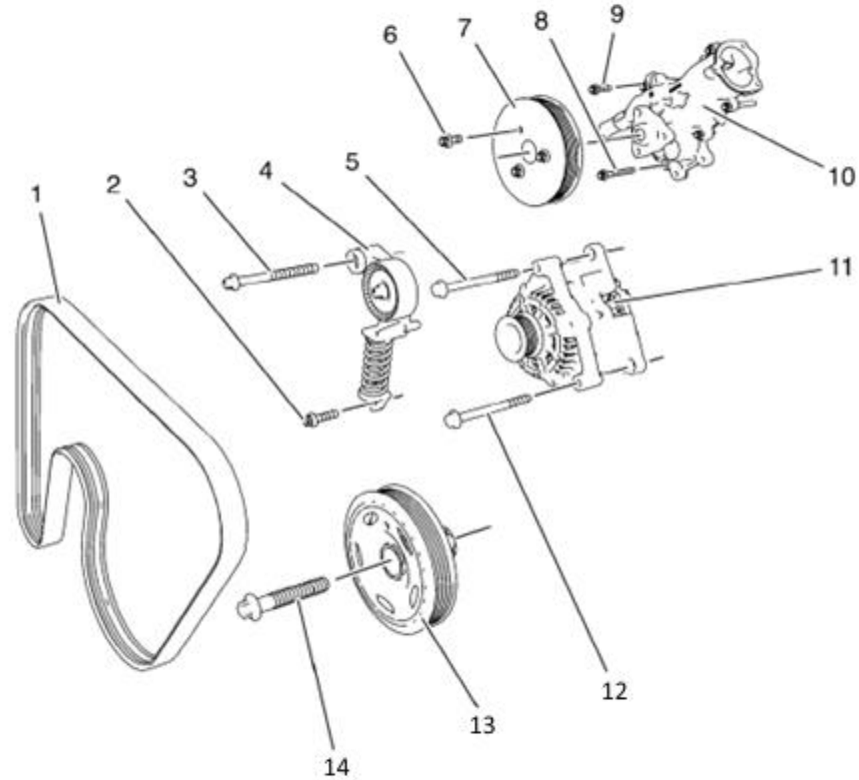
Whenever you remove the valve train components, keep the components in order. Follow this procedure in order to install the components in the same locations and with the same mating surfaces as when removed.

| **Warning:** |
|---|
| Refer to Battery Disconnect Warning. |

Disconnect the negative battery cables before you perform any major work on the engine.

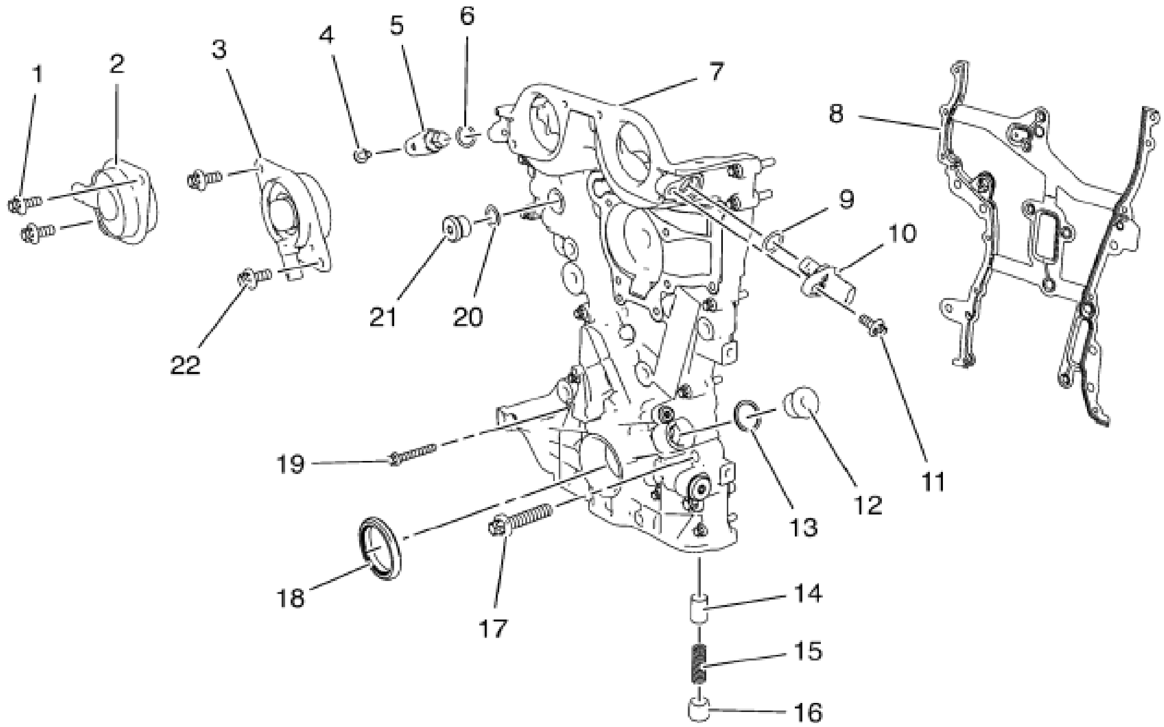
## 8.2.2. Component Locator

### 8.2.2.1. Accessory Drive Components



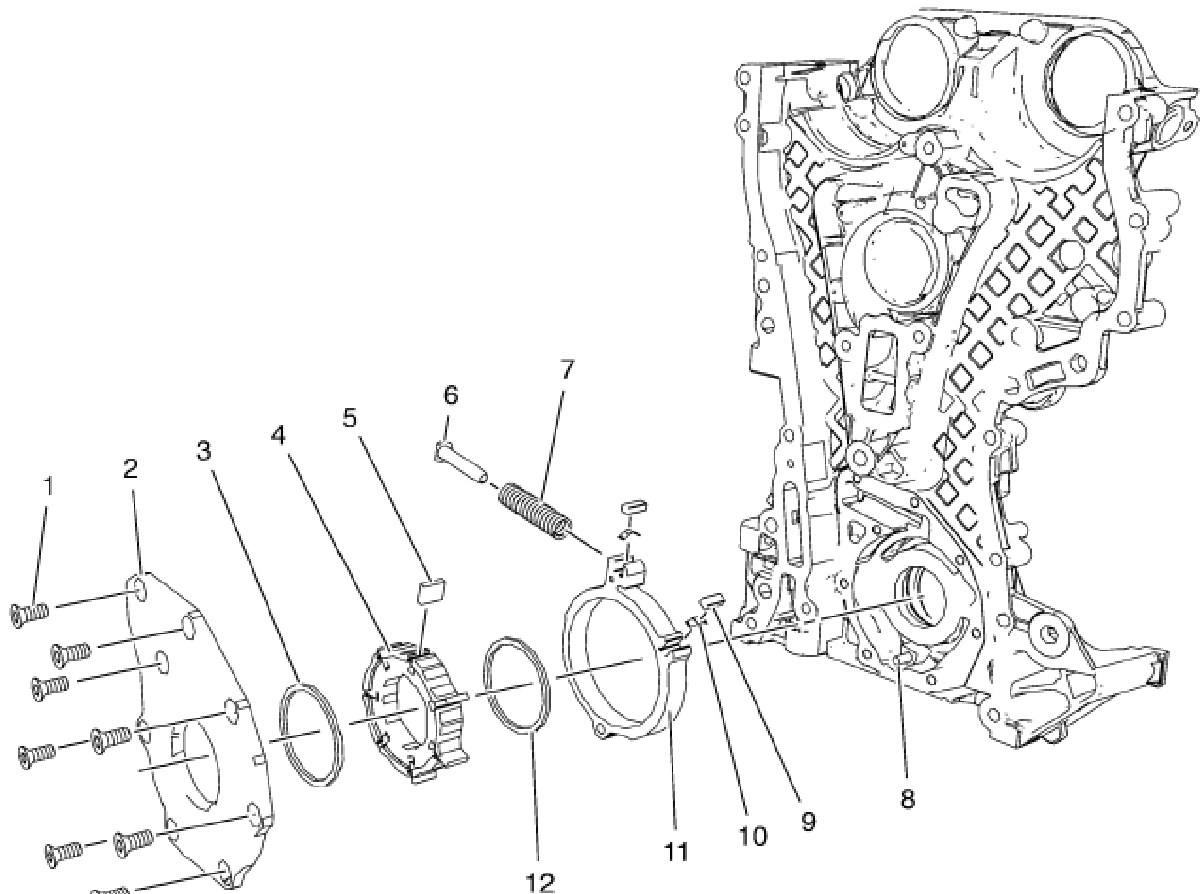

(1) Generator Belt
(2) Drive Belt Tensioner Bolt (short)
(3) Drive Belt Tensioner Bolt (long)
(4) Drive Belt Tensioner
(5) Upper Generator Bolt
(6) Water Pump Pulley Bolt
(7) Water Pump Pulley
(8) Water Pump Bolt (Long)
(9) Water Pump Bolt (Short)
(10) Water Pump
(11) Generator
(12) Lower Generator Bolt
(13) Crankshaft Balancer
(14) Crankshaft Balancer Bolt

### 8.2.2.2. Engine Front Cover And Oil Pump Assembly (1 of 2)



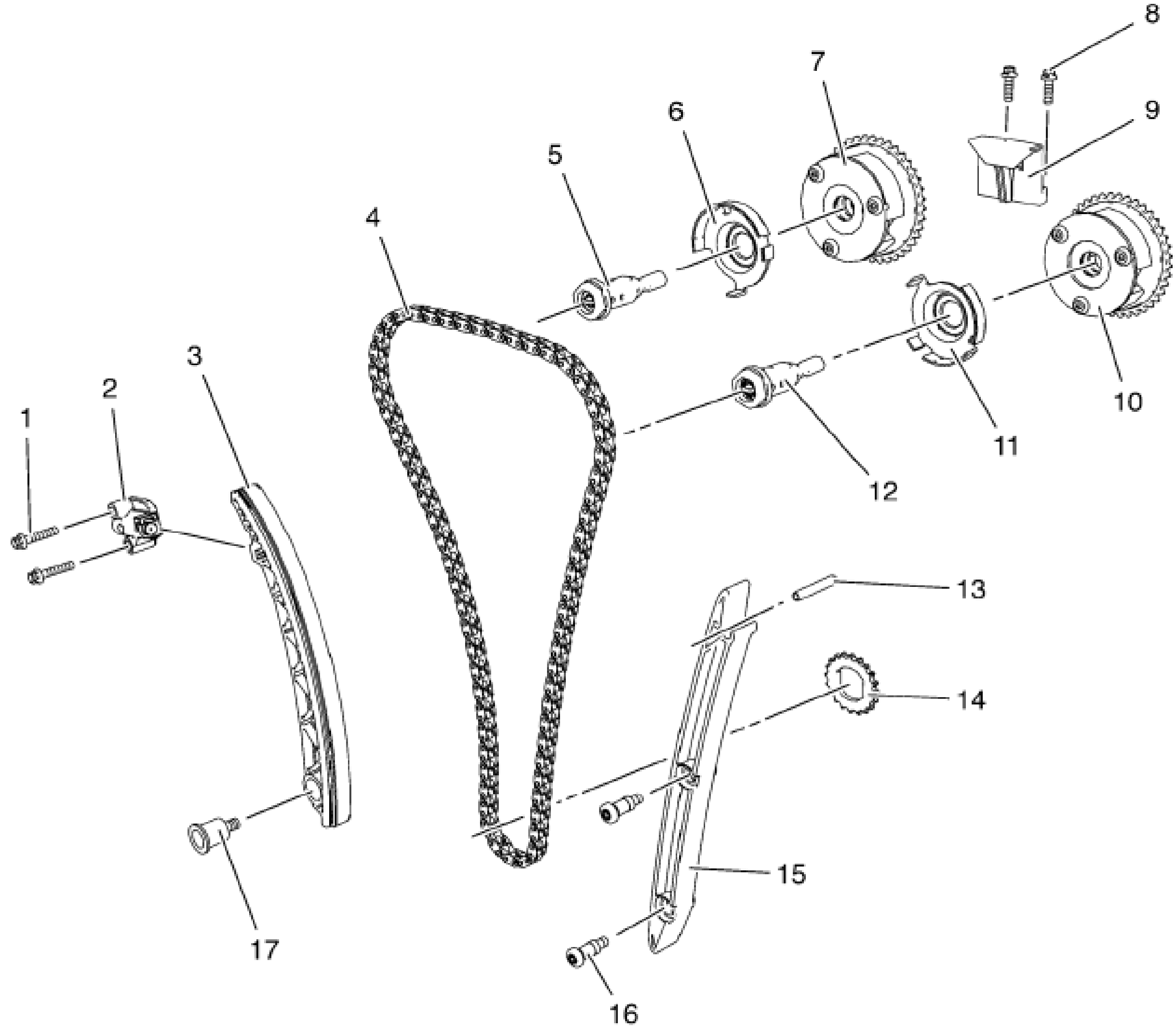

(1) Camshaft Position Actuator Solenoid Valve Bolt
(2) Intake Camshaft Position Actuator Solenoid Valve
(3) Exhaust Camshaft Position Actuator Solenoid Valve
(4) Intake Camshaft Position Sensor Bolt
(5) Intake Camshaft Position Sensor
(6) Intake Camshaft Position Sensor Seal Ring
(7) Engine Front Cover
(8) Engine Front Cover Gasket
(9) Exhaust Camshaft Position Sensor Seal Ring
(10) Exhaust Camshaft Position Sensor
(11) Exhaust Camshaft Position Sensor Bolt
(12) Engine Front Cover Oil Gallery Plug
(13) Engine Front Cover Oil Gallery Plug Seal Ring
(14) Oil Pressure Relief Valve Piston
(15) Oil Pressure Relief Valve Spring
(16) Oil Pressure Relief Valve Plug
(17) Engine Front Cover Bolt (M10)
(18) Crankshaft Front Oil Seal
(19) Engine Front Cover Bolt (M6)
(20) Water Drain Plug Seal Ring
(21) Water Drain Plug
(22) Exhaust Camshaft Position Actuator Solenoid Valve Bolt

### 8.2.2.3. Engine Front Cover And Oil Pump Assembly (2 of 2)



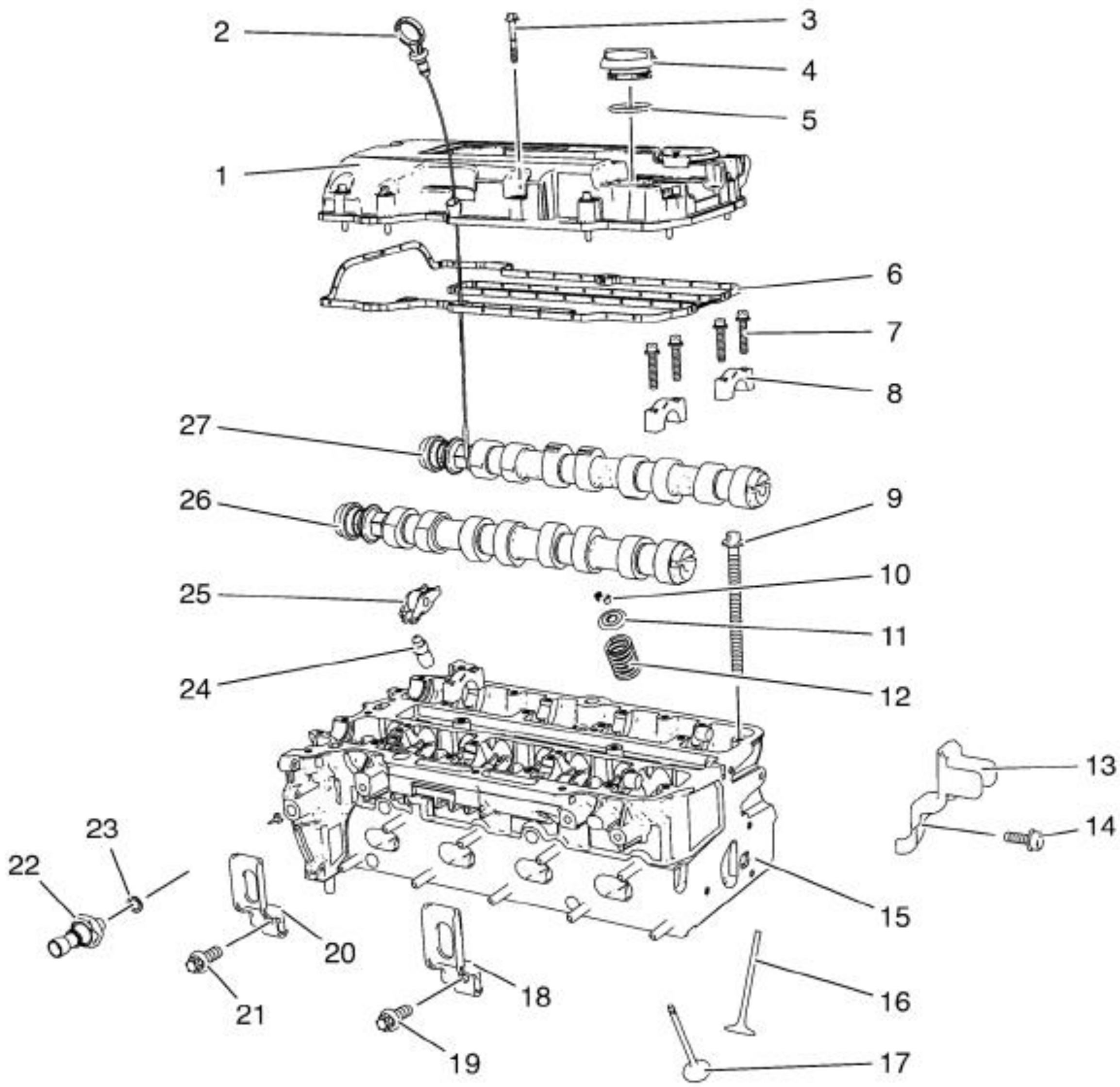

(1) Oil Pump Cover Bolt
(2) Oil Pump Cover
(3) Oil Pump Vane Ring
(4) Oil Pump Vane Rotor
(5) Oil Pump Vane
(6) Oil Pump Slide Spring Pin
(7) Oil Pump Slide Spring
(8) Oil Pump Slide Pivot Pin
(9) Oil Pump Slide Seal
(10) Oil Pump Slide Seal Spring
(11) Oil Pump Slide
(12) Oil Pump Vane Ring

**8.2.2.4. Timing Chain Components**



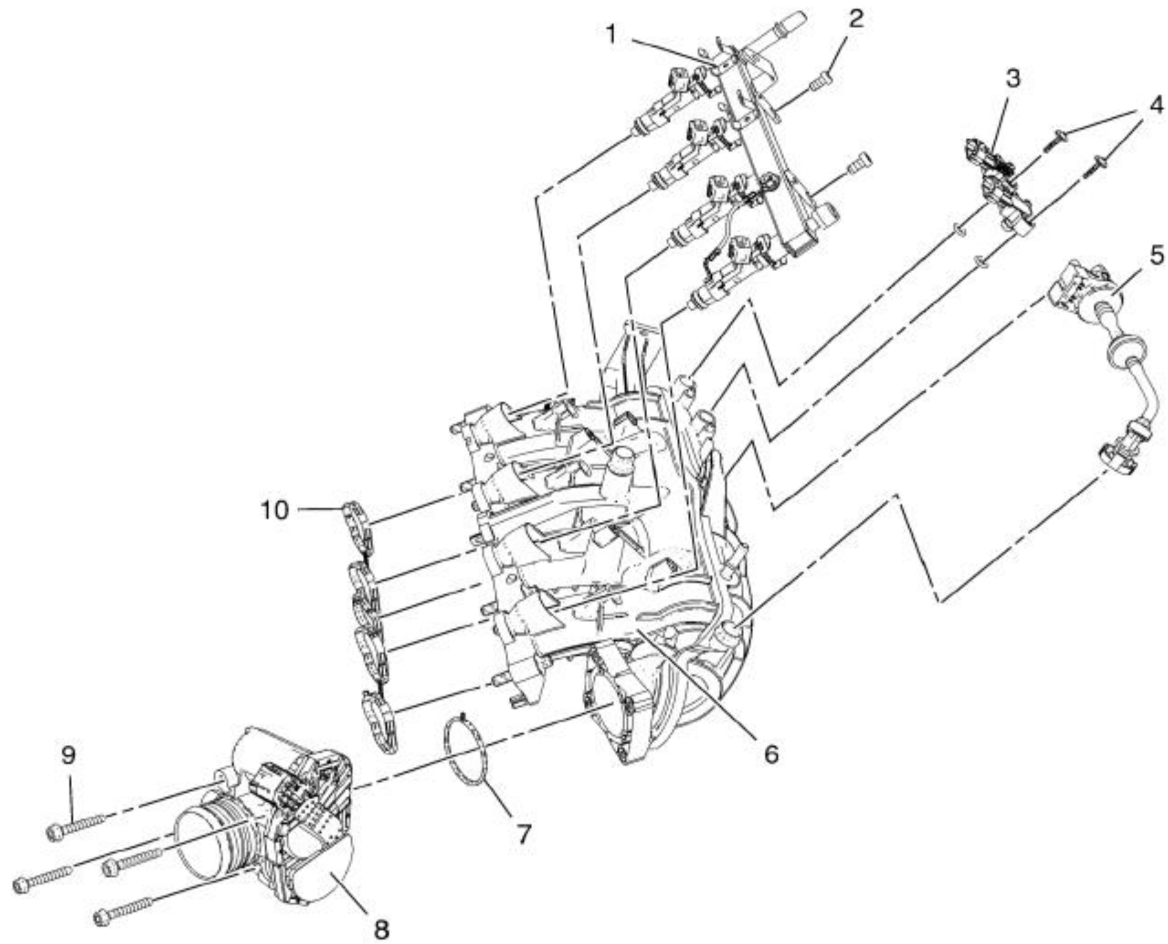

(1) Timing Chain Tensioner Bolt
(2) Timing Chain Tensioner
(3) Timing Chain Tensioner Shoe
(4) Camshaft Timing Chain
(5) Intake Camshaft Sprocket Bolt (With Actuator)
(6) Intake Camshaft Position Sensor Exciter Wheel
(7) Intake Camshaft Sprocket (With Position Actuator)
(8) Upper Timing Chain Guide Bolt
(9) Upper Timing Chain Guide
(10) Exhaust Camshaft Sprocket (With Position Actuator)
(11) Exhaust Camshaft Position Sensor Exciter Wheel
(12) Exhaust Camshaft Sprocket Bolt (With Actuator)
(13) Timing Chain Guide Pivot Pin
(14) Crankshaft Sprocket
(15) Timing Chain Guide Right Side
(16) Timing Chain Guide Bolt
(17) Timing Chain Tensioner Shoe Bolt

**8.2.2.5. Cylinder Head Assembly**



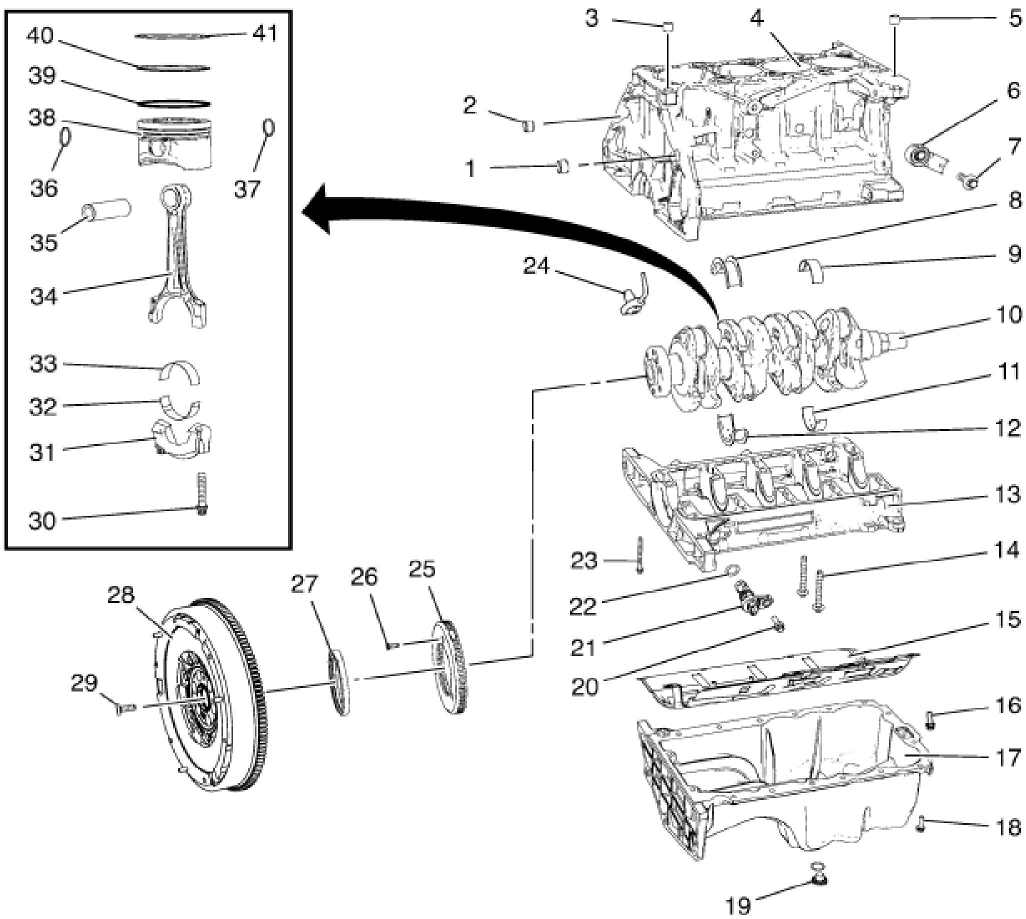

(1) Camshaft Cover
(2) Oil Level Indicator
(3) Camshaft Cover Bolt
(4) Oil Filler Cap
(5) Oil Filler Cap Seal Ring
(6) Camshaft Cover Gasket
(7) Camshaft Bearing Cap Bolt
(8) Camshaft Bearing Cap
(9) Cylinder Head Bolt
(10) Valve Keys
(11) Valve Spring Retainer
(12) Valve Spring
(13) Engine Lift Bracket Left Side
(14) Engine Lift Bracket Bolt
(15) Cylinder Head
(16) Intake Valve
(17) Exhaust Valve
(18) Engine Lift Bracket
(19) Engine Lift Bracket Bolt
(20) Engine Lift Bracket
(21) Engine Lift Bracket Bolt
(22) Oil Pressure Indicator Switch (only for 1.4L LDD)
(23) Oil Pressure Indicator Switch Seal Ring (only for 1.4L LDD)
(24) Hydraulic Valve Lash Adjuster
(25) Hydraulic Valve Lash Adjuster Arm
(26) Exhaust Camshaft
(27) Intake Camshaft

**8.2.2.6. Intake Manifold Assembly– 1.4L**



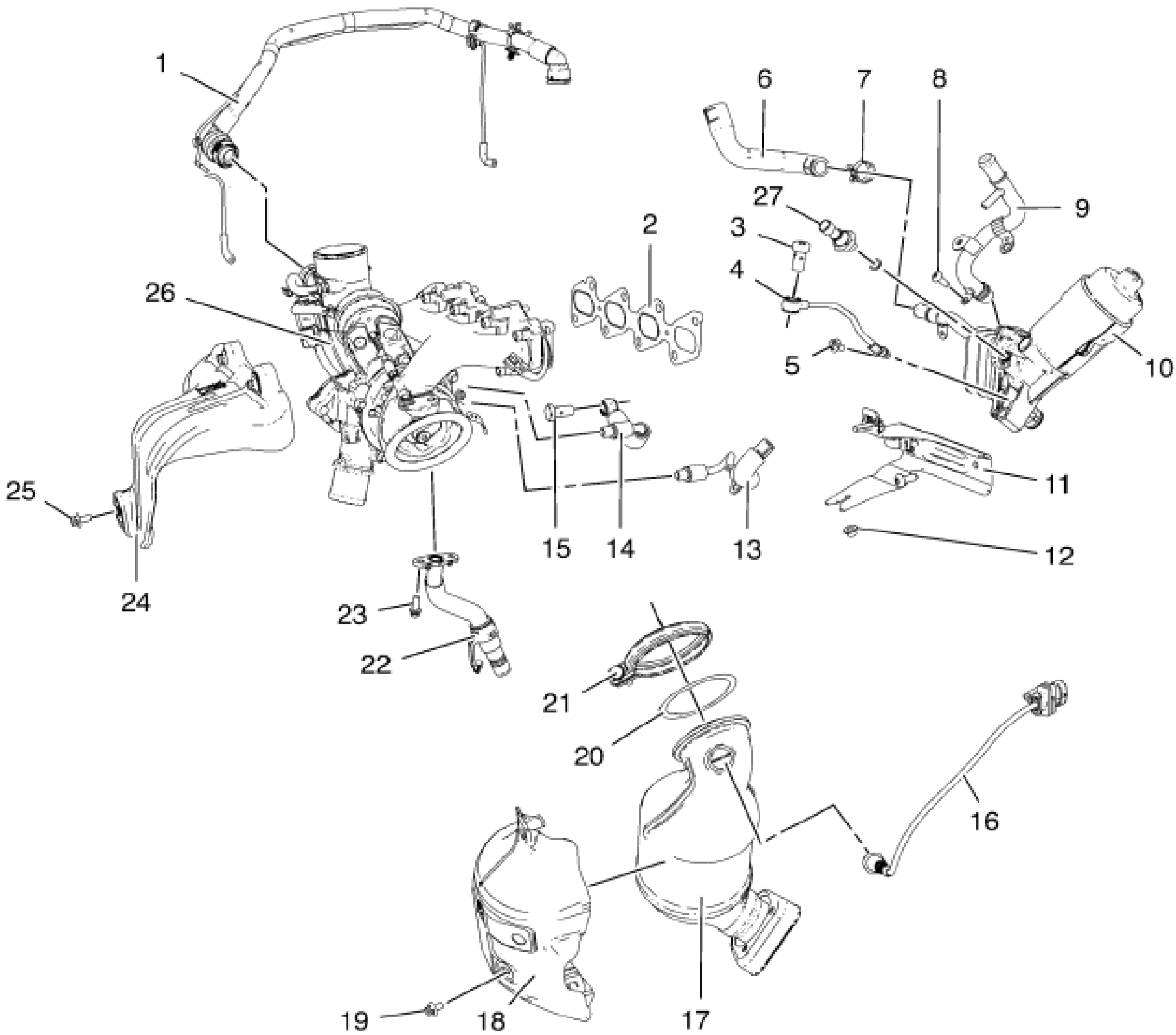

(1) Fuel Injector Fuel Rail
(2) Fuel Injector Fuel Rail Bolt
(3) Manifold Absolute Pressure Sensor
(4) Manifold Absolute Pressure Sensor Bolt
(5) Evaporative Emission Canister Purge Solenoid Valve
(6) Intake Manifold
(7) Throttle Body Seal Ring
(8) Throttle Body
(9) Throttle Body Bolt
(10) Intake Manifold Gasket

### 8.2.2.7. Engine Block Assembly– 1.4L




(1) Transmission Guide Sleeve
(2) Transmission Guide Sleeve
(3) Cylinder Head Guide Sleeve
(4) Cylinder Head
(5) Cylinder Head Guide Sleeve
(6) Knock Sensor
(7) Knock Sensor Bolt
(8) Upper Crankshaft Thrust Bearing
(9) Upper Crankshaft Bearing
(10) Crankshaft
(11) Lower Crankshaft Bearing
(12) Lower Crankshaft Thrust Bearing
(13) Crankshaft Bearing Cap Tie Plate
(14) Crankshaft Bearing Cap Tie Plate Bolt (M10)
(15) Oil Pan Baffle
(16) Oil Pan Baffle Bolt
(17) Oil Pan
(18) Oil Pan Bolt
(19) Oil Pan Drain Plug
(20) Crankshaft Position Sensor Bolt
(21) Crankshaft Position Sensor
(22) Crankshaft Position Sensor Seal Ring
(23) Crankshaft Bearing Cap Tie Plate Bolt (M8)
(24) Piston Oil Nozzle
(25) Crankshaft Position Sensor Reluctor Ring
(26) Crankshaft Position Sensor Reluctor Ring Bolt
(27) Crankshaft Rear Oil Seal
(28) Engine Flywheel (Two Mass)
(29) Engine Flywheel Bolt
(30) Connecting Rod Bearing Cap Bolt
(31) Connecting Rod Bearing Cap
(32) Lower Connecting Rod Bearing
(33) Upper Connecting Rod Bearing
(34) Connecting Rod
(35) Piston Pin
(36) Piston Pin Retainer
(37) Piston Pin Retainer
(38) Piston
(39) Piston Oil Ring (With Oil Ring Spacer)
(40) Lower Compression Ring
(41) Upper Compression Ring

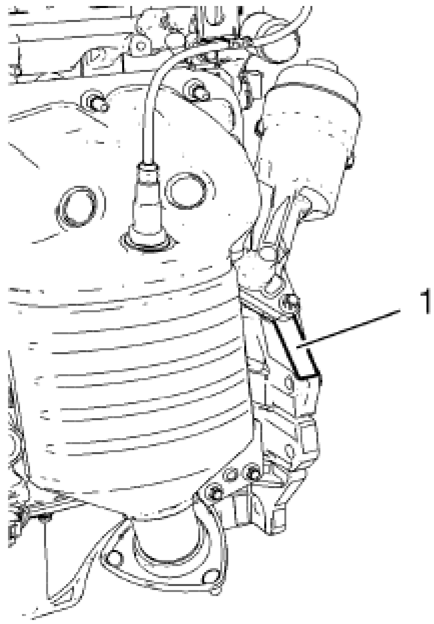
**8.2.2.8. Exhaust Side– 1.4L**




(1) Positive Crankcase Ventilation Pipe Assembly
(2) Exhaust Manifold Gasket
(3) Turbo Charger Oil Feed Pipe Hollow Screw
(4) Turbo Charger Oil Feed Pipe
(5) Turbo Charger Oil Feed Pipe Bolt
(6) Oil Cooler Coolant Outlet Hose
(7) Oil Cooler Coolant Outlet Hose Clamp
(8) Oil Cooler Coolant Feed Pipe Bolt
(9) Oil Cooler Coolant Feed Pipe
(10) Engine Oil Cooler Assembly
(11) Catalytic Converter Bracket
(12) Catalytic Converter to Catalytic Converter Bracket Nut
(13) Turbocharger Coolant Return Pipe
(14) Turbocharger Coolant Feed Pipe
(15) Turbocharger Coolant Feed Pipe Hollow Screw
(16) Heated Oxygen Sensor 1
(17) Catalytic Converter
(18) Catalytic Converter Heat Shield
(19) Catalytic Converter Heat Shield Bolt
(20) Catalytic Converter Seal
(21) Catalytic Converter VClamp
(22) Turbocharger Oil Return Pipe
(23) Turbocharger Oil Return Pipe Bolt
(24) Exhaust Manifold Heat Shield
(25) Exhaust Manifold Heat Shield Bolt
(26) Turbocharger (with Exhaust Manifold)
(27) Engine Oil Pressure Switch

### 8.2.2.9. Engine Identification

#### 8.2.2.9.1. Engine Number




| Note: |
|---|
| The engine identification number must be stamped to the cylinder block in case of engine replacement. |

The engine number is stamped to the engine block (1).

### 8.2.3. Diagnostic Information and Procedures

#### 8.2.3.1. Symptoms Engine Controls

##### 8.2.3.1.1. Diagnostic Instructions

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

##### 8.2.3.1.2. 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.

##### 8.2.3.1.3. 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.

**Fuel Odor**

A noticeable smell of unburned fuel.

**Hard Start**

Engine cranks OK, but does not start for a long time. The vehicle does eventually run, or may start but immediately stalls.

**Hesitation, Sag, Stumble**

Momentary lack of response as the accelerator is pushed down. This condition can occur at any vehicle speed. This condition is usually more pronounced when first trying to make the vehicle move, as from a stop. This condition may cause the engine to stall in severe conditions.

**Lack of Power, Sluggishness, or Sponginess**

The engine delivers less than expected power. Little or no increase in speed when the accelerator pedal is pushed down part way.

**Poor Fuel Economy**

Fuel economy, as measured by an actual road test, is noticeably lower than expected. Also, the fuel economy is noticeably lower than it was on this vehicle at one time, as previously shown by an actual road test.

**Rough, Unstable, or Incorrect Idle and Stalling**

The engine runs unevenly at idle. If severe, the engine or the vehicle may shake. Engine idle may vary in speed. Either condition may be severe enough to stall the engine.

**Surges/Chuggles**

Engine power variation under steady throttle or cruise. Feels like the vehicle speeds up and slows down with no change in the accelerator pedal position.

#### 8.2.3.1.4. Symptoms Verification

Before using the Symptom tables, perform the following inspections:

- Verify that the malfunction indicator lamp (MIL) is operating correctly. Use the scan tool to command the lamp ON and OFF.
- Verify that there are no DTCs stored.
- Verify that the scan tool data is within the normal operating range. Refer to Control Module References for scan tool information.
- Verify that there are no Bulletins concerning the current symptom.
- Verify that the vehicle tires are correctly inflated and meet original equipment specifications.
- Verify the customer concern.
- Perform the Visual/Physical Inspection in this section. The visual/physical inspection is extremely important, and can lead to correcting a condition without additional testing. It may also help reveal the cause of an intermittent condition.

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

- Moisture and water intrusion in connectors, terminals, and components
- Incomplete connector mating
- Poor terminal contact
- High circuit or component resistance—High resistance can include any resistance, regardless of the amount, which can interrupt the operation of the component.
- Harness that is too short or tight
- Wire insulation that is chaffed or cut
- High or low ambient temperature
- High or low engine coolant temperatures
- High underhood temperatures
- Heat buildup 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
- Electromagnetic
- 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 conditions listed below:
  - Collapsed
  - Damaged areas
  - Looseness
  - Incorrect installation
  - Leaking

  If any condition listed above has allowed non-metered air to enter the air induction system, the Q38 Throttle Body: Throttle/Idle Learn procedure must be performed after the repair is complete.
- Inspect for air leaks at the throttle body mounting area, the mass air flow (MAF) sensor and intake manifold sealing surfaces.
- Inspect the wiring harness for the following conditions:
  - Poor connections
  - Pinches
  - Cuts

- Inspect for loose, damaged, unseated, or missing sensors/components.
- Inspect the terminals for corrosion and correct contact.

**8.2.3.1.5. Symptoms Testing**

**Backfire, Cuts Out/Misses, Detonation/Spark Knock, Dieseling/Run-On, Engine Control Module (ECM) Commanded Reduced Engine Power, Fuel Odor, Hard Start, Hesitation/Sag/Stumble, Lack of Power/Sluggishness/Sponginess, Poor Fuel Economy, Rough, Unstable, or Incorrect Idle and Stalling, or Surges/Chuggles**

- Test/inspect the fuel system for the conditions listed below:
  - Incorrect system operation or fuel pressure—Refer to Fuel System Diagnosis.
  - Leaking or incorrectly operating fuel injectors – Refer to Fuel Injector Diagnosis.
  - Contaminated or poor quality fuel – Refer to Alcohol/Contaminants-in-Fuel
- Diagnosis.
- Test/inspect the ignition system for the conditions listed below:
  - Spark plugs with an incorrect heat range or an abnormal condition – Refer to Spark Plug Inspection and Ignition System Specifications.
  - Coolant or oil fouled spark plugs.
  - Secondary ignition system susceptible to moisture. Engine running, wet down the secondary ignition system with water from a spray bottle to help locate damaged or deteriorated components. Look/listen for arcing or misfiring as the water is applied.
  - Weak spark using the EL 26792 HEI spark tester. Refer to Electronic Ignition System Diagnosis.
- Test/inspect for the conditions listed below:
  - Non-metered air flow into the air induction system. If a leak is found, repair as necessary. The Q38 Throttle Body: Throttle/Idle Learn procedure must be performed when the repair is complete.
  - An incorrectly operating turbocharger system. Refer to Turbocharger System Description and Turbocharger Cleaning and Inspection.
  - Incorrectly operating transmission torque converter clutch (TCC) – The scan tool should indicate an engine speed drop when the TCC is commanded ON.
  - Incorrectly operating A/C compressor
  - Items that can cause an engine to run lean or rich – Refer to DTC P0171 or P0172.
  - An incorrectly installed Mass Air Flow (MAF) / Intake Air Temperature (IAT) Sensor
  - Engine oil contaminated by fuel
  - Split or kinked vacuum hoses – Verify that the routing and connections are as shown on the vehicle emission control information label.
  - Excessive knock sensor spark retard activity – Refer to Knock Sensor Replacement and DTC P0324, P0326, or P06B6.
  - Fuel octane switch setting – Verify the fuel octane switch is set to the proper fuel octane rating for the fuel being used in the vehicle.
  - Electromagnetic interference on the reference circuit, which can cause a misfire condition. You can usually detect electromagnetic interference with a scan tool by monitoring the engine speed parameter. A sudden increase in the engine speed parameter with little change in actual engine speed indicates that electromagnetic interference is present. Inspect the high voltage components near the ignition control circuit if a condition exists.
  - A crankshaft position sensor with an incorrect resistance – The crankshaft position sensor resistance may be out of range after a hot soak. The resistance should be between 700–1 200 Ω.
  - A stuck open evaporative emission (EVAP) canister purge solenoid valve.
  - Incorrectly operating positive crankcase ventilation system – check all connections for leaks or restrictions.
- Test/inspect the engine cooling system for the conditions listed below:
  - A thermostat with incorrect heat range. Refer to Thermostat Diagnosis.
  - Incorrect engine coolant level – Refer to Cooling System Draining and Filling.
  - An incorrectly operating engine coolant thermostat heater – Refer to DTC P0597P0599.
    For additional information, refer to Symptoms Engine Cooling
- Test/inspect the exhaust system components for the conditions listed below:
  - Physical damage or possible internal failure
  - Restricted 3-way catalytic converters For additional information, refer to Symptoms Engine Exhaust.

- Test/inspect the engine for the mechanical conditions listed below:
  - Excessive oil in the combustion chamber or leaking valve seals
  - Oil Consumption
  - Incorrect cylinder compression
  - Sticking or leaking valves
  - Worn camshaft lobes
  - Incorrect valve timing
  - Broken valve springs
  - Excessive carbon buildup in the combustion chambers. Clean the chambers with Top Engine Cleaner, if necessary. Follow the instructions on the can.
  - Incorrect engine parts For additional information refer to Symptoms Engine Mechanical.
- If the above conditions do not address the symptom, refer to the additional symptoms tests.

#### 8.2.3.1.6. Additional Symptoms Tests

**Detonation/Spark Knock:**

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

**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 cluster.. A DTC may not be set.

A repair may not be necessary. Observe the scan tool Reduced Engine Power History parameter or refer to K20 Engine Control Module: Scan Tool Information to determine the reason for the reduced engine power event.

Verify or inspect for the following:

- Vehicle being operated at sustained high engine speeds, or up an incline for an extended period of time, which may cause the engine oil or coolant to overheat. Inspect the airflow passageways in front of the engine for obstructions
- and clear away any debris or foreign material that is found. If no obstructions are found, review approved driving habits with the customer. The customer may need to operate the vehicle at a higher engine speed to improve cooling system performance, or, at a slower engine speed to reduce engine load.
- A cooling fan condition which may cause the ECM to reduce engine power. Refer to Cooling Fan Description and Operation and Cooling System Description and Operation to verify correct operation of the cooling fan.
- High pressure fuel system condition. Refer to Fuel System Description and Fuel System Diagnosis to verify high pressure fuel system operation.
- Turbocharger boost pressure out of range. Refer to DTC P0234 or P0299.
- Intake air temperature out of range too high. Observe the scan tool IAT Sensor 1 and IAT Sensor 2 parameters. The readings should be within 9°C (16°F) of a each other. Refer to DTC P0096 or P0111 for more information.
- If equipped with automatic transmission, an incorrect learned brake pedal position (BPP) sensor. Verify the following actions have not occurred:
  - An engine control module (ECM) has been replaced
  - A BPP sensor has been replaced
  - A BPP sensor is misaligned or incorrectly installed

  If any of the above actions have occurred, the Brake Pedal Position Sensor Learn 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.
- Inspect for a condition with the internal components of the fuel tank assembly—Refer to Fuel System Description.

**Hard Start**

- Observe the scan tool Throttle Body Idle Airflow Compensation parameter. A value greater than 90% may indicate an excessive accumulation of deposits in the throttle bore. Inspect the throttle body and bore and clean, if necessary. Refer to Throttle Body Inspection and Cleaning.
- 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 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 and provides adequate pressure for engine startup The fuel pump should turn ON for 2 s when the ignition is turned ON. Refer to Fuel System Diagnosis for additional information.

**Hesitation, Sag, Stumble**

- Test the fuel pressure. Refer to Fuel System Diagnosis.
- Test the manifold absolute pressure (MAP) sensor. Refer to DTC P0106.
- Test the generator. Refer to Symptoms Engine Electrical. Repair the charging system if the generator output voltage is less than 9 V or more than 16 V.

| Note: |
| --- |
| The following actions may need to be repeated in order to verify an intermittent intake or exhaust camshaft actuator condition. |

- Engine warm and idling, verify the correct operation of the camshaft actuator system. Command the intake and exhaust camshaft actuators from 0 degrees to 20 degrees and back to zero while observing the scan tool Intake Camshaft Position Variance and Exhaust Camshaft Position Variance parameters. Each parameter should be less than 2 degrees in each of the commanded states.
  ⇒ If any of the parameters is greater than 2 degrees, inspect the suspect camshaft actuator and camshaft actuator solenoid valve and valve bore for contamination, obstruction, and damage. Refer to Camshaft Actuator System Description and Camshaft Position Actuator Solenoid Valve Replacement.

**Lack of Power, Sluggishness, or Sponginess**

Inspect the engine electrical system for correct operation. Refer to Symptoms Engine Electrical.
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.

| Note: |
| --- |
| The following actions may need to be repeated in order to verify an intermittent intake or exhaust camshaft actuator condition. |

- Engine warm and idling, verify the correct operation of the camshaft actuator system. Command the intake and exhaust camshaft actuators from 0 degrees to 20 degrees and back to zero while observing the scan tool Intake Camshaft Position Variance and Exhaust Camshaft Position Variance parameters. Each parameter should be less than 2 degrees in each of the commanded states.
  ⇒ If any of the parameters is greater than 2 degrees, inspect the suspect camshaft actuator and camshaft actuator solenoid valve and valve bore for contamination, obstruction, and damage. Refer to Camshaft Actuator System Description and Camshaft Position Actuator Solenoid Valve Replacement.
- Verify the correct operation of the turbocharger system. Perform the following:
  - Inspect the turbocharger moving components for looseness, binding, wear, and damage.
  - Verify that the turbocharger air inlet ducts and outlet ducts are tightly sealed and that the air passages are not obstructed. Engine running, use a solution of dish soap and water in a spray bottle to pinpoint any air leaks.
  - Inspect the turbocharger system components for external fluid leaks. Inspect the gaskets and sealing surfaces and look for cracks in the turbocharger components.
  - Inspect for a loss of turbocharger pressure. Ignition ON, verify the scan tool Turbo Boost Sensor parameter is within the range specified in the Altitude Versus Barometric Pressure.

⇒ If not within the range specified, refer to DTC P0236
– For additional information, refer to Turbocharger System Description and Turbocharger Cleaning and Inspection.

**Poor Fuel Economy**

- Observe the scan tool Throttle Body Idle Airflow Compensation parameter. A value greater than 90% may indicate an excessive accumulation of deposits in the throttle bore. Inspect the throttle body and bore and clean, if necessary. Refer to Throttle Body nspection and Cleaning.
- Inspect for acceleration rate too much or too often
- Inspect for incorrect operation of the speedometer.
- Inspect the brake system for brake drag.

**Rough, Unstable, or Incorrect Idle and Stalling**

- An excessively high idle may be due to the floor mat interfering with the accelerator pedal. Inspect the accelerator pedal for binding and verify that the floor mat is not interfering with the aceclerator pedal movement.
- Engine idle speed may be unstable or the engine may stall if the ECM has learned an incorrect idle/airflow compensation value. A DTC may also set. Observe the scan tool Throttle Body Idle Airflow Compensation parameter. A value greater than 90% may indicate an excessive accumulation of deposits in the throttle bore. If the throttle body needs cleaning, refer to Throttle Body Inspection and Cleaning.
  The actions listed below may also cause the ECM to learn an incorrect idle value.
  – The engine control module has been replaced
  – The throttle body has been replaced
  – The throttle body has been cleaned but the idle learn procedure was not performed after completing the cleaning
  – The air induction system was leaking, allowing non-metered air to enter the combustion chamber. The leak was repaired but the idle learn procedure was not performed after repairing the leak
  If any of the actions listed above have occurred, the Q38 Throttle Body: Throttle/Idle Learn procedure must be performed.
- Inspect the engine mounts for looseness, wear, and damage.
- Inspect the intake and exhaust manifolds for casting flash.

**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.
- Inspect for slow responding heated oxygen sensors (HO2S). The heated oxygen sensors should respond quickly to a change in throttle position. If the heated oxygen sensors do not respond to different throttle positions, inspect for contamination from fuel, silicon, or the incorrect use of room temperature vulcanizing sealant. The sensors may have a white powdery coating and result in a high, but false, signal voltage, which gives a rich exhaust indication. The ECM reduces the amount of fuel delivered to the engine, causing a driveability condition.

### 8.2.3.2. Inspection/Maintenance System Check

#### 8.2.3.2.1. Diagnostic Instructions

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

#### 8.2.3.2.2. Circuit/System Description

Several states require for a vehicle to pass onboard diagnostic (OBD) system tests and inspection/maintenance (I/M) emission inspections in order to renew license plates. This is accomplished by viewing the Inspection/Maintenance System Status or Data display on a scan tool. Using a scan tool, the technician can observe the I/M status in order to verify that the vehicle meets the criteria that complies with the local area requirements.

#### 8.2.3.2.3. Condition for Updating the Inspection/Maintenance Emission System Status

| Note: |
|---|
| New vehicles may not report an Inspection/Maintenance System Check pass or fail status for certain post catalyst oxygen sensor or heated oxygen sensor 2 diagnostics prior to 700 miles. After replacing a catalytic converter on a vehicle with greater than 700 miles, it may require up to an additional 700 miles to prevent a false failure status. |

Each system monitor requires at least one, and sometimes several, diagnostic tests. The result of each test is reported by a 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 or Data will indicate YES in the completed or Value column.

For example, when the HO2S heater status indicates YES, either all of the oxygen sensor heater tests have passed or one of the tests has illuminated the MIL. If the vehicle has two heated oxygen sensors, either both heater circuit tests have passed or one of the heater circuit tests has illuminated the MIL. The Inspection/Maintenance System Status or Data will indicate NO under the Completed or Value 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 or Data 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.

#### 8.2.3.2.4. Monitored Emission Control Systems

The OBD II System monitors all emission control systems that are onboard. The OBD II regulations require monitoring of the following:

- The air conditioning system
- The catalyst efficiency
- Comprehensive component monitoring, emission related inputs and outputs
- The evaporative emission (EVAP) system
- The fuel delivery system
- Heated catalyst monitoring
- Misfire monitoring
- The oxygen sensor system (HO2S)
- The oxygen sensor heater system (HO2S heater)

For the specific DTCs required for each system, refer to Inspection/Maintenance (I/M) System DTC Table. 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.

**8.2.3.2.5. Circuit/System Verification**

1. Verify that all Inspection/Maintenance System Status or Data indicators report YES, and that no I/M Test DTCs are present.

**⇒ If any I/M Test DTCs are set**

Refer to Diagnostic Trouble Code (DTC) List Vehicle.

**⇓ If no I/M Test DTCs are set**

2. All OK.

**8.2.3.2.6. Circuit/System Testing**

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

1. Verify no I/M DTCs are present.

**⇒ If an I/M DTC is set that would prevent the I/M System Status tests from completing, diagnose that DTC before continuing.**

Refer to Inspection/Maintenance (I/M) System DTC Table.

**⇓ If no I/M DTCs are set**

2. Review applicable service bulletins for software updates that would prevent the I/M System Status tests from completing.

**⇒ If a control module reprogram or other repair is required,**

Perform the Inspection/Maintenance Complete System Set Procedure after repair.

**⇓ If no repair is required**

3. Observe the Inspection/Maintenance System Status or Data indicators.

**⇒ If any Inspection/Maintenance System Status or Data indicators report NO**

Perform the Inspection/Maintenance Complete System Set Procedure.

**⇓ If no Inspection/Maintenance System Status or Data indicators report NO**

4. All OK.

### 8.2.3.3. Inspection/Maintenance Complete System Set Procedure

#### 8.2.3.3.1. Diagnostic Instructions

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

#### 8.2.3.3.2. 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.

#### 8.2.3.3.3. 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 startup ECT minus startup IAT are within 50°C (90°F).
- Fuel level is between 25–75%.

#### 8.2.3.3.4. Circuit/System Verification

1. Verify that all I/M System Status indicators report YES, and that no I/M Test DTCs are present.

**⇒ If any I/M Test DTCs are set**

Refer to Diagnostic Trouble Code (DTC) List Vehicle.

**⇓ If no I/M Test DTCs are set**

2. All OK.

#### 8.2.3.3.5. Inspection/Maintenance System Set Procedure

| Note: |
| --- |
| Whenever the ignition is turned ON, ignition positive voltage is supplied to the heated oxygen sensor (HO2S) heaters. After verifying the enable criteria, turn OFF the ignition for approximately 5 minutes to allow the sensors to cool before continuing with the test. Once the engine is started, do NOT turn the engine OFF for the remaining portion of the set procedure. |

1. Ensure that the vehicle meets the conditions for a cold start listed above.

   ⇒ If the Evaporative Emission (EVAP) inspection/maintenance system status indicator displays NO, perform the EVAP Service Bay test if applicable.
2. Turn OFF all accessories; HVAC system, other electrical loads, including aftermarket/add-on equipment, etc., and open the hood.
3. Set the vehicle parking brake and ensure the vehicle is in park for automatic transmission or neutral for manual transmission.
4. Turn the ignition ON for 1 min.
5. Start and idle the engine for 5 min.
6. Run the engine for 6 min within the following conditions:
   - Calculated air flow is between 9–30 g/s
   - Engine speed is steady between 1 300–3 000 RPM

7. Apply and hold brake pedal, and shift to Drive for automatic, or apply clutch pedal for manual and operate the vehicle within the following conditions for 2 min:

- Manifold Absolute Pressure (MAP) signal is greater than 12 g/s
- Engine speed is greater than 1 000 RPM

| Note: |
|---|
| Do NOT touch the accelerator pedal until told to do so. A change in throttle position sensor angle or an increase in engine speed may invalidate this portion of the test. |

8. Release the accelerator pedal and shift the vehicle to Park for automatic, or Neutral and release clutch pedal for manual, and allow the engine to idle for 2 min.
9. Close the hood, release the parking brake and drive vehicle at 90 km/h (55 MPH) for 2 min.
10. Release the accelerator pedal for at least 10 s. This will allow the vehicle to enter the deceleration fuel cut off.
11. Safely stop the vehicle, with the engine in drive for automatic or neutral with the clutch pedal depressed and parking brake applied for manual. Allow the vehicle to idle for 2 min.

| Note: |
|---|
| Do NOT disturb the vehicle or turn ON the ignition until told to do so. Disturbing the vehicle may invalidate this portion of the test. |

12. Shift the vehicle to park for automatic and neutral for manual. Turn OFF the ignition and exit the vehicle. Do NOT disturb the vehicle for 45 min.
13. Observe the Inspection/Maintenance System Status with a scan tool. All of the inspection/maintenance System Status indicators should display YES.

⇒ If the EVAP inspection/maintenance system status indicator displays NO, turn OFF the ignition, ensure that the vehicle meets the conditions for a cold start, and repeat steps 6 through 11 three more times, or until the EVAP inspection/maintenance system status indicator transitions to yes. If the indicator continues to display NO, refer to the Inspection/Maintenance (I/M) System DTC Table 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 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.

### 8.2.3.4. Inspection/Maintenance (I/M) System DTC Table

**Inspection/Maintenance (I/M) System DTC Table**

| System | DTCs Required to Set System Status to YES |
|---|---|
| If an inspection/maintenance system status indicator did not update to yes during the Inspection/Maintenance Complete System Set Procedure, 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. |
| EGR/CMP | • DTC P0011 or P0014.<br>• DTC P05CC or P05CE |
| Evaporative emission (EVAP) | • DTC P0442<br>• DTC P0446<br>• DTC P0455 |
| Fuel System | DTC P219A. |
| Oxygen sensor | • DTC P0131, P0132, P0134, P0137, P0138, or P0140. Refer to DTC P0131, P0132, P0134, P0137, P0138, or P0140.<br>• DTC P0133, P013A, P013B, P013E, P013F, P015A, P015B, P2270, or P2271. Refer to DTC P0133, P013A, P013B, P013E, P013F, P015A, P015B, P2270, or P2271. |
| Oxygen sensor heater | DTC P0030–P0032, P0036–P0038, P0053, P0054, P0135, or P0141. Refer to DTC P0030P0032, P0036P0038, P0053, P0054, P0135, or P0141. |

### 8.2.3.5. Engine Cranks But Does Not Run

#### 8.2.3.5.1. Diagnostic Instructions

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

#### 8.2.3.5.2. 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.

#### 8.2.3.5.3. Diagnostic Aids

Inspect for any of the conditions listed below:

- 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.
- There may be fuel spray at the fuel injectors and the indicated fuel pressure may be correct, yet there may not be enough fuel to start the engine. If the fuel injectors and the injector circuit are OK, and fuel spray is detected, the fuel injector ON time may be inadequate. If the engine control module (ECM) receives incorrect inputs from the various information sensors, the fuel delivered by the fuel injectors may be inadequate to start the engine. Check all the engine data parameters with a scan tool and compare the values indicated with the expected values or the values from a known vehicle in good condition.
- Check the crankshaft position sensor engine reference signal with a scan tool. Observe the engine speed parameter while cranking the engine. The scan tool should indicate a steady 200–300 RPM while cranking. If erratic values, such as sudden spikes in the engine speed, are displayed, the engine reference signal is not stable enough for the engine to start and run properly.
- Inspect the engine for good secure electrical grounds.
- If the engine almost starts and then stalls, check for an open in the ground circuits of the crankshaft position sensor and the camshaft position sensor – intake or camshaft position sensor – exhaust.
- Water or foreign material in the fuel can cause a no start or engine will not stay running condition. During freezing weather water can freeze inside the fuel system. The engine may start after 30 min in a heated repair shop. The malfunction may not recur until parked overnight in freezing temperatures. Extreme weather conditions can cause contaminated fuel to prevent the vehicle from starting.
- An engine 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.

#### 8.2.3.5.4. Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Electrical Information Reference**

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

**Scan Tool Reference**

Control Module References for scan tool information

**Special Tools**

CH 48027 Digital Pressure Gauge

EL 26792 HEI Spark Tester
EN 36012A Ignition System Diagnostic Harness

#### 8.2.3.5.5. Circuit/System Verification

| Note: |
|---|
| This diagnostic assumes the following:<br>• The battery is completely charged.<br>• The engine cranking speed is acceptable.<br>• There is adequate fuel in the fuel tank. |

#### 8.2.3.5.6. Circuit/System Testing

1. Crank the engine for up to 15 s.
2. Verify that DTC P0117, P0118, P0122, P0123, P0222, P0223, P0335, P0336, P0513, P0562, P0563, P0601, P0602, P0603, P0604, P0606, P062F, P0633, P0685, P0689, P0690, P1516, P1631, P1682, P16F3, P2101, P2119, or P2610 is not set.

**⇒ If any of the DTCs are set**

Refer to Diagnostic Trouble Code (DTC) List Vehicle.

**⇓ If none of the DTCs are set**

3. Ignition ON
4. Verify the Theft Deterrent LED located in the driver information center illuminates momentarily.

**⇒ If the LED stays ON or is flashing**

Review the Diagnostic Trouble Code (DTC) List Vehicle for Immobilizer system DTCs. Refer to Immobilizer Description and Operation for additional information.

**⇓ If the LED does not stay ON and is not flashing**

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

**⇒ If 0 RPM**

Refer to DTC P0335 or P0336.

⇓ If greater than 0 RPM

6. Ignition OFF.

| Note: |
|---|
| It may be necessary to secure the EN-36012-A Ignition System Diagnostic Harness to the spark plug boots with electrical tape. |

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

| Note: |
|---|
| • Perform the spark test on at least 3 of the cylinders.<br>• An erratic or weak spark is considered a no spark condition. |

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

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

Refer to Electronic Ignition System Diagnosis.

**⇓ If the spark tester sparks**

11. Ignition OFF.
12. Disconnect the harness connector at a Q17 Fuel Injector.
13. Connect a test lamp between the control circuit and the ignition voltage circuit of the harness connector.

| Note: |
|---|
| Perform the fuel injector test on at least 3 fuel injectors |

14. Verify the injector test lamp flashes while cranking the engine.

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

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

**⇓ If the injector test lamp flashes**

15. Ignition OFF.
16. Install the CH 48027 Digital Pressure Gauge.
17. Ignition ON.

| Note: |
| --- |
| • If the engine is too hot, high fuel pressure readings may result due to hot soak fuel boiling. Allow the engine coolant temperature to cool to less than 60° C (150° F) before attempting to verify fuel pressure.<br>• The Fuel Pump Enable may need to be commanded On a few times in order to obtain the highest possible fuel pressure.<br>• Additional DTCs may set when using the fuel pump output control. |

18. Command the Fuel Pump Enable On several times with a scan tool.
19. Verify the fuel pressure is between 345–650 kPa (50–94 PSI) while the fuel pump is running.

**⇒ If not within the specified range**

Refer to Fuel System Diagnosis.

**⇓ If within the specified range**

20. Verify that the fuel pressure, after the fuel pump has turned OFF, decreases to less than 600 kPa (87 PSI) and does not decrease more than 34 kPa (5 PSI) in 1 minute.

**⇒ If not within the specified range**

Refer to Fuel System Diagnosis.

**⇓ If within the specified range**

21. Verify none of the conditions listed below exist:
    - Collapsed air intake duct to the throttle body
    - Air filter and air intake system for restrictions and obstructions
    - Spark plugs for being gas or coolant fouled
    - A skewed manifold absolute pressure (MAP) sensor
    - A skewed engine coolant temperature (ECT) sensor
    - Test the exhaust system for restrictions. Refer to Restricted Exhaust.
    - Test the fuel for contamination. Refer to Alcohol/Contaminants-in-Fuel Diagnosis.
    - Engine mechanical condition, for example, worn timing belt or low compression—Refer to Symptoms Engine Mechanical.

**⇒ If a condition exists**

Repair as necessary.

**⇓ If no condition exists**

22. All OK.

#### 8.2.3.5.7. Repair Verification

Perform the Diagnostic Repair Verification after completing the repair.

- Spark Plug Replacement

### 8.2.3.6. Electronic Ignition System Diagnosis

#### 8.2.3.6.1. Diagnostic Instructions

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

#### 8.2.3.6.2. 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.

#### 8.2.3.6.3. 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.

#### 8.2.3.6.4. Reference Information

**Schematic Reference**
Engine Controls Schematics
**Connector End View Reference**
Component Connector End Views
**Description and Operation**
Electronic Ignition System Description
**Electrical Information Reference**
- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

**Scan Tool Reference**
Control Module References

#### 8.2.3.6.5. 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.

#### 8.2.3.6.6. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.
- Ignition Coil Replacement
- Control Module References for engine control module replacement, programming, and setup.

### 8.2.3.7. Symptoms Engine Mechanical

#### 8.2.3.7.1. Strategy Based Diagnostics

Perform a Diagnostic System Check Vehicle.

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

#### 8.2.3.7.2. Visual/Physical Inspection

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

#### 8.2.3.7.3. Intermittent

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

#### 8.2.3.7.4. Symptom List

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

- Base Engine Misfire without Internal Engine Noises
- Base Engine Misfire with Abnormal Internal Lower Engine Noises
- Base Engine Misfire with Abnormal Valve Train Noise
- Base Engine Misfire with Coolant Consumption
- Base Engine Misfire with Excessive Oil Consumption
- Engine Noise on Start-Up, but Only Lasting a Few Seconds
- Upper Engine Noise, Regardless of Engine Speed
- Lower Engine Noise, Regardless of Engine Speed
- Engine Noise Under Load

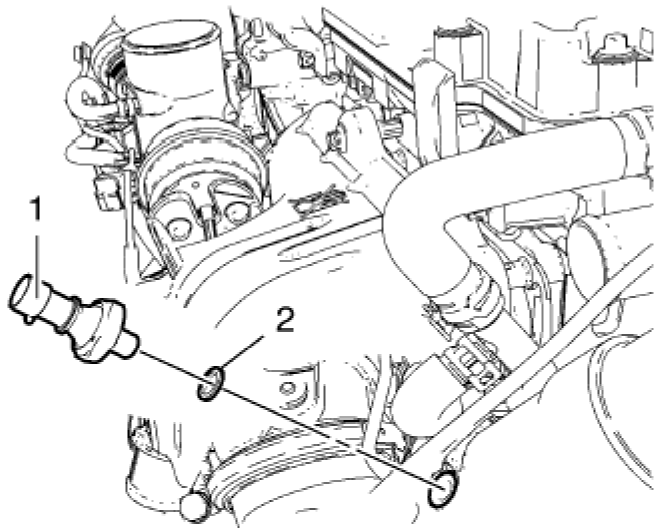
### 8.2.3.8. Oil Pressure Diagnosis and Testing

**Special Tools**

EN-498-B Oil Pressure Gauge
EN-498-3 Adapter

#### 8.2.3.8.1. Removal Procedure

1. Disconnect the oil pressure indicator switch wiring harness plug.




2. Remove the oil pressure indicator switch (1) and the oil pressure indicator switch seal ring (2).

#### 8.2.3.8.2. Measuring Procedure

1. Install EN-498-B gauge (1) along with EN-498-3 adapter (2).
2. Start Engine.

| Note: |
|---|
| The oil temperature should be between 80°C (176°F )and 100°C (212°). |

3. Measure the oil pressure:
   - The oil pressure at idle speed should be 150 kpa (22 psi).
   - The oil pressure between 3000 – 3500 rpm should be 380 – 650 kpa (55 – 94 psi).
4. Stop engine.
5. If the engine oil pressure is below specifications, inspect the engine for 1 or more of the following conditions:
   - Oil pump worn or dirty. Refer to Oil Pump Replacement and Engine Front Cover and Oil Pump Cleaning and Inspection.
   - Oil suction gallery clogged or dirty. Refer to Oil Pan Cleaning and Inspection
   - Cracked, porous, or restricted oil galleries.
   - Oil pressure relief valve malfunction.
6. Remove EN-498-B gauge and EN-498-3 adapter.

**8.2.3.8.3. Installation Procedure**

1. Install the oil pressure indicator switch (1) and a NEW oil pressure indicator switch seal ring (2).

| Caution: |
|---|
| Refer to Fastener Caution. |

2. Tighten the oil pressure indicator switch to 20 Nm (15 lb ft).

### 8.2.3.9. Oil Leak Diagnosis

**Oil Leak Diagnosis**

| Step | Action | Yes | No |
|---|---|---|---|
| **DEFINITION:** You can repair most fluid leaks by first, visually locating the leak, repairing or replacing the component, or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the leak and the cause of the leak. | | | |
| 1 | 1. Operate the vehicle until it reaches normal operating temperature. Refer to Engine Mechanical Specifications.<br>2. Park the vehicle on a level surface over a large sheet of paper or other clean surface.<br>3. Wait 15 minutes.<br>4. Inspect for drippings.<br><br>Are drippings present? | Go to Step 2 | System OK |
| 2 | Can you identify the type of fluid and the approximate location of the leak? | Go to Step 10 | Go to Step 3 |
| 3 | 1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.<br>2. Inspect for leaks at the following locations:<br>• Sealing surfaces<br>• Fittings<br>• Cracked or damaged components<br><br>Can you identify the type of fluid and the approximate location of the leak? | Go to Step 10 | Go to Step 4 |
| 4 | 1. Completely clean the entire engine and surrounding components.<br>2. Operate the vehicle for several miles at normal operating temperature and at varying speeds.<br>3. Park the vehicle on a level surface over a large sheet of paper or other clean surface.<br>4. Wait 15 minutes.<br>5. Identify the type of fluid and the approximate location of the leak.<br><br>Can you identify the type of fluid and the approximate location of the leak? | Go to Step 10 | Go to Step 5 |
| 5 | 1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.<br>2. Inspect for leaks at the following locations:<br>• Sealing surfaces<br>• Fittings<br>• Cracked or damaged components<br>Can you identify the type of fluid and the approximate location of the leak? | Go to Step 10 | Go to Step 6 |
| 6 | 1. Completely clean the entire engine and surrounding components.<br>2. Apply an aerosol type powder, for example, baby powder or foot powder, to the suspected area.<br>3. Operate the vehicle for several miles at normal operating temperature and at varying speeds.<br>4. Identify the type of fluid and the approximate location of the leak from the discolorations in the powder surface.<br><br>Can you identify the type of fluid and the approximate location of the leak? | Go to Step 10 | Go to Step 7 |
| 7 | 1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.<br>2. Inspect for leaks at the following locations:<br>• Sealing surfaces<br>• Fittings<br>• Cracked or damaged components | Go to Step 10 | Go to Step 8 |

| | | | |
|---|---|---|---|
| | Can you identify the type of fluid and the approximate location of the leak? | | |
| 8 | Identify the type of fluid and the approximate location of the leak.<br><br>Can you identify the type of fluid and the approximate location of the leak? | Go to Step 10 | Go to Step 9 |
| 9 | 3. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas.<br>4. Inspect for leaks at the following locations:<br>• Sealing surfaces<br>• Fittings<br>• Cracked or damaged components<br><br>Can you identify the type of fluid and the approximate location of the leak? | Go to Step 10 | System OK |
| 10 | 1. Inspect the engine for mechanical damage. Special interest should be shown to the following areas:<br>• Higher than recommended fluid levels<br>• Higher than recommended fluid pressures<br>• Plugged or malfunctioning fluid filters or pressure bypass<br>• valves<br>• Plugged or malfunctioning engine ventilation system<br>• Improperly tightened or damaged fasteners<br>• Cracked or porous components<br>• Improper sealants or gaskets, where required<br>• Improper sealant or gasket installation<br>• Damaged or worn gaskets or seals<br>• Damaged or worn sealing surfaces<br><br>2. Inspect the engine for customer modifications.<br><br>Is there mechanical damage or customer modifications to the engine? | Go to Step 11 | System OK |
| 11 | Repair or replace all damaged or modified components.<br><br>Did you complete the repair? | Go to Step 1 | - |

### 8.2.3.10. Oil Consumption Diagnosis

**Oil Consumption Diagnosis**

| Checks | Causes |
|---|---|
| The causes of excessive oil consumption may include the following conditions: | |
| Preliminary | • External oil leaks.<br>• Incorrect oil level or improper reading of the oil level indicator.<br>With the vehicle on a level surface, run the engine for a few minutes, allow adequate drain down time (2–3 minutes) and check for the correct engine oil level.<br>• Improper oil viscosity.<br>• Refer to the vehicle owners manual and use the recommended SAE grade and viscosity for the prevailing temperatures.<br>• Continuous high speed driving and/or severe usage.<br>• Crankcase ventilation system restrictions or malfunctioning components.<br>• Worn valve guides and/or valve stems.<br>• Worn, missing or improperly installed valve stem oil seals.<br>• Piston rings broken, worn, not seated properly.<br>Allow adequate time for the rings to seat.<br>Replace worn piston rings as necessary.<br>• Piston and rings improperly installed or miss fitted to the cylinder bore. |

#### 8.2.3.11. Engine Noise Under Load

**Engine Noise Under Load**

| Checks | Causes |
|---|---|
| Low oil pressure | Insufficient or poor oil supply to components.<br><br>1. Perform oil pressure test.<br>2. Repair or replace all damaged components. |
| Loose torque converter bolts | 1. Inspect the torque converter bolts and flywheel.<br>2. Repair or replace all damaged components. |
| Loose and/or damaged flywheel | 1. Inspect the flywheel and flywheel attaching bolts.<br>2. Repair or replace all damaged components. |
| Excessive piston-to-cylinder bore clearance | 1. Inspect the piston rings for low ring tension, broken or worn rings, inspect cylinder bore.<br>2. Repair or replace all damaged components. |
| Excessive crankshaft thrust bearing clearance | 1. Inspect the crankshaft end play and crankshaft thrust bearings.<br>2. Repair or replace all damaged components. |
| Excessive crankshaft bearing clearance | 1. Inspect the crankshaft bearings and crankshaft journals.<br>2. Repair or replace all damaged components. |

### 8.2.3.12. Engine Noise on Start-Up, but Only Lasting a Few Seconds

**Engine Noise on Start-Up, but Only Lasting a Few Seconds**

| Checks | Causes |
|---|---|
| Incorrect oil filter without anti-drainback feature | Install the correct oil filter. |
| Incorrect oil viscosity | Drain the engine oil and replace with the correct viscosity oil. |
| High stationary hydraulic lash adjuster (SHLA), valve lifter, leak down rate | Replace the SHLAs, valve lifters, as required. |
| Worn crankshaft thrust bearing | • Inspect the thrust bearing and crankshaft.<br>• Repair or replace as required. |
| Damaged or faulty oil filter bypass valve | • Inspect the oil filter by-pass valve for proper operation.<br>• Repair or replace as required. |

### 8.2.3.13. Base Engine Misfire without Internal Engine Noises

**Base Engine Misfire without Internal Engine Noises**

| Condition | Action |
|---|---|
| Abnormalities (severe cracking, bumps or missing areas) in the accessory drive belt. Also worn, damaged, or misaligned accessory drive components or excessive pulley runout. | Abnormalities in the accessory drive belt and/or components may cause engine RPM variations, noises similar to a faulty lower engine and also lead to a misfire condition. A misfire code may be present without an actual misfire condition.<br><br>1. Inspect the accessory drive components.<br>2. Repair or replace all damaged components. |
| Loose and/or damaged crankshaft pulley | A misfire code may be present without an actual misfire condition.<br><br>1. Inspect crankshaft pulley and pulley bolt.<br>2. Repair or replace all damaged components. |
| Loose torque converter bolts | A misfire code may be present without an actual misfire condition.<br><br>1. Inspect torque converter bolts and flywheel.<br>2. Repair or replace all damaged components. |
| Loose and/or damaged flywheel | A misfire code may be present without an actual misfire condition.<br><br>1. Inspect flywheel and flywheel attaching bolts.<br>2. Repair or replace all damaged components. |
| Restricted exhaust system | A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a misfire code. Possible causes of restrictions include collapsed or dented pipes, plugged mufflers and/or catalytic converters. Repair or replace all damaged components. |

## 8.2.3.14. DTC P0010, P0013, or P2088-P2091

### 8.2.3.14.1. Diagnostic Instructions

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

### 8.2.3.14.2. 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

### 8.2.3.14.3. 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 | - | - |

### 8.2.3.14.4. 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.

### 8.2.3.14.5. 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.

#### 8.2.3.14.6.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.

#### 8.2.3.14.7.Action Taken When the DTC Sets

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

#### 8.2.3.14.8.Conditions for Clearing the DTC

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

#### 8.2.3.14.9.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.

#### 8.2.3.14.10. Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Component View Reference**

Powertrain Component Views

**Description and Operation**

Camshaft Actuator System Description

**Electrical Information Reference**

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

### 8.2.3.14.11. 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 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

**⇒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.

### 8.2.3.14.12. Circuit/System Testing

1. Ignition Off and all vehicle systems Off, disconnect the harness connector at the appropriate Q6 Camshaft Position Actuator Solenoid Valve. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal 1and ground.

**⇒ If 5 Ω or greater**

2.1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
2.2. Test for less than 2 Ω in the low reference circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, replace the K20 Engine Control Module.

**⇓ If less than 5 Ω**

3. Ignition On.

| **Note:** |
|---|
| A test lamp must be used for this test. The control circuit is pulled-up to a low current voltage. The current is too low to illuminate a test lamp. A voltage on the control circuit is normal. |

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

**⇒ If the test lamp illuminates**

4.1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module, ignition On.
4.2. Test for less than 1 V between the control circuit and ground.
⇒ If 1 V or greater, repair the short to voltage on the circuit.
⇒ If less than 1 V, replace the K20 Engine Control Module.

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

5. Remove the test lamp.
6. Verify the scan tool parameters listed below do not display Malfunction when commanding the Camshaft Position Actuator Solenoid Valve On with a scan tool:

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

**⇒ If Malfunction is displayed**

6.1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
6.2. Test for less than 2 Ω in the control circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance or short to ground in the circuit.
⇒ If less than 2 Ω, replace the K20 Engine Control Module.

**⇓ If Malfunction is not displayed**

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

#### 8.2.3.14.13. Component Testing

1. Ignition Off, disconnect the harness connector at the Q6 Camshaft Position Actuator Solenoid Valve.
2. Test for 7–12 Ω between the control terminal 2 and the low reference terminal 1.
**⇒ If not between 7–12 Ω**
Replace the Q6 Camshaft Position Actuator Solenoid Valve.
**⇓ If between 7–12 Ω**
3. Test for infinite resistance between each terminal and the Q6 Camshaft Position Actuator Solenoid Valve housing.
**⇒ If not infinite resistance**
Replace the Q6 Camshaft Position Actuator Solenoid Valve.
**⇓ If infinite resistance**
4. All OK.

#### 8.2.3.14.14. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Camshaft Position Actuator Solenoid Valve Replacement
- Control Module References for Engine Control Module replacement, programming and setup

## 8.2.3.15. DTC P0011 or P0014

### 8.2.3.15.1. Diagnostic Instructions

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

### 8.2.3.15.2. DTC Descriptors

**DTC P0011**
Intake Camshaft Position System Performance
**DTC P0014**
Exhaust Camshaft Position System Performance

### 8.2.3.15.3. 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 | - | - |

### 8.2.3.15.4. 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.

### 8.2.3.15.5. 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.

### 8.2.3.15.6. 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.

### 8.2.3.15.7. Action Taken When the DTC Sets

DTCs P0011 and P0014 are Type B DTCs.

### 8.2.3.15.8. Conditions for Clearing the DTC

DTCs P0011 and P0014 are Type B DTCs.

#### 8.2.3.15.9. 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.

#### 8.2.3.15.10. Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Component View Reference**

Powertrain Component Views

**Description and Operation**

Camshaft Actuator System Description

**Electrical Information Reference**

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

**8.2.3.15.11. 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.<br><br>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. Advice 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

**⇒ 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 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.

#### 8.2.3.15.12. 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 or A 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. Verify the test lamp illuminates when commanding the appropriate Camshaft Position Actuator Solenoid Valve On with a scan tool.
**⇒ If the test lamp does not illuminate**
    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 or short to ground in the circuit.
⇒ If less than 2 Ω, replace the K20 Engine Control Module.
**⇓ If the test lamp illuminates**
6. Ignition Off, remove the Q6 Camshaft Position Actuator Solenoid Valve.
7. Verify the conditions listed below do not exist with the Q6 Camshaft Position Actuator Solenoid Valve:
    7.1. Torn, restricted, mis-positioned, or missing screens.
    7.2. Engine oil leak between the oil sealing lands of the solenoid. Inspect the lands of the solenoid for nicks.
    7.3. 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. |

8. Ignition Off, swap the Q6 Camshaft Position Actuator Solenoid Valve with the Q6 Camshaft Position Actuator Solenoid Valve that is operating correctly.
9. Engine idling.
10. 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°**
11. Test or replace the Q6 Camshaft Position Actuator Solenoid Valve.

#### 8.2.3.15.13. Component Testing

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

**⇒ If not between 7-12 Ω**

Replace the Q6 Camshaft Position Actuator Solenoid Valve.

**⇓ If between 7-12 Ω**

3. Test for infinite resistance between each terminal and the Q6 Camshaft Position Actuator Solenoid Valve housing.

**⇒ If not infinite resistance**

Replace the Q6 Camshaft Position Actuator Solenoid Valve.

**⇓ If infinite resistance**

4. All OK

#### 8.2.3.15.14. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Camshaft Position Actuator Solenoid Valve Replacement
- Control Module References for ECM replacement, programming and setup

## 8.2.3.16. DTC P0016 or P0017

### 8.2.3.16.1. Diagnostic Instructions

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

### 8.2.3.16.2. DTC Descriptors

**DTC P0016**
Crankshaft Position – Intake Camshaft Position Not Plausible
**DTC P0017**
Crankshaft Position – Exhaust Camshaft Position Not Plausible

### 8.2.3.16.3. Circuit/System Description

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

### 8.2.3.16.4. 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.

### 8.2.3.16.5. 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.

### 8.2.3.16.6. Action Taken When the DTC Sets

DTCs P0016 and P0017 are Type B DTCs.

### 8.2.3.16.7. Conditions for Clearing the DTC

DTCs P0016 and P0017 are Type B DTCs.

### 8.2.3.16.8. 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).

### 8.2.3.16.9. Reference Information

**Description and Operation**
Camshaft Actuator System Description
**DTC Type Reference**
Powertrain Diagnostic Trouble Code (DTC) Type Definitions
**Scan Tool Reference**
Control Module References for scan tool information

### 8.2.3.16.10. 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.

**⇓ If none of the DTCs are set**

3. Engine Running at normal operating temperature.
4. Verify DTC P0016 or P0017 is not set.

**⇒ If the DTC is set**

Inspect for the following and repair as necessary:

- A Q6 Camshaft Position Actuator Solenoid Valve that is stuck in the full advance or retard position.
- The correct installation of the Q6 Camshaft Position Actuator Solenoid Valves.
- The correct installation of the B23 Camshaft Position Sensors.
- The correct installation of the B26 Crankshaft Position Sensor.
- A timing chain tensioner condition.
- An incorrectly installed timing chain.
- Excessive play in the timing chain.
- A crankshaft reluctor wheel that has moved in relationship to top dead center (TDC) on the crankshaft.

**⇓ If the DTC is not set**

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

**⇒ If the DTC sets**

A mechanical condition listed above still exists.

**⇓ If the DTC does not set**

7. All OK.

### 8.2.3.16.11. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Camshaft Position Actuator Solenoid Valve Replacement
- Camshaft Position Sensor Replacement
- Crankshaft Position Sensor Replacement
- Timing Chain Tensioner Replacement

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

### 8.2.3.17.1. Diagnostic Instructions

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

### 8.2.3.17.2. 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

### 8.2.3.17.3. Diagnostic Fault Information

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

#### 8.2.3.17.4.Typical Scan Tool Data

**HO2S Sensor 1 Current/HO2S Sensor 2 Current**

| Circuit | Short to Ground | Open | Short to Voltage |
|---|---|---|---|
| Parameter Normal Range: 0.2–1.5 A | | | |
| HO2S Heater Low Control | 0 A | 0 A | 0 A |
| HO2S Heater Voltage Supply | 0 A | 0 A | 0.2–2 A |

#### 8.2.3.17.5.Circuit/System Description

Heated oxygen sensors (HO2S) are used for fuel control and post-catalyst monitoring. Each HO2S compares the oxygen content of the surrounding air with the oxygen content in the exhaust stream. Each HO2S must reach operating temperature to provide an accurate voltage signal. A heating element inside each of the HO2S minimizes the time required for the sensor to reach operating temperature. Voltage is provided to the heater by an ignition voltage circuit through a fuse. With the engine running, ground is provided to the heater by the HO2S heater low control circuit, through a low side driver within the engine control module (ECM). The ECM uses pulse-width modulation (PWM) to control the HO2S heater operation to maintain a specific HO2S operating temperature range.

#### 8.2.3.17.6.Conditions for Running the DTC

**P0030, P0031, P0032, P0036, P0037 and P0038**
- The system voltage is between 11–32 V.
- The engine speed is greater than 400 RPM.
- The DTCs run continuously when the above conditions are met for greater than 5 s.

**P0053 and P0054**
- DTCs P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119 or P2610 are not set.
- The system voltage is less than 32 V.
- The ignition is OFF for greater than 8 h.
- The engine is running.
- The ECT is between −30 to +45°C (−22 to +113°F).
- The engine coolant temperature (ECT) and the intake air temperature (IAT) are within 8°C (14°F).
- The DTCs run once per valid cold startup
- 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.

#### 8.2.3.17.7.Conditions for Setting the DTC

**P0030, P0031, P0032, P0036, P0037 and P0038**
The ECM detects that the commanded state of the driver and the actual state of the control circuit do not match for greater than 5 s.
**P0053 and P0054**
The ECM detects the HO2S heater is not within 7.5-13 Ω at engine startup.
**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.

#### 8.2.3.17.8.Action Taken When the DTC Sets

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

#### 8.2.3.17.9.Conditions for Clearing the DTC

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

#### 8.2.3.17.10. Diagnostic Aids

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

#### 8.2.3.17.11. Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Electrical Information Reference**

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

#### 8.2.3.17.12. Circuit/System Verification

1. Engine idling.
2. Verify the parameters listed below do not display Malfunction.
    - HO2S 1 or 2 Heater Control Circuit Low Voltage Test Status
    - HO2S 1 or 2 Heater Control Circuit Open Test Status
    - HO2S 1 or 2 Heater Control Circuit High Voltage Test Status

**⇒ If Malfunction is displayed**

Refer to Circuit/System Testing.

**⇓ If Malfunction is not displayed**

3. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you
observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.

**⇒ If the DTC sets**

Refer to Circuit/System Testing.

**⇓ If the DTC does not set**

5. All OK.

**8.2.3.17.13. Circuit/System Testing**

1. Ignition OFF, disconnect the harness connector at the appropriate B52 Heated Oxygen Sensor. Ignition ON.
2. Verify that a test lamp illuminates between the ignition voltage circuit terminal 1 and ground.

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

   2.1. Ignition OFF.

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

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

   ⇒ If less than 2 Ω, verify the fuse is OK and there is voltage at the fuse.

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

   2.1. Ignition OFF, remove the test lamp.

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

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

   ⇒ If infinite resistance, test all components connected to the fuse and replace as necessary.

**⇓ If the test lamp illuminates**

3. Verify that a test lamp does not illuminate between the ignition voltage circuit terminal 1 and the control circuit terminal 2.

**⇒ If the test lamp illuminates**

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

   3.2. Test for infinite resistance between the control circuit and ground.

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

   ⇒ If infinite resistance, replace the K20 Engine Control Module.

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

4. Remove the test lamp.
5. Verify the scan tool HO2S 1 or 2 Heater Control Circuit High Voltage Test Status parameter is OK when commanding the HO2S Heater Sensor 1 or 2 ON with a scan tool.

**⇒ If OK is not displayed**

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

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

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

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

**⇓ If OK is displayed**

| **Note:** |
|---|
| Less than 10 Ω of additional resistance on the ignition voltage circuit, or control circuit may set a DTC. If there is a resistance on a circuit, the driver will remain ON and the scan tool HO2S High Voltage Test Status parameter will display OK. Performing this test may set additional DTCs. |

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

| **Note:** |
|---|
| This test may only be performed once per key cycle. If test is repeated, ignition OFF, allow the engine control module to shut down completely, then ignition ON. |

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

**⇒ If Malfunction is not displayed**

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

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

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

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

**⇓ If Malfunction is displayed**

8. Test or replace the B52 Heated Oxygen Sensor.

### 8.2.3.17.14. Component Testing

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

**⇒ If not within the specified range**

Replace the B52 Heated Oxygen Sensor.

**⇓ If within the specified range**

3. All OK.

### 8.2.3.17.15. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Heated Oxygen Sensor Replacement Sensor 1
- Heated Oxygen Sensor Replacement Sensor 2
- Perform the scan tool Heated Oxygen Sensor Resistance Learn Reset after replacing a HO2S.
- Control Module References for ECM replacement, programming and setup.

### 8.2.3.18. DTC P0033-P0035

#### 8.2.3.18.1. Diagnostic Instructions

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

#### 8.2.3.18.2. DTC Descriptors

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

#### 8.2.3.18.3. Diagnostic Fault Information

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

#### 8.2.3.18.4. Circuit/System Description

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

- Ignition voltage
- Turbocharger bypass solenoid valve control

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

#### 8.2.3.18.5. Conditions for Running the DTC

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

#### 8.2.3.18.6.Conditions for Setting the DTC

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

#### 8.2.3.18.7.Action Taken When the DTC Sets

DTC P0033, P0034, P0035 are Type B DTCs.

#### 8.2.3.18.8.Conditions for Clearing the DTC

DTC P0033, P0034, P0035 are Type B DTCs.

#### 8.2.3.18.9.Reference Information

**Schematic Reference**
Engine Controls Schematics
**Connector End View Reference**
Component Connector End Views
**Description and Operation**
Turbocharger System Description
**Electrical Information Reference**
- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

**DTC Type Reference**
Powertrain Diagnostic Trouble Code (DTC) Type Definitions
**Scan Tool Reference**
Control Module References for scan tool information

#### 8.2.3.18.10. Circuit/System Verification

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

**⇒ If Malfunction is displayed**
Refer to Circuit/System Testing.
**⇓ If Malfunction is not displayed**
2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
3. Verify a DTC does not set.
**⇒ If a DTC sets**
Refer to Circuit/System Testing
**⇓ If a DTC does not set**
4. All OK

**8.2.3.18.11. Circuit/System Testing**

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

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

2.1. Ignition OFF, remove the test lamp.
2.2. Test for less than 2 Ω in the ignition circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.

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

2.1. Ignition OFF, remove the test lamp.

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

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

2.2. Test for infinite resistance between the ignition circuit and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇒ If infinite resistance, test all components connected to the ignition voltage circuit for a short and replace as necessary.

**⇓ If the test lamp illuminates**

3. Verify that a test lamp does not illuminate between the control circuit terminal 1 and the ignition circuit terminal 2.

**⇒ If the test lamp illuminates**

3.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module. Remove the test lamp.
3.2. Test for infinite resistance between the control circuit and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇒ If infinite resistance, replace the K20 Engine Control Module.

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

4. Remove the test lamp.
5. Verify the scan tool Turbocharger Bypass Solenoid Valve Control Circuit High Voltage Test Status parameter is OK when commanding the Turbocharger Bypass Solenoid Valve Active with a scan tool.

**⇒ If OK is not displayed**

5.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
5.2. Test for less than 1 V between the control circuit and ground.
⇒ If 1 V or greater, repair the short to voltage on the circuit.
⇒ If less than 1 V, replace the K20 Engine Control Module.

**⇓ If OK is displayed**

6. Install a 3 A fused jumper wire between the control circuit terminal 1 and the ignition circuit terminal 2.
7. Verify the scan tool Turbocharger Bypass Solenoid Valve Control Circuit High Voltage Test Status parameter is Malfunction when commanding the Turbocharger Bypass Solenoid Valve Active with a scan tool.

**⇒ If Malfunction is not displayed**

7.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
7.2. Test for less than 2 Ω in the control circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, replace the K20 Engine Control Module.

**⇓ If Malfunction is displayed**

8. Test or replace the Q40 Turbocharger Bypass Solenoid Valve.

### 8.2.3.18.12. Component Testing

**Static Test**

1. Ignition OFF, disconnect the harness connector at the Q40 Turbocharger Bypass Solenoid Valve.
2. Test for 20-27 Ω between terminal 1 and terminal 2 of the solenoid valve.

**⇒ If not between 20- 27Ω**

Replace the Q40 Turbocharger Bypass Solenoid Valve.

**⇓ If between 20-27Ω**

3. All OK

**Dynamic Test**

1. Install a 10 A fused jumper wire between the Ignition terminal 2 and 12 V. Install a jumper wire between the control terminal 1 and ground.
2. Verify the solenoid clicks.

**⇒ If the solenoid does not click**

Replace the Q40 Turbocharger Bypass Solenoid Valve.

**⇓ If the solenoid clicks**

3. All OK

### 8.2.3.18.13. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Charge Air Bypass Regulator Solenoid Valve Replacement
- Control Module References for ECM replacement, programming and setup

### 8.2.3.19. DTC P0068 or P1101

#### 8.2.3.19.1. Diagnostic Instructions

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

#### 8.2.3.19.2. DTC Descriptor

**DTC P0068**

Throttle Body Air Flow Performance

**DTC P1101**

Intake Air Flow System Performance

#### 8.2.3.19.3. Circuit/System Description

The engine control module (ECM) compares actual airflow based on throttle position (TP) to a calculated airflow based on manifold absolute pressure (MAP) sensor, and mass air flow (MAF).

#### 8.2.3.19.4. Conditions for Running the DTC

**DTC P0068**

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

**DTC P1101**

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

#### 8.2.3.19.5. Conditions for Setting the DTCs

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

#### 8.2.3.19.6. Action Taken When the DTCs Set

- DTC P0068 is a type A DTC.
- DTC P0068 is a type B DTC; with RPO LDD.
- DTC P1101 is a type B DTC.

#### 8.2.3.19.7. Conditions for Clearing the DTCs

- DTC P0068 is a type A DTC.
- DTC P0068 is a type B DTC; with RPO LDD.
- DTC P1101 is a type B DTC.

### 8.2.3.19.8.Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Electrical Information Reference**

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

**Powertrain Component Views**

Powertrain Component Views

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

### 8.2.3.19.9.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 for further diagnosis.

**⇓ If none of the DTCs are set**

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

**⇒ If 90 % or greater**

Refer to Throttle Body Inspection and Cleaning.

**⇓ If less than 90 %**

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

**⇒ If Disagree**

Refer to DTC P0121-P0123, P0222, P0223, or P2135 for further diagnosis.

**⇓ If Agree**

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

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

Refer to DTC P0106 for further diagnosis.

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

8. Verify the engine is equipped with a turbocharger.

**⇒ If not equipped with a turbocharger**

Refer to Step 11.

**⇓ If equipped with a turbocharger**

9. Verify the scan tool Boost Pressure Sensor parameter is within the range specified in the Altitude Versus Barometric Pressure table.

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

Refer to DTC P0236 for further diagnosis.

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

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

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

Refer to DTC P0236 for further diagnosis.

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

11. Engine idling, verify the scan tool MAP Sensor pressure parameter is between 26–52 kPa (3.8–7.5 PSI) and changes with accelerator pedal input.

**⇒ If not between 26–52 kPa (3.8–7.5 PSI) or does not change**

Refer to DTC P0106 for further diagnosis.

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

12. Verify the scan tool MAF Sensor g/s parameter changes smoothly and gradually as the engine speed is increased and decreased while performing the actions listed below.
    - 12.1. Engine idling
    - 12.2. Perform the scan tool snapshot function.
    - 12.3. Increase the engine speed slowly to 3,000 RPM and then back to idle.
    - 12.4. Exit from the scan tool snapshot and review the data.
    - 12.5. Observe the MAF Sensor parameter frame by frame with a scan tool.

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

Refer to DTC P0101 for further diagnosis.

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

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

**⇒ If the DTC does set**

Refer to Circuit/System Testing for further diagnosis.

**⇓ If the DTC does not set**

15. All OK

### 8.2.3.19.10. Circuit/System Testing

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

1. Verify the integrity of the entire air induction system by verifying that none of the following conditions exist:
    - Any damaged components
    - Improper operation of turbocharger wastegate actuator or bypass valve; where equipped
    - Improperly installed components
    - Collapsed, restricted, or damaged components
    - Loose clamps, cracks, or other damage
    - An air flow restriction
    - Restricted air filter
    - Splits, kinks, leaks, or improper connections at the vacuum hoses
    - Vacuum leaks at the intake manifold, MAP sensor, and throttle body
    - Water intrusion
    - Any snow or ice buildup, in cold climates
    - Contamination of the MAF sensor element
    - Missing, restricted, or leaking exhaust components—Refer to Symptoms Engine Exhaust for further diagnosis.

**⇒ If a condition is found**

Repair or replace component as appropriate.

**⇓ If no condition is found**

2. Test the engine for a mechanical condition. Refer to Symptoms Engine Mechanical for diagnosis.

**⇒ If a condition is found**

Repair or replace component as appropriate.

**⇓ If no condition is found**

3. All OK

### 8.2.3.19.11. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.
Control Module References for engine control module replacement, programming, and setup

## 8.2.3.20. DTC P0096 or P0111

### 8.2.3.20.1.Diagnostic Instructions

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

### 8.2.3.20.2.DTC Descriptors

**DTC P0096**
Intake Air Temperature (IAT) Sensor 2 Performance
DTC P0111
Intake Air Temperature (IAT) Sensor 1 Performance

### 8.2.3.20.3.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, P00EA, P2227, P2229 | * | - |
| *Internal ECM or sensor damage may occur if the circuit is shorted to B+.<br>**Where used. | | | | |

**IAT Sensor 2**

| Circuit | Short to Ground | Open/High Resistance | Short to Voltage | Signal Performance |
|---|---|---|---|---|
| 5 V Reference | P0097, P00F4, P0651, P2199, P2227, P2228 | P0096, P0097, P00F4, P2199, P2227, P2228 | P0097, P00F4, P0651, P2199, P2227, P2228 | - |
| Sensor | P0097, P00F5, P2199 | P0097, P00F4, P2199 | P0097, P00F4, P2199* | - |
| Low Reference | - | P0097, P00F4, P0113, P2227, P2229 | * | - |
| *Internal ECM or sensor damage may occur if the circuit is shorted to B+. | | | | |

### 8.2.3.20.4.Typical Scan Tool Data

**IAT Sensor 1**

| Circuit | Short to Ground | Open/High Resistance | Short to Voltage |
|---|---|---|---|
| **Operating Conditions:** Engine Running<br>**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 1**

| Circuit | Short to Ground | Open/High Resistance | Short to Voltage |
|---|---|---|---|
| **Operating Conditions:** Engine Running<br>**Parameter Normal Range:** Varies with ambient temperature | | | |
| 5 V Reference | −40°C (−40°F)<br>10 Hz | −40°C (−40°F)<br>10 Hz | - |
| Sensor | −40°C (−40°F) | −40°C (−40°F) | −40°C (−40°F)<br>10 Hz |
| Low Reference | - | −40°C (−40°F)<br>10 Hz | - |
| *Internal ECM or sensor damage may occur if the circuit is shorted to B+ | | | |

### 8.2.3.20.5.Circuit/System Description

The sensors listed below are integrated within the multifunction intake air sensor:

- IAT sensor 1
- IAT sensor 2
- Humidity sensor
- MAF sensor
- BARO pressure sensor

The intake air temperature (IAT) sensor 1 is a variable resistor that changes the voltage on the engine control module (ECM) supplied 5 V signal circuit. The signal varies with inlet air temperature in the sensor bore and is displayed by the scan tool as °C (°F). The IAT sensor 2 and the humidity sensor share the same circuit. The IAT sensor 2 signal is displayed by the scan tool as Hz (Hertz) and °C (°F).

The IAT sensor 1 produces an analog signal on pin-8 of the sensor. The IAT sensor 2 produces a frequency modulated signal on pin- 1 of the 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

#### 8.2.3.20.6.Conditions for Running the DTCs

**P0096 and P0111**

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

#### 8.2.3.20.7.Conditions for Setting the DTCs

**P0096**

The ECM determines the absolute difference between IAT sensor 1 startup temperature and the IAT sensor 2 startup temperature is greater than 25°C (45°F).
**AND**
The ECM determines the absolute difference between IAT sensor 2 startup temperature and the IAT sensor 3 startup temperature is greater than 25°C (45°F).
**AND**
The ECM determines the absolute difference between IAT sensor 1 startup temperature and the IAT sensor 3 startup temperature is less than or equal to 25°C (45°F).
This DTC runs once per ignition cycle when the enabling conditions are met.

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

**P0111 – Condition 1**

The ECM determines the absolute difference between IAT sensor 1 startup temperature and the IAT sensor 2 startup temperature is greater than 25°C (45°F).
**AND**
The ECM determines the absolute difference between IAT sensor 1 startup temperature and the IAT sensor 3 startup temperature is greater than 25°C (45°F).
**AND**
The ECM determines the absolute difference between IAT sensor 2 startup temperature and the IAT sensor 3 startup temperature is less than or equal to 25°C (45°F).

**P0111 – Condition 2**

The ECM determines the IAT sensor 2 startup temperature is between the IAT sensor 1 and IAT sensor 3 startup temperatures.
**AND**
The ECM determines the absolute difference between IAT sensor 1 startup temperature and the IAT sensor 3 startup temperature is greater than 25°C (45°F).
**AND**
The ECM determines the absolute difference between IAT sensor 2 and the IAT sensor 1 startup temperatures is greater than absolute difference between IAT sensor 2 and the IAT sensor 3 startup temperatures.

**P0111 – Condition 3**

The ECM determines the IAT sensor 3 startup temperature is between the IAT sensor 1 and IAT sensor 2 startup temperatures.
**AND**
The ECM determines the absolute difference between IAT sensor 1 startup temperature and the IAT sensor 2 startup temperature is greater than 25°C (45°F).
**AND**
The ECM determines the absolute difference between IAT sensor 3 and the IAT sensor 1 startup temperatures is greater than absolute difference between IAT sensor 3 and the IAT sensor 2 startup temperatures.

DTC P0111 runs once an ignition cycle when the any one, of the above 3 enabling sets of conditions is met.

#### 8.2.3.20.8. Action Taken When the DTCs Set

DTCs P0096 and P0111 are Type B DTCs.

#### 8.2.3.20.9. Conditions for Clearing the DTCs

DTCs P0096 and P0111 are Type B DTCs.

#### 8.2.3.20.10. 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.

#### 8.2.3.20.11. Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Electrical Information Reference**

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

**Special Tools**

EL-38522-A Variable Signal Generator

**8.2.3.20.12. 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 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 3 and 4 of this verification procedure only if the ignition has been OFF for 8 hours or more. |

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

**⇒ If not within 25°C (45°F)**

Refer to Circuit/System Testing.

**⇓ If within 25°C (45°F)**

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

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

Refer to Circuit System Testing.

**⇓ If between: −38 and +149°C (−36 and +300°F)**

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

**8.2.3.20.13. Circuit/System Testing**

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

1. Check the integrity of the entire air induction system and verify that none of the following conditions exist:
- A loose or disconnected charge air cooler hose or pipe; where equipped
- A blocked or obstructed charge air cooler, including: aftermarket grill covers; where equipped
- Any snow or ice buildup at the charge air cooler in cold climates; where equipped
- Any mud or dirt buildup at the charge air cooler; where equipped
- A restricted or collapsed air intake duct
- An intake manifold leak
- A MAP sensor seal that is leaking, missing, or damaged
- A misaligned or damaged air intake duct
- Any water intrusion in the induction system
- An Intake Manifold Resonator with a leaking seal, or a cracked or broken housing

**⇒ If a condition exists**
Repair or replace component as appropriate.
**⇓ If no condition exists**
2. Ignition OFF, and all vehicle systems OFF, it may take up to 2 min. for all vehicle systems to power down. Disconnect the harness connector at the B75C Multifunction Intake Air sensor.
3. Test for less than 2 Ω between the low reference circuit terminal 7 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 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 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 signal circuit terminal 8 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. Ignition ON, verify the scan tool IAT Sensor 1 parameter is colder than −39°C (−38°F).

**⇒ If warmer than −39°C (−38°F).**

6.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
6.2. Test for infinite resistance between the signal circuit terminal 8 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 colder than −39°C (−38°F).**

7. Ignition OFF, install a 3 A fused jumper wire between the signal circuit terminal 8 and the low reference circuit terminal 7.
8. Verify the scan tool IAT Sensor 3 parameter is warmer than 150°C (302°F).

**⇒ If colder than 150°C (302°F).**

8.1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
8.2. 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
8.3. Ignition OFF.
8.4. 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 150°C (302°F).**

9. Ignition ON, test for 4.8–5.2 V between the signal terminal 1 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**

| **Note:** |
|---|
| If the signal circuit is shorted to a voltage the engine control module or the sensor may be damaged. |

9.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
9.2. 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**

10. Determine if EL-38522-A Variable Signal Generator or equivalent is available.
⇒ EL-38522-A Variable Signal Generator; or equivalent is not available
10.1. Replace the K20 Engine Control Module.
10.2. 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.
10.3. Verify the DTC does not set.

**⇒ If the DTC sets**

Test or replace the B75C Multifunction Intake Air sensor.

⇓ **If no DTCs set**

10.4. Circuits, ECM, and the sensors test OK, refer to step 18.

⇓ **EL38522A, Variable Signal Generator; or equivalent is available**

11. Ignition OFF, connect the leads of the EL-38522-A 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+

12. Set the EL-38522-A Variable Signal Generator to the following specifications.

- Signal switch to 5 V
- Duty Cycle switch to 50 % (Normal)
- Frequency switch to 30 Hz

13. 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**

14. Ignition OFF and all vehicle systems OFF, disconnect the B111B Turbocharger Boost/Intake Air Temperature sensor. It may take up to 2 min for all vehicle systems to power down.

15. Test for less than 2 Ω between the low reference circuit terminal 1 and ground.

⇒ **If 2 Ω or greater**

15.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
15.2. 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**

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

⇒ **If less than 4.8 V**

16.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
16.2. 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
16.3. 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. |

16.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
16.2. 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**

17. Test or replace the appropriate temperature sensor.

18. All OK.

### 8.2.3.20.14. Component Testing

**Multifunction Intake Air Sensor**

1. Ignition OFF, disconnect the harness connector at the B75C Multifunction Intake Air sensor.

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

2. Test the IAT sensor 1 by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the Temperature Versus Resistance Intake Air Temperature Sensor table for 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.**

All OK

**Multifunction Intake Air Sensor**

1. Test the IAT Sensor 2 by varying the sensor temperature while monitoring the air temperature with a thermometer. Compare the readings with the scan tool IAT Sensor 2 parameter. The values should be within 5%.

**⇒ If not within 5%**

Replace the B75C Multifunction Intake Air sensor.

**⇓ If within 5%**

2. All OK.

**Turbocharger Boost/Intake Air Temperature sensor**

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

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

2. Test the IAT sensor 3 by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the Temperature Versus Resistance Intake Air Temperature Sensor table for the appropriate sensor. The resistance values should be in range of the table values.

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

Replace the B111B Turbocharger Boost/Intake Air Temperature sensor.

**⇓ If within the specified range.**

3. All OK

### 8.2.3.20.15. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Intake Air Pressure and Temperature Sensor Replacement for turbocharger boost/intake air temperature sensor replacement
- Mass Airflow Sensor Replacement for multifunction intake air sensor replacement
- Control Module References for Engine Control Module replacement, programming, and setup.

## 8.2.3.21. DTC P0097, P0098, or P0099

### 8.2.3.21.1. Diagnostic Instructions

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

### 8.2.3.21.2. 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

### 8.2.3.21.3. Diagnostic Fault Information

**IAT Sensor 2**

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage | Signal Performance |
|---|---|---|---|---|
| 5 V Reference | P0097, P00F4, P0651, P2199, P2227, P2228 | P0096, P0097, P00F4, P2199, P2227, P2228 | P0097, P00F4, P0651, P2199, P2227, P2228 | - |
| Sensor | P0097, P00F5, P2199 | P0097, P00F4, P2199 | P0097, P00F4, P2199* | - |
| Low Reference | - | P0097, P00F4, P0113, P2227, P2229 | * | - |
| *Internal ECM or sensor damage may occur if the circuit is shorted to B+. | | | | |

### 8.2.3.21.4. Typical Scan Tool Data

**IAT Sensor 2**

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage |
|---|---|---|---|
| 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+. | | | |

### 8.2.3.21.5. Circuit/System Description

The sensors listed below are integrated within the multifunction intake air sensor:

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

The IAT sensor 2 and the humidity sensor share the same circuit. The IAT sensor 2 signal is displayed by the scan tool as Hertz (Hz) and °C (°F).
The sensors listed below share an ECM supplied 5 V reference circuit:

IAT sensor 2
Humidity sensor
Barometric pressure (BARO) sensor

The sensors listed below share an ECM supplied low reference circuit:

IAT sensor 1
IAT sensor 2
Humidity sensor
Barometric pressure (BARO) sensor

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

#### 8.2.3.21.6.Conditions for Running the DTCs

**P0097, P0098, and P0099**

- The ignition is ON, or the engine is running.
- The Ignition voltage is at least 11 V.
- The DTCs run continuously within the enabling conditions.

#### 8.2.3.21.7.Conditions for Setting the DTCs

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

**P0097**
The ECM detects that the IAT sensor 2 signal is less than 10 Hz, colder than −60°C (−76°F), for greater than 5 s.
**P0098**
The ECM detects that the IAT sensor 2 signal is greater than 390 Hz, warmer than 150°C (302°F), for greater than 5 s.
**P0099**
The ECM detects that the IAT sensor 2 signal is intermittent or has abruptly changed for longer than 5 s.

#### 8.2.3.21.8.Action Taken When the DTC Sets

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

#### 8.2.3.21.9.Conditions for Clearing the MIL/DTCs

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

#### 8.2.3.21.10. Diagnostic Aids

- With the ignition ON, when the engine is cold and not running, properly functioning IAT sensor 2 will gradually increase the scan tool IAT Sensor 2 parameters. This is due to the heat that is generated by the multifunction intake air sensor heating elements.
- The humidity sensor and the IAT sensor 2 signals are sent to the ECM on the same circuit. If the IAT Sensor 2 parameter displays the values: 10 Hz; –40°C (-40° F), and there are also Humidity Sensor DTCs, check for a circuit problem.

### 8.2.3.21.11. Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Electrical Information Reference**

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

**Powertrain Component Views**

Powertrain Component Views

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References Control Module References for scan tool information

**Special Tools**

EL-38522-A Variable Signal Generator

### 8.2.3.21.12. 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 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 3 and 4 of this verification procedure only if the ignition has been OFF for 8 hours or more. |

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

**⇒ If not within 25°C (45°F)**

Refer to Circuit/System Testing.

**⇓ If within 25°C (45°F)**

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

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

Refer to Circuit System Testing.

**⇓ If between: −38 and +149°C (−36 and +300°F)**

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

**8.2.3.21.13. 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 B75C Multifunction Intake Air sensor.
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 5 V reference circuit terminal 2 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 5 V reference circuit is shorted to a voltage the engine control module or the sensor may be damaged. |

 3.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
 3.2. Ignition ON, test for less than 1 V between the 5 V reference circuit and ground.
 ⇒ If 1 V or greater, repair the short to voltage on the circuit.
 ⇒ If less than 1 V, replace the K20 Engine Control Module.
**⇓ If between 4.8–5.2 V**
4. Ignition ON, test for 4.8–5.2 V between the signal circuit terminal 1 and ground.
**⇒ If less than 4.8 V**
 4.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module
 4.2. Test for infinite resistance between the signal circuit and ground.
  ⇒ If less than infinite resistance, repair the short to ground on the circuit.
  ⇓ If infinite resistance
 4.3. Test for less than 2 Ω in the signal circuit end to end.
  ⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
  ⇒ If less than 2 Ω, replace the K20 Engine Control Module.
**⇒ If greater than 5.2 V**

| **Note:** |
| --- |
| If the signal circuit is shorted to a voltage the engine control module or the sensor may be damaged. |

 4.1. Ignition OFF, disconnect the 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. Determine if EL-38522-A Variable Signal Generator or equivalent is available.
**⇒ EL-38522-A, Variable Signal Generator; or equivalent is not available**
 5.1. Replace the K20 Engine Control Module.
 5.2. 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.
 5.3. Verify the DTC does not set.
 **⇒ If the DTC sets**
  Refer to step 9.
 **⇓ If the DTC does not set**

5.4. All OK.

**⇓ EL-38522-A,Variable Signal Generator; or equivalent is available**

6. Ignition OFF, connect the leads of the EL-38522-A 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+
7. Set the EL-38522-A Variable Signal Generator to the following specifications.
    - Signal switch to 5 V
    - Duty Cycle switch to 50 % (Normal)
    - Frequency switch to 30 Hz
8. 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**

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

### 8.2.3.21.14. Component Testing

**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.

### 8.2.3.21.15. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Mass Airflow Sensor Replacement for multifunction intake air sensor replacement.
- Control Module References for Engine Control Module replacement, programming, and setup.

## 8.2.3.22. DTC P00C7

### 8.2.3.22.1. Diagnostic Instructions

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

### 8.2.3.22.2. DTC Descriptor

**DTC P00C7**

Intake Air Pressure Measurement System - Multiple Sensors Not Plausible

### 8.2.3.22.3. Circuit/System Description

The Intake Air Pressure Measurement System consists of 3 sensors:

- The barometric pressure (BARO) is measured by the B75C Multifunction Intake Air Sensor
- The manifold absolute pressure (MAP) is measured by the B74 Manifold Absolute Pressure Sensor
- The boost pressure is measured by the B111B Turbocharger Boost/Intake Air Temperature Sensor

### 8.2.3.22.4. Conditions for Running the DTC

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

### 8.2.3.22.5. Conditions for Setting the DTC

The ECM detects an inconsistency between pressure sensors in the induction system in which a particular sensor cannot be identified as the failed sensor. The difference is greater than 10 kPa (1.5 PSI).

### 8.2.3.22.6. Action Taken When the DTC Sets

DTC P00C7 is a Type B DTC.

### 8.2.3.22.7. Conditions for Clearing the DTC

DTC P00C7 is a Type B DTC.

### 8.2.3.22.8. Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Electrical Information Reference**

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

### 8.2.3.22.9. Circuit/System Verification

1. Ignition ON.
2. Verify that DTCs P0106, P0107, P0236, P0237, P0238, P2227, P2228, P2229, or P2230, are not set.

**⇒ If any of the DTCs are set**

Refer to Diagnostic Trouble Code (DTC) List Vehicle for further diagnosis.

**⇓ If none of the DTCs is set**

3. Verify none of the following conditions exist:
   - The air intake duct system for loose connecting clamps, cracks, or other damage
   - A damaged Q38 Throttle Body blade or shaft
   - Splits, kinks, or improper connections at the vacuum hoses
   - Faulty positive crankcase ventilation system operation
   - Carbon deposits on the throttle blade.
   - Vacuum leaks at the intake manifold, Q38 Throttle Body, Q17 Fuel Injector O-rings, and B111 Intake Manifold Pressure and Air Temperature Sensor.

**⇒ If a condition exist**

Repair as necessary.

4. Ignition ON.
5. Verify the following scan tool parameters are within range of the Altitude vs. Barometric Pressure table. Refer to: Altitude Versus Barometric Pressure table.
   - BARO Sensor
   - MAP Sensor
   - Turbocharger Boost Sensor

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

Refer to the appropriate diagnostic below for further diagnosis.

- Barometric Pressure (BARO) Sensor. Refer to: DTC P2227P2230
- Manifold Absolute Pressure (MAP) Sensor. Refer to: DTC P0106
- Turbocharger Boost Pressure Sensor. Refer to: DTC P0236

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

6. All OK

### 8.2.3.22.10. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

Control Module References for Engine Control Module replacement, programming and setup.

## 8.2.3.23. DTC P00E9

### 8.2.3.23.1. Diagnostic Instructions

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

### 8.2.3.23.2. DTC Descriptor

**DTC P00E9**

Intake Air Temperature (IAT) Sensor 3 Circuit Performance

### 8.2.3.23.3. Diagnostic Fault Information

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

### 8.2.3.23.4. Typical Scan Tool Data

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage |
|---|---|---|---|
| **Operating Conditions:** Engine Running<br>**Parameter Normal Range:** Varies with ambient temperature; and engine bay conditions | | | |
| Sensor | 130°C (266°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+ | | | |

### 8.2.3.23.5. Circuit/System Description

The intake air temperature (IAT) sensor 3 is a variable resistor that changes an engine control module (ECM) supplied 5 V signal. The signal varies with inlet air temperature and is displayed by the scan tool as °C (°F). The IAT sensor 3 is integrated with the B111B Turbocharger Boost/Intake Air Temperature Sensor in the sensor bore, which is located before the throttle body. The ECM supplies a ground for the IAT sensor 3 low reference circuit.

The IAT sensor 1 and IAT sensor 2 are part of the B75C Multifunction Intake Air Sensor. The IAT sensor 1 produces an analog signal on pin-8 of the sensor. The IAT sensor 2 produces a frequency modulated signal on pin-1 of the sensor.

**IAT Sensor 3 — Temperature, Resistance, Voltage Table**

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

### 8.2.3.23.6. Conditions for Running the DTC

**P00E9**

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

#### 8.2.3.23.7.Conditions for Setting the DTC

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

**P00E9–Condition 1**

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

**AND**

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

**AND**

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

**P00E9–Condition 2**

The ECM determines the IAT sensor 1 startup temperature is between the IAT sensor 3 and the IAT sensor 2 startup temperatures

**AND**

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

**AND**

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

**P00E9–Condition 3**

The ECM determines the IAT sensor 2 startup temperature is between the IAT sensor 3 and the IAT sensor 1 startup temperatures

**AND**

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

**AND**

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

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

#### 8.2.3.23.8.Action Taken When the DTC Sets

- DTC P00E9 is Type C DTC, MY14 and newer vehicles.
- DTC P00E9 is Type B DTC, MY13 and older vehicles.

#### 8.2.3.23.9.Conditions for Clearing the DTCs

- DTC P00E9 is Type C DTC, MY14 and newer vehicles.
- DTC P00E9 is Type B DTC, MY13 and older vehicles.

#### 8.2.3.23.10. Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Electrical Information Reference**

- Circuit Testing

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

**Powertrain Component Views**

Powertrain Component Views

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

**Special Tools**

EL-38522-A Variable Signal Generator

### 8.2.3.23.11. 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 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 3 and 4 of this verification procedure only if the ignition has been OFF for 8 hours or more. |

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

**⇒ If not within 25°C (45°F)**

Refer to Circuit/System Testing.

**⇓ If within 25°C (45°F)**

5. Engine idling, verify the IAT Sensor 3 scan tool parameter is between: −38 and +128°C (−36 and +262°F).

**⇒ If not between: −38 and +128°C (−36 and +262°F)**

Refer to Circuit System Testing.

**⇓ If between: −38 and +128°C (−36 and +262°F)**

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

### 8.2.3.23.12. Circuit/System Testing

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

1. Check the integrity of the entire air induction system and verify that none of the following conditions exist:
   - A loose or disconnected charge air cooler hose or pipe
   - A blocked or obstructed charge air cooler, including: aftermarket grill covers
   - Any snow or ice buildup at the charge air cooler in cold climates
   - Any mud or dirt buildup at the charge air cooler
   - A restricted or collapsed air intake duct
   - An intake manifold leak
   - A MAP sensor seal that is leaking, missing, or damaged

- A misaligned or damaged air intake duct
- Any water intrusion in the induction system
- An Intake Manifold Resonator with a leaking seal, or a cracked or broken housing

**⇒ If a condition exists**

Repair or replace component as appropriate.

**⇓ If no condition exists**

2. Ignition OFF, and all vehicle systems OFF, it may take up to 2 min. for all vehicle systems to power down. Disconnect the harness connector at the B111B Turbocharger Boost/Intake Air Temperature sensor.
3. Test for less than 2 Ω between the low reference circuit terminal 1 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 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 signal 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 signal 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 signal circuit and ground.
⇒ If 1 V or greater, repair the short to voltage on the circuit.
⇒ If less than 1 V, replace the K20 Engine Control Module.

**⇓ If between 4.8–5.2 V**

5. Ignition ON, verify the scan tool IAT Sensor 3 parameter is colder than −39°C (−38°F).

**⇒ If warmer than −39°C (−38°F).**

5.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
5.2. Test for infinite resistance between the signal circuit terminal 2 and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇓ If infinite resistance
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 colder than −39°C (−38°F).**

6. Ignition OFF, install a 3 A fused jumper wire between the signal circuit terminal 2 and the low reference circuit terminal 1.
7. Verify the scan tool IAT Sensor 3 parameter is warmer than 128°C (262°F).

**⇒ If colder than 128°C (262°F).**

7.1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 ECM, ignition ON.
7.2. 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
7.3. Ignition OFF.
7.4. 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 ECM.

**⇓ If warmer than 128°C (262°F).**

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

### 8.2.3.23.13. Component Testing

**Turbocharger Boost/Intake Air Temperature sensor**

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

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

2. Test the IAT sensor 3 by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the Temperature Versus Resistance Intake Air Temperature Sensor table for the appropriate sensor. The resistance values should be in range of the table values.

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

Replace the B111B Turbocharger Boost/Intake Air Temperature sensor.

**⇓ If within the specified range.**

3. All OK

### 8.2.3.23.14. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Intake Air Pressure and Temperature Sensor Replacement for turbocharger boost/intake air temperature sensor replacement
- Mass Airflow Sensor Replacement for multifunction intake air sensor replacement
- Control Module References for Engine Control Module replacement, programming, and setup.

## 8.2.3.24. DTC P00EA-P00EC

### 8.2.3.24.1.Diagnostic Instructions

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

### 8.2.3.24.2.DTC Descriptors

**DTC P00EA**
Intake Air Temperature (IAT) Sensor 3 Circuit Low Voltage
**DTC P00EB**
Intake Air Temperature (IAT) Sensor 3 Circuit High Voltage
**DTC P00EC**
Intake Air Temperature (IAT) Sensor 3 Circuit Erratic

### 8.2.3.24.3.Diagnostic Fault Information

**IAT Sensor 3**

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage | Signal Performance |
|---|---|---|---|---|
| 5 V Reference | P0097, P00F4, P0651, P2199, P2227, P2228 | P0096, P0097, P00F4, P2199, P2227, P2228 | P0097, P00F4, P0651, P2199, P2227, P2228 | - |
| Sensor | P0097, P00F5, P2199 | P0097, P00F4, P2199 | P0097, P00F4, P2199* | - |
| Low Reference | - | P0097, P00F4, P0113, P2227, P2229 | * | - |
| *Internal ECM or sensor damage may occur if the circuit is shorted to B+. | | | | |

### 8.2.3.24.4.Typical Scan Tool Data

**IAT Sensor 3**

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage |
|---|---|---|---|
| **Operating Conditions:** Engine Running<br>**Parameter Normal Range:** Varies with ambient temperature; and engine bay conditions | | | |
| Sensor | 130°C (266°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+. | | | |

### 8.2.3.24.5.Circuit/System Description

The intake air temperature (IAT) sensor 3 is a variable resistor that changes an engine control module (ECM) supplied 5 V signal. The signal varies with inlet air temperature and is displayed by the scan tool as °C (°F). The IAT sensor 3 is integrated with the B111B Turbocharger Boost/Intake Air Temperature Sensor in the sensor bore, which is located before the throttle body. The ECM supplies a ground for the IAT sensor 3 low reference circuit.

The IAT sensor 1 and IAT sensor 2 are part of the B75C Multifunction Intake Air Sensor. The IAT sensor 1 produces an analog signal on pin-8 of the sensor. The IAT sensor 2 produces a frequency modulated signal on pin-1 of the sensor.

#### 8.2.3.24.6.Conditions for Running the DTCs

**P00EA, P00EB, and P00EC**

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

#### 8.2.3.24.7.Conditions for Setting the DTC

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

**P00EA**

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

**P00EB**

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

**P00EC**

The ECM detects that the IAT sensor 3 signal is intermittent or has abruptly changed for at least 5s.

#### 8.2.3.24.8.Action Taken When the DTCs Set

- DTCs P00EA, P00EB, and P00EC are Type B DTCs.
- The ECM commands the cooling fans ON.

#### 8.2.3.24.9.Conditions for Clearing the DTCs

DTCs P00EA, P00EB, and P00EC are Type B DTCs.

#### 8.2.3.24.10. Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Electrical Information Reference**

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

**Powertrain Component Views**

Powertrain Component Views

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

### 8.2.3.24.11. 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 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 3 and 4 of this verification procedure only if the ignition has been OFF for 8 hours or more. |

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

**⇒ If not within 25°C (45°F)**

Refer to Circuit/System Testing.

**⇓ If within 25°C (45°F)**

5. Engine idling, verify the IAT Sensor 3 scan tool parameter is between: −38 and +128°C (−36 and +262°F).

**⇒ If not between: −38 and +128°C (−36 and +262°F)**

Refer to Circuit System Testing.

**⇓ If between: −38 and +128°C (−36 and +262°F)**

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

### 8.2.3.24.12. 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, it may take up to 2 min. for all vehicle systems to power down. Disconnect the harness connector at the B111B Turbocharger Boost/Intake Air Temperature sensor.
2. Test for less than 2 Ω between the low reference circuit terminal 1 and ground.

**⇒ If 2 Ω or greater**

2.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2.2. Test for less than 2 Ω in the low reference circuit end to end.
⇒ If 2 Ω or greater, repair the open or high resistance in the circuit.
⇒ If less than 2 Ω replace the K20 Engine Control Module.

**⇓ If less than 2 Ω**

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

**⇒ If less than 4.8 V**

3.1. Ignition OFF, disconnect the 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. Ignition ON, verify the scan tool IAT Sensor 3 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 2 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 colder than −39°C (−38°F).**

5. Ignition OFF, install a 3 A fused jumper wire between the signal circuit terminal 2 and the low reference circuit terminal 1.
6. Verify the scan tool IAT Sensor 3 parameter is warmer than 128°C (262°F).

**⇒ If colder than 128°C (262°F).**

6.1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 ECM, 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 ECM.

**⇓ If warmer than 128°C (262°F).**

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

#### 8.2.3.24.13. Component Testing

**Turbocharger Boost/Intake Air Temperature sensor**

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

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

2. Test the IAT sensor 3 by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the Temperature Versus Resistance Intake Air Temperature Sensor table for the appropriate sensor. The resistance values should be in range of the table values.

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

Replace the B111B Turbocharger Boost/Intake Air Temperature sensor.

**⇓ If within the specified range.**

3. All OK

#### 8.2.3.24.14. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Intake Air Pressure and Temperature Sensor Replacement for turbocharger boost/intake air temperature replacement
- Control Module References for Engine Control Module replacement, programming, and setup.

### 8.2.3.25. DTC P00F4-P00F6

#### 8.2.3.25.1.Diagnostic Instructions

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

#### 8.2.3.25.2.DTC Descriptors

**DTC P00F4**
Intake Air Humidity Sensor Circuit Low Voltage
**DTC P00F5**
Intake Air Humidity Sensor Circuit High Voltage
**DTC P00F6**
Intake Air Humidity Sensor Circuit Erratic

#### 8.2.3.25.3.Diagnostic Fault Information

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage | Signal Performance |
|---|---|---|---|---|
| 5 V Reference | P0097, P00F4, P0651, P2199, P2227, P2228 | P0096, P0097, P00F4, P2199, P2227, P2228 | P0097, P00F4, P0651, P2199, P2227, P2228 | - |
| Sensor | P0097, P00F5, P2199 | P0097, P00F4, P2199 | P0097, P00F4, P2199* | - |
| Low Reference | - | P0097, P0113, P00F4, P2227, P2229 | * | - |
| *Internal ECM or sensor damage may occur if the circuit is shorted to B+. | | | | |

Typical Scan Tool Data

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage |
|---|---|---|---|
| **Operating Conditions**: Engine Running<br>**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+. | | | |

#### 8.2.3.25.4.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

#### 8.2.3.25.5.Conditions for Running the DTCs

**P00F4, P00F5, and P00F6**

- DTC P1682 is not set.
- The ignition is ON.
- The Ignition voltage is at least 11 V.
- These DTCs run continuously within the enabling conditions.

#### 8.2.3.25.6.Conditions for Setting the DTCs

**P00F4**

The ECM detects that the humidity sensor signal is less than or equal to 5 % for greater than 5 s.

**P00F5**

The ECM detects that the humidity sensor signal is greater than or equal to 95 % for greater than 5 s.

**P00F6**

The ECM detects that the humidity sensor signal is intermittent or has abruptly changed over a period of time greater than 5 s.

#### 8.2.3.25.7.Action Taken When the DTC Sets

DTCs P00F4,P00F5, and P00F6 are Type B DTCs.

#### 8.2.3.25.8.Conditions for Clearing the MIL/DTC

DTCs P00F4,P00F5, and P00F6 are Type B DTCs.

#### 8.2.3.25.9.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.

#### 8.2.3.25.10. Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

Component Connector End Views

Electrical Information Reference

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

Powertrain Component Views

Powertrain Component Views

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL-38522-A Variable Signal Generator

### 8.2.3.25.11. 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 for further diagnosis.

**⇓ If none of the DTCs are set**

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

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

**⇒ If not within 25°C (45°F)**

Refer to Circuit/System Testing.

**⇓ If within 25°C (45°F)**

4. Engine idling, verify the scan tool Intake Air Humidity parameter is between 5 and 90 %.

**⇒ If not between 5 and 90 %**

Refer to Circuit/System Testing.

**⇓ If between 5 and 90 %**

5. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
6. Verify the DTC does not set.

**⇒ If the DTC sets**

Refer to Circuit/System Testing.

**⇓ If the DTC does not set**

7. All OK

### 8.2.3.25.12. 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, it may take up to 2 min. for all vehicle systems to power down. Disconnect the harness connector at the B75C Mass Air Flow/Multifunction Intake Air sensor.
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 EL-38522-A Variable Signal Generator or equivalent is available.

**⇒ EL-38522-A, 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 the DTC does not set**
6.4. All OK.

**⇓ EL-38522-A, Variable Signal Generator; or equivalent is available**

7. Ignition OFF, connect the leads of the EL-38522-A Variable Signal Generator as 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 EL-38522-A 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.

#### 8.2.3.25.13. Component Testing

**Multifunction Intake Air Sensor**

1. Test the Intake Air Humidity Sensor by varying the air humidity in the intake duct near the sensor, while observing the scan tool Intake Air Humidity Sensor parameter. The parameter should change and be within 5–95%.

**⇒ If not within 5–95%.**

Replace the B75C Multifunction Intake Air sensor.

**⇓ If within 5–95%.**

2. All OK

#### 8.2.3.25.14. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.
- Mass Airflow Sensor Replacement for multifunction intake air sensor replacement.
- Control Module References for Engine Control Module replacement, programming, and setup.

### 8.2.3.26. DTC P0101

#### 8.2.3.26.1.Diagnostic Instructions

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

#### 8.2.3.26.2.DTC Descriptor

**DTC P0101**
Mass Air Flow (MAF) Sensor Performance

#### 8.2.3.26.3.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, P01101 | P0102* | P0101, P1101 |
| Ground | - | P0102 | - | - |
| *Internal ECM or sensor damage may occur if the circuit is shorted to B+. | | | | |

#### 8.2.3.26.4.Typical Scan Tool Data

**MAF Sensor**

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage |
|---|---|---|---|
| **Operating Conditions:** Engine running at various operating conditions<br>**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+. | | | |

#### 8.2.3.26.5.Circuit Description

The sensors listed below are integrated within the multifunction intake air sensor:

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

The MAF sensor is an air flow meter that measures the amount of air flowing in the sensor bore. The engine control module (ECM) uses the MAF sensor signal to provide the correct fuel delivery for all engine speeds and loads. A small quantity of air entering the engine indicates a deceleration or idle condition. A large quantity of air entering the engine indicates an acceleration or high load condition.

The ECM applies 5 V to the MAF sensor signal circuit. The sensor produces a variable frequency signal based on the inlet air flow through the sensor bore. The signal varies with engine load and is displayed by the scan tool as Hertz (Hz) and grams per second (g/s). Vehicle ignition voltage and ground circuits are also supplied to the MAF sensor.

The intake flow rationality diagnostic provides the within-range rationality check for the mass air flow (MAF), manifold absolute pressure (MAP), and the throttle position sensors. This is an explicit model-based diagnostic containing 4 separate models for the intake system.

The estimates of MAF and MAP obtained from this system of models and calculations are then compared to the actual measured values from the MAF, MAP, and the throttle position sensors and to each other to determine the appropriate DTC to fail.

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

- IAT sensor 2
- Humidity sensor
- Barometric pressure (BARO) sensor
- The sensors listed below share an ECM supplied low reference circuit:
- IAT sensor 1
- IAT sensor 2
- Humidity sensor
- Barometric pressure (BARO) sensor

#### 8.2.3.26.6. Conditions for Running the DTCs

- DTCs P0096, P0097, P0098, P0102, P0103, P0107, P0111, P0112, P0113, P0116, P0117, P0118, P0119, P0237, P0238, P0335, P0336, P2227, P2228, P2229, or P2230 are not set.
- The engine speed is between 400–7,000 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 +125°C (−4 and +257°F).
- The DTC runs continuously when the above conditions are met.

#### 8.2.3.26.7. 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 with-in range of the calculated airflow that is derived from the system of models for greater than 2 s.

#### 8.2.3.26.8. Action Taken When the DTC Sets

DTC P0101 is a Type B DTC.

#### 8.2.3.26.9. Conditions for Clearing the MIL/DTC

DTC P0101 is a Type B DTC.

#### 8.2.3.26.10. 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.

#### 8.2.3.26.11. Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Electrical Information Reference**

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

- Wiring Repairs

**Powertrain Component Views**

Powertrain Component Views

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

**Special Tools**

EL-38522-A Variable Signal Generator

#### 8.2.3.26.12. 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 for further diagnosis.

**⇓ If none of the DTCs are set**

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

**⇒ If 90 % or greater**

Refer to Throttle Body Inspection and Cleaning.

**⇓ 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 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 table.

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

Refer to DTC P0106 for further diagnosis.

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

9. Verify the engine is equipped with a turbocharger.

**⇒ If not equipped with a turbocharger**

Refer to Step 12.

**⇓ If equipped with a turbocharger**

10. Verify the scan tool Boost Pressure Sensor parameter is within the range specified in the Altitude Versus Barometric Pressure table.

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

Refer to DTC P0236 for further diagnosis.

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

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

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

Refer to DTC P0236 for further diagnosis.

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

12. Engine idling; verify the scan tool MAP Sensor pressure parameter is between 26–52 kPa (3.8–7.5 PSI) and changes with accelerator pedal input.

**⇒ If not between 26–52 kPa (3.8–7.5 PSI) or does not change**

Refer to DTC P0106 for further diagnosis.

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

13. Verify the scan tool MAF Sensor g/s parameter changes smoothly and gradually as the engine speed is increased and decreased while performing the actions listed below.

    13.1. Engine idling

    13.2. Perform the scan tool snapshot function.

    13.3. Increase the engine speed slowly to 3,000 RPM and then back to idle.

13.4. Exit from the scan tool snapshot and review the data.
13.5. Observe the MAF Sensor parameter frame by frame with a scan tool.

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

Refer to Circuit/System Testing.

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

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

**⇒ If the DTC does set**

Refer to Circuit/System Testing for further diagnosis.

**⇓ If the DTC does not set**

16. All OK

#### 8.2.3.26.13. Circuit/System Testing

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

1. Check the integrity of the entire air induction system by verifying that none of the following conditions exist:
   - Any damaged components
   - Improper operation of turbocharger wastegate actuator or bypass valve; where equipped
   - Improperly installed components
   - Collapsed, restricted, or damaged components
   - Loose clamps, cracks, or other damage
   - An air flow restriction
   - Restricted air filter
   - Splits, kinks, leaks, or improper connections at the vacuum hoses
   - Vacuum leaks at the intake manifold, MAP sensor, and throttle body
   - Water intrusion
   - Any snow or ice buildup, in cold climates
   - Contamination of the Multifunction Intake Air sensor element

**⇒ If a condition is found**

Repair or replace component as appropriate.

**⇓ If no condition is found**

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

**⇒ If 2 Ω or greater**

3.1. Ignition OFF.
3.2. Test for less than 2 Ω in the ground circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, repair the open/high resistance in the ground connection.

**⇓ If less than 2 Ω**

4. Ignition ON.
5. Verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.

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

5.1. Ignition OFF, remove the test lamp and remove the fuse for the ignition circuit.
5.2. Test for less than 2 Ω in the ignition circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.

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

5.1. Ignition OFF, remove the test lamp and remove the fuse for the ignition circuit.
5.2. Test for infinite resistance between the ignition circuit and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇒ If infinite resistance, test all components connected to the ignition circuit, replace as necessary.

**⇓ If a test lamp illuminates**

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

**⇒ If less than 4.8 V**

6.1. Ignition OFF, disconnect the 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 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. Determine if EL-38522-A Variable Signal Generator or equivalent is available.

**⇒ EL-38522-A, Variable Signal Generator; or equivalent is not available**

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

7.2. 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.

7.3. Verify the DTC does not set.

**⇒ If the DTC sets**

Replace the K20 Engine Control Module.

**⇓ If no DTCs set**

7.4. All OK.

**⇓ EL-38522-A, Variable Signal Generator; or equivalent is available**

8. Ignition OFF, connect the leads of the EL-38522-A Variable Signal Generator as follows:

- Red lead to the signal circuit terminal 3 at the harness connector
- Black leads to ground
- Battery voltage supply lead to B+

9. Set the EL-38522-A Variable Signal Generator to the following specifications.

- Signal switch to 5 V
- Frequency switch to 5 kHz
- Duty Cycle switch to 50 % (Normal)

10. 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.**

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

#### 8.2.3.26.14. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Mass Airflow Sensor Replacement for multifunction intake air sensor replacement.
- Control Module References for Engine Control Module replacement, programming, and setup.

### 8.2.3.27. DTC P0102 or P0103

#### 8.2.3.27.1.Diagnostic Instructions

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

#### 8.2.3.27.2.DTC Descriptors

**DTC P0102**
Mass Air Flow (MAF) Sensor Circuit Low Frequency
**DTC P0103**
Mass Air Flow (MAF) Sensor Circuit High Frequency

#### 8.2.3.27.3.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+. | | | | |

#### 8.2.3.27.4.Typical Scan Tool Data

**MAF Sensor**

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage |
|---|---|---|---|
| **Operating Conditions:** Engine running at various operating conditions<br>**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+. | | | |

#### 8.2.3.27.5.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

**8.2.3.27.6.Conditions for Running the DTCs**

- The engine is running for at least 1 s.
- The engine speed is at least 300 RPM.
- The ignition signal is at least 10 V.
- The above conditions are met for at least 1 s.
- The DTC runs continuously when the above conditions are met.

**8.2.3.27.7.Conditions for Setting the DTCs**

**P0102**

The ECM detects that the MAF Sensor signal parameter is less than 1,837 Hz (about 0.10 g/s) for at least 250 cylinder firing events.

**P0103**

The ECM detects that the MAF Sensor signal parameter is at least 13,200 Hz (about 193.4 g/s) for at least 250 cylinder firing events.

**8.2.3.27.8.Action Taken When the DTCs Set**

DTCs P0102 and P0103 are Type B DTCs.

**8.2.3.27.9.Conditions for Clearing the MIL/DTCs**

DTCs P0102 and P0103 are Type B DTCs.

**8.2.3.27.10. Diagnostic Aids**

Verify that any electrical aftermarket devices are properly connected and grounded. Refer to Checking Aftermarket Accessories.

**8.2.3.27.11. Reference Information**

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Electrical Information Reference**

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

**Powertrain Component Views**

Powertrain Component Views

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

**Special Tools**

EL-38522-A Variable Signal Generator

### 8.2.3.27.12. Circuit/System Verification

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

**⇒ If not between 1.75–5.5 g/s**

Refer to Circuit/System Testing.

**⇓ If between 1.75–5.5 g/s**

2. Verify the scan tool MAF Sensor g/s parameter changes smoothly and gradually as the engine speed is increased and decreased while performing the actions listed below.

2.1. Engine idling

2.2. Perform the scan tool snapshot function.

2.3. Increase the engine speed slowly to 3,000 RPM and then back to idle.

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

2.5. Observe the MAF Sensor parameter frame by frame with a scan tool.

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

Refer to Circuit/System Testing.

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

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

4. Verify the DTC does not set.

**⇒ If the DTC does set**

Refer to Circuit/System Testing for further diagnosis.

**⇓ If the DTC does not set**

5. All OK

### 8.2.3.27.13. 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, test all components connected to the ignition circuit, replace as necessary.

**⇓ If a test lamp illuminates**

5. Ignition ON, test for 4.8–5.2 V between the signal circuit terminal 3 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**

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 EL-38522-A Variable Signal Generator or equivalent is available.

**⇒ EL-38522-A, Variable Signal Generator; or equivalent is not available**

6.1. Test or replace the B75C Multifunction Intake Air sensor.
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**
Replace the K20 Engine Control Module.
**⇓ If no DTCs set**
6.4. All OK.

⇓ EL-38522-A, Variable Signal Generator; or equivalent is available

7. Ignition OFF, connect the leads of the EL-38522-A Variable Signal Generator as follows:
- Red lead to the signal circuit terminal 3 at the harness connector
- Black leads to ground
- Battery voltage supply lead to B+

8. Set the EL-38522-A Variable Signal Generator to the 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.

### 8.2.3.27.14. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.
- Mass Airflow Sensor Replacement for multifunction intake air sensor replacement.
- Control Module References for Engine Control Module replacement, programming, and setup.

## 8.2.3.28. DTC P0106

### 8.2.3.28.1. Diagnostic Instructions

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

### 8.2.3.28.2. DTC Descriptor

**DTC P0106**

Manifold Absolute Pressure (MAP) Sensor Performance

### 8.2.3.28.3. Diagnostic Fault Information

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage | Signal Performance |
|---|---|---|---|---|
| 5 V Reference | P0107, P0697 | P0106, P0107 | P0108, P0697 | P0106 |
| Sensor | P0107 | P0106, P0107 | P0108 | P0106 |
| Low Reference | - | 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 /High Resistance | Short to Voltage |
|---|---|---|---|
| **Operating Conditions:** Engine running at various operating conditions<br>**Parameter Normal Range:** 12–103 kPa (1.7–14.9 PSI) | | | |
| 5 V Reference | 0 kPa (0 PSI) | 0 kPa (0 PSI) | 104 kPa (15.1 PSI) |
| Signal | 0 kPa (0 PSI) | 0 kPa (0 PSI) | 104 kPa (15.1 PSI)* |
| Ground | - | 80–103 kPa (11.6–14.9 PSI) | - |
| *Internal ECM or sensor damage may occur if the circuit is shorted to B+. | | | |

MAP Sensor, if equipped with Turbocharger

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage |
|---|---|---|---|
| **Operating Conditions:** Engine running at various operating conditions<br>**Parameter Normal Range:** 12–225 kPa (1.7–32.6 PSI) | | | |
| 5 V Reference | 0 kPa (0 PSI) | 0 kPa (0 PSI) | 255 kPa (36.9 PSI) |
| Signal | 0 kPa (0 PSI) | 0 kPa (0 PSI) | 255 kPa (36.9 PSI)* |
| Ground | | 255 kPa (36.9 PSI) | |
| *Internal ECM or sensor damage may occur if the circuit is shorted to B+. | | | |

### 8.2.3.28.4. Circuit Description

The manifold absolute pressure (MAP) sensor measures the pressure inside the intake manifold. Pressure in the intake manifold is affected by engine speed, throttle opening, air temperature, barometric pressure (BARO); and if equipped turbocharger output. A diaphragm within the MAP sensor is displaced by the pressure changes that occur from the varying load and operating conditions of the engine. The sensor translates this action into electrical resistance.

The MAP sensor wiring includes 3 circuits. The engine control module (ECM) supplies a regulated 5 volts to the sensor on a 5 V reference circuit. The ECM supplies a ground on a low reference circuit. The MAP sensor provides a signal voltage to the ECM, relative to the pressure changes, on the MAP sensor signal circuit. The ECM converts the signal voltage input to a pressure value.

Under normal operation the greatest pressure that can exist in the intake manifold is at ignition ON, engine OFF, which is equal to the BARO. If equipped, a turbocharger can increase the pressure above BARO, when the vehicle is operated at wide-open throttle (WOT). The lowest manifold pressure occurs when the vehicle is idling or decelerating. The ECM monitors the MAP sensor signal for pressure outside of the normal range.

**8.2.3.28.5.Conditions for Running the DTC**

- DTCs P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0128, P0335, P0336 are not set.
- The engine speed is between 400–6500 RPM.
- The engine coolant temperature (ECT) sensor is between −7 to +125°C (19.4 and 257°F).
- The intake air temperature (IAT) sensor is between −20 to +125°C (−4 and +257°F).
- This DTC runs continuously when the above conditions are met.

**8.2.3.28.6.Conditions for Setting the DTC**

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

**8.2.3.28.7.Action Taken When the DTC Sets**

DTC P0106 is a Type B DTC.

**8.2.3.28.8.Conditions for Clearing the DTC**

DTC P0106 is a Type B DTC.

**8.2.3.28.9.Reference Information**

**Schematic Reference**
Engine Controls Schematics
**Connector End View Reference**
Component Connector End Views
**Description and Operation**
Turbocharger System Description
**Electrical Information Reference**

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

**DTC Type Reference**
Powertrain Diagnostic Trouble Code (DTC) Type Definitions
**Scan Tool Reference**
Control Module References for scan tool information
**Special Tools**
GE-23738-A Vacuum Pump

**8.2.3.28.10. Circuit/System Verification**

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

**⇒ If any of the DTCs are set**
Refer to DTC P0641, P0651, P0697, or P06A3 for further diagnosis.
**⇓ If none of the DTC are set**

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

**⇒ If 90% or greater**
Refer to Throttle Body Inspection and Cleaning.
**⇓ 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 for further diagnosis.
**⇓ If Agree**
7. Determine the current vehicle testing altitude.
8. Verify the scan tool MAP Sensor parameter is within the range specified in the Altitude Versus Barometric Pressure table.
**⇒ If the MAP Sensor parameter is not in range**
Refer to Circuit/System Testing.
**⇓ If the MAP Sensor parameter is in range**
9. Verify the engine is equipped with a turbocharger.
**⇒ If not equipped with a turbocharger**
Refer to Step 12.
**⇓ If equipped with a turbocharger**
10. Verify the scan tool Boost Pressure Sensor parameter is within the range specified in the Altitude Versus Barometric Pressure table.
**⇒ If the Boost Pressure Sensor parameter is not in range**
Refer to DTC P0236 for further diagnosis.
**⇓ If the Boost Pressure Sensor parameter is in range**
11. Verify the scan tool Boost Pressure Sensor parameter decreases after starting the engine.
**⇒ If the Boost Pressure Sensor parameter does not decrease**
Refer to DTC P0236 for further diagnosis.
**⇓ If the Boost Pressure Sensor parameter is within range**
12. Engine idling, verify the scan tool MAP Sensor pressure parameter is between 26–52 kPa (3.8–7.5 PSI) and changes with accelerator pedal input.
**⇒ If not between 26–52 kPa (3.8–7.5 PSI) or does not change**
Refer to Circuit/System Testing.
**⇓ If between 26–52 kPa (3.8–7.5 PSI) and changes**
13. Verify the scan tool MAF Sensor g/s parameter changes smoothly and gradually as the engine speed is increased and decreased while performing the actions listed below.
13.1. Engine idling
13.2. Perform the scan tool snapshot function.
13.3. Increase the engine speed slowly to 3000 RPM and then back to idle.
13.4. Exit from the scan tool snapshot and review the data.
13.5. Observe the MAF Sensor parameter frame by frame with a scan tool.
**⇒ If the MAF Sensor parameter does not change smoothly and gradually**
Refer to DTC P0101.
**⇓ If the MAF Sensor parameter does change smoothly and gradually**
14. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
15. Verify a DTC does not set.
**⇒ If the DTC sets**
Refer to Circuit/System Testing.
**⇓ If the DTC does not set**
16. All OK.

#### 8.2.3.28.11. Circuit/System Testing

1. Check the integrity of the entire air induction system and verify that none of the following conditions exist:
- Any damaged components
- Improper operation of turbocharger wastegate actuator or bypass valve, if equipped
- Loose or improper installation of the turbocharger and the charge air cooler, including the flexible ductwork, if equipped

- An air flow restriction
- Any vacuum leak
- Improperly routed vacuum hoses
- In cold climates, inspect for any snow or ice buildup at the BARO port on the ECM, if equipped
- A restriction in the MAP Sensor port or the BARO port
- Proper operation of the positive crankcase ventilation system
- Missing, restricted or leaking exhaust components. Refer to Symptoms Engine Exhaust.
- Engine mechanical condition; for example: low compression or incorrect timing chain installation. Refer to Symptoms Engine Mechanical.

**⇒ If a condition is found**

Repair or replace the component as appropriate.

**⇓ If no condition is found**

2. Ignition OFF, and all vehicle systems OFF, it may take up to 2 min. for all vehicle systems to power down. Disconnect the harness connector at the B74 Manifold Absolute Pressure Sensor.

3. Test for less than 2 Ω between the low reference circuit terminal 2 and ground.

**⇒ If 2 Ω or greater**

3.1. Ignition OFF, disconnect 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 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.
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 ECM or the MAP Sensor may be damaged. |

**⇒ If greater than 5.2 V**

5.1. Ignition OFF, disconnect the K20 Engine Control Module.
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.
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.
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.

### 8.2.3.28.12. Component Testing

| Note: |
|---|
| You must perform the Circuit/System Testing in order to Check the integrity of the MAP Sensor circuits before proceeding with the Component Testing. |

**Skewed Sensor Test**

1. Ignition OFF, remove the B74 Manifold Absolute Pressure Sensor from the engine. Connect the harness to the sensor, if disconnected.
2. Ignition ON, apply 17 kPa (5.0 in Hg) of vacuum to the B74 Manifold Absolute Pressure Sensor, with the GE23738A. Verify the scan tool MAP Sensor pressure parameter decreases between 13–21 kPa (1.8–3.0 PSI).

**⇒ If the parameter does not decrease between 13–21 kPa (1.8–3.0 PSI).**
Replace the B74 Manifold Absolute Pressure Sensor.

**⇓ If the parameter does decrease between 13–21 kPa (1.8–3.0 PSI).**

3. Apply 34 kPa (10.0 in Hg) of vacuum to the B74 Manifold Absolute Pressure Sensor, with the GE23738A. Verify the scan tool MAP Sensor pressure parameter decreases between 30–38 kPa (4.4–5.5 PSI).

**⇒ If the parameter does not decrease between 30–38 kPa (4.4–5.5 PSI).**
Replace the B74 Manifold Absolute Pressure Sensor.

**⇓ If the parameter does decrease between 30–38 kPa (4.4–5.5 PSI).**

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 (0–4.4 in Hg) of vacuum to the sensor with the GE-23738-A. Verify the voltage changes, without any spikes or dropouts, between 0.2–4.9 V.

**⇒ If not between 0.2– 4.9 V or has spikes or dropouts**
Replace the B74 Manifold Absolute Pressure Sensor.

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

7. All OK.

### 8.2.3.28.13. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Manifold Absolute Pressure Sensor Replacement
- Control Module References for ECM replacement, programming and setup

### 8.2.3.29. DTC P0107 or P0108

#### 8.2.3.29.1. Diagnostic Instructions

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

#### 8.2.3.29.2. DTC Descriptors

**DTC P0107**
Manifold Absolute Pressure (MAP) Sensor Circuit Low Voltage
**DTC P0108**
Manifold Absolute Pressure (MAP) Sensor Circuit High Voltage

#### 8.2.3.29.3. Diagnostic Fault Information

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage | Signal Performance |
|---|---|---|---|---|
| 5 V Reference | P0107, P0697 | P0106, P0107 | P0108, P0697 | P0106 |
| Sensor | P0107 | P0106, P0107 | P0108 | P0106 |
| Low Reference | - | P0106, P0108 | - | P0106 |
| *Internal ECM or sensor damage may occur if the circuit is shorted to B+. | | | | |

#### 8.2.3.29.4. Typical Scan Tool Data

**MAP Sensor**

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

**MAP Sensor, when equipped with Turbocharger**

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage |
|---|---|---|---|
| **Operating Conditions:** Engine running at various operating conditions<br>**Parameter Normal Range:** 12–225 kPa (1.7–32.6 PSI) | | | |
| 5 V Reference | 0 kPa (0 PSI) | 0 kPa (0 PSI) | 255 kPa (36.9 PSI) |
| Signal | 0 kPa (0 PSI) | 0 kPa (0 PSI) | 255 kPa (36.9 PSI)* |
| Ground | - | 255 kPa (36.9 PSI) | - |
| *Internal ECM or sensor damage may occur if the circuit is shorted to B+. | | | |

#### 8.2.3.29.5. Circuit Description

The manifold absolute pressure (MAP) sensor measures the pressure inside the intake manifold. Pressure in the intake manifold is affected by engine speed, throttle opening, air temperature, barometric pressure (BARO); and where equipped turbocharger output. A diaphragm within the MAP sensor is displaced by the pressure changes that occur from the varying load and operating conditions of the engine. The sensor translates this action into electrical resistance.

The MAP sensor wiring includes 3 circuits. The engine control module (ECM) supplies a regulated 5 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. Where equipped, a turbocharger can increase the pressure above BARO, when the vehicle is operated at wideopen throttle (WOT). The lowest manifold pressure occurs when the vehicle is idling or decelerating. The ECM monitors the MAP sensor signal for pressure outside of the normal range.

#### 8.2.3.29.6.Conditions for Running the DTC

**P0107**

- DTCs P0120, P0121, P0122, P0123, P0220, P0221, P0222, P0223 or P0641 are not set
- The engine speed is between 400–6,500 RPM.
- The throttle position is greater than or equal to 0% when the engine speed is less than or equal to 1,000 RPM
  or
- The throttle position is greater than or equal to 12.5% when the engine speed is greater than 1,000 RPM.
- This DTC runs continuously when the above conditions are met.

**P0108**

- The engine has been running for a length of time that is determined by the startup coolant temperature. The length of time ranges from 5.5 min at colder than −30°C (−22°F) to 10 s at greater than 30°C (+86°F).
- DTCs P0120, P0121, P0122, P0123, P0220, P0221, P0222, P0223 or P0641 are not set
- The throttle position is less than or equal to 1% when the engine speed is less than or equal to 1,200 RPM.
  or
- The throttle position is less than or equal to 20% when the engine speed is greater than 1,200 RPM.
- This DTC runs continuously when the above conditions are met.

#### 8.2.3.29.7.Conditions for Setting the DTC

**P0107**

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

**P0108**

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

#### 8.2.3.29.8.Action Taken When the DTC Sets

DTCs P0107 and P0108 are Type B DTCs.

#### 8.2.3.29.9.Conditions for Clearing the DTC

DTCs P0107 and P0108 are Type B DTCs.

#### 8.2.3.29.10. Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Electrical Information Reference**

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

- Wiring Repairs

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

**Special Tools**

GE-23738-A Vacuum Pump

### 8.2.3.29.11. Circuit/System Verification

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

**⇒ If any of the DTCs are set**

Refer to DTC P0641, P0651, P0697, or P06A3 for further diagnosis.

**⇓ If none of the DTCs are set**

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

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

Refer to Circuit/System Testing.

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

4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed in the Freeze Frame/Failure Records data.
5. Verify the DTC does not set.

**⇒ If the DTC sets**

Refer to Circuit/System Testing.

⇓ If the DTC does not set

6. All OK.

### 8.2.3.29.12. Circuit/System Testing

1. Ignition OFF, and all vehicle systems OFF, it may take up to 2 min. for all vehicle systems to power down. Disconnect the harness connector at the B74 Manifold Absolute Pressure sensor.
2. Test for less than 2 Ω between the low reference circuit terminal 2 and ground.

**⇒ If 2 Ω or greater**

2.1. Ignition OFF, disconnect 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 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.
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.
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.

⇒ 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.

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.

### 8.2.3.29.13. Component Testing

| **Note:** |
|---|
| You must perform the Circuit/System Testing in order to Check the integrity of the MAP sensor circuits before proceeding with the Component Testing. |

**Skewed Sensor Test**

1. Ignition OFF, remove the B74 Manifold Absolute Pressure sensor from the engine. Connect the harness to the sensor, if disconnected.

2. Ignition ON, apply 17 kPa (5.0 inHg) of vacuum to the B74 Manifold Absolute Pressure sensor, with the GE-23738-A Vacuum Pump. Verify the scan tool MAP pressure parameter decreases between 13 and 21 kPa (1.8 and 3.0 PSI).

**⇒ If the parameter does not decrease between 13 and 21 kPa (1.8 and 3.0 PSI).**

Replace the B74 Manifold Absolute Pressure sensor.

**⇓ If the parameter does decrease between 13 and 21 kPa (1.8 and 3.0 PSI).**

3. Apply 34 kPa (10.0 inHg) of vacuum to the B74 Manifold Absolute Pressure sensor, with the GE23738A
Vacuum Pump . Verify the scan tool MAP pressure parameter decreases between 30 and 38 kPa (4.4 and 5.5 PSI).

**⇒ If the parameter does not decrease between 30 and 38 kPa (4.4 and 5.5 PSI).**

Replace the B74 Manifold Absolute Pressure sensor.

**⇓ If the parameter does decrease between 30 and 38 kPa (4.4 and 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 and 15kPa of vacuum to the sensor with the GE-23738-A Vacuum Pump. Verify the voltage changes, without any spikes or dropouts, between 0.2 and 4.9 V.

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

Replace the B74 Manifold Absolute Pressure sensor.

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

7. All OK.

### 8.2.3.29.14. Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

- Manifold Absolute Pressure Sensor Replacement
- Control Module References for Engine Control Module replacement, programming and setup

## 8.2.3.30. DTC P0112, P0113, or P0114

### 8.2.3.30.1.Diagnostic Instructions

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

### 8.2.3.30.2.DTC Descriptors

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

### 8.2.3.30.3.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, P00F4**, P2227, P2229 | * | - |
| *Internal ECM or sensor damage may occur if the circuit is shorted to B+.<br>**Where used. | | | | |

### 8.2.3.30.4.Typical Scan Tool Data

**IAT Sensor 1**

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage |
|---|---|---|---|
| **Operating Conditions:** Engine Running<br>**Parameter Normal Range:** Varies with ambient temperature | | | |
| Signal | 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+. | | | |

### 8.2.3.30.5.Circuit/System Description

The sensors listed below are integrated within the multifunction intake air sensor:

- IAT sensor 1
- IAT sensor 2
- Humidity sensor
- MAF sensor
- BARO pressure sensor

The intake air temperature (IAT) sensor 1 is a variable resistor that changes the voltage on the engine control module (ECM) supplied 5 V signal circuit. The signal varies with inlet air temperature in the sensor bore and is displayed by the scan tool as °C (°F).

The IAT sensor 1 produces an analog signal on pin-8 of the sensor. The IAT sensor 2 produces a frequency modulated signal on pin-1 of the sensor.

The sensors listed below share an ECM supplied 5 V reference circuit:
- IAT sensor 2
- Humidity sensor
- BARO pressure sensor

The sensors listed below share an ECM supplied low reference circuit:
- IAT sensor 1
- IAT sensor 2
- Humidity sensor
- Barometric pressure (BARO) sensor

| IAT Sensor 2 | IAT Sensor 1 Resistance | IAT Sensor 1 Signal Voltage |
|---|---|---|
| Cold | High | High |
| Warm | Low | Low |

**8.2.3.30.6.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.

**8.2.3.30.7.Conditions for Setting the DTCs**

**P0112**
The ECM detects that the IAT sensor signal is warmer than 149°C (300°F) for at least 5 s.
**P0113**

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

The ECM detects that the IAT sensor signal is colder than −60°C (−76°F) for at least 5 s.
**P0114**
The ECM detects that the IAT sensor signal is intermittent or has abruptly changed for at least 5 s.

**8.2.3.30.8.Action Taken When the DTCs Set**

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

**8.2.3.30.9.Conditions for Clearing the DTCs**

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

**8.2.3.30.10. Diagnostic Aids**

With the ignition ON, when the engine is cold and not running, a properly functioning IAT sensor 1 will gradually increase the scan tool IAT Sensor 1 parameter. This is due to the heat that is generated by the multifunction intake air sensor internal heating elements.

### 8.2.3.30.11. Reference Information

**Schematic Reference**
Engine Controls Schematics
**Connector End View Reference**
Component Connector End Views
**Electrical Information Reference**
- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

**DTC Type Reference**
Powertrain Diagnostic Trouble Code (DTC) Type Definitions
**Scan Tool Reference**
Control Module References for scan tool information

### 8.2.3.30.12. 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 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 3 and 4 of this verification procedure only if the ignition has been OFF for 8 hours or more. |

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

**⇒ If not within 25°C (45°F)**
Refer to Circuit/System Testing.
**⇓ If within 25°C (45°F)**

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

**⇒ If not between: −38 and +149°C (−36 and +300°F)**
Refer to Circuit System Testing.
**⇓ If between: −38 and +149°C (−36 and +300°F)**

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 does set**
Refer to Circuit/System Testing.
**⇓ If the DTC does not set**

8. All OK

**8.2.3.30.13. 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, it may take up to 2 min. for all vehicle systems to power down. Disconnect the harness connector at the B75C Multifunction Intake Air sensor.
2. Test for less than 2 Ω between the low reference circuit terminal 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 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. Ignition ON, verify the scan tool IAT Sensor 1 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 8 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 colder than −39°C (−38°F).**

5. Ignition OFF, install a 3 A fused jumper wire between the signal circuit terminal 8 and the low reference circuit terminal 7.
6. Verify the scan tool IAT Sensor 1 parameter is warmer than 148°C (298°F).

**⇒ If colder than 148°C (298°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 148°C (298°F).**

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

### 8.2.3.30.14. Component Testing

**Multifunction Intake Air Sensor**

1. Ignition OFF, disconnect the harness connector at the B75C Multifunction Intake Air sensor.

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

2. Test the IAT sensor 1 by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the Temperature Versus Resistance Intake Air Temperature Sensor table for 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

### 8.2.3.30.15. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Mass Airflow Sensor Replacement for multifunction intake air sensor replacement
- Control Module References for Engine Control Module replacement, programming, and setup.

## 8.2.3.31. DTC P0116

### 8.2.3.31.1.Diagnostic Instructions

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

### 8.2.3.31.2.DTC Descriptor

**DTC P0116**
Engine Coolant Temperature (ECT) Sensor Performance

### 8.2.3.31.3.Diagnostic Fault Information

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage | Signal Performance |
|---|---|---|---|---|
| Signal Circuit | P0117 | P0118 | P0118* | P0116, P0119, P0128 |
| Low Reference | | P0118 | | P0119, P0128 |
| *Internal ECM or sensor damage may occur if the circuit is shorted to B+. | | | | |

### 8.2.3.31.4.Typical Scan Tool Data

| | ECT Sensor | | |
|---|---|---|---|
| Circuit | Short to Ground | Open | Short to Voltage |
| **Operating Conditions:** Engine Running<br>**Parameter Normal Range:** −39 to 149°C (−38 to 300°F) | | | |
| ECT Sensor | 150°C (302°F) | −40°C (−40°F) | −40°C (−40°F) |
| Low Reference | - | −40°C (−40°F) | - |
| *Internal ECM or sensor damage may occur if the circuit is shorted to B+. | | | |

### 8.2.3.31.5.Circuit/System Description

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

The purpose of this diagnostic is to determine if the input from the ECT sensor is skewed warmer than normal. The internal clock of the ECM will record the amount of time the engine is OFF. If the required engine OFF time is met at startup, the ECM will compare the temperature difference between the actual measured ECT and IAT sensors.

### 8.2.3.31.6.Conditions for Running the DTC

- DTCs P0111, P0112, P0113, P0114, P0117, P0118, P0128, P0502, P0503, P0601, P1621, or P2610 are not set.
- The vehicle has had a minimum ignition OFF time of 8 hours.
- The Ignition is ON.
- The startup
- IAT is warmer than −7° C (+19° F).
- Fuel level is greater than 2.5 %
- This DTC runs once per ignition cycle when the above conditions are met..

#### 8.2.3.31.7. 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 NO engine block heater was detected.

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, the engine cranked for greater than 10 s without starting and NO engine block heater was detected.

#### 8.2.3.31.8. Action Taken When the DTC Sets

DTC P0116 is a Type B DTC.

#### 8.2.3.31.9. Conditions for Clearing the DTC

DTC P0116 is a Type B DTC.

#### 8.2.3.31.10. Diagnostic Aids

Inspect the ECT sensor terminals for corrosion.
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 then 8 hours with the Vehicle OFF and the propulsion system inactive, may help isolate the condition. Compare the scan tool Radiator Coolant Temperature Sensor and ECT Sensor temperature sensor values at vehicle ON. The Radiator Coolant Temperature Sensor and the ECT Sensor values should display within 3°C (5°F).

#### 8.2.3.31.11. Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Description and Operation**

Cooling System Description and Operation

**Electrical Information Reference**

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

### 8.2.3.31.12. Circuit/System Verification

1. Ignition ON.
2. Verify the scan tool ECT Sensor parameter is warmer than –40° C (–40° F) and colder than 150° C (302° F) and changes with engine run time.

**⇒ If colder than –39° C (–38° F) or warmer than 149° C (300° F) or does not change**

Refer to Circuit/System Testing.

**⇓ If warmer than –40° C (–40°F) and colder than 150° C (302° 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.

### 8.2.3.31.13. Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the B34A Engine Coolant Temperature sensor harness connector at the sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal A or 2 and ground.

**⇒ If 5 Ω or greater**

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 B or 1 and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇒ If infinite resistance, replace the K20 Engine Control Module.

**⇓ If colder than 39° C (38° F)**

5. Install a 3 A fused jumper wire between the signal circuit terminal B or 1 and the low reference circuit terminal A or 2.
6. Verify the scan tool ECT sensor parameter is warmer than 149° C (300° F).

**⇒ If 149° C (300° F) or colder**

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. Replace the B34A Engine Coolant Temperature Sensor.

#### 8.2.3.31.14. 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 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.

#### 8.2.3.31.15. Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

- Engine Coolant Temperature Sensor Replacement
- Control Module References for ECM replacement, setup, and programming

## 8.2.3.32. DTC P0117, P0118, or P0119

### 8.2.3.32.1.Diagnostic Instructions

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

### 8.2.3.32.2.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

### 8.2.3.32.3.Diagnostic Fault Information

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage | Signal Performance |
|---|---|---|---|---|
| Sensor | 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+. | | | | |

### 8.2.3.32.4.Typical Scan Tool Data

**ECT Sensor**

| Circuit | Short to Ground | Open | Short to Voltage |
|---|---|---|---|
| Operating Conditions: Engine Running<br>Parameter Normal Range: −39 to 149°C (−38 to 300°F) | | | |
| ECT Sensor | 150°C (302°F) | −40°C (−40°F) | −40°C (−40°F) |
| Low Reference | - | −40°C (−40°F) | - |
| *Internal ECM or sensor damage may occur if the circuit is shorted to B+. | | | |

### 8.2.3.32.5.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.

### 8.2.3.32.6.Conditions for Running the DTC

**P0117**

- The ignition is ON.
  OR
- The engine is running.
- This DTC runs continuously within the enabling conditions.

**P0118**

- The ignition is ON.
  OR
- The engine is running for greater than 15 s.
  OR
- The engine run time is less than 15 s when the IAT is warmer than –7°C (19°F).

- This DTC runs continuously within the enabling conditions.

**P0119**

- No active DTCs set.
- The ignition is ON.
- This DTC runs continuously within the enabling conditions.

**8.2.3.32.7.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 3 seconds.

**8.2.3.32.8.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.

**8.2.3.32.9.Conditions for Clearing the DTC**

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

**8.2.3.32.10. Reference Information**

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Description and Operation**

Cooling System Description and Operation

**Electrical Information Reference**

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

**8.2.3.32.11. Circuit/System Verification**

1. Ignition ON.
2. Verify the scan tool ECT Sensor parameter is warmer than –40° C (–40° F) and colder than 150° C (302° F) and changes with engine run time.

**⇒ If colder than –39° C (–38° F) or warmer than 149° C (300° F) or does not change**

Refer to Circuit/System Testing.

**⇓ If warmer than –40° C (–40°F) and colder than 150° C (302° 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.

### 8.2.3.32.12. Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the B34 Engine Coolant Temperature sensor harness connector at the sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal A or 2 and ground.

**⇒ If 5 Ω or greater**

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 B or 1 and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇒ If infinite resistance, replace the K20 Engine Control Module.

**⇓ If colder than 39° C (38° F)**

5. Install a 3 A fused jumper wire between the signal circuit terminal B or 1 and the low reference circuit terminal A or 2.
6. Verify the scan tool ECT sensor parameter is warmer than 149° C (300° F).

**⇒ If 149° C (300° F) or colder**

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.

### 8.2.3.32.13. 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 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.

### 8.2.3.32.14. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Engine Coolant Temperature Sensor Replacement
- Engine Control Module Replacement engine control module replacement, programming, and setup

## 8.2.3.33. DTC P0121-P0123, P0222, P0223, or P2135

### 8.2.3.33.1. Diagnostic Instructions

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

### 8.2.3.33.2. 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

### 8.2.3.33.3. Diagnostic Fault Information

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

### 8.2.3.33.4. Typical Scan Tool Data

**Throttle Position Sensor 1**

| Circuit | Short to Ground | Open | Short to Voltage |
|---|---|---|---|
| Operating Conditions: Engine running at various operating conditions<br>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<br>Normal Range: 4.75–0.35 V | | | |
| 5 V Reference | 0 V | 0 V | 5 V |
| Throttle Position Sensor 1 Signal | 0 V | 5 V | 5 V |
| Low Reference | - | 5 V | - |

#### 8.2.3.33.5.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).

#### 8.2.3.33.6.Conditions for Running the DTC

**P0122, P0123, P0222, and P0223**

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

**P0121**

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

**P2135**

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

#### 8.2.3.33.7.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.

#### 8.2.3.33.8.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.

#### 8.2.3.33.9.Conditions for Clearing the MIL/DTC

- DTCs P0122, P0123, P0222, P0223, and P2135 are Type A DTCs.

- DTC P0121 is a Type B DTC.

#### 8.2.3.33.10. 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.

#### 8.2.3.33.11. Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Description and Operation**

Throttle Actuator Control (TAC) System Description

**Electrical Information Reference**

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

#### 8.2.3.33.12. 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 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.

**⇓ 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 table.

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

Refer to DTC P0106.

**⇓ 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.
**⇓ 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.
**⇓ The MAF Sensor parameter changes smoothly and gradually**
12. Verify the scan tool Boost Pressure Sensor pressure and BARO parameters are within 3 kPa (0.4 psi).
**⇒ The parameters are not within 3 kPa (0.4 psi)**
Refer to DTC P0236.
**⇓ The parameters are within 3 kPa (0.4 psi)**
13. Verify the scan tool MAP Sensor parameter and the Boost Pressure Sensor parameter are within 20 kPa (2.9 psi) during a WOT acceleration at the time of the 1–2 shift.
**⇒ The parameters are not within 20 kPa (2.9 psi)**
Refer to DTC P0236.
**⇓ The parameters are within 20 kPa (2.9 psi)**
14. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
15. Verify the DTC does not set.
**⇒ If the DTC sets**
Refer to Circuit/System Testing
**⇓ If the DTC does not set**
16. All OK

### 8.2.3.33.13. 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.

### 8.2.3.33.14. Repair Instructions

- Throttle Body Assembly Replacement
- Control Module References for engine control module replacement, programming, and setup

### 8.2.3.33.15. 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 for further diagnosis.

**⇓ If DTC does not set**

8. All OK

### 8.2.3.34. DTC P0128

#### 8.2.3.34.1.Diagnostic Instructions

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

#### 8.2.3.34.2.DTC Descriptor

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

#### 8.2.3.34.3.Diagnostic Fault Information

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage | Signal Performance |
|---|---|---|---|---|
| ECT Sensor Signal | P0117 | P0118 | P0118 | P0128 |
| Low Reference | - | P0118 | P0118 | P0128 |

#### 8.2.3.34.4.Typical Scan Tool Data

**ECT Sensor Temperature**

| Circuit | Short to Ground | Open | Short to Voltage |
|---|---|---|---|
| **Parameter Normal Range:** −39 to +139°C (−38 to +282°F) | | | |
| ECT Sensor 1 Signal | 140°C (284°F) | −40°C (−40°F) | −40°C (−40°F) |
| Low Reference | - | −40°C (−40°F) | −40°C (−40°F) |

#### 8.2.3.34.5.Circuit/System Description

| Note: |
|---|
| The engine coolant temperature sensor is referred to as B34A Engine Coolant Temperature Sensor 1 in schematics and other areas. |

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

#### 8.2.3.34.6.Conditions for Running the DTC

- DTCs P00B3, P00B6, P0101, P0102, P0103, P0111, P0112, P0113, P0116, P0117 or P0118 are not set.
- The engine OFF time is greater than 30 min.
- The startup
- ECT sensor is between −40° to 74°C (–40° to 165°F).
- Commanded Thermostat Heater duty cycle is less than 20%.
- Engine run time between 30 s and 30 m.
- The Ethanol in the fuel is less than 87 %.
- The vehicle has traveled greater than 1 kilometer (0.6 miles).
- The DTC runs once per ignition cycle when the above conditions are met.

#### 8.2.3.34.7.Conditions for Setting the DTC

- The ECM determines that the modeled ECT has met the calibrated target of 79° C (174 °F) and the measured ECT is less than 53° C (127° F) and the startup ambient temperature is between 10° and 52° C (50° and 126° F), for greater than 1 s.

OR

- The ECM determines that the modeled ECT has met the calibrated target of 59° C (138 °F) and the measured ECT is less than 13° C (55° F) and the startup ambient temperature is between –7° and 10° C (19° and 50° F), for greater than 1 s.

#### 8.2.3.34.8.Action Taken When the DTC Sets

DTC P0128 is a Type B DTC.

#### 8.2.3.34.9.Conditions for Clearing the DTC

DTC P0128 is a Type B DTC.

#### 8.2.3.34.10. Diagnostic Aids

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

#### 8.2.3.34.11. Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Description and Operation**

Cooling System Description and Operation

**Electrical Information Reference**

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

### 8.2.3.34.12. Circuit/System Verification

1. Verify the DTC P00B7, P0116, P0117, P0118, P0597, P0598, or P0599 is not set.
**⇒ If a DTC is set**
Refer to Diagnostic Trouble Code (DTC) List Vehicle
**⇓ If a DTC is not set**
2. Verify the cooling system is filled to the correct coolant level. Refer to Cooling System Draining and Filling and Loss of Coolant.
**⇒ If the coolant level is not correct**
Repair as necessary
**⇓ If the coolant level is correct**
3. Engine running for 15 min with the A/C OFF, increase the engine speed to 3,000 RPM.
4. Verify the scan tool ECT Sensor parameter is greater than 79°C (174°F) when commanding the Engine Coolant Thermostat Heater to 0%.
**⇒ If less than 79°C (174°F)**
Replace the Engine Coolant Thermostat.
**⇓ If greater than 79°C (174°F)**
5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify the DTC does not set.
**⇒ If the DTC sets**
Refer to Circuit/System Testing.
**⇓ If the DTC does not set**
7. All OK.

**8.2.3.34.13. Circuit/System Testing**

1. Ignition OFF and all vehicle systems OFF, disconnect the B34 Engine Coolant Temperature sensor harness connector at the sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal A or 2 and ground.

**⇒ If 5 Ω or greater**

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 B or 1 and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇒ If infinite resistance, replace the K20 Engine Control Module.

**⇓ If colder than 39° C (38° F)**

5. Install a 3 A fused jumper wire between the signal circuit terminal B or 1 and the low reference circuit terminal A or 2.
6. Verify the scan tool ECT sensor parameter is warmer than 139° C (282° F).

**⇒ If 139° C (282° F) or colder**

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 139° C (282° F)**

7. Test the B34 Engine Coolant Temperature Sensor.
Refer to Component Testing.

**8.2.3.34.14. 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 table. The resistance values should be in range of the table values.

**⇒ If not within the specified range**

Replace the B34 Engine Coolant Temperature Sensor.

**⇓ If within the specified range**

3. Test for infinite resistance between each terminal and the sensor housing.

**⇒ If less than infinite resistance**

Replace the B34 Engine Coolant Temperature Sensor.

**⇓ If infinite resistance**

4. Refer to Thermostat Diagnosis.

**8.2.3.34.15. Repair Instructions**

Perform the Diagnostic Repair Verification after completing the repair.

- Engine Coolant Temperature Sensor Replacement
- Engine Coolant Thermostat Replacement
- Control Module References for engine control module replacement, programming and setup.

## 8.2.3.35. DTC P0131, P0132, P0134, P0137, P0138, or P0140

### 8.2.3.35.1.Diagnostic Instructions

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

### 8.2.3.35.2.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

### 8.2.3.35.3.Diagnostic Fault Information

**HO2S 1 or 2**

| 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 |
| HO2S Low Signal | P0131, P0137, P0171 | P0132, P0134, P0138, P0140 | P0132, P0134, P0138, P0140 | P0133, P1133 |

### 8.2.3.35.4.Typical Scan Tool Data

**HO2S 1 or 2**

| Circuit | Short to Ground | Open | Short to Voltage |
|---|---|---|---|
| **Operating Conditions:** Engine operating in Closed Loop<br>**Parameter Normal Range:** 200–800 mV | | | |
| High Signal | 0 mV | 1,700–2,100 mV | 1,700–2,100 mV |
| Low Signal | - | 1,700–2,100 mV | 1,700–2,100 mV |

### 8.2.3.35.5.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.

#### 8.2.3.35.6.Conditions for Running the DTC

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

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

**DTC P0134 or P0140**
- DTCs P0068, P0101, P0102, P0103, P0121, P0122, P0123, P0222, P0223, P1516, P2101, P2119, P2135 and P2176 are not set.
- The ignition voltage is between 10–32 V.
- HO2S heater warm up is finished.
- Engine run time is greater than 5 s.
- The engine has been operating for greater than 50 s.
- The fuel composition is less than 87% ethanol.

#### 8.2.3.35.7.Conditions for Setting the DTC

**P0131**

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

**P0137**

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

**P0132 or P0138**

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

**P0134 or P0140**

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

#### 8.2.3.35.8.Action Taken When the DTC Sets

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

#### 8.2.3.35.9.Conditions for Clearing the DTC

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

**8.2.3.35.10. Reference Information**

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

Electrical Information Reference

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

**8.2.3.35.11. Circuit/System Verification**

1. Ignition ON
2. Verify no HO2S heater DTCs are set.

**⇒ If a DTC is set**

Refer to Diagnostic Trouble Code (DTC) List Vehicle.

**⇓ If a DTC is not set**

3. Engine warm and running. HO2S Heater Command Sensor 2 greater than 30%.
4. Verify the scan tool HO2S 1 or 2 parameters are between 50–1,050 mV.

**⇒ If not between 50–1,050 mV**

Refer to Circuit/System Testing.

**⇓ If between 50–1,050 mV**

5. Operate the vehicle within the Conditions for Running 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.

**8.2.3.35.12. Circuit/System Testing**

1. Ignition OFF and all vehicle systems OFF, disconnect the appropriate B52 Heated Oxygen Sensor harness connector. It may take up to 2 minutes for all vehicle systems to power down. Ignition ON.
2. Test for 1.7–3.0 V between the high signal circuit terminal 4 and ground.

**⇒ If less than 1.7 V**

2.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2.2. Test for infinite resistance between the high signal circuit terminal 4 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 high signal circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, replace the K20 Engine Control Module.

**⇒ If greater than 3 V**

2.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module. Ignition ON.
2.2. Test for less than 1 V between the high signal circuit terminal 4 and ground.
⇒ If 1 V or greater, repair the short to voltage on the circuit.
⇒ If less than 1 V, replace the K20 Engine Control Module.

**⇓ If between 1.7–3.0 V**

3. Verify the scan tool HO2S 1 or 2 parameter is between 1.0–3.0 V.

**⇒ If less than 1.0 V**

3.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module. Ignition ON.
3.2. Test for infinite resistance between the low signal circuit terminal 3 and ground.

⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇓ If infinite resistance, replace the K20 Engine Control Module.
**⇓ If greater than 1.0 V**
4. Connect a 3 A fused jumper wire between the high signal circuit terminal 4 and the low signal circuit terminal 3.

| Note: |
| --- |
| The low signal circuit is tied to a pull-up circuit within the engine control module. A voltage of 0.0–1.1 V on the low signal circuit is normal. |

5. Verify the scan tool HO2S 1 or 2 parameter displays 0.0 V.
**⇒ If greater than 0.0 V**

5.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module. Ignition ON.
5.2. Test for less than 2 Ω in the low signal circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇓ If less than 2 Ω
5.3. Test for less than 1 V between the low signal circuit terminal 3 and ground.
⇒ If 1 V or greater, repair the short to voltage on the circuit.
⇒ If less than 1 V, replace the K20 Engine Control Module.

**⇓ If 0.0 V**
6. Verify none of the conditions listed below exist:

- Water intrusion in the B52 HO2S harness connector
- Low or high fuel system pressure—Refer to Fuel System Diagnosis.
- Fuel that is contaminated—Refer to Alcohol/Contaminants-in-Fuel Diagnosis.
- Fuel saturation of the evaporative emission (EVAP) canister
- Exhaust leaks
- Engine vacuum leaks

**⇒ If any of the conditions exist**

Repair as necessary.

**⇓ If none of the conditions exist**
7. Test or replace the B52 Heated Oxygen Sensor.

### 8.2.3.35.13. Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

- Heated Oxygen Sensor Replacement - Sensor 1
- Heated Oxygen Sensor Replacement - Sensor 2
- Perform the scan tool Heated Oxygen Sensor Resistance Learn Reset after replacing an HO2S.
- Control Module References for ECM replacement, programming and setup

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

### 8.2.3.36.1.Diagnostic Instructions

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

### 8.2.3.36.2.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

### 8.2.3.36.3.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, P013A, P013B, P013E, P013F, P015A, P015B |
| HO2S Low Signal | P0137 | P0132, P0134, P0138, P0140 | P0132, P0134, P0138, P0140 | P0133, P013A, P013B, P013E, P013F, P015A, P015B |

### 8.2.3.36.4.Typical Scan Tool Data

**HO2S 1 or 2**

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage |
|---|---|---|---|
| **Operating Conditions:** Engine operating in Closed Loop<br>**Parameter Normal Range:** 200–800 mV | | | |
| HO2S 1 or 2 Signal | 0 mV | 1 700–2 100 mV | 1 700–2 100 mV |
| HO2S 1 or 2 Low Signal | - | 1 700–2 100 mV | 1 700–2 100 mV |

### 8.2.3.36.5.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.

### 8.2.3.36.6.Conditions for Running the DTC

**DTC P0133**

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

**P013A**

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

**P013B**

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

**P013E**

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

**P013F**

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

**P015A and P015B**

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0128, P0131, P0132, P0134, P0171, P0172, P0201, P0202, P0203, P0204, P0222, P0223, P0300, P0442, P0443, P0446, P0449, P0452, P0453, P0455, P0496, P16F3, P2101 or P2135 are not set.
- The ignition 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 engine coolant temperature (ECT) is hotter than 60°C (140°F).
- The intake air temperature (IAT) is hotter 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) 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 cutoff
- (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, P0096, P0097, P0098, P00B6, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0171, P0172, P0201, P0202, P0203, P0204, P0222, P0223, P0300, P1101, P1516, P2096, P2097, P2101, P2119, P2135, P2176 are not set.
- The ignition voltage is between 10–32 V.
- The fuel level is greater than 10%.
- The engine speed parameter is between 1 100–3 500 RPM.
- The mass air flow (MAF) is between 1–30 g/s.
- The fuel composition is less than 87% ethanol.
- The fuel system is in Closed Loop.
- DTC P013A, P013B, P013E, P013F, P2270 and P2271 have run.
- DTC P2270 and P2271 have passed.

- DTC P2270 runs once per drive cycle when the above conditions are met for 5 s.

**P2271**

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

**8.2.3.36.7.Conditions for Setting the DTC**

**P0133**

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

**P013A**

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

**P013B**

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

**P013E**

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

**P013F**

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

**P0140**

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

**P2270**

- The ECM detects that the heated oxygen sensor (HO2S) 2 sensor cannot achieve voltage equal to or less than 775 mV. and
- The ECM detects that the accumulated mass air flow monitored during the Stuck Lean Voltage Test is more than 38 g.

**P2271**

- The ECM detects that the heated oxygen sensor (HO2S) 2 sensor cannot achieve voltage equal to or less than 100 mV. and
- The ECM detects that the accumulated mass air flow monitored during the stuck rich voltage test is more than 25 g.

**8.2.3.36.8.Action Taken When the DTC Sets**

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

**8.2.3.36.9.Conditions for Clearing the DTC**

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

### 8.2.3.36.10. Reference Information

**Schematic Reference**
Engine Controls Schematics
**Connector End View Reference**
Component Connector End Views
**Electrical Information Reference**
Circuit Testing
Connector Repairs
Testing for Intermittent Conditions and Poor Connections
Wiring Repairs
**DTC Type Reference**
Powertrain Diagnostic Trouble Code (DTC) Type Definitions
**Scan Tool Reference**
Control Module References for scan tool information

### 8.2.3.36.11. Circuit/System Verification

1. Ignition ON.
2. Verify no HO2S heater DTCs are set
**⇒ If a HO2S heater DTC is set**
Refer to DTC P0131, P0132, P0134, P0137, P0138, or P0140.
**⇓ 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 DTC P0131, P0132, P0134, P0137, P0138, or P0140.
**⇓ If between 50–1 050 mV**
5. 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.
- Fuel that is contaminated—Refer to Alcohol/Contaminants-in-Fuel Diagnosis.
- Fuel saturation of the evaporative emission (EVAP) canister
- Exhaust leaks
- Engine vacuum leaks
- Engine oil consumptions—Refer to Symptoms Engine Cooling.
- Engine coolant consumption—Refer to Symptoms Engine Cooling.

**⇒ If any of the above conditions exist**
Repair as necessary.
**⇓ If none of the above conditions exist**
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**
Replace the B52 Heated Oxygen Sensor.
**⇓ If the DTC does not set**
8. All OK.

### 8.2.3.36.12. Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.
- Heated Oxygen Sensor Replacement Sensor 1
- Heated Oxygen Sensor Replacement Sensor 2
- Perform the scan tool Heated Oxygen Sensor Resistance Learn Reset after replacing a HO2S.
- Control Module References for ECM replacement, programming and setup

## 8.2.3.37. DTC P0171 or P0172

### 8.2.3.37.1.Diagnostic Instructions

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

### 8.2.3.37.2.DTC Descriptors

**DTC P0171**
Fuel Trim System Lean
**DTC P0172**
Fuel Trim System Rich

### 8.2.3.37.3.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 drivability, 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.

### 8.2.3.37.4.Conditions for Running the DTC

- DTCs P0030, P0053, P0101, P0102, P0103, P0106, P0107, P0108, P0131–P0135, P015A, P015B, P0178, P0179, P0201–P0204, P0236, P0237, P0238, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0300–P0304, P0411, P0442, P0455, P0458, P0496, P0506, P0507, P1133, P1248, P1249, P124A, P124B, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P2227, P2228, P2229, P2230, P2269, 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 evaporative emissions system leak 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 %.
- This diagnostic runs continuously when the above conditions have been met.

### 8.2.3.37.5.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.

### 8.2.3.37.6.Action Taken When the DTC Sets

DTCs P0171 and P0172 are Type B DTCs.

#### 8.2.3.37.7. Conditions for Clearing the MIL/DTC

DTCs P0171 and P0172 are Type B DTCs.

#### 8.2.3.37.8. Diagnostic Aids

- Allow the engine to reach operating temperature. With the engine running, observe the HO2S parameter with a scan tool. The HO2S value should vary from approximately 40 mV to approximately 900 mV, and respond to fueling changes.
- The normal Short Term Fuel Trim and Long Term Fuel Trim parameters should be between +10 and −10 % with 0 % the optimum, with the engine running at operating temperature.
- Any unmetered 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.
- Verify that the air filter is the correct one for this application, the engine oil fill cap is in place and is tight, and 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.

#### 8.2.3.37.9. Reference Information

**Component View Reference**

Powertrain Component Views

**Electrical Information Reference**

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

#### 8.2.3.37.10. Circuit/System Verification

1. Ignition ON.
2. Verify no other DTCs are set.

**⇒ If any other DTCs are set**

Refer to Diagnostic Trouble Code (DTC) List Vehicle for further diagnosis.

**⇓ If no other DTCs are set**

3. Verify DTC P0171 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.

### 8.2.3.37.11. 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

**⇒ If not within the specified range**

Refer to DTC P0106

**⇓ If within the specified range**

3. Engine running at the operating temperature.
4. Verify the Long Term Fuel Trim parameter is between –30 % and +35 %.

**⇒ If greater than +35 %**

4.1. Ignition OFF.
4.2. Inspect for the conditions listed below:

- 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.
- Fuel contamination. Refer to Alcohol/Contaminants-in-Fuel Diagnosis.
- Missing, restricted, or leaking exhaust components. Refer to Symptoms Engine Exhaust.
- Malfunctioning fuel injectors. Refer to Fuel Injector Diagnosis.
- Split, kinked, or improperly connected vacuum hoses
- Insufficient fuel in the tank
- Low fuel pressure. Refer to Fuel System Diagnosis.
- Vacuum leaks at the intake manifold, the throttle body, and the injector O-rings.
- Leaks in the air induction system and the air intake ducts
- Missing air filter element
- Cracked EVAP canister
- Evaporative pipes obstructed or leaking
- Leaks in the crankcase ventilation system.

⇒ If a condition is found, repair as necessary.

⇒ If no condition is found, test the engine for a mechanical condition. Refer to Symptoms Engine Mechanical.

**⇒ If less than –30 %**

4.1. Ignition OFF.
4.2. Inspect for the conditions listed below:

- Mass air flow (MAF) sensor signal skewed. If the Short Term Fuel Trim parameters for both banks changes greater than 20 % when the MAF sensor is disconnected, refer to DTC P0101.
- Fuel contamination. Refer to Alcohol/Contaminants-in-Fuel Diagnosis.
- Missing, restricted, or leaking exhaust components. Refer to Symptoms Engine Exhaust.
- Malfunctioning fuel injectors. Refer to Fuel Injector Diagnosis
- Collapsed or restricted air intake duct
- Excessive fuel pressure. Refer to Fuel System Diagnosis
- Dirty or restricted air filter
- Objects blocking the throttle body
- Improper operation of the evaporative emissions control system
- Excessive fuel in the crankcase. Change the engine oil as necessary.

⇒ If a condition is found, repair as necessary.

⇒ If no condition is found, test the engine for a mechanical condition. Refer to Symptoms Engine Mechanical.

**⇓ If between –30 % and +35 %**

5. All OK.

### 8.2.3.37.12. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.
Perform the scan tool Fuel Trim Reset after completing the repair.

## 8.2.3.38. DTC P018B-P018D (Chassis Control Module)

### 8.2.3.38.1. Diagnostic Instructions

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

### 8.2.3.38.2. DTC Descriptors

**DTC P018B**
Fuel Pressure Sensor Performance
**DTC P018C**
Fuel Pressure Sensor Circuit Low Voltage
**DTC P018D**
Fuel Pressure Sensor Circuit High Voltage

### 8.2.3.38.3. Diagnostic Fault Information

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage | Signal Performance |
|---|---|---|---|---|
| 5 V Reference | P018C, P0641, P06A6 | P018C | P018D | P06A6 |
| Sensor | P018C | P018C | P018D | P018B |
| Low Reference | - | P018D | - | P06A6 |

### 8.2.3.38.4. 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 chassis control module monitors the voltage signal from the fuel pressure sensor.

### 8.2.3.38.5. Conditions for Running the DTC

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

### 8.2.3.38.6. Conditions for Setting the DTC

The chassis 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.

### 8.2.3.38.7. Action Taken When the DTC Sets

DTCs P018B, P018C and P018D are Type A DTCs.

### 8.2.3.38.8. Conditions for Clearing the DTC

DTCs P018B, P018C and P018D are Type A DTCs.

#### 8.2.3.38.9. 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.

#### 8.2.3.38.10. Reference Information

**Schematic Reference**
Engine Controls Schematics
**Connector End View Reference**
Component Connector End Views
**Description and Operation**
Fuel System Description
**Electrical Information Reference**
- Circuit Testing
- Testing for Intermittent Conditions and Poor Connections
- Connector Repairs
- Wiring Repairs

**DTC Type Reference**
Powertrain Diagnostic Trouble Code (DTC) Type Definitions
**Scan Tool Reference**
Control Module References for scan tool information

#### 8.2.3.38.11. 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.

#### 8.2.3.38.12. 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 K38 Chassis 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 K38 Chassis 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 K38 Chassis 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 K38 Chassis Control Module.

**⇒ If greater than 5.2 V**

4.1. Ignition OFF, disconnect the harness connector at the K38 Chassis 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 K38 Chassis 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 K38 Chassis 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 K38 Chassis 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 K38 Chassis 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 K38 Chassis Control Module.

**⇓ If greater than 4.8 V**

8. Test or replace the B47 Fuel Pressure Sensor.

#### 8.2.3.38.13. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.
Control Module References for chassis control module replacement, programming and setup

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

### 8.2.3.39.1. Diagnostic Instructions

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

### 8.2.3.39.2. 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

### 8.2.3.39.3. 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.<br>** Cranks no start if the condition is between the fuse and the splice. | | | | |

#### 8.2.3.39.4.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.

#### 8.2.3.39.5.Conditions for Running the DTC

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

#### 8.2.3.39.6.Conditions for Setting the DTC

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

#### 8.2.3.39.7.Action Taken When the DTC Sets

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

#### 8.2.3.39.8.Conditions for Clearing the DTC

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

#### 8.2.3.39.9.Diagnostic Aids

Performing the Fuel Injector Diagnosis may help isolate an intermittent condition. Refer to Fuel Injector Diagnosis.

#### 8.2.3.39.10. Reference Information

**Schematic Reference**
Engine Controls Schematics
**Connector End View Reference**
Component Connector End Views
**Electrical Information Reference**
Circuit Testing
Connector Repairs
Testing for Intermittent Conditions and Poor Connections
Wiring Repairs
**DTC Type Reference**
Powertrain Diagnostic Trouble Code (DTC) Type Definitions
**Scan Tool Reference**
Control Module References for scan tool information
**Special Tool**
CH 347302C Noid Light, if available

### 8.2.3.39.11. 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.

### 8.2.3.39.12. 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.

#### 8.2.3.39.13. Component Testing

Fuel Injector Diagnosis

#### 8.2.3.39.14. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Fuel Injector Replacement
- Control Module References for Engine Control Module replacement, programming, and setup

## 8.2.3.40. DTC P0231, P0232, or P023F (Chassis Control Module)

### 8.2.3.40.1. Diagnostic Instructions

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

### 8.2.3.40.2. DTC Descriptors

**DTC P0231**
Fuel Pump Control Circuit Low Voltage
**DTC P0232**
Fuel Pump Control Circuit High Voltage
**DTC P023F**
Fuel Pump Control Circuit

### 8.2.3.40.3. 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 |

### 8.2.3.40.4. Circuit/System Description

The engine control module (ECM) supplies voltage to the chassis control module when the ECM detects that the ignition is on. The voltage from the ECM to the chassis control module remains active for 2 seconds, unless the engine is in crank or run. While this voltage is being received, the chassis control module supplies a varying voltage to the fuel tank pump module in order to maintain the desired fuel line pressure.

### 8.2.3.40.5. 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 chassis control module is inactive for 4 seconds after engine has been shut off.

### 8.2.3.40.6. Conditions for Setting the DTC

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

### 8.2.3.40.7. Action Taken When the DTC Sets

DTCs P0231, P0232, and P023F are Type A DTCs.

### 8.2.3.40.8. Conditions for Clearing the DTC

DTCs P0231, P0232, and P023F are Type A DTCs.

### 8.2.3.40.9. 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.

### 8.2.3.40.10. Reference Information

**Schematic Reference**
Engine Controls Schematics
**Connector End View Reference**
Component Connector End Views
**Description and Operation**
Fuel System Description
**Electrical Information Reference**
Circuit Testing
Connector Repairs
Testing for Intermittent Conditions and Poor Connections
Wiring Repairs
**DTC Type Reference**
Powertrain Diagnostic Trouble Code (DTC) Type Definitions
**Scan Tool Reference**
Control Module References for scan tool information

### 8.2.3.40.11. Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the A7 Fuel Pump and Level Sensor Assembly. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 10 Ω between the low reference circuit terminal 2 and ground.
**⇒ If 10 Ω or greater**
  2.1. Ignition OFF, disconnect the harness connector at the K38 Chassis 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 K38 Chassis 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 K38 Chassis 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 K38 Chassis Control Module.
**⇒ If the test lamp is always ON**
  5.1. Ignition OFF, disconnect the harness connector at the K38 Chassis 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 K38 Chassis Control Module.
**⇓ If the test lamp turns ON and OFF**
6. Replace the A7 Fuel Pump and Level Sensor Assembly.

### 8.2.3.40.12. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Fuel Tank Fuel Pump Module Replacement

- Control Module References for chassis control module replacement, programming and setup

### 8.2.3.41. DTC P0234 or P0299

#### 8.2.3.41.1. Diagnostic Instructions

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

#### 8.2.3.41.2. DTC Descriptors

**DTC P0234**
Engine Overboost

**DTC P0299**
Engine Underboost

#### 8.2.3.41.3. Circuit Description

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

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

#### 8.2.3.41.4. Conditions for Running the DTC

- DTCs P0010, P0011, P0013, P0014, P0033, P0034, P0035, P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0128, P0222, P0223, P0234, P0236, P0237, P0238, P0243, P0245, P0246, P0299, P16F3, P2101, P2227, P2228, P2229 or P2230 are not set.
- Engine speed between 2,450–6,000 RPM.
- Desired boost pressure between 135–220 kPa (19.58–31.90 PSI).
- Ambient pressure between 60–120 kPa (8.70–17.40 PSI).
- Coolant temperature between −40 to +120°C (−40 to +248°F)
- Intake air temperature between −40 to +80°C (−40 to +176°F)

#### 8.2.3.41.5. Conditions for Setting the DTC

**P0234**
The ECM detects that the actual boost pressure is greater than the desired boost pressure for greater than 2 s.

**P0299**
The ECM detects that the actual boost pressure is less than the desired boost pressure for greater than 2.5 s.

#### 8.2.3.41.6. Action Taken When the DTC Sets

- DTCs P0234 and P0299 are Type B DTCs.
- The ECM will disable boost control and limit the system to mechanical boost only, resulting in a substantial decrease in engine power.

#### 8.2.3.41.7. Conditions for Clearing the DTC

DTCs P0234 and P0299 are Type B DTCs.

#### 8.2.3.41.8. Diagnostic Aids

- The charged air cooler is connected to the turbocharger and to the throttle body by flexible duct work that requires the use of special high torque fastening clamps. These clamps cannot be substituted. In order to prevent any type of air leak when servicing the duct work, the tightening specifications and proper positioning of the clamps is critical, and must be strictly adhered to.
- Insufficient preload between the wastegate lever and actuator rod may allow the wastegate to open slightly when commanded closed, and result in P0299 being set.
- Oil ingestion or contamination of the wastegate solenoid valve may cause DTC P0299 to set.
- Charge air cooler icing may cause DTC P0299 to set.

#### 8.2.3.41.9. Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Description and Operation**

Turbocharger System Description

**Electrical Information Reference**

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

**Special Tools**

GE-23738-A Vacuum Pump

#### 8.2.3.41.10. Circuit/System Verification

1. Ignition On.
2. Verify DTC P0033, P0034, P0035, P0236, P0237, P0238, P0243, P0245, P0246 or, P2261 is not set.

**⇒ If any of the DTCs are set**

Refer to Diagnostic Trouble Code (DTC) List Vehicle.

**⇓ If none of the DTCs are set**

3. Verify the scan tool BARO Sensor parameter is within the range specified in the Altitude Versus Barometric Pressure table for the current testing altitude.

**⇒ If the parameter is not within the range specified in the table.**

Refer to DTC P2227-P2230.

**⇓ If the parameter is within the range specified in the table.**

4. Verify the scan tool MAP Sensor and BARO Sensor parameters are within 3 kPa (0.4 psi) .

**⇒ If the parameters are not within 3 kPa (0.4 psi).**

Refer to DTC P0106.

**⇓ If the parameters are within 3 kPa (0.4 psi).**

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

**⇒ If the parameters are not within 3 kPa (0.4 psi).**

Refer to DTC P0236.

**⇓ If the parameters are within 3 kPa (0.4 psi).**

6. Engine running, verify the wastegate actuator rod moves when increasing engine speed to wide open throttle (WOT) and abruptly back to idle.

**⇒ If the rod does not move**

Refer to Circuit/System Testing.

**⇓ If the rod moves**

7. Ignition On, engine Off, verify a click is heard or felt from the Q40 Turbocharger Bypass Solenoid Valve when commanding the Turbocharger Bypass Solenoid Valve On and Off with a scan tool.
**⇒ If a click is not heard or felt**
Refer to Circuit/System Testing.
**⇓ If a click is heard or felt**
8. Verify a series of clicks, which increase in frequency, are heard or felt from the Q42 Turbocharger Wastegate Solenoid Valve when commanding the Turbocharger Wastegate Solenoid Valve between 15–100 % with a scan tool.
**⇒ If a series of clicks in increasing frequency are not heard or felt**
Refer to Circuit/System Testing.
**⇓ If a series of clicks in increasing frequency is heard or felt**
9. Verify the scan tool MAP Sensor parameter and the Boost Pressure Sensor parameter are within 20 kPa (2.9 psi) during a WOT acceleration at the time of the 1-2 shift.
**⇒ If not within 20 kPa (2.9 psi)**
Refer to Circuit/System Testing.
**⇓ If within 20 kPa (2.9 psi)**
10. Verify the scan tool Desired Boost Pressure parameter and the Boost Pressure Sensor parameter are within 15.2 kPa (2.2 psi) during a WOT acceleration at the time of the 1-2 shift.
**⇒ If the not within 15.2 kPa (2.2 psi)**
Refer to Circuit/System Testing.
**⇓ If within 15.2 kPa (2.2 psi)**
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 a DTC sets**
Refer to Circuit/System Testing
**⇓ If a DTC does not set**
13. All OK

### 8.2.3.41.11. Circuit/System Testing

**P0234**

1. Ignition Off.
2. Verify the conditions listed below do not exist:
   - Restricted, blocked or incorrect routing of hoses going to the components listed below:
     – Turbocharger
     – Turbocharger wastegate solenoid valve
     – Turbocharger wastegate actuator

**⇒ If a condition exists**
Repair the condition or replace the turbocharger as necessary
**⇓ If none of the conditions exist**

| Note: |
|---|
| The hose is attached between the turbocharger inlet and the Q42 Turbocharger Wastegate Solenoid Valve. |

3. Disconnect the turbocharger wastegate solenoid valve hose at the turbocharger and apply 51 kPa (15 inches Hg) of vacuum to the hose with the GE -23738-A. Ignition On.
4. Verify the pressure decreases to 0 kPa (0 inches Hg) when commanding the Turbocharger Wastegate Solenoid Valve to 15 % with a scan tool.
**⇒ If the pressure does not decrease to 0 kPa (0 inches Hg)**
Test or replace the Q42 Turbocharger Wastegate Solenoid Valve
**⇓ If the pressure decreases to 0 kPa (0 inches Hg)**
5. Connect the turbocharger wastegate solenoid valve hose to the turbocharger.
6. Disconnect the wastegate solenoid valve hose from the turbocharger wastegate actuator and connect the exhaust/pressure port of the GE- 23738-A, or a suitable hand pressure pump, to the actuator.
7. Remove the retaining clip and disconnect the wastegate actuator rod from the wastegate lever.
8. Verify the wastegate actuator rod moves when applying pressure to the actuator.

**⇒ If the actuator does not move**

Replace the turbocharger

**⇓ If the actuator moves**

9. Verify the conditions listed below do not exist with the turbocharger assembly. Refer to Turbocharger Cleaning and Inspection

- Restricted or damaged wastegate poppet valve.
- Foreign material.
- Excessive coking.

**⇒ If a condition exists**

Repair the condition or replace the turbocharger as necessary

**⇓ If none of the conditions exist**

10. Replace the turbocharger

**P0299**

1. Verify the conditions listed below do not exist:

- Loose clamps, cracks or other damage in the air intake duct system
- Collapsed intake duct system
- Debris or restrictions in the intake duct system, including the air cleaner dirty side
- Restricted or aftermarket air filter
- Any air flow restriction
- Any air leak between the turbocharger and the throttle body, including the charge air cooler assembly
- Splits, kinks or improper connections at the vacuum hoses
- Any vacuum leak
- Restricted, leaking or incorrect routing of hoses going to the components listed below:
  - Turbocharger wastegate solenoid valve
  - Turbocharger bypass solenoid valve
  - Intake manifold and turbocharger vacuum reservoir on the bottom of intake manifold
  - Turbocharger
  - Turbocharger wastegate actuator
  - Turbocharger bypass valve
- Exhaust leak between the turbocharger and the exhaust manifold
- Loose or incorrect installation of any components
- Evidence of oil contamination in the wastegate solenoid valve and/or vacuum hoses
  Refer to Intake Manifold Cleaning and Inspection for inspection of the positive crankcase ventilation (PCV) diaphragm and check valve.
- Increased or excessive crankcase pressure
  Refer to Engine Compression Test for additional diagnosis.

**⇒ If a condition exists**

Repair or replace the affected component as necessary.

**⇓ If none of the conditions exist**

| **Note:** |
|---|
| The hose is attached between the turbocharger inlet and the Q42 Turbocharger Wastegate Solenoid Valve. |

2. Ignition Off, disconnect the turbocharger wastegate solenoid valve hose at the turbocharger and apply 51 kPa (15 inches Hg) of vacuum to the hose with the GE -23738-A. Ignition On.
3. Verify the pressure decreases to 0 kPa (0 inches Hg) when commanding the Turbocharger Wastegate Solenoid Valve to 15 % with a scan tool.

**⇒ If the pressure does not decrease to 0 kPa (0 inches Hg)**

Test or replace the Q42 Turbocharger Wastegate Solenoid Valve

**⇓ If the pressure decreases to 0 kPa (0 inches Hg)**

4. Connect the turbocharger wastegate solenoid valve hose to the turbocharger.
5. Disconnect the wastegate solenoid valve hose from the turbocharger wastegate actuator and connect the exhaust/pressure port of the GE -23738-A, or a suitable hand pressure pump, to the actuator.
6. Verify the wastegate actuator rod moves when applying pressure to the actuator.

**⇒ If the actuator does not move**

Replace the turbocharger

**⇓ If the actuator moves**

7. Disconnect the Q40 Turbocharger Bypass Solenoid Valve vacuum hose at the turbocharger bypass valve on the turbocharger.
8. Connect the GE- 23738-A to the hose.
9. Idle engine for at least 15 s.
10. Engine Off, ignition On.
11. Verify the vacuum decreases to 0 kPa (0 inches Hg) when engine is turned Off and increases to greater than 45 kPa (13 inches Hg) for at least 5 s when the Turbocharger Bypass Solenoid Valve is commanded On with a scan tool.

**⇒ If not within the specified range**

| **Note:** |
|---|
| The vacuum reservoir (tank) is integral to intake manifold and is located underneath the manifold. |

11.1. Ignition Off, disconnect the vacuum hose from the turbocharger vacuum reservoir.
11.2. Connect the GE- 23738-A to the vacuum reservoir and apply 34 kPa (10 inches Hg) of vacuum.
11.3. Verify the reservoir holds vacuum for at least 10 s.
⇒ If the vacuum is not held for at least 10 s
Replace the intake manifold
⇓ If the vacuum is held for at least 10 s
11.4. Reconnect the vacuum hose to the turbocharger vacuum reservoir.
11.5. Disconnect the vacuum hose that runs between the intake manifold and the Q40 Turbocharger Bypass Solenoid Valve hose at the intake manifold and connect the GE- 23738-A to the hose.

| **Note:** |
|---|
| Allow engine idle to stabilize before continuing. |

11.6. Engine idling, verify the vacuum is greater than 45 kPa (13 inches Hg).
⇒ If 45 kPa (13 inches Hg) or less
Replace the intake manifold
⇓ If greater than 45 kPa (13 inches Hg)
11.7. Connect the GE -23738-A to the output port on the Q40 Turbocharger Bypass Solenoid Valve.

| **Note:** |
|---|
| The Q40 Turbocharger Bypass Solenoid Valve is supplied with vacuum from both the intake manifold and the vacuum reservoir at idle. The vacuum supply hose from the intake manifold must be disconnected before proceeding, to allow vacuum to bleed off when changing command states. |

11.8. Engine idling, command the Turbocharger Bypass Solenoid Valve On and Off with a scan tool.
11.9. Verify the vacuum toggles between 0 kPa (0 inches Hg) to greater than 45 kPa (13 inches Hg).
⇒ If not within the specified range
Test or replace the Q40 Turbocharger Bypass Solenoid Valve
⇒ If within the specified range
Replace the vacuum line between the Q40 Turbocharger Bypass Solenoid Valve and the turbocharger bypass valve.

**⇓ If within the specified range**

12. Verify the conditions listed below do not exist.

- Insufficient preload between the wastegate lever and actuator rod.
- Cracked or damaged turbine blades.
- Worn turbine blades due to contact with housing.

| **Note:** |
|---|
| Excessive oil is not necessarily an indication of turbocharger failure. |

- Oil intrusion in turbocharger, hoses or charge air cooler. Refer to Turbocharger Cleaning and Inspection
- Restricted wastegate, turbine, ports or passages.
- Foreign material.

- Damaged or restricted bypass valve assembly.
- Missing, restricted or leaking exhaust components. Refer to Symptoms Engine Exhaust
- Restricted turbocharger oil supply line
- Restricted charge air cooler

**⇒ If a condition exists**

Repair or replace the turbocharger as necessary

**⇓ If none of the conditions exist**

13. Replace the turbocharger.

### 8.2.3.41.12. Component Testing

**Static Test**

1. Ignition Off, disconnect the harness connector at the appropriate solenoid Valve.
2. Test for 20-27 Ω between terminal 1 and terminal 2 of the solenoid valve.

**⇒ If not between 20-27 Ω**

Replace the solenoid Valve.

**⇓ If between 20-27 Ω**

3. All OK

**Dynamic Test**

1. Install a 10 A fused jumper wire between the Ignition terminal 2 and 12 V. Install a jumper wire between the control terminal 1 and ground.
2. Verify the solenoid clicks.

**⇒ If the solenoid does not click**

Replace the solenoid Valve.

**⇓ If the solenoid clicks**

3. All OK

### 8.2.3.41.13. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Charge Air Bypass Regulator Solenoid Valve Replacement for turbocharger bypass solenoid valve replacement.
- Intake Manifold Replacement
- Turbocharger Replacement
- Turbocharger Wastegate Regulator Solenoid Valve Replacement for turbocharger wastegate solenoid valve replacement.
- Control Module References for ECM replacement, programming and setup

### 8.2.3.42. DTC P0236

#### 8.2.3.42.1.Diagnostic Instructions

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

#### 8.2.3.42.2.DTC Descriptor

**DTC P0236**
Turbocharger Boost Sensor Performance

#### 8.2.3.42.3.Circuit Description

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

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

#### 8.2.3.42.4.Conditions for Running the DTC

- DTC P0096, P0097, P0098, P0102, P0103, P0107, P0108, P0111, P0112, P0113, P0116, P0117, P0118, P0119, P0128, P0237, P0238, P0335, P0336, P2227, P2228, P2229, or P2230 is not active.
- Engine speed is between 400–7,000 RPM.
- Engine Coolant Temperature (ECT) is between -7 to +125°C (19.4–257°F).
- Intake Air Temperature (IAT) is between -20 to +125°C (-4 to +257°F).
- The DTC runs continuously when the above conditions have been met.
  OR
- DTC P0106, P0107, P0108, P0237, P0238, P2227, P2228, P2229, P2230, or P2610 s not active.
- DTC P0107, P0108, P0237, P0238, P2228, or P2229 is not pending.
- Ignition is ON.
- Engine is OFF
- The time between current ignition cycle and the last time the engine was running is greater than 6 s.
- The DTC runs continuously when the above conditions have been met.

#### 8.2.3.42.5.Conditions for Setting the DTC

- The ECM detects that various combinations of Turbocharger Intake Flow Rationality Diagnostic Failure models, derived from engine speed, the BARO sensor, the MAF sensor, the MAP sensor, the throttle position sensor and the turbocharger boost pressure sensor have failed when the engine is running.
  OR
- The ECM detects that the boost pressure sensor signal is less than 50 kPa (7.3 psi) or greater than 115 kPa (16.7 psi) when the ignition is ON and the engine is NOT rotating.

#### 8.2.3.42.6.Action Taken When the DTC Sets

- DTC P0236 is a Type B DTC.
- The ECM will disable boost control and limit the system to mechanical boost only, resulting in a substantial decrease in engine power.

#### 8.2.3.42.7. Conditions for Clearing the MIL/DTC

DTC P0236 is a Type B DTC.

#### 8.2.3.42.8. Diagnostic Aids

- The charge air cooler is connected to the turbocharger and to the throttle body by flexible duct work that requires the use of special high torque fastening clamps. These clamps cannot be substituted. In order to prevent any type of air leak when servicing the duct work, the tightening specifications and proper positioning of the clamps is critical, and must be strictly adhered to.

- Use a smoke generating device or a solution of dish soap and water in a spray bottle to pinpoint any suspected air leaks in the induction system and in the charge air cooler assembly.

#### 8.2.3.42.9. Reference Information

**Schematic Reference**
Engine Controls Schematics
**Connector End View Reference**
Component Connector End Views
**Description and Operation**
Turbocharger System Description
**Electrical Information Reference**
- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

**DTC Type Reference**
Powertrain Diagnostic Trouble Code (DTC) Type Definitions
**Scan Tool Reference**
Control Module References for scan tool information

#### 8.2.3.42.10. Circuit/System Verification

1. Verify that DTC P0641 is not set.
**⇒ If the DTC is set**
Refer to DTC P0641, P0651, P0697, or P06A3.
**⇓ If the DTC is not set**
2. If you were sent here from DTC P0068, P0101, P0106, P0121, or P1101, refer to Circuit/System Testing.
3. Ignition ON.
4. Verify the scan tool Throttle Body Idle Airflow Compensation parameter is less than 90%.
**⇒ 90% or greater**
Refer to Throttle Body Inspection and Cleaning.
**⇓ If less than 90%**
5. Verify the scan tool Throttle Position Sensors 1 and 2 Agree/Disagree parameter displays Agree while performing the Throttle Sweep Test with a scan tool.
**⇒ If Disagree**
Refer to DTC P0121-P0123, P0222, P0223, or P2135.
**⇓ If Agree**
6. Verify the scan tool BARO parameter is within the range specified in the Altitude Versus Barometric Pressure table, for the current vehicle testing altitude.
**⇒ BARO is not in range**
Refer to DTC P2227-P2230.
**⇓ BARO is within range**
7. Verify the scan tool MAP Sensor pressure and BARO parameters are within 3 kPa (0.4 psi) .

**⇒ The parameters are not within 3 kPa (0.4 psi).**
Refer to DTC P0106.
**⇓ The parameters are within 3 kPa (0.4 psi).**
8. Engine idling.
9. Verify the scan tool MAP Sensor pressure parameter is between 26–52 kPa (3.8–7.5 psi) and changes with accelerator pedal input.
**⇒ If not between 26–52 kPa (3.8–7.5 psi) or does not change**
Refer to DTC P0106.
**⇓ If between 26–52 kPa (3.8–7.5 psi) and changes**
10. Verify the scan tool MAF Sensor g/s parameter changes smoothly and gradually as the engine speed is increased and decreased while performing the actions listed below.
10.1. Engine idling
10.2. Perform the scan tool snapshot function.
10.3. Increase the engine speed slowly to 3,000 RPM and then back to idle.
10.4. Exit from the scan tool snapshot and review the data.
10.5. Observe the MAF Sensor parameter frame by frame with a scan tool.
**⇒ The MAF Sensor parameter does not change smoothly and gradually**
Refer to DTC P0101.
**⇓ The MAF Sensor parameter changes smoothly and gradually**
11. Verify the scan tool Boost Pressure Sensor pressure and BARO parameters are within 3 kPa (0.4 psi) .
**⇒ The parameters are not within 3 kPa (0.4 psi).**
Refer to Circuit/System Testing
**⇓ The parameters are within 3 kPa (0.4 psi).**
12. Verify the scan tool MAP Sensor parameter and the Boost Pressure Sensor parameter are within 20 kPa (2.9 psi) during a WOT acceleration at the time of the 1-2 shift.
**⇒ The parameters are not within 20 kPa (2.9 psi)**
Refer to Circuit/System Testing.
**⇓ The parameters are within 20 kPa (2.9 psi)**
13. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
14. Verify a DTC does not set.
**⇒ If a DTC sets**
Refer to Circuit/System Testing.
**⇓ If a DTC does not set**
15. All OK.

### 8.2.3.42.11. Circuit/System Testing

1. Verify that DTC P0237 or P0238 is not set.
**⇒ If a DTC is set**
Refer to DTC P0237 or P0238.
**⇓ If none of the DTCs are set**
2. Verify the conditions listed below do not exist:
- Loose clamps, cracks, or other damage in the air intake duct system
- Collapsed or restricted air intake duct system
- Restricted air filter
- Splits, kinks or improper connections at the vacuum hoses
- Missing, restricted or leaking exhaust components — Refer to Symptoms Engine Exhaust.
- Vacuum leaks at the intake manifold and throttle body

**⇒ If a condition exists**
Repair as necessary.
**⇓ If none of the conditions exist**
3. Replace the B111B turbocharger boost/intake air temperature sensor.

### 8.2.3.42.12. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Intake Air Pressure and Temperature Sensor Replacement for turbocharger boost/intake air temperature sensor replacement.
- Control Module References for engine control module replacement, programming, and setup

## 8.2.3.43. DTC P0237 or P0238

### 8.2.3.43.1. Diagnostic Instructions

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

### 8.2.3.43.2. DTC Descriptors

**DTC P0237**

Turbocharger Boost Sensor Circuit Low Voltage

**DTC P0238**

Turbocharger Boost Sensor Circuit High Voltage

### 8.2.3.43.3. Diagnostic Fault Information

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage | Signal Performance |
|---|---|---|---|---|
| 5 V Reference | P0236, P0237, P0340, P0365, P0452, P0532, P0641, P2227 | P0236, P0237, P2227 | P0236, P0238, P0453, P0641, P2227 | P0236 |
| Intake Air Pressure Signal | P0236, P0237, P2227 | P0236, P0237, P2227 | P0236, P0238, P2227 | P0236 |
| Low Reference | - | P0098, P0236, P0238, P2227 | - | - |

### 8.2.3.43.4. Typical Scan Tool Data

**Boost Pressure Sensor**

| Circuit | Short to Ground | Open | Short to Voltage |
|---|---|---|---|
| 5 V Reference | 0 kPa (0 psi) | 0 kPa (0 psi) | 269 kPa (39 psi) |
| Boost Pressure Signal | 0 kPa (0 psi) | 0 kPa (0 psi) | 269 kPa (39 psi) |
| Low Reference | - | 267 kPa (38.7 psi) | - |

### 8.2.3.43.5. Circuit Description

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

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

#### 8.2.3.43.6.Conditions for Running the DTC

- Ignition is ON or the engine is running.
- The DTCs run continuously when the above conditions have been met.

#### 8.2.3.43.7.Conditions for Setting the DTC

**P0237**
The ECM detects that the boost pressure sensor voltage is less than 1.0 V for greater than 5 s.
**P0238**
The ECM detects that the boost pressure sensor voltage is greater than 4.7 V for greater than 5 s.

#### 8.2.3.43.8.Action Taken When the DTC Sets

- DTCs P0237 and P0238 are Type B DTCs.
- The ECM will disable boost control and limit the system to mechanical boost only, resulting in a substantial decrease in engine power.

#### 8.2.3.43.9.Conditions for Clearing the MIL/DTC

DTCs P0237 and P0238 are Type B DTCs.

#### 8.2.3.43.10. Reference Information

**Schematic Reference**
Engine Controls Schematics
**Connector End View Reference**
Component Connector End Views
**Description and Operation**
Turbocharger System Description
**Electrical Information Reference**
- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

**DTC Type Reference**
Powertrain Diagnostic Trouble Code (DTC) Type Definitions
**Scan Tool Reference**
Control Module References for scan tool information

#### 8.2.3.43.11. Circuit/System Verification

1. Verify that DTC P0641 is not set.
**⇒ If the DTC is set**
Refer to DTC P0641, P0651, P0697, or P06A3.
**⇓ If the DTC is not set**
2. Verify the scan tool BARO parameter is within the range specified in the Altitude Versus Barometric Pressure table, for the current vehicle testing altitude.
**⇒ BARO is not in range.**
Refer to DTC P2227P2230.
**⇓ BARO is within range.**
3. Verify the scan tool Boost Pressure Sensor pressure and BARO parameters are within 3 kPa (0.4 psi).
**⇒ The parameters are not within 3 kPa (0.4 psi).**
Refer to Circuit/System Testing.
**⇓ The parameters are within 3 kPa (0.4 psi).**

4. Verify the scan tool MAP Sensor parameter and the Boost Pressure Sensor parameter are within 20 kPa (2.9 psi) during a WOT acceleration at the time of the 1-2 shift.
**⇒ The parameters are not within 20 kPa (2.9 psi).**
Refer to Circuit/System Testing.
**⇓ The parameters are within 20 kPa (2.9 psi).**
5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify a DTC does not set.
**⇒ If the DTC sets**
Refer to Circuit/System Testing.
**⇓ If the DTC does not set**
7. All OK.

#### 8.2.3.43.12. Circuit/System Testing

1. Ignition OFF, and all vehicle systems OFF, disconnect the harness connector at the B111B turbocharger boost/intake air temperature sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal 1 and ground.
**⇒ If 5 Ω or greater**
2.1. Ignition OFF, disconnect the X1 harness connector at the K20 engine control module.
2.2. Test for less than 2 Ω in the low reference circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, replace the K20 engine control module.
**⇓ If less than 5 Ω**
3. Ignition ON.
4. Test for 4.8–5.2 V between the 5 V reference circuit terminal 3 and ground.
**⇒ If less than 4.8 V**
4.1. Ignition OFF, disconnect the X1 harness connector at the K20 engine control module.
4.2. Test for infinite resistance between the 5 V reference circuit and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇓ If infinite resistance
4.3. Test for less than 2 Ω in the 5 V reference circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, replace the K20 engine control module.

| **Note:** |
| --- |
| If the signal circuit is shorted to a voltage the engine control module or the sensor may be damaged. |

**⇒ If greater than 5.2 V**
4.1. Ignition OFF, disconnect the X1 harness connector at the K20 engine control module, ignition ON.
4.2. Test for less than 1 V between the 5 V reference circuit and ground.
⇒ If 1 V or greater, repair the short to voltage on the circuit.
⇒ If less than 1 V, replace the K20 engine control module.
**⇓ If between 4.8–5.2 V**
5. Verify the scan tool Boost Pressure Sensor voltage parameter is less than 0.2 V.
**⇒ If 0.2 V or greater**
5.1. Ignition OFF, disconnect the X1 harness connector at the K20 engine control module, ignition ON.
5.2. Test for less than 1 V between the signal circuit terminal 4 and ground.
⇒ If 1 V or greater, repair the short to voltage on the circuit.
⇒ If less than 1 V, replace the K20 engine control module.
**⇓ If less than 0.2 V**
6. Install a 3 A fused jumper wire between the signal circuit terminal 4 and the 5 V reference circuit terminal 3.
7. Verify the scan tool Boost Pressure Sensor voltage parameter is greater than 4.5 V.
**⇒ If 4.5 V or less**
7.1. Ignition OFF, remove the jumper wire, disconnect the X1 harness connector at the K20 engine control module.
7.2. Test for infinite resistance between the signal circuit terminal 4 and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇓ If infinite resistance

7.3. Test for less than 2 Ω in the signal circuit end to end.
⇒ If 2 Ω or greater, repair the open or high resistance in the circuit.
⇒ If less than 2 Ω, replace the K20 engine control module.

**⇓ If greater than 4.5 V**

8. Test or replace the B111B turbocharger boost/intake air temperature sensor.

#### 8.2.3.43.13. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.
Intake Air Pressure and Temperature Sensor Replacement for turbocharger boost/intake air temperature sensor replacement
Control Module References for ECM replacement, programming, and setup

## 8.2.3.44. DTC P0243, P0245, or P0246

### 8.2.3.44.1.Diagnostic Instructions

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

### 8.2.3.44.2.DTC Descriptors

**DTC P0243**
Turbocharger Wastegate Solenoid Valve Control Circuit
**DTC P0245**
Turbocharger Wastegate Solenoid Valve Control Circuit Low Voltage
**DTC P0246**
Turbocharger Wastegate Solenoid Valve Control Circuit High Voltage

### 8.2.3.44.3.Diagnostic Fault Information

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage | Signal Performance |
|---|---|---|---|---|
| Ignition Voltage Circuit | P0030, P0034, P0036, P0134, P0135, P0245, P0443, P0598* | P0030, P0033, P0034, P0036, P0134, P0135, P0140, P0141, P0243, P0245, P0443, P0597 | - | - |
| Control Circuit | P0245 | P0243 | P0010, P0013, P0246, P0443, P0690 | P0243 |
| * Ignition fuse opens. | | | | |

### 8.2.3.44.4.Circuit/System Description

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

- Ignition voltage
- Turbocharger wastegate solenoid control

At idle the turbocharger wastegate solenoid parameter is commanded to 0% by the ECM. When the engine load and RPM first increases under a wide open throttle, the turbocharger wastegate solenoid parameter should briefly be commanded as great as 90– 100%. When the proper level of boost pressure is attained, the ECM will decrease the PWM of the solenoid to a range of 65–85%. As soon as the throttle closes the ECM will command the turbocharger wastegate solenoid parameter back to 0%, in order to allow the turbocharger waste gate to open from the air pressure ratio differential, there by reducing the speed of the turbine.

### 8.2.3.44.5.Conditions for Running the DTC

- Ignition ON or engine running.

- The battery voltage is between 11–32 V.
- This DTC runs continuously within the enabling conditions.

#### 8.2.3.44.6.Conditions for Setting the DTC

The ECM detects an open, a short to ground, or a short to voltage on the turbocharger wastegate solenoid control circuit for greater than 0.5 s.

#### 8.2.3.44.7.Action Taken When the DTC Sets

DTCs P0243, P0245 and P0246 are Type B DTCs.

#### 8.2.3.44.8.Conditions for Clearing the DTC

DTCs P0243, P0245 and P0246 are Type B DTCs.

#### 8.2.3.44.9.Reference Information

**Schematic Reference**
Engine Controls Schematics
**Connector End View Reference**
Component Connector End Views
**Description and Operation**
Turbocharger System Description
**Electrical Information Reference**
- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

**DTC Type Reference**
Powertrain Diagnostic Trouble Code (DTC) Type Definitions
**Scan Tool Reference**
Control Module References for scan tool information

#### 8.2.3.44.10. Circuit/System Verification

1. Ignition ON
2. Verify a series of clicks, which increase in frequency, are heard or felt from the Q42 Turbocharger Wastegate Solenoid Valve when commanding the Turbocharger Wastegate Solenoid Valve between 15–100 % with a scan tool.

**⇒ If a series of clicks in increasing frequency are not heard or felt**
Refer to Circuit/System Testing.
**⇓ If a series of clicks in increasing frequency is heard or felt**

3. Verify the parameters listed below do not display Malfunction when commanding the Turbocharger Wastegate Solenoid Valve between 15–100 % with a scan tool.
   - Turbocharger Wastegate Solenoid Valve Control Circuit High Voltage Test Status
   - Turbocharger Wastegate Solenoid Valve Control Circuit Open Test Status
   - Turbocharger Wastegate Solenoid Valve Control Circuit Low Voltage Test Status

**⇒ If Malfunction is displayed**
Refer to Circuit/System Testing.
**⇓ If Malfunction is not displayed**

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

**⇒ If a DTC sets**
Refer to Circuit/System Testing
**⇓ If a DTC does not set**

6. All OK

#### 8.2.3.44.11. Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the Q42 Turbocharger Wastegate Solenoid Valve. Ignition ON.
2. Verify a test lamp illuminates between the ignition circuit terminal 2 and ground.

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

2.1. Ignition OFF, remove the test lamp.
2.2. Test for less than 2 Ω in the ignition circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.

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

2.1. Ignition OFF, remove the test lamp.

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

2.2. Test for infinite resistance between the ignition circuit and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇒ If infinite resistance, test all components connected to the ignition voltage circuit for a short and replace as necessary.

**⇓ If the test lamp illuminates**

3. Remove the test lamp.
4. Verify the scan tool Turbocharger Wastegate Solenoid Valve Control Circuit Low Voltage Test Status parameter is OK.

**⇒ If OK is not displayed**

4.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
4.2. Test for infinite resistance between the control circuit and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇒ If infinite resistance, replace the K20 Engine Control Module.

**⇓ If OK is displayed**

5. Verify the scan tool Turbocharger Wastegate Solenoid Valve Control Circuit High Voltage Test Status parameter is OK.

**⇒ If OK is not displayed**

5.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
5.2. Test for less than 1 V between the control circuit and ground.
⇒ If 1 V or greater, repair the short to voltage on the circuit.
⇒ If less than 1 V, replace the K20 Engine Control Module.

**⇓ If OK is displayed**

6. Install a 3 A fused jumper wire between the control circuit terminal 1 and the ignition circuit terminal 2.
7. Verify the scan tool Turbocharger Wastegate Solenoid Valve Control Circuit High Voltage Test Status parameter is Malfunction.

**⇒ If Malfunction is not displayed**

7.1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module.
7.2. Test for less than 2 Ω in the control circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, replace the K20 Engine Control Module.

**⇓ If Malfunction is displayed**

8. Test or replace the Q42 Turbocharger Wastegate Solenoid Valve.

#### 8.2.3.44.12. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.
Control Module References for ECM replacement, programming and setup

## 8.2.3.45. DTC P025A (Chassis Control Module)

### 8.2.3.45.1. Diagnostic Instructions

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

### 8.2.3.45.2. DTC Descriptor

**DTC P025A**
Fuel Pump Control Module Enable Circuit

### 8.2.3.45.3. Diagnostic Fault Information

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage | Signal Performance |
|---|---|---|---|---|
| Control | P025A | P025A | - | P025A |

### 8.2.3.45.4. Circuit/System Description

The engine control module (ECM) supplies voltage to the chassis control module when the ECM detects that the ignition is on. The voltage from the ECM to the chassis control module remains active for 2 seconds, unless the engine is in crank or run. While this voltage is being received, the chassis control module supplies a varying voltage to the fuel tank pump module in order to maintain the desired fuel line pressure.

### 8.2.3.45.5. Conditions for Running the DTC

The ignition is ON.

### 8.2.3.45.6. Conditions for Setting the DTC

The serial data message from the ECM to the chassis control module does not agree with the state of the control enable voltage signal supplied from the ECM to the chassis control module for more than 2 seconds.

### 8.2.3.45.7. Action Taken When the DTC Sets

DTC P025A is a Type A DTC.

### 8.2.3.45.8. Conditions for Clearing the DTC

DTC P025A is a Type A DTC.

### 8.2.3.45.9. Diagnostic Aids

The component code for the chassis control module will be K38. The chassis control module name will be used in Service Information, the Global Diagnostic System and the Service Programming System.

### 8.2.3.45.10. Reference Information

**Schematic Reference**
Engine Controls Schematics
**Connector End View Reference**
Component Connector End Views
**Description and Operation**
Fuel System Description

**Electrical Information Reference**

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

### 8.2.3.45.11. 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 K38 Chassis 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 K38 Chassis Control Module.

### 8.2.3.45.12. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.
Control Module References for ECM or chassis control module replacement, programming and setup

### 8.2.3.46. DTC P0300-P0304

#### 8.2.3.46.1. Diagnostic Instructions

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

#### 8.2.3.46.2. 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

#### 8.2.3.46.3. Circuit/System Description

The engine control module (ECM) uses information from the crankshaft position sensor and the camshaft position sensor to determine when a engine cylinder misfire is occurring. By monitoring variations in the crankshaft rotation speed for each cylinder, the ECM can detect individual cylinder misfire events.

Extreme cylinder misfire events can cause catalytic converter damage. The malfunction indicator lamp (MIL) will flash when the conditions for catalytic converter damage are present. DTCs P0301 through P0304 correspond to cylinders 1 through 4. When the ECM detects that one or more specific cylinders are misfiring, the DTC for the respective misfiring cylinder will set and up to 2 of the corresponding fuel injectors are disabled for a minimum of 30 s. The ECM will then re-enable the fuel injector and, after approximately 200 engine revolutions, will determine if the misfire is still present. If the misfire is still present, the ECM will disable the fuel injector again repeating the process. If the misfire is not present, the fuel injector will remain enabled by the ECM. In Spark Ignition Direct Injection (SIDI) system applications, if a fuel injector fault DTC is set during a misfire event, the ECM will not re-enable the injector.

#### 8.2.3.46.4. Conditions for Running the DTC

- DTCs P0016, P0101, P0102, P0103, P0112, P0113, P0117, P0118, P0121, P0122, P0123, P0222, P0223, P0315, P0335, P0336, P0502, P0651, and P2135 are not set.
- The engine speed is greater than 1000 RPM.
- The crankshaft and camshaft are syncronized.
- The ignition voltage is between 11–18 V.
- The engine coolant temperature (ECT) sensor is between −7 to +125°C (+19 to +257°F).
- The A/C compressor clutch is not changing states.
- The fuel tank level is greater than 15%.
- The ECM is not in fuel cutoff or deceleration fuel cutoff mode.
- The ECM is not receiving a rough road signal.
- The throttle angle is steady within 5%.
- The throttle angle is greater than 3% when the vehicle speed is greater than 5 km/h (3 MPH).
- The transmission is not changing gears.
- The antilock brake system (ABS) and the traction control system , if equipped, is not active.
- The DTCs run continuously when the above conditions are met.

#### 8.2.3.46.5.Conditions for Setting the DTC

**P0300**

The ECM detects a crankshaft rotation speed variation indicating a misfire rate sufficient to cause emissions levels to exceed a predetermined value or a misfire rate high enough to cause catalyst damage.

**P0301, P0302, P0303, or P0304**

The ECM detects a crankshaft rotation speed variation indicating a single cylinder misfire rate sufficient to cause emissions levels to exceed mandated standards.

#### 8.2.3.46.6.Action Taken When the DTC Sets

- DTCs P0300, P0301, P0302, P0303 and P0304 are Type B DTCs.
- The malfunction indicator lamp (MIL) will flash when the conditions for catalytic converter damage are present.

#### 8.2.3.46.7.Conditions for Clearing the DTC

DTCs P0300, P0301, P0302, P0303 and P0304 are Type B DTCs.

#### 8.2.3.46.8.Diagnostic Aids

- A misfire DTC could 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
  - An unbalanced drive shaft
  - Certain rough road conditions
  - Transmission operation
  - Cracked Spark Plug Insulators
  - Broken or weak valve spring
  - A damaged or defective accessory drive component or belt; remove the belt and safely operate the engine to evaluate if misfire counts go away.
- High resistance in the circuits of the injectors may set a misfire DTC without setting an injector DTC. Test the injector circuits of the affected cylinder(s) for a high resistance if you suspect a condition.
- If the condition is intermittent, observing the scan tool IC Circuit Test and Fuel Injector Circuit Test Status parameters may help isolate the condition. The circuit test status parameters will change from OK or Not Run to Fault/Malfunction if a condition exists.
- A condition in the heated O2 sensor (HO2S) heater control circuits may set a DTC P0300.

#### 8.2.3.46.9.Reference Information

**Description and Operation**

- Electronic Ignition System Description
- Fuel System Description

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

**Special Tools**

EL 26792 HEI Spark Tester

### 8.2.3.46.10. Circuit/System Verification

| Note: |
|---|
| Before starting the engine, review the freeze frame failure records data to determine if the misfire sets during a cold start or at operating temperature. If there is a cold start condition and the engine is started, the engine will need to be cooled down before the next attempt to start the engine within the fail conditions. |

1. Engine Running at normal operating temperature.
2. Verify there is no abnormal engine noise.

**⇒ If abnormal engine noise is present**

Refer to Symptoms Engine Mechanical.

**⇓ If abnormal engine noise is not present**

3. Perform the scan tool Crankshaft Position System Variation Learn procedure.
4. Verify no DTCs are set.

**⇒ If any DTCs other than P0300–P0304 are set**

Refer to Diagnostic Trouble Code (DTC) List Vehicle.

**⇒ If DTC P0300–P0304 is set**

Refer to Circuit/System Testing.

**⇓ If no DTCs are set**

5. Verify the scan tool Cylinder 1–4 Current Misfire Counter parameters do not increment.

**⇒ If increments**

Refer to Circuit/System Testing.

**⇓ If does not increment**

6. Engine Running, perform the Cylinder Power Balance Test with a scan tool.
7. Verify the engine speed changes when each injector is disabled and then enabled.

**⇒ If engine speed does not change**

Refer to Circuit/System Testing.

**⇓ If engine speed does change**

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

**⇒ If the DTC sets**

Refer to Circuit/System Testing.

**⇓ If the DTC does not set**

10. All OK.

### 8.2.3.46.11. Circuit/System Testing

1. Verify none of the following conditions listed below exist:
   - Damage, carbon tracking, or fluid intrusion of the spark plug boots and/or spark plugs
   - Vacuum hose splits, kinks, and incorrect connections
   - Engine vacuum leaks
   - Crankcase ventilation system for vacuum leaks
   - Fuel pressure that is too low or too high—Refer to Fuel System Diagnosis.
   - Contaminated fuel—Refer to Alcohol/Contaminants-in-Fuel Diagnosis.
   - Exhaust system restrictions

   **⇒ If a condition exists**

   Repair or replace as necessary.

   **⇓ If no conditions exist**

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

2. Ignition OFF, remove the K35 Ignition Coil Module from the spark plugs and connect the EL 26792 HEI Spark Tester to the appropriate spark plug boot, engine Cranking.
3. Verify the spark output.
**⇒ If no output or the output is weak**
Refer to Electronic Ignition System Diagnosis.
**⇓ If the output is good**
4. Ignition OFF.
5. Verify the conditions listed below. Refer to Ignition System Specifications.
- The correct spark plug type
- The correct spark plug gap
- The correct spark plug torque

**⇒ If a condition exists**
Repair or replace as necessary.
**⇓ If no conditions exist**
6. Exchange the suspect spark plug with another cylinder that is operating correctly.
7. Engine Running.
8. Verify the scan tool Cylinder 1–4 Current Misfire Counter does not increment for the cylinder where the suspect spark plug was installed.
**⇒ If increments**
Replace the spark plug.
**⇓ If does not increment**
9. Test or inspect for the conditions listed below:
- A lean or rich Q17 Fuel Injector—Refer to Fuel Injector Diagnosis.
- An engine mechanical condition—Refer to Symptoms Engine Mechanical.

### 8.2.3.46.12. Repair Instructions

- Ignition Coil Replacement
- Spark Plug Replacement

### 8.2.3.46.13. Repair Verification

1. Install any components or connectors that have been removed or replaced during diagnosis.
2. Perform any adjustment, programming or setup procedures that are required when a component or module is removed or replaced.
3. Clear the DTCs.
4. Turn OFF the ignition for 60 s.
5. If the repair was related to a DTC, duplicate the Conditions for Running the DTC and use the Freeze Frame/Failure Records, if applicable, in order to verify the DTC does not reset. If the DTC resets or another DTC is present, refer to the Diagnostic Trouble Code (DTC) List Vehicle and perform the appropriate diagnostic procedure.
6. Engine Running, verify the scan tool Cylinder 1–4 Current Misfire Counter parameters do not increment.
⇒ If the misfire counter parameters increment, a misfire condition still exists.
7. To verify that the performance of the catalytic converter has not been affected by the condition that set this DTC, perform the Repair Verification for DTC P0420. Refer to DTC P0420.

## 8.2.3.47. DTC P0315

### 8.2.3.47.1. Diagnostic Instructions

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

### 8.2.3.47.2. DTC Descriptor

**DTC P0315**
Crankshaft Position System Variation Not Learned

### 8.2.3.47.3. Circuit/System Description

The crankshaft position variation learn feature is used to calculate reference period errors caused by slight tolerance variations in the crankshaft, and the crankshaft position sensor. The calculated error allows the engine control module (ECM) to accurately compensate for reference period variations. This enhances the ability of the ECM to detect misfire events over a wider range of engine speed and load conditions.

The crankshaft position system variation compensating values are stored in ECM memory after a learn procedure has been performed and the ignition switch is turned to the OFF position for at least 30 s. If the actual variation is not within the crankshaft position system variation compensating values stored in the ECM, DTC P0300 may set.

If the crankshaft position system variation values are not stored in the ECM memory or a proper ECM power down does not occur after completing the Crankshaft Position Learn Procedure, DTC P0315 sets.

### 8.2.3.47.4. Conditions for Running the DTC

- Engine is Running.
- The DTC runs continuously when the above condition is met.

### 8.2.3.47.5. Conditions for Setting the DTC

The ECM detects that the crankshaft position system variation values are not stored in memory.

### 8.2.3.47.6. Action Taken When the DTC Sets

DTC P0315 is a Type A DTC.

### 8.2.3.47.7. Conditions for Clearing the DTC

DTC P0315 is a Type A DTC.

### 8.2.3.47.8. Diagnostic Aids

This test procedure requires that the vehicle battery has passed a load test and is completely charged. Refer to Battery Inspection/Test.

### 8.2.3.47.9. Reference Information

**DTC Type Reference**
Powertrain Diagnostic Trouble Code (DTC) Type Definitions
Scan Tool Reference
Control Module References for scan tool information

### 8.2.3.47.10. Circuit/System Verification

1. Perform the scan tool Crankshaft Position System Variation Learn procedure.
2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed in the Freeze Frame/Failure Records data.
3. Verify the DTC is not set.

**⇒ If the DTC sets**

Replace the K20 Engine Control Module.

**⇓ If the DTC does not set**

4. All OK

### 8.2.3.47.11. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.
Control Module References for ECM replacement, programming and setup

## 8.2.3.48. DTC P0324, P0326, or P06B6

### 8.2.3.48.1. Diagnostic Instructions

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

### 8.2.3.48.2. DTC Descriptor

**DTC P0324**
Knock Sensor Module Performance
**DTC P0326**
Knock Sensor Performance
**DTC P06B6**
Control Module Knock Sensor Processor Performance

### 8.2.3.48.3. Diagnostic Fault Information

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage | Signal Performance |
|---|---|---|---|---|
| High Signal | P0327, P06B6 | P0325 | P0328 | P0324*, P0326** |
| Low Signal | P0327 | P0325 | P0328 | P0324*, P0326** |
| * Signal Performance High<br>** Signal Performance Low | | | | |

### 8.2.3.48.4. Circuit/System Description

The knock sensor enables the engine control module (ECM) to control the ignition timing for the best possible performance while protecting the engine from potentially damaging levels of detonation. The knock sensor produces an alternating current (AC) voltage signal that varies depending on the vibration level during engine operation. The ECM adjusts the spark timing based on the amplitude and the frequency of the knock sensor signal. The ECM learns a minimum knock sensor noise level for all of the engine speed ranges and monitors the normal knock sensor signal. The ECM monitors the internal knock sensor processor test circuits which perform the open circuit diagnostic.

### 8.2.3.48.5. Conditions for Running the DTCs

**P0324 or P0326**

- Engine speed is between 400 and 8,500 RPM.
- Engine is running for greater than 2 s.
- 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).
  AND
- Engine speed is 400 RPM or greater for 200 or more cumulative revolutions.
  OR
- Engine speed is 8,500 RPM or greater.

**P06B6**

- Engine speed is between 500 and 5,500 RPM for 100 or more cumulative revolutions.
- Engine is running for greater than 2 s.

The DTCs run continuously when the above conditions are met.

#### 8.2.3.48.6.Conditions for Setting the DTCs

**P0324**

The ECM detects that the knock sensor signal performance is out of the normal calibrated range due to excessive engine knock on a per cylinder basis.

**P0326**

The ECM detects that the knock sensor signal performance is out of the normal calibrated range due to a low signal level.

**P06B6**

The ECM has detected a fault in the knock sensor processor open circuit diagnostic internal test circuit.

#### 8.2.3.48.7.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.

#### 8.2.3.48.8.Conditions for Clearing the DTCs

DTCs P0324, P0326, and P06B6 are Type B DTCs.

#### 8.2.3.48.9.Reference Information

**Description and Operation**

Electronic Ignition System Description

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

#### 8.2.3.48.10. 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 DTC P0325, P0327, or P0328.

**⇒ If only DTC P06B6 is set**

Replace the K20 Engine Control Module.

**⇓ If none of the DTCs are set**

3. Ignition OFF.
4. Verify none of the conditions listed below exist:
   - B68 Knock Sensor or wiring harness damage.
   - Incorrect B68 Knock Sensor installation. Refer to Fastener Tightening Specifications.
   - B68 Knock Sensor and engine mounting surface burrs, casting flash, and foreign material.
   - Close proximity of hoses, brackets, and engine wiring.
   - Loose brackets.
   - Loose or broken accessory drive belts, brackets, components.
   - An engine mechanical condition. Refer to Symptoms Engine Mechanical.
   - Contaminated or poor quality fuel.

**⇒ If a condition exists**

Repair or replace as necessary.

**⇓ If no conditions exist**

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

**⇒ If the DTC sets**

Test or replace the B68 Knock Sensor.

**⇓ If the DTC does not set**

6. All OK.

#### 8.2.3.48.11. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.
Knock Sensor Replacement
Control Module References for engine control module replacement, programming, and setup.

## 8.2.3.49. DTC P0325, P0327, or P0328

### 8.2.3.49.1. Diagnostic Instructions

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

### 8.2.3.49.2. DTC Descriptors

**DTC P0325**
Knock Sensor Circuit
**DTC P0327**
Knock Sensor Circuit Low Voltage
**DTC P0328**
Knock Sensor Circuit High Voltage

### 8.2.3.49.3. Diagnostic Fault Information

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

### 8.2.3.49.4. Circuit/System Description

The knock sensor enables the engine control module (ECM) to control the ignition timing for the best possible performance while protecting the engine from potentially damaging levels of detonation. The knock sensor produces an alternating current (AC) voltage signal that varies depending on the vibration level during engine operation. The ECM adjusts the spark timing based on the amplitude and the frequency of the knock sensor signal. The ECM learns a minimum knock sensor noise level for all of the engine speed ranges and monitors the normal knock sensor signal. The ECM monitors the internal knock sensor processor test circuits which perform the open circuit diagnostic.

### 8.2.3.49.5. Conditions for Running the DTCs

**P0325**
- Engine is running for 2 s or greater.
- Engine speed is between 500–7000 RPM for 67 or more cumulative revolutions.
- The engine coolant temperature (ECT) is −40°C (−40°F) or warmer.
- The intake air temperature (IAT) sensor is −40°C (−40°F) or warmer.

**P0327 or P0328**
- Engine speed is less than 8,500 RPM.

The DTCs run continuously when the above conditions are met.

### 8.2.3.49.6. Conditions for Setting the DTCs

**P0325**
The ECM detects that a knock sensor signal circuit is open for greater than 6 s.
**P0327**
The ECM detects that a knock sensor signal circuit is shorted to ground for greater than 6 s.
**P0328**
The ECM detects that a knock sensor signal circuit is shorted to voltage for greater than 6 s.

### 8.2.3.49.7.Action Taken When the DTCs Set

- DTCs P0325, P0327 and P0328 are Type B DTCs.
- The ignition timing is retarded to reduce the potential of engine damaging spark knock.

### 8.2.3.49.8.Conditions for Clearing the DTCs

DTCs P0325, P0327 and P0328 are Type B DTCs.

### 8.2.3.49.9.Diagnostic Aids

The following conditions listed below may cause a knock sensor DTC to set:

- Sensor damage.
- Knock sensor and engine mounting surface burrs, casting flash, and foreign material.
- Close proximity of hoses, brackets, and engine wiring.
- Loose brackets.
- Loose or broken accessory drive belts, brackets, components.
- An engine mechanical condition. Refer to Symptoms Engine Mechanical.

### 8.2.3.49.10. Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Description and Operation**

Electronic Ignition System Description

**Electrical Information Reference**

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

### 8.2.3.49.11. Circuit/System Verification

1. Engine Running
2. Verify DTC P0325, P0327 or P0328 is not set.

**⇒ If the DTC is set**

Refer to Circuit/System Testing.

**⇓ If the DTC is not set**

3. Verify the B68 Knock Sensor mounting bolt is properly tightened. Refer to Fastener Specifications.

**⇒ If not tightened to the correct specification**

Repair a necessary.

**⇓ If tightened to the correct specification**

4. Verify the scan tool parameters listed below display No while moving the related harnesses and connectors of the B68 Knock
Sensor.

- Cylinder 1 Knock Detected
- Cylinder 2 Knock Detected
- Cylinder 3 Knock Detected
- Cylinder 4 Knock Detected

**⇒ If No is not displayed**

Repair the wiring harness or connectors.

**⇓ If No is displayed**

5. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify the DTC does not set.

**⇒ If the DTC sets**

Refer to Circuit/System Testing.

**⇓ If the DTC does not set**

7. All OK.

### 8.2.3.49.12. Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the B68 Knock Sensor, ignition ON.
2. Test for 1–2 V between the low signal circuit terminal 2 and ground.

**⇒ If less than 1 V**

2.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2.2. Test for infinite resistance between the low signal circuit terminal 2 and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇓ If infinite resistance.
2.3. Test for less than 2 Ω in the low signal circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, replace the K20 Engine Control Module.

**⇒ If greater than 2 V**

2.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
2.2. Test for less than 1 V between the low signal circuit and ground.
⇒ If 1 V or greater, repair the short to voltage on the circuit.
⇒ If less than 1 V, replace the K20 Engine Control Module.

**⇓ If between 1–2 V**

3. Test for 2–4 V between the high signal circuit terminal 1 and ground.

**⇒ If less than 2 V**

3.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
3.2. Test for infinite resistance between the high signal circuit terminal 1 and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇓ If infinite resistance.
3.3. Test for less than 2 Ω in the high signal circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, replace the K20 Engine Control Module.

**⇒ If greater than 4 V**

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 high signal circuit and ground.
⇒ If 1 V or greater, repair the short to voltage on the circuit.
⇒ If less than 1 V, replace the K20 Engine Control Module.

**⇓ If between 2–4 V**

4. Test or replace the B68 Knock Sensor.

### 8.2.3.49.13. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Knock Sensor Replacement
- Control Module References for engine control module replacement, programming, and setup.

## 8.2.3.50. DTC P0335 or P0336

### 8.2.3.50.1.Diagnostic Instructions

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

### 8.2.3.50.2.DTC Descriptors

**DTC P0335**
Crankshaft Position Sensor Circuit
**DTC P0336**
Crankshaft Position Sensor Performance

### 8.2.3.50.3.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 |

### 8.2.3.50.4.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.

### 8.2.3.50.5.Conditions for Running the DTC

**P0335 Condition 1**
- DTCs P0101, P0102 and P0103 are not set.
  OR
- The starter is engaged and the engine control module detects camshaft position sensor pulses.
  AND
- The airflow into the engine is greater than 2 g/s.

**Condition 2**
- DTC P0651 is not set.
- The engine is running and the starter is not engaged.

**Condition 3**
- DTCs P0365, P0366, P0641, or P0651 are not set.
- The engine is running or the starter is engaged.

**P0336 Condition 1**

- DTCs P0335 or P0651 are not set.
- The airflow into the engine is greater than 2 g/s.
- Engine speed is greater than 450 RPM.

**Condition 2**

- DTC P0651 is not set.
- The engine is running and the starter is not engaged.

**Condition 3**

- DTCs P0101, P0102, and P0103 are not set.
- The airflow into the engine is greater than 2 g/s.
  OR
- The starter is engaged and the engine control module detects camshaft position sensor pulses.

**Condition 4**

- DTCs P0365, P0366, P0641, or P0651 are not set.
- The engine is running or the starter is engaged.
- The DTCs run continuously once the above conditions are met.

### 8.2.3.50.6. 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 resynchronizations 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.

### 8.2.3.50.7. 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.

### 8.2.3.50.8. Conditions for Clearing the DTC

DTCs P0335 and P0336 are Type B DTCs.

### 8.2.3.50.9. Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Description and Operation**

Electronic Ignition System Description

**Electrical Information Reference**

- Circuit Testing

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

### 8.2.3.50.10. Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0651 is not set.

**⇒ If the DTC is set**

Refer to DTC P0641, P0651, P0697, or P06A3.

**⇓ If the DTC is not set**

3. Engine Running.
4. Verify the scan tool Crankshaft Position Active Counter parameter increments.

**⇒ If the counter does not increment**

Refer to Circuit/System Testing.

**⇓ If the counter increments**

5. Verify the scan tool Crankshaft Position Resync Counter parameter displays 0 counts and the engine does not stumble or stall while moving the related harness/connectors of the B26 Crankshaft Position Sensor.

**⇒ If greater than 0 counts and the engine stumbles or stalls**

Refer to Circuit/System Testing.

**⇓ If 0 counts and the engine does not stumble or stall**

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

**⇒ If the DTC sets**

Refer to Circuit/System Testing.

**⇓ If the DTC does not set**

8. All OK.

### 8.2.3.50.11. Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B26 Crankshaft Position Sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal 2 and ground.

**⇒ If 5 Ω or greater**

2.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.
2.2. Test for less than 2 Ω in the low reference circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If 2 Ω or less, replace the K20 Engine Control Module.

**⇓ If less than 5 Ω**

3. Ignition ON.
4. Test for 4.8–5.2 V between the 5 V reference circuit terminal 1 and ground.

**⇒ If less than 4.8 V**

4.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.
4.2. Test for infinite resistance between the 5 V reference circuit and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇓ If infinite resistance
4.3. Test for less than 2 Ω in the 5 V reference circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, replace the K20 Engine Control Module.

**⇒ If greater than 5.2 V**

4.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module, ignition ON.
4.2. Test for less than 1 V between the 5 V reference and ground.

⇒ If 1 V or greater, repair the short to voltage on the circuit.
⇒ If less than 1 V, replace the K20 Engine Control Module.

**⇓ If between 4.8–5.2 V**

5. Test for 4.8–5.2 V between the signal circuit terminal 3 and ground.

**⇒ If less than 4.8 V**

5.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.
5.2. Test for infinite resistance between the signal circuit and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇓ If infinite resistance.
5.3. Test for less than 2 Ω in the signal circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, replace the K20 Engine Control Module.

**⇒ If greater than 5.2 V**

5.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module, ignition ON.
5.2. Test for less than 1 V between the signal circuit and ground.
⇒ If 1 V or greater, repair the short to voltage on the circuit.
⇒ If less than 1 V, replace the K20 Engine Control Module.

**⇓ If between 4.8–5.2 V**

6. Ignition OFF, connect a 3 A fused jumper wire to the signal circuit terminal 3, ignition ON.

| **Note:** |
|---|
| Additional DTCs may set when performing this test. |

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

**⇒ If the counter does not increment**

Replace the K20 Engine Control Module.

**⇓ If the counter increments**

8. Verify DTC P0336 is not set.

**⇒ If the DTC is set**

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

⇒ If any of the conditions above are found, repair as necessary.
⇒ If all components test normal, test or replace the B26 Crankshaft Position Sensor.

**⇓ If the DTC is not set**

9. Test or replace the B26 Crankshaft Position Sensor.

#### 8.2.3.50.12. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Crankshaft Position Sensor Replacement
- Control Module References for engine control module replacement, programming, and setup

## 8.2.3.51. DTC P0340, P0341, P0365, or P0366

### 8.2.3.51.1. Diagnostic Instructions

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

### 8.2.3.51.2. 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

### 8.2.3.51.3. Diagnostic Fault Information

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage | Signal Performance |
|---|---|---|---|---|
| 5 V Reference | P0107, P0452, P0532, P0641 | P0340, P0365 | P0641 | - |
| Signal | P0340, P0365 | P0340, P0365 | P0340, P0365 | P0341, P0366 |
| Low Reference | - | P0340, P0365 | P0340, P0365 | - |

### 8.2.3.51.4. 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 4tooth 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.

### 8.2.3.51.5. Conditions for Running the DTC

**P0340 or P0365 Condition 1**

- DTCs P0101, P0102, and P0103 are not set.
- The airflow into the engine is greater than 2 g/s.
  OR
- The starter is engaged and the engine control module detects camshaft position sensor pulses.

**Condition 2**

- DTC P0651 is not set.
- The engine is running and the starter is not engaged.

**Condition 3**

- DTC P0335, P0336, P0641, or P0651 are not set.
- The crankshaft is synchronized.
- The starter is engaged.

**Condition 4**

- DTC P0335, P0336, P0641, or P0651 are not set.
- The crankshaft is synchronized.

**P0341 or P0366 Condition 1**

- DTC P0335, P0336, P0641, or P0651 are not set.
- The crankshaft is synchronized.
- The starter is engaged.

**Condition 2**

- DTC P0335, P0336, P0641, or P0651 are not set.
- The crankshaft is synchronized.
- The DTCs run continuously once the above conditions are met.

#### 8.2.3.51.6. 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.

#### 8.2.3.51.7. 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.

#### 8.2.3.51.8. Conditions for Clearing the MIL/DTC

DTCs P0340, P0341, P0365, and P0366 are Type B DTCs.

#### 8.2.3.51.9. Diagnostic Aids

- With a DTC set, the engine may crank for an extended period of time at startup
- 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.

#### 8.2.3.51.10. Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Description and Operation**

Electronic Ignition System Description

**Electrical Information Reference**

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

### 8.2.3.51.11. 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.

**⇓ 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.

### 8.2.3.51.12. Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the appropriate B23 Camshaft Position Sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal 2 and ground.

**⇒ If 5 Ω or greater**

2.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.
2.2. Test for less than 2 Ω in the low reference circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If 2 Ω or less, replace the K20 Engine Control Module.

**⇓ If less than 5 Ω**

3. Ignition ON.
4. Test for 4.8–5.2 V between the 5 V reference circuit terminal 1 and ground.

**⇒ If less than 4.8 V**

4.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.
4.2. Test for infinite resistance between the 5 V reference circuit and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇓ If infinite resistance.
4.3. Test for less than 2 Ω in the 5 V reference circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω , replace the K20 Engine Control Module.

**⇒ If greater than 5.2 V**

4.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module, ignition ON.
4.2. Test for less than 1 V between the 5 V reference circuit and ground.
⇒ If 1 V or greater, repair the short to voltage on the circuit.
⇒ If less than 1 V, replace the K20 Engine Control **Module**.

**⇓ If between 4.8–5.2 V**

5. Test for 4.8–5.2 V between the signal circuit terminal 3 and ground.

**⇒ If less than 4.8 V**

5.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.
5.2. Test for infinite resistance between the signal circuit and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇓ If infinite resistance.
5.3. Test for less than 2 Ω in the signal circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, replace the K20 Engine Control Module.

**⇒ If greater than 5.2 V**

5.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module, ignition ON.
5.2. Test for less than 1 V between the signal circuit and ground.
⇒ If 1 V or greater, repair the short to voltage on the circuit.
⇒ If less than 1 V, replace the K20 Engine Control Module.

**⇓ If between 4.8–5.2 V**

6. Verify DTC P0341 or P0366 is not set.

**⇒ If any of the DTCs are set**

Inspect for the conditions listed below:

- Excessive play or looseness of the B23 Camshaft Position Sensor or the reluctor wheel
- Improper installation of the B23 Camshaft Position Sensor
- Foreign material passing between the B23 Camshaft Position Sensor and the reluctor wheel
- Damaged reluctor wheel
- Excessive air gap between the B23 Camshaft Position Sensor and the reluctor wheel
- Engine oil for debris
- Timing chain, tensioner, and sprockets for wear or damage

⇒ If any of the conditions above are found, repair as necessary.
⇒ If all components test normal, test or replace the B23 Camshaft Position Sensor.

**⇓ If none of the DTCs are set**

7. Test or replace the B23 Camshaft Position Sensor.

### 8.2.3.51.13. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Camshaft Position Sensor Replacement
- Control Module References for engine control module replacement, programming, and setup

## 8.2.3.52. DTC P0351-P0354, P2300, P2301, P2303, P2304, P2306, P2307, P2309, or P2310

### 8.2.3.52.1.Diagnostic Instructions

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

### 8.2.3.52.2.DTC Descriptors

**DTC P0351**
Ignition Coil 1 Control Circuit
**DTC P0352**
Ignition Coil 2 Control Circuit
**DTC P0353**
Ignition Coil 3 Control Circuit
**DTC P0354**
Ignition Coil 4 Control Circuit
**DTC P2300**
Ignition Coil 1 Control Circuit Low Voltage
**DTC P2301**
Ignition Coil 1 Control Circuit High Voltage
**DTC P2303**
Ignition Coil 2 Control Circuit Low Voltage
**DTC P2304**
Ignition Coil 2 Control Circuit High Voltage
**DTC P2306**
Ignition Coil 3 Control Circuit Low Voltage
**DTC P2307**
Ignition Coil 3 Control Circuit High Voltage
**DTC P2309**
Ignition Coil 4 Control Circuit Low Voltage
**DTC P2310**
Ignition Coil 4 Control Circuit High Voltage

### 8.2.3.52.3.Diagnostic Fault Information

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage | Signal Performance |
|---|---|---|---|---|
| Ignition Coil 1 Control | P0300, P0351*, P2300* | P0300, P0351 | P0300, P0351*, P2301* | P0300, P0351 |
| Ignition Coil 2 Control | P0300, P0352*, P2303* | P0300, P0352 | P0300, P0352*, P2304* | P0300, P0352 |
| Ignition Coil 3 Control | P0300, P0353*, P2306* | P0300, P0353 | P0300, P0353*, P2307* | P0300, P0353 |
| Ignition Coil 4 Control | P0300, P0354*, P2309* | P0300, P0354 | P0300, P0354*, P2310* | P0300, P0354 |
| * Depending on the application, either DTC could set. | | | | |

### 8.2.3.52.4.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.

**8.2.3.52.5.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.

**8.2.3.52.6.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.

**8.2.3.52.7.Action Taken When the DTC Sets**

DTCs P0351, P0352, P0353, P0354, P2300, P2301, P2303, P2304, P2306, P2307, P2309, or P2310 are Type B DTCs.

**8.2.3.52.8.Conditions for Clearing the MIL/DTC**

DTCs P0351, P0352, P0353, P0354, P2300, P2301, P2303, P2304, P2306, P2307, P2309, or P2310 are Type B DTCs.

**8.2.3.52.9.Reference Information**

**Schematic Reference**
Engine Controls Schematics
**Connector End View Reference**
Component Connector End Views
**Description and Operation**
Electronic Ignition System Description
**Electrical Information Reference**
Circuit Testing
Connector Repairs
Testing for Intermittent Conditions and Poor Connections
Wiring Repairs
**DTC Type Reference**
Powertrain Diagnostic Trouble Code (DTC) Type Definitions
**Scan Tool Reference**
Control Module References for scan tool information

**8.2.3.52.10. 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.

### 8.2.3.52.11. Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the K35 Ignition Coil Module.
2. Remove the fuel injector fuse.
3. Connect a DMM between the appropriate K35 Ignition Coil Module control circuit listed below and ground. Set the DMM to the DC Hz scale and utilize the Min-Max function:
   - Ignition Coil 1 terminal D
   - Ignition Coil 2 terminal E
   - Ignition Coil 3 terminal F
   - Ignition Coil 4 terminal G
4. Verify the DMM displays greater than 1.5 Hz while cranking the engine.

**⇒ If less than 1.5 Hz**

4.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.
4.2. Test for infinite resistance between the control circuit and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇓ If infinite resistance
4.3. Test for less than 2 Ω in the control circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇓ If less than 2 Ω
4.4. Ignition ON.
4.5. Test for less than 1 V between the control circuit and ground.
⇒ If 1 V or greater, repair the short to voltage on the circuit.
⇒ If less than 1 V, replace the K20 Engine Control Module.

**⇓ If greater than 1.5 Hz**

5. Replace the K35 Ignition Coil Module.

### 8.2.3.52.12. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.
- Ignition Coil Replacement
- Control Module References for engine control module replacement, programming, and setup

## 8.2.3.53. DTC P0420

### 8.2.3.53.1.Diagnostic Instructions

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

### 8.2.3.53.2.DTC Descriptor

**DTC P0420**

Catalyst System Low Efficiency

### 8.2.3.53.3.Circuit/System Description

| Note: |
|---|
| A new converter with less than 160 km (100 mi) on it may set DTC P0420 due to outgassing of the internal matting. Operating the vehicle at highway speeds for approximately 1 h may correct the condition. |

A 3-way catalyst controls emissions of hydrocarbons, carbon monoxide (CO), and oxides of nitrogen (NOX). The catalyst within the converter promotes a chemical reaction, which oxidizes the hydrocarbon(s) and the CO that are present in the exhaust gas. This process converts the hydrocarbon(s) and the CO into water vapor and carbon dioxide ($CO_2$), and reduces the NOX, converting the NOX into nitrogen. The catalyst also stores oxygen. The engine control module (ECM) monitors this process by using a heated oxygen sensor (HO2S) that is in the exhaust stream after the three way catalyst. The HO2S 2 produces an output signal that the ECM uses to calculate the oxygen storage capacity of the catalyst. This indicates the ability of the catalyst to convert the exhaust emissions efficiently. The ECM monitors the efficiency of the catalyst by allowing the catalyst to heat, then wait for a stabilization period while the engine is idling. The ECM then adds and removes fuel while monitoring the HO2S 2. When the catalyst is functioning properly, the HO2S 2 response to the extra fuel is slow compared to the response of the HO2S 1, which is located before the three way catalyst. When the HO2S 2 response is near that of the HO2S 1, the oxygen storage capability and efficiency of the catalyst may be degraded below an acceptable threshold.

### 8.2.3.53.4.Conditions for Running the DTC

- DTCs P000A, P000B, P0010, P0013, P0016, P0017, P0030, P0031, P0032, P0036, P0038, P0117, P0118, P0119, P0121, P0122, P0123, P0131, P0132, P0133, P0134, P0135, P0136, P0137, P0138, P0139, P0140, P0141, P0171, P0201, P0202, P0203, P0204, P0221, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0301, P0302, P0303, P0304, P0335, P0336, P0340, P0365, P0366, P0443, P0446, P0458, P0459, P0496, P0562, P0563, P0642, P0643, P0652, P0653, P0661, P0662, P2088, P2089, P2090, P2091, P2096, P2097, P2100, P2101, P2122, P2123, P2127, P2128, P2176, P2297, P2301, P2303, P2304, P2306,P2307, P2309, P2310, P2A00, P2A0 are not set.
- The engine speed is greater than 1 200 RPM for a minimum of 2 s.
- The vehicle speed is less than 1.24 MPH.
- The intake mass air flow (MAF) is between 2.00–7.00 g/s.
- The vehicle is in closed loop.
- The calculated exhaust mass gas flow is between 5–55.56 g/s, and stable.
- The calculated catalyst temperature is between 480–800°C (896–1 472°F).
- The rear heated oxygen sensor (HO2S) has exceeded the dew point for more than 60 s.
- This diagnostic attempts one test during each period when the above conditions have been met. This diagnostic attempts up to
- 4 tests during each drive cycle.

### 8.2.3.53.5.Conditions for Setting the DTC

- The ECM has determined the catalyst efficiency has degraded below a calibrated threshold.

- This diagnostic may conclude in 6 test attempts which will require at least 2 drive cycles. However, this diagnostic may require as many as 8 test attempts. Depending on driving conditions, more than 2 drive cycles may be required. Each test attempt may conclude within approximately 1 min.

**8.2.3.53.6.Action Taken When the DTC Sets**

DTC P0420 is a Type A DTC.

**8.2.3.53.7.Conditions for Clearing the DTC**

DTC P0420 is a Type A DTC.

**8.2.3.53.8.Diagnostic Aids**

Inspect for the following conditions, which may cause a catalyst to degrade:

- An engine misfire
- High engine oil or high coolant consumption
- Retarded spark timing
- A weak or poor spark
- A lean fuel mixture
- A rich fuel mixture
- A damaged oxygen sensor or wiring harness

**8.2.3.53.9.Reference Information**

**Schematic Reference**
Engine Controls Schematics
**Connector End View Reference**
Component Connector End Views
**Electrical Information Reference**
- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

**DTC Type Reference**
Powertrain Diagnostic Trouble Code (DTC) Type Definitions
**Scan Tool Reference**
Control Module References for scan tool information

**8.2.3.53.10. Circuit/System Testing**

1. Engine idling, observe the DTC information with a scan tool. Verify there are no HO2S or misfire DTCs set.
⇒ If any of the DTCs are set, refer to Diagnostic Trouble Code (DTC) List Vehicle.
2. Verify the following conditions do not exist with the catalyst:
   - Dents
   - A severe discoloration caused by excessive temperatures
   - Road damage
   - An internal rattle caused by damaged catalyst subset
   - Restrictions

   ⇒ If a condition is found, replace the catalyst
3. Verify the following conditions do not exist with the exhaust system:
   - Leaks
   - Physical damage
   - Loose or missing hardware
   - Properly torqued B52A Heated Oxygen Sensor 1 or B52B Heated Oxygen Sensor 2

   ⇒ If a condition is found, repair the exhaust system.

⇒ If the DTC fails this key cycle, continue with this procedure.

4. Verify the following conditions do not exist with the B52B Heated Oxygen Sensor 2.
   - A grounded B52B Heated Oxygen Sensor 2 wiring harness
   - Damage

   ⇒ If a condition is found, replace the B52B Heated Oxygen Sensor 2.
5. If no physical condition is detected and the B52B Heated Oxygen Sensor 2 is as active as the B52A Heated Oxygen Sensor 1 after operating the engine at 1 500 RPM for 1 min and then returning to a stabilized idle, then replace the catalyst.

### 8.2.3.53.11. Repair Instructions

| Note: |
| --- |
| A new converter with less than 160 km (100 mi) on it may set DTC P0420 due to outgassing of the internal matting. Operating the vehicle at highway speeds for approximately 1 h may correct the condition. |

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

- Heated Oxygen Sensor Replacement – Sensor 1
- Heated Oxygen Sensor Replacement- Sensor 2
- Catalytic Converter Replacement
- Exhaust Leakage
- Symptoms – Engine Exhaust

## 8.2.3.54. DTC P0442

### 8.2.3.54.1.Diagnostic Instructions

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

### 8.2.3.54.2.DTC Descriptor

DTC P0442
Evaporative Emission (EVAP) System Small Leak Detected

### 8.2.3.54.3.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.

### 8.2.3.54.4.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 63°C (145°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 5 km (3 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 if passed or 10 h if failed.

### 8.2.3.54.5.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.

### 8.2.3.54.6.Action Taken When the DTC Sets

DTC P0442 is a Type A DTC.

### 8.2.3.54.7.Conditions for Clearing the DTC

DTC P0442 is a Type A DTC.

#### 8.2.3.54.8.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 move all EVAP components while observing smoke with the GE-41413-SPT.
- Individual components can be isolated and tested using adapters in the GE 41413-300.
- When servicing the EVAP system, test pressure must not exceed 13 in H20 (0.5 PSI) as pressure in excess of this could cause system components to perform inaccurately.
- A condition may exist where a leak in the EVAP system only exists under a vacuum condition. This type of leak may be detected by using the scan tool Purge/Seal function to create a vacuum in the EVAP system and then observe the FTP parameter for vacuum decay.

#### 8.2.3.54.9.Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Description and Operation**

Evaporative Emission Control System Description

**Electrical Information Reference**

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

**Special Tools**

CH 48096 EVAP Service 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

#### 8.2.3.54.10. Circuit/System Testing

| Note: |
|---|
| • Refer to the GE 41413-A operation manual for detailed instructions in Evaporative Emission Control System Diagnosis<br>• 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.<br>• Ensure that the underbody temperature of the vehicle and the tester are similar. |

1. Disconnect the purge tube at the quick connector on the EVAP canister side of the Q12 Evaporative Emission Canister Purge Solenoid Valve and install the CH 48096.
2. Connect the GE 41413A to the CH 48096.
3. Command the EVAP Purge/Seal function to System Seal with a scan tool to seal the EVAP system.
4. Use the flow meter on the GE 41413A , 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 41413A to apply smoke to the EVAP system at the purge tube until the leak is located using the GE 41413SPT

⇓ No leak in the EVAP system

5. All OK.

#### 8.2.3.54.11. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

## 8.2.3.55. DTC P0443, P0458, or P0459

### 8.2.3.55.1.Diagnostic Instructions

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

### 8.2.3.55.2.DTC Descriptors

**DTC P0443**
Evaporative Emission (EVAP) Purge Solenoid Valve Control Circuit
**DTC P0458**
Evaporative Emission (EVAP) Purge Solenoid Valve Control Circuit Low Voltage
**DTC P0459**
Evaporative Emission (EVAP) Purge Solenoid Valve Control Circuit High Voltage

### 8.2.3.55.3.Diagnostic Fault Information

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage |
|---|---|---|---|
| Ignition Voltage | P0031, P0037, P0134 P0135, P0443, P0458, P0597, P0598, P0660, P0661 | P0031, P0037, P0135, P0443, P0458, P0597, P0598, P0660, P0661 | - |
| Control | P0443, P0458 | P0443 | P0459 |

### 8.2.3.55.4.Circuit/System Description

The evaporative emission (EVAP) purge solenoid valve is used to purge fuel vapor from the EVAP canister to the intake manifold. The EVAP purge solenoid valve is pulse width modulated (PWM). Ignition voltage is supplied directly to the EVAP purge solenoid valve. The engine control module (ECM) controls the solenoid valve by grounding the control circuit with a solid state device called a driver.
The driver is equipped with a feedback circuit that is pulled-up to a voltage. The ECM can determine if the control circuit is open, shorted to ground, or shorted to a voltage by monitoring the feedback voltage.

### 8.2.3.55.5.Conditions for Running the DTC

The ignition voltage is greater than 11 V.
The DTCs run continuously once the above conditions are met.

### 8.2.3.55.6.Conditions for Setting the DTC

**P0443**
The ECM detects the EVAP purge solenoid valve control circuit is open within .25 s.
**P0458**
The ECM detects the EVAP purge solenoid valve control circuit is shorted to ground within .25 s.
**P0459**
The ECM detects the EVAP purge solenoid valve control circuit is shorted to voltage within .25 s.

### 8.2.3.55.7.Action Taken When the DTC Sets

DTC P0443, P0458 and P0459 are Type B DTCs.

### 8.2.3.55.8.Conditions for Clearing the DTC

DTC P0443, P0458 and P0459 are Type B DTCs.

#### 8.2.3.55.9. Reference Information

**Schematic Reference**
Engine Controls Schematics
**Connector End View Reference**
Component Connector End Views
**Description and Operation**
Evaporative Emission Control System Description
**Electrical Information Reference**
- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

**DTC Type Reference**
Powertrain Diagnostic Trouble Code (DTC) Type Definitions
**Scan Tool Reference**
Control Module References for scan tool information

#### 8.2.3.55.10. Circuit/System Verification

| Note: |
| --- |
| The audible clicking intensity will vary depending on mounting locations and interference with the fuel injectors clicking. You may also feel a change in the frequency of clicking. |

1. Ignition ON.
2. Command the EVAP purge solenoid from 0 to 50% and back to 0% with a scan tool while observing the following control circuit status parameters:
   - EVAP Purge Solenoid Valve Control Circuit High Voltage Test Status
   - EVAP Purge Solenoid Valve Control Circuit Open Test Status
   - EVAP Purge Solenoid Valve Control Circuit Low Voltage Test Status

**⇒ If Malfunction is displayed**
Refer to Circuit/System Testing
**⇓ If Malfunction is not displayed**
3. Verify the EVAP Purge Solenoid Valve control circuit parameters above do not display Malfunction when moving the related harnesses and connectors of the Q12 Evaporative Emission Purge Solenoid Valve.
**⇒ If Malfunction is displayed**
Refer to Circuit/System Testing
**⇓ If Malfunction is not displayed**
4. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data
5. Verify the DTC does not set.
**⇒ If the DTC sets**
Refer to Circuit/System Testing
**⇓If the DTC does not set**
6. All OK.

#### 8.2.3.55.11. Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the Q12 Evaporative Emission Purge Solenoid Valve. Ignition ON,
2. Verify that a test lamp illuminates between the ignition voltage circuit terminal 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 on the circuit.
⇒ If infinite resistance, test all components connected to the ignition voltage circuit for a short and replace as necessary.

**⇓ If the test lamp illuminates**

3. Verify that a test lamp does not illuminate between the ignition circuit terminal 2 and the control circuit terminal 1.

**⇒ If the test lamp illuminates**

3.1. Ignition OFF, remove the test lamp, disconnect the harness connector at the K20 Engine Control Module.
3.2. Test for infinite resistance between the control circuit and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇒ If infinite resistance, replace the K20 Engine Control Module.

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

4. Remove the test lamp.
5. Verify the EVAP Purge Solenoid Valve Control Circuit High Voltage Test Status parameter is OK when commanding the EVAP Purge Solenoid Valve to 50% with a scan tool.

**⇒ If OK is not displayed**

5.1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, Ignition ON.
5.2. Test for less than 1 V between the control circuit and ground.
⇒ If 1 V or greater, repair the short to voltage on the circuit.
⇒ If less than 1 V, replace the K20 Engine Control Module.

**⇓ If OK is displayed**

6. Install a 3 A fused jumper wire between the control circuit terminal 1 and the ignition circuit terminal 2.
7. Verify the EVAP Purge Solenoid Valve Control Circuit High Voltage Test Status parameter is Malfunction when commanding the EVAP Purge Solenoid Valve to 50% with a scan tool.

**⇒ If Malfunction is not displayed**

7.1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module.
7.2. Test for less than 2 Ω in the control circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω replace the K20 Engine Control Module.

**⇓ If Malfunction is displayed**

8. Test or replace the Q12 Evaporative Emission Purge Solenoid Valve.

#### 8.2.3.55.12. Component Testing

**Static Test**

1. Ignition OFF, disconnect the harness connector at the Q12 Evaporative Emission Purge Solenoid Valve.
2. Test for 10-30 Ω between the control circuit terminal 1 and the ignition circuit, terminal 2.

**⇒ If not between 10-30 Ω**

Replace the Q12 Evaporative Emission Purge Solenoid Valve.

**⇓ If between 10-30 Ω**

3. All OK.

**Dynamic Test**

1. Ignition OFF, disconnect the harness connector at the Q12 Evaporative Emission Purge Solenoid Valve.
2. Install a 3 A fused jumper wire between the ignition, terminal 2 and 12 V. Install a jumper wire between the control terminal 1 and ground.
3. Verify the Evaporative Emission Purge Solenoid Valve turns on & off/clicks and flows vacuum.

**⇒ If it does not turn on & off/click or flow vacuum.**

Replace the Q12 Evaporative Emission Purge Solenoid Valve.

**⇒ If it does turns on & off/clicks and flows vacuum.**

4. All OK

**8.2.3.55.13. Repair Instructions**

Perform the Diagnostic Repair Verification after completing the repair.

- Evaporative Emission Canister Purge Solenoid Valve Replacement
- Control Module References for ECM replacement, programming and setup

### 8.2.3.56. DTC P0446

#### 8.2.3.56.1. Diagnostic Instructions

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

#### 8.2.3.56.2. DTC Descriptor

**DTC P0446**
Evaporative Emission (EVAP) Vent System Performance

#### 8.2.3.56.3. 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 |

#### 8.2.3.56.4. 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 |

#### 8.2.3.56.5. 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 are 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.

#### 8.2.3.56.6. Conditions for Setting the DTC

| Note: |
|---|
| There are 2 stages to setting this DTC. Stage 1, prep test, then stage 2 test. |

- If fuel tank pressure sensor reading is greater than 2.5 in H20 of pressure or less than –5 in H20 of vacuum for 60 s OR

- If fuel tank pressure sensor reading is less than −12 in H20 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.

#### 8.2.3.56.7.Action Taken When the DTC Sets

DTC P0446 is a Type B DTC.

#### 8.2.3.56.8.Conditions for Clearing the MIL/DTC

DTC P0446 is a Type B DTC.

#### 8.2.3.56.9.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.

#### 8.2.3.56.10. Reference Information

**Schematic Reference**
Engine Controls Schematics
**Connector End View Reference**
Component Connector End Views
**Description and Operation**
Evaporative Emission Control System Description
**Electrical Information Reference**
- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

**DTC Type Reference**
Powertrain Diagnostic Trouble Code (DTC) Type Definitions
**Scan Tool Reference**
Control Module References for scan tool information
**Special Tools**
CH 41415-30 Fuel Tank Cap Adapter
GE 41413-A Evaporative Emissions System Tester (EEST)

#### 8.2.3.56.11. 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.
**⇓ 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 P0451P0454.
**⇓ 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.

### 8.2.3.56.12. 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. |

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 41413A 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 41413A
and pressurize the fuel tank to 5.0 in H20.
7. Verify the scan tool Fuel Tank Pressure Sensor parameter is 0 in H20 when commanding the EVAP Vent Solenoid Valve to OFF.

**⇒ If not 0 in H20**

Test for a blockage or a restriction in the EVAP vent hose or inlet. If the inlet or hose test normal, replace the Q13 Evaporative Emission Vent Solenoid Valve.

**⇓ If 0 in H20**

8. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.

**⇒ If the DTC sets**

Refer to step 1 above.

**⇓ If the DTC does not set**

9. All OK.

### 8.2.3.56.13. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Evaporative Emission Canister Vent Solenoid Valve Replacement
- Evaporative Emission Canister Replacement
- Fuel Tank Pressure Sensor Replacement

### 8.2.3.57. DTC P0449, P0498, or P0499

#### 8.2.3.57.1. Diagnostic Instructions

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

#### 8.2.3.57.2. DTC Descriptors

**DTC P0449**
Evaporative Emission (EVAP) Vent Solenoid Valve Control Circuit
**DTC P0498**
Evaporative Emission (EVAP) Vent Solenoid Valve Control Circuit Low Voltage
**DTC P0499**
Evaporative Emission (EVAP) Vent Solenoid Valve Control Circuit High Voltage

#### 8.2.3.57.3. Diagnostic Fault Information

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage |
|---|---|---|---|
| B+ | P0449, P0498 | P0449 | - |
| Control | P0449, P0498 | P0449 | P0449 |

#### 8.2.3.57.4. Circuit/System Description

The evaporative emission (EVAP) vent solenoid valve is a normally open valve. Battery voltage is supplied to the EVAP vent solenoid valve through a fuse. The engine control module (ECM) grounds the EVAP vent solenoid valve control circuit through an internal switch called a driver. The evaporative emission (EVAP) vent solenoid valve is a normally open valve. Battery voltage is supplied to the EVAP vent solenoid valve through a fuse. A scan tool will display the commanded state of the EVAP vent solenoid valve as ON (Not Venting) or OFF (Venting).

#### 8.2.3.57.5. Conditions for Running the DTC

The DTCs run continuously.

#### 8.2.3.57.6. Conditions for Setting the DTC

**P0449**
The ECM detects the EVAP Vent Solenoid Valve control circuit is open within 0.25 s.
**P0498**
The ECM detects the EVAP Vent Solenoid Valve control circuit is shorted to ground within 0.25 s.
**P0499**
The ECM detects the EVAP Vent Solenoid Valve control circuit is shorted to voltage within 0.25 s.

#### 8.2.3.57.7. Action Taken When the DTC Sets

DTC P0449, P0498 and P0499 are Type B DTCs.

#### 8.2.3.57.8. Conditions for Clearing the DTC

DTC P0449, P0498 and P0499 are Type B DTCs.

#### 8.2.3.57.9. Reference Information

**Schematic Reference**

Engine Controls Schematics
**Connector End View Reference**
Component Connector End Views
**Description and Operation**
Evaporative Emission Control System Description
Electrical Information Reference
Circuit Testing
Connector Repairs
Testing for Intermittent Conditions and Poor Connections
Wiring Repairs
DTC Type Reference
Powertrain Diagnostic Trouble Code (DTC) Type Definitions
Scan Tool Reference
Control Module References for scan tool information

### 8.2.3.57.10. Circuit/System Verification

| Note: |
|---|
| An audible click may be heard when performing step 2 below. |

1. Ignition ON.
2. Command the EVAP Vent Solenoid Valve to ON (Not Venting) and OFF (Venting) with a scan tool while observing the following control circuit status parameters:
   - EVAP Vent Solenoid Valve Control Circuit Open Test Status
   - EVAP Vent Solenoid Valve Control Circuit Low Voltage Test Status
   - EVAP Vent Solenoid Valve Control Circuit High Voltage Test Status

**⇒ If Malfunction is displayed**
Refer to Circuit/System Testing
**⇓ If Malfunction is not displayed**
3. Verify the EVAP Vent Solenoid Valve control circuit parameters above do not display Malfunction when moving the related harnesses and connectors of the Q13 Evaporative Emission Vent Solenoid Valve.
**⇒ If Malfunction is displayed**
Refer to Circuit/System Testing
**⇓ If Malfunction is not displayed**
4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
5. Verify the DTC does not set.
**⇒ If the DTC sets**
Refer to Circuit/System Testing
**⇓ If the DTC does not set**
6. All OK.

### 8.2.3.57.11. Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the Q13 Evaporative Emission Vent Solenoid Valve, Ignition ON,
2. Verify that a test lamp illuminates between the B+ circuit terminal A or 2 and ground.

**⇒ If the test lamp does not illuminate and the circuit fuse is good**
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 on the circuit.
⇒ If infinite resistance, test all components connected to the B+ circuit for a short and replace as necessary.

**⇓ If the test lamp illuminates**
3. Verify that a test lamp does not illuminate between the B+ circuit terminal A or 2 and the control circuit terminal B or 1.
**⇒ If the test lamp illuminates**
3.1. Ignition OFF, remove the test lamp, disconnect the harness connector at the K20 Engine Control Module.
3.2. Test for infinite resistance between the control circuit and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇒ If infinite resistance, replace the K20 Engine Control Module.
**⇓ If the test lamp does not illuminate**
4. Remove the test lamp.
5. Verify the scan tool EVAP Vent Solenoid Valve Control Circuit High Voltage Test Status parameter is OK when commanding the EVAP Vent Solenoid Valve to ON (Not Venting) 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 B or 1 and the B+ circuit terminal A or 2.
7. Verify the scan tool EVAP Vent Solenoid Valve Control Circuit High Voltage Test Status parameter is Malfunction when commanding the EVAP Vent Solenoid Valve to ON (Not Venting) with a scan tool.
**⇒ If Malfunction is not displayed**
7.1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module.
7.2. Test for less than 2 Ω in the control circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω replace the K20 Engine Control Module.
⇓ If Malfunction is displayed
8. Test or replace the Q13 Evaporative Emission Vent Solenoid Valve.

#### 8.2.3.57.12. Component Testing

1. Ignition OFF, disconnect the harness connector at the Q13 Evaporative Emission Vent Solenoid Valve.
2. Test for 10-30 Ω between the control terminal B or 1 and the B+ circuit terminal A or 2.
**⇒ If not between 10-30 Ω**
Replace the Q13 Evaporative Emission Vent Solenoid Valve.
⇓ If between 10-30 Ω
3. All OK.

#### 8.2.3.57.13. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Evaporative Emission Canister Vent Solenoid Valve Replacement
- Control Module References for ECM replacement, programming and setup

## 8.2.3.58. DTC P0451-P0454

### 8.2.3.58.1.Diagnostic Instructions

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

### 8.2.3.58.2.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

### 8.2.3.58.3.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 |

### 8.2.3.58.4.Typical Scan Tool Data

| Circuit | Short to Ground | Open | Short to Voltage |
|---|---|---|---|
| **Operating Conditions:** Ignition ON, Engine OFF<br>Parameter Normal Range: 1.3–1.7 V | | | |
| FTP Sensor 5 V Reference | 0 V | 0 V | 4.2–5 V |
| FTP Sensor Signal0V | 0 V | 0 V | 5 V |
| FTP Sensor Low Reference | - | 4.5 V | - |

### 8.2.3.58.5.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.

### 8.2.3.58.6.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.

#### 8.2.3.58.7.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 $H_2O$ in the span of 1 s but less than 1 in $H_2O$ in 12.5 ms.

#### 8.2.3.58.8.Action Taken When the DTC Sets

- DTCs P0451 and P0454 are Type A DTCs.
- DTCs P0452 and P0453 are Type B DTCs.

#### 8.2.3.58.9.Conditions for Clearing the MIL/DTC

- DTCs P0451 and P0454 are Type A DTCs.
- DTCs P0452 and P0453 are Type B DTCs.

#### 8.2.3.58.10. 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.

#### 8.2.3.58.11. Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Description and Operation**

Evaporative Emission Control System Description

**Electrical Information Reference**

- Circuit Testing

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

**Special Tools**

GE 41413-A Evaporative Emission System Tester (EEST)

### 8.2.3.58.12. 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.

### 8.2.3.58.13. 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.

#### 8.2.3.58.14. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Fuel Tank Pressure Sensor Replacement
- Control Module References for ECM replacement, setup, and programming.

## 8.2.3.59. DTC P0455

### 8.2.3.59.1. Diagnostic Instructions

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

### 8.2.3.59.2. DTC Descriptor

**DTC P0455**

Evaporative Emission (EVAP) System Large Leak Detected

### 8.2.3.59.3. 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.

### 8.2.3.59.4. 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 4.50%
- 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.

### 8.2.3.59.5. 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 21 min. This test runs until it passes.

### 8.2.3.59.6. Action Taken When the DTC Sets

DTC P0455 is a Type B DTC.

### 8.2.3.59.7. Conditions for Clearing the MIL/DTC

DTC P0455 is a Type B DTC.

### 8.2.3.59.8. 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 at the service port to allow the system to fill faster.
- To help locate intermittent leaks using the GE 41413-A, move all EVAP components while observing smoke with the GE 41413-SPT.
- Individual components can be isolated and tested using adapters in the J 41413300.
- When servicing the EVAP system, test pressure must not exceed 13 in H20 (0.5 PSI) as pressure in excess of this could cause system components to perform inaccurately.
- A condition may exist where a leak in the EVAP system only exists under a vacuum condition. This type of leak may be detected by using the scan tool Purge/Seal function to create a vacuum in the EVAP system and then observe the FTP Sensor parameter for vacuum decay.

#### 8.2.3.59.9.Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Description and Operation**

Evaporative Emission Control System Description

**Electrical Information Reference**

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

**Special Tools**

CH 48096 EVAP Service Access Port Tool
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 (Brass Nozzle)
J 41413-VLV EVAP Service Port Vent Fitting

#### 8.2.3.59.10. 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.<br>• Refer to the GE 41413-A operation manual for detailed instructions in Evaporative Emission Control System Diagnosis. |

1. Disconnect the purge tube at the quick connector on the EVAP canister side of the purge solenoid valve and install the CH 48096.
2. Connect the GE 41413-A to the vehicle EVAP service port adapter.
3. Command the EVAP Purge/Seal function to System Seal with a scan tool to seal the EVAP system.
4. Verify that there is no leak in the EVAP system using the flow meter on the GE 41413A, calibrated to 0.51 mm (0.020 in)..

**⇒ If a leak is detected**

4.1. Apply smoke to the EVAP system at the service access port adapter with the GE 41413A.
4.2. Locate the leak using the GE 41413SPT

⇒ When the leak is located, repair or replace the affected component as necessary.

**⇓ If no leak detected**

| **Note:** |
|---|
| The steps below test for a restriction in the purge path. |

5. Connect the GE 41413A nitrogen/smoke hose to the J 41413311.
6. Disconnect the hose at the fuel cap end of the GE 4141530 and connect to the J 41413311.
7. Install the GE 4141530, filler neck end only, to the vehicle.
8. Engine idling, command the Purge/Seal function to System Seal with a scan tool to seal the system.
9. Command the EVAP Purge Solenoid Valve to 30% with a scan tool.
10. Verify the vacuum/pressure gauge on the GE 41413A and the scan tool Fuel Tank Pressure Sensor parameter 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.

11. Verify that the Fuel Tank Pressure Sensor parameter increases to greater than 3.2 V, and the pressure values are similar between the scan tool Fuel Tank Pressure Sensor and the vacuum/pressure gauge on the GE 41413A.

**⇒ If not within the specified range**

Replace the B150 Fuel Tank Pressure Sensor.

**⇓ If within the specified range**

12. All OK

### 8.2.3.59.11. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Fuel Tank Pressure Sensor Replacement
- Control Module References for ECM replacement, programming and setup

## 8.2.3.60. DTC P0496

### 8.2.3.60.1. Diagnostic Instructions

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

### 8.2.3.60.2. DTC Descriptor

**DTC P0496**
Evaporative Emission (EVAP) System Flow During Non-Purge

### 8.2.3.60.3. Circuit/System Description

This DTC tests for undesired intake manifold vacuum flow to the evaporative emission (EVAP) system. The engine control module (ECM) seals the EVAP system by commanding the EVAP purge solenoid valve OFF and the vent solenoid valve ON. The ECM monitors the fuel tank pressure (FTP) sensor to determine if a vacuum is being drawn on the EVAP system. If vacuum in the EVAP system is more than a predetermined value within a predetermined time, this DTC sets.

The table listed below illustrates the relationship between the ON and OFF states, and the Open or Closed states of the EVAP purge and vent solenoid valves.

| ECM Command | EVAP Purge Solenoid Valve | EVAP Vent Solenoid Valve |
|---|---|---|
| ON | Open | Closed |
| OFF | Closed | Open |

### 8.2.3.60.4. Conditions for Running the DTC

- DTCs P0068, P00C8, P00C9, P00CA, P0090, P0091, P0092, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0122, P0123, P0125, P0128, P0191, P0192, P0193, P0222, P0223, P0601, P0604, P0606, P0697, P06A3, P06DB, P06DE, P0A1D, P1104, P127A, P127C, P127D, P15F2, P160D, P160E, P1682, P16A0, P16A1, P16A2, P16F3, P0443, P0449, P0452, P0453, P0454, P0502, P0503, P0722, P0723, P2100, P2101, P2102, P2103, P2122, P2123, P2127, P2128, P2135, P2138, P215B, P2176, P228C, P228D, U0073, U0074, U0293, U1817, are not set.
- The ignition voltage is between 11–32 V.
- The engine OFF time is greater than 48 min,
- The barometric pressure (BARO) is greater than 70 kPa.
- The fuel level is between 10–90%.
- The startup engine coolant temperature (ECT) is less than 35°C (95°F).
- The startup intake air temperature (IAT) is between 4–34°C (39–93°F).
- DTC P0496 runs once per cold start, for up to 17 min, when the above conditions are met.

### 8.2.3.60.5. 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.

### 8.2.3.60.6. Action Taken When the DTC Sets

DTC P0496 is a Type B DTC.

### 8.2.3.60.7. Conditions for Clearing the MIL/DTC

DTC P0496 is a Type B DTC.

#### 8.2.3.60.8. Diagnostic Aids

An intermittent condition could be caused by:

- Improper installation
- Damaged
- Temporary blockage
- Valve or system tubing restriction

#### 8.2.3.60.9. Reference Information

**Schematic Reference**
Engine Controls Schematics
**Connector End View Reference**
Component Connector End Views
**Powertrain Component View**
Powertrain Component Views
**Description and Operation**
Evaporative Emission Control System Description
**Electrical Information Reference**

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

**DTC Type Reference**
Powertrain Diagnostic Trouble Code (DTC) Type Definitions
**Scan Tool Reference**
Control Module References for scan tool information

#### 8.2.3.60.10. 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

#### 8.2.3.60.11. Circuit/System Testing

| **Note:** |
|---|
| • Vehicle and service department temperature and fuel level (vapor pressure) can affect the fuel tank pressure sensor parameter. Ensure the vehicle temperature has stabilized to service department temperature to ensure greatest accuracy.<br>• Be sure the EVAP Purge Solenoid Valve command is 0% or this test will not work. |

1. Ignition ON.
2. Command the EVAP Purge/Seal function to System Seal or Not Venting with a scan tool.
3. Engine Running.
4. Verify the Fuel Tank Pressure Sensor parameter is less than 1.9 V for greater than 90 s.

**⇒ If greater than 1.9 V**
Replace the Q12 Evaporative Emission Purge Solenoid Valve
**⇓ If less than 1.9 V**

5. All OK

#### 8.2.3.60.12. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

Evaporative Emission Canister Purge Solenoid Valve Replacement

### 8.2.3.61. DTC P0506 or P0507

#### 8.2.3.61.1. Diagnostic Instructions

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

#### 8.2.3.61.2. DTC Descriptors

**DTC P0506**
Idle Speed Low
**DTC P0507**
Idle Speed High

#### 8.2.3.61.3. 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.

#### 8.2.3.61.4. Conditions for Running the DTC

- DTCs P0068, P0101, P0102, P0103, P0112, P0113, P0116, P0117, P0118, P0120, P0121, P0122, P0123, P0128, P0171, P0172, P0201–P0204, P0220, P0222, P0223, P0300–P0304, P0351–P0354, P0461– P0463, P0496, P0606, P0722, P0723, P1516, P2066– P2068, P2101, P2135 are not set.
- The engine is operating for at least 60 s.
- The barometric pressure (BARO) is greater than 70 kPa (11 psi).
- The engine coolant temperature (ECT) is greater than 60°C (140°F).
- The system voltage is between 11–32 V.
- The transmission is not changing gears.
- The torque converter clutch (TCC) is not changing states.
- The intake air temperature (IAT) is warmer than −20°C (−4°F).
- The vehicle speed is less than 3 km/h (2 mph)
- The commanded engine speed is steady within 25 RPM.
- The engine is idling for greater than 5 s.
- A scan tool output control is not active.
- DTC P0506 and P0507 run continuously when the above conditions are met for greater than 10 s.

#### 8.2.3.61.5. Conditions for Setting the DTC

**P0506**
The actual idle speed is approximately 91 RPM lower than the desired idle speed.
**P0507**
The actual idle speed is approximately 182 RPM greater than the desired idle speed.

#### 8.2.3.61.6. Action Taken When the DTC Sets

DTCs P0506 and P0507 are Type B DTCs.

#### 8.2.3.61.7. Conditions for Clearing the MIL/DTC

DTCs P0506 and P0507 are Type B DTCs.

#### 8.2.3.61.8. 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.

#### 8.2.3.61.9. Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Description and Operation**

Throttle Actuator Control (TAC) System Description

**Electrical Information Reference**

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

#### 8.2.3.61.10. Circuit/System Verification

1. Ignition ON.
2. Verify no other DTCs set.

**⇒ If any other DTC is set**

Refer to Diagnostic Trouble Code (DTC) List Vehicle for further diagnosis.

**⇓ If no other DTC is set**

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

**⇒ 90 % or greater**

Refer to Throttle Body Inspection and Cleaning.

**⇓ 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

### 8.2.3.61.11. Circuit/System Testing

**P0506**

1. Verify the conditions listed below do not exist.
   - Restricted exhaust
   - Mechanical conditions that limits engine speed
   - Parasitic load on the engine—For example, a transmission condition, a belt driven accessory condition.

**⇒ If a condition is found**

Repair as necessary.

**⇓ If a condition is not found**

2. All OK.

**P0507**

1. Verify the conditions listed below do not exist.
   - Vacuum leaks
   - A throttle valve that does not close correctly
   - Verify the correct operation of the crankcase ventilation system. Inspect for the conditions listed below:
     - Improper routing of the positive crankcase ventilation (PCV) system
     - Vacuum leaks in the PCV system.

**⇒ If a condition is found**

Repair as necessary.

**⇓ If a condition is not found**

2. All OK.

### 8.2.3.61.12. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.
Throttle Body Assembly Replacement

## 8.2.3.62. DTC P057B-P057D

### 8.2.3.62.1. Diagnostic Instructions

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

### 8.2.3.62.2. DTC Descriptors

**DTC P057B**
Brake Pedal Position Sensor Performance
**DTC P057C**
Brake Pedal Position Sensor Circuit Low Voltage
**DTC P057D**
Brake Pedal Position Sensor Circuit High Voltage

### 8.2.3.62.3. Diagnostic Fault Information

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage | Signal Performance |
|---|---|---|---|---|
| Signal | P057C | P057C | P057D | P057B |
| 5 V Reference | P057C<br>P0651 | P057C | P0651 | - |
| Low Reference | - | P057D | P057D | - |

### 8.2.3.62.4. Typical Scan Tool Data

**Brake Pedal Position Sensor**

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage |
|---|---|---|---|
| Signal | 0 V | 0 V | - |
| 5 V Reference | 0 V | 0 V | 5 V |
| Low Reference | - | 5 V | - |

### 8.2.3.62.5. Circuit/System Description

The brake pedal position (BPP) sensor is part of the engine brake pedal override feature. The engine control module (ECM) continuously monitors the vehicle speed and the position of the brake pedal. These two main inputs, along with other ECM inputs are used to determine if the vehicle is decelerating at the proper speed and rate with the brake pedal applied. When the engine brake pedal override system is active, the ECM reduces engine torque to assist in reducing vehicle speed.

The BPP sensor is a six wire sensor, and is part of a dual brake position sensor. One BPP Sensor is used for the stop lamps and the other BPP Sensor is used for the engine brake pedal override feature. The BPP Sensor for engine brake pedal override communicates with the ECM. The ECM supplies a 5 V reference circuit, low reference circuit, and signal circuit to the BPP sensor. The BPP sensor sends a voltage signal to the ECM on the signal circuit. The voltage on the signal circuit will vary from a voltage greater than 0.25 V when the brake pedal is released to a voltage less than 4.75 V when the brake pedal is fully applied.

For information on the Stop Lamps side of the BPP Sensor, refer to Exterior Lighting Systems Description and Operation.

#### 8.2.3.62.6.Conditions for Running the DTC

**P057B**

- DTC P057C or P057D is not set.
- Ignition voltage is greater than 10 V.
- Starter is not engaged.
- Shift lever has been in Park at least once during key ON.
- Shift lever is not in Park.
- Vehicle speed is 8 km/h (5 MPH) or greater.
- Accelerator Pedal Position is less than 5 %.
- DTC runs once per trip when above conditions are met.

**P057C or P057D**

- Ignition voltage is greater than 10 V.
- DTC runs continuously when above condition is met.

#### 8.2.3.62.7.Conditions for Setting the DTC

**P057B**

ECM detects the brake pedal position sensor signal is stuck in a range for less than 1 s.

**P057C**

ECM detects the brake pedal position sensor voltage is less than 0.25 V for less than 1 s.

**P057D**

ECM detects the brake pedal position sensor voltage is greater than 4.75 V for less than 1 s.

#### 8.2.3.62.8.Action Taken When the DTC Sets

- P057B, P057C, and P057D are Type A DTCs.
- Brake Pedal Position Sensor parameter defaults to 0 %.

#### 8.2.3.62.9.Conditions for Clearing the DTC

P057B, P057C, and P057D are Type A DTCs

#### 8.2.3.62.10. Reference Information

**Schematic Reference**

- Engine Controls Schematics
- Exterior Lights Schematics

**Connector End View Reference**

- Component Connector End Views
- Inline Harness Connector End Views

**Electrical Information Reference**

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

### 8.2.3.62.11. Circuit/System Verification

| Note: |
|---|
| The Brake Pedal Position sensor scan tool data is located in the ECM automatic transmission data list. |

1. Ignition ON.
2. Verify DTC P0641, P0651, P0697, or P06A3 is not set.
**⇒ If any of the DTCs are set**
Refer to Diagnostic Trouble Code (DTC) List Vehicle.
**⇓ If none of the DTCs are set**
3. Transmission in Park, and service brake pedal released.
4. Verify the scan tool Brake Pedal Position Sensor parameter is greater than 0.25 V.
**⇒ If 0.25 V or less**
Refer to Circuit/System Testing.
**⇓ If greater than 0.25 V**
5. Verify the scan tool Brake Pedal Position Sensor parameter voltage changes as the brake pedal is applied and is less than 4.75 V when the brake pedal is fully applied.
**⇒ If the voltage does not change, or is 4.74 V or greater**
Refer to Circuit/System Testing.
**⇓ If the voltage changes and is less than 4.75 V**
6. Verify the scan tool Brake Pedal Position Sensor Learned Release Position parameter is within 0.1 V of the Brake Pedal Position Sensor parameter when the brake pedal is fully released.
**⇒ If difference is greater than 0.1 V**
Perform the Brake Pedal Position Sensor Learn.
**⇓ If difference is 0.1 V or less**
7. Verify the Brake Pedal Position Sensor parameter transitions smoothly without any spikes or dropouts when slowly applying and releasing the brake pedal.
**⇒ If parameter does not transition smoothly or has spikes or dropouts**
Refer to Circuit/System Testing.
**⇓ If parameter transitions smoothly and there are no spikes or dropouts**
8. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
9. Verify the DTC does not set.
**⇒ If the DTC sets**
Refer to Circuit/System Testing.
**⇓ If the DTC does not set**
10. All OK.

### 8.2.3.62.12. Circuit/System Testing

| Note: |
|---|
| You must perform the Circuit/System Verification first. |

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B22 Brake Pedal Position Sensor. It may take up to 2 minutes for all vehicle systems to power down.

| Note: |
|---|
| All terminal references are for the vehicle harness brake pedal position sensor connector. |

2. Test for less than 10 Ω between the low reference circuit terminal 6 and ground.
**⇒ If 10 Ω or greater**
2.1. 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 10 Ω**
3. Ignition ON.
4. Test for 4.8–5.2 V between the 5 V reference circuit terminal 5 and ground.
**⇒ If less than 4.8 V**
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 Brake Pedal Position Sensor parameter is less than 0.25 V.
**⇒ If 0.25 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 0.25 V between the signal circuit terminal 4 and ground.
⇒ If 0.25 V or greater, repair the short to voltage on the circuit.
⇒ If less than 0.25 V, replace the K20 Engine Control Module.
**⇓ If less than 0.25 V**
6. Install a 3 A fused jumper wire between the signal circuit terminal 4 and the 5 V reference circuit terminal 5.
7. Verify the scan tool Brake Pedal Position Sensor parameter is greater than 4.8 V.
**⇒ If 4.8 V or less**
7.1. Ignition OFF, remove the jumper wire, and disconnect the harness connector at the K20 Engine Control Module.
7.2. Test for infinite resistance between the signal circuit terminal 4 and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇓ If infinite resistance.
7.3. Test for less than 2 Ω in the signal circuit end to end.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, replace the K20 Engine Control Module.
**⇓ If greater than 4.8 V**
8. Replace the B22 Brake Pedal Position Sensor.

### 8.2.3.62.13. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Brake Pedal Position Sensor Replacement
- Perform the Brake Pedal Position Sensor Learn following the replacement of the ECM or BPP sensor, or any repair that effects the BPP sensor alignment.
- Control Module References for Engine Control Module replacement, programming and setup.

## 8.2.3.63. DTC P05CC or P05CE

### 8.2.3.63.1.Diagnostic Instructions

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

### 8.2.3.63.2.DTC Descriptors

**DTC P05CC**
Cold Start Intake Camshaft Position System Performance
**DTC P05CE**
Cold Start Exhaust Camshaft Position System Performance

### 8.2.3.63.3.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 signal from the ECM is pulse width modulated (PWM). The ECM controls the camshaft position actuator solenoid duty cycle by controlling the amount of solenoid On time. The camshaft position actuator solenoid controls the advance or the retard of each camshaft. The camshaft position actuator solenoid controls the oil flow that applies the pressure to advance or retard the camshafts.

### 8.2.3.63.4.Conditions for Running the DTC

- DTC P0010, P0013, P0016, P0017, P0335, P0340, P0341, P0365, or P0366 is not set.
- Engine is running.
- Ignition voltage is greater than 11 V.
- Camshaft position actuator is enabled.
- The rate of change in the camshaft position is less than 3° for 4 s.
- The DTCs run continuously once the above conditions are met for greater than 0.1 s.

### 8.2.3.63.5.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.

### 8.2.3.63.6.Action Taken When the DTC Sets

DTCs P05CC and P05CE are Type B DTCs.

### 8.2.3.63.7.Conditions for Clearing the DTC

DTCs P05CC and P05CE are Type B DTCs.

### 8.2.3.63.8.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.

**8.2.3.63.9. Reference Information**

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Component View Reference**

Powertrain Component Views

**Description and Operation**

Camshaft Actuator System Description

**Electrical Information Reference**

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information.

**8.2.3.63.10. 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.<br><br>• 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.

**⇒ 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 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.

#### 8.2.3.63.11. 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.

#### 8.2.3.63.12. Component Testing

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

**⇒ If not between 7-12 Ω**

Replace the Q6 Camshaft Position Actuator Solenoid Valve.

**⇓ If between 7-12 Ω**

3. Test for infinite resistance between each terminal and the Q6 Camshaft Position Actuator Solenoid Valve housing.

**⇒ If not infinite resistance**

Replace the Q6 Camshaft Position Actuator Solenoid Valve.

**⇓ If infinite resistance**

4. All OK

#### 8.2.3.63.13. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Camshaft Position Actuator Solenoid Valve Replacement
- Control Module References for ECM replacement, programming and setup

## 8.2.3.64. DTC P0601-P0604, P0606, P062B, P062F, P0630, P16F3, or P262B (ECM)

### 8.2.3.64.1. Diagnostic Instructions

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

### 8.2.3.64.2. 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

### 8.2.3.64.3. 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.

### 8.2.3.64.4. Conditions for Running the DTCs

**P0601, P0602, P0630**
These DTCs run continuously when the ignition is in ON.
**P0603, P062F**
These DTCs run during ECM power up.
**P0604**
DTC P0604 runs continuously when the ignition is ON for greater than 30 s.
**P0606**
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 during ECM power down.

### 8.2.3.64.5. Conditions for Setting the DTCs

The ECM detects an internal failure or incomplete programming for more than 10 s.

### 8.2.3.64.6. Actions Taken When the DTC Sets

- DTCs P0601, P0602, P0603, P0604, P0606, P0630, and P16F3 are Type A DTCs.
- DTC P062F and P262B are Type B DTCs.

### 8.2.3.64.7. Conditions for Clearing the MIL/DTC

- DTCs P0601, P0602, P0603, P0604, P0606, P0630, and P16F3 are Type A DTCs.
- DTC P062F and P262B are Type B DTCs.

### 8.2.3.64.8. Diagnostic Aids

Low voltage or a momentary loss of power or ground to the ECM may cause a DTC to set. Verify the following:

- The battery cables are clean and tight, and the battery is fully charged. Refer to Battery Inspection/Test.
- The ECM ground circuits do not have an open or high resistance.
- The ECM power circuits do not have an open, short to ground, or high resistance.

### 8.2.3.64.9. Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Component View Reference**

Powertrain Component Views

**Electrical Information Reference**

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

### 8.2.3.64.10. Circuit/System Verification

1. Ignition ON, clear the DTC information with a scan tool.
2. Verify no other DTCs are set.

**⇒ If any other DTCs are set**

Refer to Diagnostic Trouble Code (DTC) List Vehicle for further diagnosis.

**⇓ If no other DTCs are set**

3. Verify DTC P0602 or P0630 is not set.

**⇒ If any of the DTCs are set**

3.1. Program the K20 Engine Control Module. Refer to Control Module References.

3.2. Verify DTC P0602 or P0630 is not set.

⇒ If any of the DTCs are set, replace the K20 Engine Control Module.

⇓ If none of the DTCs are set

3.3. All OK.

**⇓ If none of the DTCs are set**

4. Verify DTC P0601, P0603, P0604, P0606, P062F, P16F3, or P262B is not set.

**⇒ If any of the DTCs are set**

Replace the K20 Engine Control Module.

**⇓ If none of the DTCs are set**

5. All OK.

### 8.2.3.64.11. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

Control Module References for engine control module replacement, programming and setup.

## 8.2.3.65. DTC P0628

### 8.2.3.65.1.Diagnostic Instructions

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

### 8.2.3.65.2.DTC Descriptor

**DTC P0628**
Fuel Pump Enable Circuit Low Voltage

### 8.2.3.65.3.Diagnostic Fault Information

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage | Signal Performance |
|---|---|---|---|---|
| Signal | P0628 | P0628 | - | - |

### 8.2.3.65.4.Circuit/System Description

The engine control module (ECM) provides ignition voltage to the chassis control module whenever the engine is cranking or running. The control module enables the chassis 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 chassis control module supplies a varying voltage to the in-tank fuel pump module in order to maintain the desired fuel line pressure.

### 8.2.3.65.5.Conditions for Running the DTC

- 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.

### 8.2.3.65.6.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.

### 8.2.3.65.7.Action Taken When the DTC Sets

DTC P0628 is a Type B DTC.

### 8.2.3.65.8.Conditions for Clearing the DTC

DTC P0628 is a Type B DTC.

### 8.2.3.65.9.Reference Information

**Schematic Reference**
Engine Controls Schematics
**Connector End View Reference**
Component Connector End Views
**Electrical Information Reference**
- Circuit Testing
- Connector Repairs
- Testing for Intermittent Conditions and Poor Connections

- Wiring Repairs

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

### 8.2.3.65.10. Circuit/System Verification

1. Ignition ON.
2. Verify that DTC P0628 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.

### 8.2.3.65.11. Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the K38 Chassis 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 K38 Chassis Control Module.

**8.2.3.65.12. Repair Instructions**

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.
Control Module References for Engine Control Module or Chassis Control Module replacement, programming, and setup

### 8.2.3.66. DTC P0641 or P06A6 (Chassis Control Module)

#### 8.2.3.66.1. Diagnostic Instructions

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

#### 8.2.3.66.2. DTC Descriptors

**DTC P0641**
5 V Reference Circuit
**DTC P06A6**
5 V Reference 1 Performance

#### 8.2.3.66.3. Diagnostic Fault Information

| Circuit | Short to Ground | Open /High Resistance | Short to Voltage | Signal Performance |
|---|---|---|---|---|
| Signal | P018C, P0641, P06A6 | P018C | P018D, P0641, P06A6 | P06A6 |
| 5 V Reference | P018C | P018B, P018C | P018D | P018B |
| Low Reference | - | P0641, P06A6 | - | P06A6 |

#### 8.2.3.66.4. 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 chassis control module monitors the voltage signal from the fuel pressure sensor.

#### 8.2.3.66.5. Conditions for Running the DTC

The ignition is ON.

#### 8.2.3.66.6. Conditions for Setting the DTC

The chassis control module detects that the fuel pressure 5 V reference is above or below a predetermined voltage threshold.

#### 8.2.3.66.7. Action Taken When the DTC Sets

DTCs P0641 and P06A6 are Type A DTCs.

#### 8.2.3.66.8. Conditions for Clearing the DTC

DTCs P0641 and P06A6 are Type A DTCs.

#### 8.2.3.66.9. 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.

### 8.2.3.66.10. Reference Information

**Schematic Reference**
Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Description and Operation**

Fuel System Description

**Electrical Information Reference**

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

### 8.2.3.66.11. 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 K38 Chassis 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 K38 Chassis 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 K38 Chassis 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 K38 Chassis Control Module.

**⇒ If greater than 5.2 V**

4.1. Ignition OFF, disconnect the harness connector at the K38 Chassis 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 K38 Chassis 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 K38 Chassis 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 K38 Chassis 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 K38 Chassis 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 K38 Chassis Control Module.

**⇓ If greater than 4.8 V**

8. Test or replace the B47 Fuel Pressure Sensor.

#### 8.2.3.66.12. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.
Control Module References for chassis control module replacement, programming and setup

## 8.2.3.67. DTC P0641, P0651, P0697, or P06A3 (ECM)

### 8.2.3.67.1. Diagnostic Instructions

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

### 8.2.3.67.2. DTC Descriptors

**DTC P0641**
5V Reference 1 Circuit
**DTC P0651**
5V Reference 2 Circuit
**DTC P0697**
5V Reference 3 Circuit
**DTC P06A3**
5V Reference 4 Circuit

### 8.2.3.67.3. Circuit/System Description

The engine control module (ECM) has 4 internal 5V reference circuits. Each internal reference circuit provides external 5V reference circuits for more than one sensor. A short to ground or short to voltage on one external 5V reference circuit can affect all the components connected to the same internal 5V reference circuit.

### 8.2.3.67.4. Conditions for Running the DTC

These DTCs run continuously when the ignition voltage is greater than 6.4 V.

### 8.2.3.67.5. Conditions for Setting the DTC

The ECM detects a short to ground or voltage on any of the 5V reference circuits for greater than 0.5 s.

### 8.2.3.67.6. Action Taken When the DTC Sets

DTCs P0641, P0651, P0697, and P06A3 are Type A DTCs.

### 8.2.3.67.7. Conditions for Clearing the DTC

DTCs P0641, P0651, P0697, and P06A3 are Type A DTCs.

### 8.2.3.67.8. Diagnostic Aids

**P0641**
The 5V reference 1 circuit provides 5 V to the sensors listed below:
- Air conditioning (A/C) refrigerant pressure sensor
- Exhaust and intake camshaft position sensors
- Fuel tank pressure sensor
- Turbocharger boost/intake air temperature sensor

**P0651**
The 5V reference 2 circuit provides 5 V to the sensors listed below:
- Brake pedal position sensor (automatic transmission)
- Clutch pedal position sensor (manual transmission)
- Crankshaft position sensor
- Multifunction intake air sensor

- Vehicle speed sensor (manual transmission)

**P0697**

The 5V reference 3 circuit provides 5 V to the sensors listed below:

- Accelerator pedal position sensor 2
- Manifold absolute pressure sensor

**P06A3**

The 5V reference 4 circuit provides 5 V to the sensors listed below:

- Accelerator pedal position sensor 1
- Throttle position sensor

Disconnecting one component at a time from the affected 5V reference circuit while observing the scan tool 5V Reference Circuit Status parameter may help locate the fault. The scan tool parameter will change from Malfunction to OK when the source of the fault is disconnected. If all 5V reference components have been disconnected and a fault is still indicated, the fault may exist in the wiring harness.

### 8.2.3.67.9. Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Component View Reference**

Powertrain Component Views

**Electrical Information Reference**

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

### 8.2.3.67.10. Circuit/System Verification

1. Ignition ON.
2. Verify all scan tool 5V Reference Circuit Status parameters do not display Malfunction.

**⇒ If Malfunction is displayed**

Refer to Circuit/System Testing.

**⇓ If Malfunction is not displayed**

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

**⇒ If the DTC sets**

Refer to Circuit/System Testing.

**⇓ If the DTC does not set**

5. All OK.

### 8.2.3.67.11. Circuit/System Testing

| Note: |
| --- |
| Additional DTCs will set when disconnecting the components. |

1. Ignition OFF, disconnect the harness connector at all appropriate sensors for the applicable DTC. Refer to Diagnostic Aids.
2. Ignition ON.
3. Test for 4.8–5.2 V between one of the 5V reference circuits and ground.

**⇒ 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 5V reference circuit for each applicable component and ground.
⇒ If less than infinite resistance, repair the short to ground on the circuit.
⇒ If infinite resistance, replace the K20 Engine Control Module.

**⇒ If greater than 5.2 V**

3.1. Ignition OFF, disconnect the harness connectors at the K20 Engine Control Module.
3.2. Test for less than 1 V between the 5V reference circuit for each applicable component and ground.
⇒ If 1 V or greater, repair the short to voltage on the circuit.
⇒ If less than 1 V, replace the K20 Engine Control Module.

**⇓ If between 4.8–5.2 V**

| **Note:** |
| --- |
| A short to voltage or ground on the signal circuit of certain components may cause this DTC to set. |

4. Verify the appropriate scan tool 5V Reference 1, 2, 3, or 4 Circuit Status parameter displays OK while connecting each component associated with the 5V reference circuit one at a time.

**⇒ If OK is not displayed when a component is connected**

Test the signal circuit of that component for a short to ground or voltage. If the circuit tests normal, replace the component.

**⇓ If OK is displayed after all components have been connected**

5. All OK.

### 8.2.3.67.12. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Accelerator Pedal Position Sensor Replacement
- Air Conditioning (A/C) Refrigerant Pressure Sensor Replacement
- Brake Pedal Position Sensor Replacement
- Camshaft Position Sensor Replacement
- Crankshaft Position Sensor Replacement
- Fuel Tank Pressure Sensor Replacement
- Intake Air Pressure and Temperature Sensor Replacement for turbocharger boost/intake air temperature sensor replacement.
- Manifold Absolute Pressure Sensor Replacement
- Mass Airflow Sensor Replacement for multifunction intake air sensor replacement.
- Throttle Body Assembly Replacement
- Vehicle Speed Sensor Replacement
- Control Module References for engine control module replacement, programming, and setup.

### 8.2.3.68. DTC P0650, P263A, or P263B

#### 8.2.3.68.1. Diagnostic Instructions

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

#### 8.2.3.68.2. DTC Descriptor

**DTC P0650**
Malfunction Indicator Lamp (MIL) Control Circuit
**DTC P263A**
Malfunction Indicator Lamp (MIL) Control Circuit Low Voltage
**DTC P263B**
Malfunction Indicator Lamp (MIL) Control Circuit High Voltage

#### 8.2.3.68.3. Diagnostic Fault Information

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

#### 8.2.3.68.4. Circuit/System Description

The malfunction indicator lamp (MIL) illuminates to inform the driver that an emission system fault has occurred and the powertrain control system requires service. Ignition voltage is supplied directly to the MIL. The engine control module (ECM) turns the MIL ON by grounding the MIL control circuit when the emission system fault occurs. Under normal operating conditions, the MIL should be ON only when the ignition is ON and the engine is OFF.

#### 8.2.3.68.5. Conditions for Running the DTC

- The engine speed is greater than 80 RPM.
- The ignition voltage is between 11–32 V.
- Remote vehicle start is not active
- The DTCs run continuously when the above conditions are met .

#### 8.2.3.68.6. Conditions for Setting the DTC

**DTC P0650 or DTC P263A**
The ECM detects low voltage during the MIL control circuit driver OFF state. This indicates either a shorted to ground or an open MIL control circuit.
**DTC P263B**
The ECM detects high voltage on the MIL control circuit during the driver ON state. This indicates a shorted to voltage MIL control circuit.

#### 8.2.3.68.7. Action Taken When the DTC Sets

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

#### 8.2.3.68.8. Conditions for Clearing the DTC

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

#### 8.2.3.68.9. Diagnostic Aids

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

#### 8.2.3.68.10. Reference Information

**Schematic Reference**

Engine Controls Schematics
Instrument Cluster Schematics

**Connector End View Reference**

Component Connector End Views

**Electrical Information Reference**

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

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

#### 8.2.3.68.11. Circuit/System Verification

1. Ignition ON.
2. Verify the parameters listed below do not display Malfunction when commanding the Malfunction Indicator Lamp On and Off with a scan tool.
   - The MIL Control Circuit Low Voltage Test Status
   - The MIL Control Circuit Open Test Status
   - The MIL Control Circuit High Voltage Test Status

**⇒ If Malfunction is displayed**

Refer to Circuit/System Testing.

**⇓ If Malfunction is not displayed**

3. Engine running.
4. Verify the parameters listed below do not display Malfunction when commanding the Malfunction Indicator Lamp On and Off with a scan tool.
   - The MIL Control Circuit Low Voltage Test Status
   - The MIL Control Circuit Open Test Status
   - The MIL Control Circuit High Voltage Test Status

**⇒ If Malfunction is displayed**

Refer to Circuit/System Testing.

**⇓ If Malfunction is not displayed**

5. Verify the malfunction indicator lamp turns ON and OFF when commanding the Malfunction Indicator Lamp On and Off with a scan tool.

**⇒ If the malfunction indicator lamp does not turn ON and OFF**

Refer to Circuit/System Testing.

**⇓ If the malfunction indicator lamp turns ON and OFF**

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

**⇒ If the DTC sets**

Refer to Diagnostic Trouble Code (DTC) List Vehicle for further diagnosis.

**⇓ If the DTC does not set**

7. All OK.

### 8.2.3.68.12. 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 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 control circuit terminal X1 52 and ground.
5. Verify the malfunction indicator lamp illuminates.

**⇒ If the malfunction indicator lamp illuminates**

Replace the K20 Engine Control Module.

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

5.1. Test for less than 1 V between the control circuit terminal X1 52 and ground.

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

⇓ If less than 1 V

5.2. Ignition OFF.

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.

6. Ignition OFF, disconnect the harness connector at the instrument cluster.
7. Ignition ON, verify a test lamp illuminates between the ignition voltage circuit terminal 31 and ground.

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

7.1. Ignition OFF.

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

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

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

7.1. Ignition OFF.

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

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

**⇓ If the test lamp illuminates**

8. Replace the P16 Instrument Cluster.

### 8.2.3.68.13. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Instrument Cluster Replacement
- Control Module References for control module replacement, programming, and setup

## 8.2.3.69. DTC P0685, P0686, P0687, P0689, P0690, or P1682

### 8.2.3.69.1. Diagnostic Instructions

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

### 8.2.3.69.2. 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

### 8.2.3.69.3. 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 |

### 8.2.3.69.4. 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/ High Resistance | Short to Voltage |
|---|---|---|---|
| **Operating Conditions:** Component commanded OFF<br>**Parameter Normal Range:** The following illustrates the normal parameter state with no circuit conditions:<br>• Component OFF – OK for Open/Low Voltage Test Status and Not Run for High Voltage Test Status<br>• 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/ High Resistance | Short to Voltage |
|---|---|---|---|
| **Operating Conditions:** Component commanded ON<br>**Parameter Normal Range:** The following illustrates the normal parameter state with no circuit conditions:<br>• Component OFF – OK for Open/Low Voltage Test Status and Not Run for High Voltage Test Status<br>• 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 |

### 8.2.3.69.5.Circuit/System Description

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

### 8.2.3.69.6.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**

- DTC 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.

### 8.2.3.69.7.Conditions for Setting the DTC

**P0685**

The ECM detects that the commanded state of the driver and the actual state of the control circuit do not match for greater than 2 s.

**P0686**

The ECM detects a short to ground on the control circuit for greater than 2 s.

**P0687**

The ECM detects a short to voltage on the control circuit for greater than 2 s.

**P0689**

The ECM detects the engine controls ignition relay feedback circuit is less than 5 V.

**P0690**

The ECM detects the engine controls ignition relay feedback circuit is greater than 4 V for greater than 5 s.

**P1682**

The ECM detects that the voltage level difference is greater than 3 V between the 2 ignition voltage circuits for greater than 1 s.

#### 8.2.3.69.8. Action Taken When the DTC Sets

- DTCs P0685, P0686, P0687, and P0690 are Type B DTCs.
- DTC P0689 is a Type C DTC.
- DTC P1682 is a Type A DTC.

#### 8.2.3.69.9. Conditions for Clearing the DTC

- DTCs P0685, P0686, P0687, and P0690 are Type B DTCs.
- DTC P0689 is a Type C DTC.
- DTC P1682 is a Type A DTC.

#### 8.2.3.69.10. Diagnostic Aids

The engine controls ignition relay may also be labeled the powertrain relay, the engine control module relay, or the main relay. The ignition main relay may also be labeled the run/crank relay, the ignition run relay, the ignition 1 relay, or the ignition relay.

#### 8.2.3.69.11. Reference Information

**Schematic Reference**

Engine Controls Schematics
Power Distribution Schematics

**Connector End View Reference**

Component Connector End Views

**Component View Reference**

Powertrain Component Views

**Electrical Information Reference**

- Circuit Testing
- Connector Repairs
- Electrical Center Identification Views
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

**DTC Type Reference**

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

**Scan Tool Reference**

Control Module References for scan tool information

#### 8.2.3.69.12. 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.<br>• If you were sent here from Engine Cranks But Does Not Run, proceed to Circuit/System Testing. |

1. Ignition ON, observe the scan tool DTC information. Verify DTC P0685, P0686, P0687, P0689, P0690, or P1682 is not set.

**⇒ If any of the DTCs are set**

Refer to Circuit/System Testing.

**⇓ If none of the DTCs are set**

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

**⇒ If any of the DTCs are set**

Refer to Circuit/System Testing.

**⇓ If none of the DTCs are set**

3. All OK.

**8.2.3.69.13. 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 KR73 Ignition Main Relay can cause DTC P1682 to set.<br>A short to voltage on any of the circuits supplied by the engine controls ignition relay can cause DTC P0690 to set. |

3. Ignition ON.
4. Verify that a test lamp does not illuminate between the ignition voltage circuit terminal 87 and ground.

**⇒ If the test lamp illuminates**

4.1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.
4.2. Ignition ON.
4.3. Test for less than 1 V between ground and connector terminal 28.
⇒ If 1 V or greater, repair the short to voltage in the circuit.
⇒ If less than 1 V, replace the K20 Engine Control Module.

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

5. Ignition OFF, connect a 20 A fused jumper wire between the relay switch B+ circuit terminal 30 and the relay switch ignition voltage circuit terminal 87.
6. Ignition ON.
7. 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.

### 8.2.3.69.14. 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 KR75 Engine Controls Ignition 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 KR75 Engine Controls Ignition 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 KR75 Engine Controls Ignition Relay.

**⇓ If less than 2 Ω**

6. All OK.

### 8.2.3.69.15. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

- Front Compartment Fuse Block Replacement
- Relay Replacement
- Control Module References for engine control module replacement, programming, and setup.

## 8.2.3.70. DTC P069E

### 8.2.3.70.1.Diagnostic Instructions

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

### 8.2.3.70.2.DTC Descriptor

**DTC P069E**
Fuel Pump Control Module Requested MIL Illumination

### 8.2.3.70.3.Circuit/System Description

The chassis control module, sometimes called the fuel pump control module, constantly monitors the fuel pump control system for any condition which may adversely affect vehicle emissions. If a condition is detected, the chassis control module sets a DTC and sends a serial data message to the engine control module (ECM). The ECM sets DTC P069E to inform the technician that the chassis control module has set the emission related DTC. The serial data message sent by the chassis control module also contains a request for the ECM to illuminate the malfunction indicator lamp (MIL).

The technician can observe the DTC that was set by the chassis control module by reviewing the ECM Freeze Frame records on the scan tool. The ECM Freeze Frame records also contain the engine operating conditions present when the chassis control module DTC set.

### 8.2.3.70.4.Conditions for Running the DTC

The ignition is ON, or the engine is running for greater than 3 s.

### 8.2.3.70.5.Conditions for Setting the DTC

The ECM receives a serial data message from the chassis control module indicating that an emission related DTC has set in the chassis control module.

### 8.2.3.70.6.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 chassis control module is requesting MIL illumination.

### 8.2.3.70.7.Conditions for Clearing the DTC

DTC P069E is a Type A DTC.

### 8.2.3.70.8.Diagnostic Aids

- Communication codes, U-code, as well as powertrain codes, P-codes, set in the chassis control module will cause the chassis control module to request DTC P069E to be set in the ECM.

### 8.2.3.70.9.Reference Information

**DTC Type Reference**
Powertrain Diagnostic Trouble Code (DTC) Type Definitions
**Scan Tool Reference**
Control Module References for scan tool information

### 8.2.3.70.10. Circuit/System Verification

| Note: |
|---|
| • Do not replace the engine control module for this DTC. DTC P069E is an informational DTC.<br>• Correct any engine control and communication DTCs before diagnosing chassis control module DTCs. |

1. Verify there are no engine control or communication DTCs set.
**⇒ If a DTC is set**
Refer to Diagnostic Trouble Code (DTC) List Vehicle.
**⇓ If a DTC is not set**
2. Verify the DTCs are set only as History in the chassis control module.
**⇒ If a DTC is not set only as History**
Refer to Diagnostic Trouble Code (DTC) List Vehicle.
**⇒ If a DTC is set only as History**
Refer to Testing for Intermittent Conditions and Poor Connections.
**⇓ If a DTC is not set**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.
**⇒ If the DTC sets**
Refer to Diagnostic Trouble Code (DTC) List Vehicle.
**⇓ If the DTC does not set**
5. All OK.

### 8.2.3.70.11. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

## 8.2.3.71. DTC P0700

### 8.2.3.71.1.Diagnostic Instructions

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

### 8.2.3.71.2.DTC Descriptor

**DTC P0700**
Transmission Control Module Requested MIL Illumination

### 8.2.3.71.3.Circuit/System Description

The Transmission Control Module (TCM) constantly monitors the transmission system for any condition which may adversely affect vehicle emissions. If a condition is detected, the TCM sets a DTC and sends a serial data message to the ECM. The ECM sets DTC P0700 to inform the technician that the TCM has set the emission related DTC. The serial data message sent by the TCM also contains a request for the ECM to illuminate the Malfunction Indicator Lamp (MIL)

The technician can observe the DTC that was set by the TCM by reviewing the ECM Freeze Frame records on the scan tool. The ECM Freeze Frame records also contain the engine operating conditions present when the transmission DTC set.

### 8.2.3.71.4.Conditions for Running the DTC

- The ignition is ON or the engine is running.
- DTC P0700 runs continuously.

### 8.2.3.71.5.Conditions for Setting the DTC

The ECM receives a serial data message from the TCM indicating that an emission related DTC has set in the TCM.

### 8.2.3.71.6.Action Taken When the DTC Sets

DTC P0700 is a Type A DTC.

### 8.2.3.71.7.Conditions for Clearing the MIL/DTC

DTC P0700 is a Type A DTC.

### 8.2.3.71.8.Diagnostic Aids

Communication codes, U-codes, as well as powertrain codes, P-Codes, set in the TCM can cause the TCM to request DTC P0700 to be set in the ECM.

### 8.2.3.71.9.Reference Information

**DTC Type Reference**
Powertrain Diagnostic Trouble Code (DTC) Type Definitions
**Scan Tool Reference**
Control Module References for scan tool information

### 8.2.3.71.10. Circuit/System Verification

| **Note:** |
|---|

- Do not replace the engine control module for this DTC. DTC P0700 is an informational DTC.
- Correct any engine control and communication DTCs before diagnosing transmission control module DTCs.

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

**⇒ If a DTC is set**

Refer to Diagnostic Trouble Code (DTC) List Vehicle.

**⇓ If a DTC is not set**

2. Verify there are no transmission control module DTCs set.

⇒ If a DTC is set

Refer to Diagnostic Trouble Code (DTC) List Vehicle.

**⇓ If a DTC is not set**

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

**⇒ If the DTC sets**

Refer to Diagnostic Trouble Code (DTC) List Vehicle.

**⇓ If the DTC does not set**

5. All OK.

#### 8.2.3.71.11. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

### 8.2.4. Repair instructions

#### 8.2.4.1. Brake Pedal Position Sensor Learn

##### 8.2.4.1.1. Calibration Criteria

| Note: |
|---|
| Do not apply the brake pedal during the brake pedal position sensor calibration procedure. Any movement of the brake pedal during this procedure will cause the calibration procedure to fail. If this occurs, the brake pedal position sensor calibration must be repeated. |

Brake pedal position sensor calibration must be performed after the brake pedal position sensor, body control module (BCM), or engine control module (ECM) have been serviced. The calibration procedure will set the brake pedal position sensor home value. This value is used by the BCM and ECM to determine the action of the driver applying the brake system and to provide this information to the vehicle subsystems via serial data.

##### 8.2.4.1.2. Calibration Procedure

1. Apply the parking brake.
2. Ignition ON, engine OFF, place the transmission in the PARK position
3. Install a scan tool.
4. Clear all DTCs before proceeding.
5. Navigate to the Configuration/Reset Functions menu of the BCM.
6. Select the Brake Pedal Position Sensor Learn procedure and follow the directions displayed on the screen.
7. Navigate to the Configuration/Reset Functions menu of the ECM.
8. Select the Learn Functions menu.
9. Select the Brake Pedal Position Sensor Learn procedure and follow the directions displayed on the screen.

### 8.2.4.2. Throttle or Idle Learn

#### 8.2.4.2.1. Description

The engine control module (ECM) learns the airflow through the throttle body to ensure the correct idle. The learned airflow values are stored within the ECM. These values are learned to adjust for production variation and will continuously learn during the life of the vehicle to compensate for reduced airflow due to throttle body coking. Anytime the throttle body airflow rate changes, for example due to cleaning or replacing, the values must be relearned. An engine that had a heavily coked throttle body that has been cleaned or replaced may take several drive cycles to unlearn the coking. To accelerate the process, the scan tool has the ability to reset all learned values back to zero. A new ECM will also have values set to zero. The idle may be unstable or a DTC may set if the learned values do not match the actual airflow.

#### 8.2.4.2.2. Conditions for Running the Throttle Learn Procedure

**Scan tool Idle Learn or Idle Learn Reset Procedure**

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0116, P0117, P0118, P0120, P0122, P0123, P0128, P0171, P0172, P0174, P0175, P0201P0208, P0220, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282, P0283, P0300-P0308, P0351-P0358, P0496, P0601, P0604, P0606, P060D, P0641, P0651, P0697, P06A3, P06D2, P1248, P1249, P124A, P124B, P1516, P16A0P16A2, P2101, P2119, P2120, P2122, P2123, P2125, P2127, P2128, P2135, P2138, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F, P217B, P217C, P217E, P217F, P2176, P2300, P2301, P2303, P2304, P2306, P2307, P2309, P2310, P2312, P2313, P2315, P2316, P2318, P2319, P2321, or P2322 are not set.
- Ignition ON, engine OFF.
- The vehicle speed sensor (VSS) is 0 km/h (0 mph).

**Service Bay/On Road Learn Procedure**

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0116, P0117, P0118, P0120, P0122, P0123, P0128, P0171, P0172, P0174, P0175, P0201-P0208, P0220, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282, P0283, P0300-P0308, P0351-P0358, P0496, P0601, P0604, P0606, P060D, P0641, P0651, P0697, P06A3, P06D2, P1248, P1249, P124A, P124B, P1516, P16A0-P16A2, P2101, P2119, P2120, P2122, P2123, P2125, P2127, P2128, P2135, P2138, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F, P217B, P217C, P217E, P217F, P2176, P2300, P2301, P2303, P2304, P2306, P2307, P2309, P2310, P2312, P2313, P2315, P2316, P2318, P2319, P2321, or P2322 are not set.
- The engine speed is between 450–4,000 RPM.
- The manifold absolute pressure (MAP) is greater than 5 kPa.
- The mass air flow (MAF) is greater than 2 g/s.
- The ignition voltage is greater than 10 volts.

#### 8.2.4.2.3. Diagnostic Aids

A unmetered air leak in the induction system or a small vacuum leak may not set a DTC. If the condition goes undetected, the ECM may learn an incorrect Throttle Body Idle Airflow Compensation value over time. The incorrectly learned value may cause various symptoms to occur such as rough or unstable idle speeds, and/or engine stall. If this condition is detected and repaired it will be necessary perform the Idle Learn procedure to ensure any symptoms are corrected.

#### 8.2.4.2.4. Throttle Learn

**Scan Tool Idle Learn or Idle Learn Reset Procedure – Performed after the throttle body is cleaned or replaced**

1. Ignition ON, engine OFF, perform the Idle Learn or Idle Learn Reset in Configuration/Reset or Module Setup.
2. Engine idling, verify the scan tool Throttle Body Idle Airflow Compensation value is equal 0% and the engine is idling at a normal idle speed.
3. Clear the DTCs and return to the diagnostic that referred you here.

**Service Bay/On Road Idle Learn Procedure – Performed after the ECM is programmed or replaced**

| Note |
|---|
| Do NOT perform this procedure if any DTCs are set. Refer to Diagnostic Trouble Code (DTC) List Vehicle. |

1. Engine idling for 3 m.
2. The ECM will start to learn the new idle cells and the scan tool Desired Idle Speed should start to decrease.
3. Ignition OFF for 60 s.
4. Start and idle the engine for 3 m.
5. Verify the engine is idling normally.

**⇒ If the engine idle is not correct**

| Note |
|---|
| During the drive cycle the check engine light may come on with idle speed DTCs. If idle speed codes are set, clear codes so the ECM can continue to learn. |

5.1. Operate the vehicle at speeds above 70 km/h (44 mph) with several decelerations and extended idles.
5.2. Verify the engine is idling normally.
⇒ If the engine idle is not correct.
Ignition OFF for 60 s, repeat step 5.1.
⇓ If the engine idle is correct.
5.3. Clear any DTCs and return to the diagnostic that referred you here.

**⇓ If the engine idle is correct**

6. Clear any DTCs and return to the diagnostic that referred you here.

### 8.2.4.3. K20 Engine Control Module: Programming and Setup

#### 8.2.4.3.1. Special Tools

EL49642 SPS Programming Support Tool

| Note: |
|---|
| • DO NOT program a control module unless directed to by a service procedure or a service bulletin. If the control module is not properly configured with the correct calibration software, the control module will not control all of the vehicle features properly.<br>• Ensure the programming tool is equipped with the latest software and is securely connected to the data link connector (DLC). If there is an interruption during programming, programming failure or control module damage may occur.<br>• Stable battery voltage is critical during programming. Any fluctuation, spiking, over voltage or loss of voltage will interrupt programming. When required install the EL-49642 SPS Programming Support Tool to maintain system voltage. If not available, connect a fully charged 12 V jumper or booster pack disconnected from the AC voltage supply. DO NOT connect a battery charger.<br>• Turn OFF or disable systems that may put a load on the vehicles battery such as; interior lights, exterior lights (including daytime running lights), HVAC, radio, etc.<br>• During the programming procedure, follow the SPS prompts for the correct ignition switch position.<br>• Clear DTCs after programming is complete. Clearing powertrain DTCs will set the Inspection/Maintenance (I/M) system status indicators to NO.<br>• Note the engine oil life remaining percentage. |

#### 8.2.4.3.2. Replace and Program Control Module

To program a replacement K20 Engine Control Module (ECM), perform the following procedure:

1. Install EL-49642 SPS programming support tool.
2. Access the Service Programming System (SPS) and follow the onscreen instructions.
3. Before removing the old control module, perform the SPS function Prepare Control Module for Removal, if available.

| Note: |
|---|
| The Prepare Control Module for Removal function can only be performed when communication with the old control module is still possible. |

4. Replace the ECM.
5. Perform the SPS function K20 Engine Control Module Programming and follow the onscreen instructions.
6. Clear the DTCs after completing the Programming procedure.
7. If equipped, Perform the SPS function Immobilizer Learn and follow the onscreen instructions. Refer to Immobilizer System Component Programming.
8. Perform the SPS function K20 Engine Control Module Configuration & Setup and follow the onscreen instructions.
9. Clear DTCs after completing the Configuration & Setup procedure.

#### 8.2.4.3.3. Reprogram Control Module

To reprogram an existing K20 Engine Control Module, perform the following procedure:

1. Install EL-49642 SPS programming support tool.
2. Access the Service Programming System (SPS) and follow the onscreen instructions.
3. Clear DTCs after completing the Programming procedure.

| Note: |
|---|
| If vehicle fails to start during Configuration and Setup, perform the SPS Function Immobilizer Learn and follow the onscreen instructions. |

4. Perform the SPS function Engine Control Module Configuration & Setup and follow the onscreen instructions, if available.
5. Clear DTCs after completing the Configuration & Setup procedure.

#### 8.2.4.3.4. Unsuccessful Programming Recovery

In the event of an interrupted or unsuccessful programming event, perform the following:

1. Ignition ON. Ensure the control module, DLC, and programming tool connections are secure and the SPS software is up to date.
2. Reprogram the control module following the onscreen instructions.

**⇒ If the control module cannot be reprogrammed**

2.1. Ignition OFF, disconnect the MDI, and exit SPS.
2.2. Ignition ON, reconnect the MDI, and access SPS.
2.3. Reprogram the control module following the onscreen instructions.

**⇒ If the control module cannot be reprogrammed**

2.3.1. Ignition OFF, disconnect the MDI, and exit SPS.
2.3.2. Disconnect vehicle battery for 2 minutes. Reconnect battery.
2.3.3. Ignition ON, reconnect the MDI, and access SPS.
2.3.4. Reprogram the control module following the onscreen instructions.

**⇒ If the control module cannot be reprogrammed**

Replace the K20 Engine Control Module.

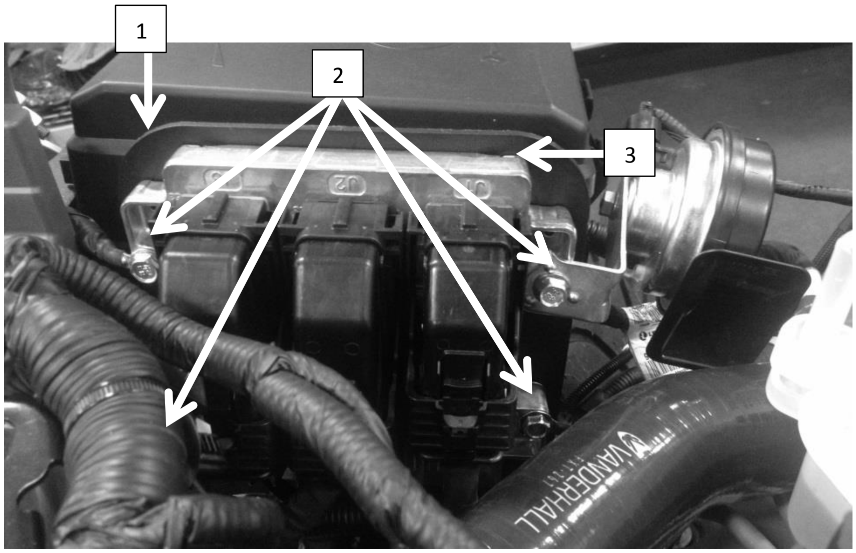
**⇓ If the control module can be reprogrammed**

3. All OK.

#### 8.2.4.3.5. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.
Control Module References for ECM replacement, programming and setup.

#### 8.2.4.4. Engine Control Module Replacement




**Engine Control Module Replacement**

<table>
<tr><th>Callout</th><th>Component Name</th></tr>
<tr><td colspan="2">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:<br>• Inability to test the ECM for warranty purposes<br>• Inability to use the ECM in other vehicles.<br>Preliminary Procedures<br>1. Remove the Hood, Refer to Hood in Body Repair<br>2. Prepare the ECM for replacement. Refer to Control Module References.<br>3. Using a scan tool, retrieve the percentage of remaining engine oil. Record the remaining engine oil life.<br>4. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection</td></tr>
<tr><td>1</td><td>Engine Control Module Mounting Bracket<br>Procedure<br>1. Disconnect the electrical wiring harness connectors from the engine control module.</td></tr>
<tr><td>2</td><td>Engine Control Module Fasteners (Qty: 4)<br>Caution: Refer to Fastener Caution.<br>Tighten<br>10 Nm(89 lb in)</td></tr>
<tr><td>3</td><td>Engine Control Module<br>Caution:<br>• 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.<br>• 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.<br>• 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.<br>• 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.<br>• The replacement control module must be programmed.<br>Procedure<br>1. Remove the engine control module from the engine control module bracket.<br>2. If replacing the ECM, refer to Control Module References for programming and setup.<br>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.</td></tr>
</table>

### 8.2.4.5. Crankshaft Position Variation Learn

The Crankshaft Position Variation Learn procedure is required when the following service procedures have been performed, regardless of whether DTC P0315 is set:

- An engine replacement.
- A engine control module (ECM) replacement.
- A crankshaft balancer replacement.
- A crankshaft replacement.
- A crankshaft position sensor replacement.
- Any engine repairs which disturb the crankshaft to crankshaft position sensor relationship.

The ECM monitors certain component signals to determine if all the conditions are met to continue with the Crankshaft Position Variation Learn procedure. The scan tool only displays the condition that inhibits the procedure. The scan tool displays the signals of the components listed below:

- Crankshaft position sensors activity: If there is a crankshaft position sensor condition, refer to the applicable DTC set.
- Camshaft position sensor signal activity: If there is a camshaft position sensor signal condition, refer to the applicable DTC set.
- Engine coolant temperature (ECT): If the engine coolant temperature is not warm enough, idle the engine until the engine coolant temperature reaches the correct temperature.

1. Verify no DTCs are set.

**⇒ If any DTCs other than P0300–P0308, or P0315 are set**

Refer to Diagnostic Trouble Code (DTC) List Vehicle.

**⇓ If DTC P0300–P0308, P0315, or no DTCs are set**

| **Note:** |
| --- |
| The Crankshaft Position Variation Learn may have to be repeated up to 5 times before the procedure is successful. |

2. Engine Running at normal operating temperature, perform the scan tool Crankshaft Position Variation Learn procedure and follow the on screen instructions.
3. Verify the scan tool displays Test Passed Successfully when completed.

**⇒ If Test Passed Successfully is not displayed**

Verify that none of the conditions listed below exist:

- The ignition switch is in the ON position until there is insufficient system voltage.
- An ECM power disconnect with the ignition ON that may have erased the crankshaft position system variation values and set DTC P0315.
- Interference in the signal circuit of the crankshaft position sensor.
- Debris between the crankshaft position sensor and the reluctor wheel.
- A damaged or misaligned reluctor wheel.
- Worn crankshaft main bearings.
- Excessive crankshaft runout.
- A damaged crankshaft.

⇒ If a condition is exists, repair or replace as necessary.

⇒ If no conditions exist, replace the K20 Engine Control Module.

**⇓ If Test Passed Successfully is displayed**

4. Clear all DTCs.
5. Engine Running.
6. Verify a DTC is not set.

**⇒ If a DTC is set**

Refer to Diagnostic Trouble Code (DTC) List Vehicle.

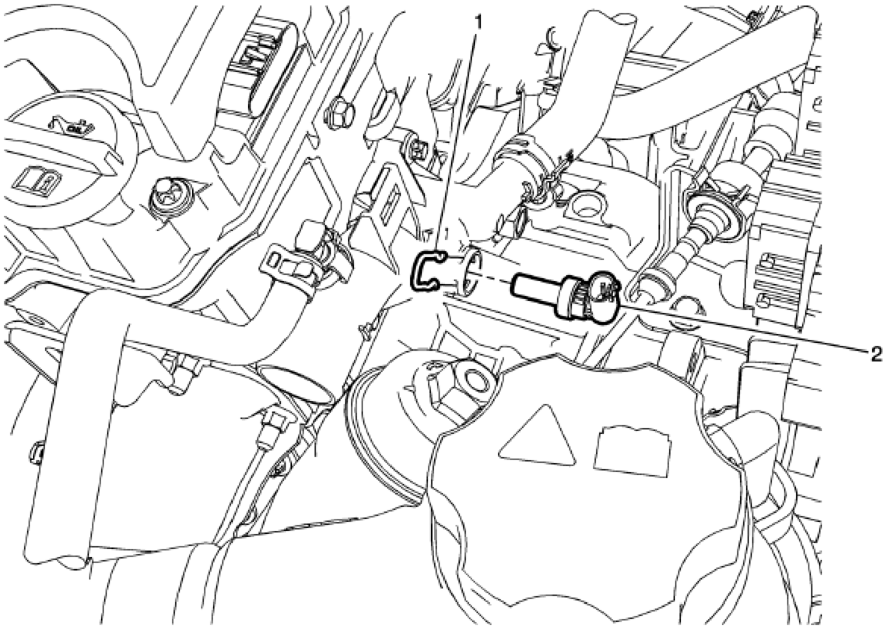
**⇓ If a DTC is not set**

7. All OK.

#### 8.2.4.5.1. Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.
Control Module References for engine control module replacement, programming, and setup.

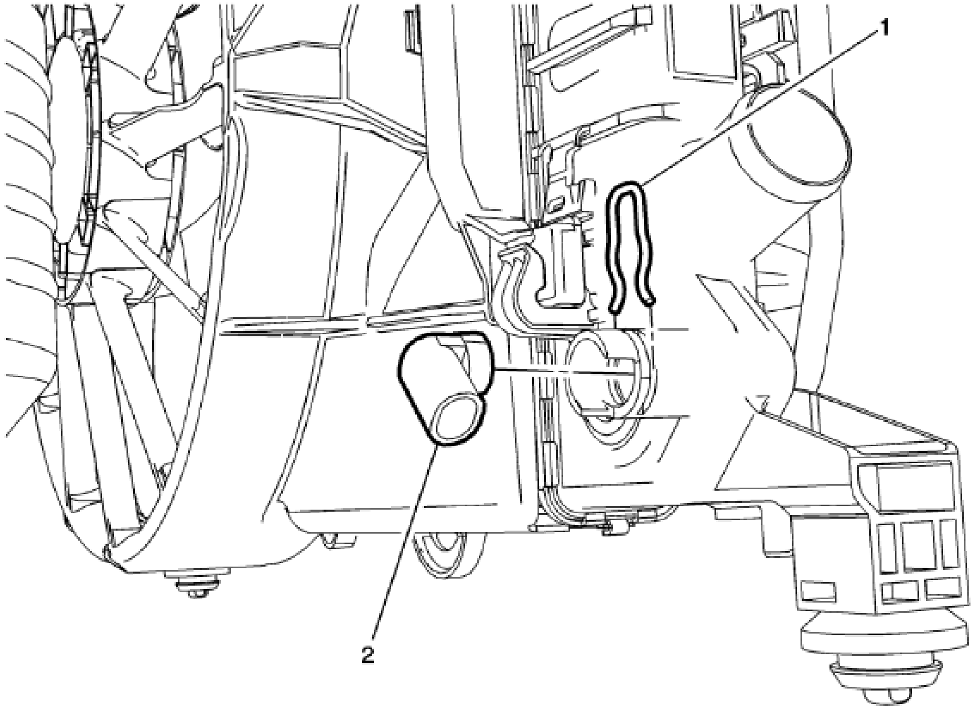
### 8.2.4.6. Engine Coolant Temperature Sensor Replacement (Water Outlet)




**Engine Coolant Temperature Sensor Replacement**

| Callout | Component Name |
|---|---|
| **Preliminary Procedure**<br>1. Remove the Hood, Refer to Hood in Body Repair<br>2. Disconnect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection.<br>3. Drain the cooling system. Refer to Cooling System Draining and Filling. | |
| 1 | Engine Coolant Temperature Sensor Fastener |
| 2 | Engine Coolant Temperature Sensor<br>**Procedure**<br>Disconnect the electrical wiring harness connector from the engine coolant temperature sensor. |

### 8.2.4.7. Engine Coolant Temperature Sensor Replacement (Radiator)



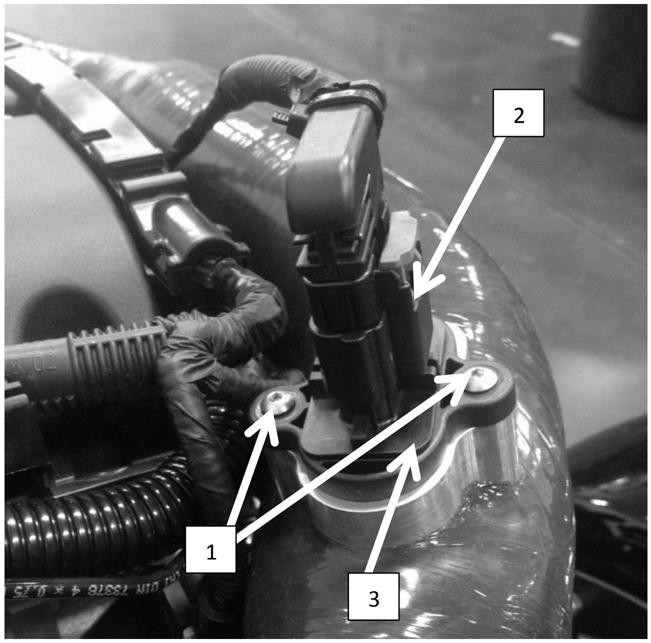

**Engine Coolant Temperature Sensor Replacement**

| Callout | Component Name |
|---|---|
| **Preliminary Procedures**<br>Drain the cooling system. Refer to Cooling System Draining and Filling. | |
| 1 | Retaining Clamp |
| 2 | Engine Coolant Temperature Sensor<br>**Procedure**<br>Disconnect the electrical connector. |

### 8.2.4.8. 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.

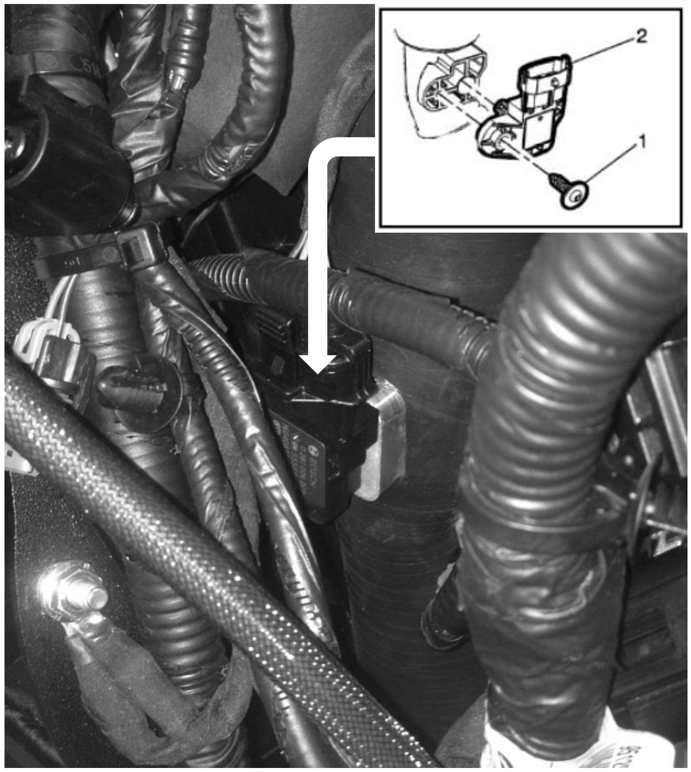
### 8.2.4.9. Mass Airflow Sensor Replacement




Mass Airflow Sensor Replacement

| Callout | Component Name |
|---|---|
| **Preliminary Procedure**<br>1. Remove the Hood, Refer to Hood in Body Repair | |
| 1 | Mass Air Flow Sensor Fasteners (Qty: 2) |
| 2 | Mass Air Flow Sensor<br>**Procedure**<br>1. Disconnect electrical connector<br>2. After replacement of mass air flow sensor, use a scan tool to perform the learn functions. Refer to K20 Engine Control Module: Programming and Setup. |
| 3 | Mass Air Flow Sensor Seal Ring |

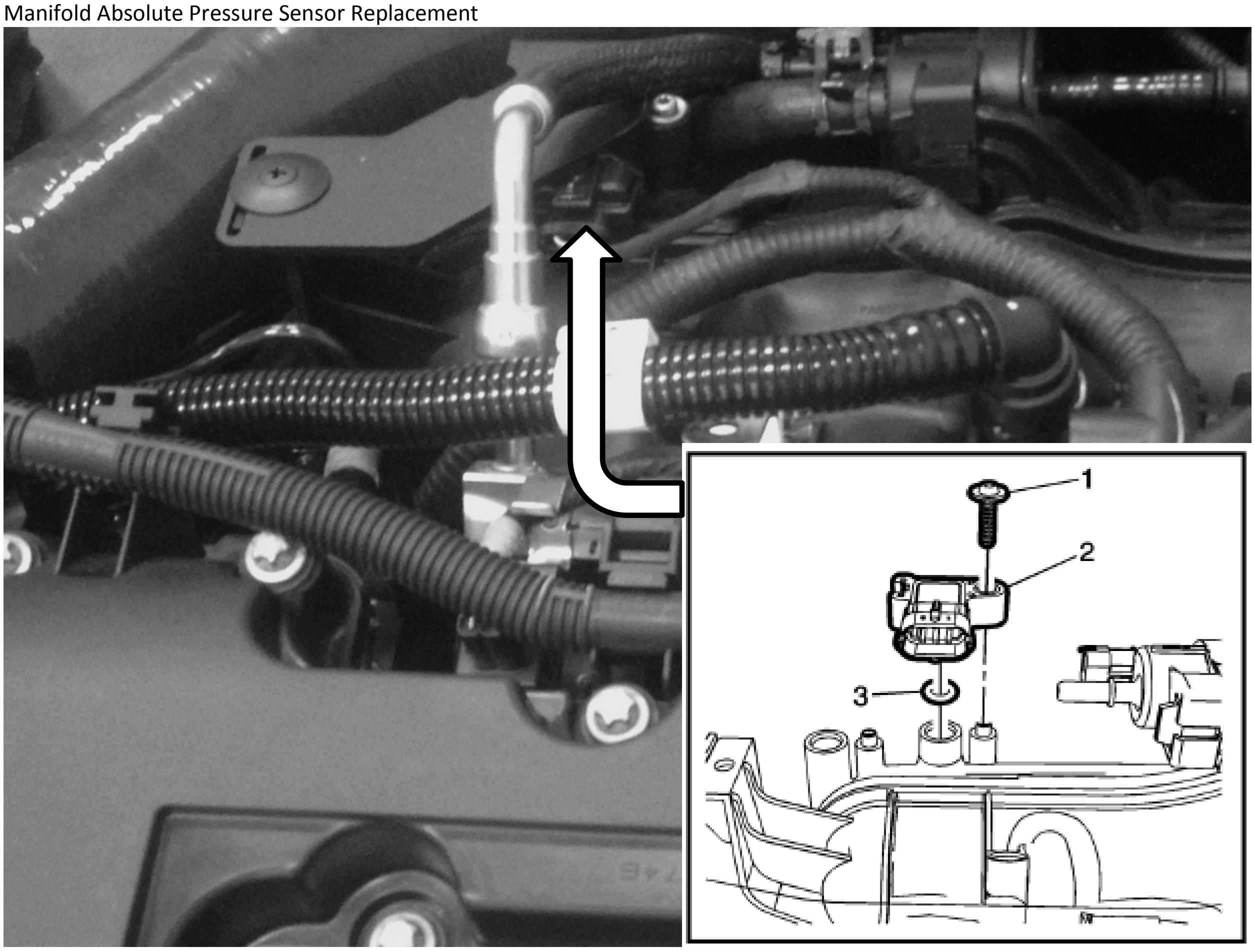
**8.2.4.10. Intake Air Pressure and Temperature Sensor Replacement**




**Intake Air Pressure and Temperature Sensor Replacement**

| Callout | Component Name |
|---|---|
| **Preliminary Procedure**<br>1. Remove the Hood, Refer to Hood in Body Repair | |
| 1 | Intake Air Temperature and Pressure Sensor Fasteners (Qty 2)<br>**Caution:** Refer to Fastener Caution. |
| 2 | Intake Air Temperature and Pressure Sensor<br>**Procedure**<br>Disconnect the electrical connector. |

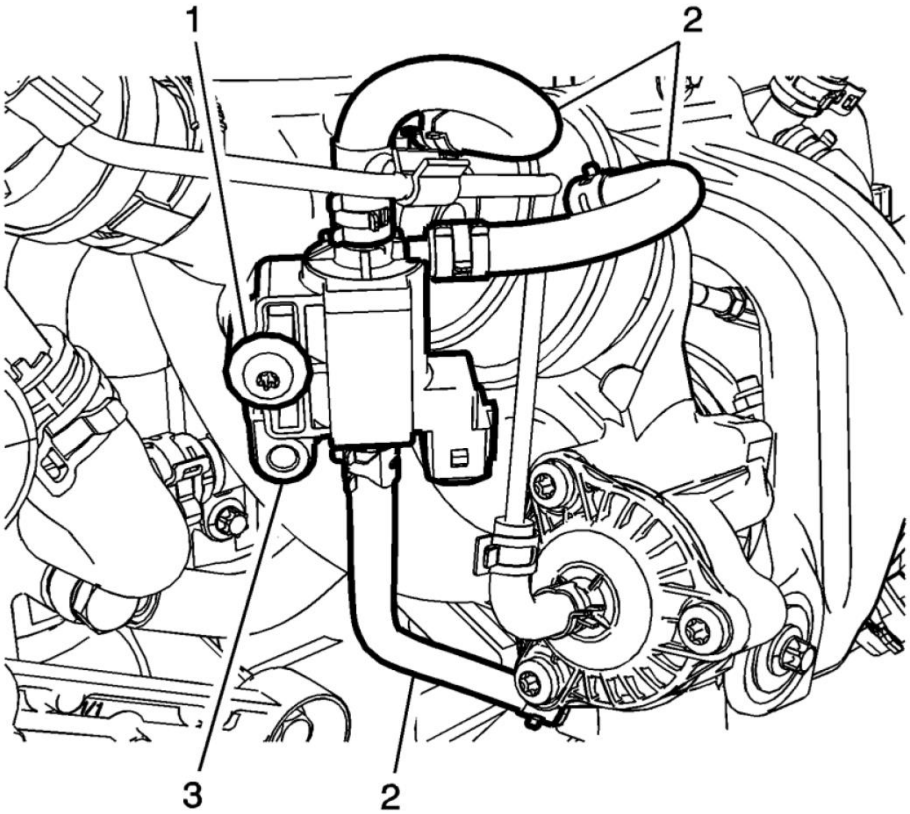
Manifold Absolute Pressure Sensor Replacement




**Manifold Absolute Pressure Sensor Replacement**

| Callout | Component Name |
|---|---|
| **Preliminary Procedure**<br>1. Remove the Hood, Refer to Hood in Body Repair | |
| 1 | Manifold Absolute Pressure Sensor Fastener |
| 2 | Manifold Absolute Pressure Sensor<br>**Procedure**<br>1. Disconnect the electrical connector.<br>2. After replacement of the manifold absolute pressure sensor use a scan tool to speed up the learn process. Refer to K20 Engine Control Module: Programming and Setup. |
| 3 | O-ring Seal |

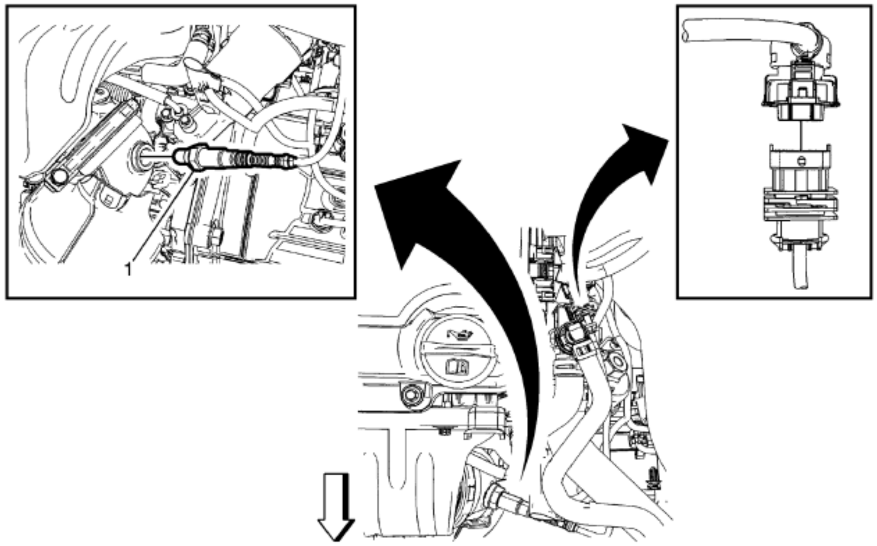
### 8.2.4.11. Turbocharger Wastegate Regulator Solenoid Valve Replacement




**Charge Air Bypass Regulator Solenoid Valve Replacement**

| Callout | Component Name |
|---|---|
| **Preliminary Procedure**<br>1. Remove the Hood, Refer to Hood in Body Repair<br>2. Disconnect the radiator outlet hose from the water inlet. Refer to Water Inlet Replacement. | |
| 1 | Turbocharger Wastegate Regulator Solenoid Valve Fastener<br>**Caution:** Refer to Fastener Caution.<br>**Tighten**<br>8 Nm (71 lb in) |
| 2 | Turbocharger Wastegate Regulator Solenoid Valve Hose (Qty: 3) |
| 3 | Turbocharger Wastegate Regulator Solenoid Valve<br>**Procedure**<br>Disconnect the electrical connector. |

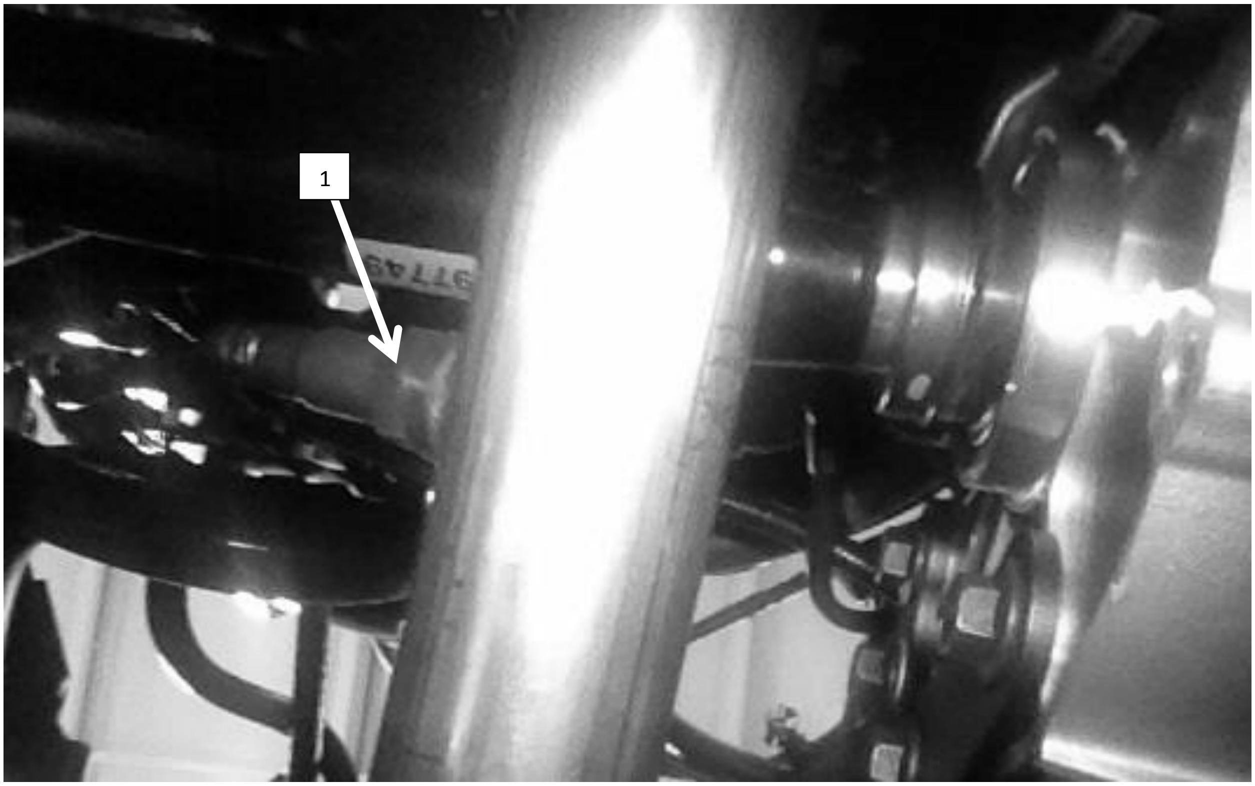
**8.2.4.12. Heated Oxygen Sensor Replacement - Sensor 1**




**Heated Oxygen Sensor Replacement - Sensor 1**

| Callout | Component Name |
|---|---|
| **Warning**: To avoid being burned, do not service the exhaust system while it is still hot. Service the system when it is cool.<br>**Preliminary Procedure**<br>1. Remove the Hood, Refer to Hood in Body Repair<br>2. Disconnect battery negative cable. Refer to Battery Negative Cable Disconnection and Connection. | |
| 1 | Heated Oxygen Sensor 1<br>**Caution:** Refer to Component Fastener Tightening Caution.<br><br>**Procedure**<br>1. Remove the wiring harness from retainer clip.<br>2. Disconnect electrical connector.<br>3. After replacement of the heated oxygen sensor, use a scan tool to speed up learn functions. Refer to K20 Engine Control Module: Programming and Setup.<br><br>**Note:** A special antiseize compound is used on the HO2S threads. The compound consists of liquid graphite and glass beads. The graphite tends to burn away, but the glass beads remain, making the sensor easier to remove. New, or service replacement sensors already have the compound applied to the threads. If the sensor is removed from an exhaust component and if for any reason the old sensor is to be reinstalled, the threads must have antiseize compound applied before the reinstallation. Refer to Adhesives, Fluids, Lubricants, and Sealers.<br><br>**Tighten**<br>42 Nm (31 lb ft)<br><br>**Special Tools**<br>EN48259 Installer/Remover |

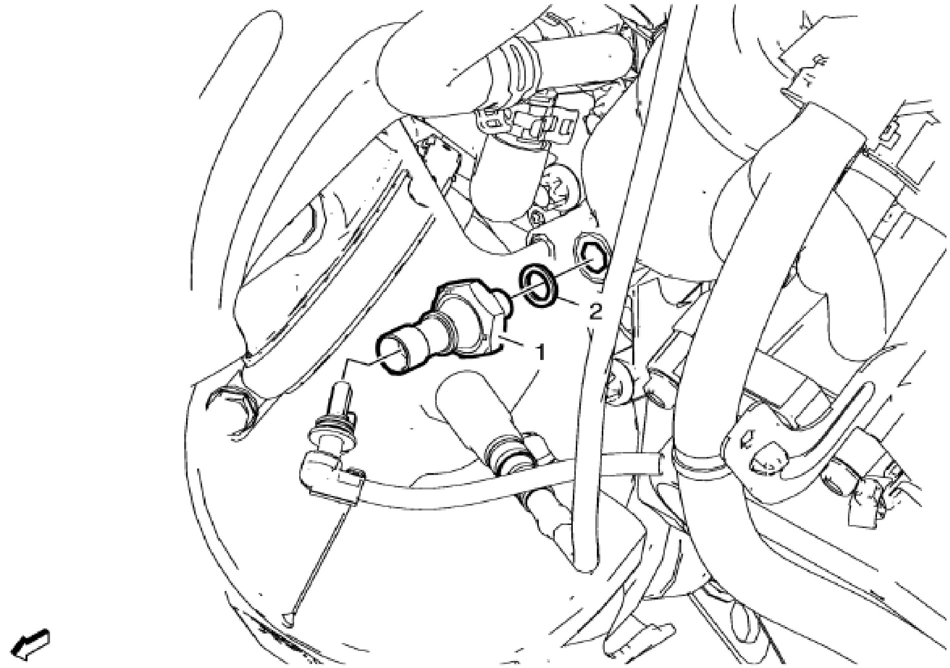
#### 8.2.4.12.1.Heated Oxygen Sensor Replacement - Sensor 2




**Heated Oxygen Sensor Replacement - Sensor 2**

| Callout | Component Name |
|---|---|
| **Warning**: In order to avoid being burned, do not service the exhaust system while it is still hot. Service the system when it is cool.<br>**Preliminary Procedure**<br>Disconnect battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.<br>Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle. | |
| 1 | Heated Oxygen Sensor 2<br><br>**Caution:** Refer to Component Fastener Tightening Caution.<br><br>**Procedure**<br>1. Disconnect electrical connector.<br>2. After replacement of the heated oxygen sensor, use a scan tool to speed up learn functions. Refer to K20 Engine Control Module: Programming and Setup.<br>3. If reusing the heated oxygen sensor, coat the thread with assembly paste.<br><br>**Tighten**<br>42 Nm (31 lb ft)<br><br>**Special Tools**<br>EN-48259 Installer/Remover |

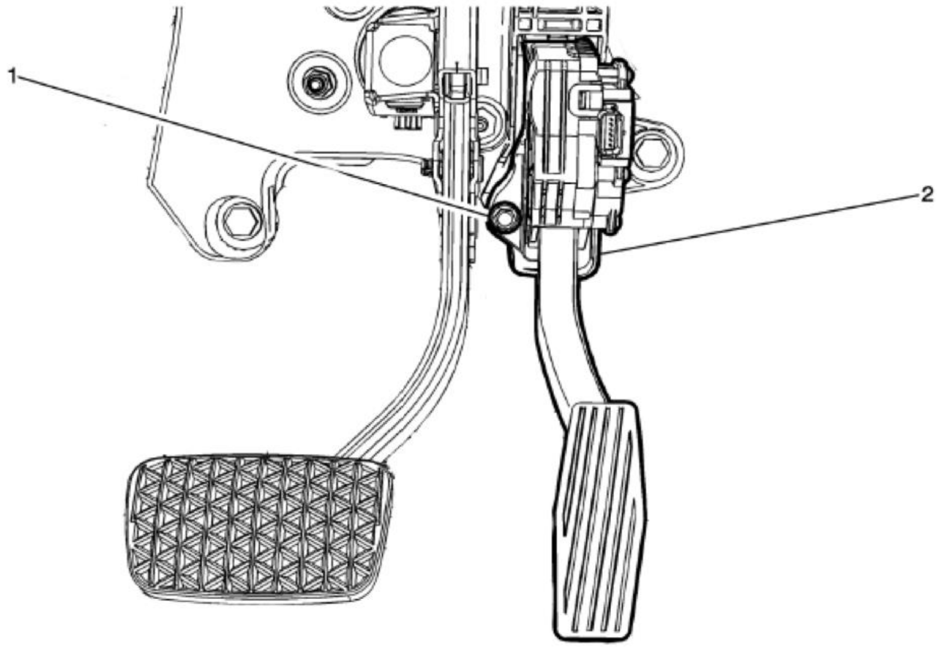
### 8.2.4.13. Engine Oil Pressure Indicator Switch Replacement




Engine Oil Pressure Indicator Switch Replacement

| Callout | Component Name |
|---|---|
| **Preliminary Procedure**<br>1. Remove the Hood, Refer to Hood in Body Repair | |
| 1 | Engine Oil Pressure Indicator Switch<br><br>**Caution:** Refer to Component Fastener Tightening Caution.<br><br>**Procedure**<br>1. Place collecting basin underneath.<br>2. Disconnect the electrical connector.<br>3. Check engine oil level after replacement.<br><br>**Tighten**<br>20 Nm (15 lb ft) |
| 2 | Engine Oil Pressure Indicator Switch Seal Ring |

### 8.2.4.14. Accelerator Pedal Position Sensor Replacement




Accelerator Pedal Position Sensor Replacement

| Callout | Component Name |
|---|---|
| **Preliminary Procedure**<br>Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection. | |
| 1 | Accelerator Pedal Position Sensor Fastener<br><br>**Caution:** Refer to Fastener Caution.<br><br>**Tighten**<br>10 Nm (89 lb in) |
| 2 | Accelerator Pedal Position Sensor<br>**Procedure**<br>1. Disconnect the electrical wiring harness connector from accelerator pedal position Sensor.<br>2. After replacement of the accelerator pedal position sensor, use a scan tool to speed up the learn process. Refer to K20 Engine Control Module: Programming and Setup. |

### 8.2.4.15. 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. Disconnect the charge air cooler outlet air hose. Refer to Charge Air Cooler Outlet Air Hose Replacement.

| Warning: |
| --- |
| Turn OFF the ignition before inserting fingers into the throttle bore. Unexpected movement of the throttle blade could cause personal injury. |

| Caution: |
| --- |
| Do not insert any tools into the throttle body bore to avoid damage to the throttle valve plate. |

2. Inspect the throttle body bore and the throttle valve plate for deposits. You will need to open the throttle valve to inspect all surfaces.

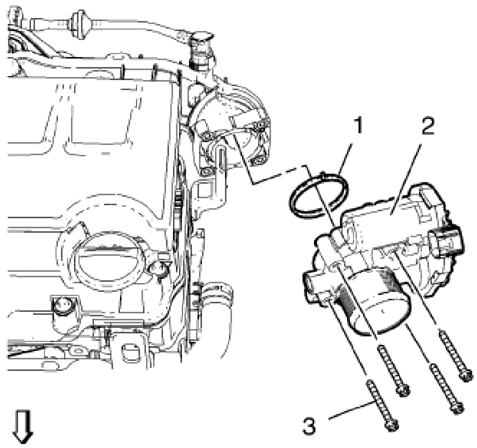
| Caution: |
| --- |
| Do not use any solvent that contains Methyl Ethyl Ketone (MEK). This solvent may damage fuel system components. |

3. Clean the throttle body bore and the throttle valve plate using a clean shop towel with an appropriate cleaner.
4. Reposition and connect the charge air cooler outlet air hose. Refer to Charge Air Cooler Outlet Air Hose Replacement.
5. Perform the Throttle/Idle Learn procedure. Refer to Q38 Throttle Body: Throttle/Idle Learn.

## 8.2.4.16. Throttle Body Assembly Replacement

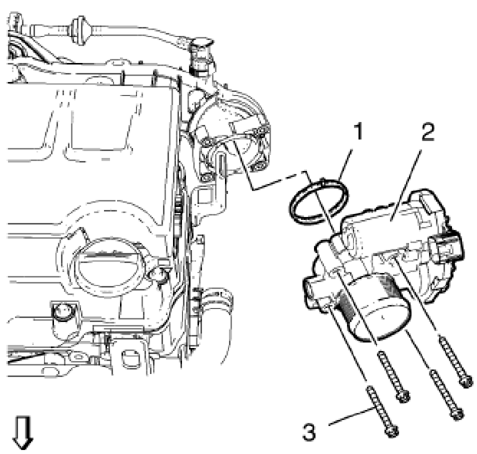
### 8.2.4.16.1.Removal Procedure

1.Remove the Hood, Refer to Hood in Body Repair
2. Disconnect the throttle body wiring harness connector.
3. Remove the charge air cooler outlet air hose from the throttle body. Refer to Charge Air Cooler Outlet Air Hose Replacement.




4. Remove the 4 throttle body fasteners (3).
5. Remove the throttle body (2) along with the throttle body seal ring (1).

### 8.2.4.16.2.Installation Procedure




1. Install the throttle fasteners (2) along with a NEW throttle body seal ring (1).

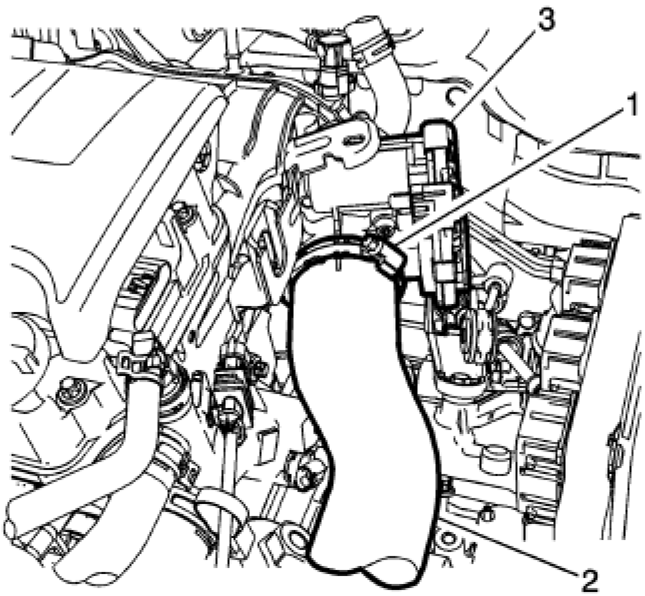
| Caution: |
|---|
| Refer to Fastener Caution. |

2. Install the 4 throttle body fastener (3) and tighten to 8 Nm (71 lb in).
3. Install the charge air cooler outlet air hose to the throttle body. Refer to Charge Air Cooler Outlet Air Hose Replacement.
4. Connect the throttle body wiring harness connector.
5. Install the Hood, Refer to Hood in Body Repair

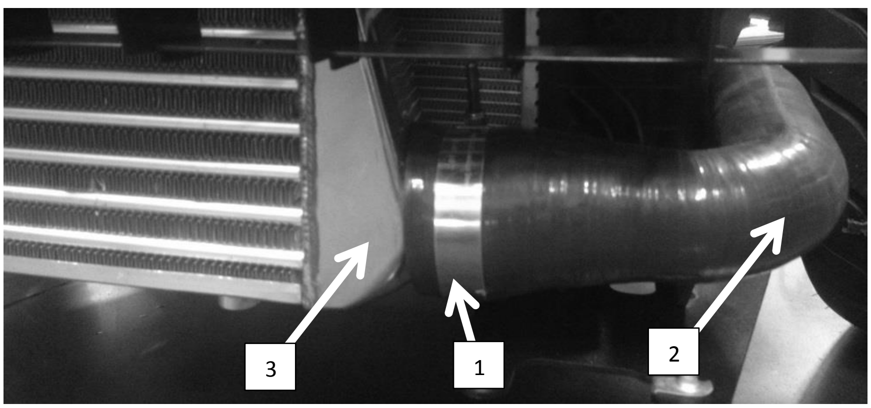
## 8.2.4.17. Charge Air Cooler Outlet Air Hose Replacement

### 8.2.4.17.1.Removal Procedure

1. Remove the Hood, Refer to Hood in Body Repair
2. Remove the Front Valance, Refer to Valance in Body Repair

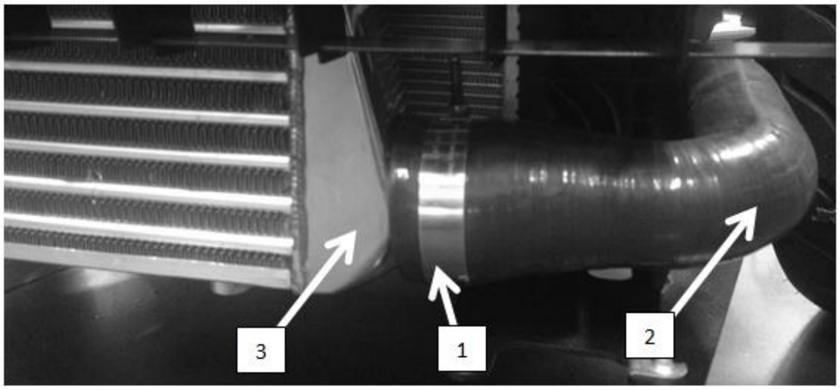



3. Loosen the clamp (1) at the charge air cooler outlet pipe (2) to throttle body (3).
4. Disconnect the intake air pressure and temperature sensor harness connector.

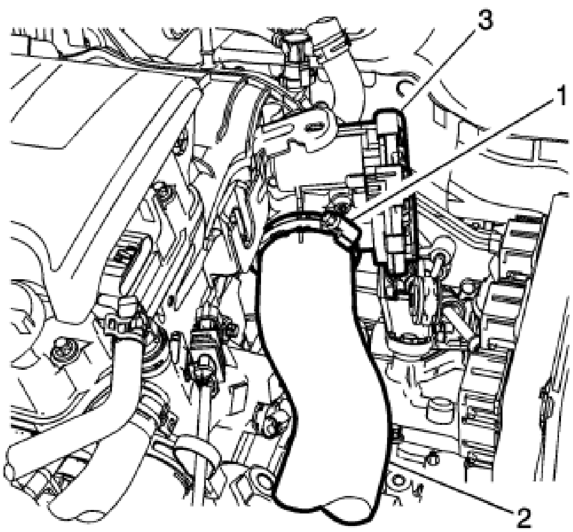



5. Loosen the clamp (1) at the charge air cooler outlet pipe (2) to the air charge cooler (3).
6. Transfer parts as necessary.

**8.2.4.17.2.Installation Procedure**




1. Install the charge air cooler outlet air hose (2) to charge air cooler (3).
2. Tighten Clamp (1)



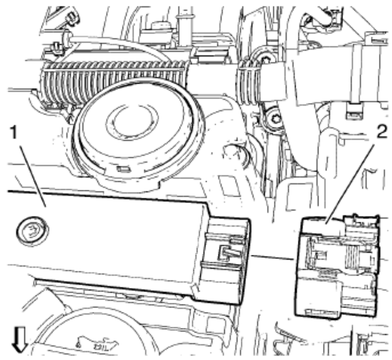

3. Install the charge air cooler inlet air pipe (2) to the throttle body (3)
4. Tighten Clamp (1) 3Nm (25 in lb)
5. Install the Front Valance, Refer to Valance in Body Repair
7. Install the Hood, Refer to Hood in Body Repair

### 8.2.4.18. Ignition Coil Replacement

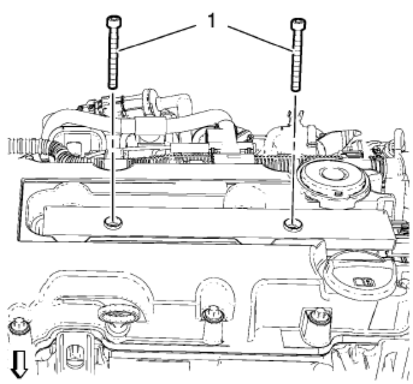
Special Tools
EN6009 Remover and Installer Ignition Module

#### 8.2.4.18.1.Removal Procedure

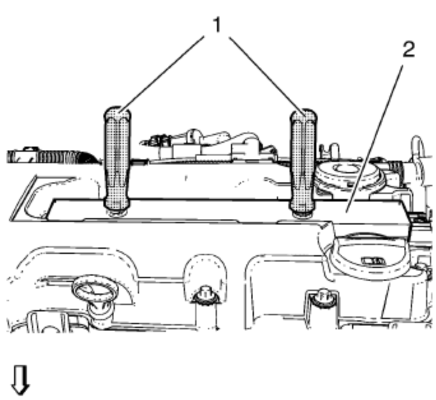
1. Remove the Hood, Refer to Hood in Body Repair




2. Disconnect ignition coil wiring harness plug (2) from ignition coil (1).



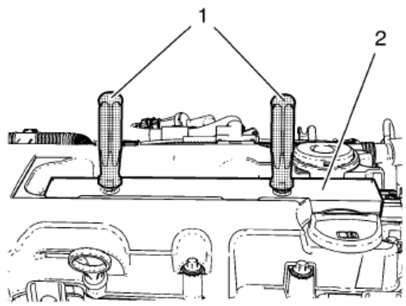

3. Remove the 2 ignition coil bolts (1).



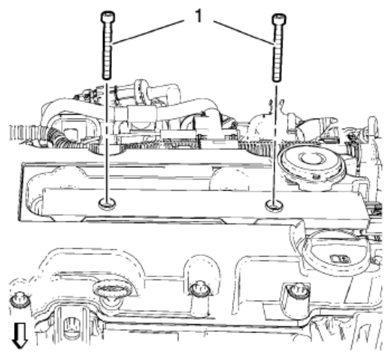

4. Install EN6009 remover/installer (1) to ignition coil (2).
5. Remove the ignition coil.

**8.2.4.18.2.Installation Procedure**

1. Install the ignition coil.

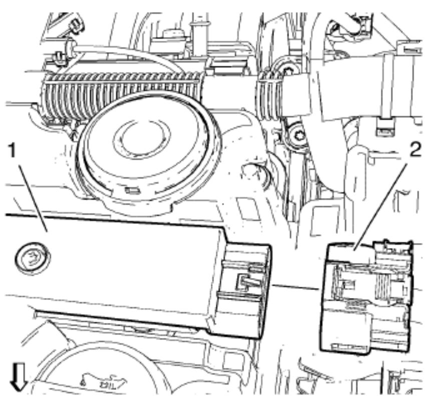



2. Remove EN6009 remover (1) from ignition coil (2).




| Caution: |
|---|
| Refer to Fastener Caution. |

3. Install the 2 ignition coil bolts (1) and tighten to 8 Nm (71 lb in).




4. Connect ignition coil wiring harness plug (2) to ignition coil (1).
5. Install the Hood, Refer to Hood in Body Repair

### 8.2.4.19. Throttle or Idle Learn

#### 8.2.4.19.1. Description

The engine control module (ECM) learns the airflow through the throttle body to ensure the correct idle. The learned airflow values are stored within the ECM. These values are learned to adjust for production variation and will continuously learn during the life of the vehicle to compensate for reduced airflow due to throttle body coking. Anytime the throttle body airflow rate changes, for example due to cleaning or replacing, the values must be relearned.

An engine that had a heavily coked throttle body that has been cleaned or replaced may take several drive cycles to unlearn the coking. To accelerate the process, the scan tool has the ability to reset all learned values back to zero. A new ECM will also have values set to zero.

The idle may be unstable or a DTC may set if the learned values do not match the actual airflow.

#### 8.2.4.19.2. Conditions for Running the Throttle Learn Procedure

**Scan tool Idle Learn or Idle Learn Reset Procedure**

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0116, P0117, P0118, P0120, P0122, P0123, P0128, P0171, P0172, P0174, P0175, P0201-P0208, P0220, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282, P0283, P0300-P0308, P0351-P0358, P0496, P0601, P0604, P0606, P060D, P0641, P0651, P0697, P06A3, P06D2, P1248, P1249, P124A, P124B, P1516, P16A0-P16A2, P2101, P2119, P2120, P2122, P2123, P2125, P2127, P2128, P2135, P2138, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F, P217B, P217C, P217E, P217F, P2176, P2300, P2301, P2303, P2304, P2306, P2307, P2309, P2310, P2312, P2313, P2315, P2316, P2318, P2319, P2321, or P2322 are not set.
- Ignition ON, engine OFF.
- The vehicle speed sensor (VSS) is 0 km/h (0 mph).

**Service Bay/On Road Learn Procedure**

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0116, P0117, P0118, P0120, P0122, P0123, P0128, P0171, P0172, P0174, P0175, P0201-P0208, P0220, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282, P0283, P0300-P0308, P0351-P0358, P0496, P0601, P0604, P0606, P060D, P0641, P0651, P0697, P06A3, P06D2, P1248, P1249, P124A, P124B, P1516, P16A0-P16A2, P2101, P2119, P2120, P2122, P2123, P2125, P2127, P2128, P2135, P2138, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F, P217B, P217C, P217E, P217F, P2176, P2300, P2301, P2303, P2304, P2306, P2307, P2309, P2310, P2312, P2313, P2315, P2316, P2318, P2319, P2321, or P2322 are not set.
- The engine speed is between 450–4,000 RPM.
- The manifold absolute pressure (MAP) is greater than 5 kPa.
- The mass air flow (MAF) is greater than 2 g/s.
- The ignition voltage is greater than 10 volts.

#### 8.2.4.19.3. Diagnostic Aids

A unmetered air leak in the induction system or a small vacuum leak may not set a DTC. If the condition goes undetected, the ECM may learn an incorrect Throttle Body Idle Airflow Compensation value over time. The incorrectly learned value may cause various symptoms to occur such as rough or unstable idle speeds, and/or engine stall. If this condition is detected and repaired it will be necessary perform the Idle Learn procedure to ensure any symptoms are corrected.

**8.2.4.19.4.Throttle Learn**

**Scan Tool Idle Learn or Idle Learn Reset Procedure – Performed after the throttle body is cleaned or replaced**

1. Ignition ON, engine OFF, perform the Idle Learn or Idle Learn Reset in Configuration/Reset or Module Setup.
2. Engine idling, verify the scan tool Throttle Body Idle Airflow Compensation value is equal 0% and the engine is idling at a normal idle speed.
3. Clear the DTCs and return to the diagnostic that referred you here.

**Service Bay/On Road Idle Learn Procedure – Performed after the ECM is programmed or replaced**

| **Note:** |
|---|
| Do NOT perform this procedure if any DTCs are set. Refer to Diagnostic Trouble Code (DTC) List Vehicle. |

1. Engine idling for 3 m.
2. The ECM will start to learn the new idle cells and the scan tool Desired Idle Speed should start to decrease.
3. Ignition OFF for 60 s.
4. Start and idle the engine for 3 m.
5. Verify the engine is idling normally.

**⇒ If the engine idle is not correct**

| **Note:** |
|---|
| During the drive cycle the check engine light may come on with idle speed DTCs. If idle speed codes are set, clear codes so the ECM can continue to learn. |

5.1. Operate the vehicle at speeds above 70 km/h (44 mph) with several decelerations and extended idles.
5.2. Verify the engine is idling normally.
⇒ If the engine idle is not correct.
Ignition OFF for 60 s, repeat step 5.1.
⇓ If the engine idle is correct.
5.3. Clear any DTCs and return to the diagnostic that referred you here.

**⇓ If the engine idle is correct**

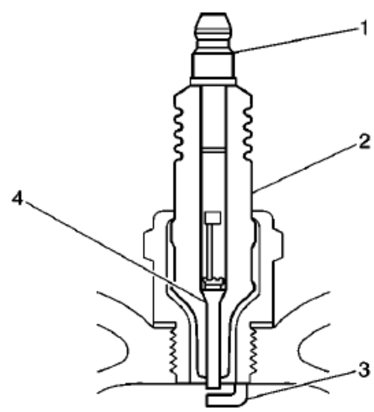
6. Clear any DTCs and return to the diagnostic that referred you here.

## 8.2.4.20. Spark Plug Inspection

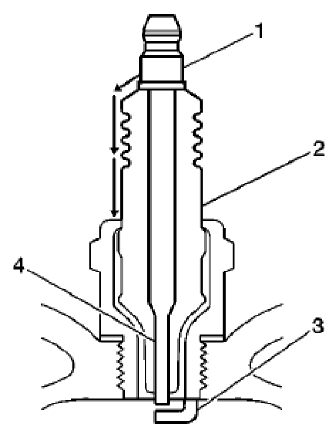
### 8.2.4.20.1.Spark Plug Usage

1. Ensure that the correct spark plug is installed. An incorrect spark plug causes drivability conditions.
2. Ensure that the spark plug has the correct heat range. An incorrect heat range causes the following conditions:
    - Spark plug fouling—Colder plug
    - Pre-ignition causing spark plug and/or engine damage—Hotter plug

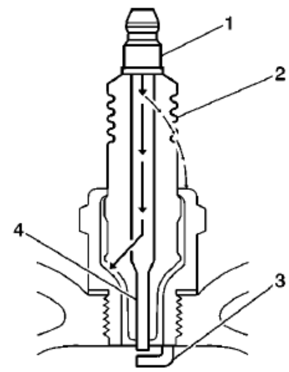
### 8.2.4.20.2.Spark Plug Inspection




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.




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.




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).

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.

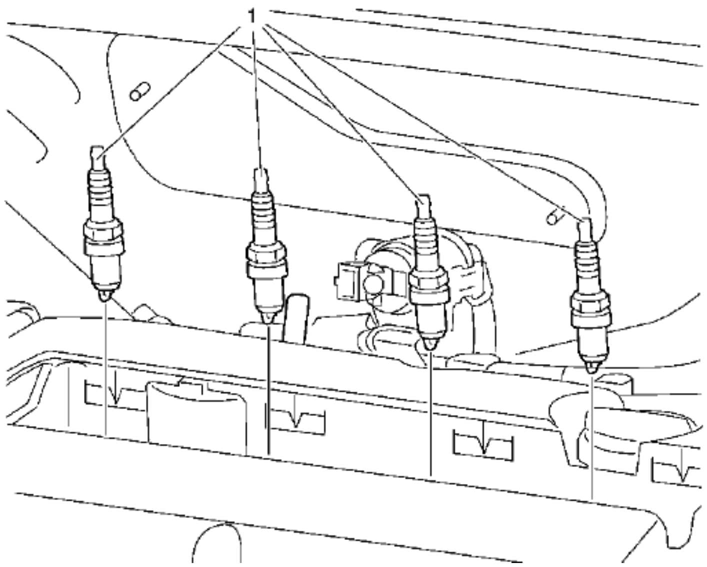
**8.2.4.20.3.Spark Plug Visual Inspection**

1. Normal operation—Brown to grayish-tan with small amounts of white powdery deposits are normal combustion byproducts 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.

### 8.2.4.21. Spark Plug Replacement



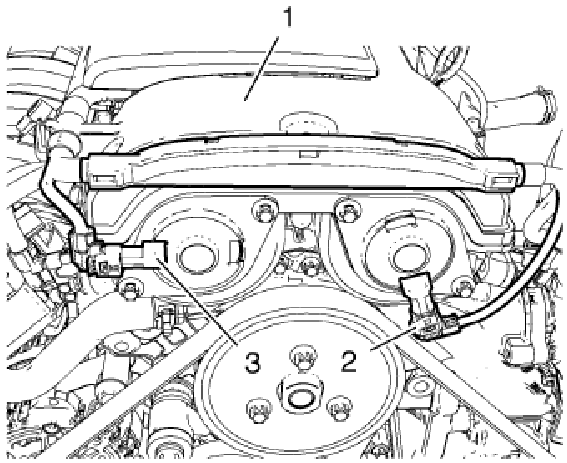

Spark Plug Replacement

| Callout | Component Name |
|---|---|
| **Preliminary Procedure**<br>1. Remove the hood.<br>2. Remove the ignition coil. Refer to Ignition Coil Replacement. | |
| 1 | Spark Plugs<br><br>**Caution:** Refer to Fastener Caution.<br><br>**Tighten**<br>25 Nm (18 lb ft)<br><br>**Special Tools**<br>EN-194-E Spark Plug Remover |

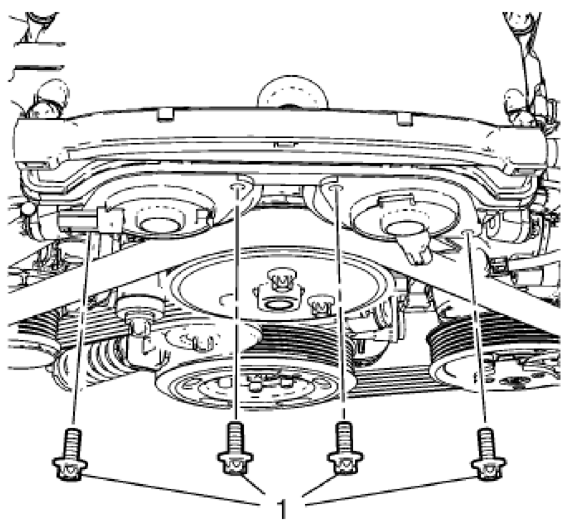
## 8.2.4.22. Camshaft Position Actuator Solenoid Valve Replacement

### 8.2.4.22.1. Removal Procedure

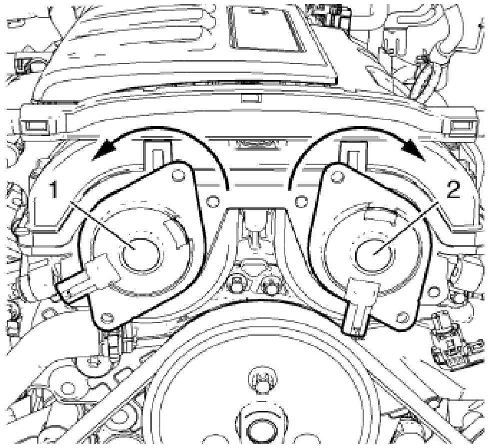
1. Remove the Hood, Refer to Hood in Body Repair
2. Remove the Air intake hose Filter to Turbo



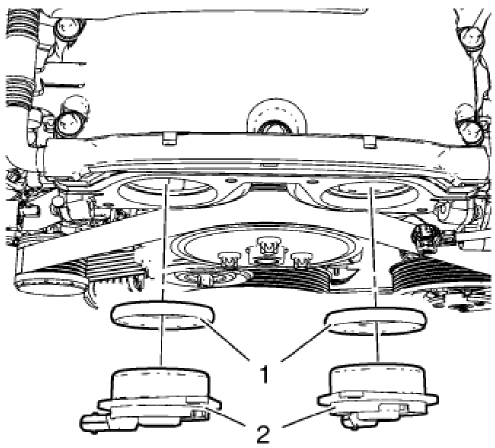

3. Disconnect the intake camshaft position actuator solenoid valve wiring harness plug (3).
4. Disconnect the exhaust camshaft position actuator solenoid valve wiring harness plug (2).
5. Unclip ECM wiring harness (1) from camshaft cover.




6. Remove the 4 camshaft position actuator solenoid valve bolts (1).



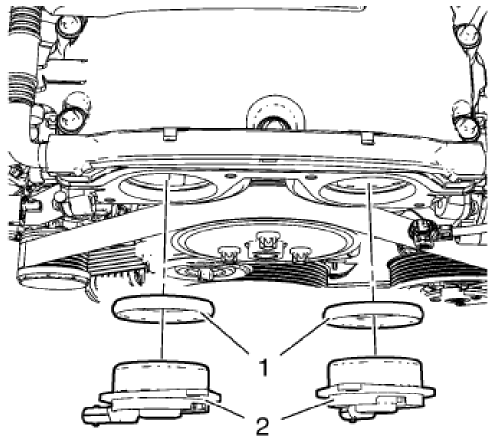

7. Carefully rotate the intake camshaft position actuator solenoid valve (1) counter clockwise as shown.
8. Carefully rotate the exhaust camshaft position actuator solenoid valve (2) clockwise as shown.




| Caution: |
| --- |
| The camshaft position actuator solenoid valves must be kept parallel to the engine front cover during removal and installation. The camshaft position actuator solenoid valves can be damaged if they become wedged or stuck during this process. |

9. Carefully remove the 2 camshaft position actuator solenoid valves (2) and the seal rings (1).

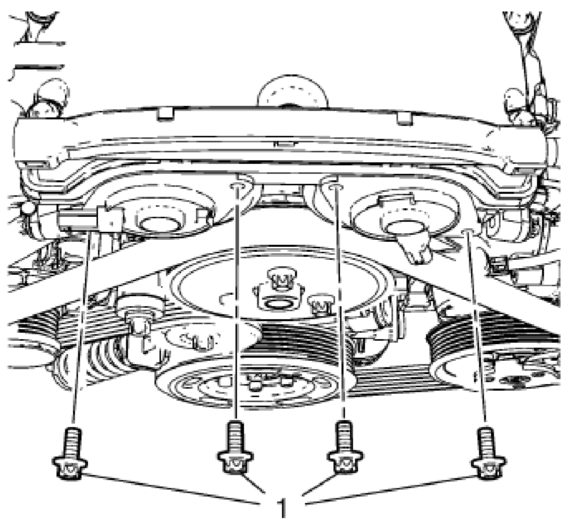
**8.2.4.22.2.Installation Procedure**




| Caution: |
| --- |
| The camshaft position actuator solenoid valves must be kept parallel to the engine front cover during removal and installation. The camshaft position actuator solenoid valves can be damaged if they become wedged or stuck during this process. |

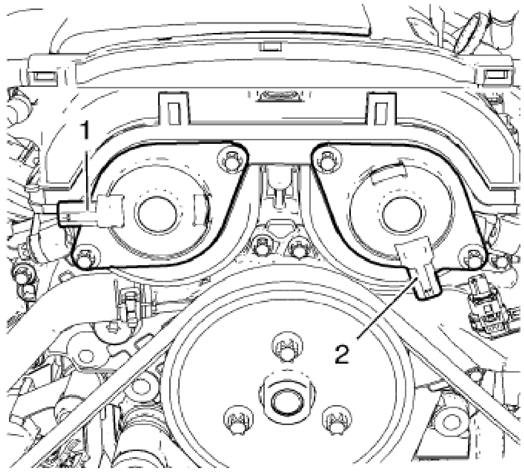
| Caution: |
| --- |
| Lubricate the seal rings with oil in order to make the installation easier. |

1. Carefully install the 2 camshaft position actuator solenoid valves (2) and the 2 seal rings (1) by gently pressing into position.

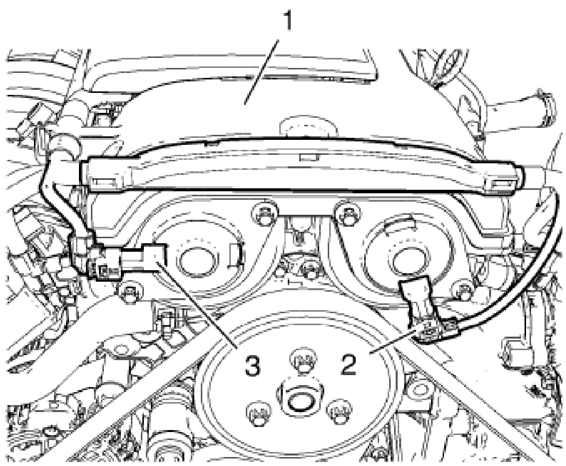



| Caution: |
| --- |
| Refer to Fastener Caution. |

2. Install the 4 camshaft position actuator solenoid valve bolts (1) and tighten to 8 Nm (71 lb in).

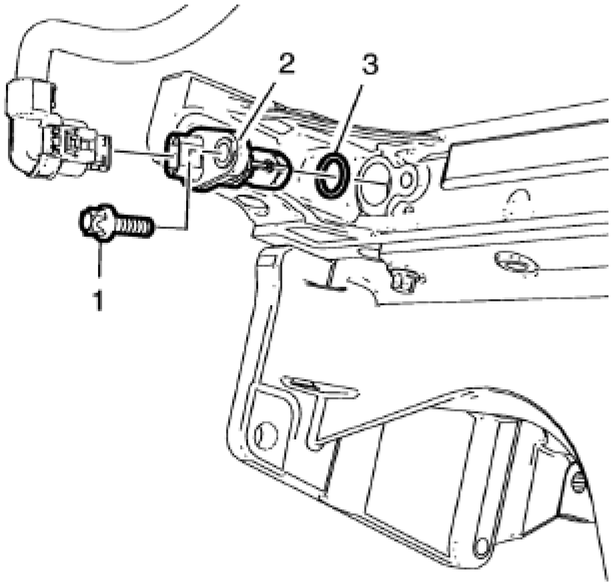



3. The 2 camshaft position actuator solenoid valves should be installed in the position as shown (1) and (2).




4. Clip ECM wiring harness (1) to camshaft cover.
5. Connect the exhaust camshaft position actuator solenoid valve wiring harness plug (2).
6. Connect the intake camshaft position actuator solenoid valve wiring harness plug (3).
7. Install the Air intake hose Filter to Turbo
8. Install the Hood, ,Refer to Hood in Body Repair

#### 8.2.4.22.3.Crankshaft Position Sensor Replacement



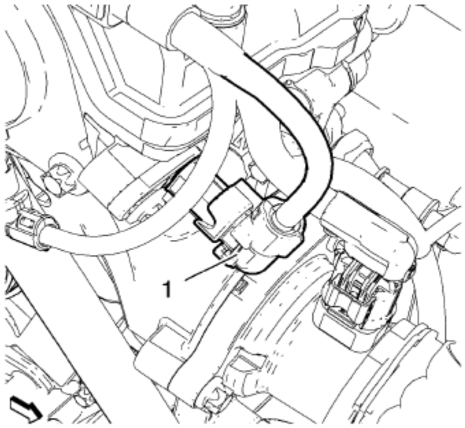

Crankshaft Position Sensor Replacement

| Callout | Component Name |
|---|---|
| **Preliminary Procedures**<br>Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle | |
| 1 | Crankshaft Position Sensor Bolt<br><br>**Caution:** Refer to Fastener Caution.<br><br>**Tighten**<br>8 Nm (71 lb in) |
| 2 | Crankshaft Position Sensor<br><br>**Procedure**<br>1. Disconnect the electrical connector.<br>2. After replacement of crankshaft position sensor, use a scan tool to speed up learn function. Refer to K20 Engine Control Module: Programming and Setup |
| 3 | Crankshaft Position Sensor Seal Ring |

### 8.2.4.23. Camshaft Position Sensor Replacement

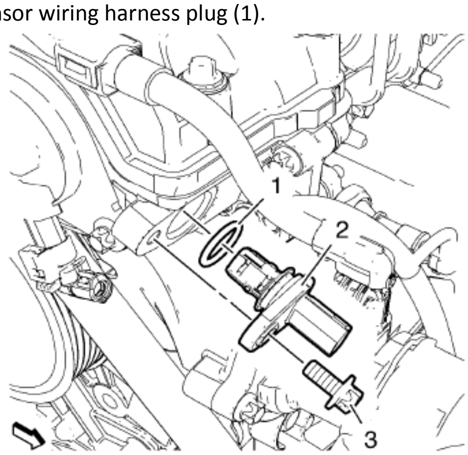
#### 8.2.4.23.1. Removal Procedure

1. Remove the Hood, Refer to Hood in Body Repair
2. Remove the Air intake hose Filter to Turbo




| Note: |
| --- |
| Graphic shows exhaust camshaft position sensor. Use same procedure for Intake camshaft position sensor. |

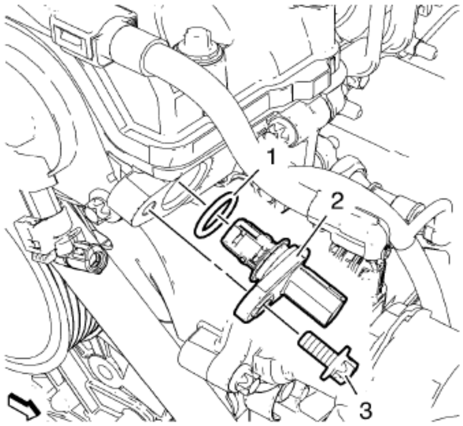
3. Disconnect the camshaft position sensor wiring harness plug (1).




| Note: |
| --- |
| Graphic shows exhaust camshaft position sensor. Use same procedure for Intake camshaft position sensor. |

4. Remove the camshaft position sensor bolt (3).
5 Remove the camshaft position sensor (2) and the seal ring (1).

**8.2.4.23.2.Installation Procedure**

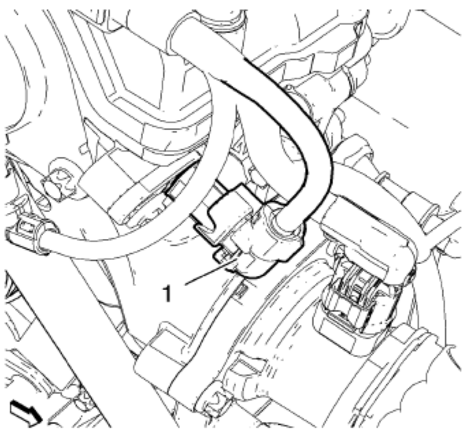



| Note: |
|---|
| Graphic shows exhaust camshaft position sensor. Use same procedure for Intake camshaft position sensor. |

1. Install the camshaft position sensor (2) and the seal ring (1).

| Caution: |
|---|
| Refer to Fastener Caution |

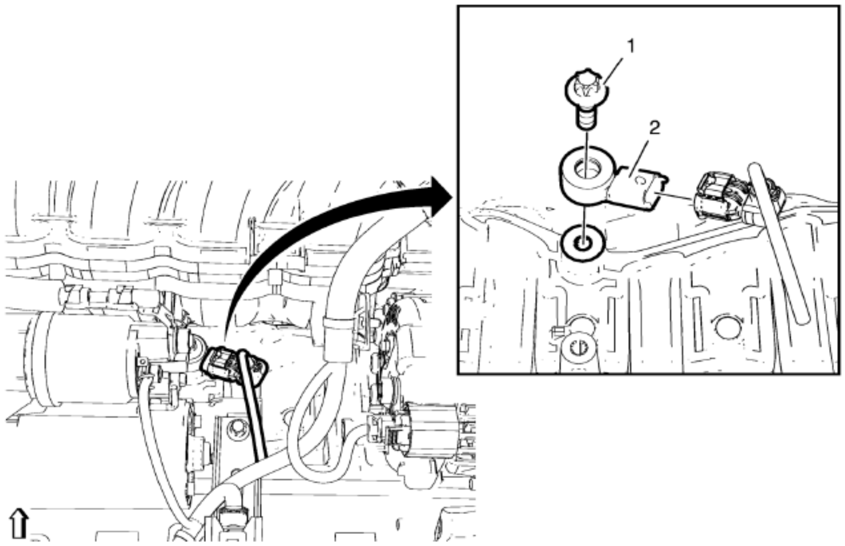
2. Install the camshaft position sensor bolt (3) and tighten to 8 Nm (71 lb in).




| Note: |
|---|
| Graphic shows exhaust camshaft position sensor. Use same procedure for Intake camshaft position sensor. |

3. Connect the camshaft position sensor wiring harness plug (1).
4. Install the Air intake hose Filter to Turbo
5. Install the Hood, Refer to Hood in Body Repair
6. After replacement of a camshaft position sensor, use a scan tool to speed up learn function. Refer to K20 Engine Control Module: Programming and Setup

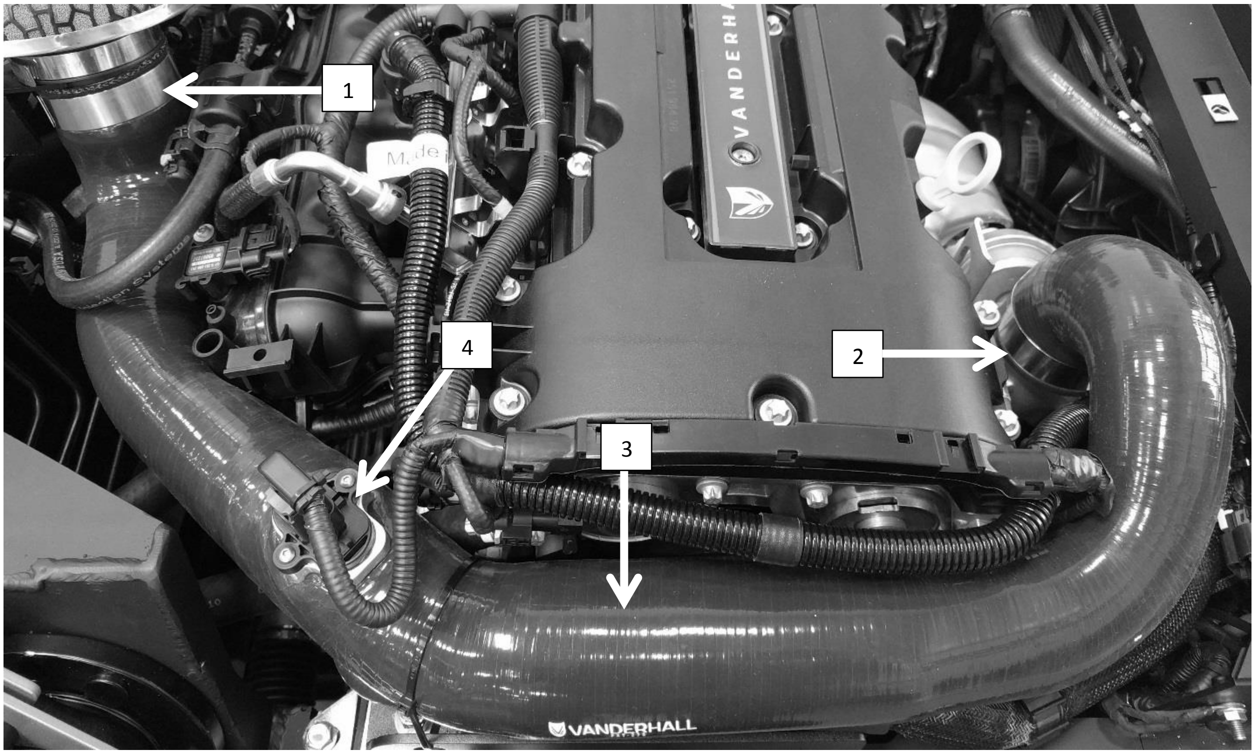
### 8.2.4.24. Knock Sensor Replacement




**Knock Sensor Replacement**

| Callout | Component Name |
|---|---|
| **Preliminary Procedures**<br>1. Disconnect battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.<br>2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle | |
| 1 | Knock Sensor Bolt<br>**Caution:** Refer to Fastener Caution.<br><br>**Procedure**<br>1. Disconnect the electrical connector.<br>2. DO NOT mistake the knock sensor electrical connector with the generator electrical connector.<br><br>**Tighten**<br>20 Nm (15 lb ft) |
| 2 | Knock Sensor |

### 8.2.4.25. Air intake hose Filter to Turbo



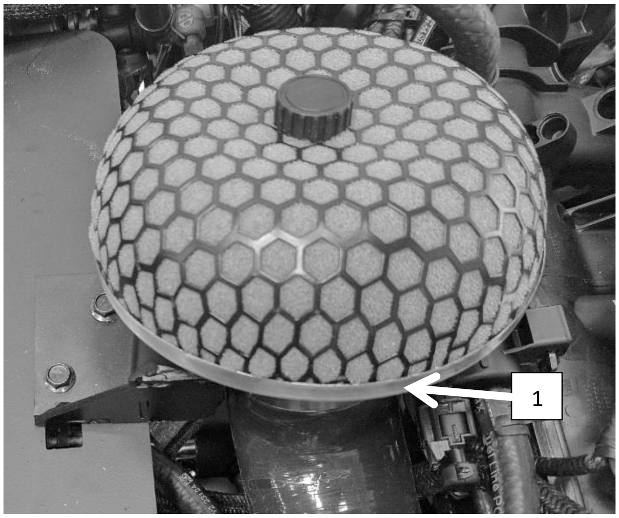

**Air intake hose Filter to Turbo**

| Callout | Component Name |
|---|---|
| **Preliminary Procedures**<br>Remove the Hood<br>Remove Mass Airflow Sensor Replacement | |
| 1 | Air Cleaner Outlet Duct Clamp<br>**Note:** Ensure the outlet duct is fully seated to the mating surfaces before clamping. Verify that the cuff is not rolled under. |
| 2 | Air Cleaner Outlet Duct Clamp<br>**Note:** Ensure the outlet duct is fully seated to the mating surfaces before clamping. Verify that the cuff is not rolled under. |
| 3 | Air intake hose<br>**Tip:** Air cleaner outlet front duct and air cleaner outlet rear duct are one part. |
| 4 | Mass Air flow Sensor<br><br>See Mass Airflow Sensor Replacement |

### 8.2.4.26. Air Cleaner Element Replacement

#### 8.2.4.26.1.Removal Procedure

1. Remove the Hood, Refer to Hood in Body Repair

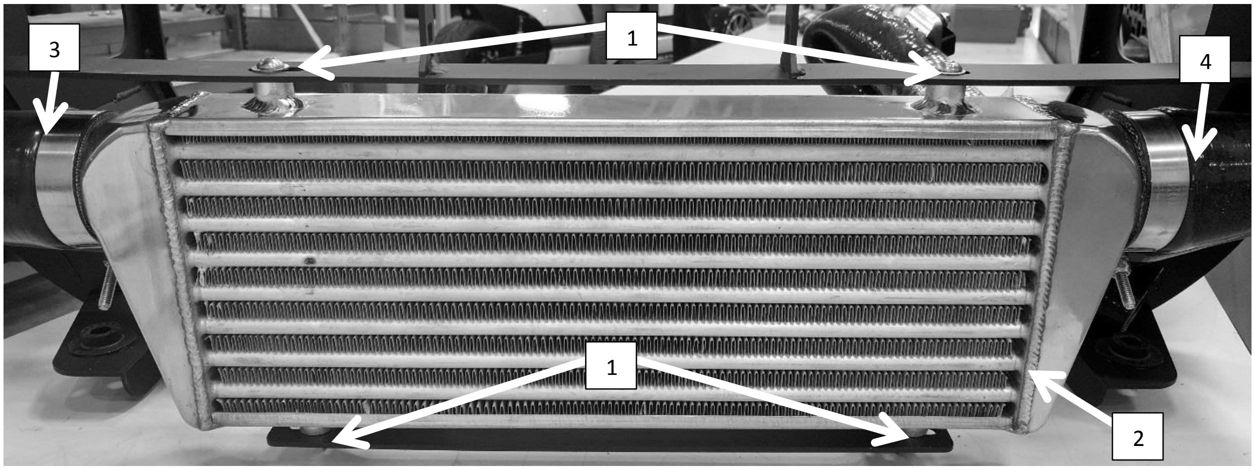



2. Remove the Hose Clamp under the Air Filter
3. Remove the Air Filter assembly

#### 8.2.4.26.2.Installation Procedure

1. Press the air filter assembly over the Air Filter support
2. Tighten the air filter clamp to 10 Nm (89 lb in)

**8.2.4.27. Charge Air Cooler Replacement**



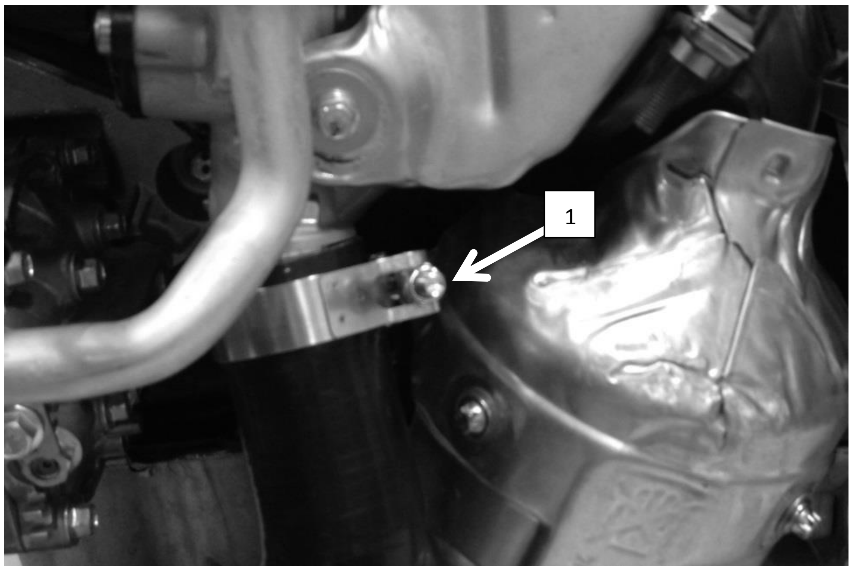

**Charge Air Cooler Replacement**

| Callout | Component Name |
|---|---|
| **Preliminary Procedure**<br>1. Remove the Hood<br>2. Remove the Lower Valiance<br>3. Remove the Front Grill | |
| 1 | Charge Air Cooler Fastener (Qty 4)<br><br>**Caution:** Refer to Fastener Caution.<br><br>**Tighten**<br>10 Nm (89 lb in) |
| 2 | Charge Air Cooler<br><br>Procedure<br>1. Remove both hoses<br>2. Remove Air Cooler Fasteners |
| 3 | Air Cooler Intake Hose<br><br>**Tighten**<br>3Nm (25 in lb) |
| 4 | Charge Air Cooler Outlet Air Hose<br><br>**Tighten**<br>3Nm (25 in lb) |

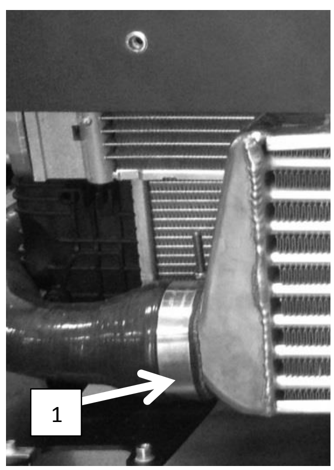
## 8.2.4.28. Charge Air Cooler Inlet Hose Replacement

### 8.2.4.28.1. Removal Procedure

1. Remove the Hood
2. Remove the Front Valance



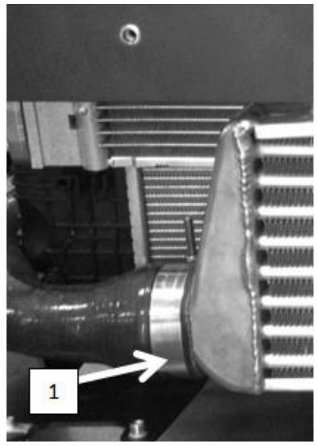

3. Loosen the charge air cooler inlet air pipe clamp (1) at the turbocharger outlet.
4. Remove the air cooler inlet air pipe from the turbocharger outlet



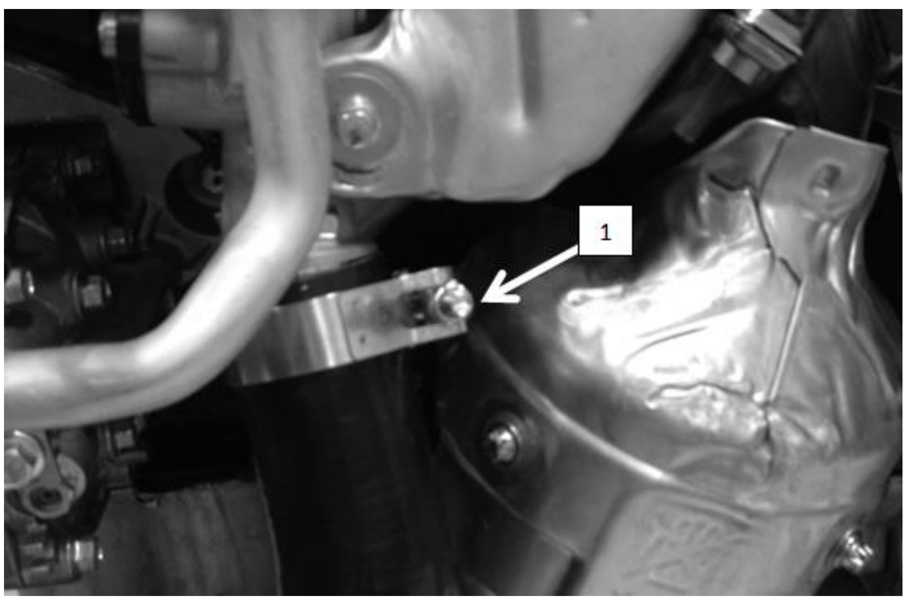

5. Loosen the charge air cooler inlet air pipe clamp (1) at the Air charge cooler
6. Remove the air cooler inlet air pipe from the turbocharger outlet
7. Remove the air cooler inlet air pipe

**8.2.4.28.2.Installation Procedure**

1. Insert the air charge inlet air pipe in to the vehicle

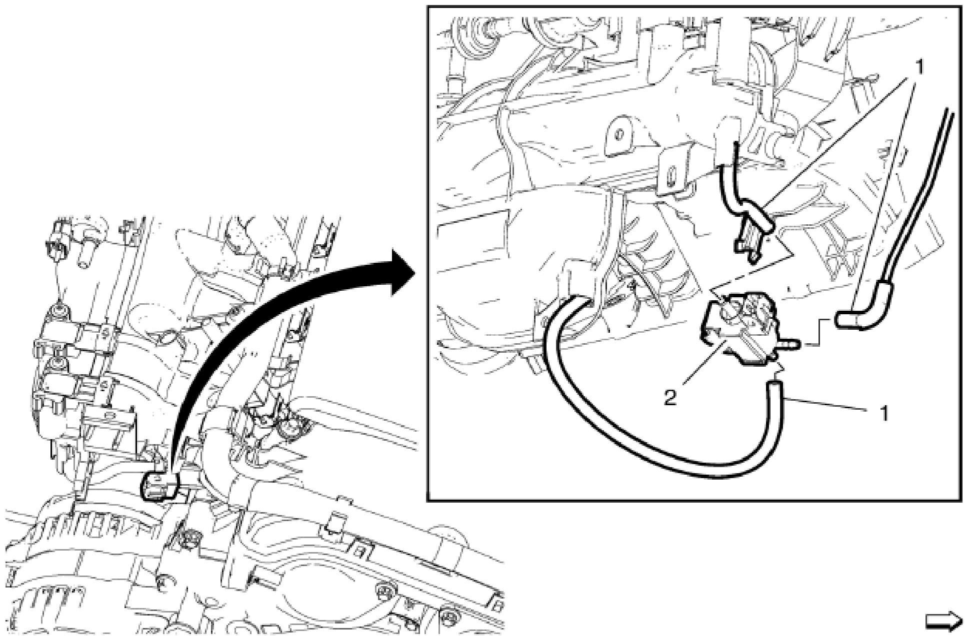



2. Push the air charge inlet air pipe over the Charge Air Cooler
3. Tighten the hose clamp (1) to 3Nm (25 in lb)




4. Push the air charge inlet air pipe over the Turbocharger outlet
5. Tighten the hose clamp (1) to 3Nm (25 in lb)
6. Install the Front Valance
7. Install the Hood

### 8.2.4.29. Charge Air Bypass Regulator Solenoid Valve Replacement




**Charge Air Bypass Regulator Solenoid Valve Replacement**

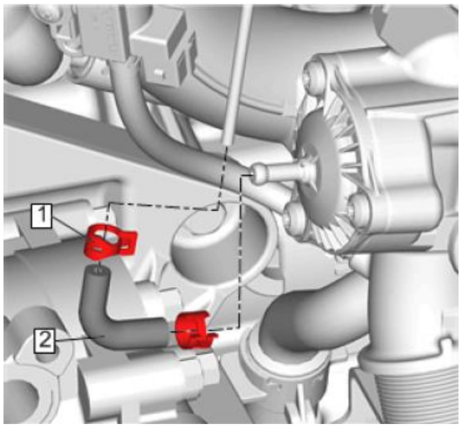
| Callout | Component Name |
|---|---|
| 1 | Charge Air Bypass Regulator Solenoid Valve Hose (Qty: 3)<br>**Procedure**<br>Disconnect the electrical connector. |
| 2 | Charge Air Bypass Regulator Solenoid Valve |

### 8.2.4.30. Charge Air Bypass Valve Replacement

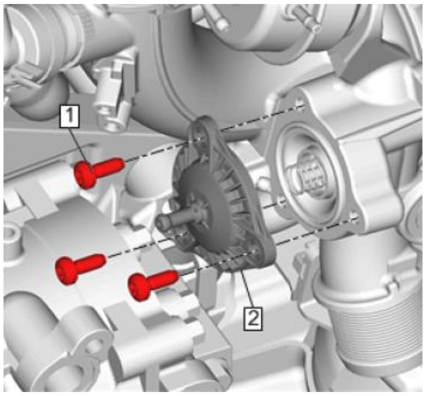
**Special Tools**
GE-23738-A Vacuum Pump

**8.2.4.30.1.Removal Procedure**

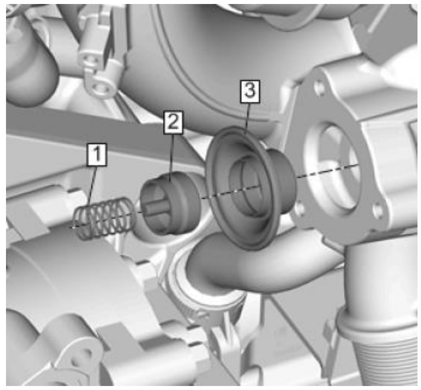
1. Hood » Remove
2. Air intake hose Filter to Turbo » Remove
3. Exhaust Manifold Heat Shield Removal » Remove




4. Turbocharger Wastegate Actuator » Remove — Turbocharger Disassemble
5. Hose Clamp (1) [2x] » Loosen & Position aside

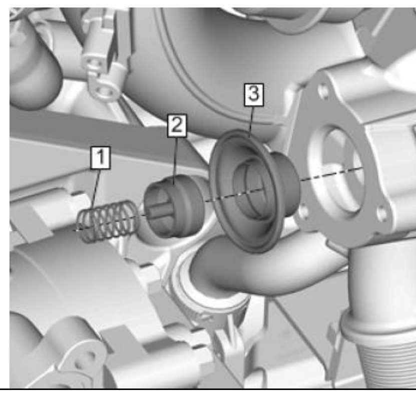



6. Charge Air Bypass Valve Tube Connector (2) » Remove
7. Fastener (1) [3x] » Remove



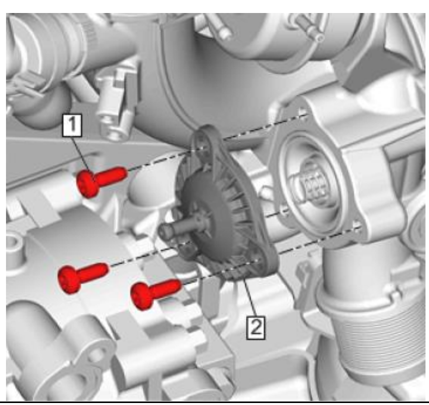

8. Charge Air Bypass Valve Cover (2) » Remove
9. Valve Spring (1) » Remove
10. Charge Air Bypass Valve Piston (2) » Remove
11. Charge Air Bypass Valve Membrane (3) » Remove

**8.2.4.30.2.Installation Procedure**




| Note: |
|---|
| Ensure there is no dirt or debris in the turbocharger housing valve cavity. |

1. Charge Air Bypass Valve Membrane (3) » Install
2. Charge Air Bypass Valve Piston (2) » Install
3. Valve Spring (1) » Install

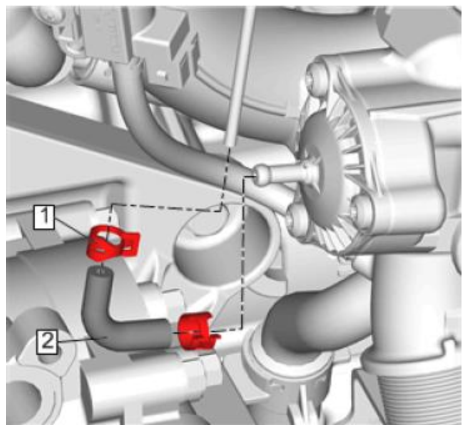



| Note: |
|---|
| The charge air bypass valve piston guide pin fits inside the charge air bypass valve cover guide bore. |

4. Charge Air Bypass Valve Cover (2) » Install

| Caution: |
|---|
| Refer to Fastener Caution. |

5. Fastener (1) [3x] » Install & Tighten the bolts until snug.
6. Fastener (1) [3x] » Tighten12 Nm (106 lb in)
7. Use GE23738A Vacuum Pump to check for vacuum leak.




8. Hose Clamp (1) [2x] @ Charge Air Bypass Valve Tube Connector (2) » Loosely install
9. Charge Air Bypass Valve Tube Connector (2) » Install
10. Hose Clamp (1) [2x] @ Charge Air Bypass Valve Tube Connector (2) » Move into position & Tighten
11. Turbocharger Wastegate Actuator » Install — Turbocharger Assemble
12. Exhaust Manifold Heat Shield Installation » Install
13. Air intake hose Filter to Turbo » Install
14. Hood » Install

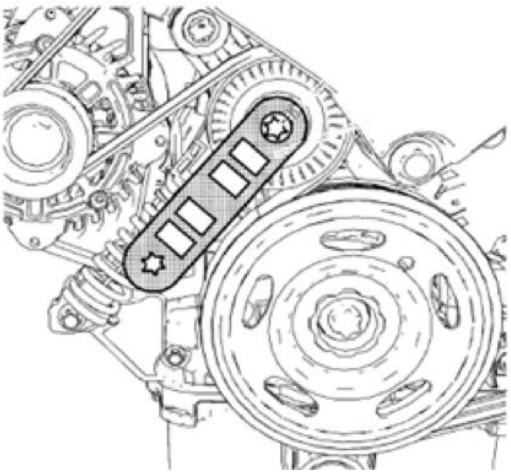
## 8.2.4.31. Drive Belt Replacement

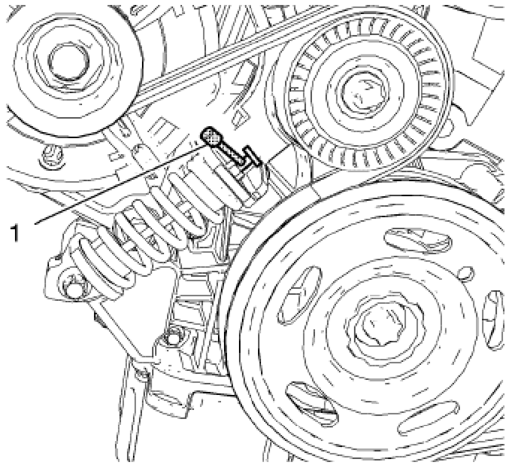
**Special Tools**

EN-48488 Holding Wrench
EN-955 Locking Pin

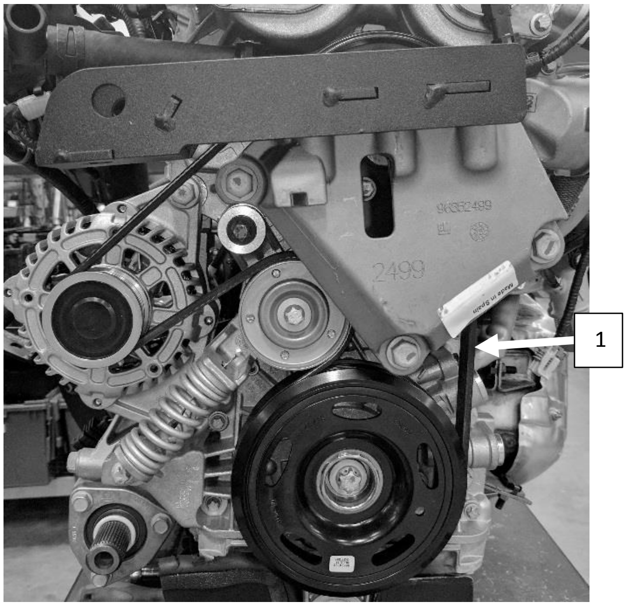
### 8.2.4.31.1.Removal Procedure

1. Remove the Air intake hose Filter to Turbo Refer to Air intake hose Filter to Turbo
2. Support the Engine, Refer to Supporting the Engine
3. Remove the engine mount bracket along with the Right side motor mount. Refer to Engine Mount Bracket Replacement Right Side and Right side Engine Mount.



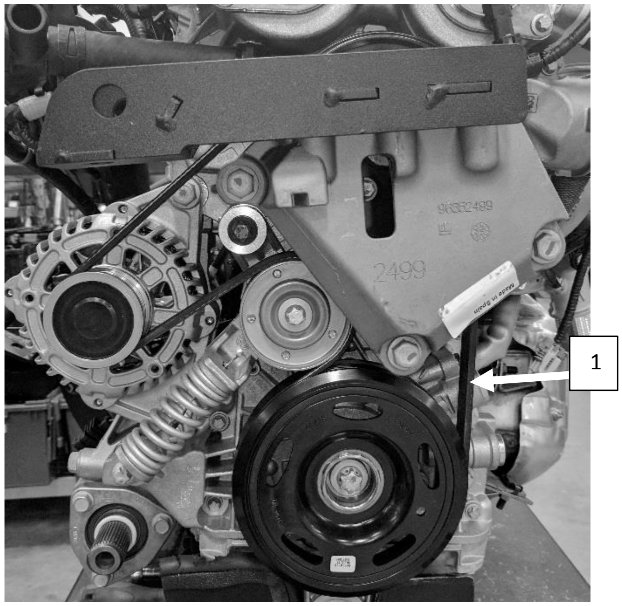



4. Using an appropriately sized start point socket or an EN-48488 Holding wrench Move the drive belt tensioner clockwise until the drive belt tensioner can be fixed with EN-955 locking pin (1).
5. Remove the start point socket or EN-48488 holding wrench.

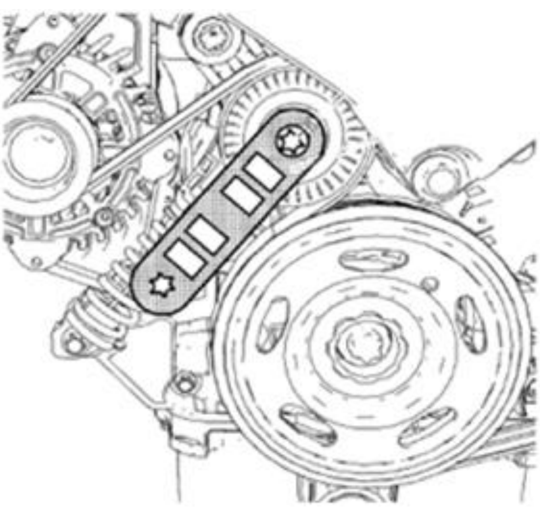


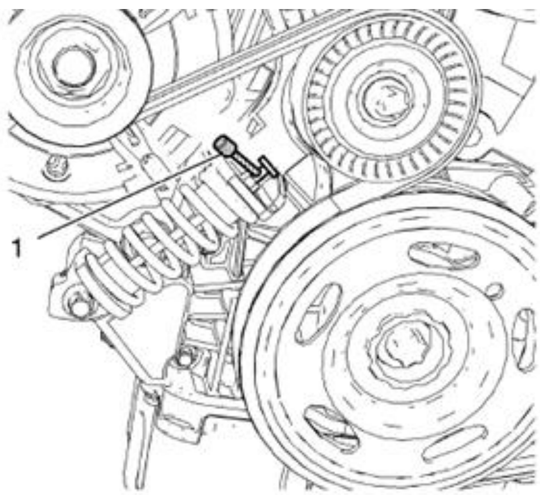

6. Remove the drive belt (1).

**8.2.4.31.2.Installation Procedure**




1. Install the drive belt (1).






2. Using an appropriately sized start point socket or an EN-48488 Holding wrench Move the drive belt tensioner clockwise until the EN-955 locking pin (1) can be removed.
3. Allow the tensioner to slide back slowly.
4. Remove the start point socket or EN-48488 holding wrench.
5. Install the engine mount bracket. Refer to Engine Mount Bracket Replacement Right Side.
6. Install the Right Side Motor Mount and the Engine Mount Bracket Right side. Refer to Engine Mount Bracket Replacement Right Side and Right side Engine Mount.
7. Remove Engine Support

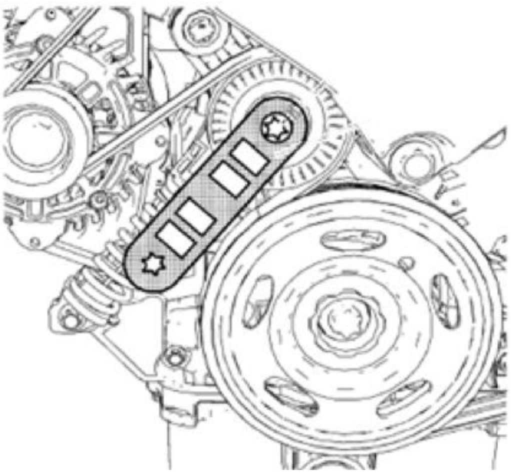
### 8.2.4.32. Drive Belt Tensioner Replacement

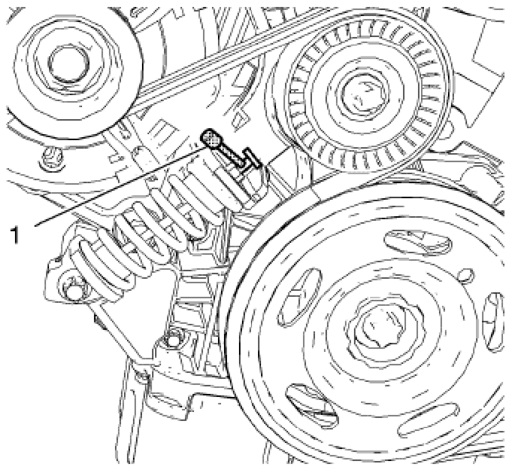
**Special Tools**

EN-955 Locking Pin
EN-48488 Holding Wrench

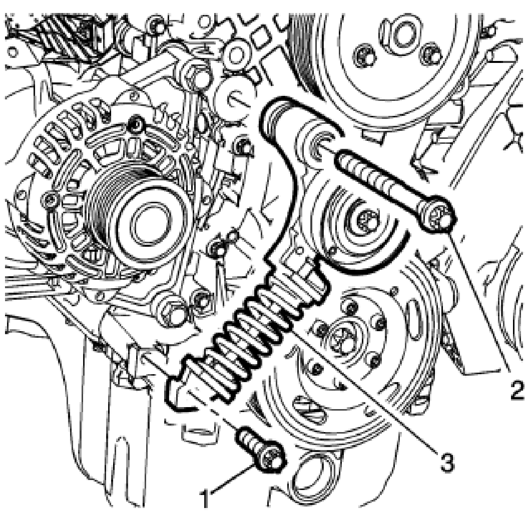
#### 8.2.4.32.1. Removal Procedure

1. Remove the Air intake hose Filter to Turbo Refer to Air intake hose Filter to Turbo
2. Support the Engine, Refer to Supporting the Engine
3. Remove the engine mount bracket along with the Right side motor mount. Refer to Engine Mount Bracket Replacement Right Side and Right side Engine Mount.



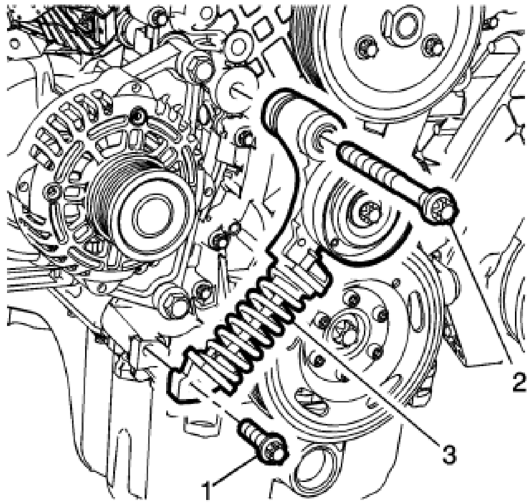



4. Using an appropriately sized start point socket or an EN-48488 Holding wrench Move the drive belt tensioner clockwise until the drive belt tensioner can be fixed with EN-955 locking pin (1).
5. Remove the start point socket or EN-48488 holding wrench.
6. Remove the drive belt.
7. Repeat steps 4 and 5 to remove the locking pin from the drive belt tensioner.

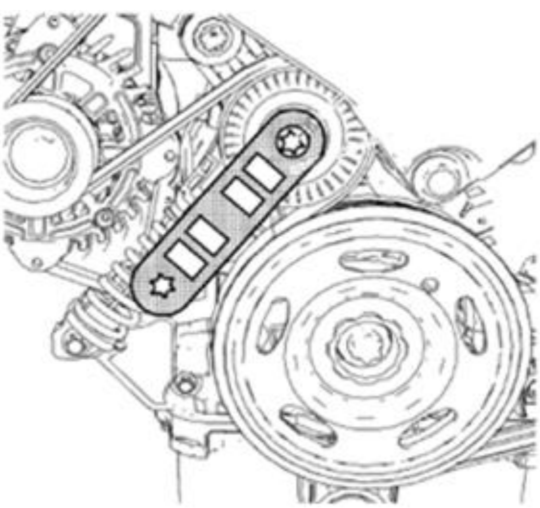


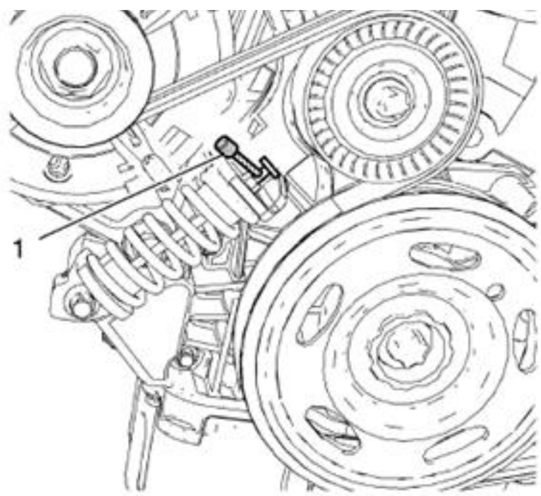

8. Remove the lower drive belt tensioner bolt (1).
9. Remove the upper drive belt tensioner bolt (2).
10. Remove the drive belt tensioner (3).

**8.2.4.32.2.Installation Procedure**

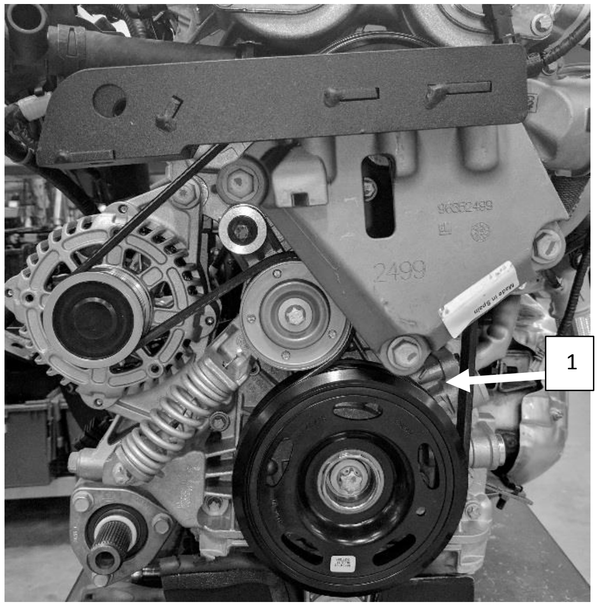



1. Install the drive belt tensioner (3).
2. Install the lower drive belt tensioner bolt (1).
3. Install the upper drive belt tensioner bolt (2).
4. Tighten the lower drive belt tensioner bolt (1) to 22 Nm (16 lb ft).
5. Tighten the upper drive belt tensioner bolt (2) to 55 Nm (41 lb ft).

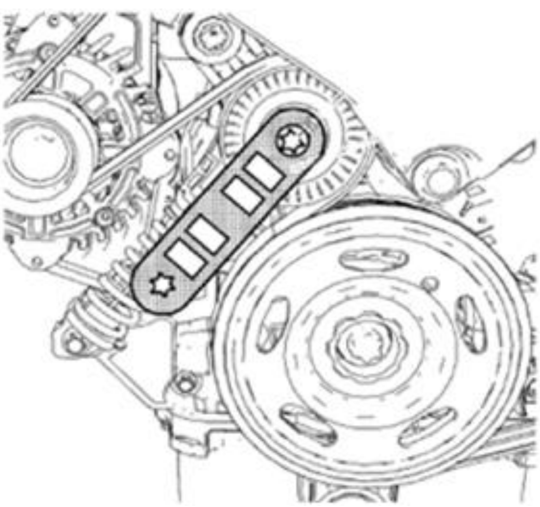


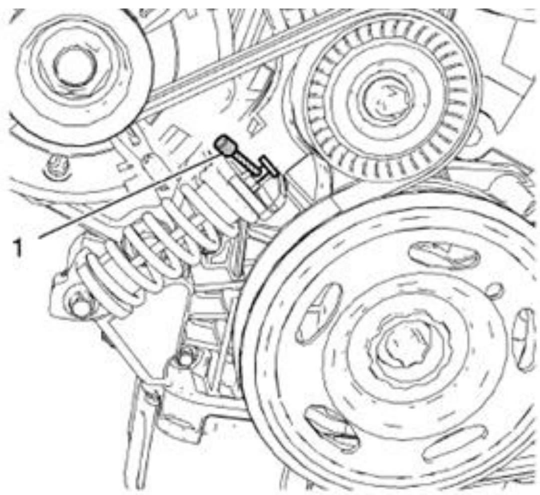



6. Using an appropriately sized start point socket or an EN-48488 Holding wrench Move the drive belt tensioner clockwise until the drive belt tensioner can be fixed with EN-955 locking pin (1).
7. Remove the start point socket or EN-48488 holding wrench.

8. 

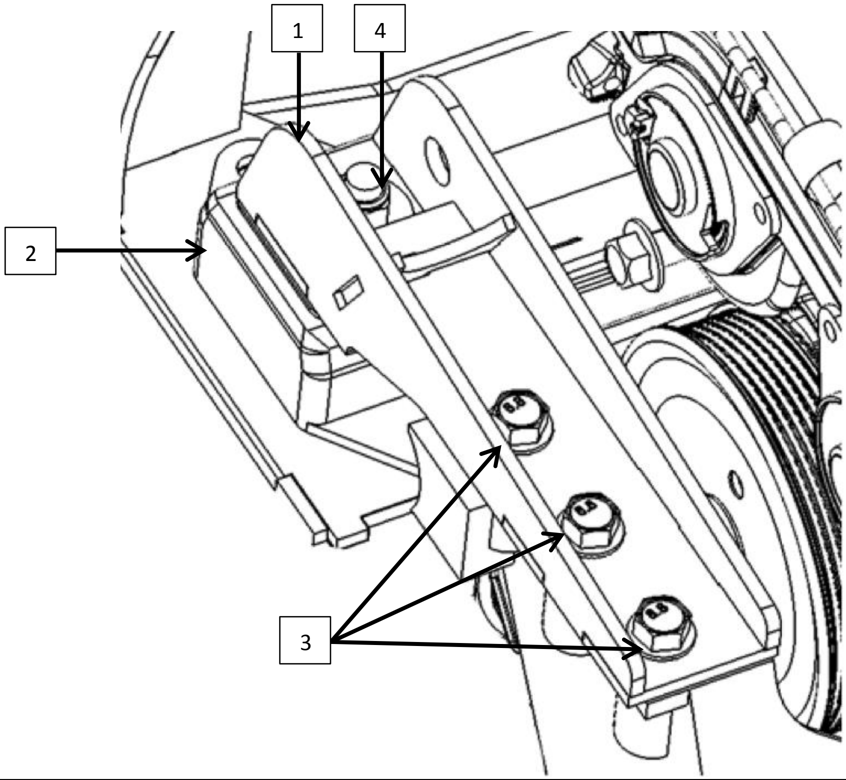

8. Install the drive belt (1).





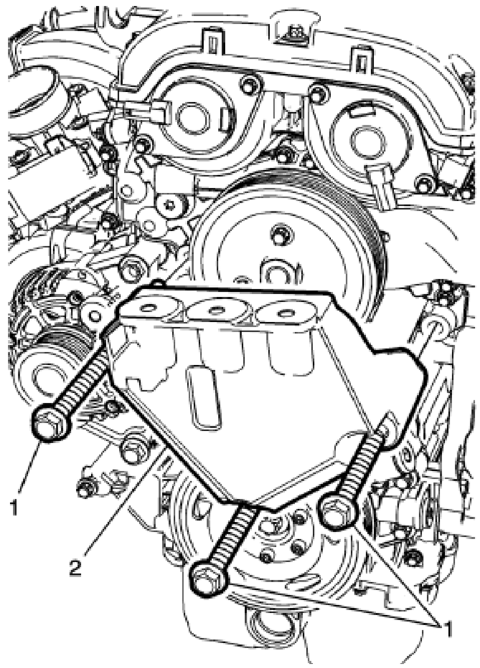

9. Using an appropriately sized start point socket or an EN-48488 Holding wrench Move the drive belt tensioner clockwise until the EN-955 locking pin (1) can be removed.
10. Allow the tensioner to slide back slowly.
11. Remove the start point socket or EN-48488 holding wrench.
12. Install the engine mount bracket. Refer to Engine Mount Bracket Replacement Right Side.
13. Install the Right Side Motor Mount and the Engine Mount Bracket Right side. Refer to Engine Mount Bracket Replacement Right Side and Right Engine Mount.
14. Remove Engine Support

### 8.2.4.33. Engine Mount Replacement Right Side




| Callout | Component Name |
|---|---|
| **Preliminary Procedures**<br>1. Remove Air intake hose Filter to Turbo from the Turbo Charger and position it out of the way.<br>2. Position the surge tank outlet hose out of the way<br>3. Support the Engine, Refer to Supporting the Engine<br>4. Prior to removing the mount, mark the mount location using a marker for correct positioning during installation. | |
| 1 | Right side Engine Mount |
| 2 | Engine Mount Bushing |
| 3 | Engine Mount Bracket to Mount Bolt (Qty: 3)<br>**Procedure**<br><br>Ensure to use a NEW bolt whenever the mount is removed. .<br><br>**Tighten**<br><br>50 Nm+ 60° to 75° (37 lb ft + 60° to 75°) |
| 4 | Engine Mount Nut (Qty: 1)<br><br>**Caution:** Over Tightening the Engine mount nut can cause the Engine Mount Bushing plate to rotate potentially damaging the internal structure<br><br>**Tighten**<br>54 Nm (40 lb ft) |

## 8.2.4.34. Engine Mount Bracket Replacement - Right Side



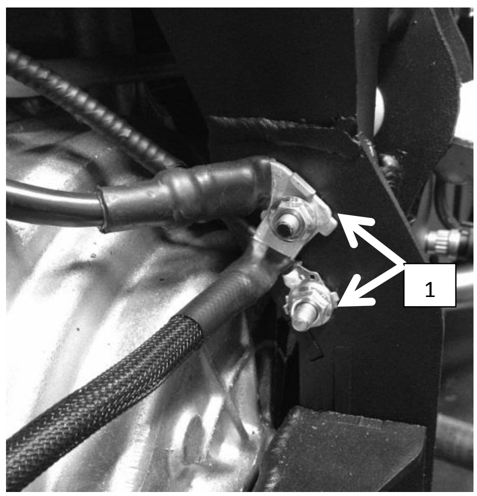

**Engine Mount Bracket Replacement Right Side**

| Callout | Component Name |
|---|---|
| **Preliminary Procedures**<br>1. Remove the engine mount. Refer to Engine Mount Replacement - Right Side. | |
| 1 | Engine Mount Bracket Fastener (Qty: 3)<br><br>**Caution:** This component uses torque-to-yield bolts. When servicing this component do not reuse the bolts, New torque-to-yield bolts must be installed. Reusing used torque-to-yield bolts will not provide proper bolt torque and clamp load. Failure to install NEW torque-to-yield bolts may lead to engine damage.<br><br>**Caution:** Refer to Fastener Caution.<br><br>**Procedure**<br>Raise and lower the engine as needed to access the bolts.<br><br>**Tighten**<br>62 Nm (46 lb ft) |
| 2 | Engine Mount Bracket |

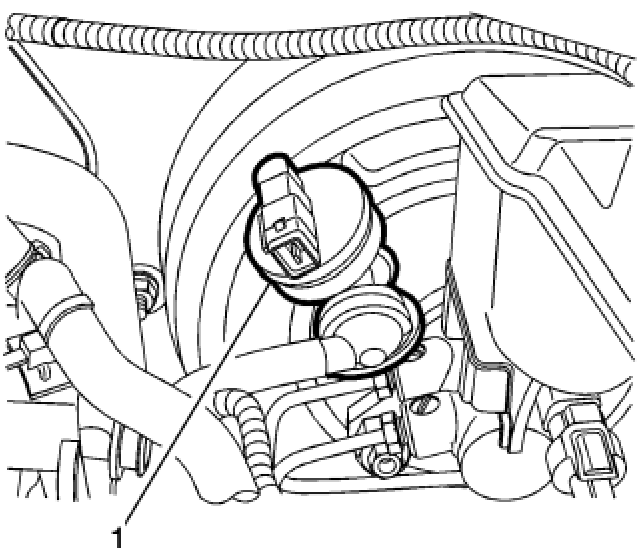
### 8.2.4.35. Engine Replacement

#### 8.2.4.35.1. Removal Procedures

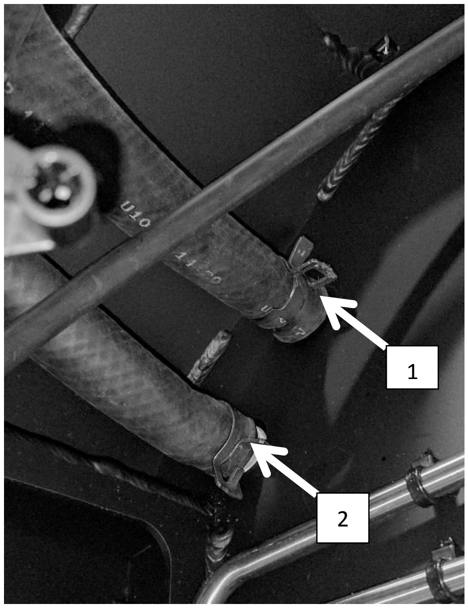
1. Disconnect the negative terminal of the battery. Refer to Battery Negative Terminal Replacement.
2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
3. Remove Front Chassis Clip, Refer to Chassis Front Clip
4. Remove the Air intake hose Filter to Turbo, Refer to Air intake hose Filter to Turbo
5. Relieve the fuel system pressure. Refer to Fuel Pressure Relief.
6. Remove the front tire and wheel assembly. Refer to Tire and Wheel Removal and Installation.
7. Remove the wheel drive shafts. Refer to Drive Shaft Replacement.
8. Remove the Battery jump Post, Refer to Battery Positive Cable Replacement (Main Breaker to Jump Post )
9. Remove the Horn, Refer to Horn Replacement
10. Remove the ECU, Refer to ECU Replacement
11. Remove the ECU/Fuse Block bracket, Refer to ECU Fuse Block Bracket Replacement



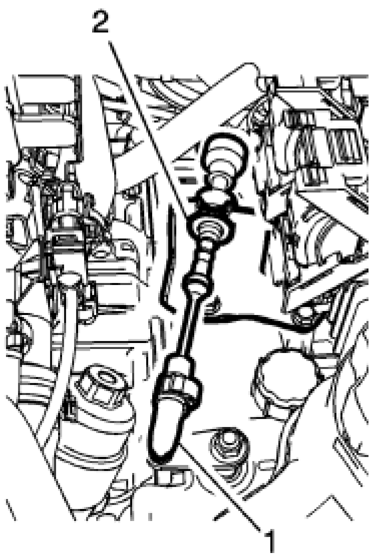

12. Remove Chassis Grounds (1)



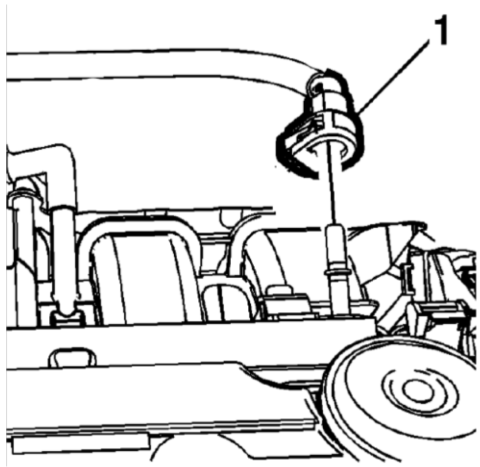

13. Disconnect the electrical connector and remove the brake booster hose (1)



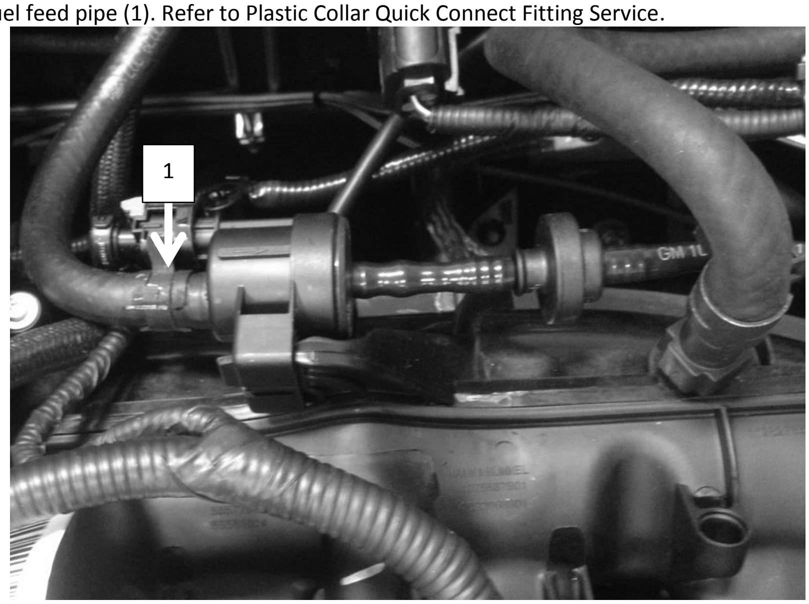

14. Disconnect the heater inlet hose (1) from the heater core. Refer to Heater Inlet Hose Replacement.
15. Disconnect the heater outlet hose (2) from the heater core. Refer to Heater Outlet Hose Replacement.



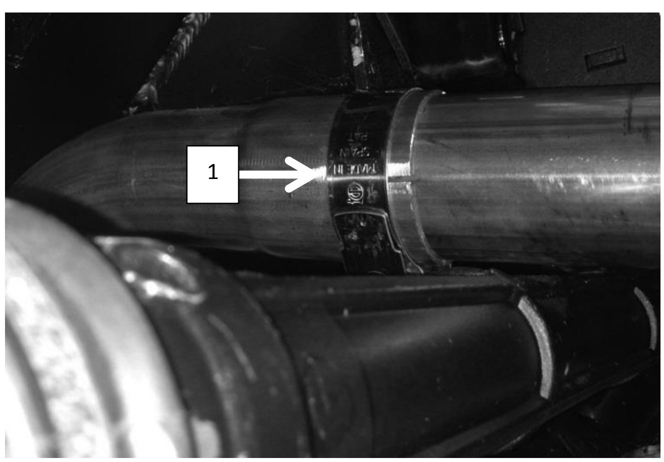

16. Disconnect the transmission range selector lever cable terminal (1) from the transmission manual shift lever pin.
17. Remove the transmission range selector lever cable (2) from the cable bracket.




18. Disconnect the fuel feed pipe (1). Refer to Plastic Collar Quick Connect Fitting Service.

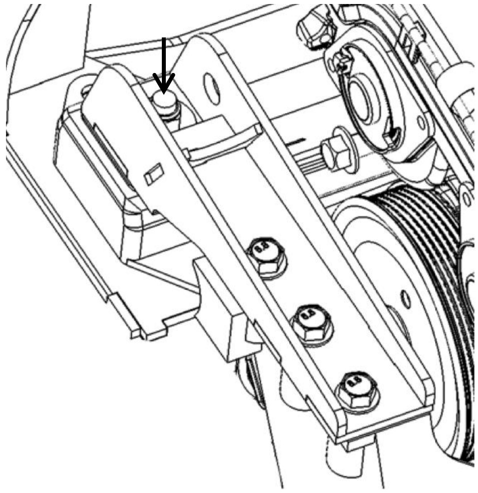



19. Disconnect the evaporative emission pipe (1).

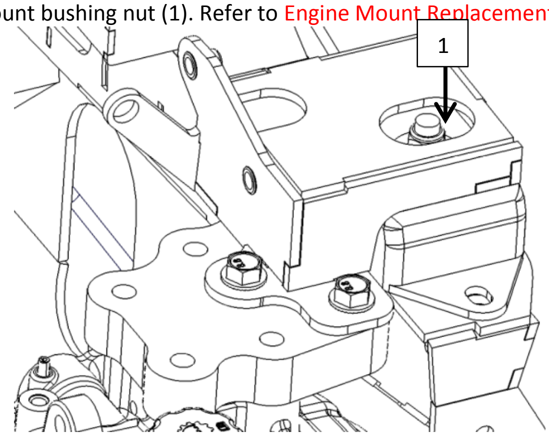



20. Disconnect the Exhaust Down Pipe from the Y-Pipe(1)

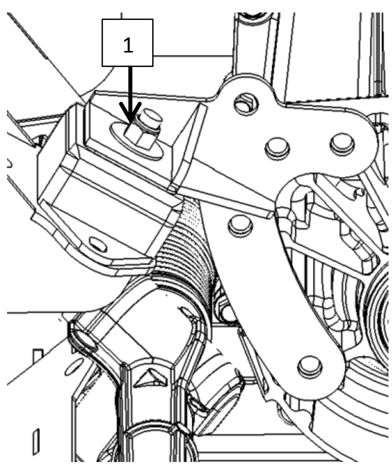
1



21. Remove the right side engine mount bushing nut (1). Refer to Engine Mount Replacement Right Side.



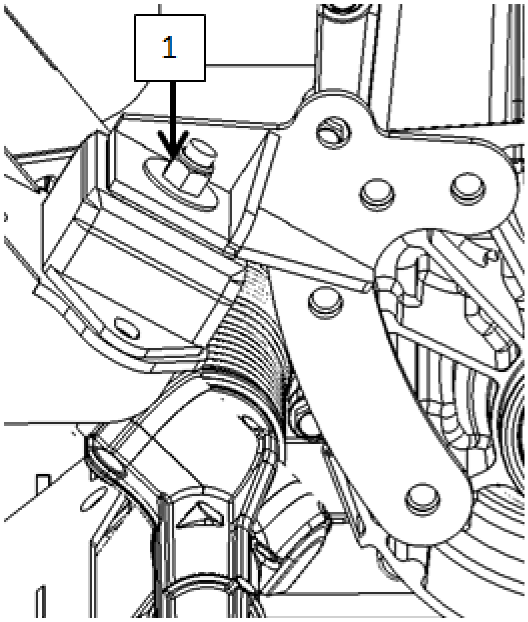

22. Remove the Left side Transmission mount bushing nut (1). Refer to Transmission Mount Replacement Left Side.



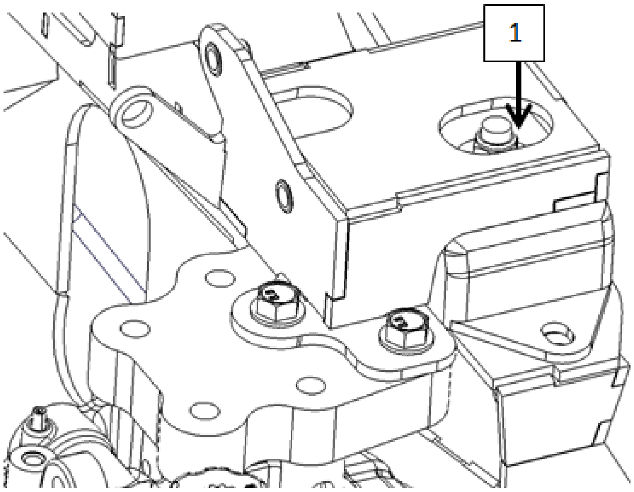

23. Remove the Transmission mount bracket bushing nut (1). Refer to Transmission Mount Bracket Replacement – Rear
24. Disconnect any additional electrical connections as necessary.
25. Using the Engine Mount Brackets Lift the engine to clear mount studs
26. Remove the Engine by pulling it forward out the front of the chassis
27. Remove the Exhaust Down Pipe from the Engine, Refer to Exhaust Down Pipe Replacement
28. Transfer parts as necessary.

**8.2.4.35.2.Installation**

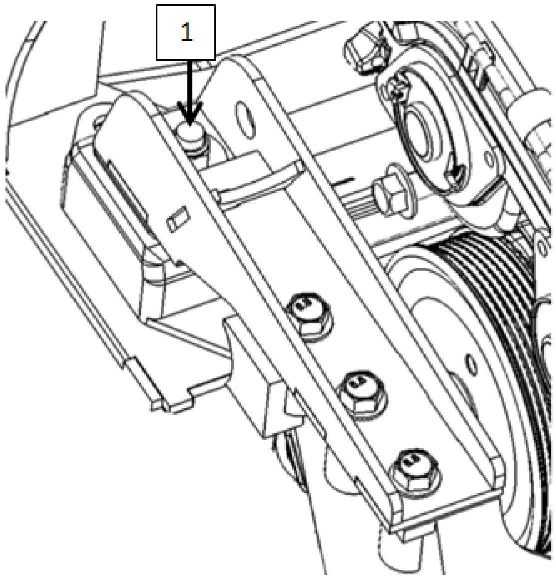
1. Insert the Exhaust Down Pipe in to the Y-Pipe
   1.1. Do not tighten the Exhaust clamp
2. Slide the engine in to the chassis and lower on to the 3 engine mount bushings



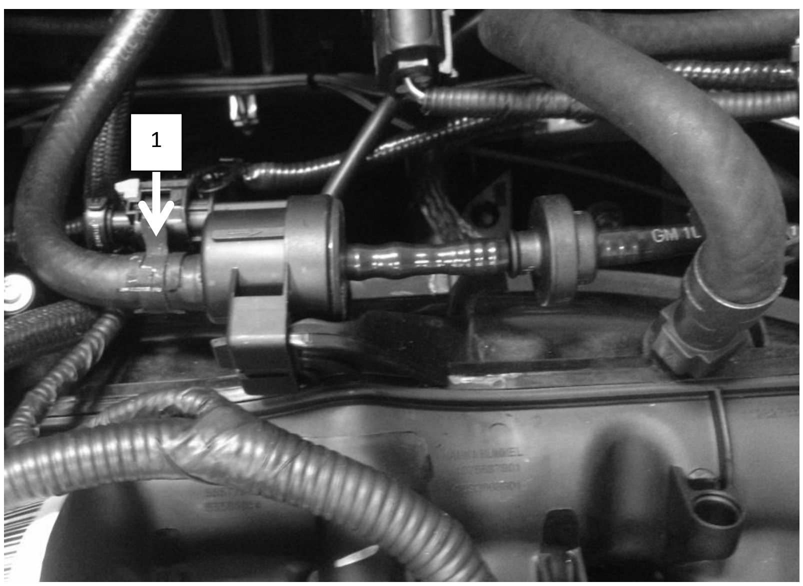

3. Install the Transmission mount bracket bushing nut (1). Refer to Transmission Mount Bracket Replacement – Rear and Tighten to 28 Nm (20 lb ft)



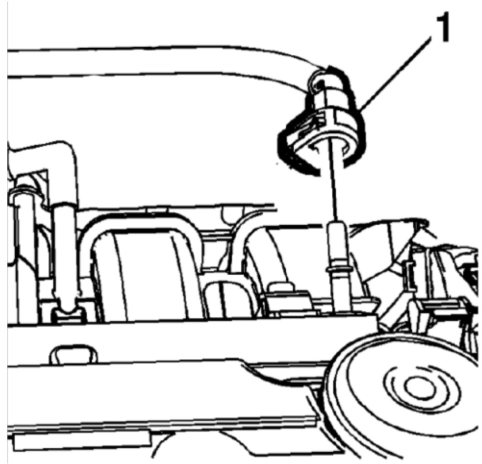

4. Install the Left side Transmission mount bushing nut (1). Refer to Transmission Mount Replacement Left Side. and Tighten to 28 Nm (20 lb ft)



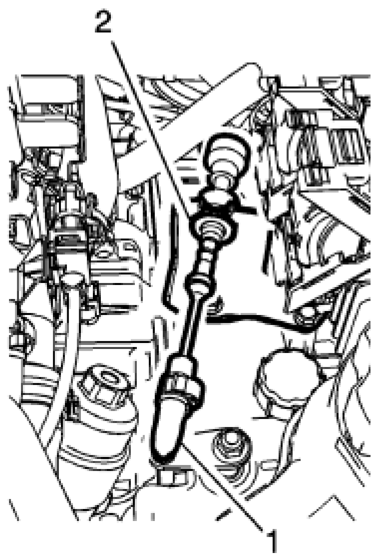

5. Install the right side engine mount bushing nut (1). Refer to Engine Mount Replacement Right Side. and Tighten to 28 Nm (20 lb ft)
6. Connect the Down Pipe to the Catalytic Converter, Refer to Exhaust Down Pipe Replacement
7. Tighten the Exhaust Clamp Down pipe to Y-Pipe to 20 Nm (15 lb ft).



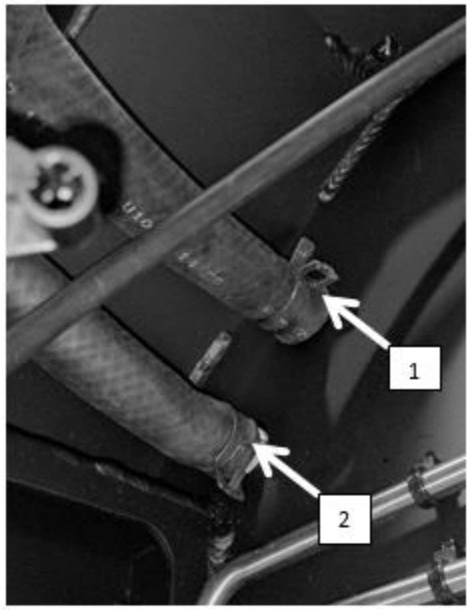

8. Connect the evaporative emission pipe (1).



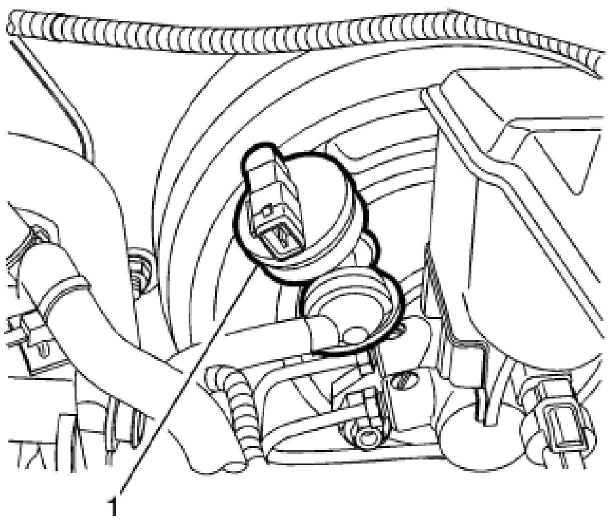

9. Connect the fuel feed pipe (1). Refer to Plastic Collar Quick Connect Fitting Service.



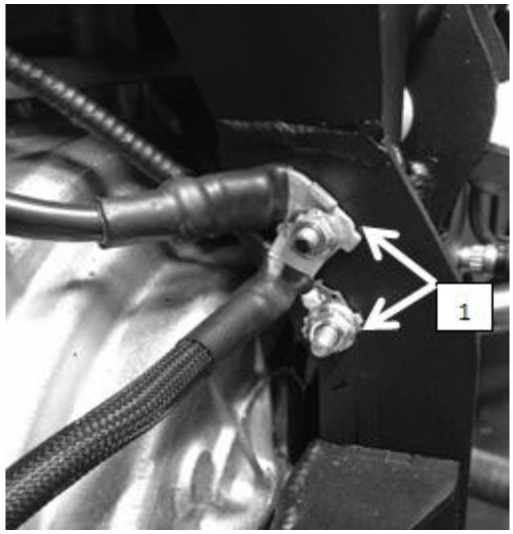

10. Insert the transmission range selector lever cable (2) in to the cable bracket.
11. Connect the transmission range selector lever cable terminal (1) to the transmission manual shift lever pin.




12. Connect the heater inlet hose (1) to the heater core. Refer to Heater Inlet Hose Replacement.
13. Connect the heater outlet hose (2) from the heater core. Refer to Heater Outlet Hose Replacement




14. Connect the electrical connector and remove the brake booster hose (1)




15. Install the Chassis Grounds and tighten to 10 Nm 88 lb in
16. Install the ECU/Fuse Block bracket, Refer to ECU Fuse Block Bracket Replacement
17. Install the ECU, Refer to ECU Replacement
18. Install the Horn, Refer to Horn Replacement
19. Install the Battery jump Post, Refer to Battery Positive Cable Replacement (Main Breaker to Jump Post )
20. Install the wheel drive shafts. Refer to Drive Shaft Replacement.
21. Install the front tire and wheel assembly. Refer to Tire and Wheel Removal and Installation.
22. Install the Air intake hose Filter to Turbo, Refer to Air intake hose Filter to Turbo
23. Install Front Chassis Clip, Refer to Chassis Front Clip
24. Lower the Vehicle
25. Connect the negative terminal of the battery. Refer to Battery Negative Terminal Replacement.
26. Fill the cooling system. Refer to Cooling System Draining and Filling.
27. Charge the refrigerant. Refer to Refrigerant Recovery and Recharging
28. Start the engine and check for leaks

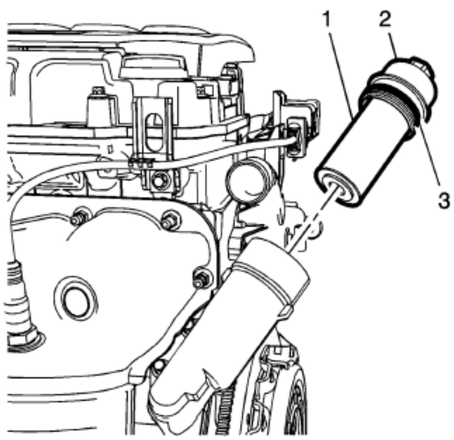
## 8.2.4.36. Engine Oil and Oil Filter Replacement

### 8.2.4.36.1.Removal Procedure

1. Remove the Hood, Refer to Hood in Body Repair
2. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
    1. Ensure the vehicle is level
3. Place a drain pan below the vehicle.

| Caution: |
| --- |
| To prevent damage to oil filter cap ensure proper tool is used. Do not use an open end wrench which may cause damage to filter cap. |

4. Using a 24mm socket or closed end wrench loosen oil filter cap. Unscrew filter cap 3 turns and let oil filter and cap assembly drain in housing for 30 seconds.




| Note: |
| --- |
| Use care when removing engine oil filter cap and filter to minimize fluid spillage. If fluid spillage occurs it must be cleaned with appropriate cleaner. |

| Note: |
| --- |
| Inspect oil filter cap for any cracks or damage. If oil filter cap is damaged it must be replaced. |

5. Remove the engine oil filter cap (2) with the engine oil filter cap seal ring (3) and the oil filter element (1).
6. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
7. Remove the oil pan drain plug and allow the oil to drain into the drain pan.

### 8.2.4.36.2.Installation Procedure

1. Clean the oil pan drain plug thread in the oil pan.

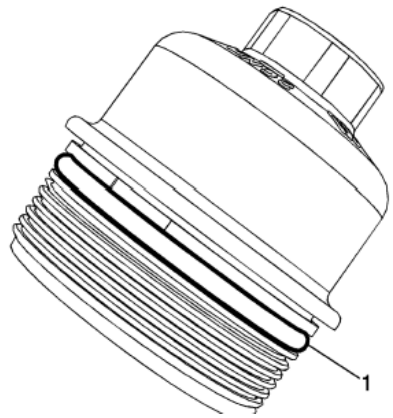
| Note: |
| --- |
| Inspect oil drain plug seal ring for damage, replace if damaged. |

2. Install a NEW seal ring, if necessary to the oil pan drain plug.

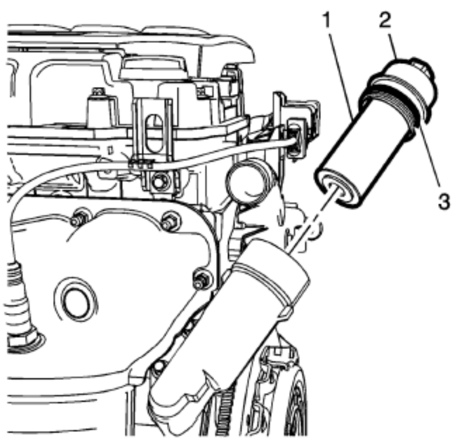
| Caution: |
| --- |
| Refer to Component Fastener Tightening Caution. |

3. Install the oil pan drain plug and tighten to 14 Nm (10 lb ft).

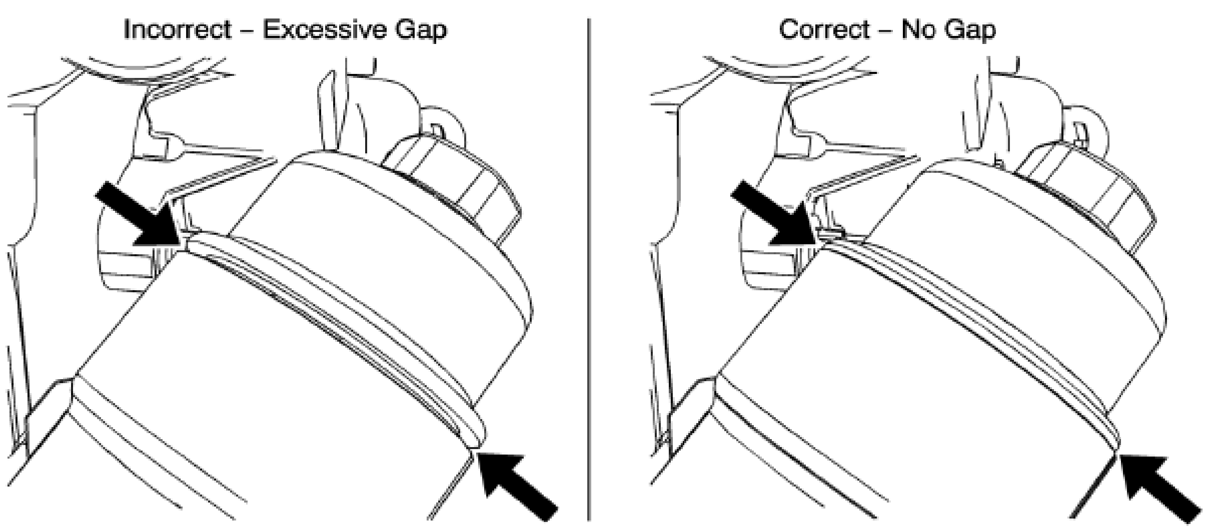
4. Lower the vehicle.




5. Clean oil filter cap and lubricate the NEW oil filter cap seal ring (1) with clean engine oil. Ensure oil filter cap seal ring is in proper position as shown.




6. Install the engine oil filter cap (2) with NEW engine oil filter cap seal ring (3) and NEW oil filter element (1) hand tight.



| **Caution:** |
|---|
| Ensure oil filter cap is completely seated on oil filter housing. If not completely seated an oil leak may occur. |

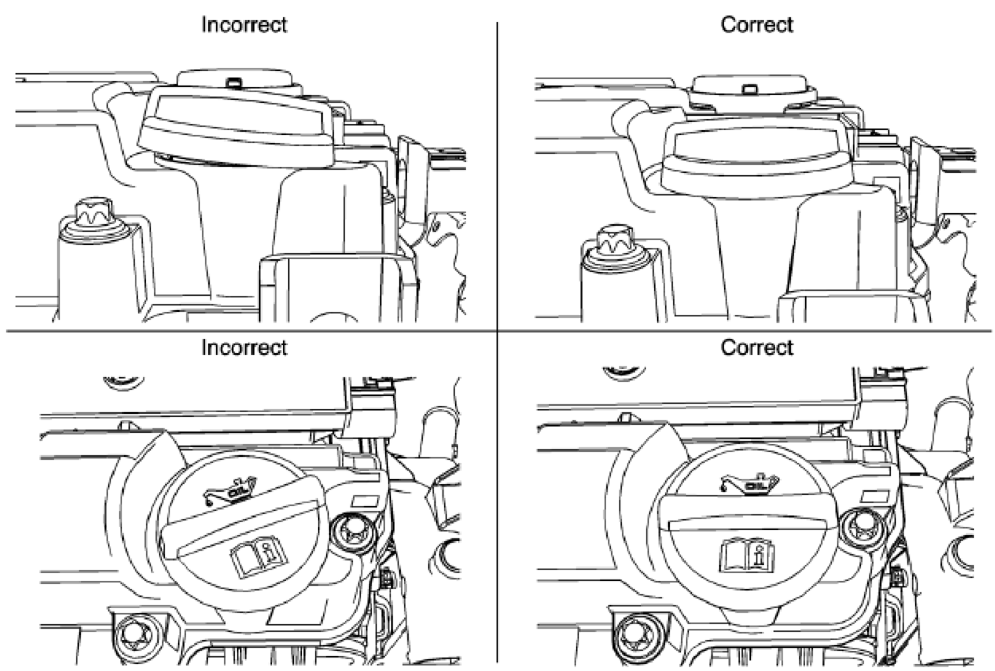
| **Caution:** |
|---|
| Over torqueing the oil filter cap may cause damage to the oil filter cap resulting in an oil leak. |

7. Using a 24mm socket or closed end wrench tighten the engine oil filter cap to 25 Nm (18 lb ft).

| **Caution:** |
|---|
| Using engine oils of any viscosity other than those viscosities recommended could result in engine damage. |

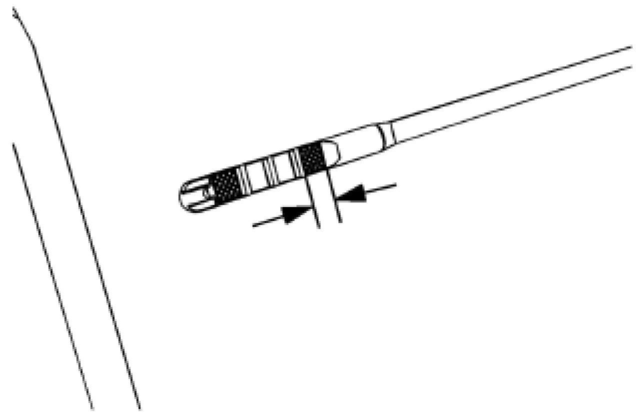
| **Note:** |
|---|
| • Do not overfill the engine with engine oil.<br>• Anytime engine oil is added (top off or oil changes) ensure all engine surfaces are completely free of residual oil. If there is oil on any engine surface clean as necessary. |

8. Fill the engine with the appropriate oil type and quantity. Approximate Fluid Capacities and Adhesives, Fluids, Lubricants, and Sealers




| **Note:** |
|---|
| Oil fill cap must be properly seated and tightened during installation. |

9. Install oil fill cap.
10. Start the engine and allow it to run until the oil pressure control indicator goes off. Inspect for any oil leaks around the drain plug, oil filter and oil fill cap.



11. Inspect the engine oil level. The oil level should be in the crosshatched section of the oil level indicator as shown.
12. Close hood.
13. Reset the engine oil life system monitor.

### 8.2.5. Specifications

#### 8.2.5.1. Engine Mechanical Specifications

**Engine Mechanical Specifications**

| Application | Specification | |
|---|---|---|
| | Metric | English |
| **General Data** | | |
| • Engine Type | 4- Cylinder Inline | |
| • Displacement | 1364 ccm | 83.24 cu in |
| • Bore | 72.5 mm | 2.854 in |
| • Stroke | 82.6 mm | 3.3 in |
| • Compression Ratio | 9.5:1 | |
| • Number of Valves | 16 | |
| • Maximum Power @ engine speed KW/RPM | 105 KW /4900 | |
| • Maximum Torque @ engine speed Nm / RPM / lb ft / RPM | 200 Nm / 1850 | 148 lb ft / 4000 |
| **Engine Block** | | |
| • Deck Surface Flatness | 0.05 mm | 0.0019 in |
| • Bearing Bore Roundness Tolerance | 0.008 mm | 0.0003 in |
| • Cylinder Bore Diameter Standard | 72.492 mm – 72.508 mm | 2.8540 in – 2.8546 in |
| • Cylinder Bore Diameter Oversize 0.5 | 72.992 mm – 73.008 mm | 2.8737 in – 2.8743 in |
| **Piston, Piston Rings and Piston Pins** | | |
| • Piston Diameter Standard | 72.453 mm – 72.467 mm | 2.8525 in – 2.8530 in |
| • Piston Diameter Oversize 0.5 | 72.953 mm – 72.967 mm | 2.8722 in – 2.8727 in |
| • Piston Clearance to Bore | 0.025 mm –0.055 mm | 0.001 in – 0.0022 in |
| • Piston – Upper Compression Ring Thickness | 1.17 mm – 1.195 mm | 0.0461 in 0.047 in |
| • Piston – Upper Compression Ring Gap | 0.25 mm – 0.4 mm | 0.0098 in – 0.0157 in |
| • Piston – Upper Compression Ring Side Clearance | 0.025 mm – 0.07 mm | 0.001 in – 0.0028 in |
| • Piston – Lower Compression Ring Thickness | 1.17 mm – 1.195 mm | 0.0461 in 0.047 in |
| • Piston – Lower Compression Ring Gap | 0.4 mm – 0.6 mm | 0.0157 in – 0.0236 in |
| • Piston – Lower Compression Ring Side Clearance | 0.025 mm – 0.07 mm | 0.001 in – 0.0028 in |
| • Piston – Oil Ring Thickness | 1.92 mm – 2 mm | 0.0756 in – 0.0787 in |
| • Piston – Oil Ring Gap | 0.25 mm – 0.75 mm | 0.0098 in – 0.0295 in |
| • Piston – Oil Ring Side Clearance | 0.04 mm – 0.12 mm | 0.0016 in – 0.0047 in |
| • Piston Pin Bore Diameter | 18.006 mm – 18.012 mm | 0.7089 in – 0.7091 in |
| • Piston Pin Outer Diameter | 17.995 mm – 18 mm | 0.7085 in – 0.7087 in |
| • Piston Pin Length | 48 mm | 1.8898 in |
| • Piston Pin Clearance to Piston Bore | 0.005 mm – 0.010 mm | 0.0002 in – 0.00039 in |
| • Piston Pin Clearance to Conrod Bore | 0.010 mm – 0.018 mm | 0.0039 in – 0.00070 in |
| **Crankshaft** | | |
| • Crankshaft Bearing Journal Standard Diameter (brown) | 50.0105–50.0170 mm | 1.96891–1.96917 in |
| • Crankshaft Bearing Journal Standard Diameter (green) | 50.0040–50.0105 mm | 1.96866–1.96891 in |
| • Crankshaft Bearing Journal Undersize 0.25 Diameter (brown/blue or green/blue) | 49.754 mm –49.767 mm | 1.9588 in – 1.9593 in |
| • Crankshaft Bearing Journal Undersize 0.5 Diameter (brown/white or green/white) | 49.504 mm –49.517 mm | 1.949 in – 1.9495 in |
| • Crankshaft Bearing Journal Width Standard | 23.000 mm –23.052 mm | 0.9055 in – 0.9076 in |
| • Crankshaft Bearing Journal Width Undersize 0.25 | 23.200 mm –23.252 mm | 0.9134 in – 0.9154 in |
| • Crankshaft Bearing Journal Width Undersize 0.4 | 23.400 mm –23.452 mm | 0.9213 in – 0.9233 in |
| • Crankshaft Bearing Mark 328N (brown) – Thickness | 1.989 mm –1.995 mm | 0.0783 in – 0.0785 in |

| | | |
|---|---|---|
| • Crankshaft Bearing Mark 329N (green) – Thickness | 1.995 mm –2.001 mm | 0.0785 in – 0.0788 in |
| • Crankshaft Bearing Mark 330N – Thickness Undersize 0.25 (brown/blue) | 2.114 mm – 2.120 mm | 0.0832 in – 0.0835 in |
| • Crankshaft Bearing Mark 331 – Thickness Undersize 0.25 (green/blue) | 2.120 mm – 2.126 mm | 0.0835 in – 0.0837 in |
| • Crankshaft Bearing Mark 332 – Thickness Undersize 0.5 (brown/white) | 2.239 mm – 2.245 mm | 0.0881 in – 0.0884 in |
| • Crankshaft Bearing Mark 332 – Thickness Undersize 0.5 (green/white) | 2.245 mm – 2.251 mm | 0.0884 in – 0.0886 in |
| • Crankshaft Bearing Clearance | 0.007 mm – 0.031 mm | 0.0003 in – 0.0012 in |
| • Crankshaft Bearing Clearance Axial | 0.100 mm – 0.202 mm | 0.0039 in – 0.008 in |
| • Crankshaft Bearing Out Of Round | 0.03 mm | 0.0012 in |
| • Connecting Rod Bearing Journal Diameter Standard | 42.971 mm – 42.987 mm | 1.6918 in – 1.6924 in |
| • Connecting Rod Bearing Journal Diameter Undersize 0.25 (blue) | 42.721 mm –42.737 mm | 1.6819 in – 1.6826 in |
| • Connecting Rod Bearing Journal Diameter Undersize 0.5 (white) | 42.471 mm –42.487 mm | 1.6721 in – 1.6727 in |
| • Connecting Rod Bearing Thickness Standard | 1.490 mm – 1.500 mm | 0.0587 in – 0.0591 in |
| • Connecting Rod Bearing Thickness Undersize 0.25 | 1.615 mm – 1.625 mm | 0.0636 in – 0.064 in |
| • Connecting Rod Bearing Thickness Undersize 0.5 | 1.740 mm – 1.750 mm | 0.0685 in – 0.0689 in |
| • Connecting Rod Bearing Diameter Standard (upper and lower) | 1.490 mm – 1.500 mm | 0.0587 in – 0.0591 in |
| • Connecting Rod Bearing Diameter Undersize 0.25 (upper and lower) | 1.615 mm – 1.625 mm | 0.0636 in – 0.064 in |
| • Connecting Rod Bearing Diameter Undersize 0.5 (upper and lower) | 1.740 mm – 1.750 mm | 0.0685 in – 0.0689 in |
| • Connecting Rod Bearing Clearance | 0.013 mm – 0.061 mm | 0.0005 in – 0.0024 in |
| **Cylinder Head** | | |
| • Cylinder Head – Intake Valve Seat Width | 1.4 mm – 1.8 mm | 0.0551 in – 0.0709 in |
| • Cylinder Head – Exhaust Valve Seat Width | 1 mm –1.4 mm | 0.0394 in – 0.0551 in |
| • Cylinder Head – Valve Seat Angle | 90° 30` | |
| • Cylinder Head – Valve Seat Angle Adjustment Upper | 110° | |
| • Cylinder Head — Valve Seat Angle Adjustment Lower | 60° | |
| • Cylinder Head – Intake Valve Guide Inner Diameter Standard | 4.991 mm – 5.007 mm | 0.1965 in – 0.1971 in |
| • Cylinder Head – Intake Valve Guide Inner Diameter + 0.075 | 5.066 mm – 5.082 mm | 0.1994 in – 0.2001 in |
| • Cylinder Head – Intake Valve Guide Inner Diameter 0.150 | 5.141 mm –5.157 mm | 0.2024 in – 0.203 in |
| • Cylinder Head – Exhaust Valve Guide Inner Diameter Standard | 4.991 mm – 5.007 mm | 0.1965 in – 0.1971 in |
| • Cylinder Head – Exhaust Valve Guide Inner Diameter + 0.075 | 5.066 mm – 5.082 mm | 0.1994 in – 0.2001 in |
| • Cylinder Head – Exhaust Valve Guide Inner Diameter + 0.150 | 5.141 mm – 5.157 mm | 0.2024 in – 0.203 in |
| • Cylinder Head – Valve Guide Length | 38.7 mm – 39.3 mm | 1.5236 in – 1.5472 in |
| • Cylinder Head – Surface Flatness (max) – Block Deck – longitude | 0.05 mm | 0.00197 in |
| • Cylinder Head – Surface Flatness (max) – Block Deck – transverse | 0.03 mm | 0.00118 in |
| **Valve Train** | | |
| • Intake Valve Length Standard | 92.9 mm | 3.6575 in |
| • Exhaust Valve Length Standard | 92.7 mm | 3.6496 in |
| • Intake Valve Stem Diameter Standard | 4.950 mm – 4.965 mm | 0.1949 in – 0.1955 in |

| | | |
|---|---|---|
| • Exhaust Valve Stem Diameter Standard | 4.930 mm – 4.945 mm | 0.1941 in – 0.1947 in |
| • Intake Valve Stem Diameter + 0.075 | 5.025 mm – 5.040 mm | 0.1978 in – 0.1984 in |
| • Exhaust Valve Stem Diameter + 0.075 | 5.005 mm – 5.020 mm | 0.197 in – 0.1976 in |
| • Intake Valve Stem Diameter + 0.150 | 5.100 mm – 5.115 mm | 0.2008 in – 0.2014 in |
| • Exhaust Valve Stem Diameter + 0.150 | 5.080 mm – 5.095 mm | 0.2 in – 0.2006 in |
| • Intake Valve Disc Diameter | 27.9 mm – 28.1 mm | 1.0984 in – 1.1063 in |
| • Exhaust Valve Disc Diameter | 24.9 mm – 25.1 | 0.9803 in — 0.9882 in |
| • Valve Spring Height Free | 40 mm | 1.5748 in |
| • Valve Spring Height Under Load – Valve open | 21.5 mm | 0.8465 in |
| • Valve Spring Height Under Load – Valve closed | 30 mm | 1.1811 in |
| • Valve Clearance to Guide Intake | 0.026 mm – 0.057 mm | 0.001 in – 0.0022 in |
| • Valve Clearance to Guide Exhaust | 0.046 mm – 0.077 mm | 0.0015 in – 0.003 in |
| **Engine Oil** | | |
| • Quality | Dexos I | |
| • Filling – With New Oil Filter | Refer to Approximate Fluid Capacities. | |
| • Viscosity | 0W30 / 0W40 / 5W30 / 5W40 | |
| • Oil Pressure @ Idle Speed | 150 kpa | 22 psi |
| • Oil Pressure @ 3000 rpm – 3500 rpm | 380 kpa – 650 kpa | 55 psi – 94 psi |
| **Oil Pump** | | |
| • Axial Clearance Vane Rotor to Cover | 0.01 mm | 0.0004 in |
| • Axial Clearance Vane to Cover | 0.09 mm | 0.0036 in |
| • Axial Clearance Vane Ring to Cover | 0.04 mm | 0.0016 in |
| • Axial Clearance Slide to Cover | 0.08 mm | 0.0031 in |
| • Axial Clearance Slide Seal to Cover | 0.09 mm | 0.0036 in |
| • Radial Clearance Vane to Vane Rotor | 0.05 mm | 0.002 in |
| • Radial Clearance Vane to Slide | 0.2 mm | 0.008 in |

### 8.2.5.2. Fastener Specifications

**Fastener Specifications**

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

### 8.2.5.3. Fastener Specifications

**Fastener Specifications**

| Application | Specification | |
|---|---|---|
| | Metric | English |
| Camshaft Actuator | 50 Nm + 60 degrees | 37 lb ft +60 degrees |
| Camshaft Bearing Cap Bolts | 8 Nm | 71 lb in |
| Camshaft Cover Bolts | 8 Nm | 71 lb in |
| Camshaft Position Actuator Solenoid Valve | 8 Nm | 71 lb in |
| Camshaft Position Sensor Bolt | 6 Nm | 53 lb in |
| Camshaft Sprocket Bolt | 50 Nm + 60 degrees (1) | 37 lb ft + 60 degrees (1) |
| Catalytic Converter Bracket to Cylinder Block | 22 Nm | 16 lb ft |
| Catalytic Converter to Bracket | 22 Nm | 16 lb ft |
| Catalytic Converter to Turbocharger (Vclamp) | 13 Nm | 115 lb in |
| Connecting Rod Bearing Cap | 25 Nm + 45 degrees (1) | 18 lb ft +45 degrees (1) |
| Crankshaft Balancer Bolt | 150 Nm + 45 – 60 degrees (1) | 111 lb ft +45 - 60 degrees (1) |
| Crankshaft Bearing Tie Plate Bolts (M6) | 10 Nm + 60 degrees + 15 degrees (1) | 80 lb in +60 degrees + 15 degrees (1) |
| Crankshaft Bearing Tie Plate Bolts (M8) | 25 Nm + 60 degrees + 15 degrees (1) | 18 lb ft + 60 degrees + 15 degrees (1) |
| Crankshaft Position Sensor Bolt | 8 Nm | 71 lb in |
| Cylinder Head Bolts | 35 Nm + 180 degrees (1) | 26 lb ft + 180 degrees (1) |
| Drive Belt Tensioner Bolt M8 | 22 Nm | 16 lb ft |
| Drive Belt Tensioner Bolt M10 | 55 Nm | 41 lb ft |
| Engine Cooling Thermostat Housing Bolts | 8 Nm | 71 lb in |
| Engine Front Cover Bolts M10 | 35 Nm | 26 lb ft |
| Engine Front Cover Bolts M6 | 8 Nm | 71 lb in |
| Engine Mount Bracket Bolts | 60 Nm + 45-60degrees (1) | 44 lb ft + 45-60 degrees (1) |
| Engine Mount Right Side to Body | 62 Nm | 46 lb ft |
| Engine Mount Right Side to Engine Mount Bracket | 50 Nm + 60-75 degrees (1) | 37 lb ft + 60+75 degrees (1) |
| Engine Oil Filter Cap | 25 Nm | 18 lb ft |
| Exhaust Manifold Heat Shield Bolts | 8 Nm | 71 lb in |
| Flywheel Bolts (Two-Mass) | 60 Nm +45 degrees + 15 degrees (1) | 44 lb ft+45 degrees + 15 degrees (1) |
| Fuel Injection Rail to Intake Manifold | 6 Nm | 53 lb in |
| Generator to Cylinder Block and Engine Cover | 35 Nm | 26 lb ft |
| Ignition Coil Bolts | 8 Nm | 71 lb in |
| Intake Manifold Bolt | 20 Nm | 15 lb ft |
| Knock Sensor | 20 Nm | 15 lb ft |
| Oil Cooler Coolant Inlet Pipe to Oil Cooler | 10 Nm | 89 lb in |
| Oil Cooler to Engine Block | 20 Nm | 15 lb ft |
| Oil Cooler to Oil Filter Assembly (only bolts serviceable) | 10 Nm | 89 lb in |
| Oil Filler Plug to Engine Front Cover (M18) | 30 Nm | 22 lb ft |
| Oil Filter Assembly to Block | 20 Nm | 15 lb ft |
| Oil Gallery Plug in Engine Front Cover (M22) | 60 Nm | 44 lb ft |
| Oil Pan Bolt | 10 Nm | 89 lb in |
| Oil Pan Baffle Bolt | 8 Nm | 71 lb in |
| Oil Pan Drain Plug | 14 Nm | 124 lb in |

| | | |
|---|---|---|
| Oil Pressure Indicator | 20 Nm | 15 lb ft |
| Oil Pressure Relief Valve | 50 Nm | 37 lb ft |
| Oil Pump Cover Bolts | 8 Nm | 71 lb in |
| Oil Pump Housing Plug (M10) | 10 Nm | 89 lb in |
| Oxygen Sensor to Exhaust Manifold | 42 Nm | 31 lb ft |
| Oxygen Sensor to Exhaust Front Pipe | 42 Nm | 31 lb ft |
| Piston Oil Nozzles to Block | 25 Nm | 18 lb ft |
| Spark Plugs | 25 Nm | 18 lb ft |
| Starter Bolts | 25 Nm | 18 lb ft |
| Throttle Body Bolts | 9 Nm | 80 lb in |
| Timing Chain Guide | 8 Nm | 71 lb in |
| Timing Chain Tensioner | 8 Nm | 71 lb in |
| Timing Chain Tensioner Plug | 35 Nm | 26 lb ft |
| Timing Chain Tensioner Shoe | 20 Nm | 15 lb ft |
| Turbocharger Coolant Feed Pipe to Engine Block | 30 Nm | 22 lb ft |
| Turbocharger Coolant Feed Pipe to Turbocharger (Quick Fitting) | 20 Nm | 15 lb ft |
| Turbocharger Coolant Return Pipe to Turbocharger (Quick Fitting) | 20 Nm | 15 lb ft |
| Turbocharger Oil Feed Pipe to Oil Cooler/Filter | 8 Nm | 71 lb in |
| Turbocharger Oil Feed Pipe to Turbocharger | 20 Nm | 15 lb ft |
| Turbocharger Oil Return Pipe to Turbocharger | | |
| Turbocharger to Cylinder Head | 8 Nm | 71 lb in |
| Water Outlet | 8 Nm (1) | 71 lb in (1) |
| Water Pump Housing Bolts | | |
| • First Pass | 8 Nm | 71 lb in |
| • Final Pass | 30 Degrees (2) | |
| Water Pump Drain Plug | 15 Nm | 11 lb ft |
| Water Pump Pulley Bolts | 22 Nm | 16 lb ft |
| 1 = Use NEW Fastener.<br>2 = Tighten only 2 bolts to a final pass, see water pump documents. | | |

### 8.2.5.4. Approximate Fluid Capacities

**Approximate Fluid Capacities**

| Application | Specification | |
|---|---|---|
| | Metric | English |
| Oil Change incl. Filter | 4 liters | 4.25 quarts |

### 8.2.5.5. Temperature Versus Resistance- Intake Air Temperature Sensor (Bosch Sensor)

**Temperature Versus Resistance - Intake Air Temperature 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 |

### 8.2.5.6. Temperature Versus Resistance Intake Air Temperature Sensor (Delco Sensor)

**Temperature Versus Resistance**

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

### 8.2.5.7. Altitude Versus Barometric Pressure

**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 |

### 8.2.5.8. Ignition System Specifications

**Ignition System Specifications**

| Application | Specification |
|---|---|
| Ignition Type | Ignition Coil Module |
| Firing Order | 1-3-4-2 |
| Spark Plug Torque | Refer to Fastener Tightening Specifications |
| Spark Plug Gap | 0.70 mm (0.028 in) |
| Spark Plug Type | Refer to Parts Catalogue |

#### 8.2.6. Schematic and Routing Diagrams

#### 8.2.7. Special Tools and Equipment

## 8.3. Engine Cooling

### 8.3.1. Description and Operation

#### 8.3.1.1. Cooling System Description and Operation

##### 8.3.1.1.1. Cooling System

The cooling system maintains the engine operating temperature at the efficient level under any speed and operating condition. When the engine is cold, the cooling system cools the engine slowly or not at all. The slow cooling of the engine allows the engine to warm up quickly. The cooling system includes a radiator and recovery subsystem, cooling fans, a thermostat and housing, an oil cooler, a water pump and a water pump drive belt. The accessory belt drives the water pump. All components must function properly in order for the cooling system to operate. Before the coolant reaches operating temperature of the thermostat, the coolant circulates through water jackets in the engine block, the cylinder head, the heater core and the oil cooler. The coolant pump draws the coolant from the bypass pipe which the pipe receives returning floe form the engine and the heater core. When the coolant reaches the operating temperature of the thermostat, the thermostat opens. The coolant then goes to the radiator where it cools. This system directs some coolant through the hoses or pipes to the heater core and oil cooler. This provides for heating, defrosting and engine oil cooling. The surge tank is connected to the radiator to recover the coolant displaced by expansion from the high temperatures. The surge tank maintains the correct coolant level. The cooling system for this vehicle has no radiator cap or filler neck. The coolant is added to the cooling system through the surge tank.

##### 8.3.1.1.2. Water Pump

The belt-driven centrifugal water pump consists of an impeller, a drive shaft, and a belt pulley. The water pump is mounted on the front of the transverse-mounted engine and is driven by the accessory belt.

The impeller is supported by a completely sealed bearing. The water pump is serviced as an assembly and cannot be disassembled.

##### 8.3.1.1.3. Thermostat

A wax pellet-type thermostat controls the flow of the engine coolant through the engine cooling system. The thermostat is located in the front of the engine at the water pump inlet. The thermostat stops the flow of the engine coolant from the engine to the radiator to provide faster warmup, and to regulate the coolant temperature. The thermostat remains closed while the engine coolant is cold, preventing circulation of the engine coolant through the radiator.

As the engine warms, the thermostat opens. This allows the engine coolant to flow through the radiator where the heat is dissipated through the radiator. This opening and closing of the thermostat permits enough engine coolant to enter the radiator to keep the engine within proper engine temperature operating limits.

The wax pellet in the thermostat is hermetically sealed in a metal case. The wax element of the thermostat expands when it is heated and contracts when it is cooled. As the vehicle is driven and the engine warms, the engine coolant temperature increases. When the engine coolant reaches a specified temperature, the wax pellet element in the thermostat expands and exerts pressure against the metal case, forcing the
valve open. This allows the engine coolant to flow through the engine cooling system and cool the engine. As the wax pellet cools, the contraction condition, the electric controlled thermostat enables changing the thermostat opening temperature. Basically, the thermostat begins to open at 105° C (221° F) and is fully open at 120° C (248° F) when the electric energy not assisted.

If a certain driving environment encountered that requiring better cooling performance, the ECM orders to put electric energy to the thermostat. The energized electric heater in the wax pellet gives thermal energy to the wax for assisting the wax expansion. Then the thermostat valve opens earlier than the specified coolant temperature. For this vehicle, the programmed temperature set value by the ECM is 105° C (221° F) for cold and part load driving mode and 90° C (194° F) for hot and full load driving mode.

#### 8.3.1.1.4. Radiator

The radiator is a heat exchanger. It consists of a core and 2 tanks. The aluminum core is a tube and fin crossflow design that extends from the inlet tank to the outlet tank. Fins are placed around the outside of the tubes to improve heat transfer to the
atmosphere.

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

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

#### 8.3.1.1.5. Surge Tank

The surge tank is a plastic tank with a threaded pressure cap. The tank is mounted at a point higher than all other coolant passages. The surge tank provides an air space in the cooling system that allows the coolant to expand and contract. The surge tank provides a coolant fill point and a central air bleed location. During vehicle use, the coolant heats and expands. The increased coolant volume flows into the surge tank. As the coolant circulates, any air is allowed to bubble out. Coolant without air bubbles absorbs heat much better than coolant with bubbles. allows a spring to close the valve. To provide fuel economy and low emission benefit during. part load driving

### 8.3.1.2. Cooling Fan Description and Operation

The engine cooling fan system is composed of one cooling fan, a series of 5 relays, the engine control module (ECM), and the associated wiring. The cooling fan assembly includes two resistors. This combination of components enables the ECM to operate the cooling fan at 3 speeds using two fan control circuits.

**Low Speed Operation**
The ECM applies ground at the FAN 1 control circuit for the coil side of the cooling fan relay. The energized cooling fan relay completes a ground, through the switch side of the relay, for the coils of the cooling fan low speed relay and the cooling fan speed control relay. The speed control relay activates and supplies B+ to the coil side of the cooling fan high speed relay. The high speed relay remains inactive because the ECM is not commanding the FAN 2 control circuit ON. The energized low speed relay switch closes to supply B+ through the internal low speed resistor of the engine cooling fan motor. The result is cooling fan operation at a reduced speed.

**Medium Speed Operation**
The ECM applies ground at the FAN 2 control circuit for the coil side of the cooling fan high speed, and medium speed relays. The high speed relay remains inactive because the ECM is not commanding the FAN 1 control circuit ON. The energized medium speed relay switch closes to supply B+ through the internal medium speed resistor of the engine cooling fan motor. The result is cooling fan operation at a medium speed.

**High Speed Operation**
The ECM applies ground at the FAN 1 control circuit for the coil side of the cooling fan relay. The energized cooling fan relay completes a ground, through the switch side of the relay, for the coil of the cooling fan speed control relay. The energized speed control relay switch closes to supply B+ to the coil side of cooling fan high speed relay. Simultaneously, the ECM applies ground at the FAN 2 control circuit for the coil side of the cooling fan high speed relay. The energized high speed relay switch closes to supply B+ directly to the engine cooling fan motor, by-passing the fans internal resistors. The result is cooling fan operation at full speed.

#### 8.3.1.2.1. Cooling System Electronic Component Description and Operation

**Engine or Radiator Coolant Temperature Sensor**

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

**Engine Metal Temperature Sensor/Cylinder Head Temperature Sensor**

The cylinder head temperature sensor is a variable resistor that measures the temperature of the cylinder head. The engine control module (ECM) supplies 5 V to the cylinder head temperature sensor signal circuit and a ground for the low reference circuit.

## 8.3.2. Diagnostic Information and Procedures

### 8.3.2.1. Symptoms – Engine Cooling

#### 8.3.2.1.1. Important Preliminary Inspections Before Starting

Before using the Symptom diagnosis, perform the following:

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

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

#### 8.3.2.1.2. Visual/Physical Inspection

| **Caution:** |
|---|
| Use the connector test adapter kit EL35616-F for any test that requires probing the following items:<br>The control module harness connectors<br>The electrical center fuse/relay cavities<br>The component terminals<br>The component harness connector<br>Using this kit will prevent damage caused by the improper probing of connector terminals. |

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

- Ensure that the control module grounds are clean, tight, and correctly located.
- Inspect cooling system hoses and pipes for splits, kinks, and improper connections. Inspect thoroughly for any type of leak or restriction.
- Inspect for a dirty or restricted radiator or HVAC condenser.
- Inspect for aftermarket devices which could affect the operation of the cooling system.
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.
- Inspect the coolant recovery reservoir for proper coolant level.

#### 8.3.2.1.3. Identifying Intermittent Conditions

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

- Water intrusion in connectors, terminals, or components
- Poor connector mating
- Terminal contact
- High circuit or component resistance—High resistance can include any resistance, regardless of the amount, which can interrupt the operation of the component.
- Harness' that are routed too tight, or chaffed circuits
- High or low ambient temperatures
- High or low engine coolant temperatures
- High underhood temperatures

- Heat buildup in components or circuits due to circuit resistance, poor terminal contact, or high electrical load
- High or low system voltage
- High vehicle load conditions
- Rough road surface
- Electromagnetic interference (EMI)/circuit interference from relays, solenoids or other electrical surge
- Incorrect installation of non-factory, aftermarket, or after factory add on accessories

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

**8.3.2.1.4. Symptom List**

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

- Cooling Fan Always On
- Cooling Fan Inoperative
- Engine Overheating
- Loss of Coolant
- Thermostat Diagnosis
- Engine Fails To Reach Normal Operating Temperature

### 8.3.2.2. Cooling Fan Always On

#### 8.3.2.2.1. Diagnostic Instructions

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

#### 8.3.2.2.2. Circuit/System Description

The engine cooling fan system is composed of one cooling fan, a series of 5 relays, the engine control module (ECM), and the associated wiring. The cooling fan assembly includes two resistors. This combination of components enables the ECM to operate the cooling fan at 3 speeds using two fan control circuits.

#### 8.3.2.2.3. Diagnostic Aids

- The scan tool cooling fan output control operates as follows:
  - Cooling Fan Relay 1 operates the fan at a low speed
  - Cooling Fan Relay 2 and 3 operates the fan at a medium speed
  - Cooling Fan Relay 1, 2 and 3 operates the fan at a high speed
- Certain resistance conditions with intake air temperature (IAT) or engine coolant temperature (ECT) sensors may cause unwarranted cooling fan activation. If the ECM is commanding the cooling fans ON for no apparent reason and without any component or system DTCs set, the IAT or ECT sensor may be skewed. If this condition is suspected, refer to the Temperature Versus Resistance tables in Specifications of the appropriate engine controls subsection.
- If the cooling fan operates at high speed when the ECM is requesting medium speed operation, test or replace the KR20E Cooling Fan Speed Control Relay.

#### 8.3.2.2.4. Reference Information

**Schematic Reference**

Engine Heating/Cooling Schematics

**Connector End View Reference**

Component Connector End Views

Electrical Center Identification Views

**Description and Operation**

Cooling Fan Description and Operation

**Electrical Information Reference**

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

**Scan Tool Reference**

Control Module References for scan tool information

#### 8.3.2.2.5. Circuit/System Verification

1. Ignition ON.
2. Verify that there are no cooling system DTCs set.

**⇒ If any DTCs are set**

Refer to Diagnostic Trouble Code (DTC) List Vehicle.

**⇓ If no DTCs are set**

3. Verify the scan tool parameters listed below display OFF.
   - Cooling Fan Relay 1 Command
   - Cooling Fan Relays 2 and 3 Command

**⇒ If a scan tool parameter displays ON**

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

**⇓ If both scan tool parameters display OFF**
4. Verify that the fan is not activated.
**⇒ If the fan is operating**
Refer to Circuit/System Testing.
**⇓ If the fan is OFF**
5. All OK.

#### 8.3.2.2.6. Circuit/System Testing

| Note: |
|---|
| The following tests must be performed on each cooling fan relay. |

1. Ignition OFF, disconnect each cooling fan relay one at a time, in the order listed below, ignition ON:
   - KR20F Cooling Fan Speed Control 2 Relay
   - KR20C Cooling Fan Low Speed Relay
   - KR20P Cooling Fan Medium Speed Relay
   - KR20D Cooling Fan High Speed Relay
2. Verify that the cooling fan is not activated after each relay is removed.

**⇒ If the cooling fan is ON with all of the listed relays removed**
2.1. Ignition OFF, disconnect the harness connector at the G10 Cooling Fan Motor, ignition ON.
2.2. Test for less than 1 V between the relay controlled output circuit terminal listed below and ground:
- KR20C Cooling Fan Low Speed Relay terminal 87
- KR20P Cooling Fan Medium Speed Relay terminal 87
- KR20D Cooling Fan High Speed Relay terminal 87

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

**⇓ If the cooling fan is OFF after a listed relay is removed**
3. Replace the appropriate cooling fan relay.

#### 8.3.2.2.7. Component Testing

1. Ignition OFF.
2. Disconnect a cooling fan relay.
3. Test for 70–110 Ω between terminals 85/2 and 86/1.

**⇒ If less than or greater than the specified range**
Replace the cooling fan relay.
**⇓ If within the specified range**
4. Test for infinite resistance between the following terminals:
- 30/3 and 86/1
- 30/3 and 87/5
- 30/3 and 85/2
- 85/2 and 87/5

**⇒ If less than infinite resistance**
Replace the cooling fan relay.
**⇓ If infinite resistance**
5. Install a 20 A fused jumper wire between relay terminal 85/2 and 12 V.
6. Install a jumper wire between relay terminal 86/1 and ground.
7. Test for less than 2 Ω between terminals 30/3 and 87/5.

**⇒ If 2 Ω or greater**
Replace the cooling fan relay.
**⇓ If less than 2 Ω**
8. All OK.

#### 8.3.2.2.8. Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.
- Relay Replacement

### 8.3.2.3. Electrically Heated Thermostat Diagnosis

#### 8.3.2.3.1. Diagnostic Instructions

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

#### 8.3.2.3.2. Circuit/System Description

The engine cooling system electrically heated thermostat is an integrated part of the thermostat housing. It is not serviced separately. The thermostat contains a wax pellet which expands when electrically energized. The ECM energizes the wax pellet during full load driving, or, when the engine coolant or the ambient temperature is higher. This causes the thermostat to open earlier than it would without electrical assistance.

During normal engine operation, the thermostat begins to open mechanically at 103° C (217° F). When coolant temperature reaches or exceeds 105° C (221° F), the ECM begins to energize the wax pellet to try to maintain coolant temperature at 105° C (221° F).

When either coolant temperature or ambient temperature is higher, the ECM energizes the wax pellet to try to maintain coolant temperature at 95° C (203° F).

During high engine speed or high torque conditions, the ECM energizes the wax pellet to try to maintain coolant temperature at 90° C (194° F).

#### 8.3.2.3.3. Diagnostic Aids

- A radiator or AC condenser with bent fins or obstructed air flow passages may cause the engine coolant temperature to be too hot.
- An incorrect engine coolant mixture may cause the engine coolant to boil at low temperature.
- An engine coolant mixture that is contaminated with debris may adversely affect the operation of the cooling system components. Verify that the coolant mixture is not contaminated.
- An engine cooling system that has been incorrectly filled or serviced may have air trapped within the system. If the system contains air, the coolant level may appear to be correct while it is actually incorrect. To avoid misdiagnosis, it may be necessary to verify that no conditions have occurred that may cause the cooling system to contain trapped air.
- For accurate test results, allow the vehicle to stabilize in an environment where ambient temperature is between 10–27° C (50– 80° F) for 8 hours prior to testing.

#### 8.3.2.3.4. Reference Information

**Schematic Reference**

Engine Controls Schematics
Engine Heating/Cooling Schematics

**Connector End View Reference**

Component Connector End Views

**Description and Operation**

Cooling System Description and Operation

**Electrical Information Reference**

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

**Scan Tool Reference**

Control Module References

**8.3.2.3.5. Circuit/System Verification**

1. Ignition ON.
2. Verify that DTC P00B3, P00B4, P00B6, P00B7, P0116, P0117, P0018, P0119, P0128, P0597, P0598, P0599, or P2181 is not set.

**⇒ If DTC P00B3, P00B4, P00B6, P00B7, P0116, P0117, P0018, P0119, P0128, P0597, P0598, P0599, or P2181 is set.**

Refer to Diagnostic Trouble Code (DTC) List Vehicle for further diagnosis.

**⇓ If DTC P00B3, P00B4, P00B6, P00B7, P0116, P0117, P0018, P0119, P0128, P0597, P0598, P0599, or P2181 is not set.**

3. Verify the coolant reservoir contains the correct level of engine coolant.

**⇒ If the coolant level is low**

Fill the coolant reservoir to the correct level and pressure test the cooling system and the coolant reservoir cap for a leak. Refer to Cooling System Draining and Filling and Cooling System Leak Testing. If a leak is found, repair as necessary.

**⇓ If the coolant level is not low**

4. Verify the engine cooling fan operates. Using the scan tool, select Control Functions, Cooling Fan, Cooling Fan relays 1, 2, and 3. Command the Cooling Fan ON and OFF.

**⇒ If the cooling fan does not turn ON and OFF**

Refer to Cooling Fan Inoperative

**⇓ If the cooling fan turns ON and OFF**

5. Close the hood and set the HVAC controls to the OFF position.
6. Start the engine and warm the engine up to operating temperature.
7. Verify the scan tool ECT Sensor parameter displays between 101–120° C (214–248° F) while the engine is running.

**⇒ If 121° C (249° F) or greater**

Refer to Circuit/System Testing – Engine Coolant Temperature too High.

**⇒ If 100° C (212° F) or less.**

Refer to Circuit/System Testing – Engine Coolant Temperature too Low.

**⇓ If between 101–120° C (214–248° F) .**

8. All OK.

**8.3.2.3.6. Circuit/System Testing**

| Note: |
|---|
| For accurate test results, allow the vehicle to stabilize in an environment where ambient temperature is between 10–27° C (50–80° F) for 8 hours prior to testing. |

**Engine Coolant Temperature too High**

1. Start the engine and verify the HVAC controls are set to the OFF position.

| Note: |
|---|
| The cooling fan should automatically turn ON when you select Engine Coolant Thermostat Heater. |

2. With the scan tool, navigate to Control Functions and select Engine Coolant Thermostat Heater and Cooling Fan. Verify the engine cooling fan turns ON when Engine Coolant Thermostat is selected.
3. Verify the hood is closed.
4. Engine running at 2,000 RPM, note or record the ECT Sensor parameter value.

| Note: |
|---|
| • An engine cooling system that has been incorrectly filled or serviced may have air trapped within the system. If the system contains air, the coolant level may appear to be correct while it is actually incorrect. For accurate test results, it may be necessary to verify that no conditions have occurred that may cause the system to contain trapped air.<br>• Depending on ambient temperature, it may take up to 4 minutes for the temperature to decrease 10°C (18°F) or greater.<br>• The ECT Sensor parameter value may increase between 3–5° C (2–9° F) at first. It should then decrease 10°C (18°F) or greater and stabilize. |

5. Engine at 2,000 RPM, verify the ECT Sensor parameter decreases by 10°C (18°F) or greater while commanding the scan tool Engine Coolant Thermostat Heater to 100 %.

**⇒ If the parameter does not decrease by 10°C (18°F) or greater**

Inspect for the conditions listed below and repair as necessary. Refer to Symptoms Engine Cooling for additional information.

- Restricted/plugged radiator
- Restricted/plugged radiator hoses
- Restricted/plugged cylinder head
- Restricted/plugged heater core or heater hoses

⇒ If none of the conditions listed above exist, replace the E41 Engine Coolant Thermostat.

| Note: |
| --- |
| If the thermostat is intermittently sticking closed, it may be necessary to repeat the Circuit/System Verification and Circuit/System Testing. |

**⇓ If the parameter decreases by 10° C (18° F) or greater**

6. All OK.

**Engine Coolant Temperature Too Low**

| Note: |
| --- |
| For accurate test results, allow the vehicle to stabilize in an environment where ambient temperature is between 10–27° C (50–80° F) for 8 hours prior to testing. |

| Note: |
| --- |
| Information for the following test may be in GDS stored data from the Circuit/System Verification. |

1. Verify the hood is closed.
2. Start the engine and set the HVAC controls to the OFF position.
3. Engine idling, verify the scan tool ECT Sensor parameter reaches between 90–100° C (194–212° F) within the guidelines listed
below:
   - At 27° C (80° F) ambient temperature, the parameter should reach 90–100° C (194–212° F) in 18 minutes or less.
   - At 20° C (68° F) ambient temperature, the parameter should reach 90–100° C (194–212° F) in 22 minutes or less.
   - At 10° C (50° F) ambient temperature, the parameter should reach 90–100° C (194–212° F) in 26 minutes or less.

**⇒ If the parameter does not display between 90–100° C (194–212° F) within the guidelines listed above**

Replace the E41 Engine Coolant Thermostat.

**⇓ If the parameter displays between 90–100° C (194–212° F) within the guidelines listed above**

4. All OK.

**8.3.2.3.7. Repair Instructions**

Perform the Diagnostic Repair Verification after completing the repair.
Engine Coolant Thermostat Housing Replacement

### 8.3.2.4. Thermostat Diagnosis

**Thermostat Diagnosis**

| Step | Action | Values | Yes | No |
|---|---|---|---|---|
| 1 | 1. Pressure test the cooling system and the cap for leaks.<br>2. Repair any leaks before proceeding. These engines use a 90°C (194°F) thermostat. The ambient temperatures should be within the specified range given.<br>3. Set the HVAC controls in the OFF position.<br>4. Run the cold engine at idle (68–70°F) for 15–20 minutes before checking the engine temperature.<br>5. Check the engine coolant temperature at idle with the scan tool.<br><br>Is the engine coolant temperature (ECT) between 90–105°C (194–221°F)? | 13–38°C (55– 100°F) | System OK | Go to Step 2 |
| 2 | Is the ECT below 90°C (194°F)? | - | Go to Step 3 | Go to Step 4 |
| 3 | The thermostat is opening early, or the thermostat seal is leaking.<br><br>Replace the thermostat and the thermostat seal.<br>Is the repair complete? | - | System OK | - |
| 4 | Is the ECT over 105°C (221°F)? | - | Go to Step 5 | - |
| 5 | Is the radiator inlet hot? | - | Go to Step 6 | Go to Step 7 |
| 6 | 1. Turn ON the heater.<br>2. Check if hot air is coming from the heater outlets.<br><br>Is the air hot? | - | Go to Step 11 | Go to Step 12 |
| 7 | There may be air in the system.<br><br>1. Add coolant to the surge tank if the coolant level is low. Refer to Cooling System Draining and Filling.<br>2. Recheck the radiator inlet hose.<br><br>Is the inlet hose hot? | - | Go to Step 6 | Go to Step 8 |
| 8 | Inspect for blockage in the following areas:<br>• The cylinder head<br>• The radiator<br>• The radiator hoses<br><br>Is there a blockage? | - | Go to Step 9 | Go to Step 10 |
| 9 | 1. Repair the blockage.<br>2. Recheck the coolant temperature with the scan tool.<br><br>Is the repair complete? | - | System OK | - |
| 10 | 1. Replace the thermostat. Refer to Engine Coolant Thermostat Replacement.<br>2. Recheck the coolant temperature with the scan tool.<br><br>Is the repair complete? | - | System OK | - |
| 11 | Inspect for blockage in the radiator.<br>Is there any blockage? | - | Go to Step 9 | Go to Step 10 |

| | | | | |
|---|---|---|---|---|
| 12 | 1. Accelerate the engine several times in order to remove any air from the system.<br>2. Inspect for blockage in the heater circuit.<br>3. Inspect for any pinched or buckled hoses.<br><br>Is there any blockage? | - | Go to Step 9 | Go to Step 13 |
| 13 | Is the repair complete? | - | System OK | - |

### 8.3.2.5. Engine Fails To Reach Normal Operating Temperature

**Engine Fails To Reach Normal Operating Temperature**

| Step | Action | Yes | No |
|---|---|---|---|
| 1 | Check the coolant level in the radiator surge tank. Refer to Cooling System Draining and Filling.<br><br>Is the coolant at the proper level? | Go to Step 3 | Go to Step 2 |
| 2 | Add coolant to the radiator surge tank as necessary.<br><br>Does the engine still fail to reach normal operating temperatures? | Go to Step 3 | System OK |
| 3 | Check for a blockage in the coolant passages.<br><br>Are there any blockages in the coolant passages? | Go to Step 4 | Go to Step 5 |
| 4 | Flush the cooling system or flow check the radiator.<br><br>Does the engine still fail to reach normal operating temperatures? | Go to Step 5 | System OK |
| 5 | Check to see if the incorrect thermostat was installed or if it is stuck or sticks in the open position.<br><br>Was the incorrect thermostat installed, or is it stuck or does it stick in the open position? | Go to Step 6 | - |
| 6 | Replace the thermostat. Refer to Engine Coolant Thermostat Replacement.<br><br>Does the engine still fail to reach normal operating temperature? | - | System OK |

#### 8.3.2.6. Loss of Coolant

**Loss of Coolant**

| Checks | Actions |
|---|---|
| Check for a leak in the radiator. | Replace a damaged radiator. |
| Check for a leak in the following locations:<br>• Surge tank<br>• Hose | Replace the following parts:<br>• Surge tank<br>• Hose |
| Check for the following loose or damaged parts:<br>• Radiator hoses<br>• Heater hoses<br>• Connections | Reseat the hoses.<br>Replace the hoses or the clamps. |
| Check for leaks in the coolant pump seal. | Replace the coolant pump seal. |
| Check for leaks in the coolant pump gasket. | Replace the coolant pump gasket. |
| Check for an improper cylinder head torque. | Tighten the cylinder head bolts to specifications.<br>Replace the cylinder head gasket, if needed. |

### 8.3.2.7. Engine Overheating

**Engine Overheating**

| Checks | Actions |
|---|---|
| Check for a loss of the coolant. | Add the coolant. |
| Check for weak coolant solution. | Confirm that the coolant solution is 50/50 mixture of ethylene glycol and water. |
| Check the front of the radiator for any dirt, any leaves, or any insects. | Clean the front of the radiator |
| Check for leakage from the hoses, the coolant pump, the heater, the thermostat housing, the radiator, the core plugs, or the head gasket. | Replace any damaged components. |
| Check for a faulty thermostat. | Replace a damaged thermostat. |
| Check for retarded ignition timing. | Perform an ECM code diagnosis. Confirm the integrity of the timing belt. |
| Check for an improperly operating electric cooling fan. | Replace the electric cooling fan. |
| Check for radiator hoses that are plugged or rotted. | Replace any damaged radiator hoses. |
| Check for a faulty water pump. | Replace a faulty water pump. |
| Check for a faulty surge tank cap. | Replace a faulty surge tank cap. |
| Check for a cylinder head or an engine block that is cracked or plugged. | Repair the damaged cylinder head or the damaged engine block. |

### 8.3.2.8. Cooling Fan Inoperative

#### 8.3.2.8.1. Diagnostic Instructions

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

#### 8.3.2.8.2. Circuit/System Description

The engine cooling fan system is composed of one cooling fan, a series of 5 relays, the engine control module (ECM), and the associated wiring. The cooling fan assembly includes two resistors. This combination of components enables the ECM to operate the cooling fan at 3 speeds using two fan control circuits.

#### 8.3.2.8.3. Diagnostic Aids

- The scan tool cooling fan output control operates as follows:
  - Cooling Fan Relay 1 operates the fan at a low speed
  - Cooling Fan Relay 2 and 3 operates the fan at a medium speed
  - Cooling Fan Relay 1, 2 and 3 operates the fan at a high speed
- When disconnecting or removing fuses and relays from a fuse block, always inspect the component electrical terminals for corrosion. Test the mating electrical terminals for tightness.

#### 8.3.2.8.4. Reference Information

**Schematic Reference**

Engine Heating/Cooling Schematics

**Connector End View Reference**

Component Connector End Views

Electrical Center Identification Views

**Description and Operation**

Cooling Fan Description and Operation

**Electrical Information Reference**

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

**Scan Tool Reference**

Control Module References for scan tool information

#### 8.3.2.8.5. Circuit/System Verification

1. Ignition ON.
2. Verify that DTC P0480, P0481, P0691, P0692, P0693, or P0694 is not set.

**⇒ If a DTC is set**

Refer to DTC P0480, P0481, P0691, P0692, P0693, or P0694.

**⇓ If no DTC is set**

3. Verify that the G10 Cooling Fan Motor operates at low, medium, and high speed, when commanding the appropriate cooling fan relays ON and OFF with a scan tool.

**⇒ If the cooling fan does not operate at all speeds**

Refer to Circuit/System Testing.

**⇓ If the cooling fan operates at all speeds**

4. All OK.

**8.3.2.8.6. Circuit/System Testing**

**Inoperative in All Speeds**

1. Ignition OFF, disconnect the harness connector at the G10 Cooling Fan Motor.
2. Verify a test lamp illuminates between the ground circuit terminal 1 and B+.

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

2.1. Ignition OFF, remove the test lamp.
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 the test lamp illuminates**

3. Test or replace the G10 Cooling Fan Motor. Replace the cooling fan fuses if necessary.

**Low, Medium, or High Speed Inoperative**

1. Ignition OFF.
2. Disconnect the following cooling fan relays, ignition ON:
   - KR20C Cooling Fan Low Speed Relay
   - KR20D Cooling Fan High Speed Relay
   - KR20E Cooling Fan Speed Control Relay
   - KR20F Cooling Fan Speed Control 2 Relay
   - KR20P Cooling Fan Medium Speed Relay
3. Verify a test lamp illuminates between ground and each of the cooling fan relay B+ circuit terminals listed below:
   - KR20C Cooling Fan Low Speed Relay terminal 30
   - KR20D Cooling Fan High Speed Relay terminal 30
   - KR20P Cooling Fan Medium Speed Relay terminal 30

**⇒ 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 appropriate relay 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**

3.1. Ignition OFF, disconnect the harness connector at the G10 Cooling Fan Resistor.
3.2. Test for infinite resistance between the appropriate relay controlled output circuit terminal listed below and ground:
   - KR20C Cooling Fan Low Speed Relay terminal 87
   - KR20D Cooling Fan High Speed Relay terminal 87
   - KR20P Cooling Fan Medium Speed Relay terminal 87

⇒ If less than infinite resistance, repair the short to ground in the circuit.
⇒ If infinite resistance, test or replace the G10 Cooling Fan Motor, replace the fuse as necessary.

**⇓ If the test lamp illuminates**

4. Verify a test lamp illuminates between the KR20F Cooling Fan Speed Control 2 Relay output circuit terminal 87 and B+.

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

4.1. Ignition OFF, remove the test lamp.
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 the test lamp illuminates**

5. Ignition OFF, Install the KR20F Cooling Fan Speed Control 2 Relay, ignition ON.
6. Verify a test lamp illuminates between each of the cooling fan relay ignition circuit terminals listed below and ground:
   - KR20C Cooling Fan Low Speed Relay terminal 85
   - KR20E Cooling Fan Speed Control Relay terminal 86 and 30

**⇒ If the test lamp does not illuminate at each terminal**

6.1. Ignition OFF, remove the test lamp.
6.2. Test for less than 2 Ω between the appropriate relay ignition circuit terminal and the fuse.
⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.

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

**⇓ If the test lamp illuminates at each terminal**

7. Command the cooling fan ON at low speed with a scan tool.
8. Verify a test lamp illuminates between B+ and each of the relay control circuit terminals listed below:
   - KR20C Cooling Fan Low Speed Relay terminal 86
   - KR20E Cooling Fan Speed Control Relay terminal 85

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

8.1. Ignition OFF, remove the test lamp and disconnect the KR20F Cooling Fan Speed Control 2 Relay.

8.2. Test for less than 2 Ω between the KR20F Cooling Fan Speed Control 2 Relay terminal 30 and the relay control circuit terminals listed below:
   - KR20C Cooling Fan Low Speed Relay terminal 86
   - KR20E Cooling Fan Speed Control Relay terminal 85

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, replace the KR20F Cooling Fan Speed Control 2 Relay.

**⇓ If the test lamp illuminates**

9. Ignition OFF, install the KR20E Cooling Fan Speed Control Relay, ignition ON.
10. Command the cooling fan ON at low speed with a scan tool.
11. Verify a test lamp illuminates between the KR20D Cooling Fan High Speed Relay ignition circuit terminal 86 and ground.

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

11.1. Ignition OFF, remove the test lamp and disconnect the KR20E Cooling Fan Speed Control Relay.

11.2. Test for less than 2 Ω between the KR20D Cooling Fan High Speed Relay terminal 86 and KR20E Cooling Fan Speed Control Relay terminal 87.

⇒ If 2 Ω or greater, repair the open/high resistance in the circuit.
⇒ If less than 2 Ω, replace the KR20E Cooling Fan Speed Control Relay.

**⇓ If the test lamp illuminates**

12. Ignition OFF, install all of the previously removed cooling fan relays. Disconnect the harness connector at the G10 Cooling Fan Motor, ignition ON.
13. Command the cooling fan ON at high speed with a scan tool.
14. Verify a test lamp illuminates between ground and each of the G10 Cooling Fan Motor circuit terminals listed below:
   - G10 Cooling Fan Motor low speed circuit terminal 2
   - G10 Cooling Fan Motor medium speed circuit terminal 3
   - G10 Cooling Fan Motor high speed circuit terminal 4

**⇒ If the test lamp does not illuminate at each terminal**

14.1. Ignition OFF, remove the test lamp.

14.2. Disconnect the appropriate relay from the list below:
   - KR20C Cooling Fan Low Speed Relay
   - KR20D Cooling Fan High Speed Relay
   - KR20P Cooling Fan Medium Speed Relay

14.3. Test for less than 2 Ω in the relay controlled output 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 relay.

**⇓ If the test lamp illuminates at each terminal**

15. Test or replace the G10 Cooling Fan Motor.

#### 8.3.2.8.7. Component Testing

**Relay Test**

1. Ignition OFF.
2. Disconnect a cooling fan relay.
3. Test for 70–110 Ω between terminals 85/2 and 86/1.

**⇒ If less than or greater than the specified range**

Replace the cooling fan relay.

**⇓ If within the specified range**

4. Test for infinite resistance between the following terminals:
   - 30/3 and 86/1

- 30/3 and 87/5
- 30/3 and 85/2
- 85/2 and 87/5

**⇒ If less than infinite resistance**

Replace the cooling fan relay.

**⇓ If infinite resistance**

5. Install a 20 A fused jumper wire between relay terminal 85/2 and 12 V.
6. Install a jumper wire between relay terminal 86/1 and ground.
7. Test for less than 2 Ω between terminals 30/3 and 87/5.

**⇒ If 2 Ω or greater**

Replace the cooling fan relay.

**⇓ If less than 2 Ω**

8. All OK.

**Cooling Fan Motor Test**

1. Ignition OFF.
2. Disconnect the harness connector at the G10 Cooling Fan Motor.
3. Connect a jumper wire between the G10 Cooling Fan Motor terminal 1 and ground.
4. Connect an appropriately fused jumper wire between a G10 Cooling Fan Motor terminal listed below and B+.
    - G10 Cooling Fan Motor low speed terminal 2
    - G10 Cooling Fan Motor medium speed terminal 3
    - G10 Cooling Fan Motor high speed terminal 4
5. Verify the G10 Cooling Fan Motor operates when voltage is applied to each terminal.

**⇒ The cooling fan does not operate**

Replace the G10 Cooling Fan Motor.

**⇓ The cooling fan operates**

6. All OK.

#### 8.3.2.8.8. Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

- Relay Replacement
- Front Compartment Fuse Block Replacement
- Engine Coolant Fan Replacement

### 8.3.3. Repair instructions

#### 8.3.3.1. Radiator Cleaning

| Warning |
|---|
| NEVER spray water on a hot heat exchanger. The resulting steam could cause personal injury. |

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

| Note: |
|---|
| Blow compressed air through the engine side of the radiator to remove any foreign material, such as insects, leaves, and dust. |

- Warm water and mild soap may be needed in some conditions.
- Wash the A/C condenser fin.
- Wash the A/C condenser and radiator thoroughly.
- Wash the radiator cooling fin.
- Repair any damaged cooling fin.

#### 8.3.3.2. Coolant System Flushing

| Note: |
|---|
| • Do not use a chemical flush.<br>• Store used coolant in the proper manner, such as in a used engine coolant holding tank.<br>• Do not pour used coolant down a drain. Ethylene glycol antifreeze is a very toxic chemical.<br>• Do not dispose of coolant into the sewer system or ground water. This is illegal and ecologically unsound.<br>• Various methods and equipment can be used to flush the cooling system. If special equipment is used, such as a back flusher,<br>• follow the manufactures instruction. However, always remove the thermostat before back flushing the system. |

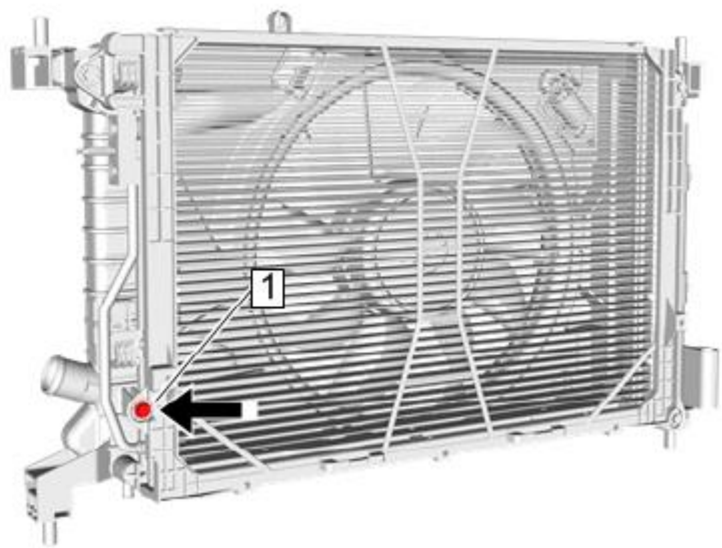
1. Apply the parking brake.
2. Drain the coolant. Refer to Cooling System Draining and Filling.
3. Fill the cooling system with clean drinkable water. Refer to Cooling System Draining and Filling.
4. Start the engine and run at 2,000 RPM until the thermostat opens.
5. Turn OFF the engine.
6. Drain the coolant system. Refer to Cooling System Draining and Filling.
7. Repeat the above procedure until the water from the coolant system is colorless.
8. Drain the coolant system. Refer to Cooling System Draining and Filling.
9. Repeat the above procedure until the water from the coolant system is colorless. Refer to Cooling System Draining and Filling.

### 8.3.3.3. Cooling System Draining and Filling

#### 8.3.3.3.1. Draining Procedure

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

1. Remove the coolant pressure cap from the radiator surge tank.
2. Raise and support the vehicle. Lifting and Jacking the Vehicle.
3. Remove the Valance, Refer to Valance in Body Repair
4. Place a drain pan under the drain cock.




5. Loosen the radiator drain cock (1).
6. Drain the cooling system.
7. Lower the vehicle.
8. Inspect the coolant.
9. Follow the appropriate procedure based on the condition of the coolant.
    - Normal in appearance—Follow the filling procedure.
    - Discolored—Follow the flush procedure. Coolant System Flushing.

#### 8.3.3.3.2. Filling Procedure

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

1. Raise and support the vehicle. Lifting and Jacking the Vehicle

| Caution: |
|---|
| Refer to Fastener Caution. |

2. Tighten the radiator drain cock (1) to 2 Nm (18 lb in).
3. Install the Valance, Refer to Valance in Body Repair
4. Lower the vehicle.

| **Note:** |
|---|
| Use a 50/50 mixture of DEXCOOL antifreeze and clean drinkable water. |

| **Note:** |
|---|
| The vent screw has a feature (1) to allow air to escape when the vent screw is in the open position. |

5. Remove the vent screw (1) on the radiator and turn in one thread to allow venting of the cooling system.
6. Slowly add a mixture of 50/50 DEX-COOL antifreeze and clean drinkable water to the surge tank until coolant is present at the vent screw (1).
7. Tighten the vent screw (1) to 1.9 Nm (17 lb in).
8. Continue to slowly fill the radiator with a 50/50 coolant mixture until the coolant level reaches the base of the radiator surge tank.
9. Allow 30 seconds for the coolant level to stabilize and continue to fill the coolant filler neck until the level stabilizes for at least 2 minutes.
10. Start the engine and allow to the engine to idle in PARK or NEUTRAL with the parking brake engaged.
11. Slowly fill the coolant mixture until the level stabilizes at the base of the radiator surge tank.
12. Install the coolant pressure cap.
13. Raise the engine RPM to 2500 rpm for 30–40 seconds.
14. Shut the engine OFF.
15. Allow the engine to cool, remove coolant fill cap and repeat steps 4–10 until the coolant level has completely stabilized within the radiator surge tank.
16. Inspect and if necessary, fill the coolant reservoir bottle as necessary.
17. Rinse away any excess coolant from the engine and the engine compartment.
18. Inspect the cooling system for leaks.
19. Top off the radiator surge tank if necessary.

### 8.3.3.4. Hose Clamp Replacement Guidelines - Spring Type

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

#### 8.3.3.4.1. Spring Type Hose Clamp Replacement Guidelines

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

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

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

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

If the spring type hose clamp(s) have any of the following conditions on any area of the clamp, replace the clamp(s) immediately.
- Rust/Corrosion
- Cracks
- Physical damage
- Leakage attributed to the retention of the clamp

#### 8.3.3.4.2. Removing The Spring Type Hose Clamp

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

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

#### 8.3.3.4.3. If The Spring Type Hose Clamp Is Being Reused

It is extremely important that the spring type hose clamp is orientated to the hose in the exact same position as it was installed during vehicle assembly so that the hose clamp is not damaged or the hose clamp does not contact or damage any adjacent components. Do not use any type of adhesive on the hose clamp prior to installation.

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

**When Reusing The Spring Type Hose Clamp with an Existing Hose**

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

#### 8.3.3.4.4. If The Spring Type Hose Clamp Is Being Replaced

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

**When Replacing The Spring Type Hose Clamp and Replacing The Hose**

- The inside and outside hose diameter must be identical between the new hose and the existing hose to guarantee proper hose clamp tension and joint integrity.

- Always place the new spring type hose clamp in the same orientation as it was positioned prior to separating the joint. The new hose might have a marking on the hose indicating the correct position of a hose clamp, which should reconfirm the correct hose clamp position. The hose clamp should not contact any adjacent components after installation.

**When Replacing The Spring Type Hose Clamp with an Existing Hose**

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

### 8.3.3.5. Cooling System Leak Testing

**Special Tools**
EN 471 Adapter
EN 6327 A Cooling System Test Adapter

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

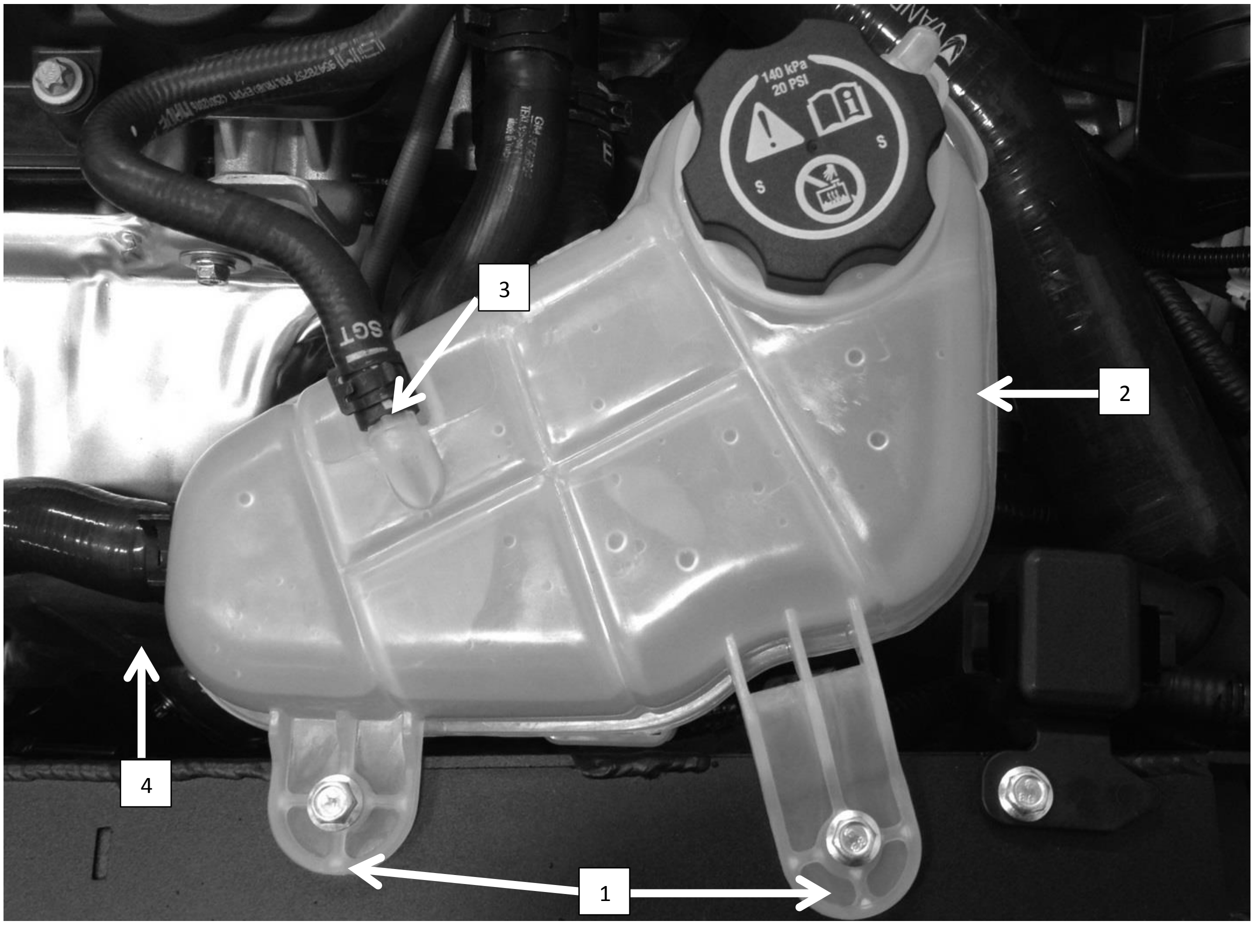
| Warning |
|---|
| In order to help avoid being burned, do not remove the radiator cap while the engine and the radiator are hot. Scalding fluid and steam can be blown out under pressure if the cap is removed too soon. |

1. Remove the surge tank cap.
2. Check the coolant level.
   Fill the coolant level to the COLD mark if necessary.

| Note: |
|---|
| Follow manufacturer instructions. |

3. Attach the coolant system tester with EN 471 adapter and EN 6327 A adapter to the coolant expansion tank.
4. Apply approximately 100 kPa (15 psi) to the cooling system.
5. Check the cooling system for leaks.
6. Remove the cooling system tester.
   - Release the pressure
   - Remove the cooling system tester with EN 471 adapter
7. Install the surge tank cap.

### 8.3.3.6. Radiator Surge Tank Replacement




Radiator Surge Tank Replacement

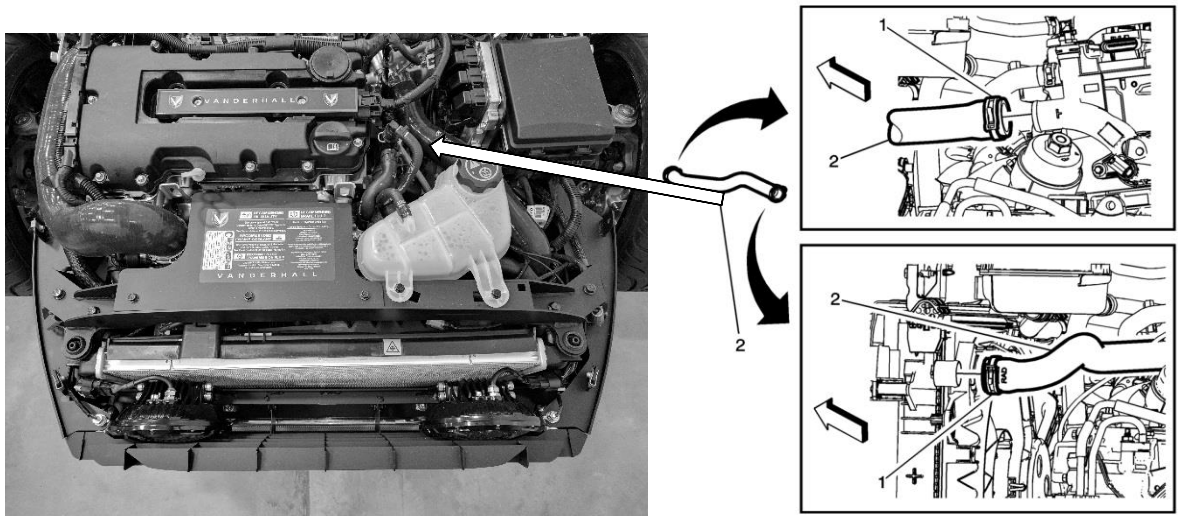
| Callout | Component Name |
|---|---|
| **Preliminary Procedure**<br>1. Remove the Hood, Refer to Hood in Body Repair<br>2. Drain the coolant. Refer to Cooling System Draining and Filling<br>3. Remove the engine coolant air bleed hose. Refer to Engine Coolant Air Bleed Hose Replacement<br>4. Remove the radiator surge tank outlet hose. Refer to Radiator Surge Tank Outlet Hose Replacement | |
| 1 | Radiator Surge Tank Bolts (Qty: 2)<br>**Caution:** Refer to Fastener Caution.<br>**Tighten:**<br>7 Nm (60 in lb) |
| 2 | Radiator Surge Tank |
| 3 | Engine Coolant Air Bleed Hose<br><br>**Special Tools**<br>BO-38185 Hose Clamp Pliers |
| 4 | Radiator Surge Tank Outlet Hose to Radiator Surge Tank<br><br>**Special Tools**<br>BO-38185 Hose Clamp Pliers |

8.3.3.7. Radiator Surge Tank Outlet Hose Replacement

**Radiator Surge Tank Outlet Hose Replacement**

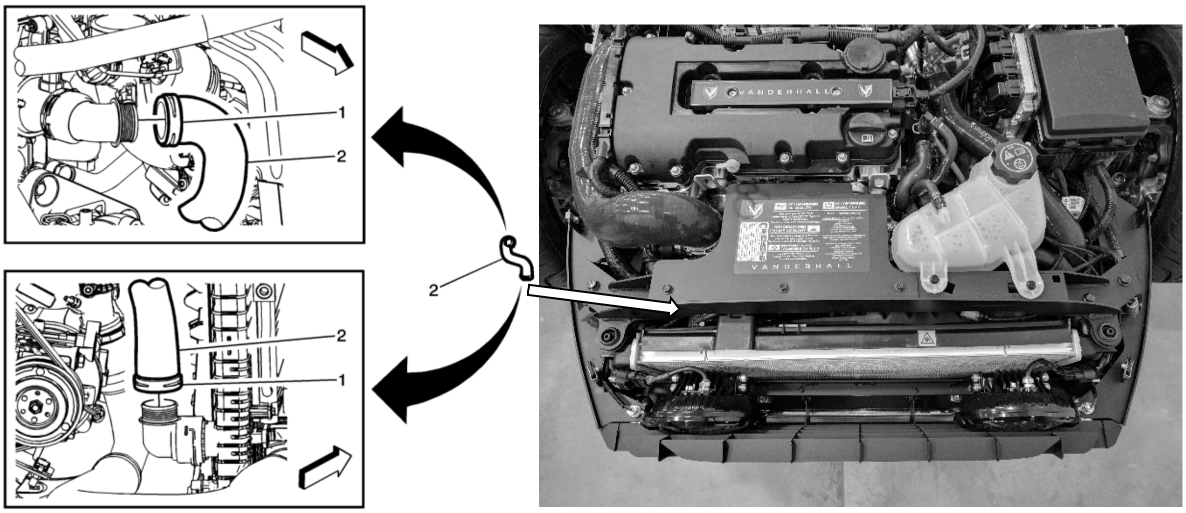
| Callout | Component Name |
|---|---|
| Preliminary Procedure<br>1. Remove the Hood, Refer to Hood in Body Repair<br>2. Remove the Air intake hose Filter to Turbo<br>3. Remove Mid Engine Cover | |
| 1 | Radiator Surge Tank Outlet Hose |
| 2 | Radiator Surge Tank |
| 3 | Radiator Surge Tank Outlet Hose to Radiator Surge Tank Hose Clamp<br><br>**Special Tools**<br>BO-38185 Hose Clamp Pliers |
| 4 | Radiator Surge Tank Outlet Hose to Engine Hose Clamp<br><br>**Special Tools**<br>BO-38185 Hose Clamp Pliers |
| | Radiator Surge Tank Outlet Hose to Heater Core Hose Clamp<br><br>**Special Tools**<br>BO-38185 Hose Clamp Pliers |

### 8.3.3.8. Radiator Inlet Hose Replacement




| Callout | Component Name |
|---|---|
| **Preliminary Procedure** | |
| | 1. Remove the Hood, Refer to Hood in Body Repair<br>2. Drain the engine coolant. Refer to Cooling System Draining and Filling.<br>3. Remove the Radiator Surge Tank |
| 1 | Radiator Inlet Hose Clamp (Qty: 2)<br><br>**Special Tools**<br>BO-38185 Hose Clamp Pliers |
| 2 | Radiator Inlet Hose |

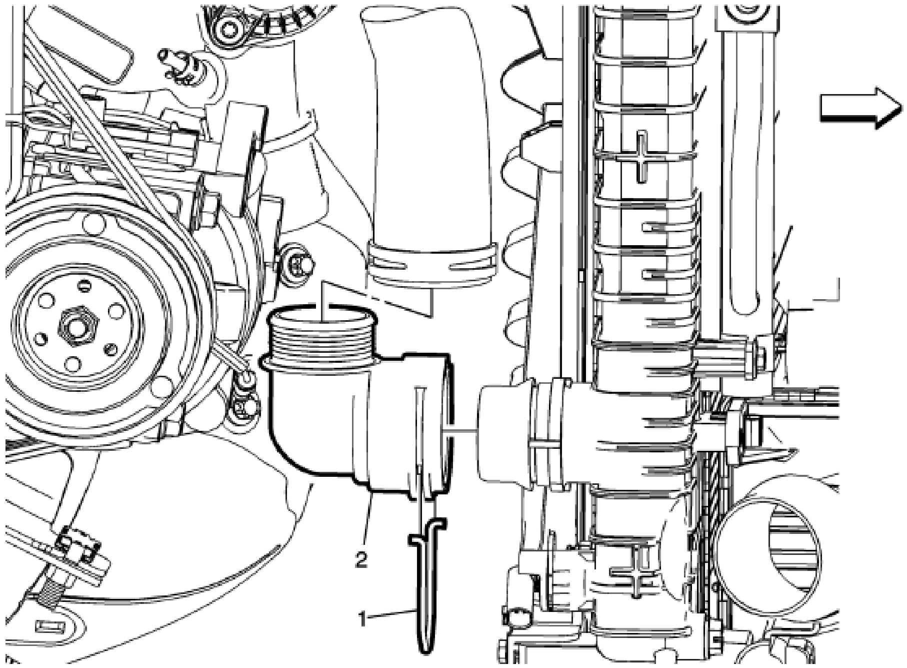
#### 8.3.3.8.1. Radiator Outlet Hose Replacement




**Radiator Outlet Hose Replacement**

| Callout | Component Name |
|---|---|
| **Preliminary Procedures**<br>1. Remove the Hood, Refer to Hood in Body Repair<br>2. Remove the Valance, Refer to Valance in Body Repair<br>3. Remove Air intake hose Filter to Turbo from the Turbo Charger and position it out of the way.<br>4. Drain the engine coolant. Refer to Cooling System Draining and Filling.<br>5. Remove the radiator surge tank outlet hose from the radiator surge tank and position it out of the way. Refer to Radiator Surge Tank Outlet Hose Replacement.<br>6. Remove the PCV Pipe assembly from the turbocharger and position it out of the way. Refer to Positive Crankcase Ventilation Hose/Pipe/Tube Replacement. | |
| 1 | Radiator Outlet Hose Clamp (Qty: 2)<br><br>**Special Tools**<br>BO-38185 Hose Clamp Pliers |
| 2 | Radiator Outlet Hose |

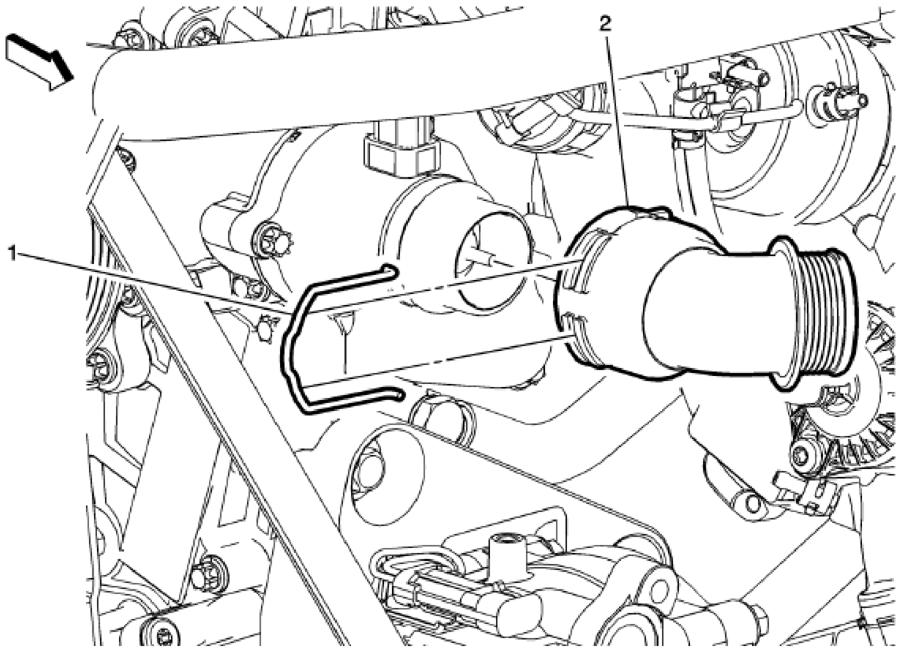
### 8.3.3.9. Radiator Outlet Hose Connector Replacement - Radiator Side




**Radiator Outlet Hose Connector Replacement - Radiator Side**

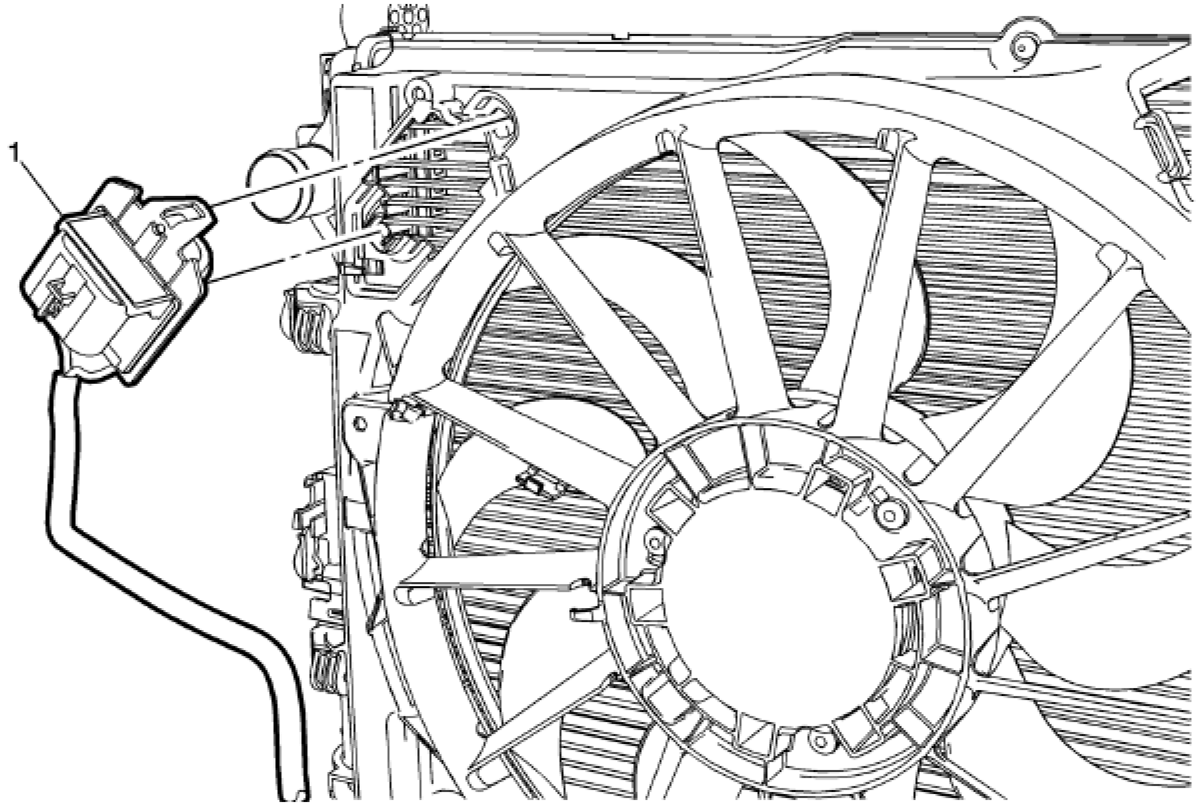
| Callout | Component Name |
|---|---|
| Preliminary Procedures<br>1. Drain the engine coolant. Refer to Cooling System Draining and Filling.<br>2. Remove the front compartment front insulator cover. Refer to Front Compartment Front Insulator Cover Replacement.<br>3. 3. Remove the radiator outlet hose from the radiator outlet hose connector and position out of the way. Refer to Radiator Outlet Hose Replacement. | |
| 1 | Radiator Outlet Hose Connector Retaining Clip |
| 2 | Radiator Outlet Hose Connector |

### 8.3.3.10. Radiator Outlet Hose Connector Replacement – Engine Side




| Callout | Component Name |
|---|---|
| **Preliminary Procedure**<br>1. Remove the Hood, Refer to Hood in Body Repair<br>2. Remove Air intake hose Filter to Turbo from the Turbo Charger and position it out of the way.<br>3. Drain the engine coolant. Refer to Cooling System Draining and Filling.<br>4. Remove the radiator surge tank outlet hose from the radiator surge tank and position it out of the way. Refer to Radiator Surge Tank Outlet Hose Replacement.<br>5. Remove the PCV Pipe assembly from the turbocharger and position it out of the way. Refer to Positive Crankcase Ventilation Hose/Pipe/Tube Replacement. | |
| 1 | Radiator Outlet Hose Connector Retaining Clip |
| 2 | Radiator Outlet Hose Connector |

### 8.3.3.11. Engine Coolant Fan Resistor Mount Repair



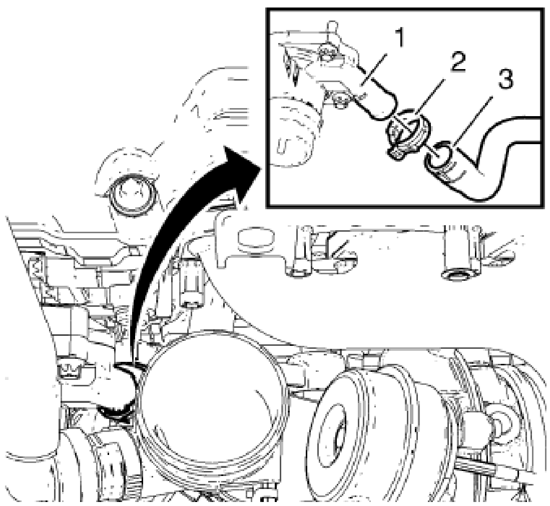

**Engine Coolant Fan Resistor Mount Repair**

| Callout | Component Name |
|---|---|
| **Preliminary Procedure**<br>1. Remove the fasteners securing the radiator surge tank to the chassis and position the surge tank out of the way. Refer to Radiator Surge Tank Replacement.<br>2. Unclip the resistor and mount from the fan shroud. | |
| 1 | Engine Coolant Fan Resistor Mount<br><br>**Procedure**<br>Disconnect the electrical connections. |

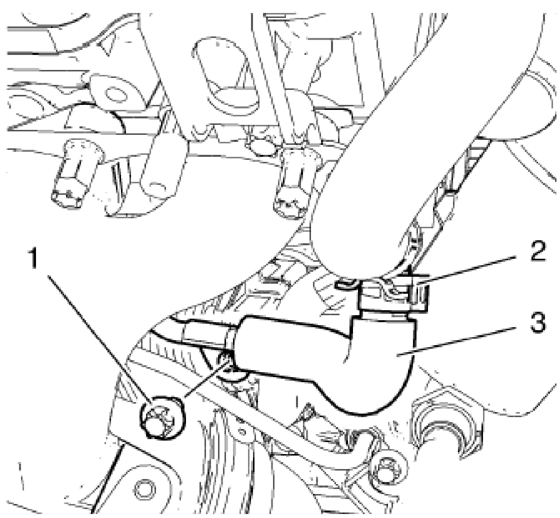
## 8.3.3.12. Engine Oil Cooler Replacement

### 8.3.3.12.1.Removal Procedure

1. Disconnect battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
2. Remove the Hood, Refer to Hood in Body Repair
3. Drain engine coolant. Refer to Cooling System Draining and Filling
4. Remove the Radiator surge tank
5. Position the Radiator surge tank Outlet hose out of the way
6. Remove the upper Radiator Support Cross Brace
7. Pull the cooling pack forward and secure
8. Remove the turbocharger oil feed pipe. Refer to Turbocharger Oil Feed Pipe Replacement.
9. Remove the catalytic converter. Refer to Catalytic Converter Replacement.
10. Lower vehicle.
11. Remove the Air intake hose filter to Turbo



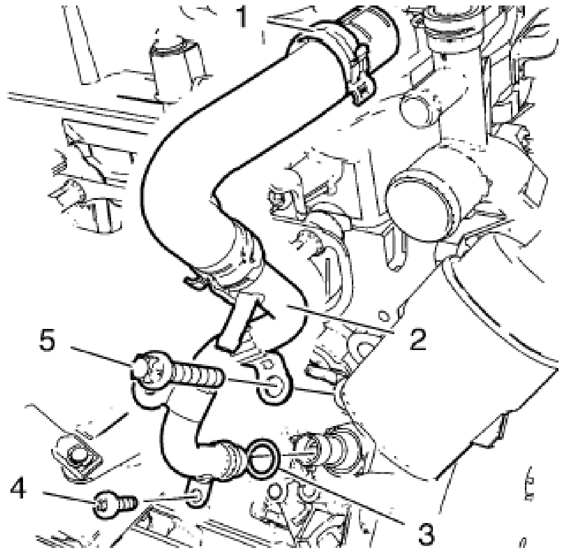

12. Remove the oil cooler outlet hose clamp (2).
13. Remove the oil cooler outlet hose (3) from the thermostat housing (1).



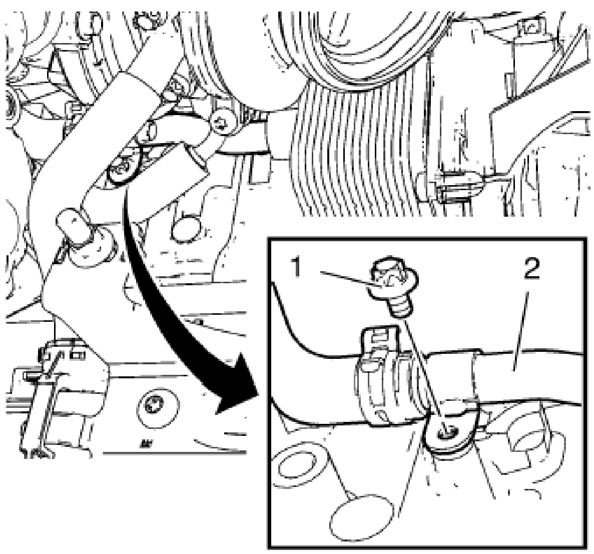

14. Remove the turbocharger coolant return pipe bolt (1) from the oil cooler housing.
15. Remove the turbocharger coolant return pipe clamp (2).

| **Note:** |
|---|
| Do not move the turbocharger coolant return pipe too much. An excessive moving of the turbocharger coolant return pipe could cause leakage. |

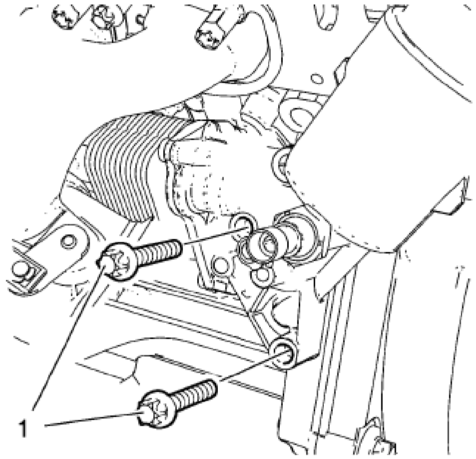
16. Remove the turbocharger coolant return pipe (3) from the oil cooler inlet pipe.
17. Disconnect the oil pressure indicator switch wiring harness plug.



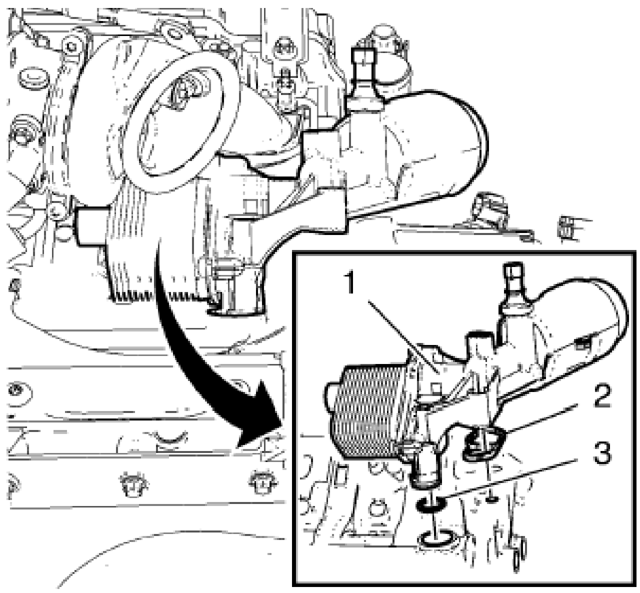

18. Remove the oil cooler inlet hose clamp (1) and remove the oil cooler inlet hose from the water outlet.
19. Remove the engine oil cooler bolt (5).
20. Remove the engine oil cooler inlet pipe bolt (4).
21. Remove the engine oil cooler inlet pipe (2) and the seal ring (3).
22. Raise vehicle.




23. Remove the oil cooler outlet pipe bolt (1) from the engine block.
24. Remove the oil cooler outlet pipe (2) in compound with the oil cooler outlet hose.
25. Lower vehicle.




26. Remove the 2 oil cooler bolts (1).
27. Raise vehicle.



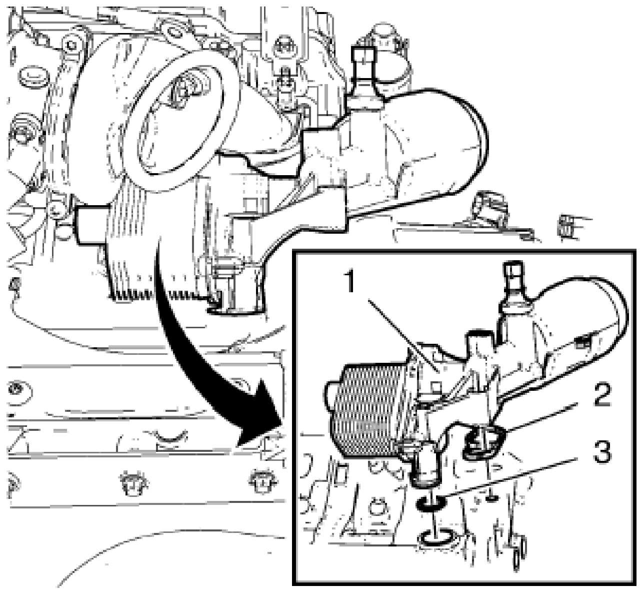

28. Remove the oil cooler (1) in compound with the oil cooler gasket (2) and the seal ring (3).
29. Remove the oil pressure indicator switch from the oil cooler.

**8.3.3.12.2.Installation Procedure**

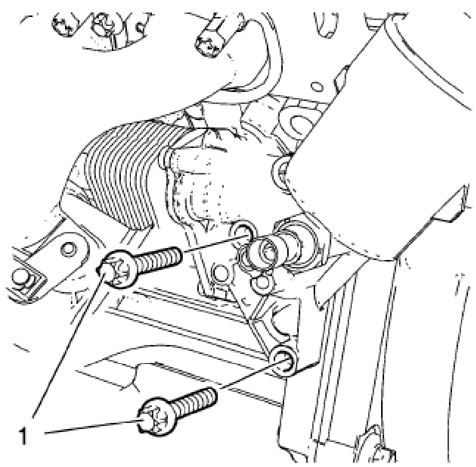
1. Install the oil pressure indicator switch to the oil cooler. Use a NEW seal ring.

| Caution: |
|---|
| Refer to Fastener Caution. |

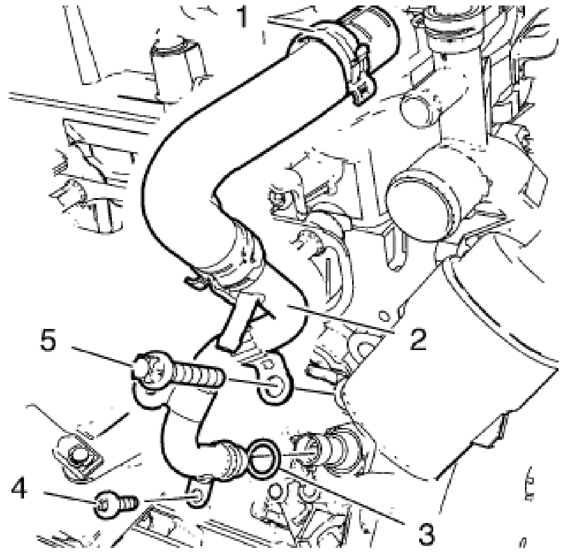
2. Tighten the oil pressure indicator switch to 20 Nm (15 lb ft).



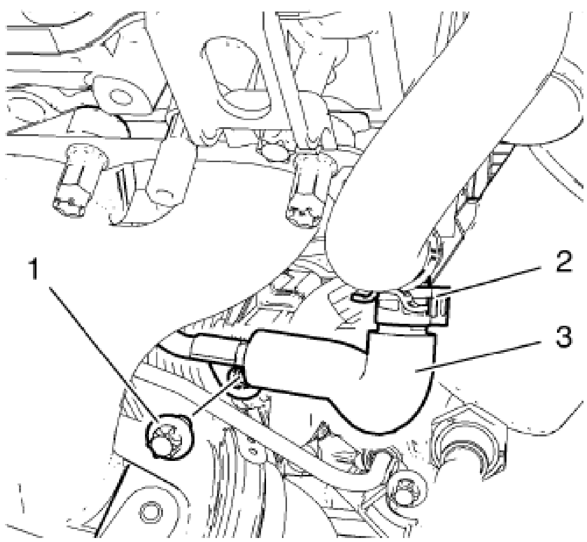

3. Clean the sealing surfaces.
4. Install the oil cooler (1) in compound with a NEW oil cooler gasket (2) and a NEW seal ring (3).
5. Lower vehicle.



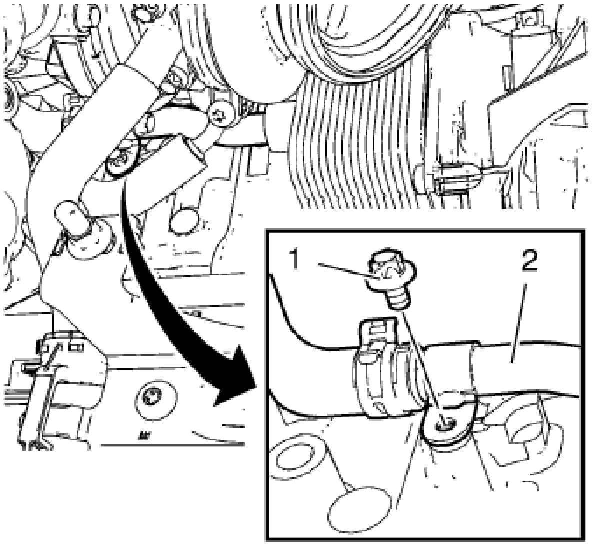

6. Install the 2 oil cooler bolts (1) and hand tighten.



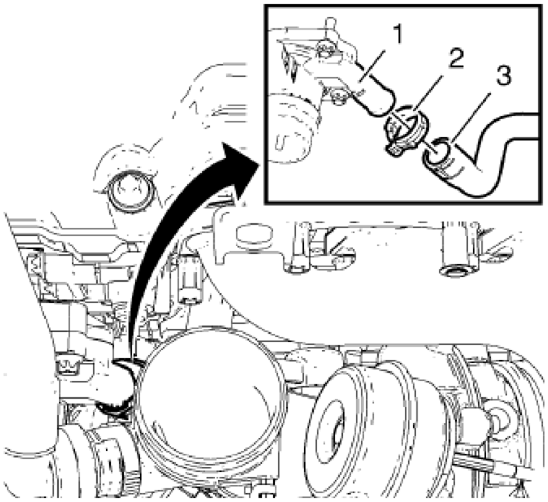

7. Install the engine oil cooler inlet pipe (2) in compound with a NEW seal ring (3).
8. Install the oil cooler inlet hose to the water outlet and install the oil cooler inlet hose clamp (1).
9. Install the engine oil cooler bolt (5).
10. Install the engine oil cooler inlet pipe bolt (4) and tighten to 10 Nm (89 lb in).
11. Tighten the 3 engine oil cooler bolts to 20 Nm (15 lb ft).




12. Install the turbocharger coolant return pipe (3) to the oil cooler inlet pipe.
13. Install the turbocharger coolant return pipe clamp (2).
14. Install turbocharger coolant return pipe bolt (1) and tighten to 10 Nm (89 lb in).
15. Connect the oil pressure indicator switch wiring harness plug.
16. Raise vehicle.

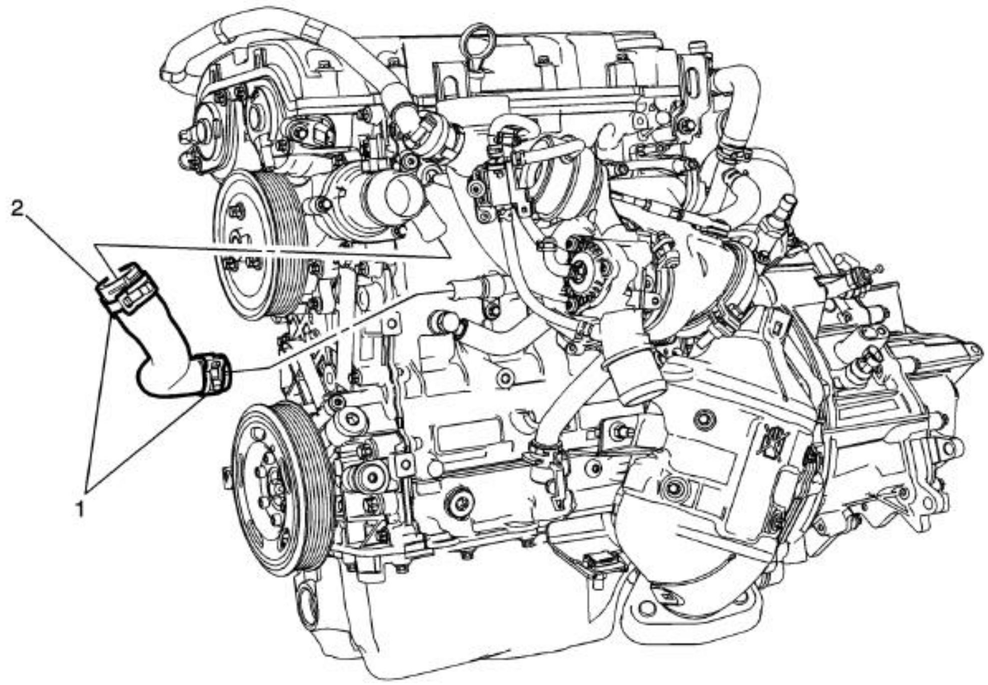



17. Install the oil cooler outlet pipe (2) in compound with the oil cooler outlet hose to the oil cooler.
18. Install the oil cooler outlet pipe bolt (1) to the engine block and tighten to 10 Nm (89 lb in).
19. Install the catalytic converter. Refer to Catalytic Converter Replacement.




20. Install the oil cooler outlet hose (3) to the thermostat housing (1).
21. Install the oil cooler outlet hose clamp (2).
22. Install the turbocharger oil feed pipe and the exhaust manifold heat shield. Refer to Turbocharger Oil Feed Pipe Replacement.
23. Install the upper Radiator Support Cross Brace
24. Install the Radiator surge tank
25. Install the Cooling Fan Relay
26. Install the Air intake hose filter to Turbo
27. Connect battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
28. Fill engine coolant. Refer to Cooling System Draining and Filling.

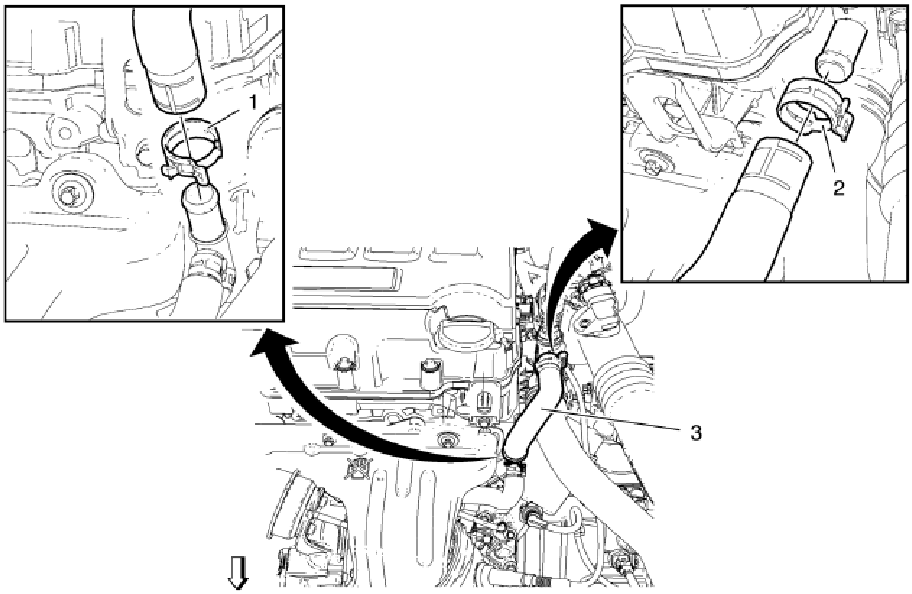
### 8.3.3.13. Engine Oil Cooler Outlet Hose Replacement




**Engine Oil Cooler Outlet Hose Replacement**

| Callout | Component Name |
|---|---|
| **Preliminary Procedure**<br>1. Remove the Front Right Quarter Panel<br>2. Remove the Air Intake hose Filter to Turbo<br>3. Remove the surge tank outlet hose from the surge tank outlet and position it out of the way<br>4. Drain the cooling system. Refer to Cooling System Draining and Filling.<br>5. Disconnect the radiator outlet hose. Refer to Radiator Outlet Hose Replacement. | |
| 1 | Engine Oil Cooler Outlet Hose Clamps (Qty: 2) |
| 2 | Engine Oil Cooler Outlet Hose |

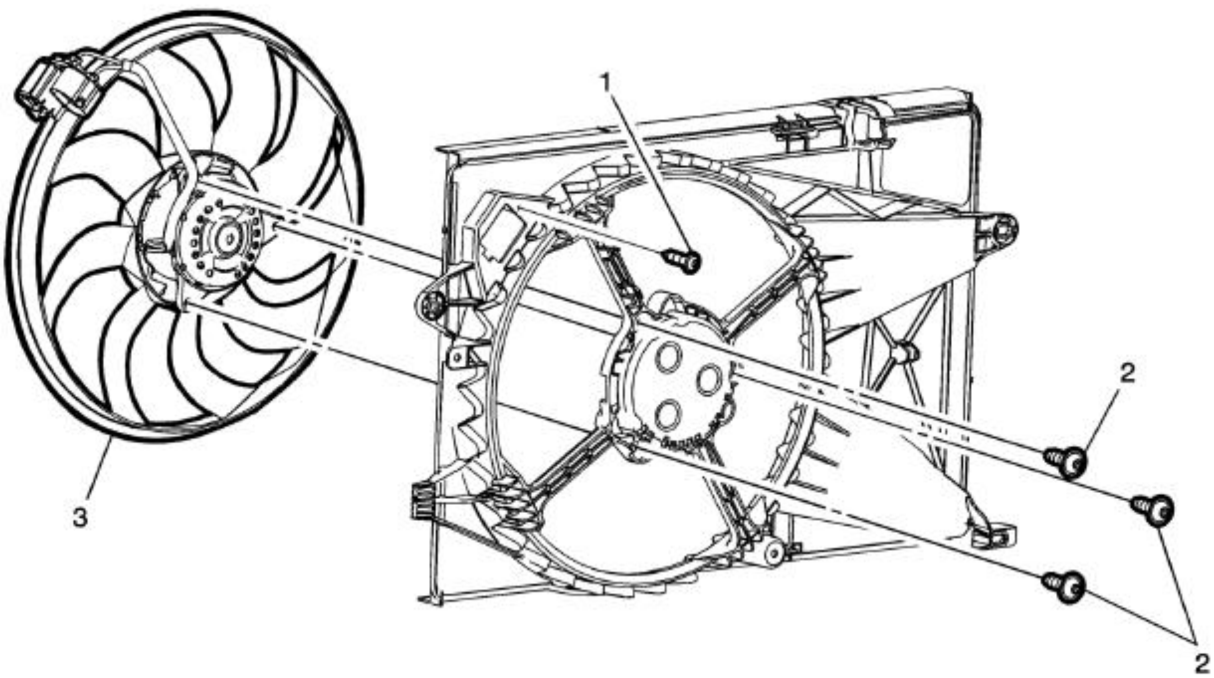
### 8.3.3.14. Engine Oil Cooler Coolant Inlet Hose Replacement




Engine Oil Cooler Coolant Inlet Hose Replacement

| Callout | Component Name |
|---|---|
| **Preliminary Procedure**<br>1. Remove the Hood, Refer to Hood in Body Repair<br>2. Drain the cooling system. Refer to Cooling System Draining and Filling.<br>3. Remove the Radiator Surge tank | |
| 1 | Oil Cooler Inlet Hose Clamp<br>Procedure<br>1. Place a drain pan below the vehicle.<br>2. Remove / install engine coolant air bleed hose clamp. |
| 2 | Oil Cooler Inlet Hose Clamp<br>Procedure<br>1. Place a drain pan below the vehicle.<br>2. Remove / install engine coolant air bleed hose clamp. |
| 3 | Oil Cooler Inlet Hose |

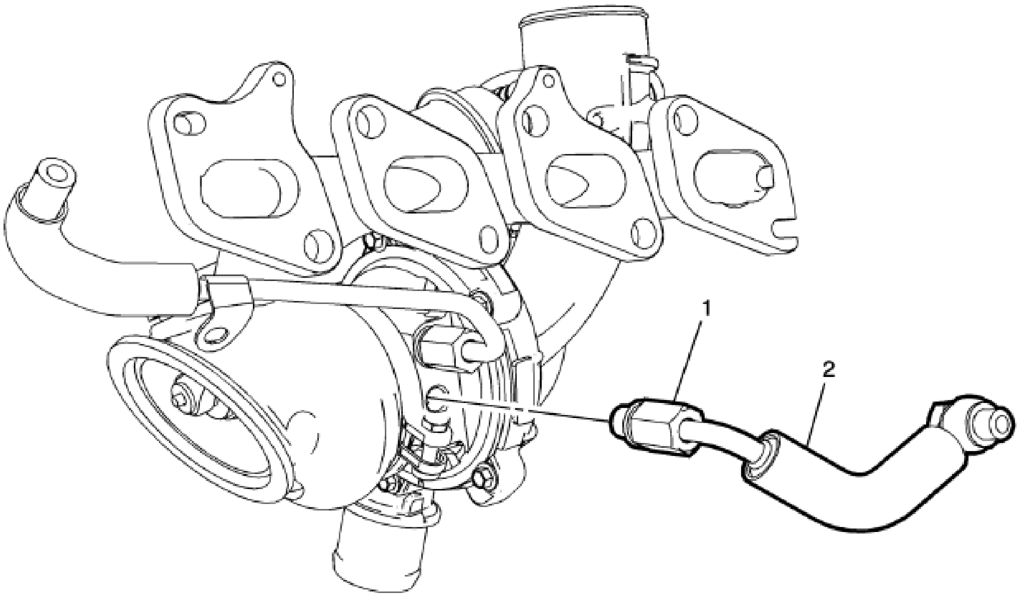
## 8.3.3.15. Engine Coolant Fan Replacement




**Engine Coolant Fan Replacement**

| Callout | Component Name |
|---|---|
| **Preliminary Procedure**<br>Remove the engine coolant fan shroud. Refer to Engine Coolant Fan Shroud Replacement. | |
| 1 | Engine Coolant Fan Motor Electrical Harness Connector Fastener<br>**Caution:** Refer to Fastener Caution. |
| 2 | Engine Coolant Fan Motor Fastener (Qty: 3) |
| 3 | Engine Coolant Fan Motor Assembly |

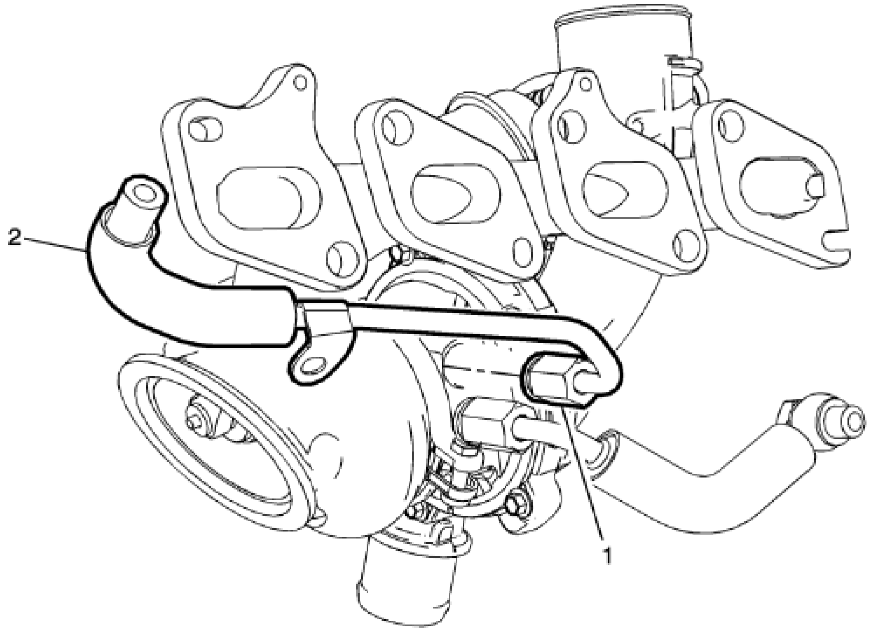
### 8.3.3.16. Turbocharger Coolant Feed Pipe Replacement




**Turbocharger Coolant Feed Pipe Replacement**

| Callout | Component Name |
|---|---|
| **Preliminary Procedure**<br>Remove the turbocharger. Refer to Turbocharger Replacement. | |
| 1 | Turbocharger Fastener<br><br>**Caution:** Refer to Fastener Caution.<br><br>**Procedure**<br>Replace seals with NEW seals.<br><br>**Tighten**<br>8 Nm (71 lb in) |
| 2 | Turbocharger Coolant Feed Pipe |

### 8.3.3.17. Turbocharger Coolant Return Pipe Replacement



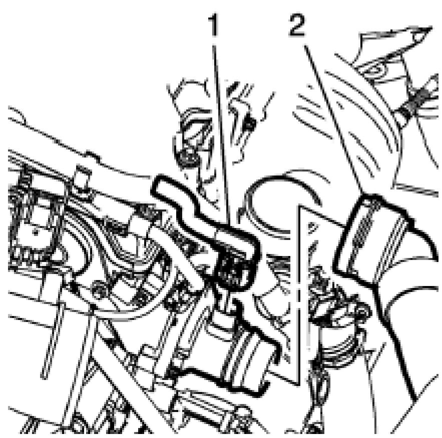

**Turbocharger Coolant Return Pipe Replacement**

| Callout | Component Name |
|---|---|
| **Preliminary Procedure**<br>Remove the turbocharger. Refer to Turbocharger Replacement. | |
| 1 | Turbocharger Fastener<br><br>**Caution:** Refer to Fastener Caution.<br><br>**Procedure**<br>Replace seals with NEW seals.<br><br>**Tighten**<br>8 Nm (71 lb in) |
| 2 | Turbocharger Coolant Return Pipe |

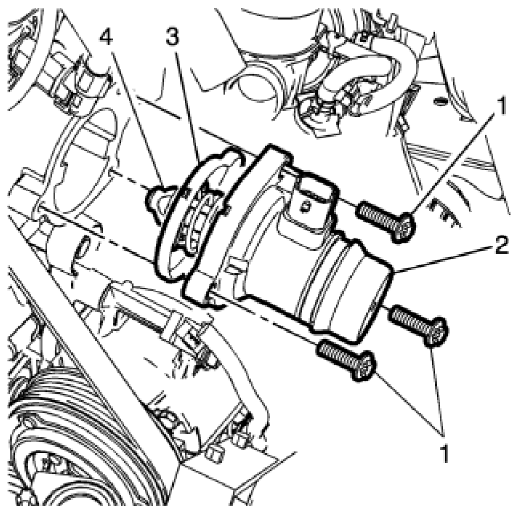
### 8.3.3.18. Engine Coolant Thermostat Replacement

#### 8.3.3.18.1. Removal Procedure

1. Drain the cooling system. Refer to Cooling System Draining and Filling.
2. Drain engine coolant. Refer to Cooling System Draining and Filling
3. Remove the Radiator surge tank
4. Position the Radiator surge tank Outlet hose out of the way
5. Remove the Air intake hose filter to Turbo



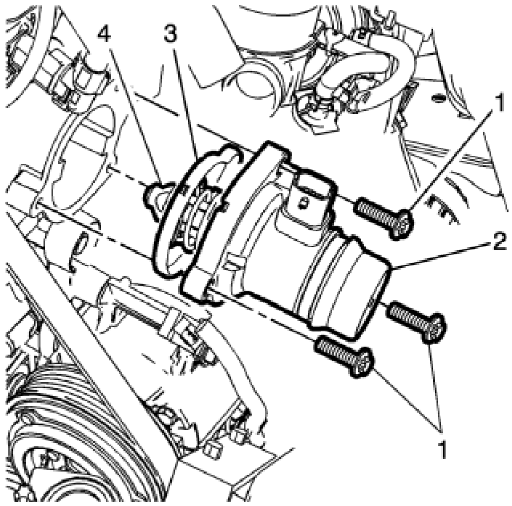

6. Remove the engine coolant temperature sensor connector (1).
7. Disconnect the radiator outlet hose connector (2) from the engine coolant thermostat and reposition. Refer to Radiator Outlet Hose Connector Replacement – Engine Side.



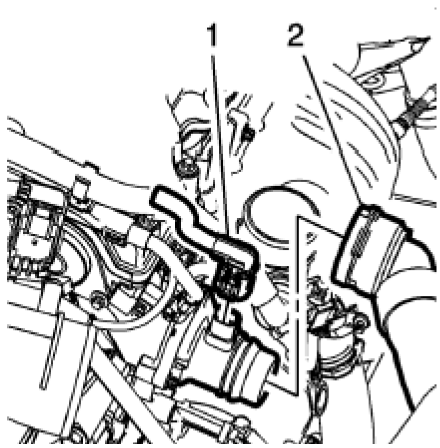

8. Remove the water inlet pipe mounting fasteners (1).
9. Remove the water inlet seal (3) and discard.
10. Remove the thermostat (4).

#### 8.3.3.18.2.Installation Procedure

1. Clean the sealing surface.

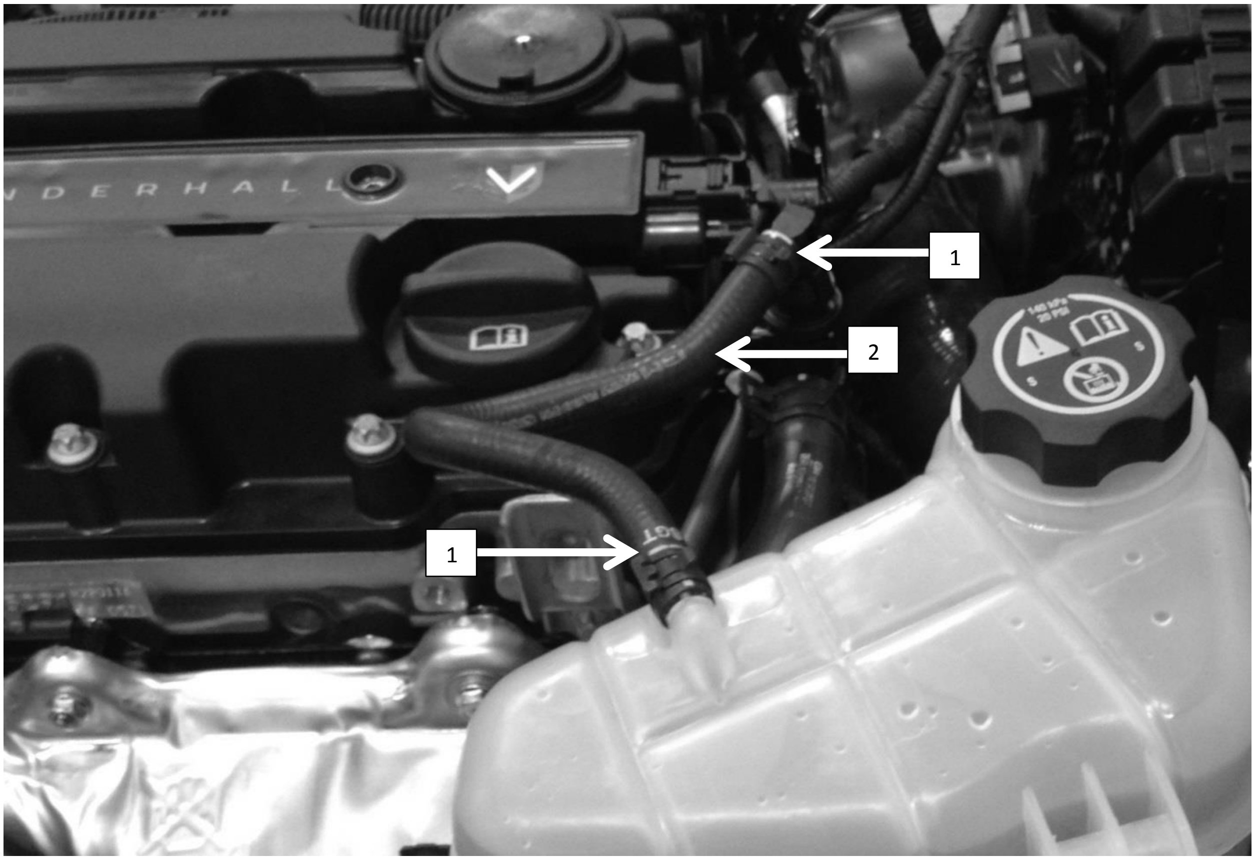



2. Install the engine thermostat (4) into the water inlet pipe (2) with a NEW seal (3).
3. Tighten the water inlet pipe mounting fasteners (1) to 9 Nm (80 lb in).




4. Install the radiator outlet hose connector (2) to the engine coolant thermostat. Refer to Radiator Outlet Hose Connector Replacement –Engine Side.
5. Connect the engine coolant temperature sensor connector (1).
6. Install the Radiator surge tank
7. Install the Air intake hose filter to Turbo
8. Fill the cooling system. Refer to Cooling System Draining and Filling.
9. After repairs, inspect cooling system for leaks.

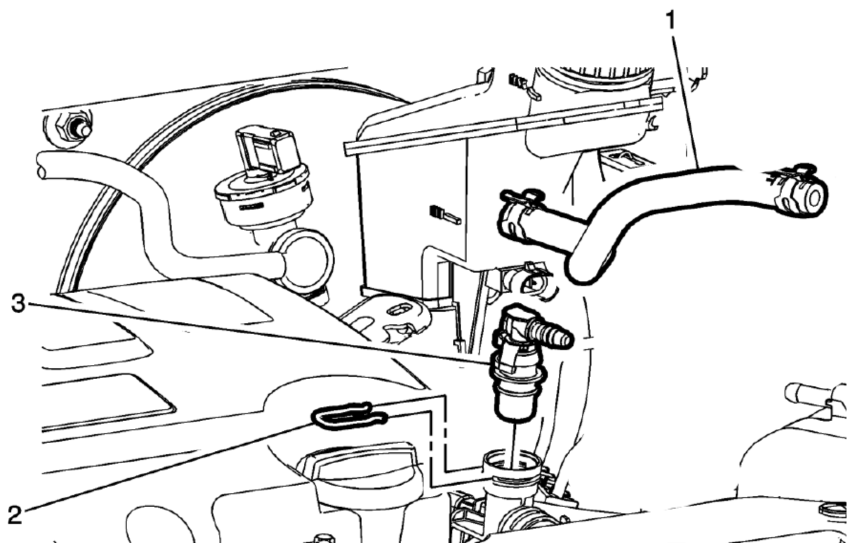
**8.3.3.19. Engine Coolant Air Bleed Hose Replacement**




**Engine Coolant Air Bleed Hose Replacement**

| Callout | Component Name |
|---|---|
| 1 | Engine Coolant Air Bleed Hose Clamp (Qty: 2)<br><br>**Special Tools**<br>BO-38185 Hose Clamp Pliers |
| 2 | Engine Coolant Air Bleed Hose |

### 8.3.3.20. Engine Coolant Air Bleed Hose Connector Replacement



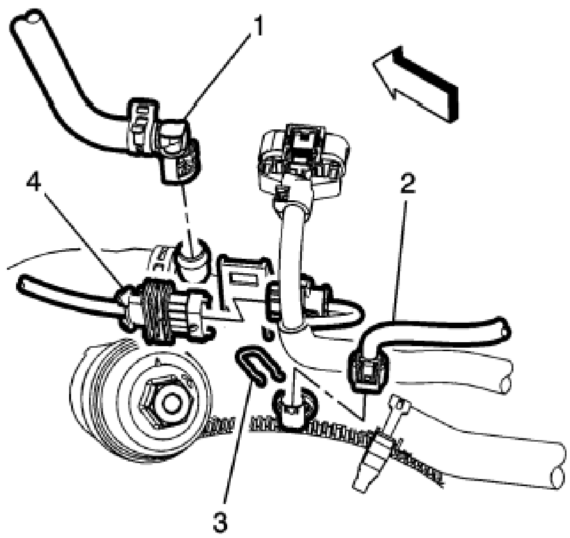

**Engine Coolant Air Bleed Hose Connector Replacement**

| Callout | Component Name |
|---|---|
| 1 | Engine Coolant Air Bleed Hose<br>Refer to Engine Coolant Air Bleed Hose Replacement. |
| 2 | Engine Coolant Air Bleed Hose Connector Retaining Clip |
| 3 | Engine Coolant Air Bleed Hose Connector |

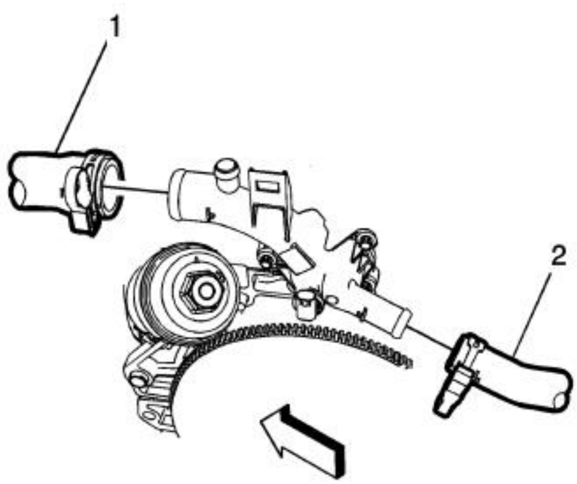
### 8.3.3.21. Water Outlet Replacement

#### 8.3.3.21.1. Removal Procedure

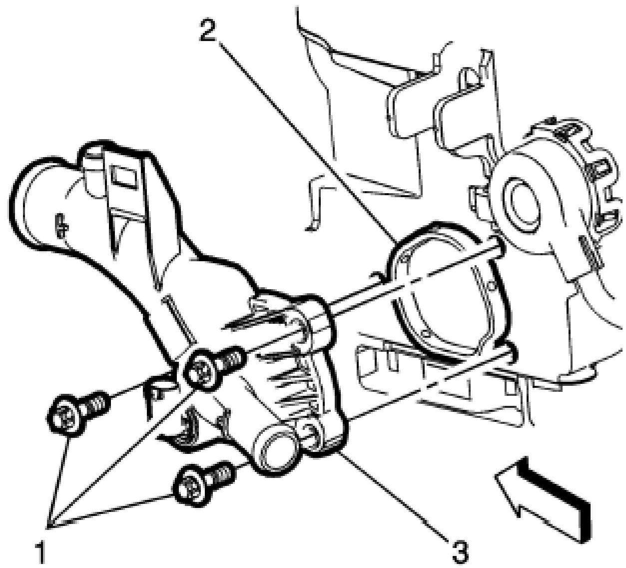
1. Drain the engine coolant system. Refer to Cooling System Draining and Filling.




2. Remove the following:
   - Engine coolant air bleed hose (1)
   - Engine coolant temperature sensor (2) and connector clip (3)
   - Heated oxygen sensor connector (4)



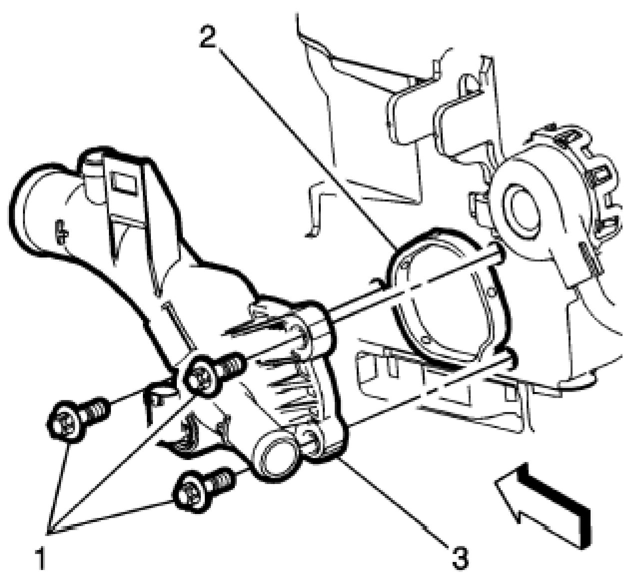

3. Remove the heater outlet hose (1) and the heater inlet hose (2).




4. Remove the water outlet bolts (1) and discard the water outlet seal (2).
5. Remove the water outlet (3).

**8.3.3.21.2.Installation Procedure**

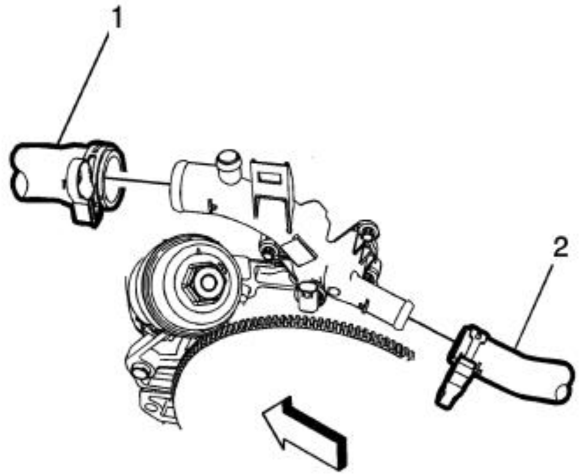
1. Clean the sealing surfaces.



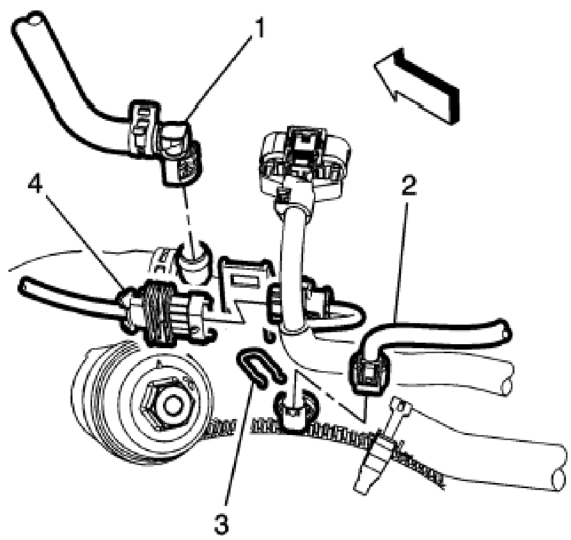

2. Install the water outlet (3) and a NEW water outlet seal (2).

| Caution: |
| --- |
| Refer to Fastener Caution. |

3. Install the water outlet bolts (1) and tighten to 8 Nm (71 lb in).




4. Install the heater outlet hose (1) and the heater inlet hose (2).

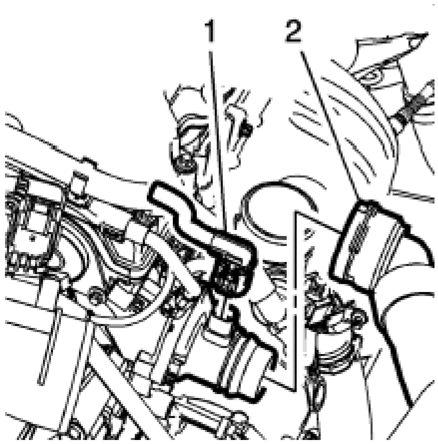



5. Connect the following:
    - Engine coolant temperature sensor (2) and connector clip (3)
    - Heated oxygen sensor connector (4)
    - Engine coolant air bleed hose connector (1)
6. Fill the engine coolant system. Refer to Cooling System Draining and Filling.
7. Start the engine and check for coolant leaks.

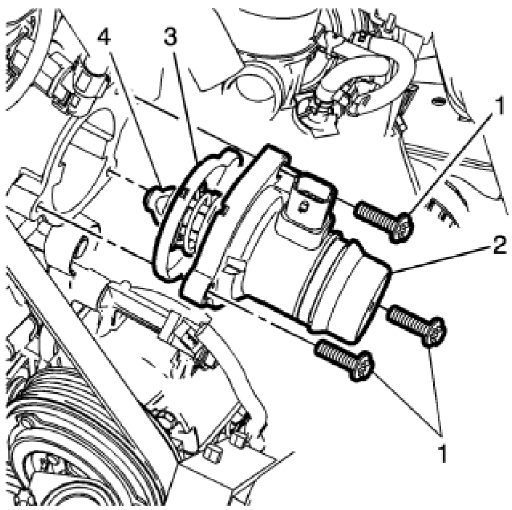
## 8.3.3.22. Water Inlet Replacement

### 8.3.3.22.1.Removal Procedure

1. Drain the cooling system. Refer to Cooling System Draining and Filling.
2. Drain engine coolant. Refer to Cooling System Draining and Filling
3. Remove the Radiator surge tank
4. Position the Radiator surge tank Outlet hose out of the way
5. Remove the Air intake hose filter to Turbo



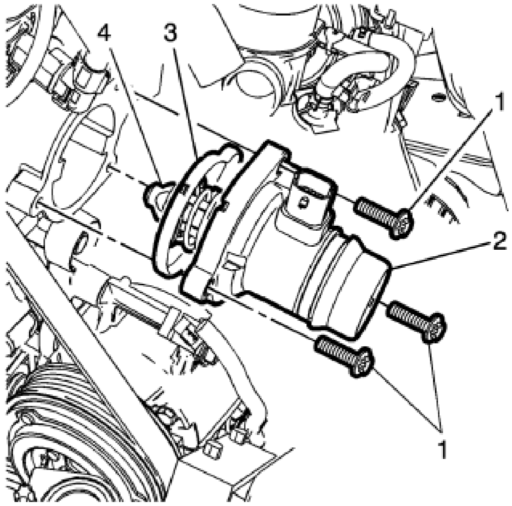

6. Remove the engine coolant temperature sensor connector (1).
7. Disconnect the radiator outlet hose connector (2) from the engine coolant thermostat and reposition. Refer to Radiator Outlet Hose Connector Replacement – Engine Side.



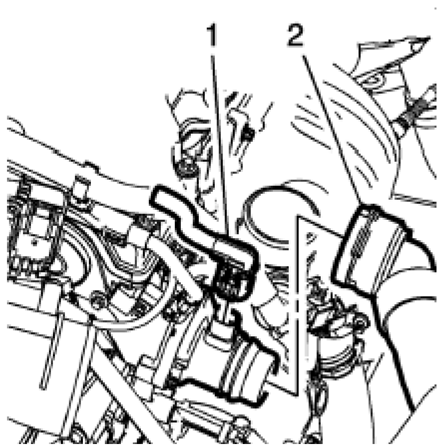

8. Remove the water inlet pipe mounting fasteners (1).
9. Remove the water inlet seal (3) and discard.
10. Remove the thermostat (4).

**8.3.3.22.2.Installation Procedure**

1. Clean the sealing surface.




2. Install the engine thermostat (4) into the water inlet pipe (2) with a NEW seal (3).
3. Tighten the water inlet pipe mounting fasteners (1) to 9 Nm (80 lb in).

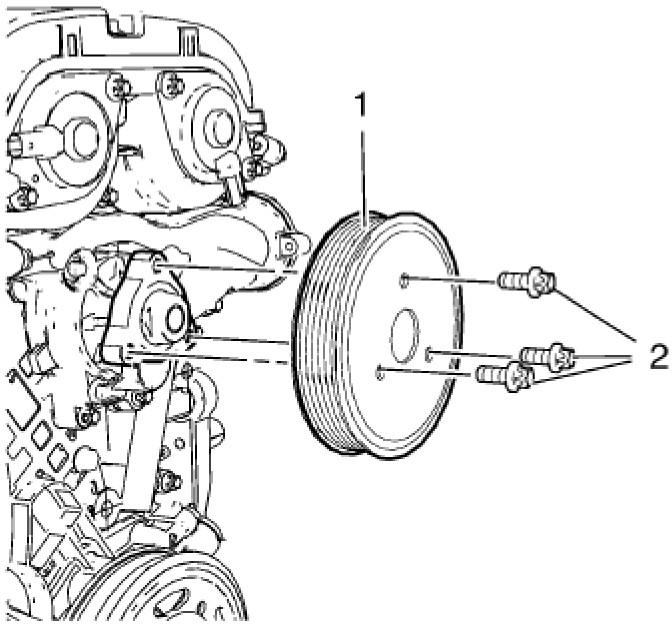



4. Install the radiator outlet hose connector (2) to the engine coolant thermostat. Refer to Radiator Outlet Hose Connector Replacement –Engine Side.
5. Connect the engine coolant temperature sensor connector (1).
6. Install the Radiator surge tank
7. Install the Air intake hose filter to Turbo
8. Fill the cooling system. Refer to Cooling System Draining and Filling.
9. After repairs, inspect cooling system for leaks.

### 8.3.3.23. Water Pump Pulley Replacement

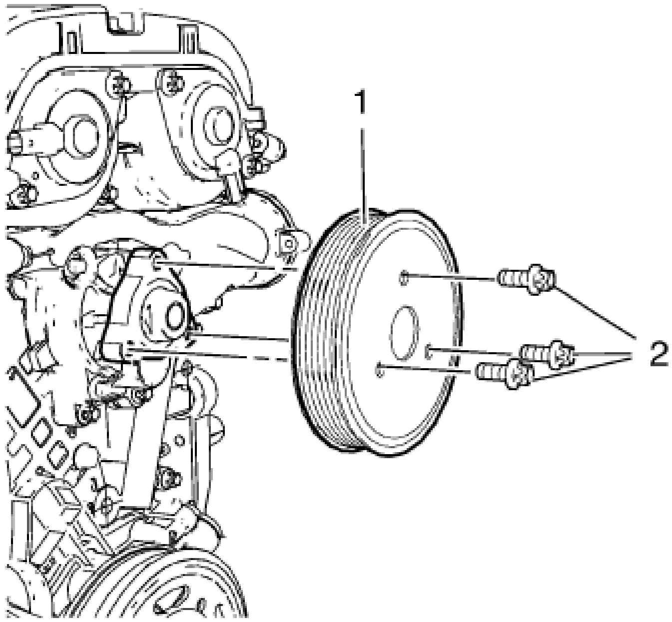
#### 8.3.3.23.1. Removal Procedure

1. Remove the engine mount bracket. Refer to Engine Mount Bracket Replacement Right Side.
2. Remove the drive belt. Refer to Drive Belt Replacement.




4. Loosen the 3 water pump pulley bolts (2) while holding the water pump pulley hub with a wrench.
5. Remove the 3 water pump pulley bolts (2).
6. Remove the water pump pulley (1).

**8.3.3.23.2.Installation Procedure**




1. Install the water pump pulley (1).
2. Install the 3 water pump pulley bolts (2).

| Caution: |
|---|
| Refer to Fastener Caution. |

3. Tighten the 3 water pump pulley bolts to 22 Nm (16 lb ft) while holding the water pump pulley hub with a wrench.
4. Install the drive belt. Refer to Drive Belt Replacement.
5. Install the engine mount bracket. Refer to Engine Mount Bracket Replacement Right Side.

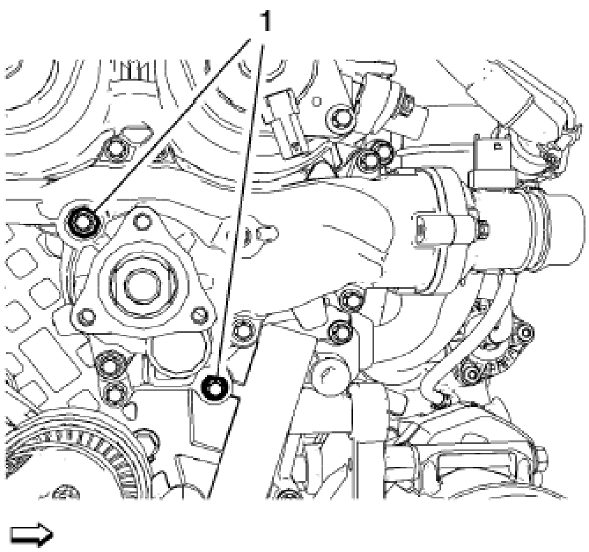
### 8.3.3.24. Water Pump Replacement

**Special Tools**

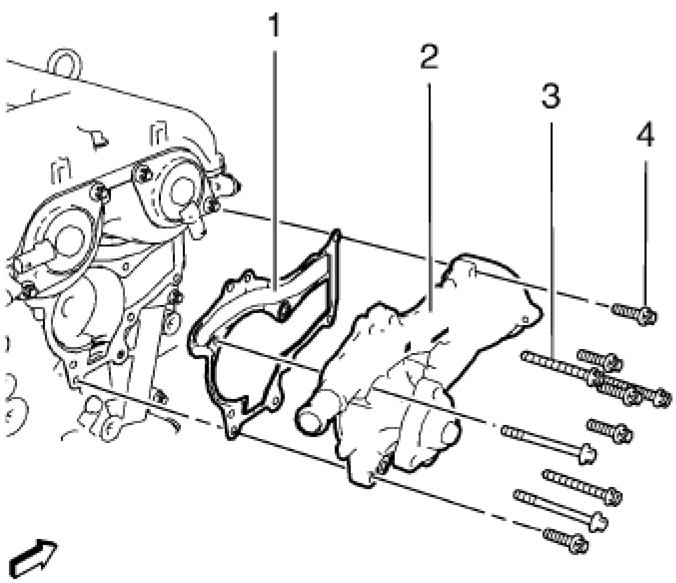
EN45059 Angle Meter

#### 8.3.3.24.1. Removal Procedure

1. Drain the cooling system. Refer to Cooling System Draining and Filling.
2. Remove the water inlet. Refer to Water Inlet Replacement.
3. Remove the water pump pulley. Refer to Water Pump Pulley Replacement
4. Remove the heater outlet hose from the water pump. Refer to Heater Outlet Hose Replacement.



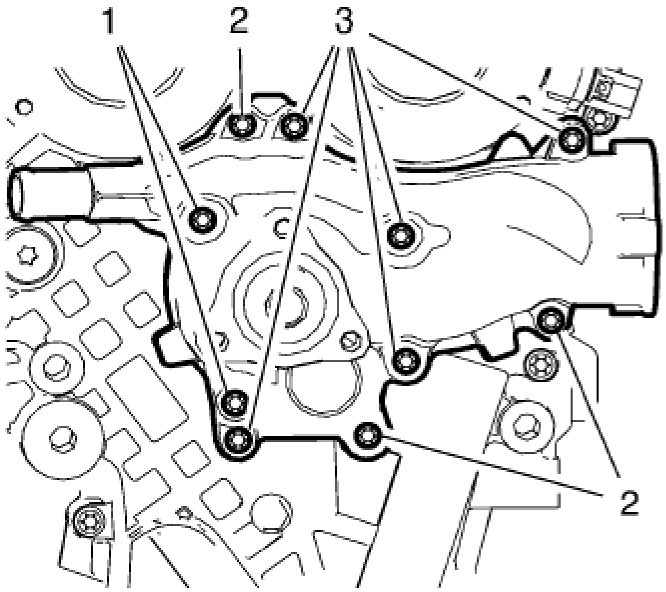

5. Remove and DISCARD the 2 front cover bolts (1).



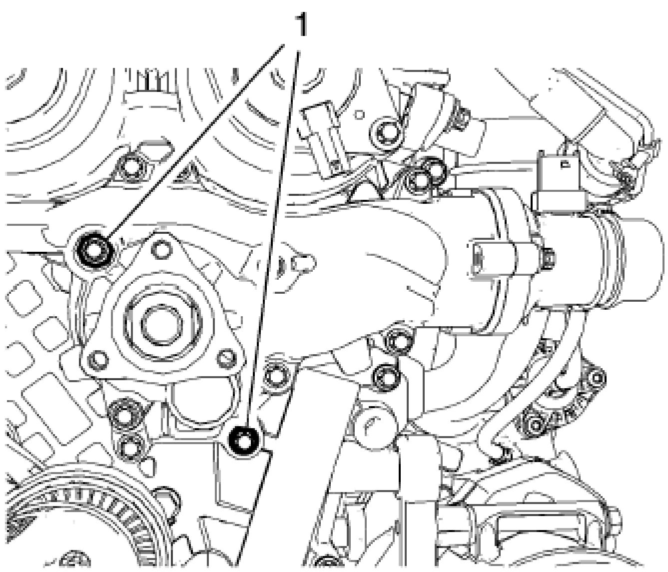

6. Remove the 5 water pump bolts (4) and the 3 long engine front cover bolts (3).
7. Remove the water pump (2).
8. Remove and DISCARD the water pump gasket (1).

**8.3.3.24.2.Installation Procedure**

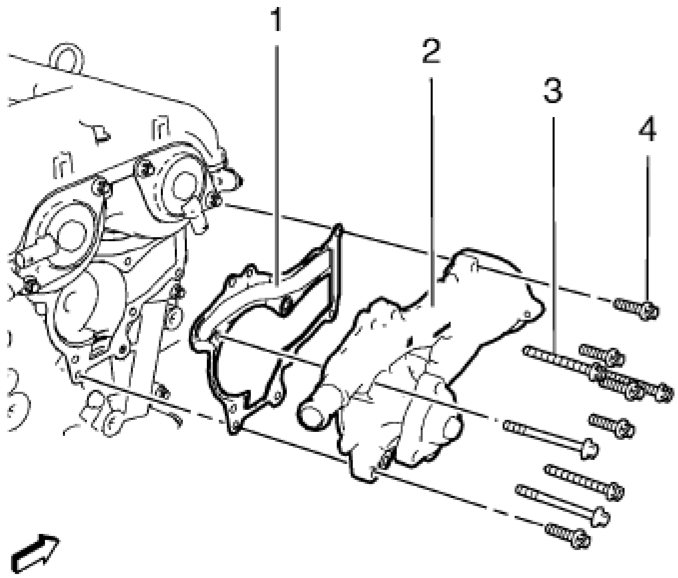
1. Clean the sealing surfaces.




2. The water pump and engine front cover bolts are located as followed:
- Engine front cover special bolt without cone end 60 mm (2.362 in) (1).
- Engine front cover standard bolt with cone end 52 mm (2.047 in) (2).
- Water pump bolt 25 mm (0.984 in) (3).



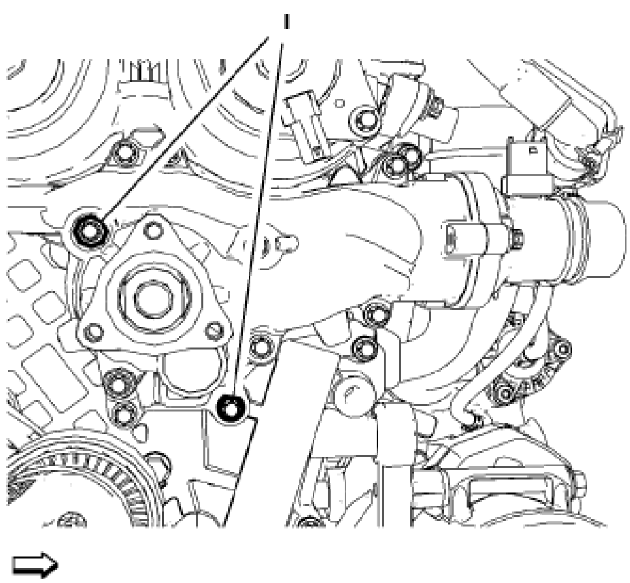

3. Install the 2 NEW front cover bolts (1).




4. Install the water pump (2) and a NEW water pump gasket (1).

| **Caution:** |
| --- |
| Refer to Fastener Caution. |

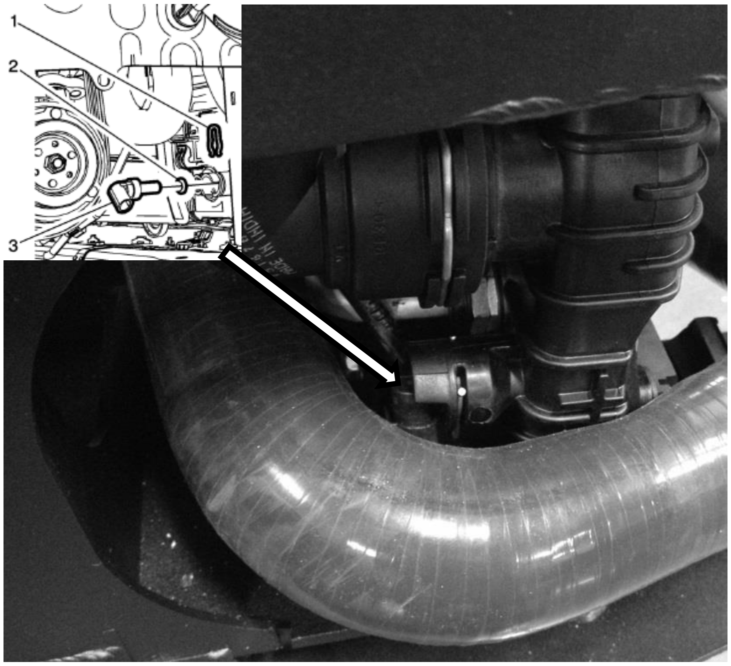
5. Install the 5 water pump bolts (4) and the 3 engine front cover bolts (3) and tighten all 10 bolts in a cross sequence to 8 Nm (71 lb in).




| **Caution:** |
| --- |
| Refer to Torque-to-Yield Fastener Caution. |

6. Tighten the 2 water pump bolts (1) to an additional 30 degrees, using the EN-45059 meter.
7. Install the heater outlet hose from the water pump. Refer to Heater Outlet Hose Replacement.
8. Install the water pump pulley. Refer to Water Pump Pulley Replacement.
9. Install the water inlet. Refer to Water Inlet Replacement.
10. Fill the cooling system. Refer to Cooling System Draining and Filling.

### 8.3.3.25. Engine Coolant Temperature Sensor Replacement - Radiator



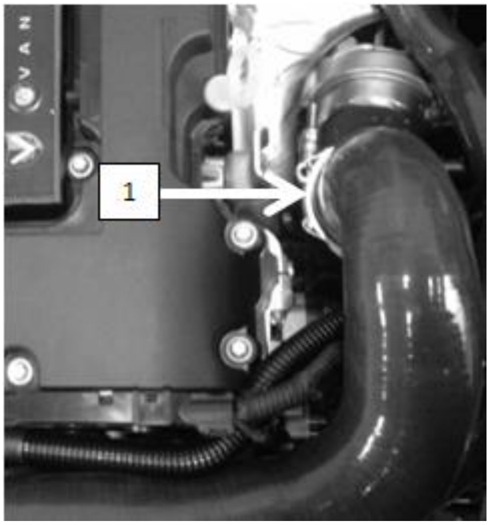

**Engine Coolant Temperature Sensor Replacement - Radiator**

| Callout | Component Name |
|---|---|
| **Preliminary Procedure**<br>1. Remove the Valance, Refer to Valance in Body Repair<br>2. Drain the coolant. Refer to Cooling System Draining and Filling | |
| 1 | Engine Coolant Temperature Sensor Retainer |
| 2 | Engine Coolant Temperature Sensor Seal<br><br>**Procedure**<br>Discard the old seal and replace with a NEW seal if not replacing the sensor. |
| 3 | Engine Coolant Temperature Sensor<br><br>**Procedure**<br>1. Disconnect the engine coolant temperature sensor radiator mounted electrical sensor.<br>2. Inspect and clean the radiator prior to installation. |

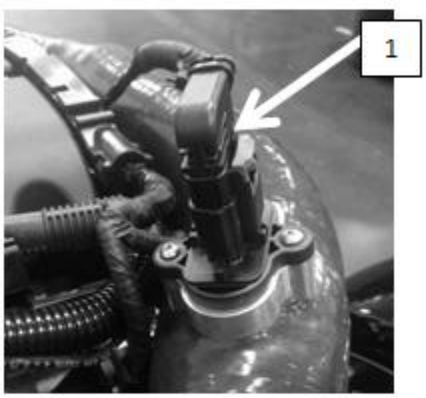
### 8.3.3.26. Engine Coolant Fan Shroud Replacement

#### 8.3.3.26.1. Removal Procedure

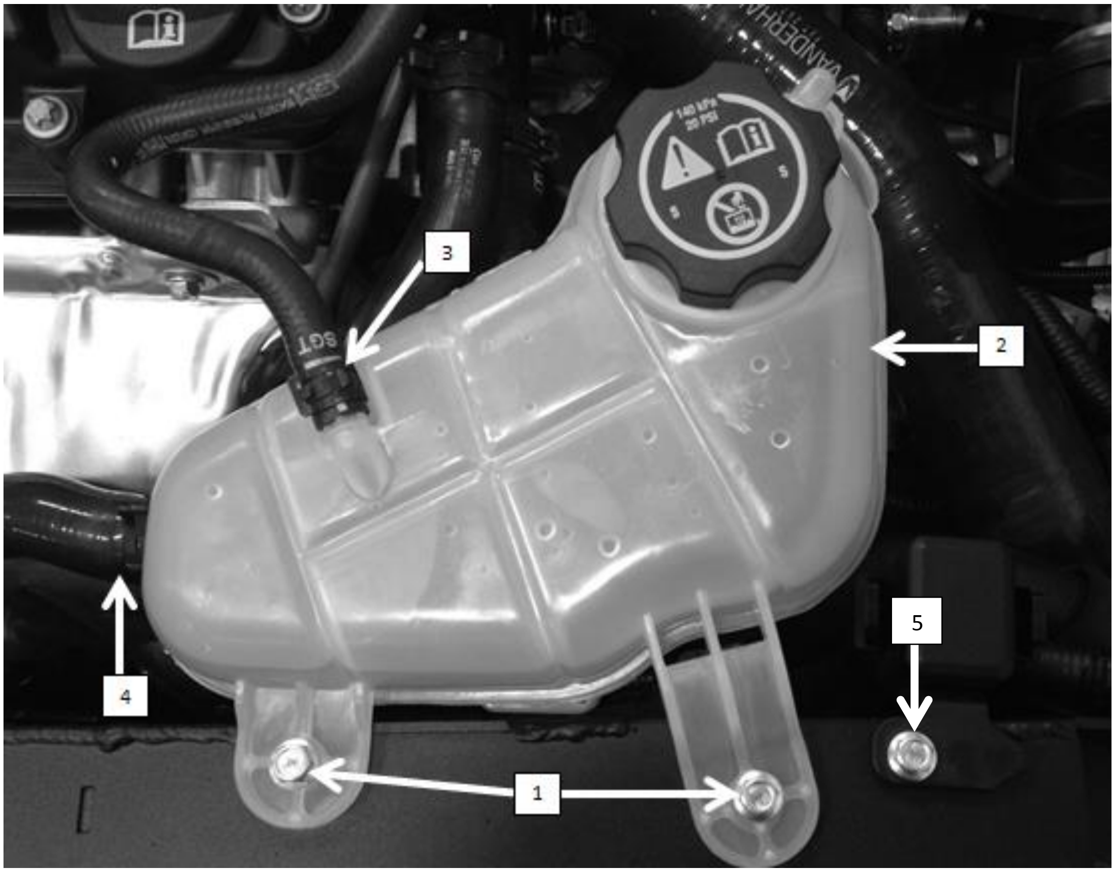
1. Battery Negative Cable Disconnection and Connection » Disconnect the battery negative cable.
2. Front Valance » Remove



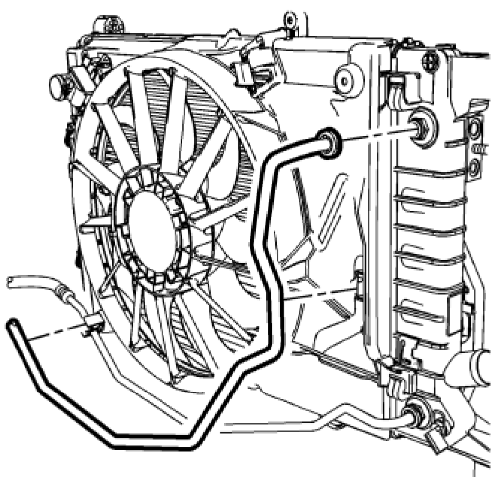

3. Air intake hose Filter to Turbo » Remove from Turbo Charger



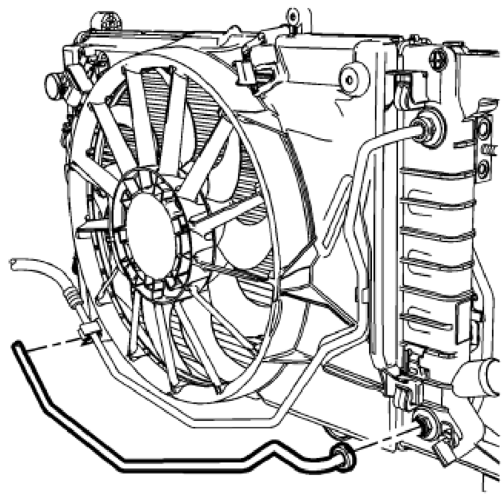

4. Mass Airflow Sensor » Disconnect Harness
5. Remove the Air intake hose Filter to Turbo Hose



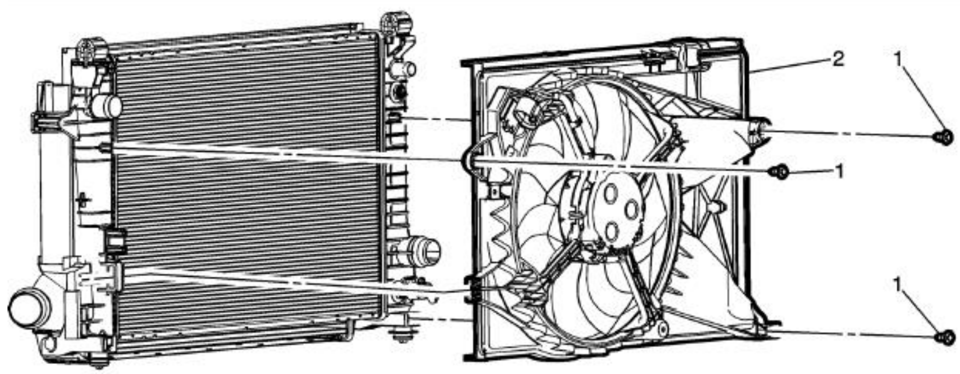

6. Radiator Surge Tank Replacement — Bolt (1) [2x] » Remove
7. Cooing Fan Relay (5) » Remove
8. Reposition the surge tank (2) and hoses out of the way.
9. Radiator Support Cross Brace» Remove



10. Fluid Cooler Outlet Hose Replacement @ Radiator » Remove

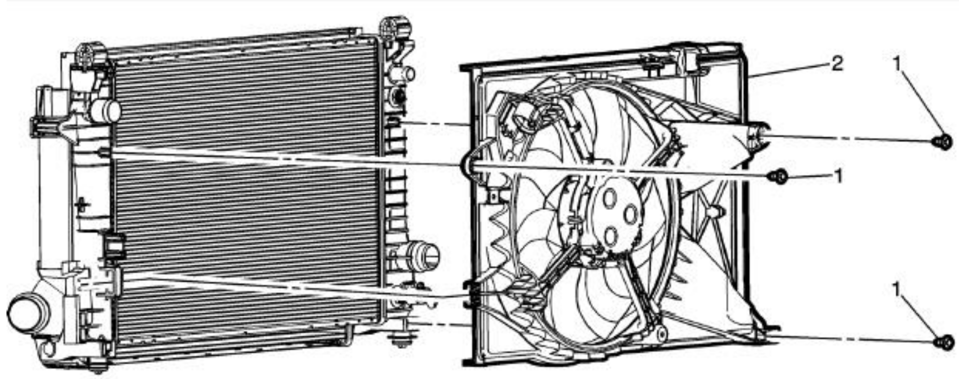


11. Fluid Cooler Inlet Hose Replacement @ Radiator » Remove



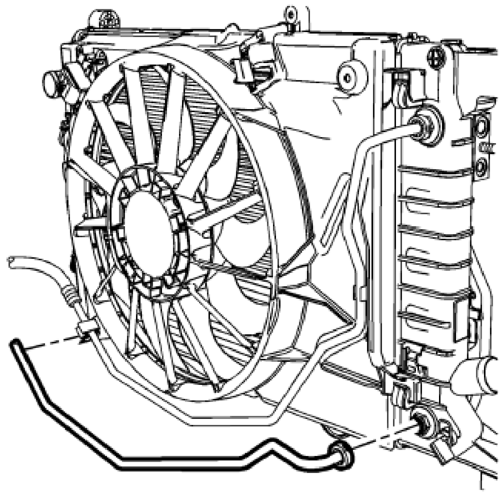

12. Engine Coolant Fan Shroud Fastener (1) [3X] » Remove
13. Engine Coolant Fan Shroud (2) » Remove

**8.3.3.26.2.Installation Procedure**

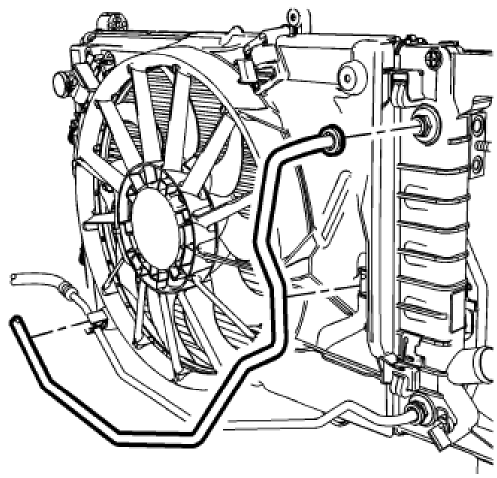



| Caution: |
|---|
| Refer to Fastener Caution. |

1. Engine Coolant Fan Shroud (2) » Install
2. Engine Coolant Fan Shroud Fastener (1) [3x] » Install and tighten 5 Nm (4 lb ft)



3. Fluid Cooler Inlet Hose Replacement @ Radiator » Install

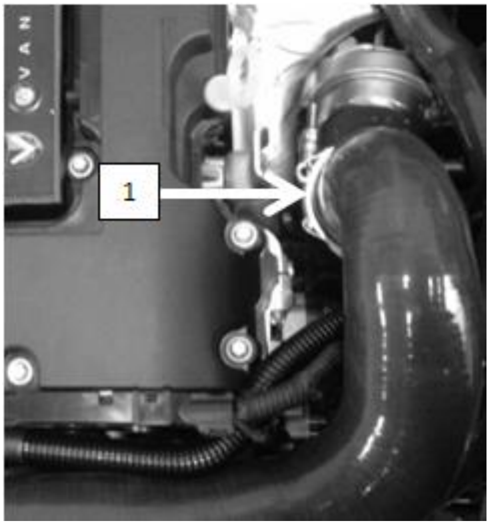


4. Fluid Cooler Outlet Hose Replacement @ Radiator » Install
5. Radiator Support Cross Brace» Install
6. Radiator Surge Tank Replacement — Bolt (1) [2x] » Install and tighten 5 Nm (4 lb ft)
7. Install the Cooling Fan Relay 5 Nm (4 lb ft)
8. Reinstall  the Air intake hose Filter to Turbo
9. Reconnect the Mass Air Flow Sensor
10. Reinstall the Valance, Refer to Valance in Body Repair
11. Battery Negative Cable Disconnection and Connection » Connect the battery negative cable.

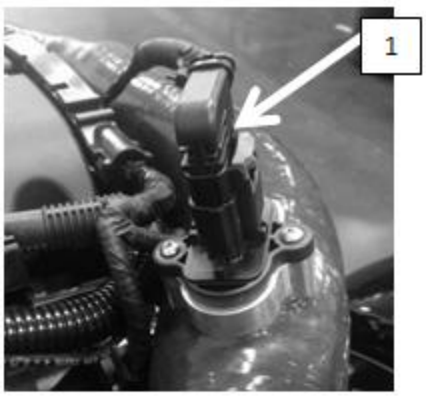
### 8.3.3.27. Radiator Replacement

#### 8.3.3.27.1. Removal Procedure

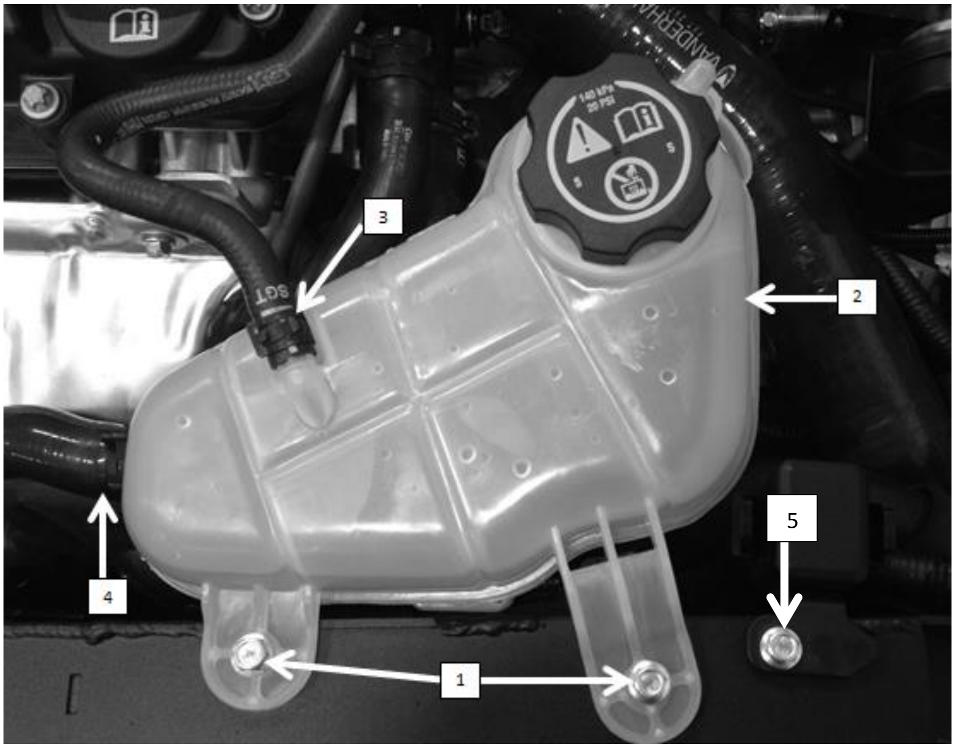
1. Disconnect the battery negative cable. Battery Negative Cable Disconnection and Connection
2. Remove the Front Grill
3. Remove the Front valance



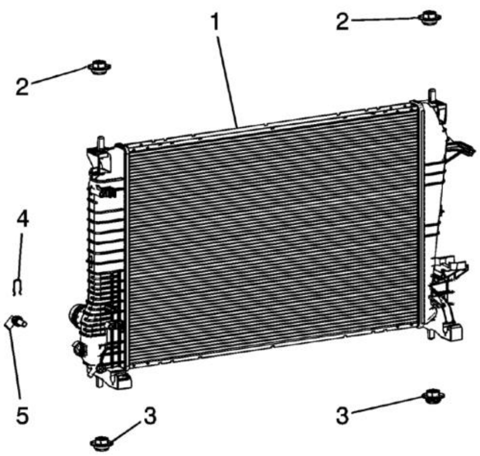

4. Remove from Turbo Charger the Air intake hose Filter to Turbo




5. Disconnect Harness of the Mass Airflow Sensor
6. Remove the Air intake hose Filter to Turbo Hose
7. Drain the engine coolant. Refer to Cooling System Draining and Filling.

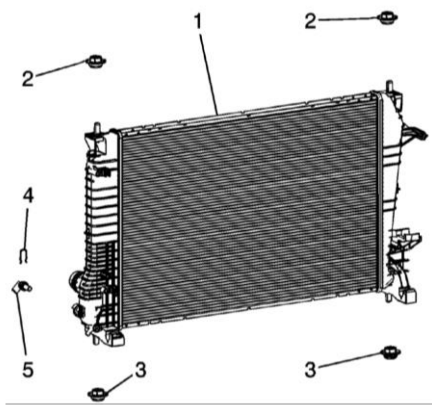



8. Remove the Radiator Surge Tank Bolts (1) [2x] »
9. Remove the Cooing Fan Relay (5) »
10. Reposition the surge tank (2) and hoses out of the way.
11. Remove the Radiator Support Cross Brace
12. Remove the radiator inlet hose from the radiator. Refer to Radiator Inlet Hose Replacement.
13. Remove the radiator outlet hose from the radiator. Refer to Radiator Outlet Hose Replacement.
14. Remove the transmission cooler lines. Refer to Fluid Cooler Inlet Hose Replacement and Fluid Cooler Outlet Hose Replacement.
15. Remove the radiator assembly from the vehicle.

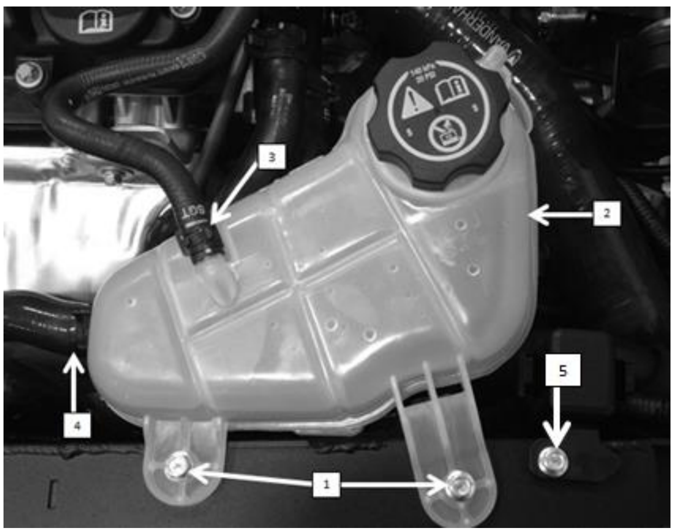



16. Remove the following components from the radiator assembly (1).
    - Radiator upper insulators (2)
    - Radiator lower insulators (3)
    - Radiator temperature sensor (5) and retainer clip (4)

**8.3.3.27.2.Installation Procedure**




1. Install the following components to the radiator assembly (1).
    - Radiator upper insulators (2)
    - Radiator lower insulators (3)
    - Radiator temperature sensor (5) and retainer clip (4)
2. Install the radiator assembly into the vehicle.
3. Install the radiator outlet hose from the radiator. Refer to Radiator Outlet Hose Replacement.
4. Install the radiator inlet hose from the radiator. Refer to Radiator Inlet Hose Replacement.
5. Install the transmission cooler lines. Refer to Fluid Cooler Inlet Hose Replacement and Fluid Cooler Outlet Hose Replacement.
6. Install the engine coolant fan shroud. Refer to Engine Coolant Fan Shroud Replacement.
7. Install the Radiator Support Cross Brace




8. Install the Radiator Surge Tank
9. Install the Cooling Fan Relay
10. Install the Air intake hose Filter to Turbo Hose
11. Connect the Mass Airflow Sensor Harness
12. Refill the Cooling System
13. Check the cooling system for leaks
14. Install the Front Valance
15. Install the Front Grill
16. Reconnect the Negative Battery Cable

### 8.3.4. Specifications

#### 8.3.4.1. Fastener specifications

| Application | Specification | |
|---|---|---|
| | Metric | English |
| Engine Coolant Fan Engine Bolts | 4 Nm | 35 lb in |
| Engine Coolant Thermostat Housing Bolts | 8 Nm | 71 lb in |
| Engine Coolant Thermostat Housing Bracket Nut | 6 Nm | 53 lb in |
| Engine Oil Cooler Assembly Bolts | 25 Nm | 19 lb ft |
| Engine Oil Cooler Bolts | 20 Nm | 15 lb ft |
| Engine Oil Cooler Inlet Pipe Bolt | 10 Nm | 89 lb in |
| Engine Oil Cooler Outlet Pipe Bolt | 8 Nm | 71 lb in |
| Engine Oil Cooler Outlet Pipe Mounting Bolts to ECM bracket to Water Pump Housing | 8 Nm | 71 lb in |
| Engine Oil Cooler Pipe Bolts | 8 Nm | 71 lb in |
| Engine Oil Cooler Pipe to Thermostat Housing Bolts | 8 Nm | 71 lb in |
| Oil Cooler Outlet Pipe Bolt to Engine Block | 10 Nm | 89 lb in |
| Oil Pressure Indicator Switch | 20 Nm | 15 lb ft |
| Radiator Drain Cock | 2 Nm | 18 lb in |
| Radiator Mounting Pin Bolt | 5 Nm | 44 lb in |
| Radiator Upper Bracket Fastener | 9 Nm | 80 lb in |
| Turbocharger Coolant Return Pipe Bolt | 10 Nm | 89 lb in |
| Turbocharger Fastener | 8 Nm | 71 lb in |
| Water Inlet Bolts | 8 Nm | 71 lb in |
| Water Inlet Pipe Mounting Fasteners | 9 Nm | 80 lb in |
| Water Outlet Bolts | 8 Nm | 71 lb in |
| Water Pump Bolt | 8 Nm | 71 lb in |
| Water Pump Pulley Bolts | 22 Nm | 16 lb ft |
| Water Pump Pulley Bolts | 20 Nm | 15 lb ft |

### 8.3.4.2. Approximate Fluid Capacities

**Approximate Fluid Capacities**

| Application | Specification | |
|---|---|---|
| | Metric | English |
| Cooling System | | |
| 1.4L | 6.5 L | 6.9 qt |

### 8.3.4.3. Temperature Versus Resistance (Engine Coolant Temperature Sensor)

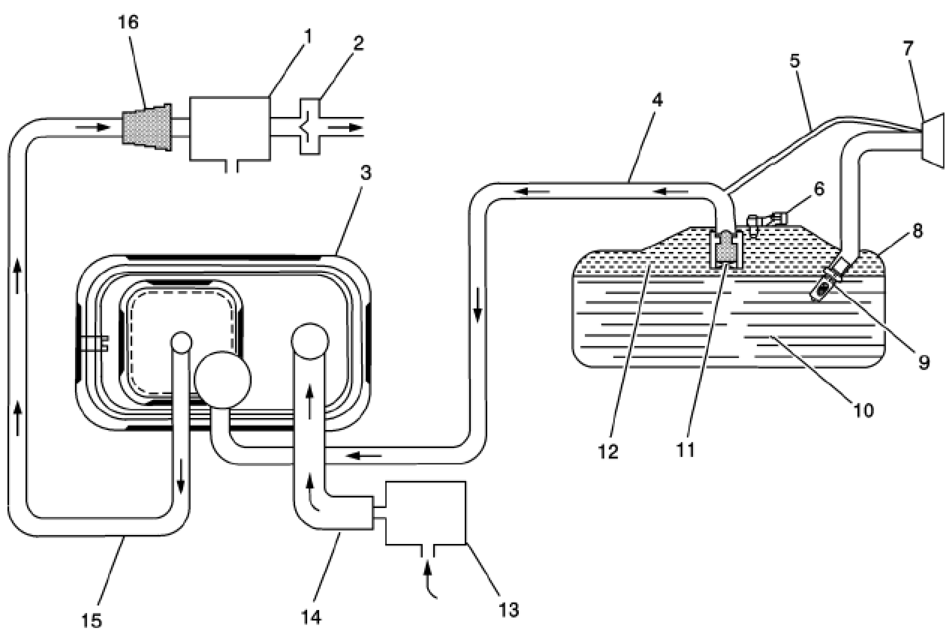
| Temperature | Resistance |
|---|---|
| 150°C (302°F) | 42 to 44 Ω |
| 140°C (284°F) | 53 to 57 Ω |
| 130°C (266°F) | 68 to 72 Ω |
| 120°C (248°F) | 88 to 92 Ω |
| 110°C (230°F) | 114 to 120 Ω |
| 100°C (212°F) | 151 to 159 Ω |
| 90°C (194°F) | 203 to 215 Ω |
| 80°C (176°F) | 275 to 293 Ω |
| 70°C (158°F) | 379 to 405 Ω |
| 60°C (140°F) | 532 to 572 Ω |
| 50°C (122°F) | 762 to 824 Ω |
| 45°C (113°F) | 921 to 997 Ω |
| 40°C (104°F) | 1118 to 1212 Ω |
| 35°C (95°F) | 1366 to 1484 Ω |
| 30°C (86°F) | 1683 to 1829 Ω |
| 25°C (77°F) | 2088 to 2266 Ω |
| 20°C (68°F) | 2608 to 2828 Ω |
| 15°C (59°F) | 3289 to 3567 Ω |
| 10°C (50°F) | 4182 to 4532 Ω |
| 5°C (41°F) | 5356 to 5800 Ω |
| 0°C (32°F) | 6914 to 7484 Ω |
| -5° C (23°F) | 8994 to 9732 Ω |
| -10° C (14°F) | 11796 to 12762 Ω |
| -15° C (5°F) | 15589 to 16871 Ω |
| -20° C (-4° F) | 20791 to 22517 Ω |
| -30° C (-22° F) | 37991 to 41273 Ω |
| -40° C (-40° F) | 72230 to 78834 Ω |

## 8.4. Fuel System

### 8.4.1. Description and Operation

#### 8.4.1.1. Evaporative Emission Control System Description

##### 8.4.1.1.1. Typical Evaporative Emission (EVAP) System Hose Routing Diagram




(1) Evaporative Emissions (EVAP) Purge Solenoid Valve
(2) Purge Tube Check Valve, Turbo-Charged Applications Only
(3) EVAP Canister
(4) EVAP Vapor Tube
(5) Vapor Recirculation Tube (ORVR)
(6) Fuel Tank Pressure Sensor
(7) Fuel Filler Cap
(8) Fuel Tank
(9) Fuel Fill Pipe Inlet Check Valve
(10) Liquid Fuel
(11) Fill Limit Vent Valve (FLVV)
(12) Fuel Vapor
(13) EVAP Canister Vent Solenoid Valve
(14) Vent hose
(15) EVAP Purge Tube
(16) EVAP Canister Purge Tube Connector

##### 8.4.1.1.2. EVAP System Operation

The EVAP control system limits fuel vapors from escaping into the atmosphere. Fuel tank vapors are allowed to move from the fuel tank, due to pressure in the tank, through the EVAP vapor tube, into the EVAP canister. Carbon in the canister absorbs and stores the fuel vapors. Excess pressure is vented through the vent hose and EVAP vent solenoid valve to the atmosphere. The EVAP canister stores the fuel vapors until the engine is able to use them. At an appropriate time, the engine control module (ECM) will command the EVAP purge solenoid valve ON, allowing engine vacuum to be applied to the EVAP canister. With the normally open EVAP vent solenoid valve OFF, fresh air is drawn through the vent solenoid valve and the vent hose to the EVAP canister. Fresh air is drawn through the canister, pulling fuel vapors from the carbon. The air/fuel vapor mixture continues through the EVAP purge tube and EVAP purge solenoid valve into the intake manifold to be consumed during normal combustion. The ECM uses several tests to determine if the EVAP system is leaking or restricted.

#### 8.4.1.1.3. Purge Solenoid Valve Leak Test

If the EVAP purge solenoid valve does not seal properly fuel vapors could enter the engine at an undesired time, causing driveability concerns. The ECM tests for this by commanding the EVAP purge solenoid valve OFF and the vent solenoid valve ON which seals the system. With the engine running, the ECM then monitors the fuel tank pressure sensor for an increase in vacuum. The ECM will set a DTC if a vacuum develops in the tank under these test conditions.

#### 8.4.1.1.4. Large Leak Test

This diagnostic creates a vacuum condition in the EVAP system. When the enabling criteria has been met, the ECM commands the normally open EVAP vent solenoid valve closed and the EVAP purge solenoid valve open, creating a vacuum in the EVAP system. The ECM then monitors the fuel tank pressure sensor voltage to verify that the system is able to reach a predetermined level of vacuum within a set amount of time. Failure to achieve the expected level of vacuum indicates the presence of a large leak in the EVAP system or a restriction in the purge path. The ECM will set a DTC if it detects a weaker than expected vacuum level under these test conditions.

#### 8.4.1.1.5. Canister Vent Restriction Test

If the EVAP vent system is restricted, fuel vapors will not be properly purged from the EVAP canister. The ECM tests this by commanding the EVAP purge solenoid valve ON while commanding the EVAP vent solenoid valve OFF, and then monitoring the fuel tank pressure sensor for an increase in vacuum. If the vacuum increases more than the expected amount, in a set amount of time, a fault will be logged by the ECM.

#### 8.4.1.1.6. 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).

#### 8.4.1.1.7. EVAP System Components

The EVAP system consists of the following components:

**EVAP Purge Solenoid Valve**
The EVAP purge solenoid valve controls the flow of vapors from the EVAP system to the intake manifold. The purge solenoid valve opens when commanded ON by the ECM. This normally closed valve is pulse width modulated (PWM) by the ECM to precisely control the flow of fuel vapor to the engine. The valve will also be opened during some portions of the EVAP testing when the engine is running, allowing engine vacuum to enter the EVAP system.

**Purge Tube Check Valve**

| Note: |
| --- |
| The presence of this one-way check valve prevents pressure testing the EVAP system for leaks at the EVAP canister purge tube connector. |

Turbocharged vehicles have a check valve in the purge tube between the EVAP purge solenoid valve and the intake manifold to prevent pressurization of the EVAP system under boost conditions. Some applications may have this check valve between the EVAP purge solenoid valve and the EVAP canister.

**EVAP Canister**
The canister is filled with carbon pellets used to absorb and store fuel vapors. Fuel vapor is stored in the canister until the ECM determines that the vapor can be consumed in the normal combustion process.

**Vapor Recirculation Tube**
A vapor path between the fuel fill pipe and the vapor tube to the carbon canister is necessary for Vehicle Onboard Diagnostics to fully diagnose the EVAP system. It also accommodates service diagnostic procedures by allowing the entire EVAP system to be diagnosed from either end of the system.

The On-Board Refueling Vapor Recovery System is an onboard vehicle system designed to recover fuel vapors during the vehicle refueling operation. The flow of liquid fuel down the fuel filler pipe provides a liquid seal which prevents vapor from leaving the fuel filler pipe. An EVAP pipe transports the fuel vapor to the EVAP canister for use by the engine.

**Fuel Tank Pressure Sensor**
The fuel tank pressure sensor measures the difference between the pressure or vacuum in the fuel tank and outside air pressure. Depending on the vehicle, the sensor can be located in the vapor space on top of the fuel tank, in the vapor tube between the canister and the tank, or on the EVAP canister. A high fuel tank pressure sensor voltage indicates a low fuel tank pressure or vacuum. A low fuel tank pressure sensor voltage indicates a high fuel tank pressure.

#### 8.4.1.1.8. Fuel Fill Pipe Check Valve

The check valve on the fuel fill pipe is there to prevent spit-back during refueling.

#### 8.4.1.1.9. EVAP Vent Solenoid Valve

The EVAP vent solenoid valve controls fresh airflow into the EVAP canister. The valve is normally open. The canister vent solenoid
valve is closed only during EVAP system tests performed by the ECM like large leak and engine off natural vacuum test.

**Fuel Fill Cap**
The fuel fill cap is equipped with a seal and a vacuum relief valve and is tethered. A torque-limiting device prevents the cap from being over tightened. To install the cap, turn the cap clockwise until you hear clicks. This indicates that the cap is correctly torqued and fully seated. A built-in device indicates that the fuel filler cap is fully seated. A fuel filler cap that is not fully seated may cause a malfunction in the emission system.

**Fill Limit Vent Valve**
This acts as a shut off valve during refueling. This will vary based on fuel tank design. The fuel limit vent valve has the following functions:

- The fuel limit vent valve is located on the inside top of the fuel tank
- This valve is not serviced separately
- Controls the fuel tank fill level by closing the primary vent from the fuel tank and forcing the fuel fill nozzle to shut off.
- Prevents liquid fuel from exiting the fuel tank via the EVAP pipe to the canister.
- Provides fuel-spillage protection in the event of a vehicle rollover by closing the vapor path from the tank to the EVAP canister.

### 8.4.1.2. Fuel System Description

#### 8.4.1.2.1. 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.

#### 8.4.1.2.2. 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 chassis control module via a GMLAN serial data message. A liquid fuel pressure sensor provides the feedback the chassis control module requires for Closed Loop fuel pressure control.

#### 8.4.1.2.3. Chassis Control Module

The chassis control module is a serviceable GMLAN module. The chassis 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 chassis 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 chassis control module.

#### 8.4.1.2.4. 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 chassis control module through a vehicle wiring harness. The sensor provides a fuel pressure signal to the chassis control module, which is used to provide Closed Loop fuel pressure control.

#### 8.4.1.2.5. 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.

#### 8.4.1.2.6. Fuel Tank Fuel Pump Module

The fuel tank fuel pump module consists of the following components:

- The fuel level sensor
- The fuel pump
- The fuel strainer
- The pressure relief regulator valve
- The jet pump

#### 8.4.1.2.7. 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.

#### 8.4.1.2.8. 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.

#### 8.4.1.2.9. 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.

#### 8.4.1.2.10.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.

#### 8.4.1.2.11.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 chassis 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.

#### 8.4.1.2.12.Nylon Fuel Pipes

| **Warning:** |
|---|
| Refer to Fuel and Evaporative Emission Pipe Warning. |

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.

#### 8.4.1.2.13.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.

#### 8.4.1.2.14.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

#### 8.4.1.2.15.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.

#### 8.4.1.2.16.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.

#### 8.4.1.2.17.Starting Mode

The ECM supplies voltage to the chassis control module when the ECM detects that the ignition is ON. The voltage from the ECM to the chassis control module remains active for 2 s, unless the engine is in Crank or Run. While this voltage is being received, the chassis 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.

#### 8.4.1.2.18.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.

#### 8.4.1.2.19.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.

#### 8.4.1.2.20.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.

#### 8.4.1.2.21.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.

#### 8.4.1.2.22.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

#### 8.4.1.2.23.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 runon.
- 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

#### 8.4.1.2.24.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 recenter 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).

### 8.4.2. Diagnostic Information and Procedures

**Poor Fuel Fill Quality**

| Condition | Causes |
|---|---|
| **DEFINITION:** During the fueling process a continual, occasional or no fuel nozzle shutoff condition has occurred. | |
| Difficult to fill | • Evaporative emission (EVAP) canister restricted<br>• High fuel temperature<br>• Fuel filler hose is kinked<br>• Faulty dispensing nozzle |
| Premature shutoff of the fuel dispensing nozzle occurs immediately after engaging dispensing nozzle, tank empty | • Restricted vapor lines or fuel fill pipe<br>• High fuel temperature<br>• Fuel tank full, gauge not accurate |
| Premature shutoff of the fuel dispensing nozzle, more than 1/8 of tank capacity dispensed | • Kinked, pinched or plugged lines in fuel tank vent system<br>• EVAP canister restricted<br>• Obstruction at top of fuel tank |
| Fuel spit-back | • Restricted EVAP canister<br>• High fuel temperature |

#### 8.4.2.1. Fuel and Evaporative Emission Pipe Warning

**Warning:**

To reduce the risk of fire and personal injury observe the following items:

- Replace all nylon fuel pipes that are nicked, scratched or damaged during installation, do not attempt to repair the sections of the nylon fuel pipes
- Do not hammer directly on the fuel harness body clips when installing new fuel pipes. Damage to the nylon pipes may result in a fuel leak.
- Always cover nylon vapor pipes with a wet towel before using a torch near them. Also, never expose the vehicle to temperatures higher than 115°C (239°F) for more than one hour, or more than 90°C (194°F) for any extended period.
- Apply a few drops of clean engine oil to the male pipe ends before connecting fuel pipe fittings. This will ensure proper reconnection and prevent a possible fuel leak. (During normal operation, the O-rings located in the female connector will swell and may prevent proper reconnection if not lubricated.)

#### 8.4.2.2. Clean, Dry, Low Pressure Gas Source Caution

**Caution**:

Use the Evaporative Emission (EVAP) System Tester GE 41413-A in order to provide a clean, dry, low pressure nitrogen gas source. Do not substitute any other pressurized source, gas or otherwise. Damage may result to the EVAP system, test equipment or cause a safety risk.

#### 8.4.2.3. Fuel and Evaporative Emission Hose/Pipe Connection Cleaning Caution

**Caution:**

Clean all of the following areas before performing any disconnections in order to avoid possible contamination in the system:

- The fuel pipe connections
- The hose connections
- The areas surrounding the connections

## 8.4.2.4. Fuel System Diagnosis

### 8.4.2.4.1. Diagnostic Instructions

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

### 8.4.2.4.2. Circuit/System Description

The engine control module (ECM) supplies voltage to the chassis control module when the ECM detects that the ignition is ON. The voltage from the ECM to the chassis control module remains active for 2 s, unless the engine is in Crank or Run. While this voltage is being received, the chassis 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 return-less –on-demand design. A return-less 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.

### 8.4.2.4.3. Diagnostic Aids

Observe the Misfire Counters or perform the Fuel Injector Balance Test to help identify a leaking fuel injector.

### 8.4.2.4.4. Reference Information

**Description and Operation**

Fuel System Description

**Electrical Information Reference**

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

**Scan Tool Reference**

Control Module References for scan tool information

**Special Tools**

CH 48027 Digital Pressure Gauge
EN 37287 Fuel Line Shutoff Adapter

### 8.4.2.4.5. Circuit/System Verification

| Note: |
| --- |
| • Repair all fuel system related DTCs, except P2635, before performing this diagnostic.<br>• Inspect the fuel system for damage or external leaks before proceeding.<br>• Verify that adequate fuel is in the fuel tank before proceeding.<br>• The Fuel Pump Enable may need to be commanded On a few times in order to obtain the highest possible fuel pressure.<br>• 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.
9. Verify the Chassis Control Module Fuel Pressure Sensor parameter is between 300–400 kPa (43–58 psi).

**⇒ If less than 300 kPa (43 psi)**
Refer to Circuit/System Testing Fuel Pressure Low.

**⇒ If greater than 400 kPa (58 psi)**
Replace the G12 Fuel Pump.

**⇓ If between 300–400 kPa (43–58 psi)**

10. Verify the scan tool Short Term Fuel Pump Trim and the Long Term Fuel Pump Trim when multiplied together are less than 1.5.

**⇒ If greater than 1.5**
Refer to Circuit/System Testing Fuel Pressure Low.

**⇓ If less than 1.5**

11. Verify the scan tool Fuel Pressure Sensor and the Desired Fuel Pressure are within 45 kPa (6.5 psi) at 300 kPa (43.5 psi) request or 60 kPa (8.7 psi) at 400 kPa (58 psi) request of each other while operating the vehicle through varying loads.

**⇒ If greater than 45 kPa (6.5 psi)/60 kPa (8.7 psi)**
Refer to Circuit/System Testing Fuel Pressure Drops Off.

**⇓ If less than 45 kPa (6.5 psi)/60 kPa (8.7 psi)**

12. If the fuel system components test normal, refer to Symptoms Engine Controls and Fuel Injector Diagnosis.

#### 8.4.2.4.6. 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 no conditions exist**
Replace the G12 Fuel Pump.

**Fuel Pressure Leaks Down**

1. Ignition OFF, relieve the fuel pressure. Refer to Fuel Pressure Relief.
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 no conditions exist**
Replace the G12 Fuel Pump.

**8.4.2.4.7. Repair Instructions**

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

- Fuel Feed Pipe Replacement
- Fuel Injector Replacement
- Fuel Tank Fuel Pump Module Replacement

### 8.4.2.5. Alcohol/Contaminants in Fuel Diagnosis

#### 8.4.2.5.1. Diagnostic Instructions

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

#### 8.4.2.5.2. 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.

#### 8.4.2.5.3. Reference Information

**Special Tool**

CH 44175A Fuel Composition Tester, if available

#### 8.4.2.5.4. 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.

#### 8.4.2.5.5. Alcohol in Fuel Testing with Special Tool, If Available

1. Test the fuel composition using the CH 44175A 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.

#### 8.4.2.5.6. 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. Reinstall 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.

#### 8.4.2.5.7. 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.

#### 8.4.2.5.8. Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.

- Fuel System Cleaning
- Fuel Tank Draining

### 8.4.2.6. Fuel Injector Diagnosis

#### 8.4.2.6.1. Diagnostic Instructions

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

#### 8.4.2.6.2. 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.

#### 8.4.2.6.3. 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.

#### 8.4.2.6.4. Reference Information

**Schematic Reference**

Engine Controls Schematics

**Connector End View Reference**

Component Connector End Views

**Description and Operation**

Fuel System Description

**Electrical Information Reference**

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

**Special Tools**

CH 48027 Digital Pressure Gauge

EL 39021 Fuel Injector Coil and Balance Tester

#### 8.4.2.6.5. 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.

#### 8.4.2.6.6. 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.<br>• Verify that adequate fuel is in the fuel tank before proceeding with this diagnostic.<br>• Before proceeding with this test review the User Manual CH 480275 for Safety Information and Instructions. |

1. Verify the correct fuel system pressure. Refer to Fuel System Diagnosis.
2. Set the amperage supply selector switch on the fuel injector tester to the Balance Test 0.5–2.5 A position.
3. Connect the EL 39021 fuel injector coil and balance tester to a Q17 Fuel Injector.
4. Command the Fuel Pump Enable On and then Off three times with a scan tool. On the last command, as the fuel pressure begins to slowly degrade and stabilize, select a fuel pressure within 34 kPa (5 psi) of the maximum pump pressure. Record this fuel pressure. This is the starting pressure at which you will pulse each injector.
5. Command the Fuel Pump Enable On one more time and energize the fuel injector by depressing the Push to Start Test button on the EL 39021 fuel injector coil and balance tester at the previously selected pressure.
6. After the injector stops pulsing, select Min from the Display Mode on the CH 48027 gauge and record the Min pressure.

| **Note:** |
|---|
| New test results will not be recorded if the Min/Max results are not cleared after each injector is tested. |

7. Clear the Min/Max results on the CH 48027 gauge.
8. Select Normal from the Display Mode on the CH 48027 gauge.
9. Repeat steps 3 and 5 through 8 for each fuel injector.
10. Subtract the minimum pressure from the starting pressure for one fuel injector. The result is the pressure drop value.
11. Obtain a pressure drop value for each fuel injector.
12. Add all of the individual pressure drop values except for the injector suspected of being faulty. This is the total pressure drop.
13. Divide the total pressure drop by the number of fuel injectors that were added together. This is the average pressure drop. The difference between any individual pressure drop and the average pressure drop should not be more than 20 kPa (3 psi).
    ⇒ If the difference between any individual pressure drop and the average pressure drop is more than 20 kPa (3 psi), replace the Q17 Fuel Injector.

#### 8.4.2.6.7. Fuel Injector Balance Test with Scan Tool

1. Verify the correct fuel system pressure. Refer to Fuel System Diagnosis.
2. Command the Fuel Pump Enable On and then Off three times with a scan tool. On the last command, as the fuel pressure begins to slowly degrade and stabilize, select a fuel pressure within 34 kPa (5 psi) of the maximum pump pressure. Record this fuel pressure. This is the starting pressure at which you will pulse each injector.
3. With a scan tool, select the Fuel Injector Balance Test function within the Special Functions menu.
4. Select an injector to be tested.
5. Press Enter to prime the fuel system.
6. Energize the fuel injector by depressing the Pulse Injector button on the scan tool at the previously selected pressure.
7. After the injector stops pulsing, select Min from the Display Mode on the CH 48027 gauge and record the Min pressure.

| Note: |
| --- |
| New test results will not be recorded if the Min/Max results are not cleared after each injector is tested. |

8. Clear the Min/Max results on the CH 48027 gauge.
9. Select Normal from the Display Mode on the CH 48027 gauge.
10. Press Enter on the scan tool to bring you back to the Select Injector screen.
11. Repeat steps 4 through 10 for each fuel injector.
12. Subtract the minimum pressure from the starting pressure for one fuel injector. The result is the pressure drop value.
13. Obtain a pressure drop value for each fuel injector.
14. Add all of the individual pressure drop values except for the injector suspected of being faulty. This is the total pressure drop.
15. Divide the total pressure drop by the number of fuel injectors that were added together. This is the average pressure drop. The difference between any individual pressure drop and the average pressure drop should not be more than 20 kPa (3 psi).

⇒ If the difference between any individual pressure drop and the average pressure drop is more than 20 kPa (3 psi), replace the Q17 Fuel Injector.

#### 8.4.2.6.8. Repair Instructions

Perform the Diagnostic Repair Verification after completing the diagnostic procedure.
Fuel Injector Replacement

### 8.4.2.7. Evaporative Emission Control System Diagnosis

Special Tools
EN 41413VLV
EVAP Service Port Vent Fitting

#### 8.4.2.7.1. Operating Instructions for the Evaporative Emission System Tester

Vehicle Setup

| **Warning:** |
|---|
| Refer to Fuel and Evaporative Emission Pipe Warning. |

| **Caution:** |
|---|
| Refer to Clean, Dry, Low Pressure Gas Source Caution. |

| **Note:** |
|---|
| When servicing the evaporative emission (EVAP) system, test pressure must not exceed 13 in H20 (0.5 PSI) as pressure in excess of this could cause system components to perform inaccurately. |

| **Note:** |
|---|
| A large difference between the vehicle temperature and shop temperature will seriously affect the accuracy of the tests. Always allow at least 15 min for the vehicle temperature to adjust to the shop temperature. Refer to Temperature Variation Instructions for more information about vehicle versus shop temperatures. |

1. Engine OFF, open the hood. Position a large fan to blow air under the vehicle onto the fuel tank area.
2. Connect the red battery clip from the tester to the positive battery terminal.

| **Note:** |
|---|
| The vehicle battery must be fully charged for optimum tester performance. |

3. Connect the black battery clip from the tester to chassis ground.

#### 8.4.2.7.2. Flow Meter Test – Leak Detection

| **Caution:** |
|---|
| Refer to Clean, Dry, Low Pressure Gas Source Caution. |

1. Open the Nitrogen tank valve and turn the NITROGEN / SMOKE valve on the front control panel to NITROGEN.
2. Connect the hose to the correct test orifice on the bottom front of the tester. For orifice size, refer to the vehicle specific information found in service procedures for DTCs that relate to EVAP system leaks.
3. Press and release the remote switch to activate the tester.

| **Note:** |
|---|
| The tester will time out after about 15 min. You may press the remote switch to reactivate the tester as desired. |

4. Position the sliding red flag on the flow meter to align with the floating indicator. When the red flag is set, press and release the remote switch to deactivate the tester.
5. Remove the hose from the test orifice and install the hose onto the vehicle. For proper connection location, and the special tool numbers for any adapters that may be required, refer to the service procedures for DTCs that relate to EVAP system leaks.

6. Ignition ON, seal the EVAP system per instructions in the service procedures for DTCs that relate to EVAP system leaks. Most systems can be sealed using a scan tool output control for the EVAP Vent Solenoid Valve, other systems require that the vent system be plugged.

| Note: |
|---|
| • Larger volume fuel tanks, and/or those with lower fuel levels, may require several minutes to fill with nitrogen.<br>• Static buildup may cause the float indicator to stick. It may be necessary to tap on the flow meter to free up the float.<br>• If fuel level is 90% or greater it will take longer to fill the system with smoke because the fuel fill tube check valve will be closed and force any smoke to pass through the on-board refueling vapor recovery pipe and orifice. |

7. Press and release the remote switch to activate the nitrogen flow and fill the system.
8. Verify the stable floating indicator position to the red flag.
**⇒ Above the red flag, result is unacceptable – fail**
Go to the Smoke Procedure
**⇓ Below the red flag – pass. Test complete**
9. Press and release the remote switch to deactivate the tester.

#### 8.4.2.7.3. Smoke Procedure – Locate the Leak

| Note: |
|---|
| It is not recommended to use the tester in an outside repair bay area because wind and sunlight may affect temperature and your ability to see the smoke. |

1. Turn OFF any fans that may cause air movement around or near the vehicle.

| Note: |
|---|
| Completely unwind the nitrogen/smoke hose from the bracket to optimize the tester's performance. |

2. Connect the nitrogen/smoke hose to the vehicle as directed in the service procedures. Some vehicles require that the nitrogen/smoke hose be connected at the front of the EVAP system at the EVAP service port. An adapter may be necessary. Other vehicles require the connection be made at the rear of the system using an adapter at the fuel fill cap or capless fuel fill. Consult the service procedures for DTCs that relate to EVAP system leaks for vehicle specific instructions regarding connection location and adapters.
3. Open the Nitrogen tank valve and turn the nitrogen/smoke valve on the control panel to smoke.

| Note: |
|---|
| The remote switch operates on a push ON, push OFF fashion. |

4. Press and release the remote switch to activate the tester and inject smoke into the EVAP system.
5. Verify smoke has filled the EVAP system by opening the system opposite the end where smoke is injected.

| Note: |
|---|
| • When injecting smoke at the service port, remove the fuel fill cap until smoke is observed. Then close the system and continue testing.<br>• If using a special tool fuel fill cap adapter at the filler neck, vent the system at the service port, with special tool EN 41413-VLV until smoke is observed then remove the vent fitting tool and close the system to continue with the test.<br>• Inject smoke in less than 2 min cycles for optimum tester performance. |

6. Press and release the remote switch to deactivate the tester.

| Note: |
|---|
| For optimum visual smoke performance, deactivate the smoke flow and allow the system pressure to drop. Allowing the smoke to exit small holes at a low flow rate greatly enhances visibility. |

7. Introduce smoke into the system for an additional 60 s. Continue introducing smoke at 15 s intervals, as necessary until leak source is identified.
8. Using a high-intensity white light, inspect the entire EVAP system path, and look for the source of the leak indicated by the exiting smoke.

**⇒ Smoke seen leaking**

Repair or replace the affected component.

**⇓ No smoke seen leaking**

9. All OK

#### 8.4.2.7.4. Temperature Variation Instructions

**The Concern**

Ideal circumstances for conducting the EVAP flow meter test require equal temperatures between the Nitrogen gas and the vehicle EVAP system. Significant differences in temperature between them can result in a flow or pressure change during testing, causing misleading results. Typically, the evaporative emission system tester is stored indoors, approximately 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 13 in. $H_2O$ (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.

### 8.4.3. Repair instructions

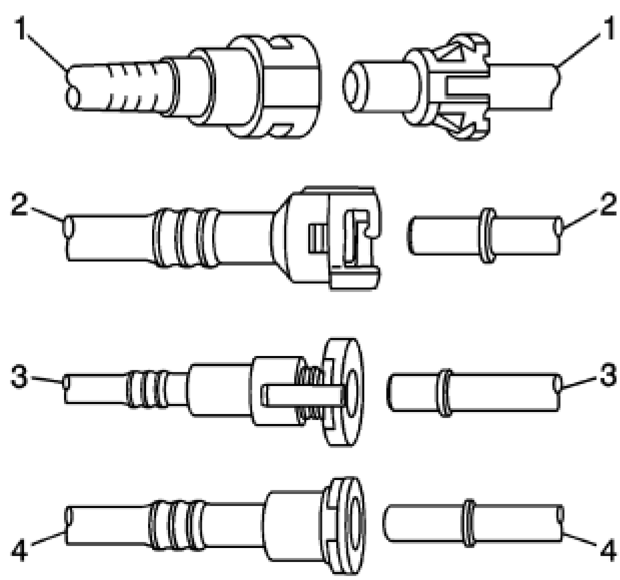
#### 8.4.3.1. Gasoline/Gasoline Vapors Warning

**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.

#### 8.4.3.2. Plastic Collar Quick Connect Fitting Service

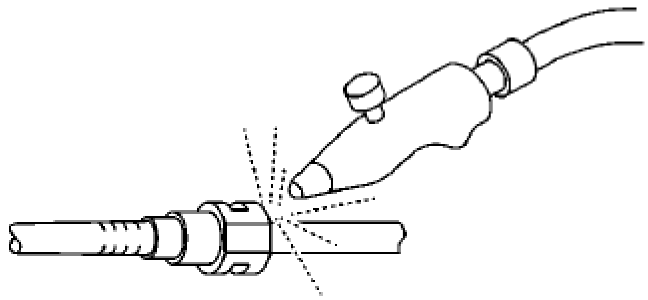
##### 8.4.3.2.1. Removal Procedure

| Warning: |
|---|
| Refer to Gasoline/Gasoline Vapors Warning. |

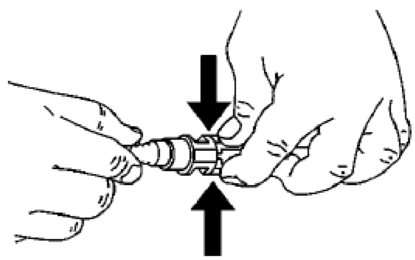



| Note: |
|---|
| There are several types of plastic collar fuel and evaporative emission quick connect fittings used on this vehicle.<br>• Bartholomew (1)<br>• Q Release (2)<br>• Squeeze to Release (3)<br>• Sliding Retainer (4) |

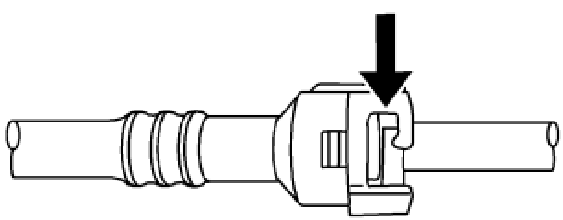
1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief



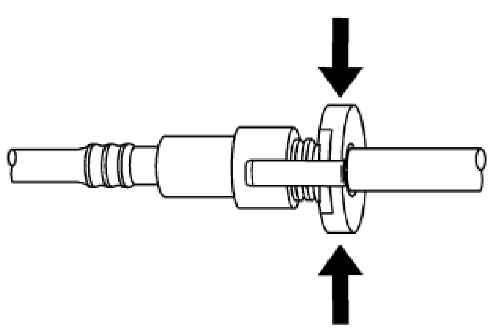
2. Using compressed air, blow any dirt out of the quick-connect fitting.



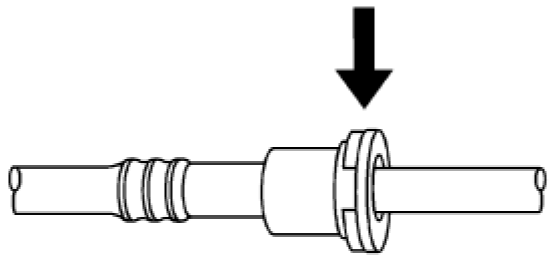
3. This step applies to Bartholomew style connectors ONLY. Squeeze the plastic quick connect fitting release tabs.



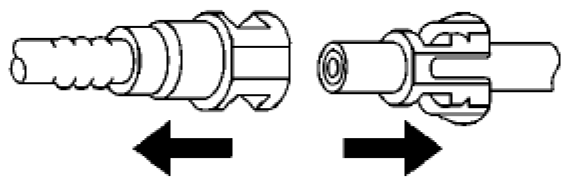
4. This step applies to Q Release style connectors ONLY. Release the fitting by pushing the tab toward the other side of the slot in the fitting.



5. This step applies to Squeeze to Release style connectors ONLY. Squeeze where indicated by arrows on both sides of the plastic ring surrounding the quick connect fitting.

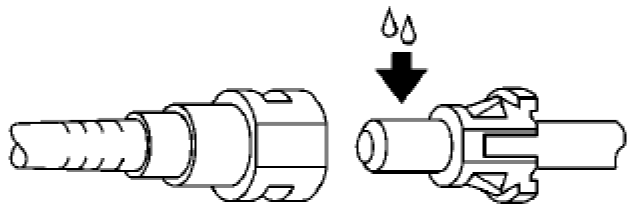


6. This step applies to Sliding Retainer style connectors ONLY. Release the fitting by pressing on one side of the release tab causing it to push in slightly. If the tab doesn't move try pressing the tab in from the opposite side. The tab will only move in one direction.

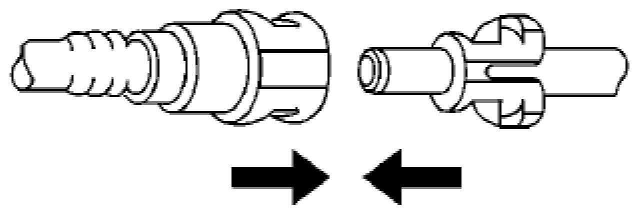


7. Pull the connection apart.

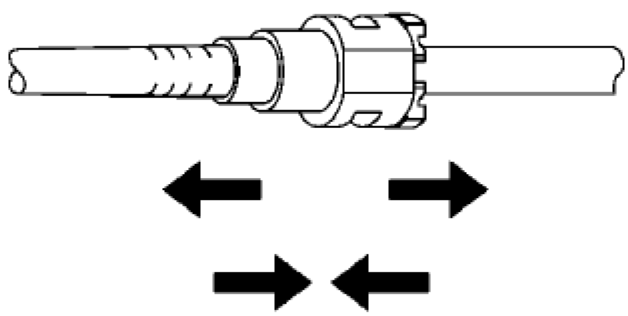
#### 8.4.3.2.2. Installation Procedure



1. Apply a few drops of clean engine oil to the male connection end.



2. Push both sides of the quick-connect fitting together in order to cause the retaining feature to snap into place.



3. Once installed, pull on both sides of the quick-connect fitting in order to make sure the connection is secure.

### 8.4.3.3. 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.
2. Remove the fuel pump module assembly. Refer to Fuel Tank Fuel Pump Module Replacement.
3. Inspect the fuel pump module strainer. Replace the pump module assembly if the fuel strainer is contaminated.

| Note: |
|---|
| When flushing the fuel tank, handle the fuel and water mixture as a hazardous material. Handle the fuel and water in accordance with all applicable local, state, and federal laws and regulations. |

4. Flush the fuel tank with hot water.
5. Pour the water out of the fuel sender assembly opening in the fuel tank. Rock the fuel tank in order to be sure that the removal of the water from the fuel tank is complete.
6. Allow the tank to dry completely before reassembly.
7. Disconnect the fuel feed pipe at the engine fuel rail. Refer to Plastic Collar Quick Connect Fitting Service.

| Note: |
|---|
| Only use oil-free compressed air to blow out the fuel pipes. |

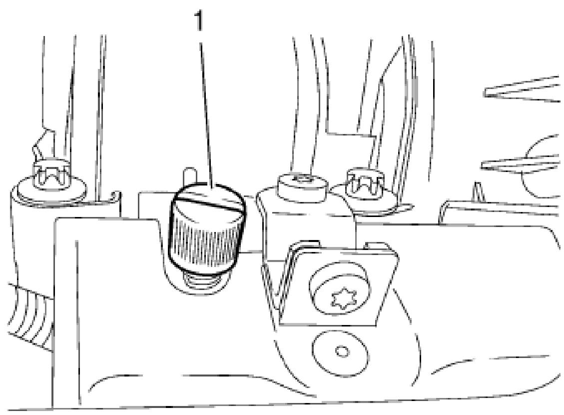
8. Clean the fuel pipes by applying air pressure in the opposite direction of the fuel flow.
9. Connect the fuel feed pipe to the engine fuel rail. Refer to Plastic Collar Quick Connect Fitting Service.
10. Install the fuel pump module assembly. Refer to Fuel Tank Fuel Pump Module Replacement.

### 8.4.3.4. Fuel Pressure Relief

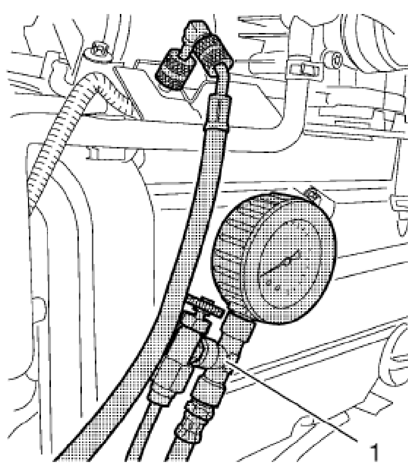
**Special Tools**
EN-34730-91 Pressure Tester

| **Warning:** |
|---|
| Gasoline or gasoline vapors are highly flammable. A fire could occur if an ignition source is present. Never drain or store gasoline or diesel fuel in an open container, due to the possibility of fire or explosion. Have a dry chemical (Class B) fire extinguisher nearby. |

| **Warning:** |
|---|
| Relieve the fuel system pressure before servicing fuel system components in order to reduce the risk of fire and personal injury.<br>After relieving the system pressure, a small amount of fuel may be released when servicing the fuel lines or connections. In order to reduce the chance of personal injury, cover the regulator and the fuel line fittings with a shop towel before disconnecting. This will catch any fuel that may leak out. Place the towel in an approved container when the disconnection is complete. |




1. Remove the fuel injector rail cap (1).




2. Relieve the fuel pressure. Use EN-34730-91 pressure tester (1).

#### 8.4.3.5. Fuel Tank Draining

| Warning: |
| --- |
| Refer to Gasoline/Gasoline Vapors Warning. |

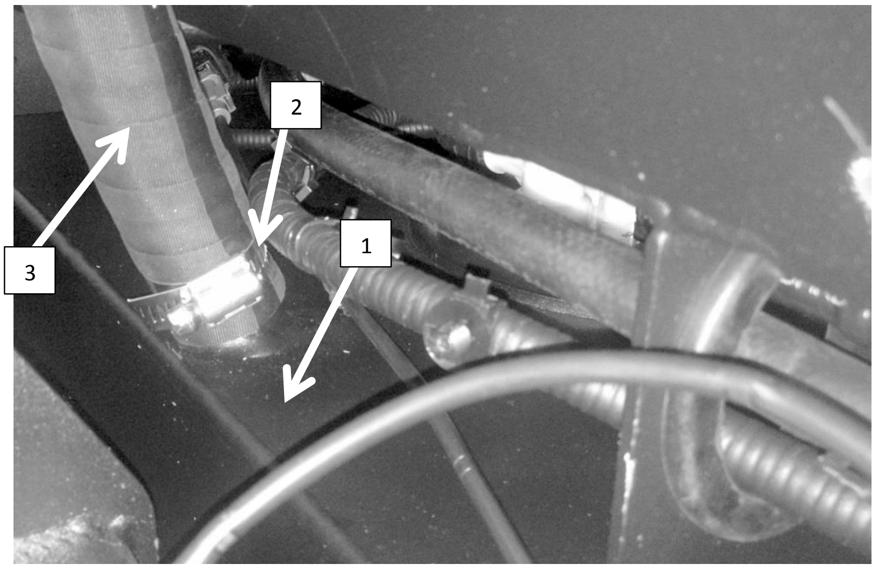
| Note: |
| --- |
| The fuel tank must be drained with a suitable, commercially-available fuel removal unit and suction hose follow safety regulations and national legislation. In the presence of fuel vapors or escaping fuel observe safety regulations and national legislation. Store drained fuel in a suitable, sealable container. |

1. Disconnect the negative battery cable. Refer to Battery Negative Cable Disconnection and Connection.
2. Remove the fuel tank filler cap.
3. Insert a suitable suction hose into the fuel tank filler pipe.
4. Attach a suitable suction hose to the hose used with the hand or air operated pump devise.
5. Using a hand or air operated pump drain as much fuel from the tank as possible.

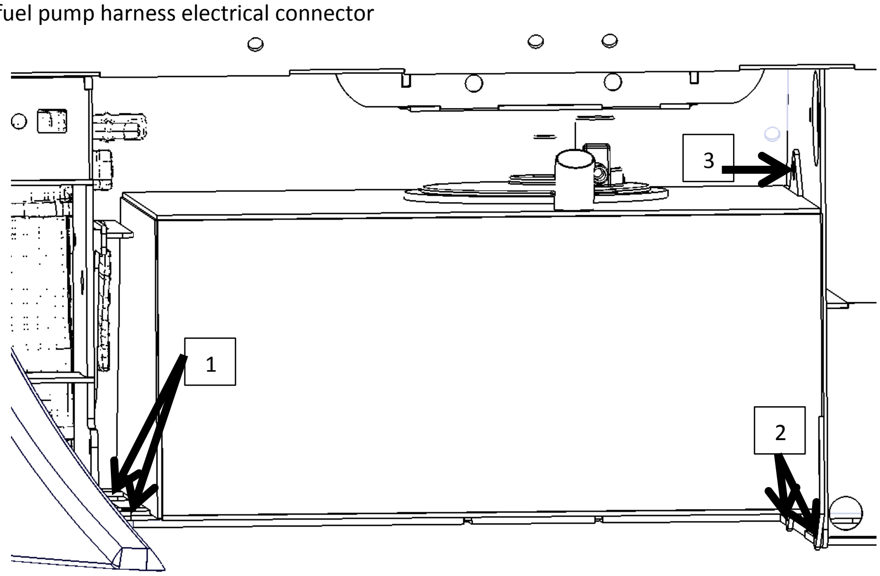
### 8.4.3.6. Fuel Tank Replacement

#### 8.4.3.6.1. Removal Procedure

1. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
2. Relieve the fuel pressure. Refer to Fuel Pressure Relief.
3. Drain the fuel Tank. Refer to Fuel Tank Draining.
4. Lift and support the vehicle. Refer to Lifting and Jacking the Vehicle.
5. Remove the Rear Trailing Arm
6. Remove the Splash Guard, Refer to Splash Guard in Body Repair




7. Loosen the hose clamps (2) and slide the filler hose (3) off the fuel tank. (1)
8. Disconnect the vent hose from the Fuel Pump
9. Disconnect the vent line from the fuel pump to the evaporative emission canister
10. Disconnect the fuel pump harness electrical connector

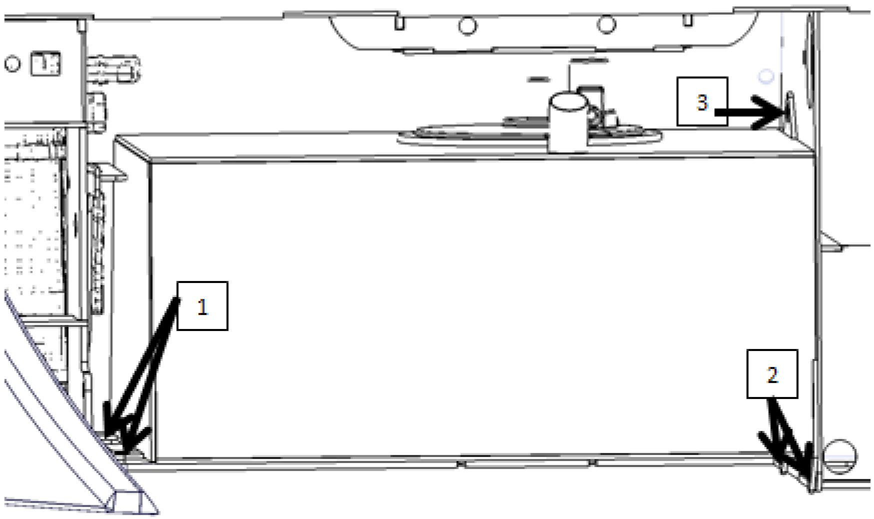



11. Remove the two bolts from under the left side of the fuel tank (1)
12. Remove the two bolts from under the right side of the fuel tank(2)
13. Remove the single upper bolt on the right side center of the fuel tank(3)

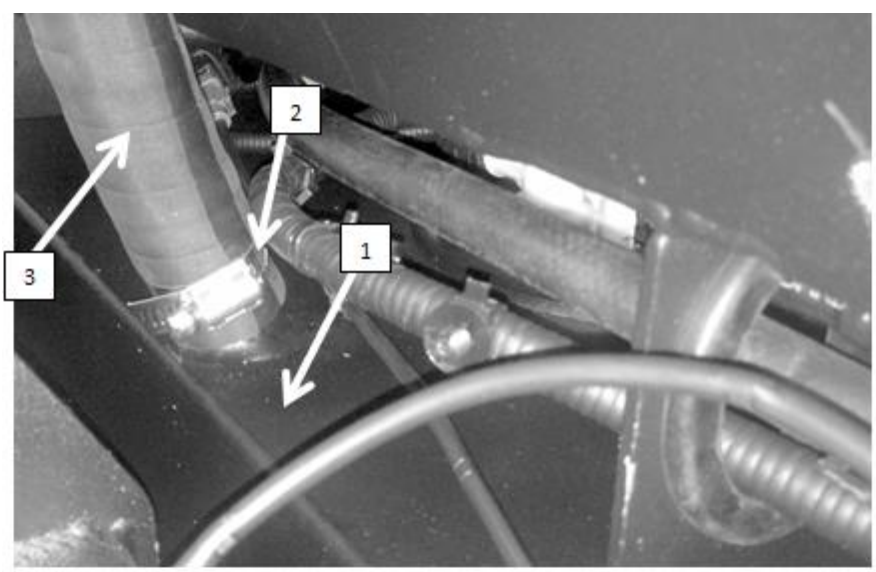
14. Remove fuel tank
15. Transfer parts as necessary

**8.4.3.6.2. Installation Procedure**

1. Slide the fuel tank in to the chassis




2. Install the single upper bolt on the right side center of the fuel tank (3) and tighten to 22 Nm (16 lb ft).
3. Install the 4 bolts on the underside of the fuel tank (1,2) and tighten to 22 Nm (16 lb ft).
4. Connect the vent line from the fuel pump to the evaporative emission canister and tighten clamp
5. Connect the vent hose from the Fuel Pump and tighten the clamp

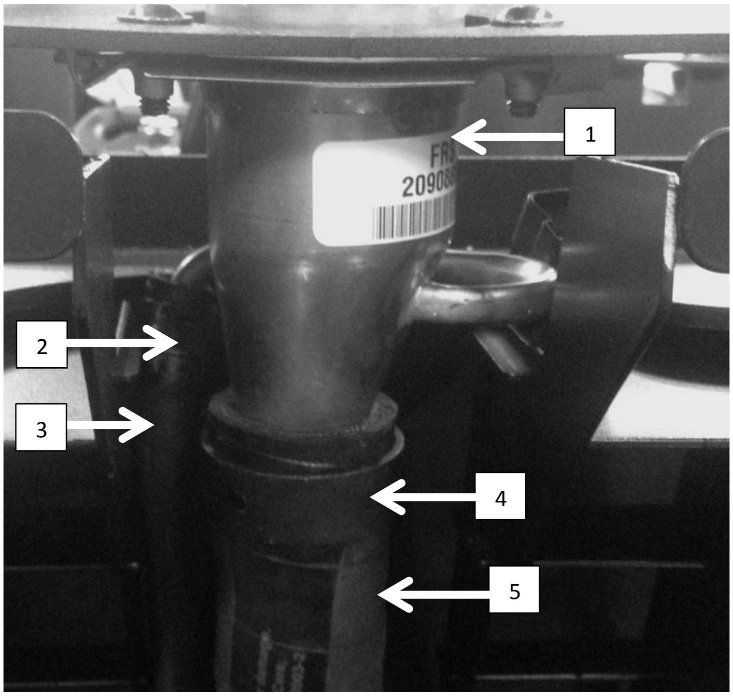



6. Slide the fill hose (3) over the fill port of the fill tank (1) and tighten hose clamp (2)
7. Install the Splash Guard, Refer to Splash Guard in body Repair
8. Install the Rear Trailing Arm
9. Lower the vehicle
10. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

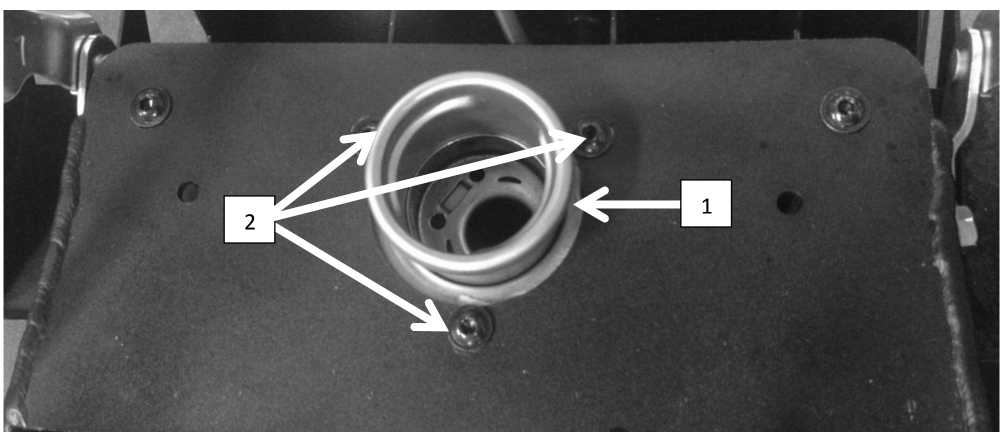
### 8.4.3.7. Fuel Tank Filler

#### 8.4.3.7.1. Removal Procedure

1. Remove the Splash Guard, Refer to Splash Guard in Body Repair

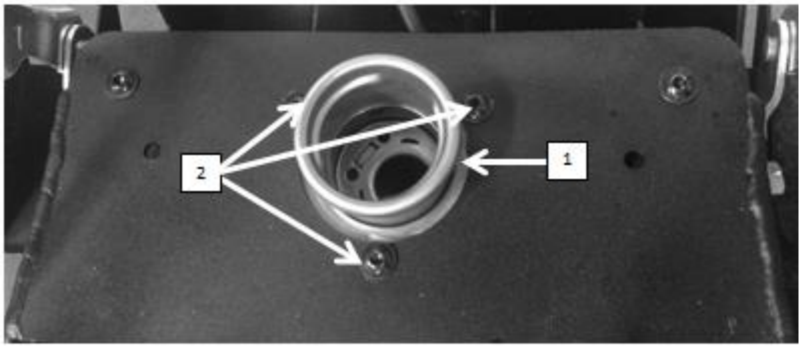



2. Loosen the Hose Clamp (2) on the Vent Tube (3)
3. Remove the Vent Tube (3) from the Fuel Tank Filler (1)
4. Loosen the Hose Clamp (4) on the Fuel Fill Tube (5)
5. Remove the Fuel Fill Tube (5) from the Fuel Tank Filler (1)
6. Open Trunk
7. Remove Trunk Liner

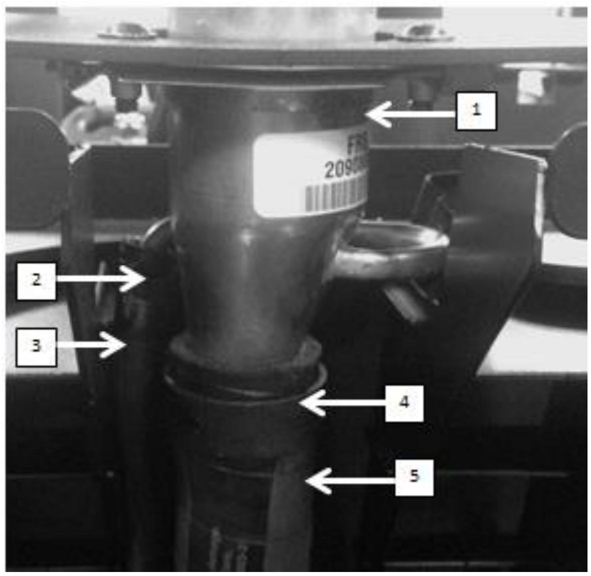



8. Remove the 3 bolts (2) around the parameter of the Fuel Tank Filler (1)
9. Remove the Fuel Tank Filler

#### 8.4.3.7.2. Installation Procedure




1. Insert the Fuel Tank Filler (1) in to the chassis and tighten the 3 bolts to 3.5 Nm( 30 in lb)

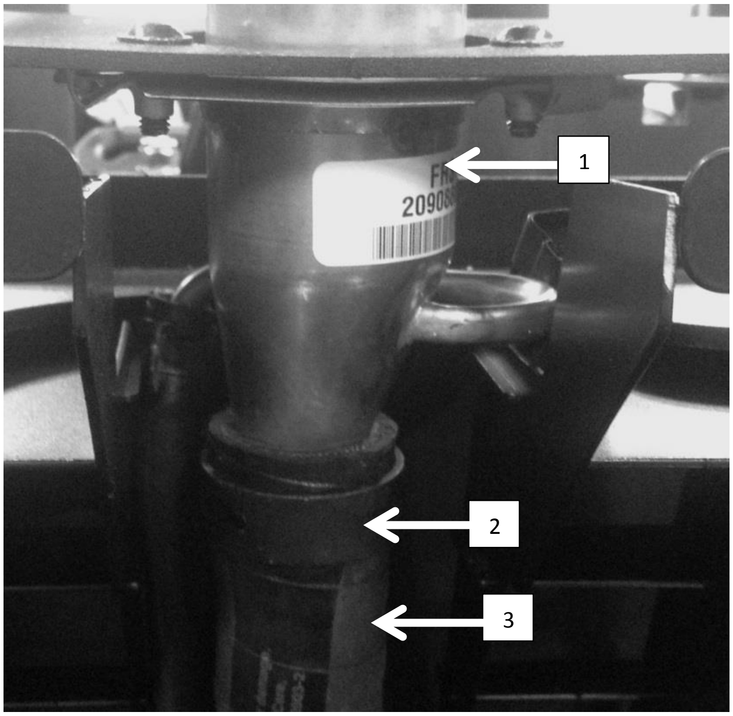



2. Slide the Fuel Fill Hose (5) over the Fuel Tank Filler (1) and tighten the hose Clamp (4)
3. Slide the Vent Tube (3) over the Fuel Tank Filler (1) and tighten hose clamp
4. Install the Trunk Liner
5. Install the third brake light

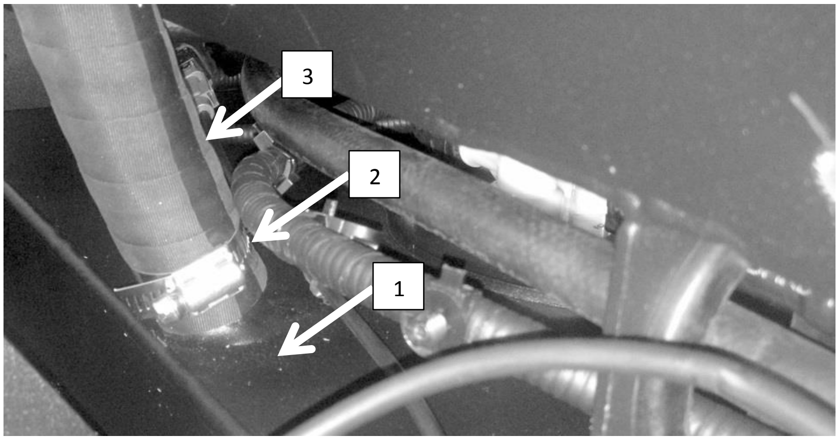
### 8.4.3.8. Fuel Fill Hose

#### 8.4.3.8.1. Removal Procedure

1. Remove the Splash Guard, Refer to Splash Guard in Body Repair
2. Remove the Fuel Hose mounting bracket from the chassis

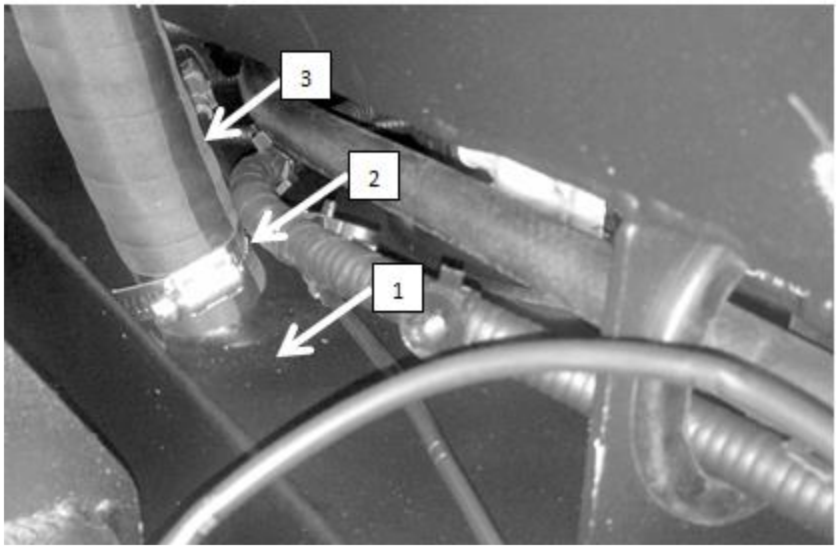



3. Loosen the Hose Clamp (2) on the Fuel Fill Tube (3)
4. Remove the Fuel Fill Tube (3) from the Fuel Tank Filler (1)

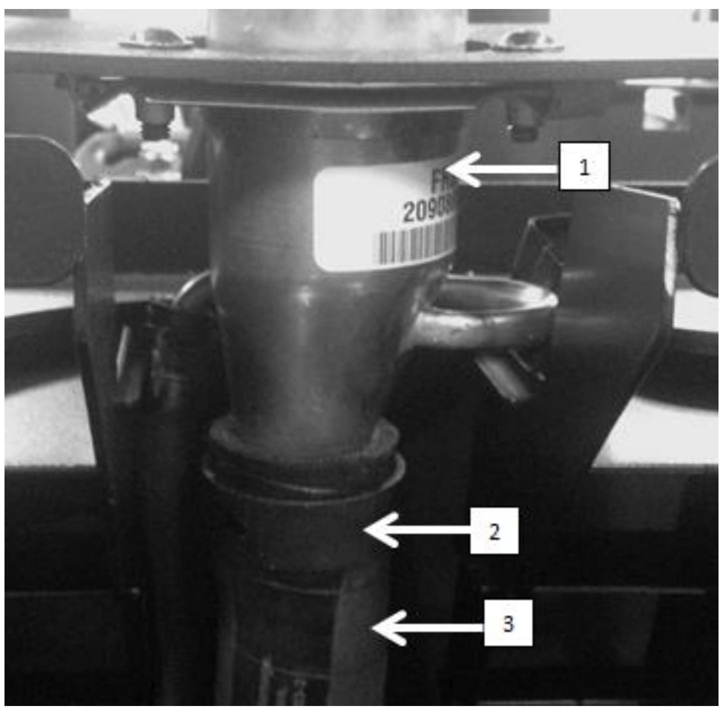



5. Loosen the Hose Clamp (2) on the Fuel Fill Tube (3)
6. Remove the Fuel Fill Tube (3) from the Fuel Tank (1)
7. Remove the Fuel Fill Tube

**8.4.3.8.2. Installation Procedure**




1. Slide the fill hose (3) over the fill port of the fill tank (1) and tighten hose clamp (2)
2. Install the fuel hose mounting bracket

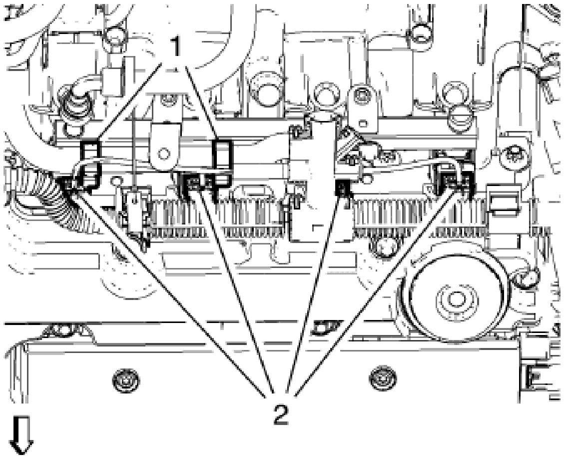



3. Slide the Fuel Fill Hose (3) over the Fuel Tank Filler (1) and tighten the hose Clamp (4)
4. Install the Splash Guard, Refer to Splash Guard in Body Repair

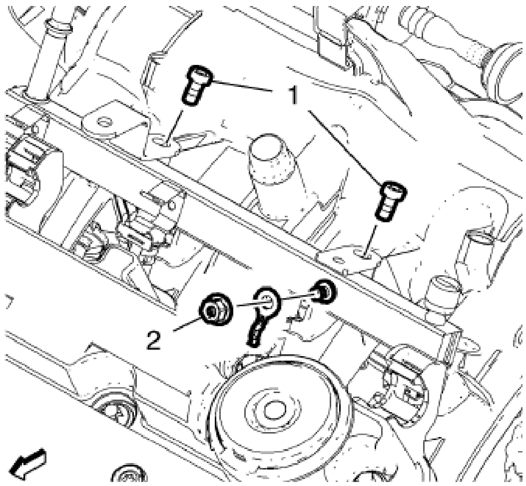
### 8.4.3.9. Fuel Injection Fuel Rail Assembly Replacement

#### 8.4.3.9.1. Removal Procedure

1. Disconnect battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
2. Remove the fuel feed pipe from fuel injection fuel rail. Refer to Fuel Feed Pipe Replacement.
3. Remove the positive crankcase ventilation pipe from the intake manifold. Refer to Positive Crankcase Ventilation Pipe Removal.

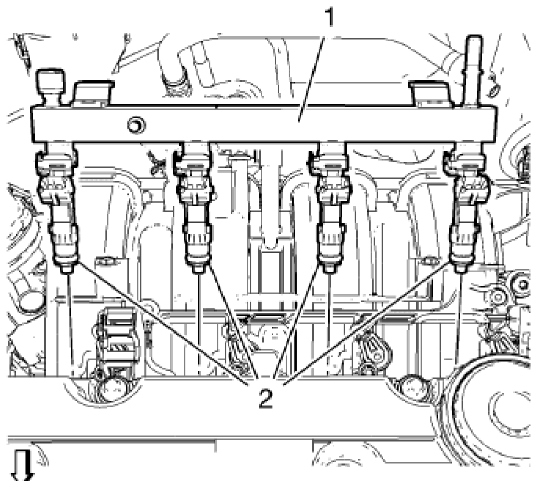



4. Disconnect the 4 fuel injector wiring harness plugs (2).
5. Unclip the ECM wiring harness from retainer clips (1) and the camshaft cover.



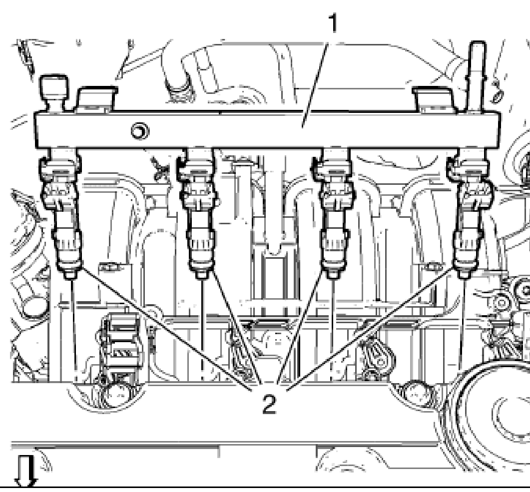

6. Remove the ground cable nut (2) and the ground cable.

8. Remove the 2 fuel injection fuel rail bolts (1).



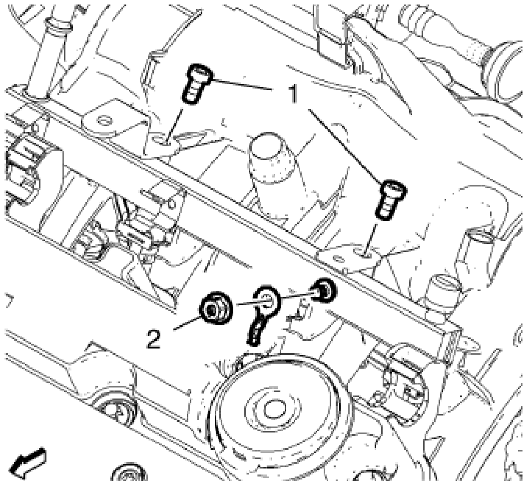

9. Remove the fuel injection fuel rail assembly (1) and the 4 fuel injector seal rings (2).

#### 8.4.3.9.2. Installation Procedure



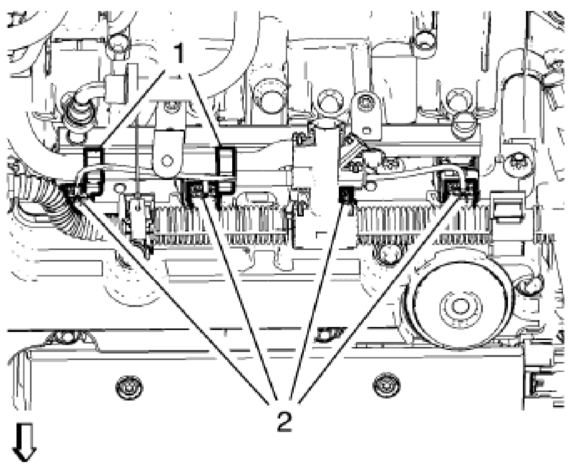

| **Note:** |
| --- |
| Lubricate the 4 fuel injector seal rings (2) with clean engine oil. |

1. Install the fuel injection fuel rail assembly (1) to the intake manifold. Use NEW fuel injector seal rings (2).



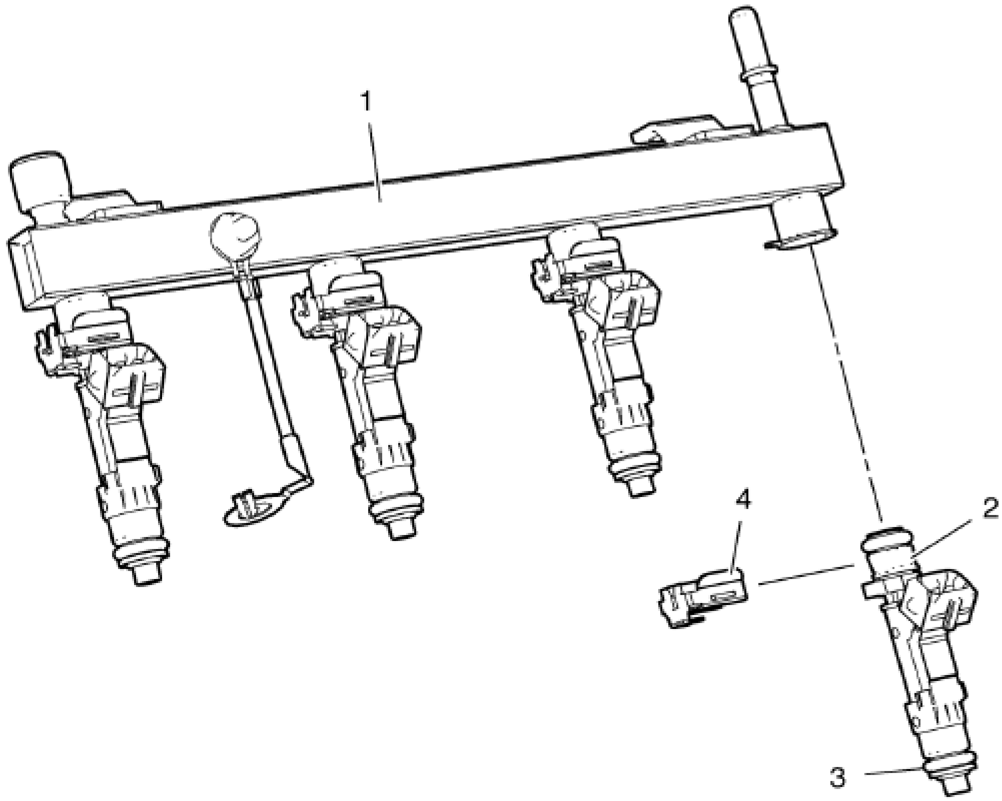

| Caution: |
|---|
| Refer to Fastener Caution. |

2. Install the 2 fuel injection fuel rail bolts (1) and tighten to 7 Nm (62 lb in).
3. Install the ground cable and the ground cable nut (2) and tighten.




4. Connect the 4 fuel injector wiring harness plugs (2).
5. Clip the ECM wiring harness to the retainer clip (1) and the camshaft cover.
6. Remove the positive crankcase ventilation pipe from the intake manifold. Refer to Positive Crankcase Ventilation Pipe Removal.
7. Install the fuel feed pipe to the fuel injection fuel rail. Refer to Fuel Feed Pipe Replacement.
8. Install the Mid Engine Cover
9. Connect battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

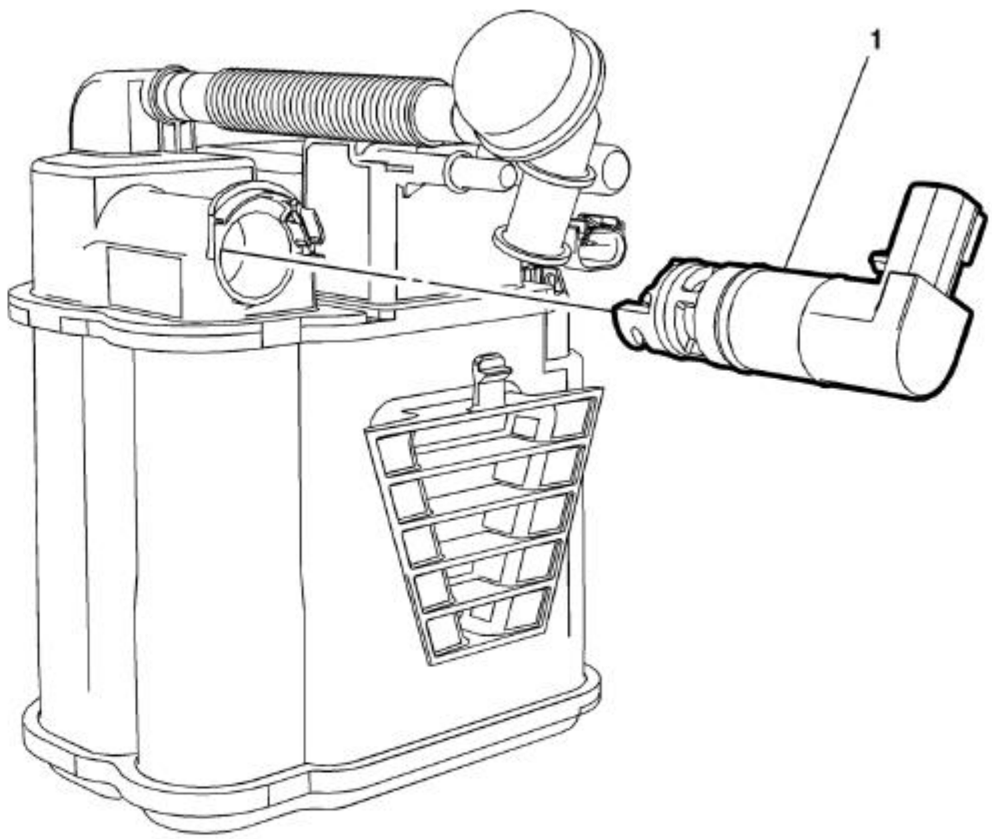
### 8.4.3.10. Fuel Injector Replacement




**Fuel Injector Replacement**

| Callout | Component Name |
|---|---|
| **Preliminary Procedure**<br>1. Disconnect battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.<br>2. Remove the fuel injection fuel rail assembly. Refer to Fuel Injection Fuel Rail Assembly Replacement. | |
| 1 | Fuel Rail |
| 2 | Fuel Injector |
| 3 | Fuel Injector Seal Ring<br>**Note:** Lubricate the NEW fuel injector O-ring seals with clean engine oil. |
| 4 | Fuel Injector Retainer Clamp |

### 8.4.3.11. Evaporative Emission Canister Vent Solenoid Valve Replacement




**Evaporative Emission Canister Vent Solenoid Valve Replacement**

| Callout | Component Name |
|---|---|
| **Preliminary Procedures**<br>1. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.<br>2. Remove the evaporative emissions canister. Refer to Evaporative Emission Canister Replacement. | |
| 1 | Evaporative Emissions Canister Vent Solenoid Valve<br>**Procedure**<br>Turn the evaporative emission canister vent solenoid valve counter clockwise 45 degrees and remove the solenoid from the evaporative emissions canister. |

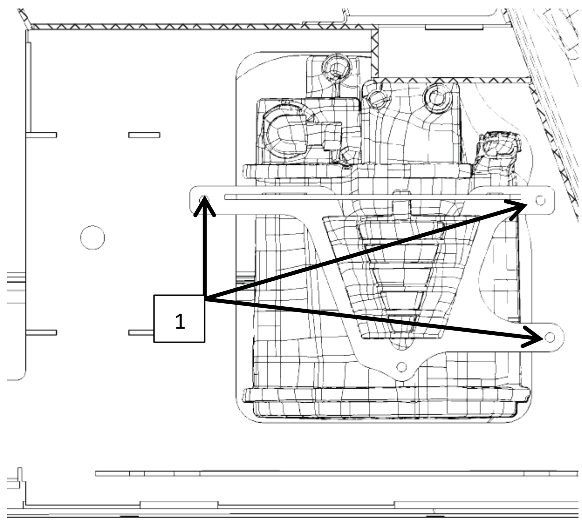
## 8.4.3.12. Evaporative Emission Canister Replacement.

### 8.4.3.12.1.Removal Procedure

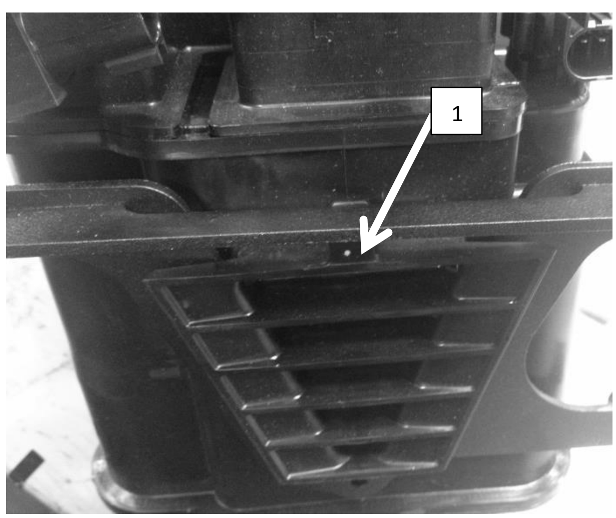
1. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle.
2. Remove the Fuel Tank. Refer to Fuel Tank Replacement
3. Disconnect both electrical harnesses from the Evaporative Emission Canister

| Warning: |
| --- |
| Do not breathe the air through the EVAP component tubes or hoses. The fuel vapors inside the EVAP components may cause personal injury. |

4. Disconnect Evaporative Emission Purge line from the Evaporative Emission Canister



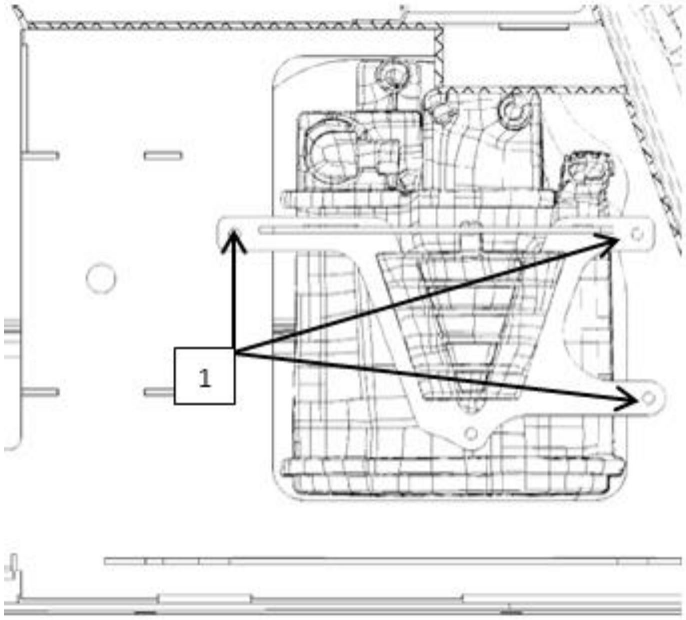

5. Remove the three bolts (1) securing the Evaporative Emission Canister Bracket from the chassis




6. Depress the tab (1) on the Evaporative Emission Canister, and slide the bracket off

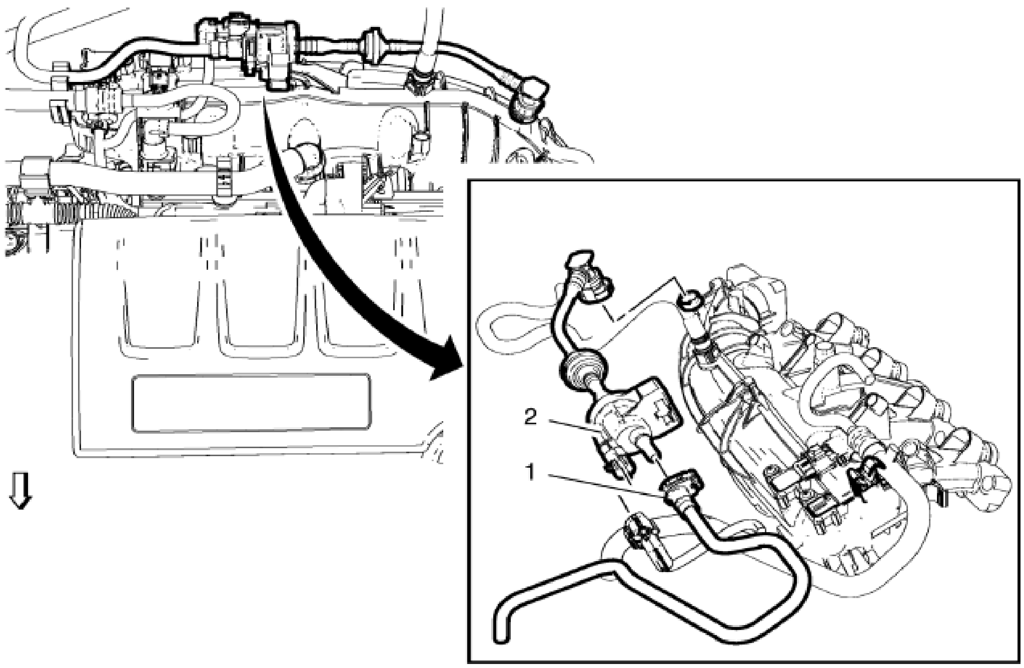
**8.4.3.12.2.Installation Procedure**

1. Slide the Evaporative Emission Canister on to the bracket




2. Place the Evaporative Emission Canister in to the chassis and tighten the three bolts (1) to 22 Nm (16 lb ft).
3. Connect the Evaporative Emission Purge line to the Evaporative Emission Canister
4. Connect both the electrical harnesses to the Evaporative Emission Canister
5. Install the Fuel Tank Refer to Fuel Tank Replacement

### 8.4.3.13. Evaporative Emission Canister Purge Solenoid Valve Replacement




**Evaporative Emission Canister Purge Solenoid Valve Replacement**

<table>
<tr><th>Callout</th><th>Component Name</th></tr>
<tr><td colspan="2">Warning:<br>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.<br><br>Preliminary Procedure<br>Disconnect battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.</td></tr>
<tr><td>1</td><td>Fuel Ventilation Pipe</td></tr>
<tr><td>2</td><td>Evaporative Emission Canister Purge Solenoid Valve<br>Procedure<br>Disconnect the electrical connector.</td></tr>
</table>

### 8.4.3.14. Fuel Feed Pipe Replacement

#### 8.4.3.14.1. Removal Procedure

| Warning: |
|---|
| Refer to Gasoline/Gasoline Vapors Warning. |

1. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
2. Lift and Support the Vehicle, Refer to Lifting the vehicle
3. Relief the fuel pressure. Refer to Fuel Pressure Relief.
4. Remove the Right Rocker, Refer to Rocker
5. Remove the Right Rear Grill, Refer to Rear Grill
6. Cut the zip ties holding the Fuel Feed Pipe to the chassis
7. Remove Zip tie Holders from chassis
8. Disconnect the fuel feed pipe connector (1) from the fuel injector rail feed pipe(2)
9. Disconnect the fuel tank feed pipe connector (1) from fuel feed pipe.
10. Disconnect the Fuel Pressure sensor wire harness
11. Remove the Fuel Feed Pipe
12. Transfer over parts as necessary

#### 8.4.3.14.2. Installation Procedure

1. Insert the Fuel Feed Pipe in to the chassis
2. Insert new push mount Zip Ties in to the chassis
3. Tighten Zip Ties around Fuel Lines and Brake Lines
4. Connect the fuel tank feed pipe connector (1) to the fuel feed pipe.
5. Connect the fuel feed pipe connector (1) to the fuel injector rail feed pipe(2)
6. Connect The Fuel pressure sensor wire harness
7. Install the Right Rear Grill, Refer to Rear Grill
8. Install the Right Rocker, Refer to Rocker
9. Lower the Vehicle
10. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

## 8.4.3.15. Evaporative Emission Feed Pipe Replacement

### 8.4.3.15.1. Removal Procedure

| Warning: |
|---|
| Refer to Gasoline/Gasoline Vapors Warning. |

1. Disconnect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.
2. Lift and Support the Vehicle, Refer to Lifting the vehicle
3. Remove the Right Rocker, Refer to Rocker
4. Remove the Right Rear Grill, Refer to Rear Grill
5. Cut the zip ties holding the Evaporative Emission Feed Pipe to the chassis
6. Remove Zip tie Holders from chassis
7. Disconnect the Evaporative Emission Feed Pipe from the Evaporative Emission Canister Purge Solenoid Valve supply hose
8. Disconnect the Evaporative Emission Feed Pipe from the Evaporative Emission Canister
9. Remove the Evaporative Emission Feed Pipe
10. Transfer over parts as necessary

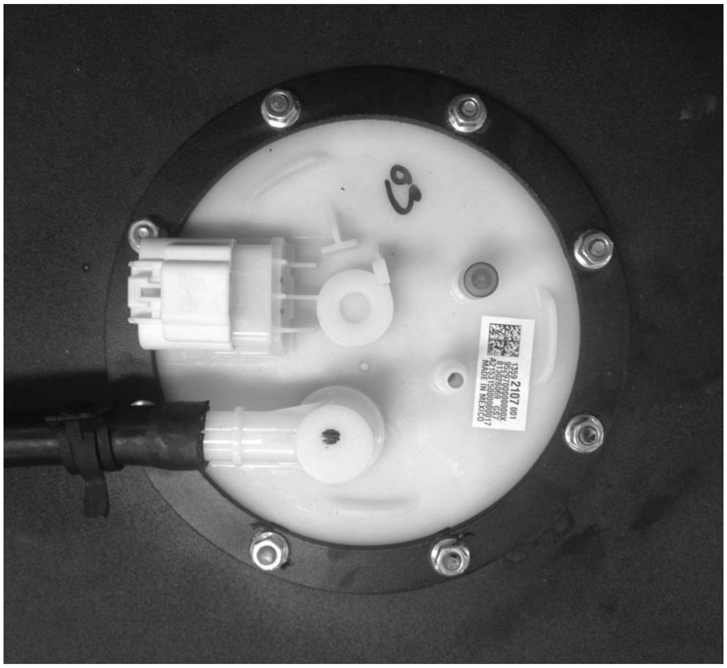
### 8.4.3.15.2. Installation Procedure

1. Insert the Fuel Feed Pipe in to the chassis
2. Insert new push mount Zip Ties in to the chassis
3. Tighten Zip Ties around Fuel Lines and Brake Lines
4. Connect the Evaporative Emission Feed Pipe to the Evaporative Emission Canister
5. Connect the Evaporative Emission Feed Pipe to the Evaporative Emission Canister Purge Solenoid Valve supply hose
6. Connect The Fuel pressure sensor wire harness
7. Install the Right Rear Grill, Refer to Rear Grill
8. Install the Right Rocker, Refer to Rocker
9. Lower the Vehicle
10. Connect the battery negative cable. Refer to Battery Negative Cable Disconnection and Connection.

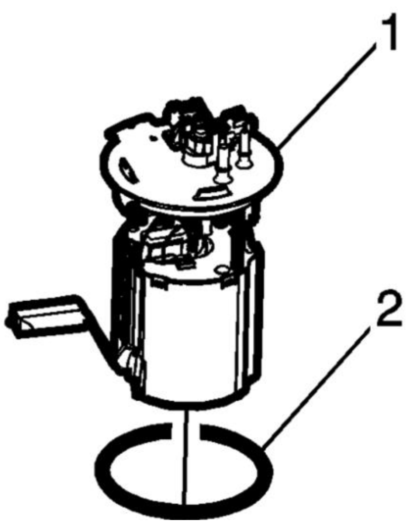
### 8.4.3.16. Fuel Tank Fuel Pump Module Replacement

#### 8.4.3.16.1. Removal Procedure

1. Relieve the fuel system pressure. Refer to Fuel Pressure Relief
2. Remove the fuel tank. Refer to Fuel Tank Replacement.



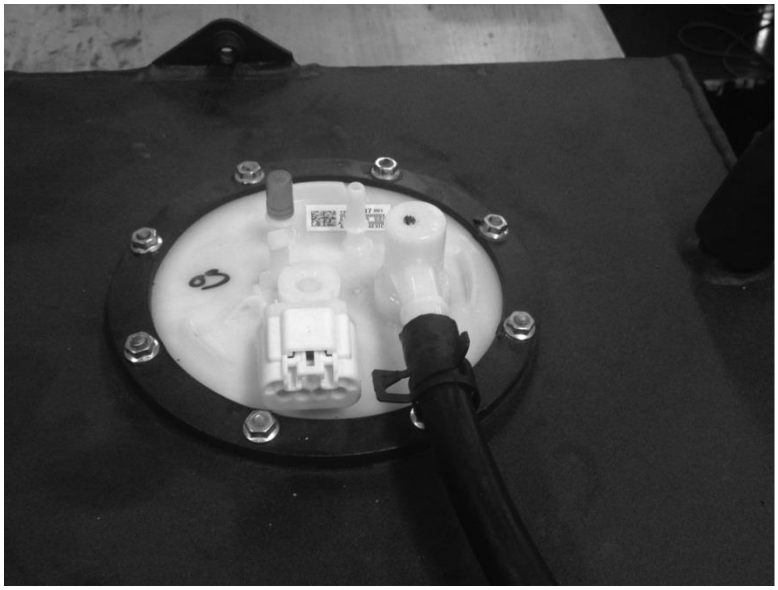
3. Remove the 8 nuts from the fuel sender lock ring

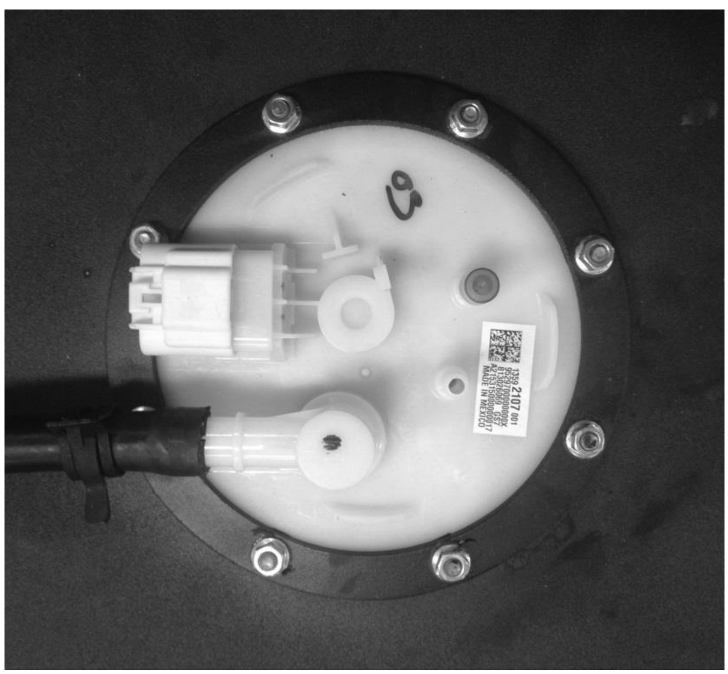



4. Remove the Fuel Pump (1) and O-Ring (2)

#### 8.4.3.16.2.Installation Procedure

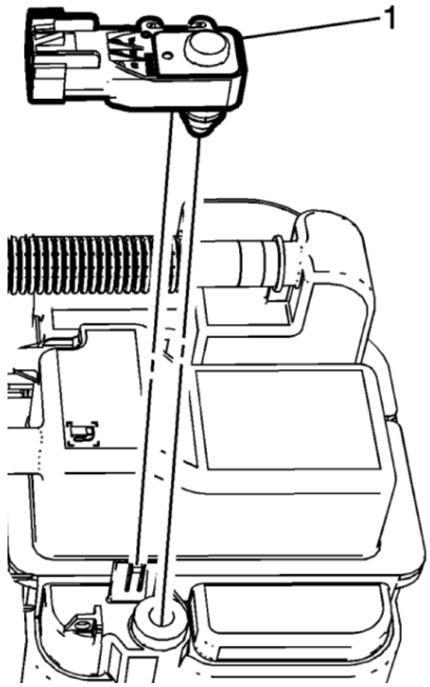
1. Install the fuel pump module and a NEW O-ring in to the Fuel Tank

| Note: |
| --- |
| When installing the Fuel Pump Module ensure it is clocked properly in the Fuel tank  |



2. Install the 8 nuts from the fuel sender lock ring, tighten to 14 Nm (10 ft lb)
3. Install the fuel tank. Refer to Fuel Tank Replacement.

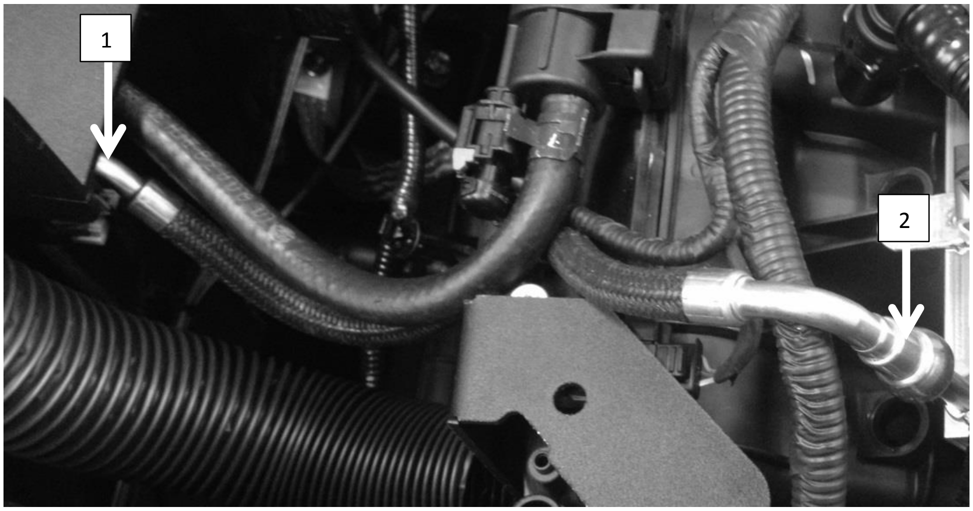
### 8.4.3.17. Fuel Tank Pressure Sensor Replacement




Fuel Tank Pressure Sensor Replacement

| Callout | Component Name |
|---|---|
| **Preliminary Procedure**<br>Remove the fuel tank. Refer to Fuel Tank Replacement.<br>Remove the Evaporative Emission Canister Vent Solenoid Valve Refer to Evaporative Emission Canister Vent Solenoid Valve Replacement | |
| 1 | Fuel Tank Pressure Sensor<br><br>**Procedure**<br>Disconnect the FTP sensor electrical connector. |

### 8.4.3.18. Fuel injector rail feed pipe




Fuel injector rail feed pipe

| Callout | Component Name |
|---|---|
| **Preliminary Procedure**<br>Remove Air intake hose Filter to Turbo, Refer to Air intake hose Filter to Turbo<br>Remove Mid-Engine Cover, Refer to Mid Engine Cover<br>Relieve Fuel Pressure, Refer to Fuel Pressure Relief | |
| 1 | Fuel Injector rail feed pipe to Fuel feed Pipe Connector<br><br>**Special Tools:**<br>Push Lock Fuel Line Disconnect tool |
| | Fuel Injector rail feed pipe to Fuel Rail<br><br>**Special Tools:**<br>Push Lock Fuel Line Disconnect tool |