2014 Engine

Engine Controls and Fuel - 2.0L (LTG) - Description and Operation - Regal

DESCRIPTION AND OPERATION

CAMSHAFT ACTUATOR SYSTEM DESCRIPTION

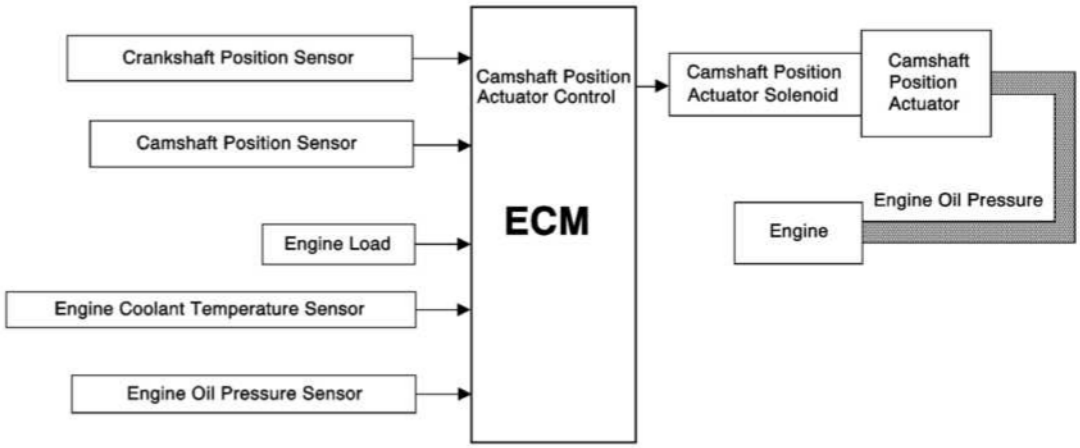


Fig. 1: Camshaft Actuator System Description
Courtesy of GENERAL MOTORS COMPANY

Camshaft Position (CMP) Actuator System

The camshaft position (CMP) actuator system is an electro-hydraulic 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.

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 affect on Cam Actuator performance.

ENGINE CONTROL MODULE DESCRIPTION

The Engine Control Module (ECM) interacts with many emission related components and systems, and monitors emission related components and systems for deterioration. OBD II diagnostics monitor the system performance and a diagnostic trouble code (DTC) sets if the system performance degrades. The ECM is part of a network and communicates with various other vehicle control modules.

Malfunction indicator lamp (MIL) operation and DTC storage are dictated by the DTC type. A DTC is ranked as a Type A or Type B if the DTC is emissions related. Type C is a non-emissions related DTC.

The ECM is the control center of the engine controls system. Review the components and wiring diagrams in order to determine which systems are controlled by the ECM.

The ECM constantly monitors the information from various sensors and other inputs, and controls the systems that affect engine performance and emissions. The ECM also performs diagnostic tests on various parts of the system and can turn on the MIL when it recognizes an operational problem that affects emissions. When the ECM detects a malfunction, the ECM stores a DTC. The condition area is identified by the particular DTC that is set. This aids the technician in making repairs.

ECM Function

The ECM can supply 5 V or 12 V to various sensors or switches. This is done through pull-up resistors to regulated power supplies within the ECM. In some cases, even an ordinary shop voltmeter will not give an accurate reading due to low input resistance. Therefore, a digital multimeter (DMM) with at least 10 megaohms input impedance is required in order to ensure accurate voltage readings.

The ECM controls the output circuits by controlling the ground or the power feed circuit through transistors or a device called an output driver module.

EEPROM

The electronically erasable programmable read only memory (EEPROM) is an integral part of the ECM. The EEPROM contains program and calibration information that the ECM needs in order to control engine operation.

Special equipment, as well as the correct program and calibration for the vehicle, are required in order to reprogram the ECM.

Data Link Connector (DLC)

The data link connector (DLC) provides serial data communication for ECM diagnosis. This connector allows the technician to use a scan tool in order to monitor various serial data parameters, and display DTC information. The DLC is located inside the driver's compartment, underneath the instrument panel.

Malfunction Indicator Lamp (MIL)

The malfunction indicator lamp (MIL) is inside the instrument panel cluster (IPC). The MIL is controlled by the ECM and illuminates when the ECM detects a condition that affects vehicle emissions.

ECM Service Precautions

The ECM, by design, can withstand normal current draws that are associated with vehicle operations. However, care must be used in order to avoid overloading any of these circuits. When testing for opens or shorts, do not ground or apply voltage to any of the ECM circuits unless the diagnostic procedure instructs you to do so. These circuits should only be tested with a DMM unless the diagnostic procedure instructs otherwise.

Emissions Diagnosis For State I/M Programs

This OBD II equipped vehicle is designed to diagnose any conditions that could lead to excessive levels of the following emissions:

- Hydrocarbons (HC)
- Carbon monoxide (CO)
- Oxides of nitrogen (NOx)
- Evaporative emission (EVAP) system losses

Should this vehicle's on-board diagnostic system (ECM) detect a condition that could result in excessive emissions, the ECM turns ON the MIL and stores a DTC that is associated with the condition.

Aftermarket (Add-On) Electrical And Vacuum Equipment

CAUTION: Do not attach add-on vacuum operated equipment to this vehicle. The use of add-on vacuum equipment may result in damage to vehicle components or systems.

CAUTION: Connect any add-on electrically operated equipment to the vehicle's electrical system at the 12 V battery (power and ground) in order to prevent damage to the vehicle.

Aftermarket, add-on, electrical and vacuum equipment is defined as any equipment installed on a vehicle after leaving the factory that connects to the vehicle's electrical or vacuum systems. No allowances have been made in the vehicle design for this type of equipment.

Add-on electrical equipment, even when installed to these strict guidelines, may still cause the powertrain system to malfunction. This may also include equipment not connected to the vehicle electrical system, such as portable telephones and radios. Therefore, the first step in diagnosing any powertrain condition is to eliminate all of the aftermarket electrical equipment from the vehicle. After this is done, if the problem still exists, the problem may be diagnosed in the normal manner.

Electrostatic Discharge (ESD) Damage

NOTE: In order to prevent possible electrostatic discharge damage to the ECM, DO

NOT touch the connector pins on the ECM.

The electronic components that are used in the control systems are often designed to carry very low voltage. These electronic components are susceptible to damage caused by electrostatic discharge. Less than 100 V of static electricity can cause damage to some electronic components. By comparison, it takes as much as 4,000 V for a person to even feel a static discharge.

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

Charging by induction occurs when a person with well insulated shoes stands near a highly charged object and momentarily touches ground. Charges of the same polarity are drained off leaving the person highly charged with the opposite polarity. Static charges can cause damage, therefore, it is important to use care when handling and testing electronic components.

Emissions Control Information Label

The underhood Vehicle Emissions Control Information Label contains important emission specifications. This identifies the year, the displacement of the engine in liters, and the class of the vehicle.

This label is located in the engine compartment of every General Motors vehicle. If the label has been removed, it can be ordered from GM service parts operations (GMSPO).

EVAPORATIVE EMISSION CONTROL SYSTEM DESCRIPTION

Typical Evaporative Emission (EVAP) System Hose Routing Diagram

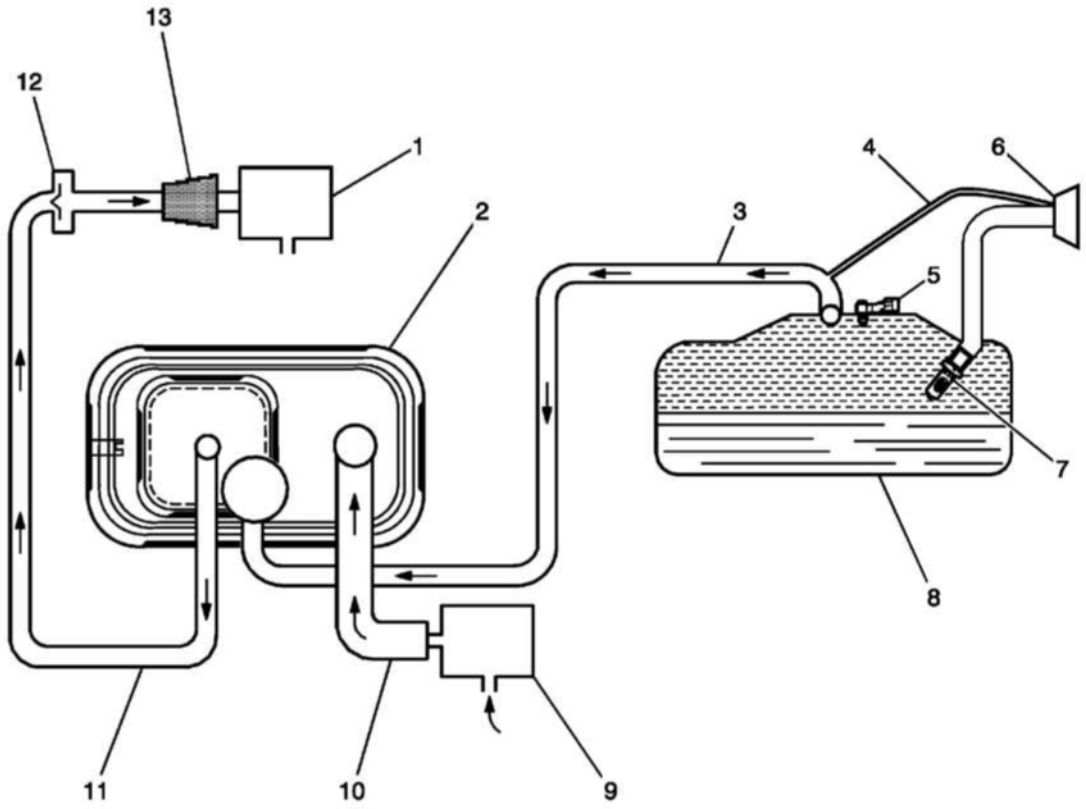


Fig. 2: View Of Evaporative Emission (EVAP) System Hose Routing Diagram
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Evaporative Emissions (EVAP) Purge Solenoid Valve
2	EVAP Canister
3	EVAP Vapor Tube
4	Vapor Recirculation Tube
5	Fuel Tank Pressure Sensor
6	Fuel Filler Cap (Some Vehicles May Have A Capless Design)
7	Fuel Fill Pipe Inlet Check Valve
8	Fuel Tank
9	EVAP Canister Vent Solenoid Valve
10	Vent hose
11	EVAP Purge Tube
12	Purge Tube Check Valve, Turbo-Charged Applications Only
13	EVAP Canister Purge Tube Connector

EVAP System Operation

The evaporative emission (EVAP) control system limits fuel vapors from escaping into the atmosphere. Fuel tank vapors are allowed to move from the fuel tank, due to pressure in the tank, through the EVAP vapor tube, into the EVAP canister. Carbon in the canister absorbs and stores the fuel vapors. Excess pressure is vented through the vent hose and EVAP vent solenoid valve to the atmosphere. The EVAP canister stores the fuel vapors until the engine is able to use them. At an appropriate time, the engine control module (ECM) will command the EVAP purge solenoid valve ON, allowing engine vacuum to be applied to the EVAP canister. With the normally open EVAP vent solenoid valve OFF, fresh air is drawn through the vent solenoid valve and the vent hose to the EVAP canister. Fresh air is drawn through the canister, pulling fuel vapors from the carbon. The air/fuel vapor mixture continues through the EVAP purge tube and EVAP purge solenoid valve into the intake manifold to be consumed during normal combustion. The ECM uses several tests to determine if the EVAP system is leaking or restricted.

Purge Solenoid Valve Leak Test

If the EVAP purge solenoid valve does not seal properly fuel vapors could enter the engine at an undesired time, causing driveability concerns. The ECM tests for this by commanding the EVAP purge solenoid valve OFF and the vent solenoid valve ON which seals the system. With the engine running, the ECM then monitors the fuel tank pressure (FTP) sensor for an increase in vacuum. The ECM will log a fault if a vacuum develops in the tank under these test conditions.

Large Leak Test

This diagnostic creates a vacuum condition in the EVAP system. When the enabling criteria has been met, the ECM commands the normally open EVAP vent solenoid valve closed and the EVAP purge solenoid valve open, creating a vacuum in the EVAP system. The ECM then monitors the FTP sensor voltage to verify that the system is able to reach a predetermined level of vacuum within a set amount of time. Failure to achieve the expected level of vacuum indicates the presence of a large leak in the EVAP system or a restriction in the purge path. The ECM will log a fault if it detects a weaker than expected vacuum level under these test conditions.

Canister Vent Restriction Test

If the EVAP vent system is restricted, fuel vapors will not be properly purged from the EVAP canister. The ECM tests this by commanding the EVAP purge solenoid valve ON while commanding the EVAP vent solenoid valve OFF, and then monitoring the FTP sensor for an increase in vacuum. If the vacuum increases more than the expected amount, in a set amount of time, a fault will be logged by the ECM.

Small Leak Test

The engine off natural vacuum diagnostic is the small-leak detection diagnostic for the EVAP system. The engine off natural vacuum diagnostic monitors the EVAP system pressure with the ignition OFF. Because of this, it may be normal for the ECM to remain active for up to 40 min after the ignition is turned OFF. This is important to remember when performing a parasitic draw test on vehicles equipped with engine off natural vacuum.

When the vehicle is driven, the temperature rises in the tank due to heat transfer from the exhaust system. After the vehicle is parked, the temperature in the tank continues to rise for a period of time, then starts to drop. The engine off natural vacuum diagnostic relies on this temperature change, and the corresponding pressure change in a sealed system, to determine if an EVAP system leak is present.

The engine off natural vacuum diagnostic is designed to detect leaks as small as 0.51 mm (0.020 in).

EVAP System Components

The EVAP system consists of the following components:

EVAP Purge Solenoid Valve

The EVAP purge solenoid valve controls the flow of vapors from the EVAP system to the intake manifold. The purge solenoid valve opens when commanded ON by the ECM. This normally closed valve is pulse width modulated (PWM) by the ECM to precisely control the flow of fuel vapor to the engine. The valve will also be opened during some portions of the EVAP testing when the engine is running, allowing engine vacuum to enter the EVAP system.

Purge Tube Check Valve

Turbocharged vehicles have a check valve in the purge tube between the EVAP purge solenoid valve and the EVAP canister to prevent pressurization of the EVAP system under boost conditions. Note that the presence of this one-way check valve prevents pressure testing the EVAP system for leaks at the EVAP canister purge tube connector.

EVAP Canister

The canister is filled with carbon pellets used to absorb and store fuel vapors. Fuel vapor is stored in the canister until the ECM determines that the vapor can be consumed in the normal combustion process.

Vapor Recirculation Tube

A vapor path between the fuel fill pipe and the vapor tube to the carbon canister is necessary for Vehicle Onboard Diagnostics to fully diagnose the EVAP system. It also accommodates service diagnostic procedures by allowing the entire EVAP system to be diagnosed from either end of the system.

Fuel Tank Pressure Sensor

The FTP sensor measures the difference between the pressure or vacuum in the fuel tank and outside air pressure. The ECM provides a 5 V reference and a ground to the FTP sensor. Depending on the vehicle, the sensor can be located in the vapor space on top of the fuel tank, in the vapor tube between the canister and the tank, or on the EVAP canister. The FTP sensor provides a signal voltage back to the ECM that can vary between 0.1-4.9 V. A high FTP sensor voltage indicates a low fuel tank pressure or vacuum. A low FTP sensor voltage indicates a high fuel tank pressure.

Fuel Fill Pipe Check Valve

The check valve on the fuel fill pipe is there to prevent spit-back during refueling.

EVAP Vent Solenoid Valve

The EVAP vent solenoid valve controls fresh airflow into the EVAP canister. The valve is normally open. The canister vent solenoid valve is closed only during EVAP system tests performed by the ECM.

Fuel Fill Cap

The fuel fill cap is equipped with a seal and a vacuum relief valve.

Capless Fuel Fill

Some vehicles may have a capless fuel fill design behind a locking fuel door. There is no fuel fill cap to remove. One just fully inserts the fuel nozzle into the fill neck, making sure it latches before refueling. Flapper valves close to seal this interface once the fill nozzle is removed.

ELECTRONIC IGNITION SYSTEM DESCRIPTION

The electronic ignition system produces and controls a high-energy secondary spark. This spark is used to ignite the compressed air/fuel mixture at precisely the correct time. This provides optimal performance, fuel economy, and control of exhaust emissions. This ignition system uses an individual coil for each cylinder. The ignition coils are mounted in the center of each camshaft cover with short integrated boots connecting the coils to the spark plugs. The driver modules within each ignition coil are commanded ON/OFF by the engine control module (ECM). The ECM primarily uses engine speed, the mass air flow (MAF) sensor signal, and position information from the crankshaft position and the camshaft position sensors. This controls the sequence, dwell, and timing of the spark. The electronic ignition system consists of the following components:

Crankshaft Position Sensor

The crankshaft position sensor works in conjunction with a reluctor wheel on the crankshaft (front mounted crankshaft position sensor) or a reluctor wheel that is part of the flywheel (rear mounted crankshaft position sensor). The engine control module (ECM) monitors the voltage frequency on the crankshaft position sensor signal circuit. As each reluctor wheel tooth rotates past the sensor, the sensor creates a digital ON/OFF pulse. This digital signal is processed by the ECM. This creates a signature pattern that enables the ECM to determine the crankshaft position. The ECM uses the signal to determine which pair of cylinders is approaching top dead center based on the crankshaft position signal alone. The camshaft position sensor signals are used in order to determine which of these 2 cylinders is on a firing stroke, and which is on the exhaust stroke. The ECM uses this to properly synchronize the ignition system, the fuel injectors, and the knock control. This sensor is also used in order to detect misfire.

The ECM also has a dedicated replicated crankshaft position sensor signal output circuit that may be used as an input signal to other modules for monitoring engine RPM.

Camshaft Position Sensor

This engine uses a camshaft position sensor for each camshaft. The camshaft position sensor signals are a digital ON/OFF pulse and output 4 times per revolution of the camshaft. The camshaft position sensor does not directly affect the operation of the ignition system. The camshaft position sensor information is used by the engine control module (ECM) to determine the position of the camshaft relative to the crankshaft position. By monitoring the camshaft position and crankshaft position signals the ECM can accurately time the operation of the fuel injectors. The ECM supplies the camshaft position sensor with a 5 V reference circuit and a low reference circuit. The camshaft position sensor signals are an input to the ECM. These signals are also used to detect camshaft alignment with the crankshaft.

The ECM also has a dedicated replicated camshaft position sensor signal output circuit that may be used as an input signal to other modules for monitoring engine RPM.

Knock Sensor

The knock sensor system enables the 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 2-wire sensors. The sensor uses piezo-electric crystal technology that produces an AC voltage signal of varying amplitude and frequency based on the engine vibration or noise level. The amplitude and frequency depend upon the level of knock that the knock sensor detects. The control module receives the knock sensor signal through the signal circuit. The knock sensor ground is supplied by the control module through the low reference circuit.

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

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

Ignition Coils

Each ignition coil contains a solid state driver module as its primary element. The engine control module (ECM) signals the coil driver to initiate a firing event by applying ignition control (IC) circuit voltage for the appropriate amount of time otherwise known as dwell. When the voltage is removed the coil fires the spark plug.

Engine Control Module (ECM)

The engine control module (ECM) controls all ignition system functions and constantly corrects the spark timing. The ECM monitors information from various sensor inputs that may include the following components, if applicable:

- Throttle position sensor
- Engine coolant temperature (ECT) sensor
- Mass air flow (MAF) sensor
- Intake air temperature (IAT) sensor
- Vehicle speed sensor (VSS)
- Transmission gear position or range information sensors
- Engine knock sensors
- Ambient pressure sensor (BARO)

FUEL SYSTEM DESCRIPTION

Fuel System Overview

The fuel system is an electronic returnless on-demand design. The returnless fuel system reduces the internal temperature of the fuel tank by not returning hot fuel from the engine to the fuel tank. Reducing the internal temperature of the fuel tank results in lower evaporative emissions.

An electric turbine style fuel pump attaches to the fuel tank fuel pump module inside the fuel tank. The fuel pump supplies fuel through the fuel feed pipe to the high pressure fuel pump. The high pressure fuel pump supplies fuel to a variable-pressure fuel rail. Fuel enters the combustion chamber through precision multi-hole fuel injectors. The high pressure fuel pump, fuel rail pressure, fuel injection timing, and injection duration are controlled by the engine control module (ECM).

Electronic Returnless Fuel System

The electronic returnless fuel system is a microprocessor controlled fuel delivery system which transports fuel from the tank to the fuel rail. It functions as an electronic replacement for a traditional, mechanical fuel pressure regulator. The pressure relief regulator valve within the fuel tank provides an added measure of over-pressure protection. Desired fuel pressure is commanded by the engine control module (ECM), and transmitted to the fuel pump power control module via a GMLAN serial data message. A fuel pressure sensor located on the fuel feed pipe provides the feedback the ECM requires for Closed Loop fuel pressure control.

Fuel Pump Power Control Module

The fuel pump power control module is a serviceable GMLAN module. The fuel pump power control module receives the desired fuel pressure message from the engine control module (ECM) and controls the fuel pump located within the fuel tank to achieve the desired fuel pressure. The fuel pump power 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 amps. A fuel pressure sensor located on the fuel feed pipe provides fuel pressure feedback to the ECM.

Fuel Pressure Sensor

The fuel pressure sensor is a serviceable 5 V, 3-pin device. It is located on the fuel feed pipe forward of the fuel tank, and receives power and ground from the ECM through a vehicle wiring harness. The sensor provides a fuel pressure signal to the ECM, which is used to provide Closed Loop fuel pressure control.

Fuel Tank

The fuel tank stores the fuel supply. The fuel tank is located in the rear of the vehicle. The fuel tank is held in place by 2 metal straps that attach to the underbody of the vehicle. The fuel tank is molded from high-density polyethylene.

Fuel Fill Pipe

The fuel fill pipe has a built-in restrictor in order to prevent refueling with leaded fuel.

Fuel Filler Cap

The fuel fill pipe has a tethered fuel filler cap. A torque-limiting device prevents the cap from being over-tightened. To install the cap, turn the cap clockwise until you hear audible clicks. This indicates that the cap is correctly torqued and fully seated.

Fuel Tank Fuel Pump Module

The electric turbine style fuel pump attaches to the fuel tank fuel pump module inside the fuel tank and supplies fuel through the fuel feed pipe to the high pressure fuel pump. The fuel tank fuel pump module contains a reverse flow check valve. The check valve maintains fuel pressure in the fuel feed pipe in order to prevent long cranking times.

The fuel tank fuel pump module consists of the following major components:

- The fuel level sensor
- The fuel pump and reservoir assembly
- The fuel filter
- The pressure relief regulator valve

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.

Fuel Pump

The fuel pump is mounted in the fuel tank fuel pump module reservoir. The fuel pump is an electric turbine style pump which pumps fuel to the high pressure fuel pump at a pressure that is based on feedback from the fuel feed pipe fuel pressure sensor. The fuel pump delivers a constant flow of fuel even during low fuel conditions and aggressive vehicle maneuvers. The fuel pump flex pipe acts to dampen the fuel pulses and noise generated by the fuel pump.

Pressure Relief Regulator Valve

The pressure relief regulator valve replaces the typical fuel pressure regulator used on a mechanical returnless fuel system. The pressure relief regulator valve is closed during normal vehicle operation. The pressure relief regulator valve is used to vent pressure during hot soaks and also functions as a fuel pressure regulator in the event of the fuel pump power control module defaulting to 100 percent pulse width modulation (PWM) of the fuel pump. Due to variation in the fuel system pressures, the opening pressure for the pressure relief regulator valve is set higher than the pressure that is used on a mechanical returnless fuel system pressure regulator.

Nylon Fuel Pipes

WARNING: In order to reduce the risk of fire and personal injury observe the following items:

- **Replace all nylon fuel pipes that are nicked, scratched or damaged during installation, do not attempt to repair the sections of the nylon fuel pipes**
- **Do not hammer directly on the fuel harness body clips when installing new fuel pipes. Damage to the nylon pipes may result in a fuel leak.**

- **Always cover nylon vapor pipes with a wet towel before using a torch near them. Also, never expose the vehicle to temperatures higher than 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.)**

Nylon pipes are constructed to withstand maximum fuel system pressure, exposure to fuel additives, and changes in temperature.

Heat resistant rubber hose or corrugated plastic conduit protect the sections of the pipes that are exposed to chafing, high temperature, or vibration.

Nylon fuel pipes are somewhat flexible and can be formed around gradual turns under the vehicle. However, if nylon fuel pipes are forced into sharp bends, the pipes may kink and restrict the fuel flow. Also, once exposed to fuel, nylon pipes may become stiffer and are more likely to kink if bent too far. Take special care when working on a vehicle with nylon fuel pipes.

Quick-Connect Fittings

Quick-connect fittings provide a simplified means of installing and connecting fuel system components. The fittings consist of a unique female connector and a compatible male pipe end. O-rings, located inside the female connector, provide the fuel seal. Integral locking tabs inside the female connector hold the fittings together.

High Pressure Fuel Pump

The high fuel pressure necessary for direct injection is supplied by the high pressure fuel pump. The pump is mounted on the rear of the engine and is driven by a three-lobe cam on the camshaft. This pump also regulates the fuel pressure using an actuator in the form of an internal solenoid-controlled valve. In order to keep the engine running efficiently under all operating conditions, the engine control module (ECM) requests pressure ranging from 2 to 15 MPa (290 to 2176 psi), depending on engine speed and load. Output drivers in the ECM provide the pump control circuit with a 12 V pulse-width modulated (PWM) signal, which regulates fuel pressure by closing and opening the control valve at specific times during pump strokes. This effectively regulates the portion of each pump stroke that is delivered to the fuel rail. When the control solenoid is NOT powered, the pump operates at maximum flow rate. In the event of pump control failure, the high pressure system is protected by a relief valve in the pump.

Fuel Rail Assembly

The fuel rail assembly attaches to the cylinder head and distributes the high pressure fuel to the fuel injectors. The fuel rail assembly consists of the following components:

- The direct fuel injectors
- The fuel rail pressure sensor

Fuel Injectors

The fuel injection system is a high pressure, direct injection, returnless on-demand design. The fuel injectors are mounted in the cylinder head beneath the intake ports and spray fuel directly into the combustion chamber. Direct injection requires high fuel pressure due to the fuel injector's location in the combustion chamber. Fuel pressure must be higher than compression pressure requiring a high pressure fuel pump. The fuel injectors also require more electrical power due to the high fuel pressure. The ECM supplies a high voltage supply circuit and a high voltage control circuit for each fuel injector. The injector high voltage supply circuit and the high voltage control circuit are both controlled by the ECM. The ECM energizes each fuel injector by grounding the control circuit. The ECM controls each fuel injector with 65 V. This is controlled by a boost capacitor in the ECM. During the 65 V boost phase, the capacitor is discharged through an injector, allowing for initial injector opening. The injector is then held open with 12 V.

The fuel injector assembly is an inside opening electrical magnetic injector. The injector has six precision machined holes that generate a cone shaped oval spray pattern. The fuel injector has a slim extended tip in order to allow a sufficient cooling jacket in the cylinder head.

Fuel Injection Fuel Rail Fuel Pressure Sensor

The fuel rail pressure sensor detects fuel pressure within the fuel rail. The engine control module (ECM) provides a 5 V reference voltage on the 5 V reference circuit and ground on the reference ground circuit. The ECM receives a varying signal voltage on the signal circuit. The ECM monitors the voltage on the fuel rail pressure sensor circuits. When the fuel pressure is high, the signal voltage is high. When the fuel pressure is low, the signal voltage is low.

Fuel Metering Modes of Operation

The ECM monitors voltages from several sensors in order to determine how much fuel to give the engine. The ECM controls the amount of fuel delivered to the engine by changing the fuel injector pulse width. The fuel is delivered under one of several modes.

Starting Mode

The ECM supplies voltage to the fuel pump power control module when the ECM detects that the ignition is ON. The voltage from the ECM to the fuel pump power control module remains active for 2 s, unless the engine is in Crank or Run. While this voltage is being received, the fuel pump power control module closes the ground switch of the fuel tank fuel pump module and also supplies a varying voltage to the fuel tank fuel pump module in order to maintain the desired fuel line pressure. The ECM calculates the air/fuel ratio based on inputs from the engine coolant temperature (ECT), manifold absolute pressure (MAP), mass air flow (MAF), and throttle position sensors. The system stays in starting mode until the engine speed reaches a predetermined RPM.

During a cold start, the ECM commands dual-pulse mode during Open Loop operation to improve cold start emissions. In dual-pulse mode, the injectors are energized twice during each injection event.

Clear Flood Mode

If the engine floods, the engine can be cleared by pressing the accelerator pedal down to the floor and then cranking the engine. When the throttle position sensor is at wide open throttle (WOT), the ECM reduces the fuel injector pulse width in order to increase the air to fuel ratio. The ECM holds this injector rate as long as the throttle stays wide open and the engine speed is below a predetermined RPM. If the throttle is not held wide open, the ECM returns to the starting mode.

Run Mode

The run mode has 2 conditions called Open Loop and Closed Loop. When the engine is first started and the engine speed is above a predetermined RPM, the system begins Open Loop operation. The ECM ignores the signal from the heated oxygen sensor (HO2S). The ECM calculates the air/fuel ratio based on inputs from the engine coolant temperature (ECT), manifold absolute pressure (MAP), mass air flow (MAF), and throttle position sensors. The system stays in Open Loop until meeting the following conditions:

- The HO2S has varying voltage output, showing that the HO2S is hot enough to operate properly.
- The ECT sensor is above a specified temperature.
- A specific amount of time has elapsed after starting the engine.

Specific values for the above conditions exist for each different engine, and are stored in the electrically erasable programmable read-only memory (EEPROM). The system begins Closed Loop operation after reaching these values. In Closed Loop, the ECM calculates the air/fuel ratio, injector ON time, based upon the signal from various sensors, but mainly from the HO2S. This allows the air/fuel ratio to stay very close to 14.7:1.

Acceleration Mode

When the driver pushes on the accelerator pedal, air flow into the cylinders increases rapidly. To prevent possible hesitation, the ECM increases the pulse width to the injectors to provide extra fuel during acceleration. This is also known as power enrichment. The ECM determines the amount of fuel required based upon throttle position, engine coolant temperature (ECT), manifold absolute pressure (MAP), mass air flow (MAF), and engine speed.

Deceleration Mode

When the driver releases the accelerator pedal, air flow into the engine is reduced. The ECM monitors the corresponding changes in throttle position, mass air flow (MAF), and manifold absolute pressure (MAP). The ECM shuts OFF fuel completely if the deceleration is very rapid, or for long periods, such as long, closed-throttle coast-down. The fuel shuts OFF in order to prevent damage to the catalytic converters.

Battery Voltage Correction Mode

When the battery voltage is low, the ECM compensates for the weak spark delivered by the ignition system in the following ways:

- Increasing the amount of fuel delivered
- Increasing the idle RPM
- Increasing the ignition dwell time

Fuel Cutoff Mode

The ECM cuts OFF fuel from the fuel injectors when the following conditions are met in order to protect the powertrain from damage and improve driveability:

- The ignition is OFF. This prevents engine run-on.
- The ignition is ON but there is no ignition reference signal. This prevents flooding or backfiring.

- The engine speed is too high, above red line.
- The vehicle speed is too high, above rated tire speed.
- During an extended, high speed, closed throttle coast down-This reduces emissions and increases engine braking.
- During extended deceleration, in order to prevent damage to the catalytic converters

Fuel Trim

The ECM controls the air/fuel metering system in order to provide the best possible combination of driveability, fuel economy, and emission control. The ECM monitors the heated oxygen sensor (HO2S) signal voltage while in Closed Loop and regulates the fuel delivery by adjusting the pulse width of the injectors based on this signal. The ideal fuel trim values are around 0 percent for both short and long term fuel trim. A positive fuel trim value indicates the ECM is adding fuel in order to compensate for a lean condition by increasing the pulse width. A negative fuel trim value indicates that the ECM is reducing the amount of fuel in order to compensate for a rich condition by decreasing the pulse width. A change made to the fuel delivery changes the long and short term fuel trim values. The short term fuel trim values change rapidly in response to the HO2S signal voltage. These changes fine tune the engine fueling. The long term fuel trim makes coarse adjustments to fueling in order to re-center and restore control to short term fuel trim. A scan tool can be used to monitor the short and long term fuel trim values. The long term fuel trim diagnostic is based on an average of several of the long term speed load learn cells. The ECM selects the cells based on the engine speed and engine load. If the ECM detects an excessively lean or rich condition, the ECM will set a fuel trim diagnostic trouble code (DTC).

THROTTLE ACTUATOR CONTROL (TAC) SYSTEM DESCRIPTION

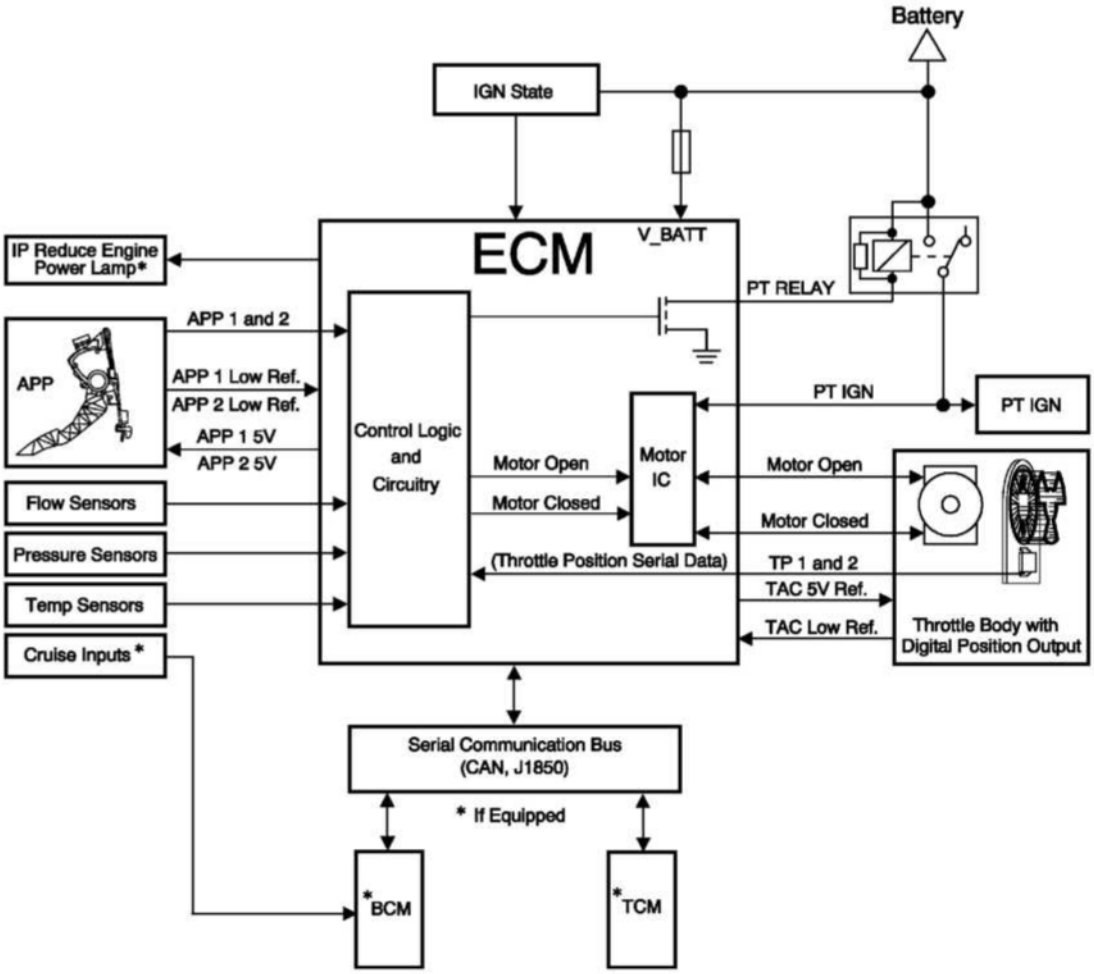


Fig. 3: Throttle Actuator Control (TAC) System Diagram
Courtesy of GENERAL MOTORS COMPANY

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

Modes Of Operation

Normal Mode

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

- Minimum pedal value-At key-up, the ECM updates the learned minimum pedal value.
- Minimum throttle position values-At key-up, the ECM updates the learned minimum throttle position value. In order to learn the minimum throttle position value, the throttle blade is moved to the Closed position.
- Ice break mode-If the throttle blade is not able to reach a predetermined minimum throttle position, the ice break mode is entered. During the ice break mode, the ECM commands the maximum pulse

width several times to the throttle actuator motor in the closing direction.

- Battery saver mode-After a predetermined time without engine speed, the ECM commands the battery saver mode. During the battery saver mode, the TAC module removes the voltage from the motor control circuits, which removes the current draw used to maintain the idle position and allows the throttle to return to the spring loaded default position.

Reduced Engine Power Mode

When the ECM detects a condition with the TAC system, the ECM may enter a reduced engine power mode. Reduced engine power may cause one or more of the following conditions:

- Acceleration limiting-The ECM will continue to use the accelerator pedal for throttle control, however, the vehicle acceleration is limited.
- Limited throttle mode-The ECM will continue to use the accelerator pedal for throttle control, however, the maximum throttle opening is limited.
- Throttle default mode-The ECM will turn OFF the throttle actuator motor, and the throttle will return to the spring loaded default position.
- Forced idle mode-The ECM will perform the following actions:
  - Limit engine speed to the idle position
  - Ignore the accelerator pedal input.
- Engine shutdown mode-The ECM will disable fuel and de-energize the throttle actuator.

TURBOCHARGER SYSTEM DESCRIPTION

Turbocharger Description and Operation

A turbocharger is a compressor that is used to increase the power output of an engine by increasing the mass of the oxygen and therefore the fuel entering the engine. The dual-scroll turbocharger is mounted either to the exhaust manifold or directly to the head. The turbine is driven by the 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 centrifugal compressor blades compress the intake air above atmospheric pressure, thereby 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 control boost pressure. A turbocharger bypass valve (compressor recirculation valve), controlled by the ECM, 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 to the turbocharger compressor inlet. 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 pipe. The oil is required for the bearing system function and also serves to carry some heat from the turbocharger. There is a cooling system circuit in the turbocharger that further reduces operating temperatures and passively dissipates bearing housing heat away from the turbocharger on shut down.

Wastegate Solenoid Valve

The wastegate valve opens and closes a bypass passage beside the turbine wheel. A spiral spring works in the closing direction while the pressure in the diaphragm works in the opening direction. The ECM supplies

a PWM signal to the solenoid valve, which then allows pressure from the turbo to come through. When the pressure overcomes the spring force the actuator rod begins to move, opening the wastegate valve to a corresponding degree. The ECM changes wastegate valve opening by varying the PWM signal, which regulates the turbine speed.

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

When the air displacement becomes so large that the current air mass per combustion cannot be controlled with the throttle alone, the turbo must be regulated. This is done by opening the wastegate valve so that some of the exhaust gas passes through the wastegate. Consequently, this gas does not contribute to driving the turbine and the turbine speed will be regulated so that the turbo air displacement will be correct.

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

The following diagrams illustrate the turbocharger wastegate closed and open conditions:

Turbocharger Wastegate Closed

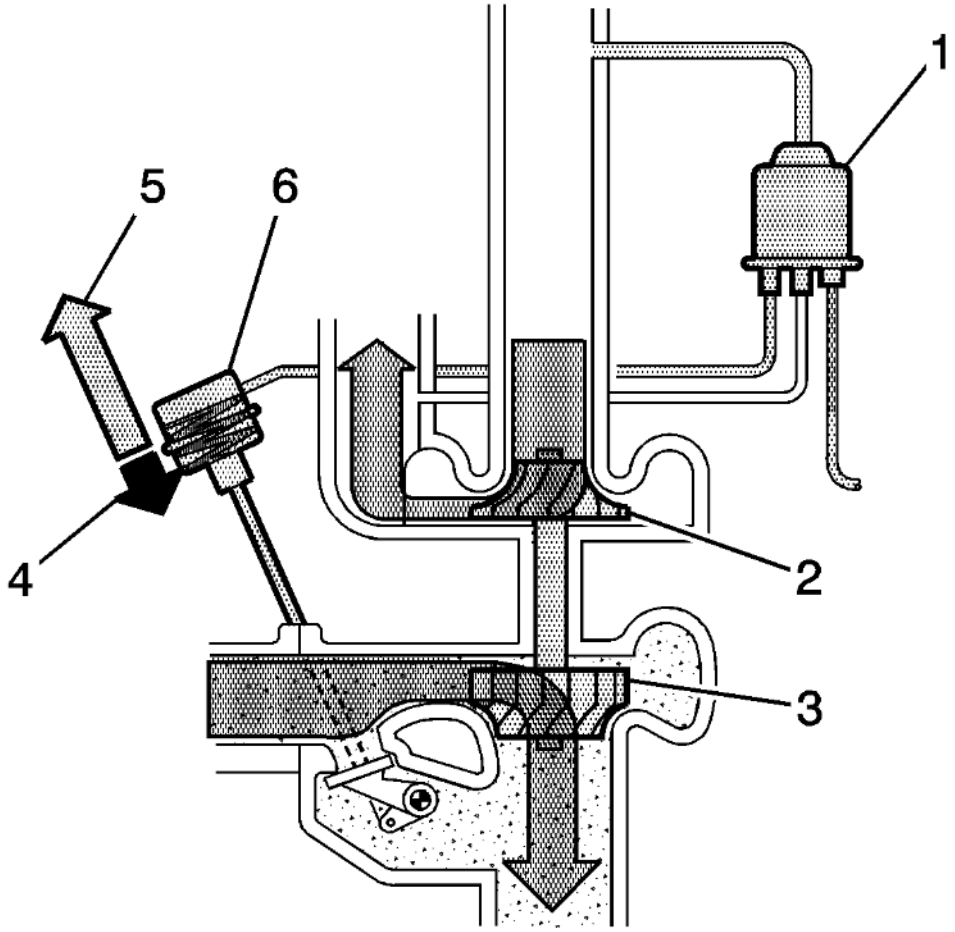


Fig. 4: TC Wastegate Closed
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
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

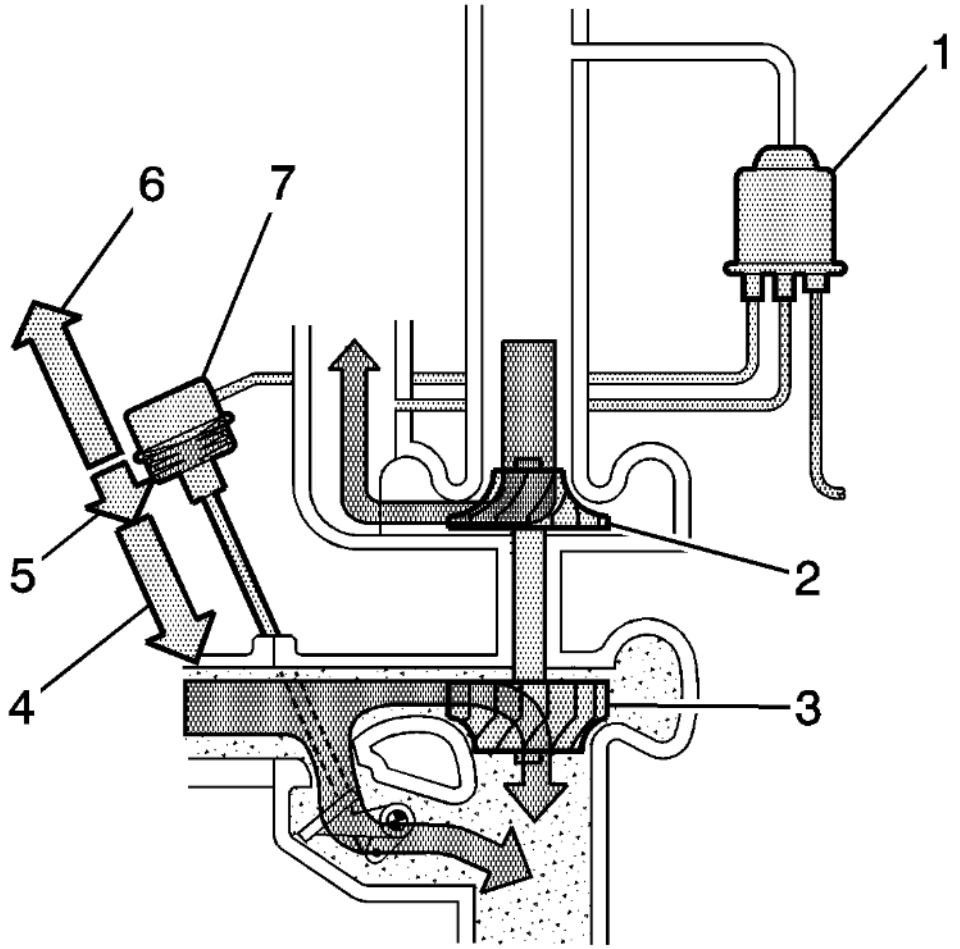


Fig. 5: TC Wastegate Open
Courtesy of GENERAL MOTORS COMPANY

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

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

During normal operation, when wide open throttle is requested at lower engine speeds, the ECM commands the wastegate solenoid with a duty cycle of 100 % to minimize any turbo lag. During engine loads in the middle and upper RPM ranges, the ECM commands the solenoid with a duty cycle of 65-80 %.

Bypass Solenoid Valve (Compressor Recirculation Valve)

The turbocharger bypass valve prevents the turbo from exceeding the surge limit of the compressor at low

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

Accelerator Pedal Depressed

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

Accelerator Pedal Released

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

Charge Air Cooler

The turbocharger intake system 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 hot compressed air exiting the turbo compressor, prior to delivery to the engine combustion 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, cleanliness and proper positioning of the clamps is critical, and must be strictly adhered to.

2014 Engine

Engine Controls and Fuel - 2.0L (LTG) - Diagnostic Information and Procedures - Regal

DIAGNOSTIC INFORMATION AND PROCEDURES

DTC P0010, P0013, OR P2088-P2091

Diagnostic Instructions

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

DTC Descriptors

DTC 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 Valve Control Circuit Low Voltage

DTC P2089

Intake Camshaft Position Actuator Solenoid Valve Control Circuit High Voltage

DTC P2090

Exhaust Camshaft Position Actuator Solenoid Valve Control Circuit Low Voltage

DTC P2091

Exhaust Camshaft Position Actuator Solenoid Valve Control Circuit High Voltage

Diagnostic Fault Information

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

Actuator Solenoid Valve Low Reference	-	P0010, P0013	P0010, P0013	-	-

Circuit/System Description

The camshaft position actuator system enables the engine control module (ECM) to change the timing of the camshafts while the engine is operating. The camshaft position actuator solenoid valve signal from the ECM is pulse width modulated (PWM). The ECM controls the camshaft position actuator solenoid valve duty cycle by controlling the amount of solenoid valve On time. The camshaft position actuator solenoid valve controls the advance or the retard of each camshaft. The camshaft position actuator solenoid valve controls the oil flow that applies the pressure to advance or retard the camshafts.

The ECM controls the camshaft position actuator solenoid valve by supplying a 12 V pulse width modulated (PWM) signal. The ECM supplies a ground to the low reference circuit.

Conditions for Running the DTC

- The ignition voltage is greater than 11 V.
- The ECM has commanded the camshaft position actuator solenoid valve On.
- the DTCs are run continuously once the above conditions are met.

Conditions for Setting the DTC

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

Action Taken When the DTC Sets

DTCs P0010, P0013 and P2088 - P2091 are type B DTCs.

Conditions for Clearing the DTC

DTCs P0010, P0013 and P2088 - P2091 are type B DTCs.

Diagnostic Aids

If the condition is intermittent, move the related harnesses and connectors, with the engine operating, while monitoring the scan tool Circuit Test Status parameters for the component. The Circuit Test Status parameters change from OK or Not Run to Malfunction if there is a condition with the circuit or a connection.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Description and Operation

Camshaft Actuator System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

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

1. Ignition On.
2. Verify DTC P0335, P0336, P0340, or P0341 is not set.
   - **If any of the DTCs are set**

     If any of the DTCs are set, refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .

   - **If none of the DTCs are set**
3. Verify the scan tool parameters listed below do not display Malfunction:
   - Camshaft Position Actuator Solenoid Valve Control Circuit Open test status
   - Camshaft Position Actuator Solenoid Valve Control Circuit High Voltage test status
   - Camshaft Position Actuator Solenoid Valve Control Circuit Low Voltage test status
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing

   - **If Malfunction is not displayed**
4. Engine idling at normal operating temperature.
5. Verify the scan tool parameters listed below do not display Malfunction when commanding the appropriate scan tool Camshaft Position Actuator from 0-10° and back to 0° with a scan tool:

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

- **If Malfunction is displayed**

  Refer to Circuit/System Testing

- **If Malfunction is not displayed**

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

     Refer to Circuit/System Testing

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

Circuit/System Testing

1. Ignition Off and all vehicle systems Off, disconnect the appropriate harness connector at the Q6 Camshaft Position Actuator Solenoid Valve. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 ohms between the low reference circuit terminal B or 2 and ground.
   - **If 5 ohms or greater**
     1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
     2. Test for less than 2 ohms in the low reference circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
   - **If less than 5 ohms**
3. Ignition On.

NOTE: A test lamp must be used for this test. The control circuit is pulled-up to a low current voltage, 1.5-3.5 V on the control circuit is normal.

4. Verify that a test lamp does not illuminate between the control circuit terminal A or 1 and ground.
   - **If the test lamp illuminates**
     1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module, ignition On.
     2. Test for less than 1 V between the control circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
   - **If the test lamp does not illuminate**
5. Remove the test lamp.
6. Connect the DMM negative lead to the control circuit terminal A or 1. Connect the DMM positive

lead to B+. Set the DMM on the diode setting. Command the Camshaft Position Actuator Solenoid Valve On and Off with a scan tool. The DMM should transition from OL when commanded Off to less than 1 V when commanded On.

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

1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
2. Test for less than 2 ohms in the control circuit end to end.
   - If 2 ohms or greater, repair the open/high resistance in the circuit
   - If less than 2 ohms
3. Test for infinite resistance between the control circuit terminal A or 1 and ground.
   - If less than infinite resistance, repair the short to ground in the circuit
   - If infinite resistance, replace the K20 Engine Control Module

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

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

Component Testing

1. Ignition Off, disconnect the harness connector at the appropriate Q6 Camshaft Position Actuator Solenoid Valve.
2. Test for 4.1-7.7 ohms between the control terminal A or 1 and the low reference circuit terminal B or 2
   - **If not between 4.1-7.7 ohms**

     Replace the Q6 Camshaft Position Actuator Solenoid Valve.

   - **If between 4.1-7.7 ohms**
3. Test for infinite resistance between each terminal and the Q6 Camshaft Position Actuator Solenoid Valve housing.
   - **If not infinite resistance**

     Replace the Q6 Camshaft Position Actuator Solenoid Valve.

   - **If infinite resistance**
4. All OK

Repair Instructions

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

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

DTC P0011 OR P0014

Diagnostic Instructions

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

DTC Descriptors

DTC P0011

Intake Camshaft Position System Performance

DTC P0014

Exhaust Camshaft Position System Performance

Diagnostic Fault Information

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

Circuit/System Description

The camshaft position 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.

Conditions for Running the DTC

- DTC P0010, P0013, P0016, P0017, P0335, P0336, P0340, P0341, P0365, or P0366 is not set.
- The ignition voltage is greater than 11 V.
- The engine is operating.
- The desire camshaft position is not changing greater than 4.5 degrees for at least 1 s.
- Both of the desired and actual camshaft position actuator values cannot be greater than 25 degrees or less than 5 degrees.
- DTCs P0011 and P0014 run continuously once the above conditions are met.

Conditions for Setting the DTC

The ECM detects the difference between the desired camshaft position angle and the actual camshaft

position angle is greater than 6 degrees for greater 13.5 s.

Action Taken When the DTC Sets

- DTCs P0011 and P0014 are Type B DTCs.
- The Auto Stop and Auto Start function of the hybrid system is disabled.

Conditions for Clearing the DTC

DTCs P0011 and P0014 are Type B DTCs.

Diagnostic Aids

- The engine oil condition has a major impact on the camshaft actuator system.
- A low oil level condition may set this DTC. The engine may require an oil change. Inquire with the customer when the last oil change was performed. You may also monitor the scan tool Engine Oil Life Remaining parameter. Advise the customer an oil change may be required.
- Inspect the engine for any recent engine mechanical repairs. An incorrectly installed camshaft, camshaft actuator, or timing chain can cause this DTC to set.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

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Camshaft Actuator System Description

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

NOTE:

- **The engine oil level and the oil pressure are critical to the correct operation of the camshaft position actuator system. Verify that the engine has the correct oil level and the correct oil pressure before continuing with this diagnostic.**
- **The engine oil condition has a major impact on the camshaft actuator system. Debris in the oil can interfere with the camshaft position actuator solenoid and the mechanical camshaft actuator operation. Inspect for dirty or degraded crankcase oil. The engine may require an oil change. Inquire with the customer when the last oil change was performed. You may also monitor the scan tool Engine Oil Life Remaining parameter. Advise the customer an oil change may be required.**

1. Ignition On.
2. Verify the engine has the correct oil level and 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
   - Intake Camshaft Position Variance
   - Exhaust Camshaft Position Variance
   - **If 2° or greater**

Refer to Circuit/System Testing.

- **If less than 2°**

6. Verify that DTC P0011 or P0014 is not set.
   - **If any of the DTCs are set**

     Refer to Circuit/System Testing.

   - **If none of the DTCs set**
7. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
8. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Ignition Off and all vehicle systems Off, disconnect the appropriate harness connector at the Q6 Camshaft Position Actuator Solenoid Valve. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 ohms between the low reference circuit terminal B and ground.
   - **If 5 ohms or greater**
     1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
     2. Test for less than 2 ohms in the low reference circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
   - **If less than 5 ohms**
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. Ignition On, verify that a test lamp does not illuminate between the control circuit terminal A and ground.
   - **If the test lamp illuminates**
     1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module, ignition On.
     2. Test for less than 1 V between the control circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
   - **If the test lamp does not illuminate**
5. Remove the test lamp.

6. 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 Low Voltage Test Status
   - Exhaust Camshaft Position Actuator Solenoid Valve Control Circuit Low Voltage Test Status
   - **If Malfunction is displayed**
   1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 ohms in the control circuit end to end.
   - If 2 ohms or greater, repair the open/high resistance or short to ground in the circuit.
   - If less than 2 ohms, 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:
   1. Torn, restricted, mis-positioned, or missing screens.
   2. Engine oil leak between the oil sealing lands of the solenoid. Inspect the lands of the solenoid for nicks.
   3. Oil seepage at the solenoid connector.
   - **If a condition is found**

     Replace the Q6 Camshaft Position Actuator Solenoid Valve.

   - **If a condition is not found**

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

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

      Replace the mechanical camshaft position actuator.

    - **If less than 2°**
12. Test or replace the Q6 Camshaft Position Actuator Solenoid Valve.

Component Testing

1. Ignition Off, disconnect the harness connector at the appropriate Q6 Camshaft Position Actuator Solenoid Valve.

2. Test for 4.1-7.7 ohms between the control terminal A or 1 and the low reference circuit terminal B or 2
    - **If not between 4.1-7.7 ohms**

      Replace the Q6 Camshaft Position Actuator Solenoid Valve.

    - **If between 4.1-7.7 ohms**
3. Test for infinite resistance between each terminal and the Q6 Camshaft Position Actuator Solenoid Valve housing.
    - **If less than infinite resistance**

      Replace the Q6 Camshaft Position Actuator Solenoid Valve.

    - **If infinite resistance**
4. All OK

Repair Instructions

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

- **Camshaft Position Actuator Intake Solenoid Valve Replacement**
- **Camshaft Position Actuator Exhaust Solenoid Valve Replacement**
- **Camshaft Timing Chain, Sprocket, and Tensioner Cleaning and Inspection**
- **Camshaft Timing Chain and Tensioner Removal**
- **Control Module References** for engine control module replacement, programming, and setup

DTC P0016 OR P0017

Diagnostic Instructions

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

DTC Descriptors

DTC P0016

Crankshaft Position - Intake Camshaft Position Not Plausible

DTC P0017

Crankshaft Position - Exhaust Camshaft Position Not Plausible

Circuit/System Description

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

camshaft, and exhaust camshaft position.

Conditions for Running the DTC

- DTC P0335, P0336, P0340, P0341, P0365, P0366, P0641, and P0651 are not set.
- The engine is cranking or running.
- The crankshaft and camshaft position signals are synchronized.
- The camshaft position actuator solenoid valves are in the parked position.

The DTCs run continuously once the above conditions are met.

Conditions for Setting the DTC

The ECM detects a camshaft that is greater than 9 degrees advanced or 12 degrees retarded in relationship to the crankshaft.

Action Taken When the DTC Sets

DTCs P0016 and P0017 are Type B DTCs.

Conditions for Clearing the DTC

DTCs P0016 and P0017 are Type B DTCs.

Diagnostic Aids

- Inspect the engine for any recent engine mechanical repairs. An incorrectly installed timing chain can cause this DTC to set.
- A camshaft position actuator solenoid valve that is in the full advance or retard position can cause this DTC to set.

Reference Information

Description and Operation

Camshaft Actuator System Description

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0010, P0013, P0335, P0336, P0340, P0341, P0365, or P0366 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 timing chain that jumped teeth.
     - A crankshaft reluctor wheel that has moved in relationship to top dead center (TDC) on the crankshaft.

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

     A mechanical condition listed above still exists.

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

Repair Instructions

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

- **Camshaft Position Actuator Exhaust Solenoid Valve Replacement**
- **Camshaft Position Actuator Intake Solenoid Valve Replacement**
- **Camshaft Position Sensor Replacement - Exhaust**
- **Camshaft Position Sensor Replacement - Intake**
- **Crankshaft Position Sensor Replacement (FWD)** , **Crankshaft Position Sensor Replacement (AWD)**
- **Timing Chain Tensioner Replacement**

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

Diagnostic Instructions

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

DTC Descriptors

DTC P0030

HO2S Heater Control Circuit Sensor 1

DTC P0031

HO2S Heater Control Circuit Low Voltage Sensor 1

DTC P0032

HO2S Heater Control Circuit High Voltage Sensor 1

DTC P0036

HO2S Heater Control Circuit Sensor 2

DTC P0037

HO2S Heater Control Circuit Low Voltage Sensor 2

DTC P0038

HO2S Heater Control Circuit High Voltage Sensor 2

DTC P0053

HO2S Heater Resistance Sensor 1

DTC P0054

HO2S Heater Resistance Sensor 2

DTC P0135

HO2S Heater Performance Sensor 1

DTC P0141

HO2S Heater Performance Sensor 2

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
HO2S Heater Voltage Supply	P0030, P0036, P0037, P0097, P0102, P0132, P0134, P0135, P0138, P0141, P0443, P0597, P06DA, P11C2, P2199, *	P0030, P0031, P0036, P0037, P0132, P0134, P0135, P0138, P0140, P0141, P0154, P0155, P0158, P0160, P0161	P0690	P0135, P0141
HO2S Heater Control	P0030, P0031, P0036, P0037, P0053, P0054, P0135, P0141	P0030, P0036, P0053, P0132, P0134, P0135, P0138, P0140, P0141	P0030, P0032, P0036, P0038, P0132, P0134, P0135, P0138, P0140, P0141, P0690	P0135, P0141
* Opens Fuse				

Typical Scan Tool Data

HO2S Sensor 1 Current/HO2S Sensor 2 Current

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

Circuit/System Description

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

Conditions for Running the DTC

P0030-P0032 or P0036-P0038

- The ignition voltage is greater than 11 V.
- The engine speed is greater than 400 RPM.
- The DTCs run continuously when the above conditions are met.

P0053 or P0054

- DTCs P0112, P0113, P0117, P0118, or P2610 are not set.
- The ignition voltage is less than 32 V.
- The engine run time is less than 0.22 s.
- The ignition is OFF for greater than 8 h.
- The engine coolant temperature (ECT) is between -30 to +45°C (-22 to +113°F) at engine start-up.
- The ECT and the intake air temperature (IAT) are within 8°C (14°F) at engine start-up.
- The DTCs run once per drive cycle when the above conditions are met.

P0135 or P0141

- DTCs P0116, P0117, P0118, P0125, or P0128 are not set.
- The ignition voltage is between 10-32 V.
- The HO2S is at operating temperature.
- The DTCs run twice per drive cycle with a 30 s delay between tests and a 1 s execution rate when the above conditions are met for 120 s.

Conditions for Setting the DTC

P0030 or P0036

The engine control module detects an open in the heater circuits of the HO2S when the heater is commanded OFF for greater than 6 s.

P0031 or P0037

The engine control module detects a short to ground in the heater output low side driver circuit of the heated oxygen sensor when the heater is commanded OFF for greater than 6 s.

P0032 or P0038

The engine control module detects a short to voltage in the heater output low side driver circuit of the heated oxygen sensor when the heater is commanded ON for greater than 6 s.

P0053 or P0054

The ECM detects the HO2S heater is not within a specified resistance range at engine start-up.

P0135 or P0141

The ECM detects that the HO2S heater current is greater than 2.5 A or less than 0.3 A for greater than 10 s.

Action Taken When the DTC Sets

DTCs P0030-P0032, P0036-P0038, P0053, P0054, P0135, and P0141 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P0030-P0032, P0036-P0038, P0053, P0054, P0135, and P0141 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Engine running.
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 fail**
5. All OK.

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the appropriate B52 Heated Oxygen Sensor. Ignition ON.
2. Verify that a test lamp illuminates between the ignition voltage circuit terminal 2 and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition OFF.
   2. Test for less than 2 ohms in the ignition circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, verify the fuse is OK and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**
   1. Ignition OFF.
   2. Test for infinite resistance between the ignition circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, test all components connected to the fuse and replace as necessary.
   - **If the test lamp illuminates**
3. Verify that a test lamp does not illuminate between the ignition voltage circuit terminal 2 and the control circuit terminal 1.
   - **If the test lamp illuminates**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the control circuit and ground.
   - If less than infinite resistance, repair the short to ground on the circuit.
   - If infinite resistance, replace the K20 Engine Control Module.
   - **If the test lamp does not illuminate**
4. Remove the test lamp.
5. 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**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the control circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If OK is displayed**

NOTE:

- **Less than 10 ohms 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 1 and the ignition voltage circuit terminal 2.

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

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**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 ohms in the control circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 Engine Control Module.
   - **If Malfunction is displayed**
8. Test or replace the B52 Heated Oxygen Sensor.

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 an Heated Oxygen Sensor.
- **Control Module References** for Engine Control Module replacement, programming and setup

DTC P0033-P0035

Diagnostic Instructions

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

DTC Descriptors

DTC P0033

Turbocharger Bypass Solenoid Valve Control Circuit

DTC P0034

Turbocharger Bypass Solenoid Valve Control Circuit Low Voltage

DTC P0035

Turbocharger Bypass Solenoid Valve Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
Ignition Voltage Circuit	P0033, P0034, P0243, P0245, P0443, P06DA, P06DB*	0 P0033	P0033	-	-
Turbocharger Bypass Valve Solenoid Control Circuit	P0034	P0033	P0033	P0035, P0690	P0033
* Ignition fuse opens. A message center or an indicator displays ENGINE POWER IS REDUCED. Engine experiences NO Crank - NO Start condition.					

Circuit/System Description

The dual-scroll turbocharger incorporates a wastegate that is controlled by the engine control module (ECM) by means of a pulse width modulation (PWM) solenoid, to regulate the pressure ratio of the compressor. An ECM controlled compressor bypass valve is integrated into the unit to prevent compressor surging and damage from vibrations by opening during abrupt closed throttle conditions. The bypass valve is open during closed throttle deceleration conditions to allow air to recirculate in the turbocharger and maintain compressor speed.

As engine load and RPM increase, the turbocharger bypass valve is commanded closed by the ECM. As soon as the throttle closes, the valve is commanded open to allow the turbocharger air to recirculate to prevent compressor surging.

Conditions for Running the DTCs

- Ignition is On or the engine is running.
- Battery voltage is between 11-32 V.
- The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTCs

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 10 s.

Action Taken When the DTCs Set

DTCs P0033, P0034, and P0035 are Type B DTCs.

Conditions for Clearing the MIL/DTCs

DTCs P0033, P0034, and P0035 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

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.

Circuit/System Verification

1. Ignition On
2. Verify a click is heard or felt from the Q40 Turbocharger Bypass Solenoid Valve when commanding the Turbocharger Bypass Solenoid Valve between Active and Inactive with a scan tool.
    - **If a click is not heard or felt**

      Refer to Circuit/System Testing

    - **If a click is heard or felt**
3. Verify the circuit status parameters listed below do not display Malfunction when commanding the Turbocharger Bypass Solenoid Valve between Inactive and Active with a scan tool:
    - Turbocharger Bypass Solenoid Valve Control Circuit High Voltage Test Status
    - Turbocharger Bypass Solenoid Valve Control Circuit Open Test Status
    - Turbocharger Bypass Solenoid Valve Control Circuit Low Voltage Test Status
    - **If Malfunction is displayed**

      Refer to Circuit/System Testing

    - **If Malfunction is not displayed**
4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

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

     Refer to Circuit/System Testing

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

Circuit/System Testing

1. Ignition Off, disconnect the harness connector at the Q40 Turbocharger Bypass Solenoid Valve, 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**
   1. Ignition Off.
   2. Test for less than 2 ohms in the ignition circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, verify the fuse is not open and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**
   1. Ignition Off, remove the test lamp.

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

   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 supplied by the fuse and replace as necessary.
      - **If the test lamp illuminates**
3. Verify that a test lamp does not illuminate between the control circuit terminal 2 and the ignition circuit terminal 1.
   - **If the test lamp illuminates**
   1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the control circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.
   - **If the test lamp does not illuminate**
4. Remove the test lamp.
5. 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**
   1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module, ignition On.
   2. Test for less than 1 V between the control circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.

- If less than 1 V, replace the K20 Engine Control Module.
- **If OK is displayed**

6. Install a 3 A fused jumper wire between the control circuit terminal 2 and the ignition circuit terminal 1.
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**
   1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 ohms in the control circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 Engine Control Module.
   - **If Malfunction is displayed**
8. Test or replace the Q40 Turbocharger Bypass Solenoid Valve.

Component Testing

Static Test

1. Ignition Off, disconnect the harness connector at the Q40 Turbocharger Bypass Solenoid Valve.
2. Test for 10-14 ohms between the control terminal 2 and the Ignition terminal 1 of the Q40 Turbocharger Bypass Solenoid Valve.
   - **If not between 10-14 ohms**

     Replace the Q40 Turbocharger Bypass Solenoid Valve.

   - **If between 10-14 ohms**
3. All OK

Dynamic Test

1. Install a 10 A fused jumper wire between the ignition terminal 2 of the Q40 Turbocharger Bypass Solenoid Valve and 12 V. Install a jumper wire between the control terminal 1 and ground.
2. Verify the Q40 Turbocharger Bypass Solenoid Valve plunger retracts.
   - **If the plunger does not retract.**

     Replace the Q40 Turbocharger Bypass Solenoid Valve.

   - **If the plunger retracts.**
3. All OK

Repair Instructions

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

- **Turbocharger Bypass Valve Solenoid Replacement**

- **Control Module References** for ECM replacement, programming, and setup

DTC P0068 OR P1101

Diagnostic Instructions

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

DTC Descriptor

DTC P0068

Throttle Body Air Flow Performance

DTC P1101

Intake Air Flow System Performance

Circuit/System Description

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

Conditions for Running the DTC

DTC P0068

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

DTC P1101

- DTC P0101, P0102, P0103, P0107, P0108, P0111, P0112, P0113, P0116, P0117, P0118, P0128, P0335, or P0336 is not set
- The engine speed is between 575-6,600 RPM
- The engine coolant temperature (ECT) is between -7 to +129°C (+19 to +264°F).
- The intake air temperature (IAT) is between -20 to +125°C (-4 to +257°F).
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTCs

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

Action Taken When the DTCs Set

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

Conditions for Clearing the DTCs

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

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

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

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

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)** .

Circuit/System Verification

1. Ignition ON, verify that DTC DTC P0641, P0651, P0697, or P06A3 is not set.
    - **If any of the DTCs are set**

Refer to **DTC P0641, P0651, P0697, or P06A3 (ECM)** for further diagnosis.

- **If none of the DTCs are set**

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

     Refer to **Throttle Body Cleaning** .

   - **If less than 90 %**
4. Verify the scan tool Throttle Position Sensors 1 and 2 Agree/Disagree parameter displays Agree while performing the Throttle Sweep Test with a scan tool.
   - **If Disagree**

     Refer to **DTC P0121-P0123, P0222, P0223, P16A0-P16A2, or P2135** for further diagnosis.

   - **If Agree**
5. Determine the current vehicle testing altitude.
6. Verify the scan tool MAP Sensor pressure parameter is within the range specified in the **Altitude Versus Barometric Pressure** table.
   - **If the MAP Sensor parameter is not in range**

     Refer to **DTC P0106** for further diagnosis.

   - **If the MAP Sensor parameter is within range**
7. Verify the engine is equipped with a turbocharger.
   - **If not equipped with a turbocharger**

     Refer to Step 10.

   - **If equipped with a turbocharger**
8. 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**
9. 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**

10. 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**
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.
    1. Engine idling
    2. Perform the scan tool snapshot function.
    3. Increase the engine speed slowly to 3,000 RPM and then back to idle.
    4. Exit from the scan tool snapshot and review the data.
    5. Observe the MAF Sensor parameter frame by frame with a scan tool.
    - **If the MAF Sensor parameter does not change smoothly and gradually**

      Refer to **DTC P0101** for further diagnosis.

    - **If the MAF Sensor parameter changes smoothly and gradually**
12. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
13. Verify the DTC does not set.
    - **If the DTC sets**

      Refer to Circuit/System Testing.

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

Circuit/System Testing

NOTE: 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, improperly installed, collapsed, or restricted components
    - Improper operation of turbocharger wastegate actuator or bypass valve, where equipped
    - 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

Repair Instructions

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

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

DTC P0089, P00C6, P228C, OR P228D

Diagnostic Instructions

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

DTC Descriptors

DTC P0089

Fuel Pressure Regulator Performance

DTC P00C6

Fuel Rail Pressure Low During Engine Cranking

DTC P228C

Fuel Pressure Regulator Control Performance - Low Pressure

DTC P228D

Fuel Pressure Regulator Control Performance - High Pressure

Circuit/System Description

The fuel rail pressure sensor detects fuel pressure within the fuel rail. The engine control module (ECM) provides a 5 V reference voltage on the 5 V reference circuit and ground on the low reference circuit. The ECM receives a varying signal voltage on the signal circuit.

High pressure fuel is regulated by the high pressure fuel pump actuator, which is a part of the high pressure fuel pump. The high pressure fuel pump actuator is a solenoid valve. The ECM provides a voltage on the actuator high control circuit and ground on the actuator low control circuit. Both circuits are controlled through output drivers within the ECM. When deactivated, both drivers are disabled. When activated, the high control circuit driver energizes the high pressure fuel pump actuator and the low control circuit driver pulse-width modulates (PWM) the low control circuit to ground.

The high pressure mechanical fuel pump is driven by three lobes on the camshaft. The ECM uses the camshaft and crankshaft position sensor inputs to synchronize the high pressure fuel pump actuator with the position of each of the camshaft lobes. The ECM regulates fuel pressure by adjusting the portion of each pump stroke that provides fuel to the rail.

The ECM monitors the fuel rail fuel pressure sensor and the high pressure fuel pump actuator to determine if the commanded and actual pressure are within a predetermined range, or if the amount of fuel pressure correction exceeds a calibrated pressure.

Conditions for Running the DTC

P0089, P228C, or P228D

- DTC P0016, P0017, P0090, P0091, P0092, P00C8, P00C9, P00CA, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0128, P0191, P0192, P0193, P0335, P0336, P0340, P0341, P0365, P0366, P0628, or P1682 is not set.
- The ignition voltage is greater than 11 V.
- The engine is running.
- The low side fuel pressure is greater than 250 kPa (36 psi).
- The barometric (BARO) pressure is greater than 70 kPa.
- The intake air temperature (IAT) is warmer than -20°C (-4°F).
- The DTC runs continuously when the above conditions are met for 60 s.

P00C6

- DTC P0016, P0017, P0090, P0091, P0092, P00C8, P00C9, P00CA, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0128, P0191, P0192, P0193, P0335, P0336, P0340, P0341, P0365, P0366, P0628, or P1682 is not set.
- The ignition voltage is greater than 8 V.
- The engine coolant temperature is between -100 and +80°C (-148 and +176°F).
- The low side fuel pressure is greater than 0 kPa (0 psi).
- The engine is not running.
- The DTC runs once for each engine start.

Conditions for Setting the DTC

P0089

The high pressure fuel pump actuator command is greater than or equal to 100 ° or less than or equal to 0 °. The condition exists for greater than 5 s.

P00C6

The ECM detects that the fuel pressure is not rising or has fallen beyond acceptable limits during engine cranking.

P228C

The actual fuel rail pressure is 3 MPa (435 psi) less than the desired fuel pressure. The condition exists for greater than 5 s.

P228D

The actual fuel rail pressure is 3 MPa (435 psi) greater than the desired fuel rail pressure. The condition exists for greater than 5 s.

Action Taken When the DTC Sets

- DTCs P0089 and P00C6 are Type B DTCs.
- DTCs P228C and P228D are Type A DTCs.
- A message center or an indicator displays Reduced Engine Power.
- Scan tool control of the high pressure fuel pump is inhibited.

Conditions for Clearing the DTC

- DTCs P0089 and P00C6 are Type B DTCs.
- DTCs P228C and P228D are Type A DTCs.

Diagnostic Aids

- A restricted fuel feed pipe between the fuel feed pipe fuel pressure sensor and the high pressure fuel pump may set a DTC.
- A condition with the fuel tank fuel pump module or the fuel pump power control module may set a DTC.
- A skewed fuel rail pressure sensor, or an intermittent condition in the fuel rail pressure sensor circuits may set a DTC.
- A leaking or restricted fuel injector may set a DTC.
- A short to voltage in the crankshaft position signal circuit may set a DTC.
- A short to voltage in the camshaft position actuator solenoid valve control circuit may set a DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

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Fuel System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0628, P069E, or U0109 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. Attempt to start and idle the engine.
4. Verify DTC P0089, P00C6, P228C, or P228D is not set.
   - **If any of the DTCs are set**

     Refer to Circuit/System Testing.

   - **If none of the DTCs are set**
5. Engine idling.
6. Verify the scan tool Fuel Rail Pressure Sensor parameter is approximately 2.96-3.24 Mpa (429-470 psi).
   - **If not between 2.96-3.24 Mpa (429-470 psi)**

     Refer to Circuit/System Testing.

- **If between 2.96-3.24 Mpa (429-470 psi)**

7. Command an increase and decrease in Fuel Rail Pressure with a scan tool. Verify the scan tool Fuel Rail Pressure Sensor parameter increases or decreases with each commanded state.
   - **Does not change**

     Refer to Circuit/System Testing.

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

     Refer to Circuit/System Testing.

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

Circuit/System Testing

NOTE: Circuit/System Verification must be performed first or misdiagnosis may result.

1. Ignition ON.
2. Command an increase in Fuel Pressure with a scan tool. Verify the scan tool Fuel Pressure Sensor parameter increases to greater than 414 kPa (60 psi) as commanded.
   - **Does not increase**

     Refer to **Fuel System Diagnosis** for further diagnosis.

   - **Increases**
3. Remove the G18 High Pressure Fuel Pump.
4. Inspect the lobes on the camshaft for unusual wear.
   - **Lobes are worn**

     Replace the camshaft.

   - **Lobes are normal**

     Replace the G18 High Pressure Fuel Pump.

Component Testing

Static Test

1. Ignition OFF, disconnect the harness connector at the G18 High Pressure Fuel Pump.

NOTE: The DMM and test leads must be calibrated to 0 ohms in order to prevent misdiagnosis.

2. Test for 0.3-0.7 ohms at 20°C (68°F) between the high control circuit terminal 1 and the low control circuit terminal 2.
   - **If not between 0.3-0.7 ohms**

     Replace the G18 High Pressure Fuel Pump.

   - **If between 0.3-0.7 ohms**
3. Test for infinite resistance between each terminal and the G18 High Pressure Fuel Pump housing.
   - **If less than infinite resistance**

     Replace the G18 High Pressure Fuel Pump.

   - **If infinite resistance**
4. All OK

Repair Instructions

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

- **Camshaft Position Actuator and Camshaft Replacement - Intake**
- **Fuel Injection Fuel Rail Fuel Pressure Sensor Replacement**
- **Fuel Pump Replacement**
- Perform the Fuel Rail Pressure Relief Valve Reset procedure, if supported on the scan tool.

DTC P0090-P0092, P00C8, P00C9, OR P00CA

Diagnostic Instructions

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

DTC Descriptors

DTC P0090

Fuel Pressure Regulator Control Circuit

DTC P0091

Fuel Pressure Regulator Control Circuit Low Voltage

DTC P0092

Fuel Pressure Regulator Control Circuit High Voltage

DTC P00C8

Fuel Pressure Regulator High Control Circuit

DTC P00C9

Fuel Pressure Regulator High Control Circuit Low Voltage

DTC P00CA

Fuel Pressure Regulator High Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
High Pressure Fuel Pump Actuator High Control	P0091, P00C9	P0090, P00C8	P0092, P00C9, P00CA, P0690	-
High Pressure Fuel Pump Actuator Low Control	P0091, P00C9	P0090, P00C8	P0092, P00C9, P00CA, P0690	-

Circuit/System Description

High pressure fuel is regulated by the high pressure fuel pump actuator, which is a part of the high pressure fuel pump. The high pressure fuel pump actuator is a solenoid valve. The engine control module (ECM) provides battery voltage on the actuator high control circuit and ground on the actuator low control circuit. Both circuits are controlled through output drivers within the ECM. When deactivated, both drivers are disabled. When activated, the high control circuit driver energizes the high pressure fuel pump actuator and the low control circuit driver pulse-width modulates (PWM) the low control circuit to ground. The ECM monitors the voltage on the circuits to detect a failure.

Conditions for Running the DTC

- The ignition voltage is greater than 11 V.
- The engine speed is greater than 50 RPM.
- The DTCs run continuously within the enabling conditions.

Conditions for Setting the DTC

P0090

- The ECM detects an open circuit in the high pressure fuel pump actuator low control circuit.
- The DTC sets when the above condition is present for 4 s.

P0091

- The ECM detects a short to ground in the high pressure fuel pump actuator low control circuit.
- The DTC sets when the above condition is present for 4 s.

P0092

- The ECM detects a short to voltage in the high pressure fuel pump actuator low control circuit.
- The DTC sets when the above condition is present for 4 s.

P00C8

- The ECM detects an open circuit in the high pressure fuel pump actuator high control circuit.
- The DTC sets when the above condition is present for 4 s.

P00C9

- The ECM detects a short to ground in the high pressure fuel pump actuator high control circuit.
- The DTC sets when the above condition is present for 4 s.

P00CA

- The ECM detects a short to voltage in the high pressure fuel pump actuator high control circuit.
- The DTC sets when the above condition is present for 4 s.

Action Taken When the DTC Sets

- DTCs P0090, P0091, P0092, P00C8, P00C9, and P00CA are Type A DTCs.
- A message center or an indicator displays Reduced Engine Power.

Conditions for Clearing the DTC

DTCs P0090, P0091, P0092, P00C8, P00C9, and P00CA are Type A DTCs.

Reference Information

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- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0090, P0091, P0092, P00C8, P00C9, P00CA, P0685, or P1682 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. Command the Fuel Pressure Regulator ON and OFF with a scan tool while observing the following control circuit status parameters:
   - Fuel Pressure Regulator Control Circuit High Voltage Test Status
   - Fuel Pressure Regulator Control Circuit Open Test Status
   - Fuel Pressure Regulator Control Circuit Low Voltage Test Status
   - Fuel Pressure Regulator High Control Circuit High Voltage Test Status
   - Fuel Pressure Regulator High Control Circuit Open Test Status
   - Fuel Pressure Regulator High Control Circuit Low Voltage Test Status
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing.

   - **If OK or Not Run is displayed**
4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
5. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing

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

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the G18 High Pressure Fuel Pump.
2. Ignition ON, verify that a test lamp does not illuminate between the high control circuit terminal 1 and

ground and the low control circuit terminal 2 and ground.

- **If the test lamp illuminates**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the appropriate 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**

3. Verify that a test lamp does not illuminate between the high control circuit terminal 1 and B+ and the low control circuit terminal 2 and B+.

- **If the test lamp illuminates**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the appropriate control circuit and ground.
   - If less than infinite resistance, repair the short to ground on the circuit.
   - If infinite resistance
3. Test for less than 2 ohms in the control circuit end to end.
   - If 2 ohms or greater, repair the open/high resistance in the circuit.
   - If less than 2 ohms, replace the K20 Engine Control Module.

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

4. Connect a 3 A fused jumper wire between the high control circuit terminal 1 and ground.
5. Verify the Fuel Pressure Regulator High Control Circuit Open Test Status transitions from Malfunction to OK and the Fuel Pressure Regulator High Control Circuit Low Voltage Test Status transitions from OK to Malfunction.

- **The parameters do not change**

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

- **The parameters change**

6. Connect a 3 A fused jumper wire between the low control circuit terminal 2 and B+.
7. Verify the Fuel Pressure Regulator Control Circuit Open Test Status transitions from Malfunction to OK and the Fuel Pressure Regulator Control Circuit High Voltage Test Status transitions from OK to Malfunction.

- **The parameters do not change**

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

- **The parameters change**

8. Test or replace the G18 High Pressure Fuel Pump.

Component Testing

Static Test

1. Ignition OFF, disconnect the harness connector at the G18 High Pressure Fuel Pump.

   NOTE: The DMM and test leads must be calibrated to 0 ohms in order to prevent misdiagnosis.

2. Test for 0.3-0.7 ohms at 20°C (68°F) between the high control circuit terminal 1 and the low control circuit terminal 2.
   - **If not between 0.3-0.7 ohms**

     Replace the G18 High Pressure Fuel Pump.

   - **If between 0.3-0.7 ohms**
3. Test for infinite resistance between each terminal and the G18 High Pressure Fuel Pump housing.
   - **If less than infinite resistance**

     Replace the G18 High Pressure Fuel Pump.

   - **If infinite resistance**
4. All OK

Repair Instructions

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

- **Fuel Pump Replacement**
- **Control Module References** for K20 Engine Control Module replacement, setup, and programming
- Perform the Fuel Rail Pressure Relief Valve Reset procedure, if supported on the scan tool.

DTC P0096 OR P0111

Diagnostic Instructions

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

DTC Descriptor

DTC P0096

Intake Air Temperature (IAT) Sensor 2 Performance

DTC P0111

Intake Air Temperature (IAT) Sensor 1 Performance

Diagnostic Fault Information

IAT Sensor 1

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	P0112, P0114**, P2199**	P0111, P0113, P0114**, P2199**	P0113*, P0114**, P2199**	P0111, P2199**
Low Reference	-	P0111, P0113, P0114**, P2199**	P0113*, P0114**	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+. **Where used.				

IAT Sensor 2

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0096, P0097, P00F4, P0102, P2199**	P0096, P0097, P00F4, P0102, P2199**	-	P0096
Signal	P0096, P0097, P00F5, P2199**	P0096, P0097, P00F4, P0102, P2199**	P0096*, P0097, P00F4, P0102, P2199**	P0096
Ground	-	P0096, P0097, P00F4, P0102, P2199**	-	P0096
*Internal ECM or sensor damage may occur if the circuit is shorted to B+. **Where used.				

Typical Scan Tool Data

IAT Sensor 1

Circuit	Short to Ground	Open or High Resistance	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** Varies with ambient temperature			
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+			

IAT Sensor 2

Circuit	Short to Ground	Open or High Resistance	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** Varies with ambient temperature			
Ignition Voltage	-40°C (-40°F) 10 Hz	-40°C (-40°F) 10 Hz	-
	-40°C (-40°F)	-40°C (-40°F)	-40°C (-40°F)

Signal	10 Hz	10 Hz	10 Hz*
Ground	-	-40°C (-40°F) 10 Hz	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+			

Circuit/System Description

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

The IAT sensor 2 produces a frequency signal based on the inlet air temperature very close to the humidity sensor within the sensor bore. The signal varies with inlet air temperature and is displayed by the scan tool as °C (°F) and Hertz (Hz). The ECM applies 5 V to the circuit. The signal circuit is shared by the IAT sensor 2 and the humidity sensor. Ignition voltage and ground circuits are also supplied to the multifunction intake air sensor's internal circuits for these sensors:

- IAT sensor 2
- Humidity sensor
- MAF sensor

The multifunction intake air sensor houses the following:

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

IAT Sensor 1 - Temperature, Resistance, Voltage Table

IAT Sensor 1	IAT Sensor 1 Resistance	IAT Sensor 1 Signal Voltage
Cold	High	High
Warm	Low	Low

IAT Sensor 2 - Temperature, Frequency Table

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

Conditions for Running the DTCs

P0096 and P0111

- DTCs P0097, P0098, P0112, P0113, P0117, P0118, P0119, or P1682 are not set.
- The vehicle has been OFF at least 8 hours.
- Ignition 1 voltage is at least 11 V.

- These DTCs run once per ignition cycle when the enabling conditions are met.

Conditions for Setting the DTCs

P0096

- The ECM determines the absolute difference between IAT sensor 1 start-up temperature and the IAT sensor 2 start-up temperature is greater than 30°C (54°F).

  AND

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

P0111

- The ECM determines the absolute difference between IAT sensor 1 start-up temperature and the IAT sensor 2 start-up temperature is greater than 30°C (54°F).

  AND

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

Action Taken When the DTCs Set

DTCs P0096 and P0111 are Type B DTCs.

Conditions for Clearing the DTCs

DTCs P0096 and P0111 are Type B DTCs.

Diagnostic Aids

The humidity sensor and the IAT sensor 2 signals are sent to the ECM on the same circuit. If the IAT Sensor 2 parameter displays the values: 10 Hz; -40°C (-40°F), and there are also Humidity Sensor DTCs, check for a circuit problem.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

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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

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)** .

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC DTC P0641, P0651, P0697, or P06A3 is not set.
   - **If any of the DTCs are set**

     Refer to **DTC P0641, P0651, P0697, or P06A3 (ECM)** 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 30°C (54°F) of each other.
   - Start-Up IAT Sensor 1
   - IAT Sensor 2
   - IAT Sensor 3; where equipped

- **If not within 30°C (54°F)**

  Refer to Circuit/System Testing.

- **If within 30°C (54°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

Circuit/System Testing

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

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

Repair or replace component as appropriate.

- **If no condition exists**

2. Ignition OFF, and all vehicle systems OFF, 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 ohms between the low reference circuit terminal 3 and ground.
   - **If 2 ohms or greater**
     1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
     2. Test for less than 2 ohms in the low reference circuit end to end.
        - If 2 ohms or greater, repair the open or high resistance in the circuit.
        - If less than 2 ohms replace the K20 Engine Control Module.
   - **If less than 2 ohms**
4. Ignition OFF, all vehicle systems OFF, test for less than 2 ohms between the ground circuit terminal 7 and ground.
   - **If 2 ohms or greater**
     1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
     2. Test for less than 2 ohms in the ground circuit end to end.
        - If 2 ohms or greater, repair the open or high resistance in the circuit.
        - If less than 2 ohms, repair the open/high resistance in the ground connection.
   - **If less than 2 ohms**
5. Ignition ON, verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**
     1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
     2. Test for less than 2 ohms in the ignition voltage circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, verify the fuse is not open and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**
     1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
     2. Test for infinite resistance between the ignition voltage circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
     3. Test for greater than 2 ohms between the ignition voltage circuit terminal 5 and ground.
        - If less than 2 ohms, repair the short to ground on the circuit.
        - If greater than 2 ohms, test all the components connected to the circuit and repair or replace as necessary.
   - **If a test lamp illuminates**
6. Ignition ON, test for 4.8-5.2 V between the intake air temperature sensor 1 signal circuit terminal 1 and ground.
   - **If less than 4.8 V**
     1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
     2. Test for infinite resistance between the signal circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit

- If infinite resistance

3. Test for less than 2 ohms in the signal circuit end to end.
   - If 2 ohms or greater, repair the open/high resistance in the circuit.
   - If less than 2 ohms, replace the K20 Engine Control Module.

- **If greater than 5.2 V**

NOTE: If the signal circuit is shorted to a voltage the engine control module or the sensor may be damaged.

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Ignition ON, test for less than 1 V between the signal circuit and ground.
   - If 1 V or greater, repair the short to voltage on the circuit.
   - If less than 1 V, replace the K20 Engine Control Module.

- **If between 4.8-5.2 V**

7. Ignition ON, verify the scan tool IAT Sensor 1 parameter is colder than -39°C (-38°F).
   - **If warmer than -39°C (-38°F).**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the signal circuit terminal 1 and ground.
   - If less than infinite resistance, repair the short to ground on the circuit.
   - If infinite resistance
3. Test for less than 2 ohms in the signal circuit end to end.
   - If 2 ohms or greater, repair the open/high resistance in the circuit.
   - If less than 2 ohms, replace the K20 Engine Control Module.

- **If colder than -39°C (-38°F).**

8. Ignition OFF, install a 3 A fused jumper wire between the signal circuit terminal 1 and the low reference circuit terminal 3.
9. Verify the scan tool IAT Sensor 1 parameter is warmer than 148°C (298°F).
   - **If colder than 148°C (298°F).**

1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the signal circuit and ground.
   - If 1 V or greater, repair the short to voltage on the circuit.
   - If less than 1 V
3. Ignition OFF.
4. Test for less than 2 ohms in the signal circuit end to end.
   - If 2 ohms or greater, repair the open/high resistance in the circuit.
   - If less than 2 ohms, replace the K20 Engine Control Module.

- **If warmer than 148°C (298°F).**

10. Ignition ON, test for 4.8-5.2 V between the intake air temperature sensor 2 signal circuit terminal 8 and ground.
    - **If less than 4.8 V**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the signal circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance
3. Test for less than 2 ohms in the signal circuit end to end.
    - If 2 ohms or greater, repair the open/high resistance in the circuit.
    - If less than 2 ohms, replace the K20 Engine Control Module.

- **If greater than 5.2 V**

NOTE: If the signal circuit is shorted to a voltage the engine control module or the sensor may be damaged.

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

11. Determine if **EL-38522-A** Variable Signal Generator or equivalent is available.
    - **EL-38522-A, Variable Signal Generator; or equivalent is not available**
    1. Replace the K20 Engine Control Module.
    2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
    3. Verify the DTC does not set.
        - **If the DTC sets**

          Refer to step 21.

        - **If the DTC does not set**
    4. All OK.
    - **EL-38522-A, Variable Signal Generator; or equivalent is available**
12. Ignition OFF, connect the leads of the **EL-38522-A** Variable Signal Generator as follows:
    - Red lead to the signal circuit terminal 8 at the harness connector
    - Black leads to ground
    - Battery voltage supply lead to B+
13. Set the **EL-38522-A** Variable Signal Generator to the following specifications.
    - Signal switch to 5 V
    - Duty Cycle switch to 50 % (Normal)
    - Frequency switch to 30 Hz
14. 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**

15. 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.
16. Test for less than 2 ohms between the intake air temperature sensor 3 low reference circuit terminal 1 and ground.
    - **If 2 ohms or greater**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for less than 2 ohms in the low reference circuit end to end.
        - If 2 ohms or greater, repair the open or high resistance in the circuit.
        - If less than 2 ohms replace the K20 Engine Control Module.
    - **If less than 2 ohms**
17. Ignition ON, test for 4.8-5.2 V between the signal circuit terminal 2 and ground.
    - **If less than 4.8 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 ohms in the signal circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
    - **If greater than 5.2 V**

      NOTE: If the signal circuit is shorted to a voltage the engine control module or the sensor may be damaged.

    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    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**
18. Ignition ON, verify the scan tool IAT Sensor 3 parameter is colder than -39°C (-38°F).
    - **If warmer than -39°C (-38°F).**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit terminal 2 and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 ohms in the signal circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
    - **If colder than -39°C (-38°F).**

19. Ignition OFF, install a 3 A fused jumper wire between the signal circuit terminal 2 and the low reference circuit terminal 1.
20. Verify the scan tool IAT Sensor 3 parameter is warmer than 148°C (298°F).
    - **If colder than 148°C (298°F).**
    1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V
    3. Ignition OFF.
    4. Test for less than 2 ohms in the signal circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
    - **If warmer than 148°C (298°F).**
21. Test or replace the appropriate temperature sensor.

Component Testing

Multifunction Intake Air Sensor

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

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

2. Test the IAT sensor 1 by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the **Temperature Versus Resistance - Intake Air Temperature Sensor (Hitachi Sensor)** , **Temperature Versus Resistance - Intake Air Temperature Sensor (Delco Sensor)** table for Hitachi Sensors. The resistance values should be in range of the table values.
    - **If not within the specified range**

      Replace the B75C Multifunction Intake Air Sensor.

    - **If within the specified range**
3. All OK.

Multifunction Intake Air Sensor

1. Test the IAT Sensor 2 by varying the sensor temperature while monitoring the air temperature with a thermometer. Compare the readings with the scan tool IAT Sensor 2 parameter. The values should be within 5%.
    - **If not within the specified range**

      Replace the B75C Multifunction Intake Air Sensor.

    - **If within the specified range**
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 (Hitachi Sensor)** , **Temperature Versus Resistance - Intake Air Temperature Sensor (Delco Sensor)** table for Delco Sensors. The resistance values should be in range of the table values.
   - **If not within the specified range**

     Replace the B111B Turbocharger Boost/Intake Air Temperature sensor.

   - **If within the specified range**
3. All OK.

Repair Instructions

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

- **Intake Air Pressure and Temperature Sensor Replacement** for turbocharger boost/intake air temperature sensor replacement
- **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement** for multifunction intake air sensor replacement
- **Control Module References** for engine control module replacement, programming, and setup

DTC P0097, P0098, OR P0099

Diagnostic Instructions

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

DTC Descriptors

DTC P0097

Intake Air Temperature (IAT) Sensor 2 Circuit Low Voltage

DTC P0098

Intake Air Temperature (IAT) Sensor 2 Circuit High Voltage

DTC P0099

Intake Air Temperature (IAT) Sensor 2 Circuit Intermittent

Diagnostic Fault Information

IAT Sensor 2

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0096, P0097, P00F4, P0102, P2199**	P0096, P0097, P00F4, P0102, P2199**	-	P0096
Signal	P0096, P0097, P00F5, P2199**	P0096, P0097, P00F4, P0102, P2199**	P0096*, P0097, P00F4, P0102, P2199**	P0096
Ground	-	P0096, P0097, P00F4, P0102, P2199**	-	P0096
*Internal ECM or sensor damage may occur if the circuit is shorted to B+. **Where used.				

Typical Scan Tool Data

IAT Sensor 2

Circuit	Short to Ground	Open or High Resistance	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** Varies with ambient temperature			
Ignition Voltage	-40°C (-40°F) 10 Hz	-40°C (-40°F) 10 Hz	-
Signal	-40°C (-40°F) 10 Hz	-40°C (-40°F) 10 Hz	-40°C (-40°F)* 10 Hz
Ground	-	-40°C (-40°F) 10 Hz	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+			

Circuit/System Description

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

The IAT sensor 2 produces a frequency signal based on the inlet air temperature very close to the humidity sensor within the sensor bore. The signal varies with inlet air temperature and is displayed by the scan tool as °C (°F) and Hertz (Hz). The ECM applies 5 V to the circuit. The signal circuit is shared by the IAT sensor 2 and the humidity sensor. Ignition voltage and ground circuits are also supplied to the multifunction intake air sensor's internal circuits for these sensors:

- IAT sensor 2
- Humidity sensor
- Mass Air Flow (MAF) sensor

The multifunction intake air sensor houses the following:

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

IAT Sensor 1 - Temperature, Resistance, Voltage Table

IAT Sensor 1	IAT Sensor 1 Resistance	IAT Sensor 1 Signal Voltage
Cold	High	High
Warm	Low	Low

IAT Sensor 2 - Temperature, Frequency Table

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

Conditions for Running the DTCs

P0097, P0098, and P0099

- The ignition is ON, or the engine is running.
- The Ignition 1 voltage is at least 11 V.
- The DTCs run continuously within the enabling conditions.
- Where P0099 is used, the DTC runs continuously within the enabling conditions.

Conditions for Setting the DTCs

P0097

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

The ECM detects that the IAT sensor 2 signal is less than 13 Hz, colder than -60°C (-76°F), for greater than 5 s.

P0098

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

P0099

Where P0099 used, the ECM detects that the IAT sensor 2 signal is intermittent or has abruptly changed for longer than 5 s.

Action Taken When the DTC Sets

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

Conditions for Clearing the MIL/DTCs

- DTCs P0097, P0098, and P0099* are Type B DTCs.
- *Where used..

Diagnostic Aids

- With the ignition ON, the engine OFF, if the engine is cold, a properly functioning IAT sensor 2 will gradually increase the scan tool IAT Sensor 2 parameter. This is due to the heat that is generated by the MAF sensor heating elements.
- The humidity sensor and the IAT sensor 2 signals are sent to the ECM on the same circuit. If the IAT Sensor 2 parameter displays the values: 10 Hz; -40°C (-40°F), and there are also Humidity Sensor DTCs, check for a circuit problem.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

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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

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)** .

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC DTC P0641, P0651, P0697, or P06A3 is not set.
   - **If any of the DTCs are set**

     Refer to **DTC P0641, P0651, P0697, or P06A3 (ECM)** 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 30°C (54°F) of each other.
   - Start-Up IAT Sensor 1
   - IAT Sensor 2
   - IAT Sensor 3; where equipped
   - **If not within 30°C (54°F)**

     Refer to Circuit/System Testing.

   - **If within 30°C (54°F)**
5. Engine idling, verify the following scan tool parameters are between: 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

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 ohms between the low reference circuit terminal 3 and ground.
   - **If 2 ohms or greater**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 ohms in the low reference circuit end to end.
      - If 2 ohms or greater, repair the open or high resistance in the circuit.
      - If less than 2 ohms replace the K20 Engine Control Module.
   - **If less than 2 ohms**
3. Ignition OFF, all vehicle systems OFF, test for less than 2 ohms between the ground circuit terminal 7 and ground.
   - **If 2 ohms or greater**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 ohms in the ground circuit end to end.
      - If 2 ohms or greater, repair the open or high resistance in the circuit.
      - If less than 2 ohms, repair the open/high resistance in the ground connection.
   - **If less than 2 ohms**
4. Ignition ON, verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
   2. Test for less than 2 ohms in the ignition voltage circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, verify the fuse is not open and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**
   1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
   2. Test for infinite resistance between the ignition voltage circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for greater than 2 ohms between the ignition voltage circuit terminal 5 and ground.
      - If less than 2 ohms, repair the short to ground on the circuit.
      - If greater than 2 ohms, test all the components connected to the circuit and repair or replace as necessary.
   - **If a test lamp illuminates**
5. Ignition ON, test for 4.8-5.2 V between the intake air temperature sensor 2 signal circuit terminal 8

and ground.

- **If less than 4.8 V**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the signal circuit and ground.
   - If less than infinite resistance, repair the short to ground on the circuit.
   - If infinite resistance
3. Test for less than 2 ohms in the signal circuit end to end.
   - If 2 ohms or greater, repair the open/high resistance in the circuit.
   - If less than 2 ohms, replace the K20 Engine Control Module.

- **If greater than 5.2 V**

NOTE: If the signal circuit is shorted to a voltage the engine control module or the sensor may be damaged.

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
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**
   1. Replace the K20 Engine Control Module.
   2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
   3. Verify the DTC does not set.
      - **If the DTC sets**

        Refer to step 10.

      - **If the DTC does not set**
   4. All OK.
   - **EL-38522-A, Variable Signal Generator; or equivalent is available**
7. Ignition OFF, connect the leads of the **EL-38522-A** Variable Signal Generator as follows:
   - Red lead to the signal circuit terminal 8 at the harness connector
   - Black leads to ground
   - Battery voltage supply lead to B+
8. Set the **EL-38522-A** Variable Signal Generator to the following specifications.
   - Signal switch to 5 V
   - Duty Cycle switch to 50 % (Normal)
   - Frequency switch to 30 Hz
9. Ignition ON, verify the scan tool IAT Sensor 2 parameter is between 28-32 Hz.
   - **If not between 28-32 Hz**

Replace the K20 Engine Control Module.

- **If between 28-32 Hz**

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

Component Testing

Multifunction Intake Air Sensor

1. 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 the specified range**

     Replace the B75C Multifunction Intake Air Sensor.

   - **If within the specified range**
2. All OK.

Repair Instructions

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

- **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement** for multifunction intake air sensor replacement
- **Control Module References** for engine control module replacement, programming, and setup.

DTC P00C7 (LTG)

Diagnostic Instructions

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

DTC Descriptor

DTC P00C7

Intake Air Pressure Measurement System - Multiple Sensors Not Plausible

Circuit/System Description

The Intake Air Pressure Measurement System consists of 3 sensors, the barometric pressure (BARO) sensor, the manifold absolute pressure (MAP) sensor, and the Turbocharger Boost sensor.

Conditions for Running the DTC

- DTCs P0106, P0107, P0108, P0237, P0238, P2227, P2228, P2229, P2230 or P2610 are not set.

- The engine is not running.
- Time between current ignition cycle and the last time the engine was running is greater than 10 s.
- Manifold pressure between 50-115 kPa (7.25-16.68 PSI).
- BARO pressure between 50-115 kPa (7.25-16.68 PSI).
- Turbocharger boost pressure between 50-115 kPa (7.25-16.68 PSI).
- This DTC runs continuously within the enabling conditions.

Conditions for Setting the DTC

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

Action Taken When the DTC Sets

DTC P00C7 is a Type B DTC.

Conditions for Clearing the DTC

DTC P00C7 is a Type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

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- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON, observe the DTC information with a scan tool. Verify that DTCs P0106, P0107, P0236,

P0237, P0238, P2227, P2228, P2229 or P2230 are not set.

- **If any of the DTCs are set**

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

- **If none of the DTCs is set**

2. Ignition ON, verify the following scan tool parameters are within range of the Altitude vs. Barometric Pressure table. Refer to: **Altitude Versus Barometric Pressure** 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 P2227-P2230**
   - Manifold Absolute Pressure (MAP) Sensor. Refer to: **DTC P0106**
   - Turbocharger Boost Pressure Sensor. Refer to: **DTC P0236**, or **DTC P0237 or P0238**
   - **If all sensor parameters are within range**
3. All OK

Repair Instructions

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

Control Module References for ECM replacement, programming and setup

DTC P00E9

Diagnostic Instructions

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

DTC Descriptor

DTC P00E9

Intake Air Temperature (IAT) Sensor 3 Circuit Performance

Diagnostic Fault Information

IAT Sensor 3

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
		P00E9, P00EB,	P00EB,	

Signal	P00EA, P00EB	P00EC	P00EC*	P00E9
Low Reference	-	P00E9, P00EB, P00EC	P00EB, P00EC*	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

IAT Sensor 3

Circuit	Short to Ground	Open or High Resistance	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** Varies with ambient temperature; and engine bay conditions			
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+			

Circuit/System Description

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

IAT Sensor 3 - Temperature, Resistance, Voltage Table

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

Conditions for Running the DTC

P00E9

- DTCs P0097, P0098, P0112, P0113, P0117, P0118, P0119, P00EA, or P00EB are not set.
- The vehicle has been OFF at least 8 hours.
- Ignition voltage is at least 11 V.
- These DTCs run once per ignition cycle when the enabling conditions are met.

Conditions for Setting the DTC

P00E9-Condition 1

- The ECM determines the absolute difference between IAT sensor 1 start-up temperature and the IAT sensor 2 start-up temperature is less or equal to 30°C (54°F).

AND

- The ECM determines the absolute difference between IAT sensor 3 start-up temperature and the IAT

sensor 1 start-up temperature is greater than 25°C (77°F).

AND

- The ECM determines the absolute difference between IAT sensor 3 start-up temperature and the IAT sensor 2 start-up temperature is greater than 25°C (77°F).

P00E9-Condition 2

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

AND

- The ECM determines the absolute difference between IAT sensor 3 start-up temperature and the IAT sensor 2 start-up temperature is greater than 25°C (77°F).

AND

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

P00E9-Condition 3

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

AND

- The ECM determines the absolute difference between IAT sensor 3 start-up temperature and the IAT sensor 1 start-up temperature is greater than 25°C (77°F).

AND

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

Action Taken When the DTC Sets

DTC P00E9 is a Type B DTC.

Conditions for Clearing the DTCs

DTC P00E9 is a Type B DTC.

Reference Information

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Engine Controls Schematics

Connector End View Reference

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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

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)** .

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC P0641, P0651, P0697, or P06A3 is not set.
   - **If any of the DTCs are set**

     Refer to **DTC P0641, P0651, P0697, or P06A3 (ECM)** 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 30°C (54°F) of each other.

- Start-Up IAT Sensor 1
- IAT Sensor 2
- IAT Sensor 3
- **If not within 30°C (54°F)**

  Refer to Circuit/System Testing.

- **If within 30°C (54°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
   - **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

Circuit/System Testing

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

1. Check the integrity of the entire air induction system and verify that none of the following conditions exist:
   - A loose or disconnected charge air cooler hose or pipe; where equipped
   - A blocked or obstructed charge air cooler, including: after-market grill covers; where equipped
   - Any snow or ice build-up at the charge air cooler in cold climates; where equipped
   - Any mud or dirt build-up at the charge air cooler; where equipped
   - A restricted or collapsed air intake duct
   - An intake manifold leak
   - A MAP sensor seal that is leaking, missing, or damaged
   - A restricted or collapsed air intake duct
   - A misaligned or damaged air intake duct

- Any water intrusion in the induction system
- An Intake Manifold Resonator with a leaking seal, or a cracked or broken housing

- **If a condition exists**

  Repair or replace component as appropriate.

- **If no condition exists**

2. Ignition OFF, and all vehicle systems OFF, 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 ohms between the low reference circuit terminal 3 and ground.
   - **If 2 ohms or greater**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 ohms in the low reference circuit end to end.
      - If 2 ohms or greater, repair the open or high resistance in the circuit.
      - If less than 2 ohms replace the K20 Engine Control Module.
   - **If less than 2 ohms**
4. Ignition OFF, all vehicle systems OFF, test for less than 2 ohms between the ground circuit terminal 7 and ground.
   - **If 2 ohms or greater**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 ohms in the ground circuit end to end.
      - If 2 ohms or greater, repair the open or high resistance in the circuit.
      - If less than 2 ohms, repair the open/high resistance in the ground connection.
   - **If less than 2 ohms**
5. Ignition ON, verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
   2. Test for less than 2 ohms in the ignition voltage circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, verify the fuse is not open and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**
   1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
   2. Test for infinite resistance between the ignition voltage circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for greater than 2 ohms between the ignition voltage circuit terminal 5 and ground.
      - If less than 2 ohms, repair the short to ground on the circuit.
      - If greater than 2 ohms, test all the components connected to the circuit and repair or replace as necessary.
   - **If a test lamp illuminates**
6. Ignition ON, test for 4.8-5.2 V between the intake air temperature signal 1 circuit terminal 1 and ground.

- **If less than 4.8 V**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the signal circuit and ground.
   - If less than infinite resistance, repair the short to ground on the circuit.
   - If infinite resistance
3. Test for less than 2 ohms in the signal circuit end to end.
   - If 2 ohms or greater, repair the open/high resistance in the circuit.
   - If less than 2 ohms, replace the K20 Engine Control Module.

- **If greater than 5.2 V**

NOTE: If the signal circuit is shorted to a voltage the engine control module or the sensor may be damaged.

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Ignition ON, test for less than 1 V between the signal circuit and ground.
   - If 1 V or greater, repair the short to voltage on the circuit.
   - If less than 1 V, replace the K20 Engine Control Module.

- **If between 4.8-5.2 V**

7. Ignition ON, verify the scan tool IAT Sensor 1 parameter is colder than -39°C (-38°F).
   - **If warmer than -39°C (-38°F).**

   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the signal circuit terminal 1 and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 ohms in the signal circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 Engine Control Module.

   - **If colder than -39°C (-38°F).**
8. Ignition OFF, install a 3 A fused jumper wire between the signal circuit terminal 1 and the low reference circuit terminal 3.
9. Verify the scan tool IAT Sensor 1 parameter is warmer than 148°C (298°F).
   - **If colder than 148°C (298°F).**

   1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the signal circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V
   3. Ignition OFF.
   4. Test for less than 2 ohms in the signal circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 Engine Control Module.

- **If warmer than 148°C (298°F).**

10. Ignition ON, test for 4.8-5.2 V between the intake air temperature sensor 2 signal circuit terminal 8 and ground.
    - **If less than 4.8 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 ohms in the signal circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
    - **If greater than 5.2 V**

      NOTE: If the signal circuit is shorted to a voltage the engine control module or the sensor may be damaged.

    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    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**
11. Determine if **EL-38522-A** Variable Signal Generator or equivalent is available.
    - **EL-38522-A, Variable Signal Generator; or equivalent is not available**
    1. Replace the K20 Engine Control Module.
    2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
    3. Verify the DTC does not set.
        - **If the DTC sets**

          Refer to step 21.

        - **If the DTC does not set**
    4. All OK.
    - **EL-38522-A, Variable Signal Generator; or equivalent is available**
12. Ignition OFF, connect the leads of the **EL-38522-A** Variable Signal Generator as follows:
    - Red lead to the signal circuit terminal 8 at the harness connector
    - Black leads to ground
    - Battery voltage supply lead to B+
13. Set the **EL-38522-A** Variable Signal Generator to the following specifications.
    - Signal switch to 5 V
    - Duty Cycle switch to 50 % (Normal)
    - Frequency switch to 30 Hz

14. 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**
15. 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.
16. Test for less than 2 ohms between the low reference circuit terminal 1 and ground.
    - **If 2 ohms or greater**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for less than 2 ohms in the low reference circuit end to end.
        - If 2 ohms or greater, repair the open or high resistance in the circuit.
        - If less than 2 ohms replace the K20 Engine Control Module.
    - **If less than 2 ohms**
17. Ignition ON, test for 4.8-5.2 V between the intake air temperature signal 3 signal circuit terminal 2 and ground.
    - **If less than 4.8 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 ohms in the signal circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
    - **If greater than 5.2 V**

      NOTE: If the signal circuit is shorted to a voltage the engine control module or the sensor may be damaged.

    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    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**
18. Ignition ON, verify the scan tool IAT Sensor 3 parameter is colder than -39°C (-38°F).
    - **If warmer than -39°C (-38°F).**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit terminal 2 and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance

3. Test for less than 2 ohms in the signal circuit end to end.
    - If 2 ohms or greater, repair the open/high resistance in the circuit.
    - If less than 2 ohms, replace the K20 Engine Control Module.
- **If colder than -39°C (-38°F).**

19. Ignition OFF, install a 3 A fused jumper wire between the signal circuit terminal 2 and the low reference circuit terminal 1.
20. Verify the scan tool IAT Sensor 3 parameter is warmer than 148°C (298°F).
    - **If colder than 148°C (298°F).**
    1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V
    3. Ignition OFF.
    4. Test for less than 2 ohms in the signal circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
    - **If warmer than 148°C (298°F).**
21. Test or replace the appropriate sensor.

Component Testing

Multifunction Intake Air Sensor

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

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

2. Test the IAT sensor 1 by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the **Temperature Versus Resistance - Intake Air Temperature Sensor (Hitachi Sensor)** , **Temperature Versus Resistance - Intake Air Temperature Sensor (Delco Sensor)** table for Hitachi Sensors. The resistance values should be in range of the table values.
    - **If not within the specified range**

      Replace the B75C Multifunction Intake Air Sensor.

    - **If within the specified range**
3. All OK.

Multifunction Intake Air Sensor

1. Test the IAT Sensor 2 by varying the sensor temperature while monitoring the air temperature with a thermometer. Compare the readings with the scan tool IAT Sensor 2 parameter. The values should be within 5%.
    - **If not within the specified range**

Replace the B75C Multifunction Intake Air Sensor.

- **If within the specified range**

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 (Hitachi Sensor)** , **Temperature Versus Resistance - Intake Air Temperature Sensor (Delco Sensor)** table for Delco Sensors. The resistance values should be in range of the table values.
   - **If not within the specified range**

     Replace the B111B Turbocharger Boost/Intake Air Temperature sensor.

   - **If within the specified range**
3. All OK.

Repair Instructions

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

- **Intake Air Pressure and Temperature Sensor Replacement** for turbocharger boost/intake air temperature sensor replacement
- **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement** for multifunction intake air sensor replacement
- **Control Module References** for engine control module replacement, programming, and setup

DTC P00EA-P00EC

Diagnostic Instructions

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

DTC Descriptors

DTC 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

Diagnostic Fault Information

IAT Sensor 3

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	P00EA, P00EB	P00E9, P00EB, P00EC	P00EB, P00EC*	P00E9
Low Reference	-	P00E9, P00EB, P00EC	P00EB, P00EC*	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

IAT Sensor 3

Circuit	Short to Ground	Open or High Resistance	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** Varies with ambient temperature; and engine bay conditions			
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+			

Circuit/System Description

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

IAT Sensor 3 - Temperature, Resistance, Voltage Table

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

Conditions for Running the DTCs

P00EA, P00EB, and P00EC

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

Conditions for Setting the DTC

P00EA

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

P00EB

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

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

P00EC

The ECM detects that the IAT sensor 3 signal is intermittent or has abruptly changed for at least 5 s.

Action Taken When the DTCs Set

- DTCs P00EA, P00EB, and P00EC are Type B DTCs.
- The ECM commands the cooling fans ON.

Conditions for Clearing the DTCs

DTCs P00EA, P00EB, and P00EC are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

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

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

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC P0641, P0651, P0697, or P06A3 is not set.
   - **If any of the DTCs are set**

     Refer to **DTC P0641, P0651, P0697, or P06A3 (ECM)** 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 30°C (54°F) of each other.
   - Start-Up IAT Sensor 1
   - IAT Sensor 2
   - IAT Sensor 3
   - **If not within 30°C (54°F)**

     Refer to Circuit/System Testing.

   - **If within 30°C (54°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
   - **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

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 ohms between the intake air temperature sensor 3 low reference circuit terminal 1 and ground.
   - **If 2 ohms or greater**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 ohms in the low reference circuit end to end.
      - If 2 ohms or greater, repair the open or high resistance in the circuit.
      - If less than 2 ohms replace the K20 Engine Control Module.
   - **If less than 2 ohms**
3. Ignition ON, test for 4.8-5.2 V between the intake air temperature signal 3 signal circuit terminal 2 and ground.
   - **If less than 4.8 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the signal circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 ohms in the signal circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 Engine Control Module.
   - **If greater than 5.2 V**

     NOTE: If the signal circuit is shorted to a voltage the engine control module or the sensor may be damaged.

   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   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).**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the signal circuit terminal 2 and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.

- If infinite resistance

3. Test for less than 2 ohms in the signal circuit end to end.
   - If 2 ohms or greater, repair the open/high resistance in the circuit.
   - If less than 2 ohms, 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 148°C (298°F).
   - **If colder than 148°C (298°F).**

   1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the signal circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V
   3. Ignition OFF.
   4. Test for less than 2 ohms in the signal circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 Engine Control Module.

   - **If warmer than 148°C (298°F).**
7. Test or replace the B111B Turbocharger Boost/Intake Air Temperature sensor.

Component Testing

Turbocharger Boost/Intake Air Temperature sensor

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

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

2. Test the IAT sensor 3 by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the **Temperature Versus Resistance - Intake Air Temperature Sensor (Hitachi Sensor)** , **Temperature Versus Resistance - Intake Air Temperature Sensor (Delco Sensor)** table for Delco sensors. The resistance values should be in range of the table values.
   - **If not within the specified range.**

     Replace the B111B Turbocharger Boost/Intake Air Temperature sensor.

   - **If within the specified range.**
3. All OK

Repair Instructions

Perform the **Diagnostic Repair Verification** 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.

DTC P00F4-P00F6

Diagnostic Instructions

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

DTC Descriptors

DTC P00F4

Intake Air Humidity Sensor Circuit Low Voltage

DTC P00F5

Intake Air Humidity Sensor Circuit High Voltage

DTC P00F6

Intake Air Humidity Sensor Circuit Erratic

Diagnostic Fault Information

Intake Air Humidity

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0096, P0097, P00F4, P0102, P2199**	P0096, P0097, P00F4, P0102, P2199**	-	P0096
Signal	P0096, P0097, P00F5, P2199**	P0096, P0097, P00F4, P0102, P2199**	P0096*, P0097, P00F4, P0102, P2199**	P0096
Ground	-	P0096, P0097, P00F4, P0102, P2199**	-	P0096
*Internal ECM or sensor damage may occur if the circuit is shorted to B+. **Where used.				

IAT Sensor 2

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0096, P0097, P00F4, P0102,	P0096, P0097, P00F4, P0102,	-	P0096

	P2199**	P2199**		
Signal	P0096, P0097, P00F5, P2199**	P0096, P0097, P00F4, P0102, P2199**	P0096*, P0097, P00F4, P0102, P2199**	P0096
Ground	-	P0096, P0097, P00F4, P0102, P2199**	-	P0096
*Internal ECM or sensor damage may occur if the circuit is shorted to B+. **Where used.				

Typical Scan Tool Data

Intake Air Humidity

Circuit	Short to Ground	Open or High Resistance	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** Varies with ambient humidity and temperature; and engine bay conditions			
Ignition 1	0 %	0 %	-
Signal	100 %	0 %	0 %*
Ground	-	0 %	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+			

IAT Sensor 2

Circuit	Short to Ground	Open or High Resistance	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** Varies with ambient temperature			
Ignition 1	-40°C (-40°F) 10 Hz	-40°C (-40°F) 10 Hz	-
Signal	-40°C (-40°F) 10 Hz	-40°C (-40°F) 10 Hz	-40°C (-40°F) 10 Hz*
Ground	-	-40°C (-40°F) 10 Hz	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+			

Circuit/System Description

The sensors listed below are integrated within the Multifunction Intake Air sensor:

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

The 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 humidity sensor and the intake air temperature (IAT) sensor 2 share the same signal circuit. The ECM applies 5 V to the circuit.

Ignition voltage and ground circuits are supplied to the multifunction intake air sensor's internal circuits for these sensors:

- IAT sensor 2
- Humidity sensor
- MAF sensor

Conditions for Running the DTCs

P00F4, P00F5, and P00F6

- DTC P1682 is not active.
- The ignition is ON.
- The Ignition 1 voltage is at least 11 V for longer than 0.9 s.
- These DTCs run continuously within the enabling conditions.

Conditions for Setting the DTCs

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

Action Taken When the DTC Sets

DTCs P00F4, P00F5, and P00F6 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P00F4, P00F5, and P00F6 are Type B DTCs.

Diagnostic Aids

- The Intake Air Humidity Signal parameter displays the measured humidity within the air intake system and may differ from atmospheric humidity measured outside the air intake system.
- With the ignition ON, the engine OFF, if the engine is cold, a properly functioning humidity sensor will gradually increase the scan tool Intake Air Humidity Signal parameter. This is due to the heat that is generated by the multifunction intake air sensor heating elements.

- The humidity sensor and the IAT sensor 2 signals are sent to the ECM on the same circuit. If the Intake Air Humidity parameter displays the value: 0 % or 100 %, and there are also IAT Sensor 2 DTCs, check for a circuit problem.
- With the ignition ON, the engine OFF, if the engine is cold, a properly functioning IAT sensor 2 will gradually increase the scan tool IAT Sensor 2 parameter. This is due to the heat that is generated by the multifunction intake air sensor heating elements.

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Control Module References for scan tool information

Special Tools

EL-38522-A Variable Signal Generator

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)** .

Circuit/System Verification

NOTE: **To minimize the effects of residual engine heat and sensor internal heating elements, perform Steps 1 and 2 of this verification procedure only if the ignition has been OFF for 8 hours or more.**

1. Ignition ON.
2. Verify the following scan tool parameters are within 30°C (54°F) of each other.
   - Start-Up IAT Sensor 1
   - IAT Sensor 2
   - IAT Sensor 3; where equipped
   - **If not within 30°C (54°F)**

     Refer to Circuit/System Testing.

   - **If within 30°C (54°F)**
3. Engine idling, verify the scan tool Intake Air Humidity parameter is between 5 and 90 %.
   - **If not between 5 and 90 %**

     Refer to Circuit/System Testing.

   - **If between 5 and 90 %**
4. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
5. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

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

Circuit/System Testing

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

1. Ignition OFF, disconnect the harness connector at the B75C Multifunction Intake Air sensor (Humidity Sensor).
2. Test for less than 2 ohms between the ground circuit terminal 7 and ground.
   - **If 2 ohms or greater**
     1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
     2. Test for less than 2 ohms in the low reference circuit end to end.
        - If 2 ohms or greater, repair the open or high resistance in the circuit.
        - If less than 2 ohms replace the K20 Engine Control Module.
   - **If less than 2 ohms**
3. Ignition ON, verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**
     1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
     2. Test for less than 2 ohms in the ignition voltage circuit end to end.

- If 2 ohms or greater, repair the open/high resistance in the circuit.
- If less than 2 ohms, verify the fuse is not open and there is voltage at the fuse.

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

1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
2. Test for infinite resistance between the ignition voltage circuit and ground.
   - If less than infinite resistance, repair the short to ground on the circuit.
   - If infinite resistance
3. Test for greater than 2 ohms between the ignition voltage circuit terminal 5 and ground.
   - If less than 2 ohms, repair the short to ground on the circuit.
   - If greater than 2 ohms, test all the components connected to the circuit and repair or replace as necessary.

- **If a test lamp illuminates**

4. Ignition ON, test for 4.8-5.2 V between the humidity signal circuit terminal 8 and ground.
   - **If less than 4.8 V**

   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the signal circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 ohms in the signal circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 Engine Control Module.

   - **If greater than 5.2 V**

   NOTE: If the signal circuit is shorted to a voltage the engine control module or the sensor may be damaged.

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

   1. Replace the K20 Engine Control Module.
   2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
   3. Verify the DTC does not set.
      - **If the DTC sets**

        Refer to step 9.

      - **If the DTC does not set**

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 8 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
   - Frequency switch to 250 Hz
   - Duty Cycle switch to 50 % (Normal)
8. Ignition ON, observe the scan tool Intake Air Humidity parameter. The scan tool parameter should be between 45-55 %.
   - **If not between 45-55 %.**

     Replace the K20 Engine Control Module.

   - **If between 45-55 %.**
9. Test or replace the B75C Multifunction Intake Air sensor (Humidity Sensor).

Component Testing

Multifunction Intake Air Sensor

1. Test the Intake Air Humidity Sensor by varying the air humidity in the intake duct near the sensor, while observing the scan tool Intake Air Humidity Sensor parameter. The parameter should change and be within 5-95%.
   - **If not within the specified range**

     Replace the B75C Multifunction Intake Air Sensor.

   - **If within the specified range**
2. All OK.

Repair Instructions

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

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

DTC P0101

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.

- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- **Diagnostic Procedure Instructions** provides an overview of each diagnostic category.

DTC Descriptor

DTC P0101

Mass Air Flow (MAF) Sensor Performance

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
Ignition Voltage	P0096, P0097, P00F4, P0102, P2199**	P0096, P0097, P00F4, P0102, P2199**	P0102	P0096	P0101, P0103
Signal	P0102	P0102	P0102	P0102	P0101, P0103, P1101
Ground	-	P0096, P0097, P00F4, P0102, P2199**	P0102	-	P0102
**Where used.					

Typical Scan Tool Data

MAF Sensor

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running at various operating conditions **Parameter Normal Range:** 2,000-10,000 Hz			
Ignition Voltage	0 Hz	0 Hz	-
Signal	0 Hz	0 Hz	0 Hz
Ground	-	0 Hz	-

Circuit Description

The intake flow rationality diagnostic provides the within-range rationality check for the mass air flow (MAF), manifold absolute pressure (MAP), and the throttle position sensors. This is an explicit model-based diagnostic containing 4 separate models for the intake system.

The estimates of MAF and MAP obtained from this system of models and calculations are then compared to the actual measured values from the MAF, MAP, and the throttle position sensors and to each other to determine the appropriate DTC to fail.

Conditions for Running the DTCs

- DTC P0101, P0102, P0103, P0107, P0108, P0111, P0112, P0113, P0116, P0117, P0118, P0128, P0335, or P0336 is not set

- The engine speed is between 575-6,600 RPM.
- The engine coolant temperature (ECT) is between -7 to +129°C (+19 to +264°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.

Conditions for Setting the DTC

The engine control module (ECM) detects that the actual measured airflow from the MAF, MAP, and throttle position sensors is not within range of the calculated airflow that is derived from the system of models for greater than 2 s.

Action Taken When the DTC Sets

DTC P0101 is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P0101 is a Type B DTC.

Diagnostic Aids

- Any type of contamination on the MAF sensor heating elements will degrade the proper operation of the sensor. Certain types of contaminants act as a heat insulator, which will impair the response of the sensor to airflow changes. Water or snow can create the opposite effect, and cause the signal to increase rapidly.
- Certain aftermarket air filters may cause this DTC to set.
- Certain aftermarket air induction systems may cause this DTC to set.
- Modifications to the air induction system may cause this DTC to set.

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Control Module References for scan tool information

Special Tools

EL-38522-A Variable Signal Generator

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)** .

Circuit/System Verification

1. Ignition ON, verify that DTC DTC P0641, P0651, P0697, or P06A3 is not set.
   - **If any of the DTCs are set**

     Refer to **DTC P0641, P0651, P0697, or P06A3 (ECM)** for further diagnosis.

   - **If none of the DTCs are set**
2. If you were sent here from DTC P0068, P0106, P0121, P0236, or P1101; refer to Circuit/System Testing.
3. Ignition ON, verify the scan tool Throttle Body Idle Airflow Compensation parameter is less than 90 %.
   - **90 % or greater**

     Refer to **Throttle Body Cleaning** .

   - **If less than 90 %**
4. Verify the scan tool Throttle Position Sensors 1 and 2 Agree/Disagree parameter displays Agree while performing the Throttle Sweep Test with a scan tool.
   - **If Disagree**

     Refer to **DTC P0121-P0123, P0222, P0223, P16A0-P16A2, or P2135** for further diagnosis.

   - **If Agree**
5. Determine the current vehicle testing altitude.
6. Verify the scan tool MAP Sensor pressure parameter is within the range specified in the **Altitude Versus Barometric Pressure** table.
   - **If the MAP Sensor parameter is not in range**

     Refer to **DTC P0106** for further diagnosis.

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

7. Verify the engine is equipped with a turbocharger.
   - **If not equipped with a turbocharger**

     Refer to Step 10.

   - **If equipped with a turbocharger**
8. 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**
9. 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**
10. 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**
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.
    1. Engine idling
    2. Perform the scan tool snapshot function.
    3. Increase the engine speed slowly to 3,000 RPM and then back to idle.
    4. Exit from the scan tool snapshot and review the data.
    5. Observe the MAF Sensor parameter frame by frame with a scan tool.

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

      Refer to Circuit/System Testing.

    - **If the MAF Sensor parameter changes smoothly and gradually**
12. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
13. Verify the DTC does not set.
    - **If the DTC sets**

      Refer to Circuit/System Testing.

- **If the DTC does not set**

14. All OK

Circuit/System Testing

NOTE: 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 Mass Air Flow 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 ohms between the ground circuit terminal 7 and ground.
   - **If 2 ohms or greater**
     1. Ignition OFF.
     2. Test for less than 2 ohms in the ground circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, repair the open/high resistance in the ground connection.
   - **If less than 2 ohms**
4. Ignition ON, verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**
     1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
     2. Test for less than 2 ohms in the ignition voltage circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, verify the fuse is not open and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**

1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
2. Test for infinite resistance between the ignition voltage circuit and ground.
   - If less than infinite resistance, repair the short to ground on the circuit.
   - If infinite resistance
3. Test for greater than 2 ohms between the ignition voltage circuit terminal 5 and ground.
   - If less than 2 ohms, repair the short to ground on the circuit.
   - If greater than 2 ohms, test all the components connected to the circuit and repair or replace as necessary.

- **If a test lamp illuminates**

5. Ignition ON, test for 4.8-5.2 volts between the signal circuit terminal 6 and ground.
   - **If less than 4.8 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the signal circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 ohms in the signal circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 Engine Control Module.
   - **If greater than 5.2 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   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**
   1. Replace the K20 Engine Control Module.
   2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
   3. Verify the DTC does not set.
      - **If the DTC sets**

        Test or replace the B75C Multifunction Intake Air sensor.

      - **If the DTC does not set**
   4. All OK.
   - **EL-38522-A, Variable Signal Generator; or equivalent is available**
7. Ignition OFF, connect the leads of the **EL-38522-A** Variable Signal Generator as follows:
   - Red lead to the signal circuit terminal 6 at the harness connector
   - Black leads to ground
   - Battery voltage supply lead to B+

8. Set the **EL-38522-A** Variable Signal Generator to the following specifications.
   - Signal switch to 5 V
   - Frequency switch to 5 kHz
   - Duty Cycle switch to 50 % (Normal)
9. Engine idling, observe the scan tool MAF Sensor parameter. The scan tool MAF Sensor parameter should be between 4,950-5,050 Hz.
   - **If not between 4,950-5,050 Hz.**

     Replace the K20 Engine Control Module.

   - **If between 4,950-5,050 Hz.**
10. Test or replace the B75C Multifunction Intake Air sensor.

Repair Instructions

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

- **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement** for multifunction intake air sensor replacement
- **Control Module References** for engine control module replacement, programming, and setup

DTC P0102 OR P0103

Diagnostic Instructions

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

DTC Descriptors

DTC P0102

Mass Air Flow (MAF) Sensor Circuit Low Frequency

DTC P0103

Mass Air Flow (MAF) Sensor Circuit High Frequency

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
Ignition Voltage	P0096, P0097, P00F4, P0102, P2199**	P0096, P0097, P00F4, P0102, P2199**	P0102	P0096	P0101, P0103

Signal	P0102	P0102	P0102	P0102	P0101, P0103, P1101
Ground	-	P0096, P0097, P00F4, P0102, P2199**	P0102	-	P0102
**Where used.					

Typical Scan Tool Data

MAF Sensor

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running at various operating conditions **Parameter Normal Range:** 2,000-10,000 Hz			
Ignition Voltage	0 Hz	0 Hz	-
Signal	0 Hz	0 Hz	0 Hz
Ground	-	0 Hz	-

Circuit/System Description

The mass air flow (MAF) sensor is integrated with the multifunction intake air sensor. The MAF sensor is an air flow meter that measures the amount of air in the sensor bore. The engine control module (ECM) uses the MAF sensor signal to provide the correct fuel delivery for all engine speeds and loads. A small quantity of air entering the engine indicates a deceleration or idle condition. A large quantity of air entering the engine indicates an acceleration or high load condition.

The ECM applies 5 V to the MAF sensor on the MAF sensor signal circuit. The sensor uses the voltage to produce a variable frequency signal based on the inlet air flow through the sensor bore. The signal varies with engine load and is displayed by the scan tool as Hertz (Hz) and grams per second (g/s). Ignition voltage and ground circuits are also supplied to the multifunction intake air sensor's internal circuits for these sensors:

- Intake Air Temperature (IAT) sensor 2
- Humidity sensor
- MAF sensor

The multifunction intake air sensor houses the following:

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

Conditions for Running the DTC

- The engine is running for at least 1 s.
- The engine speed is at least 300 RPM.

- The ignition signal is at least 11 V.
- The above conditions are met for at least 1 s.
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

P0102

The ECM detects that the MAF Sensor signal parameter is less than 500 Hz (about 0.25 g/s) for at least 250 cylinder firing events.

P0103

The ECM detects that the MAF Sensor signal parameter is at least 11,000 Hz (about 328 g/s) for at least 250 cylinder firing events.

Action Taken When the DTCs Set

DTCs P0102 and P0103 are Type B DTCs.

Conditions for Clearing the MIL/DTCs

DTCs P0102 and P0103 are Type B DTCs.

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Control Module References for scan tool information

Special Tools

EL-38522-A Variable Signal Generator

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)** .

Circuit/System Verification

1. Engine idling, observe the scan tool MAF Sensor parameter. The reading should be between 2.5-5.5 g/s.
   - **If not between 2.5-5.5 g/s**

     Refer to Circuit/System Testing.

   - **If between 2.5-5.5 g/s**
2. Verify the scan tool MAF Sensor g/s parameter changes smoothly and gradually as the engine speed is increased and decreased while performing the actions listed below.
   1. Engine idling
   2. Perform the scan tool snapshot function.
   3. Increase the engine speed slowly to 3,000 RPM and then back to idle.
   4. Exit from the scan tool snapshot and review the data.
   5. Observe the MAF Sensor parameter frame by frame with a scan tool.
   - **The MAF Sensor parameter does not change smoothly and gradually**

     Refer to Circuit/System Testing.

   - **The MAF Sensor parameter changes smoothly and gradually**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

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

Circuit/System Testing

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

1. Ignition OFF, disconnect the harness connector at the B75C Multifunction Intake Air sensor.
2. Test for less than 2 ohms between the ground circuit terminal 7 and ground.
    - **If 2 ohms or greater**
    1. Ignition OFF. Disconnect the sensor chassis ground.
    2. Test for less than 2 ohms in the ground circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, repair the open/high resistance in the chassis ground connection.
    - **If less than 2 ohms**
3. Ignition ON, verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.
    - **If the test lamp does not illuminate and the circuit fuse is good**
    1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
    2. Test for less than 2 ohms in the ignition voltage circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, verify the fuse is not open and there is voltage at the fuse.
    - **If the test lamp does not illuminate and the circuit fuse is open**
    1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
    2. Test for infinite resistance between the ignition voltage circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for greater than 2 ohms between the ignition voltage circuit terminal 5 and ground.
        - If less than 2 ohms, repair the short to ground on the circuit.
        - If greater than 2 ohms, test all the components connected to the circuit and repair or replace as necessary.
    - If 2 ohms or greater, repair the open or high resistance in the circuit.
    - If the circuit tests normal and the fuse is open, test all the components connected to the circuit and repair or replace as necessary.
    - **If a test lamp illuminates**
4. Ignition ON, test for 4.8-5.2 volts between the signal circuit terminal 6 and ground.
    - **If less than 4.8 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 ohms in the signal circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
    - **If greater than 5.2 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    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**
   1. Replace the K20 Engine Control Module.
   2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
   3. Verify the DTC does not set.
      - **If the DTC sets**

        Refer to step 9.

      - **If the DTC does not set**
   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 6 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
   - Frequency switch to 5 kHz
   - Duty Cycle switch to 50 % (Normal)
8. Engine idling, verify the scan tool MAF Sensor parameter is between 4,950-5,050 Hz.
   - **If not between 4,950-5,050 Hz.**

     Replace the K20 Engine Control Module.

   - **If between 4,950-5,050 Hz.**
9. Test or replace the B75C Multifunction Intake Air sensor.

Repair Instructions

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

- **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement** for multifunction intake air sensor replacement
- **Control Module References** for engine control module replacement, programming, and setup

DTC P0106

Diagnostic Instructions

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

- **Diagnostic Procedure Instructions** provides an overview of each diagnostic category.

DTC Descriptor

DTC P0106

Manifold Absolute Pressure (MAP) Sensor Performance

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
5 V Reference	P0107, P0697	P0106, P0107	P0107	P0106, P0108, P0697	P0106
Signal	P0106, P0107, P0697	P0106, P0107	P0107	P0106, P0108*	P0106, P1101
Low Reference	-	P0106, P0108	P0106, P0108	-	P0106
* Internal ECM or sensor damage may occur if the circuit is shorted to B+.					

Typical Scan Tool Data

MAP Sensor

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

MAP Sensor, if equipped with Turbocharger

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running at various operating conditions **Parameter Normal Range:** 12-225 kPa (1.7-32.6 PSI)			
5 V Reference	0 kPa (0 PSI)	0 kPa (0 PSI)	255 kPa (36.9 PSI)
Signal	0 kPa (0 PSI)	0 kPa (0 PSI)	255 kPa (36.9 PSI) *
Low Reference	-	255 kPa (36.9 PSI)	-
* Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

Circuit Description

The manifold absolute pressure (MAP) sensor measures the pressure inside the intake manifold. Pressure in the intake manifold is affected by engine speed, throttle opening, air temperature, barometric pressure (BARO); and 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 5V reference circuit. The ECM supplies a ground on a low reference circuit. The MAP sensor provides a signal voltage to the ECM, relative to the pressure changes, on the MAP sensor signal circuit. The ECM converts the signal voltage input to a pressure value.

Under normal operation the greatest pressure that can exist in the intake manifold is at ignition ON, engine OFF, which is equal to the BARO. If equipped, a turbocharger can increase the pressure above BARO, when the vehicle is operated at wide-open throttle (WOT). The lowest manifold pressure occurs when the vehicle is idling or decelerating. The ECM monitors the MAP sensor signal for pressure outside of the normal range.

Conditions for Running the DTC

- DTCs P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0125, P0128, P222C, P222D, P0335, P0336, P0401, P042E, P2227, P2228, P2229, P2230, or P2610 are not set
- The engine speed is between 500 and 6800 RPM.
- The ECT Sensor is between -7 to +126°C (+19 to +258°F).
- The IAT Sensor is between -20 to +125°C (-4 to +257°F).
- This DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

The engine control module (ECM) detects that the MAP sensor pressure is not within range of the calculated pressure that is derived from a system of models, for greater than 0.5 s.

Action Taken When the DTC Sets

DTC P0106 is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P0106 is a Type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

GE-23738-A Vacuum Pump

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)** .

Circuit/System Verification

1. Ignition ON, verify that DTC P0641, P0651, P0697, or P06A3 is not set.
   - **If any of the DTCs are set**

     Refer to **DTC P0641, P0651, P0697, or P06A3 (ECM)** for further diagnosis.

   - **If none of the DTCs are set**
2. If you were sent here from DTC P0068, P0101, P0121, P0236, or P1101, refer to Circuit/System Testing.
3. Ignition ON, verify the scan tool Throttle Body Idle Airflow Compensation parameter is less than 90%.
   - **If 90% or greater**

     Refer to **Throttle Body Cleaning** for this publication.

   - **If less than 90%**
4. Verify the scan tool Throttle Position Sensors 1 and 2 Agree/Disagree parameter displays Agree while performing the Throttle Sweep Test with a scan tool.
   - **If Disagree**

     Refer to **DTC P0121-P0123, P0222, P0223, P16A0-P16A2, or P2135** for further diagnosis.

   - **If Agree**
5. Determine the current vehicle testing altitude.

6. Verify the scan tool MAP Sensor parameter is within the range specified in the **Altitude Versus Barometric Pressure** table.
   - **If the MAP Sensor parameter is not in range**

     Refer to Circuit/System Testing.

   - **If the MAP Sensor parameter is within range**
7. Verify if the engine is equipped with a turbocharger.
   - **If not equipped with a turbocharger**

     Refer to Step 10.

   - **If equipped with a turbocharger**
8. 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**
9. 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**
10. 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**
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:
    1. Engine idling
    2. Perform the scan tool snapshot function.
    3. Increase the engine speed slowly to 3000 RPM and then back to idle.
    4. Exit from the scan tool snapshot and review the data.
    5. Observe the MAF Sensor parameter frame by frame with a scan tool.
    - **The MAF Sensor parameter does not change smoothly and gradually**

      Refer to **DTC P0101** for further diagnosis.

    - **The MAF Sensor parameter changes smoothly and gradually**
12. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle

within the conditions that you observed from the Freeze Frame/Failure Records data.

13. Verify a DTC does not set.
    - **If any DTC sets**

      Refer to Circuit/System Testing.

    - **If no DTCs set**
14. All OK.

Circuit/System Testing

1. Verify the integrity of the entire air induction system and verify that none of the following conditions exist:
    - Any damaged components
    - Improper operation of turbocharger wastegate actuator or bypass valve; if equipped
    - Loose or improper installation of the turbocharger and the charge air cooler, including the flexible ductwork, if equipped
    - An air flow restriction
    - Any vacuum leak
    - Improperly routed vacuum hoses
    - A restriction in the MAP Sensor port, or the BARO port, if equipped
    - 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 ohms between the low reference circuit terminal 2 and ground.
    - **If 2 ohms or greater**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for less than 2 ohms in the low reference circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
    - **If less than 2 ohms**
4. Ignition ON, test for 4.8-5.2 V between the 5 V reference circuit terminal 1 and ground.
    - **If less than 4.8 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the 5 V reference circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.

- If infinite resistance

3. Test for less than 2 ohms in the 5 V reference circuit end to end.
   - If 2 ohms or greater, repair the open/high resistance in the circuit.
   - If less than 2 ohms, 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.

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- **If greater than 5.2 V**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Ignition ON, test for less than 1 V between the 5 V reference circuit and ground.
   - If 1 V or greater, repair the short to voltage on the circuit.
   - If less than 1 V, replace the K20 Engine Control Module.

- **If between 4.8-5.2 V**

5. Ignition ON, verify the scan tool MAP Sensor parameter is less than 0.5 V.
   - **If 0.5 V or greater**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Ignition ON, test for less than 1 V between the signal circuit terminal 3 and ground.
   - If 1 V or greater, repair the short to voltage on the circuit.
   - If less than 1 V, replace the K20 Engine Control Module.

   - **If less than 0.5 V**

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

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. 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

3. Test for less than 2 ohms in the signal circuit end to end.
   - If 2 ohms or greater, repair the open or high resistance in the circuit.
   - If less than 2 ohms, replace the K20 Engine Control Module.

   - **If greater than 4.5 V**

8. Test or replace the B74 Manifold Absolute Pressure Sensor.

Component Testing

NOTE: You must perform the Circuit/System Testing in order to verify the integrity of the MAP Sensor circuits before proceeding with the Component Testing.

Skewed Sensor Test

1. Ignition OFF, remove the B74 Manifold Absolute Pressure Sensor from the engine. Connect the harness to the sensor, if disconnected.
2. Ignition ON, apply 17 kPa (5.0 in Hg) of vacuum to the B74 Manifold Absolute Pressure Sensor, with the **GE-23738-A** . Verify the scan tool MAP Sensor 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 **GE-23738-A** . Verify the scan tool MAP Sensor 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 and is between 0.2-4.9 V.
    - **If not between 0.2-4.9 V or has spikes or dropouts**

      Replace the B74 Manifold Absolute Pressure Sensor.

    - **If between 0.2-4.9 V and there are no spikes or dropouts**
7. All OK.

Repair Instructions

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

- **Manifold Absolute Pressure Sensor Replacement** .
- **Control Module References** for ECM replacement, programming, and setup

DTC P0107 OR P0108

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** provide an overview of each diagnostic category.

DTC Descriptors

DTC P0107

Manifold Absolute Pressure (MAP) Sensor Circuit Low Voltage

DTC P0108

Manifold Absolute Pressure (MAP) Sensor Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
5 V Reference	P0107, P0697	P0106, P0107	P0107	P0106, P0108, P0697	P0106
Signal	P0106, P0107, P0697	P0106, P0107	P0107	P0106, P0108*	P0106, P1101
Low Reference	-	P0106, P0108	P0106, P0108	-	P0106
* Internal ECM or sensor damage may occur if the circuit is shorted to B+.					

Typical Scan Tool Data

MAP Sensor

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

MAP Sensor, if equipped with Turbocharger

Circuits	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running at various operating conditions **Parameter Normal Range:** 12-225 kPa (1.7 to 32.6 PSI) (Varies with altitude)			
5 V Reference	0 kPa (0 PSI)	0 kPa (0 PSI)	255 kPa (36.9 PSI)

Signal	0 kPa (0 PSI)	0 kPa (0 PSI)	255 kPa (36.9 PSI)*
Low Reference	-	255 kPa (36.9 PSI)	-
* Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

Circuit Description

The manifold absolute pressure (MAP) sensor measures the pressure inside the intake manifold. Pressure in the intake manifold is affected by engine speed, throttle opening, air temperature, barometric pressure (BARO) and if equipped turbocharger output. A diaphragm within the MAP sensor is displaced by the pressure changes that occur from the varying load and operating conditions of the engine. The sensor translates this action into electrical resistance.

The MAP sensor wiring includes 3 circuits. The engine control module (ECM) supplies a regulated 5 volts to the sensor on a 5 V reference circuit. The ECM supplies a ground on a low reference circuit. The MAP sensor provides a signal voltage to the ECM, relative to the pressure changes, on the MAP sensor signal circuit. The ECM converts the signal voltage input to a pressure value.

Under normal operation the greatest pressure that can exist in the intake manifold is at ignition ON, engine OFF, which is equal to the BARO. If equipped, a turbocharger can increase the pressure above BARO, when the vehicle is operated at wide-open throttle (WOT). The lowest manifold pressure occurs when the vehicle is idling or decelerating. The ECM monitors the MAP sensor signal for pressure outside of the normal range.

Conditions for Running the DTC

P0107

This DTC runs continuously.

P0108

This DTC runs continuously.

Conditions for Setting the DTC

P0107

The ECM detects that the MAP Sensor voltage is less than 0.15 V for more than 13 ms.

P0108

The ECM detects that the MAP Sensor voltage is more than 4.50 V for greater than 13 ms.

Action Taken When the DTC Sets

DTCs P0107 and P0108 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P0107 and P0108 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

GE-23738-A Vacuum Pump

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)**

Circuit/System Verification

1. Ignition ON, verify that DTC P0641, P0651, P0697, or P06A3 is not set.
   - **If any of the DTCs are set**

     Refer to **DTC P0641, P0651, P0697, or P06A3 (ECM)** for further diagnosis.

   - **If none of the DTCs are set**
2. Determine the current vehicle testing altitude.
3. Verify the scan tool MAP Sensor parameter is within the range specified in the **Altitude Versus Barometric Pressure** table.
   - **If the MAP Sensor parameter is not in range**

     Refer to Circuit/System Testing for further diagnosis.

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

4. Verify the engine is equipped with a turbocharger.
    - **If not equipped with a turbocharger**

      Refer to Step 6.

    - **If equipped with a turbocharger**
5. Engine idling, verify the scan tool MAP Sensor voltage parameter is between 0.3-4.8 V and changes with accelerator pedal input.
    - **If not between 0.3-4.8 V or does not change**

      Refer to Circuit/System Testing.

    - **If between 0.3-4.8 V and changes**

      Refer to Step 7.

6. Engine idling, verify the scan tool MAP Sensor voltage parameter is between 0.2-4.5 V and changes with accelerator pedal input.
    - **If not between 0.2-4.5 V or does not change**

      Refer to Circuit/System Testing.

    - **If between 0.2-4.5 V and changes**
7. 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.
8. Verify the DTC does not set.
    - **If any DTC sets**

      Refer to Circuit/System Testing.

    - **If no DTC sets**
9. All OK.

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the B74 Manifold Absolute Pressure Sensor.
2. Ignition OFF and all vehicle systems OFF. It may take up to 2 min for all vehicle systems to power down. Test for less than 2 ohms between the low reference circuit terminal 2 and ground.
    - **If 2 ohms or greater**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for less than 2 ohms in the low reference circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
    - **If less than 2 ohms**
3. Ignition ON, test for 4.8-5.2 V between the 5 V reference circuit terminal 1 and ground.
    - **If less than 4.8 V**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the 5 V reference circuit and ground.
   - If less than infinite resistance, repair the short to ground on the circuit.
   - If infinite resistance
3. Test for less than 2 ohms in the 5 V reference circuit end to end.
   - If 2 ohms or greater, repair the open/high resistance in the circuit.
   - If less than 2 ohms, 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.

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- **If greater than 5.2 V**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Ignition ON, test for less than 1 V between the 5 V reference circuit and ground.
   - If 1 V or greater, repair the short to voltage on the circuit.
   - If less than 1 V, replace the K20 Engine Control Module.

- **If between 4.8-5.2 V**

4. Ignition ON, verify the scan tool MAP Sensor parameter is less than 0.5 V.
   - **If 0.5 V or greater**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
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**
5. Ignition OFF, install a 3 A fused jumper wire between the signal circuit terminal 3 and the 5 V reference circuit terminal 1.
6. Ignition ON, verify the scan tool MAP voltage parameter is greater than 4.5 V.
   - **If 4.5 V or less**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. 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
3. Test for less than 2 ohms in the signal circuit end to end.
   - If 2 ohms or greater, repair the open or high resistance in the circuit.
   - If less than 2 ohms, replace the K20 Engine Control Module.

   - **If greater than 4.5 V**
7. Test or replace the B74 Manifold Absolute Pressure Sensor.

Component Testing

NOTE: **You must perform the Circuit/System Testing in order to verify the integrity of the MAP Sensor circuits before proceeding with the Component Testing.**

Skewed Sensor Test

1. Ignition OFF, remove the B74 Manifold Absolute Pressure Sensor from the engine. Connect the harness to the sensor, if disconnected.
2. Ignition ON, apply 17 kPa (5.0 in Hg) of vacuum to the B74 Manifold Absolute Pressure Sensor, with the **GE-23738-A** . Verify the scan tool MAP pressure parameter decreases between 13-21 kPa (1.8-3.0 PSI).
   - **If the parameter does not decrease between 13-21 kPa (1.8-3.0 PSI).**

     Replace the B74 Manifold Absolute Pressure Sensor.

   - **If the parameter does decrease between 13-21 kPa (1.8-3.0 PSI).**
3. Apply 34 kPa (10.0 in Hg) of vacuum to the B74 Manifold Absolute Pressure Sensor, with the **GE-23738-A** . Verify the scan tool MAP pressure parameter decreases between 30-38 kPa (4.4-5.5 PSI).
   - **If the parameter does not decrease between 30-38 kPa (4.4-5.5 PSI).**

     Replace the B74 Manifold Absolute Pressure Sensor.

   - **If the parameter does decrease between 30-38 kPa (4.4-5.5 PSI).**
4. All OK.

Erratic Signal Test

1. Ignition OFF, remove the B74 Manifold Absolute Pressure Sensor and disconnect the harness.
2. Install a 3 A fused jumper wire between the 5 V reference circuit terminal 1 of the sensor and the sensor harness.
3. Install a jumper wire between the low reference circuit terminal 2 of the sensor and ground.
4. Install a jumper wire to the signal circuit terminal 3 of the sensor.
5. Connect a DMM between the jumper wire and ground.
6. Ignition ON, observe the DC voltage on the DMM. Slowly apply between 0-15 kPa (0-4.4 in Hg) of vacuum to the sensor with the **GE-23738-A** .
7. Verify the voltage changes, without any spikes or dropouts and is between 0.2-4.9 V.
   - **If not between 0.2-4.9 V or has spikes or dropouts**

     Replace the B74 Manifold Absolute Pressure Sensor.

   - **If between 0.2-4.9 V and there are no spikes or dropouts**
8. All OK.

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

DTC P0112, P0113, OR P0114

Diagnostic Instructions

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

DTC Descriptors

DTC P0112

Intake Air Temperature (IAT) Sensor 1 Circuit Low Voltage

DTC P0113

Intake Air Temperature (IAT) Sensor 1 Circuit High Voltage

DTC P0114

Intake Air Temperature (IAT) Sensor 1 Circuit Intermittent

Diagnostic Fault Information

IAT Sensor 1

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	P0112, P0114, P2199**	P0111, P0113, P0114, P2199**	P0097*, P0113, P0114, P11C2, P2199**	P0111, P2199**
Low Reference	-	P0111, P0113, P0114, P2199**	P0113*, P0114	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+. **Where used.				

Typical Scan Tool Data

IAT Sensor 1

Circuit	Short to Ground	Open or High Resistance	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** Varies with ambient temperature			
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+			

Circuit/System Description

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

The multifunction intake air sensor houses the following:

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

IAT Sensor 1 - Temperature, Resistance, Voltage Table

IAT Sensor 1	IAT Sensor 1 Resistance	IAT Sensor 1 Signal Voltage
Cold	High	High
Warm	Low	Low

Conditions for Running the DTCs

P0112, P0113, and P0114

- The ignition is ON, or the engine is running.
- The DTCs run continuously when the above conditions are met.
- Where P0114 is used, the DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

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

P0112

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

P0113

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

P0114

Where this DTC is used, the ECM detects that the IAT sensor signal is intermittent or has abruptly changed for at least 5 s.

Action Taken When the DTCs Set

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

- The ECM commands the cooling fans ON.

Conditions for Clearing the DTCs

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

Diagnostic Aids

With the ignition ON, the engine OFF, if the engine is cold, a properly functioning IAT sensor 1 will gradually increase the scan tool IAT Sensor 1 parameter. This is due to the heat that is generated by the MAF sensor heating elements.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

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Circuit/System Verification

NOTE: To minimize the effects of residual engine heat and sensor internal heating elements, perform Steps 1 and 2 of this verification procedure only if the ignition has been OFF for 8 hours or more.

1. Ignition ON.
2. Verify the following scan tool parameters are within 30°C (54°F) of each other.

- Start-Up IAT Sensor 1
- IAT Sensor 2
- IAT Sensor 3; where equipped
- **If not within 30°C (54°F)**

  Refer to Circuit/System Testing.

- **If within 30°C (54°F)**

3. Engine idling, verify the following scan tool parameters are between: -38 and +149°C (-36 and +300° F).
   - IAT Sensor 1
   - IAT Sensor 2
   - 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)**
4. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
5. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

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

Circuit/System Testing

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 ohms between the low reference circuit terminal 3 and ground.
   - **If 2 ohms or greater**
     1. Ignition OFF, disconnect the harness connector at the K20 engine control module.
     2. Test for less than 2 ohms in the low reference circuit end to end.
        - If 2 ohms or greater, repair the open or high resistance in the circuit.
        - If less than 2 ohms replace the K20 engine control module.
   - **If less than 2 ohms**
3. Ignition ON, test for 4.8-5.2 V between the intake air temperature sensor 1 signal circuit terminal 1 and ground.

- **If less than 4.8 V**

1. Ignition OFF, disconnect the harness connector at the K20 engine control module.
2. Test for infinite resistance between the signal circuit and ground.
   - If less than infinite resistance, repair the short to ground on the circuit.
   - If infinite resistance
3. Test for less than 2 ohms in the signal circuit end to end.
   - If 2 ohms or greater, repair the open/high resistance in the circuit.
   - If less than 2 ohms, replace the K20 engine control module.

- **If greater than 5.2 V**

NOTE: If the signal circuit is shorted to a voltage the engine control module or the sensor may be damaged.

1. Ignition OFF, disconnect the harness connector at the K20 engine control module.
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).**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the signal circuit terminal 1 and ground.
   - If less than infinite resistance, repair the short to ground on the circuit.
   - If infinite resistance
3. Test for less than 2 ohms in the signal circuit end to end.
   - If 2 ohms or greater, repair the open/high resistance in the circuit.
   - If less than 2 ohms, 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 1 and the low reference circuit terminal 3.
6. Verify the scan tool IAT Sensor 1 parameter is warmer than 148°C (298°F).
   - **If colder than 148°C (298°F).**

1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the signal circuit and ground.
   - If 1 V or greater, repair the short to voltage on the circuit.
   - If less than 1 V
3. Ignition OFF.
4. Test for less than 2 ohms in the signal circuit end to end.
   - If 2 ohms or greater, repair the open/high resistance in the circuit.
   - If less than 2 ohms, replace the K20 Engine Control Module.

- **If warmer than 148°C (298°F).**

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

Component Testing

Multifunction Intake Air Sensor

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

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

2. Test the IAT sensor 1 by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the **Temperature Versus Resistance - Intake Air Temperature Sensor (Hitachi Sensor)** , **Temperature Versus Resistance - Intake Air Temperature Sensor (Delco Sensor)** table for Hitachi Sensors. The resistance values should be in range of the table values.
   - **If not within the specified range**

     Replace the B75C Multifunction Intake Air Sensor.

   - **If within the specified range**
3. All OK.

Repair Instructions

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

- **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement** for multifunction intake air sensor replacement
- **Control Module References** for engine control module replacement, programming, and setup.

DTC P0116

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** provide an overview of each diagnostic category.

DTC Descriptor

DTC P0116

Engine Coolant Temperature (ECT) Sensor Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance

Signal	P0117, P0119	P0118, P0119	P0118, P0119	P0116, P0128
Low Reference	-	P0118	-	P0128

Typical Scan Tool Data

ECT Sensor

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running at various operating conditions **Parameter Normal Range:** Varies with coolant temperature			
ECT Sensor	150°C (302°F)	-40°C (-40°F)	-40°C (-40°F)
Low Reference	-	-40°C (-40°F)	-

Circuit/System Description

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

The ECM uses this high side coolant rationality diagnostic to determine if the input from the ECT sensor is skewed warmer than normal. The internal clock of the ECM will record the amount of time the ignition is OFF. If the calibrated ignition OFF time is met at start-up, the ECM will compare the temperature difference between the ECT and the intake air temperature (IAT) to determine if the temperatures are within an acceptable operating range of each other.

Conditions for Running the DTC

- DTC P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0128, P0502, P0503, P0601, or P2610 is not set.
- The vehicle has had a minimum ignition OFF time of 8 h.
- The ignition is ON.
- The start-up IAT is warmer than -7°C (+19°F).
- The Fuel Level Sensor parameter is greater than 2.5%.
- This DTC runs once per ignition cycle within the enabling conditions.

Conditions for Setting the DTC

- The ECM detects a temperature difference at power-up that indicates that the ECT sensor is 30°C (54° F) warmer than the IAT sensor.

  OR

- The ECM detects a temperature difference at power-up that indicates that the ECT sensor is 16°C (29° F) warmer than the IAT sensor, and the time spent cranking the engine is greater than 30 s when the fuel level is greater than 2.5%.

  OR

- The ECM detects a temperature difference at power-up that indicates that the ECT sensor is 16°C (29°

F) warmer than the IAT sensor. Then the vehicle must be driven for greater than 6 min and 40 s at greater than 24 km/h (15 mph). If the IAT sensor then decreases greater than 5°C (9°F), an engine block heater was detected and the test is aborted. If the IAT sensor does not decrease, an engine block heater was not detected and DTC P0116 will set.

Action Taken When the DTC Sets

DTC P0116 is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P0116 is a Type B DTC.

Diagnostic Aids

- Engine coolant that is leaking through the sensor will create a high resistance short to ground. This condition results in less voltage on the ECT sensor signal circuit, which is interpreted by the ECM as a warmer ECT.
- An IAT sensor that is skewed colder at various ambient temperatures due to greater resistance than is normal will increase the range between these two sensors. Measure and record the resistance of the IAT sensor at various ambient temperatures, then compare those measurements to the **Temperature Versus Resistance - Engine Coolant Temperature Sensor** table.
- A slight to moderate resistance in the IAT sensor signal circuit or low reference circuit will increase the range between these two sensors. This condition results in a greater voltage on the IAT sensor signal circuit, which is interpreted by the ECM as a colder IAT.

Reference Information

Schematic Reference

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Connector End View Reference

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Electrical Information Reference

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- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify the scan tool ECT Sensor parameter is between -39 to + 120°C (-38 to +248°F) and changes with engine run time.
   - **If not between -39 to + 120°C (-38 to +248°F) or does not change**

     Refer to Circuit/System Testing.

   - **If between -39 to + 120°C (-38 to +248°F) and changes**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B34 Engine Coolant Temperature Sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 ohms between the low reference terminal A and ground.
   - **If 5 ohms or greater**
     1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
     2. Test for less than 2 ohms in the low reference circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
   - **If less than 5 ohms**
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)**
     1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
     2. Test for infinite resistance between the signal circuit terminal B and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance, replace the K20 Engine Control Module.
   - **If colder than -39°C (-38°F)**
5. Install a 3 A fused jumper wire between the signal circuit terminal B and the low reference circuit terminal A.
6. Verify the scan tool ECT sensor parameter is warmer than 149°C (300°F).

- **If colder than the 149°C (300°F)**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the signal circuit and ground.
   - If 1 V or greater, repair the short to voltage on the circuit.
   - If less than 1 V
3. Ignition OFF
4. Test for less than 2 ohms in the signal circuit end to end.
   - If 2 ohms or greater, repair the open/high resistance in the circuit.
   - If less than 2 ohms, replace the K20 Engine Control Module.

- **If warmer than 149°C (300°F)**

7. Test or replace the B34 Engine Coolant Temperature Sensor.

Component Testing

1. Ignition OFF, disconnect the harness connector at the B34 Engine Coolant Temperature Sensor.
2. Test the ECT sensor by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the **Temperature Versus Resistance - Engine Coolant Temperature Sensor** table. The resistance values should be in range of the table values.
   - **If not within the specified range**

     Replace the B34 Engine Coolant Temperature Sensor.

   - **If within the specified range**
3. Test for infinite resistance between each terminal and the sensor housing.
   - **If less than infinite resistance**

     Replace the B34 Engine Coolant Temperature Sensor.

   - **If infinite resistance**
4. All OK.

Repair Instructions

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

- **Engine Coolant Temperature Sensor Replacement**
- **Control Module References** for engine control module replacement, setup, and programming

DTC P0117, P0118, OR P0119

Diagnostic Instructions

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

DTC Descriptors

DTC P0117

Engine Coolant Temperature (ECT) Sensor Circuit Low Voltage

DTC P0118

Engine Coolant Temperature (ECT) Sensor Circuit High Voltage

DTC P0119

Engine Coolant Temperature (ECT) Sensor Circuit Intermittent

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	P0117	P0118, P0119	P0118*,P0119	P0128, P111E
Low Reference	-	P0118, P0119	-	P0128
*ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

ECT Sensor

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running at various operating conditions **Parameter Normal Range:** Varies with coolant temperature			
Signal	140°C (284°F)	-40°C (-40°F)	-40°C (-40°F)
Low Reference	-	-40°C (-40°F)	-

Circuit/System Description

The engine coolant temperature (ECT) sensor is a variable resistor that measures the temperature of the engine coolant. The engine control module (ECM) supplies 5 V to the ECT sensor signal circuit and a ground for the low reference circuit. This diagnostic checks for an open, short to ground or an intermittent circuit condition between the ECM and ECT sensor.

Conditions for Running the DTC

P0117

- The ignition is ON.

  OR

- The engine is running for greater than 10 s.

  OR

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

P0118

- The ignition is ON.

  OR

- The engine is running for greater than 10 s.

  OR

- The engine run time is less than 10 s when the IAT is warmer than 0°C (32°F).
- This DTC runs continuously within the enabling conditions.

P0119

This DTC runs continuously within the enabling conditions.

Conditions for Setting the DTC

P0117

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

P0118

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

P0119

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

Action Taken When the DTC Sets

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

Conditions for Clearing the DTC

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

Diagnostic Aids

NOTE: **The engine coolant temperature (ECT) sensor 1 is mounted on the engine and the engine coolant temperature (ECT) sensor 2, radiator coolant temperature (RCT) sensor, is mounted on the radiator.**

- The engine coolant temperature gauge will display full cold when an ECT DTC set's.
- After starting the engine, the engine coolant temperature (ECT) sensor 1 temperature should rise steadily, then stabilize after the thermostat opens.

Reference Information

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DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify the scan tool ECT Sensor parameter is between -39 to + 120°C (-38 to +248°F) and changes with engine run time.
    - **If not between -39 to + 120°C (-38 to +248°F) or does not change**

      Refer to Circuit/System Testing.

    - **If between -39 to + 120°C (-38 to +248°F) and changes**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.
    - **If the DTC sets**

Refer to Circuit/System Testing.

- **If the DTC does not set**

5. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the 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 ohms between the low reference circuit terminal 2 and ground.
   - **If 5 ohms or greater**
     1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
     2. Test for less than 2 ohms in the low reference circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
   - **If less than 5 ohms**
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)**
     1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
     2. Test for infinite resistance between the signal circuit terminal 1 and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance, replace the K20 Engine Control Module.
   - **If colder than -39°C (-38°F)**
5. Install a 3 A fused jumper wire between the signal circuit terminal 1 and the low reference circuit terminal 2.
6. Verify the scan tool ECT sensor parameter is warmer than 149°C (300°F).
   - **If colder than 149°C (300°F)**
     1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
     2. Test for less than 1 V between the signal circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V
     3. Ignition OFF.
     4. Test for less than 2 ohms in the signal circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
   - **If warmer than 149°C (300°F)**
7. Test or replace the B34 Engine Coolant Temperature Sensor.

Component Testing

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

2. Test the ECT sensor by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the **Temperature Versus Resistance - Engine Coolant Temperature Sensor** table. The resistance values should be in range of the table values.
    - **If not within the specified range**

      Replace the B34 Engine Coolant Temperature Sensor.

    - **If within the specified range**
3. Test for infinite resistance between each terminal and the sensor housing.
    - **If less than infinite resistance**

      Replace the B34 Engine Coolant Temperature Sensor.

    - **If infinite resistance**
4. All OK.

Repair Instructions

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

- **Engine Coolant Temperature Sensor Replacement**
- **Engine Control Module Replacement** engine control module replacement, programming, and setup.

DTC P0121-P0123, P0222, P0223, P16A0-P16A2, OR P2135

Diagnostic Instructions

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

DTC Descriptors

DTC P0121

Throttle Position Sensor 1 Performance

DTC P0122

Throttle Position Sensor 1 Circuit Low Voltage

DTC P0123

Throttle Position Sensor 1 Circuit High Voltage

DTC P0222

Throttle Position Sensor 2 Circuit Low Voltage

DTC P0223

Throttle Position Sensor 2 Circuit High Voltage

DTC P16A0

Sensor Communication Circuit Low Voltage

DTC P16A1

Sensor Communication Circuit High Voltage

DTC P16A2

Sensor Communication Circuit Performance

DTC P2135

Throttle Position Sensors 1-2 Not Plausible

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P06A3	P0122*, P0222*, P16A0	P06A3	P0121*, P16A2, P2135*
Signal	P0122*, P0222*, P16A0	P0122*, P0222*, P16A1	P0123*, P0223*, P16A0**, P16A1**, P16A2**	P0121*, P16A2, P2135*
Low Reference	-	P0123*, P0223*, P16A1	-	P0121*, P16A2, P2135*
* This DTC set indicates an internal throttle body condition. ** A short to voltage causes P16A1 to set. If DTC P16A0, P16A1, and P16A2 set at the same time, an intermittent circuit condition exists.				

Typical Scan Tool Data

Throttle Position Sensor 1

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: The engine is operating with the throttle closed. All accessories OFF. **Parameter Normal Range:** Throttle Position Sensor 1 3.75-4.75 V			
5 V Reference	5.0 V	5.0 V	5.0 V
Signal	5.0 V	0.0 V	0.0 V
Low Reference	-	0.0 V	-

Throttle Position Sensor 2

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: The engine is operating with the throttle closed. All accessories OFF. **Parameter Normal Range:** Throttle Position Sensor 2 0.45-0.90 V			
5 V Reference	0.0 V	0.0 V	0.0 V
Signal	0.0 V	5.0 V	5.0 V
Low Reference	-	5.0 V	-

Circuit/System Description

The throttle body assembly contains a contact-less inductive throttle position sensing element that is managed by a customized integrated circuit. The throttle position sensor is mounted within the throttle body assembly and is not serviceable. The engine control module (ECM) supplies the throttle body with a 5 V reference circuit, a low reference circuit, an H-bridge motor directional control circuit, and an asynchronous signal/serial data circuit. The asynchronous signal means communication is only going from the throttle body to the ECM. The throttle body cannot receive data from the ECM over the signal/serial data circuit. The throttle position sensor provides a signal voltage that changes relative to throttle blade angle. The customized integrated circuit translates the voltage based position information into serial data using the Society of Automotive Engineers (SAE) J2716 Single Edge Nibble Transmission (SENT) protocol. The throttle position sensor information is transmitted between the throttle body and the ECM on the signal/serial data circuit. The ECM decodes the serial data signal into separate voltages which are displayed on a scan tool as the voltage inputs from TP sensors 1 and 2.

Conditions for Running the DTC

P0121

- DTCs P0102, P0103, P0107, P0108, P0112, P0113, P0117, P0118, P0335, or P0336 is not set.
- The engine speed is between 500-6,800 RPM.
- The engine coolant temperature (ECT) is between -7 to +125°C (19-257°F).
- The intake air temperature (IAT) is between -20 to +126°C (-4 to +259°F).
- The DTC runs continuously when the above conditions are met.

P0122, P0123, P0222, P0223

- DTC P06A3 is not set.
- The ignition is ON or the engine is running.
- The run/crank or powertrain relay voltage is greater than 6.41 V and reduced power is not active.
- The DTCs run continuously when the above condition are met.

P16A0, P16A1, or P16A2

- DTC P06A3 is not set.
- The ignition is ON or the engine is operating.
- The run/crank voltage is greater than 6.41 V.
- The DTCs run continuously once the above conditions are met for greater than 1 s.

P2135

- DTCs P0122, P0123, P0222, P0223, or P06A3 are not set.
- The ignition is ON or the engine is running.
- The run/crank or powertrain relay voltage is greater than 6.41 V and reduced power is not active.
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

P0121

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

P0122

The ECM detects the throttle position sensor 1 signal voltage is less than 0.33 V for greater than 1 s.

P0123

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

P0222

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

P0223

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

P16A0

The ECM detects a low voltage circuit condition on the throttle position sensor signal circuit for greater than 1 s.

P16A1

The ECM detects a high voltage circuit condition on the throttle position sensor signal circuit for greater than 1 s.

P16A2

The ECM detects an incorrect message was received over the throttle position sensor signal circuit for greater than 1 s.

P2135

- The ECM detects that throttle position sensors 1 and 2 disagree greater than 7-10 percent for greater than 1 s.

  OR

- The ECM detects that the TP sensor 1 and 2 learned minimum throttle position is greater than 5 percent of the 5 volt reference voltage.

Action Taken When the DTC Sets

- DTCs P0121 is a Type B DTC.
- DTCs P0122, P0123, P0222, P0223, P16A0, P16A1, P16A2, and P2135 are Type A DTCs.
- The ECM commands the throttle actuator control (TAC) system to operate in a Reduced Engine Power mode.
- A message center or an indicator displays Reduced Engine Power.
- Under certain conditions, the ECM commands the engine OFF.

Conditions for Clearing the DTC

- DTCs P0121 is a Type B DTC.
- DTCs P0122, P0123, P0222, P0223, P16A0, P16A1, P16A2, and P2135 are Type A DTCs.

Diagnostic Aids

- A high resistance condition on the throttle position and throttle actuator control circuits could cause a DTC to set.
- If the accelerator pedal is pressed to the wide open throttle position, the throttle blade angle or Throttle Position angle is limited to less than 40 percent.

Reference Information

Schematic Reference

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Description and Operation

Throttle Actuator Control (TAC) System Description

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- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON,
2. Verify that DTC P0601-P0606, P06A3, and P16F3 is not set.
   - **If a DTC is set**

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

   - **If a DTC is not set**
3. Verify the scan tool Throttle Body Idle Air flow Compensation parameter is less than 90 %.
   - **If 90 % or greater**

     Refer to **Throttle Body Cleaning** .

   - **If less than 90 %**
4. Verify that DTC P0122, P0123, P0222, P0223, P16A0, P16A1, P16A2, or P2135 are not set.
   - **If DTC P0122, P0123, P0222, P0223, or P2135 are the only DTCs set**

     Test or replace the Q38 Throttle Body.

   - **If any of the DTCs are set**

     Refer to Circuit/System Testing

   - **If none of the DTCs are set**
5. Verify the Throttle Position Sensors 1 and 2 Agree/Disagree parameter displays Agree while performing the Throttle Sweep Test with a scan tool.
   - **If Agree is not displayed**

     Test or replace the Q38 Throttle Body Assembly.

   - **If Agree is displayed**
6. Verify DTC P0121, P0122, P0123, P0222, P0223, P16A0, P16A1, P16A2, and P2135 is not set.
   - **If a DTC is set**

     Refer to Circuit/System Testing.

   - **If a DTC is not set**
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.
   - **If the MAP Sensor pressure is not in range**

Refer to **DTC P0106**.

- **If 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.
    1. Engine idling
    2. Perform the scan tool snapshot function.
    3. Increase the engine speed slowly to 3,000 RPM and then back to idle.
    4. Exit from the scan tool snapshot and review the data.
    5. Observe the MAF Sensor parameter frame by frame with a scan tool.
    - **If the MAF Sensor parameter does not change smoothly and gradually**

      Refer to **DTC P0101**.

    - **If 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).
    - **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)**
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.
    - **If the parameters are not within 20 kPa (2.9 psi)**

      Refer to **DTC P0236**

    - **If the parameters are within 20 kPa (2.9 psi)**
14. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
15. Verify the DTC does not set.
    - **If the DTC sets**

      Refer to Circuit/System Testing.

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

Circuit/System Testing

NOTE: Disconnecting the throttle body harness connector causes additional DTCs to set.

1. Ignition OFF, and all vehicle systems OFF, disconnect the harness connector at Q38 Throttle Body Assembly. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 ohms between the low reference circuit terminal 4 and ground.
   - **If 5 ohms or greater**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 ohms in the low reference circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 Engine Control Module.
   - **If less than 5 ohms**
3. Ignition ON.
4. Test for 4.8-5.2 V between the 5 V reference circuit terminal 5 and ground.
   - **If less than 4.8 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the 5 V reference circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 ohms in the 5 V reference circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 Engine Control Module.
   - **If greater than 5.2 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the 5 V reference circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If between 4.8-5.2 V**
5. Ignition ON.
6. Test for 4.8-5.2 V between the signal circuit terminal 3 and ground.
   - **If less than 4.8 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the signal circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 ohms in the signal circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 Engine Control Module.

- **If greater than 5.2 V**

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

- **If between 4.8-5.2 V**

7. Test or replace the Q38 Throttle Body Assembly.

Repair Instructions

- **Throttle Body Assembly Replacement**
- **Control Module References** for engine control module replacement, programming, and setup

Repair Verification

1. Install any components that have been removed or replaced during diagnosis.
2. Perform any adjustments, programming or setup procedures that are required when a component is removed or replaced.
3. Clear the DTCs with a scan tool.
4. Ignition OFF and all vehicle systems OFF. It may take up to 2 minutes for all vehicle systems to power down.
5. Ignition ON.
6. Verify the Throttle Position Sensors 1 and 2 Agree/Disagree parameter displays Agree while performing the Throttle Sweep Test with a scan tool.
   - **If Agree is not displayed**

     Test or replace the Q38 Throttle Body Assembly.

   - **If Agree is displayed**
7. If the repair was related to a DTC, duplicate the Conditions for Running the DTC and use the Freeze Frame/Failure Records, if applicable, in order to verify the DTC does not set.
   - **If DTC sets**

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

   - **If DTC does not set**
8. All OK.

DTC P0128

Diagnostic Instructions

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

DTC Descriptor

DTC P0128

Engine Coolant Temperature (ECT) Below Thermostat Regulating Temperature

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
ECT Sensor Signal	P0117, P0119	P0118	P0118	P0116, P0119, P0128
Low Reference	-	P0118, P0119	-	P0119, P0128

Typical Scan Tool Data

ECT Sensor

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: The ignition is ON, or the engine is running **Parameter Normal Range:** Varies with ambient temperature, within a range of -39 to +120°C (-38 to +248°F)			
ECT Sensor Signal	140°C (284°F)	-40°C (-40°F)	-40°C (-40°F)
Low Reference	-	-40°C (-40°F)	-40°C (-40°F)

Circuit/System Description

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

The purpose of this diagnostic is to analyze the performance of the thermostat by comparing the measured ECT to a modeled ECT using information from the following inputs:

- ECT
- Engine load
- Intake air temperature (IAT)
- Mass air flow (MAF)
- Vehicle speed (VS)

The ECM uses the start-up ECT and the start-up intake air temperature (IAT) to begin the diagnostic calculation. The air flow into the engine is accumulated, and vehicle speed, distance, engine load, and engine run time are also factored in to determine if the ECT does increase normally and then maintains that temperature within a calibrated range of the modeled ECT.

Conditions for Running the DTC

- DTC P0102, P0103, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0221, P0222, P0223, P0335, P0336, or P0501 is not set.

- The decrease in ECT after engine start is within a calibrated range.
- The decrease in IAT after engine start is within a calibrated range.
- The engine idle time is less than 40 %.
- The engine run time is greater than 8 s.
- The engine run time at minimum load is less than 50 %.
- The engine run time at maximum load is less than 90 %.
- The ignition voltage is greater than 10 V.
- The start-up ECT is between -10 and +75°C (14-167°F).
- The start-up IAT is warmer than -10°C (14°F).
- The DTC runs once per drive cycle within the enabling conditions.

Conditions for Setting the DTC

The ECM determines that the modeled ECT has met the calibrated target of 92°C (198°F) and the measured ECT is less than 81°C (178°F) for greater than 2 s.

Action Taken When the DTC Sets

- DTC P0128 is a Type B DTC.
- The Engine Coolant Temperature Gauge is inoperative.
- The cooling fans will be commanded ON.
- The AC compressor will be commanded OFF.

Conditions for Clearing the MIL/DTC

DTC P0128 is a Type B DTC.

Diagnostic Aids

- DTC P0128 occurring with insufficient vehicle interior heating is an indication of improper thermostat operation.
- Corrosion on 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.

Reference Information

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information.

Circuit/System Verification

1. Verify the cooling system is filled to the correct coolant level. Refer to **Cooling System Leak Testing** , and **Cooling System Draining and Filling (Static Fill)** , **Cooling System Draining and Filling (GE 47716)** .
   - **If the coolant level is not correct**

     Repair as necessary

   - **If the coolant level is correct**

   NOTE: A critical analysis of the operation of the thermostat is necessary to properly diagnose this DTC.

2. Verify the proper heat range and the operation of the thermostat. Refer to **Thermostat Diagnosis** .
   - **If a condition is found**

     Replace the Thermostat.

   - **If a condition is not found**
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 Step 1.

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

Repair Instructions

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

- **ENGINE COOLANT THERMOSTAT HOUSING REPLACEMENT (LTG)**
- **Control Module References** for ECM replacement, setup and programming

DTC P0131, P0132, P0134, P0137, P0138, P0140, OR P2A00

Diagnostic Instructions

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

DTC Descriptors

DTC 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

DTC P2A00

HO2S Performance Sensor 1

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, P2A00	P0133, P013A, P013B, P013E, P013F, P015A, P015B
HO2S Low Signal	P0131, P0137, P0171	P0132, P0134, P0138, P0140	P0132, P0134, P0138, P0140, P2A00	P0133, P013A, P013B, P013E, P013F, P015A, P015B

Typical Scan Tool Data

HO2S Sensor 1 or 2

Circuit	Short to Ground	Open	Short to Voltage
Parameter Normal Range: 200-800 mV			
HO2S High Signal	0.00 V	1.7-2.1 V	1.7-2.1 V
HO2S Low Signal	0.00 V	1.7-2.1 V	1.7-2.1 V

Circuit/System Description

The heated oxygen sensors (HO2S) are used for fuel control and catalyst monitoring. Each HO2S compares the oxygen content of the surrounding air with the oxygen content of the exhaust stream. When the engine is started, the control module operates in an Open Loop mode, ignoring the HO2S signal voltage while calculating the air-to-fuel ratio. While the engine runs, the HO2S heats up and begins to generate a voltage within a range of 0-1,000 mV. Once sufficient HO2S voltage fluctuation is observed by the control module, Closed Loop is entered. The control module uses the HO2S voltage to determine the air-to-fuel ratio. An HO2S voltage that increases toward 1,000 mV indicates a rich fuel mixture. An HO2S voltage that decreases toward 0 mV indicates a lean fuel mixture.

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

Conditions for Running the DTC

P0131 or P0137

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0112, P0113, P0116, P0117, P0118, P0120, P0121, P0122, P0123, P0128, P0201, P0202, P0203, P0204, P0205, P0206, P0207, P0208, P0220, P0222, P0223, P0442, P0443, P0446, P0449, P0455, P0496, P1516, P2101, P2119, P2135, P2176 are not set.
- The Ignition voltage is between 10-32 V.
- The fuel system is operating in Closed Loop.
- Device controls are not active.
- The fuel level is greater than 10 percent.
- The throttle position (TP) is between 3-70 percent.
- Ethanol content is less than 87 percent.
- Decel fuel cut-off is not active.
- The DTCs run continuously when the above conditions are met for 5 s.

P0132 or P0138

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0112, P0113, P0116, P0117, P0118, P0120, P0121, P0122, P0123, P0128, P0201, P0202, P0203, P0204, P0205, P0206, P0207, P0208, P0220, P0222, P0223, P0442, P0443, P0446, P0449, P0455, P0496, P1516, P2101, P2119, P2135, P2176 are not set.
- The Ignition voltage is between 10-32 V.
- The fuel system is operating in Closed Loop.
- Ethanol content is less than 87 percent.
- The fuel level is greater than 10 percent.
- The engine run time is greater than 20 s.
- The DTCs run continuously when the above conditions are met for 5 s.

P0134 or P0140

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0112, P0113, P0116, P0117, P0118, P0120, P0121, P0122, P0123, P0128, P0201, P0202, P0203, P0204, P0205, P0206, P0207, P0208,

P0220, P0222, P0223, P0442, P0443, P0446, P0449, P0455, P0496, P1516, P2101, P2119, P2135, P2176 are not set.

- The Ignition voltage is between 10-32 V.
- The engine run time is greater than 150 s.
- The fuel system is in Closed Loop.
- Ethanol content is less than 87 percent.
- The DTCs run continuously when the above conditions are met.

P2A00

- DTCs P0068, P0106, P0107, P0108, P0116, P0117, P0118, P0120, P0121, P0122, P0123, P0128, P0131, P0132, P0151, P0152, P0201, P0202, P0203, P0204, P0220, P0222, P0223, P1516, P2101, P2119, P2135, P2176 are not set.
- The Ignition voltage is between 10-32 V.
- The engine run time is greater than 100 s.
- The engine speed is between 1,000-3,400 RPM.
- The engine air flow is between 4-30 g/s.
- The engine coolant temperature (ECT) is warmer than 65°C (149°F).
- Decel fuel cut-off is not active.
- DTC P2A00 runs continuously when the above conditions are met for 5 s.

Conditions for Setting the DTC

P0131 or P0137

The engine control module detects that the heated oxygen sensor voltage is less than 50 mV and the circuit is shorted to ground for greater than 50 s.

P0132 or P0138

The engine control module detects that the heated oxygen sensor voltage is greater than 1,050 mV and the circuit is shorted to voltage for greater than 13 s.

P0134 or P0140

The engine control module detects that the heated oxygen sensor voltage is greater than 1.7 V and is an open circuit for greater than 50 s.

P2A00

The ECM detects that the Loop Status parameter is open for greater than 50 s.

Action Taken When the DTC Sets

DTCs P0131, P0132, P0134, P0137, P0138, P0140 and P2A00 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P0131, P0132, P0134, P0137, P0138, P0140 and P2A00 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
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 running.
4. Verify the scan tool HO2S Sensor 1 or 2 parameters are between 50-1,050 mV.
   - **If not between 50-1,050 mV.**

     Refer to Circuit/System Testing.

   - **If between 50-1,050 mV.**
5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify the DTC does not set.
   - **If the DTC sets.**

Refer to Circuit/System Testing.

- **If the DTC does not set.**

7. All OK.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the appropriate B52 Heated Oxygen Sensor harness connector. It may take up to 2 minutes for all vehicle systems to power down. Ignition ON.
2. Test for 1.7-3.0 V between the high signal circuit terminal 4 and ground.
   - **If less than 1.7 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the high signal circuit terminal 4 and ground.
      - If less than infinite resistance repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 ohms in the high signal circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 Engine Control Module.
   - **If greater than 3.0 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the high signal circuit 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 sensor 1 or 2 parameter is between 1.7-2.1 V.
   - **If less than 1.7 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the low signal circuit terminal 3 and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.
   - **If between 1.7-2.1 V**
4. Connect a 3 A fused jumper wire between the high signal circuit terminal 4 and the low signal circuit terminal 3.

NOTE: **The low signal circuit is tied to a pull-up circuit within the engine control module. A voltage of 0.0-1.10 V on the low signal circuit is normal.**

5. Verify the scan tool HO2S sensor 1 or 2 parameter displays 0.0 V.
   - **If greater than 0.0 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

2. Test for less than 2 ohms in the low signal circuit end to end.
    - If 2 ohms or greater, repair the open/high resistance in the circuit.
    - If less than 2 ohms
3. Test for less than 1 V between the low signal circuit terminal 3 and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.
    - **If 0.0 V**
6. Verify none of the conditions listed below exist:
    - Water intrusion in the B52 Heated Oxygen Sensor harness connector
    - Low or high fuel system pressure-Refer to **Fuel System Diagnosis** .
    - Fuel that is contaminated-Refer to **Alcohol/Contaminants-in-Fuel Diagnosis** .
    - Fuel saturation of the evaporative emission (EVAP) canister
    - Exhaust leaks
    - Engine vacuum leaks
    - **If any of the conditions exist**

      Repair as necessary.

    - **If none of the conditions exist**

      Test or replace the B52 Heated Oxygen Sensor.

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 an HO2S.
- **Control Module References** for ECM replacement, programming and setup

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

Diagnostic Instructions

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

DTC Descriptors

DTC P0133

HO2S Slow Response Sensor 1

DTC P013A

HO2S Slow Response Rich to Lean Sensor 2

DTC P013B

HO2S Slow Response Lean to Rich Sensor 2

DTC P013E

HO2S Delayed Response Rich to Lean Sensor 2

DTC P013F

HO2S Delayed Response Lean to Rich Sensor 2

DTC P015A

HO2S Delayed Response Rich to Lean Sensor 1

DTC P015B

HO2S Delayed Response Lean to Rich Sensor 1

DTC P2270

HO2S Signal Stuck Lean Sensor 2

DTC P2271

HO2S Signal Stuck Rich Sensor 2

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
HO2S High Signal	P0131, P0137	P0132, P0134, P0138, P0140	P0132, P0134, P0138, P0140	P0133, P013A, P013B, P013E, P013F, P015A, P015B
HO2S Low Signal	P0131, P0137	P0132, P0134, P0138, P0140	P0132, P0134, P0138, P0140	P0133, P013A, P013B, P013E, P013F, P015A, P015B

Typical Scan Tool Data

HO2S Sensor 1 or 2

Circuit	Short to Ground	Open	Short to Voltage

Parameter Normal Range: 200-800 mV			
HO2S High Signal	0.00 V	1.7-2.1 V	1.7-2.1 V
HO2S Low Signal	0.00 V	1.7-2.1 V	1.7 - 2.1 V

Circuit/System Description

The heated oxygen sensors (HO2S) are used for fuel control and catalyst monitoring. Each HO2S compares the oxygen content of the surrounding air with the oxygen content of the exhaust stream. When the engine is started, the control module operates in an Open Loop mode, ignoring the HO2S signal voltage while calculating the air-to-fuel ratio. While the engine runs, the HO2S heats up and begins to generate a voltage within a range of 0-1,000 mV. Once sufficient HO2S voltage fluctuation is observed by the control module, Closed Loop is entered. The control module uses the HO2S voltage to determine the air-to-fuel ratio. An HO2S voltage that increases toward 1,000 mV indicates a rich fuel mixture. An HO2S voltage that decreases toward 0 mV indicates a lean fuel mixture.

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

Conditions for Running the DTC

P0133

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0116, P0117, P0118, P0120, P0121, P0122, P0123, P0128, P0131, P0132, P0134, P0201, P0202, P0203, P0204, P0205, P0206, P0207, P0208, P0220, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282, P0283, P0300-P0308, P0442, P0443, P0446, P0449, P0452, P0453, P0455, P0496, P1104, P1248, P1249, P124A, P124B, P124C, P124D, P124E, P124F, P1516, P16F3, P2100-P2103, P2119, P2135, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F, P217B, P217C, P217E, P217F, P2176, P2227-P2230 are not set.
- The Ignition voltage is between 10-32 V.
- The engine coolant temperature (ECT) is warmer than 70°C (158°F).
- The intake air temperature (IAT) is warmer than -40°C (-40°F)
- The fuel level is greater than 10%.
- The engine run time is greater than 1205 s.
- The engine speed is between 1,000-3,500 RPM.
- The barometric (BARO) pressure is greater than 70 kPa.
- The mass airflow (MAF) is between 10-40 g/s.
- The fuel system is in Closed Loop.
- Ethanol content is less than 87%.
- Fuel control is not in power enrichment.
- Decel fuel cut-off is not active.
- The DTCs run once per drive cycle when the above conditions are met for 3 s.

P013A or P013E

- Before the ECM can report DTC P013A, or P013C failed, DTCs P013E, P014A, P2270, and P2272 must run and pass.
- Before the ECM can report DTC P013E, or P014A failed, DTCs P2270 and P2272 must run and pass.
- DTCs P0030, P0036, P0053, P0054, P0101, P0102, P0103, P0106, P0107, P0108, P0120, P0121, P0122, P0123, P0131, P0132, P0133, P0134, P0135, P0137, P0138, P013A, P013B, P013E, P013F, P0140, P0141, P0171, P0172, P0201-P0208, P0220, P0222, P0223, P0300-P0308, P0442, P0443, P0446, P0449, P0455, P0496, P1133, P1174, P1516, P2101, P2119, P2135, P2176, P2270, P2271, P2A00 are not set.
- The Ignition voltage is between 10-32 V.
- The learned heater resistance is valid.
- The fuel level is greater than 10%.
- After the above conditions are met decel fuel cut-off continues without driver initiated pedal input.
- The DTCs run once per ignition cycle, during decel fuel cut-off (DFCO), when the above conditions are met.

P013B or P013F

- Before the ECM can report DTC P013B, or P013D failed, DTCs P013A, P013C, P013E, P013F, P014A, P014B, P2270, P2271, P2272, and P2273 must run and pass.
- Before the ECM can report DTC P013F, or P014B failed, DTCs P013A, P013C, P013E, P014A, P2270, P2271, P2272, and P2273 must run and pass.
- DTCs P0030, P0036, P0053, P0054, P0101, P0102, P0103, P0106, P0107, P0108, P0120, P0121, P0122, P0123, P0131, P0132, P0133, P0134, P0135, P0137, P0138, P013A, P013B, P013E, P013F, P0140, P0141, P0171, P0172, P0201-P0208, P0220, P0222, P0223, P0300-P0308, P0442, P0443, P0446, P0449, P0455, P0496, P1133, P1174, P1516, P2101, P2119, P2135, P2176, P2270, P2271, P2A00 are not set.
- The Ignition voltage is between 10-32 V.
- The learned heater resistance is valid.
- The fuel level is greater than 10%.
- After the above conditions are met, fuel enrich mode is continued.
- The DTCs run once per ignition cycle when the above conditions are met.

P015A or P015B

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0112, P0113, P0116, P0117, P0118, P0120, P0121, P0122, P0123, P0128, P0201, P0202, P0203, P0204, P0205, P0206, P0207, P0208, P0220, P0222, P0223, P0442, P0443, P0446, P0449, P0455, P0496, P1516, P2101, P2119, P2135, P2176 are not set.
- The Ignition voltage is between 10-32 V.
- The engine coolant temperature (ECT) is warmer than 70°C (158°F).
- The intake air temperature (IAT) is warmer than -40°C (-40°F)
- The fuel level is greater than 10%.
- The engine run time is greater than 120 s.
- The engine speed is between 1,250-2,300 RPM.
- The vehicle speed is between 56-119 km/h (35-74 mph).

- The mass airflow (MAF) is between 3-12 g/s.
- The fuel system is in Closed Loop.
- Device controls are not active.
- The evaporative emission (EVAP) diagnostics are not in control of purge.
- The heated oxygen sensor 1 heater is on for greater than 40 s.
- The heated oxygen sensor 2 heater is on for greater than 175 s
- After the above conditions are met for 1 s the fuel mixture is forced rich.
- At the end of the forced rich fuel state, the heated oxygen sensor 1 is greater than 0.690 V and decel fuel cut-off is active.
- The DTCs run once per drive cycle when the above conditions are met.

P2270

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0112, P0113, P0116, P0117, P0118, P0120, P0121, P0122, P0123, P0128, P013A, P013B, P013E, P013F, P0171, P0172, P0201, P0202, P0203, P0204, P0220, P0222, P0223, P0300, P0411, P0412, P0418, P1174, P1516, P2101, P2119, P2135, P2176, P2270, P2271 are not set.
- The system voltage is between 10-32 V.
- The fuel level is greater than 10%.
- The pedal position is less than 4%.
- The engine speed is between 1,250-2,300 RPM.
- The engine airflow is between 3-12 g/s.
- The vehicle speed is between 55-120 km/h (35-74 mph).
- The fuel state is in Closed Loop.
- The evaporative emission (EVAP) diagnostics are not in control of purge.
- The HO2S heaters are ON for more than 180 s.
- The predicted catalytic converter temperature is between 600-850°C (1,112-1,562°F).
- This DTC runs once per trip when all of the above conditions have been met for 1 s.

P2271

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0112, P0113, P0116, P0117, P0118, P0120, P0121, P0122, P0123, P0128, P013A, P013B, P013E, P013F, P0171, P0172, P0201, P0202, P0203, P0204, P0220, P0222, P0223, P0300, P0411, P0412, P0418, P1174, P1516, P2101, P2119, P2135, P2176, P2270 are not set.
- The system voltage is between 10-32 V.
- The fuel level is greater than 10%.
- The engine speed is between 1,250-2,300 RPM.
- The engine airflow is between 3-12 g/s.
- The vehicle speed is between 55-120 km/h (34.2-74.6 mph).
- The fueling state is in Closed Loop.
- The evaporative emission (EVAP) diagnostics are not in control of purge.
- Power take-off is not active.

- The heated oxygen sensor heaters have been on more than 180 s.
- The predicted catalyst temperature is between 600-850°C (1,112-1,562°F).
- DTCs P013A, P013E, and P2270 have run and passed.

THEN

- Decel fuel cut-off is active.
- The accelerator pedal position is stable.
- This DTC runs once per trip when the above conditions are met for 3 s.

Conditions for Setting the DTC

P0133, P015A or P015B

- The engine control module detects that the heated oxygen sensor rich-to-lean or lean-to-rich average response time is greater than a calibrated value.
- The DTCs set within 60 s when the above condition is met.

P013A

The engine control module detects that the accumulated mass air flow monitored during rich-to-lean transitions between 450-150 mV is greater than 75 grams.

P013B

The engine control module detects that the accumulated mass air flow monitored during lean-to-rich transitions between 300-600 mV is greater than 75 grams.

P013E

The engine control module detects that the heated oxygen sensor voltage has not decreased below 450 mV within a calibrated value of accumulated air flow.

P013F

The engine control module detects that the heated oxygen sensor voltage has not increased above 300 mV within a calibrated value of accumulated air flow.

P2270

The engine control module does not detect a heated oxygen sensor voltage greater than 825 mV before accumulated mass air flow exceeds a calibrated value.

P2271

The engine control module does not detect an heated oxygen sensor voltage less than 100 mV before accumulated mass air flow exceeds a calibrated value.

Action Taken When the DTC Sets

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

Conditions for Clearing the DTC

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

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
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. Verify none of the conditions listed below exist:
    - Lean or rich fuel injectors-Refer to **Fuel Injector Solenoid Coil Test** .
    - 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 consumption-Refer to **Oil Consumption Diagnosis** .
- Engine coolant consumption-Refer to **Loss of Coolant** .
    - **If any of the above conditions exist**

      Repair as necessary.

    - **If any of the conditions exist**

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

      Test or replace the appropriate B52 HO2S.

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

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 an HO2S.
- **Control Module References** for ECM replacement, programming and setup

DTC P0171 OR P0172

Diagnostic Instructions

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

DTC Descriptors

DTC P0171

Fuel Trim System Lean

DTC P0172

Fuel Trim System Rich

Circuit/System Description

The engine control module (ECM) controls a Closed Loop air/fuel metering system in order to provide the best possible combination of driveability, fuel economy, and emission control. The ECM monitors the heated oxygen sensor (HO2S) signal voltage, and adjusts the fuel delivery based on the signal voltage while in Closed Loop. A change made to the fuel delivery changes the long and short term fuel trim values. The short term fuel trim values change rapidly in response to the HO2S signal voltages. These changes fine tune the engine fueling. The long term fuel trim values change in response to trends in the short term fuel trim The long term fuel trim makes coarse adjustments to fueling in order to re-center and restore control to short term fuel trim. The ideal fuel trim values are around 0 %. A positive fuel trim value indicates that the ECM is adding fuel in order to compensate for a lean condition. A negative fuel trim value indicates that the ECM is reducing the amount of fuel in order to compensate for a rich condition.

Conditions for Running the DTC

- DTCs P0030, P0053, P0101, P0102, P0103, P0106, P0107, P0108, P0131-P0135, P015A, P015B, P0178, P0179, P0201-P0204, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0300-P0304, P0411, P0442, P0455, P0458, P0496, P0506, P0507, P1248, P1249, P124A, P124B, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P2227, P2228, P2229, P2230, P2269, P2440, P2444, or P2A00 are not set.
- The engine is in Closed Loop status.
- The catalyst monitor diagnostic intrusive test, post 02 diagnostic intrusive test, device control, and evaporative emission leak test are not active.
- The engine coolant temperature (ECT) is between -20 and +130°C (-4 and +266°F).
- The intake air temperature (IAT) is between -20 and +150°C (-4 and +302°F).
- The manifold absolute pressure (MAP) is between 15-255 kPa (2.2-37 psi).
- The engine speed is between 400-6,600 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.

Conditions for Setting the DTC

- The average long term fuel trim weighted average value is greater or less than a calibrated value.
- The above condition is present for approximately 3 min after the Conditions for Running the DTC have been met.

Action Taken When the DTC Sets

DTCs P0171 and P0172 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P0171 and P0172 are Type B DTCs.

Diagnostic Aids

- Allow the engine to reach operating temperature. With the engine running, observe the HO2S parameter with a scan tool. The HO2S value should vary from approximately 40 mV to approximately 900 mV, and respond to fueling changes.
- The normal Short Term Fuel Trim and Long Term Fuel Trim parameters should be between +10 and -10 % with 0 % the optimum, with the engine running at operating temperature.
- Any un-metered air into the engine causes this DTC to set. Thoroughly inspect all areas of the engine for vacuum leaks.
- A MAF sensor condition can cause this DTC without setting a MAF DTC. If there is a MAF sensor condition, the MAF sensor parameters will appear to be within range.
- Inspect the air filter for being the correct one for this application. Make sure that the engine oil fill cap is in place and that it is tight. Verify that the engine oil dip stick is fully seated.
- Certain aftermarket air filters may cause a DTC to set.
- Certain aftermarket air induction systems or modifications to the air induction system may cause a DTC to set.
- Certain aftermarket exhaust system components may cause a DTC to set.

Reference Information

Component View Reference

Powertrain Component Views

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify no other DTCs are set.
    - **If any other DTCs are set**

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

    - **If no other DTCs are set**
3. Verify DTC P0171 or P0172 is not set.

- **If a DTC is set**

  Refer to Circuit/System Testing.

- **If no DTC is set**

4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed in the Freeze Frame/Failure Records data.
5. Verify DTC P0171 or P0172 is not set.
   - **If any of the DTCs set**

     Refer to Circuit/System Testing.

   - **If none of the DTCs set**
6. All OK.

Circuit/System Testing

1. Ignition ON.
2. Verify the manifold absolute pressure sensor is within the range specified for your altitude. Refer to **Altitude Versus Barometric Pressure**
   - **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 -21 % and +38.5 %.
   - **If greater than +38.5 %**
   1. Ignition OFF.
   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 Solenoid Coil Test** .
      - Vacuum hoses for splits, kinks, and improper connections
      - 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
      - Leaks in the components of the vacuum operated engine mount system
      - Missing air filter element
      - Cracked EVAP canister

- Evaporative pipes obstructed or leaking
- The crankcase ventilation system for leaks-Refer to **Crankcase Ventilation System Inspection/Diagnosis** .
  - If a condition is found, repair as necessary.
  - If no condition is found, inspect the engine for a mechanical condition. Refer to **Symptoms - Engine Mechanical** .

- **If less than -21 %**

1. Ignition OFF.
2. Inspect for the conditions listed below:
   - Mass air flow (MAF) sensor signal skewed-If the Short Term Fuel Trim parameters for both banks changes greater than 20 % when the MAF sensor is disconnected, refer to **DTC P0101**.
   - 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 Solenoid Coil Test**
   - Collapsed or restricted air intake duct
   - Excessive fuel pressure - Refer to **Fuel System Diagnosis**
   - Dirty or restricted air filter
   - Objects blocking the throttle body
   - Improper operation of the evaporative emissions control system
   - Excessive fuel in the crankcase-Change the engine oil as necessary.
   - If a condition is found, repair as necessary.
   - If no condition is found, inspect the engine for a mechanical condition. Refer to **Symptoms - Engine Mechanical** .
   - **If between -21 % and +38.5 %**
5. All OK.

Repair Instructions

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

Reset the fuel trim after completing the repair.

DTC P018B-P018D

Diagnostic Instructions

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

DTC Descriptors

DTC P018B

Fuel Pressure Sensor Performance

DTC P018C

Fuel Pressure Sensor Circuit Low Voltage

DTC P018D

Fuel Pressure Sensor Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P018C, P0192, P0452, P0522, P0532, P0641, P2227, P2228	P018C	P018D, P0193, P0453, P0523, P0641, P2227	P018B
Signal	P018C	P018C	P018D	P018B
Low Reference	-	P018D	P018D	P018B

Circuit/System Description

The fuel pressure sensor is located on the fuel pipe. The fuel pressure sensor monitors the fuel pressure in the fuel line. The engine control module (ECM) monitors the voltage signal from the fuel pressure sensor. The sensor provides a fuel pressure signal to the ECM, which is used to provide Closed Loop fuel pressure control.

Conditions for Running the DTC

P018B

- DTC P018C, P018D, P0231, P0232, P023F, P0606, P0641, or P1255 is not set.
- The engine is running for greater than 5 s.
- The fuel pump enable circuit is commanded ON.
- Low fuel level warning not present.
- The DTC runs continuously when the conditions above are met.

P018C or P018D

- The engine is cranking or running.
- The DTCs run continuously when the condition above is met.

Conditions for Setting the DTC

P018B

The engine control module does not detect a normal fuel pressure change 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.

P018C

The engine control module detects that the fuel pressure sensor voltage is less than 0.2 V for 1 s.

P018D

The engine control module detects that the fuel pressure sensor voltage is greater than 4.8 V for 1 s.

Action Taken When the DTC Sets

DTC P018B, P018C and P018D are Type A DTCs.

Conditions for Clearing the DTC

DTC P018B, P018C and P018D are Type A DTCs.

Diagnostic Aids

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

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Engine running.
2. Verify the scan tool Fuel Pressure Sensor parameter is between 0.2-4.8 V.
   - **If not between 0.2-4.8 V**

     Refer to Circuit/System Testing.

   - **If between 0.2-4.8 V**
3. Verify the scan tool Fuel Pressure Sensor increases or decreases when commanding an increase and decrease in Fuel Pressure with a scan tool.
   - **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.

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 5 ohms between the low reference circuit terminal 2 and ground.
   - **If 5 ohms or greater**
     1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
     2. Test for less than 2 ohms in the low reference circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
   - **If less than 5 ohms**
3. Ignition ON.
4. Test for 4.8-5.2 V between the 5 V reference circuit terminal 3 and ground.
   - **If less than 4.8 V**
     1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

2. Test for infinite resistance between the 5 V reference circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance
3. Test for less than 2 ohms in the 5 V reference circuit end to end.
    - If 2 ohms or greater, repair the open/high resistance in the circuit.
    - If less than 2 ohms, replace the K20 Engine Control Module.

- **If greater than 5.2 V**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the 5 V reference circuit and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.

- **If between 4.8-5.2 V**

5. Verify the scan tool Fuel Pressure Sensor parameter is less than 1 V.
    - **If 1 V or greater**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit terminal 1 and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If less than 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 parameter is greater than 4.8 V.
    - **If 4.8 V or less**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit terminal 1 and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 ohms in the signal circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
    - **If greater than 4.8 V**
8. Replace the B47 Fuel Pressure Sensor.

Repair Instructions

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

- **Fuel Pressure Sensor Replacement - Fuel Feed Pipe (FWD)** , **Fuel Pressure Sensor Replacement - Fuel Feed Pipe (AWD)**
- **Control Module References** for ECM replacement, programming and setup

DTC P0191, P0192, OR P0193

Diagnostic Instructions

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

DTC Descriptors

DTC P0191

Fuel Rail Pressure Sensor Performance

DTC P0192

Fuel Rail Pressure Sensor Circuit Low Voltage

DTC P0193

Fuel Rail Pressure Sensor Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference Voltage	P018C, P0192, P0193, P0522, P0532, P0641, P2227, P2228	P0192	P018D, P0193, P0523, P0641, P2227	P0191
Fuel Rail Pressure Sensor Signal	P0192	P0192	P0193	P0191
Low Reference	-	P0193, P0506	-	P0191

Circuit/System Description

The fuel rail fuel pressure sensor detects fuel pressure within the fuel rail. The engine control module (ECM) provides a 5 V reference voltage on the 5 V reference circuit and ground on the reference ground circuit. The ECM receives a varying signal voltage on the signal circuit. The ECM monitors the voltage on the fuel rail fuel pressure sensor circuits. When the fuel pressure is high, the signal voltage is high. When the fuel pressure is low, the signal voltage is low.

Conditions for Running the DTC

P0191 - Condition 1

- The engine is not cranking.
- The ignition voltage is greater than 11 V.
- The vehicle speed is less than or equal to 1 km/h (0.62 mph).

- The low side fuel pressure is greater than or equal to 250 kPa (36 psi).
- The Accelerator Pedal Position is 0 percent for 2.5 s.
- The engine is running for greater than 30 s.

P0191 - Condition 2 and 3

- The engine is not cranking.
- The ignition voltage is greater than 11 V.
- The engine speed is between 1,000-3,000 RPM.
- The vehicle speed is greater than or equal to 35 km/h (22 mph).
- The low side fuel pressure is greater than or equal to 250 kPa (36 psi).
- The Desired Fuel Rail Pressure is between 4-6 MPa (580-870 psi).
- The Accelerator Pedal Position is greater than or equal to 10 percent.
- The engine is running for greater than 30 s.

P0191 - Condition 4

- DTC P0016, P0017, P0090, P0091, P0092, P00C8, P00C9, P00CA, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0122, P0123, P0128, P0192, P0193, P0201, P0202, P0203, P0204, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0300, P0301, P0302, P0303, P0304, P0335, P0336, P0340, P0341, P0351-P0354, P0365, P0366, P0506, P0507, P0628, P0697, P06A3, P0722, P0723, P1248, P1249, P124A, P124B, P1682, P2122, P2123, P2127, P2128, P2135, P2138, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157 is not set.
- The engine is not cranking.
- The vehicle speed is greater than or equal to 30 km/h (18.64 mph).
- The engine speed is greater than or equal to 2,000 RPM.
- The barometric (BARO) pressure is greater than 70 kPa.
- The intake air temperature (IAT) is warmer than -20°C (-4°F).

P0192 or P0193

- The engine is running.
- The ignition voltage is greater than 11 V.
- The DTCs run continuously within the enabling conditions.

Conditions for Setting the DTC

P0191 - Condition 1

The difference between the low side fuel pressure and the high side fuel pressure is less than or equal to -1 MPa (-145 psi) or greater than or equal to 1 MPa (145 psi) with the high pressure fuel pump actuator commanded OFF. The condition exists for greater than 3 s.

P0191 - Condition 2

The difference between the relief pressure and the measured high pressure is less than or equal to -1.6 MPa (-232 psi) with the high pressure fuel pump actuator commanded ON. The condition exists for greater than 2 s.

P0191 - Condition 3

The difference between the commanded high pressure and the measured high pressure is greater than or equal to 3 MPa (435 psi) and the modeled injection pressure is greater than or equal to 1.6 MPa (232 psi) with the high pressure fuel pump actuator commanded ON. The condition exists for greater than 3 s.

P0191 - Condition 4

The difference between the measured maximum high pressure and the measured minimum high pressure is less than or equal to 0.1 MPa (14.5 psi) with the high pressure fuel pump actuator commanded ON. The condition exists for greater than 30 s with the engine running or greater than 10 s with the engine cranking.

P0192

The ECM detects that the fuel rail fuel pressure sensor signal voltage is low for greater than 5 s.

P0193

The ECM detects that the fuel rail fuel pressure sensor signal voltage is high for greater than 5 s.

Action Taken When the DTC Sets

- DTCs P0191, P0192, and P0193 are Type A DTCs.
- A message center or an indicator may display Reduced Engine Power.

Conditions for Clearing the DTC

DTCs P0191, P0192 and P0193 are Type A DTCs.

Reference Information

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Engine Controls Schematics

Connector End View Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0641 is not set.
   - **If the DTC is set**

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

   - **If the DTC is not set**
3. Engine idling.
4. Verify DTC P0191, P0192 or P0193 is not set.
   - **If any of the DTCs are set**

     Refer to Circuit/System Testing.

   - **If none of the DTCs are set**
5. Operate the vehicle within the Conditions for Running the DTC to verify the DTC does not reset. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the fuel injector multi-way harness connector X160. It may take up to 2 minutes for all vehicle systems to power down.

NOTE: Testing for steps 2 through 7 is performed on the ECM side of the multi-way harness connector.

2. Test for less than 5 ohms between the low reference circuit terminal 5 and ground.
    - **If 5 ohms or greater**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for less than 2 ohms in the low reference circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
    - **If less than 5 ohms**
3. Ignition ON.
4. Test for 4.8-5.2 V between the 5 V reference circuit terminal 11 and ground.
    - **If less than 4.8 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the 5 V reference circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 ohms in the 5 V reference circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
    - **If greater than 5.2 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the 5 V reference circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If between 4.8-5.2 V**
5. Verify the scan tool Fuel Rail Pressure Sensor voltage parameter is less than 0.02 V.
    - **If 0.02 V or greater**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit terminal 12 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 0.02 V**
6. Install a 3 A fused jumper wire between the signal circuit terminal 12 and the 5 V reference circuit terminal 11.
7. Verify the scan tool Fuel Rail Pressure Sensor voltage parameter is greater than 4.96 V.
    - **If 4.96 V or less**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit terminal 12 and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 ohms in the signal circuit end to end.

- If 2 ohms or greater, repair the open/high resistance in the circuit.
- If less than 2 ohms, replace the K20 Engine Control Module.

- **If greater than 4.96 V**

8. Ignition OFF, remove the intake manifold.
9. Connect the fuel injector multi-way harness connector X160.
10. Disconnect the B47B fuel rail fuel pressure sensor connector.

NOTE: Testing for steps 11 through 17 is performed at the fuel rail fuel pressure sensor connector.

11. Test for less than 5 ohms between the low reference circuit terminal 3 and ground.
    - **If 5 ohms or greater**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for less than 2 ohms in the low reference circuit end to end.
       - If 2 ohms or greater, repair the open/high resistance in the circuit.
       - If less than 2 ohms, replace the K20 Engine Control Module.
    - **If less than 5 ohms**
12. Ignition ON.
13. Test for 4.8-5.2 V between the 5 V reference circuit terminal 1 and ground.
    - **If less than 4.8 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the 5 V reference circuit and ground.
       - If less than infinite resistance, repair the short to ground on the circuit.
       - If infinite resistance
    3. Test for less than 2 ohms in the 5 V reference circuit end to end.
       - If 2 ohms or greater, repair the open/high resistance in the circuit.
       - If less than 2 ohms, replace the K20 Engine Control Module.
    - **If greater than 5.2 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the 5 V reference circuit and ground.
       - If 1 V or greater, repair the short to voltage on the circuit.
       - If less than 1 V, replace the K20 Engine Control Module.
    - **If between 4.8-5.2 V**
14. Ignition ON.
15. Verify the scan tool Fuel Rail Pressure Sensor voltage parameter is less than 0.02 V.
    - **If 0.02 V or greater**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit terminal 12 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 0.02 V**

16. Install a 3 A fused jumper wire between the signal circuit terminal 2 and the 5 V reference circuit terminal 1.
17. Verify the scan tool Fuel Rail Pressure Sensor voltage parameter is greater than 4.96 V.
    - **If 4.96 V or less**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit terminal and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 ohms in the signal circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
    - **If greater than 4.96 V**
18. Replace the B47B fuel rail fuel pressure sensor.

Repair Instructions

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

- **Fuel Injection Fuel Rail Fuel Pressure Sensor Replacement**
- **Control Module References** for ECM replacement, setup, and programming

DTC P0201-P0204, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P1248, P1249, P124A, P124B, P2147, P2148, P2150, P2151, P2153, P2154, P2156, OR P2157

Diagnostic Instructions

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

DTC Descriptors

DTC 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

DTC P1248

Cylinder 1 Injector High Control Circuit Shorted to Control Circuit

DTC P1249

Cylinder 2 Injector High Control Circuit Shorted to Control Circuit

DTC P124A

Cylinder 3 Injector High Control Circuit Shorted to Control Circuit

DTC P124B

Cylinder 4 Injector High Control Circuit Shorted to Control Circuit

DTC P2147

Cylinder 1 Injector High Control Circuit Low Voltage

DTC P2148

Cylinder 1 Injector High Control Circuit High Voltage

DTC P2150

Cylinder 2 Injector High Control Circuit Low Voltage

DTC P2151

Cylinder 2 Injector High Control Circuit High Voltage

DTC P2153

Cylinder 3 Injector High Control Circuit Low Voltage

DTC P2154

Cylinder 3 Injector High Control Circuit High Voltage

DTC P2156

Cylinder 4 Injector High Control Circuit Low Voltage

DTC P2157

Cylinder 4 Injector High Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Short from Supply Circuit to Control Circuit
Direct Fuel Injector High Voltage Supply Cylinder 1	P2147	P0201	P2148	P1248
Direct Fuel Injector High Voltage Control Cylinder 1	P0261	P0201	P0262, P2148	P1248
Direct Fuel Injector High Voltage Supply Cylinder 2	P2150	P0202	P2151	P1249
Direct Fuel Injector High Voltage Control Cylinder 2	P0264	P0202	P0265, P2151	P1249
Direct Fuel Injector High	P2153	P0203	P2154	P124A

Voltage Supply Cylinder 3				
Direct Fuel Injector High Voltage Control Cylinder 3	P0267	P0203	P0268, P2154	P124A
Direct Fuel Injector High Voltage Supply Cylinder 4	P2156	P0204	P2157	P124B
Direct Fuel Injector High Voltage Control Cylinder 4	P0270	P0204	P0271, P2157	P124B

Circuit/System Description

The engine control module (ECM) supplies voltage to each fuel injector on the injector high voltage supply circuits. The ECM energizes each fuel injector by grounding the high voltage control circuit of the fuel injector. The ECM monitors the status of the injector high voltage supply circuits and the fuel injector high voltage control circuits. When a fuel injector circuit condition is detected by the ECM, the affected fuel injector(s) is disabled.

Conditions for Running the DTC

- DTC P062B is not set.
- The engine is running for greater than 5 s.
- The ignition voltage is greater than 11 V.
- The DTCs run continuously once the above conditions are met.

Conditions for Setting the DTC

P0201, P0202, P0203, or P0204

The ECM detects the injector high voltage supply circuit or the injector high voltage control circuit is open for greater than 1 s.

P0261, P0264, P0267, or P0270

The ECM detects the injector high voltage control circuit is shorted to ground for greater than 1 s.

P0262, P0265, P0268, or P0271

The ECM detects the injector high voltage control circuit is shorted to voltage for greater than 1 s.

P1248, P1249, P124A, or P124B

The ECM detects the injector high voltage supply circuit is shorted to the injector high voltage control circuit for greater than 1 s.

P2147, P2150, P2153, or P2156

The ECM detects the injector high voltage supply circuit is shorted to ground for greater than 1 s.

P2148, P2151, P2154, or P2157

The ECM detects the injector high voltage supply circuit is shorted to voltage for greater than 1 s.

Action Taken When the DTC Sets

DTCs P0201, P0202, P0203, P0204, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P1248, P1249, P124A, P124B, P2147, P2148, P2150, P2151, P2153, P2154, P2156, and P2157 are Type A DTCs.

Conditions for Clearing the DTC

DTCs P0201, P0202, P0203, P0204, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P1248, P1249, P124A, P124B, P2147, P2148, P2150, P2151, P2153, P2154, P2156, and P2157 are Type A DTCs.

Diagnostic Aids

- Performing the fuel injector coil test may help isolate an intermittent condition. Refer to **Fuel Injector Solenoid Coil Test** .
- If the condition is intermittent, move the related harnesses and connectors, with the engine operating, while monitoring the scan tool Injector Control Circuit Status parameters. An Injector Control Circuit Status parameter will change from OK or Not Run to Malfunction if there is a condition with the circuit or a connection.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

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- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0685 or P1682 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 DTC P0201, P0202, P0203, P0204, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P1248, P1249, P124A, P124B, P2147, P2148, P2150, P2151, P2153, P2154, P2156, or P2157 is not set.
   - **If any of the DTCs are set**

     Refer to Circuit/System Testing

   - **If none of the DTCs are set**
4. Engine running.
5. Verify the scan tool Current Misfire Counter parameters are not incrementing.
   - **If the Current Misfire Counters are incrementing**

     Refer to Circuit/System Testing

   - **If the Current Misfire Counters are not incrementing**
6. Verify the scan tool Cylinder 1-4 Injector Control Circuit Status parameters display OK.
   - **If the Cylinder 1-4 Injector Control Circuit Status parameters display Malfunction**

     Refer to Circuit/System Testing.

   - **If the Cylinder 1-4 Injector Control Circuit Status parameters display OK**
7. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
8. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing

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

Circuit/System Testing

1. Ignition OFF, disconnect the fuel injector multi-way harness connector X160, ignition ON.
2. Verify the scan tool Cylinder 1-4 Injector Control Circuit Status parameters display Open.
   - **If the parameters do not display Open**
     1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.

2. Test for infinite resistance between the appropriate high voltage supply circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance
3. Test for less than 1 V between the high voltage 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 parameters display Open**

3. Ignition ON, connect a test lamp between the appropriate high voltage supply circuit and the high voltage control circuit.
4. Verify the scan tool Injector Control Circuit Status transitions from Open to OK.

- **If the parameter displays Open**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for less than 2 ohms in the high voltage supply circuit end to end.
    - If 2 ohms or greater, repair the open/high resistance in the circuit.
    - If less than 2 ohms
3. Test for infinite resistance between the high voltage control circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance
4. Test for less than 1 V between the high voltage supply circuit and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.

- **If the parameter displays OK**

NOTE: Testing for the following steps is performed on the fuel injector side of the multi-way harness connector. It may be necessary to remove the intake manifold to isolate the condition.

5. Ignition OFF.
6. Test for infinite resistance between the high voltage supply circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance, test or replace the Q17 fuel injector(s).
7. Test for 2-3 ohms between the high voltage supply circuit and high voltage control circuit.

- **If less than 2 ohms**

1. Test for infinite resistance between the appropriate high voltage supply circuit or high voltage control circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance, test the Q17 fuel injector for a short and replace as necessary.

- **If greater than 3 ohms**

1. Disconnect the harness connector at the Q17 fuel injector.
2. Test for less than 2 ohms in the high voltage supply circuit or high voltage control circuit end to end.
    - If 2 ohms or greater, repair the open/high resistance in the circuit.

- If less than 2 ohms, test the Q17 fuel injector for an open/high resistance and replace as necessary.
- **If between 2-3 ohms**

8. Test or replace the Q17 fuel injectors.

Component Testing

- **Fuel Injector Solenoid Coil Test**
- **Fuel Injector Balance Test**

Repair Instructions

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

- **Fuel Injector Replacement**
- **Control Module References** for ECM replacement, setup, and programming

DTC P0231, P0232, OR P023F

Diagnostic Instructions

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

DTC Descriptors

DTC P0231

Fuel Pump Control Circuit Low Voltage

DTC P0232

Fuel Pump Control Circuit High Voltage

DTC P023F

Fuel Pump Control Circuit

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control	P0171, P0232, P023F	P0171, P0232, P023F	P0171, P0232, P023F	P023F, P2635
Low Reference	-	P0232, P023F, P0506	P0232, P023F, P0506	P023F, P2635

Circuit/System Description

The engine control module (ECM) supplies voltage to the fuel pump power control module when the ECM detects that the ignition is on. The voltage from the ECM to the fuel pump power control module remains active for 2 seconds, unless the engine is in crank or run. While this voltage is being received, the fuel pump power control module supplies a varying voltage to the fuel tank fuel pump module in order to maintain the desired fuel line pressure.

Conditions for Running the DTC

P0231

- The ignition voltage is greater than 7 V.
- The engine is cranking or running.
- The fuel pump enable circuit is commanded ON.
- The DTC runs continuously when the conditions above are met.

P0232

- The ignition voltage is greater than 7 V.
- The fuel pump enable circuit is commanded ON.
- The DTC runs continuously when the conditions above are met.

P023F

- The ignition voltage is greater than 11 V.
- The commanded duty cycle is greater than approximately 50 percent.
- The DTC runs continuously when the conditions above are met.

Conditions for Setting the DTC

P0231

The fuel pump power control module detects that the fuel pump current is greater than 14.48 A for 1 s.

P0232

The fuel pump power control module detects that the fuel pump output circuit voltage is greater than 4.5 V for 0.5 s when the voltage should be 0 V.

P023F

The fuel pump power control module detects that the fuel pump current is less than 1 A and the fuel pump duty cycle is greater than approximately 50 percent for 1 s.

Action Taken When the DTC Sets

DTCs P0231, P0232, and P023F are Type A DTCs.

Conditions for Clearing the DTC

DTCs P0231, P0232, and P023F are Type A DTCs.

Diagnostic Aids

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

On vehicles equipped with a high pressure mechanical pump on Direct Fuel Injection engines, the vehicle may continue to run even though the pump in the fuel tank is not operating.

Reference Information

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DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify the fuel pump turns ON and OFF when commanding the Fuel Pump Enable On and Off with a scan tool.
    - **If the fuel pump does not turn ON and OFF**

Refer to Circuit/System Testing.

- **If the fuel pump turns ON and OFF**

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

     Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the G12 Fuel Pump and at the K111 Fuel Pump Power Control Module.
2. Test for less than 2 ohms in the low reference circuit end to end.
   - **If 2 ohms or greater**

     Repair the open/high resistance in the circuit.

   - **If less than 2 ohms**
3. Connect the harness connector at the K111 Fuel Pump Power Control Module.
4. Ignition ON, connect a test lamp between the supply voltage circuit terminal 1 and the low reference circuit terminal 2 of the harness connector at the G12 Fuel Pump.
5. Verify the test lamp turns ON and OFF when commanding the Fuel Pump Enable On and Off with a scan tool.
   - **If the test lamp is always OFF**
   1. Ignition OFF, disconnect the harness connector at the K111 Fuel Pump Power Control Module.
   2. Test for infinite resistance between the supply voltage circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 ohms in the supply voltage circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, test or replace the K111 Fuel Pump Power Control Module.
   - **If the test lamp is always ON**
   1. Ignition OFF, remove the test lamp, disconnect the harness connector at the K111 Fuel Pump Power Control Module, ignition ON.
   2. Test for less than 1 V between the supply voltage circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, test or replace the K111 Fuel Pump Power Control Module.
   - **If the test lamp turns ON and OFF**
6. Replace the G12 Fuel Pump.

Component Testing

Static Test

1. Ignition OFF, disconnect the harness connector at the K111 Fuel Pump Power Control Module.
2. Connect a DMM, set on the diode setting, with the positive lead at terminal 16 and the negative lead at terminal 9 of the K111 Fuel Pump Power Control Module
3. Test for 0.4-0.8 V between terminal 16 and terminal 9.
   - **If not between 0.4-0.8 V**

     Replace the K111 Fuel Pump Power Control Module.

   - **If between 0.4-0.8 V**
4. Connect a DMM, set on the diode setting, with the positive lead at terminal 9 and the negative lead at terminal 16 of the K111 Fuel Pump Power Control Module
5. Test for OL between terminal 9 and terminal 16.
   - **If not OL**

     Replace the K111 Fuel Pump Power Control Module.

   - **If OL**
6. All OK

Repair Instructions

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

- **Fuel Pump Power Control Module Replacement**
- **Fuel Tank Fuel Pump Module Replacement (FWD)** , **Fuel Tank Fuel Pump Module Replacement (AWD)**

DTC P0234 OR P0299

Diagnostic Instructions

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

DTC Descriptors

DTC P0234

Engine Overboost

DTC P0299

Engine Underboost

Circuit Description

The intake air pressure sensor is integrated with the intake air temperature (IAT) sensor 2. The intake air 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, 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, on the intake air pressure signal circuit. 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 vehicle is operated at wide-open throttle (WOT) the turbocharger can increase the pressure to near 240 kPa (34.8 psi). The least pressure that occurs is when the vehicle is idling or decelerating, and it is equal to BARO.

Conditions for Running the DTCs

- DTC P0010, P0011, P0013, P0014, P0016, P0017, P0033, P0034, P0035, P0068, P00C8, P00C9, P0111, P0112, P0113, P0114, P0116, P0122, P0123, P0128, P0222, P0223, P0234, P0236, P0237, P0238, P0243, P0245, P0246, P0299, P0601, P0604, P0606, P1682, P16A0, P16A1, P16F3, P2101, P2176, P2227, P2228, P2229, P2230 or P2261 is not set.
- The driver requested boost pressure level exceeds the level of the base boost pressure.
- The engine speed is between 1,600-6,000 RPM.
- The desired boost pressure is between 140-300 kPa (20.3-43.5 psi)
- The Barometric Pressure (BARO) is between 60-120 kPa (8.7-17.4 psi).
- The Engine Coolant Temperature (ECT) is between -40 to +120°C (-40 to +248°F).
- The Intake Air Temperature (IAT) is between -40 to +80°C (-40 to +176°F)
- The turbocharger wastegate is not under output device control.
- The turbocharger bypass valve is not under output device control.
- The DTCs run continuously when the above conditions have been met.

Conditions for Setting the DTC

P0234

The ECM detects that the actual boost pressure is greater than the desired boost pressure by a calibrated amount for greater than 3 s.

P0299

The ECM detects that the actual boost pressure is less than the desired boost pressure by a calibrated amount for greater than 3 s.

Action Taken When the DTC Sets

- DTCs P0234 and P0299 are Type B DTCs.
- The ECM will disable boost control and limit the system to mechanical boost only, resulting in a substantial decrease in engine power.

Conditions For Clearing the MIL/DTC

DTCs P0234 and P0299 are Type B DTCs.

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 ductwork, the tightening specifications and proper positioning of the clamps is critical, and must be strictly adhered to.
- Use a solution of dish soap and water in a spray bottle to pinpoint any air leaks.

Reference Information

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Engine Controls Schematics

Connector End View Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

GE-23738-A Vacuum Pump

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)** .

Circuit/System Verification

1. Ignition On.
2. Verify DTC P0106, P0107, P0108, P0236, P0237, P0238, P0243, P0245, P0246, P2227, P2228, P2229, or P2230 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. Verify a click is heard or felt from the Q40 turbocharger bypass valve solenoid when commanding the Turbocharger Bypass Solenoid Valve between Active and Inactive with a scan tool.
   - **If a click is not heard or felt**

     Refer to **DTC P0033-P0035**.

   - **If a click is heard or felt**
7. Verify the parameters listed below do not display Malfunction when commanding the Turbocharger Bypass Solenoid Valve between Active and Inactive with a scan tool.
   - Turbocharger Bypass Solenoid Valve Control Circuit High Voltage Test Status
   - Turbocharger Bypass Solenoid Valve Control Circuit Open Test Status
   - Turbocharger Bypass Solenoid Valve Control Circuit Low Voltage Test Status
   - **If Malfunction is displayed**

     Refer to **DTC P0033-P0035**.

   - **If Malfunction is not displayed**
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 **DTC P0243, P0245, or P0246**.

- **If a series of clicks in increasing frequency is heard or felt**

9. 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 **DTC P0243, P0245, or P0246**.

   - **If Malfunction is not displayed**
10. 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.

    - **parameter are within 20 kPa (2.9 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

Circuit/System Testing

1. Verify the conditions listed below do not exist:
   - Loose clamps, cracks or other damage in the air intake duct system
   - Collapsed or restricted intake duct system
   - Restricted air filter
   - Any air flow restriction
   - Any air leak between the turbocharger and the throttle body, including the charge air cooler assembly
   - Splits, kinks or improper connections at the vacuum hoses
   - Any vacuum leak
   - Restricted, leaking or incorrect routing of hoses going to the components listed below:

- Q42 turbocharger wastegate solenoid valve
- Turbocharger wastegate actuator
- Turbocharger

- Missing, restricted or leaking exhaust components. Refer to **Restricted Exhaust** .
- Exhaust leak between the turbocharger and the exhaust manifold
- Restricted or leaking turbocharger oil supply line
- Loose or incorrect installation of any components
  - **If a condition exists**

    Repair or replace the affected component as necessary.

  - **If none of the conditions exist**

2. Ignition Off, disconnect the turbocharger wastegate solenoid valve supply hose at the turbocharger and apply 51 kPa (15 inches Hg) of vacuum to the hose with the **GE 23738-A** , ignition On.
3. Verify the pressure decreases to 0 kPa (0 inches Hg) when commanding the Turbocharger Wastegate Solenoid Valve to 15 % with a scan tool.
   - **The pressure does not decrease to 0 kPa (0 inches Hg)**

     Replace the Q42 turbocharger wastegate solenoid valve

   - **The pressure decreases to 0 kPa (0 inches Hg)**
4. Connect the turbocharger wastegate solenoid valve supply hose to the turbocharger.
5. Disconnect the hose from the turbocharger wastegate actuator and connect the exhaust/pressure port of the **GE 23738-A** , or a suitable hand pressure pump, to the actuator.
6. Verify the wastegate actuator rod moves when applying pressure to the actuator.
   - **If the actuator does not move**
     1. Disconnect the wastegate actuator arm from the wastegate.
     2. Verify the wastegate actuator rod moves when applying pressure to the actuator.
        - If the actuator does not move, replace the turbocharger wastegate actuator
        - If the actuator moves, replace the turbocharger
   - **If the actuator moves**

NOTE: **Leave harness connector connected or re-connect it after removing valve.**

7. Ignition Off. Disconnect the Q40 turbocharger bypass solenoid valve ignition On.
8. Verify the turbocharger bypass valve plunger retracts and extends when commanding the Turbocharger Bypass Solenoid Valve between Active and Inactive with a scan tool.
   - **The valve plunger does not retract and extend**

     Replace the Q40 turbocharger bypass solenoid valve

   - **The valve plunger retracts and extends**
9. Verify the conditions listed below do not exist with the turbocharger assembly. Refer to

Turbocharger Cleaning and Inspection

- Cracked, damaged or worn turbine blades
- Restricted wastegate, turbine, ports or passages
- Foreign material
- **A condition exists**

  Repair or replace the turbocharger as necessary

- **None of the conditions exist**

10. Replace the turbocharger.

Repair Instructions

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

- **Turbocharger Replacement**
- **Turbocharger Bypass Valve Solenoid Replacement**
- **Turbocharger Wastegate Actuator Replacement**
- **Turbocharger Wastegate Regulator Solenoid Valve Replacement**
- **Control Module References** for ECM replacement, programming, and setup

DTC P0236

Diagnostic Instructions

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

DTC Descriptor

DTC P0236

Turbocharger Boost Sensor Performance

Circuit Description

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

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

Conditions for Running the DTC

- DTC P0106, P0107, P0108, P0237, P0238, P2227, P2228, P2229, or P2230 is not set.
- DTC P0106, P0107, P0108, P0237, or P0238 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 10 s.
- The DTC runs continuously when the above conditions have been met.

OR

- DTC P0102, P0103, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0128, P0237, P0238, P0335, P0336, P2227, P2228, P2229 or P2230 is not set.
- DTC P0112, P0113, P0117, or P0118 is not pending.
- Engine speed is between 400-6,000 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.

Conditions for Setting the DTC

- The ECM detects that the boost pressure sensor signal is not within range of a model derived from engine speed, the BARO sensor, the MAF sensor, the MAP sensor, the throttle position sensor and the turbocharger boost pressure sensor 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.

OR

- The ECM detects that the difference between MAP and BARO is less than or equal to 10 kPa and the difference between turbocharger boost pressure and MAP is greater than 10 kPa and the difference between turbocharger boost pressure and BARO is greater than 10 kPa when the ignition is ON and the engine is NOT rotating.

Action Taken When the DTC Sets

DTC P0236 is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P0236 is a Type B DTC.

Diagnostic Aids

- The charge air cooler is connected to the turbocharger and to the throttle body by flexible duct work

that requires the use of special high torque fastening clamps. These clamps cannot be substituted. In order to prevent any type of air leak when servicing the duct work, the tightening specifications and proper positioning of the clamps is critical, and must be strictly adhered to.

- Use a smoke generating device or a solution of dish soap and water in a spray bottle to pinpoint any suspected air leaks in the induction system and in the charge air cooler assembly.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

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- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Verify that DTC P0641 is not set.
   - **If the DTC is set**

     Refer to **DTC P0641, P0651, P0697, or P06A3 (ECM)** .

   - **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%.
   - **If 90% or greater**

Refer to **Throttle Body Cleaning** .

- **If less than 90%**

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

     Refer to **DTC P0121-P0123, P0222, P0223, P16A0-P16A2, 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.
    1. Engine idling
    2. Perform the scan tool snapshot function.
    3. Increase the engine speed slowly to 3,000 RPM and then back to idle.
    4. Exit from the scan tool snapshot and review the data.
    5. Observe the MAF Sensor parameter frame by frame with a scan tool.
    - **The MAF Sensor parameter does not change smoothly and gradually**

      Refer to **DTC P0101**.

    - **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 the DTC sets**

      Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Verify that DTC P0237 or P0238 is not set.
    - **If a DTC is set**

      Refer to **DTC P0237 or P0238**.

    - **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.

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

DTC P0237 OR P0238

Diagnostic Instructions

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

DTC Descriptors

DTC P0237

Turbocharger Boost Sensor Circuit Low Voltage

DTC P0238

Turbocharger Boost Sensor Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P018C, P0192, P0236, P0237, P0340, P0365, P0452, P0532, P0641, P2227*	P0236, P0237	P018D, P0193, P0236, P0237, P0453, P0523, P0641, P2227*	P0236
Intake Air Pressure Signal	P0236, P0237, P2227	P0236, P0237	P0193, P0236, P0238, P0641, P2227*	P0236
Low Reference	-	P00EB, P0236, P0238, P2227	-	-
* A message center or an indicator may display ENGINE POWER IS REDUCED. Engine may experience Crank - NO Start condition.				

Typical Scan Tool Data

Boost Pressure Sensor

Circuit	Short to Ground	Open	Short to Voltage
Parameter Normal Range: BARO to 240 kPa (34.8 psi) **Operating Conditions:** Engine running under various operating conditions			
5 V Reference	0 kPa (0 psi)	0 kPa (0 psi)	0 kPa (0 psi)
Boost Pressure Sensor	0 kPa (0 psi)	0 kPa (0 psi)	392 kPa (56.9 psi)
Low Reference	-	387 kPa (56.1 psi)	-

Circuit Description

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

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

Conditions for Running the DTC

- Ignition is ON or the engine is running.
- The DTCs run continuously when the above conditions have been met.

Conditions for Setting the DTC

P0237

The ECM detects that the boost pressure sensor voltage is less than 0.9 V for greater than 5 s .

P0238

The ECM detects that the boost pressure sensor voltage is greater than 3.9 V for greater than 5 s .

Action Taken When the DTC Sets

- DTCs P0237 and P0238 are Type B DTCs.
- The ECM will disable boost control and limit the system to mechanical boost only, resulting in a substantial decrease in engine power.

Conditions for Clearing the MIL/DTC

DTCs P0237 and P0238 are Type B DTCs.

Reference Information

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Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Verify that DTC P0641 is not set.
   - **If the DTC is set**

     Refer to **DTC P0641, P0651, P0697, or P06A3 (ECM)** .

   - **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 P2227-P2230** .

   - **BARO is within range**
3. Verify the scan tool Boost Pressure Sensor pressure and BARO parameters are within 3 kPa (0.4 psi) .
   - **The parameters are not within 3 kPa (0.4 psi).**

     Refer to Circuit/System Testing

   - **The parameters are within 3 kPa (0.4 psi).**
4. Verify the scan tool MAP Sensor parameter and the Boost Pressure Sensor parameter are within 20 kPa (2.9 psi) during a WOT acceleration at the time of the 1-2 shift.
   - **The parameters are not within 20 kPa (2.9 psi)**

     Refer to Circuit/System Testing.

   - **The parameters are within 20 kPa (2.9 psi)**
5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

6. Verify a DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Ignition OFF, and all vehicle systems OFF, disconnect the harness connector at the B111B turbocharger boost/intake air temperature sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 ohms between the low reference circuit terminal 1 and ground.
   - **If 5 ohms or greater**
   1. Ignition OFF, disconnect the X1 harness connector at the K20 engine control module.
   2. Test for less than 2 ohms in the low reference circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 engine control module.
   - **If less than 5 ohms**
3. Ignition ON.
4. Test for 4.8-5.2 V between the 5 V reference circuit terminal 3 and ground.
   - **If less than 4.8 V**
   1. Ignition OFF, disconnect the X1 harness connector at the K20 engine control module.
   2. Test for infinite resistance between the 5 V reference circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 ohms in the 5 V reference circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, 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**
   1. Ignition OFF, disconnect the X1 harness connector at the K20 engine control module, ignition ON.
   2. Test for less than 1 V between the 5 V reference circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 engine control module.
   - **If between 4.8-5.2 V**
5. Verify the scan tool Boost Pressure Sensor voltage parameter is less than 0.2 V.

- **If 0.2 V or greater**

1. Ignition OFF, disconnect the X1 harness connector at the K20 engine control module, ignition ON.
2. Test for less than 1 V between the signal circuit terminal 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**

   1. Ignition OFF, disconnect the X1 harness connector at the K20 engine control module.
   2. Test for infinite resistance between the signal circuit terminal 4 and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 ohms in the signal circuit end to end.
      - If 2 ohms or greater, repair the open or high resistance in the circuit.
      - If less than 2 ohms, replace the K20 engine control module.

   - **If greater than 4.5 V**
8. Test or replace the B111B turbocharger boost/intake air temperature sensor.

Repair Instructions

Perform the **Diagnostic Repair Verification** 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

DTC P0243, P0245, OR P0246

Diagnostic Instructions

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

DTC Descriptors

DTC P0243

Turbocharger Wastegate Solenoid Valve Control Circuit

DTC P0245

Turbocharger Wastegate Solenoid Valve Control Circuit Low Voltage

DTC P0246

Turbocharger Wastegate Solenoid Valve Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
Ignition Voltage	P0033, P0034, P0243, P0245, P0443, P06DA, P06DB*	P0243	P0243	-	-
Turbocharger Wastegate Solenoid Control	P0245	P0243	P0243	P0246	P0243
* Ignition fuse opens. A message center or an indicator may display ENGINE POWER IS REDUCED. Engine may experience NO Crank - NO Start condition.					

Circuit/System Description

The dual-scroll turbocharger incorporates a wastegate that is controlled by the engine control module (ECM) by means of a pulse width modulation (PWM) solenoid, to regulate the pressure ratio of the compressor. An ECM controlled compressor bypass valve is integrated into the unit to prevent compressor surging and damage from vibrations by opening during abrupt closed throttle conditions. The bypass valve is open during closed throttle deceleration conditions to allow air to recirculate in the turbocharger and maintain compressor speed.

As engine load and RPM increase, the turbocharger bypass valve is commanded closed by the ECM. As soon as the throttle closes, the valve is commanded open to allow the turbocharger air to recirculate to prevent compressor surging.

Conditions for Running the DTCs

- Ignition is On or the engine is running.
- Battery voltage is between 11-32 V.
- The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTCs

P0243

The ECM detects an open circuit on the turbocharger wastegate solenoid control circuit for greater than 2 s.

P0245

The ECM detects a short to ground on the turbocharger wastegate solenoid control circuit for greater than 2

s.

P0246

The ECM detects a short to voltage on the turbocharger wastegate solenoid control circuit for greater than 2 s.

Action Taken When the DTCs Set

- DTCs P0243, P0245, and P0246 are Type B DTCs.
- The ECM will disable boost control and limit the system to mechanical boost only, resulting in a substantial decrease in engine power.

Conditions for Clearing the MIL/DTCs

DTCs P0243, P0245, and P0246 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

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

Circuit/System Verification

1. Ignition On

2. Verify a series of clicks, which increase in frequency, are heard or felt from the Q42 turbocharger wastegate solenoid valve when commanding the Turbocharger Wastegate Solenoid Valve between 15-100 % with a scan tool.
    - **If a series of clicks in increasing frequency are not heard or felt**

      Refer to Circuit/System Testing.

    - **If a series of clicks in increasing frequency is heard or felt**
3. Verify the parameters listed below do not display Malfunction when commanding the Turbocharger Wastegate Solenoid Valve between 15-100 % with a scan tool.
    - Turbocharger Wastegate Solenoid Valve Control Circuit High Voltage Test Status
    - Turbocharger Wastegate Solenoid Valve Control Circuit Open Test Status
    - Turbocharger Wastegate Solenoid Valve Control Circuit Low Voltage Test Status
    - **If Malfunction is displayed**

      Refer to Circuit/System Testing.

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

      Refer to Circuit/System Testing

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

Circuit/System Testing

1. Ignition Off, disconnect the harness connector at the Q42 turbocharger wastegate solenoid valve, ignition On.
2. Verify a test lamp illuminates between the ignition circuit terminal 1 and ground.
    - **If the test lamp does not illuminate and the circuit fuse is good**
    1. Ignition Off.
    2. Test for less than 2 ohms in the ignition circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, verify the fuse is not open and there is voltage at the fuse.
    - **If the test lamp does not illuminate and the circuit fuse is open**
    1. Ignition Off, remove the test lamp.

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

    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 supplied by the fuse and replace as necessary.

- **If the test lamp illuminates**

3. Verify that a test lamp does not illuminate between the control circuit terminal 2 and the ignition circuit terminal 1.
   - **If the test lamp illuminates**
   1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the control circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.
   - **If the test lamp does not illuminate**
4. Remove the test lamp.
5. Verify the scan tool Turbocharger Wastegate Solenoid Valve Control Circuit High Voltage Test Status parameter is OK when commanding the Turbocharger Wastegate Solenoid Valve between 15-100 % with a scan tool.
   - **If OK is not displayed**
   1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module, ignition On.
   2. Test for less than 1 V between the control circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If OK is displayed**
6. Install a 3 A fused jumper wire between the control circuit terminal 2 and the ignition circuit terminal 1.
7. Verify the scan tool Turbocharger Wastegate Solenoid Valve Control Circuit High Voltage Test Status parameter is Malfunction when commanding the Turbocharger Wastegate Solenoid Valve between 15-100 % with a scan tool.
   - **If Malfunction is not displayed**
   1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 ohms in the control circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 Engine Control Module.
   - **If Malfunction is displayed**
8. Test or replace the Q42 turbocharger wastegate solenoid valve.

Repair Instructions

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

- **Turbocharger Wastegate Regulator Solenoid Valve Replacement**
- **Control Module References** for ECM replacement, programming and setup

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DIAGNOSTIC INFORMATION AND PROCEDURES

DTC P0300-P0304

Diagnostic Instructions

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

DTC Descriptors

DTC P0300

Engine Misfire Detected

DTC P0301

Cylinder 1 Misfire Detected

DTC P0302

Cylinder 2 Misfire Detected

DTC P0303

Cylinder 3 Misfire Detected

DTC P0304

Cylinder 4 Misfire Detected

Circuit/System Description

The engine control module (ECM) uses information from the crankshaft position sensor and the camshaft position sensors in order to determine when an engine misfire is occurring. By monitoring variations in the crankshaft rotation speed for each cylinder, the ECM is able to detect individual misfire events. A misfire rate that is high enough can cause 3-way catalytic converter damage. The malfunction indicator lamp (MIL) will flash ON and OFF when the conditions for catalytic converter damage are present. DTCs P0301 through P0304 correspond to cylinders 1 through 4. If the ECM is able to determine that a specific cylinder is misfiring, the DTC for that cylinder will set, and the corresponding fuel injector is disabled and/or add fuel. The ECM will re-enable the fuel injector after 3 crankshaft revolutions (6 for manual transmission vehicles) to determine if a misfire is still present and either disable for 3 crankshaft revolutions (6 for manual transmission vehicles) again or stay enabled, depending on whether the misfire is still present.

Conditions for Running the DTC

- DTC 0010, P0011, P0013, P0014, P0016, P0017, P0018, P0019, P0020, P0021, P0023, P0024, P0068, P00C8, P00C9, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0122, P0123, P0191, P0192, P0193, P0222, P0223, P0335, P0336, P0340, P0341, P0345, P0346, P0365, P0366, P0390, P0391, P0601, P0604, P0606, P0651, P16A0, P16A1, P16A2, P16F3, P2101, P2135, P2227, P2228, P2229, or P2230 is not set.

  AND

- DTC P0806, P0807, or P0808 is not set; with manual transmission.
- The engine speed is between 350 and 6,500 RPM without DTC P0315 set..

  OR

- The engine speed is less than 1,000 RPM and DTC P0315 is set.
- The engine coolant temperature (ECT) is between -7 and +125°C (19 and 257°F).
- If the ECT is colder than -7°C (+19°F) at start-up, this diagnostic will not run until the ECT is between 21°C and 125°C (69 and 257°F).
- The ignition voltage is between 9 and 32 V.
- The vehicle is not in a decel condition.
- The ECM is not detecting a rough road signal.
- The fuel level is at least 11 %.
- The ECM is not in fuel cut-off or decel fuel cut-off mode.
- DTCs P0300 through P0304 run continuously when the above conditions exist.

Conditions for Setting the DTC

P0300

The ECM detects a crankshaft rotation speed variation indicating a misfire rate sufficient to cause emissions levels to exceed a predetermined value or a misfire rate high enough to cause catalyst damage.

P0301, P0302, P0303, P0304

The ECM detects a crankshaft rotation speed variation indicating a single cylinder misfire rate sufficient to cause emissions levels to exceed mandated standards.

Action Taken When the DTC Sets

- DTCs P0300-P0304 are Type B DTCs.
- The ECM may disable up to two fuel injector's of the misfiring cylinder's when a catalyst damaging level of misfire is present. And will flash the malfunction indicator lamp (MIL).

Conditions for Clearing the DTC

DTCs P0300-P0304 are Type B DTCs.

Diagnostic Aids

- A misfire 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.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

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

J 26792 HEI Spark Tester

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)** .

Circuit/System Verification

NOTE: **Before starting vehicle, review freeze frame data to determine if misfire sets during cold start or warmed up operation. If the vehicle has a cold start problem and the vehicle is started, the vehicle will require a soak of many hours before next attempt to operate the vehicle within the fail conditions.**

1. Engine idling at the normal operating temperature.
2. Verify there is no abnormal engine noise.
   - **If there is an abnormal engine noise**

     Refer to **Symptoms - Engine Mechanical** .

   - **If there is no abnormal engine noise**
3. Verify no DTCs other than P0300-P0304 are set.
   - **If any DTCs other than P0300-P0304 are set**

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

   - **If only DTCs P0300-P0304 are set**

     Refer to Circuit/System Testing.

   - **If no DTCs are set**
4. Verify the scan tool Cylinder 1-4 Current Misfire Counter are not incrementing.
   - **If a Counter is incrementing**

     Refer to Circuit/System Testing.

   - **If a Counter is not incrementing**
5. Engine idling.
6. Verify the engine speed changes when performing the Cylinder Power Balance Test with a scan tool.
   - **If engine speed does not change**

     Refer to Circuit/System Testing.

   - **If the engine speed changes**
7. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
8. Verify the DTCs are not set.
   - **If any of the DTCs set**

Refer to Circuit/System Testing.

- **If none of the DTCs set**

9. All OK.

Circuit/System Testing

1. Perform the **Crankshaft Position System Variation Learn** procedure. The scan tool should display Learned Successful.
   - If the Crankshaft Position System Variation Learn Procedure cannot be performed successfully, inspect for the following conditions and repair as necessary:
   - Worn crankshaft main bearings
   - A damaged or misaligned reluctor wheel
   - Excessive crankshaft runout
   - A damaged crankshaft-Refer to **Crankshaft Balancer Cleaning and Inspection** .
   - Interference in the signal circuit of the crankshaft position sensor
   - The ignition switch is in the ON position until there is insufficient system voltage.
   - An ECM power disconnect with the ignition ON that may have erased the crankshaft position system variation values and set DTC P0315
   - Debris between the crankshaft position sensor and the reluctor wheel
   - **If a condition exists**

     Repair or replace as necessary.

   - **If no conditions exist**
2. Verify the Learn Procedure is successful.
   - If the engine control module is unable to complete the learn procedure, replace the K20 Engine Control Module.
3. Verify that the following conditions do not exist:
   - Vacuum hose splits, kinks, and incorrect connections
   - Engine vacuum leaks
   - Crankcase ventilation system for vacuum leaks
   - Fuel pressure that is too low or too high-Refer to **Fuel System Diagnosis**.
   - 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**
4. Ignition OFF, remove the T8 Ignition Coil of the misfiring cylinder, but leave the electrical connector connected.
5. Verify none of the conditions listed below exist with the boot of the T8 Ignition Coil:
   - Holes

- Tears
- Carbon tracking
- Oil contamination
- Water intrusion
- **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.

6. Verify the **J 26792 (EL 26792)** HEI Spark Tester sparks while cranking or starting the engine.
   - **If there is no spark**

     Refer to **Electronic Ignition System Diagnosis** for diagnosis of the ignition coil.

   - **If there is spark**
7. Ignition OFF, remove the spark plug from the misfiring cylinder.
8. Exchange the suspected spark plug with another cylinder that is operating correctly.
9. Engine idling.
10. Verify the scan tool Cylinder 1-4 Current Misfire Counter parameter does not increment on the spark plug coil it was removed from.
    - **If the misfire does follow the spark plug exchange**

      Replace the spark plug.

    - **If the misfire does not follow the spark plug exchange**
11. If all conditions test normal, test or inspect for the conditions listed below:
    - A lean or rich Q17 Fuel Injector-Refer to **Fuel Injector Balance Test**.
    - An engine mechanical condition-Refer to **Symptoms - Engine Mechanical** .

Repair Instructions

- **Ignition Coil Replacement**
- **Spark Plug Replacement**

Repair Verification

1. Install any components or connectors that have been removed or replaced during diagnosis.
2. Perform any adjustment, programming or setup procedures that are required when a component or module is removed or replaced.
3. Clear the DTCs.
4. Turn OFF the ignition for 60 s.
5. If the repair was related to a DTC, duplicate the Conditions for Running the DTC and use the Freeze

Frame/Failure Records, if applicable. 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 idling, observe the Misfire Current Cyl. 1-4 parameters with a scan tool. The misfire counter parameters should not be incrementing.
    - If the misfire counter parameters are incrementing, a misfire 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**.

DTC P0315

Diagnostic Instructions

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

DTC Descriptor

DTC P0315

Crankshaft Position System Variation Not Learned

Circuit/System Description

The crankshaft position system variation learn feature is used to calculate reference period errors caused by slight tolerance variations in the crankshaft, and the crankshaft position sensor. The calculated error allows the engine control module (ECM) to accurately compensate for reference period variations. This enhances the ability of the ECM to detect misfire events over a wider range of engine speed and load conditions.

The crankshaft position system variation compensating values are stored in ECM memory after a learn procedure has been performed and the ignition switch is turned to the OFF position for at least 30 s. If the actual variation is not within the crankshaft position system variation compensating values stored in the ECM, DTC P0300 may set.

If the crankshaft position system variation values are not stored in the ECM memory or a proper ECM power down does not occur after completing the Crankshaft Position Learn Procedure, DTC P0315 sets.

Conditions for Running the DTC

DTC P0315 runs continuously.

Conditions for Setting the DTC

The ECM detects that the crankshaft position system variation values are not stored in memory.

Action Taken When the DTC Sets

DTC P0315 is a Type A DTC.

Conditions for Clearing the MIL/DTC

DTC P0315 is a Type A DTC.

Diagnostic Aids

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

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End Views

COMPONENT CONNECTOR END VIEWS - INDEX

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Testing

NOTE: The Crankshaft Position Variation Learn may have to be repeated up to 5 times before the procedure is successful.

1. Perform the **Crankshaft Position System Variation Learn** procedure. The scan tool should display Learned Successful.
    - If the Crankshaft Position System Variation Learn Procedure cannot be performed successfully, inspect for the following conditions:
    - Worn crankshaft main bearings
    - A damaged or misaligned reluctor wheel
    - Excessive crankshaft runout
    - A damaged crankshaft-Refer to **Crankshaft Balancer Cleaning and Inspection** .
    - Interference in the signal circuit of the crankshaft position sensor
    - The ignition switch is in the ON position until there is insufficient system voltage.
    - An ECM power disconnect with the ignition ON that may have erased the crankshaft position system variation values and set DTC P0315
    - Debris between the crankshaft position sensor and the reluctor wheel
2. Verify the Learn Procedure is successful.
    - If the ECM is unable to complete the learn procedure, replace the K20 engine control module.

Repair Instructions

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

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

DTC P0324, P0326, P0331, P06B6, OR P06B7

Diagnostic Instructions

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

DTC Descriptors

DTC P0324

Knock Sensor System Performance

DTC P0326

Knock Sensor 1 Performance

DTC P0331

Knock Sensor 2 Performance

DTC P06B6

Control Module Knock Sensor Processor 1 Performance

DTC P06B7

Control Module Knock Sensor Processor 2 Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Knock Sensor 1 Signal	P0327	P0325	P0328	P0326
Knock Sensor 2 Signal	P0332	P0330	P0333	P0331
Knock Sensor 1 Low Reference	P0327	P0325, P06B6	P0328	P0326
Knock Sensor 2 Low Reference	P0332	P0330, P06B7	P0333	P0331

Circuit/System Description

The knock sensors enable the engine control module (ECM) to control the ignition timing for the best possible performance while protecting the engine from potentially damaging levels of detonation. The knock

sensors produce an alternating current (AC) voltage signal that varies depending on the vibration level during engine operation. The ECM adjusts the spark timing based on the amplitude and the frequency of the two knock sensor signals. The ECM receives the two knock sensor signals through 2 isolated circuits. The ECM learns a minimum knock sensor noise level for all of the engine speed ranges. The ECM monitors for a normal knock sensor signal. The ECM monitors the two internal knock sensor processors by verifying a 20 KHz signal generated on the signal circuits is detected on the sensors' low reference circuits.

Conditions for Running the DTCs

P0324, P0326, and P0331-Condition 1

- 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).
- The DTCs run continuously when the above conditions are met.

P0326 and P0331-Condition 2

- Engine speed is greater than 2,200 RPM.
- Engine is running for greater than 1 s.
- The ECT is warmer than -40°C (-40°F).
- The IAT sensor 1 is warmer than -40°C (-40°F).
- The DTCs run continuously when the above conditions are met.

P06B6 and P06B7

- Engine speed is between 400 and 3,500 RPM.
- Engine is running greater than 2 s.
- The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTCs

P0324

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

P0326 and P0331

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

  OR

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

P06B6 and P06B7

The ECM has detected an internal knock sensor processor fault.

Action Taken When the DTCs Set

- DTCs P0324, P0326, P0331, P06B6, and P06B7 are Type B DTCs.
- The ignition timing is retarded to reduce the potential of engine damaging spark knock.

Conditions for Clearing the DTCs

DTCs P0324, P0326, P0331, P06B6, and P06B7 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

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Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Engine running, observe the DTC information with a scan tool.
3. Verify DTC P0325, P0327, P0328, P0330, P0332, P0333, P06B6, and P06B7 is not set.
    - **IF DTC P0325, P0327, P0328, P0330, P0332, or P0333 is set with P06B6 or P06B7**

      Refer to **DTC P0325, P0327, P0328, P0330, P0332, or P0333** for further diagnosis.

    - **If only DTC P06B6 or P06B7 is set**

      Verify that no external knock sensor circuit issues exist, then; replace the K20 Engine Control Module.

- **If none of the DTCs is set**

4. Vehicle OFF, inspect for the following:
   - The affected B68 knock sensor for physical damage. A sensor that is dropped or damaged may cause a DTC to set
   - The sensor for proper installation. A sensor that is loose or not at the correct torque may cause a DTC to set. Refer to **Fastener Tightening Specifications** .
   - The sensor mounting surface for burrs, casting flash, and foreign material
   - The sensor must be clear of hoses, brackets, and engine electrical wiring
   - Loose brackets
   - Loose or broken accessory drive belts, brackets, components
   - An engine mechanical condition-Refer to **Symptoms - Engine Mechanical**
   - **If a condition is found**

     Repair or replace component as appropriate.

   - **If no condition is found**
5. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure Records data.
   - **If any of the DTCs set**

     Test or replace the B68 Knock Sensor.

   - **If none of the DTCs set**
6. All OK

Repair Instructions

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

- **Knock Sensor Replacement**
- **Control Module References** for engine control module replacement, programming, and setup.

DTC P0325, P0327, P0328, P0330, P0332, OR P0333

Diagnostic Instructions

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

DTC Descriptors

DTC P0325

Knock Sensor 1 Circuit

DTC P0327

Knock Sensor 1 Circuit Low Voltage

DTC P0328

Knock Sensor 1 Circuit High Voltage

DTC P0330

Knock Sensor 2 Circuit

DTC P0332

Knock Sensor 2 Circuit Low Voltage

DTC P0333

Knock Sensor 2 Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Sensor 1 Signal	P0327	P0325	P0328	P0326
Sensor 2 Signal	P0332	P0330	P0333	P0331
Sensor 1 Low Reference	P0327	P0325, P06B6	P0328	P0326
Sensor 2 Low Reference	P0332	P0330, P06B7	P0333	P0331

Circuit/System Description

The knock sensors enable the engine control module (ECM) to control the ignition timing for the best possible performance while protecting the engine from potentially damaging levels of detonation. The knock sensors produce an alternating current (AC) voltage signal that varies depending on the vibration level during engine operation. The ECM adjusts the spark timing based on the amplitude and the frequency of the two knock sensor signals. The ECM receives the two knock sensor signals through 2 isolated circuits. The ECM learns a minimum knock sensor noise level for all of the engine speed ranges. The ECM monitors for a normal knock sensor signal. The ECM monitors the two internal knock sensor processors by verifying a 20 KHz signal generated on the signal circuits is detected on the sensors' low reference circuits.

Conditions for Running the DTCs

P0325 and P0330

- Engine speed is between 500 and 8,500 RPM.
- Engine is running at least 2 s.
- The ECT is warmer than -40°C (-40°F).
- The IAT sensor 1 is warmer than -40°C (-40°F).
- The DTCs run continuously when the above conditions are met.

P0327, P0328, P0332, and P0333

- Engine speed is less than 8,500 RPM.
- The DTCs run continuously when the above condition is met.

Conditions for Setting the DTCs

P0325 and P0330

The ECM detects that a knock sensor signal circuit is open for longer than 6 s.

P0327 and P0332

The ECM detects that a knock sensor signal circuit is shorted to ground for longer than 6 s.

P0328 and P0333

The ECM detects that a knock sensor signal circuit is shorted to voltage for longer than 6 s.

Action Taken When the DTCs Set

- DTCs P0325, P0327, P0328, P0330, P0332, and P0333 are Type B DTCs.
- The ignition timing is retarded to reduce the potential of engine damaging spark knock.

Conditions for Clearing the DTCs

DTCs P0325, P0327, P0328, P0330, P0332, and P0333 are Type B DTCs.

Diagnostic Aids

- Inspect the affected knock sensor for physical damage. A sensor that is dropped or damaged may cause a DTC to set.
- The sensor mounting surface must be free of burrs, casting flash, and foreign material.
- The sensor must be clear of hoses, brackets, and engine electrical wiring.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

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

Circuit/System Verification

1. Engine Running.
2. Verify DTC P0325, P0327, P0328, P0330, P0332, or P0333 is not set.
   - **If the DTC is set**

     Refer to Circuit/System Testing.

   - **If the DTC is not set**
3. Verify the appropriate B68 Knock Sensor is properly tightened. Refer to **Fastener Tightening Specifications** .
4. Verify the scan tool parameters below display NO while moving the related harnesses and connectors for the appropriate B68 Knock Sensor.
   - Cylinder 1 Knock Detected
   - Cylinder 2 Knock Detected
   - Cylinder 3 Knock Detected
   - Cylinder 4 Knock Detected
     - **If NO is not displayed**

       Refer to Circuit/System Testing.

     - **If NO is displayed**
5. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure Records data.
   - **If the DTC is set**

     Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the appropriate B68 Knock Sensor. It may take up to 2 min for all vehicle systems to power down.

2. Test for less than 10 ohms between the low reference circuit terminal B and ground.
    - **If 10 ohms or greater**
    1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.
    2. Test for less than 2 ohms in the low reference circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
    - **If less than 10 ohms**
3. Test for 1-4 V between the signal circuit terminal A and ground.
    - **If greater than 4 V**
    1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the 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 less than 1 V**
    1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 ohms in the signal circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
    - **If between 1-4 V**
4. Replace the B68 Knock Sensor.

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.

DTC P0335 OR P0336

Diagnostic Instructions

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

DTC Descriptors

DTC P0335

Crankshaft Position Sensor Circuit

DTC P0336

Crankshaft Position Sensor Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P057C, P0335, P0651	P0335	P0651	P0336
Signal	P0335, P0506	P0335	P0335	P0336
Low Reference	-	P0335	-	P0336

Circuit/System Description

The crankshaft position sensor circuits consist of an engine control module (ECM) supplied 5 V reference circuit, low reference circuit, and an output signal circuit. The crankshaft position sensor is an internally magnetic biased digital output integrated circuit sensing device. The sensor detects magnetic flux changes of the teeth and slots of a 58-tooth reluctor wheel on the crankshaft. Each tooth on the reluctor wheel is spaced at 60-tooth spacing, with 2 missing teeth for the reference gap. The crankshaft position sensor produces an ON/OFF DC voltage of varying frequency, with 58 output pulses per crankshaft revolution. The frequency of the crankshaft position sensor output depends on the velocity of the crankshaft. The crankshaft position sensor sends a digital signal, which represents an image of the crankshaft reluctor wheel, to the ECM as each tooth on the wheel rotates past the crankshaft position sensor. The ECM uses each crankshaft position signal pulse to determine crankshaft speed and decodes the crankshaft reluctor wheel reference gap to identify crankshaft position. This information is then used to determine the optimum ignition and injection points of the engine. The ECM also uses crankshaft position sensor output information to determine the camshaft relative position to the crankshaft, to control camshaft phasing, and to detect cylinder misfire.

Conditions for Running the DTC

P0335 Condition 1

- The starter is engaged and the engine control module detects camshaft position (CMP) sensor pulses.

  Or

- DTCs P0101, P0102 and P0103 are not set.

  And

- The airflow into the engine is greater than 3 g/s.

Condition 2

- The engine is running and the starter is not engaged.
- DTC P0651 is not set.

Condition 3

- The engine is running or the starter is engaged.
- DTCs P0365, P0366, P0641, and P0651 are not set.

P0336 Condition 1

- The airflow into the engine is greater than 3 g/s.
- Engine speed is greater than 450 RPM.
- DTCs P0335 or P0651 are not set.

Condition 2

- The engine is running and the starter is not engaged.
- DTC P0651 is not set.

Condition 3

- The starter is engaged and the engine control module detects camshaft position (CMP) sensor pulses.

  Or

- DTCs P0101, P0102, and P0103 are not set.
- The airflow into the engine is greater than 3 g/s.

Condition 4

- The engine is running or the starter is engaged.
- DTCs P0365, P0366, P0641, and P0651, are not set.

The DTCs run continuously once the above conditions are met.

Conditions for Setting the DTC

P0335 Condition 1

The ECM does not detect a crankshaft position sensor pulse for greater than 4 s.

Condition 2

The ECM does not detect a crankshaft position sensor pulse for greater than 1.0 s.

Condition 3

The ECM does not detect a crankshaft position sensor pulse for 2 out of 10 engine revolutions.

P0336 Condition 1

The ECM detects that 10 or more crankshaft resynchronization have occurred within 10.0 s.

Condition 2

The ECM does not detect the synchronization gap on the reluctor wheel for greater than 0.4 s.

Condition 3

The ECM does not detect the synchronization gap on the reluctor wheel for 1.5 s after the starter was engaged.

Condition 4

The ECM detects less than 51 or greater than 65 crankshaft position sensor pulses during 1 engine revolution for 8 out of 10 engine revolutions.

Action Taken When the DTC Sets

- DTCs P0335 and P0336 are Type B DTCs.
- The camshaft position sensor is used to determine engine position.
- The camshaft actuators are commanded to the parked position.

Conditions for Clearing the DTC

DTCs P0335 and P0336 are Type B DTCs.

Reference Information

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0651 is not set.
   - **If the DTC is set**

     Refer to **DTC P0641, P0651, P0697, or P06A3 (ECM)**.

   - **If the DTC is not set**
3. Engine running.
4. Verify the scan tool Crankshaft Position Active Counter parameter increments.
   - **If the counter does not increment**

     Refer to Circuit/System Testing.

   - **If the counter increments**
5. Verify the scan tool Crankshaft Position Resync Counter parameter displays 0 counts and the engine does not stumble or stall while moving the related harness/connectors of the B26 Crankshaft Position Sensor.
   - **If greater than 0 counts and the engine stumbles or stalls**

     Refer to Circuit/System Testing.

   - **If 0 counts and the engine does not stumble or stall**
6. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
7. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B26 Crankshaft Position Sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 ohms between the low reference circuit terminal 2 and ground.
   - **If 5 ohms or greater**
     1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.

2. Test for less than 2 ohms in the low reference circuit end to end.
    - If 2 ohms or greater, repair the open/high resistance in the circuit.
    - If 2 ohms or less, replace the K20 Engine Control Module.
- **If less than 5 ohms**

3. Ignition ON.
4. Test for 4.8-5.2 V between the 5 V reference circuit terminal 1 and ground.
    - **If less than 4.8 V**
    1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the 5 V reference circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 ohms in the 5 V reference circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms , replace the K20 Engine Control Module.
    - **If greater than 5.2 V**
    1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the 5 V reference and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If between 4.8-5.2 V**
5. Test for 4.8-5.2 V between the signal circuit terminal 3 and ground.
    - **If less than 4.8 V**
    1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance.
    3. Test for less than 2 ohms in the signal circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
    - **If greater than 5.2 V**
    1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If between 4.8-5.2 V**
6. Ignition OFF, connect a 3 A fused jumper wire to the signal circuit terminal 3, ignition ON.

NOTE: Additional DTCs may set when performing this test.

7. Verify the scan tool Crankshaft Position Sensor Active Counter parameter increments while rapidly tapping the fused jumper wire end to ground.
    - **If the counter does not increment**

      Replace the K20 Engine Control Module.

    - **If the counter increments**
8. Verify DTC P0336 is not set.
    - **If the DTC is set**

      Inspect for the conditions listed below:

      - Excessive play or looseness of the B26 Crankshaft Position Sensor or the reluctor wheel
      - Improper installation of the B26 Crankshaft Position Sensor
      - Foreign material passing between the B26 Crankshaft Position Sensor and the reluctor wheel
      - Damaged reluctor wheel
      - Excessive air gap between the B26 Crankshaft Position Sensor and the reluctor wheel
      - Engine oil for debris
      - Timing chain, tensioner, and sprockets for wear or damage
    - If any of the conditions above are found, repair as necessary.
    - If all components test normal, test or replace the B26 Crankshaft Position Sensor.
    - **If the DTC is not set**
9. Test or replace the B26 Crankshaft Position Sensor.

Repair Instructions

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

- **Crankshaft Position Sensor Replacement (FWD)** , **Crankshaft Position Sensor Replacement (AWD)**
- **Control Module References** for engine control module replacement, programming, and setup

DTC P0340, P0341, P0365, OR P0366

Diagnostic Instructions

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

DTC Descriptors

DTC P0340

Intake Camshaft Position Sensor Circuit

DTC P0341

Intake Camshaft Position Sensor Performance

DTC P0365

Exhaust Camshaft Position Sensor Circuit

DTC P0366

Exhaust Camshaft Position Sensor Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P018C, P0192, P0452, P0522, P0532, P0641, P2227, P2228	P0340, P0365	P018D, P0193, P0453, P0523, P0641, P2227	-
Signal	P0340, P0365	P0340, P0365	P0340, P0365	P0341, P0366
Low Reference	-	P0340, P0365	P0340, P0365	-

Circuit/System Description

The camshaft position sensors each have 3 circuits consisting of an engine control module (ECM) supplied 5 V reference circuit, low reference circuit, and an output signal circuit. The camshaft position sensor is an internally magnetic biased digital output integrated circuit sensing device. The sensor detects magnetic flux changes of the teeth and slots of a 4-tooth reluctor wheel attached to the camshaft. As each reluctor wheel tooth rotates past the camshaft position sensor, the resulting change in the magnetic field is used by the sensor electronics to produce a digital output pulse. The sensor returns a digital ON/OFF DC voltage pulse of varying frequency with 4 varying width output pulses per camshaft revolution that represent an image of the camshaft reluctor wheel. The frequency of the camshaft position sensor output depends on the velocity of the camshaft. The ECM decodes the narrow and wide tooth pattern to identify camshaft position. This information is then used to determine the optimum ignition and injection points of the engine. The ECM uses the cylinder 1 exhaust camshaft position sensor to determine injector and ignition system synchronization. The intake and exhaust camshaft position sensors are also used to determine camshaft to crankshaft relationship. The ECM also uses camshaft position sensor output information to determine the camshaft relative position to the crankshaft to control camshaft phasing and limp-home operation.

Conditions for Running the DTC

P0340 or P0365 Condition 1

- The starter is engaged and the engine control module detects camshaft position sensor pulses.

  OR

- DTCs P0101, P0102, and P0103 are not set.
- The airflow into the engine is greater than 3 g/s.

Condition 2

- The engine is running and the starter is not engaged.
- DTC P0651 is not set.

Condition 3

- The crankshaft is synchronized.
- The starter is engaged.
- DTC P0335, P0336, P0641, or P0651 are not set.

Condition 4

- The crankshaft is synchronized.
- DTC P0335, P0336, P0641, or P0651 are not set.

P0341 or P0366 Condition 1

- The crankshaft is synchronized.
- The starter is engaged.
- DTC P0335, P0336, P0641, or P0651 are not set.

Condition 2

- The crankshaft is synchronized.
- DTC P0335, P0336, P0641, or P0651 are not set.

The DTCs run continuously once the above conditions are met.

Conditions for Setting the DTC

P0340 or P0365 Condition 1

- The ECM does not detect a camshaft position sensor pulse for greater than 5.5 s.

  OR

- The ECM does not detect a camshaft position sensor pulse for greater than 4.0 s since the time the starter has been engaged.

Condition 2

The ECM detects less than 4 camshaft position sensor pulse for greater than 3.0 s.

Condition 3

The ECM does not detect a camshaft position sensor pulse during the first 2 engine revolutions.

Condition 4

The ECM does not detect a camshaft position sensor pulse during 200 engine revolutions.

P0341 or P0366 Condition 1

- The ECM detects less than 4 camshaft position sensor pulses during 2 engine revolutions.

  OR

- The ECM detects greater than 10 camshaft position sensor pulses during 2 engine revolutions.

Contion 2

The ECM detects less than 398 or greater than 402 camshaft position sensor pulses during 200 engine revolutions.

Action Taken When the DTC Sets

- DTCs P0340, P0341, P0365, and P0366 are Type B DTCs.
- The camshaft position actuator is commanded to the Home or Parked position.
- The ignition system defaults to a failed camshaft position sensor limp home mode.

Conditions for Clearing the MIL/DTC

DTCs P0340, P0341, P0365, and P0366 are Type B DTCs.

Diagnostic Aids

- With a DTC set, the engine may crank for an extended period of time at start-up
- The exhaust camshaft position sensor is used for injector and ignition system synchronization. A stalling condition will occur if the camshaft position sensor signal is intermittent and a DTC may not set. Inspect all camshaft position sensor circuits for poor connections.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0641 or P0651 is not set.
   - **If any of the DTCs are set**

     Refer to **DTC P0641, P0651, P0697, or P06A3 (ECM)**.

   - **If none of the DTCs are set**
3. Engine running.
4. Verify the scan tool parameters listed below increment:
   - Exhaust Camshaft Position Active Counter
   - Intake Camshaft Position Active Counter
   - **If any counter does not increment**

     Refer to Circuit/System Testing.

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

     Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the appropriate B23 Camshaft Position Sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 ohms between the low reference circuit terminal 2 and ground.

- **If 5 ohms or greater**
  1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
  2. Test for less than 2 ohms in the low reference circuit end to end.
     - If 2 ohms or greater, repair the open/high resistance in the circuit.
     - If 2 ohms or less, replace the K20 Engine Control Module.
- **If less than 5 ohms**

3. Ignition ON.
4. Test for 4.8-5.2 V between the 5 V reference circuit terminal 1 and ground.
   - **If less than 4.8 V**
     1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
     2. Test for infinite resistance between the 5 V reference circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance.
     3. Test for less than 2 ohms in the 5 V reference circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms , replace the K20 Engine Control Module.
   - **If greater than 5.2 V**
     1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module, ignition ON.
     2. Test for less than 1 V between the 5 V reference circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
   - **If between 4.8-5.2 V**
5. Test for 4.8-5.2 V between the signal circuit terminal 3 and ground.
   - **If less than 4.8 V**
     1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
     2. Test for infinite resistance between the signal circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance.
     3. Test for less than 2 ohms in the signal circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
   - **If greater than 5.2 V**
     1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module, ignition ON.
     2. Test for less than 1 V between the signal circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
   - **If between 4.8-5.2 V**
6. Verify DTC P0341 or P0366 is not set.

- **If any of the DTCs are set**

  Inspect for the conditions listed below:

- Excessive play or looseness of the B23 Camshaft Position Sensor or the reluctor wheel
- Improper installation of the B23 Camshaft Position Sensor
- Foreign material passing between the B23 Camshaft Position Sensor and the reluctor wheel
- Damaged reluctor wheel
- Excessive air gap between the B23 Camshaft Position Sensor and the reluctor wheel
- Engine oil for debris
- Timing chain, tensioner, and sprockets for wear or damage
- If any of the conditions above are found, repair as necessary.
- If all components test normal, test or replace the B23 Camshaft Position Sensor.
- **If none of the DTCs are set**

7. Test or replace the B23 Camshaft Position Sensor.

Repair Instructions

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

- **Camshaft Position Sensor Replacement - Exhaust**
- **Camshaft Position Sensor Replacement - Intake**
- **Control Module References** for engine control module replacement, programming, and setup

DTC P0351-P0354, P2300, P2301, P2303, P2304, P2306, P2307, P2309, OR P2310

Diagnostic Instructions

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

DTC Descriptors

DTC 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

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Coil 1 Control	P0300, P2300	P0300, P0351	P0300, P2301	P0300, P0351
Ignition Coil 2 Control	P0300, P2303	P0300, P0352	P0300, P2304	P0300, P0352
Ignition Coil 3 Control	P0300, P2306	P0300, P0353	P0300, P2307	P0300, P0353
Ignition Coil 4 Control	P0300, P2309	P0300, P0354	P0300, P2310	P0300, P0354

Circuit/System Description

The ignition system on this engine uses an individual coil for each cylinder. The engine control module (ECM) controls the spark event for each cylinder through the 4 individual ignition control circuits. When the

ECM commands the ignition control circuit ON, electrical current will flow through the primary winding of the ignition coil, creating a magnetic field. When a spark event is requested, the ECM will command the ignition control circuit OFF, interrupting current flow through the primary winding. The magnetic field created by the primary winding will collapse across the secondary coil windings, producing a high voltage across the spark plug electrodes. The ECM uses information from the crankshaft position sensor, and the camshaft position sensor for sequencing and timing of the spark events. The ECM monitors each ignition control circuit for improper voltage levels.

Conditions for Running the DTC

- The engine is cranking or running.
- Ignition voltage greater than 5 V.

The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

The ECM detects that the commanded state of the driver and the actual state of the control circuit do not match. The engine control module detects an open in the ignition coil control circuit.

Action Taken When the DTC Sets

DTCs P0351, P0352, P0353, P0354, P2300, P2301, P2303, P2304, P2306, P2307, P2309, and P2310 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P0351, P0352, P0353, P0354, P2300, P2301, P2303, P2304, P2306, P2307, P2309, and P2310 are Type B DTCs.

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Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL 26792 HEI Spark Tester

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)** .

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

     Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the appropriate T8 Ignition Coil, engine Running.
2. Verify the appropriate scan tool Ignition Coil Control Circuit Low Voltage Test Status does not display Malfunction.
   - **If Malfunction is displayed**
   1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the control circuit and ground.
      - If less than infinite resistance, repair the short to ground on the control circuit.

- If infinite resistance, replace the K20 Engine Control Module.
- **If Malfunction is not displayed**

3. Verify the appropriate scan tool Ignition Coil Control Circuit High Voltage Test Status does not display Malfunction.
   - **If Malfunction is displayed**
   1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
   2. Test for less than 1 V between the control circuit and ground.
      - If 1 V or greater, repair the short to voltage in the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If Malfunction is not displayed**
4. Ignition OFF, install a 3 A fused jumper wire between the control circuit terminal 3 and ground, engine Running.
5. Verify the appropriate scan tool Ignition Coil Control Circuit Low Voltage Test Status displays Malfunction.
   - **If Malfunction is not displayed**
   1. Ignition OFF, remove the fused jumper, and disconnect the X3 harness connector at the K20 Engine Control Module.
   2. Test for less than 2 ohms in the control circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 Engine Control Module.
   - **If Malfunction is displayed**
6. Test or replace the T8 Ignition Coil.

Component Test

NOTE: You must perform the Circuit/System Testing before proceeding with Component Testing.

1. Ignition OFF, connect the **EL 26792** HEI spark tester to the appropriate T8 Ignition Coil.
2. Engine Running.
3. Verify the spark output of the T8 Ignition Coil.
   - **If no output or the output is weak**

     Replace the T8 Ignition Coil.

   - **If the output is normal**
4. All OK.

Repair Instructions

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

- **Ignition Coil Replacement**
- **Control Module References** for engine control module replacement, programming, and setup

DTC P0420

Diagnostic Instructions

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

DTC Descriptor

DTC P0420

Catalyst System Low Efficiency

Circuit/System Description

A 3-way catalyst controls emissions of hydrocarbons, carbon monoxide (CO) and nitrogen oxide (NOx). The catalyst within the converter promotes a chemical reaction, which oxidizes the hydrocarbons and the CO that are present in the exhaust gas. This process converts the hydrocarbons and the CO into water vapor and carbon dioxide (CO2), and reduces the NOx, converting the NOx into nitrogen. The catalyst also stores oxygen. The engine control module (ECM) monitors this process by using heated oxygen sensors (HO2S) that are in the exhaust stream before and after the 3- way catalyst. The HO2S produces an output signal that the ECM uses to calculate the oxygen storage capacity of the catalyst. This indicates the ability of the catalyst to convert the exhaust emissions efficiently. The ECM monitors the efficiency of the catalyst by monitoring the HO2S during an off-idle, decel fuel cut off (DFCO) event. When the catalyst is functioning properly, the post catalyst HO2S response to the fuel conditions during the DFCO event is slow compared to the response of the pre catalyst HO2S. When the post HO2S response is near that of the pre HO2S, the oxygen storage capability and efficiency of the catalyst may be degraded below an acceptable threshold.

Conditions for Running the DTC

- DTC P0030, P0031, P0032, P0036, P0037, P0038, P0053, P0054, P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0117, P0118, P0119, P0121, P0122, P0123, P0128, P0131, P0132, P0133, P0135, P0137, P0138, P013A, P013B, P013E, P013F, P0141, P015A, P015B, P0171, P0172, P0201, P0202, P0203, P0204, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0300, P0301, P0302, P0303, P0304, P1248, P1249, P124A, P124B, P16F3, P2101, P2135, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P2270, or P2271 is not set.
- The engine speed is between 950-2,950 RPM to enable the catalyst diagnostic. Once the engine speed is in range, the engine speed must be between 900-3,050 RPM to keep the test enabled.
- The accelerator pedal position is at most 4 %.
- Ethanol estimation is not active.
- The evaporative emission (EVAP) purge is not active.
- The post HO2S heater is ON for greater than 180 s.
- The mass air flow (MAF) is between 2-13 g/s.
- The system voltage is between 10-32 V.
- The vehicle speed is between 64-126 km/h (40-78 MPH) to enable the catalyst diagnostic. To keep the test enabled the vehicle speed is between 56-132 km/h (35-82 MPH).
- The catalyst calculated temperature is between 500-900°C (932-1,652°F).

- The engine is operating in closed loop.
- The engine is operating in Decel Fuel Cut Off (DFCO).

This diagnostic attempts one test during each valid OFF-idle period once the above conditions have been met. This diagnostic attempts up to 4 tests during each drive cycle.

Conditions for Setting the DTC

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

Action Taken When the DTC Sets

DTC P0420 is a Type A DTC.

Conditions for Clearing the DTC

DTC P0420 is a Type A DTC.

Diagnostic Aids

Inspect for the following conditions, which may cause a catalytic converter to degrade:

- An engine misfire
- High engine oil or high coolant consumption
- Retarded spark timing
- A weak or poor spark
- A lean fuel mixture
- A rich fuel mixture
- A damaged oxygen sensor or wiring harness

Reference Information

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify there are no other DTCs set.
    - **If a DTC is set**

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

- **If a DTC is not set**

3. Operate the vehicle within the Conditions for Running the DTC.
4. Verify the scan tool Catalyst Monitor Not At Idle Test Conditions Met parameter changes to Yes.
   - **If Yes is not displayed**

     Refer to step 3.

   - **If Yes is displayed**
5. Monitor the scan tool Catalyst Monitor Test State parameter. When the parameter indicates Active, the Catalyst Monitor Test is running.

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

6. Continue to monitor the parameter. When the parameter indicates Inactive, the Catalyst Monitor Test has completed.
   - **If the Catalyst Monitor Test Result parameter indicates No Result**

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

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

     Refer to Circuit /System Testing

   - **If the Catalyst Monitor Test Result parameter indicates Pass**
7. All OK.

Circuit/System Testing

1. Verify the conditions listed below do not exist with the catalytic converter:
   - Dents
   - Severe discoloration caused by excessive temperatures
   - Road damage
   - Internal rattles caused by damaged catalyst substrate
   - Restrictions
     - **If a condition is found**

       Replace the catalytic converter.

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

- **If a condition is found**

  Repair or replace the component as necessary.

- **If no condition is found**

3. Verify the conditions listed below do not exist with the B52B heated oxygen sensor 2:
   - Incorrect torque
   - Damage
     - **If a condition is found**

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

     - **If no condition is found**
4. Test or replace the catalytic converter.

Repair Instructions

- **Catalytic Converter Replacement (LTG)**
- **Exhaust Leakage**
- **Heated Oxygen Sensor Replacement - Sensor 2**
- **Restricted Exhaust**

Repair Verification

1. Install any components that have been removed or replaced during diagnosis.
2. Perform any adjustments, programming or setup procedures that are required when a component is removed or replaced.
3. Clear the DTCs with a scan tool.
4. Turn OFF the ignition for 60 s
5. Operate the vehicle within the Conditions for Running the DTC.
6. Verify the scan tool Catalyst Monitor Not At Idle Test Conditions Met parameter changes to Yes.
   - **If Yes is not displayed**

     Refer to step 5.

   - **If Yes is displayed**
7. Monitor the scan tool Catalyst Monitor Test State parameter. When the parameter indicates Active, the Catalyst Monitor Test is running.

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

8. Continue to monitor the parameter. When the parameter indicates Inactive, the Catalyst Monitor Test has completed.
   - **If the Catalyst Monitor Test Result parameter indicates No Result**

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

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

  Refer to Circuit /System Testing

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

9. All OK.

DTC P0442

Diagnostic Instructions

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

DTC Descriptor

DTC P0442

Evaporative Emission (EVAP) System Small Leak Detected

Circuit/System Description

The engine off natural vacuum (EONV) test is the small leak detection diagnostic for the evaporative emission (EVAP) system. This diagnostic tests the EVAP system for a small leak when the key is turned OFF and the correct conditions are met. Heat from the exhaust system is transferred into the fuel tank while the vehicle is operating. When the vehicle is turned OFF and the EVAP system is sealed a change in the fuel tank vapor temperature occurs which results in a corresponding pressure change in the fuel tank vapor space. This change is monitored by the engine control module (ECM) using the fuel tank pressure (FTP) sensor input. With a leak in the system, the amount of pressure change will be less than that of a sealed system.

Conditions for Running the DTC

- DTCs 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.

Conditions for Setting the DTC

- The ECM detects a leak in the EVAP system that is greater than a calibrated amount.
- The ECM must complete several EONV tests before the diagnostic can turn the MIL on or off.

Action Taken When the DTC Sets

DTC P0442 is a Type A DTC.

Conditions for Clearing the DTC

DTC P0442 is a Type A DTC.

Diagnostic Aids

- The EVAP system can be filled with smoke more quickly and completely by opening the system opposite the end where the smoke is injected. When injecting smoke at the service port tool temporarily leave the EVAP Vent Solenoid Valve open until smoke is observed then close the system and continue testing.
- To help locate intermittent leaks using the **GE 41413-A** , 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 Sensor parameter for vacuum decay.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Evaporative Emission Control System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

- **CH 48096** EVAP Service Port Access Tool
- **GE 41413-A** Evaporative Emissions System Tester (EEST)
- **GE 41413-300** EVAP Cap and Plug Kit
- **GE 41413-SPT** High Intensity White Light

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)** .

Circuit/System Testing

NOTE:

- **Refer to the GE 41413-A operation manual for detailed instructions in Evaporative Emission System Diagnosis.**
- **Larger volume fuel tanks and/or those with lower fuel levels may require several minutes for the floating indicator to stabilize or produce smoke from a leak.**
- **Ensure that the underbody temperature of the vehicle and the tester are similar.**

1. Disconnect the purge tube at the quick connector on the EVAP canister side of the Q12 Evaporative Emission Canister Purge Solenoid Valve and install the **CH 48096** .
2. Connect the **GE 41413-A** 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 41413-A** calibrated to 0.51 mm (0.020 in) to determine if there is a leak.
    - **If a leak is detected**
    1. Use the **GE 41413-A** to apply smoke to the EVAP system at the purge tube service port until the leak is located using the **GE 41413-SPT** .
        - If leak is detected, repair or replace the affected component as necessary.
    - **If no leak is detected**
5. All OK.

Repair Instructions

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

DTC P0443, P0458, OR P0459

Diagnostic Instructions

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

DTC Descriptors

DTC P0443

Evaporative Emission (EVAP) Purge Solenoid Valve Control Circuit

DTC P0458

Evaporative Emission (EVAP) Purge Solenoid Valve Control Circuit Low Voltage

DTC P0459

Evaporative Emission (EVAP) Purge Solenoid Valve Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage
Ignition	P0443, P0458	P0443	P0690
Control	P0443, P0458	P0443	P0459, P0690

Circuit/System Description

The evaporative emission (EVAP) purge solenoid valve is used to purge fuel vapor from the EVAP canister to the intake manifold. The EVAP purge solenoid valve is pulse width modulated (PWM). Ignition voltage is supplied directly to the EVAP purge solenoid valve. The engine control module (ECM) controls the solenoid valve by grounding the control circuit with a solid state device called a driver. The driver is equipped with a feedback circuit that is pulled-up to a voltage. The ECM can determine if the control circuit is open, shorted to ground, or shorted to a voltage by monitoring the feedback voltage. A scan tool will display the amount of ON time as a percentage.

Conditions for Running the DTC

- The ignition voltage is greater than 11 V.
- The DTCs run continuously once the above conditions are met.

Conditions for Setting the DTC

P0443

The ECM detects the EVAP Purge Solenoid Valve control circuit is open within 0.25 s.

P0458

The ECM detects the EVAP Purge Solenoid Valve control circuit is shorted to ground within 0.25 s.

P0459

The ECM detects the EVAP Purge Solenoid Valve control circuit is shorted to voltage within 0.25 s.

Action Taken When the DTC Sets

DTC P0443, P0458 and P0459 are Type B DTCs.

Conditions for Clearing the DTC

DTC P0443, P0458 and P0459 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Evaporative Emission Control System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

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, verify DTC P0690 is not set.
   - **If the DTC is set**

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

   - **If the DTC is not set**
2. Command the EVAP Purge Solenoid Valve 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 Open Test Status
   - EVAP Purge Solenoid Valve Control Circuit Low Voltage Test Status
   - EVAP Purge Solenoid Valve Control Circuit High Voltage Test Status
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing

   - **If Malfunction is not displayed**
3. Verify the EVAP Purge Solenoid Valve control circuit parameters above do not display Malfunction when moving the related harnesses and connectors of the Q12 Evaporative Emission Purge Solenoid Valve.
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing

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

     Refer to Circuit/System Testing

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

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the Q12 Evaporative Emission Purge Solenoid Valve. Ignition ON,
2. Verify that a test lamp illuminates between the ignition voltage circuit terminal A or 1 and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**

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

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

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

- **If the test lamp illuminates**

3. Verify that a test lamp does not illuminate between the ignition circuit terminal A or 1 and the control circuit terminal B or 2.
    - **If the test lamp illuminates**

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

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

4. Remove the test lamp.
5. Verify the scan tool EVAP Purge Solenoid Valve Control Circuit High Voltage Test Status parameter is OK when commanding the EVAP Purge Solenoid Valve to 50% with a scan tool.
    - **If OK is not displayed**

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

    - **If OK is displayed**

6. Install a 3 A fused jumper wire between the control circuit terminal B or 2 and the ignition circuit terminal A or 1.
7. Verify the scan tool EVAP Purge Solenoid Valve Control Circuit High Voltage Test Status parameter is Malfunction when commanding the EVAP Purge Solenoid Valve to 50% with a scan tool.
    - **If Malfunction is not displayed**

    1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for less than 2 ohms in the control circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms replace the K20 Engine Control Module.

    - **If Malfunction is displayed**

8. Test or replace the Q12 Evaporative Emission Purge Solenoid Valve.

Component Testing

Static Test

1. Ignition OFF, disconnect the harness connector at the Q12 Evaporative Emission Purge Solenoid Valve.
2. Test for 10-30 ohms between the control terminal B or 2 and the ignition circuit terminal A or 1.
   - **If not between 10-30 ohms**

     Replace the Q12 Evaporative Emission Purge Solenoid Valve.

   - **If between 10-30 ohms**
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 A or 1 and 12 V. Install a jumper wire between the control terminal B or 2 and ground.
3. Verify the Evaporative Emission Purge Solenoid Valve turns on & off/clicks and flows vacuum.
   - **If it does not turn on & off/click or flow vacuum.**

     Replace the Q12 Evaporative Emission Purge Solenoid Valve.

   - **If it does turns on & off/clicks and flows vacuum.**
4. All OK

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

DTC P0446

Diagnostic Instructions

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

DTC Descriptor

DTC P0446

Evaporative Emission (EVAP) Vent System Performance

Typical Scan Tool Data

Fuel Tank Pressure Sensor Signal Voltage	Fuel Tank Pressure
1.5 V	Atmospheric Pressure / BARO
Less than 1.5 V	Positive Pressure
More than 1.5 V	Negative Pressure / Vacuum

Circuit/System Description

This DTC tests the evaporative emission (EVAP) system for a restricted or blocked EVAP vent path that would cause excess amounts of vacuum to be developed in the EVAP system. The engine control module (ECM) uses the fuel tank pressure (FTP) sensor to monitor EVAP system vacuum. With the purge valve and vent valve open, if the EVAP system vacuum goes above a calibrated threshold, P0446 will set.

The following table illustrates the relationship between the ON and OFF states, and the OPEN or CLOSED states of the EVAP purge and vent solenoid valves.

ECM Command	EVAP Purge Solenoid Valve	EVAP Vent Solenoid Valve
ON	Open	Closed
OFF	Closed	Open

Conditions for Running the DTC

- DTCs P0068, P00C8, P00C9, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0121, P0122, P0123, P0128, P0191, P0192, P0193, P0222, P0223, P0443, P0601, P0604, P0606, P16A0, P16A1, P16A2, P16F3, P2101, P2135, P2176, 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.

Conditions for Setting the DTC

NOTE: There are two stages to setting this DTC. Stage one, prep test, then stage two test.

- If fuel tank pressure sensor reading is greater than 2.5 in H2O of pressure or less than -5 in H2O of vacuum for 60 s.

  OR

- If fuel tank pressure sensor reading is less than -12 in H2O of vacuum for 5 s before 10 L (2.6 gal) of purge volume.
- After setting the DTC for the first time, 2 L (0.5 gal) of fuel must be consumed before setting the DTC for the second time.

Action Taken When the DTC Sets

DTC P0446 is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P0446 is a Type B DTC.

Diagnostic Aids

- An intermittent condition could be caused by a damaged EVAP vent housing, a temporary blockage at the EVAP vent solenoid valve inlet, or a pinched vent hose. A blockage in the vent system may also cause a poor fuel fill condition.
- An EVAP canister filter that is restricted can cause this DTC to set.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Evaporative Emission Control System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

- **CH 41415-30** Fuel Tank Cap Adapter
- **GE 41413-A** Evaporative Emissions System Tester (EEST)

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)**

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 P0451-P0454**

   - **If between the 1.3-1.7 V**
5. Install the fuel tank filler cap. Engine idling at operating temperature for 5 min.
6. Verify the scan tool Fuel Tank Pressure Sensor parameter does not increase to greater than 2.5 V when commanding the EVAP Purge Solenoid Valve to 50 %.
   - **If greater than 2.5 V**

     Refer to Circuit/System Testing.

   - **If 2.5 V or less**
7. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

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

Circuit/System Testing

NOTE: Perform the Circuit/System Verification before proceeding with the Circuit/System Testing.

1. Test for a blockage or restrictions in the EVAP system components listed below and repair as necessary.
   - Evaporative Emission Vent System Hoses
   - Evaporative Emission Canister
   - Q13 Evaporative Emission Vent Solenoid Valve

- Evaporative Emission Vent Filter

2. Reconnect all previously disconnected EVAP hardware.

NOTE: Refer to the GE 41413-A Evaporative Emissions System Tester (EEST) operation manual for detailed instructions in Evaporative Emission System Diagnosis.

3. Remove the fuel fill cap and connect the **CH 41415-30** fuel tank cap adapter to the fuel tank filler neck. Connect the **GE 41413-A** evaporative emissions system tester (EEST) to the **CH 41415-30** fuel tank cap adapter 0.
4. Command the EVAP Purge/Seal function to System Seal with a scan tool to seal the EVAP system.
5. Turn the nitrogen/smoke valve on the **GE 41413-A** evaporative emissions system tester (EEST) to nitrogen.

NOTE: DO NOT exceed the specified value in this step. Exceeding the specified value may produce incorrect test results.

6. Use the remote switch to activate the **GE 41413-A** evaporative emissions system tester (EEST) and pressurize the fuel tank to 5.0 in H2O.
7. Verify the scan tool Fuel Tank Pressure Sensor parameter is 0 in H2O when commanding the EVAP Vent Solenoid Valve to OFF.
   - **If not 0 in H20**

     Test for a blockage or a restriction in the EVAP vent hose or inlet. If the inlet or hose test normal, replace the Q13 Evaporative Emission Vent Solenoid Valve.

   - **If 0 in H2O**
8. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
   - **If the DTC sets**

     Refer to step 1 above.

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

Repair Instructions

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

- **Evaporative Emission Canister Solenoid Replacement (FWD)** , **Evaporative Emission Canister Solenoid Replacement (AWD)** for EVAP Vent Solenoid Valve replacement
- **Evaporative Emission Canister Replacement (FWD)** , **Evaporative Emission Canister Replacement (AWD)**
- **Fuel Tank Pressure Sensor Replacement (AWD)** , **Fuel Tank Pressure Sensor Replacement (FWD)**

DTC P0449, P0498, OR P0499

Diagnostic Instructions

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

DTC Descriptors

DTC P0449

Evaporative Emission (EVAP) Vent Solenoid Valve Control Circuit

DTC P0498

Evaporative Emission (EVAP) Vent Solenoid Valve Control Circuit Low Voltage

DTC P0499

Evaporative Emission (EVAP) Vent Solenoid Valve Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage
B+	P0449, P0498	P0449	-
Control	P0449, P0498	P0449	P0499

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).

Conditions for Running the DTC

- The system voltage is greater than 11 V.
- The DTCs run continuously once the above conditions are met.

Conditions for Setting the DTC

P0449

The ECM detects the EVAP Vent Solenoid Valve control circuit is open within 0.25 s.

P0498

The ECM detects the EVAP Vent Solenoid Valve control circuit is shorted to ground within 0.25 s.

P0499

The ECM detects the EVAP Vent Solenoid Valve control circuit is shorted to voltage within 0.25 s.

Action Taken When the DTC Sets

DTC P0449, P0498 and P0499 are Type B DTCs.

Conditions for Clearing the DTC

DTC P0449, P0498 and P0499 are Type B DTCs.

Reference Information

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- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

NOTE: An audible click may be heard when performing step 2 below.

1. Ignition ON.
2. 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.

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the Q13 Evaporative Emission Vent Solenoid Valve, Ignition ON,
2. Verify that a test lamp illuminates between the B+ circuit terminal A or 2 and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition OFF, remove the test lamp.
   2. Test for less than 2 ohms in the B+ circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, verify the fuse is not open and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**
   1. Ignition OFF, remove the test lamp.
   2. Test for infinite resistance between the B+ circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, test all components connected to the B+ circuit for a short and replace as necessary.

- **If the test lamp illuminates**

3. Verify that a test lamp does not illuminate between the B+ circuit terminal A or 2 and the control circuit terminal B or 1.
   - **If the test lamp illuminates**
   1. Ignition OFF, remove the test lamp, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the control circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.
   - **If the test lamp does not illuminate**
4. Remove the test lamp.
5. Verify the scan tool EVAP Vent Solenoid Valve Control Circuit High Voltage Test Status parameter is OK when commanding the EVAP Vent Solenoid Valve to ON (Not Venting) with a scan tool.
   - **If OK is not displayed**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, Ignition ON.
   2. Test for less than 1 V between the control circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If OK is displayed**
6. Install a 3 A fused jumper wire between the control circuit terminal B or 1 and the B+ circuit terminal A or 2.
7. Verify the scan tool EVAP Vent Solenoid Valve Control Circuit High Voltage Test Status parameter is Malfunction when commanding the EVAP Vent Solenoid Valve to ON (Not Venting) with a scan tool.
   - **If Malfunction is not displayed**
   1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 ohms in the control circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms replace the K20 Engine Control Module.
   - **If Malfunction is displayed**
8. Test or replace the Q13 Evaporative Emission Vent Solenoid Valve.

Component Testing

1. Ignition OFF, disconnect the harness connector at the Q13 Evaporative Emission Vent Solenoid Valve.
2. Test for 10-30 ohms between the control terminal B or 1 and the B+ circuit terminal A or 2.
   - **If not between 10-30 ohms**

     Replace the Q13 Evaporative Emission Vent Solenoid Valve.

   - **If between 10-30 ohms**

3. All OK.

Repair Instructions

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

- **Evaporative Emission Canister Solenoid Replacement (FWD)** , **Evaporative Emission Canister Solenoid Replacement (AWD)** for EVAP Vent Solenoid Valve replacement.
- **Control Module References** for ECM replacement, programming and setup

DTC P0451-P0454

Diagnostic Instructions

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

DTC Descriptors

DTC P0451

Fuel Tank Pressure Sensor Performance

DTC P0452

Fuel Tank Pressure Sensor Circuit Low Voltage

DTC P0453

Fuel Tank Pressure Sensor Circuit High Voltage

DTC P0454

Fuel Tank Pressure Sensor Circuit Intermittent

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
FTP Sensor 5 V Reference	P018C, P0192, P0452, P0522, P0532, P0641, P2227, P2228	P0451	P0446, P0452	P018D, P0193, P0453, P0523, P0641, P2227	-
			P0452,		

FTP Sensor Signal	P0452	P0451	P0453	P0453	P0451, P0454
FTP Sensor Low Reference	-	P0446, P0451	P0446, P0453, P0463	-	P0451

Typical Scan Tool Data

FTP Sensor Voltage

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Ignition ON, Engine OFF **Parameter Normal Range:** 1.3-1.7 V			
FTP Sensor 5 V Reference	0 V	0 V	4.2-5 V
FTP Sensor Signal	0 V	0 V	5 V
FTP Sensor Low Reference	-	4.5 V	-

Circuit/System Description

The Fuel Tank Pressure (FTP) sensor measures air pressure or vacuum in the evaporative emission (EVAP) system. The engine control module (ECM) supplies a 5 V reference and a low reference circuit to the FTP sensor. The FTP sensor signal voltage varies depending on EVAP system pressure or vacuum. The controller also uses this FTP signal to determine atmospheric pressure for use in the engine-off small leak test, DTC P0442. Before using this signal as an atmospheric reference it must first be re-zeroed.

Conditions for Running the DTC

P0451

- DTC P0451 runs only when the engine-off natural vacuum small leak test, P0442, executes.
- The number of times this test runs can range from 0-2 per engine-off period. The length of the test can be up to 10 min.

P0452 and P0453

DTC P0452 and P0453 run continuously when the ignition is ON.

P0454

- DTC P0454 runs only when the engine-off natural vacuum small leak test, P0442, executes.
- This test can run once per engine-off period. The length of the test can be up to 10 min.
- A refueling event is not detected. A refueling event is confirmed if the fuel level has a persistent change of 10 % for 30 s.

Conditions for Setting the DTC

P0451

This DTC will set if the controller is unable to re-zero the FTP sensor voltage within a calibrated range during the engine-off small leak test, P0442.

P0452

The FTP sensor voltage is less than 0.15 V for more than 10 s.

P0453

The FTP sensor voltage is more than 4.9 V for more than 10 s.

P0454

If, during the engine-off natural vacuum small leak test, P0442, the ECM detects an abrupt FTP signal change, other than a refueling event, this DTC will set. An abrupt change is defined as a change of 0.45 in H2O in the span of 1 s but less than 1 in H2O in 12.5 ms.

Action Taken When the DTC Sets

- DTCs P0451 and P0454 are Type A DTCs.
- DTCs P0452 and P0453 are Type B DTCs.

Conditions for Clearing the MIL/DTC

- DTCs P0451 and P0454 are Type A DTCs.
- DTCs P0452 and P0453 are Type B DTCs.

Diagnostic Aids

P0451 and P0454

- A restriction in the EVAP canister or vent lines could prevent fuel vapor pressure from bleeding off fast enough. If the vent system cannot bleed off pressure fast enough, the re-zero procedure may not complete successfully, which could cause this code to set.
- Ensure that the reference port on the FTP sensor is unobstructed.
- An FTP sensor that is skewed or does not have a linear transition from low to high may cause this code to set. Scan tool output controls, snapshot, and plot functions can help detect erratic sensor response. To test the sensor signal under vacuum conditions, use the Quick Snapshot and the Purge/Seal functions to capture data while commanding purge to 20 %, then plot the data to look for erratic sensor operation. A similar test can be done for the pressure side of the sensor operation by applying pressure with the **GE 41413-A** Evaporative Emission System Tester (EEST) while taking a snapshot.

Reference Information

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DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

GE 41413-A Evaporative Emission System Tester (EEST)

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)** .

Circuit/System Verification

1. Remove the fuel cap.
2. Ignition ON, engine OFF.
3. Verify the scan tool Fuel Tank Pressure sensor parameter is between 1.3 and 1.7 V.
    - **If not between 1.3-1.7 V**

      Refer to Circuit/System Testing.

    - **If between 1.3-1.7 V**
4. All OK.

Circuit/System Testing

1. Ignition OFF, all vehicle systems OFF, this may take up to 2 min, for all vehicle systems to power down. Disconnect the harness connector at the B150 Fuel Tank Pressure Sensor.
2. Test for less than 5 ohms of resistance between the low reference circuit terminal 2 and ground.
    - **If 5 ohms or greater**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for less than 2 ohms in the low reference circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.

- If less than 2 ohms, replace the K20 Engine Control Module.
- **If less than 5 ohms**

3. Ignition ON.
4. Test for 4.8-5.2 V between the 5 V reference circuit terminal 3 and ground.
   - **If less than 4.8 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the 5 V reference circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 ohms in the 5 V reference circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 Engine Control Module.
   - **If greater than 5.2 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the 5 V reference circuit and ground.
   - If 1 V or greater, repair the short to voltage on the circuit.
   - If less than 1 V, replace the K20 Engine Control Module.
   - **If between 4.8-5.2 V**
5. Verify the scan tool Fuel Tank Pressure parameter is less than 0.2 V.
   - **If 0.2 V or greater**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON
   2. Test for less than 1 V between the signal circuit terminal 1 and ground.
   - If 1 V or greater, repair the short to voltage on the circuit.
   - If less than 1 V, replace the K20 Engine Control Module.
   - **If less than 0.2 V**
6. Install a 3 A fused jumper wire between the signal circuit terminal 1 and the 5 V reference circuit terminal 3.
7. Verify the scan tool Fuel Tank Pressure sensor parameter is greater than 4.7 V.
   - **If 4.7 V or less**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the signal circuit terminal 1 and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 ohms in the signal circuit end to end.
   - If 2 ohms or greater, repair the open/high resistance in the circuit.
   - If less than 2 ohms, replace the K20 Engine Control Module.
   - **If greater than 4.7 V**
8. Test or replace the B150 Fuel Tank Pressure Sensor.

Repair Instructions

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

- **Fuel Tank Pressure Sensor Replacement (AWD)** , **Fuel Tank Pressure Sensor Replacement (FWD)**
- **Control Module References** for ECM replacement, setup, and programming

DTC P0455

Diagnostic Instructions

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

DTC Descriptor

DTC P0455

Evaporative Emission (EVAP) System Large Leak Detected

Circuit/System Description

The engine control module (ECM) tests the evaporative emission (EVAP) system for a large leak or restrictions to the purge path in the EVAP system. When the enabling criteria has been met, the ECM commands the EVAP vent solenoid valve and purge solenoid valve ON, allowing vacuum into the EVAP system. The ECM monitors the fuel tank pressure (FTP) sensor voltage to verify that the system is able to reach a predetermined level of vacuum within a set amount of time.

Conditions for Running the DTC

- DTCs P00C8, P00C9, P010C, P010D, P16A0, P16A1, P16A2, P160E, P160D, P16F3, P0068, P0101, P0102, P0103, P0111, P0112, P0113, P0114 P0116, P0117, P0118, P0122, P0123, P0125, P0128, P0191, P0192, P0193, P0222, P0223, P0443, P0449, P0452, P0453, P0454, P0502, P0503, P0601, P0604, P0606, P0722, P0723, P1104, P1682, P2100, P2101, P2102, P2103, P2135, P2176, P2227, P2228, P2229, P2230 are not set.
- The ignition voltage is between 11-32 V.
- The barometric pressure (BARO) is greater than 70 kPa.
- The fuel level is between 10-90 %.
- The cold startup engine coolant temperature (ECT) and the startup intake air temperature (IAT) are within 8°C (46°F).
- The startup engine coolant temperature (ECT) is less than 35°C (95°F).
- The startup intake air temperature (IAT) is between 4-30°C (39-86°F).
- DTC P0455 runs once per cold start, for up to 17 min, when the above conditions are met.

Conditions for Setting the DTC

- The EVAP system is not able to achieve or maintain a calibrated level of vacuum within a set amount of time.

- After setting the DTC for the first time, 2 L (0.5 gal) of fuel must be consumed before setting the DTC for the second time.
- With a DTC P0455 detected a weak vacuum follow-up test (fuel cap replacement test) will run and pass if tank vacuum is greater than 2.74 kPa (11 in H2O). This test will run for a maximum of 21 min. This test runs until it passes.

Action Taken When the DTC Sets

DTC P0455 is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P0455 is a Type B DTC.

Diagnostic Aids

- Inspect for a loose, missing, damaged, or incorrect fuel fill cap.
- Inspect for a damaged fuel filler neck seal surface.
- A blockage or restriction in the EVAP purge solenoid valve, purge pipe, EVAP canister, or vapor pipe, can cause this DTC to set.
- The EVAP system can be filled with smoke more quickly and completely by opening the system opposite the end where the smoke is injected. For example, when injecting smoke at the service port remove the fuel fill cap, or temporarily leave the vent open, until smoke is observed, then close the system and continue testing. If using a fuel cap adapter at the filler neck, use the **J 41413-VLV** 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 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 Sensor parameter for vacuum decay.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

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- **Wiring Repairs**

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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

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)**

Circuit/System Testing

NOTE:

- **Larger volume fuel tanks and/or those with lower fuel levels may require several minutes for the floating indicator to stabilize or produce smoke from a leak.**
- **Refer to the GE 41413-A operation manual for detailed instructions in Evaporative Emission 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 41413-A** , calibrated to 0.51 mm (0.020 in).
    - **If a leak is detected**
    1. Apply smoke to the EVAP system at the service access port adapter with the **GE 41413-A** .
    2. Locate the leak using the **GE 41413-SPT** .

- When the leak is located, repair or replace the affected component as necessary.
- **If no leak detected**

NOTE: The steps below test for a restriction in the purge path.

5. Connect the **GE 41413-A** nitrogen/smoke hose to the **J 41413-311** .
6. Disconnect the hose at the fuel cap end of the **GE 41415-30** and connect to the **J 41413-311** .
7. Install the **GE 41415-30** , 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 41413-A** and the scan tool Fuel Tank Pressure Sensor parameter both show vacuum.
    - **If the vacuum/pressure gauge shows vacuum, and the Fuel Tank Pressure Sensor parameter does not show vacuum**

      Replace the B150 Fuel Tank Pressure Sensor.

    - **If both the Fuel Tank Pressure Sensor parameter and the vacuum/pressure gauge do not show 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 41413-A** .
    - **If not within the specified range**

      Replace the B150 Fuel Tank Pressure Sensor.

    - **If within the specified range**
12. All OK

Repair Instructions

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

- **Fuel Tank Pressure Sensor Replacement (AWD)** , **Fuel Tank Pressure Sensor Replacement (FWD)**
- **Control Module References** for ECM replacement, programming and setup

DTC P0496

Diagnostic Instructions

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

DTC Descriptor

DTC P0496

Evaporative Emission (EVAP) System Flow During Non-Purge

Circuit/System Description

This DTC tests for undesired intake manifold vacuum flow to the evaporative emission (EVAP) system. The engine control module (ECM) seals the EVAP system by commanding the EVAP purge solenoid valve OFF and the vent solenoid valve ON. The ECM monitors the fuel tank pressure (FTP) sensor to determine if a vacuum is being drawn on the EVAP system. If vacuum in the EVAP system is more than a predetermined value within a predetermined time, this DTC sets.

The following table illustrates the relationship between the ON and OFF states, and the Open or Closed states of the EVAP purge and vent solenoid valves.

ECM Command	EVAP Purge Solenoid Valve	EVAP Vent Solenoid Valve
ON	Open	Closed
OFF	Closed	Open

Conditions for Running the DTC

- DTCs P00C8, P00C9, P010C, P010D, P16A0, P16A1, P16A2, P160E, P160D, P16F3, P0068, P0101, P0102, P0103, P0111, P0112, P0113, P0114 P0116, P0117, P0118, P0122, P0123, P0125, P0128, P0191, P0192, P0193, P0222, P0223, P0443, P0449, P0452, P0453, P0454, P0502, P0503, P0601, P0604, P0606, P0722, P0723, P1104, P1682, P2100, P2101, P2102, P2103, P2135, P2176, P2227, P2228, P2229, P2230 are not set.
- The ignition voltage is between 11-32 V.
- The engine OFF time is greater than 8 h,
- The barometric pressure (BARO) is greater than 70 kPa.
- The fuel level is between 10-90 %.
- The startup engine coolant temperature (ECT) is less than 35°C (95°F).
- The startup intake air temperature (IAT) is between 4-30°C (39-86°F).
- DTC P0496 runs once per cold start, for up to 17 min, when the above conditions are met.

Conditions for Setting the DTC

The ECM detects more than 10 in H2O vacuum for 5 s during a non-purge condition.

Action Taken When the DTC Sets

DTC P0496 is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P0496 is a Type B DTC.

Diagnostic Aids

An intermittent condition could be caused by an improperly installed or damaged EVAP purge solenoid valve or by a temporary blockage or restriction in the EVAP purge solenoid valve.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

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- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
2. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing

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

Circuit/System Testing

1. Ignition ON, engine OFF.
2. Seal the EVAP system using the Purge/Seal function with a scan tool.

3. Start the engine.
4. Observe the FTP sensor with a scan tool. The FTP sensor parameter should be less than 1.7 V after 90 s.
    - **If not within specifications**

      Replace the Q12 Evaporative Emission Purge Solenoid Valve

    - **If within Specifications**
5. All OK

Repair Instructions

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

Evaporative Emission Canister Purge Solenoid Valve Replacement

DTC P0506 OR P0507

Diagnostic Instructions

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

DTC Descriptors

DTC P0506

Idle Speed Low

DTC P0507

Idle Speed High

Circuit/System Description

The throttle actuator control (TAC) motor is a DC motor that is part of the throttle body assembly. The TAC motor drives the throttle valve. The engine control module (ECM) controls the TAC motor based on throttle position sensor input. The idle speed is controlled by the ECM based on various inputs. The ECM commands the TAC motor to open or close the throttle valve in order to maintain the desired idle speed.

Conditions for Running the DTC

- DTCs P0068, P0101, P0102, P0103, P0112, P0113, P0117, P0118, P0121, P0122, P0123, P0171, P0172, P0174, P0175, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268. P0270, P0271, P0273, P0274, P0276, P0277, P0300-P0306, P0351-P0356, P0461-P0464, P0496, P0627, P0628, P0629, P0722, P1516, P2066-P2068, are not set.
- The barometric pressure (BARO) is greater than 70 kPa.
- The engine coolant temperature (ECT) is greater than 60°C (140°F).

- The engine run time is greater than 60 s.
- The ignition 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.
- The DTCs run when the above conditions are met.

Conditions for Setting the DTC

P0506

The actual engine speed is 94 RPM less than the desired idle speed for 10 s.

P0507

The actual engine speed is 188 RPM greater than the desired idle speed for 10 s.

Action Taken When the DTC Sets

DTCs P0506 and P0507 are Type B DTCs.

Conditions for Clearing the DTC

DTCs P0506 and P0507 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Throttle Actuator Control (TAC) System Description

Electrical Information Reference

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

- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify there are no other DTCs set.
   - **If any other DTCs are set**

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

   - **If no other DTCs are set**
3. Verify the scan tool Throttle Body Idle Airflow Compensation parameter is less than 90 %.
   - **If 90 % or greater**

     Refer to **Throttle Body Cleaning** .

   - **If less than 90 %**
4. Engine Idling at the normal operating temperature.
5. Verify the actual Engine Speed is not 100 RPM less than the Desired Idle Speed.
   - **If 100 RPM less than the Desired Idle Speed**

     Refer to Circuit/System Testing.

   - **If 100 RPM greater than the Desired Idle Speed**
6. Verify the actual Engine Speed is not 200 RPM greater than the Desired Idle Speed.
   - **If 200 RPM greater than the Desired Idle Speed**

     Refer to Circuit/System Testing.

   - **If 200 RPM less than the Desired Idle Speed**
7. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
8. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**

9. All OK

Circuit/System Testing

P0506

1. Verify the conditions listed below do not exist.
   - Restricted exhaust
   - Mechanical conditions that limits engine speed
   - Parasitic load on the engine-For example, a transmission condition, a belt driven accessory condition.
   - **If a condition is found**

     Repair as necessary.

   - **If a condition is not found**
2. All OK.

P0507

1. Verify the conditions listed below do not exist.
   - Vacuum leaks
   - A throttle valve that does not close correctly
   - Verify the correct operation of the crankcase ventilation system. Inspect for the conditions listed below:
     - Improper routing of the positive crankcase ventilation (PCV) system
     - Vacuum leaks in the PCV system-Refer to **Crankcase Ventilation System Inspection/Diagnosis** .
   - **If a condition is found**

     Repair as necessary.

   - **If a condition is not found**
2. All OK.

Repair Instructions

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

Throttle Body Assembly Replacement

DTC P050D

Diagnostic Instructions

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

- **Diagnostic Procedure Instructions** provides an overview of each diagnostic category.

DTC Descriptor

DTC P050D

Cold Start Rough Idle

Circuit/System Description

During a cold start, the engine control module (ECM) commands dual-pulse mode during Open Loop operation to improve cold start emissions. In dual-pulse mode, the injectors are energized twice during each injection event. As with misfire diagnosis, in dual-pulse mode the ECM monitors the crankshaft position sensor and the camshaft position sensors to calculate crankshaft rotation speed. In normal operation, optimum fuel delivery during dual-pulse mode produces a steady crankshaft rotation speed. If the variations exceed a calibrated value, the code will be set.

Conditions for Running the DTC

- DTCs P0010, P0011, P0013, P0014, P0090, P0091, P0092, P00C8, P00C9, P00CA, P0101-P0103, P0106-P0108, P0112, P0113, P0117-P0118, P0122, P0123, P0128, P0171, P0172, P0192, P0193, P0201-P0204, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0300, P0301-P0304, P0335, P0336, P0351-P0354, P0506, P0507, P0628, P0697, P06A3, P0722, P0723, P1248, P1249, P124A, P124B, P182E, P1915, P2122, P2123, P2127, P2128, P2135, P2138, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157 are not set.
- The catalyst temperature is less than 500°C (932°F).
- The engine coolant temperature is warmer than -12°C (10.4°F).
- The barometric pressure is greater than 75 kPa.
- The engine speed is between 250-3000 RPM.
- The accelerator pedal position is less than 1 percent.
- The engine is running for less than 20 s and a cold start has been detected.
- DTC P050D runs once per cold start.

Conditions for Setting the DTC

This DTC will set if the ECM detects variations in crankshaft rotation speed caused by the lack of adequate fuel delivery during dual-pulse mode.

Action Taken When the DTC Sets

- DTC P050D is a Type B DTC.
- The ECM disables dual pulse mode and energizes the fuel injector as it would for a warm engine.

Conditions for Clearing the DTC

DTC P050D is a Type B DTC.

Diagnostic Aids

- This DTC may be set with a misfire DTC, however the existence of this DTC is a higher priority and indicates the condition to diagnose is related to fuel and/or injectors, not the ignition/spark system.
- A restricted fuel injector may cause this DTC to set.
- High resistance in the circuits of the injectors could set this DTC without setting an injector DTC. Test the injector circuits of the affected cylinders for a high resistance if you suspect a condition.
- A drop in system voltage during cold start may set this DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

NOTE: Circuit/System Verification requires cold start. Do not start vehicle prior to connecting scan tool and preparing to evaluate the condition during engine crank.

1. Start the engine and verify that the scan tool Cylinder 1-4 Current Misfire Counters are not incrementing during first 500 engine cycles.
    - **If Cylinder 1-4 Current Misfire Counters are incrementing**

      Refer to Circuit/System Testing.

    - **If Cylinder 1-4 Current Misfire Counters are not incrementing**
2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

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

      Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Verify that the fuel pressure is not too low or too high-Refer to **Fuel System Diagnosis**.
    - If a condition is found, repair or replace components as necessary.
    - If the fuel pressure is OK
2. Verify that the fuel is not contaminated-Refer to **Alcohol/Contaminants-in-Fuel Diagnosis**.
    - If the fuel is contaminated, clean the fuel system-Refer to **Fuel System Cleaning** .
    - If the fuel is not contaminated
3. Replace fuel injectors as indicated by high misfire counts.

Repair Instructions

Fuel Injector Replacement

Repair Verification

NOTE: Repair Verification requires cold start.

1. Ignition ON, engine OFF, clear the DTCs with a scan tool.
2. Start the engine.
3. Verify the DTC does not reset.

DTC P057B-P057D

Diagnostic Instructions

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

DTC Descriptors

DTC P057B

Brake Pedal Position Sensor Performance

DTC P057C

Brake Pedal Position Sensor Circuit Low Voltage

DTC P057D

Brake Pedal Position Sensor Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	P057C	P057C	P057D	P057B
5 V Reference	P057C P0651	P057C	P0651	-
Low Reference	-	P057D	P057D	-

Typical Scan Tool Data

Brake Pedal Position Sensor

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Ignition ON. **Brake Pedal Position Sensor Parameter Normal Range:** 0.25-4.75 V			
5 V Reference	0 V	0 V	-
Signal	0 V	0 V	5 V
Low Reference	-	5 V	-

Circuit/System Description

The brake pedal position (BPP) sensor is part of the engine brake pedal override feature. The engine control module (ECM) continuously monitors the vehicle speed and the position of the brake pedal. These two main inputs, along with other ECM inputs are used to determine if the vehicle is decelerating at the proper speed and rate with the brake pedal applied. When the engine brake pedal override system is active, the ECM reduces engine torque to assist in reducing vehicle speed.

The BPP sensor is a six wire sensor, and is part of a dual brake position sensor. One BPP Sensor is used for the stop lamps and the other BPP Sensor is used for the engine brake pedal override feature. The BPP Sensor for engine brake pedal override communicates with the ECM. The ECM supplies a 5 V reference circuit, low reference circuit, and signal circuit to the BPP sensor. The BPP sensor sends a voltage signal to the ECM on the signal circuit. The voltage on the signal circuit will vary from a voltage greater than 0.25 V when the brake pedal is released to a voltage less than 4.75 V when the brake pedal is fully applied.

For information on the Stop Lamps side of the BPP Sensor, refer to **Exterior Lighting Systems Description and Operation** .

Conditions for Running the DTC

- Ignition voltage is greater than 10 V.
- DTC runs continuously when above condition is met.

Conditions for Setting the DTC

P057B

ECM detects the BPP sensor signal is stuck in a range.

P057C

ECM detects the BPP sensor voltage is less than 0.25 V for 1 s.

P057D

ECM detects the BPP sensor voltage is greater than 4.75 V for 1 s.

Action Taken When the DTC Sets

- P057B, P057C, and P057D are Type A DTCs.
- Engine torque is reduced to 50% of available engine torque during brake torque management.
- Brake torque management is active at 25 kPa (3.7 PSI) of brake apply pressure.

Conditions for Clearing the DTC

P057B, P057C, and P057D are Type A DTCs

Reference Information

Schematic Reference

- **Engine Controls Schematics**
- **Exterior Lights Schematics**

Connector End View Reference

- **COMPONENT CONNECTOR END VIEWS - INDEX**
- **INLINE HARNESS CONNECTOR END VIEWS - INDEX**

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. 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**
2. Ignition ON, transmission in Park, and service brake pedal released.
3. Verify the scan tool Brake Pedal Position Sensor parameter in the ECM displays greater than 0.25 V.
   - **If 0.25 V or less**

     Refer to Circuit/System Testing.

   - **If greater than 0.25 V**
4. Verify the scan tool Brake Pedal Position Sensor parameter voltage changes as the brake pedal is applied and displays less than 4.75 V when the brake pedal is fully applied.
   - **If the voltage does not change, or is greater than 4.74 V**

     Refer to Circuit/System Testing.

   - **If the voltage changes and less than 4.75 V**
5. 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**
6. 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**
7. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
8. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

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

Circuit/System Testing

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 ohms between the low reference circuit terminal 5 and ground.
   - **If 10 ohms or greater**
   1. Disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 ohms in the low reference circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 Engine Control Module.
   - **If less than 10 ohms**
3. Ignition ON.
4. Test for 4.8-5.2 V between the 5 V reference circuit terminal 6 and ground.
   - **If less than 4.8 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the 5 V reference circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance.
   3. Test for less than 2 ohms in the 5 V reference circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 Engine Control Module.
   - **If greater than 5.2 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the 5 V reference circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If between 4.8-5.2 V**
5. Verify the scan tool Brake Pedal Position Sensor parameter is less than 0.25 V.
   - **If 0.25 V or greater**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 0.25 V between the signal circuit terminal 4 and ground.
      - If 0.25 V or greater, repair the short to voltage on the circuit.
      - If less than 0.25 V, replace the K20 Engine Control Module.
   - **If less than 0.25 V**
6. Install a 3 A fused jumper wire between the signal circuit terminal 4 and the 5 V reference circuit terminal 6.

7. Verify the scan tool Brake Pedal Position Sensor parameter is greater than 4.8 V.
   - **If 4.8 V or less**
     1. Ignition OFF, remove the jumper wire, and disconnect the harness connector at the K20 Engine Control Module.
     2. Test for infinite resistance between the signal circuit terminal 4 and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance.
     3. Test for less than 2 ohms in the signal circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
   - **If greater than 4.8 V**
8. Replace the B22 Brake Pedal Position Sensor.

Repair Instructions

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

- **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.

DTC P05CC OR P05CE

Diagnostic Instructions

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

DTC Descriptors

DTC P05CC

Cold Start Intake Camshaft Position System Performance

DTC P05CE

Cold Start Exhaust Camshaft Position System Performance

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.

Conditions for Running the DTC

- DTC P0010, P0016, P0017, P0018, P0019, P0335, P0336, P0340, P0341, P0345, P0346, P0365, P0366,P0390 or P0391, is not set.
- Ignition voltage is greater than 11 V.
- Engine is running.
- Desired camshaft position is greater than 0 degrees.
- Desired camshaft position is not changing greater than 4.5° for at least 1 s.
- Both of the desired and actual camshaft position actuator values cannot be greater than 20 degrees or less than 5 degrees.
- The DTCs run continuously once the above conditions are met.

Conditions for Setting the DTC

The ECM detects the difference between the desired and actual camshaft position angle is greater than 4.5 degrees for greater 1 s.

Action Taken When the DTC Sets

DTCs P05CC and P05CE are type B DTCs.

Conditions for Clearing the DTC

DTCs P05CC and P05CE are type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Description and Operation

Camshaft Actuator System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

J 35616-200 Test Lamp Kit

Diagnostic Aids

- The engine oil condition has a major impact on the camshaft actuator system.
- A low oil level condition may set this DTC. The engine may require an oil change. Inquire with the customer when the last oil change was performed. You may also monitor the scan tool Engine Oil Life parameter. Advise the customer an oil change may be required.
- Inspect the engine for any recent engine mechanical repairs. An incorrectly installed camshaft, camshaft actuator, or timing chain can cause this DTC to set.

Circuit/System Verification

NOTE:

- **The engine oil level and the oil pressure are critical to the correct operation of the camshaft position actuator system. Verify that the engine has the correct oil level and the correct oil pressure before continuing with this diagnostic.**
- **The engine oil condition has a major impact on the camshaft actuator system. Debris in the oil can interfere with the camshaft position actuator solenoid and the mechanical camshaft actuator operation. Inspect for dirty or degraded crankcase oil. The engine may require an oil change. Inquire with the customer when the last oil change was performed. You may also monitor the scan tool Engine Oil Life Remaining parameter. Advise the customer an oil change may be required.**

1. Ignition On.
2. Verify the engine has the correct oil level and the correct oil pressure.
   - **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, P0016, P0017, P0018, P0019, P0335, P0336, P0340, P0341, P0345, P0346, P0365, P0366,P0390 or P0391, is not set.
   - **If any of the DTCs are set**

     If any of the DTCs are set, refer to **Diagnostic Trouble Code (DTC) List - Vehicle** for further diagnosis.

   - **If none of the DTCs are set**
4. Engine idling at normal operating temperature.
5. Verify the 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. 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 DTC sets**

     Refer to Circuit/System Testing.

   - **If a DTCs does not set**
7. All OK.

Circuit/System Testing

1. Ignition Off and all vehicle systems Off, disconnect the appropriate harness connector at the Q6 Camshaft Position Actuator Solenoid Valve. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 ohms between the low reference circuit terminal 2 and ground.
   - **If 5 ohms or greater**
   1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 ohms in the low reference circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 Engine Control Module.
   - **If less than 5 ohms**

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.**

3. Ignition On, verify that a test lamp does not illuminate between the control circuit terminal 1 and

ground.

- **If the test lamp illuminates**

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

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

4. Remove the test lamp.
5. Ignition On, command the appropriate Q6 Camshaft Position Actuator Solenoid Valve from Off to On with a scan tool while observing the scan tool Camshaft Position Actuator Solenoid Valve Control Circuit Low Voltage Test Status. The value should toggle between OK and Not Run in each of the commanded states.
   - **If the parameter does not correspond to the specified values**

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

   - **If the parameter corresponds to the specified values**

NOTE: **If debris is found on CMP screens, clean the screens and reinspect for damage. If the screens are not damaged, reinstall in the engine.**

6. Remove the Q6 Camshaft Position Actuator Solenoid Valve and verify the following conditions do not exist:
   - Torn, mis-positioned, or missing screens at the CMP actuator solenoid.
   - Engine oil leak between the oil sealing lands of the CMP actuator solenoid. Inspect the lands of the CMP actuator solenoid for nicks.
   - Oil seepage at the CMP actuator solenoid connector.
   - **If a condition is found.**

     Replace the Q6 Camshaft Position Actuator Solenoid Valve.

   - **If no condition is found**

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

7. Ignition Off, swap the intake or exhaust Q6 Camshaft Position Actuator Solenoid Valve with the Q6 Camshaft Position Actuator Solenoid Valve that is operating correctly.
8. Engine idling.
9. 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°**

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

Component Testing

1. Ignition Off, disconnect the harness connector at the appropriate Q6 Camshaft Position Actuator Solenoid Valve .
2. Test for 5-12 ohms between the ignition circuit terminal 1 and the control circuit terminal 2 of the Q6 Camshaft Position Actuator Solenoid Valve.
   - **If not between the specified values**

     Replace the Q6 Camshaft Position Actuator Solenoid Valve.

   - **If between the specified values**
3. Test for infinite resistance between each terminal and the Q6 Camshaft Position Actuator Solenoid Valve housing.
   - **If less than infinite resistance**

     Replace the Q6 Camshaft Position Actuator Solenoid Valve.

   - **If infinite resistance**
4. All OK.

Repair Instructions

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

- **Camshaft Position Actuator and Camshaft Replacement - Intake**
- **Camshaft Position Actuator and Camshaft Replacement - Exhaust**
- **Camshaft Position Actuator Exhaust Solenoid Valve Replacement**
- **Camshaft Position Actuator Intake Solenoid Valve Replacement**
- **Control Module References** for K20 Engine Control Module replacement, programming, and setup.

DTC P0601-P0604, P0606, P062B, P062F, P0630, P16F3, OR P262B (ECM)

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** 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 of the diagnostic category.

DTC Descriptors

DTC P0601

Control Module Read Only Memory Performance

DTC P0602

Control Module Not Programmed

DTC P0603

Control Module Long Term Memory Reset

DTC P0604

Control Module Random Access Memory Performance

DTC P0606

Control Module Processor Performance

DTC P062B

Control Module Fuel Injector Control Performance

DTC P062F

Control Module Long Term Memory Performance

DTC P0630

VIN Not Programmed or Mismatched - Engine Control Module (ECM)

DTC P16F3

Control Module Redundant Memory Performance

DTC P262B

Control Module Power Off Timer Performance

Circuit/System Description

This diagnostic applies to internal microprocessor integrity conditions within the engine control module (ECM). This diagnostic also addresses if the ECM is not programmed.

Conditions for Running the DTCs

P0601, P0602, P0630

These DTCs run continuously when the ignition is 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, P062B

These DTCs run continuously when Ignition 1 Signal voltage is greater than 11 V.

P16F3

- The engine speed is greater than 625 RPM.
- DTCs P0101, P0102, P0103, P0106, P0107, P0108, P2227, P2228, P2229, or P2230 are not set.
- DTC P16F3 runs continuously when the above conditions are met.

P262B

DTC P262B runs during ECM power down.

Conditions for Setting the DTCs

The ECM detects an internal failure or incomplete programming for more than 10 s.

Actions Taken When the DTC Sets

North America

- DTCs P0601, P0602, P0603, P0604, P0606, P062B, P0630, and P16F3 are Type A DTCs.
- DTCs P062F and P262B are Type B DTCs.

Europe, China

- DTCs P0601, P0602, P0603, P0604, P0606, P062B, P0630, and P16F3 are Type A DTCs.
- DTC P062F is a Type C DTC.
- DTC P262B is a Type B DTC.

Conditions for Clearing the MIL/DTC

North America

- DTCs P0601, P0602, P0603, P0604, P0606, P062B, P0630, and P16F3 are Type A DTCs.
- DTCs P062F and P262B are Type B DTCs.

Europe, China

- DTCs P0601, P0602, P0603, P0604, P0606, P062B, P0630, and P16F3 are Type A DTCs.
- DTC P062F is a Type C DTC.

- DTC P262B is a Type B DTC.

Diagnostic Aids

Low voltage or a momentary loss of power or ground to the ECM may cause a DTC to set. Verify the following:

- The battery cables are clean and tight, and the battery is fully charged. Refer to **Battery Inspection/Test** .
- The ECM ground circuits do not have an open or high resistance.
- The ECM power circuits do not have an open, short to ground, or high resistance.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON, clear the DTC information with a scan tool. Observe the DTC information with a scan tool.
2. Verify that DTC P0641, P0651, P0697, or P06A3 does not set.
    - **If any of the DTCs are set**

Refer to **DTC P0641, P0651, P0697, or P06A3 (ECM)** for further diagnosis.

- **If none of the DTCs are set**

3. Observe the DTC information with a scan tool. Verify DTC P0602 or P0630 is not set.
   - **If any of the DTCs are set**
   1. Program the K20 Engine Control Module. Refer to **Control Module References** .
   2. Verify DTC P0602 or P0630 is not set.
      - If any of the DTCs are set, replace the K20 Engine Control Module.
      - If none of the DTCs are set
   3. All OK.
   - **If none of the DTCs are set**
4. Verify DTC P0601, P0603, P0604, P0606, P062B, P062F, P16F3, or P262B is not set.
   - **If any of the DTCs are set**

     Replace the K20 Engine Control Module.

   - **If none of the DTCs are set**
5. All OK.

Repair Instructions

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

Control Module References for engine control module replacement, programming and setup.

DTC P0628

Diagnostic Instructions

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

DTC Descriptor

DTC P0628

Fuel Pump Enable Circuit Low Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control	P0171, P0506, P0628, P12A6	P0171, P0506, P0628, P12A6	-	-

Circuit/System Description

The engine control module (ECM) provides ignition voltage to the fuel pump power control module whenever the engine is cranking or running. The control module enables the fuel pump power control module as long as the engine is cranking or running, and ignition system reference pulses are received. While this enable voltage is being received, the fuel pump power control module supplies a varying voltage to the in-tank fuel pump module in order to maintain the desired fuel line pressure.

Conditions for Running the DTC

- The engine speed is greater than 0 RPM.
- The ignition voltage is greater than 11 V.
- The fuel pump enable circuit is commanded ON.
- The DTC runs continuously when the conditions above are met.

Conditions for Setting the DTC

The ECM detects that the commanded state of the driver and the actual state of the control circuit do not match for greater than 2 s.

Action Taken When the DTC Sets

DTC P0628 is a Type B DTC.

Conditions for Clearing the DTC

DTC P0628 is a Type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC P0628 is not set.
   - **If the DTC is set**

     Refer to Circuit/System Testing.

   - **If the DTC is not set**
3. Verify the parameters listed below do not display Malfunction when commanding the Fuel Pump Enable On and Off with a scan tool.
   - Fuel Pump Enable Circuit Low Voltage Test Status
   - Fuel Pump Enable Circuit Open Test Status
   - Fuel Pump Enable Circuit High Voltage Test Status
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing.

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

     Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Ignition OFF, disconnect the K111 Fuel Pump Power Control Module harness connector.
2. Ignition ON for 10 s.
3. Verify that a test lamp does not illuminate between the control circuit terminal 2 and ground.
   - **If the test lamp illuminates**
   1. Ignition OFF, remove the test lamp, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the control circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.

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

4. Remove the test lamp.
5. Verify the scan tool Fuel Pump Enable Circuit Low Voltage Test Status parameter is OK when commanding the Fuel Pump Enable On with a scan tool.
   - **If OK is not displayed**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the control circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.
   - **If OK is displayed**
6. Install a 3 A fused jumper wire between the control circuit terminal 2 and ground.
7. Verify the scan tool Fuel Pump Enable Circuit Low Voltage Test Status parameter is Malfunction when commanding the Fuel Pump Enable On with a scan tool.
   - **If Malfunction is not displayed**
   1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 ohms in the control circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 Engine Control Module.
   - **If Malfunction is displayed**
8. Test or replace the K111 Fuel Pump Power Control Module.

Repair Instructions

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

- **Fuel Pump Power Control Module Replacement**
- **Control Module References** for Engine Control Module replacement, setup, and programming

DTC P0641, P0651, P0697, OR P06A3 (ECM)

Diagnostic Instructions

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

DTC Descriptors

DTC P0641

5V Reference 1 Circuit

DTC P0651

5V Reference 2 Circuit

DTC P0697

5V Reference 3 Circuit

DTC P06A3

5V Reference 4 Circuit

Circuit/System Description

The engine control module (ECM) has 4 internal 5V reference circuits. Each internal reference circuit provides external 5V reference circuits for more than one sensor. A short to ground or short to voltage on one external 5V reference circuit can affect all the components connected to the same internal 5V reference circuit.

Conditions for Running the DTC

These DTCs run continuously when the ignition voltage is greater than 6.4 V.

Conditions for Setting the DTC

The ECM detects a short to ground or voltage on any of the 5V reference circuits for greater than 0.5 s.

Action Taken When the DTC Sets

DTCs P0641, P0651, P0697, and P06A3 are Type A DTCs.

Conditions for Clearing the DTC

DTCs P0641, P0651, P0697, and P06A3 are Type A DTCs.

Diagnostic Aids

The 5V reference 1 circuit provides 5 V circuits to the following sensors:

- Air conditioning (A/C) refrigerant pressure sensor
- Exhaust and intake camshaft position sensors
- Engine oil pressure sensor
- Fuel pressure sensor
- Fuel rail pressure sensor
- Fuel tank pressure sensor
- Turbocharger boost/intake air temperature sensor

The 5V reference 2 circuit provides 5 V circuits to the following sensors:

- Brake pedal position sensor (automatic transmission)
- Clutch pedal position sensor (manual transmission)

- Crankshaft position sensor
- Multifunction intake air sensor
- Vehicle speed sensor

The 5V reference 3 circuit provides 5 V circuits to the following sensors:

- Accelerator pedal position sensor 2
- Manifold absolute pressure sensor

The 5V reference 4 circuit provides 5 V circuits to the following sensors:

- Accelerator pedal position sensor 1
- Throttle position sensor 1 and 2

Disconnecting one component at a time from the affected 5V reference circuit while observing the scan tool 5V Reference Circuit Status parameter may help locate the fault. The scan tool parameter will change from Malfunction to OK when the source of the fault is disconnected. If all 5V reference components have been disconnected and a fault is still indicated, the fault may exist in the wiring harness.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify all scan tool 5V Reference Circuit Status parameters do not display Malfunction.
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing.

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

     Refer to Circuit/System Testing.

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

Circuit/System Testing

NOTE: Additional DTCs will set when disconnecting the components.

1. Ignition OFF, disconnect the harness connector at all appropriate sensors for the applicable DTC. Refer to Diagnostic Aids.
2. Ignition ON.
3. Test for 4.8-5.2 V between one of the 5V reference circuits and ground.
   - **If less than 4.8 V**
     1. Ignition OFF, disconnect the harness connectors at the K20 Engine Control Module.
     2. Test for infinite resistance between the 5V reference circuit for each applicable component and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance, replace the K20 Engine Control Module.
   - **If greater than 5.2 V**
     1. Ignition OFF, disconnect the harness connectors at the K20 Engine Control Module.
     2. Test for less than 1 V between the 5V reference circuit for each applicable component and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
   - **If between 4.8-5.2 V**

     NOTE: A short to voltage or ground on the signal circuit of certain components may cause this DTC to set.

4. Verify the appropriate scan tool 5V Reference 1, 2, 3, or 4 Circuit Status parameter displays OK while

connecting each component associated with the 5V reference circuit one at a time.

- **If OK is not displayed when a component is connected**

  Replace the component

- **If OK is displayed after all components have been connected**

5. All OK.

Repair Instructions

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

- **Accelerator Pedal with Position Sensor Assembly Replacement**
- **Air Conditioning (A/C) Refrigerant Pressure Sensor Replacement**
- **Brake Pedal Position Sensor Replacement**
- **Camshaft Position Sensor Replacement - Intake**
- **Camshaft Position Sensor Replacement - Exhaust**
- **Crankshaft Position Sensor Replacement (FWD)** , **Crankshaft Position Sensor Replacement (AWD)**
- **Fuel Injection Fuel Rail Fuel Pressure Sensor Replacement**
- **Fuel Pressure Sensor Replacement - Fuel Feed Pipe (FWD)** , **Fuel Pressure Sensor Replacement - Fuel Feed Pipe (AWD)**
- **Fuel Tank Pressure Sensor Replacement (AWD)** , **Fuel Tank Pressure Sensor Replacement (FWD)**
- **Intake Air Pressure and Temperature Sensor Replacement** for turbocharger boost/intake air temperature sensor replacement
- **Manifold Absolute Pressure Sensor Replacement**
- **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement**
- **Throttle Body Assembly Replacement**
- **Vehicle Speed Sensor Replacement**
- **Control Module References** for engine control module replacement, programming, and setup.

DTC P0650, P263A, OR P263B

Diagnostic Instructions

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

DTC Descriptor

DTC P0650

Malfunction Indicator Lamp (MIL) Control Circuit Open

DTC P263A

Malfunction Indicator Lamp (MIL) Control Circuit Low Voltage

DTC P263B

Malfunction Indicator Lamp (MIL) Control Circuit High Voltage

Diagnostic Fault Information

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

Circuit/System Description

The malfunction indicator lamp (MIL) illuminates to inform the driver that an emission system fault has occurred and the engine control system requires service. Ignition voltage is supplied directly to the MIL. The engine control module (ECM) turns the MIL ON by grounding the MIL control circuit when the emission system fault occurs. Under normal operating conditions, the MIL should be ON only when the ignition is ON and the engine is OFF.

Conditions for Running the DTC

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

Conditions for Setting the DTC

DTC P0650

The ECM detects low voltage during the MIL control circuit driver OFF state. This indicates an open MIL control circuit.

DTC P263A

The ECM detects low voltage during the MIL control circuit driver OFF state. This indicates a shorted to ground MIL control circuit.

DTC P263B

The ECM detects high voltage on the MIL control circuit during the driver ON state. This indicates a shorted to voltage MIL control circuit.

Action Taken When the DTC Sets

DTC P0650, P263A, and P263B are Type B DTCs

Conditions for Clearing the DTC

DTC P0650, P263A, and P263B are Type B DTCs

Diagnostic Aids

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

Reference Information

Schematic Reference

- **Engine Controls Schematics**
- **Instrument Cluster Schematics**

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify the parameters listed below do not display Malfunction when commanding the malfunction indicator lamp ON and OFF with a scan tool.
    - The MIL Control Circuit Low Voltage Test Status
    - The MIL Control Circuit Open Test Status

- The MIL Control Circuit High Voltage Test Status
- **If Malfunction is displayed**

  Refer to Circuit/System Testing.

- **If Malfunction is not displayed**

3. Engine running.
4. Verify the parameters listed below do not display Malfunction when commanding the malfunction indicator lamp ON and OFF with a scan tool.
   - The MIL Control Circuit Low Voltage Test Status
   - The MIL Control Circuit Open Test Status
   - The MIL Control Circuit High Voltage Test Status
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing.

   - **If Malfunction is not displayed**
5. Verify the malfunction indicator lamp turns ON and OFF when commanding the malfunction indicator lamp ON and OFF with a scan tool.
   - **If the malfunction indicator lamp does not turn ON and OFF**

     Refer to Circuit/System Testing.

   - **If the malfunction indicator lamp turns ON and OFF**
6. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
   - **If any DTC sets**

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

   - **If a DTC does not set**
7. All OK.

Circuit/System Testing

1. Ignition OFF.
2. Disconnect the X1 harness connector at the K20 Engine Control Module.
3. Ignition ON, verify the malfunction indicator lamp does not illuminate.
   - **If the malfunction indicator lamp illuminates**
     1. Test for infinite resistance between the malfunction indicator lamp control circuit terminal X1 46 and ground.
        - If less than infinite resistance, repair the short to ground in the circuit.
        - If infinite resistance, replace the P16 Instrument Cluster.
   - **If the malfunction indicator lamp does not illuminate**
4. Connect a 3 A fused jumper wire between the malfunction indicator lamp control circuit terminal X1

46 and ground.

5. Verify the malfunction indicator lamp illuminates.
    - **If the malfunction indicator lamp illuminates**

      Replace the K20 Engine Control Module.

    - **If the malfunction indicator lamp does not illuminate**
    1. Test for less than 1 V between the malfunction indicator lamp control circuit terminal X1 46 and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V
    2. Ignition OFF.
    3. Test for less than 2 ohms in the malfunction indicator lamp control circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms.
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**
    1. Ignition OFF.
    2. Test for infinite resistance between the ignition voltage circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
    - **If the test lamp does not illuminate and the circuit fuse is good**
    1. Ignition OFF.
    2. Test for less than 2 ohms in the ignition voltage circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
    - **If the test lamp illuminates**
8. All OK.

Repair Instructions

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

- **Instrument Cluster Replacement**
- **Control Module References** for engine control module replacement, programming, and setup.

DTC P0685-P0687, P0689, P0690, OR P1682

Diagnostic Instructions

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

DTC Descriptors

DTC P0685

Engine Controls Ignition Relay Control Circuit

DTC P0686

Engine Controls Ignition Relay Control Circuit Low Voltage

DTC P0687

Engine Controls Ignition Relay Control Circuit High Voltage

DTCP0689

Engine Controls Ignition Relay Feedback Circuit Low Voltage

DTC P0690

Engine Controls Ignition Relay Feedback Circuit High Voltage

DTC P1682

Ignition 1 Switch Circuit 2

Diagnostic Fault Information

Engine Controls Ignition Relay

Circuit	Short to Ground	Open/High Resistance	Short to Voltage
Relay Coil Supply Voltage	P0689, P1682	P0685, P0689, P1682	-
Relay Control Circuit	P0686, P0690	P0685, P0689, P1682	P0685, P0687, P0689, P1682
Relay Feedback Circuit	P0689, P1682	P0689, P1682	P0690

Typical Scan Tool Data

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

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

B+	Malfunction	Malfunction	-
Control	Malfunction	Malfunction	Not Run

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

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

Circuit/System Description

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

Conditions for Running the DTC

P0685, P0686, P0687

The DTC runs when Ignition 1 signal voltage is greater than 11 V.

P0689

- DTCs P0685, P0686, or P0687 are not set.
- The engine controls ignition relay is commanded ON.
- Ignition 1 signal voltage is greater than 11 V.
- The DTC runs continuously when the above conditions are met.

P0690

- DTCs P0685, P0686, or P0687 are not set.
- The engine controls ignition relay is commanded OFF.
- The DTC runs continuously when the above conditions are met.

P1682

- The engine controls ignition relay is commanded ON.
- Ignition voltage is greater than 5.5 V.
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

P0685

The ECM detects that the commanded state of the driver and the actual state of the control circuit do not match for greater than 2 s.

P0686

The ECM detects a short to ground on the control circuit for greater than 2 s.

P0687

The ECM detects a short to voltage on the control circuit for greater than 2 s.

P0689

The ECM detects the engine controls ignition relay feedback circuit is less than 5 V.

P0690

The ECM detects the engine controls ignition relay feedback circuit is greater than 4 V for greater than 5 s.

P1682

The ECM detects that the voltage level difference is greater than 3 V between the 2 ignition voltage circuits for greater than 1 s.

Action Taken When the DTC Sets

North America

- DTCs P0685, P0686, P0687, and P0690 are Type B DTCs.
- DTC P0689 is a Type C DTC.
- DTC P1682 is a Type A DTC.

Europe

- DTCs P0685, P0686, P0687, P0689, and P0690 are Type C DTCs.
- DTC P1682 is a Type A DTC.

Conditions for Clearing the DTC

North America

- DTCs P0685, P0686, P0687, and P0690 are Type B DTCs.
- DTC P0689 is a Type C DTC.
- DTC P1682 is a Type A DTC.

Europe

- DTCs P0685, P0686, P0687, P0689, and P0690 are Type C DTCs.
- DTC P1682 is a Type A DTC.

Diagnostic Aids

The engine controls ignition relay may also be labeled the powertrain relay, the engine control module relay, or the main relay. The ignition main relay may also be labeled the run/crank relay, the ignition run relay, the ignition 1 relay, or the ignition relay.

Reference Information

Schematic Reference

- **Engine Controls Schematics**
- **Power Distribution Schematics**

Connector End View Reference

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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

Circuit/System Verification

NOTE:

- **A short to voltage on other components may cause DTC P0690 to set. If any other DTC is set, diagnose that DTC first.**
- **If you were sent here from Engine Cranks But Does Not Run, proceed to Circuit/System Testing.**

1. Ignition ON, observe the scan tool DTC information. Verify DTC P0685, P0686, P0687, P0689, P0690, or P1682 is not set.
   - **If any of the DTCs are set**

     Refer to Circuit/System Testing.

   - **If none of the DTCs are set**
2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
   - **If any of the DTCs are set**

     Refer to Circuit/System Testing.

   - **If none of the DTCs are set**
3. All OK.

Circuit/System Testing

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

1. Ignition OFF, disconnect the KR75 Engine Controls Ignition Relay.
2. Verify a test lamp illuminates between ground and the relay circuit terminals listed below:
   - Terminal 85
   - Terminal 30
   - **If the test lamp does not illuminate**

     Replace the front compartment fuse block.

   - **If the test lamp illuminates**

     NOTE:
     - **High resistance in the circuit/underhood fuse block for either the KR75 Engine Controls Ignition Relay or the KR73 Ignition Main Relay can cause DTC P1682 to set.**
     - **A short to voltage on any of the circuits supplied by the engine controls ignition relay can cause DTC P0690 to set.**
3. Ignition ON.
4. Verify that a test lamp does not illuminate between the ignition voltage circuit terminal 87 and ground.
   - **If the test lamp illuminates**
     1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.
     2. Ignition ON.
     3. Test for less than 1 V between ground and connector terminals 73.

- If 1 V or greater, repair the short to voltage in the circuit.
- If less than 1 V, replace the K20 Engine Control Module.

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

5. Ignition OFF, connect a 20 A fused jumper wire between the 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**
   1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module
   2. Test for less than 2 ohms in the relay switch ignition voltage circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms
   3. Test for infinite resistance between the relay switch ignition voltage circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.
   - **If B+ is displayed**
8. Ignition OFF, connect a DMM, set to the diode setting, between control circuit terminal 86 and ground.
9. Verify the DMM displays OL.
   - **If OL is not displayed**
   1. Disconnect the X1 harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between ground and the relay control circuit.
      - If less than infinite resistance, repair the short to ground in the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.
   - **If OL is displayed**
10. Ignition ON.
11. Verify the DMM displays less than 1 V.
    - **If 1 V or greater**
    1. Ignition OFF, disconnect the X1 connector at the K20 Engine Control Module.
    2. Ignition ON.
    3. Test for less than 1 V on the relay control circuit.
       - If 1 V or greater, repair the short to voltage on the circuit.
       - If less than 1 V
    4. Test for less than 2 ohms in the control circuit end to end.
       - If 2 ohms or greater, repair the open/high resistance in the circuit.
       - if less than 2 ohms, replace the K20 Engine Control Module.
    - **If less than 1 V**
12. Test or replace the KR75 Engine Controls Ignition Relay.

Component Testing

Relay Test

1. Ignition OFF, disconnect the KR75 Engine Controls Ignition Relay.
2. Test for 70-110 ohms between terminals 85 and 86:
   - **If less than 70 ohms or greater than 110 ohms**

     Replace the relay.

   - **If between 70-110 ohms**
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 ohms between terminals 30 and 87.
   - **If 2 ohms or greater**

     Replace the relay.

   - **If less than 2 ohms**
6. All OK.

Repair Instructions

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

- **Front Compartment Fuse Block Housing Replacement**
- **Relay Replacement (Within an Electrical Center)** , **Relay Replacement (Attached to Wire Harness)**
- **Control Module References** for engine control module replacement, programming, and setup.

DTC P0700

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 of the diagnostic category.

DTC Descriptor

DTC P0700

Transmission Control Module Requested MIL Illumination

Circuit/System Description

The transmission control module (TCM) constantly monitors the transmission system for any condition which may adversely affect vehicle emissions. If a condition is detected, the TCM sets a DTC and sends a serial data message to the engine control module (ECM). The ECM sets DTC P0700 to inform the technician that the TCM has set the emission related DTC. The serial data message sent by the TCM also contains a request for the ECM to illuminate the malfunction indicator lamp (MIL)

The technician can observe the DTC that was set by the TCM by reviewing the ECM Freeze Frame records on the scan tool. The ECM Freeze Frame records also contain the engine operating conditions present when the transmission DTC set.

Conditions for Running the DTC

- The ignition is ON or the engine is operating.
- DTC P0700 runs continuously.

Conditions for Setting the DTC

The ECM receives a serial data message from the TCM indicating that an emission related DTC has set in the TCM.

Action Taken When the DTC Sets

DTC P0700 is a Type A DTC.

Conditions for Clearing the MIL/DTC

DTC P0700 is a Type A DTC.

Diagnostic Aids

Communication codes, U-codes, as well as powertrain codes, P-codes, set in the TCM can cause the TCM to request DTC P0700 to be set in the ECM.

Reference Information

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

NOTE:

- **Do not replace the engine control module for this DTC. DTC P0700 is an informational DTC.**
- **Correct any engine control and communication DTCs before diagnosing transmission control module DTCs.**

1. Verify there are no engine control or communication DTCs set.
   - **If a DTC is set**

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

   - **If a DTC is not set**
2. Verify there are no transmission control module DTCs set.
   - **If a DTC is set**

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

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

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

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

Repair Instructions

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

DTC P1255

Diagnostic Instructions

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

DTC Descriptors

DTC P1255

Fuel Pump Control Module Driver High Temperature

Circuit/System Description

The engine control module (ECM) supplies voltage to the fuel pump power control module when the ECM detects that the ignition is on. The voltage from the ECM to the fuel pump power control module remains active for 2 seconds, unless the engine is in crank or run. While this voltage is being received, the fuel pump power control module supplies a varying voltage to the fuel tank fuel pump module in order to maintain the desired fuel pressure.

Conditions for Running the DTC

- The ignition voltage is greater than 9 V.
- The engine is cranking or running.
- The fuel pump enable circuit is commanded ON.
- The DTC runs continuously when the conditions above are met.

Conditions for Setting the DTC

The fuel pump power control module detects a driver temperature greater than 302°F (150°C) for less than 0.5 s.

Action Taken When the DTC Sets

DTC P1255 is a Type A DTC.

Conditions for Clearing the DTC

DTC P1255 is a Type A DTC.

Diagnostic Aids

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

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0231, P0232, or P023F is not set.
   - **If any of the DTCs are set**

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

   - **If none of the DTCs are set**
3. Verify that the area where the fuel pump power control module is located is free of debris, clutter, or any insulating material that would cause the fuel pump power control module to overheat.
   - **If any debris, clutter, or other material is found**
   1. Clear the area where the fuel pump power control module is located.
   2. Clear the DTC and test drive the vehicle.
   3. Verify DTC P1255 is not set.
      - If DTC P1255 is set, replace the fuel pump power control module.
      - If DTC P1255 is not set
   4. All OK.
   - **If no debris, clutter, or other material is found**
4. Clear the DTC and test drive the vehicle.
5. Verify DTC P1255 is not set.
   - **If DTC P1255 is set**

     Replace the fuel pump power control module.

   - **If DTC P1255 is not set.**
6. All OK.

Repair Instructions

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

Fuel Pump Power Control Module Replacement

DTC P129B OR P129C

Diagnostic Instructions

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

DTC Descriptors

DTC P129B

Fuel Pump Driver Control Module System Voltage Low

DTC P129C

Fuel Pump Driver Control Module System Voltage High

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage
B+	P018B, P0506, P129B, P2635, U18A2	P018B, P0506, P129B, P2635, U18A2	P129C

Circuit/System Description

The fuel pump power control module monitors the battery positive voltage circuit to verify the voltage is between the normal operating range. The DTC can set for a circuit or system voltage out of range.

Conditions for Running the DTC

P129B

- The engine is running.
- The ignition voltage is greater than 7 V.
- The fuel pump enable circuit is commanded ON.
- The DTC runs continuously when the conditions above are met.

P129C

- The engine is not running.
- The ignition voltage is greater than 7 V.
- The fuel pump enable circuit is commanded ON.
- The DTC runs continuously when the conditions above are met.

Conditions for Setting the DTC

P129B

The fuel pump power control module detects the battery positive voltage is less than 7 V for 1 s.

P129C

The fuel pump power control module detects the battery positive voltage is greater than 18 V for 1 s.

Action Taken When the DTC Sets

DTCs P129B and P129C are Type C DTCs.

Conditions for Clearing the DTC

DTCs P129B and P129C are Type C DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Electrical Center Identification Views**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition OFF.
2. Test for 12.4-12.8 V at the battery terminals and record the reading. The battery voltage should stabilize after a few minutes of turning the ignition OFF.
   - **If not between 12.4 V-12.8 V**

     Refer to **Battery Inspection/Test** .

   - **If between 12.4 V-12.8 V**
3. Engine running, accessories OFF.
4. Test for 13.4-15 V at the battery terminals and record the reading.
   - **If not between 13.4-15 V**

     Refer to **Charging System Test** .

   - **If between 13.4-15 V**
5. Verify the engine control module scan tool Ignition 1 Signal voltage parameter is 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**
6. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
7. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the Fuel Pump Power Control Module. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 ohms between the ground circuit terminal 9 and ground.
   - **If 5 ohms or greater**
     1. Ignition OFF.
     2. Test for less than 2 ohms in the ground circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, repair the open/high resistance in the ground connection.
   - **If less than 5 ohms**
3. Verify a test lamp illuminates between the B+ circuit terminal 1 and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**

1. Ignition OFF, remove the test lamp.
2. Test for less than 2 ohms in the B+ circuit end to end.
    - If 2 ohms or greater, repair the open/high resistance in the circuit.
    - If less than 2 ohms, verify the fuse is not open and there is voltage at the fuse.

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

1. Ignition OFF, remove the test lamp.
2. Test for infinite resistance between the B+ circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance, replace the Fuel Pump Power Control Module.

- **If the test lamp illuminates**

4. Replace the Fuel Pump Power Control Module.

Repair Instructions

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

Fuel Pump Power Control Module Replacement

DTC P129D

Diagnostic Instructions

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

DTC Descriptor

DTC P129D

Fuel Pump Driver Control Module Ignition 1 Switch Circuit Low Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition	P129D	P129D	-	-

Circuit/System Description

The fuel pump power control module monitors the ignition voltage circuit in order to determine if the voltage is within the normal operating range.

Conditions for Running the DTC

The DTC runs continuously when the modules are awake.

Conditions for Setting the DTC

The fuel pump power control module Power Mode does not agree with the engine control module (ECM) Power Mode for 1 s.

Action Taken When the DTC Sets

DTC P129D is a Type A DTC.

Conditions for Clearing the DTC

DTC P129D is a Type A DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P129D is not set.
    - **If the DTC is set**

      Refer to Circuit/System Testing.

- **If the DTC is not set**

3. All OK.

Circuit/System Testing

1. Ignition ON.
2. Verify DTC P0562 is not set.
   - **If the DTC is set**

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

3. Ignition OFF, disconnect the harness connector at the Fuel Pump Driver Control Module, ignition ON.
4. Verify a test lamp illuminates between the ignition circuit terminal 6 and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition OFF, remove the test lamp.
   2. Test for less than 2 ohms in the ignition circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, verify the fuse is not open and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**
   1. Ignition OFF, remove the test lamp.
   2. Test for infinite resistance between the ignition circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the Fuel Pump Power Control Module.
   - **If the test lamp illuminates**
5. Replace the Fuel Pump Power Control Module.

Repair Instructions

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

Fuel Pump Power Control Module Replacement

DTC P129E

Diagnostic Instructions

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

DTC Descriptors

DTC P129E

Fuel Pump Driver Control Module Signal Message Counter Incorrect

Circuit/System Description

The fuel pump power control module is constantly sending serial data messages to the ECM regarding the operating state of the fuel pump power control system. These messages are sent in a continuously repeating series of rolling counts with associated password protect samples and each count/sample is assigned a value. When the ECM determines that too many of the counts/samples contain an error value, the ECM sets DTC P129E.

Conditions for Running the DTC

- The ignition voltage is greater than 9 V.
- The DTC runs continuously when the above condition is met.

Conditions for Setting the DTC

The ECM detects that 64 of 80 counts/samples contain an error value.

Action Taken When the DTC Sets

DTC P129E is a Type A DTC.

Conditions for Clearing the DTC

DTC P129E is a Type A DTC.

Diagnostic Aids

An intermittent fault in the CAN circuits will cause the ECM to set DTC P129E.

Reference Information

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

NOTE:

- **DTC P129E is an informational DTC.**
- **Diagnose all other engine control module DTCs prior to DTC P129E.**

1. Verify there are no other engine control module or communication DTCs set.
   - **If a DTC is set**

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

- **If a DTC is not set**

2. Complete the diagnosis by looking for an intermittent CAN circuit fault. Refer to **Scan Tool Does Not Communicate with High Speed GMLAN Device** .
   - **If an intermittent CAN circuit fault is found**

     Refer to Circuit/System Testing.

   - **If an intermittent CAN circuit fault is not found**
3. All OK.

Circuit/System Testing

1. Verify that no other DTCs are set except for DTC P129E.
   - **If any other DTCs are set**

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

   - **If only DTC P129E is set**
2. Replace the K111 Fuel Pump Power Control Module.
3. Verify the DTC does not set while operating the vehicle within the Conditions for Running the DTC.
   - **If DTC sets**

     Replace the K20 Engine Control Module.

   - **If DTC does not set**
4. All OK.

Repair Instructions

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

- **Fuel Pump Power Control Module Replacement**
- **Control Module References** for Engine Control Module replacement, programming, and setup.

DTC P12A6

Diagnostic Instructions

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

DTC Descriptor

DTC P12A6

Fuel Pump Driver Control Module Enable Circuit Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control	P0171, P0506, P0628, P12A6	P0171, P0506, P12A6	-	P12A6

Circuit/System Description

The engine control module (ECM) provides ignition voltage to the fuel pump power control module whenever the engine is cranking or running. The control module enables the fuel pump power control module as long as the engine is cranking or running, and ignition system reference pulses are received. While this enable voltage is being received, the fuel pump power control module supplies a varying voltage to the in-tank fuel pump module in order to maintain the desired fuel line pressure.

Conditions for Running the DTC

- The ignition voltage is greater than 7 V.
- The DTC runs continuously when the condition above is met.

Conditions for Setting the DTC

The ECM state of the fuel pump enable circuit does not match the state of the fuel pump enable circuit sensed by the fuel pump power control module for 0.5 s.

Action Taken When the DTC Sets

DTC P12A6 is a Type A DTC.

Conditions for Clearing the DTC

DTC P12A6 is a Type A DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Electrical Information Reference

- **Circuit Testing**

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC P12A6 is not set.
   - **If the DTC is set**

     Refer to Circuit/System Testing.

   - **If the DTC is not set**
3. Verify the parameters listed below do not display Malfunction when commanding the Fuel Pump Enable On and Off with a scan tool.
   - Fuel Pump Enable Circuit Low Voltage Test Status
   - Fuel Pump Enable Circuit Open Test Status
   - Fuel Pump Enable Circuit High Voltage Test Status
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing.

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

     Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the Fuel Pump Power Control Module.
2. Ignition ON for 10 s.
3. Verify that a test lamp does not illuminate between the control circuit terminal 2 and ground.

- **If the test lamp illuminates**

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

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

4. Remove the test lamp.
5. Verify the scan tool Fuel Pump Enable Circuit Low Voltage Test Status parameter is OK when commanding the Fuel Pump Enable On with a scan tool.
   - **If OK is not displayed**

   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the control circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.

   - **If OK is displayed**
6. Install a 3 A fused jumper wire between the control circuit terminal 2 and ground.
7. Verify the scan tool Fuel Pump Enable Circuit Low Voltage Test Status parameter is Malfunction when commanding the Fuel Pump Enable On with a scan tool.
   - **If Malfunction is not displayed**

   1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 ohms in the control circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 Engine Control Module.

   - **If Malfunction is displayed**
8. Replace the Fuel Pump Power Control Module.

Repair Instructions

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

- **Fuel Pump Power Control Module Replacement**
- **Control Module References** for ECM replacement, setup, and programming

DTC P12A8

Diagnostic Instructions

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

DTC Descriptors

DTC P12A8

Fuel Pump Control Signal Message Counter Incorrect

Circuit/System Description

The fuel pump power control module is constantly sending serial data messages to the ECM regarding the operating state of the fuel pump power control system. These messages are sent in a continuously repeating series of rolling counts with associated password protect samples and each count/sample is assigned a value. When the ECM determines that too many of the counts/samples contain an error value, the ECM sets DTC P12A8.

Conditions for Running the DTC

- The ignition voltage is greater than 9 V.
- The engine run time is greater than 0.5 s.
- No other CAN errors are present.
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

The ECM detects that 64 of 80 counts/samples contain an error value.

Action Taken When the DTC Sets

DTC P12A8 is a Type A DTC.

Conditions for Clearing the DTC

DTC P12A8 is a Type A DTC.

Diagnostic Aids

An intermittent fault in the CAN circuits will cause the ECM to set DTC P12A8.

Reference Information

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

NOTE:

- **DTC P12A8 is an informational DTC.**
- **Diagnose all other engine control module DTCs prior to DTC P12A8.**

1. Verify there are no other engine control module or communication DTCs set.
   - **If a DTC is set**

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

   - **If a DTC is not set**
2. Complete the diagnosis by looking for an intermittent CAN circuit fault. Refer to **Scan Tool Does Not Communicate with High Speed GMLAN Device** .
   - **If an intermittent CAN circuit fault is found**

     Refer to Circuit/System Testing.

   - **If an intermittent CAN circuit fault is not found**
3. All OK.

Circuit/System Testing

1. Verify that no other DTCs are set except for DTC P12A8.
   - **If any other DTCs are set**

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

   - **If only DTC P12A8 is set**
2. Replace the K111 Fuel Pump Power Control Module.
3. Verify the DTC does not set while operating the vehicle within the Conditions for Running the DTC.
   - **If DTC sets**

     Replace the K20 Engine Control Module.

   - **If DTC does not set**
4. All OK.

Repair Instructions

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

- **Fuel Pump Power Control Module Replacement**
- **Control Module References** for Engine Control Module replacement, programming, and setup.

DTC P135A

Diagnostic Instructions

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

DTC Descriptor

DTC P135A

Ignition Coil Supply Voltage Circuit Bank 1

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0201, P0202, P0203, P0204, P0300, P0351, P0352, P0353, P0354, P135A	P0201, P0202, P0203, P0204, P0300, P0351, P0352, P0353, P0354, P135A	-	-

Circuit/System Description

The ignition system uses an individual ignition coil for each cylinder. The engine control module (ECM) monitors the ignition voltage from the fuse to the individual coils.

Conditions for Running the DTC

- The ignition is ON.
- Ignition Run/Crank and PT relay voltages are greater than 11 V

The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

The ECM detects less than 2.5 V on the ignition coil supply voltage circuit for greater than 313 ms.

Action Taken When the DTC Sets

DTC P135A is a Type A DTC.

Conditions for Clearing the DTC

DTC P135A is a Type A DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Electronic Ignition System Description

Electrical Information Reference

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

Scan Tool Reference

Control Module References

Circuit/System Verification

1. Ignition ON.
2. Verify the scan tool Ignition Coil Supply Voltage parameter displays ON.
    - **If ON is not displayed**

      Refer to Circuit/System Testing.

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

      Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.
2. Connect a 3 A fused jumper wire between the control circuit terminal 72 and ground, ignition ON.
3. Verify a test lamp illuminates between the ignition circuit terminal 62 and ground.
    - **If the test lamp does not illuminate and the circuit fuse is good**
    1. Ignition OFF, remove the test lamp.
    2. Test for less than 2 ohms in the ignition circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, verify the fuse is not open and there is voltage at the fuse.
    - **If the test lamp does not illuminate and the circuit fuse is open**

NOTE: **The ignition circuit may supply voltage to other components. Make sure to test all circuits and components for a short to ground that share the ignition circuit.**

1. Ignition OFF, remove the test lamp, and disconnect all components on the circuit.
2. Test for infinite resistance between the ignition circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance
3. Replace the fuse, ignition ON.
4. Verify the fuse is good after connecting each of the components one at a time.
    - If the fuse opens, replace the component that opens the fuse when connected.
    - If the fuse is good, all OK.

- **If the test lamp illuminates**

4. Replace the K20 Engine Control Module.

Repair Instructions

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

- **Ignition Coil Replacement**
- **Control Module References** for engine control module replacement, programming, and setup

DTC P1400

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** provide an overview of each diagnostic category.

DTC Descriptor

DTC P1400

Cold Start Emission Reduction Control System

Circuit/System Description

The catalyst must be warmed to efficiently reduce the emissions. The cold start strategy is to reduce the amount of time it takes to warm the catalyst. During a cold start, the engine spark timing is altered to allow the catalyst to warm quickly. This diagnostic monitors the following to build an exhaust energy model:

- Spark advance
- Engine airflow
- Engine coolant temperature
- Engine run time

The actual model is then compared to the expected exhaust energy model.

Conditions for Running the DTC

- DTCs P0101, P0102, P0103, P0106, P0107, P0108, P0112, P0113, P0114, P0116, P0117, P0118, P0121, P0122, P0123, P0201, P0202, P0203, P0204, P0222, P0223, P0300, P0301, P0302, P0303, P0304, P0335, P0336, P0351, P0352, P0353, P0354, P0641, P0651, P0697, P06A3, P2122, P2123, P2127, P2128, P2135, and P2138 are not set.
- The engine coolant temperature (ECT) is between -12 to +56°C (10-132°F).
- The calculated 3-way catalyst temperature is colder than 500°C (932°F).
- The barometric (BARO) pressure is greater than 75 kPa.
- The engine control module (ECM) will exit the diagnostic if the calculated 3-way catalyst temperature is greater than 1,000°C (1832°F) when the engine run time is greater than 17 s.
- Vehicle speed is less than 1.6 km/h (1 mph).
- The accelerator pedal is not depressed.
- The ECM will exit the diagnostic if the engine run time is greater than a calibrated value.
- This DTC runs within the first 15 s of start-up. This diagnostic runs once per trip when a cold start has been determined.

Conditions for Setting the DTC

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

Action Taken When the DTC Sets

DTC P1400 is a Type A DTC.

Conditions for Clearing the DTC

DTC P1400 is a Type A DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Vehicle OFF, allow the engine to cool to be within the temperatures listed in the Conditions for Running the DTC.
2. Engine running.
3. Operate the vehicle within the Conditions for Running the DTC to verify the DTC does not reset. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify the DTC does not set.
   - **If the DTC sets**

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

   - **If the DTC is not set**
5. Verify that none of the conditions listed below exists with the air intake system:
   - Damage, restriction, or modification
   - Dirty or deteriorating air filter element
   - Crankcase ventilation system for correct operation
   - Water intrusion
   - Vacuum leak and other unmetered air downstream of the mass air flow (MAF) sensor
   - Intake manifold leak
   - **If any of the above conditions exist**

     Repair as necessary.

   - **If none of the conditions exist**
6. Verify that none of the conditions listed below exists with the exhaust system:
   - Exhaust leak
   - Damaged, restricted, or modified exhaust system - Refer to **Symptoms - Engine Exhaust** .
   - **If any of the above conditions exist**

     Repair as necessary.

   - **If none of the conditions exist**
7. If all of the above conditions test normal, inspect for an engine mechanical condition that could alter the air flow into the combustion chamber. Refer to **Symptoms - Engine Mechanical** .
   - **If the DTC does not set**

8. All OK.

Repair Instructions

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

DTC P150C

Diagnostic Instructions

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

DTC Descriptor

DTC P150C

Transmission Control Module Engine Speed Request Signal Message Counter Incorrect

Circuit/System Description

To improve vehicle shift feel, the transmission control module (TCM) is constantly sending the ECM serial data messages with information regarding its request for modifying engine speed or torque. The ECM sets this code when it detects a discrepancy in the structure of this message causing its integrity to be questioned.

An intermittent fault in the controller area network (CAN) circuits will cause DTC P150C to set.

Conditions for Running the DTC

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

Conditions for Setting the DTC

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

Action Taken When the DTC Sets

DTC P150C is a Type B DTC.

Conditions for Clearing the DTC

DTC P150C is a Type B DTC.

Reference Information

Description and Operation

Data Link Communications Description and Operation

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

NOTE:

- **DTC P150C is an informational DTC.**
- **Diagnose all other engine control module DTCs prior to DTC P150C.**

1. Verify that no other DTCs are set except for DTC P150C.
   - **If any other DTCs are set**

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

   - **If only DTC P150C is set**
2. Replace the K17 Electronic Brake Control Module.
3. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
4. Verify the DTC does not set.
   - **If the DTC sets**

     Replace the K20 Engine Control Module.

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

Repair Instructions

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

Control Module References for ECM or control solenoid valve assembly replacement, programming, and setup.

DTC P1516, P2101, P2119, OR P2176

Diagnostic Instructions

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

DTC Descriptors

DTC P1516

Throttle Actuator Control (TAC) Module Throttle Actuator Position Performance

DTC P2101

Throttle Actuator Position Performance

DTC P2119

Throttle Closed Position Performance

DTC P2176

Minimum Throttle Position Not Learned

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
TAC Motor Control Closed	P1516, P2101, P2176	P1516, P2101, P2176	P1516, P2101, P2176	P0690, P1516, P2101, P2176	P1516, P2101, P2176
TAC Motor Control Open	P1516, P2101, P2119, P2176	P1516, P2101, P2176	P1516, P2101, P2176	P0690, P1516, P2101, P2176	P1516, P2101, P2176

Circuit/System Description

The Throttle Body Assembly contains a contact-less inductive throttle position sensing element that is managed by a customized integrated circuit. The throttle position sensor is mounted within the Throttle Body Assembly and is not serviceable. The Engine Control Module (ECM) supplies the throttle body with a 5 V reference circuit, a low reference circuit, an H-bridge motor directional control circuit, and an asynchronous signal/serial data circuit. The asynchronous signal means communication is only going from the throttle body to the ECM. The throttle body cannot receive data from the ECM over the signal/serial data circuit. The throttle position sensor provides a signal voltage that changes relative to throttle blade angle. The customized integrated circuit translates the voltage based position information into serial data using the Society of Automotive Engineers (SAE) J2716 Single Edge Nibble Transmission (SENT) protocol. The throttle position sensor information is transmitted between the throttle body and the ECM on the signal/serial data circuit. The ECM decodes the serial data signal and is used as voltages for throttle position sensor 1 and 2.

The ECM controls the throttle valve by applying a varying voltage to the control circuits of the throttle actuator control (TAC) motor. The ECM monitors the duty cycle that is required to actuate the throttle valve. The ECM monitors the throttle position sensor signal/serial data circuit to determine the actual throttle valve position.

Conditions for Running the DTC

P1516

- DTC P1682 is not set.
- The run/crank or powertrain relay voltage is greater than 6.41 V and reduced power is not active.
- DTC P1516 runs continuously when the above conditions are met.

P2101

- DTC P1682 is not set.
- The run/crank or powertrain relay voltage is greater than 6.41 V and reduced power is not active.
- The engine is running or the following conditions are met:
  - The engine is not running.
  - The ignition voltage is greater than 11 V.
  - The TAC system is not in the Battery Saver mode.
  - The ECM is commanding the throttle.
  - The ECM has learned the minimum throttle position.
- DTC P2101 runs continuously when the above conditions are met.

P2119

- DTCs P0122, P0123, P0222, P0223, or P06A3 is not set.
- The run/crank or powertrain relay voltage is greater than 5.5 V and reduced power is not active.
- The system is not in the Battery Save mode.
- The ECM is not commanding the throttle.
- DTC P2119 runs continuously when the above conditions are met.

P2176

- The run/crank or powertrain relay voltage is greater than 6.4 V and reduced power is not active.
- DTC P2176 runs continuously when the above conditions are met.

Conditions for Setting the DTC

P1516

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

P2101

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

  OR

- The ECM detects the throttle control is driving the throttle in the incorrect direction or exceed the reduced power limit.

P2119

The ECM determines that the throttle blade did not return to the rest position within 1 s.

P2176

The ECM detects that both throttle position sensors were greater than a predetermined voltage during the minimum throttle learn procedure for greater than 2 s.

Action Taken When the DTC Sets

- DTC P1516 is a Type B DTC.
- DTCs P2101 and P2176 are type A DTCs.
- DTC P2119 is a type C DTC.
- The ECM commands the TAC system to operate in the Reduced Engine Power mode.
- A message center or an indicator displays Reduced Engine Power.
- Under certain conditions, the control module commands the engine OFF.

Conditions for Clearing the MIL/DTC

- DTC P1516 is a Type B DTC.
- DTCs P2101 and P2176 are type A DTCs.
- DTC P2119 is a type C DTC.

Diagnostic Aids

- Depending on the Start Up ECT, the Desired Throttle Position percentage maybe greater or less than the Throttle Position with the TAC motor at rest. When the ignition is initially turned ON, or when the engine is cranking or running the Desired and Actual Throttle positions should closely match.
- Inspect for a condition in which the throttle valve may have been held open. For example, ice may have formed in the throttle bore causing the throttle valve not to close.
- A high resistance condition on the throttle position and throttle actuator control circuits could cause a DTC to set.
- A low battery condition may cause a DTC to set.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Throttle Actuator Control (TAC) System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.

   NOTE: A low battery voltage or charging system condition may cause a DTC to set.

2. Verify DTC P0121, P0122, P0123, P0222, P0223, P0562, P0621, P0622, or P2135 is not set.
   - **If any of the DTCs are set**

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

   - **If none of the DTCs are set**
3. Verify the scan tool Throttle Body Idle Air flow Compensation parameter is less than 90 %.
   - **If 90 % or greater**

     Refer to **Throttle Body Cleaning** .

   - **If less than 90 %**
4. Clear the DTCs with a scan tool.
5. Ignition OFF and all vehicle systems OFF. It may take up to 2 minutes for all vehicle systems to power down.
6. Ignition ON.
7. Verify the scan tool TAC Motor parameter displays Enabled while slowly depressing the accelerator pedal.
   - **If Enabled is not displayed**

     Refer to Circuit/System Testing.

- **If Enabled is displayed**

8. Verify DTC P1516, P2101, P2119, or P2176 is not set.
   - **If any of the DTCs are set**

     Refer to Circuit/System Testing.

   - **If none of the DTCs are set**

NOTE: **If there is a condition with the throttle body, the TAC Motor Command parameter will go to 99 % for a predetermined amount of time and then a DTC sets. Once a DTC is set, the TAC Motor Command parameter will go to 0 % and the TAC Motor parameter will display Disabled.**

9. Verify the scan tool TAC Motor parameter displays Enabled while performing the Throttle Sweep Test with a scan tool.
   - **If Enabled is not displayed**

     Test or replace the Q38 Throttle Body Assembly.

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

      Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Ignition OFF.

WARNING: **Turn OFF the ignition before inserting fingers into the throttle bore. Unexpected movement of the throttle blade could cause personal injury.**

2. Verify the conditions listed below do not exist with the Q38 Throttle Body Assembly:

NOTE:

- **The rest position is defined as the actual Throttle Position percentage when the ignition is OFF or with the ignition ON for greater than 30 seconds.**
- **When the ignition is OFF, spring tension should hold the throttle plate in the rest position. You should be able to open the throttle plate to wide open throttle (WOT) or push the throttle plate to the fully closed position. In each case, the**

throttle plate should return to the rest position without assistance.

- A throttle blade that is not in the rest position
- A throttle blade that is binding open or closed
- A throttle blade that is free to move open or closed without spring pressure
  - **If a condition is found**

    Test or replace the Q38 Throttle Body Assembly.

  - **If a condition is not found**

3. Ignition OFF.

NOTE:

- **Disconnecting the throttle body harness connector may cause additional DTCs to set.**
- **The ignition must be OFF and the ECM completely powered down before testing each circuit.**
- **The Test Lamp must be connected to circuit before turning ignition on or incorrect diagnosis may occur.**

4. Disconnect the harness connector at the Q38 Throttle Body Assembly, ignition ON.
5. Verify that a test lamp does not illuminate continuously between each motor control circuit listed below and ground.
   - TAC Motor Control Open circuit terminal 1
   - TAC Motor Control Closed circuit terminal 2
   - **If the test lamp illuminates continuously**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON
   2. Test for less than 1 V between the control circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If the test lamp is always OFF**
6. Verify that a test lamp does not illuminate between each motor control circuit listed below and B+.
   - TAC Motor Control Open circuit terminal 1
   - TAC Motor Control Closed circuit terminal 2
     - **If the test lamp illuminates**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the control circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.
      - **If the test lamp is always OFF**
7. Ignition OFF, set the DMM to the 40 V scale or higher, select the Min/Max Recording Mode, and set the Peak Min/Max response time to 1 ms or faster.

NOTE:

- **The DMM Min/Max Recording Mode and the response time of 1 ms or faster must be reset after testing each circuit or a lower voltage will be recorded.**
- **The ignition must be OFF and the ECM completely powered down before testing each circuit or a lower voltage will be recorded.**

8. Verify the Max voltage is within 3 V of B+ while using DMM Min/Max Recording Mode function on each control circuit listed below as the ignition is turned ON.
   - TAC Motor Control Open circuit terminal 1
   - TAC Motor Control Closed circuit terminal 2
     - **If not within 3 V of B+**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 ohms in the control circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 Engine Control Module.
      - **If within 3 V of B+**
9. Test or replace the Q38 Throttle Body Assembly.

Repair Instructions

- **Throttle Body Assembly Replacement**
- **Control Module References** for ECM replacement, programming, and setup

Repair Verification

1. Install any components that have been removed or replaced during diagnosis.
2. Perform any adjustments, programming or setup procedures that are required when a component is removed or replaced.
3. Clear the DTCs with a scan tool.
4. Ignition OFF and all vehicle systems OFF. It may take up to 2 minutes for all vehicle systems to power down.
5. Ignition ON.
6. Verify the scan tool TAC Motor parameter displays Enabled while performing the Throttle Sweep Test with a scan tool.
   - **If Enabled is not displayed**

     Test or replace the Q38 Throttle Body Assembly.

   - **If Enabled is displayed**
7. If the repair was related to a DTC, duplicate the Conditions for Running the DTC and use the Freeze Frame/Failure Records, if applicable, in order to verify the DTC does not set.
   - **If DTC sets**

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

- **If DTC does not set**

8. All OK.

DTC P163A

Diagnostic Instructions

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

DTC Descriptor

DTC P163A

Control Module Fuel Pressure Regulator 1 Control System Circuitry Performance

Circuit/System Description

This diagnostic applies to internal microprocessor integrity conditions within the engine control module (ECM) or an out of range high pressure fuel pump actuator current.

Conditions for Running the DTC

- DTC P0016, P0017, P0090, P0091, P0092, P00C8, P00C9, P00CA, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0128, P0191, P0192, P0193, P0335, P0336, P0340, P0341, P0365, P0366, P0628, or P1682 is not set.
- The engine is running.
- The ignition voltage is greater than 11 V.
- The low side fuel pressure is greater than 250 kPa (36 psi).
- The barometric (BARO) pressure is greater than 70 kPa.
- The intake air temperature (IAT) is warmer than -20°C (-4°F).
- DTC P163A runs continuously when the conditions are met for greater than 500 mS.

Conditions for Setting the DTC

The ECM detects a condition with the integrated circuits of the high pressure fuel pump actuator driver module or the ECM detects that the current used to drive the high pressure fuel pump actuator is greater than 11 A or less than 0.1 A for greater than 4 s.

Action Taken When the DTC Sets

DTC P163A is a Type B DTC.

Conditions for Clearing the DTC

DTC P163A is a Type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the G18 High Pressure Fuel Pump.

   NOTE: The DMM and test leads must be calibrated to 0 ohms in order to prevent misdiagnosis.

2. Test for 0.3-0.7 ohms at 20°C (68°F) between the high control circuit terminal 1 and the low control circuit terminal 2.
   - **If not between 0.3-0.7 ohms**

     Replace the G18 High Pressure Fuel Pump.

   - **If between 0.3-0.7 ohms**
3. Test for infinite resistance between each terminal and the G18 High Pressure Fuel Pump housing.
   - **If less than infinite resistance**

     Replace the G18 High Pressure Fuel Pump.

- **If infinite resistance**

4. Ignition ON, verify that a test lamp does not illuminate between the high control circuit terminal 1 and ground and the low control circuit terminal 2 and ground.
   - **If the test lamp illuminates**
   1. Ignition OFF, disconnect the harness connector at the ECM, ignition ON.
   2. Test for less than 1 V between the appropriate control circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If the test lamp does not illuminate**
5. Verify that a test lamp does not illuminate between the high control circuit terminal 1 and B+ and the low control circuit terminal 2 and B+.
   - **If the test lamp illuminates**
   1. Ignition OFF, disconnect the harness connector at the ECM.
   2. Test for infinite resistance between the appropriate control circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 ohms in the control circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 Engine Control Module.
   - **If the test lamp does not illuminate**
6. Connect a 3 A fused jumper wire between the high control circuit terminal 1 and ground.
7. Verify the Fuel Pressure Regulator High Control Circuit Open Test Status transitions from Malfunction to OK and the Fuel Pressure Regulator High Control Circuit Low Voltage Test Status transitions from OK to Malfunction.
   - **The parameters do not change**
   1. Ignition OFF, disconnect the harness connector at the ECM.
   2. Test for less than 2 ohms in the high control circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 Engine Control Module.
   - **The parameters change**
8. Connect a 3 A fused jumper wire between the low control circuit terminal 2 and B+.
9. Verify the Fuel Pressure Regulator Control Circuit Open Test Status transitions from Malfunction to OK and the Fuel Pressure Regulator Control Circuit High Voltage Test Status transitions from OK to Malfunction.
   - **The parameters do not change**
   1. Ignition OFF, disconnect the harness connector at the ECM.
   2. Test for less than 2 ohms in the low control circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 Engine Control Module.
   - **The parameters change**

   Replace the K20 Engine Control Module.

Repair Instructions

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

- **Fuel Pump Replacement**
- **Control Module References** for engine control module replacement, setup, and programming
- Perform the Fuel Rail Pressure Relief Valve Reset procedure, if supported on the scan tool.

DTC P2096

Diagnostic Instructions

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

DTC Descriptor

DTC P2096

Post Catalyst Fuel Trim System Low Limit

Circuit Description

Fuel trim bias is used to keep the post catalyst air/fuel ratio within a predetermined range. This allows optimal catalyst efficiency under various operating conditions. The engine control module (ECM) constantly monitors how lean or rich the fuel trim bias is commanded, to determine if the fuel trim bias is greater than a calibrated amount.

Conditions for Running the DTC

- DTC P0016, P0017, P0030, P0036, P0053, P0054, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0128, P0131, P0132, P0133, P0134, P0135, P0137, P0138, P013A, P013B, P013E, P013F, P0140, P0141, P015A, P015B, P0201, P0202, P0203, P0204, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0300, P0301, P0302, P0303, P0304, P0340, P0341, P0365, P0366, P0411, P0442, P0443, P0446, P0449, P0452, P0453, P0455, P0458, P0459, P0496, P0498, P0499, P111E, P1248, P1249, P124A, P124B, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P219A, P2227, P2228, P2229, P2230, P2270, P2271, P2440, P2444, or P2A00 is not set.
- The barometric pressure (BARO) is greater than 70 kPa (10.2 PSI).
- The manifold absolute pressure (MAP) is between 0-200 kPa (0-29 PSI).
- The intake air temperature (IAT) is between -20°C and +200°C (-4 and +392°F).
- The start up engine coolant temperature is warmer than -20°C (-4°F).
- The fuel control intrusive diagnostics are not active.
- The engine is operating under light acceleration, heavy acceleration, or cruise conditions.
- DTC P2096 runs continuously when the conditions above have been met.

Conditions for Setting the DTC

The lean correction limit for a condition causing a rich air/fuel ratio has been exceeded.

Action Taken when the DTC Sets

- DTCs P2096 is a Type B DTC.
- The ECM records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the ECM stores this information in the Failure records. If the diagnostic reports a failure on the second ignition cycle, the ECM records the operating conditions at the time of the failure. The ECM writes the operating conditions to the Freeze Frame and updates the Failure records. The ECM illuminates the malfunction indicator lamp (MIL) when one of the following occurs:
  - The ECM detects the same fuel trim failure during 2 consecutive trips.
  - The ECM detects any fuel trim failure during any subsequent trip if the conditions at the time of failure meet the following criteria:
    - The engine load is within 20 percent of the previous test that failed.
    - The engine speed is within 375 RPM of the previous test that failed.
    - The engine coolant temperature is in the same range of the previous test that failed.

Conditions for Clearing the MIL/DTC

- DTCs P2096 is a Type B DTC.
- The ECM turns OFF the malfunction indicator lamp (MIL) at the beginning of the fourth ignition cycle, after 3 ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.

Diagnostic Aids

- The post catalyst fuel trim diagnostic is very sensitive to heated oxygen sensor (HO2S) design. A non-OE sensor or an incorrect part number may cause a DTC to set.
- Certain aftermarket air filters may cause a DTC to set.
- Certain aftermarket air induction systems or modifications to the air induction system may cause a DTC to set.
- Certain aftermarket exhaust system components may cause a DTC to set.

Reference Information

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify no other HO2S or fuel trim DTC is set.
   - **If any other HO2S or fuel trim DTC is set**

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

   - **If no other HO2S or fuel trim DTC is set**
3. Verify DTC P2096 is not set.
   - **If a DTC is set**

     Refer to Circuit/System Testing.

   - **If no DTC is set**
4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed in the Freeze Frame/Failure Records data.
5. Verify DTC P2096 is not set.
   - **If a DTC is set**

     Refer to Circuit/System Testing.

   - **If no DTC is set**
6. All OK.

Circuit/System Testing

Inspect for the conditions listed below:

- Air intake duct collapsed or restricted.
- Air filter dirty or restricted.
- Objects blocking the throttle body.
- Excessive fuel in the crankcase. Change engine oil as necessary.

- Rich fuel injectors. Refer to **Fuel Injector Solenoid Coil Test**.
- Excessive fuel system pressure. Refer to **Fuel System Diagnosis**.
- Fuel contamination. Refer to **Alcohol/Contaminants-in-Fuel Diagnosis**.
- Fuel saturation of the evaporative emissions (EVAP) canister
- Stuck open or leaking EVAP purge valve
- Restricted exhaust. Refer to **Symptoms - Engine Exhaust** .
- Crankcase ventilation system for improper operation. Refer to **Crankcase Ventilation System Inspection/Diagnosis** .

- If a condition is found

  Repair as necessary.

Repair Instructions

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

DTC P2097

Diagnostic Instructions

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

DTC Descriptors

DTC P2097

Post Catalyst Fuel Trim System High Limit

Circuit Description

Fuel trim bias is used to keep the post catalyst air/fuel ratio within a predetermined range. This allows optimal catalyst efficiency under various operating conditions. The engine control module (ECM) constantly monitors how lean or rich the fuel trim bias is commanded, to determine if the fuel trim bias is greater than a calibrated amount.

Conditions for Running the DTC

- DTC P0016, P0017, P0030, P0036, P0053, P0054, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0128, P0131, P0132, P0133, P0134, P0135, P0137, P0138, P013A, P013B, P013E, P013F, P0140, P0141, P0201, P0202, P0203, P0204, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0300, P0301, P0302, P0303, P0304, P0340, P0341, P0365, P0366, P0411, P0442, P0443, P0446, P0449, P0452, P0453, P0455, P0458, P0459, P0496, P0498, P0499, P111E, P1248, P1249, P124A, P124B, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P219A, P2227, P2228, P2229, P2230, P2270, P2271, P2440, P2444, or P2A00 is not set.

- The barometric pressure (BARO) is greater than 70 kPa (10.2 PSI).
- The manifold absolute pressure (MAP) is between 0-200 kPa (0-29 PSI).
- The intake air temperature (IAT) is between -20 and +200°C (-4 and +392°F).
- The start up engine coolant temperature is warmer than -20°C (-4°F).
- The fuel control intrusive diagnostics are not active.
- The engine is operating under light acceleration, heavy acceleration, or cruise conditions.
- DTC P2097 runs continuously when the conditions above have been met.

Conditions for Setting the DTC

The rich correction limit for a condition causing a lean air/fuel ratio has been exceeded.

Action Taken when the DTC Sets

- DTCs P2097 is a Type B DTC.
- The ECM records the operating conditions at the time the diagnostic fails. The first time the diagnostic fails, the ECM stores this information in the Failure records. If the diagnostic reports a failure on the second ignition cycle, the ECM records the operating conditions at the time of the failure. The ECM writes the operating conditions to the Freeze Frame and updates the Failure records. The ECM illuminates the malfunction indicator lamp (MIL) when one of the following occurs:
  - The ECM detects the same fuel trim failure during 2 consecutive trips.
  - The ECM detects any fuel trim failure during any subsequent trip if the conditions at the time of failure meet the following criteria:
    - The engine load is within 20 percent of the previous test that failed.
    - The engine speed is within 375 RPM of the previous test that failed.
    - The engine coolant temperature is in the same range of the previous test that failed.

Conditions for Clearing the MIL/DTC

- DTCs P2097 is a Type B DTC.
- The ECM turns OFF the malfunction indicator lamp (MIL) at the beginning of the fourth ignition cycle, after 3 ignition cycles that the diagnostic runs and does not fail.
- A current DTC, Last Test Failed, clears when the diagnostic runs and passes.

Diagnostic Aids

- The post catalyst fuel trim diagnostic is very sensitive to heated oxygen sensor (HO2S) design. A non-OE sensor or an incorrect part number may cause a DTC to set.
- An exhaust system leak that may not be audible can set this DTC.
- Certain aftermarket air filters may cause a DTC to set.
- Certain aftermarket air induction systems or modifications to the air induction system may cause a DTC to set.
- Certain aftermarket exhaust system components may cause a DTC to set.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify no other HO2S or fuel trim DTC is set.
   - **If any other HO2S or fuel trim DTC is set**

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

   - **If no other HO2S or fuel trim DTC is set**
3. Verify DTC P2097 is not set.
   - **If a DTC is set**

     Refer to Circuit/System Testing.

   - **If no DTC is set**
4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed in the Freeze Frame/Failure Records data.
5. Verify DTC P2097 is not set.
   - **If a DTC is set**

Refer to Circuit/System Testing.

- **If no DTC is set**

6. All OK.

Circuit/System Testing

Inspect for the conditions listed below:

- Exhaust system leaks. Refer to **Symptoms - Engine Exhaust** .
- Vacuum hoses for splits, kinks, and proper connections
- Insufficient fuel in the tank
- Air induction system and air intake ducts for leaks
- Missing air filter element
- Cracked evaporative canister
- Evaporative pipes plugged, obstructed, or leaking
- Crankcase ventilation system leaking. Refer to **Crankcase Ventilation System Inspection/Diagnosis** .
- Engine vacuum leaks
- Low fuel system pressure. Refer to **Fuel System Diagnosis**.
- Contaminated fuel. Refer to **Alcohol/Contaminants-in-Fuel Diagnosis**.
- Lean fuel injectors. Refer to **Fuel Injector Solenoid Coil Test**.

- If a condition is found

  Repair as necessary.

Repair Instructions

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

DTC P2122, P2123, P2127, P2128, OR P2138

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** provide an overview of each diagnostic category.

DTC Descriptors

DTC P2122

Accelerator Pedal Position (APP) Sensor 1 Circuit Low Voltage

DTC P2123

Accelerator Pedal Position (APP) Sensor 1 Circuit High Voltage

DTC P2127

Accelerator Pedal Position (APP) Sensor 2 Circuit Low Voltage

DTC P2128

Accelerator Pedal Position (APP) Sensor 2 Circuit High Voltage

DTC P2138

Accelerator Pedal Position (APP) Sensors 1-2 Not Plausible

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
APP Sensor 1 5 V Reference	P06A3	P2138	P2122	P06A3	P2138
APP Sensor 2 5 V Reference	P0108, P0697	P2138	P2127	P0107, P0522, P0532, P0697	P2138
APP Sensor 1 Signal	P2122	P2138	P2122	P2123	P2138
APP Sensor 2 Signal	P2127	P2138	P2127	P2128	P2138
APP Sensor 1 Low Reference	-	P2138	P2123	-	P2138
APP Sensor 2 Low Reference	-	P2138	P2128	-	P2138

Typical Scan Tool Data

APP Sensor 1

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: The engine is operating at idle. **Parameter Normal Range:** APP Sensor 1 0.88-1.08 V			
APP Sensor 1 5 V Reference	0.00 V	0.00 V	2-4 V
APP Sensor 1 Signal	0.00 V	0.00 V	4-5 V
APP Sensor 1 Low Reference	-	4-5 V	-

APP Sensor 2

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: The engine is operating at idle. **Parameter Normal Range:** APP Sensor 2 0.39-0.59 V			
APP Sensor 2 5 V Reference	0.00 V	0.00 V	1-3 V
APP Sensor 2 Signal	0.00 V	0.00 V	2-5 V
APP Sensor 2 Low Reference	-	4-5 V	-

Circuit/System Description

The accelerator pedal assembly contains 2 accelerator pedal position (APP) sensors. The APP sensors are mounted to the accelerator pedal assembly and are not serviceable. The APP sensors provide a signal voltage that changes relative to pedal position. The engine control module (ECM) supplies each APP sensor with a 5 V reference circuit, a low reference circuit, and a signal circuit.

Conditions for Running the DTC

P2122, P2123, P2127, P2128

- DTC P0697 and P06A3 are not set.
- The ignition is ON or the engine is running.
- The run/crank or powertrain relay voltage is greater than 6.0 V and reduced power is not active.
- DTC P2122, P2123, P2127, P2128 run continuously when the above conditions are met.

P2138

- DTC P0697, P06A3, P2122, P2123, P2127, and P2128 are not set.
- The ignition is ON or the engine is running.
- The run/crank or powertrain relay voltage is greater than 6.0 V and reduced power is not active.
- DTC P2138 runs continuously when the above conditions are met.

Conditions for Setting the DTC

P2122

The ECM detects the APP sensor 1 voltage is less than 0.46 V for greater than 1 s.

P2123

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

P2127

The ECM detects the APP sensor 2 voltage is less than 0.32 V for greater than 1 s.

P2128

The ECM detects the APP sensor 2 voltage is greater than 2.6 V for greater than 1 s.

P2138

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

Action Taken When the DTC Sets

- DTCs P2122, P2123, P2127, P2128, and P2138 are Type A DTCs.

- The control module commands the TAC system to operate in the Reduced Engine Power mode.
- A message center or an indicator displays Reduced Engine Power.
- Under certain conditions the control module commands the engine OFF.

Conditions for Clearing the MIL/DTC

DTCs P2122, P2123, P2127, P2128, and P2138 are Type A DTCs.

Diagnostic Aids

A high resistance condition on the accelerator pedal sensor circuits could cause a DTC to set.

Ensure that the in-line harness connector seals are installed correctly. Improper installation could result in water intrusion into the connector and cause a DTC to set.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

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Description and Operation

Throttle Actuator Control (TAC) System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0697 or P06A3 is not set.

- **If any of the DTCs are set**

  Refer to **DTC P0641, P0651, P0697, or P06A3 (ECM)** for further diagnosis.

- **If none of the DTCs are set**

3. Verify the scan tool APP Sensor 1 Circuit Status and APP Sensor 2 Circuit Status parameters display OK.
   - **If OK is not displayed**

     Refer to Circuit/System Testing.

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

     Refer to Circuit/System Testing

   - **If Agree**
5. Verify that DTC P2122, P2123, 2127, P2128, or P2138 is not set.
   - **If any of the DTCs are set**

     Refer to Circuit/System Testing

   - **If none of the DTCs set**
6. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
7. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing

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

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B107 Accelerator Pedal Position Sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 ohms between the appropriate low reference circuit terminal listed below and ground.
   - APP sensor 1 low reference circuit terminal 4

- APP sensor 2 low reference circuit terminal 5
- **If 5 ohms or greater**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for less than 2 ohms in the low reference circuit end to end.
   - If 2 ohms or greater, repair the open/high resistance in the circuit.
   - If less than 2 ohms, replace the K20 Engine Control Module.

- **If less than 5 ohms**

3. Ignition ON.
4. Test for 4.8-5.2 V between the appropriate 5 V reference circuit terminal listed below and ground.
   - APP sensor 1 5 V reference circuit terminal 2
   - APP sensor 2 5 V reference circuit terminal 1
   - **If less than 4.8 V**

   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the 5 V reference circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 ohms in the 5 V reference circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.
      - If less than 2 ohms, replace the K20 Engine Control Module.

   - **If greater than 5.2 V**

   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the 5 V reference circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.

   - **If between 4.8-5.2 V**

5. Verify the scan tool APP sensor 1 and APP sensor 2 voltage parameters are less than 0.3 V.
   - **If 0.3 V or greater**

   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the signal circuit terminal listed below and ground.
      - APP sensor 1 signal circuit terminal 3
      - APP sensor 2 signal circuit terminal 6
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
      - **If less than 0.3 V**

6. Install a 3 A fused jumper wire between the appropriate signal circuit terminal listed below and the 5 V reference circuit terminal 1.
   - APP sensor 1 signal circuit terminal 3
   - APP sensor 2 signal circuit terminal 6
7. Verify the scan tool APP sensor 1 or APP sensor 2 voltage parameter is greater than 4.8 V.

- **If 4.8 V or less**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the signal circuit terminal and ground.
   - If less than infinite resistance, repair the short to ground on the circuit.
   - If infinite resistance
3. Test for less than 2 ohms in the signal circuit end to end.
   - If 2 ohms or greater, repair the open/high resistance in the circuit.
   - If less than 2 ohms, replace the K20 Engine Control Module.

- **If greater than 4.8 V**

8. Test or replace the B107 Accelerator Pedal Position Sensor.

Repair Instructions

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

- **Accelerator Pedal with Position Sensor Assembly Replacement**
- **Control Module References** for engine control module replacement, programming, and setup

DTC P2199

Diagnostic Instructions

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

DTC Descriptor

DTC P2199

Intake Air Temperature (IAT) Sensor 1-2 Not Plausible

Diagnostic Fault Information

IAT Sensor 1

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	P0112, P0114**, P2199	P0111, P0113, P0114**, P2199	P0113*, P0114**, P2199	P0111, P2199
Low Reference	-	P0111, P0113, P0114**, P2199	P0113*, P0114**	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+. **Where used.				

IAT Sensor 2

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0096, P0097, P00F4, P0102, P2199	P0096, P0097, P00F4, P0102, P2199	-	P0096
Signal	P0096, P0097, P00F5, P2199	P0096, P0097, P00F4, P0102, P2199	P0096*, P0097, P00F4, P0102, P2199	P0096
Ground	-	P0096, P0097, P00F4, P0102, P2199	-	P0096
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

IAT Sensor 1

Circuit	Short to Ground	Open or High Resistance	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** Varies with ambient temperature			
Signal	150°C (302°F)	-40°C (-40°F)	-40°C (-40°F)*
Low Reference	-	-40°C (-40°F)	-40°C (-40°F)*
*Internal ECM or sensor damage may occur if the circuit is shorted to B+			

IAT Sensor 2

Circuit	Short to Ground	Open or High Resistance	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** Varies with ambient temperature			
Ignition Voltage	-40°C (-40°F) 10 Hz	-40°C (-40°F) 10 Hz	-
Signal	-40°C (-40°F) 10 Hz	-40°C (-40°F) 10 Hz	-40°C (-40°F) 10 Hz*
Ground	-	-40°C (-40°F) 10 Hz	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+			

Circuit/System Description

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

The IAT sensor 2 produces a frequency signal based on the inlet air temperature very close to the humidity sensor within the sensor bore. The signal varies with inlet air temperature and is displayed by the scan tool as °C (°F) and Hertz (Hz). The ECM applies 5 V to the circuit. The signal circuit is shared by the IAT sensor 2 and the humidity sensor. Ignition voltage and ground circuits are also supplied to the multifunction

intake air sensor's internal circuits for these sensors:

- IAT sensor 2
- Humidity sensor
- MAF sensor

The multifunction intake air sensor houses the following:

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

IAT Sensor 1 - Temperature, Resistance, Voltage Table

IAT Sensor 1	IAT Sensor 1 Resistance	IAT Sensor 1 Signal Voltage
Cold	High	High
Warm	Low	Low

IAT Sensor 2 - Temperature, Frequency Table

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

Conditions for Running the DTC

- The ignition is ON.
- Ignition 1 voltage is at least 11 V.
- This DTC runs continuously within the enabling conditions.

Conditions for Setting the DTC

The ECM detects that the absolute difference between the IAT sensor 1 and the IAT sensor 2 temperatures is greater than 55°C (99°F) for longer than 5 s.

Action Taken When the DTC Sets

DTC P2199 is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P2199 is a Type B DTC.

Diagnostic Aids

- With the ignition ON, the engine OFF, if the engine is cold, a properly functioning IAT sensor 2 will gradually increase the scan tool IAT Sensor 2 parameter. This is due to the heat that is generated by

the 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 Humidity Sensor DTCs, check for a circuit problem.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

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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

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)** .

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC DTC P0641, P0651, P0697, or P06A3 is not set.
    - **If any of the DTCs are set**

      Refer to **DTC P0641, P0651, P0697, or P06A3 (ECM)** 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 30°C (54°F) of each other.
   - Start-Up IAT Sensor 1
   - IAT Sensor 2
   - IAT Sensor 3; where equipped
   - **If not within 30°C (54°F)**

     Refer to Circuit/System Testing.

   - **If within 30°C (54°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

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 ohms between the low reference circuit terminal 3 and ground.
   - **If 2 ohms or greater**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for less than 2 ohms in the low reference circuit end to end.
    - If 2 ohms or greater, repair the open or high resistance in the circuit.
    - If less than 2 ohms replace the K20 Engine Control Module.

- **If less than 2 ohms**

3. Ignition OFF, all vehicle systems OFF, test for less than 2 ohms between the ground circuit terminal 7 and ground.

- **If 2 ohms or greater**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for less than 2 ohms in the ground circuit end to end.
    - If 2 ohms or greater, repair the open or high resistance in the circuit.
    - If less than 2 ohms, repair the open/high resistance in the ground connection.

- **If less than 2 ohms**

4. Ignition ON, verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.

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

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

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

1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
2. Test for infinite resistance between the ignition voltage circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance
3. Test for greater than 2 ohms between the ignition voltage circuit terminal 5 and ground.
    - If less than 2 ohms, repair the short to ground on the circuit.
    - If greater than 2 ohms, test all the components connected to the circuit and repair or replace as necessary.

- **If a test lamp illuminates**

5. Ignition ON, test for 4.8-5.2 V between the intake air temperature sensor 1 signal circuit terminal 1 and ground.

- **If less than 4.8 V**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the signal circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance
3. Test for less than 2 ohms in the signal circuit end to end.
    - If 2 ohms or greater, repair the open/high resistance in the circuit.
    - If less than 2 ohms, replace the K20 Engine Control Module.

- **If greater than 5.2 V**

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

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
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).**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit terminal 1 and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 ohms in the signal circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, 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 1 and the low reference circuit terminal 3.
8. Verify the scan tool IAT Sensor 1 parameter is warmer than 148°C (298°F).
    - **If colder than 148°C (298°F).**
    1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V
    3. Ignition OFF.
    4. Test for less than 2 ohms in the signal circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
    - **If warmer than 148°C (298°F).**
9. Ignition ON, test for 4.8-5.2 V between the intake air temperature sensor 2 signal circuit terminal 8 and ground.
    - **If less than 4.8 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 ohms in the signal circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.

- If less than 2 ohms, replace the K20 Engine Control Module.

- **If greater than 5.2 V**

NOTE: If the signal circuit is shorted to a voltage the engine control module or the sensor may be damaged.

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
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**
    1. Replace the K20 Engine Control Module.
    2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
    3. Verify the DTC does not set.
       - **If the DTC sets**

         Refer to step 17.

       - **If the DTC does not set**
    4. All OK.
    - **EL-38522-A, 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 8 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, 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.
15. Test for less than 2 ohms between the intake air temperature sensor 3 low reference circuit terminal 1 and ground.

- **If 2 ohms or greater**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for less than 2 ohms in the low reference circuit end to end.
   - If 2 ohms or greater, repair the open or high resistance in the circuit.
   - If less than 2 ohms replace the K20 Engine Control Module.

- **If less than 2 ohms**

16. Ignition ON, test for 4.8-5.2 V between the signal circuit terminal 2 and ground.
    - **If less than 4.8 V**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the signal circuit and ground.
   - If less than infinite resistance, repair the short to ground on the circuit.
   - If infinite resistance
3. Test for less than 2 ohms in the signal circuit end to end.
   - If 2 ohms or greater, repair the open/high resistance in the circuit.
   - If less than 2 ohms, replace the K20 Engine Control Module.

- **If greater than 5.2 V**

NOTE: If the signal circuit is shorted to a voltage the engine control module or the sensor may be damaged.

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
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 B75C Multifunction Intake Air Sensor.

Component Testing

Multifunction Intake Air Sensor

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

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

2. Test the IAT sensor 1 by varying the sensor temperature while monitoring the sensor resistance. Compare the readings with the **Temperature Versus Resistance - Intake Air Temperature Sensor (Hitachi Sensor)** , **Temperature Versus Resistance - Intake Air Temperature Sensor (Delco Sensor)** table for Hitachi Sensors. The resistance values should be in range of the table values.
   - **If not within the specified range**

     Replace the B75C Multifunction Intake Air Sensor.

   - **If within the specified range**

3. All OK.

Multifunction Intake Air Sensor

1. Test the IAT Sensor 2 by varying the sensor temperature while monitoring the air temperature with a thermometer. Compare the readings with the scan tool IAT Sensor 2 parameter. The values should be within 5%.
    - **If not within the specified range**

      Replace the B75C Multifunction Intake Air Sensor.

    - **If within the specified range**
2. All OK.

Repair Instructions

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

- **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement** for multifunction intake air sensor replacement
- **Control Module References** for engine control module replacement, programming, and setup.

DTC P219A

Diagnostic Instructions

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

DTC Descriptor

DTC P219A

Fuel Trim Cylinder Balance

Circuit/System Description

The Fuel Trim Cylinder Balance diagnostic detects a rich or lean cylinder to cylinder air/fuel ratio imbalance. The diagnostic monitors the pre-catalyst heated oxygen sensor (HO2S) signal's frequency and amplitude characteristics by calculating an accumulated voltage over a predetermined sample period. An imbalance is indicated when multiple samples of the accumulated voltage are consistently higher than the desired value.

Conditions for Running the DTC

- DTCs P0016, P0017, P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0116, P0117, P0118, P0122, P0123, P0128, P0201-P0204, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0300, P0301-P0304, P0340, P0341, P0365, P0366, P0411, P0442, P0455, P0458,

P0496, P111E, P1248, P1249, P124A, P124B, P2101, P2135, P2147, P2148, P2150. P2151, P2153, P2154, P2156, P2157, P2440, P2444 are not set.

- The evaporative emission system device control and intrusive diagnostics are not active.
- The engine overspeed protection is not active.
- The engine is in closed loop status.
- The system voltage is greater than 11 V.
- The engine coolant temperature (ECT) is warmer than -20°C (-4°F).
- The engine speed is between 1,250-4,000 RPM.
- The mass air flow is between 0-100 g/s.
- The secondary air injection pump (if equipped) is not ON.
- Engine run time is greater than 30 s.
- Fuel level is greater than 10% and no fuel level sensor fault is present.
- The DTC runs continuously when the above conditions have been met.

Conditions for Setting the DTC

Multiple samples of the pre-catalyst HO2S accumulated voltage are consistently greater than the desired value.

Action Taken When the DTC Sets

DTC P219A is a Type A DTC.

Conditions for Clearing the MIL/DTC

DTC P219A is a Type A DTC.

Diagnostic Aids

- The fuel trim cylinder balance diagnostic is very sensitive to heated oxygen sensor (HO2S) design. A non-OE sensor or an incorrect part number may cause a DTC to set.
- Monitoring the misfire current counters, or misfire graph, may help to isolate the cylinder that is causing the condition.
- Certain aftermarket air filters may cause a DTC to set.
- Certain aftermarket air induction systems or modifications to the air induction system may cause a DTC to set.
- Certain aftermarket exhaust system components may cause a DTC to set.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Electrical Information Reference

- **Circuit Testing**
- **Troubleshooting with a Test Lamp**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**
- **Connector Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify no other DTCs are set.
   - **If any other DTCs are set**

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

   - **If no other DTCs are set**
3. Verify DTC P219A is not set.
   - **If a DTC is set**

     Refer to Circuit/System Testing.

   - **If no DTC is set**
4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed in the Freeze Frame/Failure Records data.
5. Verify DTC P219A is not set.
   - **If a DTC is set**

     Refer to Circuit/System Testing.

   - **If no DTC is set**
6. All OK.

Circuit/System Testing

1. Engine idling, transmission in Park or Neutral, verify the manifold absolute pressure (MAP) sensor parameter is between 20-48 kPa.
    - **If not within the specified range** .

      Refer to **DTC P0106** , or **DTC P0107 or P0108**

    - **If within the specified range, inspect for the conditions listed below:**
    - Air induction system for modified, damaged, leaking, or restricted components.
    - Crankcase ventilation system for improper operation. Refer to **Crankcase Ventilation System Inspection/Diagnosis** .
    - Vacuum hoses for splits, kinks, and improper connections.
    - Restricted, damaged, leaking, or modified exhaust system from the catalytic converter forward. Refer to **Symptoms - Engine Exhaust** .
    - Fuel injectors for improper operation. Refer to **Fuel Injector Solenoid Coil Test**.
    - Test for fuel contamination. Refer to **Alcohol/Contaminants-in-Fuel Diagnosis**.
    - Excessive fuel in the crankcase due to leaking injectors. Change engine oil as necessary.
    - Ignition system for improper operation. Refer to **Electronic Ignition System Diagnosis**.
    - **If a condition is found**

      Repair as necessary.

    - **If no condition is found**
2. Test the engine for any mechanical conditions such as sticking valves, lifters, etc., which could alter the flow into the combustion chamber. Refer to **Symptoms - Engine Mechanical** .

Repair Instructions

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

DTC P2227-P2230

Diagnostic Instructions

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

DTC Descriptors

DTC P2227

Barometric Pressure (BARO) Sensor Performance

DTC P2228

Barometric Pressure (BARO) Sensor Circuit Low Voltage

DTC P2229

Barometric Pressure (BARO) Sensor Circuit High Voltage

DTC P2230

Barometric Pressure (BARO) Sensor Circuit Erratic

Diagnostic Fault Information

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

Typical Scan Tool Data

BARO

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

Circuit/System Description

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

Conditions for Running the DTC

P2227

- Engine is running.
  - DTC P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0121, P0122, P0123, P0222, P0223, P1516, P2101, P2135, P2228, or P2229 is not active.
  - DTC P2227 runs continuously when the above conditions are met.

OR

- Ignition is ON, engine is OFF for at least 10 s.
  - DTC P0106, P0107, P0108, P2228, P2229, P2230, or P2610 is not active .
  - DTC P0107, P0108, P2228, or P2229 is not pending.
  - DTC P2227 runs continuously when the above conditions are met.

P2228 or P2229

- Engine is running.
- The DTCs run continuously when the above condition is met .

P2230

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

Conditions for Setting the DTC

P2227

- The engine is running.
  - The ECM detects that the difference between the actual BARO and the calculated BARO is greater than 15 kPa when the distance traveled since the last calculated BARO update is less than or equal to 0.1 km (0.06 mi).

    OR

  - The ECM detects that the difference between the actual BARO and the calculated BARO is greater than 20 kPa when the distance traveled since the last calculated BARO update is greater than 0.1 km (0.06 mi).

    OR

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

    OR

  - The ECM detects that the absolute value of the difference between MAP and actual BARO is greater than 10 kPa and the absolute value of the difference between Boost Pressure and MAP is less than or equal to 10 kPa and the absolute value of the difference between Boost Pressure and BARO is greater than 10 kPa.

P2228

The ECM detects that the BARO sensor voltage is less than 1.7 V for greater than 5 s.

P2229

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

P2230

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

Action Taken When the DTC Sets

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

Conditions for Clearing the MIL/DTC

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

Diagnostic Aids

A skewed boost pressure sensor (Turbocharger Boost/Intake Air Temperature Sensor) may cause this DTC to set.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify the scan tool BARO parameter is within the range specified in the **Altitude Versus Barometric Pressure** table.
   - **If the BARO is not within the specified range**

     Refer to Circuit/System Testing.

   - **If the BARO is within the specified range**
3. Verify the scan tool Boost Pressure parameter and the BARO parameter are within 3 kPa (0.43 PSI).
   - **If not within 3 kPa (0.43 PSI)**

     Refer to **DTC P0236** .

   - **If within 3 kPa (0.43 PSI)**
4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed in the Freeze Frame/Failure Records data.
5. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Verify the conditions listed below do not exist with the B75C Multifunction Intake Air Sensor:
   - Damage
   - Restrictions in the inlet port
   - **If a condition exists**

     Repair or replace the B75C Multifunction Intake Air Sensor as necessary.

   - **If none of the conditions exist**
2. Ignition OFF, and all vehicle systems OFF, it may take up to 2 minutes for all vehicle systems to power down. Disconnect the harness connector at the B75C Multifunction Intake Air Sensor.
3. Test for less than 5 ohms between the low reference circuit terminal 3 and ground.
   - **If 5 ohms or greater**
     1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
     2. Test for less than 2 ohms in the low reference circuit end to end.
        - If greater than the specified value, repair the open or high resistance in the circuit.
        - If 2 ohms or less replace the K20 Engine Control Module.
   - **If less than 5 ohms**

4. Ignition ON.
5. Test for 4.8-5.2 V between the 5 V reference circuit terminal 2 and ground.
    - **If less than 4.8 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the 5 V reference circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 ohms in the 5 V reference circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
    - **If greater than 5.2 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the 5 V reference circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If between 4.8-5.2 V**
6. Verify the scan tool BARO Sensor parameter is less than 0.2 V.
    - **If 0.2 V or greater**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit terminal 4 and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If less than 0.2 V**
7. Install a 3 A fused jumper wire between the signal circuit terminal 4 and the 5 V reference circuit terminal 2.
8. Verify the scan tool BARO Sensor parameter is greater than 4.5 V.
    - **If 4.5 V or less**
    1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit terminal 4 and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 ohms in the signal circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
    - **If greater than 4.5 V**
9. Test or replace the B75C Multifunction Intake Air Sensor.

Repair Instructions

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

- **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement** for multifunction intake air sensor replacement
- **Control Module References** for engine control module replacement, programming, and setup

DTC P2261

Diagnostic Instructions

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

DTC Descriptor

DTC P2261

Turbocharger Bypass Valve Stuck

Circuit/System Description

The dual-scroll turbocharger incorporates a wastegate that is controlled by the engine control module (ECM) by means of a pulse width modulation (PWM) solenoid, to regulate the pressure ratio of the compressor. An ECM controlled compressor bypass valve is integrated into the unit to prevent compressor surging and damage from vibrations by opening during abrupt closed throttle conditions. The bypass valve is open during closed throttle deceleration conditions to allow air to recirculate in the turbocharger and maintain compressor speed.

As engine load and RPM increase, the turbocharger bypass valve is commanded closed by the ECM. As soon as the throttle closes, the valve is commanded open to allow the turbocharger air to recirculate to prevent compressor surging.

Conditions for Running the DTC

- DTC P0033, P0034, P0035, P0101, P0102, P0103, P0236, P0237, or P0238 is not set.
- Engine speed is at least 1,500 rpm
- The boost pressure versus the BARO pressure ratio is between 1.1-3.3.
- The turbocharger bypass valve has been commanded Open greater than 6% for greater than 1 s immediately after an abrupt closed throttle has occurred and the resulting pressure ratio across the compressor exceeds the calibrated pressure ratio limit.
- The DTC runs continuously when the above conditions have been met.

Conditions for Setting the DTC

The ECM has detected a series of pulsations in the induction system that exceed a calibrated threshold.

Action Taken When the DTC Sets

DTC P2261 is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P2261 is a Type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

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.

Circuit/System Verification

1. Ignition On.
2. Verify that DTC P0033, P0034, or P0035 is not set
   - **If any of the DTCs are set**

     Refer to **DTC P0033-P0035** .

   - **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 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).**
5. Verify a click is heard or felt from the Q40 turbocharger bypass solenoid valve when commanding the Turbocharger Bypass Solenoid Valve between Active and Inactive with a scan tool.
   - **If a click is not heard or felt**

     Refer to Circuit/System Testing

   - **If a click is heard or felt**
6. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
7. Verify a DTC does not set.
   - **If a DTC sets**

     Refer to Circuit/System Testing

   - **If a DTC does not set**
8. All OK

Circuit/System Testing

NOTE: Leave harness connector connected or re-connect it after removing valve.

1. Ignition Off. Disconnect the Q40 turbocharger bypass solenoid valve, ignition On.
2. Verify the turbocharger bypass valve plunger retracts and extends when commanding the Turbocharger Bypass Solenoid Valve between Active and Inactive with a scan tool.
   - **The valve plunger does not retract and extend**

     Replace the Q40 turbocharger bypass solenoid valve

   - **The valve plunger retracts and extends**
3. Verify the conditions listed below do not exist with the turbocharger assembly. Refer to **Turbocharger Cleaning and Inspection**
   - Cracked, damaged or worn turbine blades
   - Restricted wastegate, turbine, ports or passages
   - Foreign material
   - **If a condition exists**

Repair or replace the turbocharger as necessary

- **If none of the conditions exist**

4. Replace the Q40 turbocharger bypass solenoid valve

Component Testing

Static Test

1. Ignition Off, disconnect the harness connector at the Q40 turbocharger bypass solenoid valve .
2. Test for 10-14 ohms between the control terminal 2 and the Ignition terminal 1 of the Q40 turbocharger bypass solenoid valve .
   - **If not between 10-14 ohms**

     Replace the Q40 turbocharger bypass solenoid valve .

   - **If between 10-14 ohms**
3. All OK

Dynamic Test

1. Install a 10 A fused jumper wire between the ignition terminal 2 of the Q40 turbocharger bypass solenoid valve and 12 V. Install a jumper wire between the control terminal 1 and ground.
2. Verify the Q40 turbocharger bypass solenoid valve plunger retracts.
   - **If the plunger does not retract.**

     Replace the Q40 turbocharger bypass solenoid valve .

   - **If the plunger retracts.**
3. All OK

Repair Instructions

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

Turbocharger Bypass Valve Solenoid Replacement

DTC P2544

Diagnostic Instructions

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

DTC Descriptors

DTC P2544

Transmission Torque Request Signal Message Counter Incorrect

Circuit/System Description

To improve shift feel, the transmission control module (TCM) is constantly sending the engine control module (ECM) serial data messages with information regarding it's request for modifying engine speed or torque. The serial data messages are sent through two circuits which are part of a communication network called the controller area network (CAN). The ECM sets DTC P2544 when it detects a discrepancy in the structure of the message causing the integrity of the message to be questioned.

Conditions for Running the DTC

- The engine run time is greater than 0.5 s.
- No other CAN errors are present.

Conditions for Setting the DTC

The ECM detects that the engine speed and torque modification messages from the TCM are either corrupted or intermittently missing for greater than 4 s.

Action Taken When the DTC Sets

- DTC P2544 is a Type B DTC.
- The TCM commands maximum line pressure during shifts, which results in harsh shifts.
- The TCM freezes adaptive functions.

Conditions for Clearing the DTC

DTC P2544 is a Type B DTC.

Diagnostic Aids

An intermittent fault in the CAN circuits will cause the ECM to set DTC P2544.

Reference Information

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Circuit/System Verification

NOTE:

- **DTC P2544 is an informational DTC.**
- **Diagnose all other engine control module DTCs prior to DTC P2544.**

1. Verify that no other DTCs are set except for DTC P2544.
   - **If any other DTCs are set**

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

- **If only DTC P2544 is set**

2. Replace the K71 Transmission Control Module.
3. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
4. Verify the DTC does not set.
   - **If DTC sets**

     Replace the K20 Engine Control Module.

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

Repair Instructions

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

Control Module References for ECM or control solenoid valve assembly replacement, programming, and setup.

DTC P2635

Diagnostic Instructions

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

DTC Descriptor

DTC P2635

Fuel Pump Flow Performance

Circuit/System Description

The engine control module (ECM) supplies voltage to the fuel pump power control module when the ECM detects that the ignition is on. The voltage from the ECM to the fuel pump power control module remains active for 2 seconds, unless the engine is in crank or run. While this voltage is being received, the fuel pump power control module closes the ground switch of the fuel pump. The fuel pump power control module maintains correct fuel pressure based on the information from the fuel pressure sensor and varying the Pulse Width Modulation (PWM) controlled current to the fuel pump.

Conditions for Running the DTC

- DTC P018B, P018C, P018D, P0231, P0232, P023F, P0641, P064A, P0606, P1255, P129E, or P12A6 are not active.
- Fuel pump control is enabled and the fuel pump control state is normal.
- The ignition voltage is between 11-32 V.

- The engine has been running for more than 30 seconds.
- The engine fuel flow is not 0.
- Low fuel level warning not present.
- The DTC runs continuously when the conditions above are met.

Conditions for Setting the DTC

The fuel pump power control module detects a difference of ± 60 kPa at 400 kPa request or ±45 kPa at 300 kPa request between the desired fuel pressure and the actual fuel pressure for approximately 10 s.

Action Taken When the DTC Sets

DTC P2635 is a Type B DTC.

Conditions for Clearing the DTC

DTC P2635 is a Type B DTC.

Diagnostic Aids

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

On vehicles equipped with a high pressure mechanical pump on Direct Fuel Injection engines, the vehicle may continue to run even though the pump in the fuel tank is not operating.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC P018B, P018C, P018D, P0231, P0232, or P023F is not set.
   - **If any of the DTCs are set**

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

   - **If none of the DTCs are set**
3. Verify the scan tool Short Term Fuel Pump Trim and the Long Term Fuel Pump Trim when multiplied together are less than 1.5.
   - **If greater than 1.5**

     Refer to Circuit/System Testing.

   - **If less than 1.5**
4. Verify the scan tool Fuel Pressure Sensor and the Desired Fuel Pressure are within 45 kPa (6.5 psi) at 300 kPa (43.5 psi) request or 60 kPa (8.7 psi) at 400 kPa (58 psi) request of each other while operating the vehicle through varying loads.
   - **If greater than 45 kPa (6.5 psi)/60 kPa (8.7 psi)**

     Refer to Circuit/System Testing.

   - **If less than 45 kPa (6.5 psi)/60 kPa (8.7 psi)**
5. Operate the vehicle within the Conditions for Running the DTC to verify the DTC does not reset. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

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

Circuit/System Testing

NOTE: Do not replace the fuel pump power control module based on a history DTC P2635. DTC P2635 may be stored but that does not indicate a failure of the

fuel pump power control module. Refer to Strategy Based Diagnosis for further history DTC diagnostics.

1. Verify the proper fuel system pressure. Refer to **Fuel System Diagnosis**.
   - **If the fuel pressure is not normal**

     Repair the fuel system as necessary.

   - **If the fuel pressure is normal**
2. All OK.

Repair Instructions

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

- **Fuel Feed Front Pipe Replacement**
- **Fuel Feed Pipe Replacement (FWD)** , **Fuel Feed Pipe Replacement (AWD)**
- **Fuel Injector Replacement**
- **Fuel Tank Fuel Pump Module Replacement (FWD)** , **Fuel Tank Fuel Pump Module Replacement (AWD)**
- Perform the Fuel Pump Trim Reset procedure with a scan tool after the repair.

Repair Verification

1. Install any components that have been removed or replaced during diagnosis.
2. Perform any adjustments, programming or setup procedures that are required when a component is removed or replaced.
3. Clear the DTCs with a scan tool.
4. Turn OFF the ignition for 60 s.
5. Operate the vehicle within the Conditions for Running the DTC.
6. Verify the scan tool Short Term Fuel Pump Trim and the Long Term Fuel Pump Trim when multiplied together are less than 1.5.
   - **If greater than 1.5**

     Refer to Circuit/System Testing.

   - **If less than 1.5**
7. Verify the scan tool Fuel Pressure Sensor and the Desired Fuel Pressure are within 45 kPa (6.5 psi) at 300 kPa (43.5 psi) request or 60 kPa (8.7 psi) at 400 kPa (58 psi) request of each other while operating the vehicle through varying loads.
   - **If greater than 45 kPa (6.5 psi)/60 kPa (8.7 psi)**

     Refer to Circuit/System Testing.

   - **If less than 45 kPa (6.5 psi)/60 kPa (8.7 psi)**
8. All OK.

SYMPTOMS - ENGINE CONTROLS

Diagnostic Instructions

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

Symptoms Description

Symptoms covers conditions that are not covered by DTCs. Certain conditions can cause multiple symptoms. These conditions are listed together under Symptoms Testing. Conditions that may only cause specific symptoms are listed separately under Additional Symptoms Testing. Perform the Symptoms Testing before using the Additional Symptoms Testing.

Symptoms Definition

Backfire

The 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 occurs worse while under acceleration. The engine makes sharp metallic knocks that change with throttle opening.

Dieseling, Run-On

The engine continues to run after the key is turned OFF, but runs very rough.

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

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

Hesitation, Sag, Stumble

A 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 vehicle 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 speed may vary. Either condition may be severe enough to stall the engine.

Surges/Chuggles

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

Symptoms Verification

Before using the Symptom tables, perform the following inspections:

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

Identifying Intermittent Conditions

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

- Moisture and water intrusion in connectors, terminals, and components
- Incomplete connector mating

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

Visual/Physical Check

- Verify the control module grounds are clean, tight, and correctly located.
- Verify the vacuum hoses are not split or kinked, and are properly connected.
- Verify the air filter is clean and free from restrictions.
- Verify there is no water intrusion in connectors terminals and components.
- Inspect the air intake ducts for the following conditions:
  - Collapsed
  - Damaged areas
  - Looseness
  - Incorrect installation
  - Leaking
- Inspect for air leaks at the throttle body mounting area, the mass air flow (MAF) sensor and intake manifold sealing surfaces.
- Inspect the wiring harness for the following conditions:
  - Poor connections
  - Pinches
  - Cuts
- Inspect for loose, damaged, unseated, or missing sensors/components.
- Inspect the terminals for corrosion and correct contact.

Symptoms Testing

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

or Surges/Chuggles

- Test the fuel system for the following:
  - Incorrect fuel system operation and pressure-Refer to **Fuel System Diagnosis**.
  - Incorrectly operating fuel injectors-Refer to **Fuel Injector Solenoid Coil Test**.
  - Poor fuel quality condition-Refer to **Alcohol/Contaminants-in-Fuel Diagnosis**.
- Test the ignition system for the following:
  - Spark plugs with incorrect heat range or an abnormal condition-Refer to **Spark Plug Inspection** , and **Ignition System Specifications** .
  - Coolant or oil fouled spark plugs-For diagnosis, refer to **Coolant in Combustion Chamber** , or **Oil Consumption Diagnosis** .
  - Secondary ignition system susceptible to water. 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 **J-26792** Spark Tester -Refer to **Electronic Ignition System Diagnosis**.
- Inspect for the following conditions:
  - Incorrect operation of the transmission torque converter clutch (TCC)-The scan tool should indicate an engine speed drop when the TCC is commanded ON. Refer to **Torque Converter Diagnosis** .
  - Incorrect operation of the A/C compressor.
  - An engine that runs lean or rich. Observe the Fuel Trim parameters with a scan tool-Refer to **DTC P0171 or P0172** for more information.
  - Slow responding heated oxygen sensors (HO2S)-The HO2S should respond quickly to different throttle positions-Refer to **DTC P0133, P013A, P013B, P013E, P013F, P015A, P015B, P2270, or P2271** for more information.

CAUTION: Refer to Heated Oxygen and Oxygen Sensor Caution .

  - Water intrusion in the HO2S connector

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

  - Incorrect mass air flow sensor installation. A mass air flow sensor that is incorrectly installed may cause a hard start. Install the mass air flow in the proper direction. Refer to **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement** .
  - Incorrect mass air flow sensor connections.
  - Engine oil contaminated by fuel
  - Split or kinked vacuum hoses-Verify that the routing and connections are correct.
  - Excessive knock sensor system spark retard activity-Observe the Knock Retard parameter on the scan tool for activity more than 0°.
- Inspect for electromagnetic interference (EMI) 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.

- Inspect the crankshaft position sensor for an intermittent condition-Observe the scan tool Crankshaft Position Resync Counter parameter. The Resync Counter parameter should remain at 0 during all operating conditions, and when moving the related harnesses and connectors between the crankshaft position sensor and the ECM.
- Inspect for a stuck open evaporative emission (EVAP) canister purge solenoid.
- Inspect for incorrect operation of the crankcase ventilation valve-Refer to **Crankcase Ventilation System Inspection/Diagnosis** .
- Inspect the exhaust system components for the following:
  - Physical damage or possible internal failure
  - Restricted three-way catalytic converters

  For more information, refer to **Symptoms - Engine Exhaust** .

- Inspect the engine cooling system for the following conditions:
  - A thermostat with incorrect heat range. Refer to **Thermostat Diagnosis** .
  - Incorrect engine coolant level-If the level is low, refer to **Loss of Coolant** .
- Inspect the engine for the following mechanical failures:

  Refer to **Symptoms - Engine Mechanical** .

  - 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
  - Worn rocker arms
  - Broken valve springs
  - Excessive carbon buildup in the combustion chambers-Clean the chambers with top engine cleaner, if necessary. Follow the instructions on the can.
  - Incorrect engine parts
- If the above conditions do not address the symptom, refer to the Additional Symptoms Tests.

Additional Symptoms Tests

Detonation/Spark Knock

- Verify that the engine coolant temperature (ECT) has not shifted in value. Allow the engine to run and reach operating temperature. Observe the ECT Sensor parameter with a scan tool and compare the reading to that parameter listed on the **K20 Engine Control Module: Scan Tool Information** , list. If the reading is not in the range specified in the list, test the resistance of the ECT sensor. Refer to **Temperature Versus Resistance - Engine Coolant Temperature Sensor** , for resistance specifications. Replace the ECT sensor if the resistance is not within specification. Refer to **Engine**

Coolant Temperature Sensor Replacement . If the sensor is within the specification, test the ECT sensor circuits for high resistance.

- Test for an engine overheating condition. Refer to **Engine Overheating** .
- 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 (ECM) may limit engine power by reducing engine torque and, for some vehicles, fuel pressure as well. For most, but not all of the conditions, the engine control module will illuminate the reduced engine power lamp on the instrument panel cluster, however a DTC may not be set. Observe the scan tool Reduced Engine Power History parameter, if applicable, or refer to **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, towing heavy loads up an incline for an extended period of time, which may cause the engine oil or coolant to overheat. A repair may not be necessary. Inspect the airflow passageways in front of the engine for obstructions and clear away any debris or foreign material that is found. If no obstructions are found, review approved driving habits with the customer. The customer may need to operate the vehicle at a higher engine speed to improve cooling system performance, or, at a slower engine speed to reduce engine load.
- A cooling fan condition which may cause the engine control module to reduce engine power. Refer to **Cooling Fan Description and Operation** , and **Cooling System Description and Operation** to verify correct operation of the cooling fan.
- Temporarily reduced engine power. Under extremely cold ambient temperatures some SIDI equipped vehicles may experience ECM commanded reduced engine power for a few minutes during engine warm-up. This would be a normal condition, noticeable only at wide open throttle, and the reduced engine power lamp would not be illuminated.
- Reduced engine power due to OnStar® remote command. Verify the vehicle is not in the OnStar® initiated Stolen Vehicle Slowdown mode.
- Turbocharger boost pressure out of range, if equipped. Refer to **DTC P0234 or P0299** .
- High pressure fuel system condition. Refer to **Fuel System Diagnosis**, and **Fuel System Description** to verify high pressure fuel system operation.
- Maximum recommended engine oil life exceeded. Refer to the Owners Manual for scheduled maintenance recommendations.
- 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.
- Fuel temperature out of range too high. Observe the scan tool Fuel Temperature Sensor parameter.
- If equipped with automatic transmission, an incorrect learned brake pedal position (BPP) sensor. Verify the following actions have not occurred:
    - An engine control module has been replaced
    - A BPP sensor that has been replaced
    - An incorrect BPP sensor alignment or installation

If any of the above actions occurred, the **Brake Pedal Position Sensor Learn** 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 Throttle Body Idle Airflow Compensation parameter with a scan tool. A value greater than 90 % may indicate an excessive accumulation of deposits in the throttle bore. Inspect the throttle body and clean, if necessary. Refer to **Throttle Body Cleaning** .
- Test the engine coolant temperature (ECT) sensor. Compare the ECT sensor value to the intake air temperature (IAT) sensor value on a cold engine. The ECT and IAT sensor values should be within ± 3°C (5°F). If the engine coolant temperature sensor is out of range with the intake air temperature sensor, test the resistance of the engine coolant temperature sensor. Refer to **Temperature Versus Resistance - Engine Coolant Temperature Sensor** , for resistance specifications. Replace the engine coolant temperature sensor if the resistance is not within specification. Refer to **Engine Coolant Temperature Sensor Replacement** . If the sensor is within the specification, test the engine coolant temperature sensor circuits for high resistance.
- Verify that the fuel system has adequate pressure for engine start-up. The fuel pump control module should command the fuel pump ON for 2 s when the ignition is turned ON. Refer to **Fuel System Description** , and **Fuel System Diagnosis**.
- Inspect for excessive crankshaft endplay that will cause the crankshaft position sensor reluctor wheel to move out of alignment with the crankshaft position sensor. Refer to **Crankshaft and Bearing Cleaning and Inspection** , and **Engine Mechanical Specifications** .

Hesitation, Sag, Stumble

- Test the fuel pressure. Refer to **Fuel System Diagnosis**.
- Inspect the mass air flow (MAF) sensor for obstruction, contamination, and damage. Refer to **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement** .
- 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.
- Test the manifold absolute pressure (MAP) sensor. Refer to **DTC P0106** .
- Inspect for excessive crankshaft endplay that will cause the crankshaft position sensor reluctor wheel to move out of alignment with the crankshaft position sensor. Refer to **Crankshaft and Bearing Cleaning and Inspection** , and **Engine Mechanical Specifications** .

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

- Engine warm and idling, verify the correct operation of the camshaft actuator system. Command the intake and exhaust camshaft actuators from 0 degrees to 25 degrees and back to zero while observing the scan tool Intake Camshaft Position Variance and Exhaust Camshaft Position Variance parameters.

Each parameter should be less than 2 degrees in each of the commanded states.

- If any of the parameters is greater than 2 degrees, inspect the suspect camshaft actuator and camshaft actuator solenoid valve and valve bore for contamination, obstruction, and damage. Refer to **Camshaft Position Actuator Exhaust Solenoid Valve Replacement** , **Camshaft Position Actuator Intake Solenoid Valve Replacement** , and **Camshaft Actuator System Description** .

Lack of Power, Sluggishness, or Sponginess

- Inspect the engine electrical system for incorrect 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 with Intake Air Temperature 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 25 degrees and back to zero while observing the scan tool Intake Camshaft Position Variance and Exhaust Camshaft Position Variance parameters. Each parameter should be less than 2 degrees in each of the commanded states.
  - If any of the parameters is greater than 2 degrees, inspect the suspect camshaft actuator and camshaft actuator solenoid valve and valve bore for contamination, obstruction, and damage. Refer to **Camshaft Position Actuator Exhaust Solenoid Valve Replacement** , **Camshaft Position Actuator Intake Solenoid Valve Replacement** , and **Camshaft Actuator System Description** .
- 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 for external fluid leaks. Inspect the gaskets and sealing surfaces and look for cracks in the turbocharger components. Refer to **Turbocharger Leaking Fluids Externally** , and **Turbocharger Smoke or Smell** .
  - Inspect for excessive turbocharger system noise. Refer to **Turbocharger Noise** .
  - Inspect for a loss of turbocharger pressure. Refer to **Turbocharger Loss of Boost Pressure** .
  - For additional information, refer to **Turbocharger System Description** , and **Turbocharger Cleaning and Inspection** .

Poor Fuel Economy

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

- Verify that the engine coolant temperature (ECT) has not shifted in value. Allow the engine to run and reach operating temperature. Observe the ECT Sensor parameter with a scan tool and compare the reading to that parameter listed on the **K20 Engine Control Module: Scan Tool Information** , list. If the reading is not in the range specified in the list, test the resistance of the engine coolant temperature sensor. Refer to **Temperature Versus Resistance - Engine Coolant Temperature Sensor** , for resistance specifications. Replace the engine coolant temperature sensor if the resistance is not within specification. Refer to **Engine Coolant Temperature Sensor Replacement** . If the sensor is within the specification, test the engine coolant temperature sensor circuits for high resistance.
- Inspect the mass air flow (MAF) sensor for obstruction, contamination, and damage. Refer to **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement** .
- Inspect the brake system for brake drag.

Rough, Unstable, or Incorrect Idle and Stalling

- Observe the Throttle Body Idle Airflow Compensation parameter with a scan tool. A value greater than 90 % may indicate an excessive accumulation of deposits in the throttle bore. Inspect the throttle body and clean, if necessary. Refer to **Throttle Body Cleaning** .
- Inspect the mass air flow (MAF) sensor for obstruction, contamination, and damage. Refer to **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement** .
- Inspect the engine mounts. Refer to **Engine Mount Inspection** .
- Inspect the intake and exhaust manifolds for casting flash.
- An excessively high idle may be due to the floor mat interfering with the accelerator pedal. With this condition present, it may not be possible to shift the transmission into gear. Inspect the accelerator pedal for binding and verify that the floor mat is not interfering with the aceclerator pedal movement.

Surges/Chuggles

- Verify that each injector harness is connected to the correct injector.
- Inspect the mass air flow (MAF) sensor for obstruction, contamination, and damage. Refer to **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement** .
- Inspect for slow responding heated oxygen sensors (HO2S). The HO2S should respond quickly to a change in throttle position. If the HO2S do not respond to different throttle positions, inspect for contamination from fuel, silicon, or the incorrect use of RTV sealant. The sensors may have a white powdery coating and result in a high, but false, signal voltage, which gives a rich exhaust indication. The PCM reduces the amount of fuel delivered to the engine, causing a driveability condition. Refer to **DTC P0133, P013A, P013B, P013E, P013F, P015A, P015B, P2270, or P2271** for more information.

MALFUNCTION INDICATOR LAMP (MIL) DIAGNOSIS

Diagnostic Instructions

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

Circuit/System Description

The malfunction indicator lamp (MIL) illuminates to inform the driver that an emission system fault has occurred and the engine control system requires service. Ignition voltage is supplied directly to the MIL. The engine control module (ECM) turns the MIL ON by grounding the MIL control circuit when the emission system fault occurs. Under normal operating conditions, the MIL should be ON only when the ignition is ON and the engine is OFF.

Diagnostic Aids

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

Reference Information

Schematic Reference

- **Engine Controls Schematics**
- **Instrument Cluster Schematics**

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

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

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

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

1. Ignition ON.
2. Verify the parameters listed below do not display Malfunction when commanding the malfunction indicator lamp ON and OFF with a scan tool.
    - The MIL Control Circuit Low Voltage Test Status
    - The MIL Control Circuit Open Test Status
    - The MIL Control Circuit High Voltage Test Status
    - **If Malfunction is displayed**

Refer to Circuit/System Testing.

- **If Malfunction is not displayed**

3. Engine running.
4. Verify the parameters listed below do not display Malfunction when commanding the malfunction indicator lamp ON and OFF with a scan tool.
   - The MIL Control Circuit Low Voltage Test Status
   - The MIL Control Circuit Open Test Status
   - The MIL Control Circuit High Voltage Test Status
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing.

   - **If Malfunction is not displayed**
5. Verify the malfunction indicator lamp turns ON and OFF when commanding the malfunction indicator lamp ON and OFF with a scan tool.
   - **If the malfunction indicator lamp does not turn ON and OFF**

     Refer to Circuit/System Testing.

   - **If the malfunction indicator lamp turns ON and OFF**
6. All OK.

Circuit/System Testing

1. Ignition OFF.
2. Disconnect the X1 harness connector at the K20 Engine Control Module.
3. Ignition ON, verify the malfunction indicator lamp does not illuminate.
   - **If the malfunction indicator lamp illuminates**
     1. Test for infinite resistance between the malfunction indicator lamp control circuit terminal X1 46 and ground.
        - If less than infinite resistance, repair the short to ground in the circuit.
        - If infinite resistance, replace the P16 Instrument Cluster.
   - **If the malfunction indicator lamp does not illuminate**
4. Connect a 3 A fused jumper wire between the malfunction indicator lamp control circuit terminal X1 46 and ground.
5. Verify the malfunction indicator lamp illuminates.
   - **If the malfunction indicator lamp illuminates**

     Replace the K20 Engine Control Module.

   - **If the malfunction indicator lamp does not illuminate**
     1. Test for less than 1 V between the malfunction indicator lamp control circuit terminal X1 46 and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.

- If less than 1 V

2. Ignition OFF.
3. Test for less than 2 ohms in the malfunction indicator lamp control circuit end to end.
   - If 2 ohms or greater, repair the open/high resistance in the circuit.
   - If less than 2 ohms.

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**

   1. Ignition OFF.
   2. Test for infinite resistance between the ignition voltage circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.

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

   1. Ignition OFF.
   2. Test for less than 2 ohms in the ignition voltage circuit end to end.
      - If 2 ohms or greater, repair the open/high resistance in the circuit.

   - **If the test lamp illuminates**
8. All OK.

Repair Instructions

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

- **Instrument Cluster Replacement**
- **Control Module References** for replacement. programming, and setup.

ENGINE CRANKS BUT DOES NOT RUN

Diagnostic Instructions

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

Circuit/System Description

This 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.

Diagnostic Aids

Inspect for any of the following conditions:

- When attempting to start the engine, the mechanical portion of the vehicle key must be locked in the fully extended position with the fob parallel to the key. Leaving the key partially retracted or folded over when starting may interrupt transponder authentication and result in an intermittent no-start

condition. In such instances, DTC B3055 may also be set. If an intermittent no-start complaint is received, it may be necessary to discuss with the customer their starting habits and verify they are locking the key in the fully extended position, fob parallel to the key, before starting.

- 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.
- The engine control module (ECM) uses the camshaft position sensors to determine engine speed and position when there is a crankshaft position sensor condition. If a crankshaft position sensor condition exists, the engine will operate only if the ECM has stored the learned reference position of the camshafts in ECM memory. With a crankshaft position sensor condition in the signal circuit, the engine will go into a limp home mode after a hard restart. The ECM then calculates engine speed from the camshaft position sensor.
- The fuel pump control module controls and monitors the operation of the in-tank fuel pump. If the fuel pump control module detects a fault, a DTC sets in the fuel pump control module. The fuel pump control module will then send a serial data message to the engine control module (ECM) requesting the illumination of the malfunction indicator lamp (MIL).
- 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 Solenoid Coil Test**.
- 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 good vehicle.
- Inspect the engine for good secure electrical grounds.
- Water or foreign material in the fuel can cause a no start or engine will not stay running condition. During freezing weather water can freeze inside the fuel system. The engine may start after 30 min in a heated repair shop. The malfunction may not recur until parked overnight in freezing temperatures. Extreme weather conditions can cause contaminated fuel to prevent the vehicle from starting.
- A vehicle that starts and runs after being brought to the repair shop for a no start condition, may have an ignition system that is susceptible to moisture. Spray water on the ignition system components and the wiring in order to check for an engine starting or will not stay running concern.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**
- **Starting System Description and Operation**

Scan Tool Reference

Control Module References for scan tool information

Special Tools

J 26792 HEI Spark Tester

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)** .

Circuit/System Verification

NOTE: This diagnostic assumes the following:

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

1. Engine cranking, observe the scan tool DTC information. Verify that P0201-P0204, P0230, P0231, P0232, P023F, P025A, P0335, P0336, P0351-P0354, P0601, P0602, P0603, P0604, P0606, P0607, P060E, P062F, P0685, P0689, P0690, P069E, P1516, P1682, P2610, or P2635 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**
2. Ignition ON.
3. Verify the security indicator on the instrument panel cluster illuminates momentarily.
   - **If the indicator stays ON or is flashing**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** , and **Immobilizer Description and Operation**

   - **If the indicator does not stay ON and is not flashing**
4. Verify the scan tool Engine Speed parameter is greater than 0 RPM while cranking the engine.
   - **If 0 RPM**

     Refer to **DTC P0335 or P0336** for further diagnosis.

- **If greater than 0 RPM**

5. Ignition OFF.
6. Disconnect the T8 ignition coil from a cylinder and spark plug.
7. Connect a **J 26792** HEI Spark Tester between the boot of the ignition coil and ground.

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

8. Verify that the spark tester sparks while cranking the engine.
   - **If the spark tester does not spark**

     Refer to **Electronic Ignition System Diagnosis** for further diagnosis.

   - **If the spark tester sparks**
9. Ignition ON.

NOTE: If the engine is too hot, high fuel pressure readings may result due to hot soak fuel boiling. Allow the engine to cool down until the engine coolant temperature is less than 60 °C (150 °F) before verifying fuel pressure readings.

10. Command the Fuel Pump Enable ON several times.
11. Verify that the scan tool Fuel Pressure Sensor parameter 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**
12. Verify that the scan tool Fuel Pressure Sensor parameter, after the pump has turned OFF, decreases to less than 600 kPa (87 psi), and does not decrease greater than 34 kPa (5 psi) in 1 minute.
    - **If not within the specified range**

      Refer to **Fuel System Diagnosis**.

    - **If within the specified range**
13. Verify that the following conditions do not exist:
    - Collapsed or restricted air intake duct to the throttle body
    - Restricted air filter
    - Gas or coolant fouled spark plugs
    - A skewed manifold absolute pressure (MAP) sensor. Refer to **DTC P0106**
    - A skewed engine coolant temperature (ECT) sensor. Refer to **DTC P0116** , and **DTC P0117, P0118, or P0119**
    - A restricted exhaust system. Refer to **Restricted Exhaust** .
    - Contaminated fuel. Refer to **Alcohol/Contaminants-in-Fuel Diagnosis**.
    - An engine mechanical condition, for example, worn timing chain and gears or low compression.

Refer to **Symptoms - Engine Mechanical** , or **Engine Compression Test**

- **If a condition exists**

  Repair as necessary.

- **If no condition exists not found**

14. All OK

Repair Instructions

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

Spark Plug Replacement

FUEL SYSTEM DIAGNOSIS

Diagnostic Instructions

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

Circuit/System Description

The engine control module (ECM) supplies voltage to the fuel pump power control module when the ECM detects that the ignition is ON. The voltage from the ECM to the fuel pump power control module remains active for 2 s, unless the engine is in Crank or Run. While this voltage is being received, the fuel pump power control module closes the ground switch of the fuel tank fuel pump module and also supplies a varying voltage to the fuel tank fuel pump module in order to maintain the desired fuel line pressure.

The fuel system is an electronic returnless on-demand design. A returnless fuel system reduces the internal temperature of the fuel tank by not returning hot fuel from the engine to the fuel tank. Reducing the internal temperature of the fuel tank results in lower evaporative emissions.

An electric turbine style fuel pump attaches to the fuel tank pump module inside the fuel tank. The fuel pump supplies fuel through the fuel feed pipe to the high pressure fuel pump. The high pressure fuel pump supplies fuel to a variable-pressure fuel rail. Fuel enters the combustion chamber through precision multi-hole fuel injectors. The high pressure fuel pump, fuel rail pressure, fuel injection timing, and injection duration are controlled by the engine control module (ECM).

Diagnostic Aids

Observe the Misfire Counters or perform the Fuel Injector Balance Test to help identify a leaking fuel injector.

Reference Information

Description and Operation

Fuel System Description

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

EN 37287 Fuel Line Shut-Off Adapter

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)** .

Circuit/System Verification

NOTE:

- **Repair all fuel system related DTCs, except P2635, before performing this diagnostic.**
- **Inspect the fuel system for damage or external leaks before proceeding.**
- **Verify that adequate fuel is in the fuel tank before proceeding.**
- **The Fuel Pump Enable may need to be commanded ON a few times in order to obtain the highest possible fuel pressure.**
- **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.**

1. Ignition ON, engine OFF, command the Fuel Pump Enable On several times with a scan tool.
2. Verify the Fuel Pressure Sensor parameter 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)**
3. Verify that the Fuel Pressure Sensor parameter, after the fuel pump is turned off, decreases to less than 600 kPa (87 psi).
   - **If greater than 600 kPa (87 psi)**

Replace the G12 Fuel Pump.

- **If less than 600 kPa (87 psi)**

4. Verify that the Fuel Pressure Sensor parameter does not decrease greater 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)**
5. Engine idling.
6. Verify the 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)**
7. 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**
8. Verify the scan tool 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)**
9. If the fuel system components test normal, refer to **Symptoms - Engine Controls**, **Fuel Injector Solenoid Coil Test**, and **Fuel Injector Balance Test** for further diagnosis.

Circuit/System Testing

Fuel Pressure Low

1. Verify none of the conditions listed below exist:
   - Restricted fuel feed pipe
   - 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 high pressure fuel pump.
3. Open the valve on the **EN 37287** Adapter.
4. Ignition ON, command the Fuel Pump Enable On and then Off with a scan tool.
5. Close the valve on the **EN 37287** Adapter.
6. Verify that the Fuel Pressure Sensor parameter does not decrease greater than 34 kPa (5 psi) in 1 minute.
   - **If greater than 34 kPa (5 psi)**

     Replace the G12 Fuel Pump.

   - **If less than 34 kPa (5 psi)**

     Locate and replace the leaking Q17 Fuel Injector.

Fuel Pressure Drops Off

1. Verify none of the conditions listed below exist:
   - Restricted fuel feed pipe
   - 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.

Repair Instructions

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

- **Fuel Feed Front Pipe Replacement**
- **Fuel Feed Pipe Replacement (FWD)** , **Fuel Feed Pipe Replacement (AWD)**
- **Fuel Injector Replacement**
- **Fuel Tank Fuel Pump Module Replacement (FWD)** , **Fuel Tank Fuel Pump Module Replacement (AWD)**

FUEL INJECTOR SOLENOID COIL TEST

Diagnostic Instructions

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

Circuit/System Description

The engine control module (ECM) supplies a separate high voltage supply circuit and a high voltage control circuit for each fuel injector. The injector high voltage supply circuit and the high voltage control circuit are both controlled by the ECM. The ECM energizes each fuel injector by grounding the control circuit. The ECM controls each fuel injector with 65 V. This is controlled by a boost capacitor in the ECM. During the 65 V boost phase, the capacitor is discharged through the injector high voltage supply circuit, allowing for initial injector opening. The injector is then held open with 12 V. A fuel injector coil winding resistance that is too high or too low will affect the engine driveability. The fuel injector coil windings are affected by temperature. The resistance of the fuel injector coil windings will increase as the temperature of the fuel injector increases.

Reference Information

Schematic Reference

Engine Controls Schematics

Electrical Information Reference

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

Component Testing

NOTE:

- **The resistance test must be performed at the fuel injector or mis-diagnosis will occur.**
- **The DMM and test leads must be calibrated to 0 ohms in order to prevent mis-diagnosis.**

1. Remove the intake manifold and disconnect the appropriate Q17 fuel injector.
2. Test for 1.35-1.65 ohms at 20°C (68°F) between the high voltage supply circuit terminal 2 and the high voltage control circuit terminal 1 at the fuel injector.
    - **If not between 1.35-1.65 ohms**

      Replace the Q17 fuel injector.

    - **If between 1.35-1.65 ohms**
3. Test for infinite resistance between each terminal at the Q17 fuel injector and the Q17 fuel injector housing/case.

- **If less than infinite resistance**

  Replace the Q17 fuel injector.

- **If infinite resistance**

4. All OK. Perform the Fuel Injector Balance Test. Refer to **Fuel Injector Balance Test**.

Repair Instructions

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

Fuel Injector Replacement

FUEL INJECTOR BALANCE TEST

Diagnostic Instructions

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

Circuit/System Description

The fuel injector balance test is performed while the engine is running at idle. The scan tool pressurizes the fuel rail to a predetermined pressure before each injector is pulsed for a precise amount of time allowing a measured amount of the fuel to be injected. This causes a drop in the system fuel pressure that is recorded and used to compare each injector.

Diagnostic Aids

- Monitoring the Current Misfire Counters may help to isolate the fuel injector that is causing the condition.
- Operating the vehicle over a wide temperature range may help isolate the fuel injector that is causing the condition.

Component Testing

NOTE:

- **DO NOT perform this test if the engine coolant temperature (ECT) is above 60°C (140°F). Irregular fuel pressure readings may result due to hot soak fuel boiling.**
- **Verify that adequate fuel is in the fuel tank before proceeding with this diagnostic.**

Fuel Injector Balance Test

1. Verify the correct low side fuel pressure. Refer to **Fuel System Diagnosis**.
2. Engine idling, observe the Fuel Rail Pressure Sensor parameter with a scan tool. The pressure should be approximately 3 MPa (435 psi).

NOTE: The engine speed must be between 600-1000 RPM to perform this test.

3. With a scan tool, select the Fuel Injector Balance function within the Output Controls menu.
4. Select and test an injector. Repeat for each injector in order to obtain a pressure drop value for each injector.
5. After all injectors are tested, record the fuel pressure drops.
6. Add all of the individual pressure drop values except for the injector suspected of being faulty. This is the total pressure drop.
7. Divide the total pressure drop by the number of fuel injectors that were added together. This is the average pressure drop.
8. Multiply the average pressure drop by 0.20. This is the acceptable variance from the average pressure drop, 20 percent.
    - If the difference between any individual pressure drop and the average pressure drop is more than the acceptable variance, replace the fuel injector.

Repair Instructions

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

Fuel Injector Replacement

ALCOHOL/CONTAMINANTS-IN-FUEL DIAGNOSIS

Diagnostic Instructions

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

Test Description

Water contamination in the fuel system may cause driveability conditions such as hesitation, stalling, no start, or misfires in one or more cylinders. Water may collect near a single fuel injector at the lowest point in the fuel injection system and cause a misfire in that cylinder. If the fuel system is contaminated with water, inspect the fuel system components for rust or deterioration.

Ethanol concentrations of greater than 10 percent can cause driveability conditions and fuel system deterioration. Fuel with more than 10 percent ethanol could result in driveability conditions such as hesitation, lack of power, stalling, or no start. Excessive concentrations of ethanol used in vehicles not designed for it may cause fuel system corrosion, deterioration of rubber components, and fuel filter restriction.

Reference Information

Special Tool

CH 44175-A Fuel Composition Tester , if available

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)** .

System Verification

The fuel sample should be drawn from the bottom of the tank so that any water present in the tank will be detected. The sample should be bright and clear.

- If the sample appears cloudy, or contaminated with water, as indicated by a water layer at the bottom of the sample, perform the Particulate Contaminants in Fuel Testing Procedure.
- If alcohol contamination is suspected, perform the Alcohol in Fuel Testing procedure.

Alcohol in Fuel Testing with Special Tool, If Available

1. Test the fuel composition using the **CH 44175-A** Fuel Composition Tester and the Instruction Manual.
2. If water appears in the fuel sample, clean the fuel system.
3. Subtract 50 from the reading on the DMM in order to obtain the percentage of alcohol in the fuel sample.
4. If the fuel sample contains more than 15 percent ethanol, add fresh, regular gasoline to the vehicle's fuel tank.
5. Test the fuel composition.
6. If testing shows the ethanol percentage is still more than 15 percent, replace the fuel in the vehicle.

Alcohol in Fuel Testing without Special Tool

1. Using a 100 ml (3.38 oz) specified cylinder with 1 ml (0.034 oz) graduation marks, fill the cylinder with fuel to the 90 ml (3.04 oz) mark.
2. Add 10 ml (0.34 oz) of water in order to bring the total fluid volume to 100 ml (3.38 oz) and install a stopper.
3. Shake the cylinder vigorously for 10-15 seconds.
4. Carefully loosen the stopper in order to release the pressure.
5. Re-install the stopper and shake the cylinder vigorously again for 10-15 seconds.
6. Put the cylinder on a level surface for approximately 5 min in order to allow adequate liquid separation. If alcohol is present in the fuel, the volume of the lower layer, which would now contain both alcohol and water, will be more than 10 ml (0.34 oz). For example, if the volume of the lower layer is increased to 15 ml (0.51 oz), this indicates at least 5 percent alcohol in the fuel. The actual amount of alcohol may be somewhat more because this procedure does not extract all of the alcohol from the fuel.

Particulate Contaminants in Fuel Testing Procedure

1. Using an approved fuel container, draw approximately 0.5 liter (0.53 qt) of fuel.
2. Place the container on a level surface for approximately 5 min in order to allow settling of the particulate contamination. Particulate contamination will show up in various shapes and colors. Sand will typically be identified by a white or light brown crystals. Rubber will appear as black and irregular particles.
3. Observe the fuel sample. If any physical contaminants or water are present, clean the fuel system.

Repair Instructions

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

- **Fuel System Cleaning**
- **Fuel Tank Draining**

EVAPORATIVE EMISSION SYSTEM DIAGNOSIS

Special Tools

EN 41413-VLV EVAP Service Port Vent Fitting

Operating Instructions for the Evaporative Emission System Tester (EEST)

Vehicle Setup

WARNING: Refer to Fuel and Evaporative Emission Pipe Warning .

CAUTION: Refer to Clean, Dry, Low Pressure Gas Source Caution .

NOTE: 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.

NOTE: A large difference between the vehicle temperature and shop temperature will seriously affect the accuracy of the tests. Always allow at least 15 min for the vehicle temperature to adjust to the shop temperature. Refer to Temperature Variation Instructions for more information about vehicle versus shop temperatures.

1. Engine OFF, open the hood. Position a large fan to blow air under the vehicle onto the fuel tank area.
2. Connect the red battery clip from the tester to the positive battery terminal.

NOTE: The vehicle battery must be fully charged for optimum tester performance.

3. Connect the black battery clip from the tester to chassis ground.

Flow Meter Test - Leak Detection

CAUTION: Refer to Fuel and Evaporative Emission Hose/Pipe Connection Cleaning Caution .

1. Open the Nitrogen tank valve and turn the NITROGEN/SMOKE valve on the front control panel to

NITROGEN.

2. Connect the hose to the correct test orifice on the bottom front of the tester. For orifice size, refer to the vehicle specific information found in service procedures for DTCs that relate to evaporative emission (EVAP) system leaks.
3. Press and release the remote switch to activate the tester.

NOTE: **The tester will time out after about 15 min. You may press the remote switch to reactivate the tester as desired.**

4. Position the sliding red flag on the flow meter to align with the floating indicator. When the red flag is set, press and release the remote switch to deactivate the tester.
5. Remove the hose from the test orifice and install the hose onto the vehicle. For proper connection location, and the special tool numbers for any adapters that may be required, refer to the service procedures for DTCs that relate to EVAP system leaks.
6. Ignition ON, seal the EVAP system per instructions in the service procedures for DTCs that relate to EVAP system leaks. Most systems can be sealed using a scan tool output control for the EVAP Vent Solenoid Valve, other systems require that the vent system be plugged.

NOTE:

- **Larger volume fuel tanks, and/or those with lower fuel levels, may require several minutes to fill with nitrogen.**
- **Static buildup may cause the float indicator to stick. It may be necessary to tap on the flow meter to free up the float.**
- **If fuel level is 90 % or greater it will take longer to fill the system with smoke because the fuel fill tube check valve will be closed and force any smoke to pass through the ORVR pipe and orifice.**

7. Press and release the remote switch to activate the nitrogen flow and fill the system.
8. Compare the stable floating indicator position to the red flag.
   - Below the red flag, the result is acceptable, Pass. Test complete
   - Above the red flag, the result is unacceptable, Fail. Go to the Smoke Procedure
9. Press and release the remote switch to deactivate the tester.

Smoke Procedure - Locate the Leak

NOTE: **It is not recommended to use the tester in an outside repair bay area because wind and sunlight may affect temperature and your ability to see the smoke.**

1. Turn OFF any fans that may cause air movement around or near the vehicle.

NOTE: **Completely unwind the nitrogen/smoke hose from the bracket to optimize the tester's performance.**

2. Connect the nitrogen/smoke hose to the vehicle as directed in the service procedures. Some vehicles require that the nitrogen/smoke hose be connected at the front of the EVAP system at the EVAP service port. An adapter may be necessary. Other vehicles require the connection be made at the rear

of the system using an adapter at the fuel fill cap. Consult the service procedures for DTCs that relate to evaporative emission (EVAP) system leaks for vehicle specific instructions regarding connection location and adapters.

3. Open the Nitrogen tank valve and turn the nitrogen/smoke valve on the control panel to smoke.

NOTE: The remote switch operates on a push ON, push OFF fashion.

4. Press and release the remote switch to activate the tester and inject smoke into the EVAP system.
5. Verify smoke has filled the EVAP system by opening the system opposite the end where smoke is injected. When injecting smoke at the service port, remove the fuel fill cap until smoke is observed. Then close the system and continue testing. If using a special tool fuel fill cap adapter at the filler neck, vent the system at the service port, with special tool EN 41413-VLV EVAP Service Port Vent Fitting, until smoke is observed then remove the vent fitting tool and close the system to continue with the test.

NOTE: Inject smoke in less than 2 min cycles for optimum tester performance.

6. Press and release the remote switch to deactivate the tester.

NOTE: For optimum visual smoke performance, deactivate the smoke flow and allow the system pressure to drop. Allowing the smoke to exit small holes at a low flow rate greatly enhances visibility.

7. Introduce smoke into the system for an additional 60 s. Continue introducing smoke at 15 s intervals, as necessary.
8. Using a high-intensity white light, inspect the entire EVAP system path, and look for the source of the leak indicated by the exiting smoke. Introduce smoke at 15 s intervals, as needed, until leak source is identified.

Temperature Variation Instructions

The Concern

Ideal circumstances for conducting the EVAP flow meter test require equal temperatures between the Nitrogen gas and the vehicle EVAP system. Significant differences in temperature between them can result in a flow or pressure change during testing, causing misleading results. Typically, the EEST is stored indoors, approximately 21°C (70°F). Vehicles brought in for diagnosis may have an EVAP system at significantly different temperatures.

For Example

NOTE: With no temperature difference between the Nitrogen gas and EVAP system, the resulting vehicle EVAP system pressure will remain stable at 3.2 kPa, 13 in. H2O (0.5 PSI) once pressurized, providing no leaks are present.

When the EVAP flow meter tests are performed with significant differences in temperature between the Nitrogen gas and the vehicle EVAP system, the following results can occur:

- An increase in flow during the flow meter test can be caused by a vehicle's warm EVAP system cooling down.
- A decrease in flow during the flow meter test can be caused by a vehicle's cool EVAP system warming up.

The Solution

When working on a vehicle with significant temperature differences between the vehicle EVAP system and the Nitrogen gas, allow the vehicle EVAP system temperature to stabilize as close as possible to the temperature of the Nitrogen gas before conducting the Flow Meter Test.

ELECTRONIC IGNITION SYSTEM DIAGNOSIS

Diagnostic Instructions

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

Circuit/System Description

This ignition system uses an individual coil for each cylinder. The engine control module (ECM) controls the spark events by transmitting the timing pulses on the ignition control (IC) circuits to the individual ignition coils in firing order sequence.

Diagnostic Aids

- An open/high resistance on the low reference circuit to the ignition coil may cause a misfire.
- An erratic or weak spark is considered a no spark condition.

Reference Information

Schematic Reference

Engine Controls Schematics

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Electronic Ignition System Description

Electrical Information Reference

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

- **Wiring Repairs**

Scan Tool Reference

Control Module References

Special Tools

EL 26792 HEI Spark Tester

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)** .

Circuit/System Testing

NOTE: Do not perform this diagnostic procedure unless you were sent here from a misfire DTC or the Engine Cranks But Does Not Run diagnostic.

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the appropriate T8 Ignition Coil. It may take up to 2 min for all vehicle systems to power down.
2. Test for less than 5 ohms between the ground circuit terminal 1 and ground.
    - **If 5 ohms or greater**
    1. Ignition OFF.
    2. Test for less than 2 ohms in the ground circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, repair the open/high resistance in the ground connection.
    - **If less than 5 ohms**
3. Test for less than 5 ohms between the low reference circuit terminal 2 and ground.
    - **If 5 ohms or greater**
    1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
    2. Test for less than 2 ohms in the low reference circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, replace the K20 Engine Control Module.
    - **If less than 5 ohms**
4. Ignition ON.
5. Verify a test lamp illuminates between the ignition circuit terminal 4 and ground.
    - **If the test lamp does not illuminate**
    1. Ignition OFF, remove the test lamp.
    2. Test for less than 2 ohms in the ignition circuit end to end.
        - If 2 ohms or greater, repair the open/high resistance in the circuit.
        - If less than 2 ohms, verify the fuse is not open and there is voltage at the fuse.
    - **If the test lamp illuminates**
6. Ignition OFF, exchange the suspect T8 Ignition Coil with the T8 Ignition Coil of a known functioning cylinder.

7. Engine Running.
8. Verify the scan tool Ignition Coil Control Circuit Status parameter displays OK for the same cylinder that the suspect T8 Ignition Coil was removed from.
    - **If OK is not displayed**

      Replace the K20 Engine Control Module.

    - **If OK is displayed**

      Test or replace the T8 Ignition Coil.

Component Testing

NOTE: You must perform the Circuit/System Testing before proceeding with Component Testing.

1. Ignition OFF, connect the **EL 26792** HEI Spark Tester to the appropriate T8 Ignition Coil.
2. Engine Running.
3. Verify the spark output of the T8 Ignition Coil.
    - **If no output or the output is weak**

      Replace the T8 Ignition Coil

    - **If the output is good**
4. All OK.

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.

INSPECTION/MAINTENANCE SYSTEM CHECK

Diagnostic Instructions

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

Description

The purpose of the Inspection/Maintenance Complete System Set Procedure is to satisfy the enable criteria necessary to execute all of the I/M readiness diagnostics and complete the drive cycles for those particular diagnostics. When all I/M monitored diagnostic tests are completed, the I/M System Status indicators are set to YES. Perform the Inspection/Maintenance Complete System Set Procedure if any I/M System Status indicators are set to NO.

Conditions for Meeting a Cold Start

- The ignition voltage between 11-18 V.
- The barometric pressure is more than 75 kPa (10.9 psi).
- The start-up engine coolant temperature (ECT) is between 4-30°C (39-86°F).
- The start-up intake air temperature (IAT) is between 4-30°C (39-86°F).
- The difference between the IAT and the ECT is less than or equal to 6°C (43°F).
- The ambient air temperature is between 4-30°C (39-86°F).
- The fuel level is between 15-85 %.

Circuit/System Verification

Review the inspection/maintenance system status indicators with a scan tool. All I/M system status indicators should report YES, and no I/M Test DTCs should be present.

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 min to allow the sensors to cool before continuing with the test. When the engine is started, DO NOT turn the engine OFF for the remaining portion of the set procedure.

1. Ensure that the vehicle meets the conditions for a cold start listed above.
2. The evaporative emission inspection/maintenance system status indicator should display YES.
    - If the inspection/maintenance system status indicator displays NO, perform the Service Bay Test, if applicable. If the Service Bay Test is NOT available, it may take up to 6 drive cycles, with up to 17 h between drive cycles, for the inspection/maintenance system status indicator to transition to YES.
3. The O2S Heater inspection/maintenance system status indicator should display YES.
    - If the O2S Heater inspection/maintenance system status indicator displays NO, ensure that the ignition has been turned OFF for at least 10 h.
4. Turn OFF all accessories; HVAC system, other electrical loads, including aftermarket/add-on equipment, etc.
5. Set the vehicle parking brake and ensure the vehicle is in Park for automatic transmission or Neutral for manual transmission.
6. Turn OFF all accessories; HVAC system, other electrical loads, including aftermarket/add-on equipment, etc.
7. Start and idle the engine for at least 2 min and until 65°C (149°F) is achieved.
8. Run the engine for 6.5 min within the following conditions:
    - MAF parameter between 4-30 g/s
    - Engine speed steady between 1,000-3,000 RPM
9. Return the engine to idle for 1 minute.
10. Apply and hold the brake pedal, and shift to Drive for automatic transmission, or apply the clutch pedal for manual transmission and operate the vehicle within the following conditions for 2 min:

- Depress the accelerator pedal until throttle position sensor angle is more than 2 %.
- Mass air flow signal between 15-30 g/s
- RPM steady between 1,200-2,000 RPM

NOTE: DO NOT touch the accelerator pedal during the idle period. A change in throttle position sensor angle or an increase in engine speed may invalidate this portion of the test.

11. Release the accelerator pedal and shift the vehicle to Park for automatic transmission, or Neutral and release the clutch pedal for manual transmission, and allow the engine to idle for 2 min.
12. Quickly depress the accelerator pedal until throttle position sensor angle is more than 8 % and return to idle, repeat 3 times.
13. Allow engine to idle for at least 2 min.

WARNING: Refer to Road Test Warning .

14. Release the parking brake and drive vehicle at 24 km/h (15 mph) or slower for 2 min.
15. Continue to drive the vehicle for at least 5.5 mi between 45-112 km/h (28-70 mph) with the vehicle reaching at least 80 km/h (50 mph).
16. Release the accelerator pedal for at least 2 s. This will allow the vehicle to enter decel fuel cut-off.
17. Depress the accelerator pedal until the throttle position sensor angle is increased 3-20 % and maintain a safe speed for 1 min.
18. Safely stop the vehicle, with the engine in Drive for automatic transmission or in Neutral with the clutch pedal depressed and parking brake applied for manual transmission, idle for 2 min.
19. Shift to Park for automatic and apply the parking brake, or neutral and release clutch pedal for manual.

NOTE: DO NOT disturb the vehicle or turn ON the ignition until told to do so. Disturbing the vehicle may invalidate this portion of the test.

20. Turn OFF the ignition and exit the vehicle. Do NOT disturb the vehicle for 60 min.
21. Observe the Inspection/Maintenance System Status with a scan tool. All of the Inspection/Maintenance System Status indicators should display YES.
    - If the evaporative emission Inspection/Maintenance System Status indicator displays NO, turn OFF the ignition for 17 h, ensure that the vehicle meets the conditions for a cold start, and repeat steps 12-18 six more times, or until the evaporative emission 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. Follow the Conditions for Running the DTC in order to set the evaporative emission Inspection/Maintenance System Status indicator
    - If any of the Inspection/Maintenance System Status 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. Follow the Conditions for Running the DTC in order to set the associated status indicator.

NOTE: An I/M Test DTC will not be stored or erased from the ECU except at the end of trip processing which occurs 5 s after ignition OFF.

22. Observe the I/M Test DTC information with a scan tool. Verify there are no I/M Test DTCs present.
    - If an I/M Test DTC is set, diagnose the DTC using the **Diagnostic Trouble Code (DTC) List - Vehicle** , and refer to **Inspection/Maintenance System Check** for clearing I/M Test DTCs.
    - If an I/M Test DTC is set and the I/M System Status indicators are NO, diagnosis the DTC and perform the **Inspection/Maintenance Complete System Set Procedure**.
23. Observe the engine DTC information with a scan tool. Verify no DTCs are present.
    - If a DTC is set, diagnose using the **Diagnostic Trouble Code (DTC) List - Vehicle** , . After repairs, perform the **Inspection/Maintenance Complete System Set Procedure** to verify no further DTCs are set.

INSPECTION/MAINTENANCE COMPLETE SYSTEM SET PROCEDURE

Diagnostic Instructions

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

Description

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

Conditions for Updating the I/M System Status

Each system requires at least one, and sometimes several, diagnostic tests. The results of these tests are reported by a diagnostic trouble code (DTC). A system monitor is complete when either all of the DTCs comprising the monitor have Run and Passed, or any one of the DTCs comprising the monitor have illuminated the malfunction indicator lamp (MIL) . Once all of the tests are completed, the I/M System Status display will indicate YES in the Completed column.

For example, when the HO2S Heater Monitor indicates YES, either all of the oxygen sensor heater tests have passed or one of the tests has illuminated the MIL. If the vehicle has four heated oxygen sensors, either all four heater circuit tests have passed or one of the heater circuit tests has illuminated the MIL. The I/M System Status will indicate NO under the Completed column when any of the required tests for that system have not run. The following is a list of conditions that would set the I/M System Status indicator to NO:

- The vehicle is new from the factory and has not yet been driven through the necessary drive conditions to complete the tests.
- The battery has been disconnected or discharged below operating voltage.
- The control module power or ground has been interrupted.
- The control module has been reprogrammed.
- The control module DTCs have been cleared as part of a service procedure.

Conditions for Clearing I/M Test DTCs

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

Monitored Emission Control Systems

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

- The air conditioning system
- The catalytic converter efficiency
- Comprehensive component monitoring-Emission related inputs and outputs
- The evaporative emission (EVAP) system
- The fuel delivery system
- Heated catalyst monitoring
- Misfire monitoring
- The oxygen sensor system (O2S or HO2S)
- The oxygen sensor heater system (HO2S heater)

For the specific DTCs required for each system, refer to **Inspection/Maintenance (I/M) System DTC Table**. Systems such as misfire and comprehensive components may not be listed in a system status list. These tests run continuously and do not require an I/M System Status indicator.

Diagnostic Aids

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

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

Circuit/System Verification

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

Circuit/System Testing

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

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

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 I/M System Status indicator did NOT update to YES during the **Inspection/Maintenance Complete System Set Procedure** , review each indicator and reference this table to determine each	

DTC associated with the I/M System Status Indicator. Each DTC listed below has specific conditions that must be met for the diagnostic to run. Included within the conditions are additional DTCs, which if set, may inhibit the DTCs listed below from running. Reviewing and operating the vehicle within the Conditions for Running for each DTC listed below will allow the I/M System Status Indicators to transition to YES.	
Catalyst	**DTC P0420**
EGR/CMP	• **DTC P0011 or P0014** • **DTC P05CC or P05CE**
EVAP	• **DTC P0442** • **DTC P0446** • **DTC P0455**
Fuel System	**DTC P219A**
HO2S	**DTC P0030-P0032, P0036-P0038, P0053, P0054, P0135, or P0141**
H02S/02S	**DTC P0133, P013A, P013B, P013E, P013F, P015A, P015B, P2270, or P2271**

2014 Engine

Engine Controls and Fuel - 2.0L (LTG) - Diagnostic Information and Procedures - Poor Fuel Fill Quality - Regal

DIAGNOSTIC INFORMATION AND PROCEDURES

POOR FUEL FILL QUALITY

Poor Fuel Fill Quality

Problem	Causes
DEFINITION: During the fueling process a continual, occasional, or no-fuel nozzle shut-off condition has occurred.	
Difficult to fill	• Fuel fill limiter vent valve stuck closed • Evaporative emission (EVAP) canister restricted • EVAP vent valve stuck closed • Hose between canister and canister vent solenoid twisted or kinked if applicable • High fuel temperature • Fuel filler hose is kinked • Faulty dispensing nozzle • Ignition switch ON, vent valve closed
Over fill	• Fill limiter vent valve stuck open or leaking • Fuel inlet check valve stuck open
Pre-mature shut-off of the fuel dispensing nozzle occurs immediately after engaging dispensing nozzle, tank empty	• Restricted vapor lines or fuel fill pipe • High fuel temperature • Inlet check valve at tank stuck closed, fill pipe full of fuel • Fuel tank full, gauge not accurate
Pre-mature shut-off of the fuel dispensing nozzle, more than 1/8 of tank capacity dispensed	• Kinked, pinched or plugged lines in fuel tank vent system • EVAP vent valve stuck closed or restricted • EVAP canister restricted • Fuel limiting vent valve stuck closed or obstruction at top of fuel tank
Fuel Spitback	• Restricted EVAP canister • High fuel temperature • Ignition switch ON, EVAP vent valve closed

2014 Engine

Engine Controls and Fuel - 2.0L (LTG) - Repair Instructions - Regal

REPAIR INSTRUCTIONS

BRAKE PEDAL POSITION SENSOR LEARN

NOTE: Brake system does not use a brake switch, stoplight switch or brakelight switch. System uses a Brake Pedal Position Sensor to control these functions.

Calibration Criteria

NOTE: Do not apply the brake pedal during the brake pedal position sensor calibration procedure. Any movement of the brake pedal during this procedure will cause the calibration procedure to fail. If this occurs, the brake pedal position sensor calibration must be repeated.

Brake pedal position sensor calibration must be performed after the brake pedal position sensor, body control module (BCM), or engine control module (ECM) have been serviced. The calibration procedure will set the brake pedal position sensor home value. This value is used by the BCM and ECM to determine the action of the driver applying the brake system and to provide this information to the vehicle subsystems via serial data.

Calibration Procedure

1. Apply the parking brake.
2. Ignition ON, engine OFF, place the transmission in the PARK position for automatic transmission or NEUTRAL position for manual transmission.
3. Install a scan tool.
4. Clear all DTCs before proceeding.
5. Navigate to the Configuration/Reset Functions menu of the BCM.
6. Select the Brake Pedal Position Sensor Learn procedure and follow the directions displayed on the screen.
7. Navigate to the Configuration/Reset Functions menu of the ECM.
8. Select the Learn Functions menu.
9. Select the Brake Pedal Position Sensor Learn procedure and follow the directions displayed on the screen.

Q38 THROTTLE BODY: THROTTLE/IDLE LEARN

Description

The engine control module (ECM) learns the airflow through the throttle body to ensure the correct idle. The learned airflow values are stored within the ECM. These values are learned to adjust for production variation and will continuously learn during the life of the vehicle to compensate for reduced airflow due to throttle body coking. Anytime the throttle body airflow rate changes, for example due to cleaning or

replacing, the values must be relearned.

An engine that had a heavily coked throttle body that has been cleaned or replaced may take several drive cycles to learn out the coking. To accelerate the process, the scan tool has the ability to reset all learned values back to zero. A new ECM will also have values set to zero.

The idle may be unstable or a DTC may set if the learned values do not match the actual airflow.

Conditions for Running the Throttle Learn Procedure

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, P1516, P2101, P2119, P2120, P2122, P2123, P2125, P2127, P2128, P2135, P2138, or P2176 are not set.
- Ignition ON, engine OFF.
- The vehicle speed sensor (VSS) is 0 km/h (0 mph).

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, P1516, P2101, P2119, P2120, P2122, P2123, P2125, P2127, P2128, P2135, P2138, or P2176 are not set.
- The engine speed is between 450-4,000 RPM.
- The manifold absolute pressure (MAP) is greater than 5 kPa.
- The mass air flow (MAF) is greater than 2 g/s.
- The ignition voltage is greater than 10 volts.

Throttle Learn

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, observe the scan tool Throttle Body Idle Airflow Compensation parameter. The Throttle Body Idle Airflow Compensation value should equal 0 % and the engine should be 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 DTCs are set. Refer to Diagnostic Trouble Code (DTC) List - Vehicle .**

1. Engine idling for 3 minutes.
2. Observe the scan tool Desired Idle Speed and the actual Engine Speed parameters.
3. The ECM will start to learn the new idle cells and the Desired Idle Speed should start to decrease.
4. Ignition OFF for 60 seconds.
5. Start and idle the engine for 3 minutes.
6. After the 3 minute run time the engine should be idling normal.

NOTE: During the drive cycle the check engine light may come on with idle speed DTCs. If idle speed codes are set, clear codes so the ECM can continue to learn.

   - If the engine idle speed has not been learned the vehicle will need to be driven at speeds above 70 km/h (44 mph) with several decelerations and extended idles.

7. After the drive cycle, the engine should be idling normally.
   - If the engine idle speed has not been learned, turn OFF the ignition for 60 seconds and repeat step 6.
8. Once the engine speed has returned to normal, clear DTCs and return to the diagnostic that referred you here.

CRANKSHAFT POSITION SYSTEM VARIATION LEARN

NOTE: The Crankshaft Position Variation Learn procedure is also required when the following service procedures have been performed, regardless of whether DTC P0315 is set:

- **An engine replacement**
- **An engine control module (ECM) or body control module (BCM) replacement**
- **A crankshaft balancer replacement**
- **A crankshaft removal and/or replacement**
- **A crankshaft position sensor disturbance/removal and/or replacement**
- **Any engine repairs which disturb the crankshaft to crankshaft position sensor relationship.**

NOTE: The ECM monitors certain component signals to determine if all the conditions are met to continue with the Crankshaft Position Variation Learn procedure.

1. Ignition ON, observe the DTC information with a scan tool. Verify no other DTCs are set, except DTCs P0300-P0304, or P0315.
   - If DTCs are set, except DTCs P0300-P0304, or P0315, refer to **Diagnostic Trouble Code (DTC) List - Vehicle** for further diagnosis.
2. Select the Crankshaft Position Variation Learn Procedure with a scan tool and follow the on screen instructions:
3. Verify DTC P0315 does not set.

- **If DTC P0315 set, or another DTC is present** refer to **Diagnostic Trouble Code (DTC) List - Vehicle** for the applicable DTC that set.
- **If the DTC does not set**

4. All OK.

2014 Engine

Engine Controls and Fuel - 2.0L (LTG) - Repair Instructions - Regal

REPAIR INSTRUCTIONS

ENGINE CONTROL MODULE REPLACEMENT

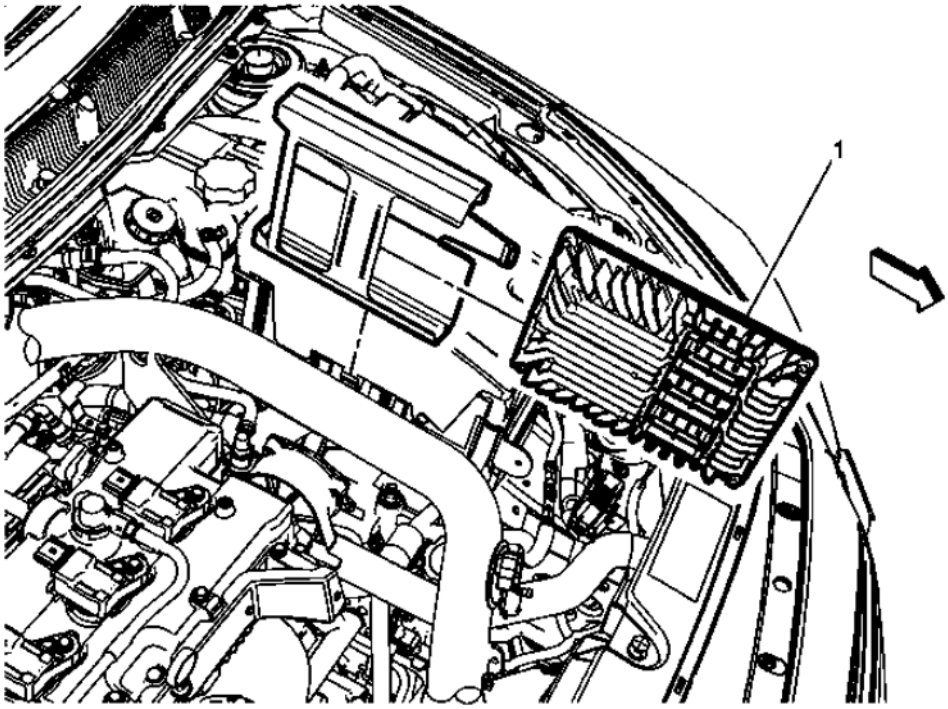


Fig. 1: Engine Control Module (LTG)
Courtesy of GENERAL MOTORS COMPANY

Engine Control Module Replacement

Callout	Component Name
Preliminary Procedure Disconnect the negative battery cable. Refer to **Battery Negative Cable Disconnection and Connection** .	
	Electronic Control Module **WARNING:** **Refer to Safety Glasses Warning .** **CAUTION:** **Always turn the ignition off when installing or removing the ECM connectors in order to prevent damage to the components.** **CAUTION:** • **Turn the ignition OFF when installing or removing the control module**

1	**connectors and disconnecting or reconnecting the power to the control module (battery cable, powertrain control module (PCM)/engine control module (ECM)/transaxle control module (TCM) pigtail, control module fuse, jumper cables, etc.) in order to prevent internal control module damage.** • **Control module damage may result when the metal case contacts battery voltage. DO NOT contact the control module metal case with battery voltage when servicing a control module, using battery booster cables, or when charging the vehicle battery.** • **In order to prevent any possible electrostatic discharge damage to the control module, do no touch the connector pins or the soldered components on the circuit board.** • **Remove any debris from around the control module connector surfaces before servicing the control module. Inspect the control module connector gaskets when diagnosing or replacing the control module. Ensure that the gaskets are installed correctly. The gaskets prevent contaminant intrusion into the control module.** • **The replacement control module must be programmed.** **Procedure** 1. Disconnect the electrical connectors. 2. Release the retaining tab. 3. If replacing, program the ECM. Refer to **Control Module References** . **NOTE:** **Before removing the engine control module (ECM), use the scan tool to capture the ECM data. This captured data will then need to be restored into the NEW ECM. Refer to Control Module References .**

ENGINE COOLANT TEMPERATURE SENSOR REPLACEMENT

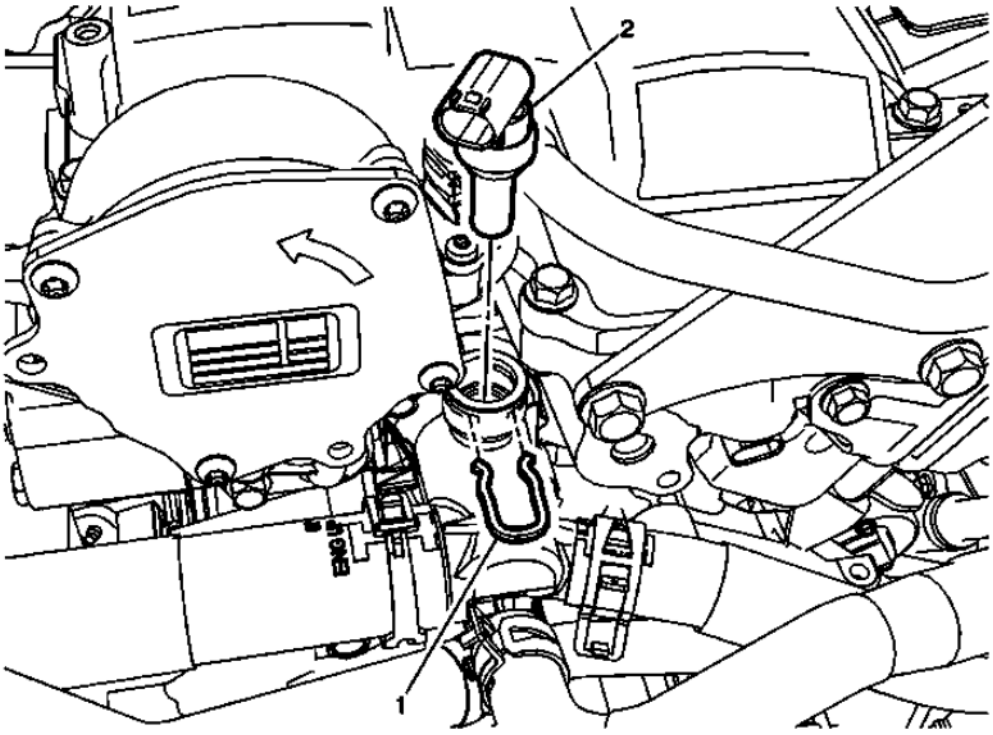


Fig. 2: Engine Coolant Temperature Sensor
Courtesy of GENERAL MOTORS COMPANY

Engine Coolant Temperature Sensor Replacement

Callout	Component Name
Preliminary Procedure 1. Drain the cooling system. Refer to **Cooling System Draining and Filling (Static Fill)** , **Cooling System Draining and Filling (GE 47716)** . 2. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement** . 3. Remove the charge air cooler outlet air tube. Refer to **Charge Air Cooler Outlet Air Tube Replacement**.	
1	Engine Coolant Temperature Sensor Retaining Clip
2	Engine Coolant Temperature Sensor **Procedure** 1. Disconnect the engine wiring harness electrical connector from the engine coolant temperature sensor. 2. Remove the engine coolant temperature sensor from the thermostat housing. 3. Install a NEW seal if not replacing the sensor.

INTAKE AIR PRESSURE AND TEMPERATURE SENSOR REPLACEMENT

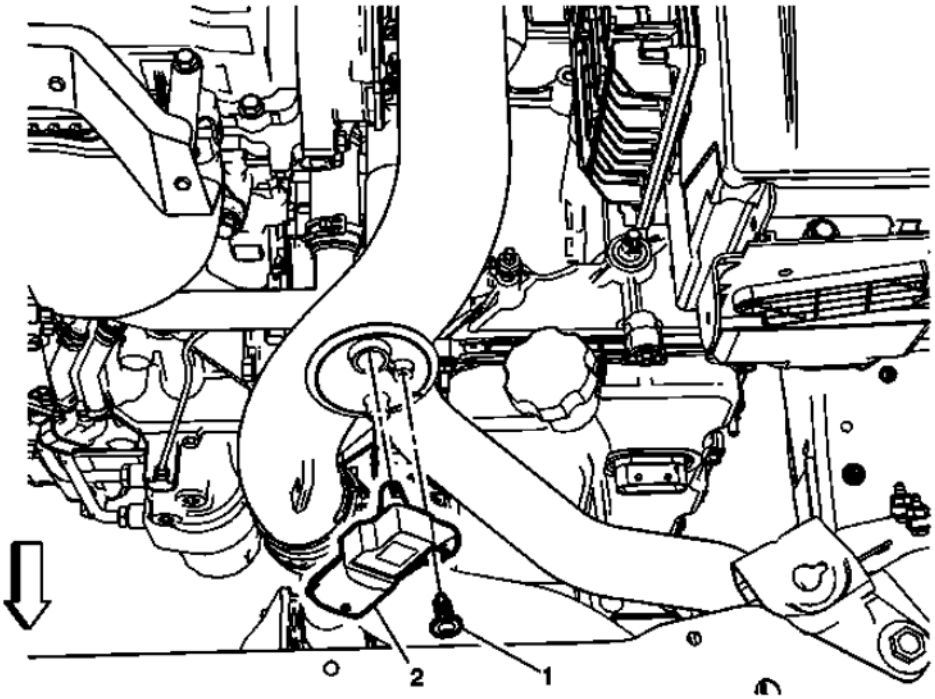


Fig. 3: Intake Air Pressure and Temperature Sensor (LTG)
Courtesy of GENERAL MOTORS COMPANY

Intake Air Pressure and Temperature Sensor Replacement

Callout	Component Name
Preliminary Procedure Disconnect the electrical connector.	
1	Intake Air Pressure and Temperature Sensor Fastener **CAUTION:** **Refer to Fastener Caution .**
2	Intake Air Pressure and Temperature Sensor

MASS AIRFLOW SENSOR WITH INTAKE AIR TEMPERATURE SENSOR REPLACEMENT

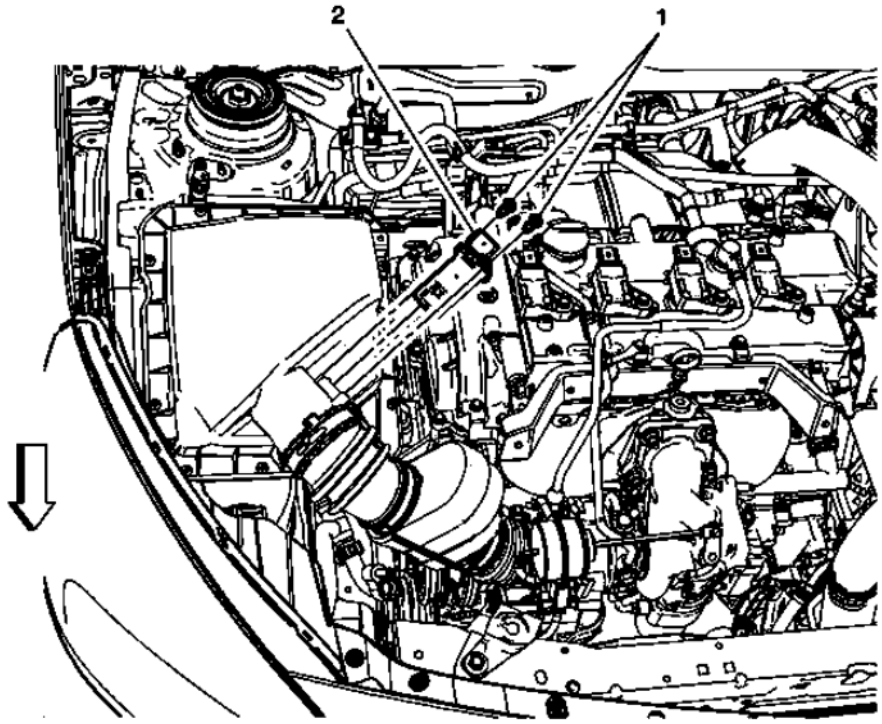


Fig. 4: Mass Airflow Sensor with Intake Air Temperature Sensor (LTG)
Courtesy of GENERAL MOTORS COMPANY

Mass Airflow Sensor with Intake Air Temperature Sensor Replacement

Callout	Component Name
1	Mass Air Flow Sensor Fasteners (Qty :2) **CAUTION:** **Refer to Fastener Caution .**
2	Mass Air Flow Sensor **Procedure** Disconnect the electrical connector.

MANIFOLD ABSOLUTE PRESSURE SENSOR REPLACEMENT

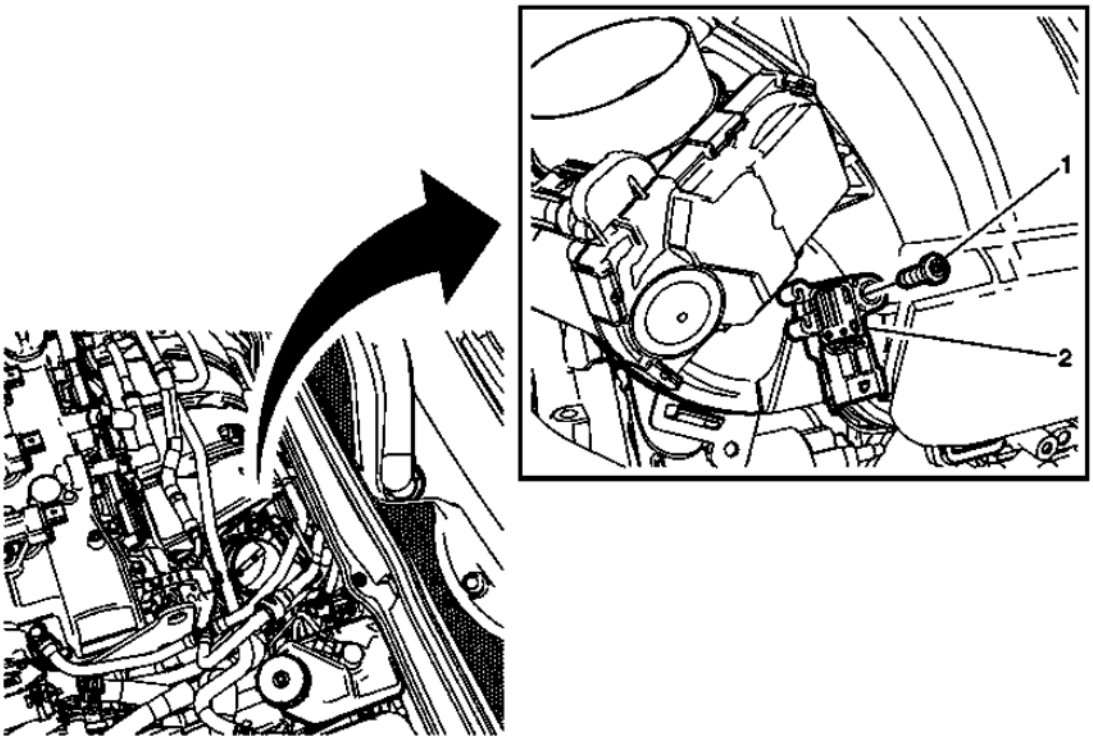


Fig. 5: Manifold Absolute Pressure Sensor
Courtesy of GENERAL MOTORS COMPANY

Manifold Absolute Pressure Sensor Replacement

Callout	Component Name
Preliminary Procedure Remove the charge air cooler outlet air tube. Refer to **Charge Air Cooler Outlet Air Tube Replacement**.	
1	Manifold Absolute Pressure Sensor Fastener **CAUTION:** **Refer to Fastener Caution .** **Tighten** 5 (44 lb in)
2	Manifold Absolute Pressure Sensor **Procedure** 1. Disconnect the engine wiring harness electrical connector from the manifold absolute pressure sensor. 2. Remove the manifold absolute pressure sensor from the intake manifold.

HEATED OXYGEN SENSOR REPLACEMENT - SENSOR 1

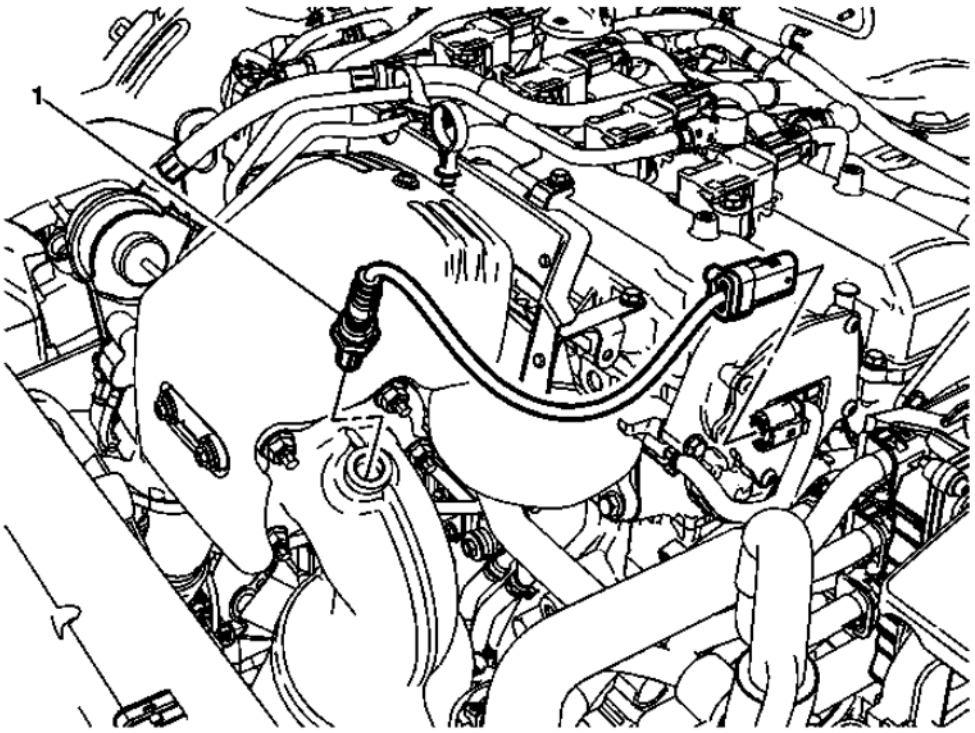


Fig. 6: Heated Oxygen Sensor - Sensor 1 (LTG)
Courtesy of GENERAL MOTORS COMPANY

Heated Oxygen Sensor Replacement - Sensor 1

Callout	Component Name
1	Heated Oxygen Sensor **CAUTION:** **The oxygen sensor uses a permanently attached pigtail and connector. Do not remove the pigtail from the oxygen sensor. Damage to or removal of the pigtail connector could affect proper operation of the oxygen sensor.** **CAUTION:** **The use of excessive force may damage the threads in the exhaust manifold/pipe.** **CAUTION:** **Refer to Heated Oxygen Sensor Resistance Learn Reset Caution .** **CAUTION:** **Refer to Component Fastener Tightening Caution .** **Procedure** Disconnect the electrical connector. **NOTE:** • **The in-line connector and louvered end must be kept clear of grease, dirt or**

	other contaminants. Avoid using cleaning solvents of any type. DO NOT drop or roughly handle the heated oxygen sensor (HO2S). • **The HO2S may be difficult to remove when the engine temperature is less than 48°C (120°F).** • **A special anti-seize compound is used on the HO2S threads. The compound consists of a liquid graphite and glass beads. The graphite will burn away, but the glass beads will remain, making the sensor easier to remove. New or service sensors will have the compound applied to the threads. If a sensor is removed and is to be reinstalled, the threads must have an anti-seize compound applied before installation.** **Tighten** 42 (31 lb ft) **Special Tools** **J-39194** Oxygen Sensor Wrench For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)** .

HEATED OXYGEN SENSOR REPLACEMENT - SENSOR 2

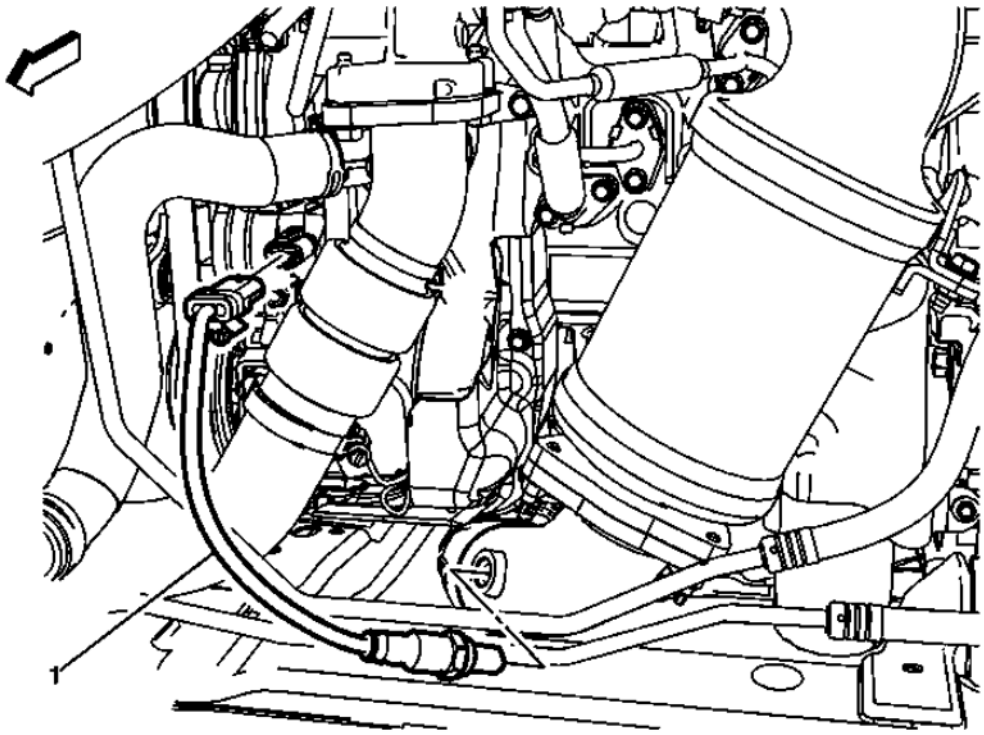


Fig. 7: Heated Oxygen Sensor - Sensor 2 (LTG)
Courtesy of GENERAL MOTORS COMPANY

Heated Oxygen Sensor Replacement - Sensor 2

Callout	Component Name
Preliminary Procedure Raise and properly support the vehicle. Refer to **Lifting and Jacking the Vehicle** .	
	Heated Oxygen Sensor

CAUTION:
The oxygen sensor uses a permanently attached pigtail and connector. Do not remove the pigtail from the oxygen sensor. Damage to or removal of the pigtail connector could affect proper operation of the oxygen sensor.

CAUTION:
The use of excessive force may damage the threads in the exhaust manifold/pipe.

CAUTION:
Refer to Heated Oxygen Sensor Resistance Learn Reset Caution .

CAUTION:
Refer to Component Fastener Tightening Caution .

Procedure
Disconnect the electrical connector.

1 **NOTE:**

- **The in-line connector and louvered end must be kept clear of grease, dirt or other contaminants. Avoid using cleaning solvents of any type. DO NOT drop or roughly handle the heated oxygen sensor (HO2S).**
- **The HO2S may be difficult to remove when the engine temperature is less than 48°C (120°F).**
- **A special anti-seize compound is used on the HO2S threads. The compound consists of a liquid graphite and glass beads. The graphite will burn away, but the glass beads will remain, making the sensor easier to remove. New or service sensors will have the compound applied to the threads. If a sensor is removed and is to be reinstalled, the threads must have an anti-seize compound applied before installation.**

Tighten
42 (31 lb ft)
Special Tools
J-39194 Oxygen Sensor Wrench
For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)** .

ACCELERATOR PEDAL WITH POSITION SENSOR ASSEMBLY REPLACEMENT

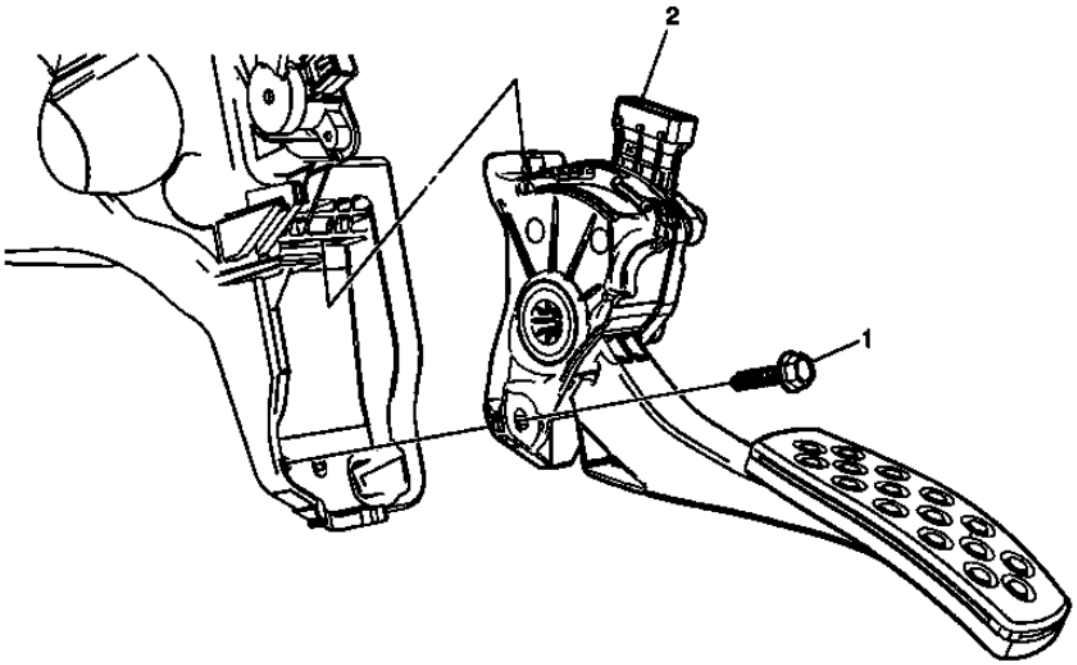


Fig. 8: Identifying Accelerator Pedal With Position Sensor Assembly
Courtesy of GENERAL MOTORS COMPANY

Accelerator Pedal with Position Sensor Assembly Replacement

Callout	Component Name
1	Accelerator Pedal Position Sensor Bolt **CAUTION:** **Refer to Fastener Caution** **Tighten** 9 N.m(80 lb in)
2	Accelerator Pedal Position Sensor

THROTTLE BODY ASSEMBLY REPLACEMENT

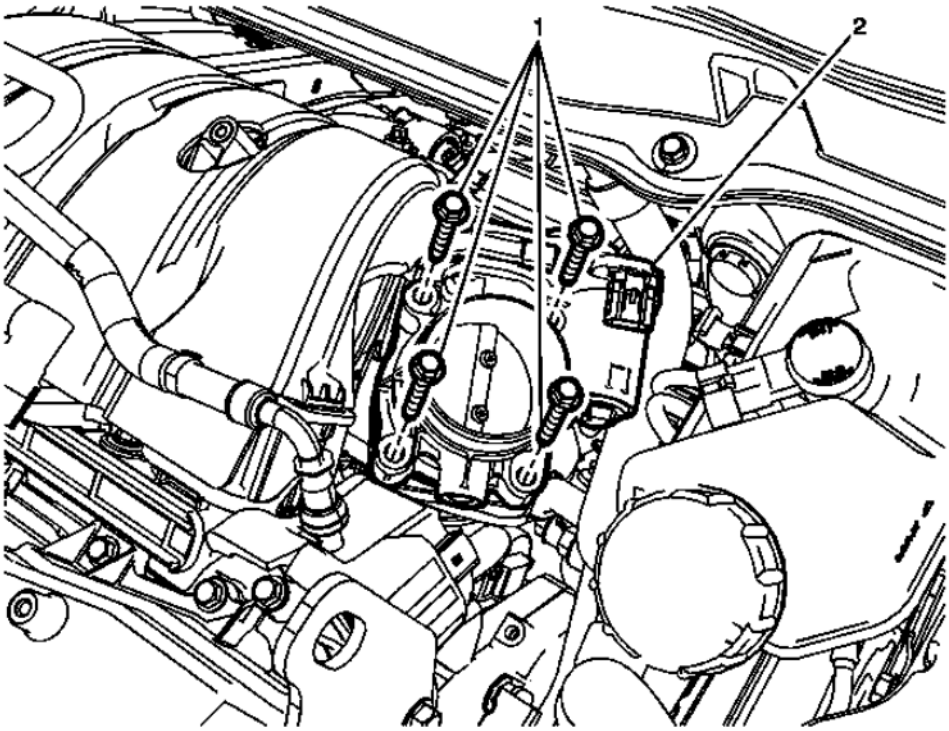


Fig. 9: Throttle Body Assembly (LTG)
Courtesy of GENERAL MOTORS COMPANY

Throttle Body Assembly Replacement

Callout	Component Name
	CAUTION: **Do not use solvent of any type when cleaning the gasket surfaces on the intake manifold and the throttle body assembly, as damage to the gasket surfaces and throttle body assembly may result.** **Use care in cleaning the gasket surfaces on the intake manifold and the throttle body assembly, as sharp tools may damage the gasket surfaces.** **CAUTION:** **Do not use any solvent that contains Methyl Ethyl Ketone (MEK). This solvent may damage fuel system components.** **NOTE:** **DO NOT prop open the throttle blade with the ignition key in the ON position as it may set a diagnostic trouble code (DTC).** **Preliminary Procedure** 1. Remove the charge air cooler outlet air tube. Refer to **Charge Air Cooler Outlet Air Tube Replacement**.
	Throttle Body Assembly Fasteners (Qty: 4) **CAUTION:** **Refer to Fastener Caution .**

1	**Tighten** 10 (89 lb in)
2	Throttle Body Assembly **Procedure** 1. Disconnect the engine wiring harness electrical connector from the throttle body assembly. 2. Inspect the throttle body gasket, and replace if necessary. 3. Perform the throttle learn procedure. Refer to **Q38 Throttle Body: Throttle/Idle Learn** .

THROTTLE BODY CLEANING

WARNING: Turn OFF the ignition before inserting fingers into the throttle bore. Unexpected movement of the throttle blade could cause personal injury.

CAUTION: Do not insert any tools into the throttle body bore in order to avoid damage to the throttle valve plate.

CAUTION: Do not use any solvent that contains Methyl Ethyl Ketone (MEK). This solvent may damage fuel system components.

1. Remove the charge air cooler outlet air tube. Refer to **Intake Manifold Cover Replacement** .

NOTE: DO NOT prop open the throttle blade with the ignition key in the ON position as it may set a diagnostic trouble code (DTC).

2. Inspect the throttle body bore and the throttle valve plate for deposits. You must open the throttle valve in order to inspect all of the surfaces.
3. Clean the throttle body bore and the throttle valve plate using a clean shop towel and approved cleaner.
4. Install the charge air cooler outlet air tube. Refer to **Intake Manifold Cover Replacement** .
5. Perform the Throttle/Idle Learn procedure. Refer to **Q38 Throttle Body: Throttle/Idle Learn** .

FUEL PRESSURE RELIEF

WARNING: Fuel that flows out at high pressure can cause serious injury to the skin and eyes. ALWAYS depressurize the fuel system before removing components that are under high fuel pressure.

1. Remove the fuel pump control module 20A fuse from the underhood electrical center. Refer to **Electrical Center Identification Views** .

2. Start the vehicle and allow the engine to idle until the engine stops. The engine will stop in approximately 20-30 seconds.
3. Turn the ignition OFF.

FUEL PRESSURE GAUGE INSTALLATION AND REMOVAL

Special Tools

- **CH-47831** Fuel Line Disconnect Tool
- **J 34730-1A** Fuel Pressure Gauge
- **J 42982** Fuel Pressure Gauge Adapter

Installation Procedure

WARNING: Gasoline or gasoline vapors are highly flammable. A fire could occur if an ignition source is present. Never drain or store gasoline or diesel fuel in an open container, due to the possibility of fire or explosion. Have a dry chemical (Class B) fire extinguisher nearby.

WARNING: Wrap a shop towel around the fuel pressure connection in order to reduce the risk of fire and personal injury. The towel will absorb any fuel leakage that occurs during the connection of the fuel pressure gauge. Place the towel in an approved container when the connection of the fuel pressure gauge is complete.

CAUTION: Clean all of the following areas before performing any disconnections in order to avoid possible contamination in the system:

- **The fuel pipe connections**
- **The hose connections**
- **The areas surrounding the connections**

1. Relieve the fuel pressure. Refer to **Fuel Pressure Relief**.
2. Disconnect the quick connect coupling of the fuel feed hose from the fuel feed pipe of the fuel rail. Use a shop towel in order to catch any remaining fuel that may leak.
3. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement** .
4. Install the **J 42982** adapter between the fuel feed pipe of the fuel rail and of the fuel feed hose.

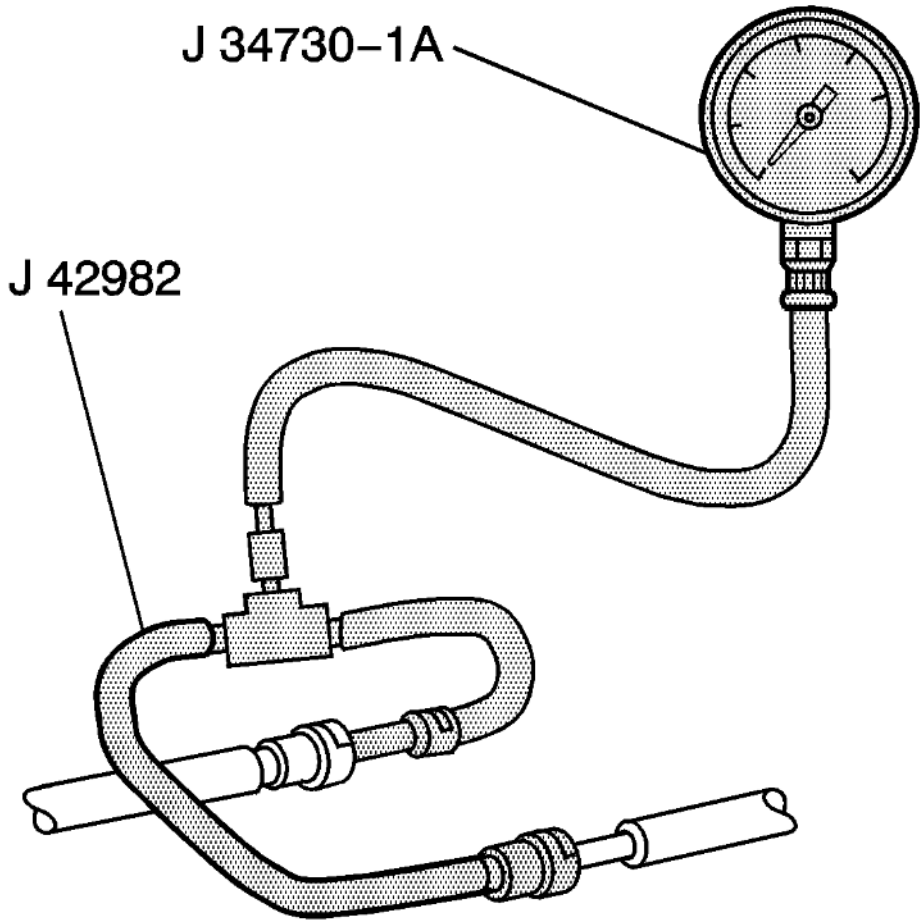


Fig. 10: Fuel Pressure Gage
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

5. Install the **J 34730-1A** gauge to the **J 42982** adapter , and tighten securely.
6. Turn ON the ignition in order to pressurize the fuel system.
7. Turn OFF the ignition.
8. Check for any fuel leaks.

Removal Procedure

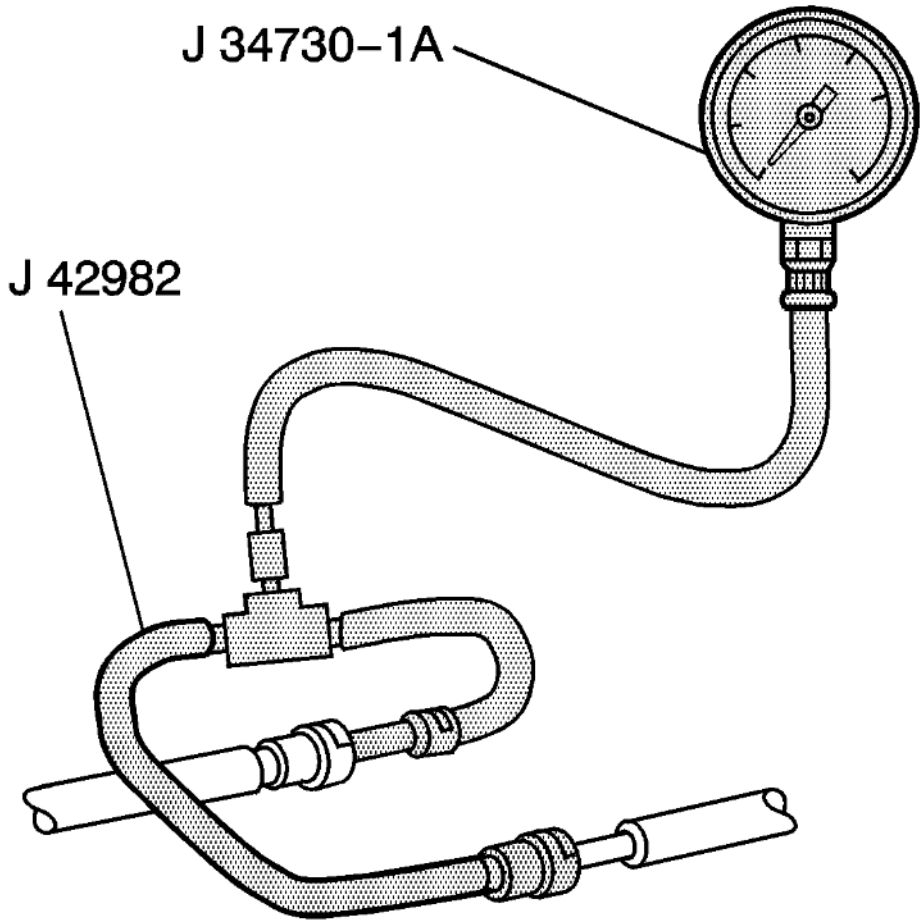


Fig. 11: Fuel Pressure Gage
Courtesy of GENERAL MOTORS COMPANY

1. Relieve the fuel pressure. Refer to the **Fuel Pressure Relief**.
2. Remove the **J 34730-1A** gauge from the **J 42982** adapter.
3. Using the **CH-47831** tool , disconnect the quick connect coupling of the **J 42982** adapter from the fuel feed pipe of the fuel rail. Use a shop towel in order to catch any remaining fuel that may leak.
4. Disconnect the quick connect coupling of the fuel feed hose (3) from the **J 42982** adapter , and remove the adapter. Use a shop towel in order to catch any remaining fuel that may leak.
5. Connect the quick-connect fitting of the fuel feed hose (3) to the fuel feed pipe of the fuel rail.
6. Turn ON the ignition in order to pressurize the fuel system.
7. Turn OFF the ignition.
8. Check for any fuel leaks.
9. Install the intake manifold cover. Refer to **Intake Manifold Cover Replacement** .

METAL COLLAR QUICK CONNECT FITTING SERVICE

Special Tools

- **CH-41769** Fuel Line Disconnect Tool Set

- **CH-44581** Fuel Line Disconnect Tool

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)** .

Removal Procedure

WARNING: Refer to Gasoline/Gasoline Vapors Warning .

1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief**.

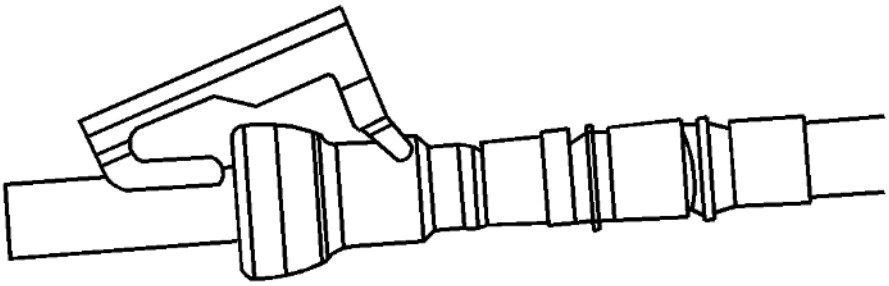


Fig. 12: View Of Quick-Connect Fitting Retainer
Courtesy of GENERAL MOTORS COMPANY

2. Remove the retainer from the quick-connect fitting.

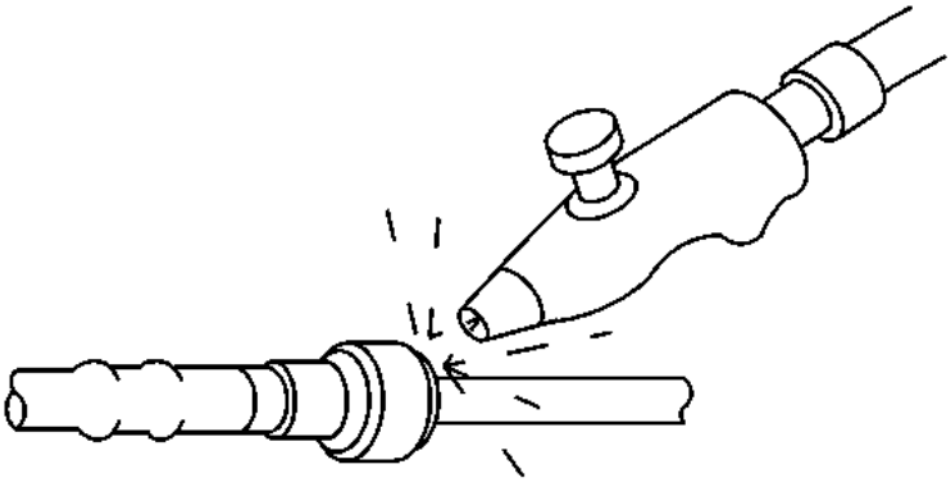


Fig. 13: Blowing Dirt Out Of Fitting (Metal Collar)
Courtesy of GENERAL MOTORS COMPANY

WARNING: Wear safety glasses when using compressed air, as flying dirt particles may cause eye injury.

3. Blow dirt out of the fitting using compressed air.

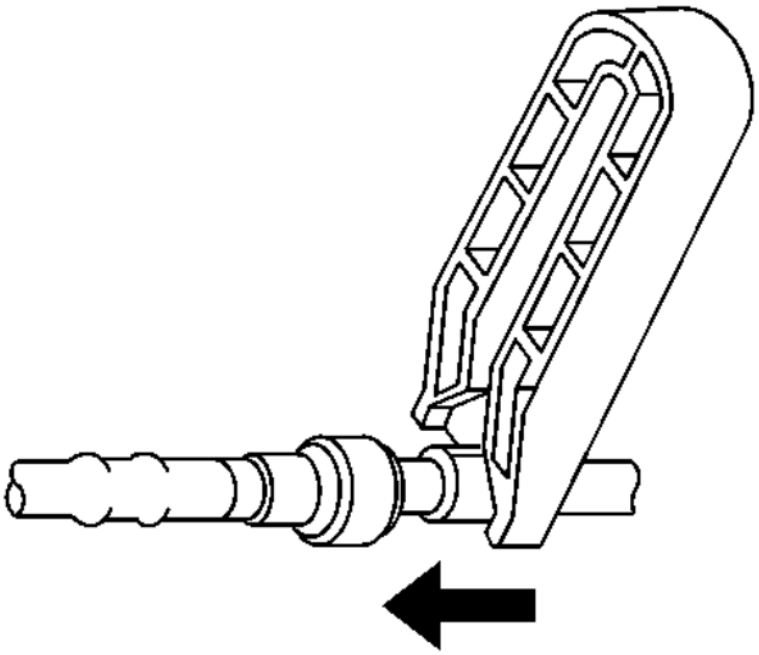


Fig. 14: View Of Quick Connect Locking Tabs (Metal Collar)
Courtesy of GENERAL MOTORS COMPANY

4. Depending on the fuel line size and ability to access the fitting, choose the appropriate tool: **CH-41769** fuel line disconnect tool set or **CH-44581** fuel line disconnect tool. Insert the **CH-41769** fuel line disconnect tool set or **CH-44581** fuel line disconnect tool into the female connector, then push inward to release the locking tabs.

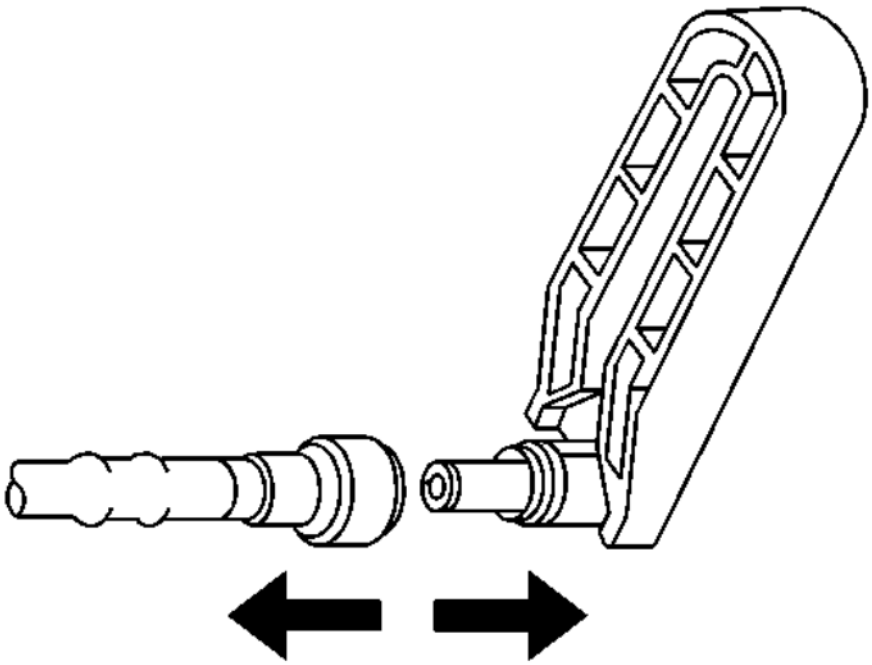


Fig. 15: View Of Quick Connect Locking Tabs (Metal Collar)
Courtesy of GENERAL MOTORS COMPANY

5. Pull the connection apart.

CAUTION: If necessary, remove rust or burrs from the fuel pipes with an emery cloth. Use a radial motion with the fuel pipe end in order to prevent damage to the O-ring sealing surface. Use a clean shop towel in order to wipe off the male tube ends. Inspect all the connections for dirt and burrs. Clean or replace the components and assemblies as required.

6. Using a clean shop towel, wipe off the male pipe end.
7. Inspect both ends of the fitting for dirt and burrs.
8. Clean or replace the components as required.

Installation Procedure

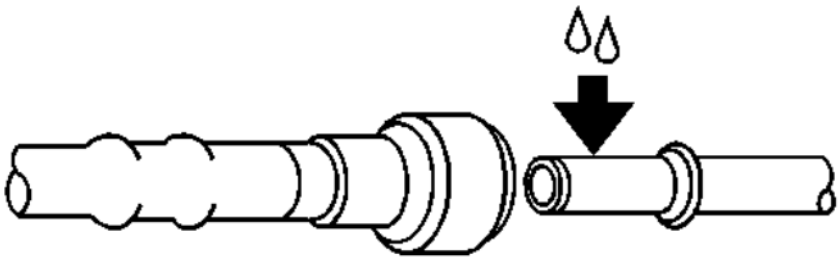


Fig. 16: Oiling Male Pipe Ends (Metal Collar)
Courtesy of GENERAL MOTORS COMPANY

WARNING: In order to reduce the risk of fire and personal injury, before connecting fuel pipe fittings, always apply a few drops of clean engine oil to the male pipe ends.

This will ensure proper reconnection and prevent a possible fuel leak.

During normal operation, the O-rings located in the female connector will swell and may prevent proper reconnection if not lubricated.

1. Apply a few drops of clean engine oil to the male pipe end.

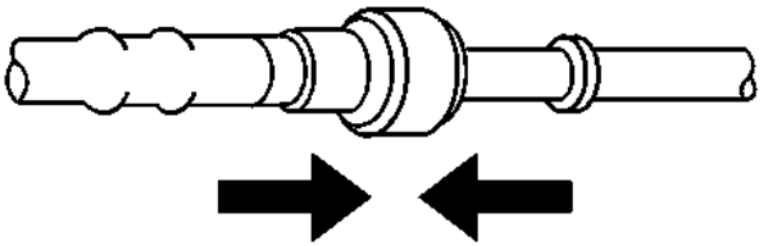


Fig. 17: View Of Connectors (Metal Collar)
Courtesy of GENERAL MOTORS COMPANY

2. Push both sides of the quick-connect fitting together to cause the retaining tabs to snap into place.

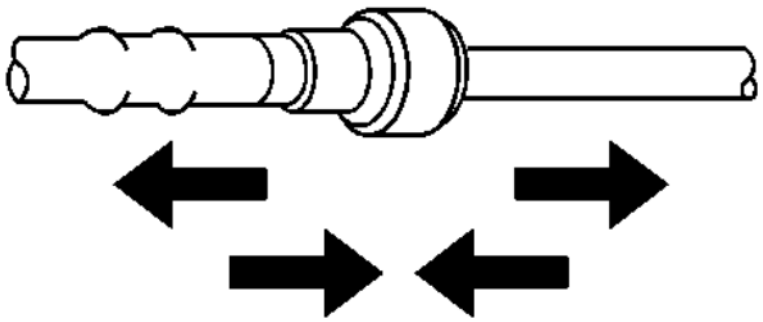


Fig. 18: Ensuring Connection (Metal Collar) Is Secure
Courtesy of GENERAL MOTORS COMPANY

3. Pull on both sides of the quick-connect fitting to make sure the connection is secure.

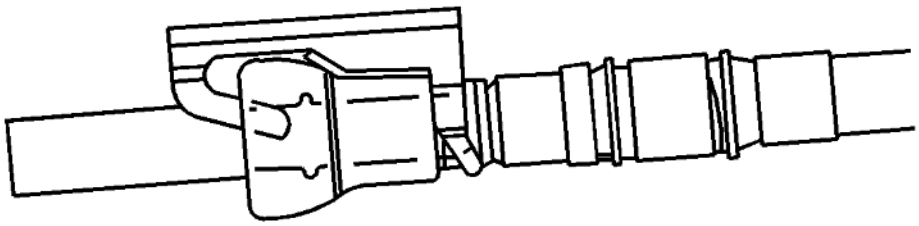


Fig. 19: View Of Fuel Pipe Retainer
Courtesy of GENERAL MOTORS COMPANY

4. Install the retainer to the quick-connect fitting.
5. Inspect for leaks using the following procedure:
    1. Turn the ignition ON, with the engine OFF for 2 seconds.
    2. Turn the ignition OFF, for 10 seconds.
    3. Turn the ignition ON, with the engine OFF for 2 seconds.
    4. Turn the ignition OFF.
    5. Inspect for leaks.

PLASTIC COLLAR QUICK CONNECT FITTING SERVICE

Removal Procedure

WARNING: Refer to Gasoline/Gasoline Vapors Warning .

NOTE: If servicing a fuel system, insure the fuel pressure has been relieved.

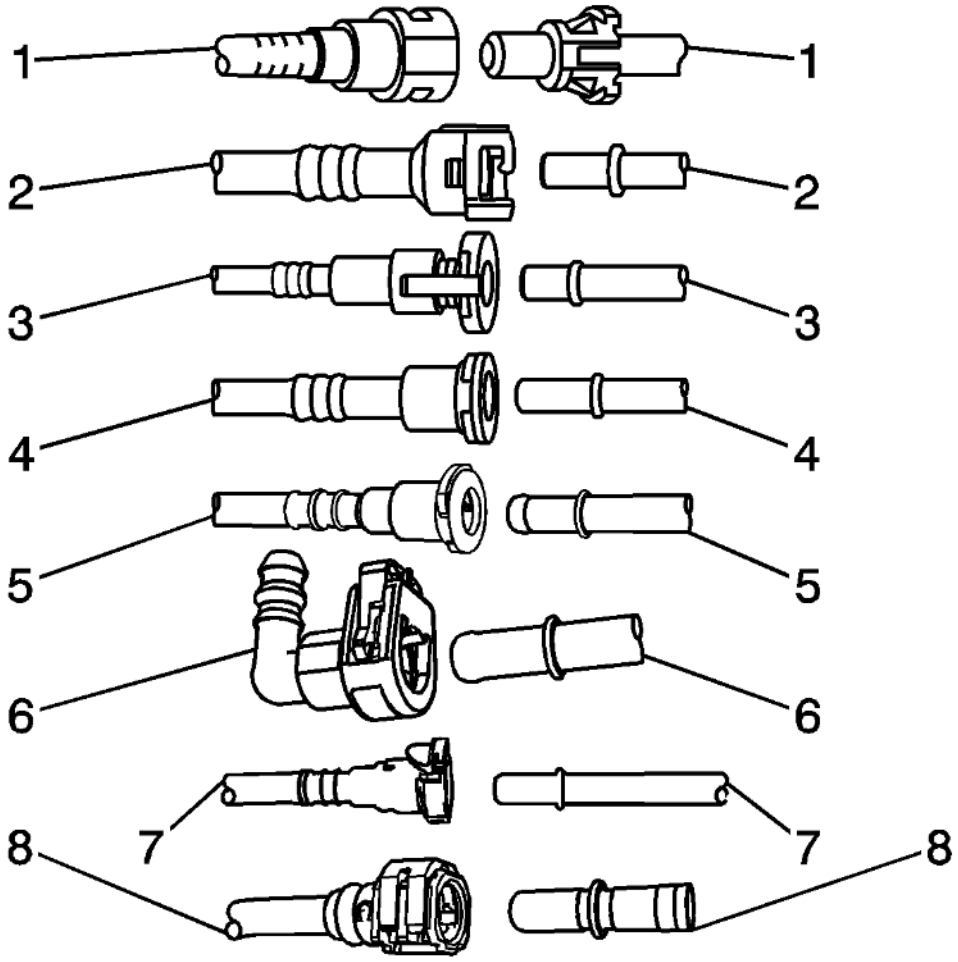


Fig. 20: Plastic Collar Quick Connect Fitting Service
Courtesy of GENERAL MOTORS COMPANY

NOTE: **There are several types of plastic collar fuel and evaporative emission quick connect fittings used on this vehicle.**

- **Bartholomew (1)**
- **Q Release (2)**
- **Squeeze to Release (3)**
- **Sliding Retainer (4)**
- **Global Connect (5)**
- **Tl Loc (6)**
- **Safe Lock (7)**
- **Plastic Connector (8)**

The following instructions apply to all of these types of plastic collar quick connect fittings except where indicated.

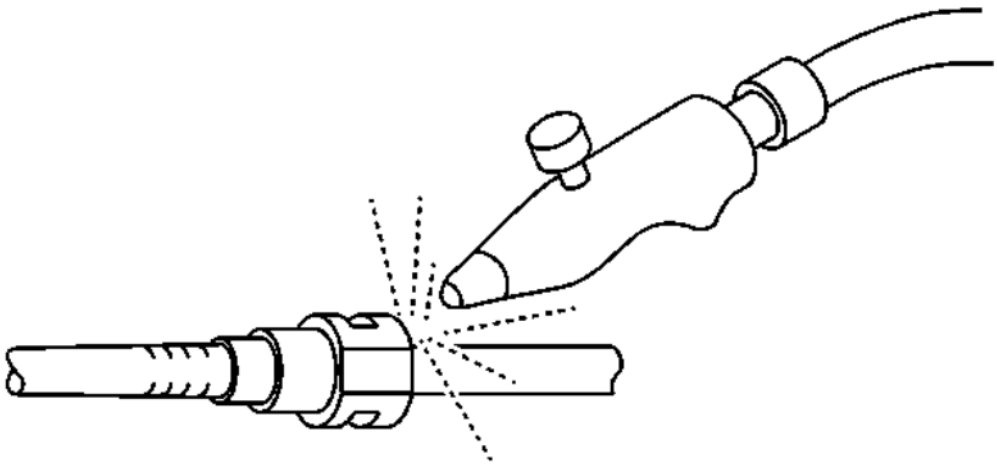


Fig. 21: Blowing Dirt Out Of Fitting (Plastic Collar)
Courtesy of GENERAL MOTORS COMPANY

WARNING: Always apply a few drops of clean engine oil to the male pipe ends before connecting the fuel pipe fittings. This will ensure proper reconnection and prevent a possible fuel leak. Always replace O-rings.

1. Using compressed air, blow any dirt out of the quick-connect fitting.

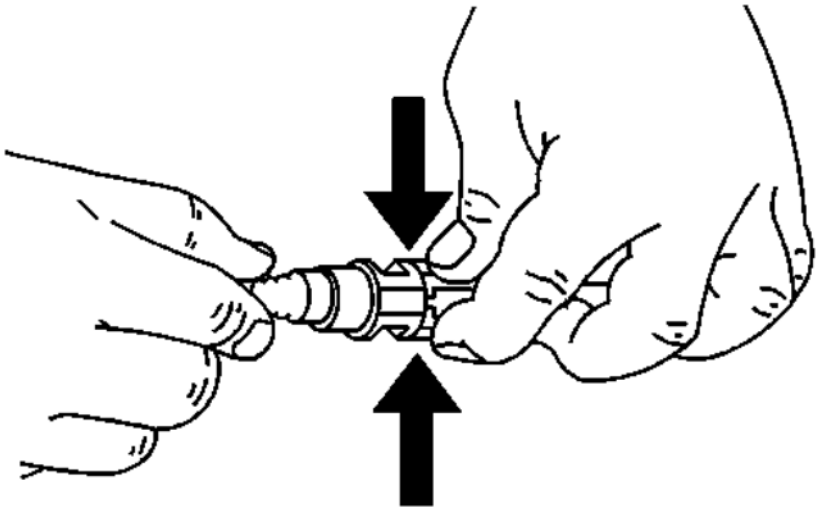


Fig. 22: View Of Quick Connect Fitting Release Tabs (Plastic Collar)
Courtesy of GENERAL MOTORS COMPANY

2. This step applies to Bartholomew style connectors ONLY. Squeeze the plastic quick-connect fitting release tabs.

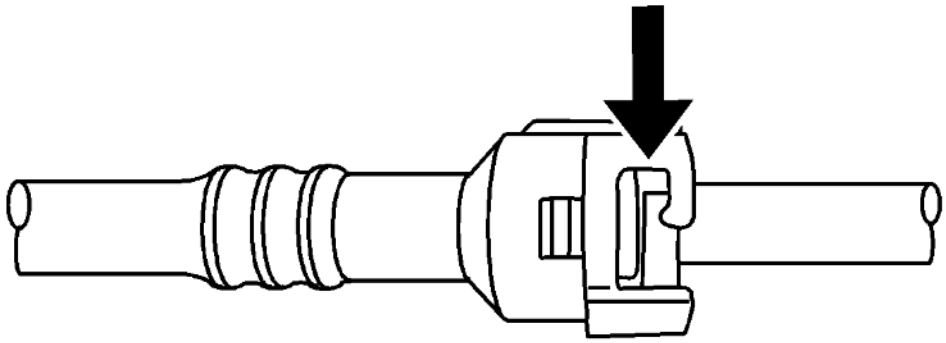


Fig. 23: Releasing Q Release Style Connectors (Plastic Collar)
Courtesy of GENERAL MOTORS COMPANY

3. This step applies to Q Release style connectors ONLY. Release the fitting by Pushing the tab toward the other side of the slot in the fitting.

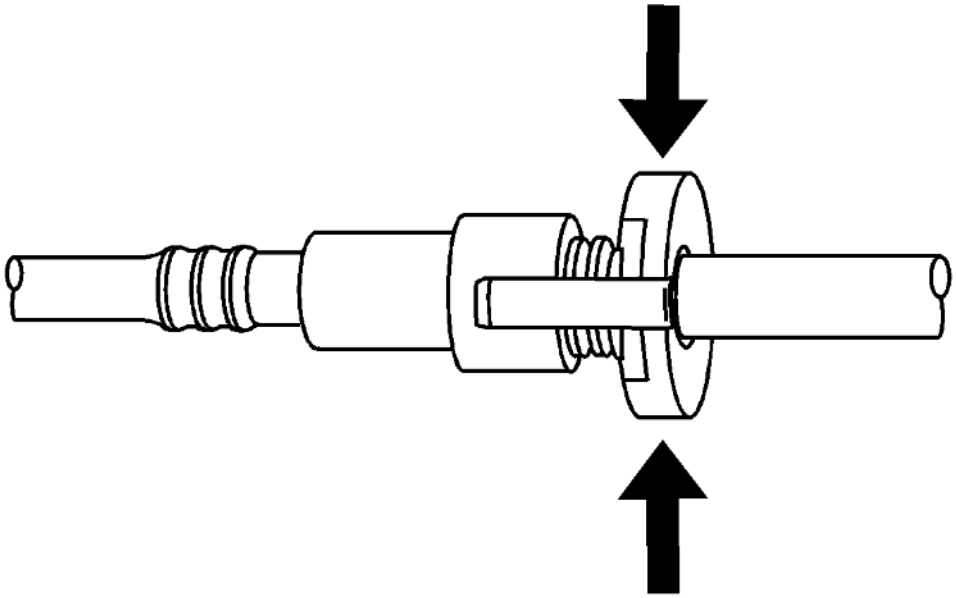


Fig. 24: Disengaging Quick Connect Fitting (Plastic Collar)
Courtesy of GENERAL MOTORS COMPANY

4. This step applies to Squeeze to Release style connectors ONLY. Squeeze where indicated by arrows on both sides of the plastic ring surrounding the quick-connect fitting.

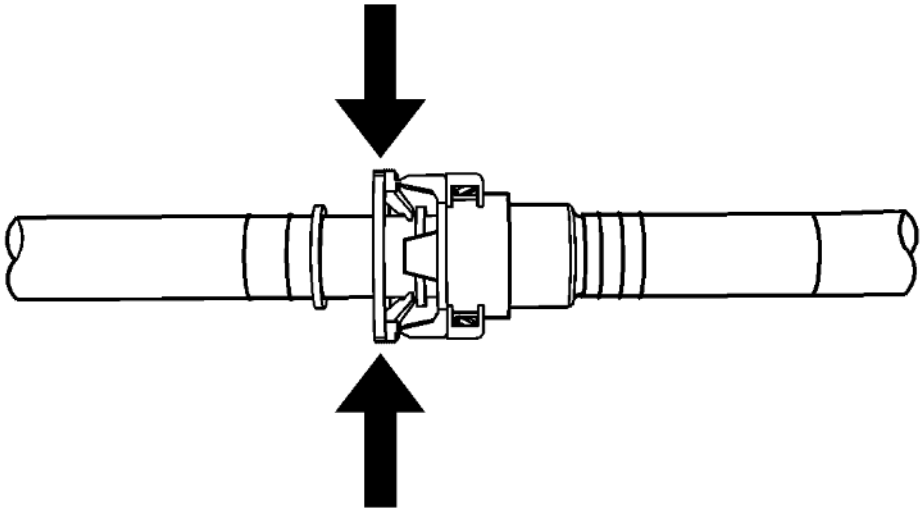


Fig. 25: Pushing In Male Side Of Connector
Courtesy of GENERAL MOTORS COMPANY

5. This step applies to Squeeze to Release style connectors ONLY. Push in the male side slightly in order to slide the retainer away from the retainers, squeeze where indicated by arrows on both sides of the plastic ring surrounding the quick-connect fitting.

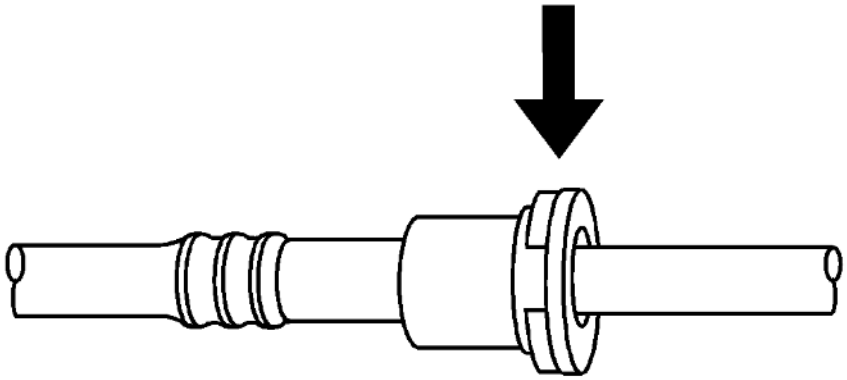


Fig. 26: View Of Sliding Retainer Style Connector
Courtesy of GENERAL MOTORS COMPANY

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.

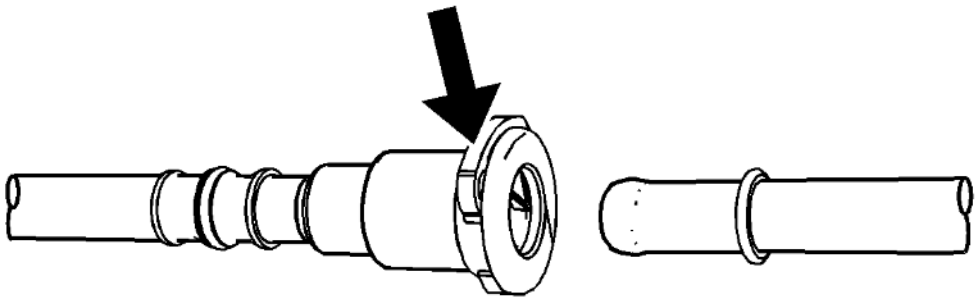


Fig. 27: Global Connector Style
Courtesy of GENERAL MOTORS COMPANY

7. This step applies to the Global Connector style only. Push the connector toward the tube in order to release the pressure. Press and hold down the release mechanism, and pull the connector straight out.

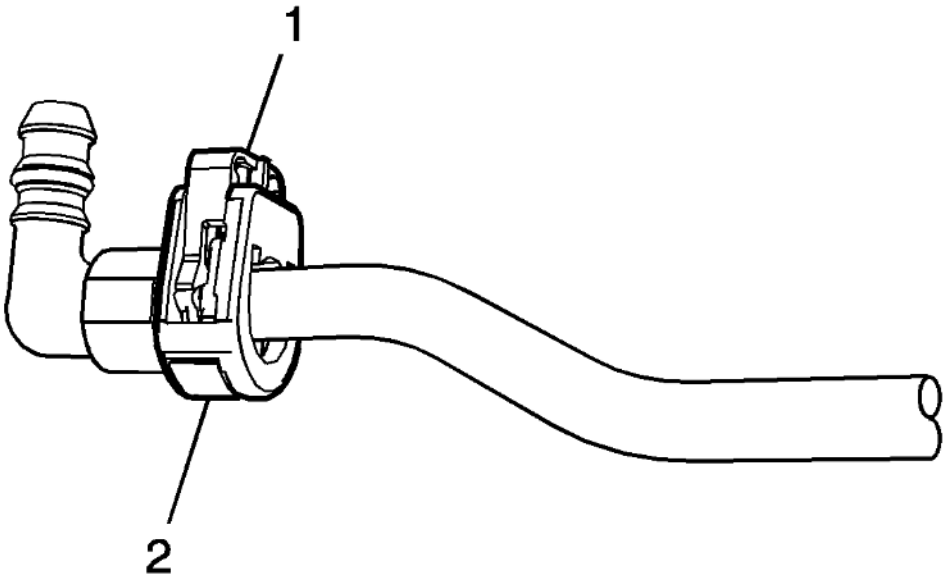


Fig. 28: TI Loc style
Courtesy of GENERAL MOTORS COMPANY

8. This step applies to the TI Loc style only. Push the connector toward the tube in order to release the pressure. Release the redundant latch (1) with two fingers or a flat bladed tool. Then press and hold down the bottom release mechanism (2) and pull the connector straight out.

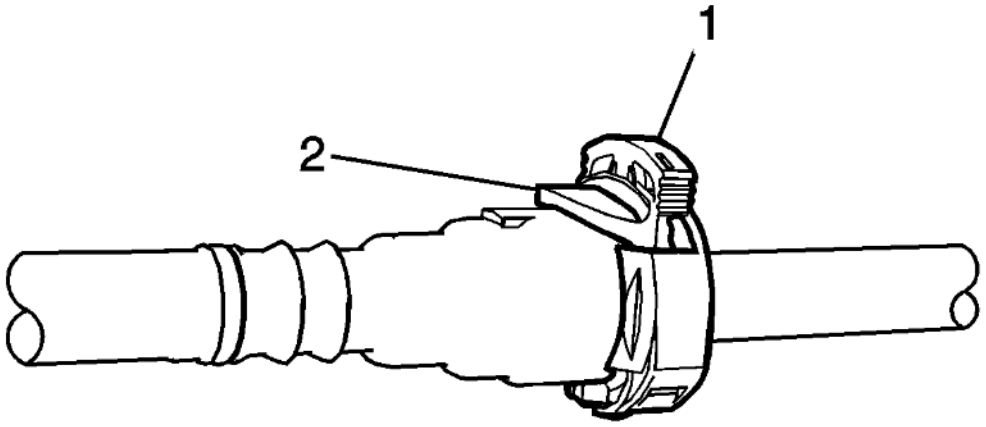


Fig. 29: Safe Lock Style
Courtesy of GENERAL MOTORS COMPANY

WARNING: Refer to Relieving Fuel Pressure Warning .

9. This step applies to the Safe Lock style only. Push the connector toward the tube in order to release the pressure. Release the second latch (1) with two fingers. Then press and hold down the bottom release mechanism (2) and pull the connector straight out.

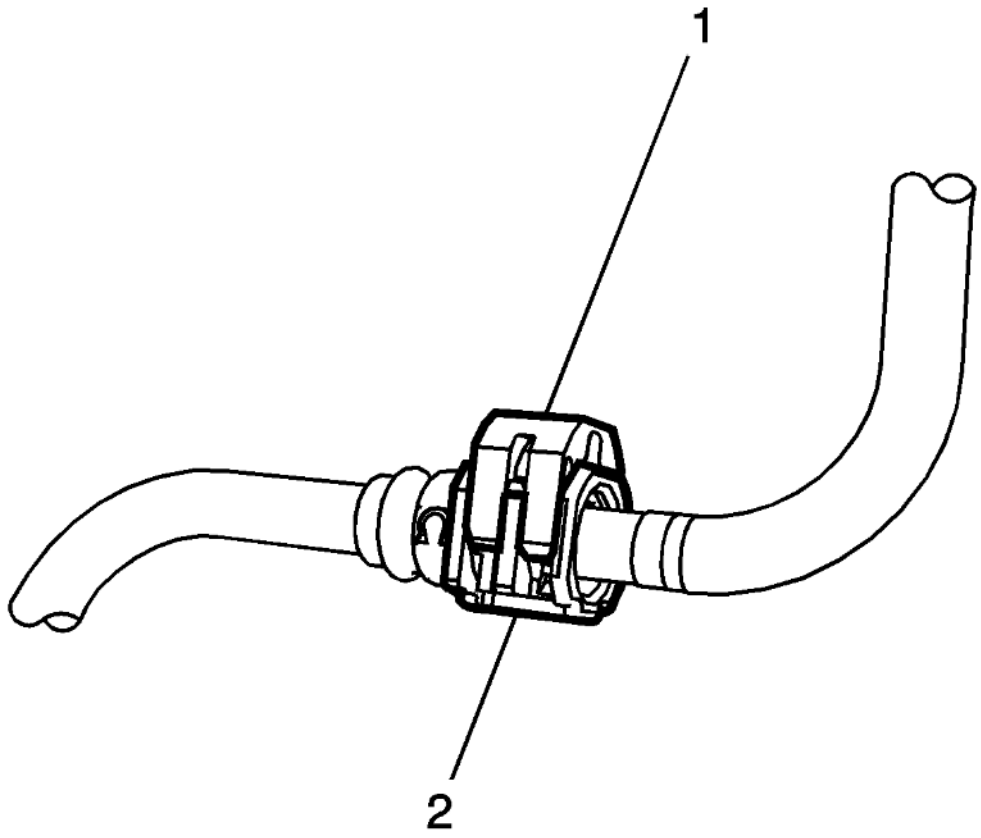


Fig. 30: Releasing Latch And Pulling Connector Straight Out
Courtesy of GENERAL MOTORS COMPANY

10. This step applies to the Plastic Connector style 8, push the connector toward the tube in order to release the pressure. Press the latch (1) inward in order to release the pipe, while pulling the connector (2) straight out.
11. Using a clean shop towel, wipe off the male pipe end.
12. Inspect both ends of the fitting for dirt and burrs.
13. Clean or replace components as necessary.

Installation Procedure

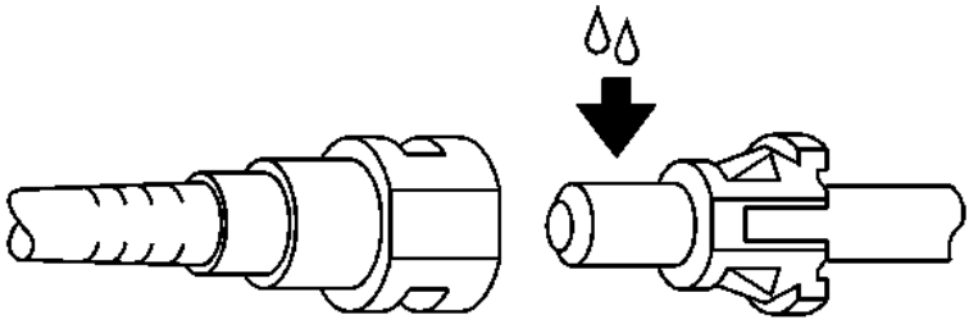


Fig. 31: Lubricating Male Pipe End
Courtesy of GENERAL MOTORS COMPANY

WARNING: Always apply a few drops of clean engine oil to the male pipe ends before connecting the fuel pipe fittings. This will ensure proper reconnection and prevent a possible fuel leak. Always replace O-rings.

1. Apply a few drops of clean engine oil to the male pipe end.

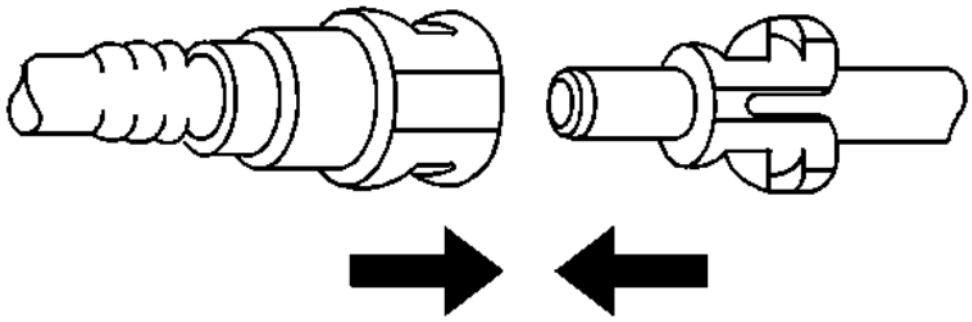


Fig. 32: Connecting Quick-Connect Fittings
Courtesy of GENERAL MOTORS COMPANY

2. Push both sides of the quick-connect fitting together in order to cause the retaining feature to snap into place.

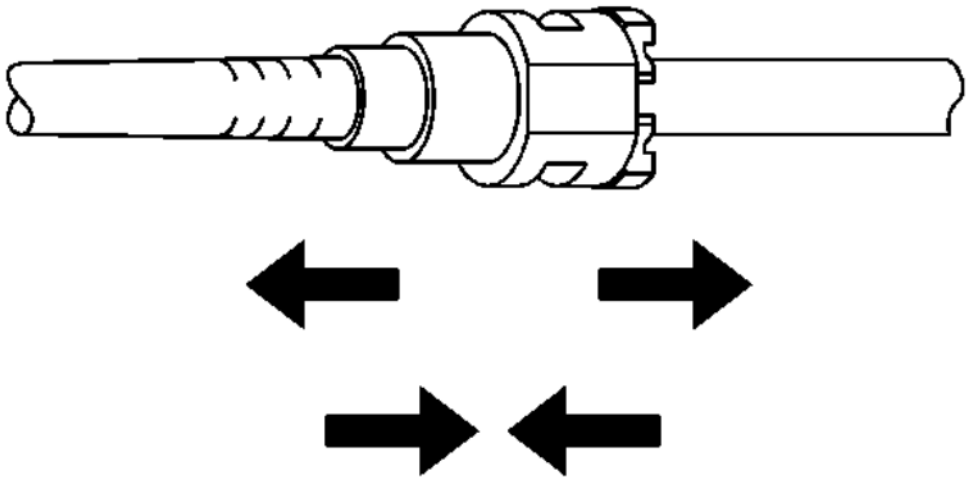


Fig. 33: View Of Quick-Connect Fitting
Courtesy of GENERAL MOTORS COMPANY

3. Pull on both sides of the quick-connect fitting to make sure the connection is secure.

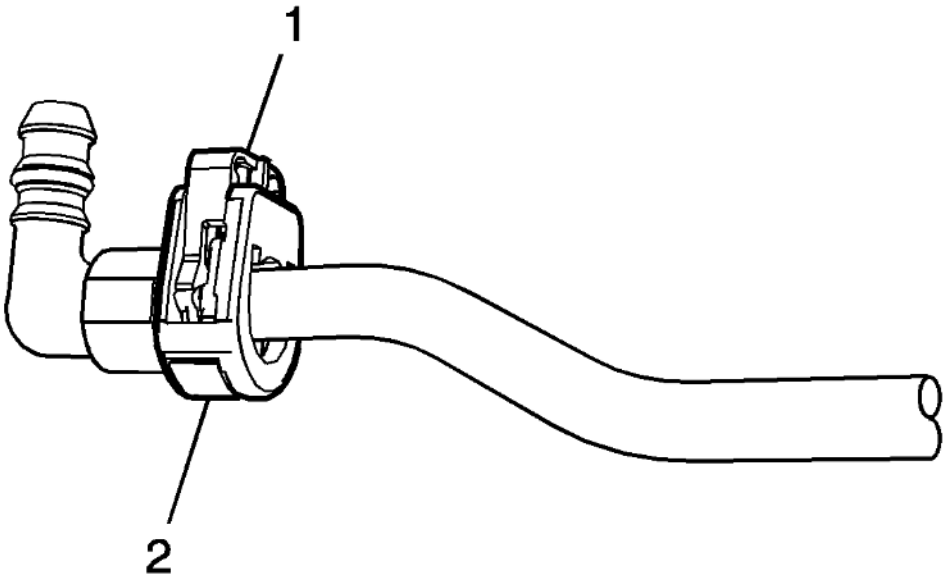


Fig. 34: TI Loc style
Courtesy of GENERAL MOTORS COMPANY

4. Insert the tube in the connector until the retainer snaps in place.
5. Push down on the redundant latch (1) until it is fully engaged and snapped into position.

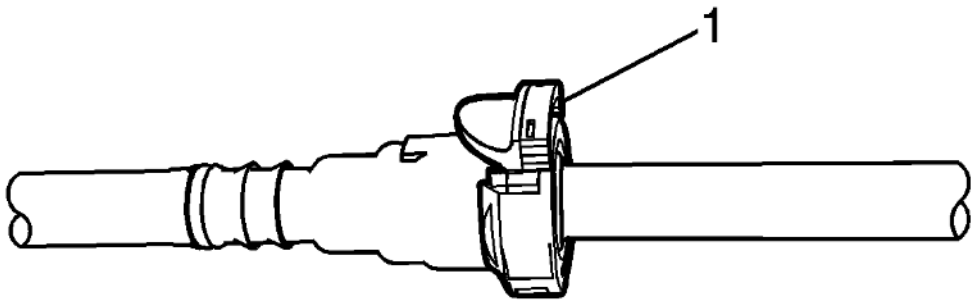


Fig. 35: Identifying Redundant Latch
Courtesy of GENERAL MOTORS COMPANY

6. Insert the tube in the connector until the retainer snaps in place.
7. Push down on the second latch (1) in order to secure the connection.

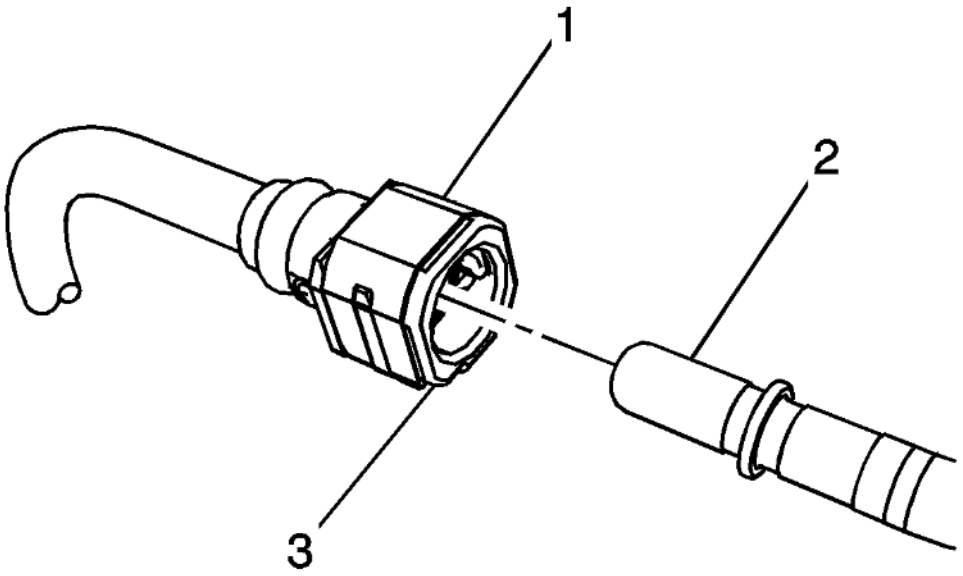


Fig. 36: Latch And Connector
Courtesy of GENERAL MOTORS COMPANY

8. For the plastic connector type 8, depress the latch (1) while inserting the connector (3) on to the pipe (2) .
9. Move the latch (1) upward in order to secure the connection.
10. Inspect for leaks using the following procedure:
    1. Turn the ignition ON, with the engine OFF for 2 seconds.
    2. Turn the ignition OFF, for 10 seconds.
    3. Turn the ignition ON, with the engine OFF for 2 seconds.
    4. Turn the ignition OFF.
    5. Inspect for leaks.

FUEL TANK DRAINING

Special Tools

- **DT 36850** Transjel Lubricant
- **CH 45004** Fuel Tank Drain Hose

WARNING: Never drain or store fuel in an open container. Always use an approved fuel storage container in order to reduce the chance of fire or explosion.

WARNING: Place a dry chemical (Class B) fire extinguisher nearby before performing any on-vehicle service procedures. Failure to follow these precautions may result in personal injury.

1. Raise and Support the Vehicle. Refer to **Lifting and Jacking the Vehicle**

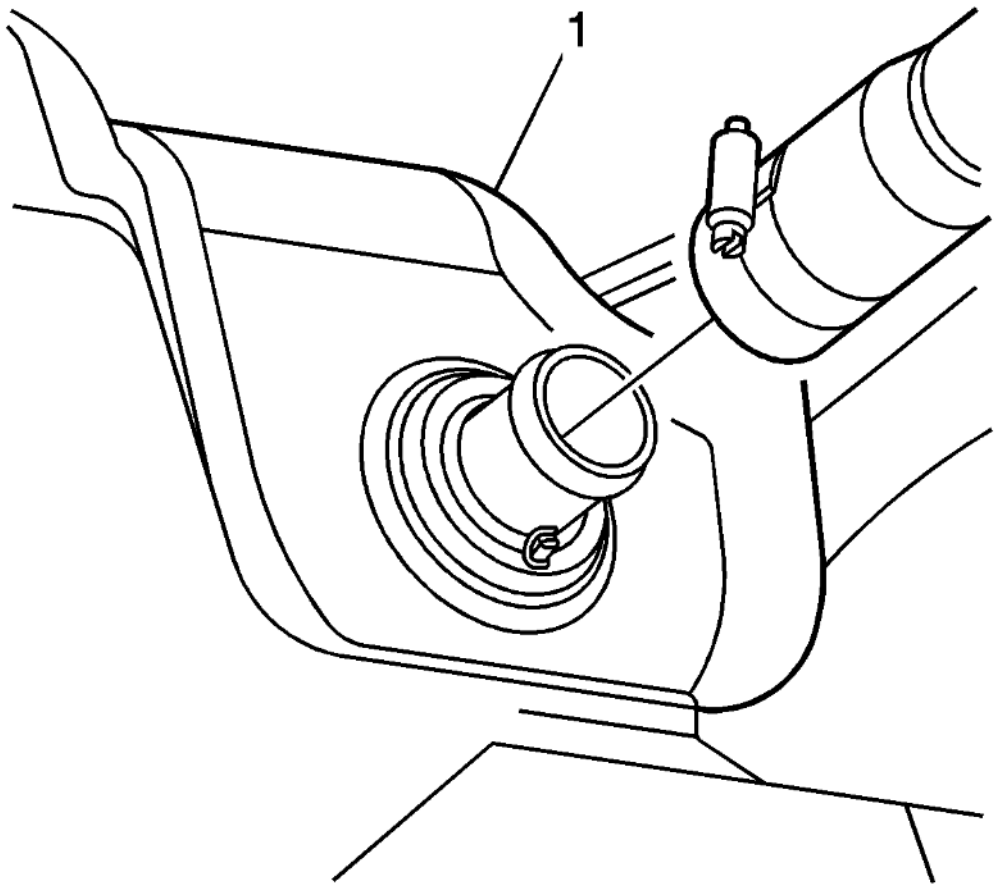


Fig. 37: Inserting Fuel Tank Drain Hose Into Fuel Tank
Courtesy of GENERAL MOTORS COMPANY

NOTE: Lubricate the fuel drain hose with DT 36850 Transjel Lubricant or equivalent to aid in hose insertion. Do not use an unapproved lubricant.

2. Loosen the lower drain hose clamp in order to separate the drain hose from the fuel tank (1).
3. Insert the **CH 45004** Fuel Tank Drain Hose into the fuel tank (1) until the hose reaches the bottom of the fuel tank.
4. Use a hand or air operated pump device in order to drain as much fuel from the fuel tank as possible.

FUEL TANK PROTECTOR REPLACEMENT (FWD)

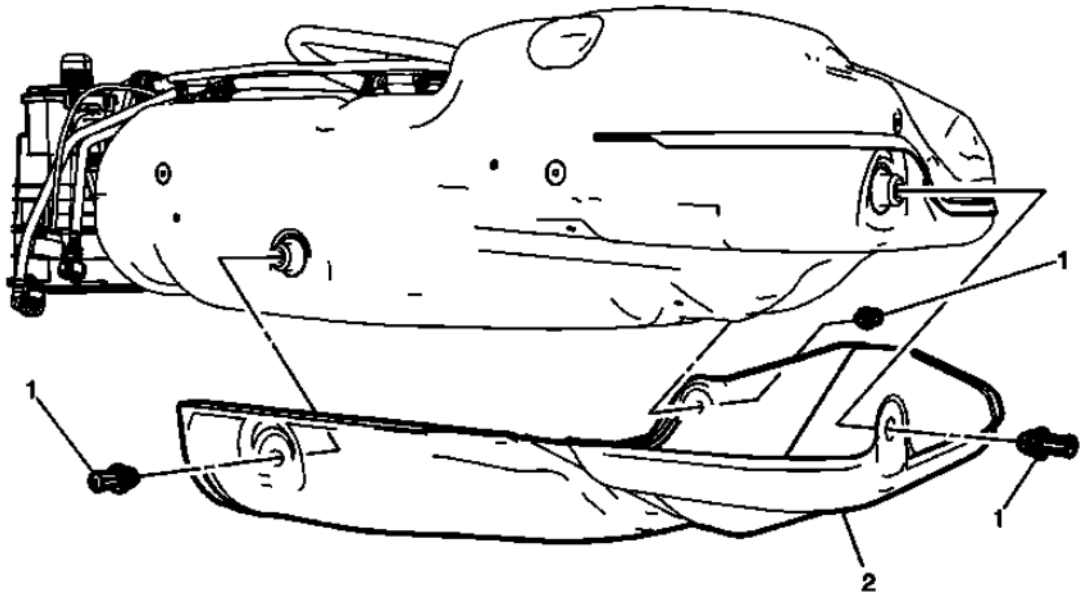


Fig. 38: Fuel Tank Protector & Retainers (FWD)
Courtesy of GENERAL MOTORS COMPANY

Fuel Tank Protector Replacement (FWD)

Callout	Component Name
Preliminary Procedure Remove the left fuel tank strap. Refer to **Fuel Tank Replacement (FWD)**.	
1	Fuel Tank Protector Retainers (Qty: 3)
2	Fuel Tank Protector

FUEL TANK PROTECTOR REPLACEMENT (AWD)

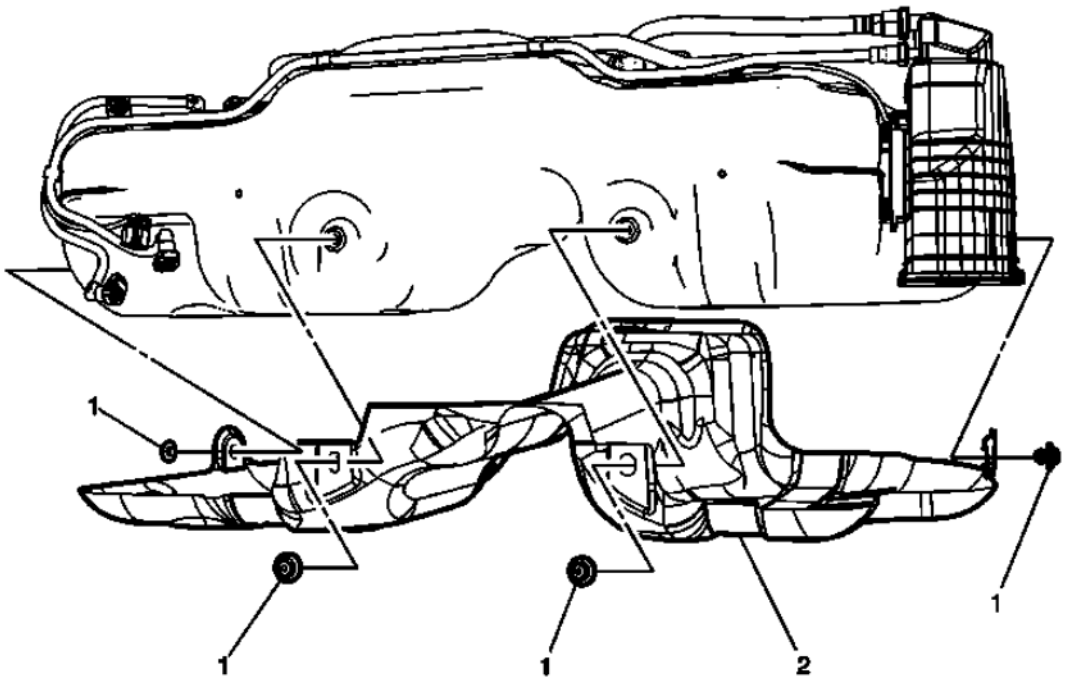


Fig. 39: Fuel Tank Protector & Retainers (AWD)
Courtesy of GENERAL MOTORS COMPANY

Fuel Tank Protector Replacement (AWD)

Callout	Component Name
Preliminary Procedure Remove the fuel tank. Refer to **Fuel Tank Replacement (AWD)**.	
1	Fuel Tank Protector Retainers (Qty: 4)
2	Fuel Tank Protector

FUEL TANK REPLACEMENT (AWD)

Removal Procedure

WARNING: Refer to Gasoline/Gasoline Vapors Warning .

WARNING: Refer to Safety Glasses Warning .

1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief**.
2. Drain the fuel tank. Refer to **Fuel Tank Draining**.
3. Remove the propeller shaft. Refer to **Propeller Shaft Replacement** .
4. Remove the exhaust system. Refer to **REPAIR INSTRUCTIONS** .

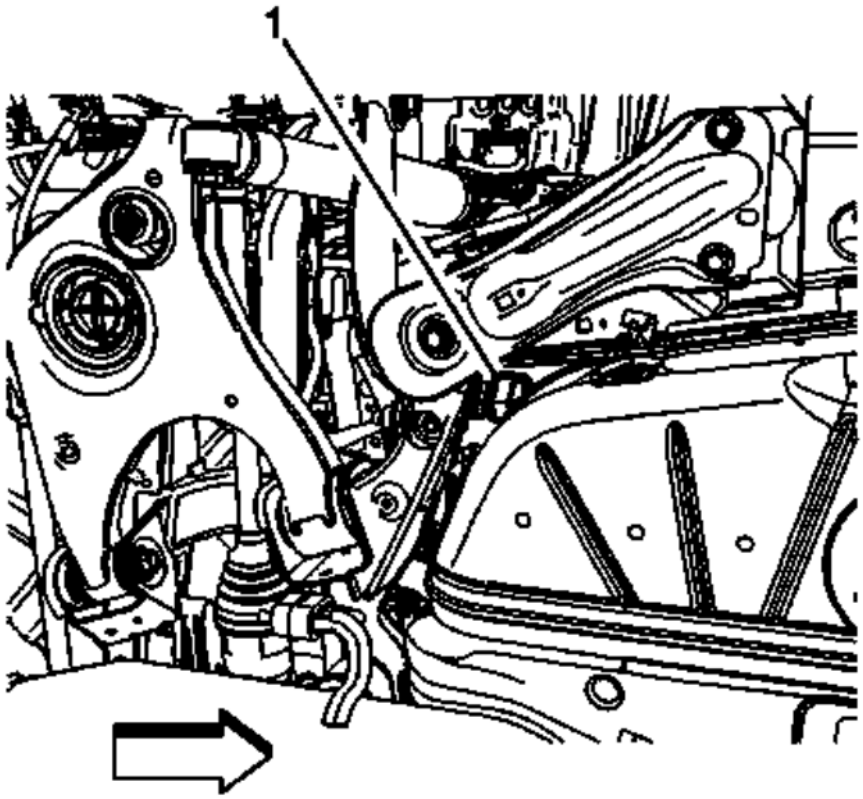


Fig. 40: Fuel Pump Module Wiring Harness
Courtesy of GENERAL MOTORS COMPANY

5. Disconnect the fuel tank fuel pump module wiring harness (1).

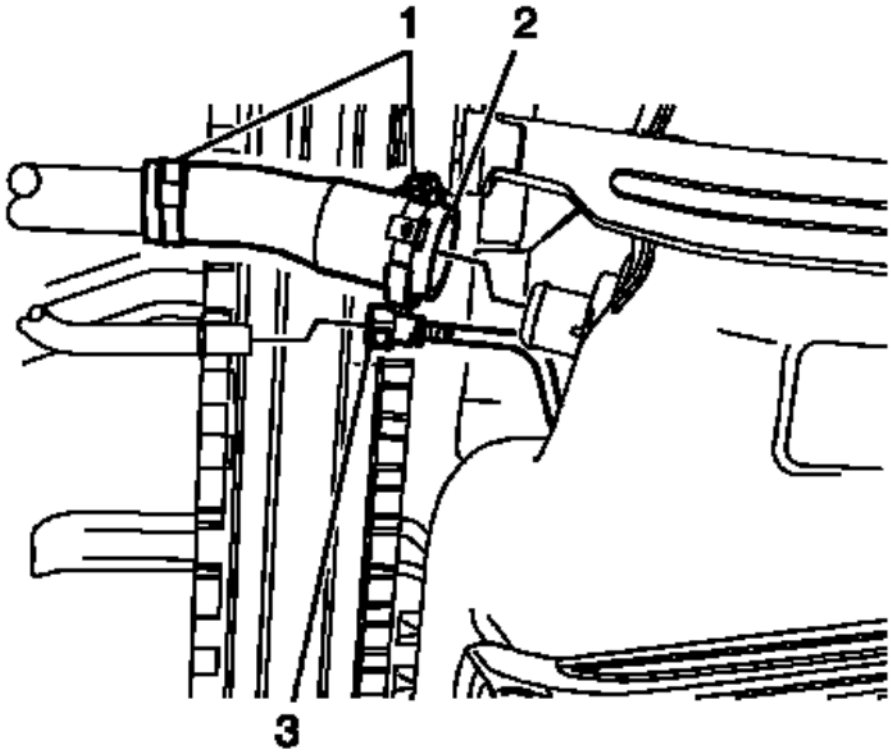


Fig. 41: Hose Clamps & Filler Tube
Courtesy of GENERAL MOTORS COMPANY

WARNING: Do not breathe the air through the EVAP component tubes or hoses. The fuel vapors inside the EVAP components may cause personal injury.

6. Disconnect the fuel tank filler vent pipe from the fuel tank vent pipe (3). Refer to **Plastic Collar Quick Connect Fitting Service**.
7. Disconnect the fuel tank filler tube (2) from the fuel tank.

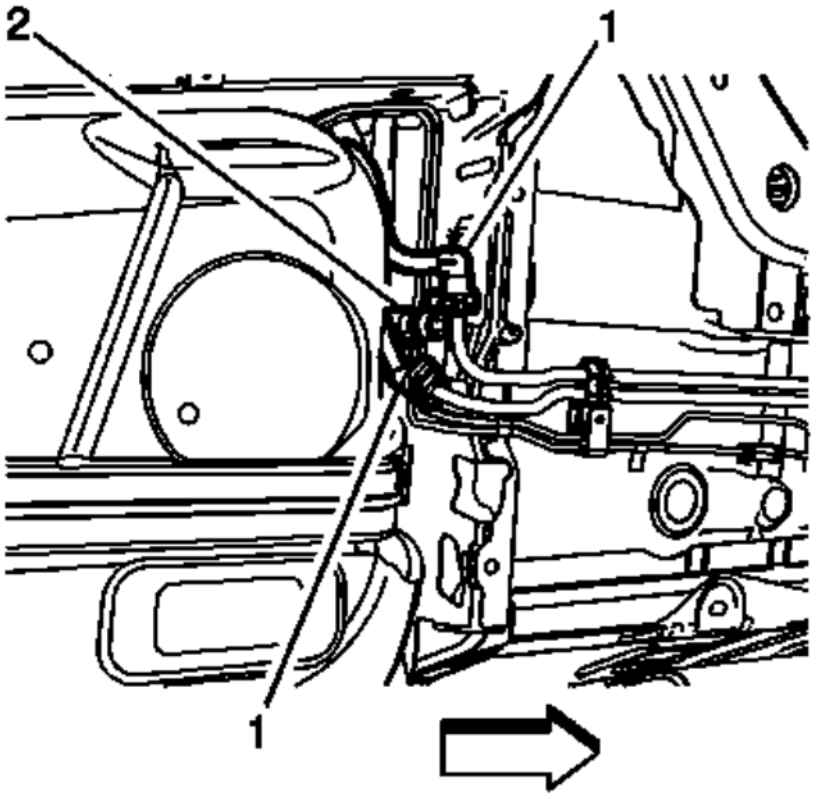


Fig. 42: Evaporative Emission Purge & Fuel Feed Pipes With Fuel Pressure Sensor Harness Connector
Courtesy of GENERAL MOTORS COMPANY

8. Disconnect the evaporative emission purge and fuel feed pipes (1). Refer to **Plastic Collar Quick Connect Fitting Service**.
9. Disconnect the fuel pressure sensor harness connector (2).
10. Disconnect the wiring harness connector from the fuel pipe.
11. Position a suitable hydraulic lift below the fuel tank.

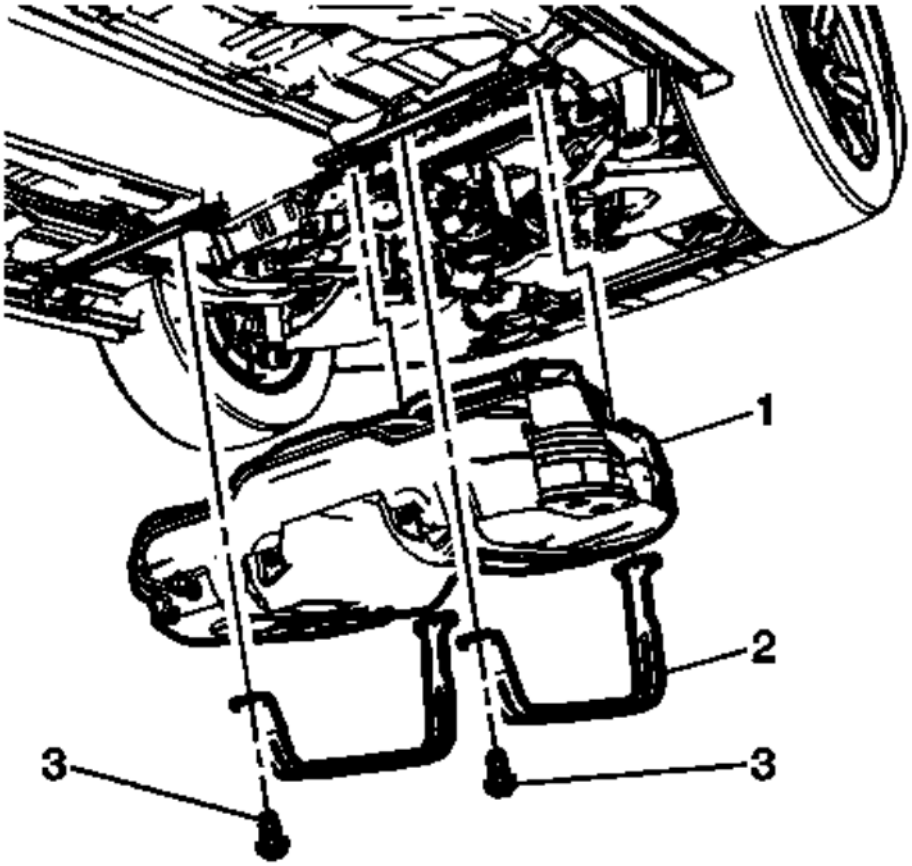


Fig. 43: Fuel Tank Straps And Fuel Tank
Courtesy of GENERAL MOTORS COMPANY

12. Remove both fuel tank strap fasteners (3).
13. Remove both fuel tank straps (2) from the fuel tank (1).

WARNING: To help avoid personal injury, always use jack stands when you are working on or under any vehicle that is supported only by a jack.

CAUTION: When you are jacking or lifting a vehicle at the frame side rails or other prescribed lift points, be certain that the lift pads do not contact the catalytic converter, the brake pipes or the fuel lines. If such contact occurs, vehicle damage or unsatisfactory vehicle performance may result.

NOTE: Carefully maneuver the fuel tank past the exhaust system.

14. With the aid of an assistant, lower the hydraulic lift to remove the fuel tank from the vehicle.
15. Remove the fuel tank from the hydraulic lift.

Installation Procedure

1. If replacing the fuel tank transfer parts as necessary.

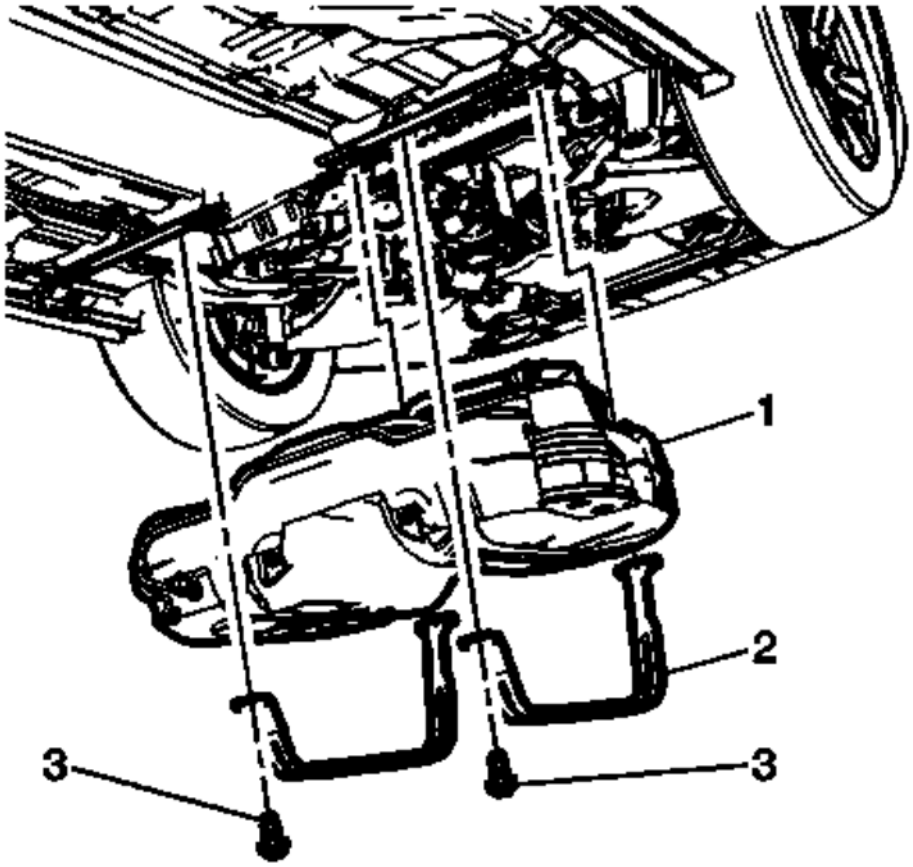


Fig. 44: Fuel Tank Straps And Fuel Tank
Courtesy of GENERAL MOTORS COMPANY

NOTE: carefully maneuver the fuel tank past the exhaust system.

2. With the aid of an assistant, position the fuel tank on a hydraulic lift and raise into vehicle position.

CAUTION: Refer to Fastener Caution .

3. Install both fuel tank straps (2) to the fuel tank (1) and tighten the fasteners (3) to 27 N.m (20 lb ft).
4. Remove the hydraulic lift from the fuel tank.

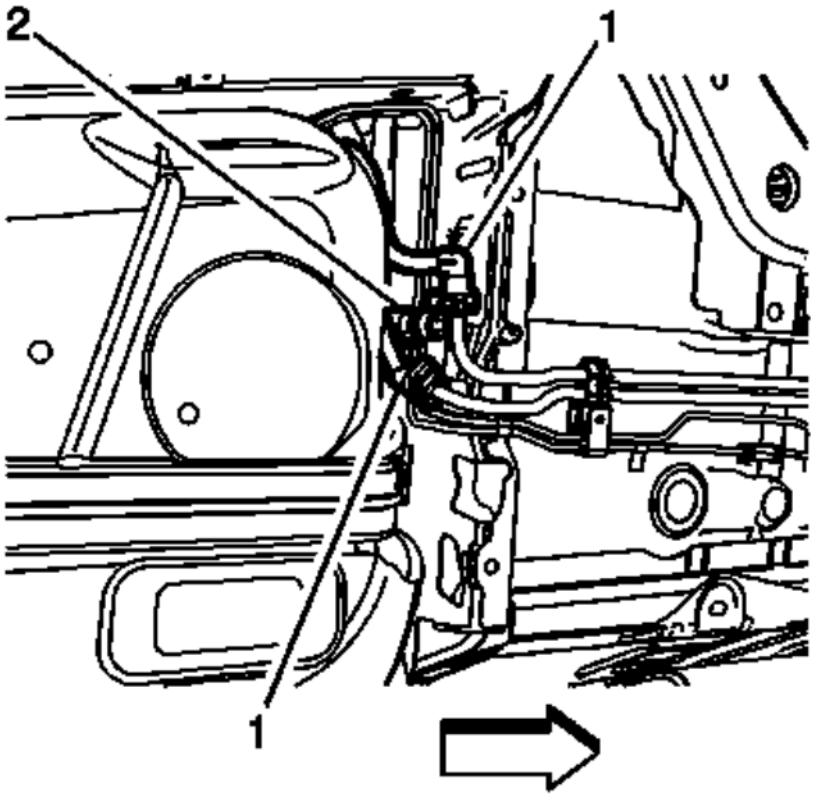


Fig. 45: Evaporative Emission Purge & Fuel Feed Pipes With Fuel Pressure Sensor Harness Connector
Courtesy of GENERAL MOTORS COMPANY

5. Connect the evaporative emission purge and fuel pipes (1). Refer to **Plastic Collar Quick Connect Fitting Service**.
6. Connect the fuel pressure sensor harness connector (2).

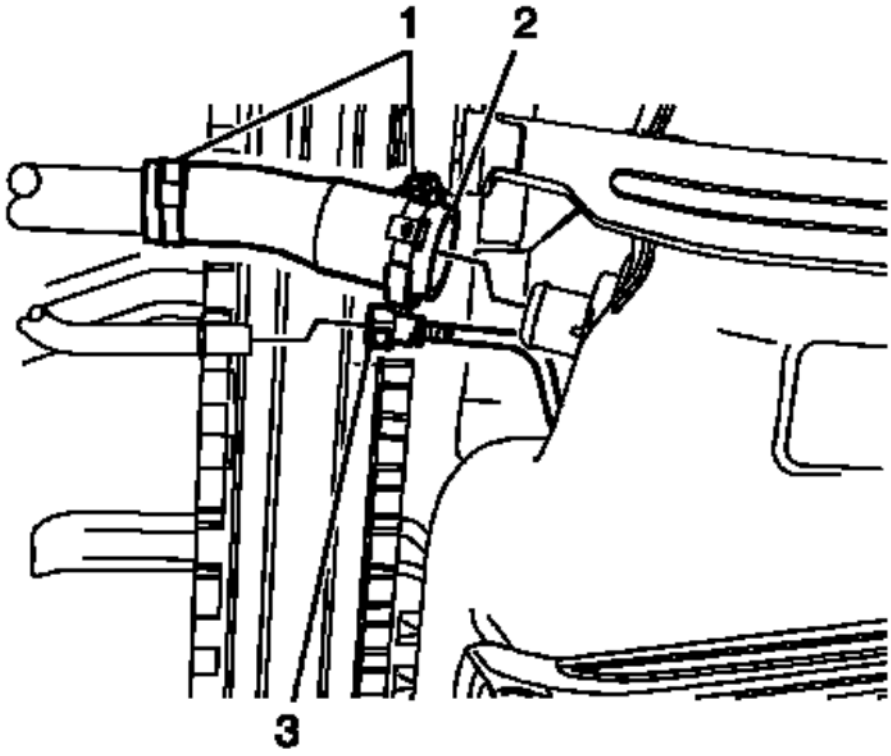


Fig. 46: Hose Clamps & Filler Tube
Courtesy of GENERAL MOTORS COMPANY

7. Install the fuel tank filler tube (2) and tighten the clamp (1).
8. Connect the fuel tank filler vent pipe to the fuel tank vent pipe (3). Refer to **Plastic Collar Quick Connect Fitting Service**.

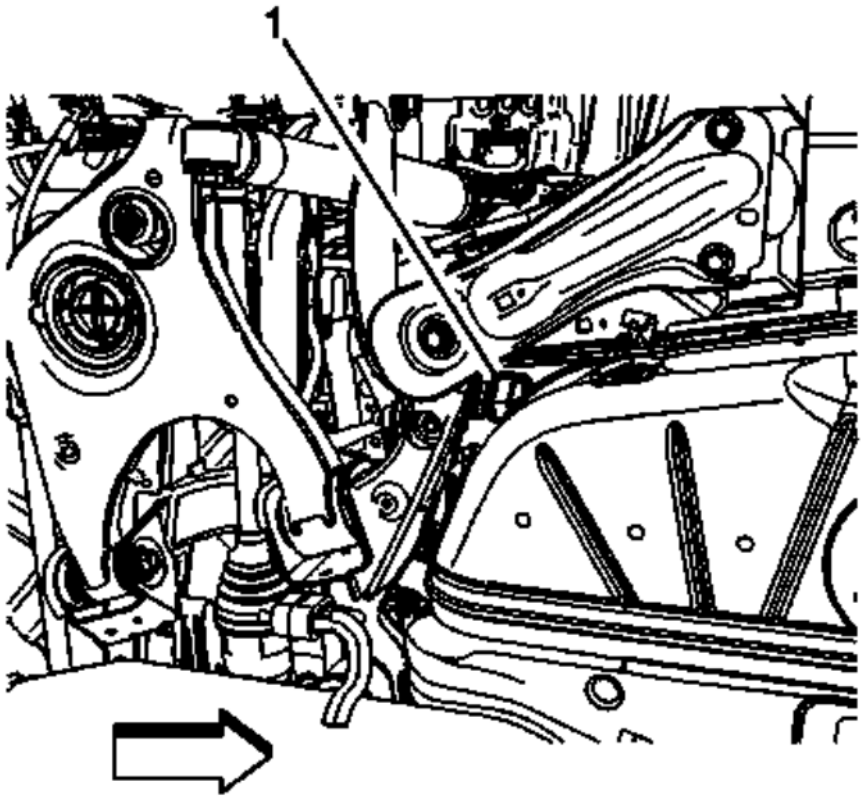


Fig. 47: Fuel Pump Module Wiring Harness
Courtesy of GENERAL MOTORS COMPANY

9. Connect the fuel tank fuel pump module wiring harness (1).
10. Install the exhaust system. Refer to **REPAIR INSTRUCTIONS** .
11. Install the propeller shaft. Refer to **Propeller Shaft Replacement** .
12. Refuel the fuel tank.

FUEL TANK REPLACEMENT (FWD)

Removal Procedure

WARNING: To avoid any vehicle damage, serious personal injury or death when major components are removed from the vehicle and the vehicle is supported by a hoist, support the vehicle with jack stands at the opposite end from which the components are being removed and strap the vehicle to the hoist.

WARNING: Refer to Gasoline/Gasoline Vapors Warning .

WARNING: Refer to Safety Glasses Warning .

1. Relieve the system fuel pressure. Refer to **Fuel Pressure Relief**
2. Drain the fuel tank. Refer to **Fuel Tank Draining**.
3. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
4. Remove the left rear underbody air deflector.
5. Remove the right rear underbody air deflector.

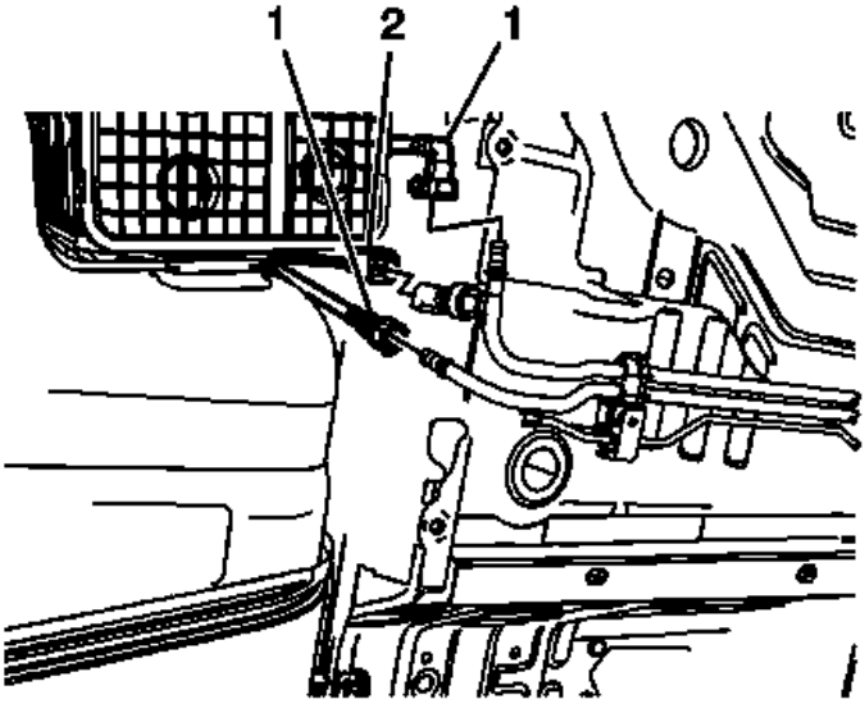


Fig. 48: Evaporative Emission, Fuel Pipes And Fuel Pressure Sensor Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

6. Disconnect the evaporative emission and fuel pipes (1). Refer to **Plastic Collar Quick Connect Fitting Service**.
7. Disconnect the fuel pressure sensor electrical connector (2).

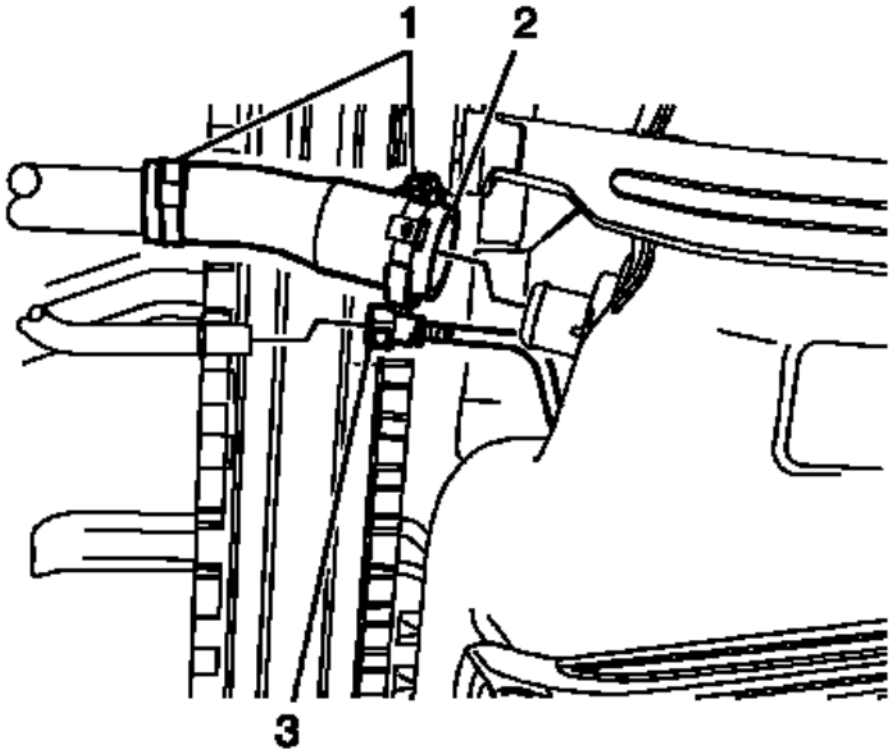


Fig. 49: Hose Clamps & Filler Tube
Courtesy of GENERAL MOTORS COMPANY

8. Loosen the hose clamps (1) and remove the filler tube (2).
9. Disconnect the evaporative emission line (3) from the filler pipe assembly. Refer to **Plastic Collar Quick Connect Fitting Service**.

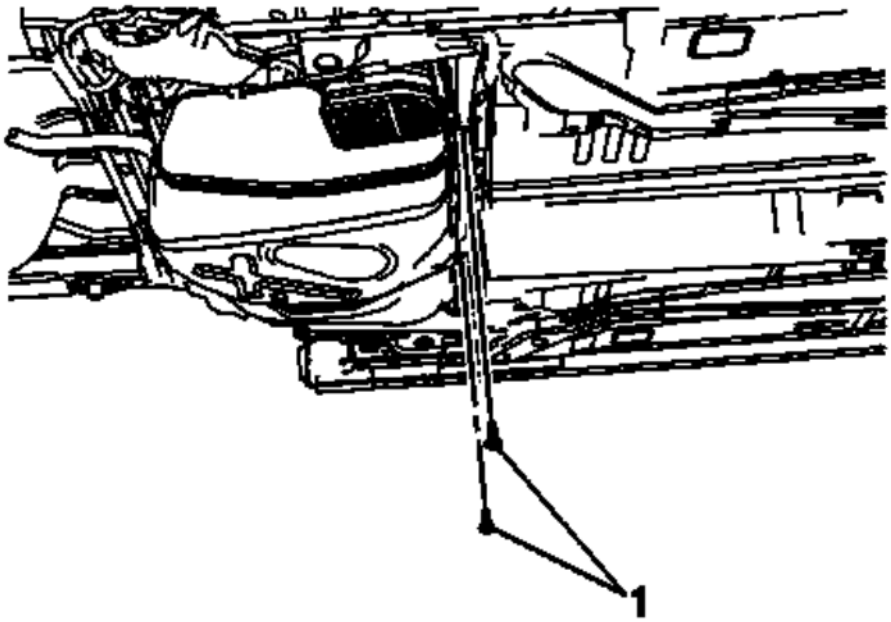


Fig. 50: Fuel Tank Strap Bolts
Courtesy of GENERAL MOTORS COMPANY

10. Support the fuel tank with a suitable jack.
11. Remove the fuel tank strap bolts (1).

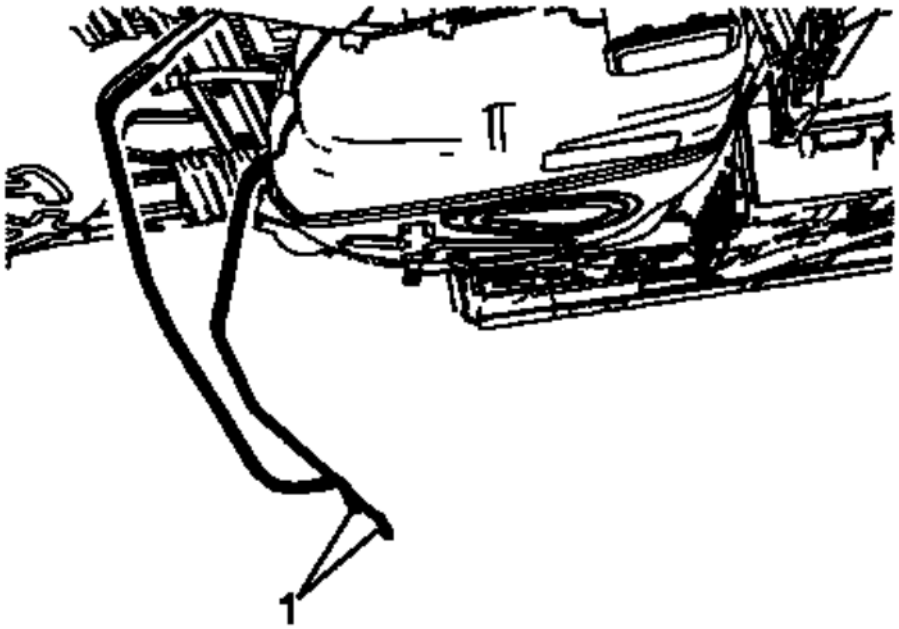


Fig. 51: Fuel Tank Straps
Courtesy of GENERAL MOTORS COMPANY

12. Swing the fuel tank straps (1) out of the way.

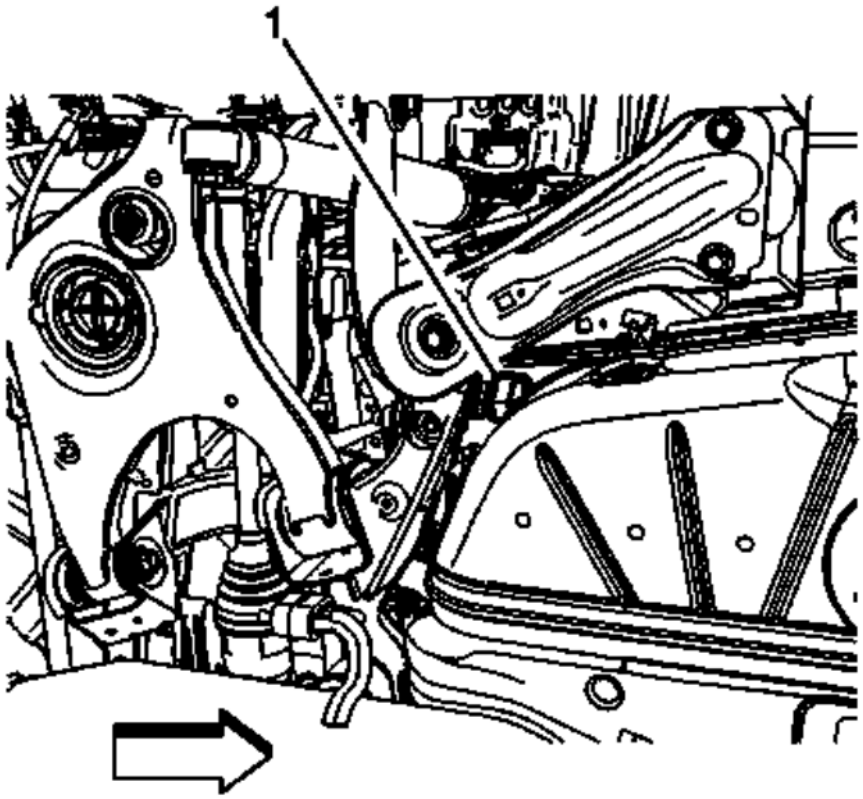


Fig. 52: Fuel Pump Module Wiring Harness
Courtesy of GENERAL MOTORS COMPANY

13. Disconnect the fuel tank harness electrical connector (1).

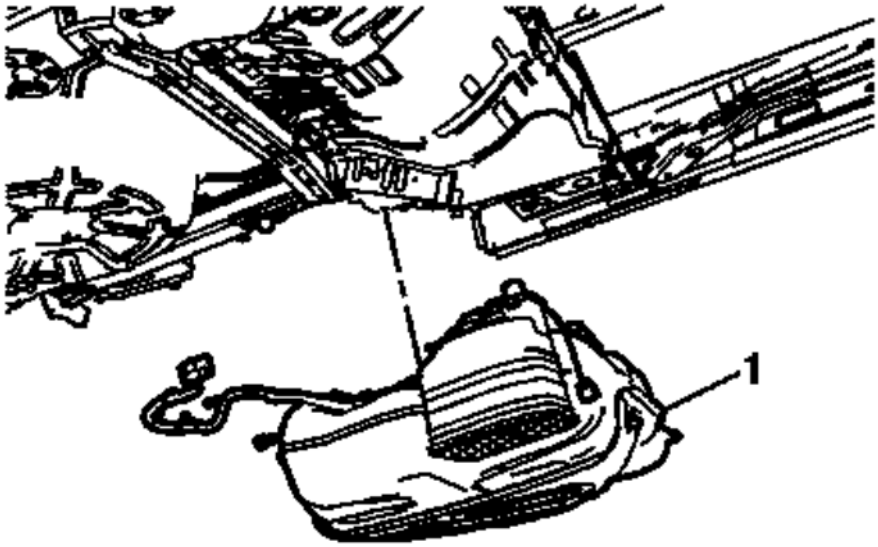


Fig. 53: Fuel Tank
Courtesy of GENERAL MOTORS COMPANY

14. Remove the fuel tank (1).
15. Remove the following components if replacing just the fuel tank.
    1. Fuel tank fuel pump module. Refer to **Fuel Tank Fuel Pump Module Replacement (FWD)**.
    2. Evaporative emission carbon canister. Refer to **Evaporative Emission Canister Replacement (FWD)**.
    3. Transfer components as necessary.

Installation Procedure

1. Install the following components if fuel tank replacement was necessary:
    1. Fuel tank fuel pump module. Refer to **Fuel Tank Fuel Pump Module Replacement (FWD)**.
    2. Evaporative emission carbon canister. Refer to **Evaporative Emission Canister Replacement (FWD)**.

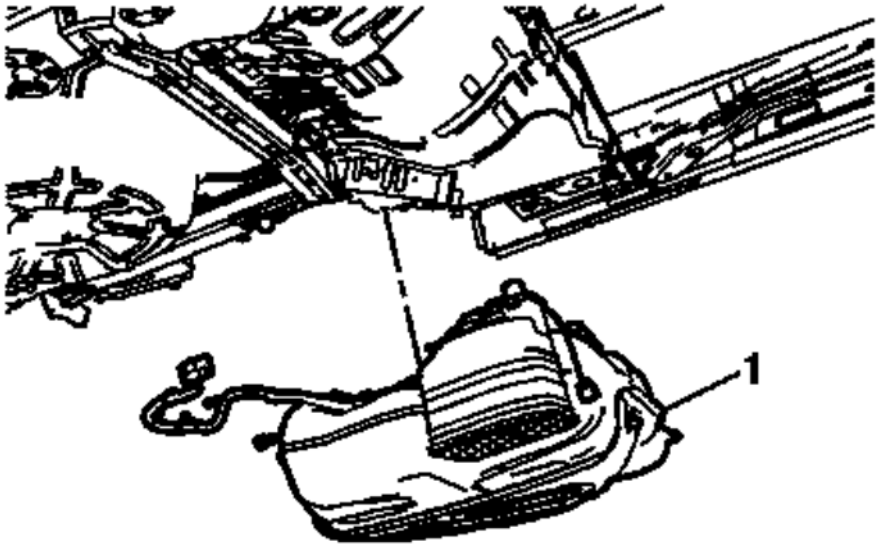


Fig. 54: Fuel Tank
Courtesy of GENERAL MOTORS COMPANY

2. Use a suitable jack and install the fuel tank (1).

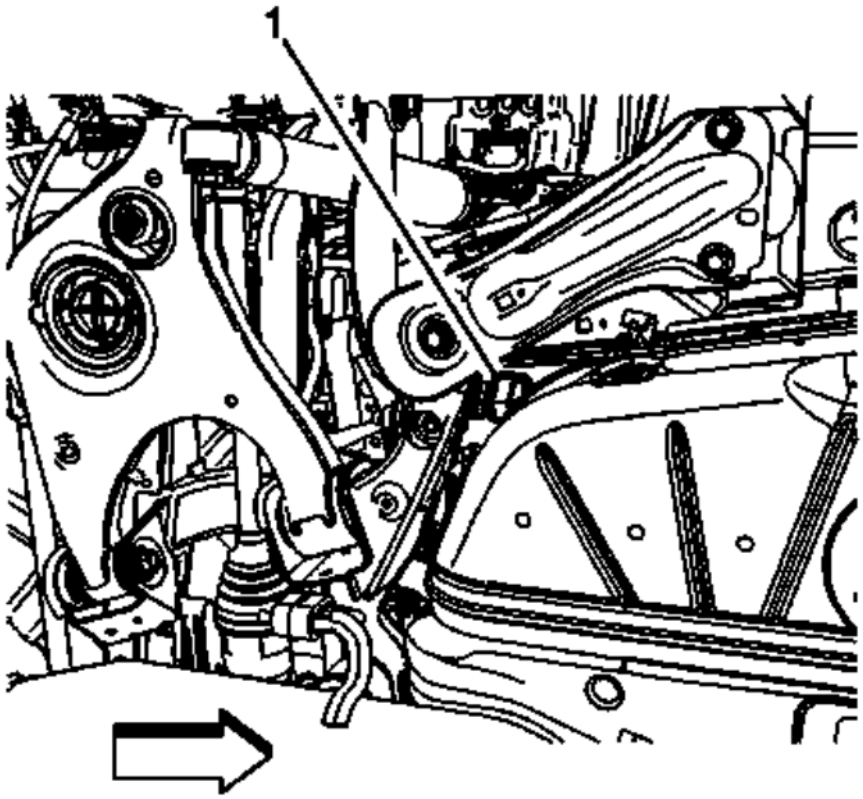


Fig. 55: Fuel Pump Module Wiring Harness
Courtesy of GENERAL MOTORS COMPANY

3. Connect the fuel tank harness electrical connector (1).

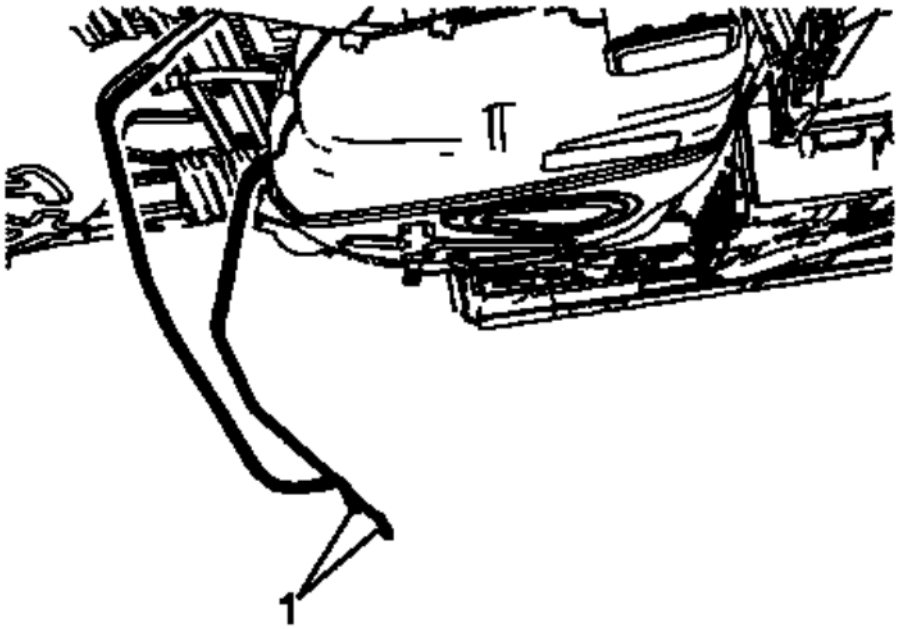


Fig. 56: Fuel Tank Straps
Courtesy of GENERAL MOTORS COMPANY

4. Reposition the fuel tank straps (1).

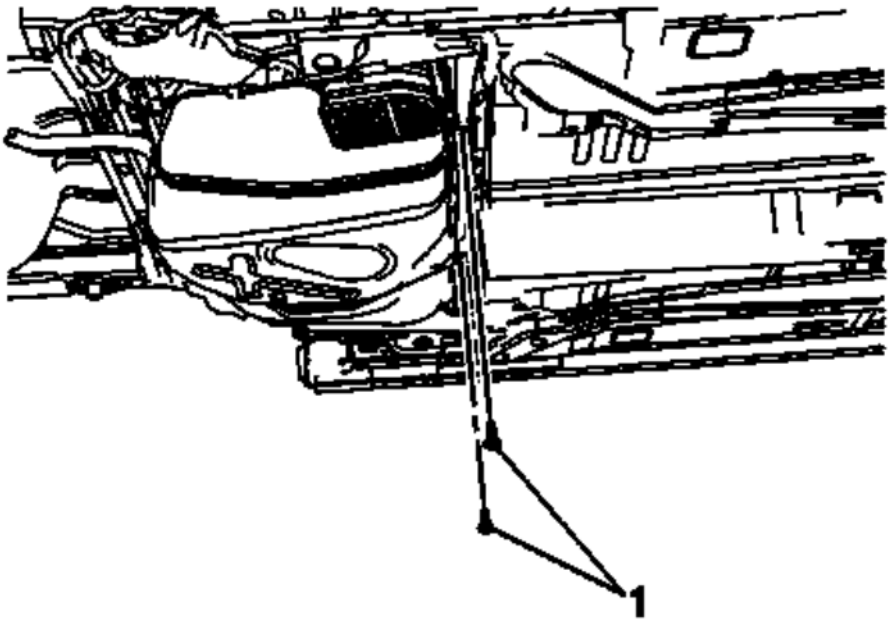


Fig. 57: Fuel Tank Strap Bolts
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fastener Caution .

5. Install the fuel tank strap bolts (1) and tighten to 20 (15 lb ft).

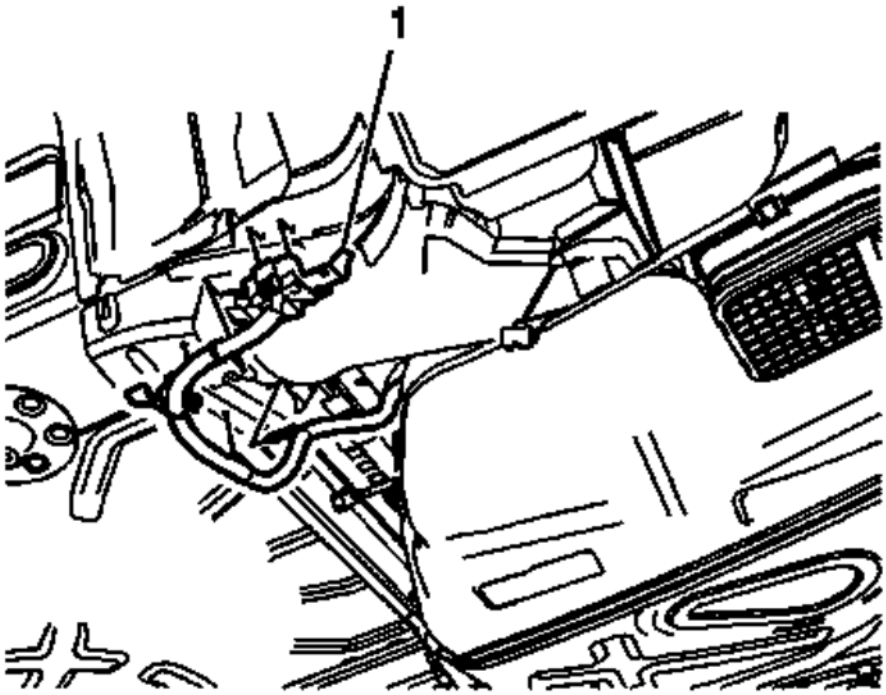


Fig. 58: Fuel Tank Harness Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

6. Connect the fuel tank harness electrical connector (1).

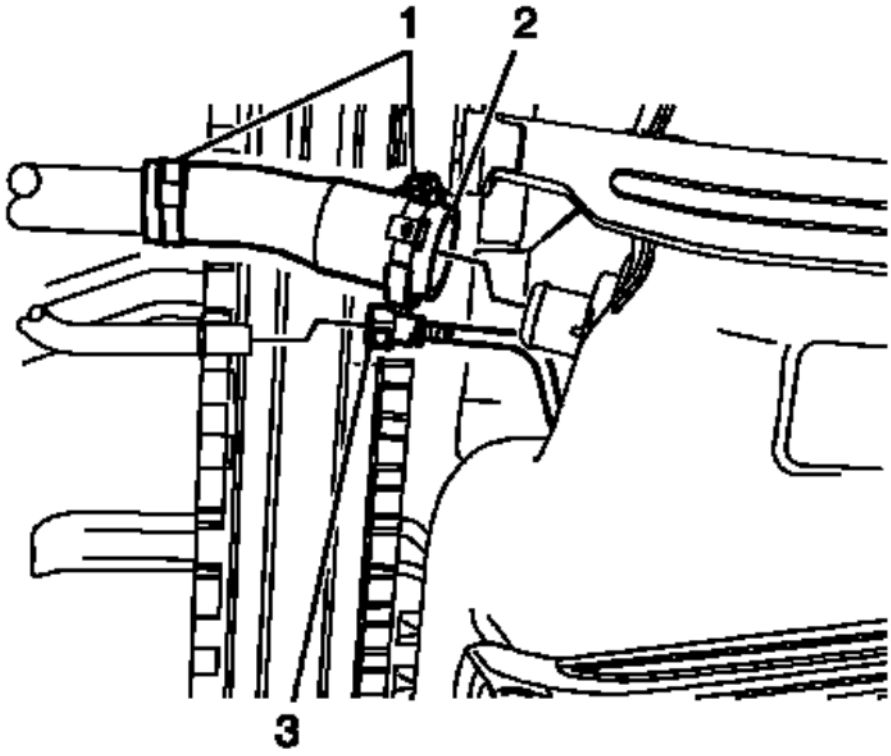


Fig. 59: Hose Clamps & Filler Tube
Courtesy of GENERAL MOTORS COMPANY

7. Install the filler tube (2) and tighten the hose clamps (1) to 4 (35 lb in).
8. Connect the evaporative emission line (3). Refer to **Plastic Collar Quick Connect Fitting Service**.

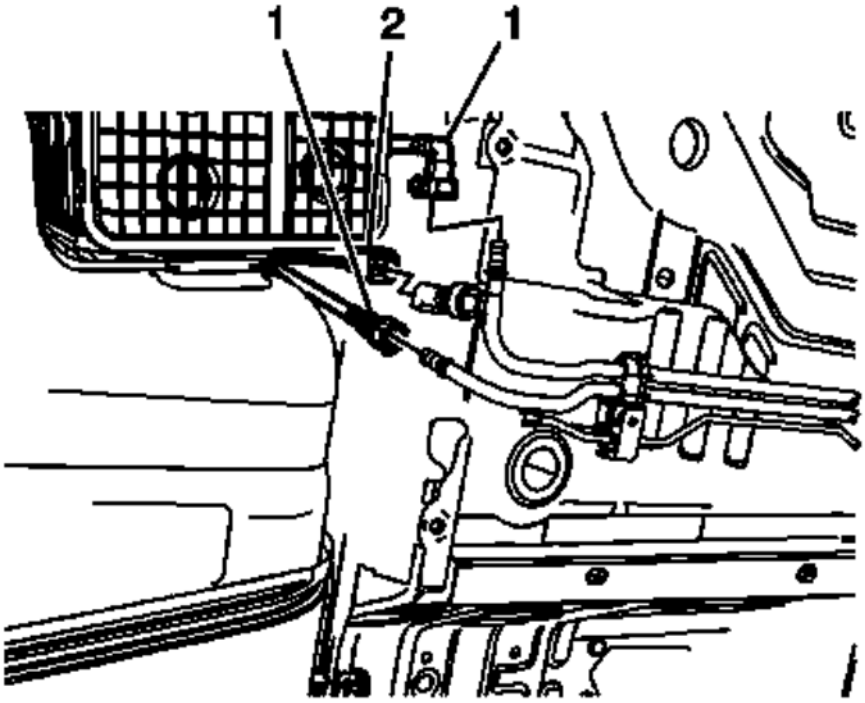


Fig. 60: Evaporative Emission, Fuel Pipes And Fuel Pressure Sensor Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

9. Connect the evaporative emission and fuel pipes (1). Refer to **Plastic Collar Quick Connect Fitting Service**.
10. Connect the fuel pressure sensor electrical connector (2).
11. Install the left rear underbody air deflector.
12. Install the right rear underbody air deflector.
13. Lower the vehicle.
14. Refill the fuel tank.
15. Inspect for fuel leaks.

FUEL SYSTEM CLEANING

NOTE: When flushing the fuel tank, treat the fuel and water mixture as a hazardous material. Handle the material in accordance with all local, state and federal laws and regulations.

NOTE: Whenever the fuel tank is cleaned, inspect the fuel pump fuel strainer. If the fuel pump fuel strainer is contaminated, replace the fuel pump fuel strainer and inspect the fuel pump.

NOTE: Always maintain cleanliness when servicing fuel system components.

1. Remove the fuel tank fuel pump module. Refer to **Fuel Tank Fuel Pump Module Replacement (FWD)**, **Fuel Tank Fuel Pump Module Replacement (AWD)**.
2. Inspect the fuel pump inlet for dirt and debris. If dirt and debris are found, replace the fuel pump.
3. Flush fuel tank with hot water.
4. Pour the water out of the fuel sender assembly opening in the fuel tank. Rock the fuel tank in order to ensure that the removal of the water from the fuel tank is complete.
5. Allow tank to dry completely before reassembly.
6. Install the fuel tank fuel pump module. Refer to **Fuel Tank Fuel Pump Module Replacement (FWD)**, **Fuel Tank Fuel Pump Module Replacement (AWD)**.

FUEL TANK FUEL PUMP MODULE REPLACEMENT (FWD)

Special Tools

CH 45722 Fuel Sender Lock Ring Wrench

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)**

Removal Procedure

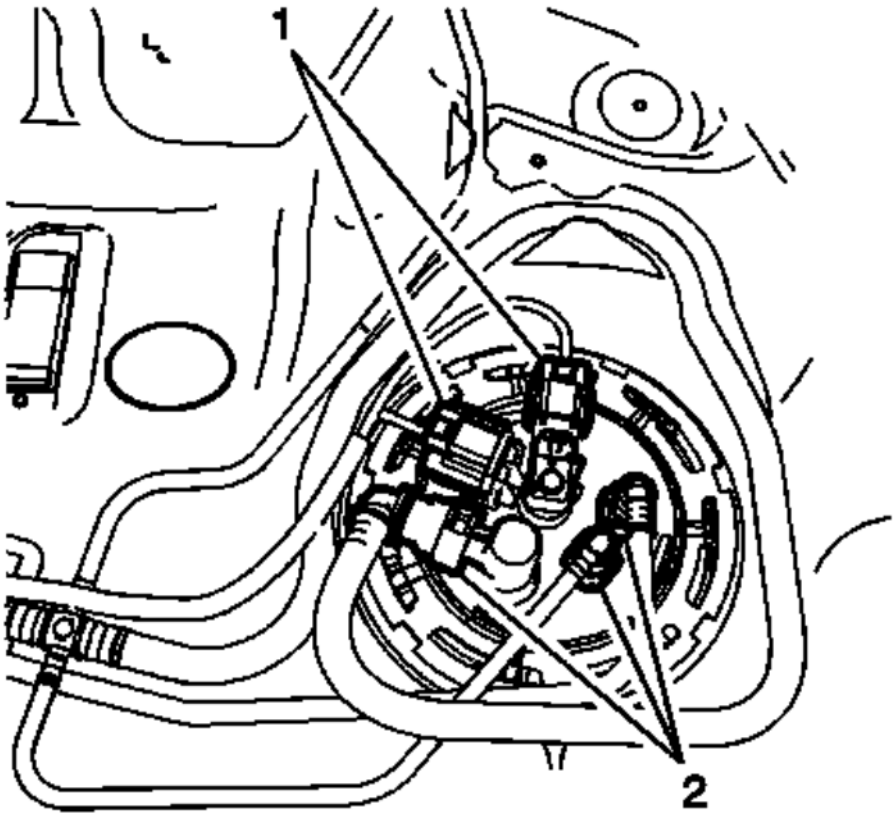


Fig. 61: Fuel Pump Electrical Connectors
Courtesy of GENERAL MOTORS COMPANY

WARNING: Refer to Gasoline/Gasoline Vapors Warning .

1. Remove the fuel tank. Refer to **Fuel Tank Replacement (FWD)**.
2. Disconnect the fuel pump electrical connector (1) and the quick connects (2). Refer to **Plastic Collar Quick Connect Fitting Service**.

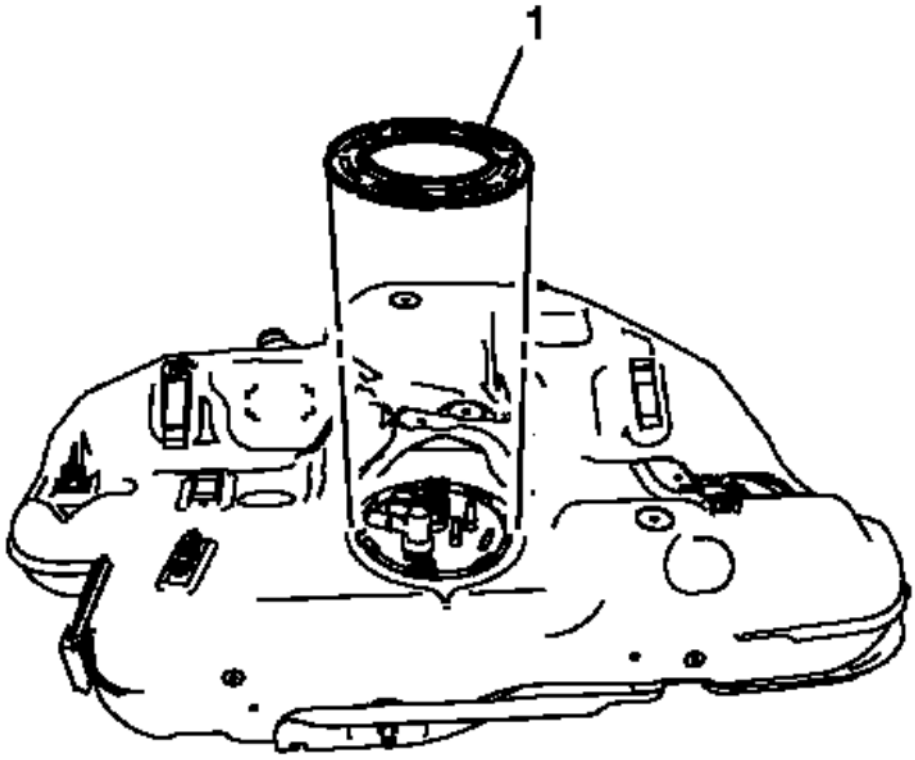


Fig. 62: Lock Ring
Courtesy of GENERAL MOTORS COMPANY

3. Use the **CH 45722** wrench by turning counter clockwise and remove the lock ring (1).

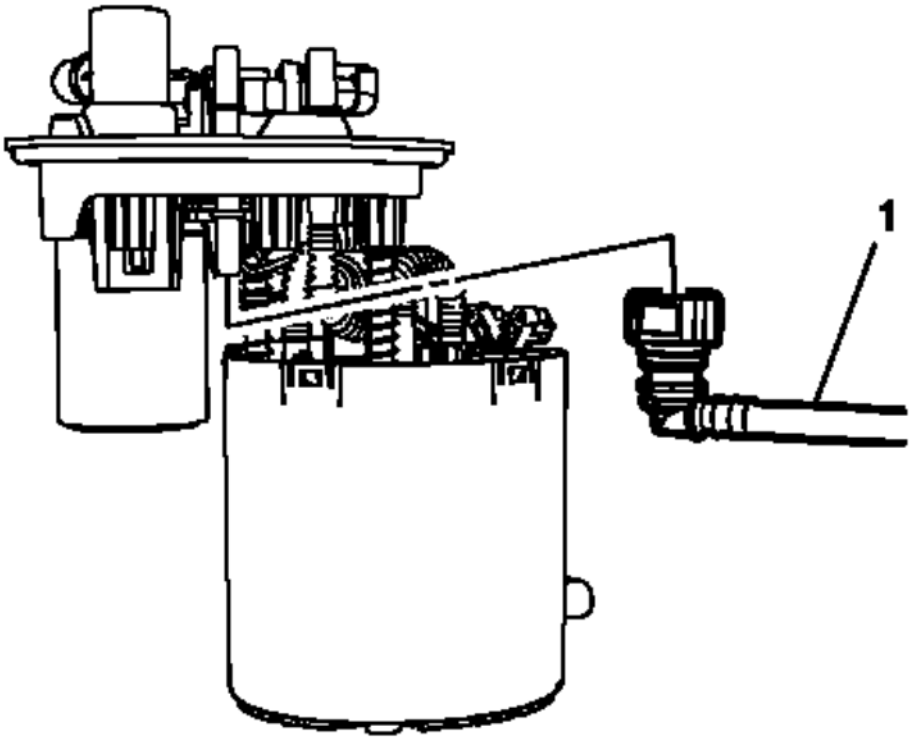


Fig. 63: Fuel Pump Vent Hose
Courtesy of GENERAL MOTORS COMPANY

4. Disconnect the fuel pump vent hose. Refer to **Plastic Collar Quick Connect Fitting Service**.

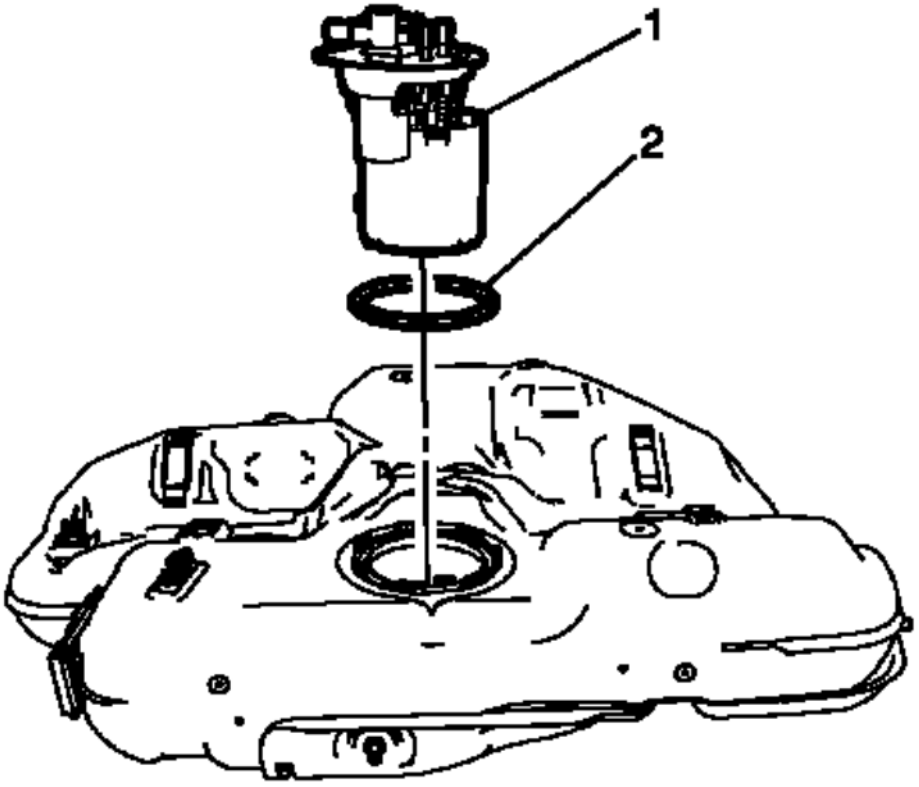


Fig. 64: Fuel Tank Module And O-Ring
Courtesy of GENERAL MOTORS COMPANY

5. Remove the fuel tank module (1) and the O-ring (2).

Installation Procedure

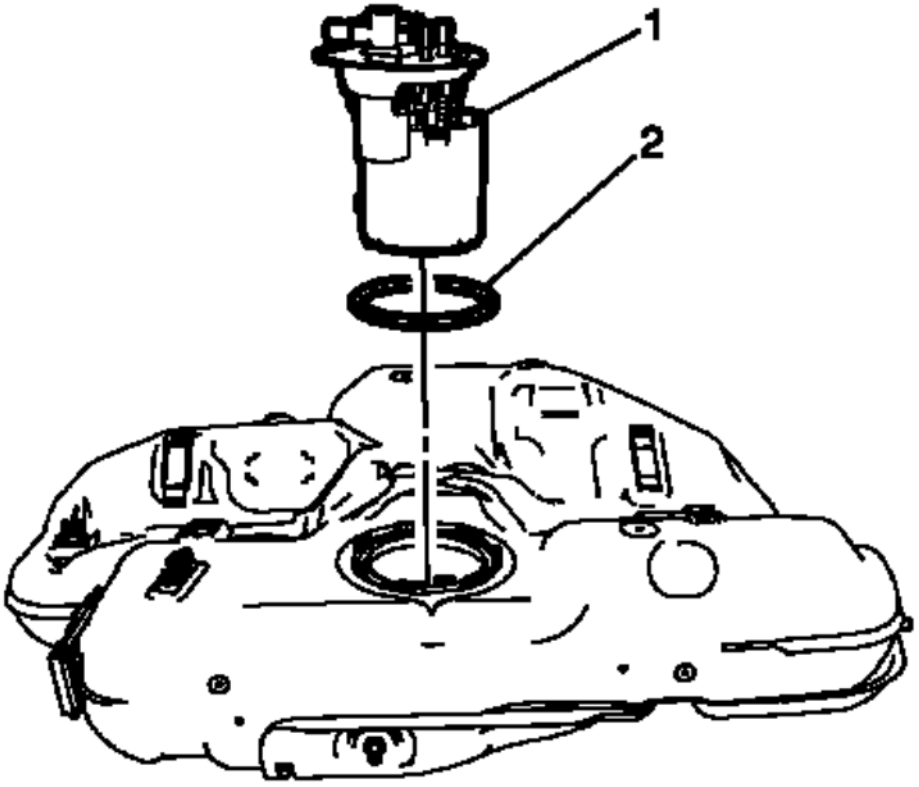


Fig. 65: Fuel Tank Module And O-Ring
Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW seal (2) and the fuel tank module (1).

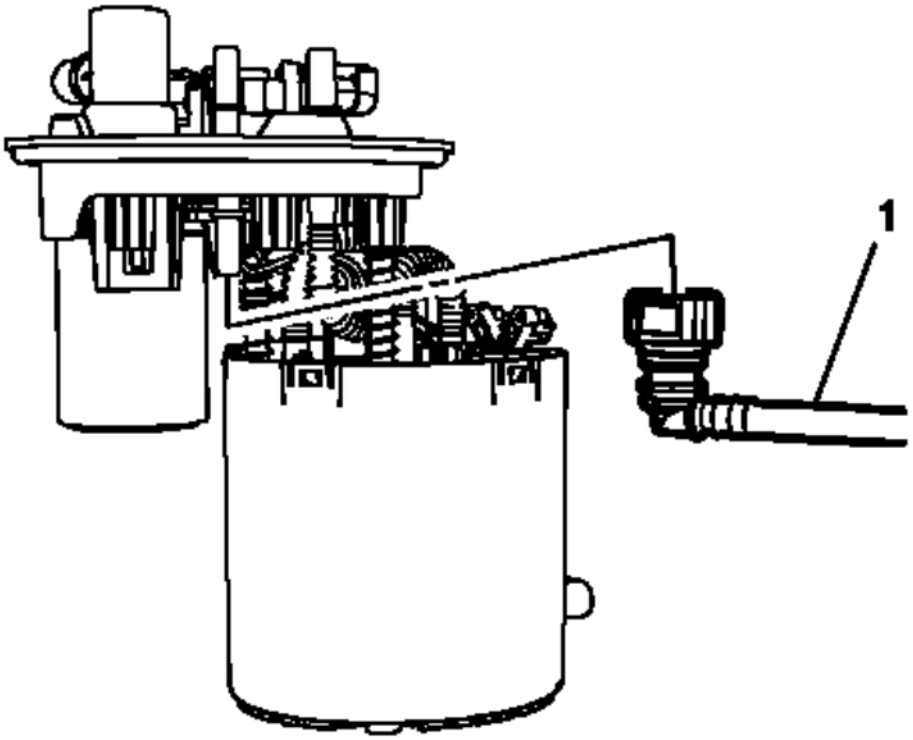


Fig. 66: Fuel Pump Vent Hose
Courtesy of GENERAL MOTORS COMPANY

2. Connect the fuel pump vent hose. Refer to **Plastic Collar Quick Connect Fitting Service**.

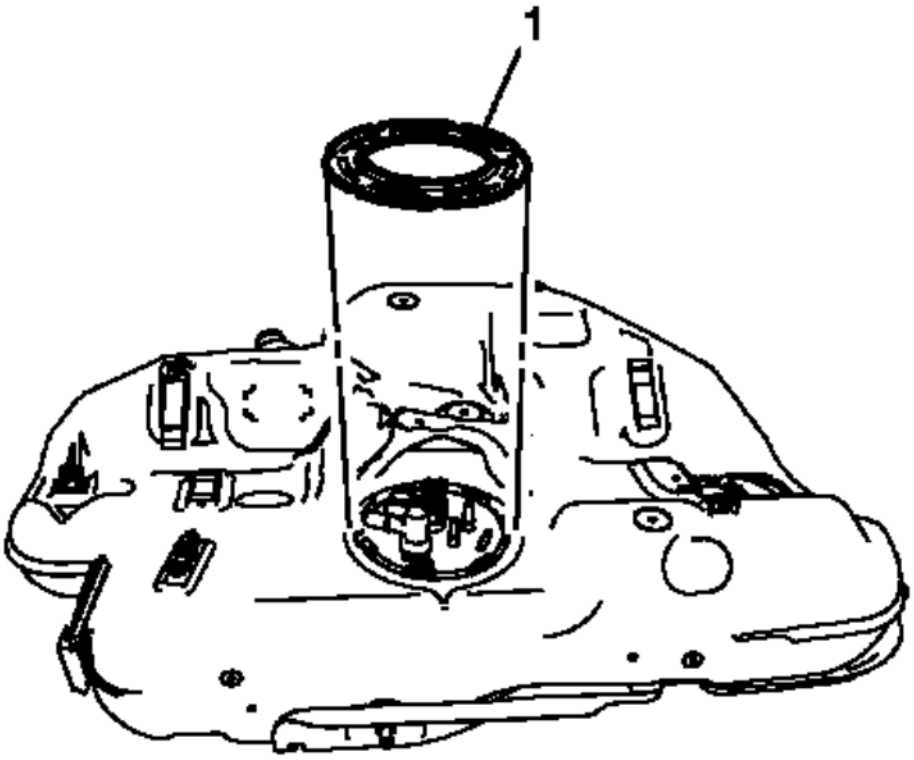


Fig. 67: Lock Ring
Courtesy of GENERAL MOTORS COMPANY

3. Use the **CH 45722** wrench by turning clockwise and install the lock ring (1).

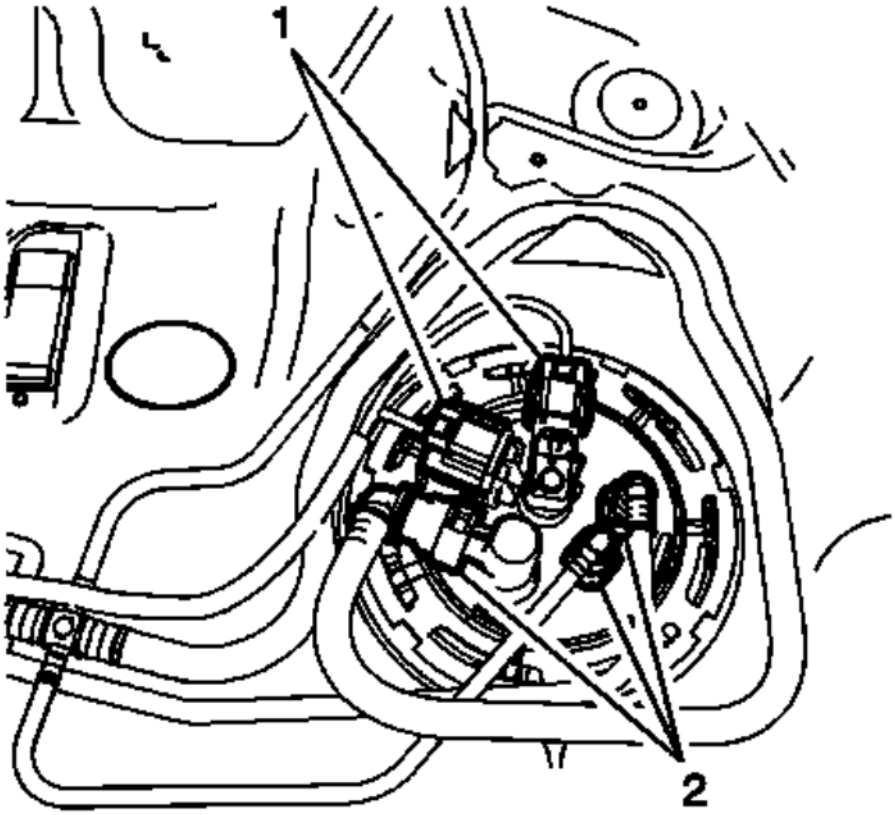


Fig. 68: Fuel Pump Electrical Connectors
Courtesy of GENERAL MOTORS COMPANY

4. Connect the fuel pump electrical connector (1) and the quick connects (2). Refer to **Plastic Collar Quick Connect Fitting Service**.
5. Install the fuel tank. Refer to **Fuel Tank Replacement (FWD)**.

FUEL TANK FUEL PUMP MODULE REPLACEMENT (AWD)

Special Tools

CH-45722 Fuel Sender Lock Ring Wrench

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)** .

Removal Procedure

1. Remove the fuel tank. Refer to **Fuel Tank Replacement (AWD)**.
2. Remove the fuel sender assembly from the fuel tank. Refer to **Fuel Sender Assembly Replacement (AWD)**.

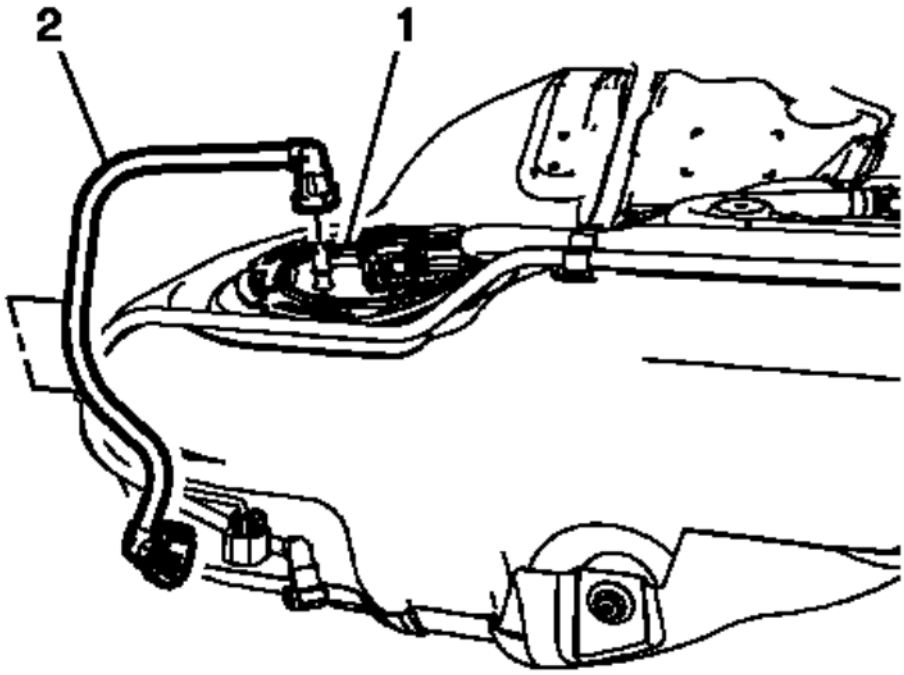


Fig. 69: Fuel Tank Feed Pipe
Courtesy of GENERAL MOTORS COMPANY

3. Disconnect the fuel feed pipe (2) from the fuel pump module (1). Refer to **Plastic Collar Quick Connect Fitting Service**.
4. Disconnect the fuel tank module harness connectors.

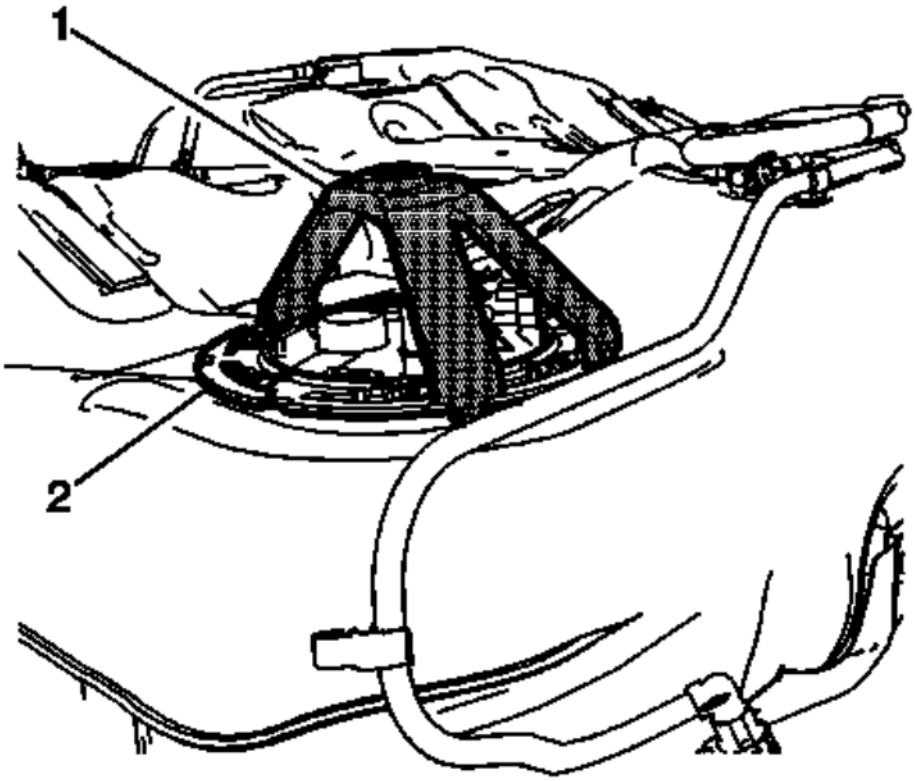


Fig. 70: Fuel Sender Lock Ring And Special Tool
Courtesy of GENERAL MOTORS COMPANY

5. Use the **CH-45722** fuel sender lock ring wrench (1), to remove the fuel sender lock ring (2) from the fuel pump module.

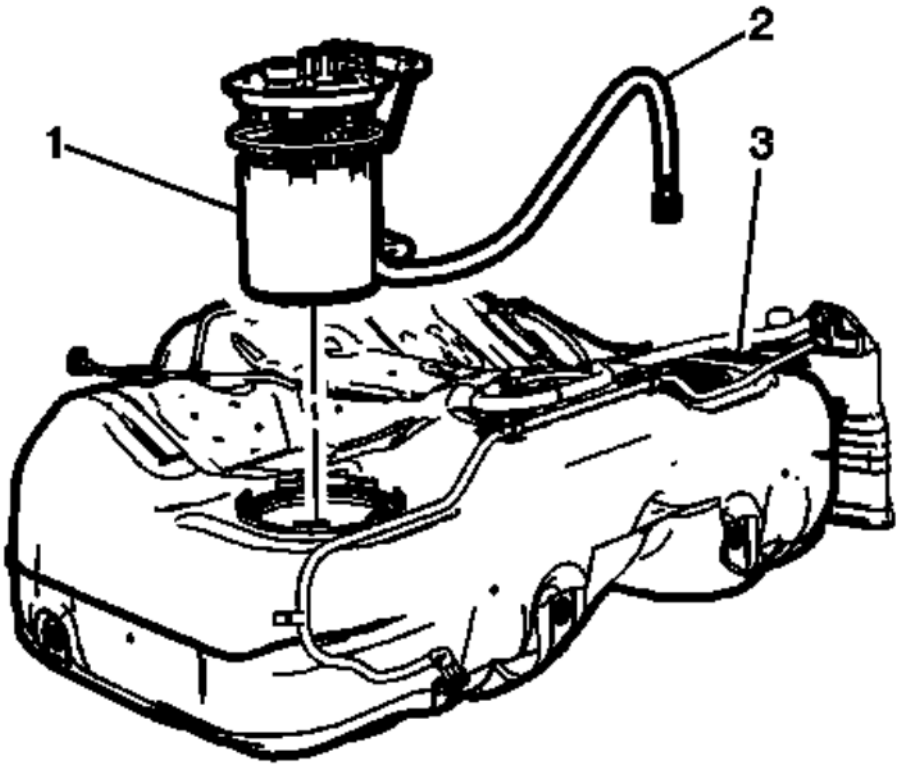


Fig. 71: Fuel Tank Fuel Pump Module
Courtesy of GENERAL MOTORS COMPANY

6. Carefully lift the fuel pump module (1) while guiding the fuel tank crossover pipe (2) from the fuel tank (3).
7. Remove and DISCARD the fuel pump module O-ring.

Installation Procedure

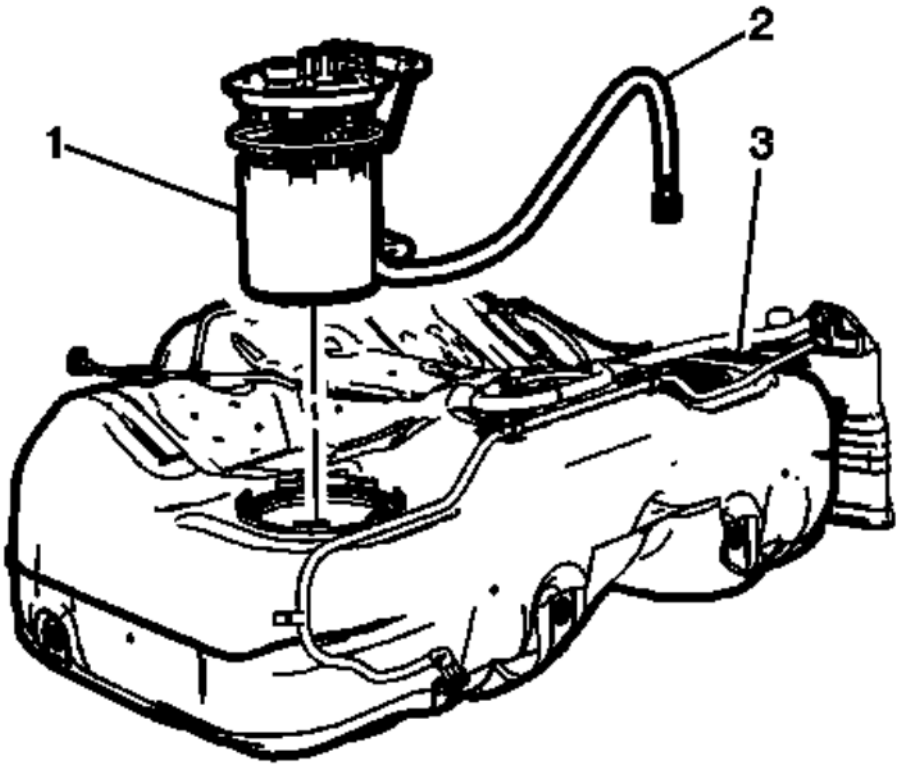


Fig. 72: Fuel Tank Fuel Pump Module
Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW the fuel pump O-ring.
2. Carefully lower the fuel pump module (1) while guiding the fuel tank crossover pipe (2) into the fuel tank (3).

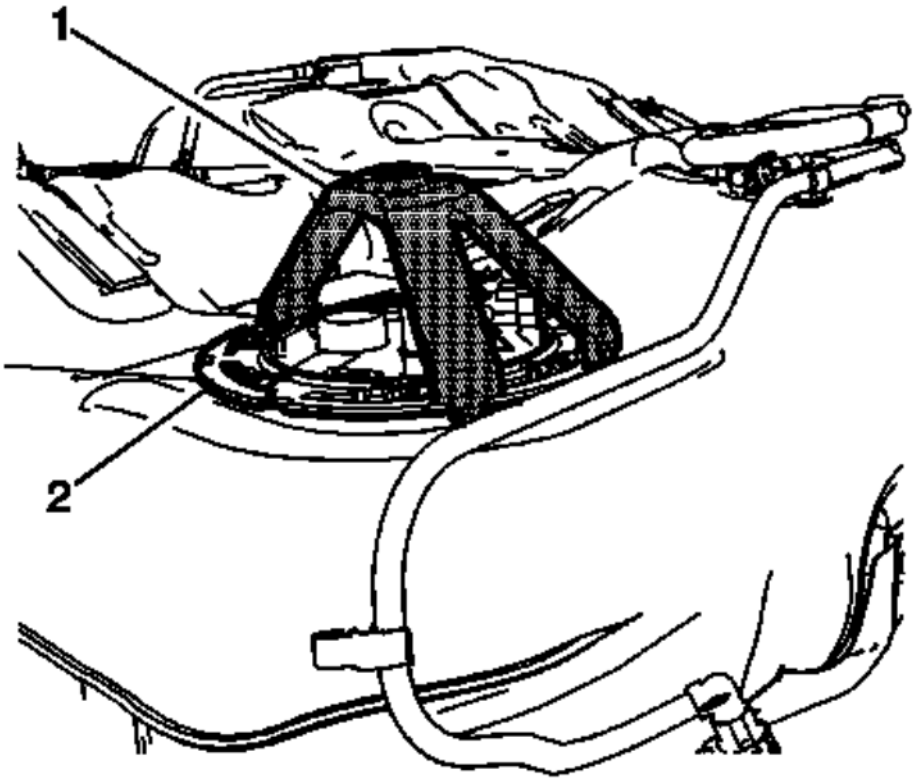


Fig. 73: Fuel Sender Lock Ring And Special Tool
Courtesy of GENERAL MOTORS COMPANY

3. Use the **CH-45722** fuel sender lock ring wrench (1), to install the fuel sender lock ring (2).
4. Connect the fuel tank module harness connectors.

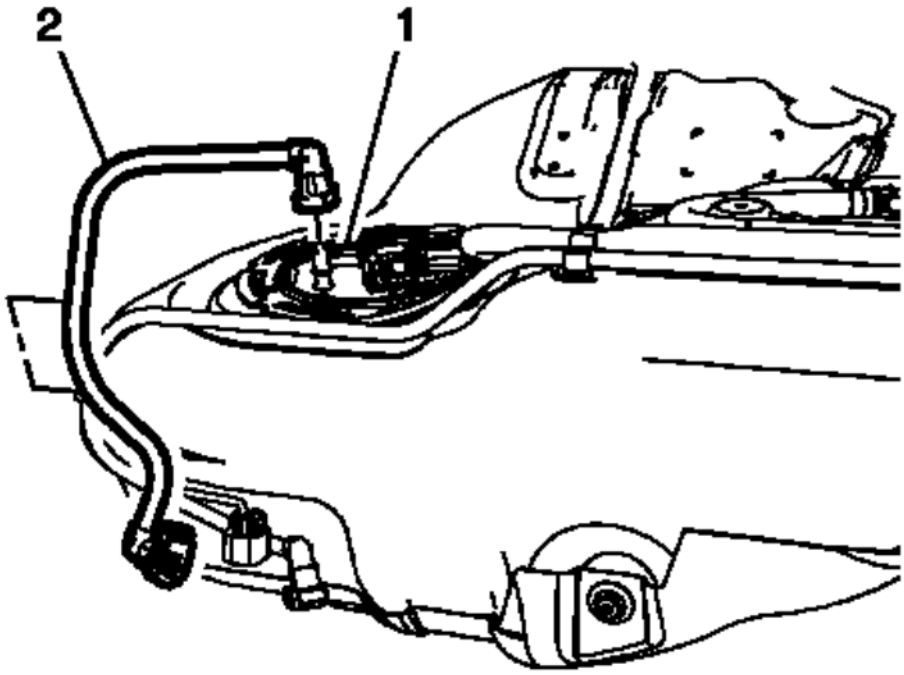


Fig. 74: Fuel Tank Feed Pipe
Courtesy of GENERAL MOTORS COMPANY

5. Connect the fuel feed pipe (2) to the fuel pump module. Refer to **Plastic Collar Quick Connect Fitting Service**.
6. Install the fuel sender assembly to the fuel tank. Refer to **Fuel Sender Assembly Replacement (AWD)**.
7. Install the fuel tank. Refer to **Fuel Tank Replacement (AWD)**.

CHASSIS CONTROL MODULE REPLACEMENT

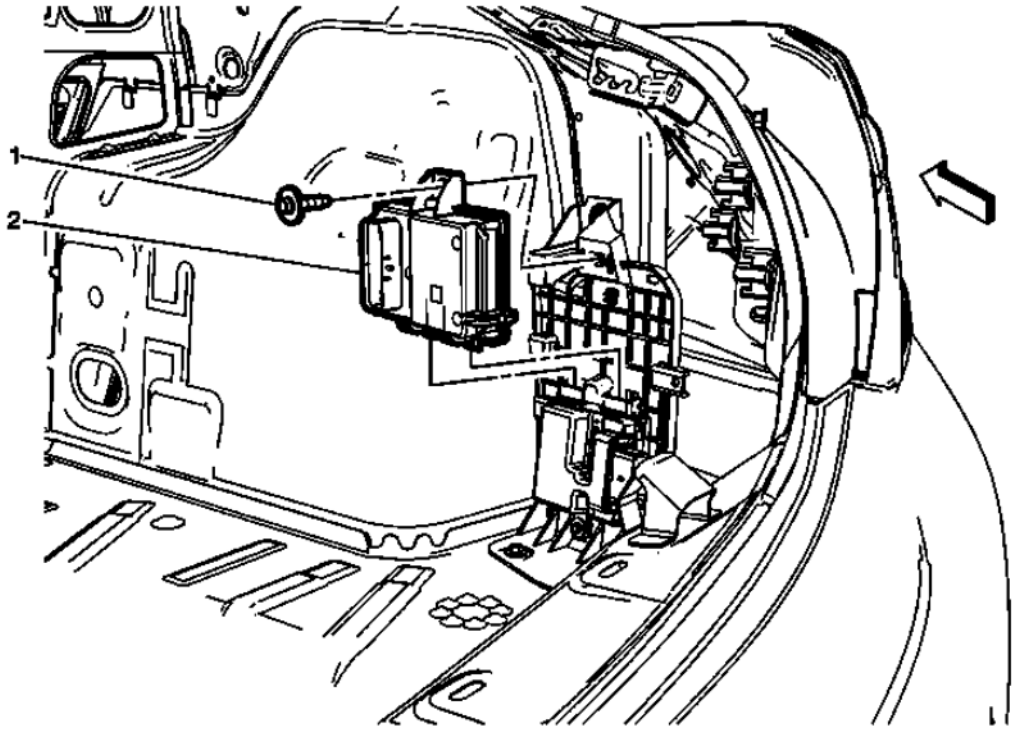


Fig. 75: Chassis Control Module
Courtesy of GENERAL MOTORS COMPANY

NOTE: Preliminary Procedure: Remove the passenger rear side trim panel. Refer to Rear Compartment Side Trim Panel Replacement

1. Remove Fuel Pump Flow Control Module Fastener (1) Caution: Refer to Fastener Caution. Tighten to 9 N.m (80 lb in) on installation.
2. Remove Fuel Pump Flow Control Module (2)
    1. Disconnect the electrical connector
    2. If replacing, reprogram the module. Refer to Control Module References

FUEL PUMP FLOW CONTROL MODULE REPLACEMENT

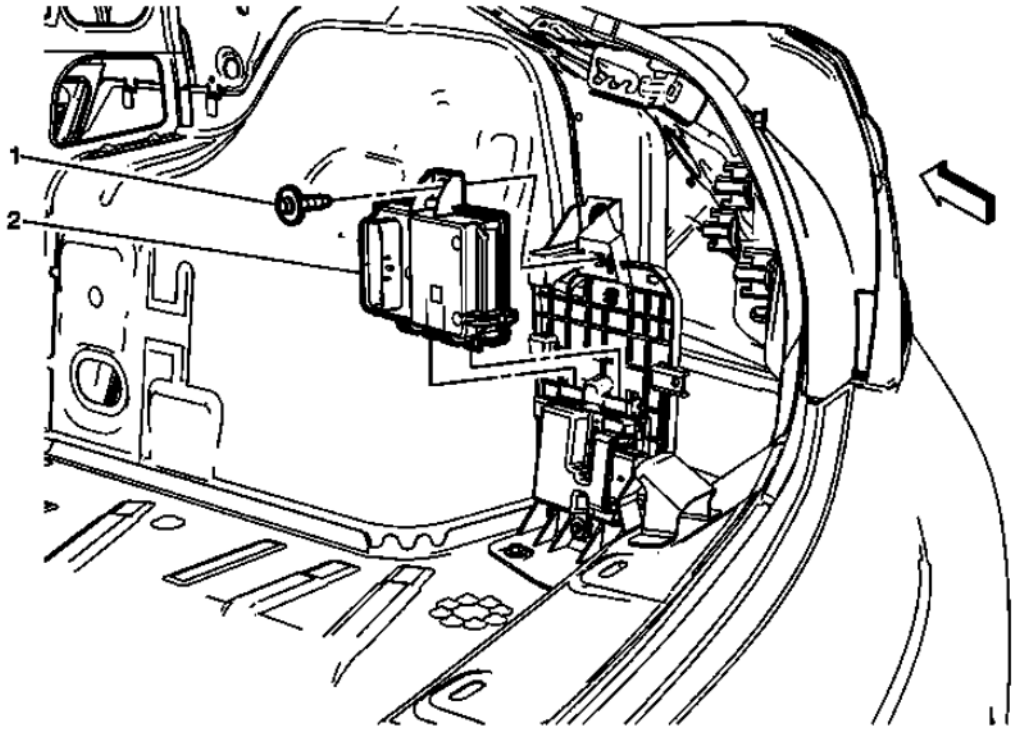


Fig. 76: Fuel Pump Flow Control Module
Courtesy of GENERAL MOTORS COMPANY

Fuel Pump Flow Control Module Replacement

Callout	Component Name
Preliminary Procedure **Remove the passenger rear side trim panel. Refer to Rear Compartment Side Trim Panel Replacement (without HP6) .**	
1	Fuel Pump Flow Control Module Fastener **CAUTION:** **Refer to Fastener Caution .** **Tighten** 9 N.m (80 lb in)
2	Fuel Pump Flow Control Module **Procedure** 1. Disconnect the electrical connector. 2. If replacing, reprogram the module. Refer to **Control Module References** .

FUEL PUMP POWER CONTROL MODULE REPLACEMENT

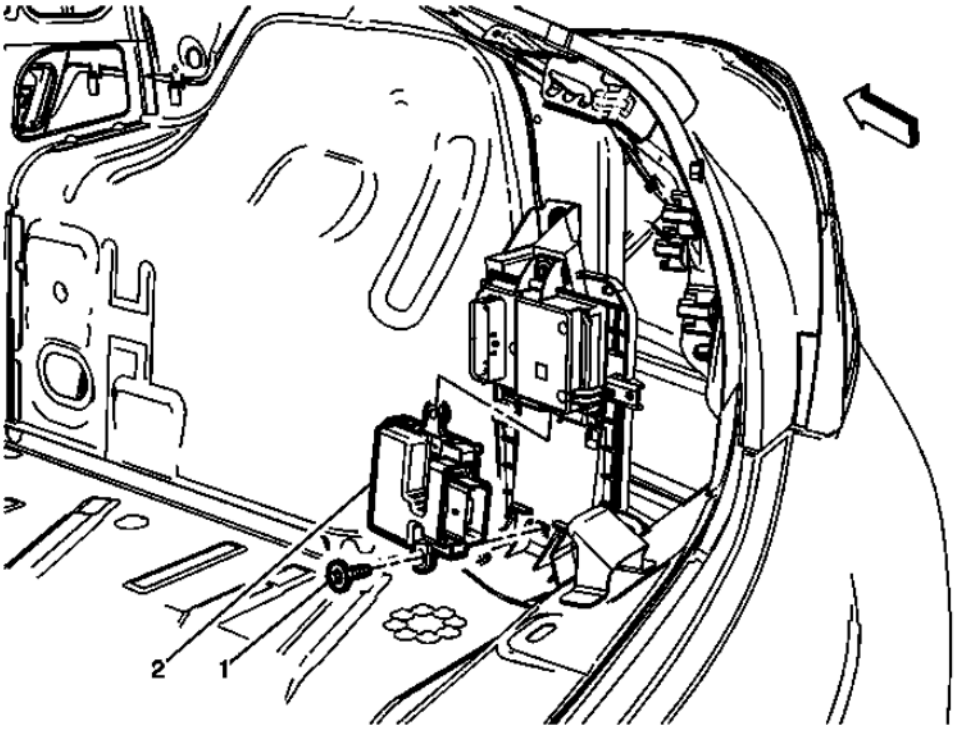


Fig. 77: Fuel Pump Power Control Module
Courtesy of GENERAL MOTORS COMPANY

Fuel Pump Power Control Module Replacement

Callout	Component Name
	Preliminary Procedure **Remove the passenger rear side trim panel. Refer to Rear Compartment Side Trim Panel Replacement (without HP6) .**
1	Fuel Pump Power Control Module Fastener **CAUTION:** **Refer to Fastener Caution .** **Tighten** 9 N.m (80 lb in)
2	Fuel Pump Power Control Module **Procedure** 1. Disconnect the electrical connector. 2. If replacing, reprogram the module. Refer to **Control Module References** .

FUEL TANK PRESSURE SENSOR REPLACEMENT (AWD)

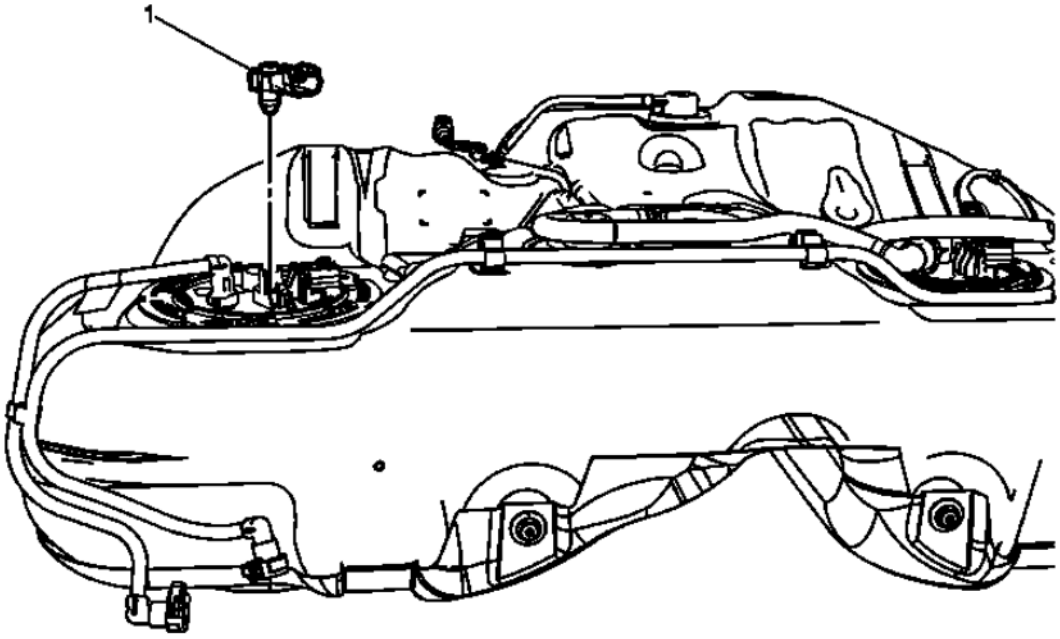


Fig. 78: Fuel Tank Pressure Sensor (AWD)
Courtesy of GENERAL MOTORS COMPANY

Fuel Tank Pressure Sensor Replacement (AWD)

Callout	Component Name
Preliminary Procedure Remove the fuel tank. Refer to **Fuel Tank Replacement (AWD)**.	
1	Fuel Tank Pressure Sensor **Procedure** 1. Disconnect the electrical connector. 2. Release the retaining tab.

FUEL TANK PRESSURE SENSOR REPLACEMENT (FWD)

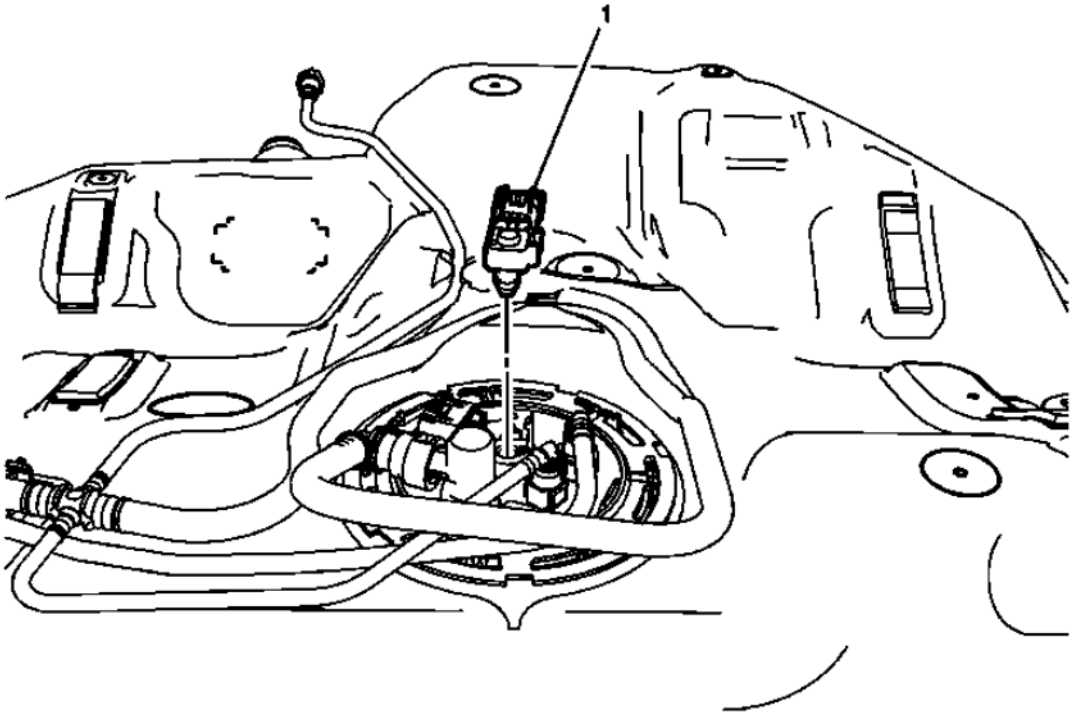


Fig. 79: Fuel Tank Pressure Sensor
Courtesy of GENERAL MOTORS COMPANY

Fuel Tank Pressure Sensor Replacement (FWD)

Callout	Component Name
Preliminary Procedure Remove the fuel tank. Refer to **Fuel Tank Replacement (FWD)**.	
1	Fuel Tank Pressure Sensor **Procedure** 1. Disconnect the electrical connector. 2. Release the retaining tab.

FUEL SENDER ASSEMBLY REPLACEMENT (AWD)

Special Tools

CH-48482 Fuel Sender Lock Ring Wrench

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)** .

Removal Procedure

1. Remove the fuel tank. Refer to **Fuel Tank Replacement (AWD)**.
2. Disconnect the fuel sender harness connector.
3. Disconnect the evaporative emission canister vent pipe from the fuel sender assembly. Refer to

Plastic Collar Quick Connect Fitting Service.

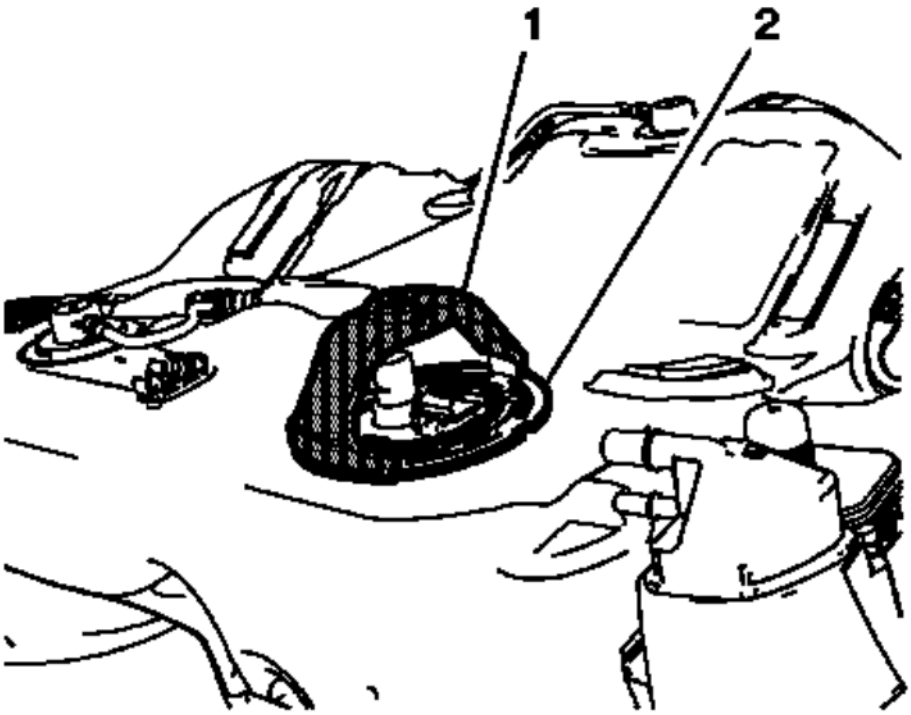


Fig. 80: Fuel Sender Lock Ring And Special Tool
Courtesy of GENERAL MOTORS COMPANY

4. Use the **CH-48482** fuel sender lock ring wrench, (1) to remove the fuel sender lock ring (2) from the fuel sender assembly.

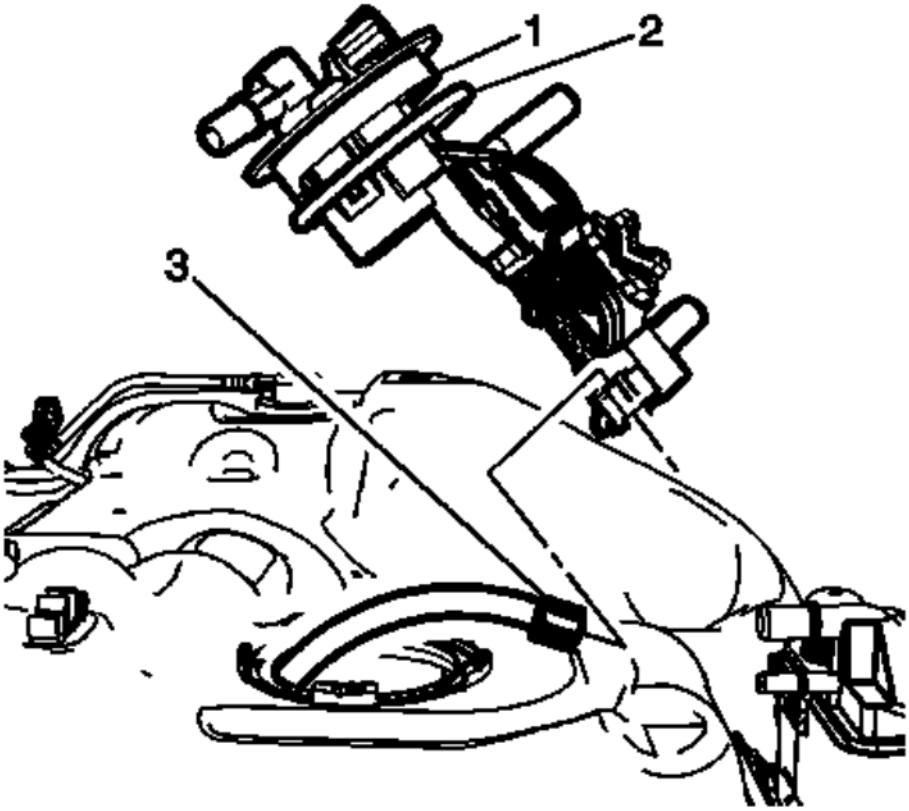


Fig. 81: Fuel Sender Assembly
Courtesy of GENERAL MOTORS COMPANY

5. Carefully lift the fuel sender assembly (1) from the fuel tank. Do not disconnect the fuel crossover pipe at this time.
6. Gently pull enough of the fuel crossover pipe (3) to disconnect it from the fuel sender assembly (1).
7. Remove and DISCARD the fuel sender O-ring (2).

Installation Procedure

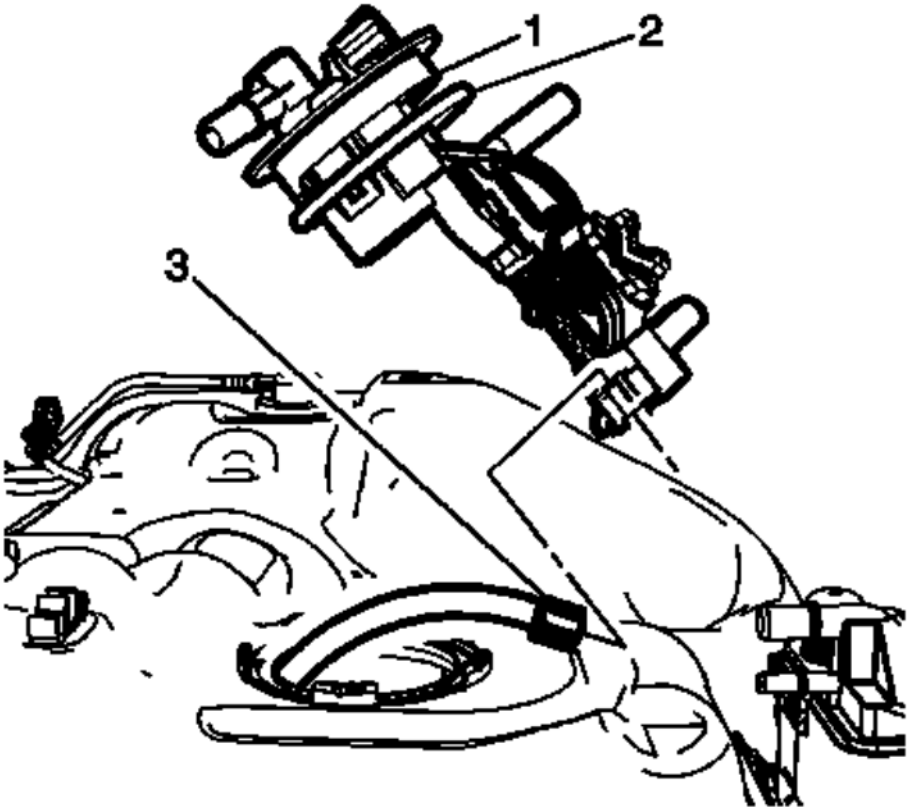


Fig. 82: Fuel Sender Assembly
Courtesy of GENERAL MOTORS COMPANY

1. Install a NEW the fuel sender O-ring (2).
2. Connect the fuel sender to the fuel tank crossover fuel line (3).
3. Carefully position the fuel sender assembly (1) into the fuel tank.

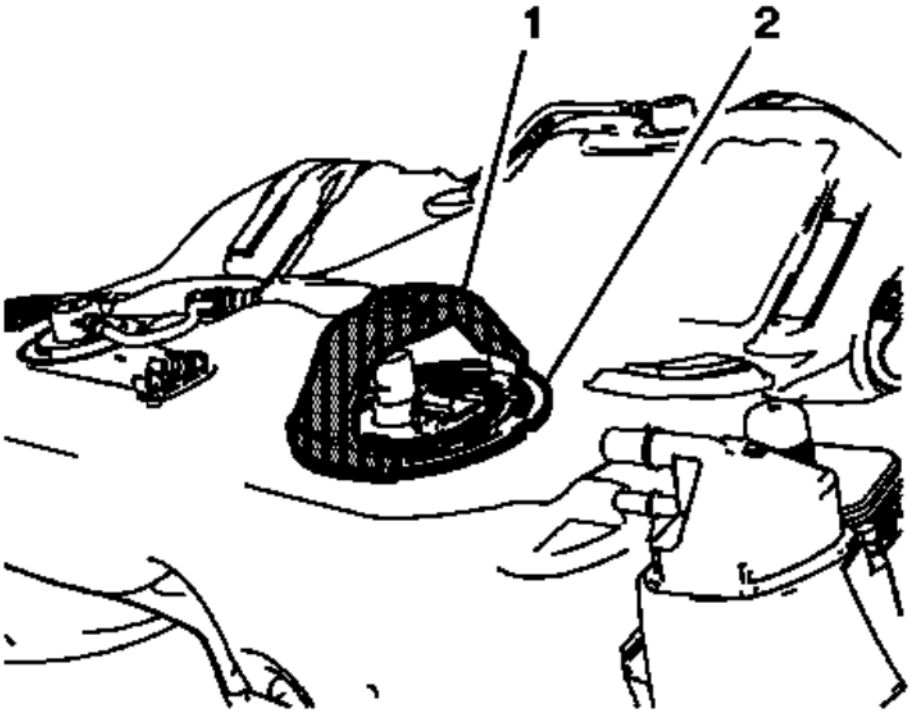


Fig. 83: Fuel Sender Lock Ring And Special Tool
Courtesy of GENERAL MOTORS COMPANY

4. Use the **CH-48482** fuel sender lock ring wrench, (1) to install the fuel sender lock ring (2) .
5. Connect the evaporative emission canister vent pipe to the fuel sender assembly. Refer to **Plastic Collar Quick Connect Fitting Service**.
6. Connect the fuel sender harness connector.
7. Install the fuel tank. Refer to **Fuel Tank Replacement (AWD)**.

FUEL LEVEL SENSOR REPLACEMENT

Removal Procedure

WARNING: Fuel Vapors can collect while servicing fuel system parts in enclosed areas such as a trunk. To reduce the risk of fire and increased exposure to vapors:

- **Use forced air ventilation such as a fan set outside of the trunk.**
- **Plug or cap any fuel system openings in order to reduce fuel vapor formation.**
- **Clean up any spilled fuel immediately.**
- **Avoid sparks and any source of ignition.**
- **Use signs to alert others in the work area that fuel system work is**

in process.

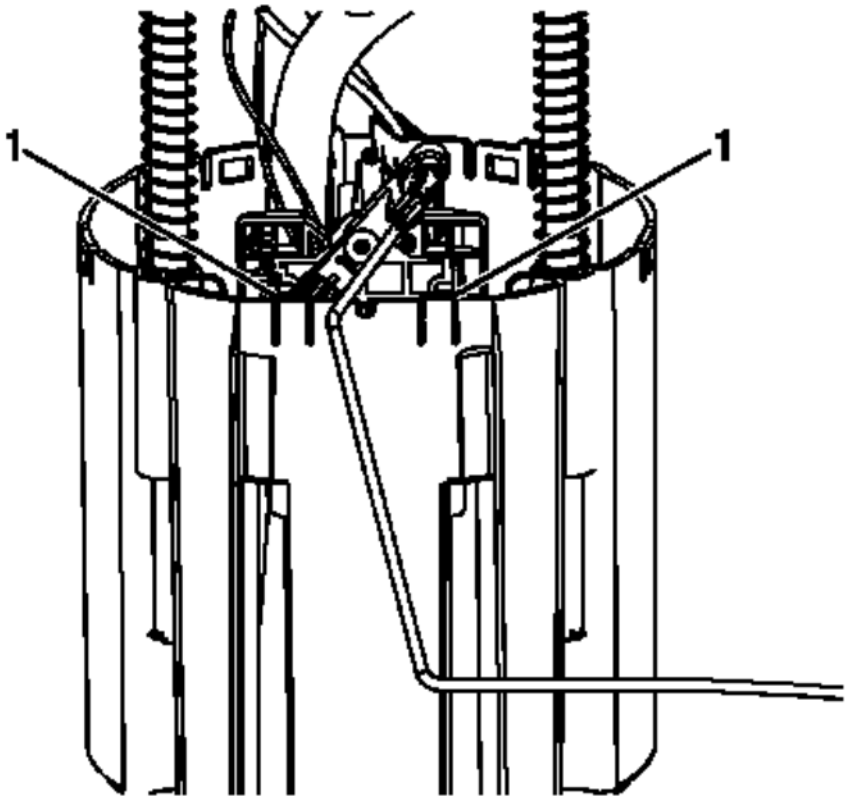


Fig. 84: Identifying Locking Tabs
Courtesy of GENERAL MOTORS COMPANY

1. Remove the fuel tank pump module. Refer to **Fuel Tank Fuel Pump Module Replacement (FWD)**, **Fuel Tank Fuel Pump Module Replacement (AWD)**.
2. Using two flat-bladed tools, carefully pull both locking tabs (1) outward while simultaneously lifting the level sensor.

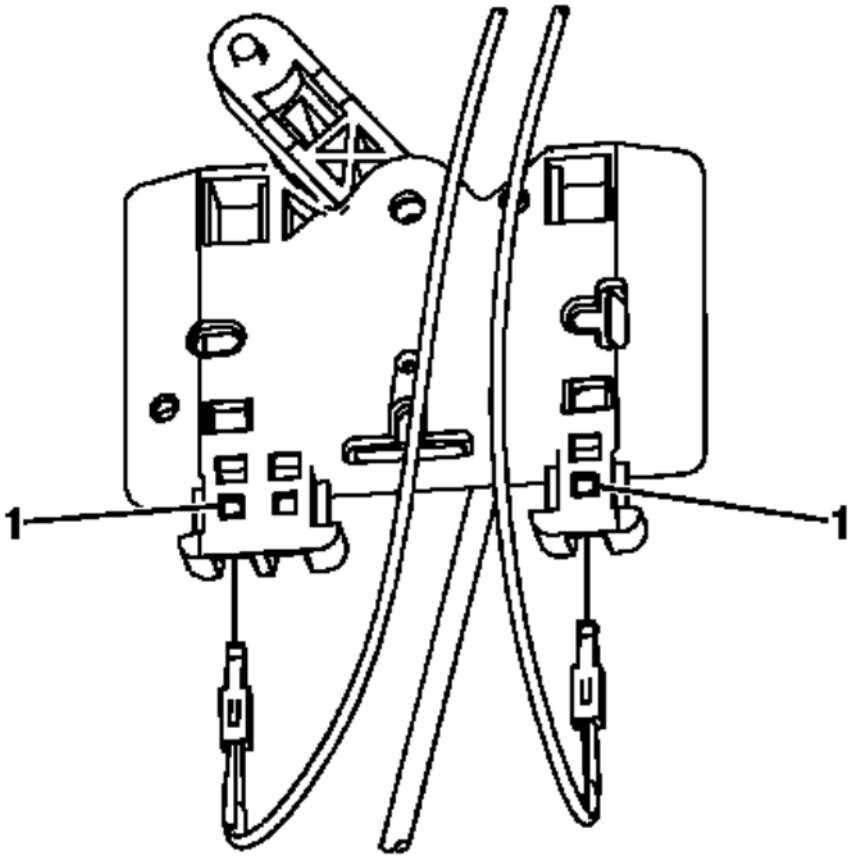


Fig. 85: Identifying Electrical Terminals
Courtesy of GENERAL MOTORS COMPANY

3. Using a small bladed tool, gently release the retaining tabs on the electrical terminals (1) while simultaneously pulling the terminals out.
4. Inspect the terminals for bending and reposition as necessary.

Installation Procedure

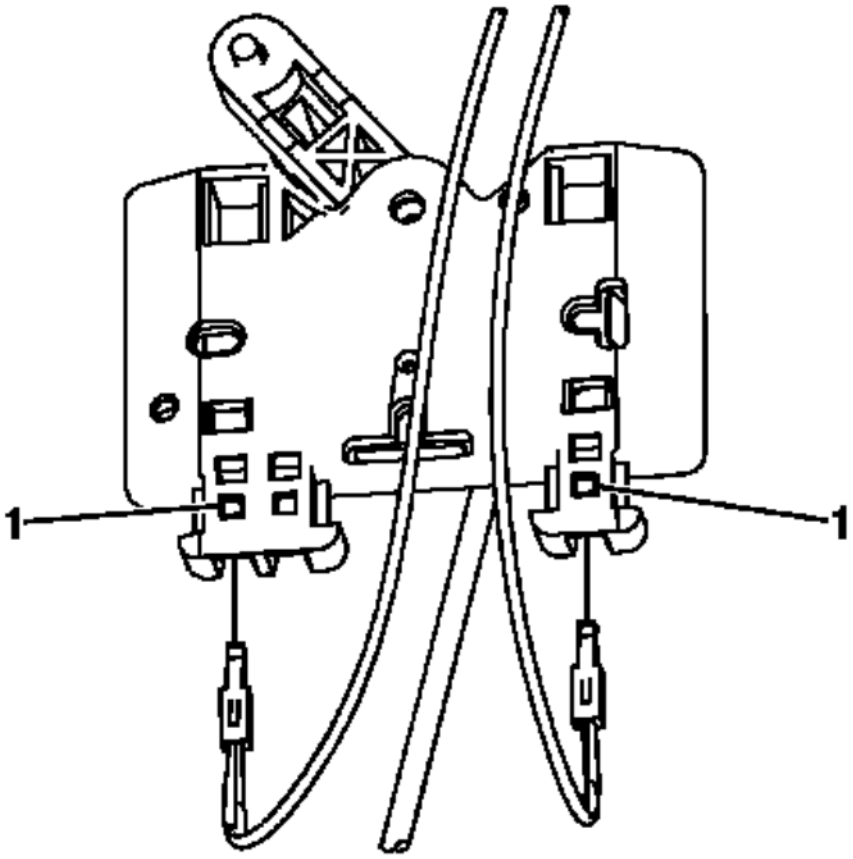


Fig. 86: Identifying Electrical Terminals
Courtesy of GENERAL MOTORS COMPANY

1. Push in the electrical terminals (1) and ensure the terminals are secure.

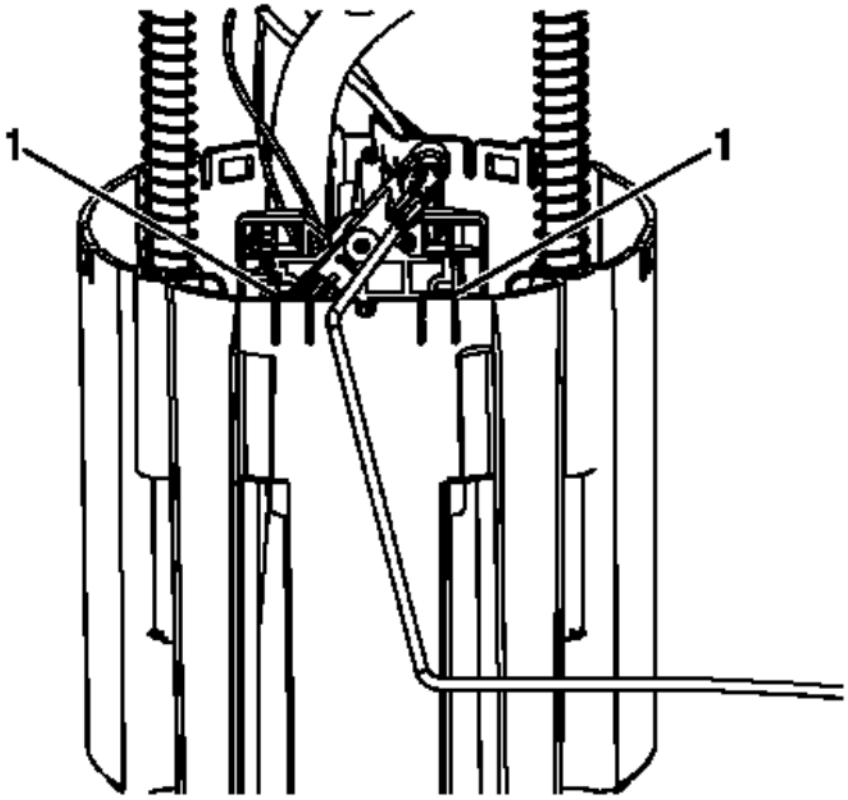


Fig. 87: Identifying Locking Tabs
Courtesy of GENERAL MOTORS COMPANY

2. Carefully insert the level sensor until the locking tabs (1) snap into the locking position.
3. Install the fuel tank pump module. Refer to **Fuel Tank Fuel Pump Module Replacement (FWD)**, **Fuel Tank Fuel Pump Module Replacement (AWD)**.

FUEL TANK FILLER PIPE REPLACEMENT

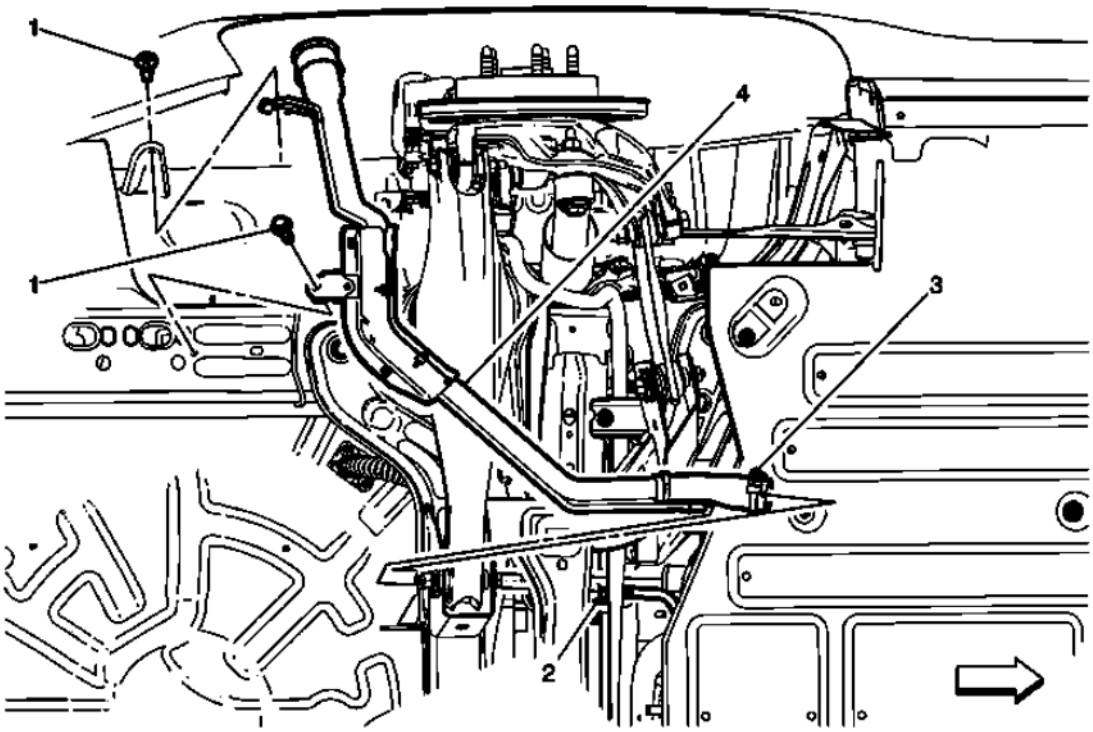


Fig. 88: Fuel Tank Filler Pipe
Courtesy of GENERAL MOTORS COMPANY

Fuel Tank Filler Pipe Replacement

Callout	Component Name
Preliminary Procedure **Remove the filler pipe housing. Refer to Fuel Tank Filler Pipe Housing Replacement .**	
1	Filler Pipe Fastener (Qty: 2) **CAUTION:** **Refer to Fastener Caution .** **Tighten** 9 N.m (80 lb in)
2	Rear Evaporative Emission Pipe **Procedure** Disconnect the quick connect fitting. Refer to **Plastic Collar Quick Connect Fitting Service**.
3	Hose Clamp
4	Fuel Tank Filler Pipe

FUEL PUMP COVER REPLACEMENT

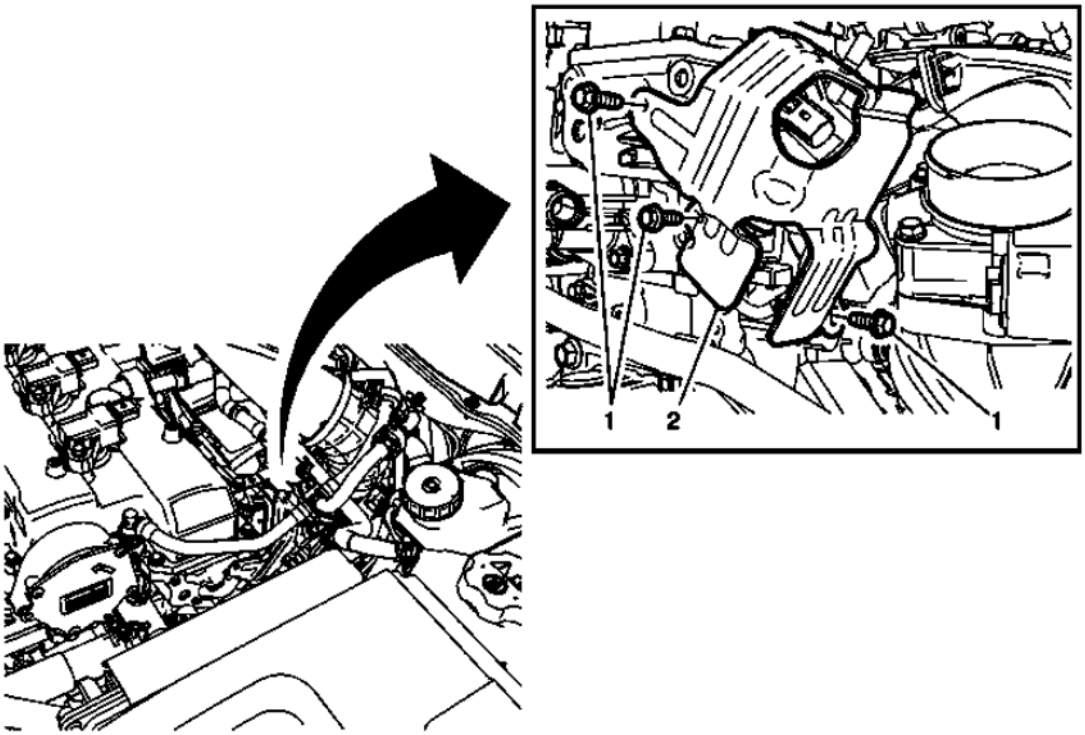


Fig. 89: Fuel Pump Cover
Courtesy of GENERAL MOTORS COMPANY

Fuel Pump Cover Replacement

Callout	Component Name
Preliminary Procedure Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement** .	
1	Fuel Pump Cover Fasteners (Qty: 3) **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 (89 lb in)
2	Fuel Pump Cover **Procedure** Disconnect the electrical wiring harness connector from the fuel pump.

FUEL PUMP INSULATOR REPLACEMENT

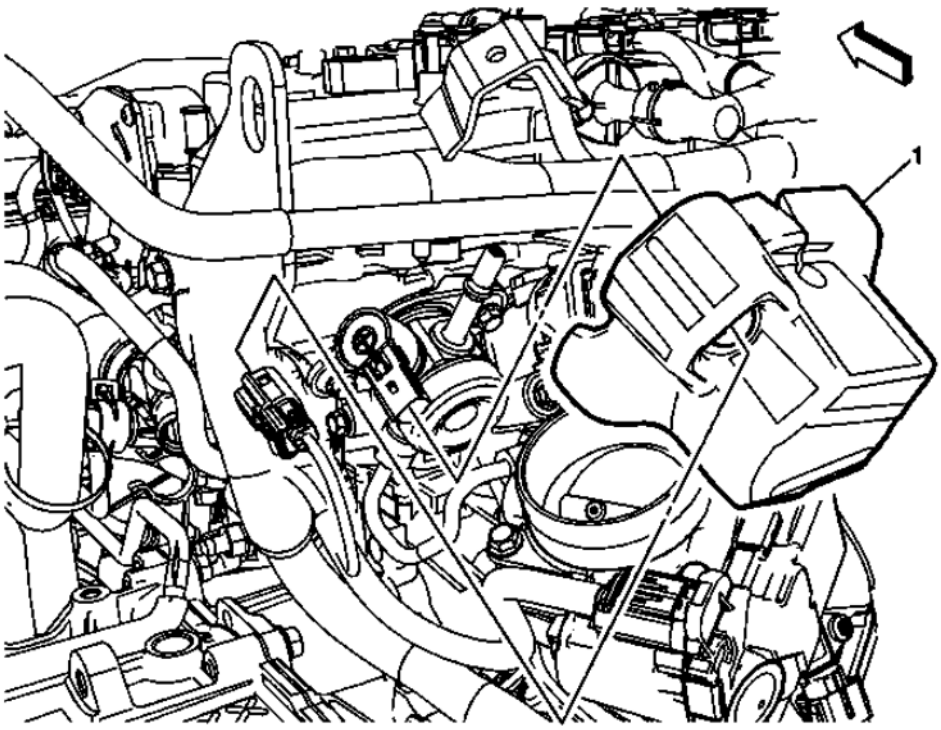


Fig. 90: Fuel Pump Insulator
Courtesy of GENERAL MOTORS COMPANY

Fuel Pump Insulator Replacement

Callout	Component Name
Preliminary Procedure 1. Remove the fuel pump cover. Refer to **Fuel Pump Cover Replacement** 2. Disconnect the fuel pump harness connector.	
1	Fuel Pump Insulator **NOTE:** **The fuel pump cover just snaps into place.**

FUEL FEED PIPE REPLACEMENT (FWD)

Removal Procedure

WARNING: Refer to Gasoline/Gasoline Vapors Warning .

WARNING: Refer to Safety Glasses Warning .

1. Relieve the system fuel pressure. Refer to **Fuel Pressure Relief** .
2. Remove the fuel feed front pipe. Refer to **Fuel Feed Front Pipe Replacement**.

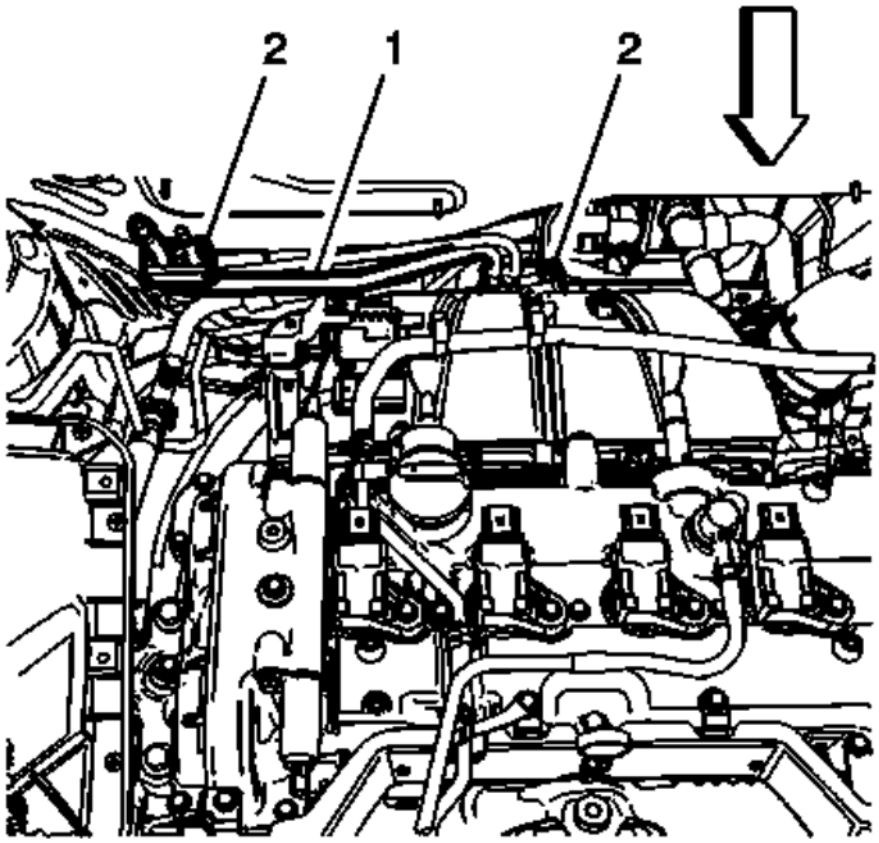


Fig. 91: Fuel Feed Pipe
Courtesy of GENERAL MOTORS COMPANY

3. Remove the fuel feed pipe (1) from the retainers (2).
4. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

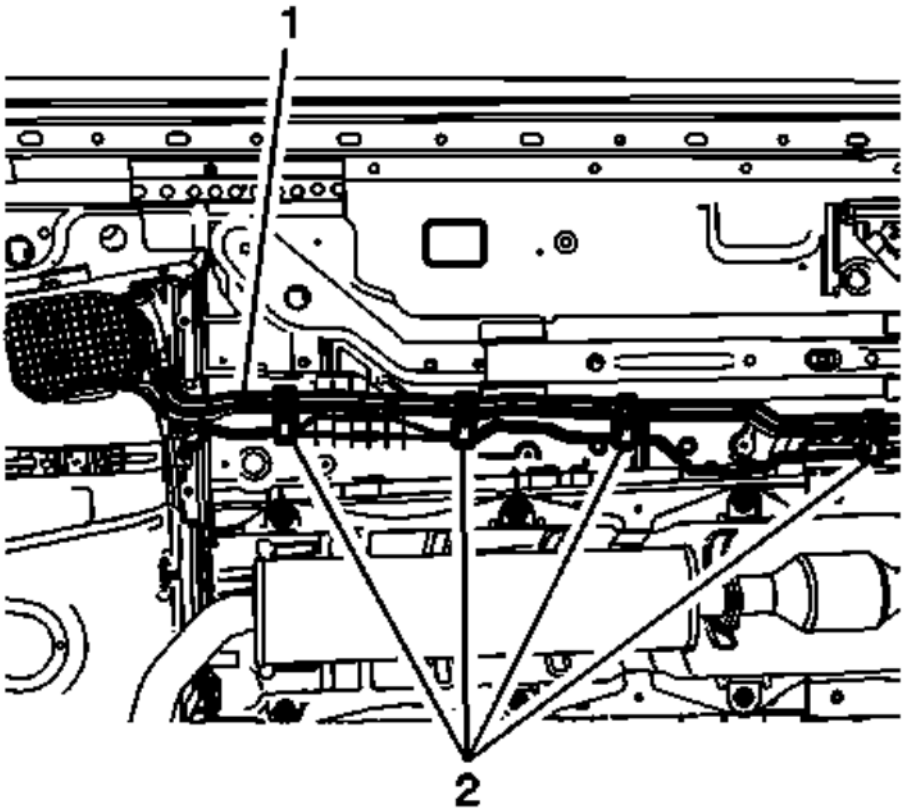


Fig. 92: Fuel Feed Pipe And Retainers
Courtesy of GENERAL MOTORS COMPANY

5. Disconnect the fuel feed pipe (1) and remove from retainers (2). Refer to **Plastic Collar Quick Connect Fitting Service**.
6. Remove the fuel feed pipe (1) from the vehicle.

Installation Procedure

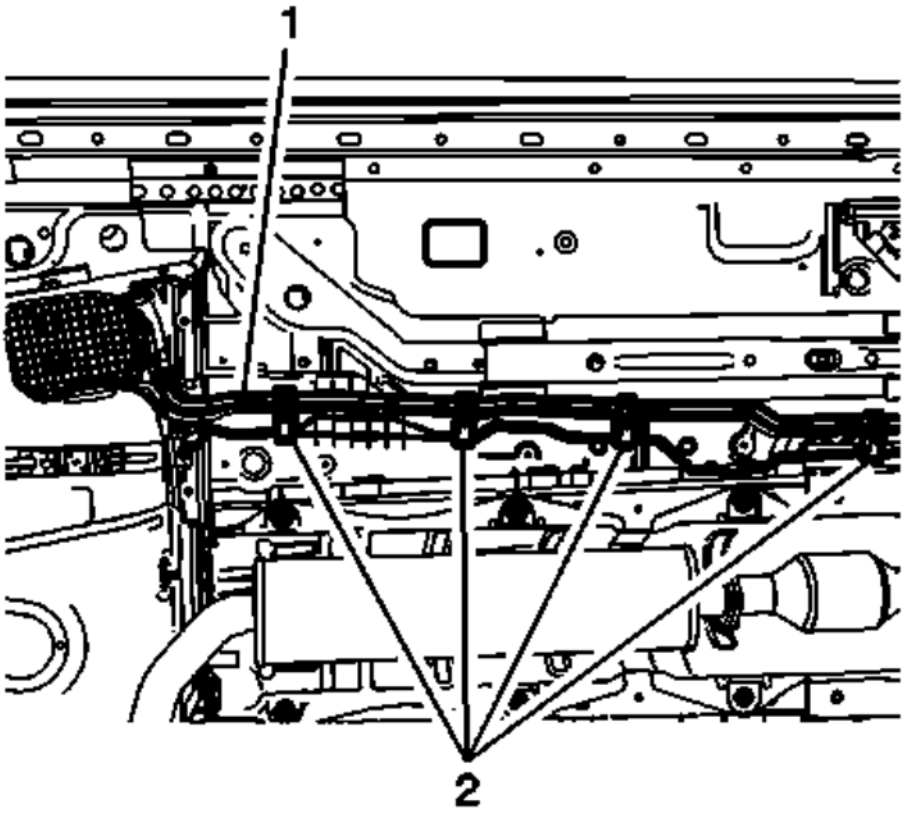


Fig. 93: Fuel Feed Pipe And Retainers
Courtesy of GENERAL MOTORS COMPANY

1. Install the fuel feed pipe (1) to the vehicle.
2. Connect the fuel feed pipe (1) and install to the retainers (2). Refer to **Plastic Collar Quick Connect Fitting Service**.
3. Lower the vehicle.

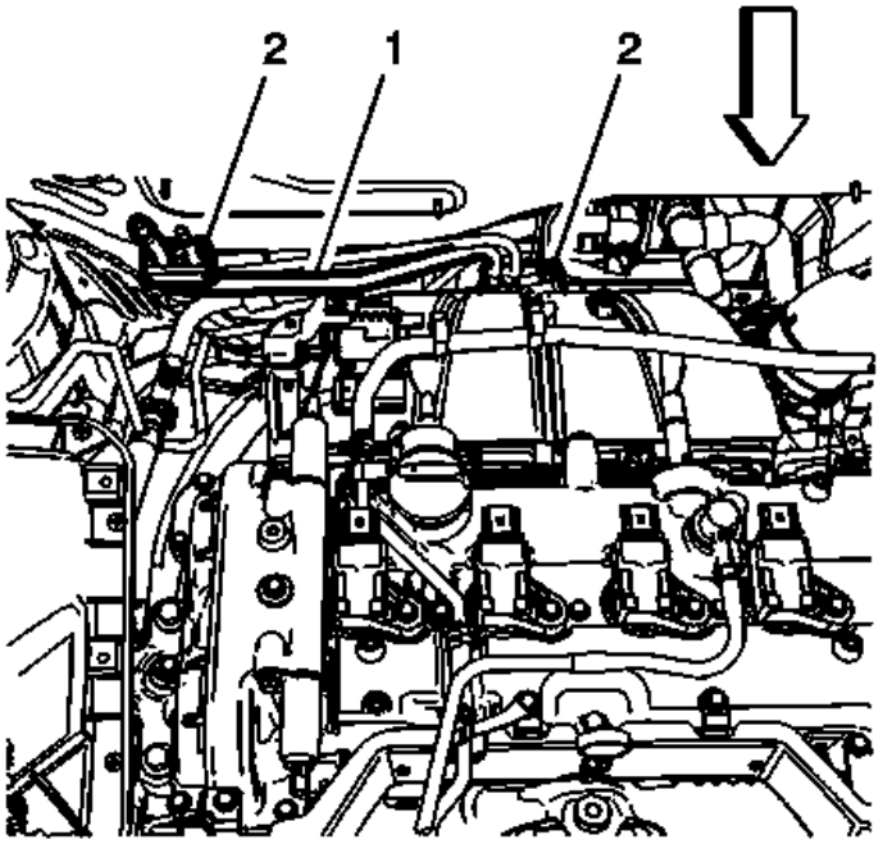


Fig. 94: Fuel Feed Pipe
Courtesy of GENERAL MOTORS COMPANY

4. Install the fuel feed pipe (1) to the retainers (2).
5. Install the fuel feed front pipe. Refer to **Fuel Feed Front Pipe Replacement**.

FUEL FEED PIPE REPLACEMENT (AWD)

Removal Procedure

WARNING: Refer to Gasoline/Gasoline Vapors Warning .

WARNING: Refer to Safety Glasses Warning .

1. Relieve the system fuel pressure. Refer to **Fuel Pressure Relief** .
2. Remove the fuel feed front pipe. Refer to **Fuel Feed Front Pipe Replacement**.

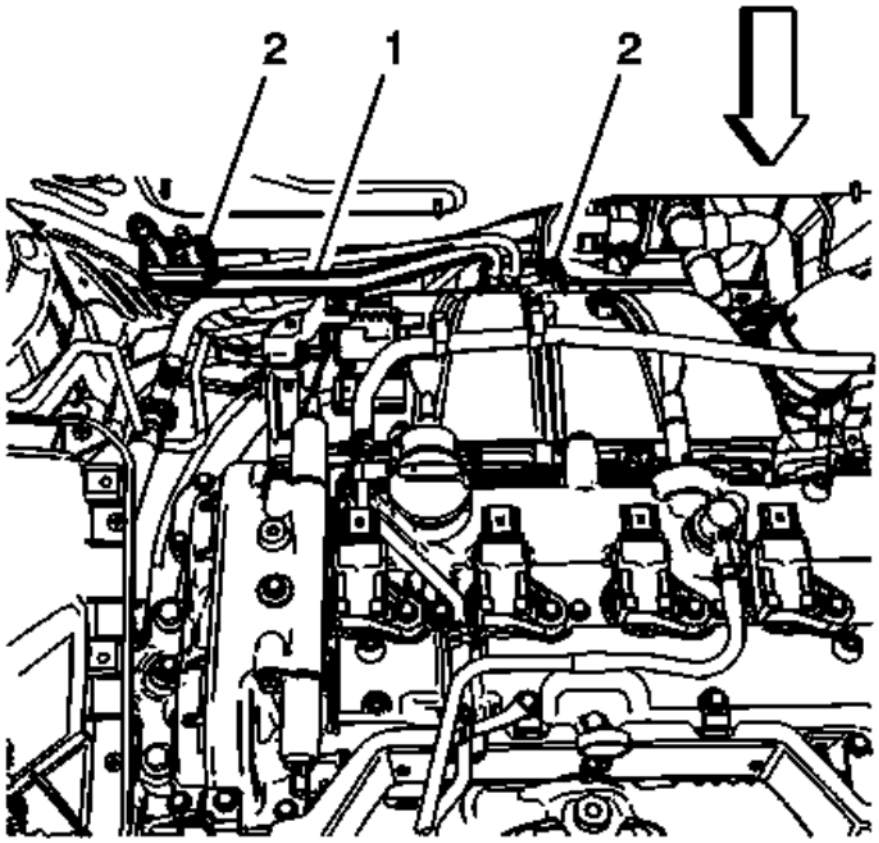


Fig. 95: Fuel Feed Pipe
Courtesy of GENERAL MOTORS COMPANY

3. Remove the fuel feed pipe (1) from the retainers (2).
4. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

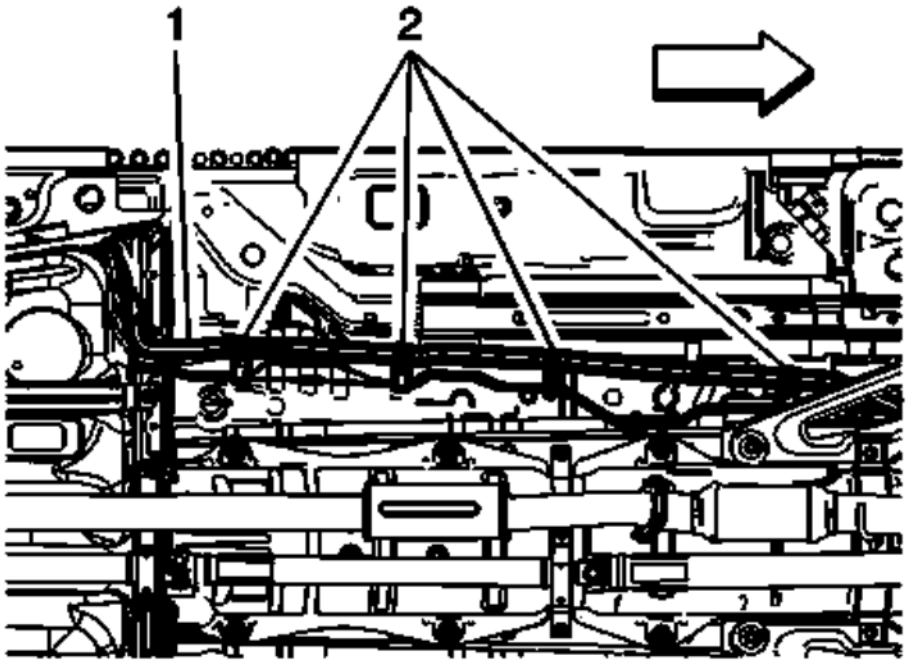


Fig. 96: Fuel Feed Pipe
Courtesy of GENERAL MOTORS COMPANY

5. Disconnect the fuel feed pipe (1) and remove from retainers (2). Refer to **Plastic Collar Quick Connect Fitting Service**.
6. Remove the fuel feed pipe (1) from the vehicle.

Installation Procedure

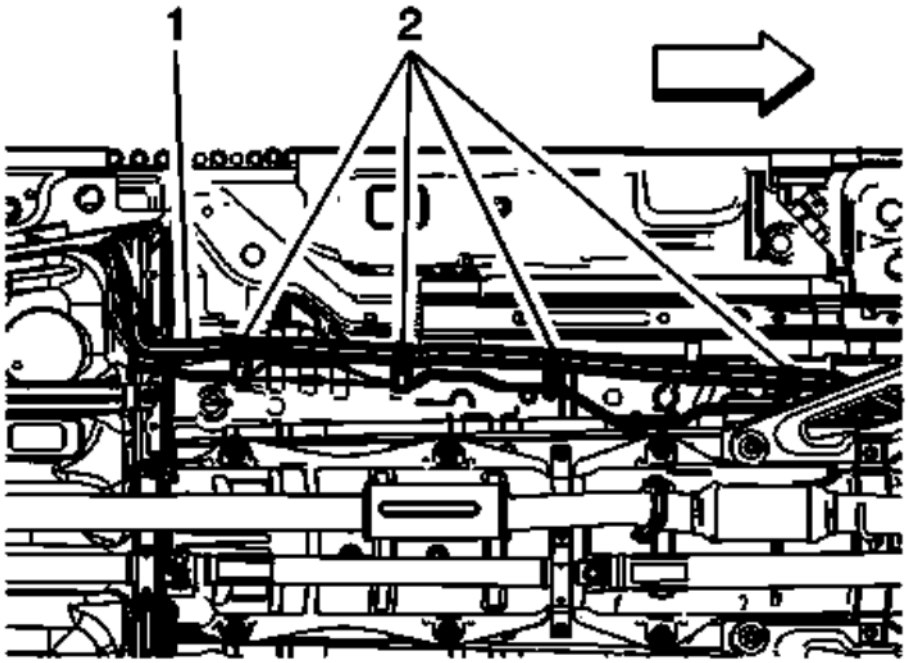


Fig. 97: Fuel Feed Pipe
Courtesy of GENERAL MOTORS COMPANY

1. Install the fuel feed pipe (1) to the vehicle.
2. Connect the fuel feed pipe (1) and install to the retainers (2). Refer to **Plastic Collar Quick Connect Fitting Service**.
3. Lower the vehicle.

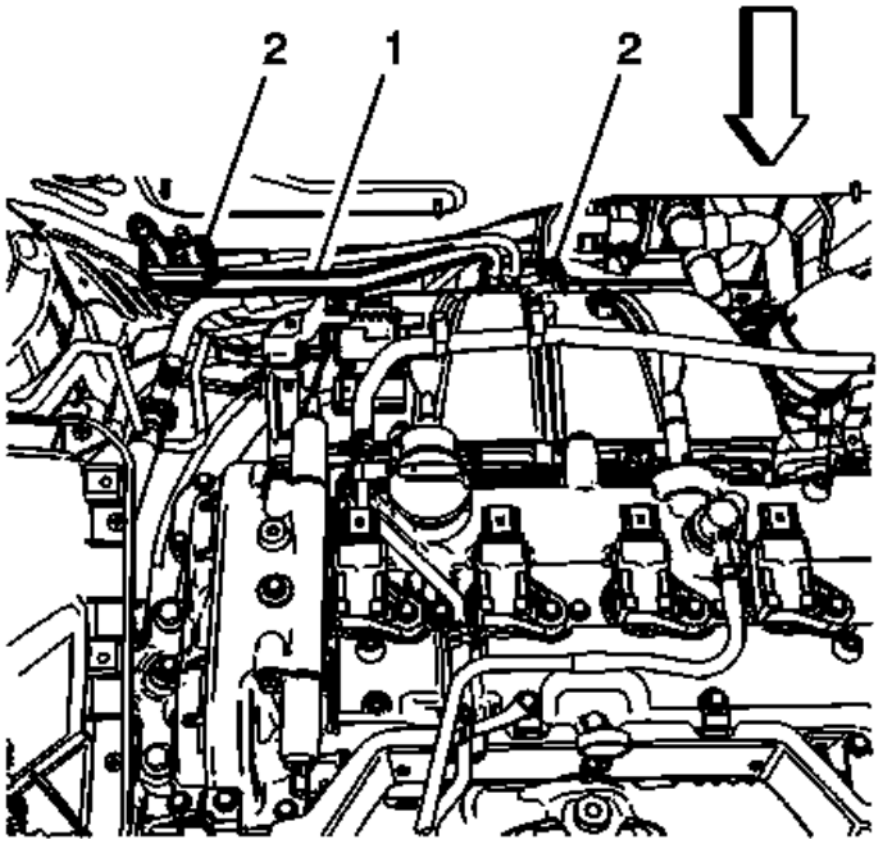


Fig. 98: Fuel Feed Pipe
Courtesy of GENERAL MOTORS COMPANY

4. Install the fuel feed pipe (1) to the retainers (2).
5. Install the fuel feed front pipe. Refer to **Fuel Feed Front Pipe Replacement**.

FUEL FEED FRONT PIPE REPLACEMENT

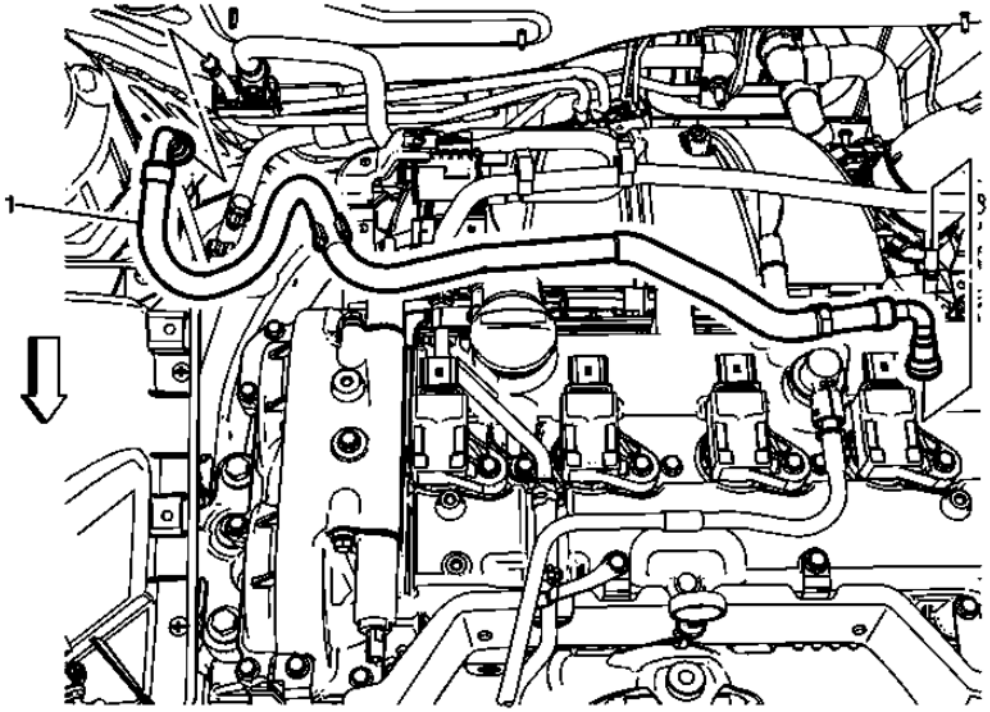


Fig. 99: Fuel Feed Front Pipe (LTG)
Courtesy of GENERAL MOTORS COMPANY

Fuel Feed Front Pipe Replacement

Callout	Component Name
Preliminary Procedure 1. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement** . 2. Relieve the system fuel pressure. Refer to **Fuel Pressure Relief** .	
1	Fuel Feed Front Pipe **Procedure** 1. Disconnect the fuel feed front pipe from the retainers. 2. Disconnect the fuel feed front pipe from the pump and line. Refer to **Metal Collar Quick Connect Fitting Service**.

FUEL PRESSURE SENSOR REPLACEMENT - FUEL FEED PIPE (FWD)

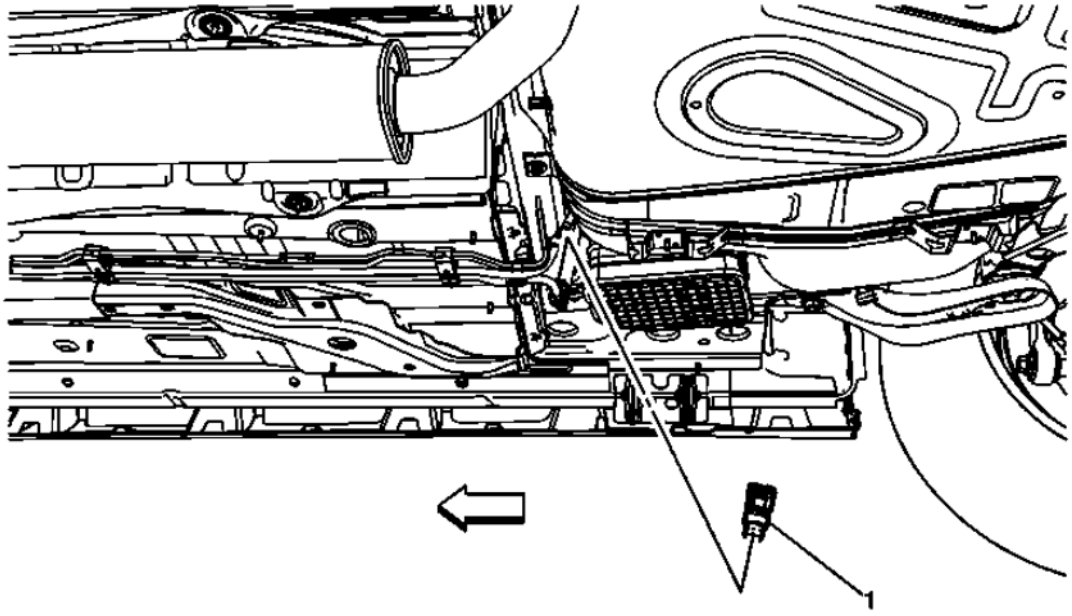


Fig. 100: Fuel Pressure Sensor - Fuel Feed Pipe (FWD)
Courtesy of GENERAL MOTORS COMPANY

Fuel Pressure Sensor Replacement - Fuel Feed Pipe (FWD)

Callout	Component Name
Preliminary Procedures 1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief**. 2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** . 3. Remove the right side rear air deflector.	
1	Fuel Pressure Sensor **CAUTION:** **Refer to Component Fastener Tightening Caution .** **Procedure** 1. Disconnect the electrical connector. 2. Use a NEW O-ring whenever the sensor is removed. **Tighten** 9Y (80 lb in)

FUEL PRESSURE SENSOR REPLACEMENT - FUEL FEED PIPE (AWD)

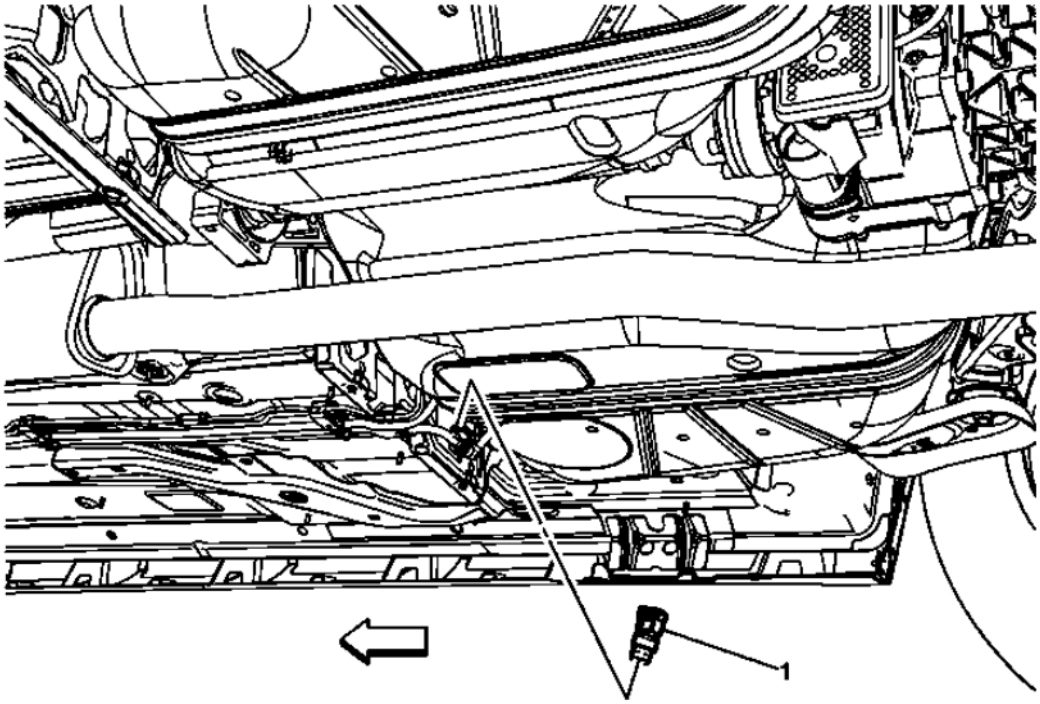


Fig. 101: Fuel Pressure Sensor - Fuel Feed Pipe (AWD)
Courtesy of GENERAL MOTORS COMPANY

Fuel Pressure Sensor Replacement - Fuel Feed Pipe (AWD)

Callout	Component Name
Preliminary Procedures 1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief**. 2. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .	
1	Fuel Pressure Sensor **CAUTION:** **Refer to Component Fastener Tightening Caution .** **Procedure** 1. Disconnect the electrical connector. 2. Use a NEW O-ring whenever the sensor is removed. **Tighten** 9 (80 lb in)

FUEL FEED INTERMEDIATE PIPE REPLACEMENT

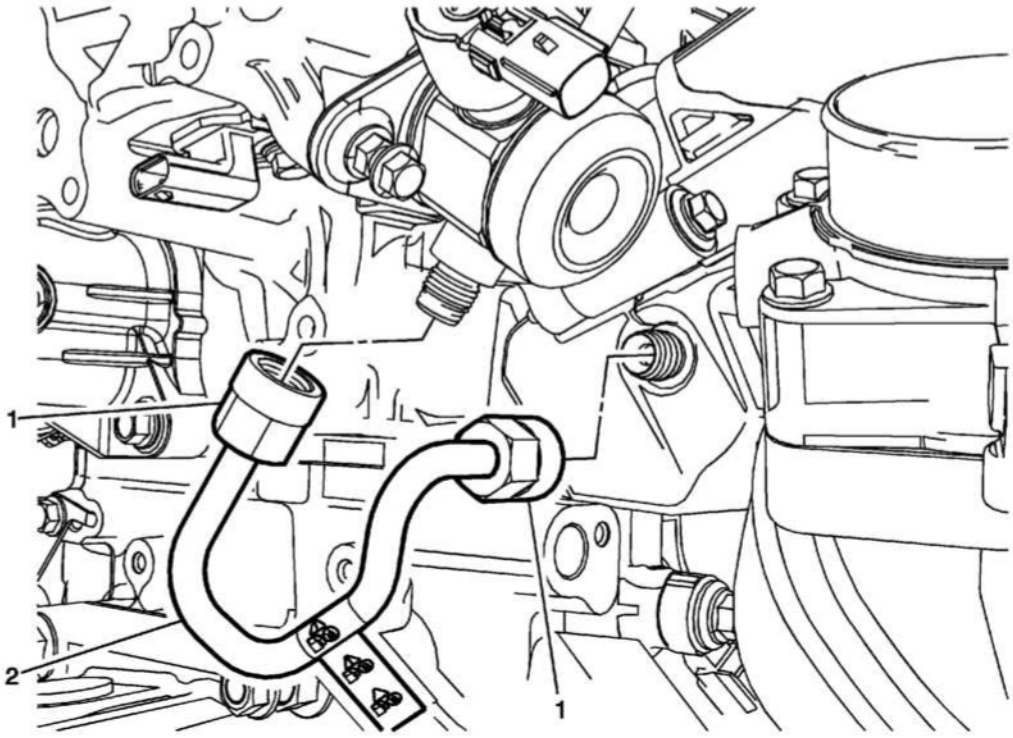


Fig. 102: Fuel Feed Intermediate Pipe
Courtesy of GENERAL MOTORS COMPANY

Fuel Feed Intermediate Pipe Replacement

Callout	Component Name
	WARNING: **Refer to Gasoline/Gasoline Vapors Warning .** **Preliminary Procedure** **1. Remove the intake manifold cover. Refer to Intake Manifold Cover Replacement .** **2. Remove the charge air cooler outlet air tube. Refer to Charge Air Cooler Outlet Air Tube Replacement.** **3. Remove the fuel pump cover. Refer to Fuel Pump Cover Replacement.**
1	Fuel Pump Intermediate Pipe Fittings (Qty:2) **WARNING:** **Remove the fuel tank cap and relieve the fuel system pressure before servicing the fuel system in order to reduce the risk of personal injury. After you relieve the fuel system pressure, a small amount of fuel may be released when servicing the fuel lines, the fuel injection pump, or the connections. In order to reduce the risk of personal injury, cover the fuel system components with a shop towel before disconnection. This will catch any fuel that may leak out. Place the towel in an approved container when the disconnection is complete.** **CAUTION:** **Refer to Component Fastener Tightening Caution .**

	Tighten 30 N.m(22 lb ft).
2	Fuel Pump Intermediate Pipe **NOTE:** **The pipe fittings are a one time use, always install a New fuel pump intermediate pipe.**

FUEL TANK VENT PIPE REPLACEMENT (FWD)

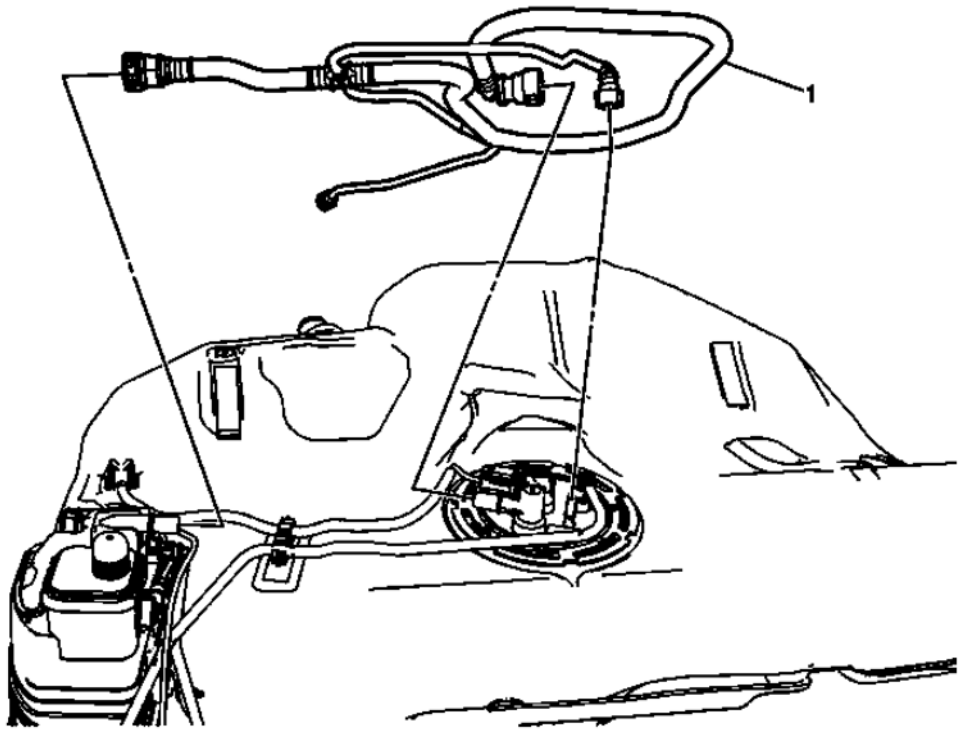


Fig. 103: Fuel Tank Vent Pipe
Courtesy of GENERAL MOTORS COMPANY

Fuel Tank Vent Pipe Replacement (FWD)

Callout	Component Name
	Preliminary Procedure **Remove the fuel tank. Refer to Fuel Tank Replacement (FWD).**
1	Fuel Tank Vent Pipe **Procedure** Disconnect the fuel tank vent pipe quick connects. Refer to **Plastic Collar Quick Connect Fitting Service**.

FUEL PUMP REPLACEMENT

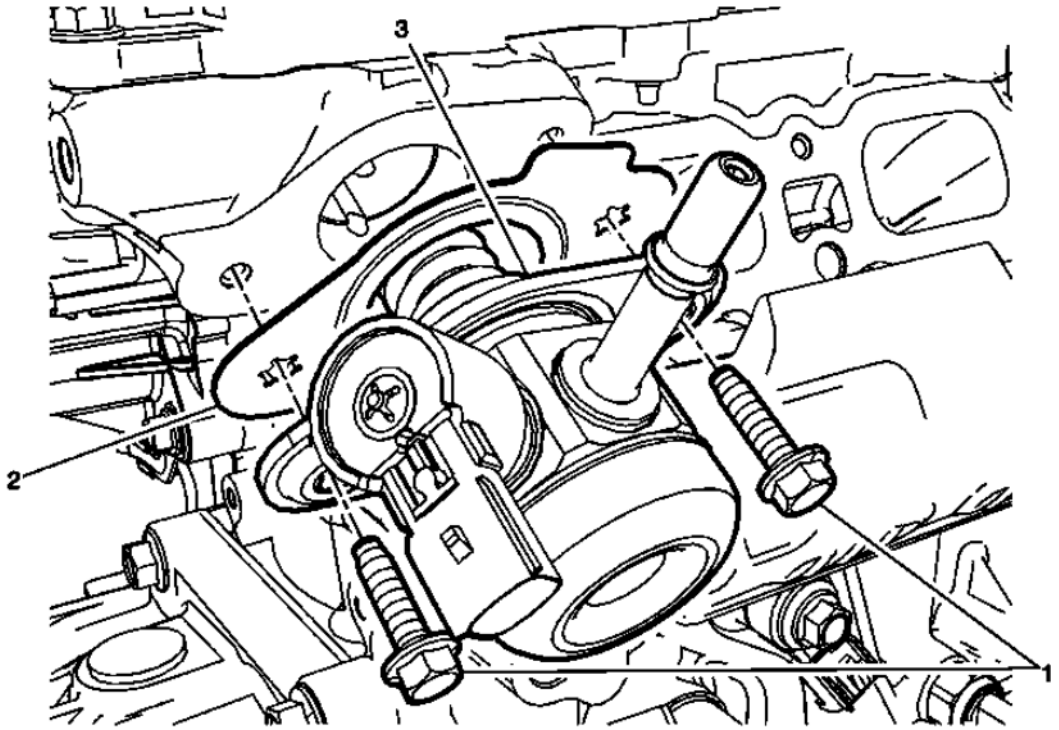


Fig. 104: Fuel Pump
Courtesy of GENERAL MOTORS COMPANY

Fuel Pump Replacement

Callout	Component Name
	WARNING: **Refer to Gasoline/Gasoline Vapors Warning .** **Preliminary Procedure** 1. Remove the fuel pump insulator. Refer to **Fuel Pump Insulator Replacement**. 2. Remove the fuel pump intermediate pipe. Refer to **Fuel Feed Intermediate Pipe Replacement**. Install a NEW fuel pump intermediate pipe. 3. Disconnect the fuel pump fuel feed hose from the fuel pump. Refer to **Plastic Collar Quick Connect Fitting Service**. **Special Tools EN-50790 HP** Fuel Pump Installation Alignment GaugeFor equivalent regional tools, refer to **Special Tools** .
1	Fuel Pump Fasteners (Qty: 2) **WARNING:** **Remove the fuel tank cap and relieve the fuel system pressure before servicing the fuel system in order to reduce the risk of personal injury. After you relieve the fuel system pressure, a small amount of fuel may be released when servicing the fuel lines, the fuel injection pump, or the connections. In order to reduce the risk of personal injury, cover the fuel system components with a shop towel before disconnection. This will catch any fuel that may leak out. Place the towel in an approved container when the disconnection is complete.**

	CAUTION: **Refer to Fastener Caution .** **Tighten** 15 (11 lb ft)
2	Fuel Pump Gasket **NOTE:** **Install a NEW fuel pump ring and gasket (2). Ensure the fuel pump housing gasket (2) is properly aligned with the tab upward at the 2 o'clock position.**
3	Fuel Pump **NOTE:** **To aid installation of the fuel pump, rotate the engine so that the fuel pump lobe of the intake cam is at it's lowest point. Use the EN-50790 alignment gauge to ensure that the camshaft lobe is in the base circle position. At the base circle position, the tool will be flush with the head. Lubricate the high pressure fuel pump cylinder head bore with clean silicone free 5W30 engine oil.**

FUEL INJECTION FUEL RAIL ASSEMBLY REPLACEMENT

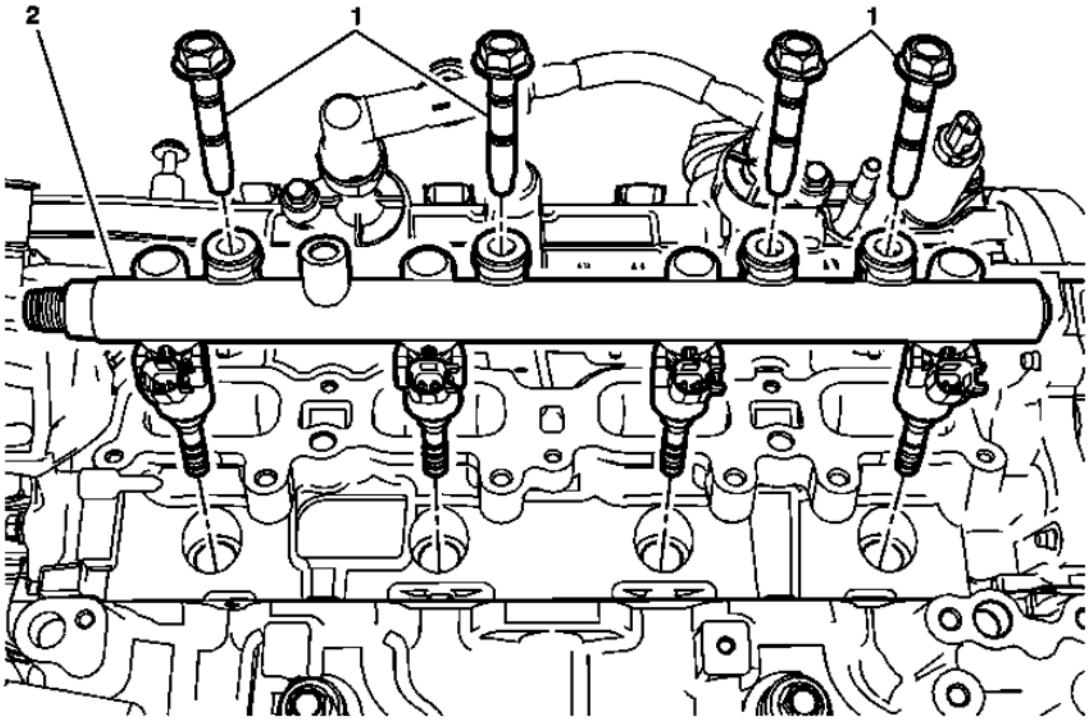


Fig. 105: Fuel Injection Fuel Rail Assembly
Courtesy of GENERAL MOTORS COMPANY

Fuel Injection Fuel Rail Assembly Replacement

Callout	Component Name

WARNING:

Refer to Gasoline/Gasoline Vapors Warning .

Preliminary Procedure

1. **Remove the intake manifold. Refer to Intake Manifold Replacement .**
2. **Remove the fuel injector noise shield from the fuel injector rail. Refer to Fuel Injection Fuel Rail Noise Shield Replacement.**
3. **Remove the fuel pump intermediate pipe. Refer to Fuel Feed Intermediate Pipe Replacement.**
4. **Remove the fuel injection fuel rail fuel pressure sensor. Fuel Injection Fuel Rail Fuel Pressure Sensor Replacement.**

1	Fuel Injection Fuel Rail Assembly Fasteners (Qty:4) **WARNING:** **Remove the fuel tank cap and relieve the fuel system pressure before servicing the fuel system in order to reduce the risk of personal injury. After you relieve the fuel system pressure, a small amount of fuel may be released when servicing the fuel lines, the fuel injection pump, or the connections. In order to reduce the risk of personal injury, cover the fuel system components with a shop towel before disconnection. This will catch any fuel that may leak out. Place the towel in an approved container when the disconnection is complete.** **CAUTION:** **Refer to Fastener Caution .** **Tighten** 25 (18 lb ft)
2	Fuel Injection Fuel Rail Assembly **Procedure** When reinstalling the existing fuel injectors, it's important to replace the fuel injector seals. Refer to **Fuel Injector Replacement**.

FUEL INJECTION FUEL RAIL NOISE SHIELD REPLACEMENT

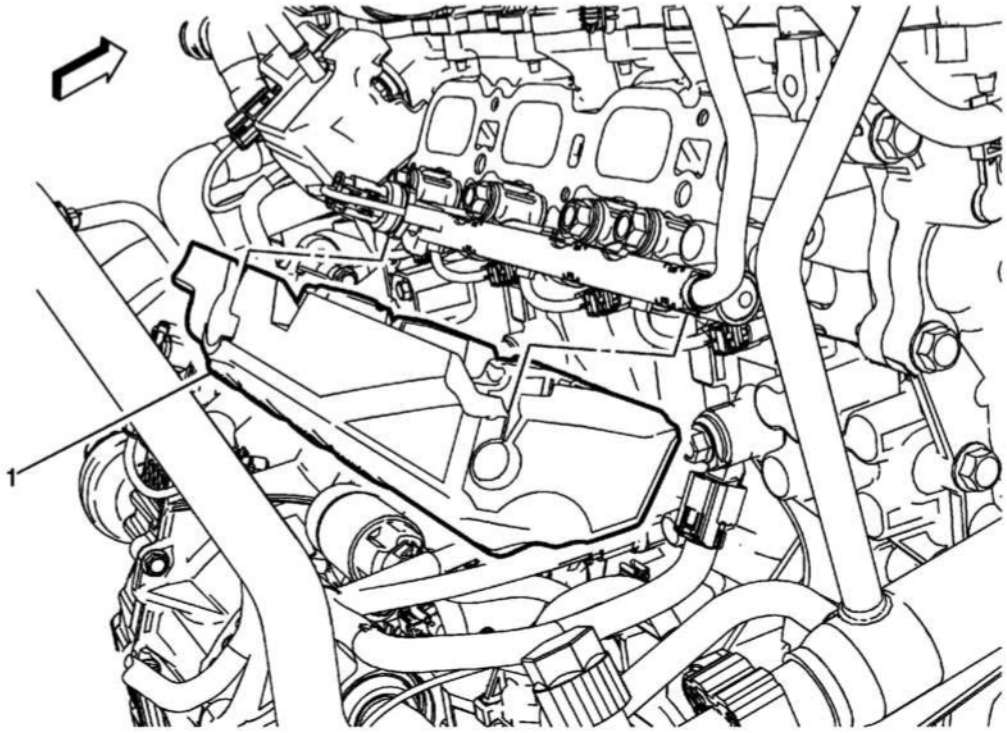


Fig. 106: Fuel Injection Fuel Rail Noise Shield
Courtesy of GENERAL MOTORS COMPANY

Fuel Injection Fuel Rail Noise Shield Replacement

Callout	Component Name
Preliminary Procedure Remove the intake manifold. Refer to **Intake Manifold Replacement** .	
1	Fuel Injection Fuel Rail Noise Shield **NOTE:** **The fuel injection noise shield just snaps into place.**

FUEL INJECTION FUEL RAIL FUEL PRESSURE SENSOR REPLACEMENT

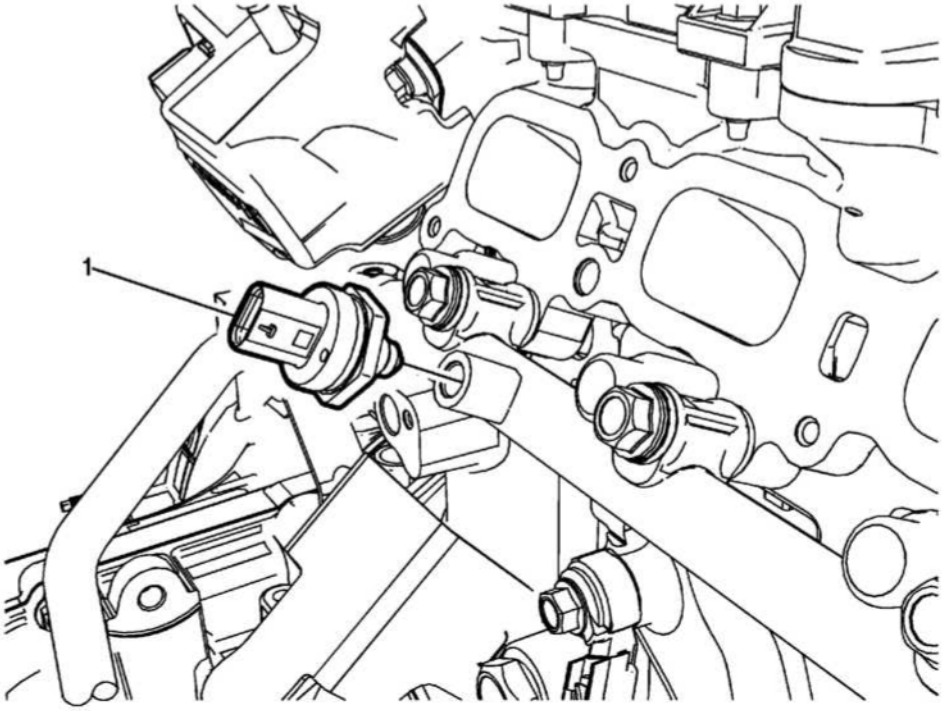


Fig. 107: Fuel Injection Fuel Rail Fuel Pressure Sensor
Courtesy of GENERAL MOTORS COMPANY

Fuel Injection Fuel Rail Fuel Pressure Sensor Replacement

Callout	Component Name
	WARNING: **Refer to Gasoline/Gasoline Vapors Warning .** **Preliminary Procedure** Remove the intake manifold. Refer to **Intake Manifold Replacement** .
1	Fuel Injection Fuel Rail Fuel Pressure Sensor **WARNING:** **Remove the fuel tank cap and relieve the fuel system pressure before servicing the fuel system in order to reduce the risk of personal injury. After you relieve the fuel system pressure, a small amount of fuel may be released when servicing the fuel lines, the fuel injection pump, or the connections. In order to reduce the risk of personal injury, cover the fuel system components with a shop towel before disconnection. This will catch any fuel that may leak out. Place the towel in an approved container when the disconnection is complete.** **CAUTION:** **Refer to Component Fastener Tightening Caution .** **Procedure** Disconnect the electrical wiring harness connector from the fuel injection fuel rail fuel pressure sensor. **Tighten**

	33 (24 lb ft)

FUEL INJECTOR REPLACEMENT

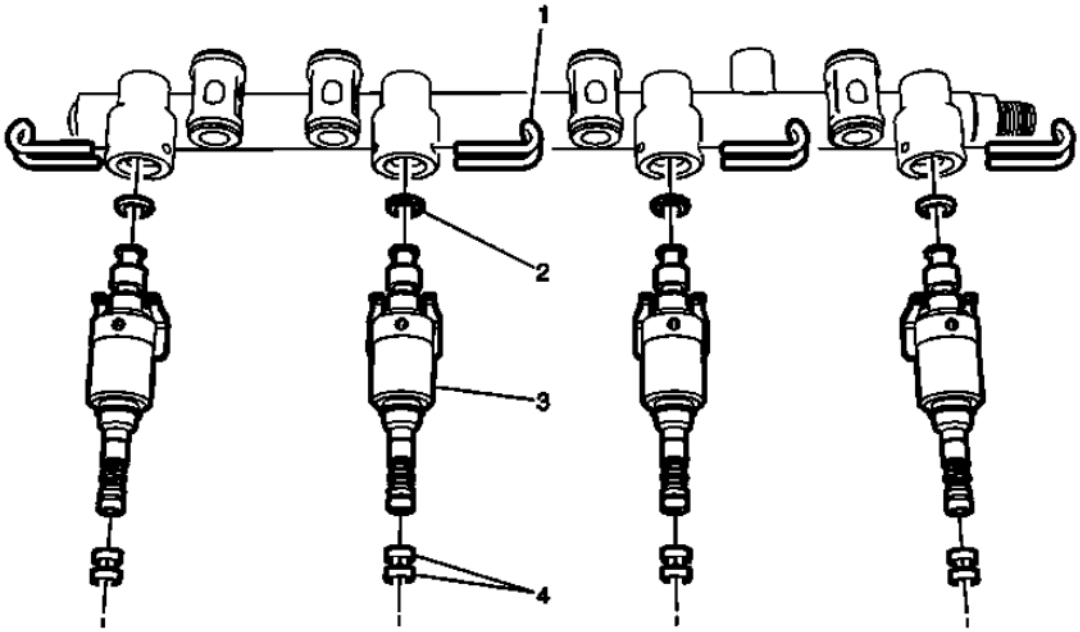


Fig. 108: Fuel Injector
Courtesy of GENERAL MOTORS COMPANY

Fuel Injector Replacement

Callout	Component Name
CAUTION: **Use care in removing the fuel injectors in order to prevent damage to the fuel injector electrical connector pins or the fuel injector nozzles. Do not immerse the fuel injector in any type of cleaner. The fuel injector is an electrical component and may be damaged by this cleaning method.** **Preliminary Procedure** Remove the fuel injection fuel rail assembly. Refer to **Fuel Injection Fuel Rail Assembly Replacement** .	
1	Fuel Injector Retaining Clips (Qty: 4) **Special Tools** **EN-50791** Fuel Injector Nozzle Installer For regional tools refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)** .
2	Fuel Injector Seals **Procedure** 1. Remove and discard the old fuel injector seals. 2. Coat new seals with clean engine oil and install onto injectors.

3	Fuel Injectors **NOTE:** **If reusing the fuel injectors, note the location of each injector and reinstall in same location.**

EVAPORATIVE EMISSION CANISTER PURGE SOLENOID VALVE REPLACEMENT

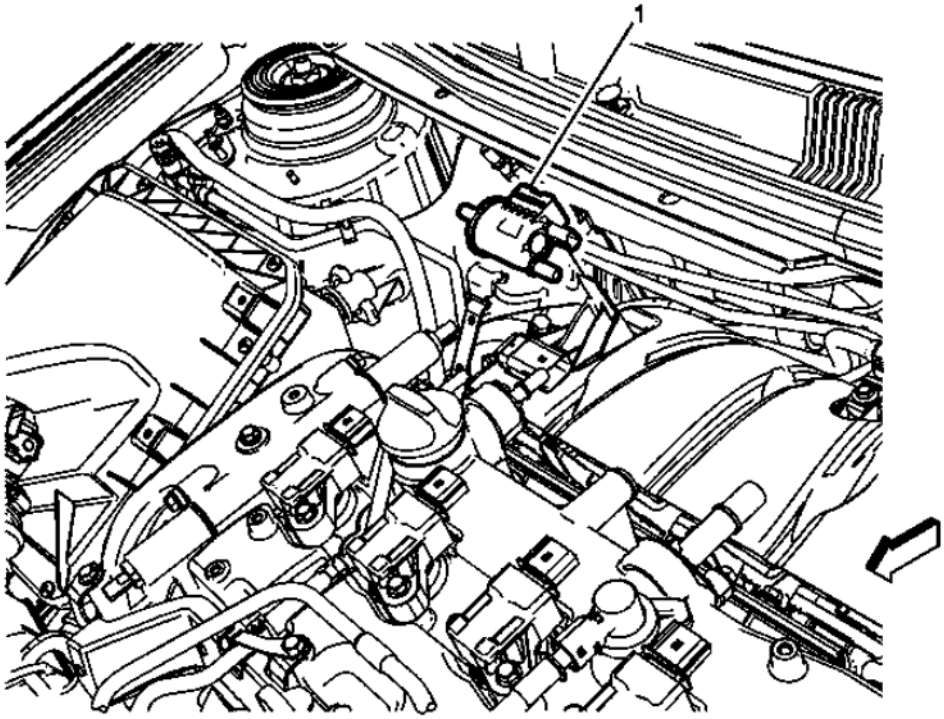


Fig. 109: Evaporative Emission Canister Purge Solenoid Valve (LTG)
Courtesy of GENERAL MOTORS COMPANY

Evaporative Emission Canister Purge Solenoid Valve Replacement

Callout	Component Name
Preliminary Procedure Disconnect the EVAP hoses. Refer to **Plastic Collar Quick Connect Fitting Service**.	
1	Evaporative Emission Canister Purge Solenoid Valve **Procedure** 1. Disconnect the electrical connector. 2. Release the retaining tab.

EVAPORATIVE EMISSION CANISTER PURGE PIPE REPLACEMENT (FWD)

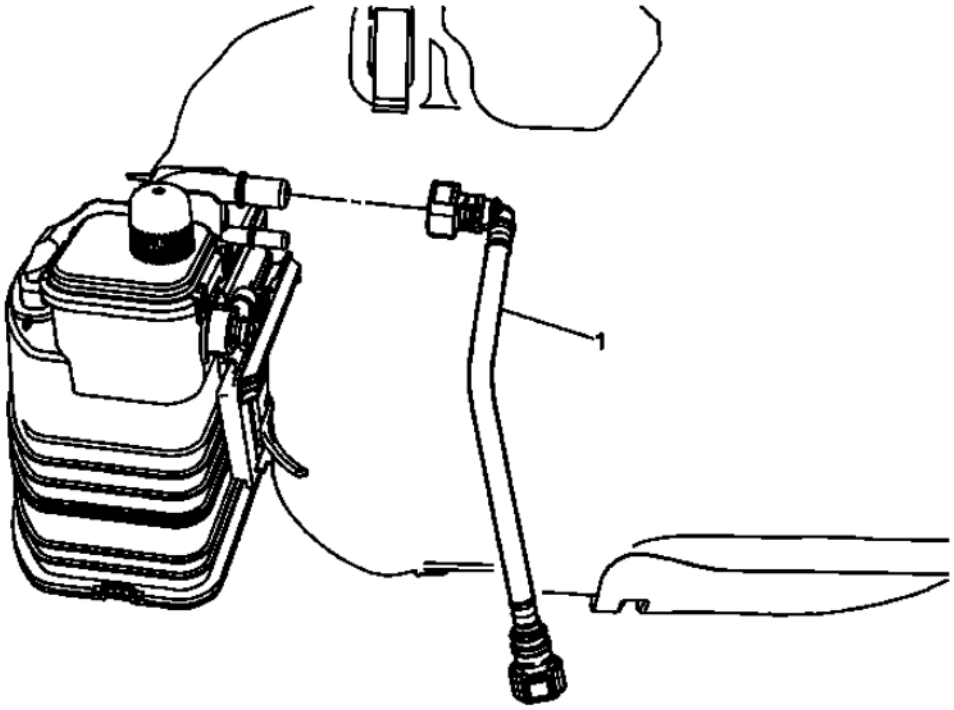


Fig. 110: Evaporative Emission Canister Purge Pipe
Courtesy of GENERAL MOTORS COMPANY

Evaporative Emission Canister Purge Pipe Replacement (FWD)

Callout	Component Name
	Preliminary Procedure **Remove the fuel tank. Refer to Fuel Tank Replacement (FWD).**
1	Evaporative Emission Canister Purge Pipe **Procedure** Disconnect the evaporative emission quick connects. Refer to **Plastic Collar Quick Connect Fitting Service**.

EVAPORATIVE EMISSION CANISTER PURGE PIPE REPLACEMENT (AWD)

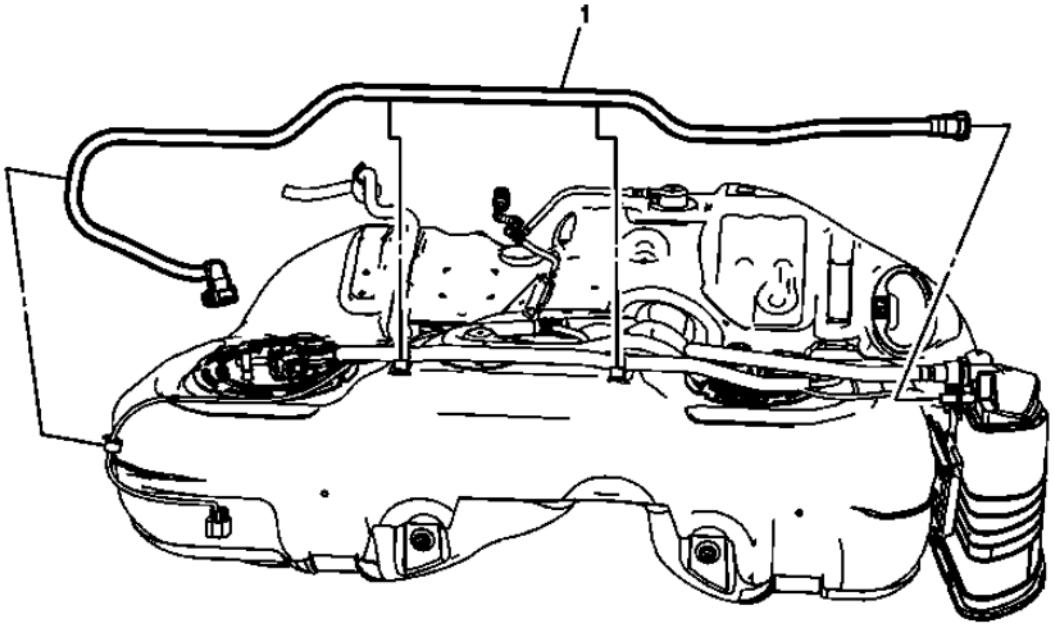


Fig. 111: Evaporative Emission Canister Purge Pipe (With AWD)
Courtesy of GENERAL MOTORS COMPANY

Evaporative Emission Canister Purge Pipe Replacement (AWD)

Callout	Component Name
Preliminary Procedure Remove the fuel tank. Refer to **Fuel Tank Replacement (AWD)**.	
1	Evaporative Emission Canister Purge Pipe **Procedure** 1. Disconnect the evaporative emission canister purge pipe from the fuel tank retainers. 2. Disconnect the evaporative emission canister purge pipe from the evaporative emission canister. Refer to **Plastic Collar Quick Connect Fitting Service**.

EVAPORATIVE EMISSION CANISTER PURGE TUBE REPLACEMENT

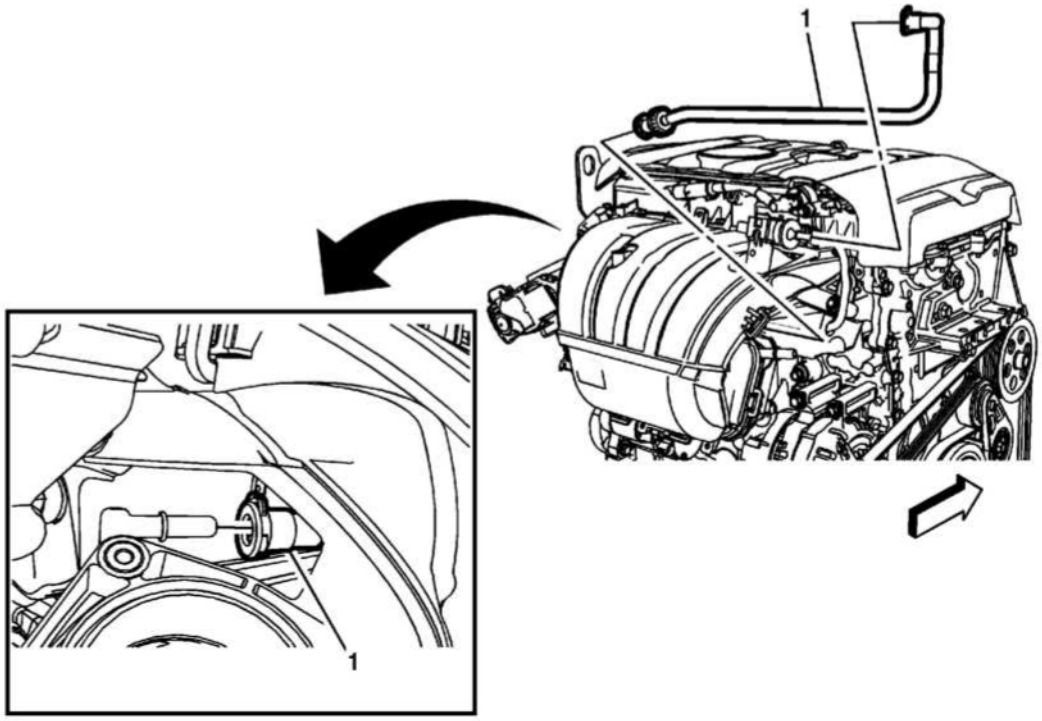


Fig. 112: Evaporative Emission Canister Purge Tube
Courtesy of GENERAL MOTORS COMPANY

Evaporative Emission Canister Purge Tube Replacement

Callout	Component Name
Preliminary Procedure 1. Remove the throttle body. Refer to **Throttle Body Assembly Replacement**. 2. Disconnect the evaporative emission canister purge tube from the intake manifold and the evaporative emission canister purge valve. Refer to **Plastic Collar Quick Connect Fitting Service**.	
1	Evaporative Emission Canister Purge Tube

EVAPORATIVE EMISSION CANISTER SOLENOID REPLACEMENT (FWD)

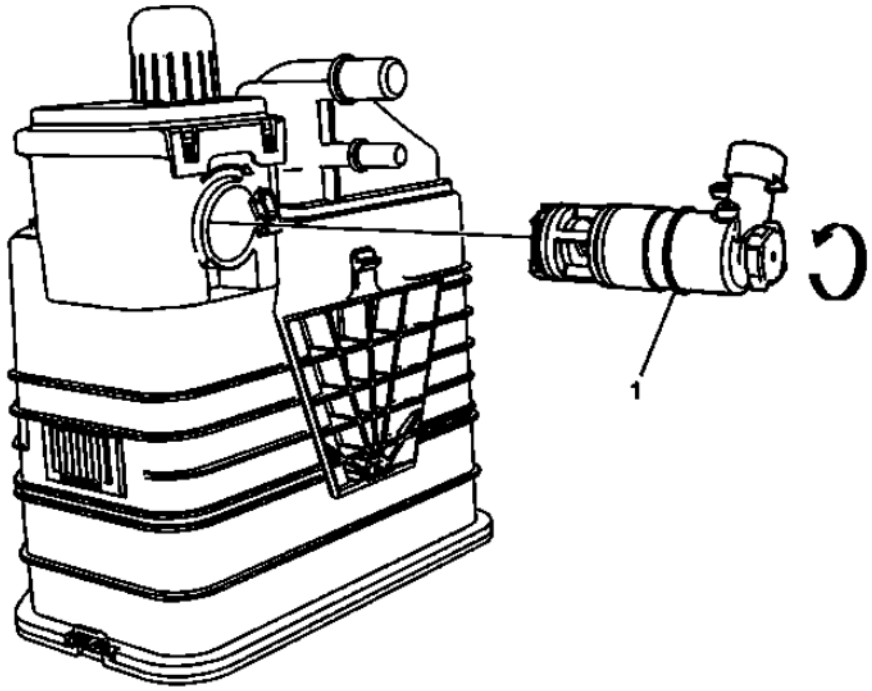


Fig. 113: Evaporative Emission Canister Vent Solenoid Valve (FWD)
Courtesy of GENERAL MOTORS COMPANY

Evaporative Emission Canister Solenoid Replacement (FWD)

Callout	Component Name
Preliminary Procedure Remove the evaporative emission canister. Refer to **Evaporative Emission Canister Replacement (FWD)**.	
1	Evaporative Emission Canister Solenoid **Procedure** Disconnect the electrical connector.

EVAPORATIVE EMISSION CANISTER SOLENOID REPLACEMENT (AWD)

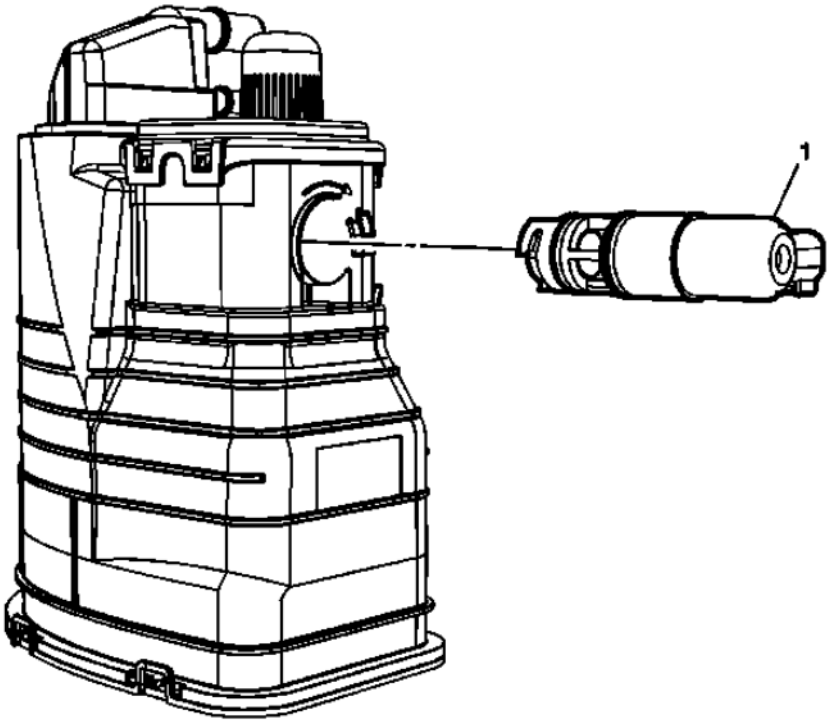


Fig. 114: Evaporative Emission Canister Vent Solenoid Valve (AWD)
Courtesy of GENERAL MOTORS COMPANY

Evaporative Emission Canister Solenoid Replacement (AWD)

Callout	Component Name
Preliminary Procedure Remove the evaporative emission canister. Refer to **Evaporative Emission Canister Replacement (AWD)**.	
1	Evaporative Emission Canister Solenoid **Procedure** Disconnect the electrical connector.

EVAPORATIVE EMISSION FRONT PIPE REPLACEMENT

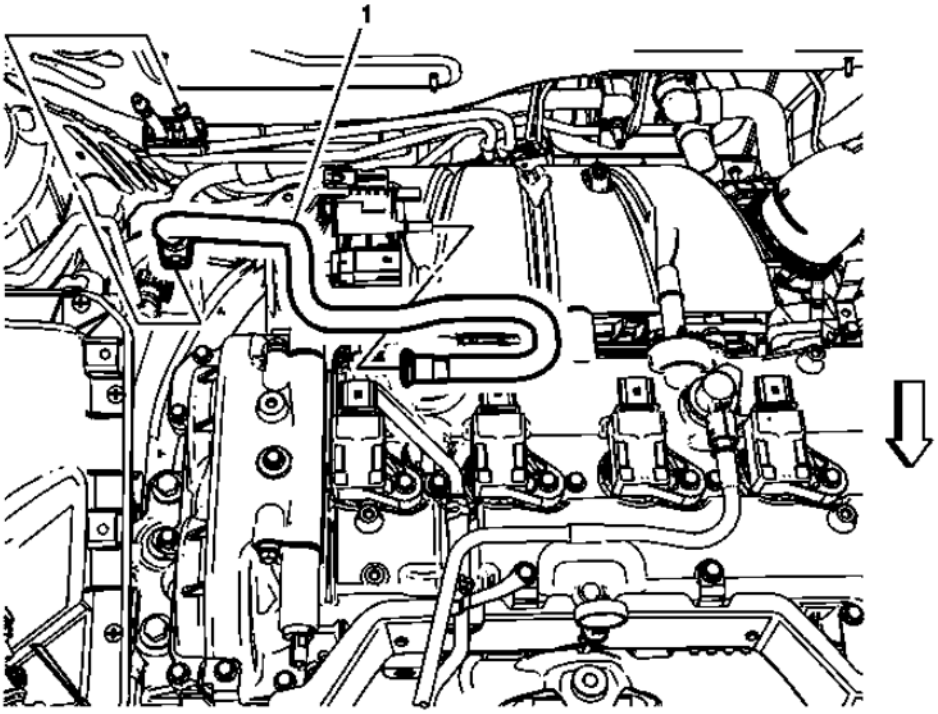


Fig. 115: Evaporative Emission Front Pipe (LTG)
Courtesy of GENERAL MOTORS COMPANY

Evaporative Emission Front Pipe Replacement

Callout	Component Name
Preliminary Procedure Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement** .	
1	Evaporative Emission Front Pipe **Procedure** Disconnect the evaporative emission front pipe from the purge valve and line. Refer to **Plastic Collar Quick Connect Fitting Service**.

EVAPORATIVE EMISSION LINE REPLACEMENT - ENGINE TO CHASSIS (FWD)

Removal Procedure

WARNING: Refer to Gasoline/Gasoline Vapors Warning .

WARNING: Refer to Safety Glasses Warning .

1. Remove the evaporative emission front pipe. Refer to **Evaporative Emission Front Pipe Replacement**.

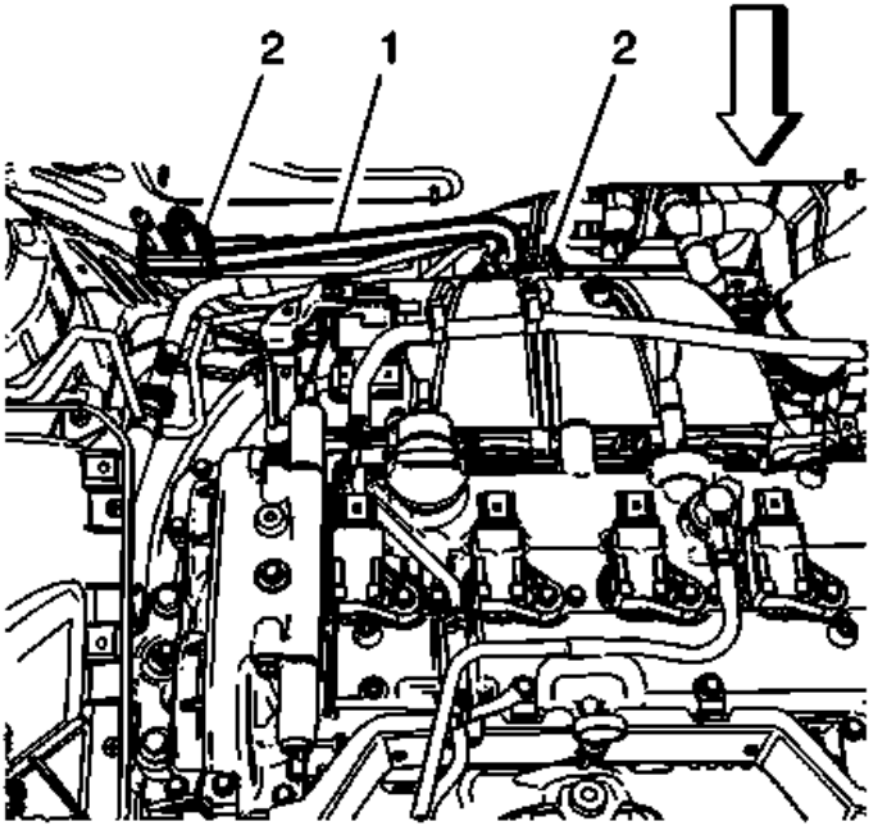


Fig. 116: Evaporative Emission Pipe And Retainers
Courtesy of GENERAL MOTORS COMPANY

2. Remove the evaporative emission pipe (1) from the retainers (2).
3. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

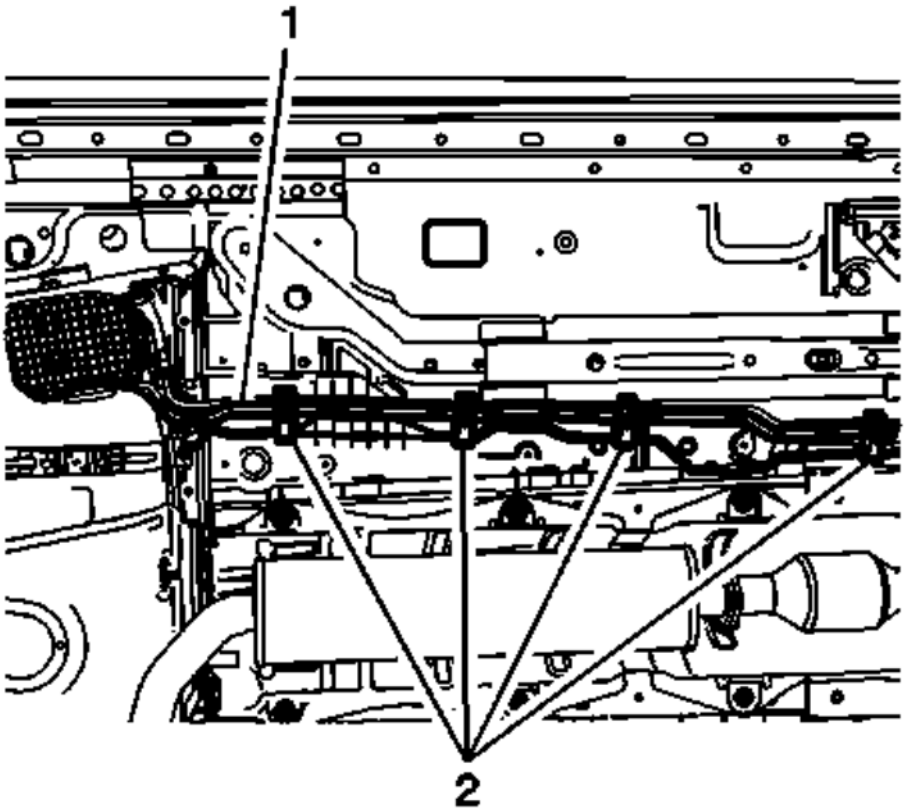


Fig. 117: Evaporative Emission Pipe
Courtesy of GENERAL MOTORS COMPANY

4. Disconnect the evaporative emission pipe (1) and remove from retainers (2). Refer to **Plastic Collar Quick Connect Fitting Service**.
5. Remove the evaporative emission pipe (1) from the vehicle.

Installation Procedure

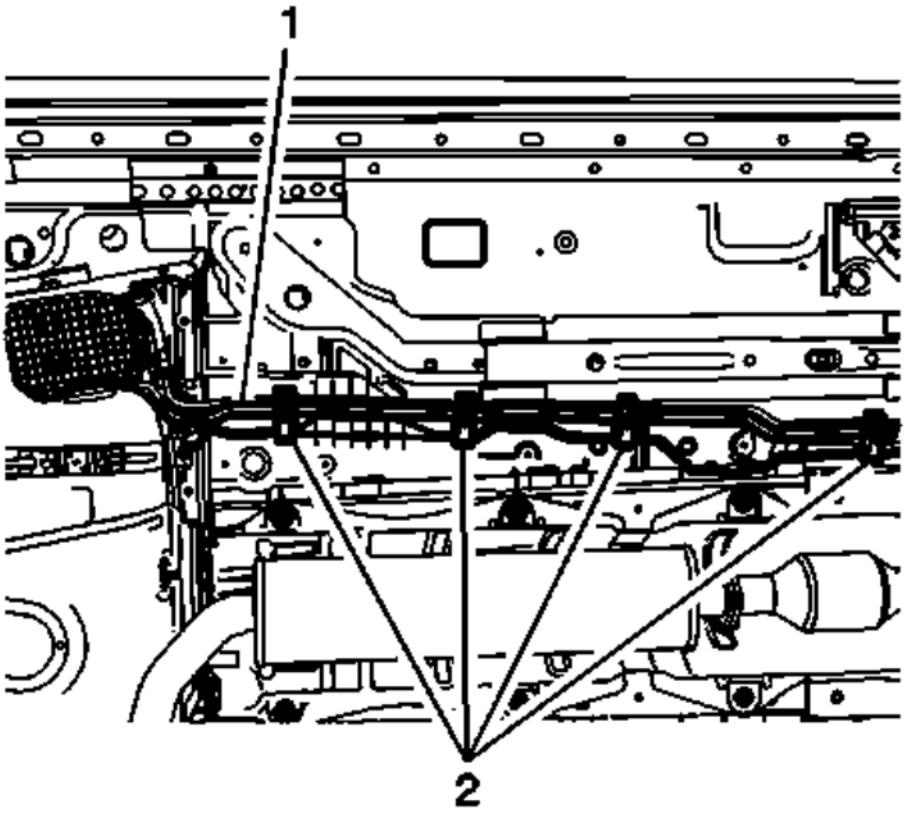


Fig. 118: Evaporative Emission Pipe
Courtesy of GENERAL MOTORS COMPANY

1. Install the evaporative emission pipe (1) to the vehicle.
2. Connect the evaporative emission pipe (1) and install to the retainers (2). Refer to **Plastic Collar Quick Connect Fitting Service**.
3. Lower the vehicle.

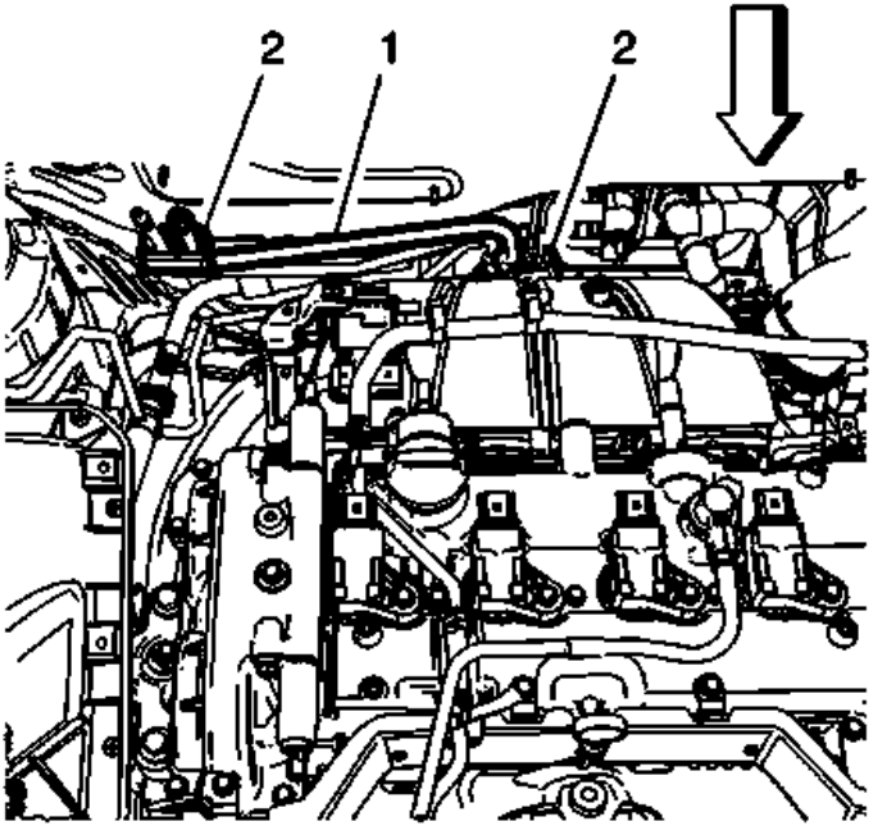


Fig. 119: Evaporative Emission Pipe And Retainers
Courtesy of GENERAL MOTORS COMPANY

4. Install the evaporative emission pipe (1) to the retainers (2).
5. Install the evaporative emission front pipe. Refer to **Evaporative Emission Front Pipe Replacement**.

EVAPORATIVE EMISSION LINE REPLACEMENT - ENGINE TO CHASSIS (AWD)

Removal Procedure

WARNING: Refer to Gasoline/Gasoline Vapors Warning .

WARNING: Refer to Safety Glasses Warning .

1. Remove the evaporative emission front pipe. Refer to **Evaporative Emission Front Pipe Replacement**.

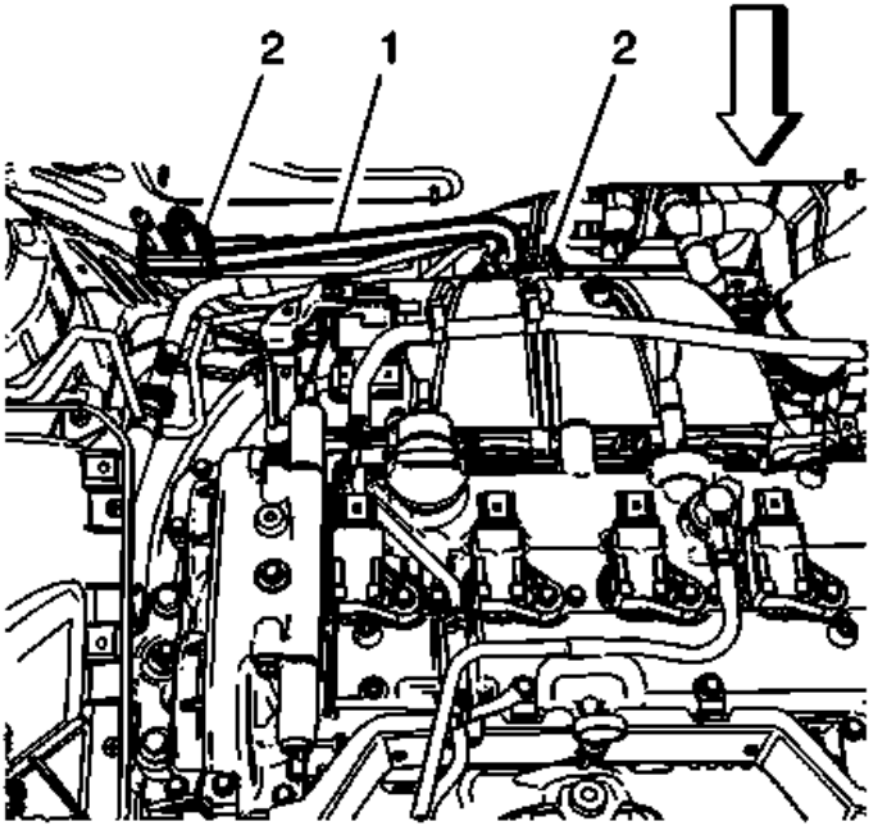


Fig. 120: Evaporative Emission Pipe And Retainers
Courtesy of GENERAL MOTORS COMPANY

2. Remove the evaporative emission pipe (1) from the retainers (2).
3. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

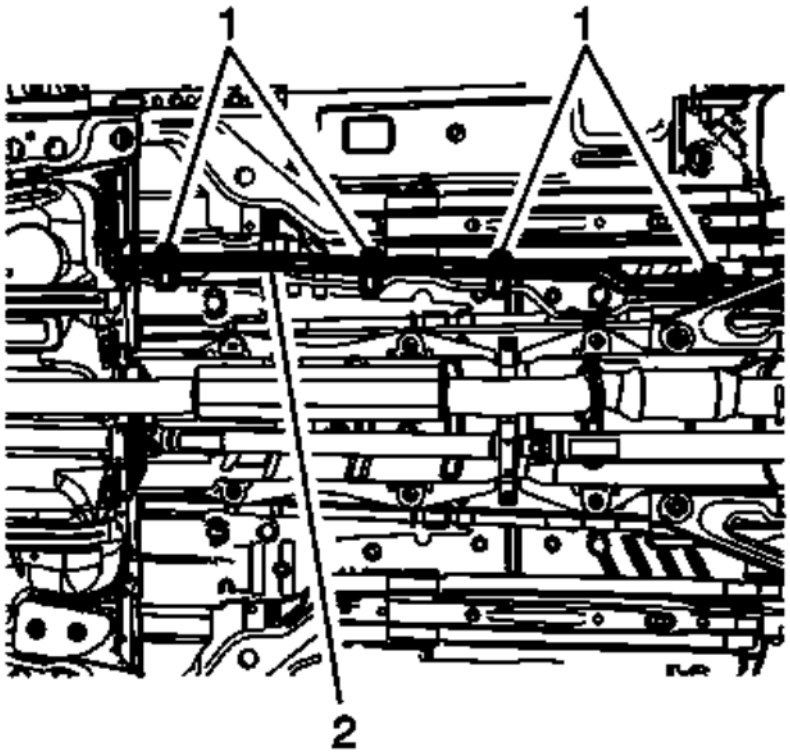


Fig. 121: Evaporative Emission Pipe And Evaporative Emission Canister Purge Pipe
Courtesy of GENERAL MOTORS COMPANY

4. Disconnect the evaporative emission pipe (2) from the evaporative emission canister purge pipe. Refer to **Plastic Collar Quick Connect Fitting Service**.
5. Disconnect the evaporative emission pipe retainers (1).
6. Remove the evaporative emission pipe (2) from the vehicle.

Installation Procedure

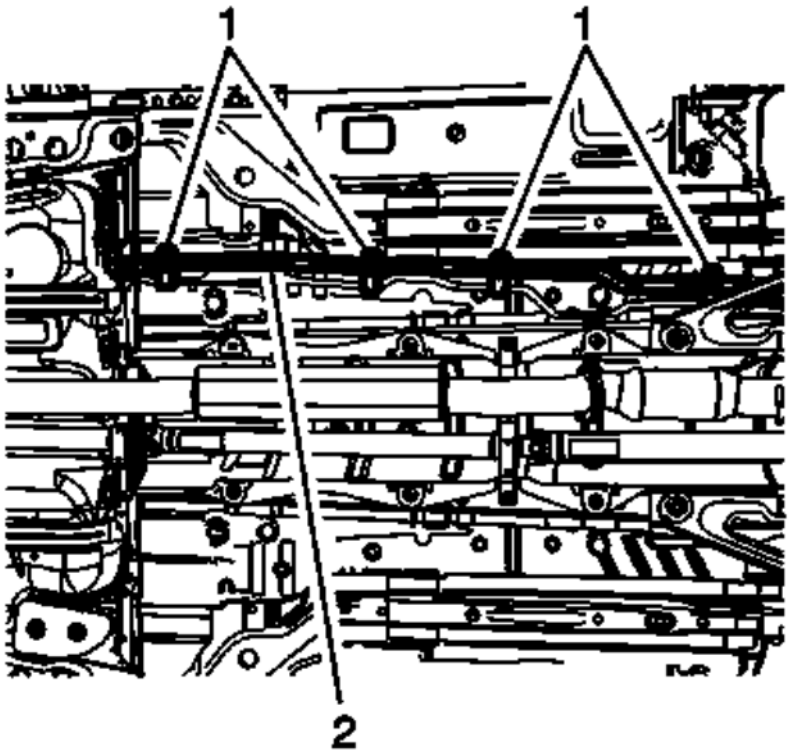


Fig. 122: Evaporative Emission Pipe And Evaporative Emission Canister Purge Pipe
Courtesy of GENERAL MOTORS COMPANY

1. Install the evaporative emission pipe (2) to the vehicle.
2. Connect the evaporative emission pipe retainers (1).
3. Connect the evaporative emission pipe (2) to the evaporative emission canister purge pipe. Refer to **Plastic Collar Quick Connect Fitting Service**.
4. Lower the vehicle.

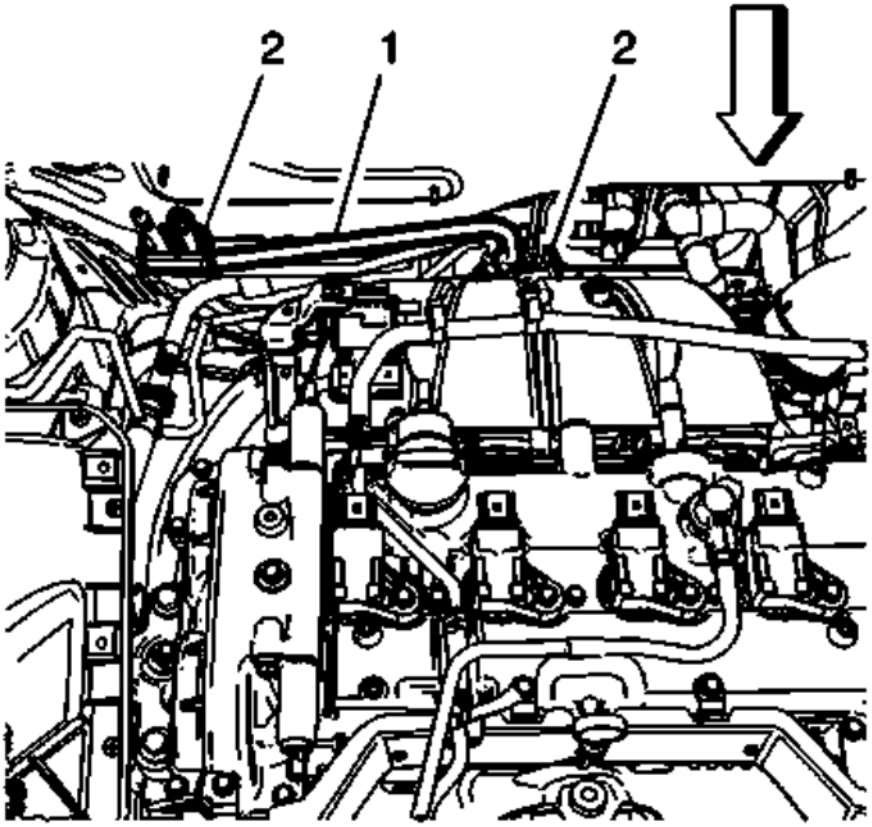


Fig. 123: Evaporative Emission Pipe And Retainers
Courtesy of GENERAL MOTORS COMPANY

5. Install the evaporative emission pipe (1) to the retainers (2).
6. Install the evaporative emission front pipe. Refer to **Evaporative Emission Front Pipe Replacement**.

EVAPORATIVE EMISSION CANISTER REPLACEMENT (FWD)

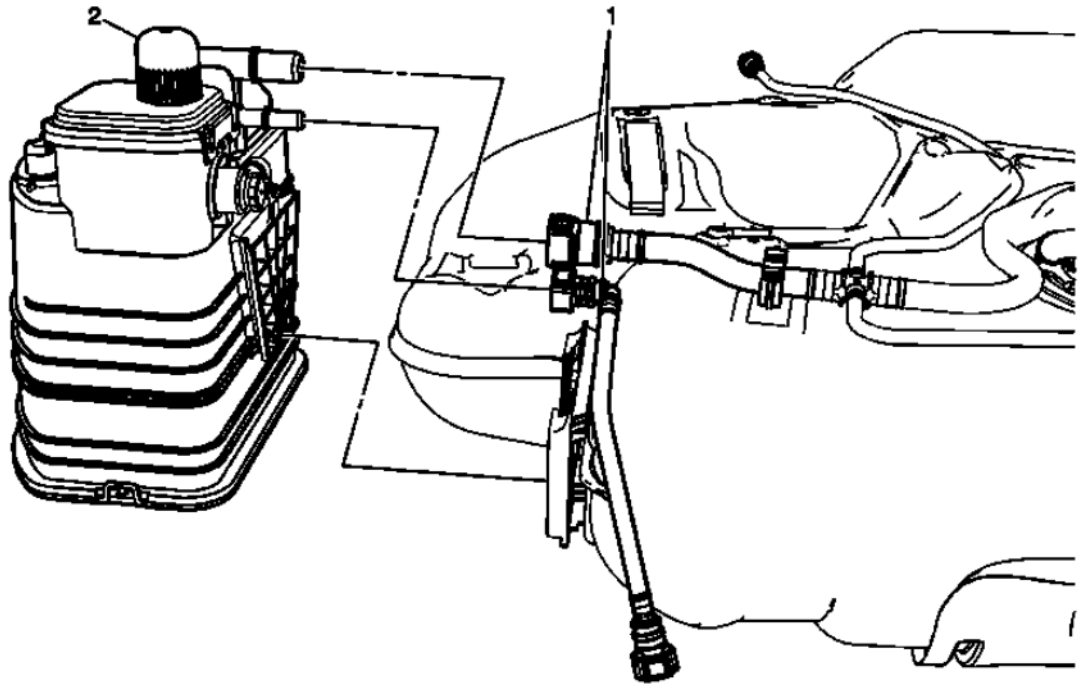


Fig. 124: Evaporative Emission Canister & Hoses (FWD)
Courtesy of GENERAL MOTORS COMPANY

Evaporative Emission Canister Replacement (FWD)

Callout	Component Name
Preliminary Procedure Remove the fuel tank. Refer to **Fuel Tank Replacement (FWD)**.	
1	Evaporative Emission Hose (Qty: 2) **Procedure** Disconnect the quick connects. Refer to **Plastic Collar Quick Connect Fitting Service**.
2	Evaporative Emission Canister **Procedure** 1. Disconnect the electrical connector. 2. Release the retaining tab.

EVAPORATIVE EMISSION CANISTER REPLACEMENT (AWD)

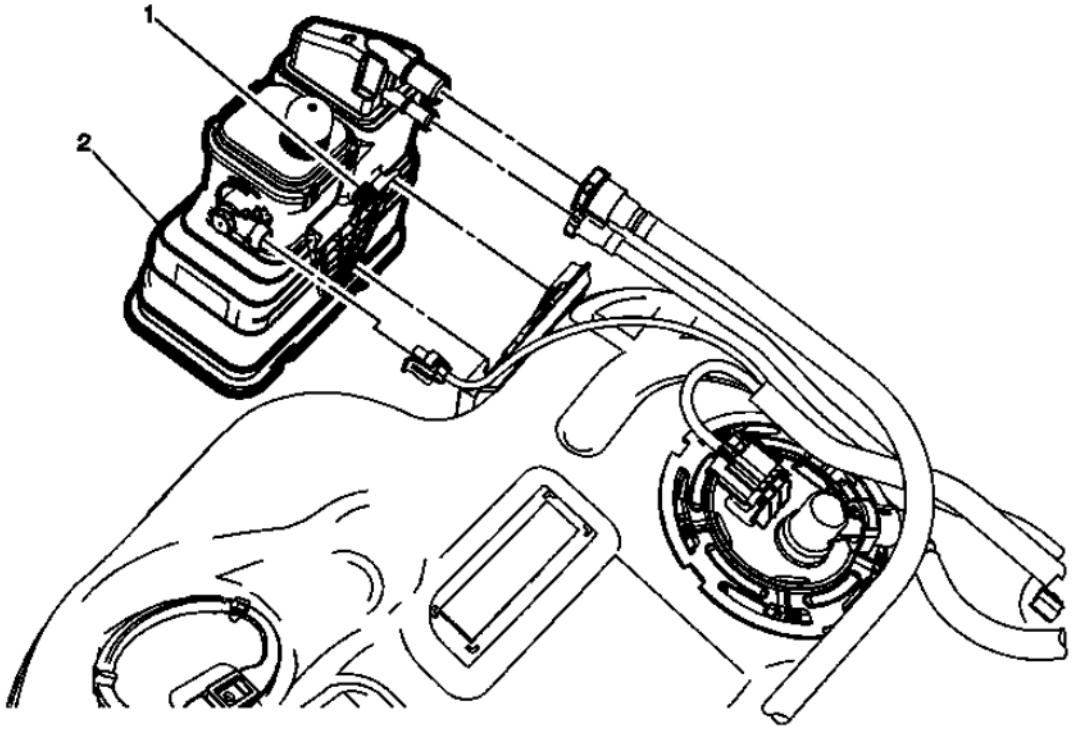


Fig. 125: Evaporative Emission Canister (AWD)
Courtesy of GENERAL MOTORS COMPANY

Evaporative Emission Canister Replacement (AWD)

Callout	Component Name
Preliminary Procedure Lower the fuel tank enough to allow evaporative emission canister removal. Refer to **Fuel Tank Replacement (AWD)**.	
1	Evaporative Emission Canister Retaining Tab **Procedure** Depress the retaining tab in order to release the evaporative emission canister from the fuel tank.
2	Evaporative Emission Canister **Procedure** 1. Release the evaporative emission vent pipe from the evaporative emission canister. Refer to **Plastic Collar Quick Connect Fitting Service**. 2. Release the evaporative emission canister purge pipe from the evaporative emission canister. Refer to **Plastic Collar Quick Connect Fitting Service**. 3. Disconnect the evaporative emission canister solenoid wiring harness.

EVAPORATIVE EMISSION SYSTEM CLEANING

Special Tools

GE 41413-200 Evaporative Pressure and Purge Station

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** , **Special Tools (Mechanical Tools)** .

Inspection Procedure

CAUTION: Use the Evaporative Emission (EVAP) System Tester (EEST) 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.

NOTE: Proceed with the following procedure only if referenced by an evaporative emission (EVAP) diagnostic or repair procedure.

1. Turn OFF the ignition.
2. Remove the EVAP canister purge valve. Refer to **Evaporative Emission Canister Purge Solenoid Valve Replacement**.
3. Lightly tap the EVAP canister purge valve on a hard surface.
4. Inspect for carbon particles exiting either of the vacuum ports.
   - If no carbon particles were detected, but a blockage was detected during a diagnostic procedure, install the original EVAP canister purge valve. Continue with the cleaning procedure.
   - If carbon particles are found during the inspection procedure, continue with the cleaning procedure.
   - If a diagnostic procedure directed you to replace the EVAP canister purge valve and no carbon particles were detected, replace the EVAP canister purge valve. Return to the published service procedure.

Cleaning Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .
2. Remove the EVAP canister. Refer to **Evaporative Emission Canister Replacement (FWD)**, **Evaporative Emission Canister Replacement (AWD)**.
3. Turn OFF the main valve on the **GE 41413-200** station.
4. Disconnect the hose from the diagnostic station pressure regulator.
5. Using a section of vacuum hose, connect one end onto the EVAP pressure/purge diagnostic station pressure regulator.
6. Connect the other end of the vacuum hose to the canister side of the purge pipe.
7. Turn ON the main nitrogen cylinder valve and continue to discharge nitrogen for 15 seconds.
8. If the nitrogen does not clear the blockage, replace the purge pipe.
9. Return the EVAP pressure/purge diagnostic station to the stations original condition.
10. Install a new EVAP canister. Refer to **Evaporative Emission Canister Replacement (FWD)**, **Evaporative Emission Canister Replacement (AWD)**.
11. Lower the vehicle.
12. Install a new EVAP canister purge valve. Refer to **Evaporative Emission Canister Purge Solenoid Valve Replacement**.
13. Return to the diagnostic table that sent you here.

IGNITION COIL REPLACEMENT

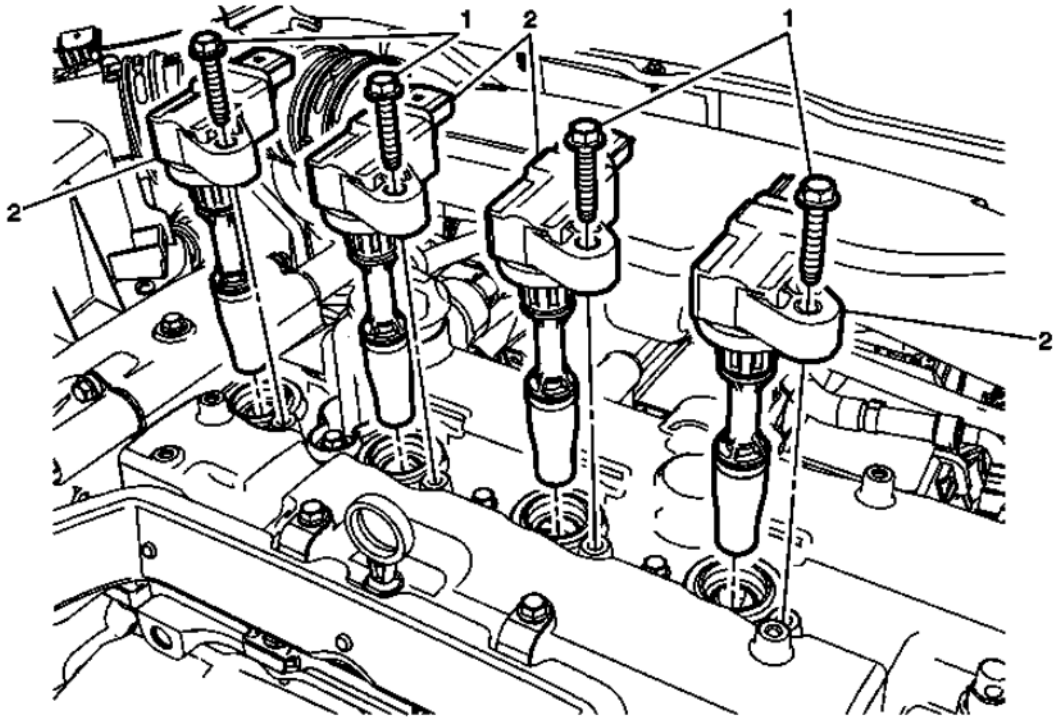


Fig. 126: Ignition Coil
Courtesy of GENERAL MOTORS COMPANY

Ignition Coil Replacement

Callout	Component Name
Preliminary Procedure Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement** .	
1	Ignition Coil Fasteners (Qty: 4) **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 (89 lb in)
2	Ignition Coils **Procedure** 1. Disconnect the electrical wiring harness connectors from the ignition coils and remove coils as necessary. 2. Apply a thin coating of dielectric grease to the inside of the ignition coil rubber boot, up to a depth of 15 mm from the end of the boot. Refer to **Adhesives, Fluids, Lubricants, and Sealers** . 3. Remove any excess grease from around the end of the boot, and ensure there is not an excessive amount within the boot.

	NOTE: **Inspect the inside of the ignition coil rubber boot for a thin, even coat of grease. If there is no grease present or additional grease is necessary, complete the following procedure.**

SPARK PLUG REPLACEMENT

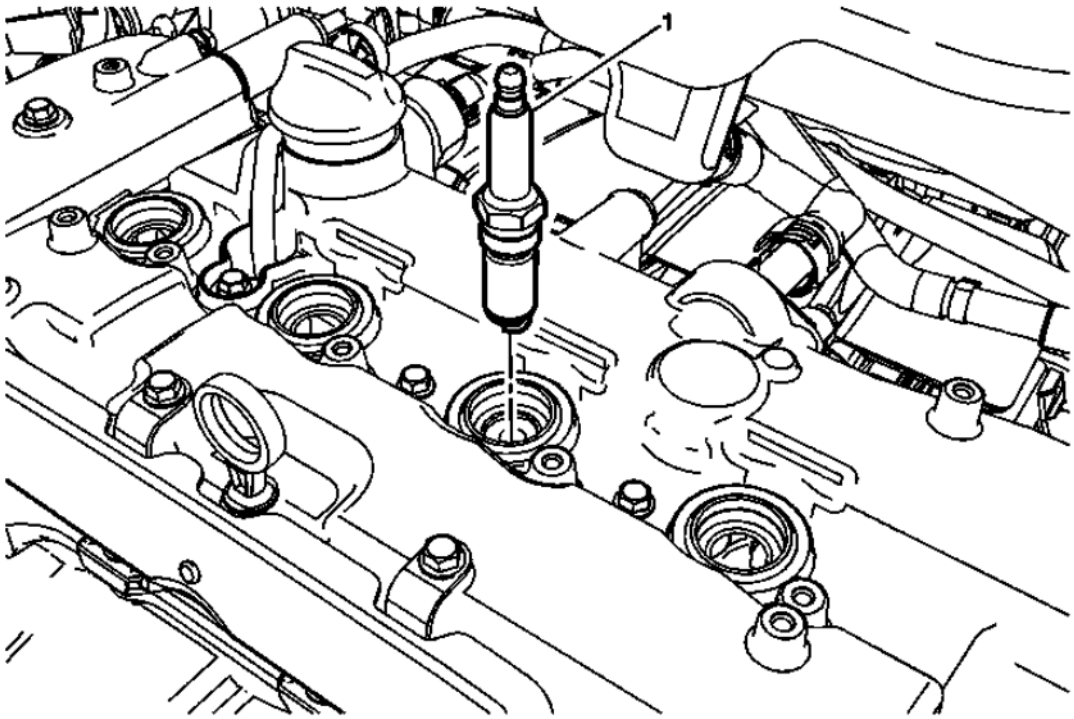


Fig. 127: Spark Plug
Courtesy of GENERAL MOTORS COMPANY

Spark Plug Replacement

Callout	Component Name
CAUTION: **This engine has aluminum cylinder heads. Do not remove the spark plugs from a hot engine, allow it to cool first. Removing the spark plugs from a hot engine may cause spark plug thread damage or cylinder head damage.** **Preliminary Procedure** Remove the ignition coils. Refer to **Ignition Coil Replacement** .	
1	Spark Plugs (Qty: 4) **CAUTION:** **Refer to Component Fastener Tightening Caution .** **Tighten** 20 (15 lb ft)

SPARK PLUG INSPECTION

Spark Plug Usage

Ensure that the correct spark plug is installed. An incorrect spark plug causes driveability conditions. Refer to the Electronic Parts Catalog.

Spark Plug Inspection

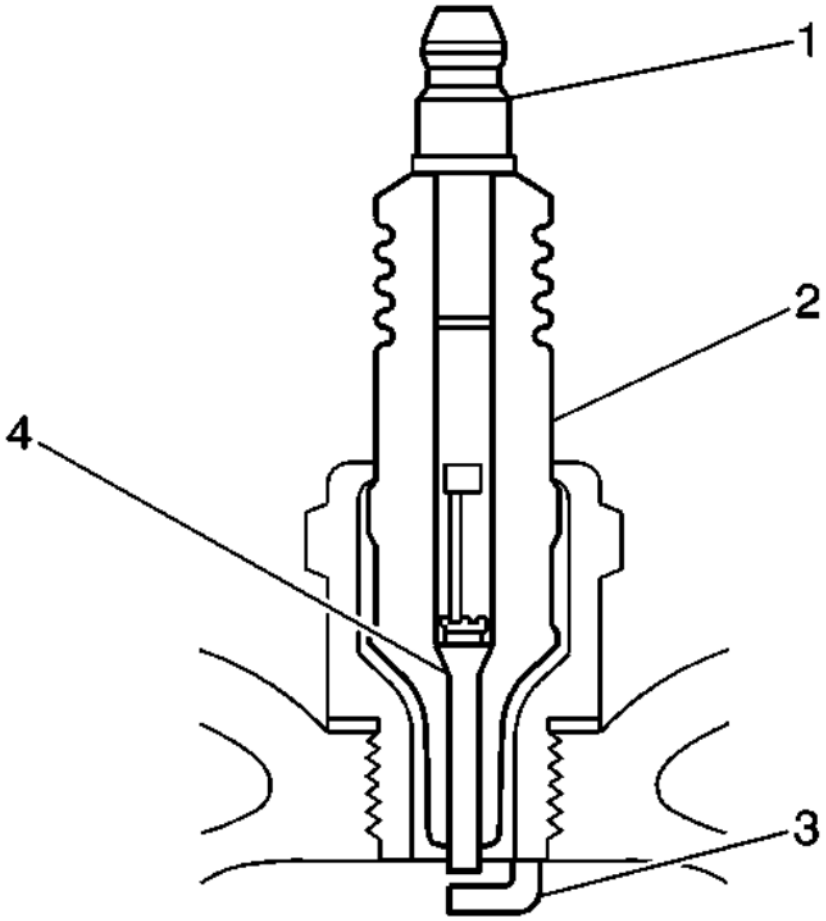


Fig. 128: Cross Sectional View Of Spark Plug
Courtesy of GENERAL MOTORS COMPANY

- Inspect the terminal post (1) for damage.
  - Inspect for a bent or broken terminal post (1).
  - Test for a loose terminal post (1) by twisting and pulling the post. The terminal post (1) should NOT move.
- Inspect the insulator (2) for flashover or carbon tracking, soot. This condition is often mistakenly identified as a cracked insulator. This is caused by the electrical charge traveling across the insulator (2) between the terminal post (1) and ground. Inspect for the following conditions:
  - Inspect the spark plug boot for damage.

- Inspect the spark plug recess area of the cylinder head for moisture, such as oil, coolant, or water. A spark plug boot that is saturated causes arcing to ground.

- Inspect the insulator (2) for cracks. All or part of the electrical charge may arc through the crack instead of the electrodes (3, 4).
- Inspect for evidence of improper arcing.
  - Measure the gap between the center electrode (4) and the side electrode (3) terminals. This must be done carefully in order to avoid damaging the small diameter Iridium center electrode. Refer to **Ignition System Specifications** . An excessively wide electrode gap can prevent correct spark plug operation.
  - Inspect for the correct spark plug torque. Refer to **Ignition System Specifications** . Insufficient torque can prevent correct spark plug operation. An over torqued spark plug, causes the insulator (2) to crack.
  - Inspect for signs of tracking that occurred near the insulator tip instead of the center electrode (4).
  - Inspect for a broken or worn side electrode (3).
  - Inspect for a broken, worn, or loose center electrode (4) by shaking the spark plug.
    - A rattling sound indicates internal damage.
    - A loose center electrode (4) reduces the spark intensity.
  - Inspect for bridged electrodes (3, 4). Deposits on the electrodes (3, 4) reduce or eliminates the gap.
  - Inspect for worn or missing platinum pads on the electrodes (3, 4) If equipped.
  - Inspect for excessive fouling.
- Inspect the spark plug recess area of the cylinder head for debris. Dirty or damaged threads can cause the spark plug not to seat correctly during installation.

Spark Plug Visual Inspection

- Normal operation-Brown to grayish-tan with small amounts of white powdery deposits are normal combustion by-products from fuels with additives. Reddish orange deposits can indicate MMT fuel additive which is still used in some markets around the world (will cause misfire and cannot be burned off). MMT fuel additive use should be avoided.
- Carbon Fouled-Dry, fluffy black carbon, or soot caused by the following conditions:
  - Rich fuel mixtures
    - Leaking fuel injectors
    - Excessive fuel pressure
    - Restricted air filter element
    - Incorrect combustion
  - Reduced ignition system voltage output
    - Weak coils
    - Worn ignition wires
    - Incorrect spark plug gap
  - Excessive idling or slow speeds under light loads can keep spark plug temperatures so low that normal combustion deposits may not burn off.
- Deposit Fouling-Oil, coolant, or additives that include substances such as silicone, very white coating,

reduces the spark intensity. Most powdery deposits will not effect spark intensity unless they form into a glazing over the electrode.

CRANKSHAFT POSITION SENSOR REPLACEMENT (FWD)

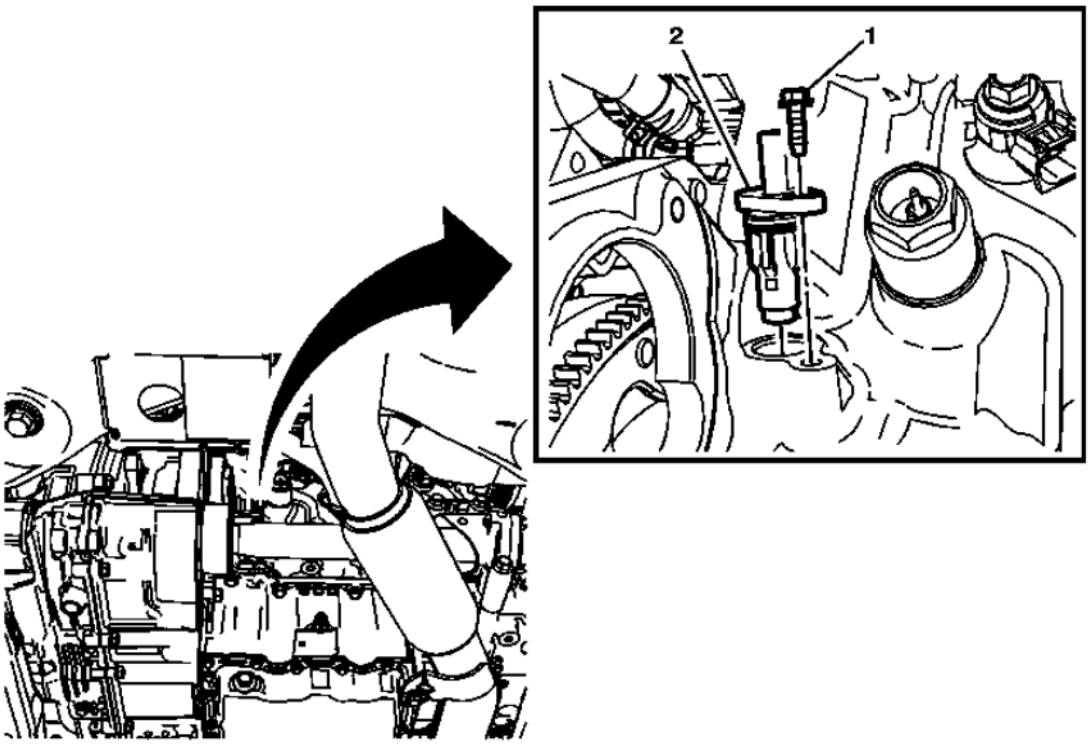


Fig. 129: Crankshaft Position Sensor
Courtesy of GENERAL MOTORS COMPANY

Crankshaft Position Sensor Replacement (FWD)

Callout	Component Name
Preliminary Procedure Remove the starter. Refer to **Starter Replacement (LTG)** .	
1	Crankshaft Position Sensor Fastener **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 (89 lb in)
2	Crankshaft Position Sensor **Procedure** 1. Disconnect the electrical wiring harness connector from the crankshaft position sensor. 2. Install a NEW seal if not replacing the sensor.

	3. If installing a new sensor, perform the crankshaft position system variation learn procedure. Refer to **Crankshaft Position System Variation Learn** .

CRANKSHAFT POSITION SENSOR REPLACEMENT (AWD)

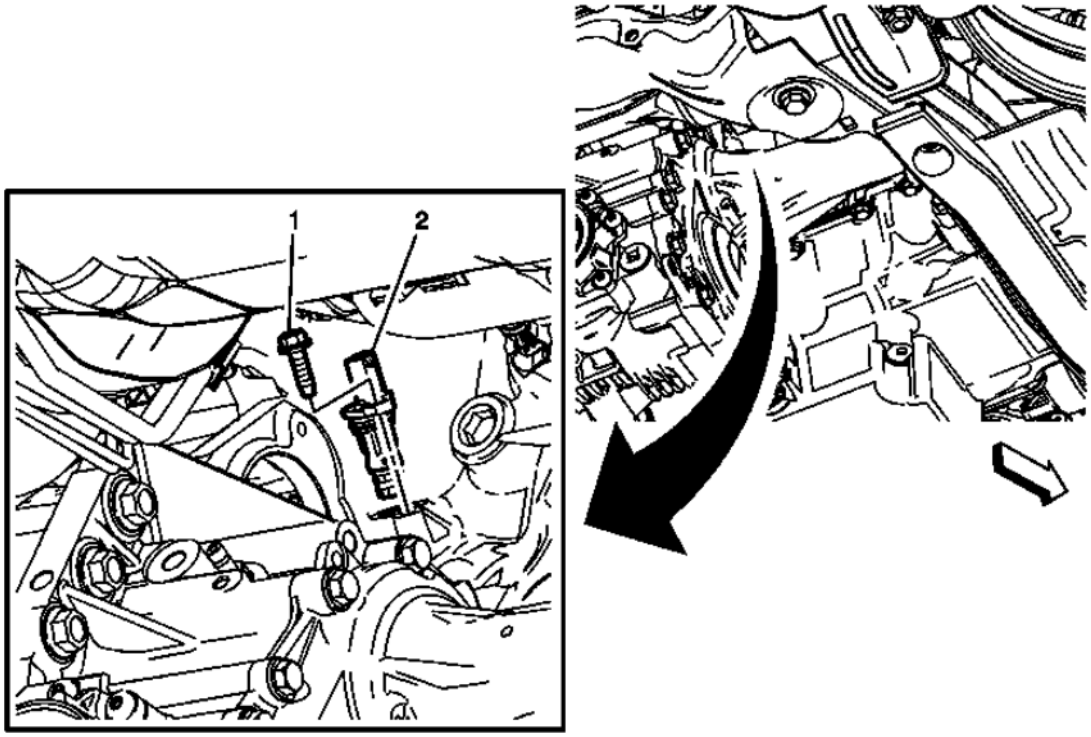


Fig. 130: Crankshaft Position Sensor (AWD)
Courtesy of GENERAL MOTORS COMPANY

Crankshaft Position Sensor Replacement (AWD)

Callout	Component Name
Preliminary Procedure Remove the starter. Refer to **Starter Replacement (LTG)** .	
1	Crankshaft Position Sensor Fastener **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 (89 lb in)
2	Crankshaft Position Sensor **Procedure** 1. Disconnect the electrical wiring harness connector from the crankshaft position sensor. 2. Install a NEW seal if not replacing the sensor.

	3. After installation of the sensor, perform the crankshaft position system variation learn procedure. Refer to **Crankshaft Position System Variation Learn** .

CAMSHAFT POSITION SENSOR REPLACEMENT - INTAKE

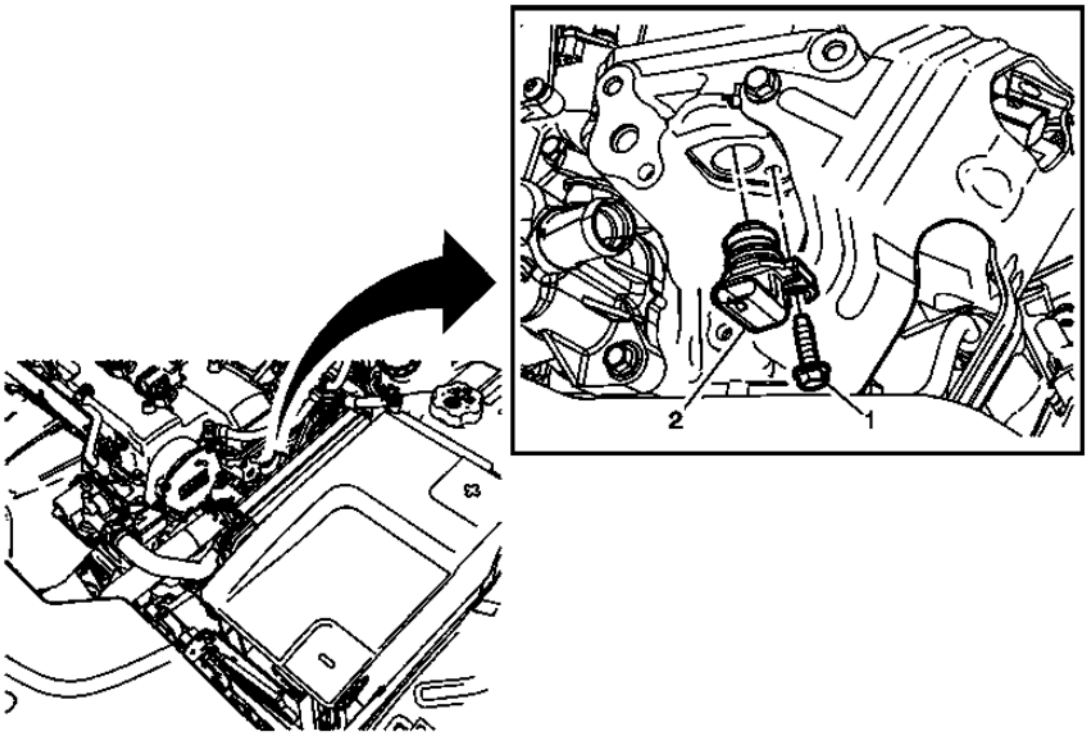


Fig. 131: Camshaft Position Sensor - Intake
Courtesy of GENERAL MOTORS COMPANY

Camshaft Position Sensor Replacement - Intake

Callout	Component Name
Preliminary Procedure Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement** .	
1	Camshaft Position Sensor Fastener **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 (89 lb in)
2	Camshaft Position Sensor **Procedure** 1. Disconnect the electrical wiring harness connector from the camshaft position sensor. 2. Install a NEW seal if not replacing the sensor.

CAMSHAFT POSITION SENSOR REPLACEMENT - EXHAUST

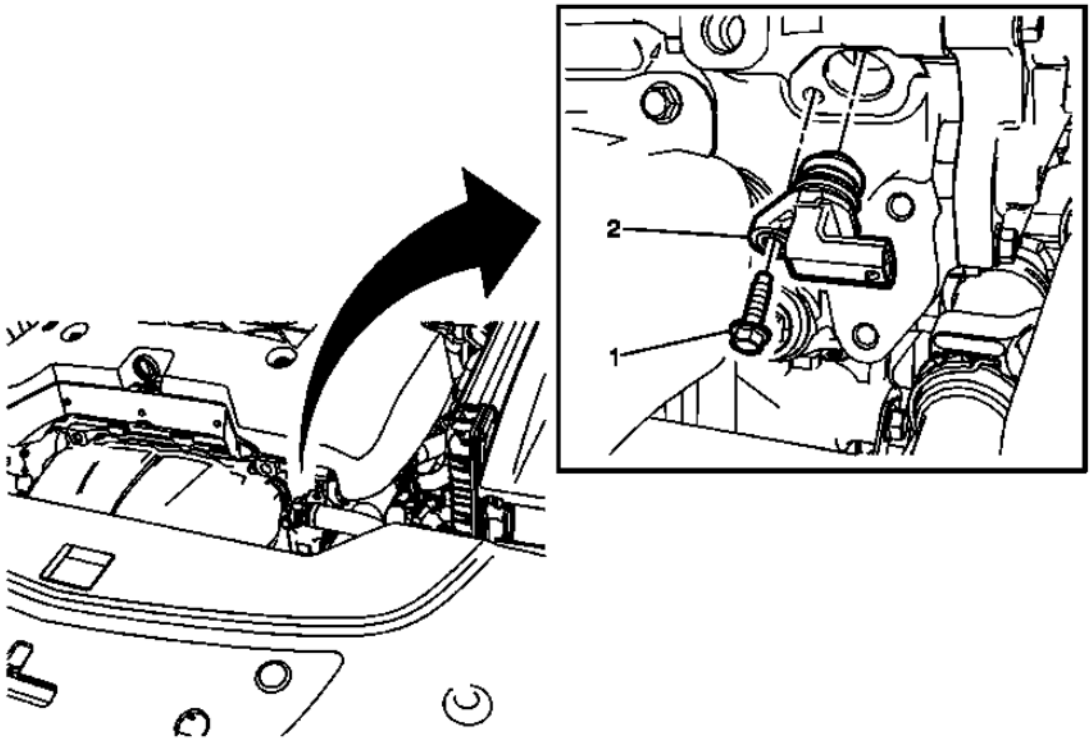


Fig. 132: Camshaft Position Sensor - Exhaust
Courtesy of GENERAL MOTORS COMPANY

Camshaft Position Sensor Replacement - Exhaust

Callout	Component Name
Preliminary Procedure Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement** .	
1	Camshaft Position Sensor Fastener **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 (89 lb in)
2	Camshaft Position Sensor **Procedure** 1. Disconnect the electrical wiring harness connector from the camshaft position sensor. 2. Install a NEW seal if not replacing the sensor.

CAMSHAFT POSITION ACTUATOR EXHAUST SOLENOID VALVE REPLACEMENT

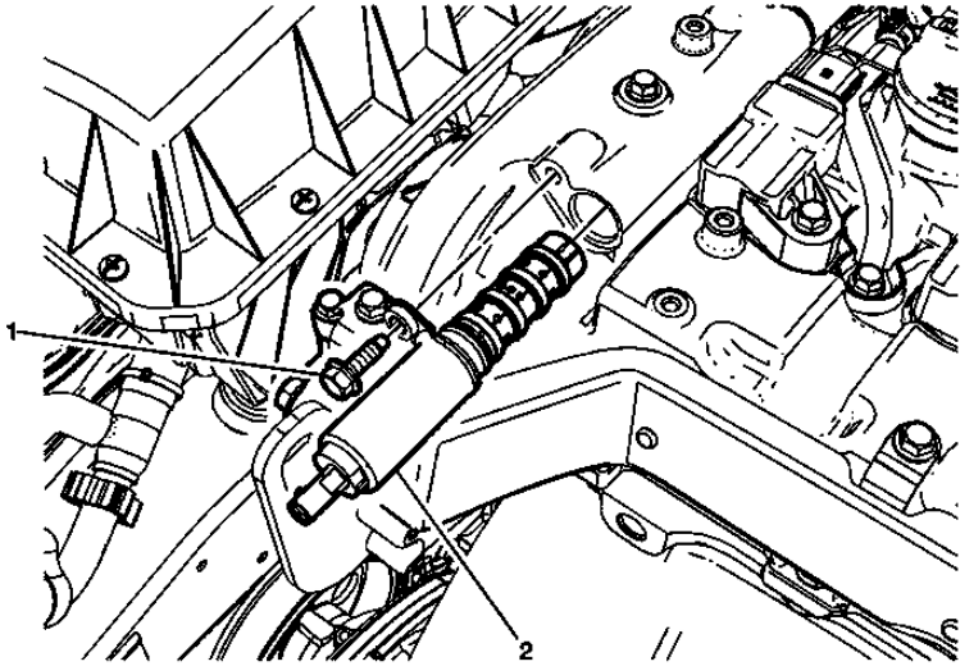


Fig. 133: Camshaft Position Actuator Exhaust Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

Camshaft Position Actuator Exhaust Solenoid Valve Replacement

Callout	Component Name
Preliminary Procedure Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement** .	
1	Camshaft Position Actuator Exhaust Solenoid Valve Fastener **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 (89 lb in)
2	Camshaft Position Actuator Exhaust Solenoid Valve **Procedure** 1. Disconnect the electrical wiring harness connector from the camshaft position actuator exhaust solenoid valve. 2. Install a NEW seal if not replacing the solenoid valve.

CAMSHAFT POSITION ACTUATOR INTAKE SOLENOID VALVE REPLACEMENT

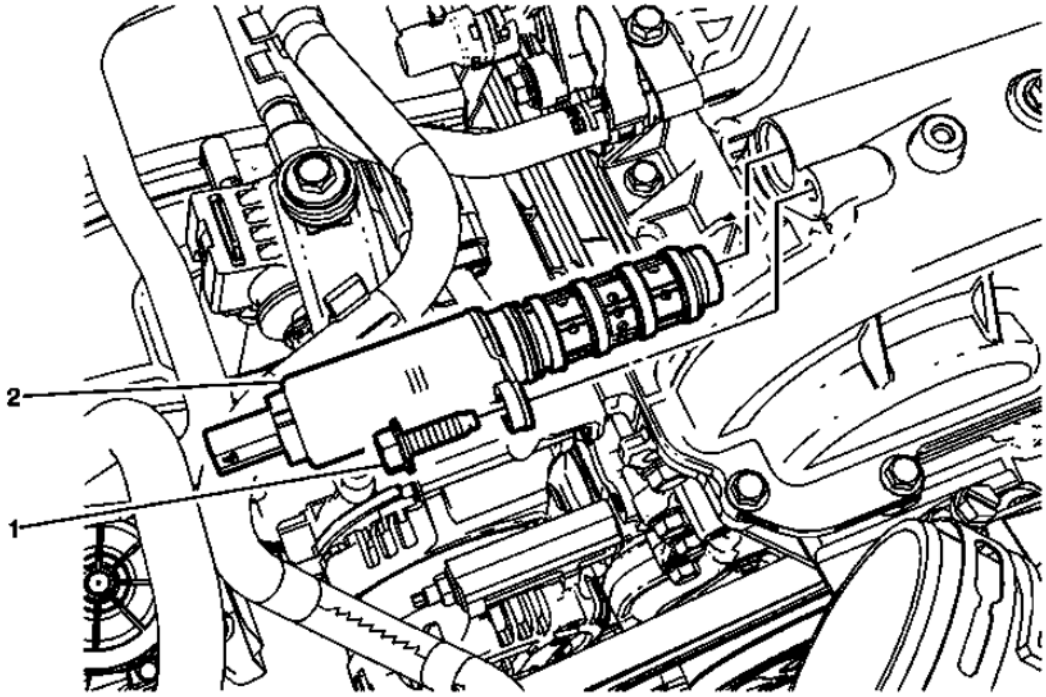


Fig. 134: Camshaft Position Actuator Intake Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

Camshaft Position Actuator Intake Solenoid Valve Replacement

Callout	Component Name
Preliminary Procedure Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement** .	
1	Camshaft Position Actuator Intake Solenoid Valve Fastener **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 (89 lb in)
2	Camshaft Position Actuator Intake Solenoid Valve **Procedure** 1. Disconnect the electrical wiring harness connector from the camshaft position actuator intake solenoid valve. 2. Install a NEW seal if not replacing the solenoid valve.

KNOCK SENSOR REPLACEMENT

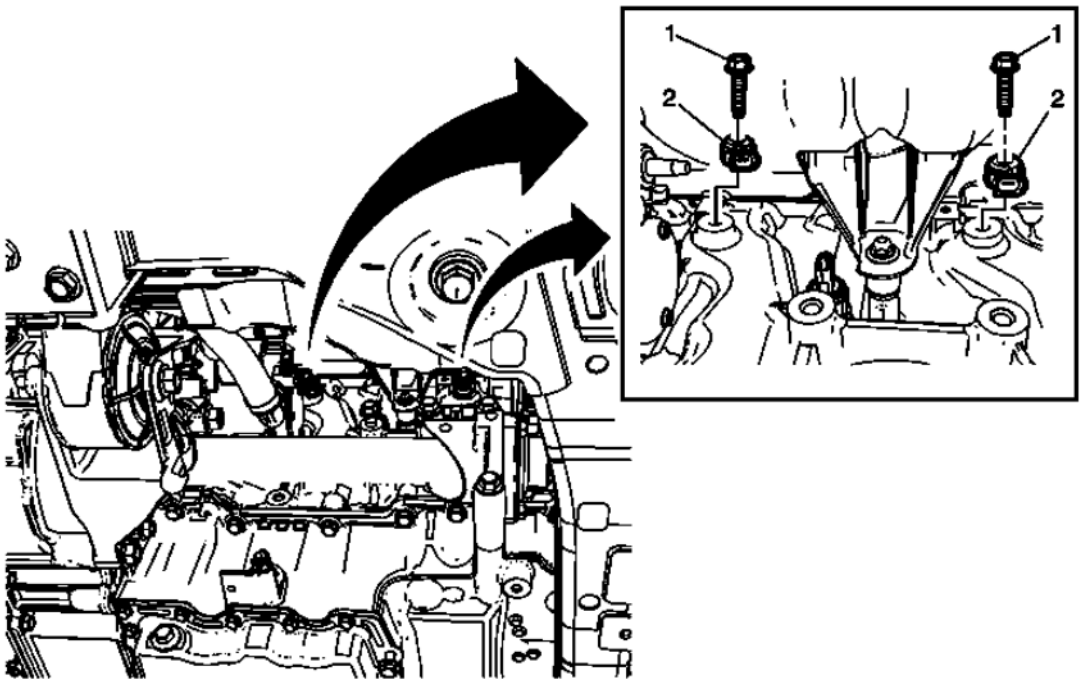


Fig. 135: Knock Sensor
Courtesy of GENERAL MOTORS COMPANY

Knock Sensor Replacement

Callout	Component Name
Preliminary Procedure 1. Raise and properly support the vehicle. Refer to **Lifting and Jacking the Vehicle** . 2. Remove the transmission mount. Refer to **Transmission Mount Replacement - Left Side** . 3. Remove the starter. Refer to **Starter Replacement (LTG)** .	
1	Knock Sensor Fasteners (Qty: 2) **CAUTION:** **Refer to Fastener Caution .** **Tighten** 25 (18 lb ft)
2	Knock Sensors (Qty: 2) **Procedure** Disconnect the electrical wiring harness connectors from the knock sensors.

OIL PUMP FLOW CONTROL VALVE REPLACEMENT

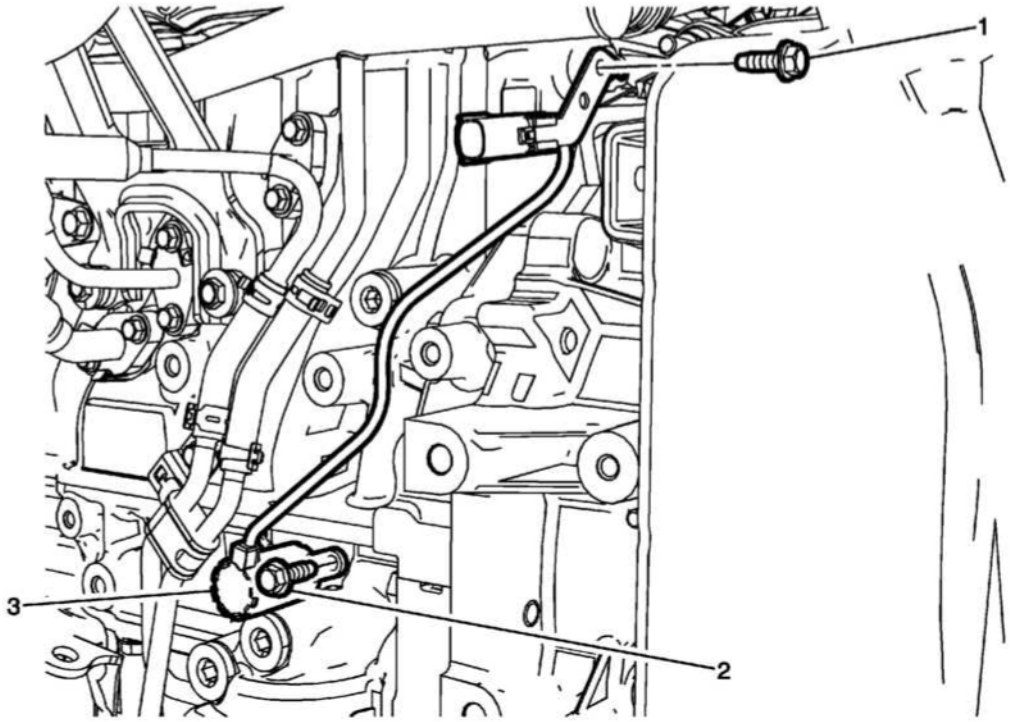


Fig. 136: Oil Pump Flow Control Valve (LTG)
Courtesy of GENERAL MOTORS COMPANY

Oil Pump Flow Control Valve Replacement

Callout	Component Name
Preliminary Procedure 1. Remove the catalytic converter. Refer to **Catalytic Converter Replacement (LTG)** . 2. Remove the oil pump flow control valve heat shield. Refer to **Oil Pump Flow Control Valve Heat Shield Replacement**.	
1	Oil Pump Flow Control Valve Electrical Wiring Harness Connector Bracket Fastener **CAUTION:** **Refer to Fastener Caution .** **Tighten** 9 (80 lb in)
2	Oil Pump Flow Control Valve Fastener **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 (89 lb in)
	Oil Pump Flow Control Valve

3	**Procedure** Disconnect the electrical wiring harness connector from the oil pump flow control valve.

OIL PUMP FLOW CONTROL VALVE HEAT SHIELD REPLACEMENT

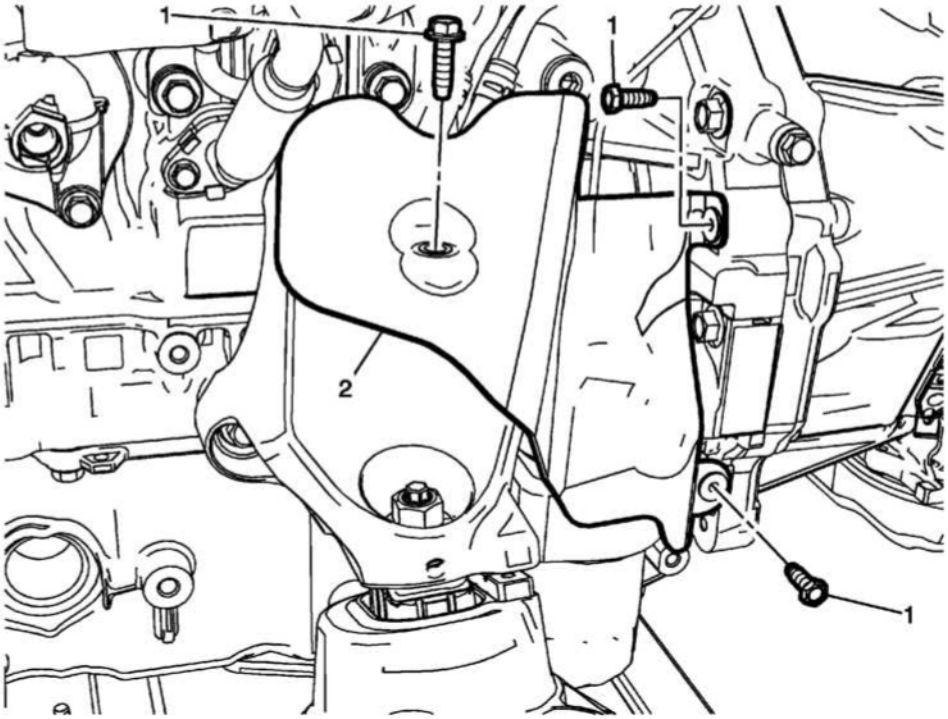


Fig. 137: Oil Pump Flow Control Valve Heat Shield
Courtesy of GENERAL MOTORS COMPANY

Oil Pump Flow Control Valve Heat Shield Replacement

Callout	Component Name
1	Oil Pump Flow Control Valve Heat Shield Fasteners (Qty 3) **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 (89 lb in)
2	Oil Pump Flow Control Valve Heat Shield

VACUUM PUMP REPLACEMENT

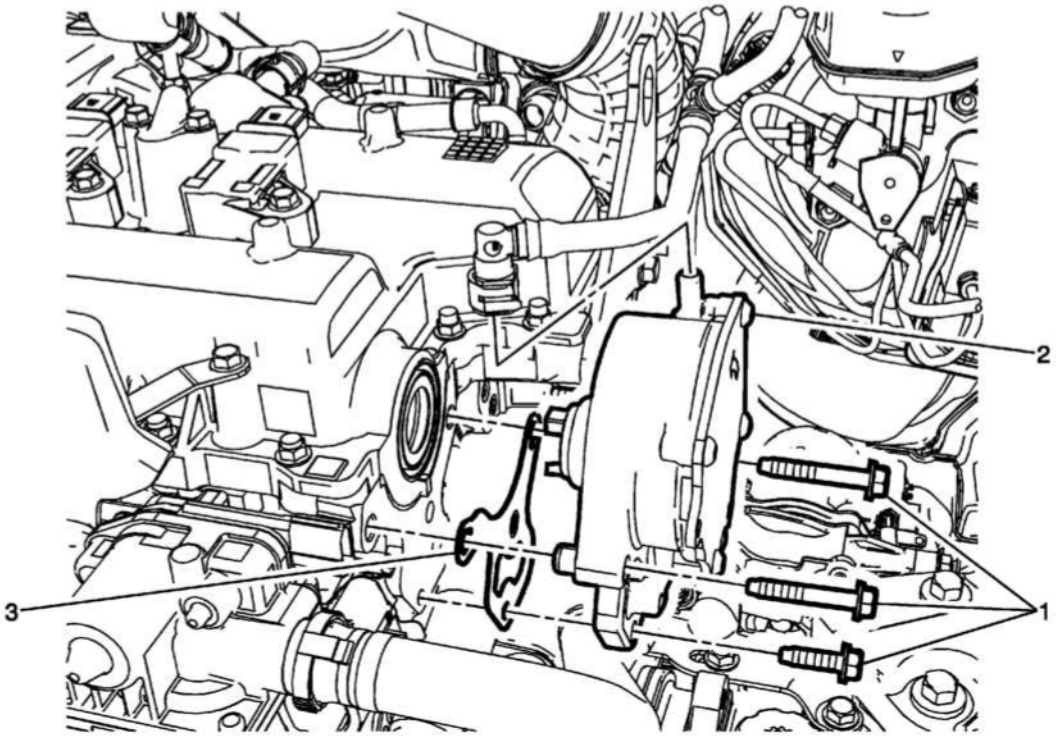


Fig. 138: Vacuum Pump
Courtesy of GENERAL MOTORS COMPANY

Vacuum Pump Replacement

Callout	Component Name
Preliminary Procedure 1. Remove the intake manifold cover. Refer to **Intake Manifold Cover Replacement** . 2. Disconnect the vacuum hose from the vacuum pump. Refer to **Plastic Collar Quick Connect Fitting Service**.	
1	Vacuum Pump Fasteners (Qty: 3) **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 (89 lb in)
2	Vacuum Pump **Procedure** Lubricate the vacuum pump seal with clean engine oil. Refer to **Adhesives, Fluids, Lubricants, and Sealers** . **NOTE:** **Inspect the vacuum pump seal and replace as necessary.**
3	Vacuum Pump Gasket **Procedure**

	Inspect the vacuum pump gasket and replace as necessary.

TURBOCHARGER WASTEGATE ACTUATOR REPLACEMENT

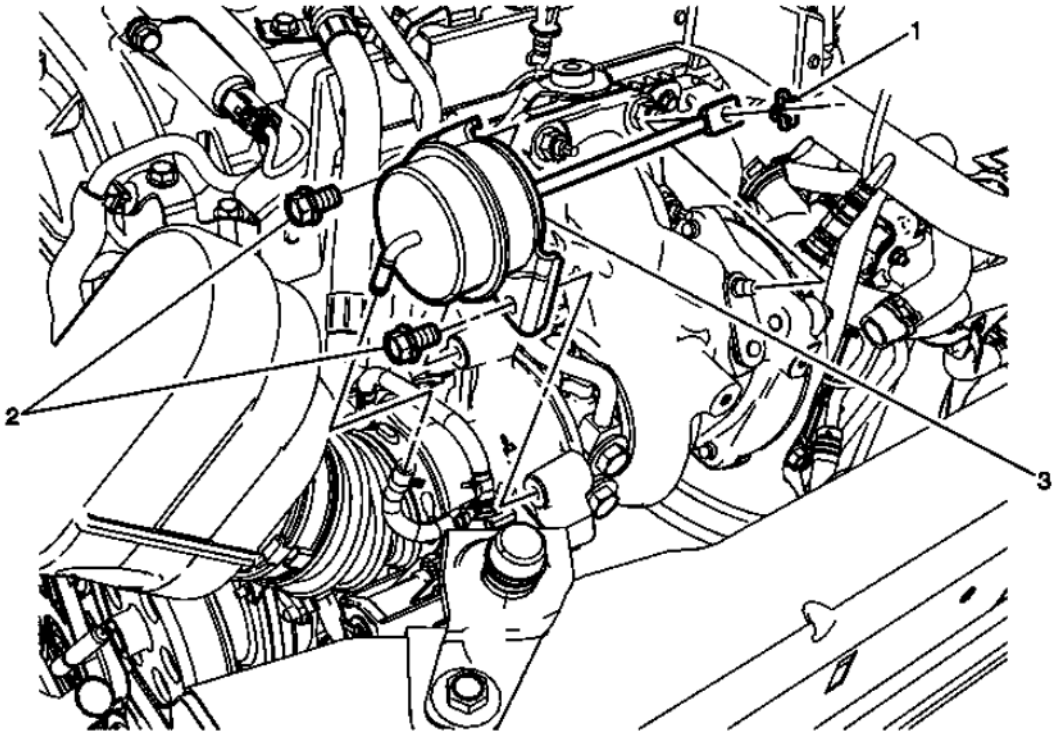


Fig. 139: Turbocharger Wastegate Actuator (LTG)
Courtesy of GENERAL MOTORS COMPANY

Turbocharger Wastegate Actuator Replacement

Callout	Component Name
Preliminary Procedure Remove the turbocharger heat shield. Refer to **Turbocharger Heat Shield Replacement** .	
1	Turbocharger Wastegate Actuator Arm Retainer
2	Turbocharger Wastegate Actuator Fastener (Qty: 2) **CAUTION:** **Refer to Fastener Caution .** **Tighten** 20 (15 lb ft)
3	Turbocharger Wastegate Actuator **Procedure** Disconnect the vacuum line from the turbocharger wastegate actuator.

TURBOCHARGER WASTEGATE REGULATOR SOLENOID VALVE REPLACEMENT

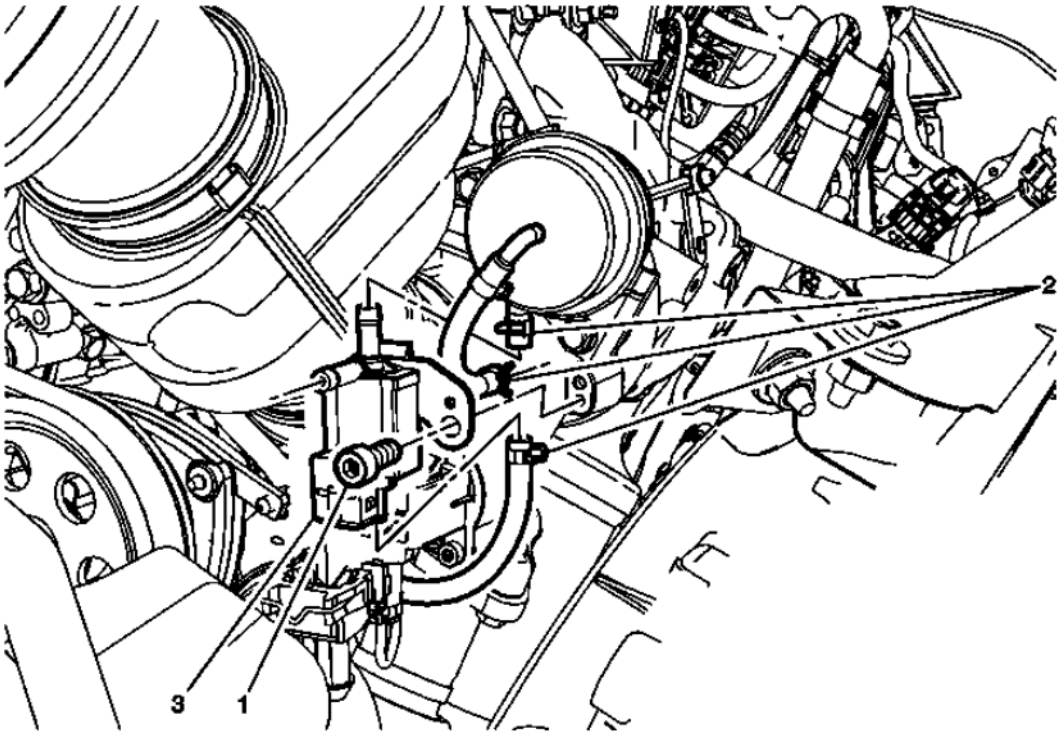


Fig. 140: Turbocharger Wastegate Regulator Solenoid Valve (LTG)
Courtesy of GENERAL MOTORS COMPANY

Turbocharger Wastegate Regulator Solenoid Valve Replacement

Callout	Component Name
1	Turbocharger Wastegate Regulator Solenoid Valve Fastener **CAUTION:** **Refer to Fastener Caution .** **Tighten** 7.8 (69 lb in)
2	Vacuum Hose and Clamp (Qty: 2)
3	Turbocharger Wastegate Regulator Solenoid Valve **Procedure** Disconnect the turbocharger wastegate regulator harness connector.

TURBOCHARGER BYPASS VALVE SOLENOID REPLACEMENT

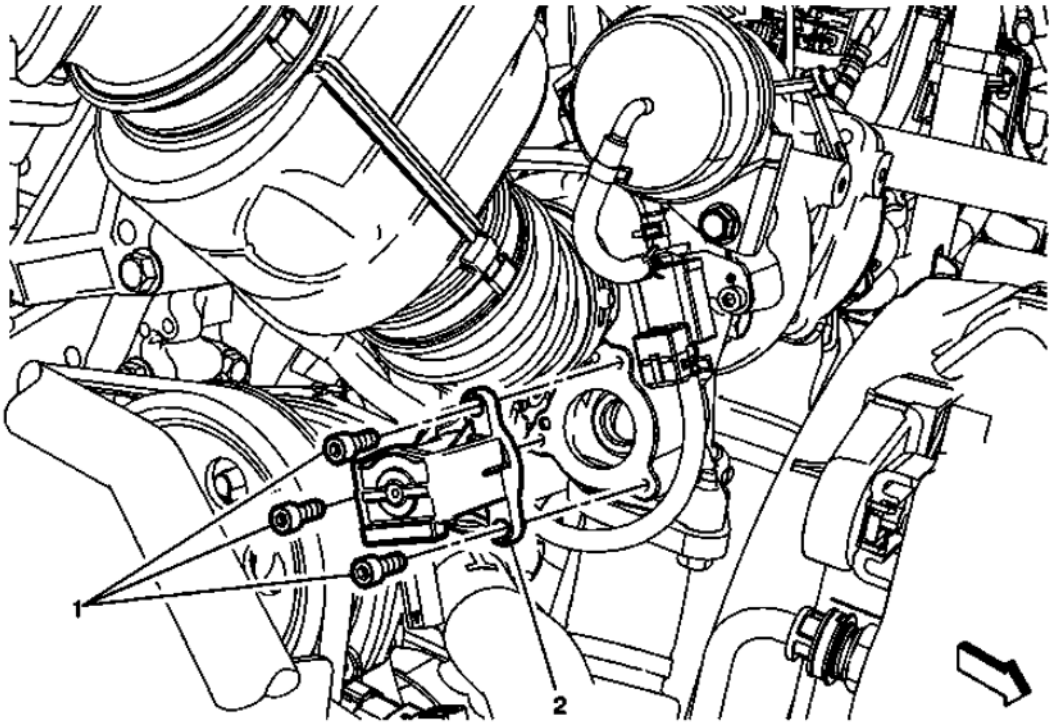


Fig. 141: Turbocharger Bypass Valve Solenoid (LTG)
Courtesy of GENERAL MOTORS COMPANY

Turbocharger Bypass Valve Solenoid Replacement

Callout	Component Name
1	Turbocharger Bypass Valve Solenoid Fasteners (Qty: 3) **CAUTION:** **Refer to Fastener Caution .** **Tighten** 7.8 (69 lb in)
2	Turbocharger Bypass Valve Solenoid **Procedure** 1. Disconnect the turbocharger bypass valve solenoid harness connector. 2. Inspect the turbocharger bypass valve solenoid seal and replace if necessary.

AIR CLEANER ELEMENT REPLACEMENT

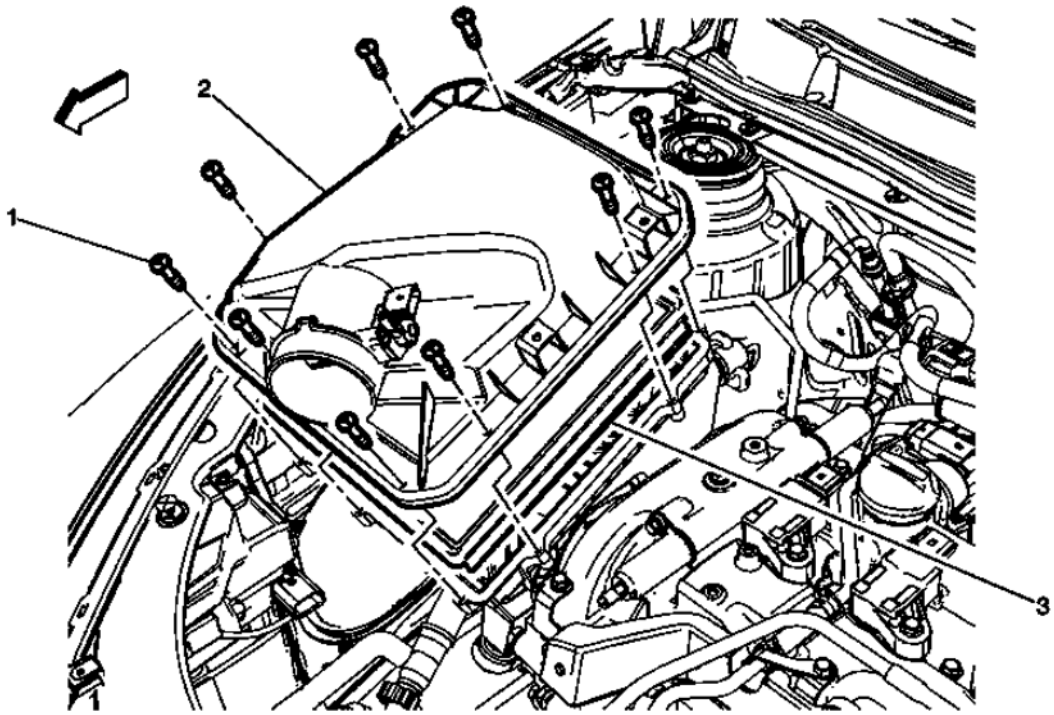


Fig. 142: Air Cleaner Element (LTG)
Courtesy of GENERAL MOTORS COMPANY

Air Cleaner Element Replacement

Callout	Component Name
Preliminary Procedure 1. Disconnect the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement**. 2. Disconnect the mass airflow sensor electrical connector.	
1	Air Cleaner Assembly Fasteners (Qty: 9) **CAUTION:** **Refer to Fastener Caution .**
2	Air Cleaner Upper Cover
3	Air Cleaner Element

AIR CLEANER ASSEMBLY REPLACEMENT

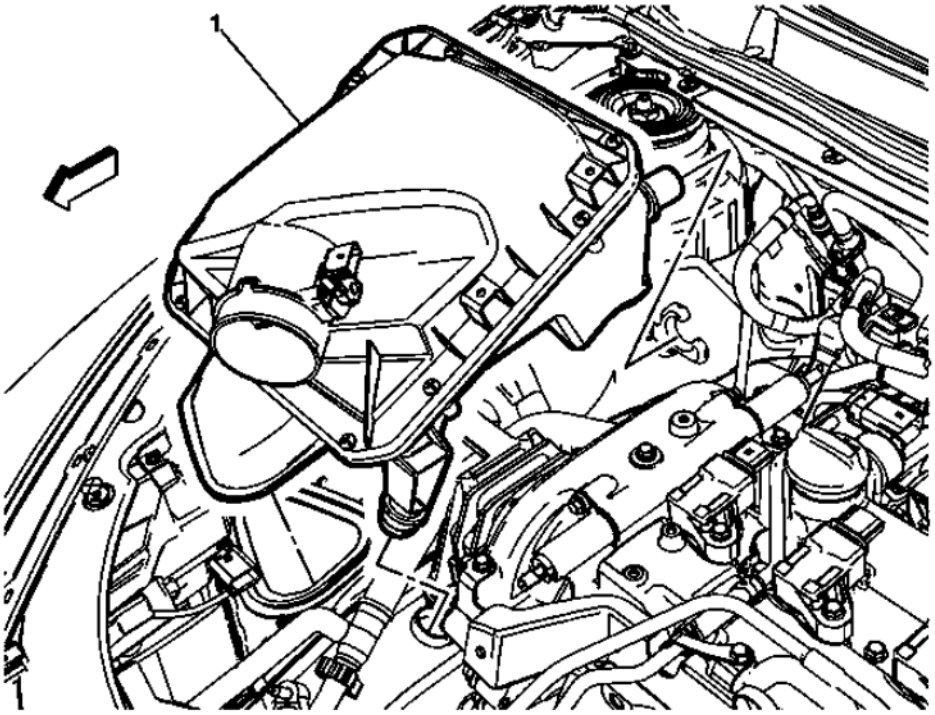


Fig. 143: Air Cleaner Assembly (LTG)
Courtesy of GENERAL MOTORS COMPANY

Air Cleaner Assembly Replacement

Callout	Component Name
Preliminary Procedures 1. Disconnect the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement**. 2. Disconnect the mass airflow sensor electrical connector.	
1	Air Cleaner Assembly **Procedure** 1. Remove the air cleaner housing from the retainers, while guiding the housing out of the inlet duct. 2. Transfer parts as necessary.

AIR CLEANER OUTLET DUCT REPLACEMENT

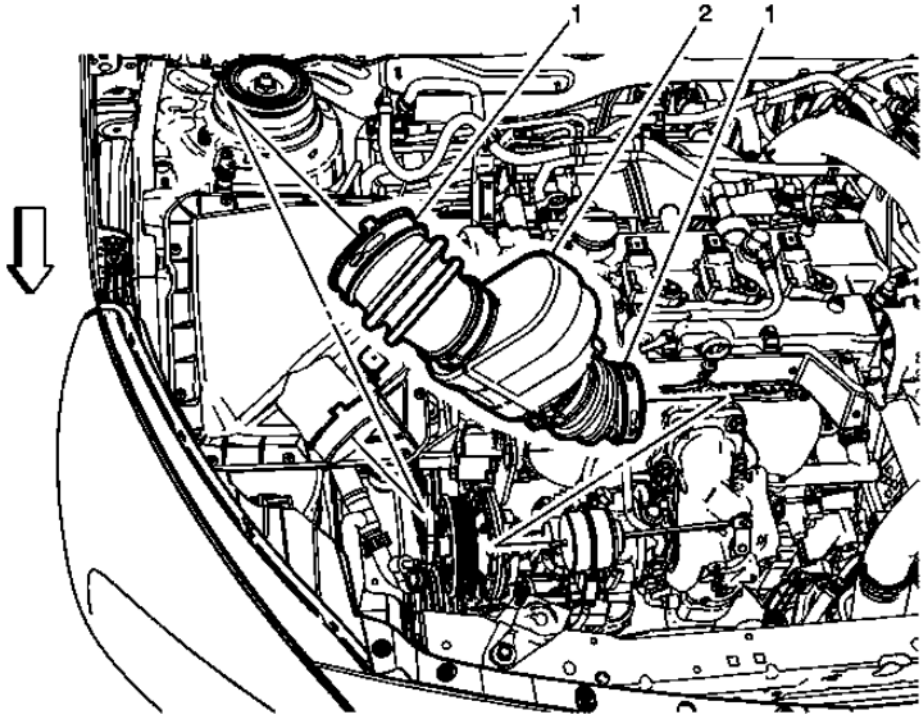


Fig. 144: Air Cleaner Outlet Duct (LTG)
Courtesy of GENERAL MOTORS COMPANY

Air Cleaner Outlet Duct Replacement

Callout	Component Name
1	Air Cleaner Outlet Duct Clamps (Qty 2) **CAUTION:** **Refer to Fastener Caution .**
2	Air Cleaner Outlet Duct **Procedure** Disconnect the PVC tube from the air cleaner outlet duct.

AIR CLEANER INLET DUCT REPLACEMENT

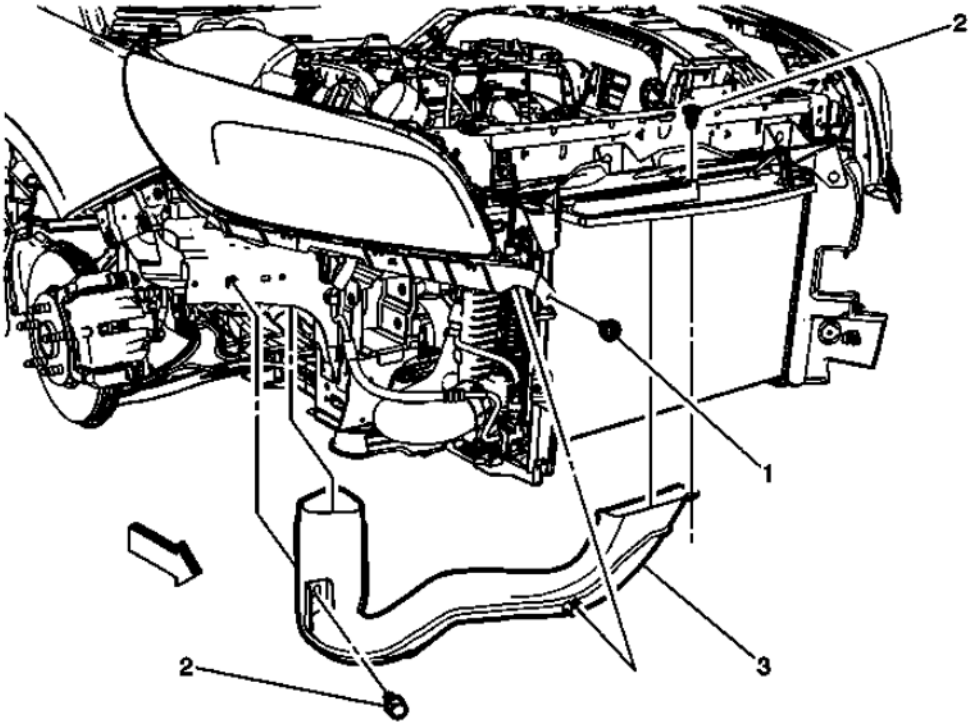


Fig. 145: Air Cleaner Inlet Duct (LTG)
Courtesy of GENERAL MOTORS COMPANY

Air Cleaner Inlet Duct Replacement

Callout	Component Name
Preliminary Procedures 1. Remove the front bumper fascia. Refer to **Front Bumper Fascia Replacement** . 2. Remove the right side front bumper fascia reinforcement.	
1	Air Cleaner Inlet Duct Fastener **CAUTION:** **Refer to Fastener Caution .**
2	Air Cleaner Inlet Duct Retainer (Qty: 3)
3	Air Cleaner Inlet Duct **NOTE:** **Remove the front intake air duct and deflector together as an assembly. Separate after the assembly is removed from the vehicle.**

FRONT INTAKE AIR DUCT DEFLECTOR REPLACEMENT

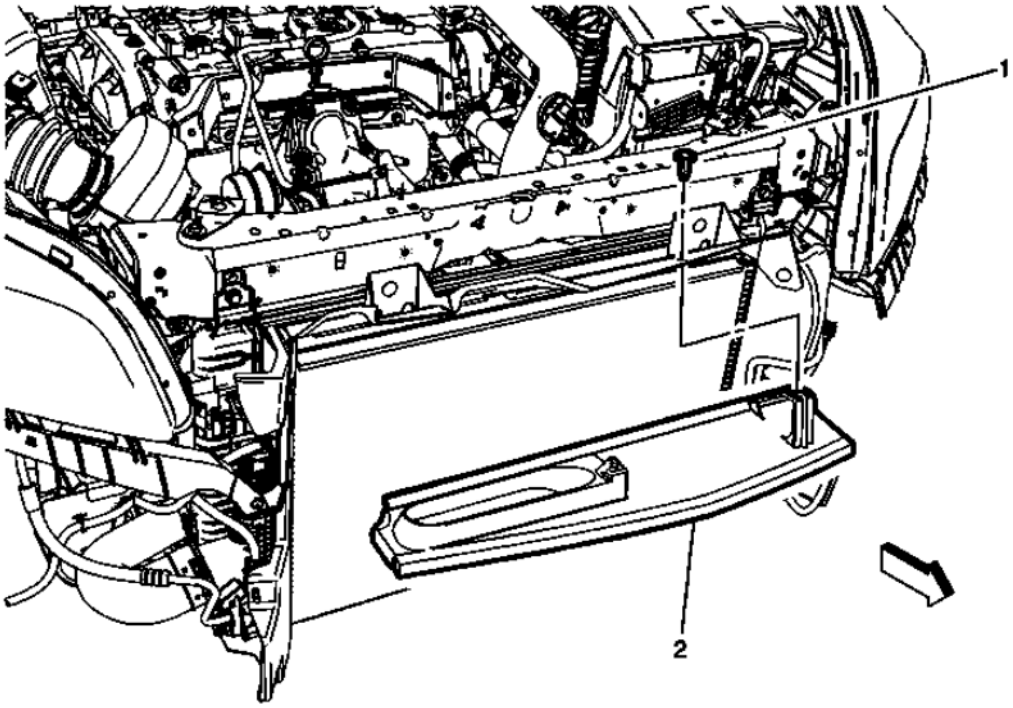


Fig. 146: Front Intake Air Duct Deflector
Courtesy of GENERAL MOTORS COMPANY

Front Intake Air Duct Deflector Replacement

Callout	Component Name
Preliminary Procedure Remove the air cleaner inlet duct. Refer to **Air Cleaner Inlet Duct Replacement**.	
1	Front Intake Air Duct Deflector Retainer
2	Front Intake Air Duct Deflector

CHARGE AIR COOLER OUTLET AIR TUBE REPLACEMENT

Removal Procedure

1. Remove the brake boost pump inlet hose from the charge air cooler outlet air tube.

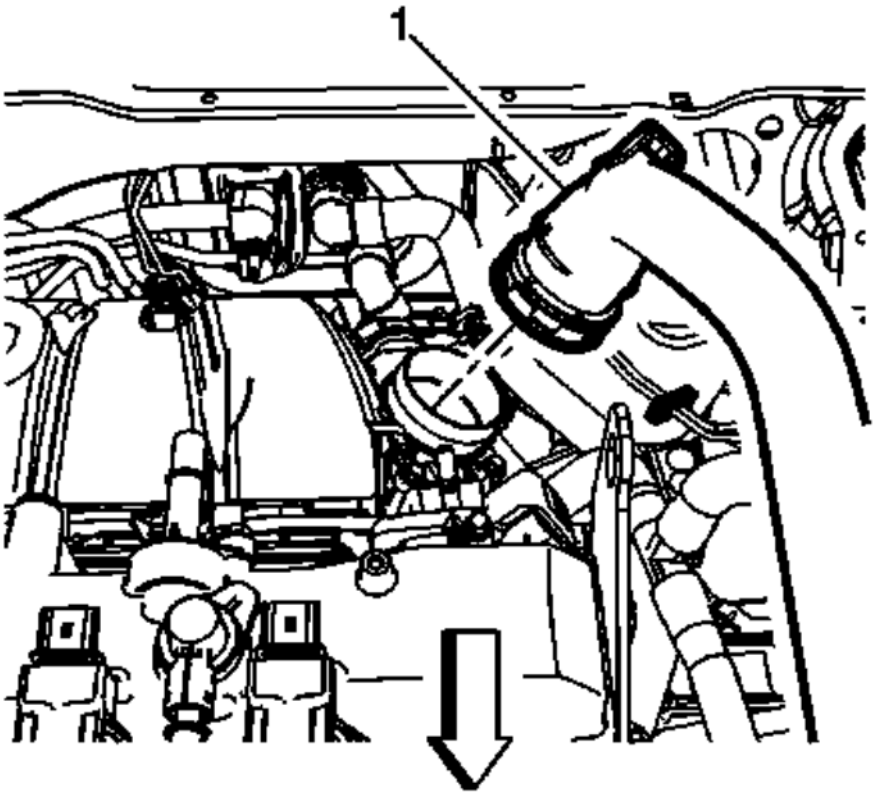


Fig. 147: Charge Air Cooler Outlet Air Tube
Courtesy of GENERAL MOTORS COMPANY

2. Remove the charge air cooler outlet air tube (1) from the throttle body.

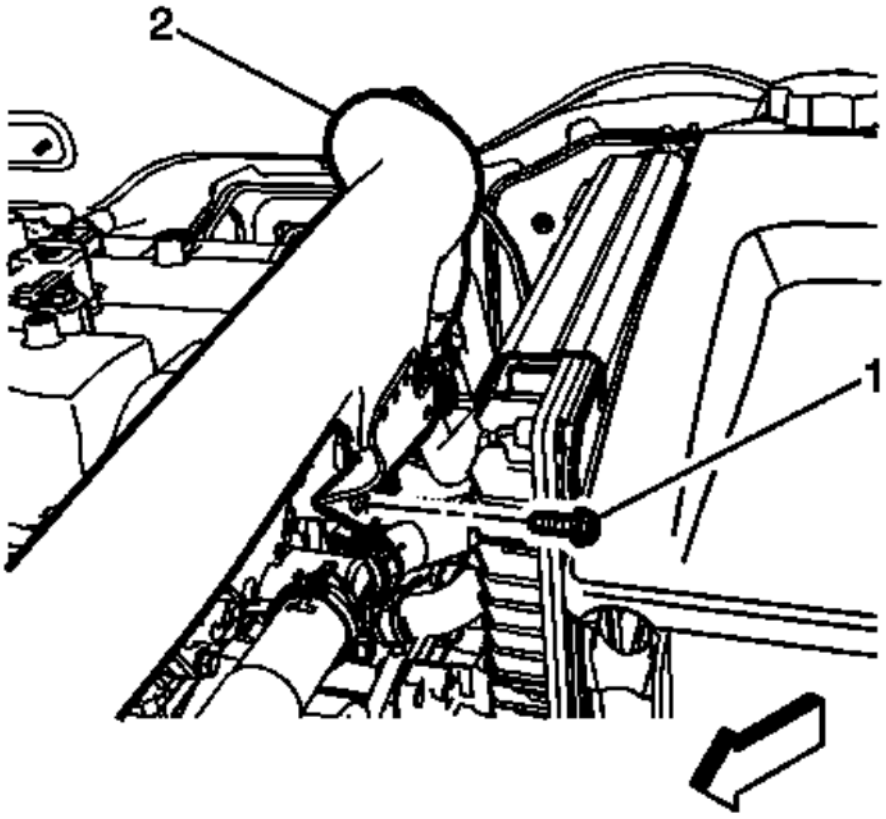


Fig. 148: Charge Air Cooler Outlet Air Tube Bolt
Courtesy of GENERAL MOTORS COMPANY

3. Remove the charge air cooler outlet air tube bolt (1) from the charge air cooler outlet air tube (2).

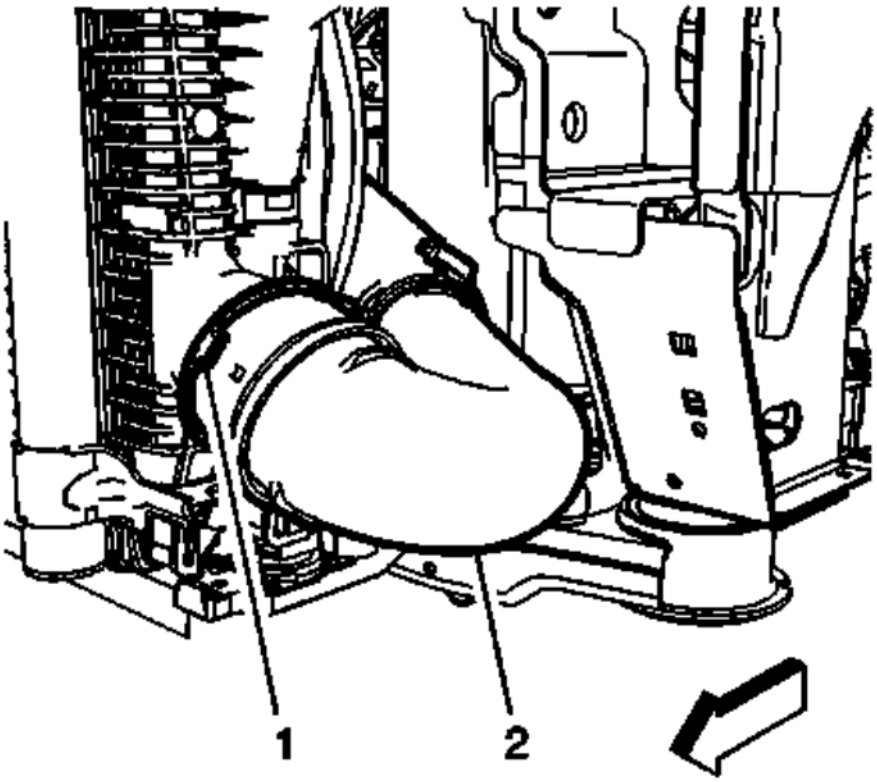


Fig. 149: Release Clip
Courtesy of GENERAL MOTORS COMPANY

4. Pull the release clip (1) outward and disconnect the charge air cooler outlet air tube (2) from the charge air cooler.
5. Remove the charge air cooler outlet air tube (2) from the vehicle.

Installation Procedure

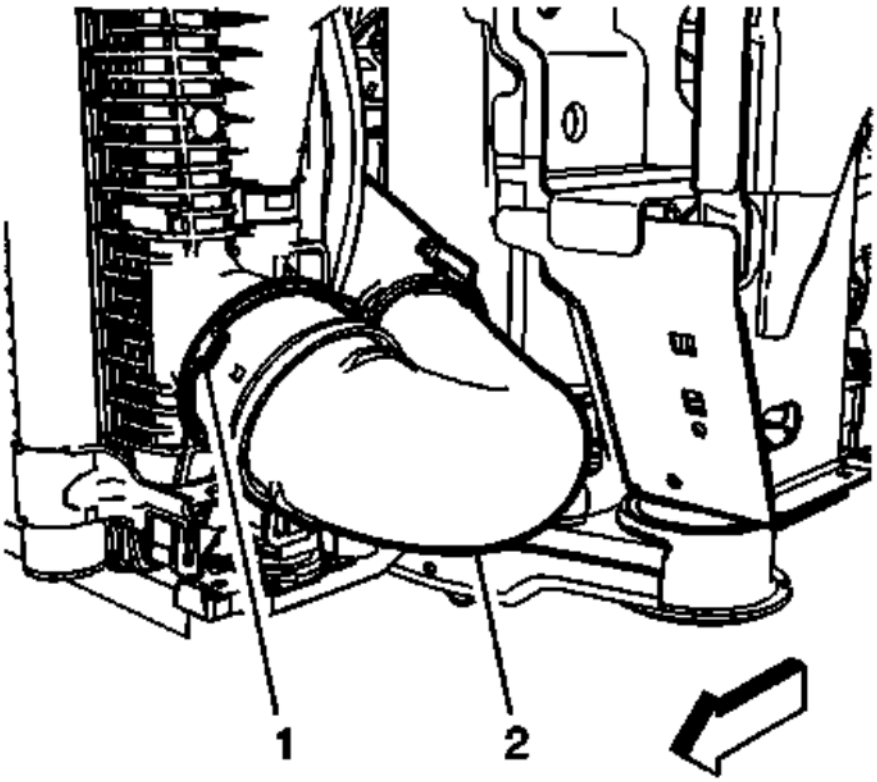


Fig. 150: Release Clip
Courtesy of GENERAL MOTORS COMPANY

1. Install the charge air cooler outlet air tube (2) to the vehicle.
2. Connect the charge air cooler outlet air tube (2) to the charge air cooler and engage the retaining clip (1).

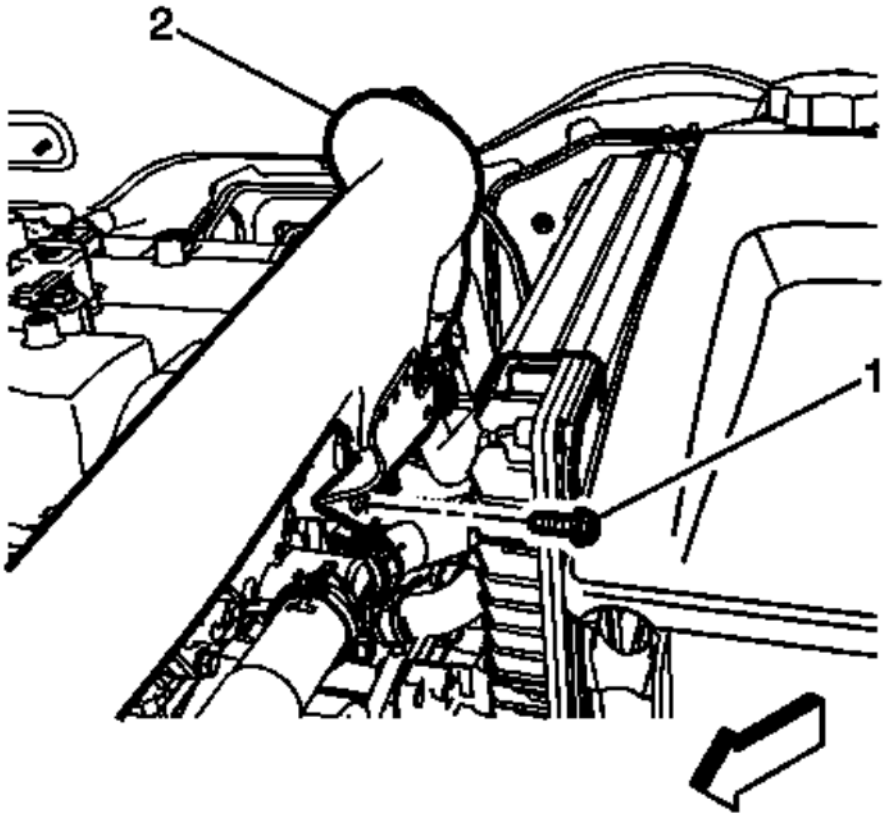


Fig. 151: Charge Air Cooler Outlet Air Tube Bolt
Courtesy of GENERAL MOTORS COMPANY

3. Install the charge air cooler outlet air tube bolt (1) to the charge air cooler outlet air tube (2) and tighten to 9 (80 lb in).

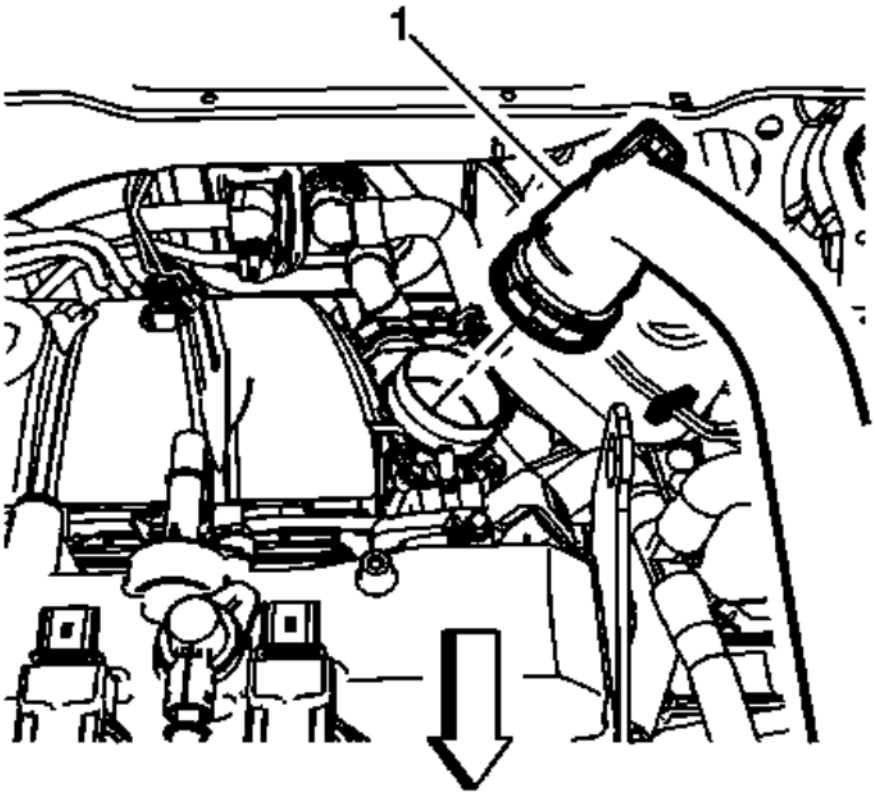


Fig. 152: Charge Air Cooler Outlet Air Tube
Courtesy of GENERAL MOTORS COMPANY

4. Install the charge air cooler outlet air tube (1) to the throttle body.
5. Install the brake boost pump inlet hose to the charge air cooler outlet air tube.

CHARGE AIR COOLER INLET AIR TUBE REPLACEMENT

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle** .

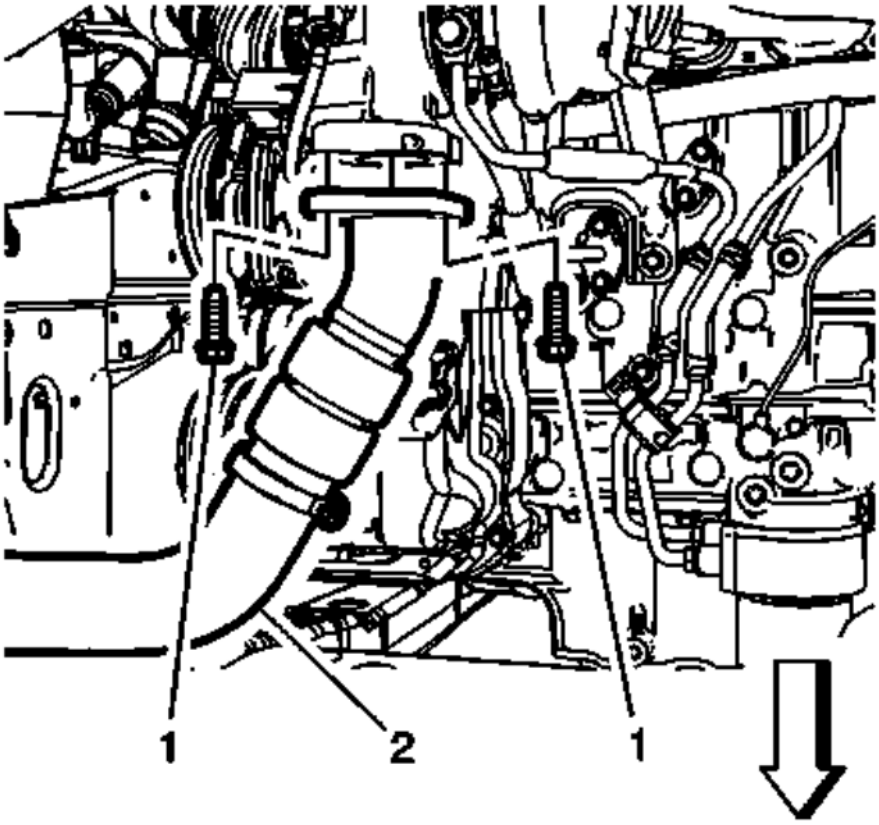


Fig. 153: Charge Air Cooler Inlet Air Tube Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Remove the charge air cooler inlet air tube bolts (1) from the charge air cooler inlet air tube (2).

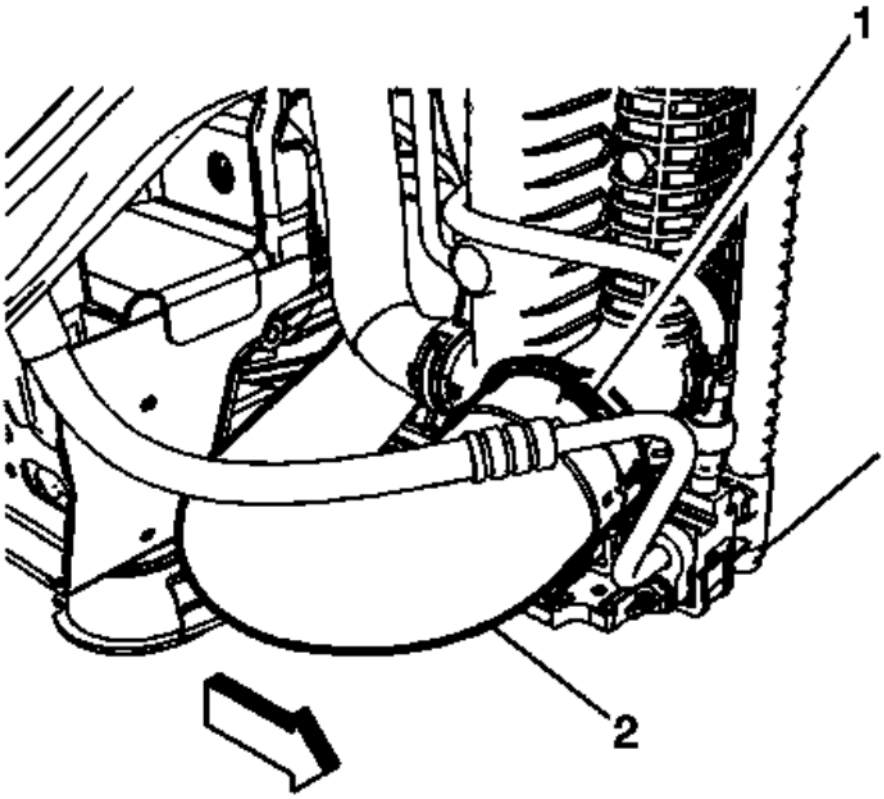


Fig. 154: Release Clip
Courtesy of GENERAL MOTORS COMPANY

3. Pull the release clip (1) outward and disconnect the charge air cooler inlet air hose (2) from the charge air cooler.
4. Remove the charge air cooler inlet air tube (2) from the vehicle.

Installation Procedure

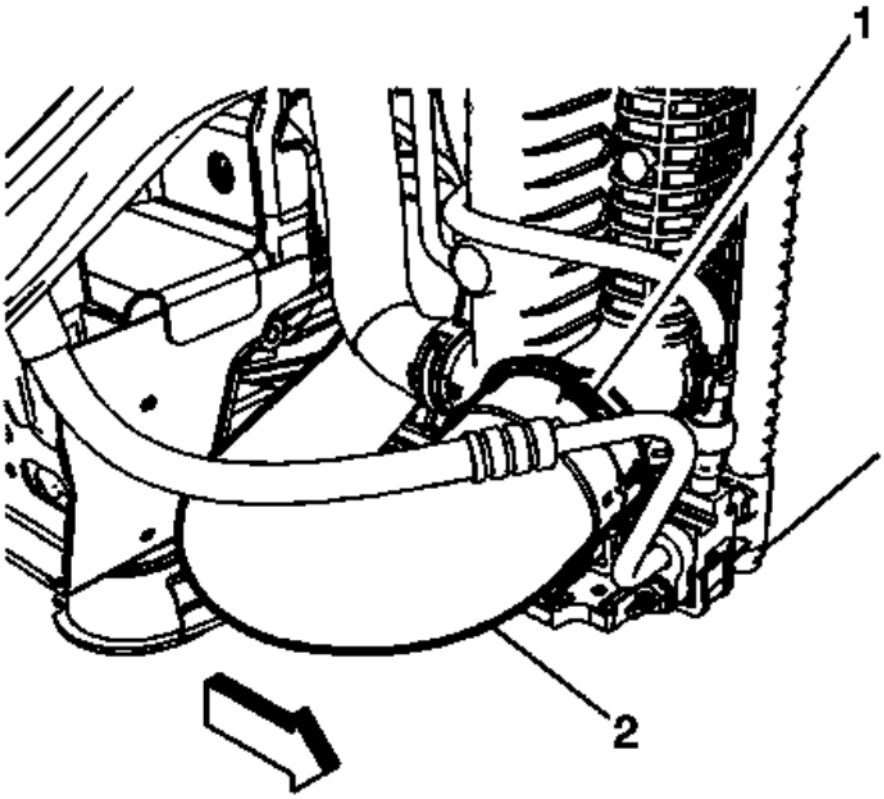


Fig. 155: Release Clip
Courtesy of GENERAL MOTORS COMPANY

1. Install the charge air cooler inlet air tube (2) to the vehicle.
2. Connect the charge air cooler inlet air hose (2) to the charge air cooler and engage the retaining clip (1).

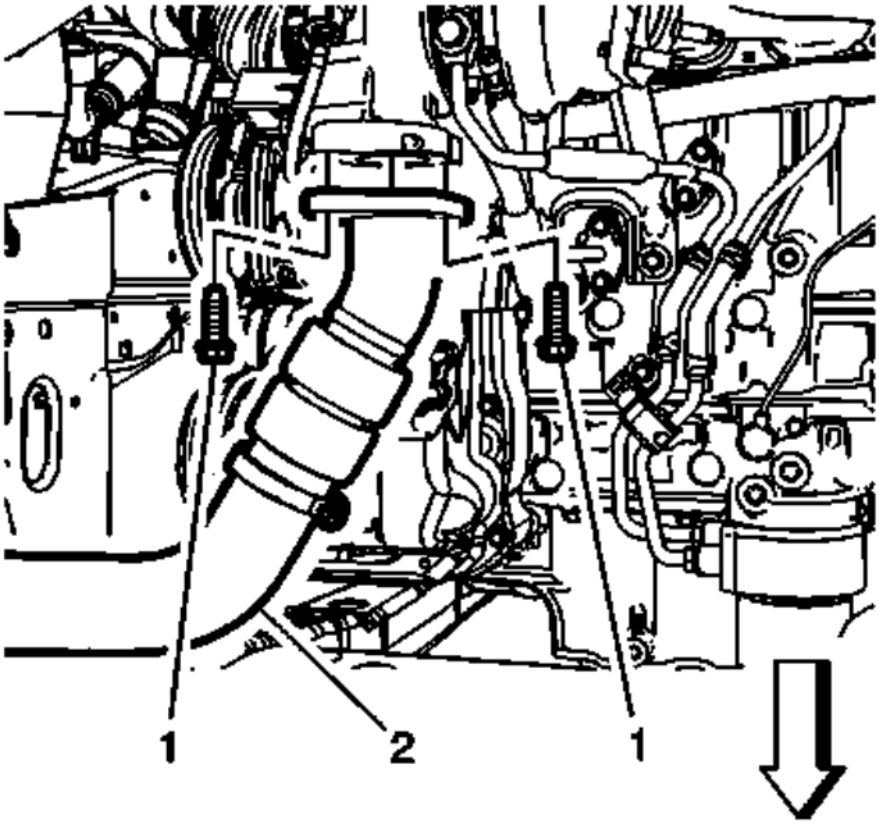


Fig. 156: Charge Air Cooler Inlet Air Tube Bolts
Courtesy of GENERAL MOTORS COMPANY

3. Install the charge air cooler inlet air tube bolts (1) to the charge air cooler inlet air tube (2) and tighten to 10 (89 lb in).
4. Lower the vehicle.

CHARGE AIR COOLER RADIATOR REPLACEMENT

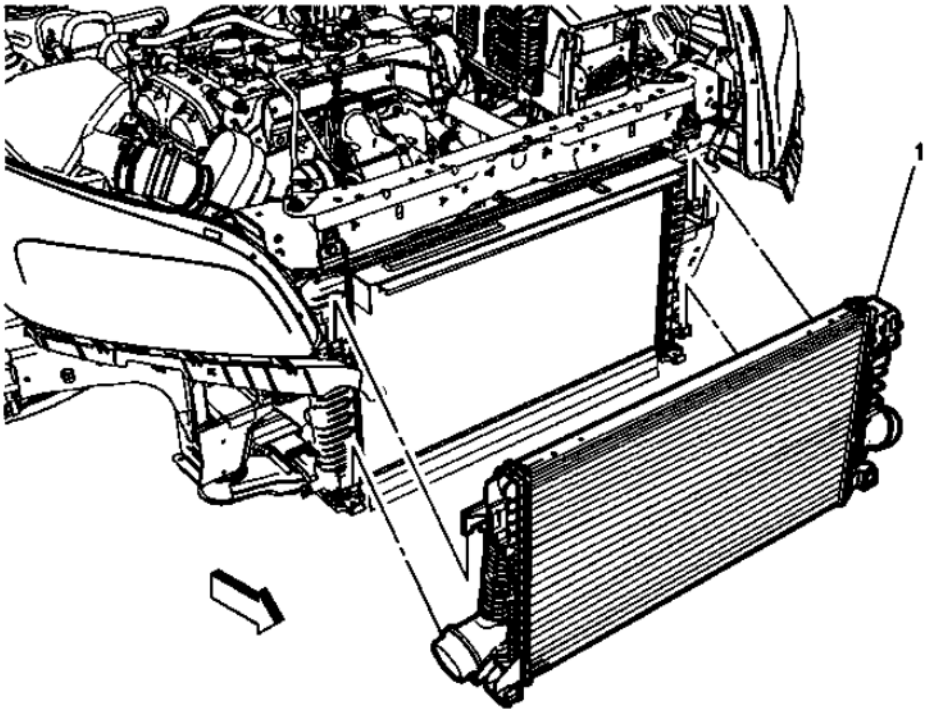


Fig. 157: Charge Air Cooler Radiator
Courtesy of GENERAL MOTORS COMPANY

Charge Air Cooler Radiator Replacement

Callout	Component Name
Preliminary Procedure 1. Remove the air conditioning condenser. Refer to **Air Conditioning Condenser Replacement (LTG)** . 2. Remove the charge air cooler inlet air tube. Refer to **Charge Air Cooler Inlet Air Tube Replacement**. 3. Remove the charge air cooler outlet air tube. Refer to **Charge Air Cooler Outlet Air Tube Replacement**.	
1	Charge Air Cooler Radiator

2014 Engine

Engine Controls and Fuel - 2.0L (LTG) - Schematic Wiring Diagrams - Regal

SCHEMATIC WIRING DIAGRAMS

ENGINE CONTROLS WIRING SCHEMATICS

Module Power, Ground, Serial Data, and MIL

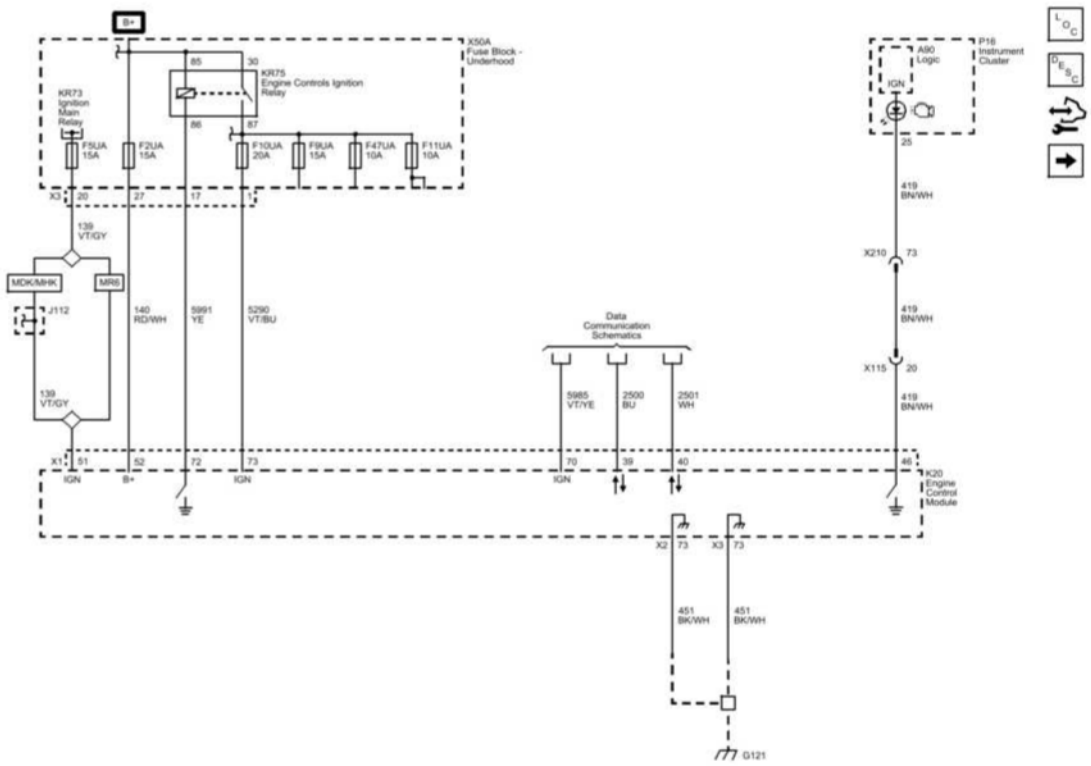


Fig. 1: Module Power, Ground, Serial Data, and MIL
Courtesy of GENERAL MOTORS COMPANY

5V1, and Low Reference Bus (1 of 2)

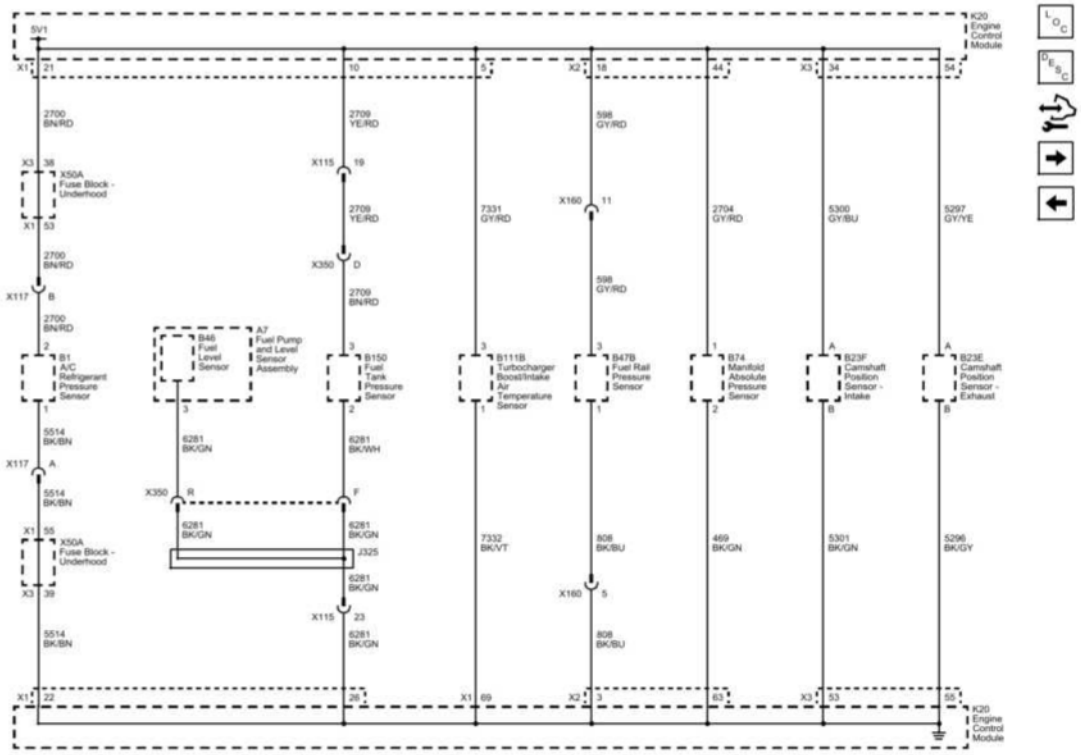


Fig. 2: 5V1, and Low Reference Bus (1 of 2)
Courtesy of GENERAL MOTORS COMPANY

5V2, 5V3, 5V4, and Low Reference Bus (2 of 2)

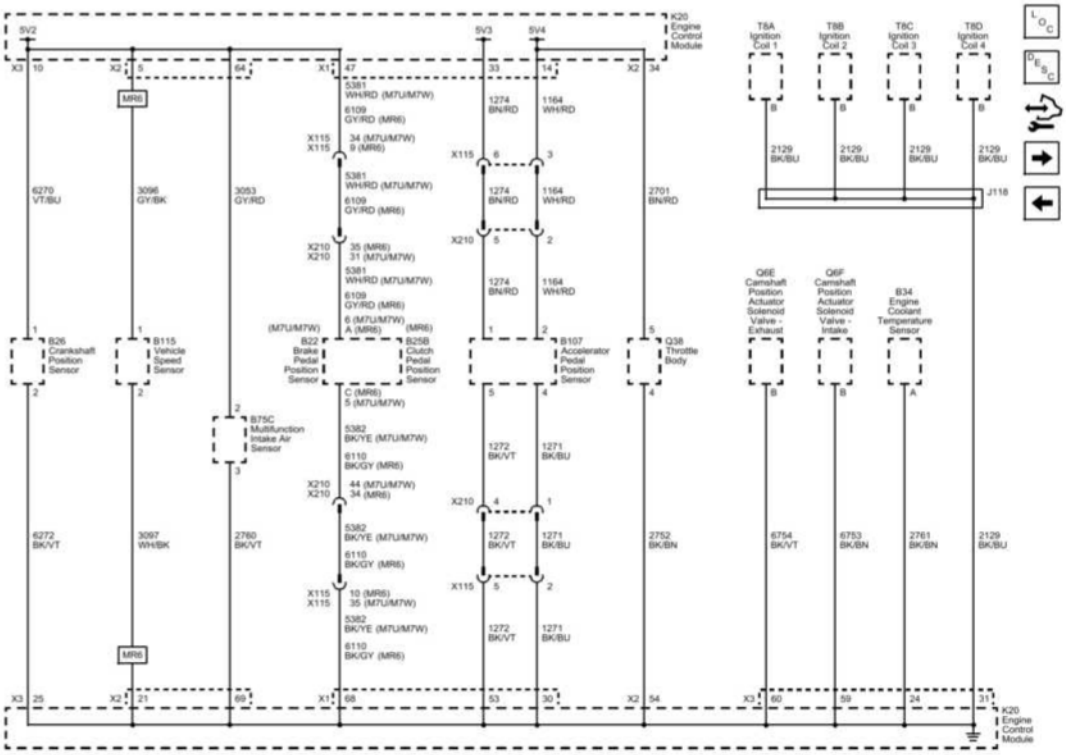


Fig. 3: 5V2, 5V3, 5V4, and Low Reference Bus (2 of 2)
Courtesy of GENERAL MOTORS COMPANY

Engine Data Sensors - Pressure and Temperature

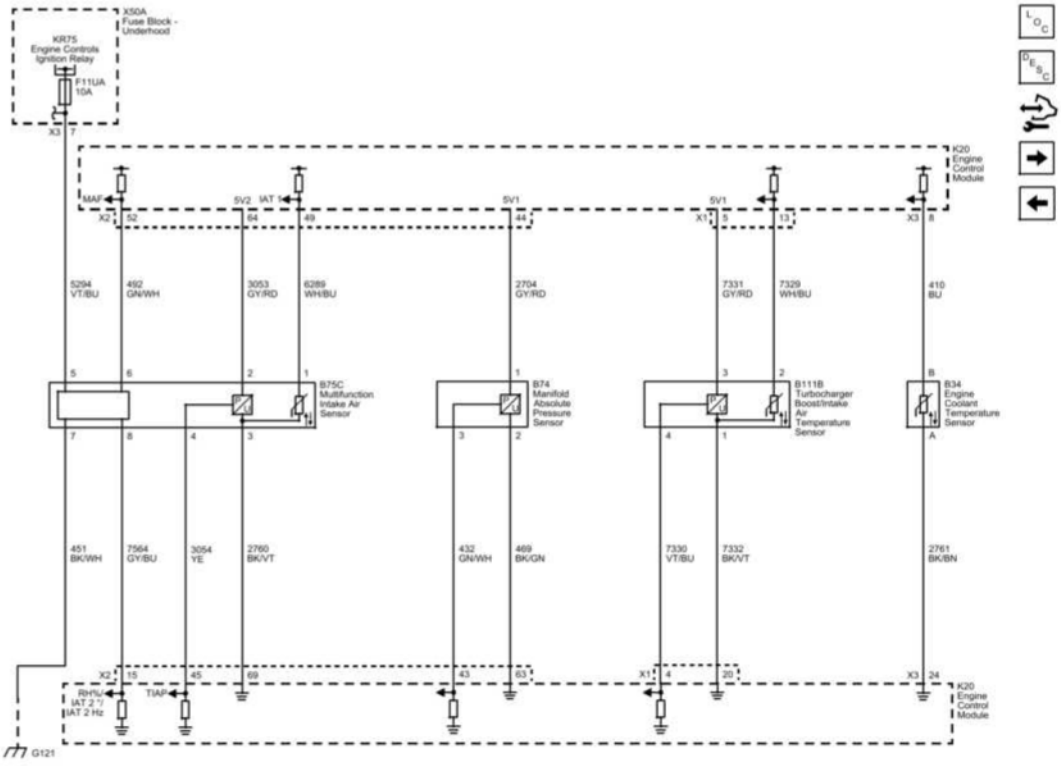


Fig. 4: Engine Data Sensors - Pressure and Temperature
Courtesy of GENERAL MOTORS COMPANY

Engine Data Sensors - Oxygen Sensors

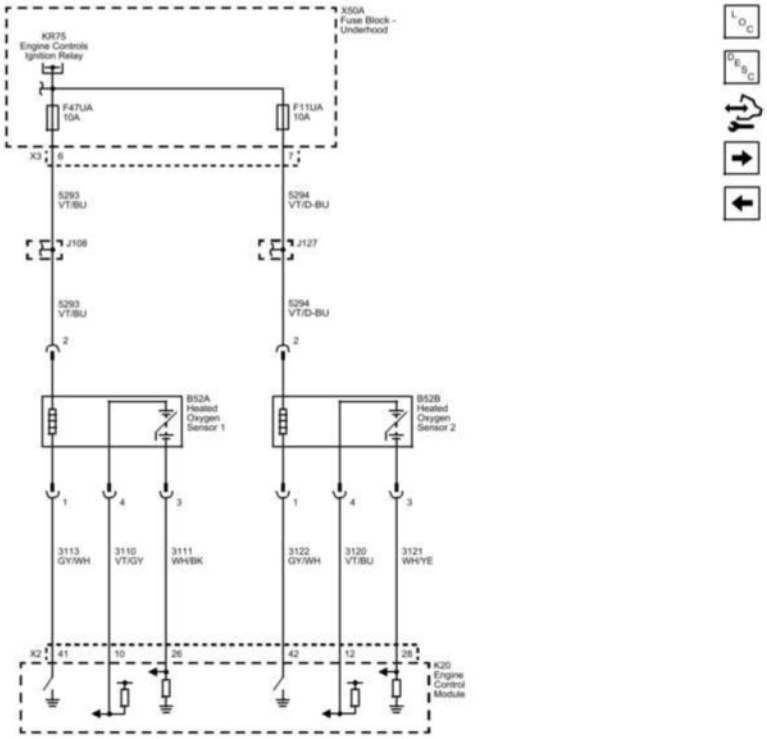


Fig. 5: Engine Data Sensors - Oxygen Sensors
Courtesy of GENERAL MOTORS COMPANY

Engine Data Sensors - Throttle Controls

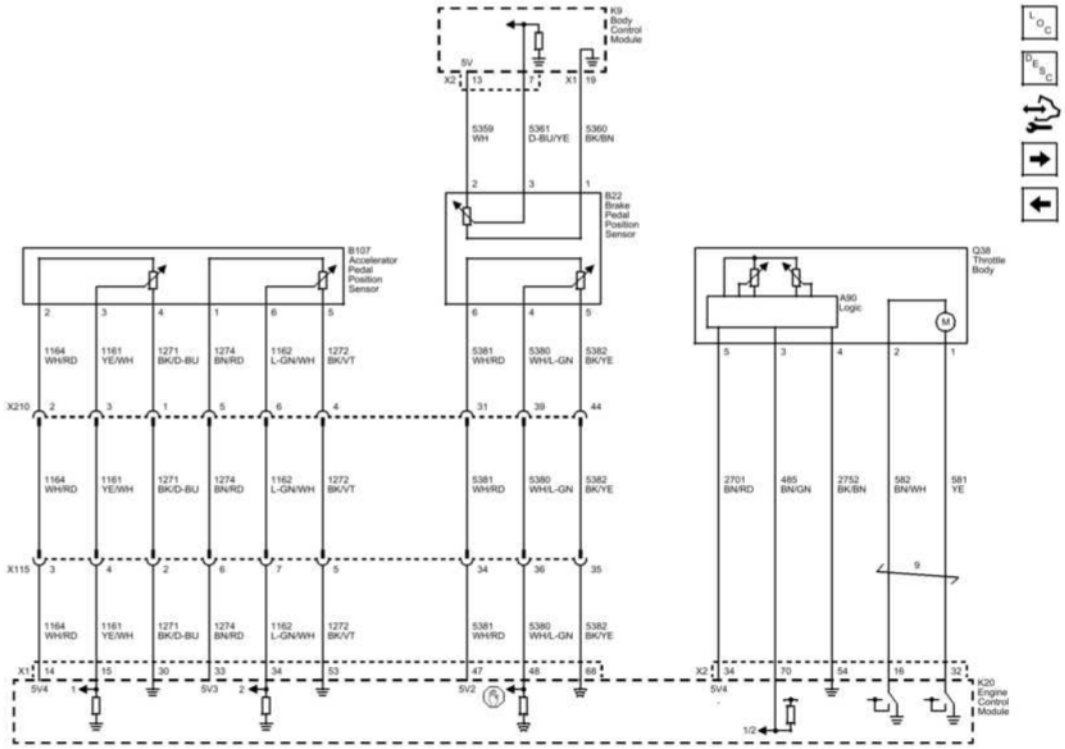


Fig. 6: Engine Data Sensors - Throttle Controls
Courtesy of GENERAL MOTORS COMPANY

Ignition Controls - Ignition System

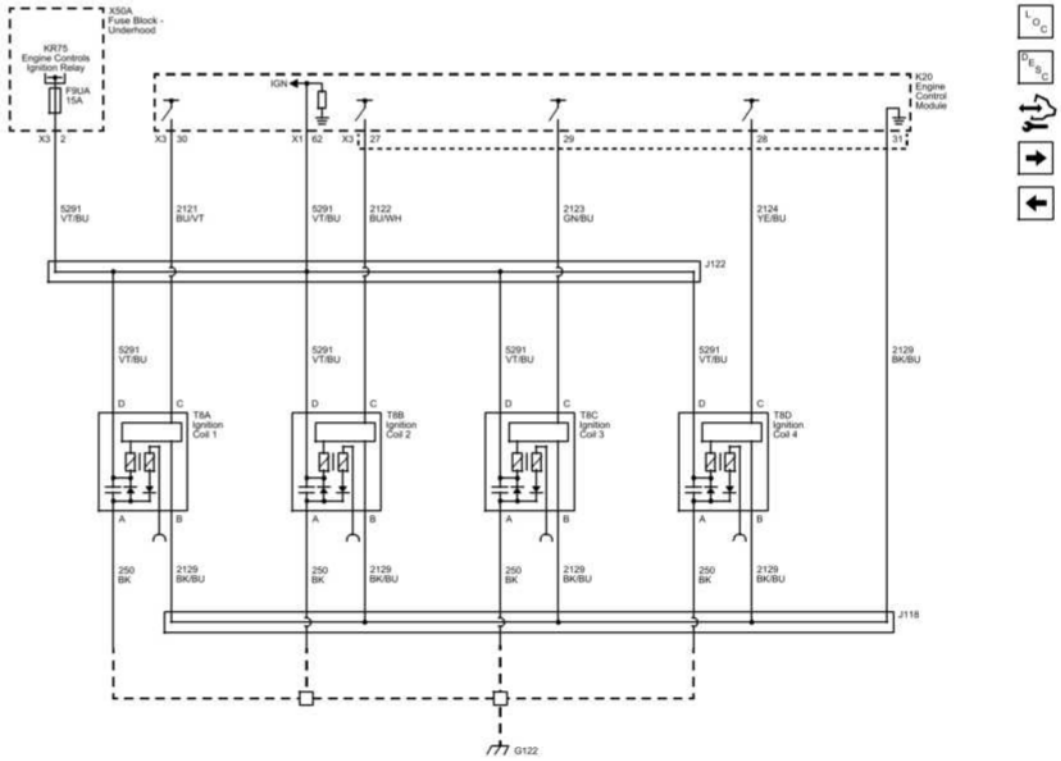


Fig. 7: Ignition Controls - Ignition System
Courtesy of GENERAL MOTORS COMPANY

Ignition Controls - Camshaft, Crankshaft, Knock Sensors, and Camshaft Actuators

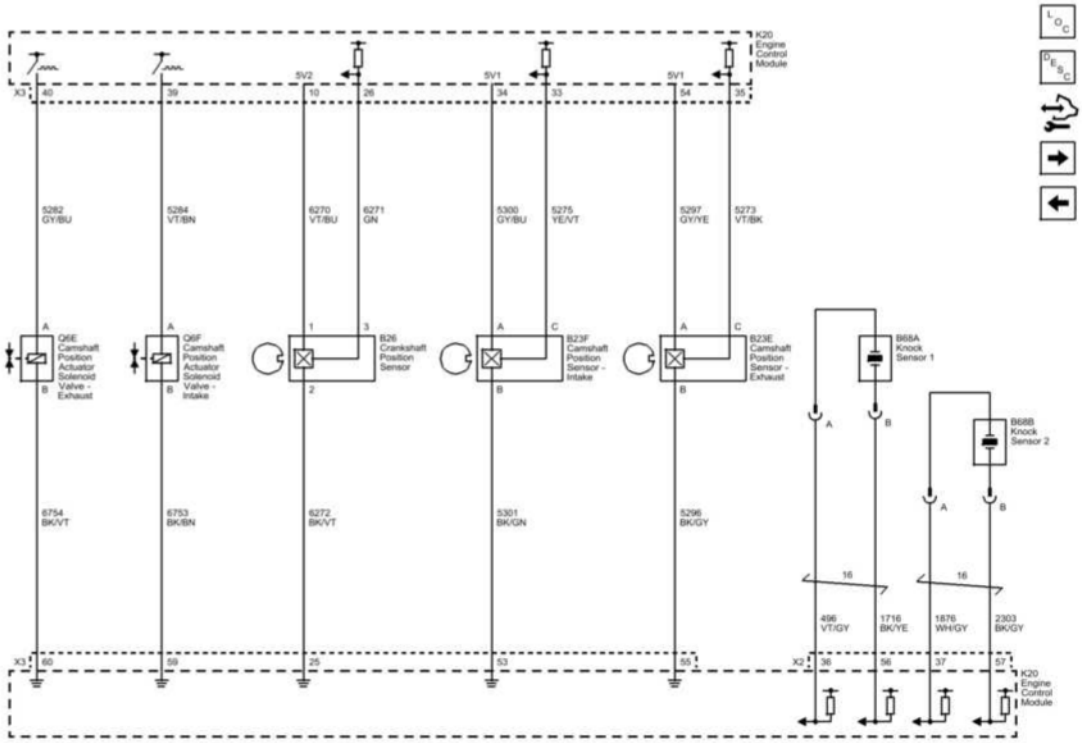


Fig. 8: Ignition Controls - Camshaft, Crankshaft, Knock Sensors, and Camshaft Actuators
Courtesy of GENERAL MOTORS COMPANY

Fuel Controls - Fuel Injectors, Fuel Composition, and High Pressure Controls

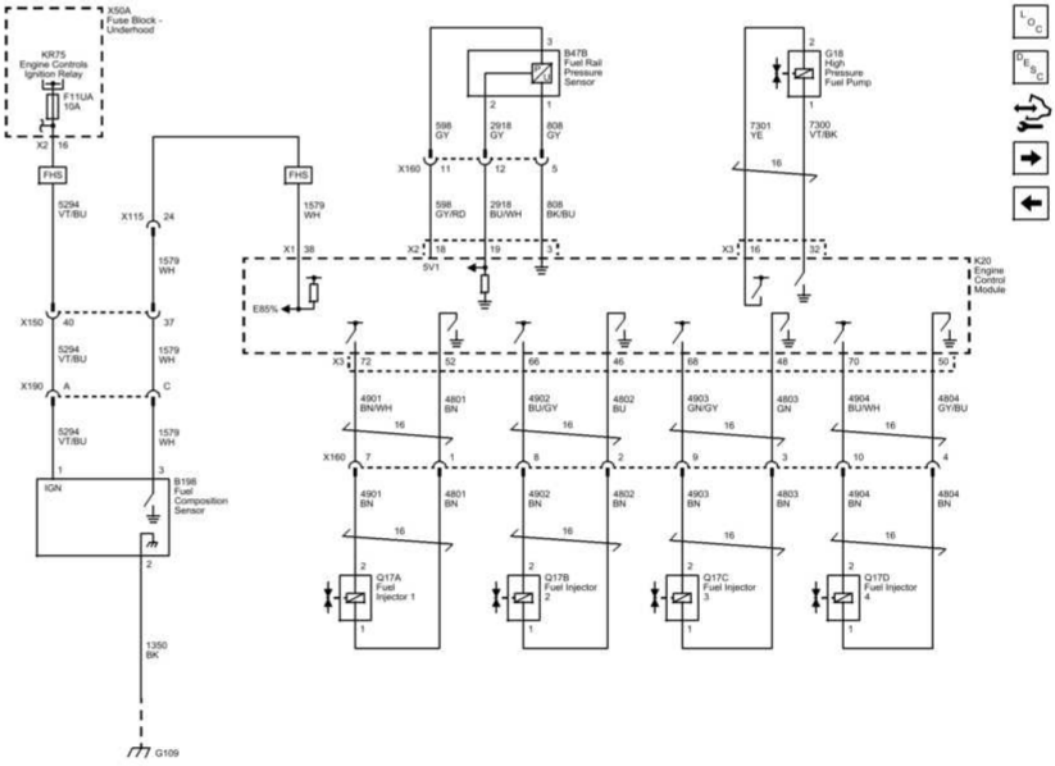


Fig. 9: Fuel Controls - Fuel Injectors, Fuel Composition, and High Pressure Controls
Courtesy of GENERAL MOTORS COMPANY

Fuel Controls - Fuel Pump Controls

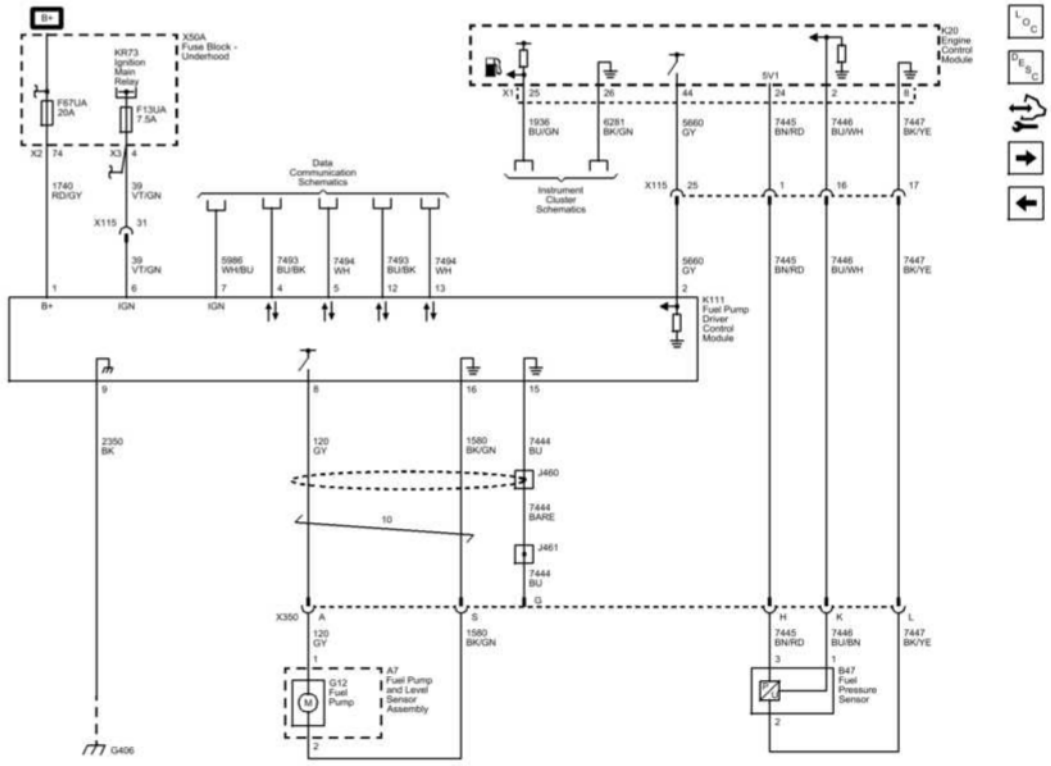


Fig. 10: Fuel Controls - Fuel Pump Controls
Courtesy of GENERAL MOTORS COMPANY

Fuel Controls - Evaporative Emissions and Turbocharger Controls

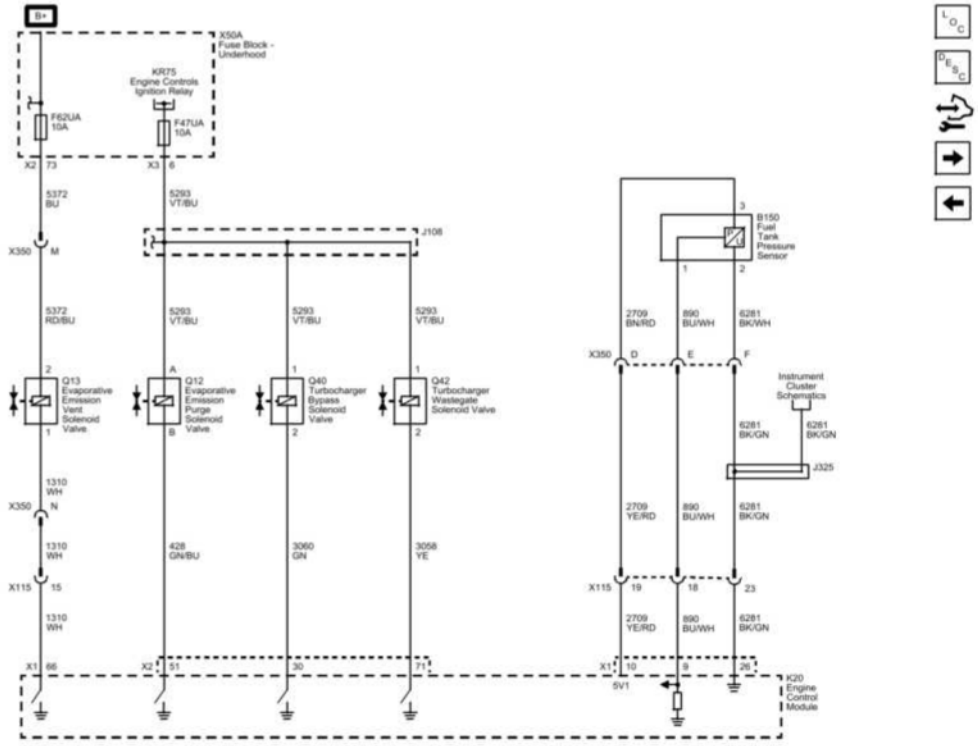


Fig. 11: Fuel Controls - Evaporative Emissions and Turbocharger Controls
Courtesy of GENERAL MOTORS COMPANY

Controlled/Monitored Subsystem References

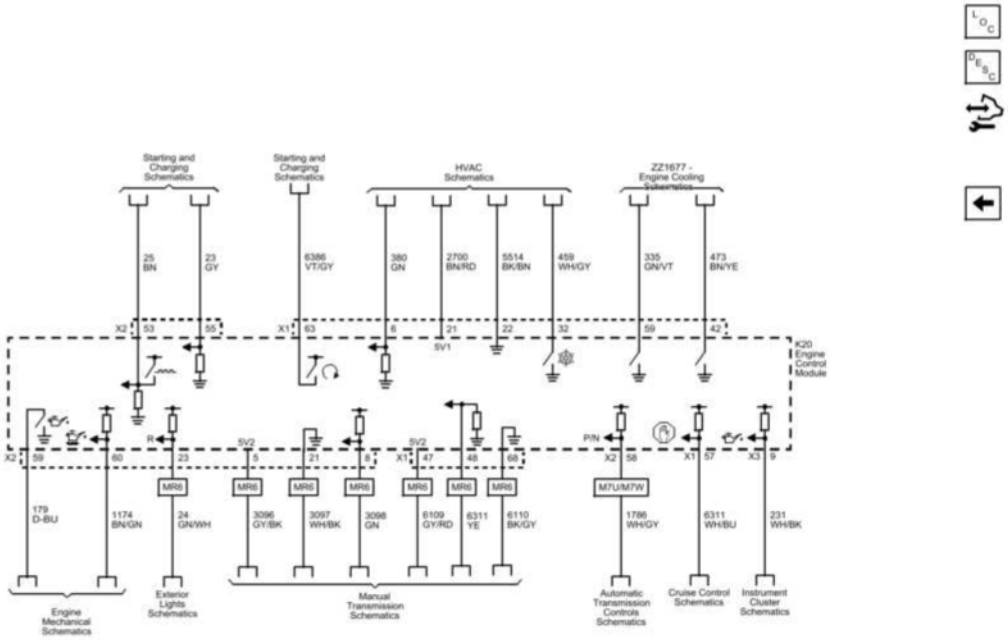


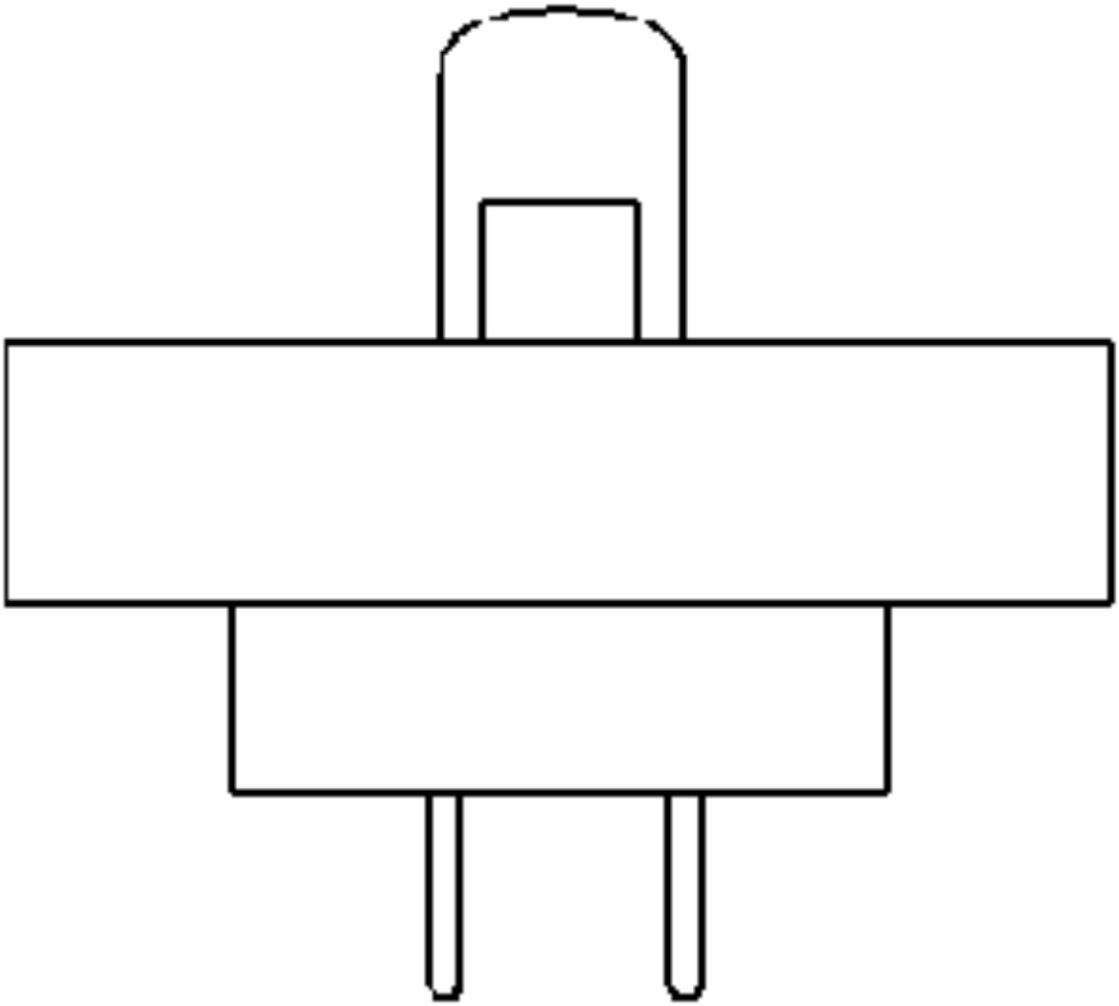
Fig. 12: Controlled/Monitored Subsystem References
Courtesy of GENERAL MOTORS COMPANY

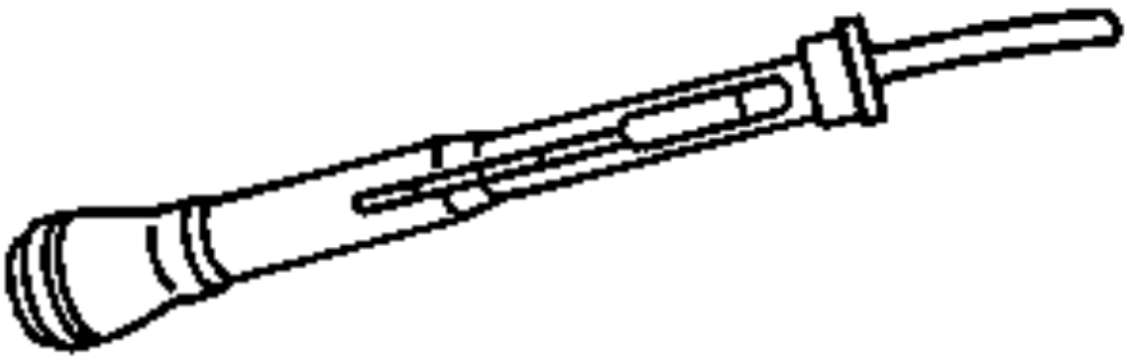
2014 Engine

Engine Controls and Fuel - 2.0L (LTG) - Special Tools and Equipment - Regal

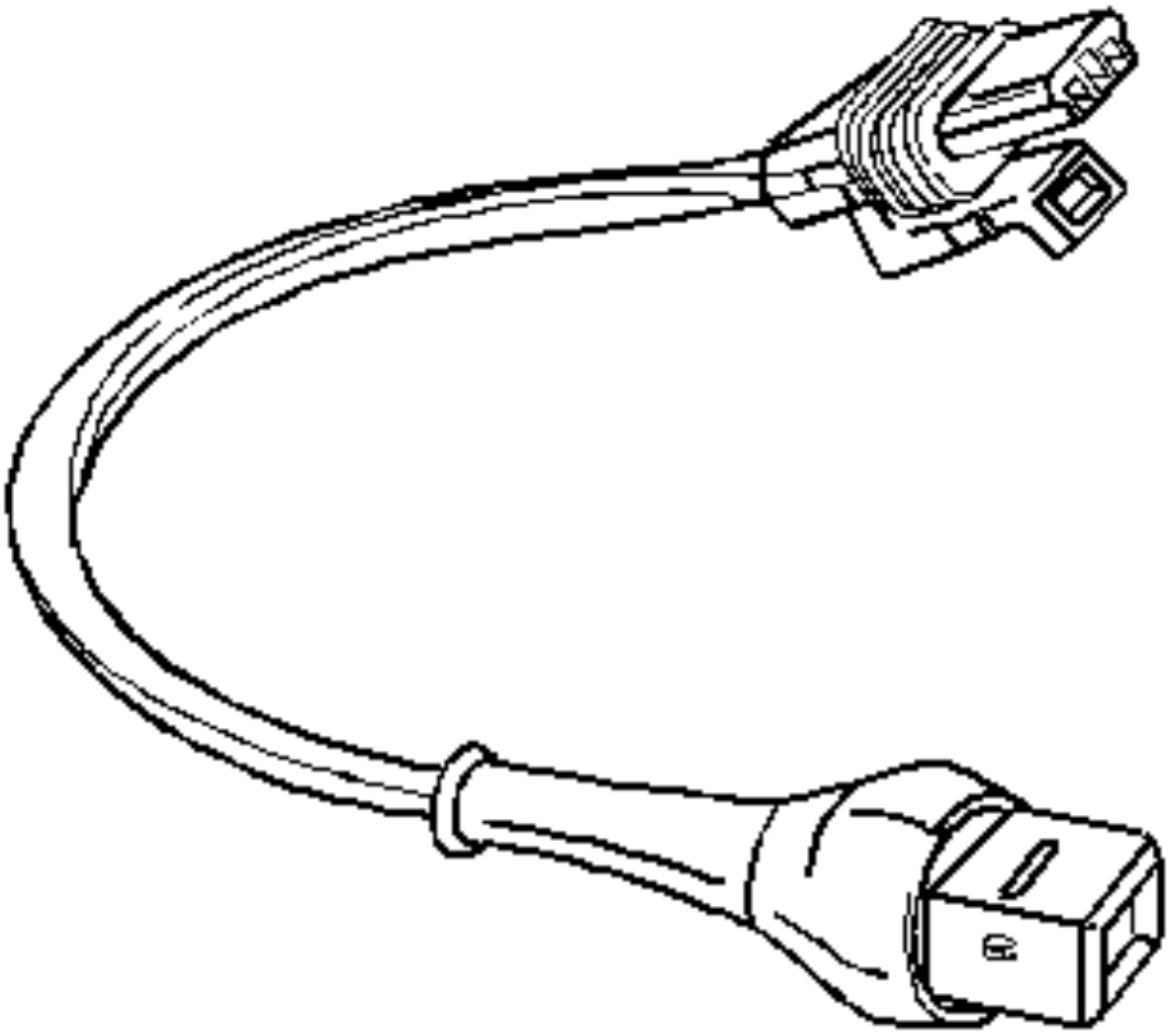
SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS (DIAGNOSTIC TOOLS)

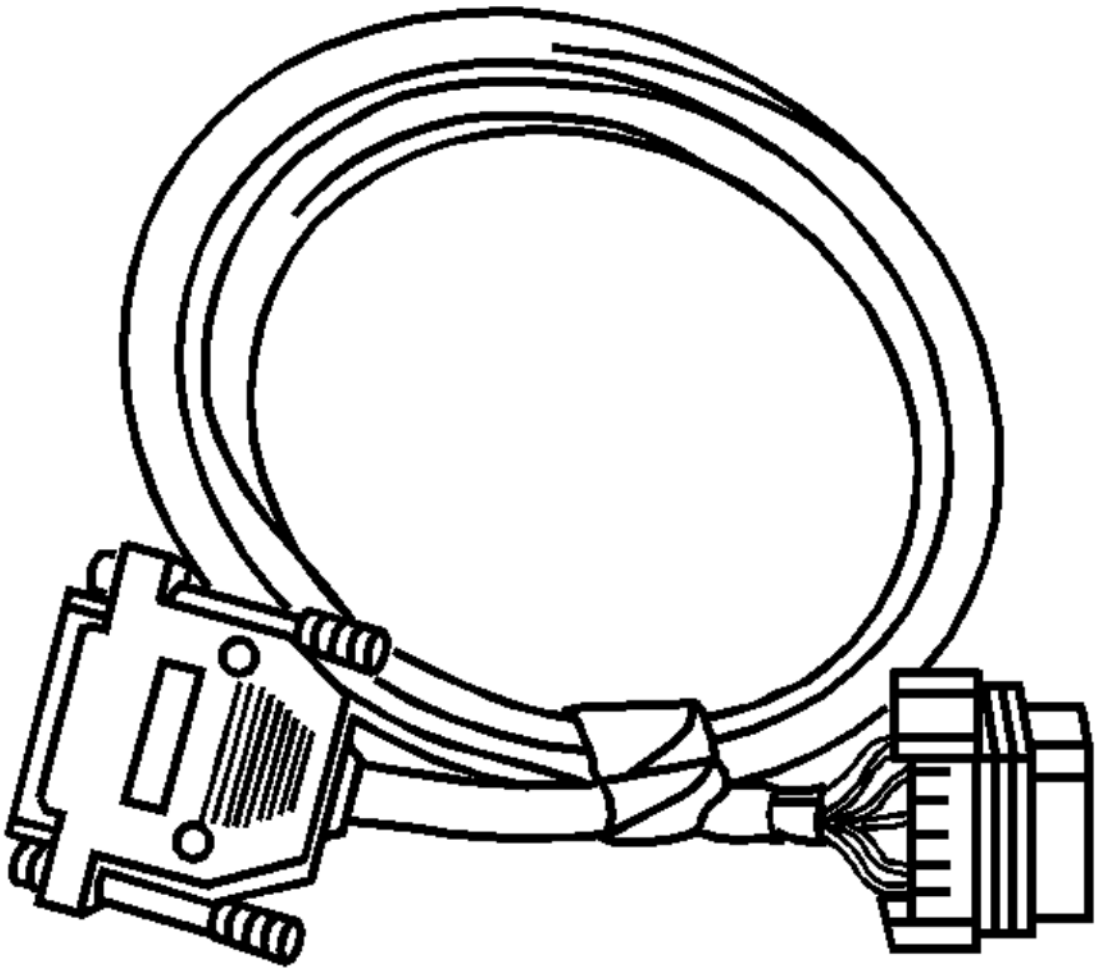
Illustration	Tool Number/Desc
	CH-34730 J-34730- Injector Test



CH-3864
J-38641-
Diesel Fuel C
Tester



CH-39021·
J-39021-3
Fuel Injector I
Adapte



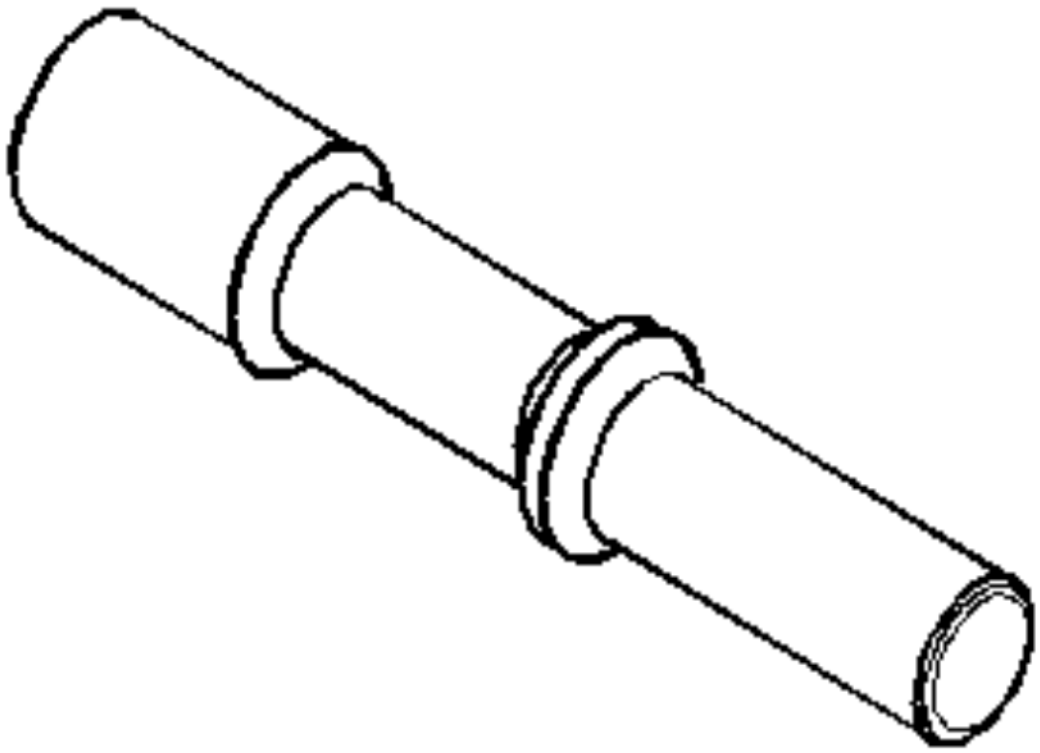
CH-39021-
J-39021-4
Fuel Injecto
Adapte

CH-41415
GE-41415
J-41415-

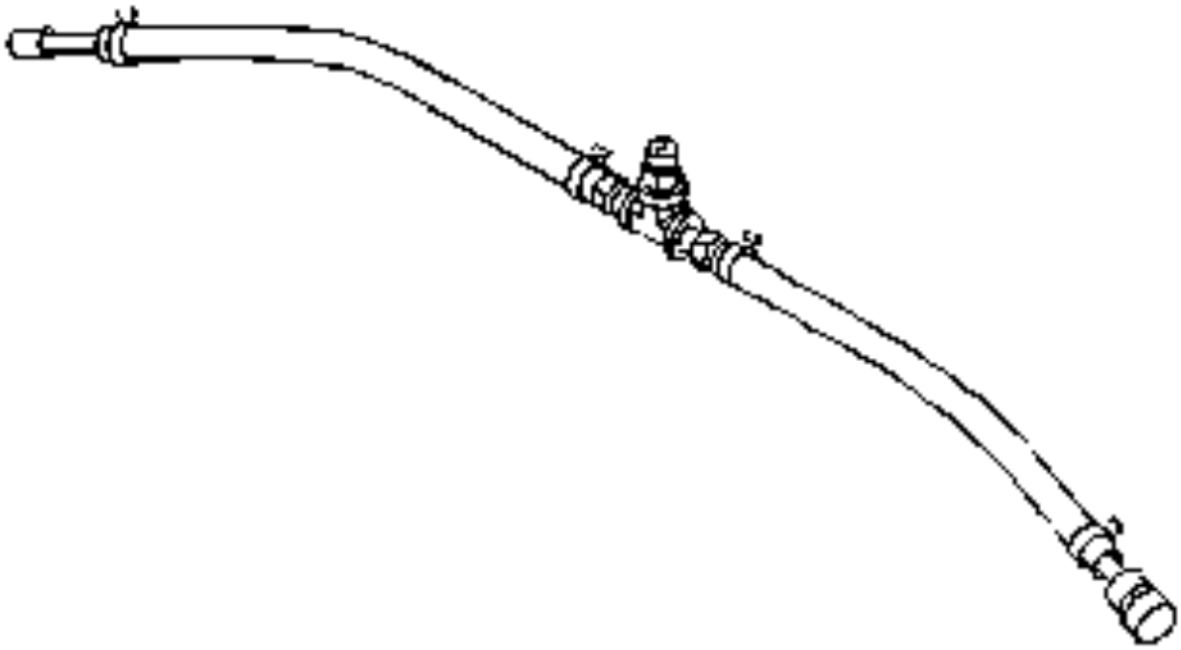
Fuel Tank
Adapte



CH-4296

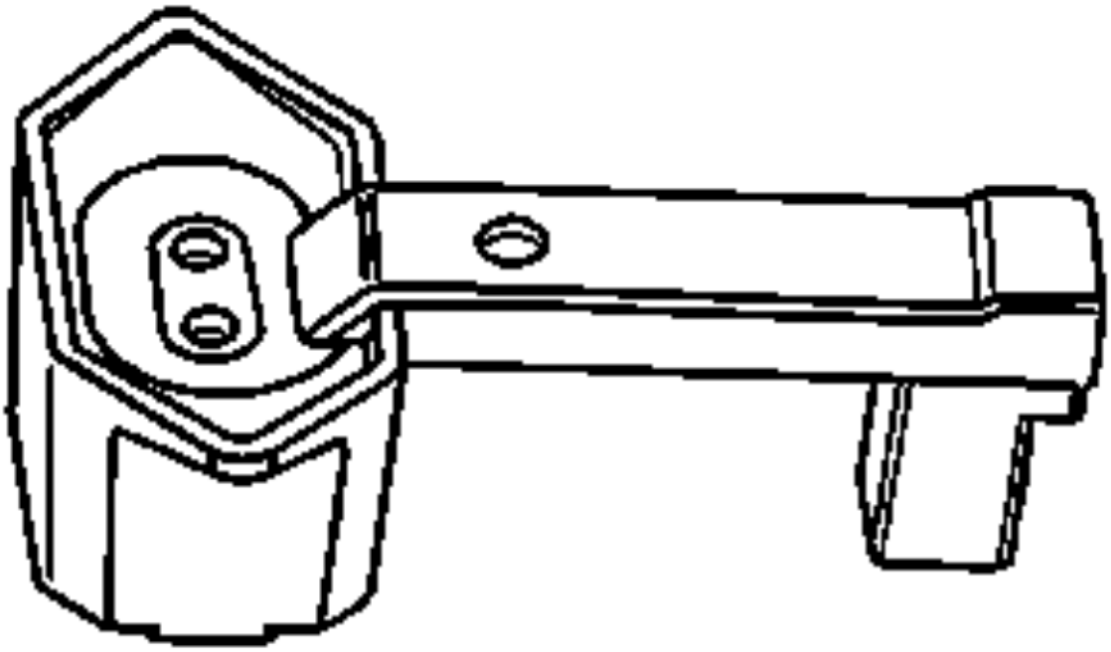


J-42960
Fuel Flapper
Holder



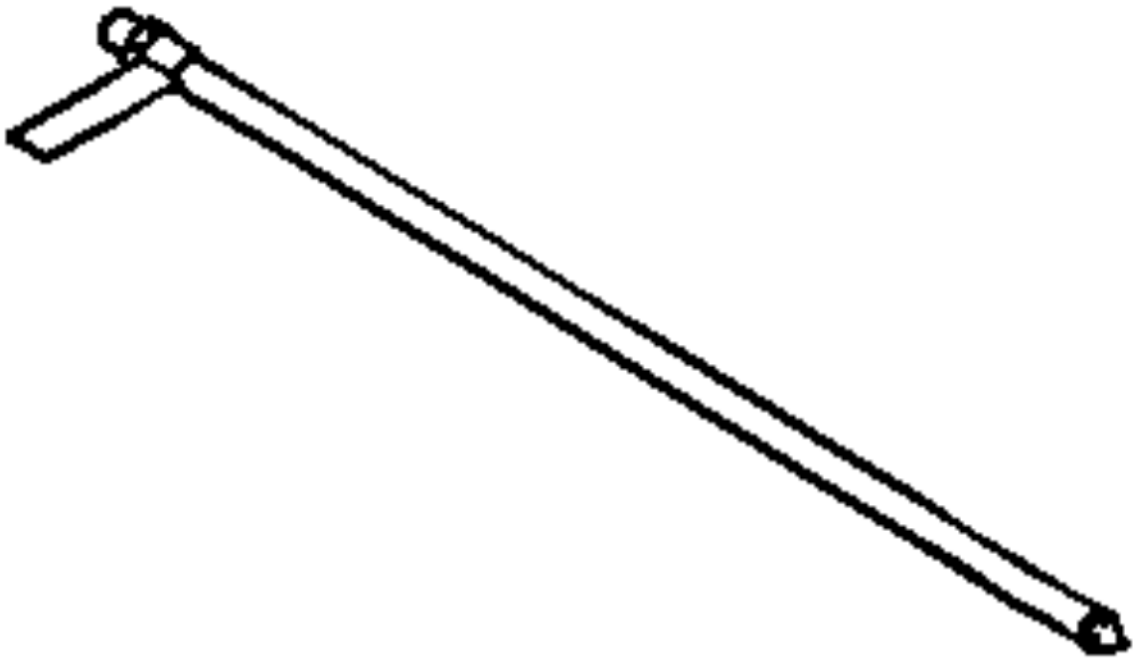
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J-4298
Fuel Pressure
Adapte

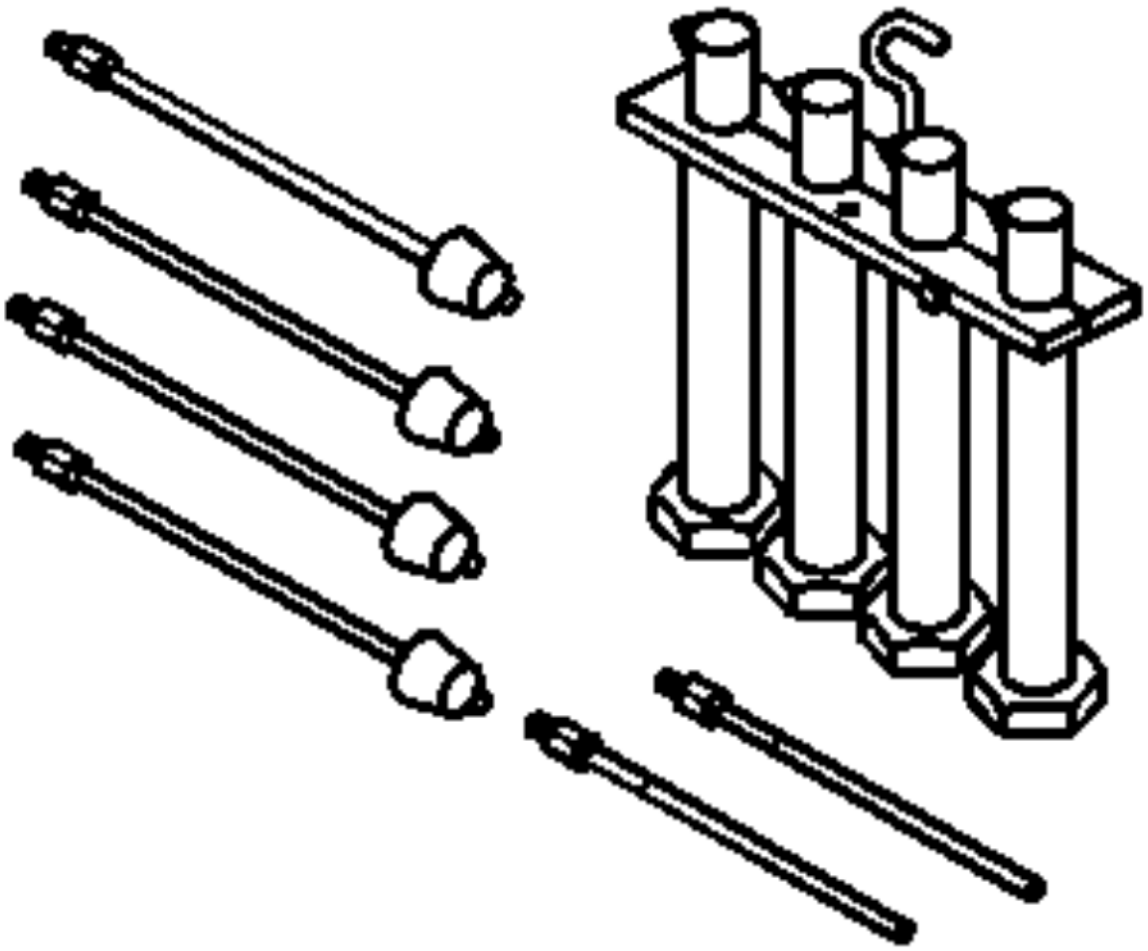
CH-4417
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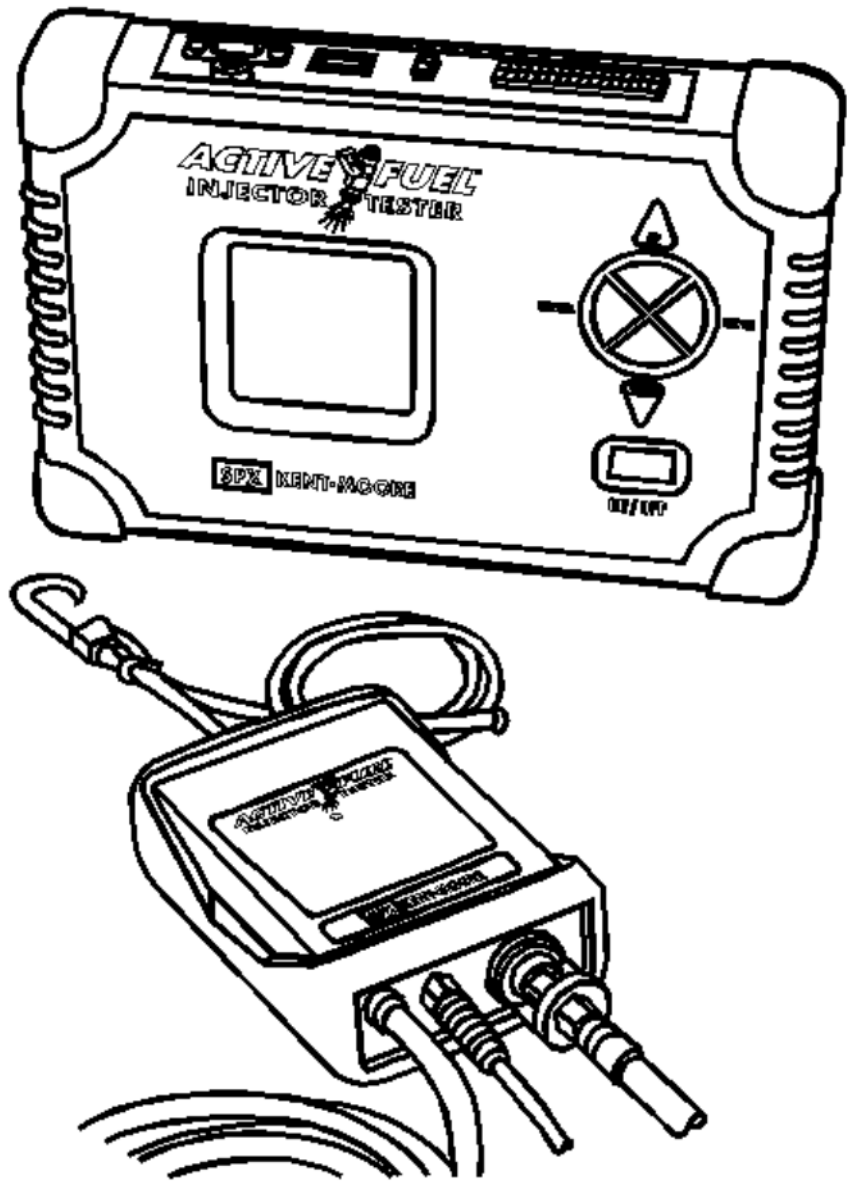


Fuel Compo
Tester

CH-450(
J-4500

	Fuel Tank I Hose
	CH-458 J-4587

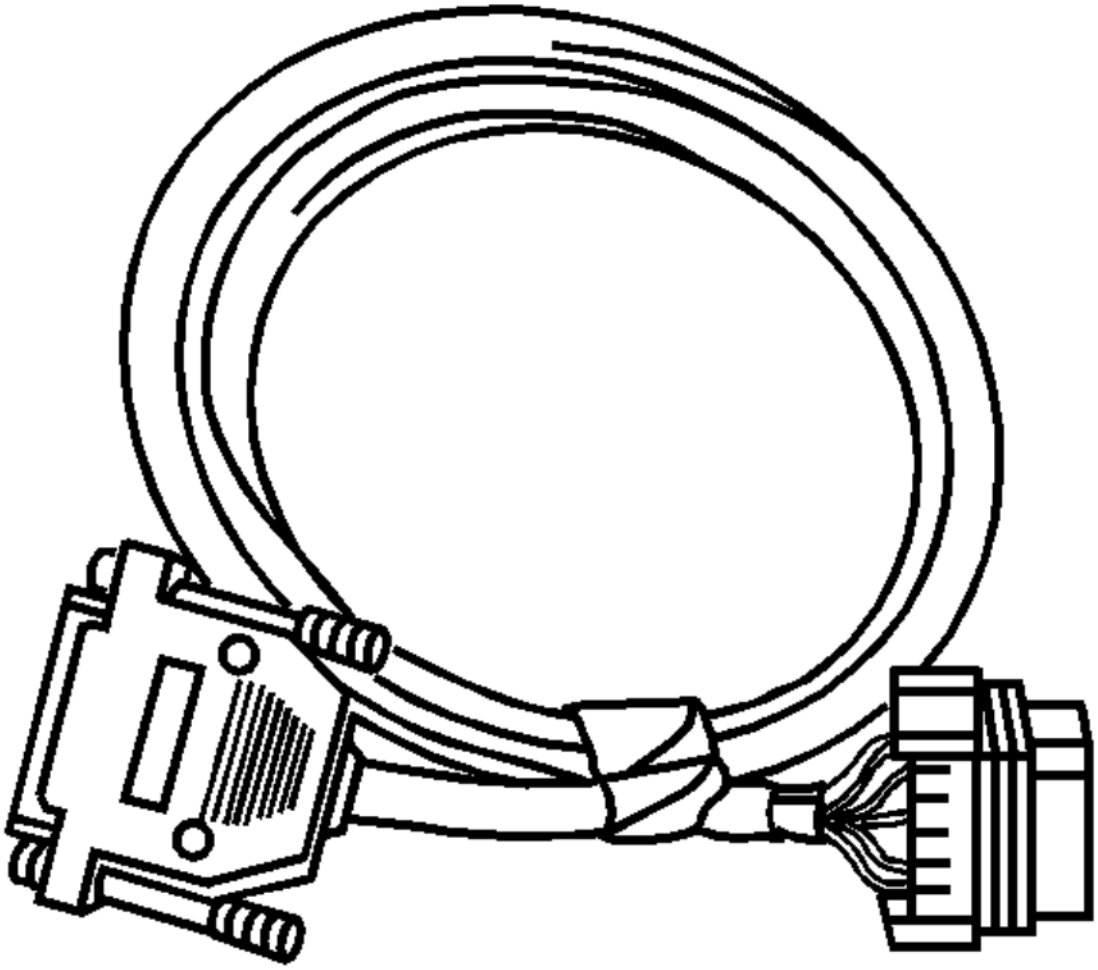
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	CH-479 Active Fuel I



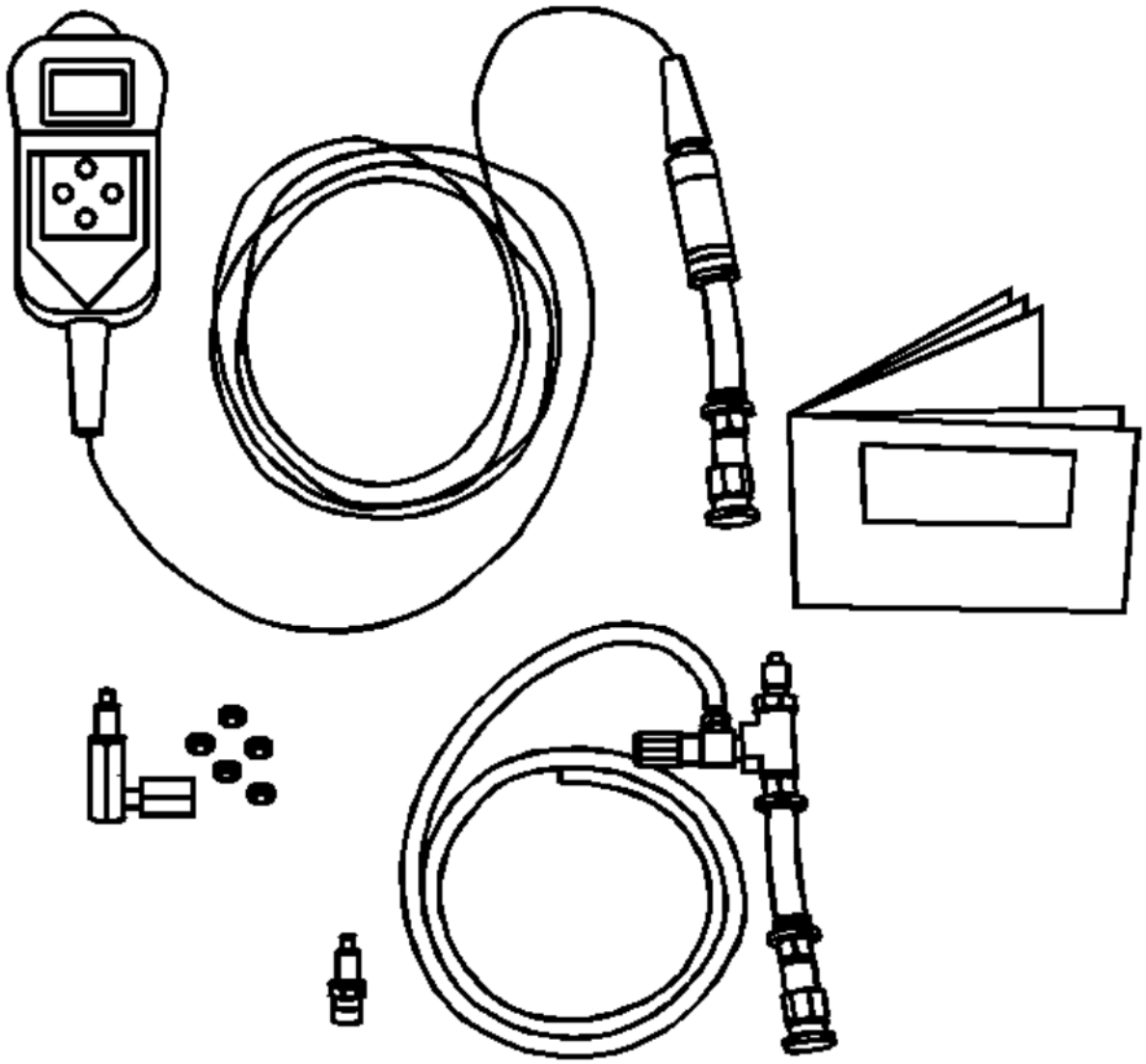
Tester (AF

CH-47976
Fuel Injector I

Adapte

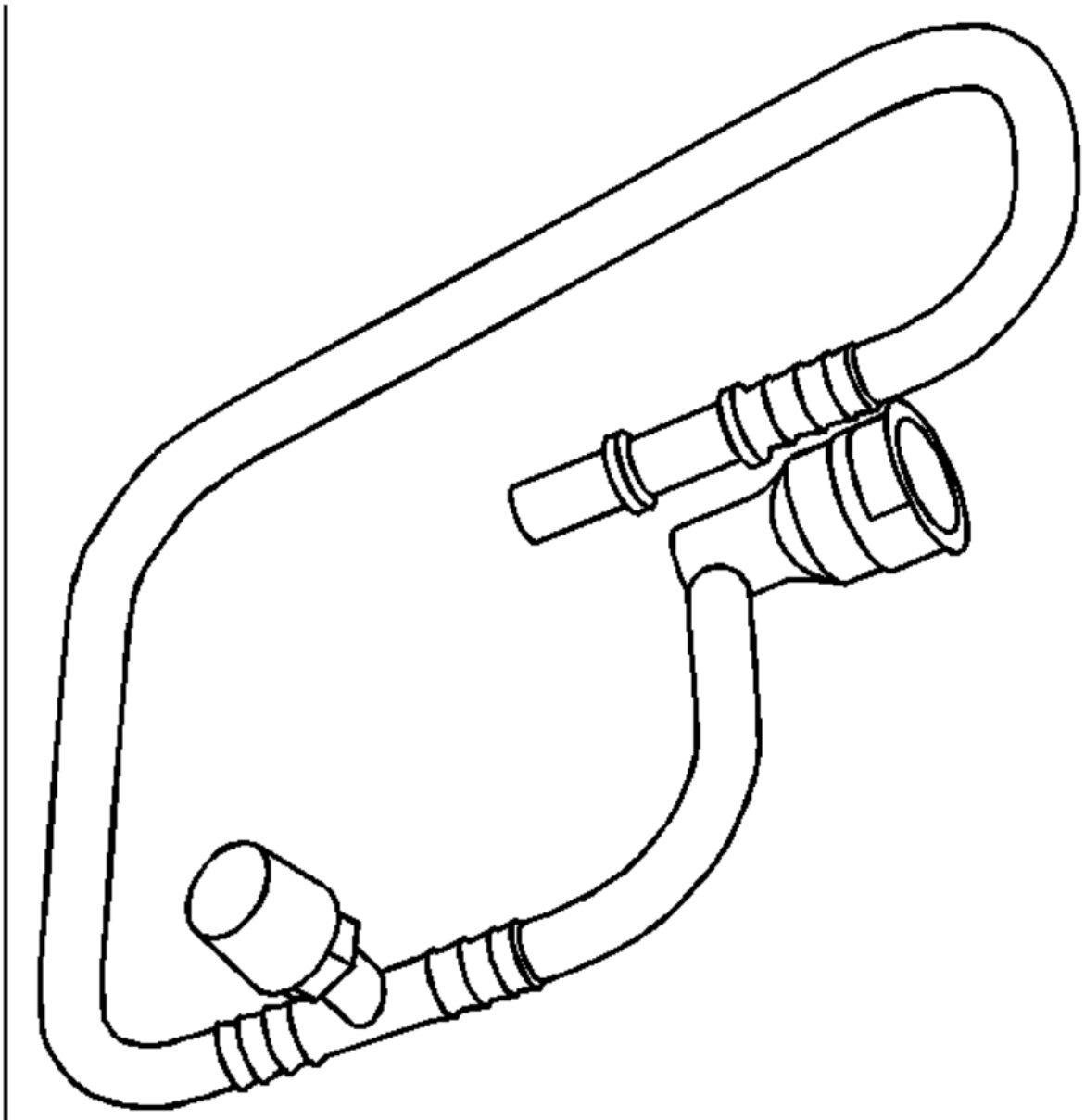


CH-480



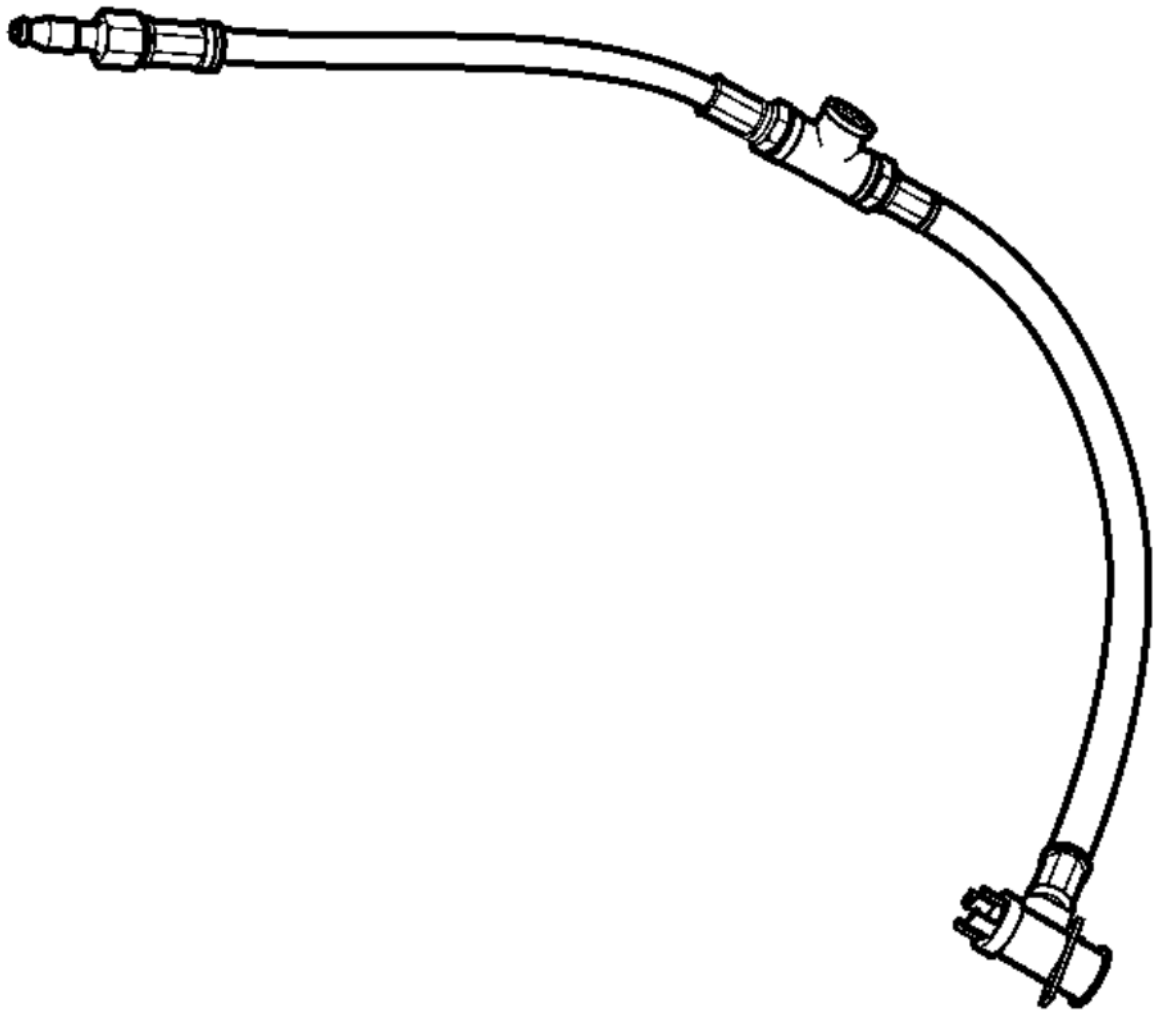
Fuel Pressure

CH-480
EVAP Ser



Access Port

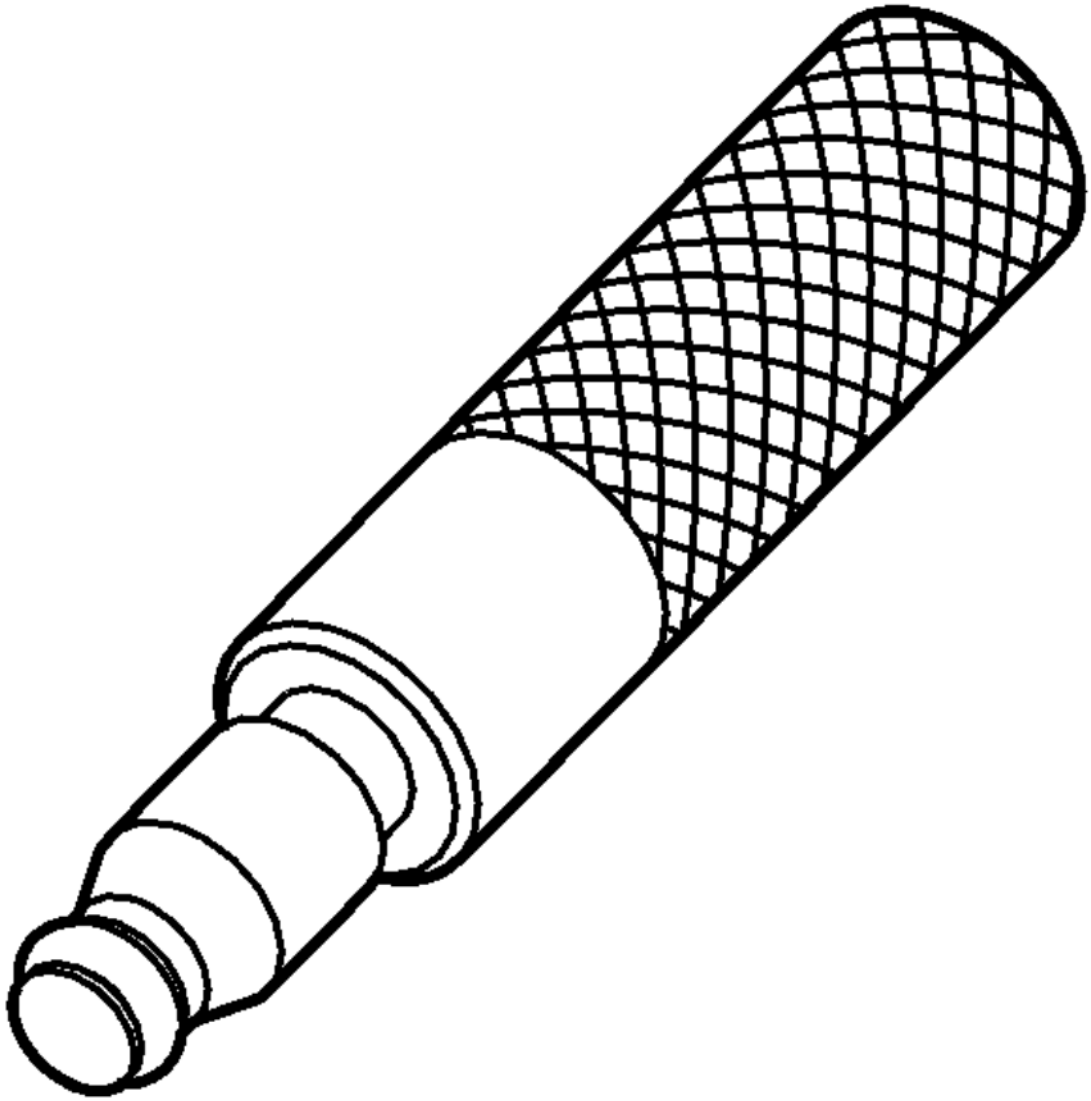
CH-503
Diesel Inje



Return Line P
Adapte

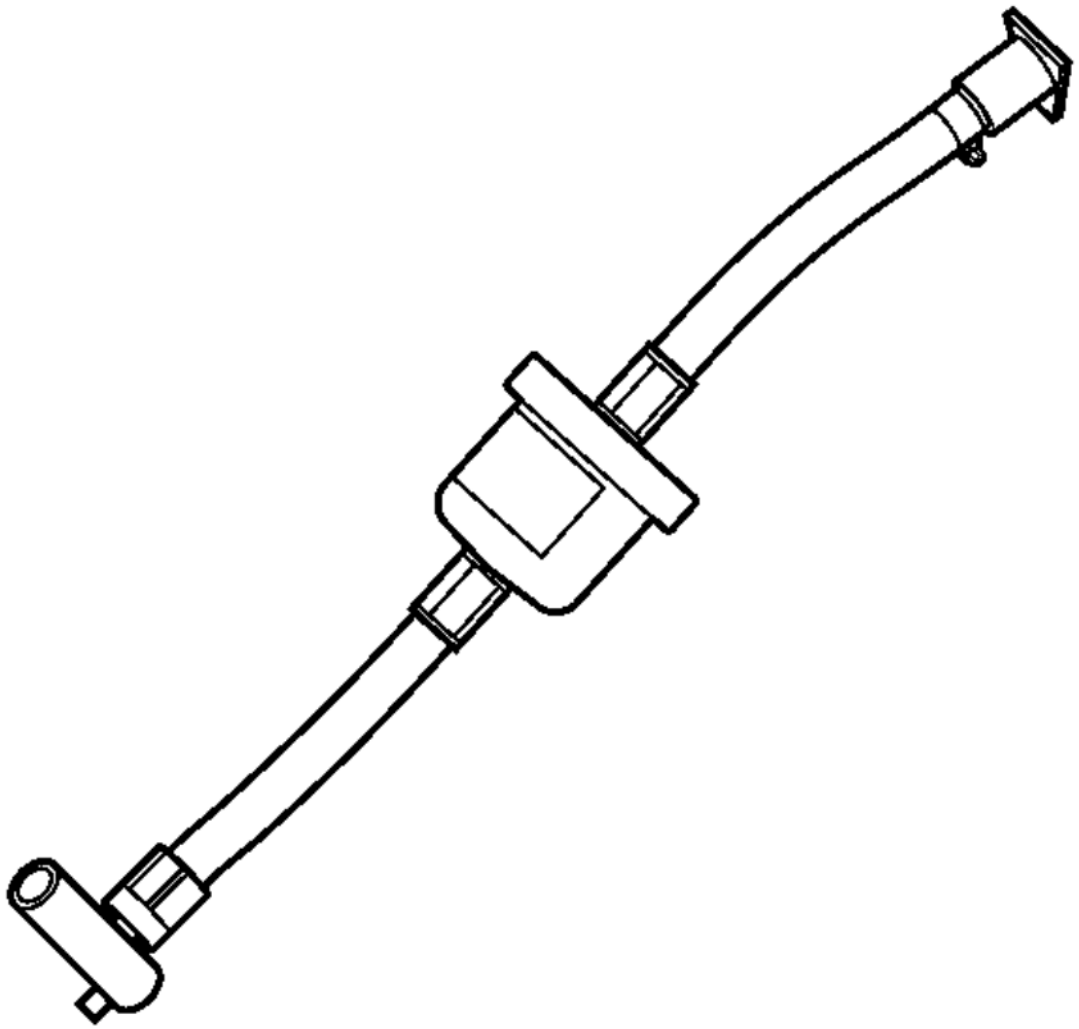
CH-5037
Injector Retu

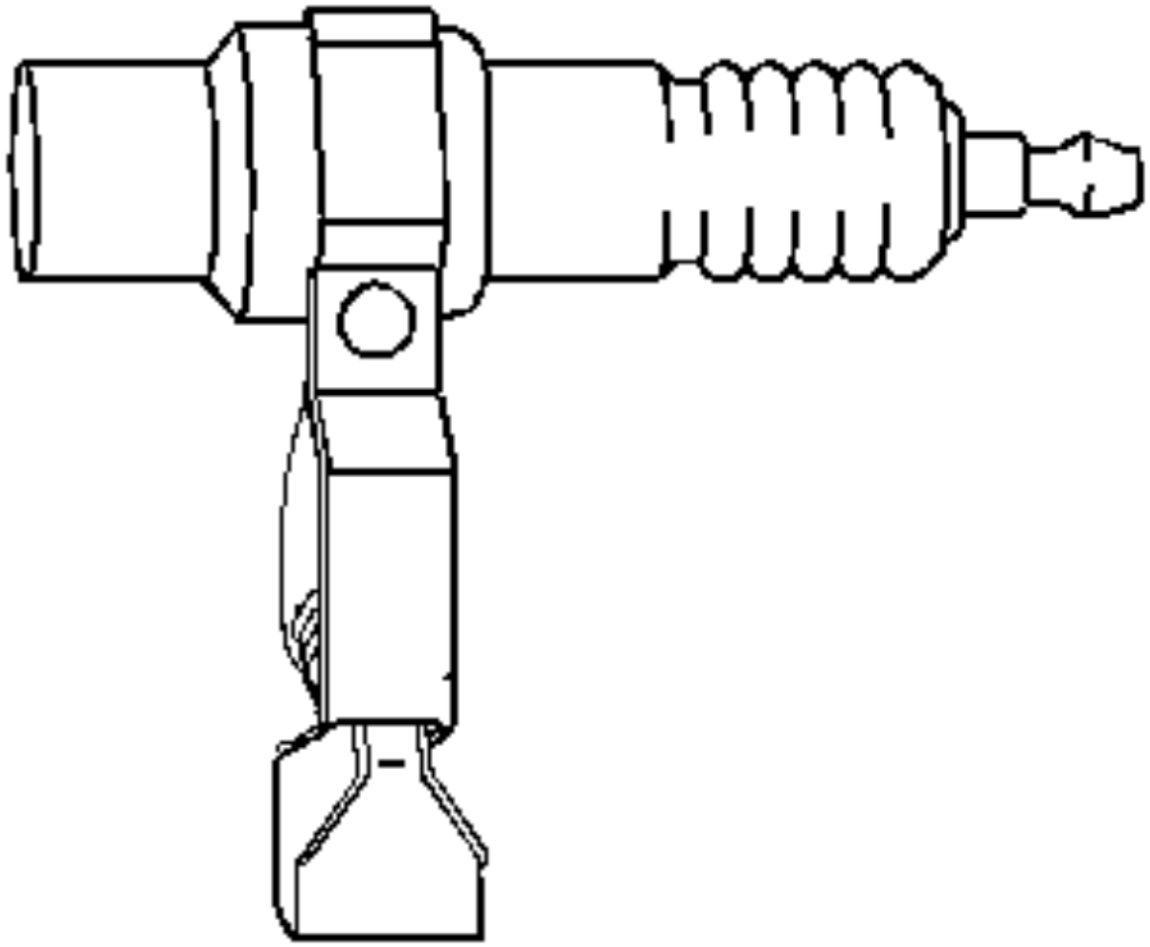
Cap



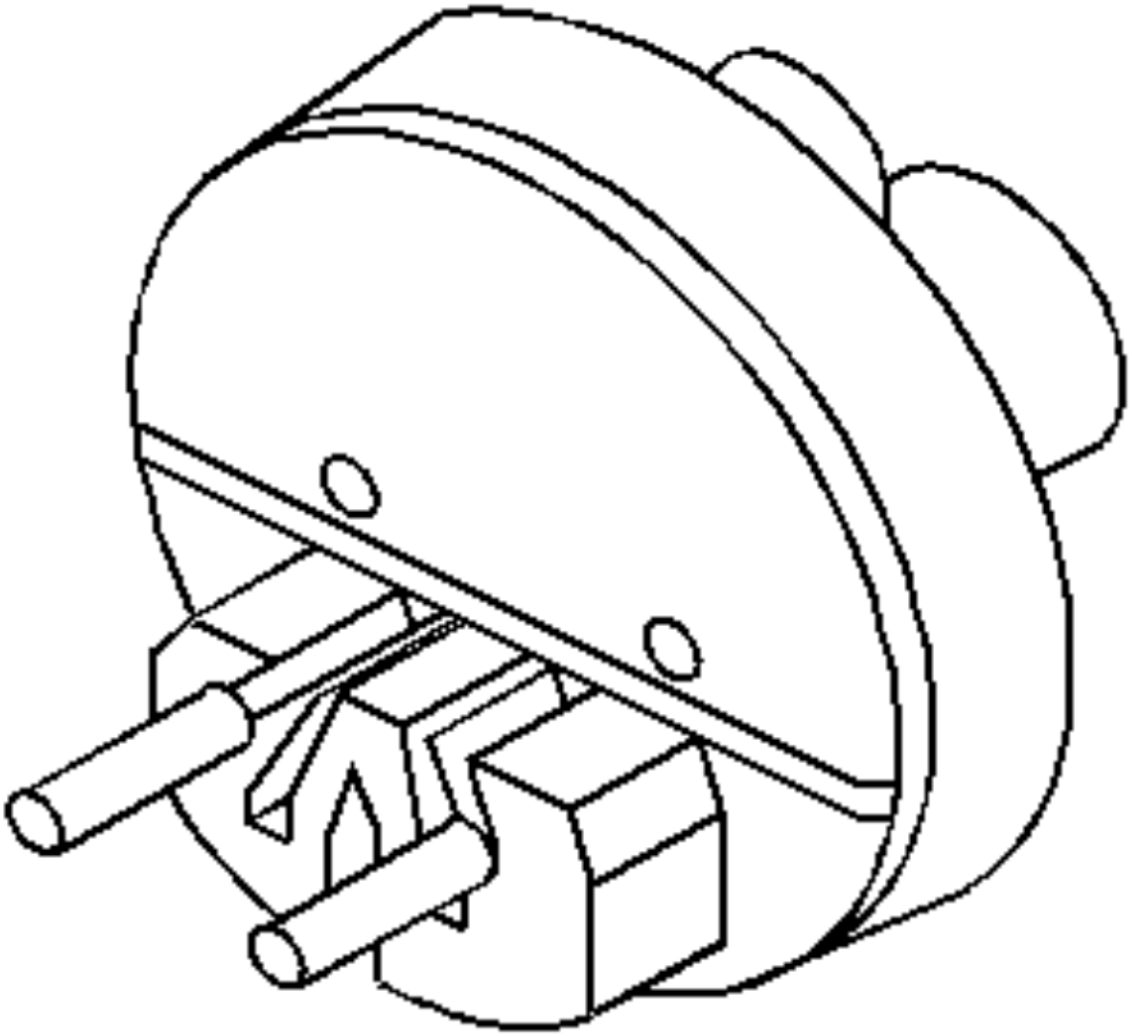
CH-503
Injector Re

Leakage T
Adapte

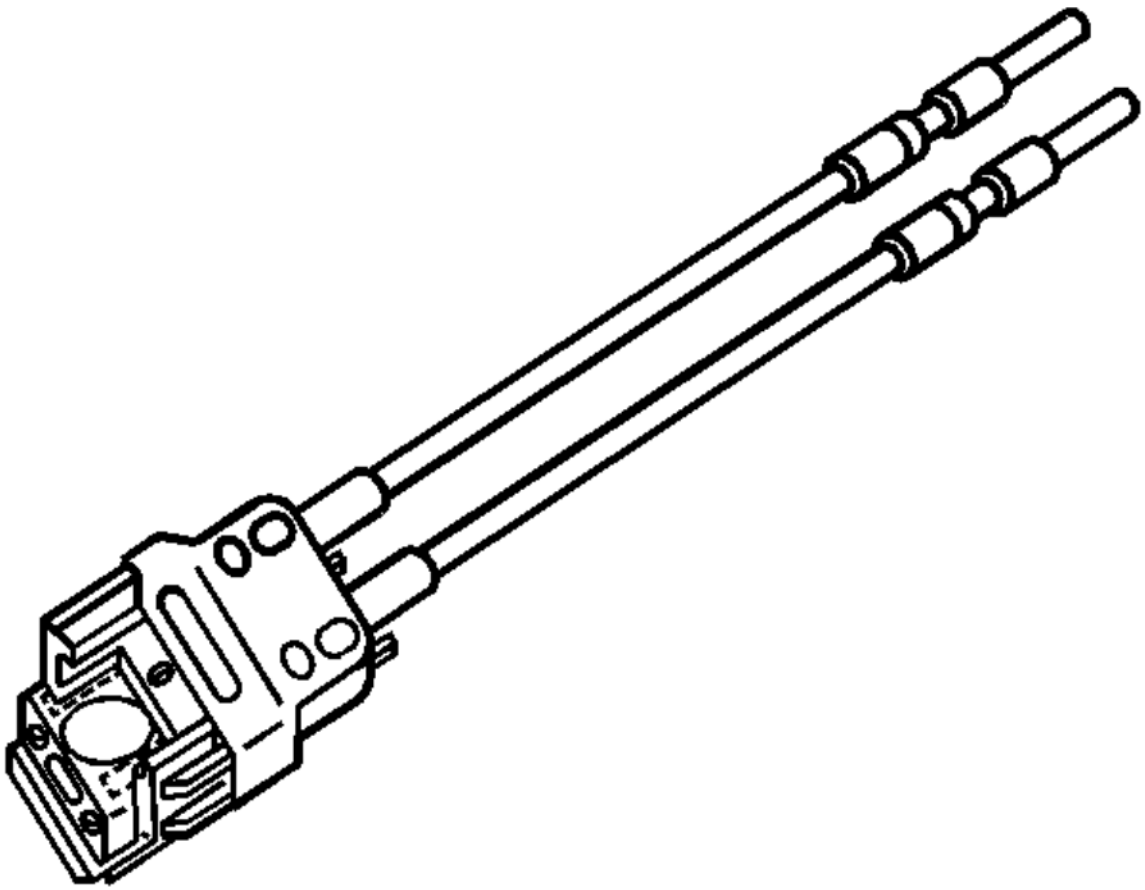




EL-2679
J-2679
HEI Spark T

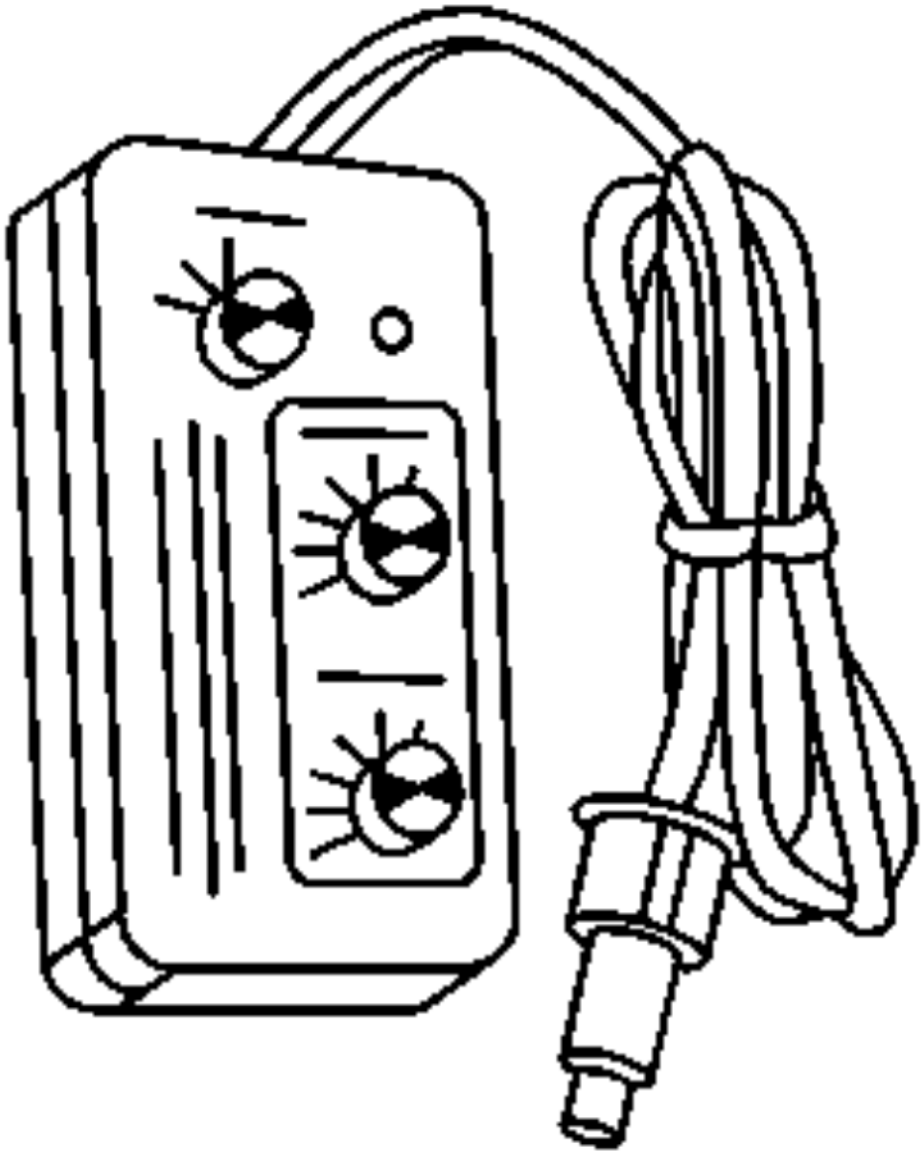


EL-34730-
J-34730-4
Injector Test

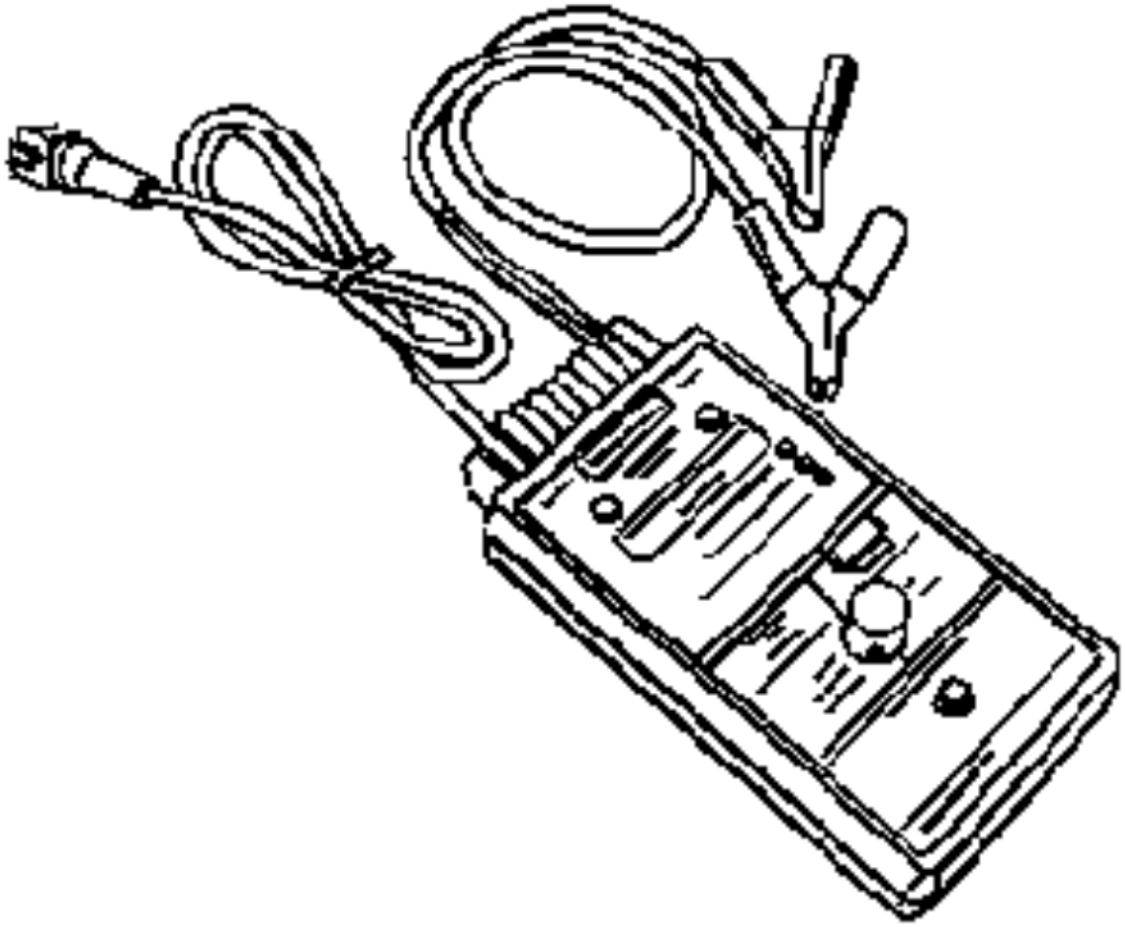


EL-36169-
Heavy Duty
Jumper

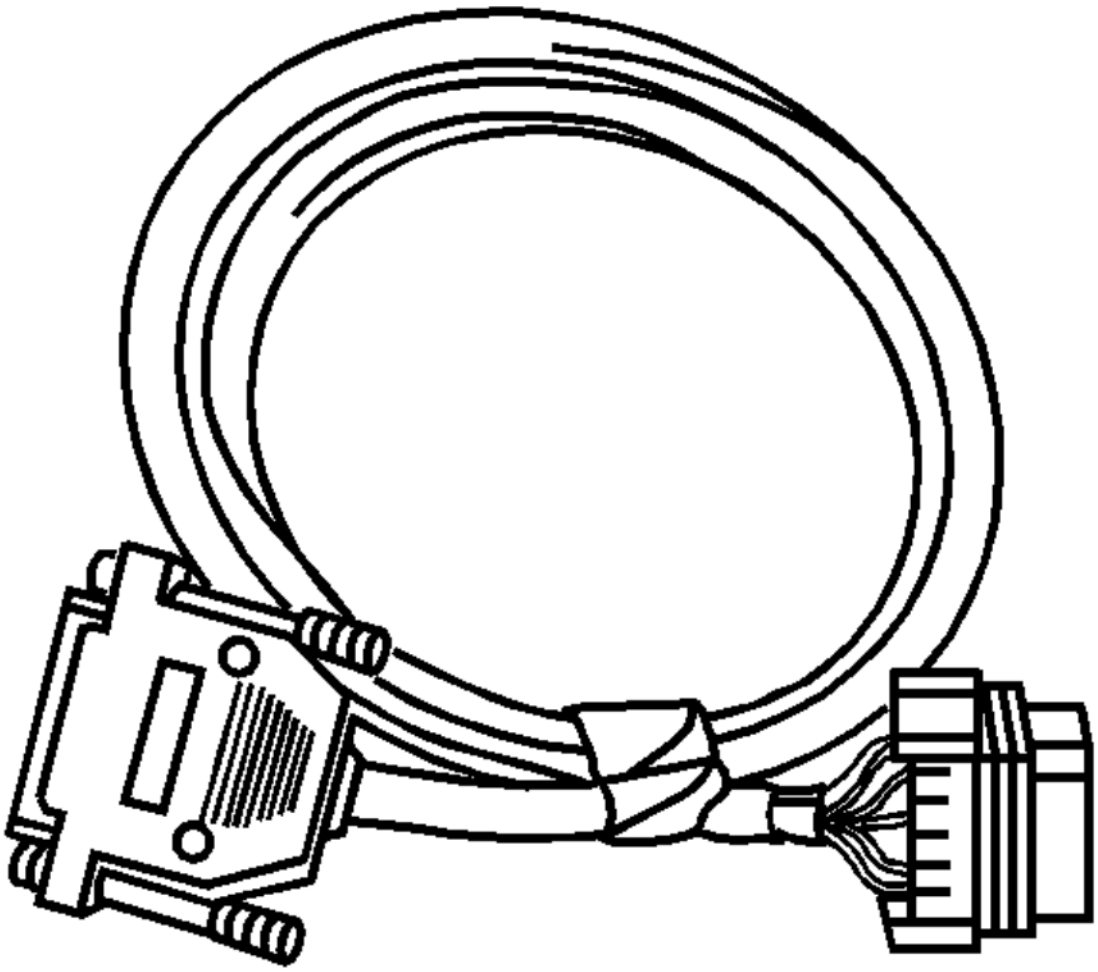
EL-38522



J-38522-
Variable Si
Generat

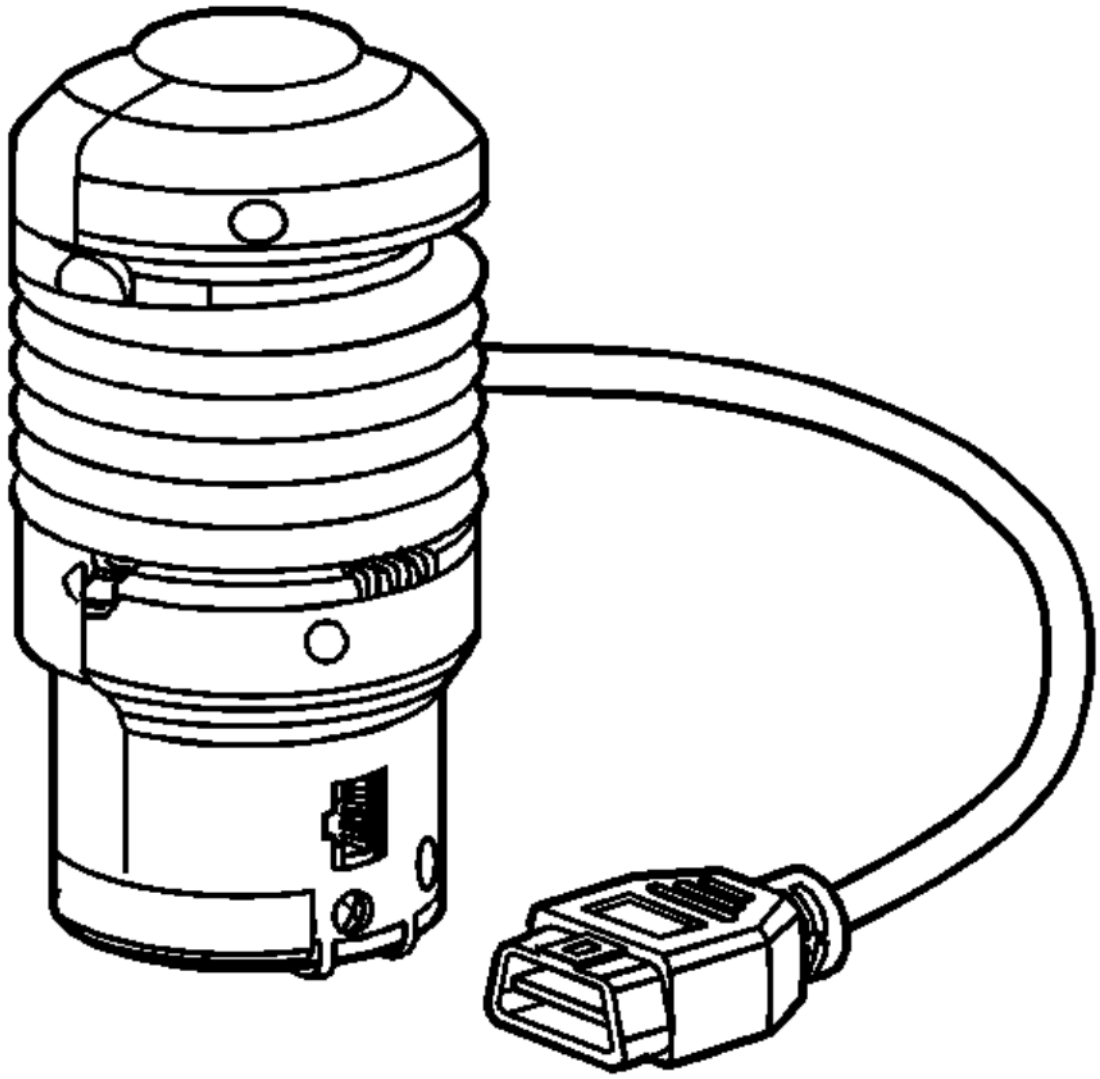


EL-3902
J-3902
Fuel Injecto
Balance Te



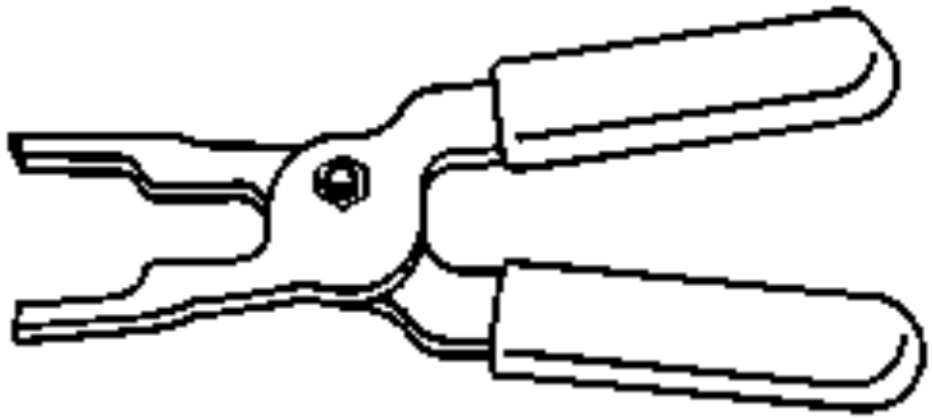
EL-39021-
J-39021-4
Fuel Injecto
Adapte

EL-42598
J-42598-



Vehicle D
Recorde

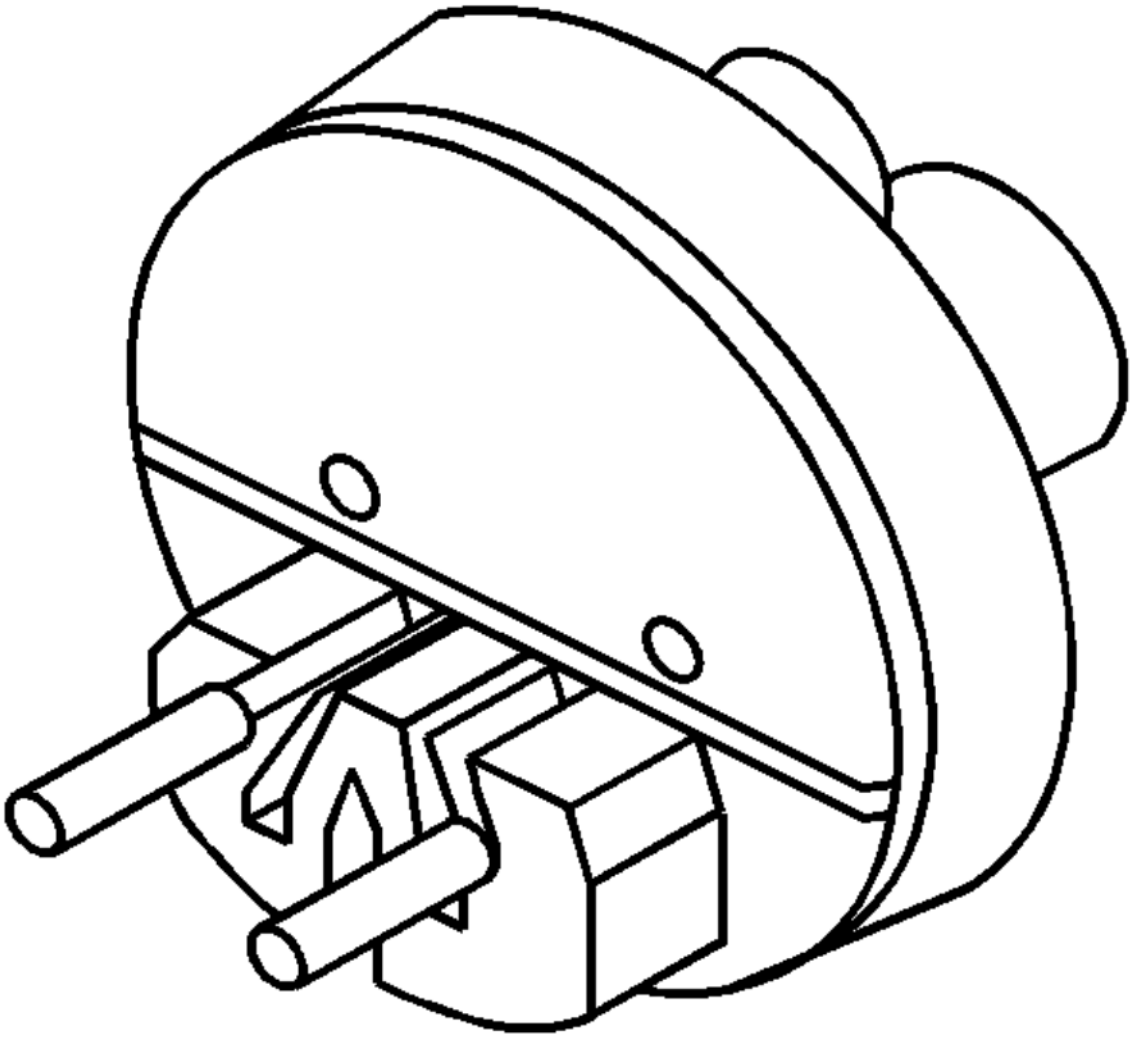
EL-432
J-4324



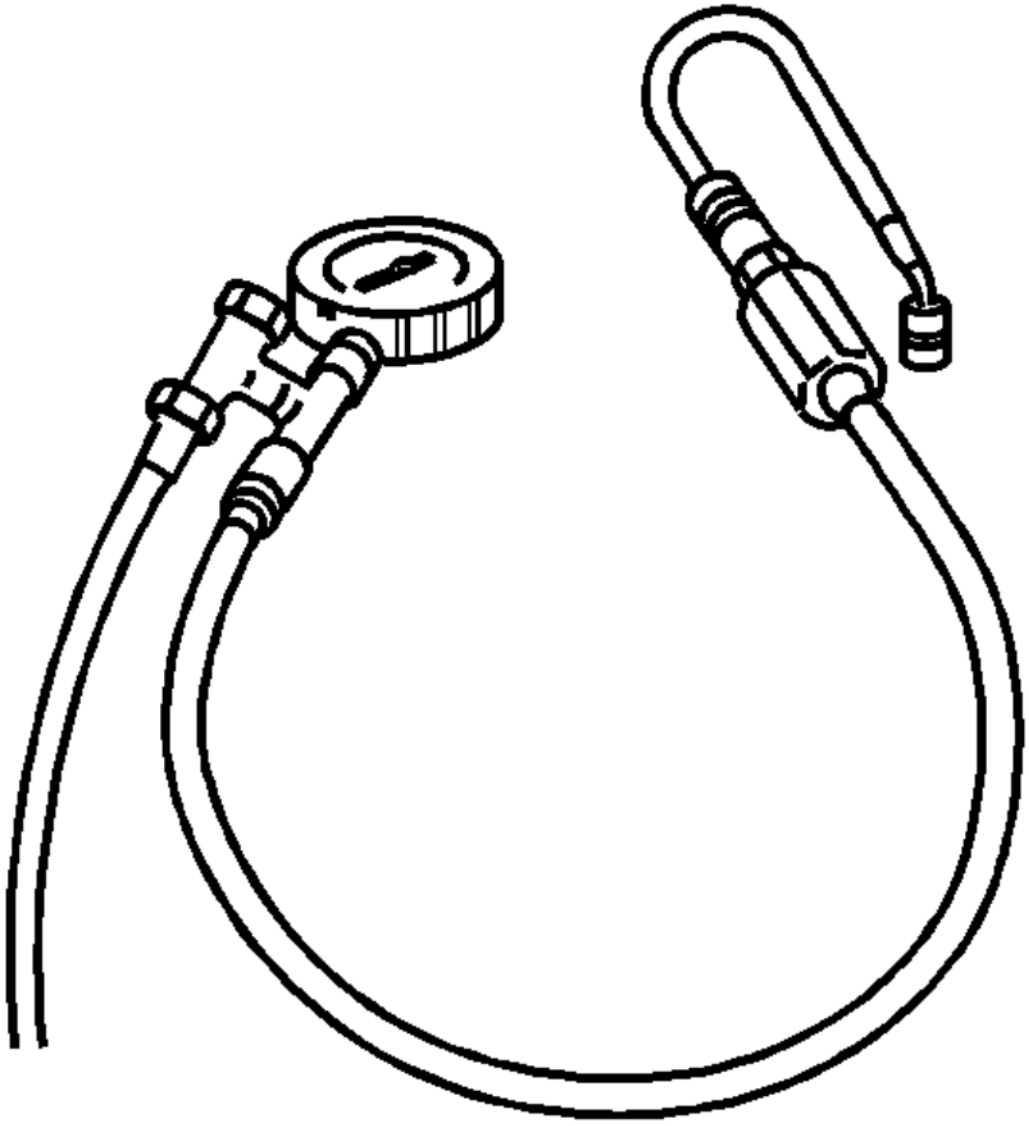
Relay Puller

EL-4460
J-4460

Injector Test

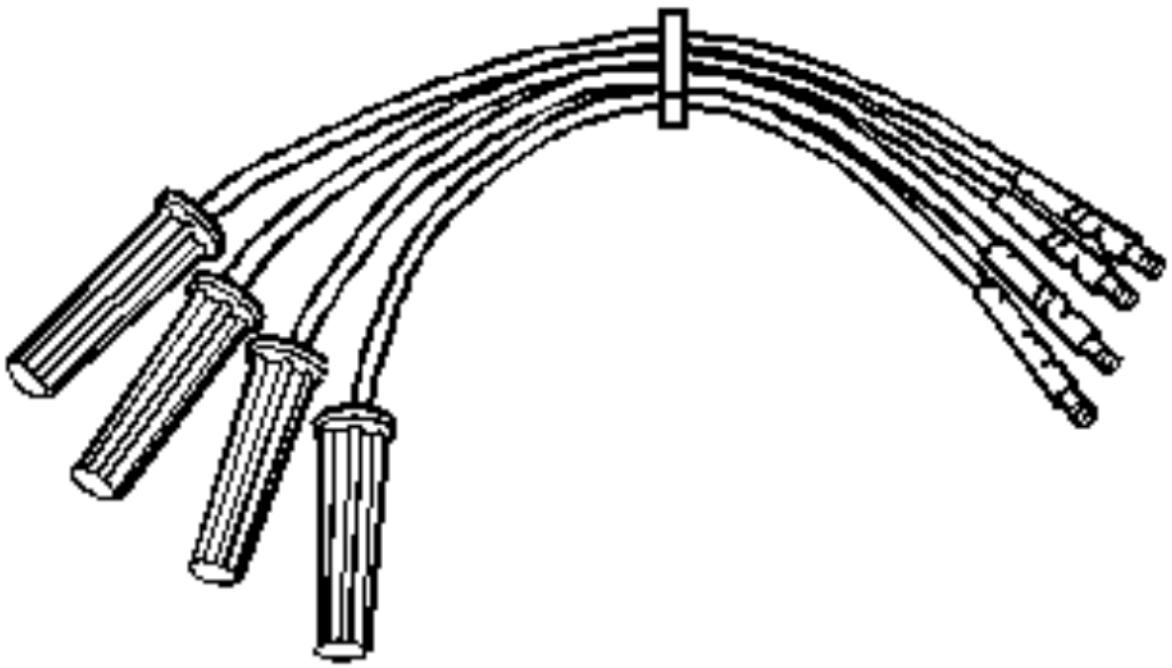


EN-34730
J-34730-

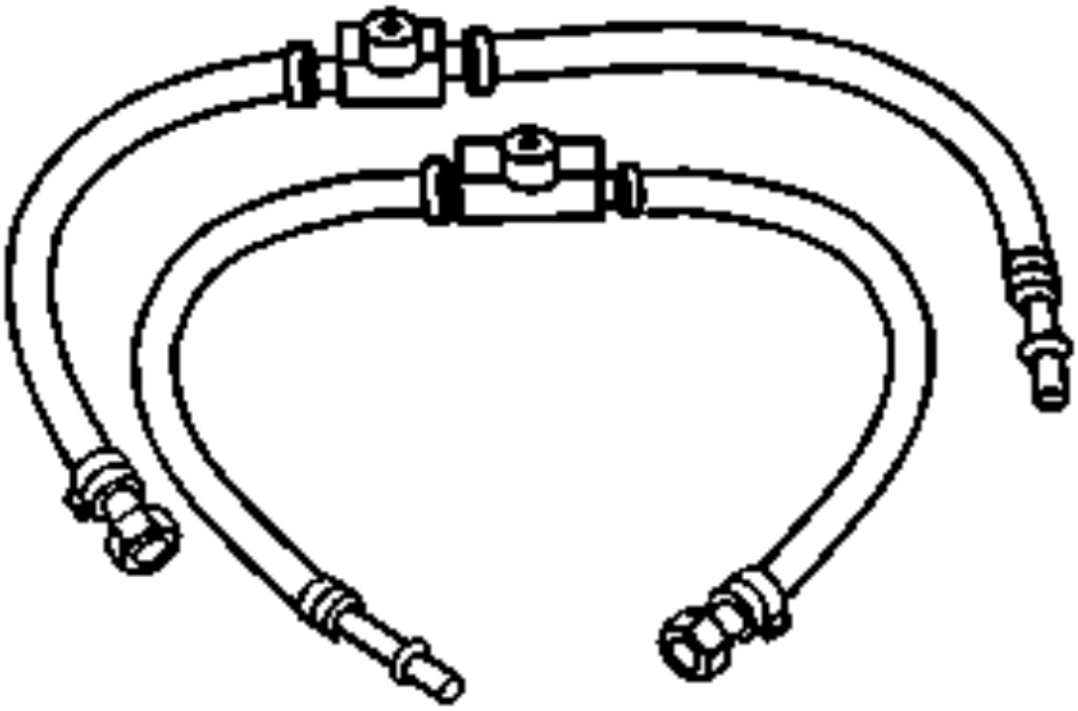


KM-J-3473
Pressure T

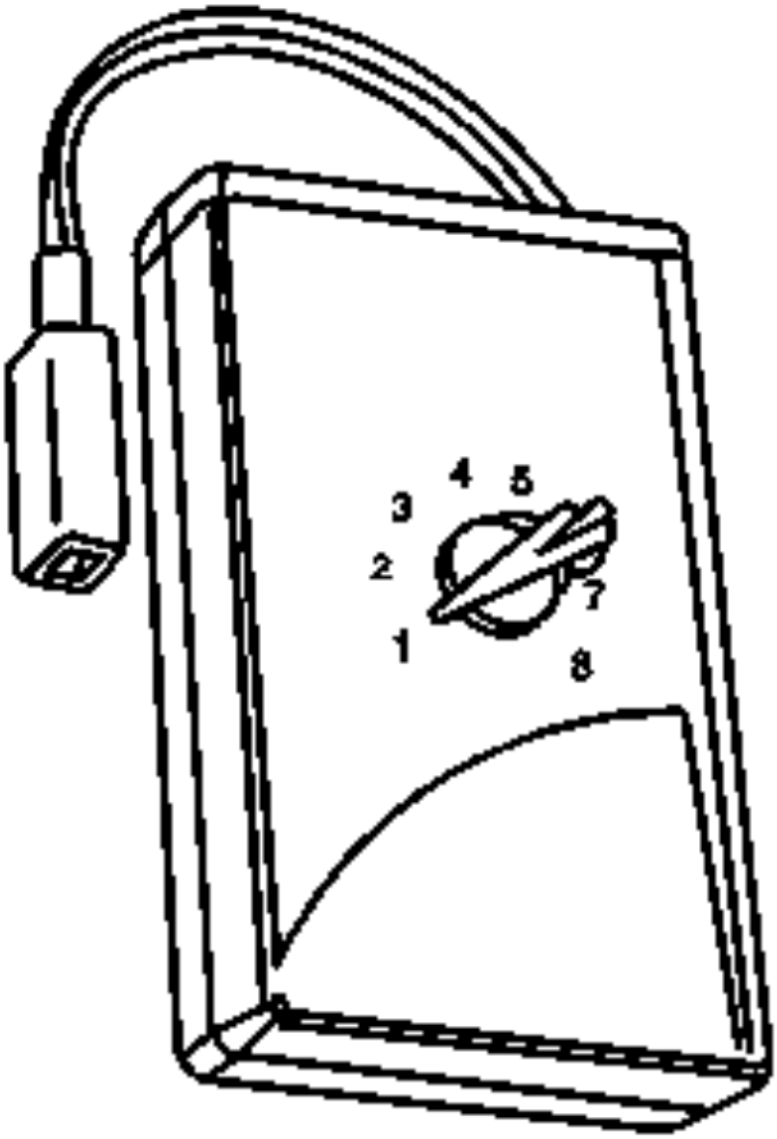
EN-3601



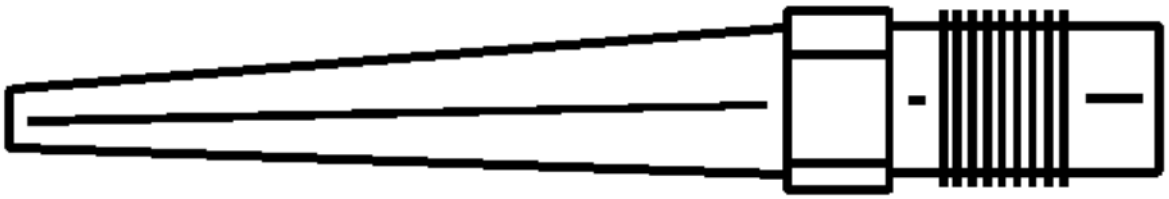
J-36012-
Ignition Sy
Diagnosis H



EN-372
J-3728
Fuel Line Sh
Adapter

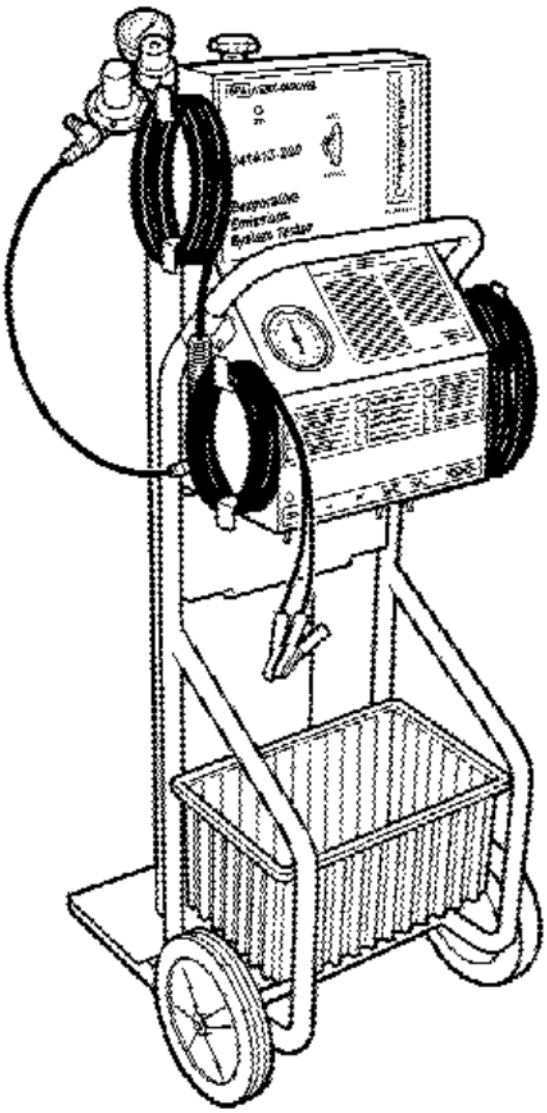


EN-39021-
J-39021-2
Injector Te
Adapter E



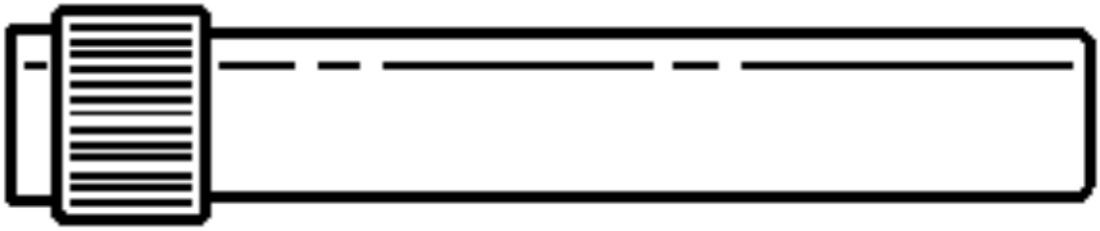
EN-41413-
J-41413-3
EVAP Pl

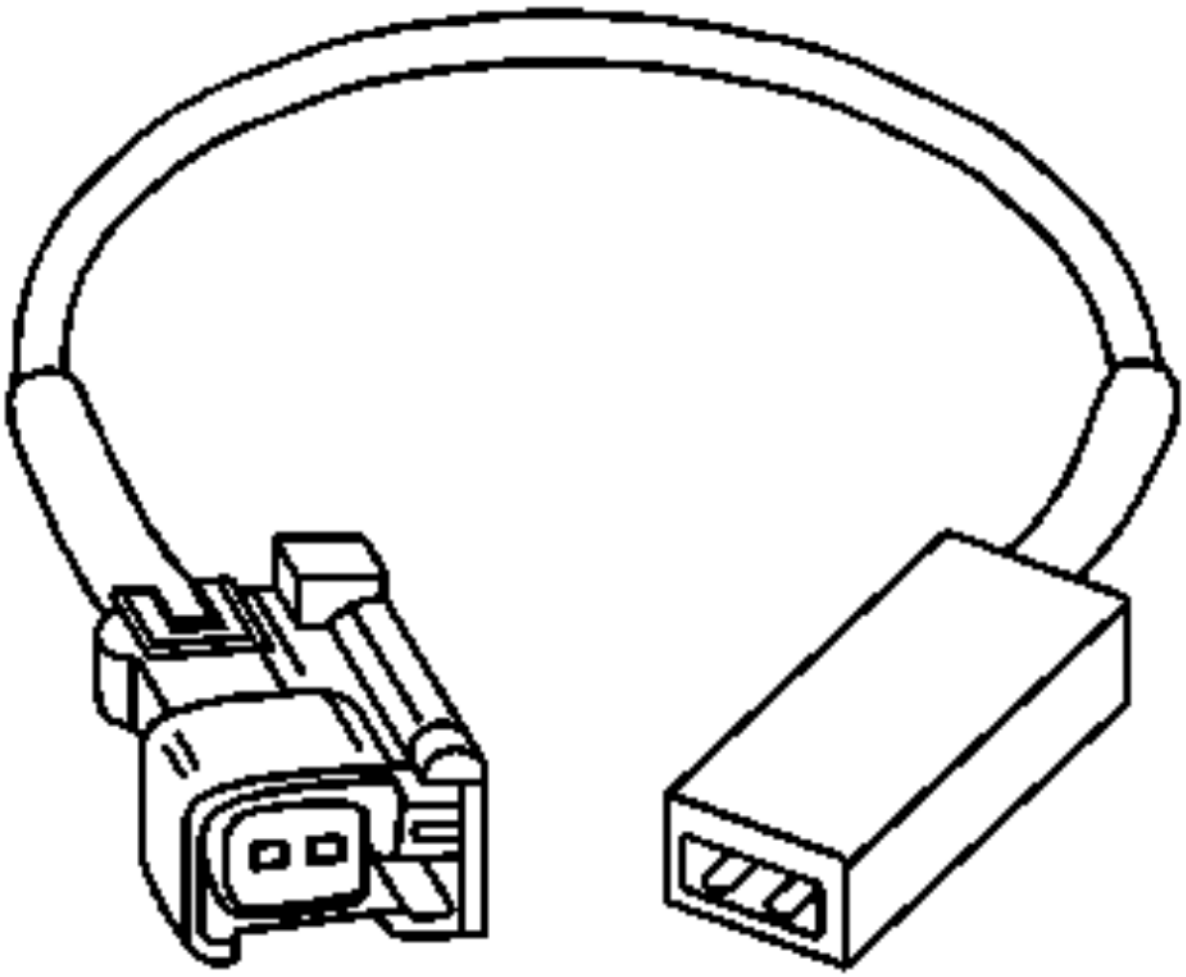
GE-41413
EN-41413
J-41413-



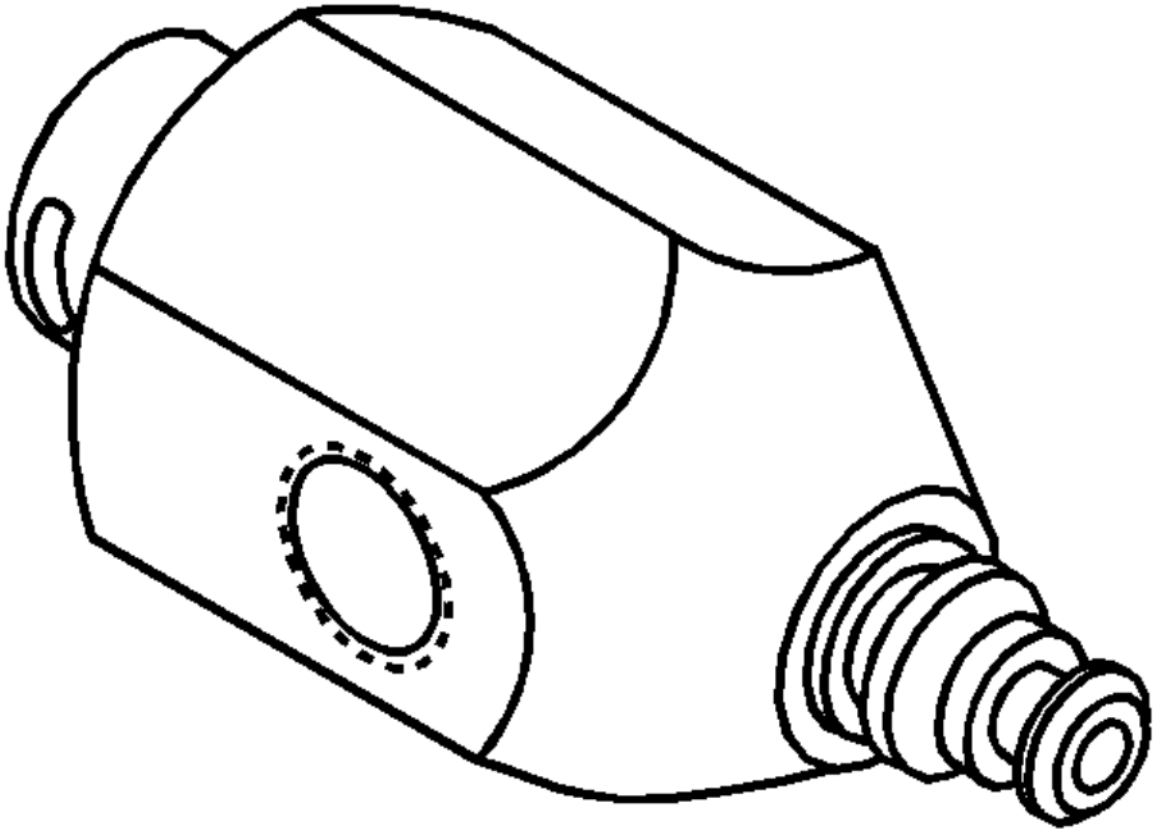
Evaporat
Emissions S
Tester (EE

EN-41413-
J-41413-V

	EVAP Servic Vent Fitti

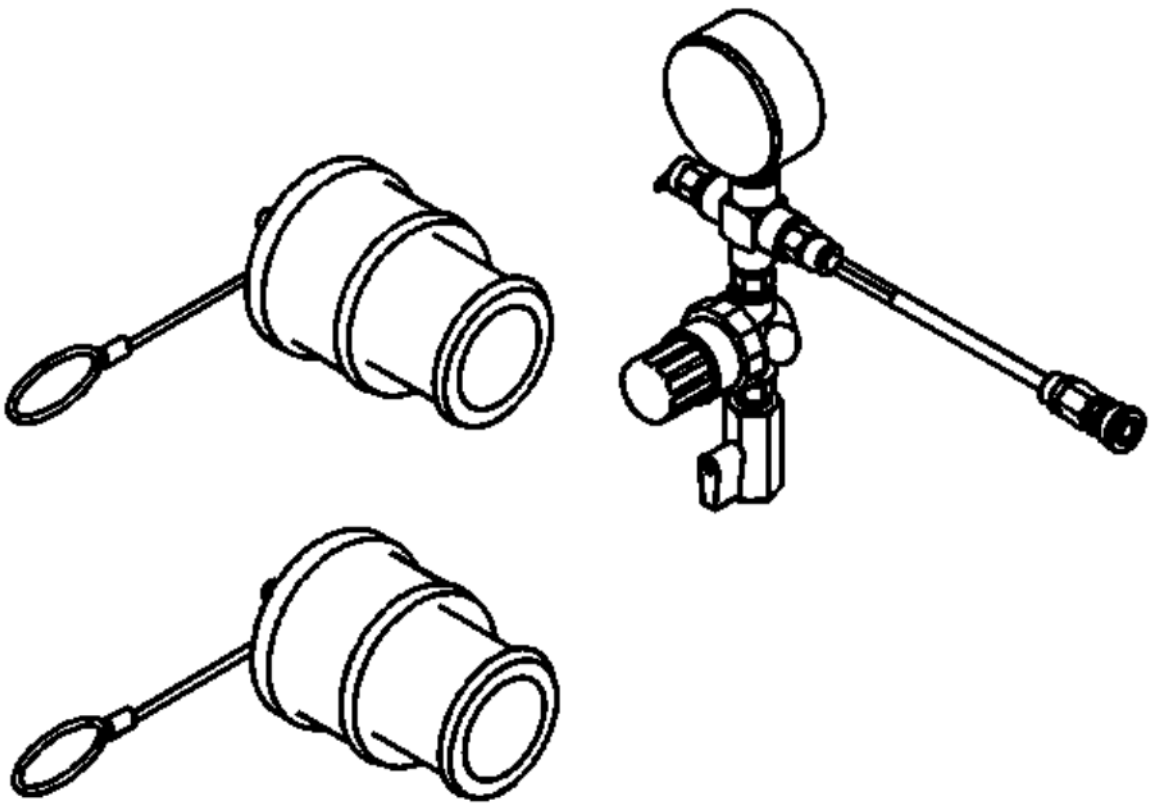


EN-446(
J-4460:
Injector Test A



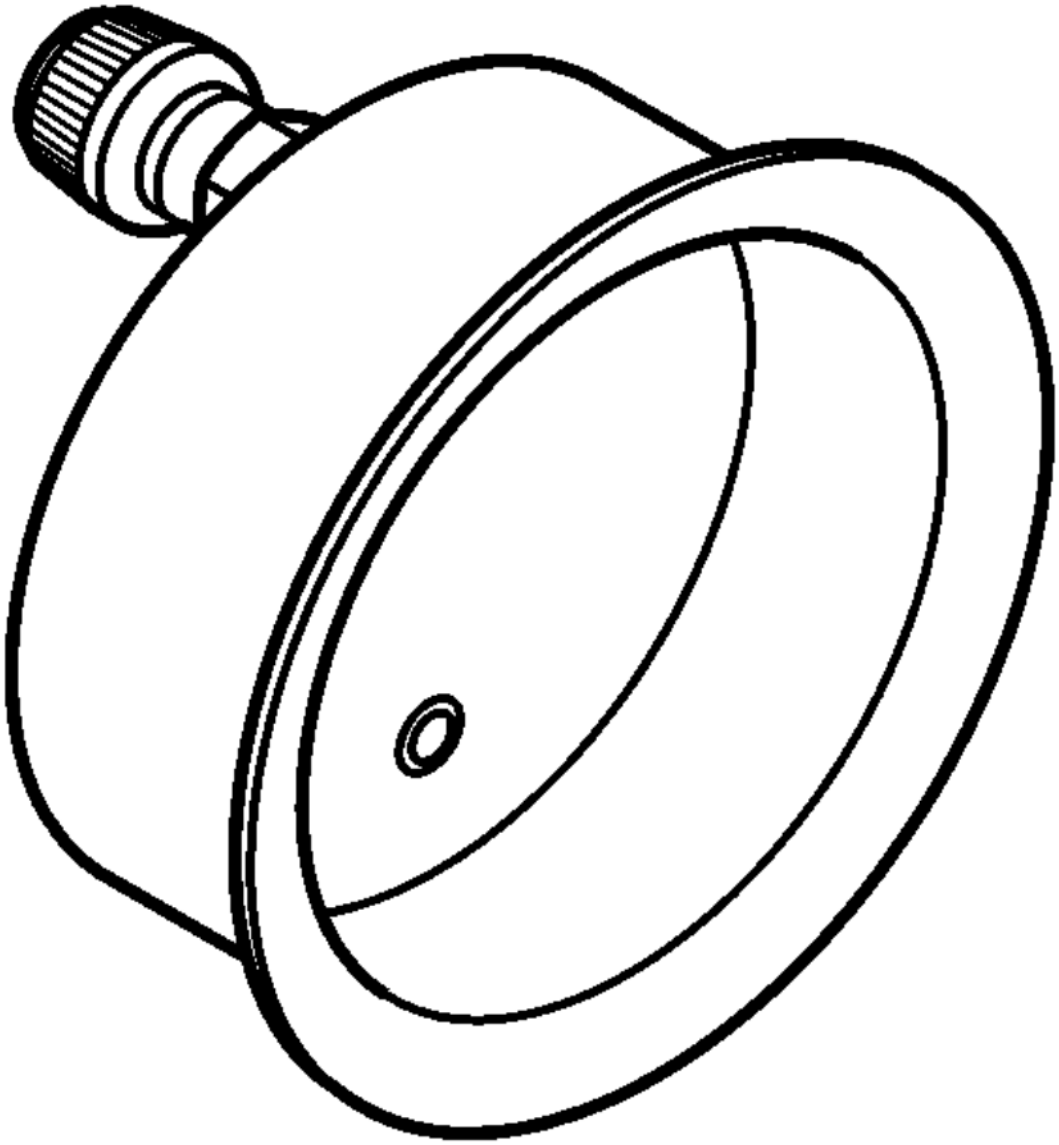
EN-45873
J-45873-
Injector Flo
Adapte

EN-4609
J-4609



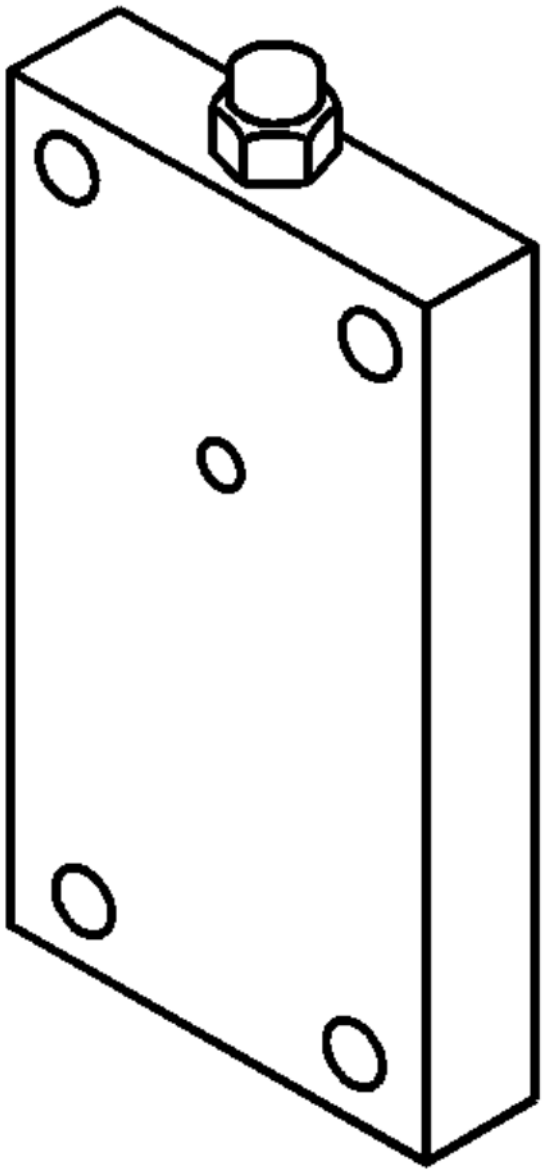
Charge Air C
Tester

EN-46091-
J-46091-1
Diesel Eng



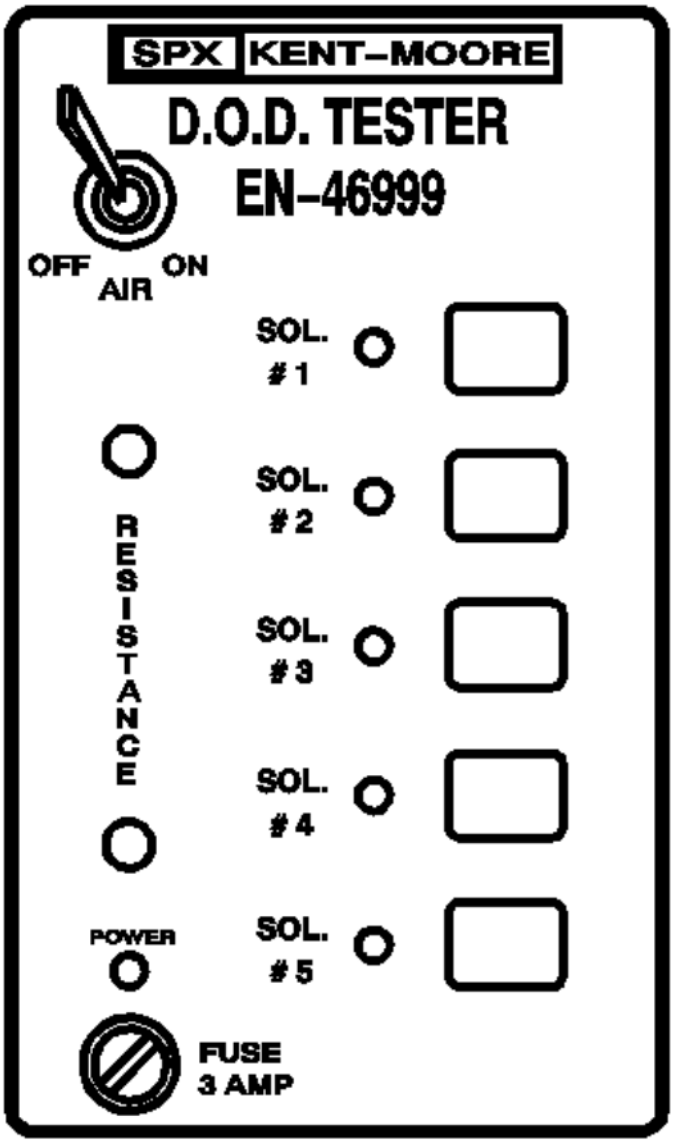
Pressure T
Adapte

EN-4609
J-46091



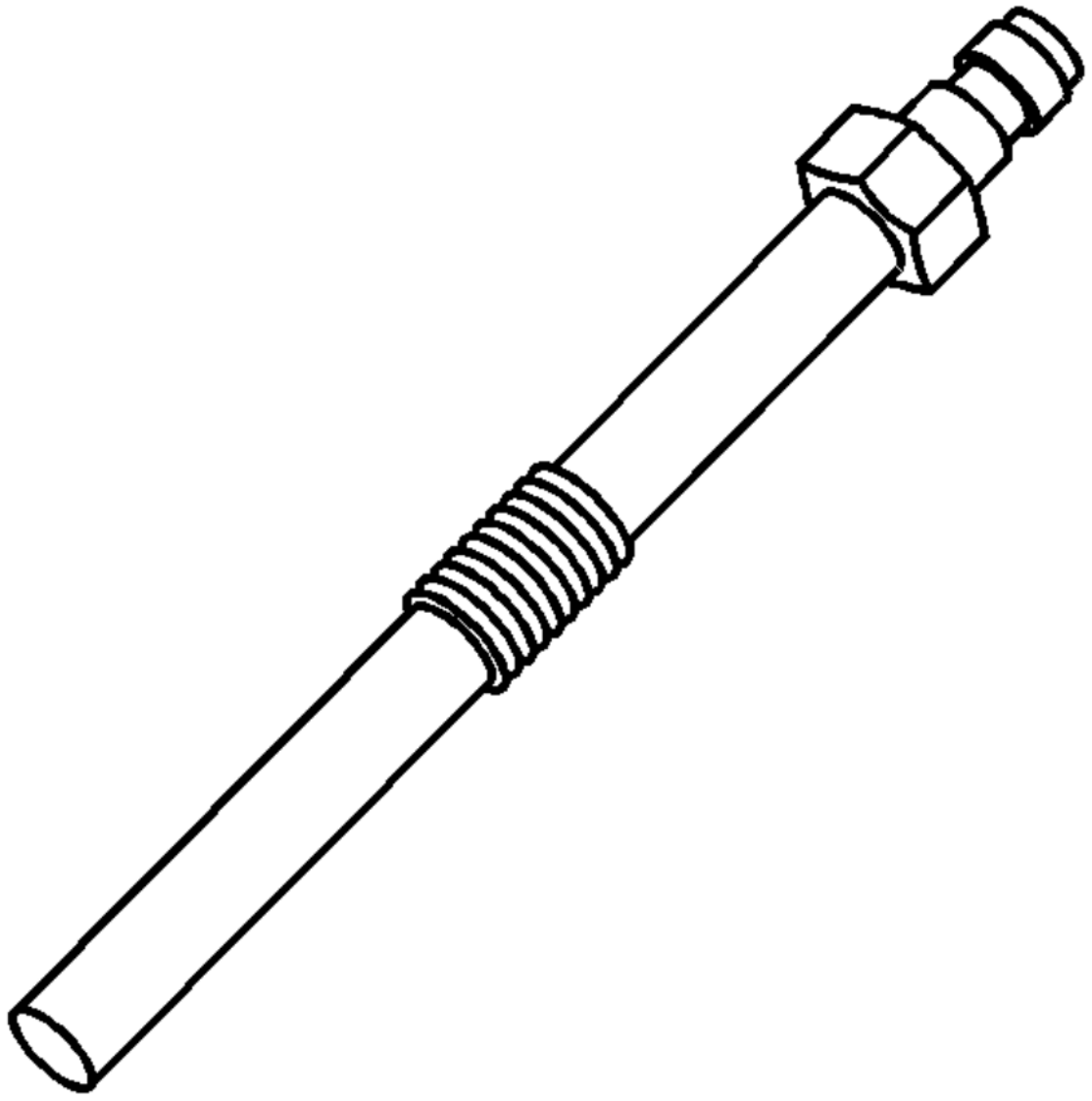
Charge Air C
Tester Ada

EN-469
Displaceme

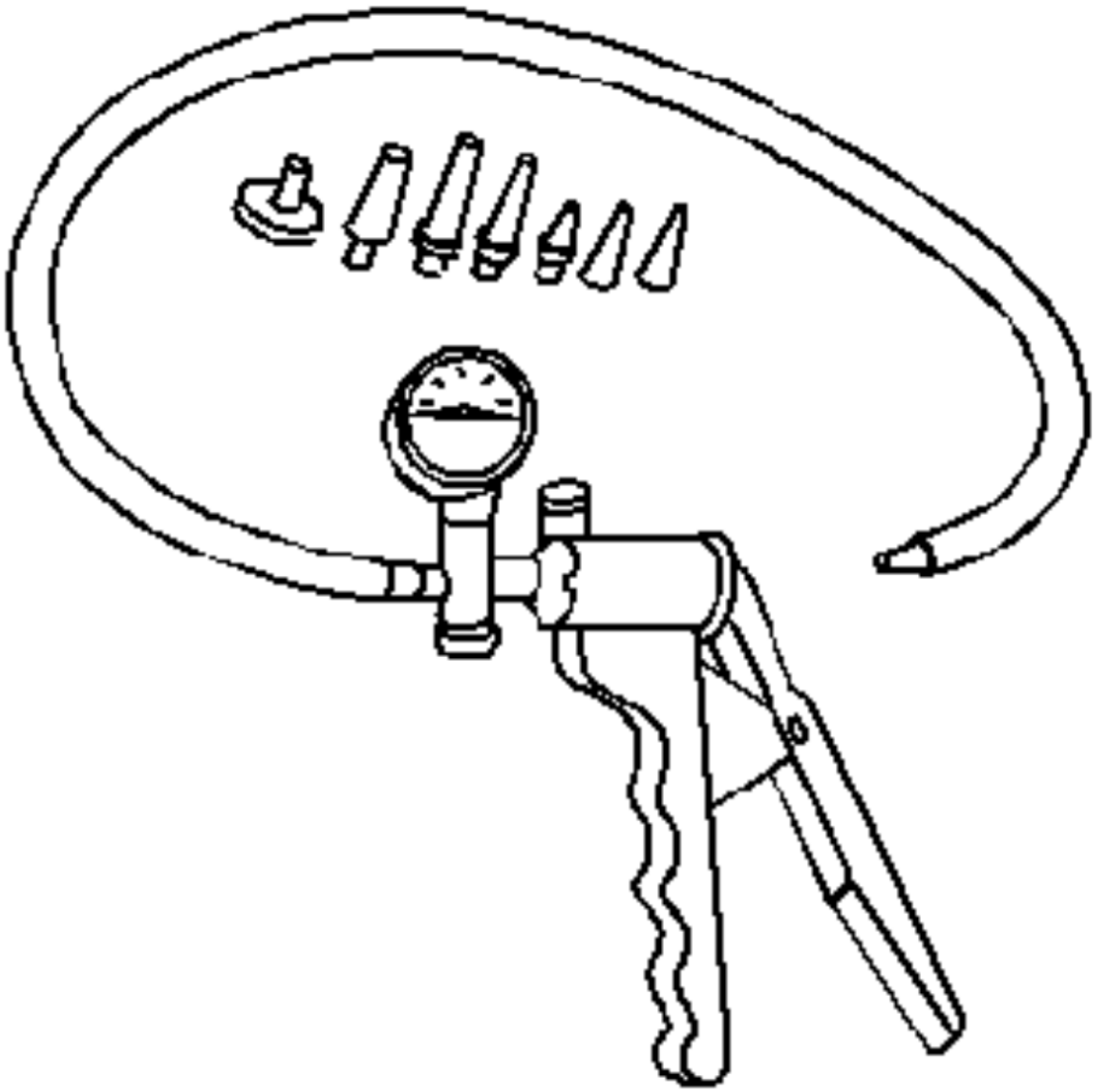


Demand El
Tool

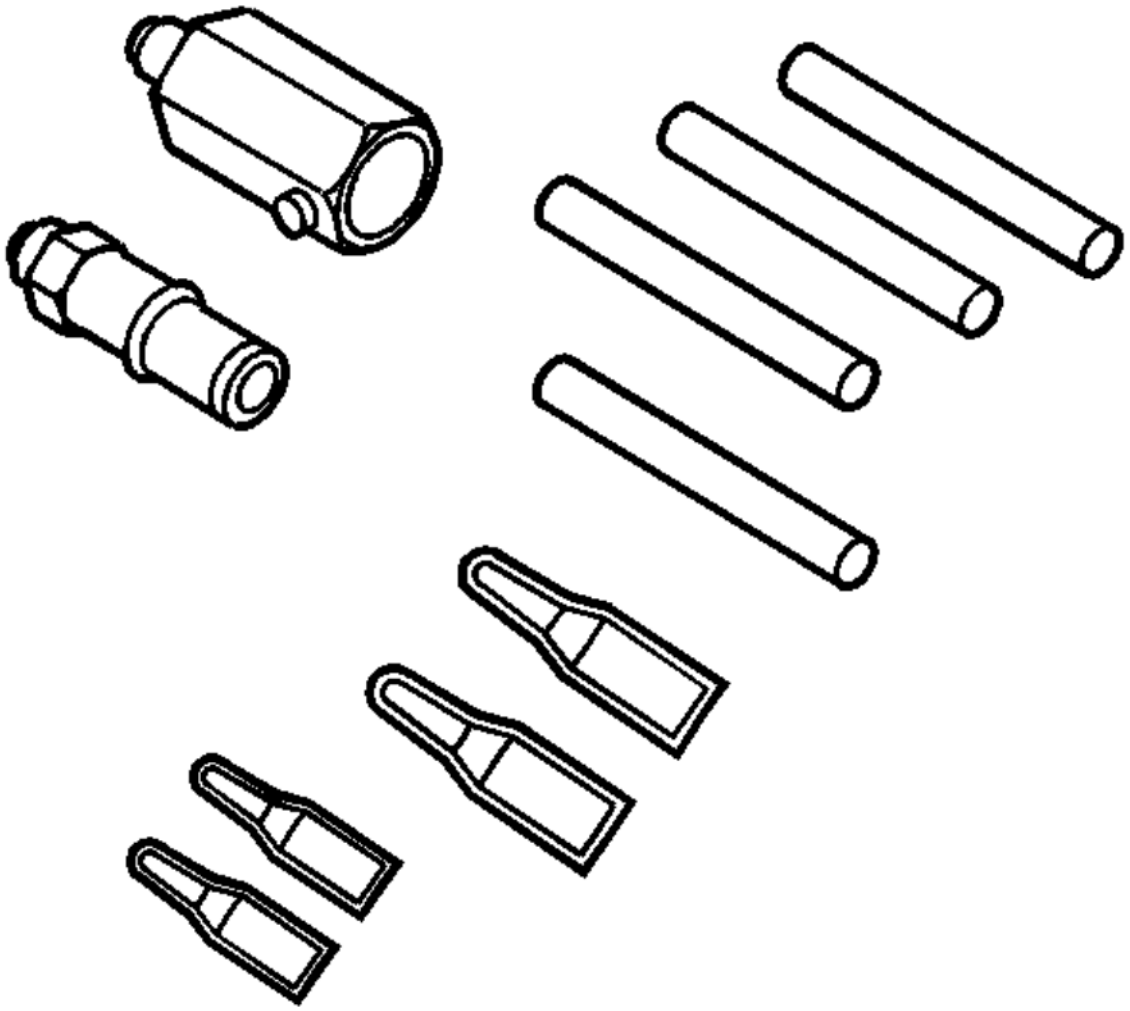
EN-476(
Compression



Adapte

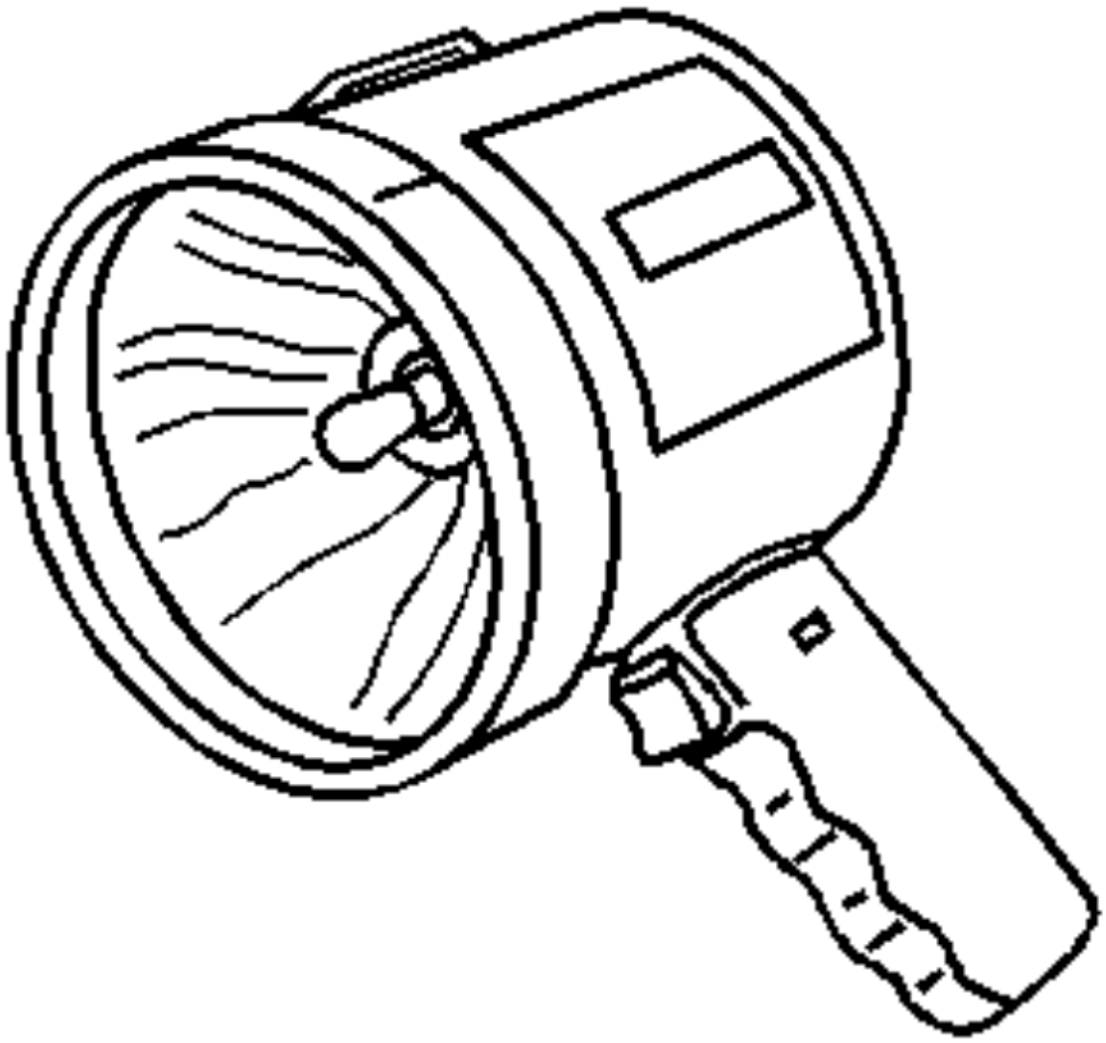


GE-23738
J-23738-
Vacuum P



GE-41413·
EN-41413·
J-41413-3
EVAP Cap ar
Kit

GE-41413-
J-41413-S



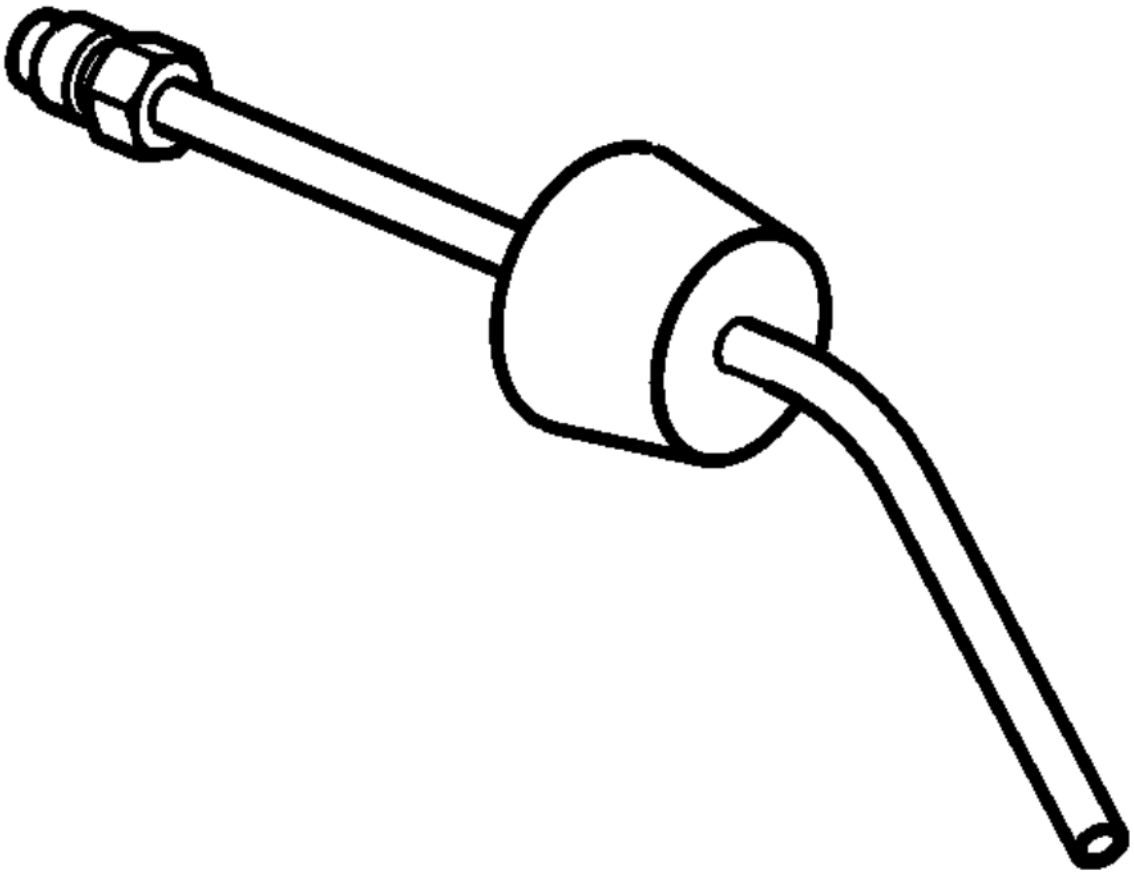
High Intensity Light

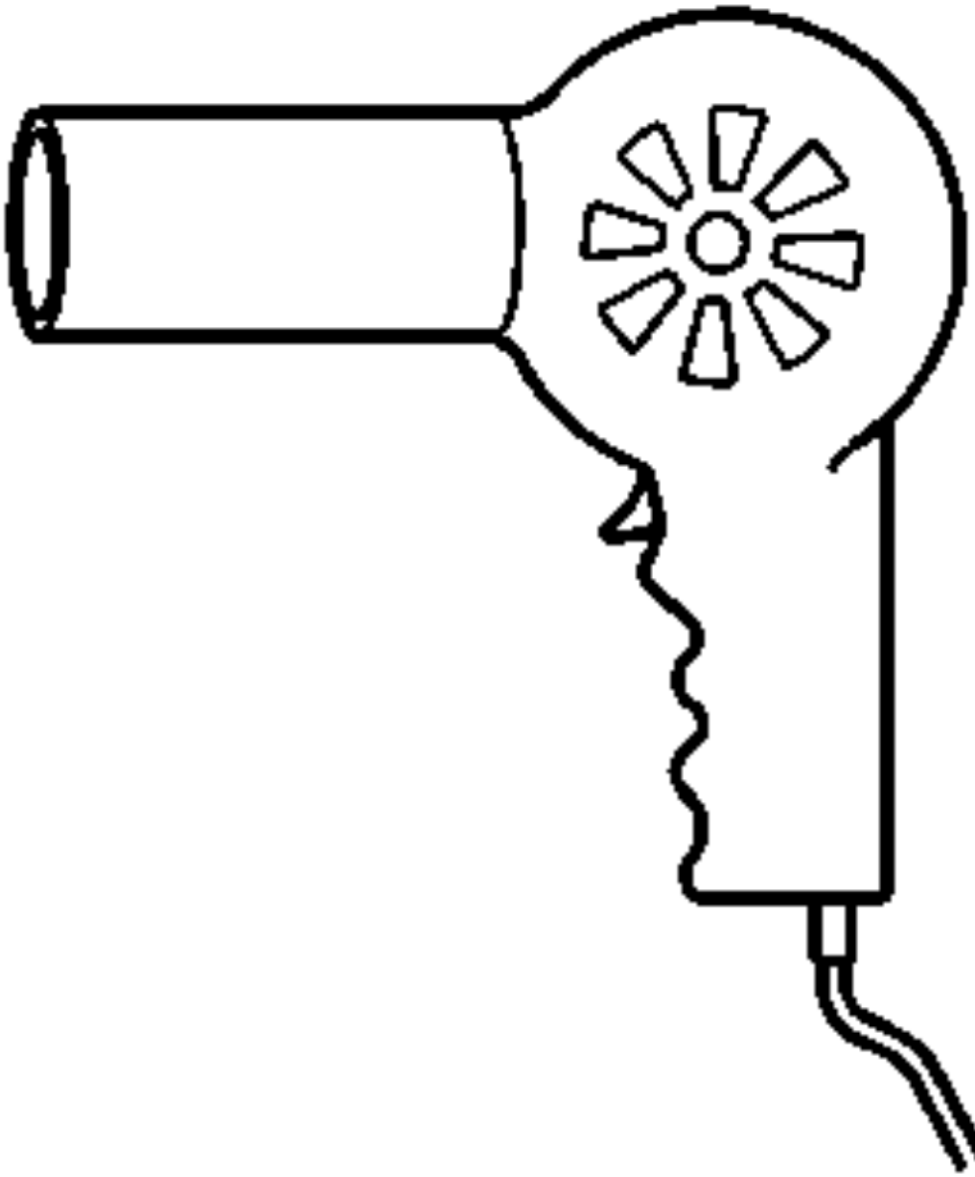
GE-41415
J-41415-



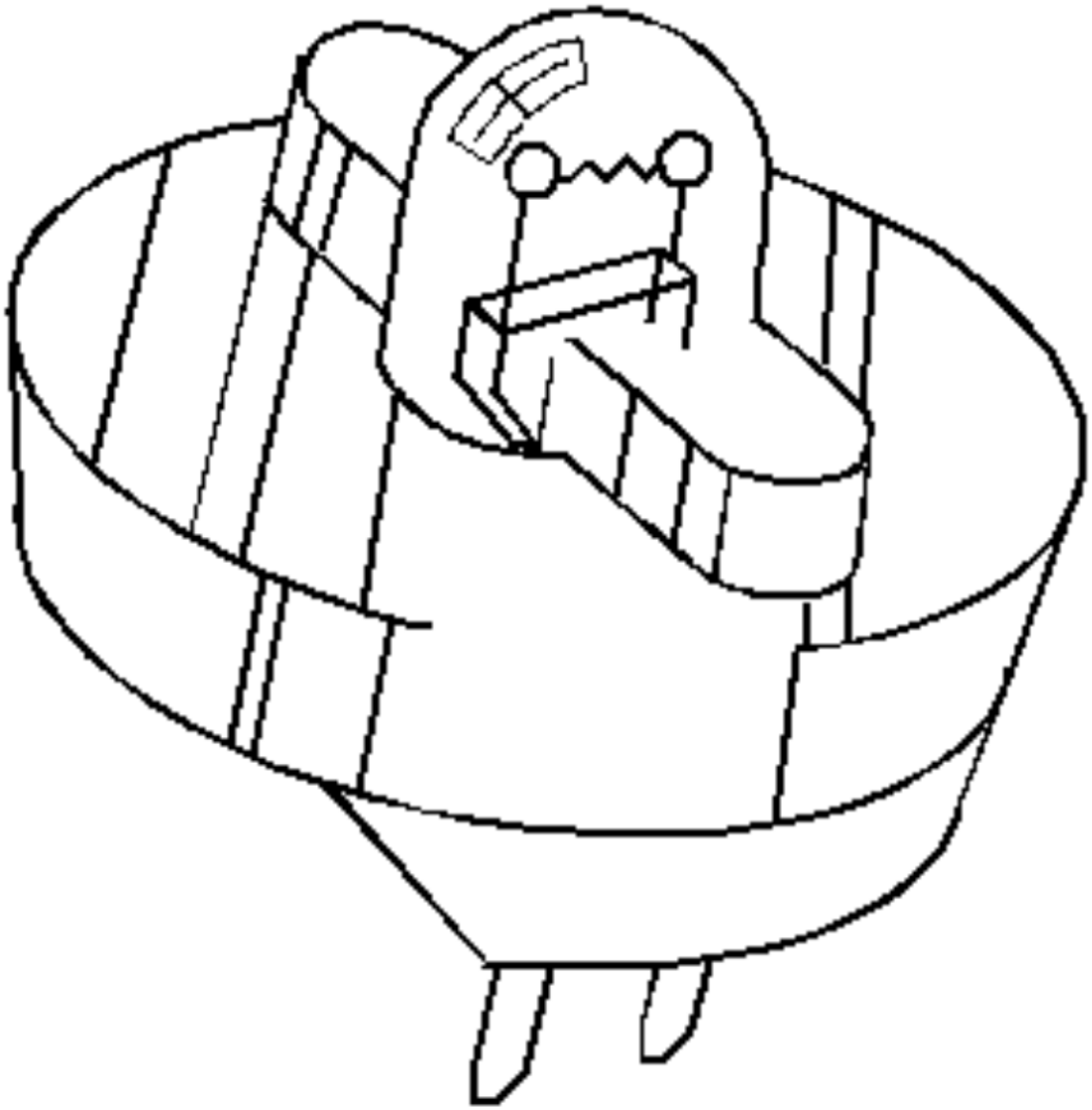
Fuel Tank
Adapte

GE-41415
Engine Indu

	System Leal Adapte



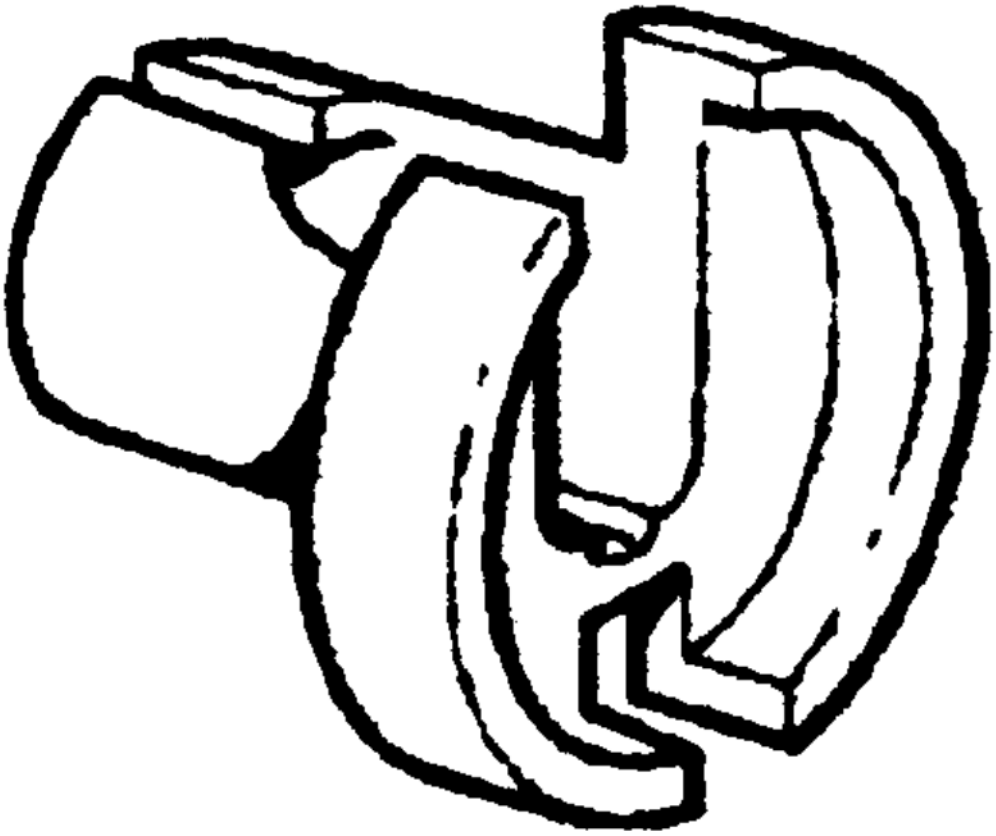
J-2507(
Heat Gun 260
(500-750(



J-34730-3
Injector Test

SPECIAL TOOLS (MECHANICAL TOOLS)

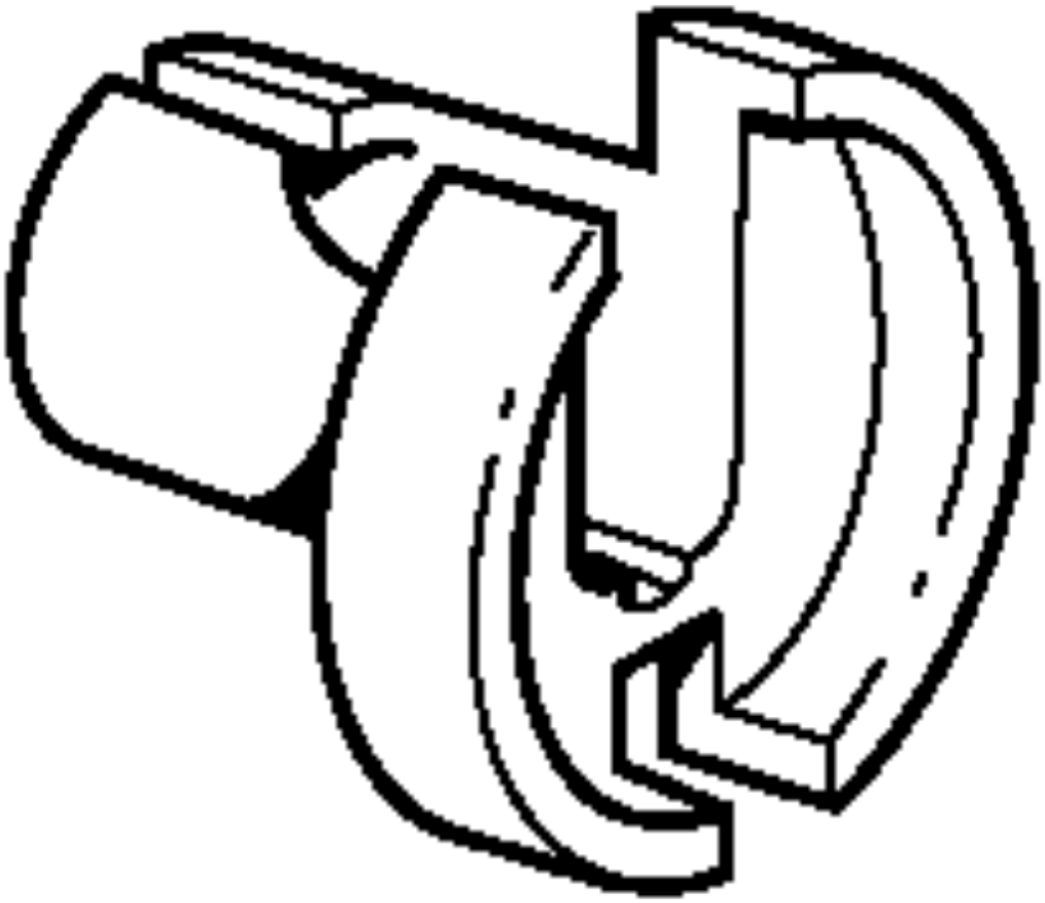
Illustration	Tool Number/Desc



CH-4176
Fuel Line Dis
Tool 3/

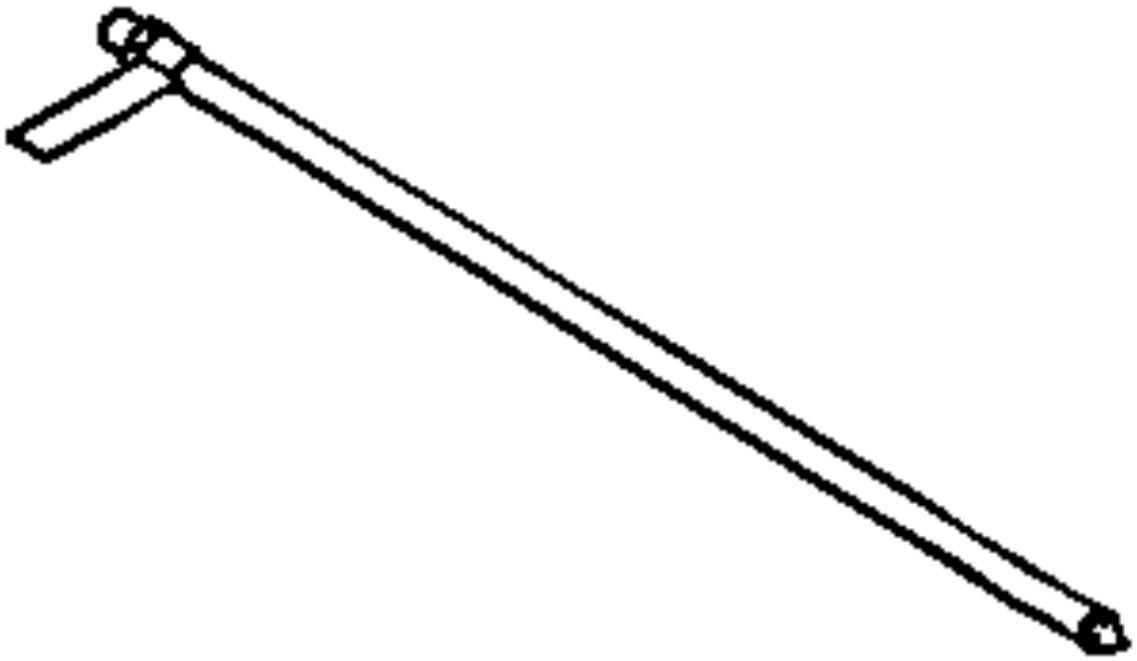
CH-4176
Fuel Line Dis

Tool 5/1

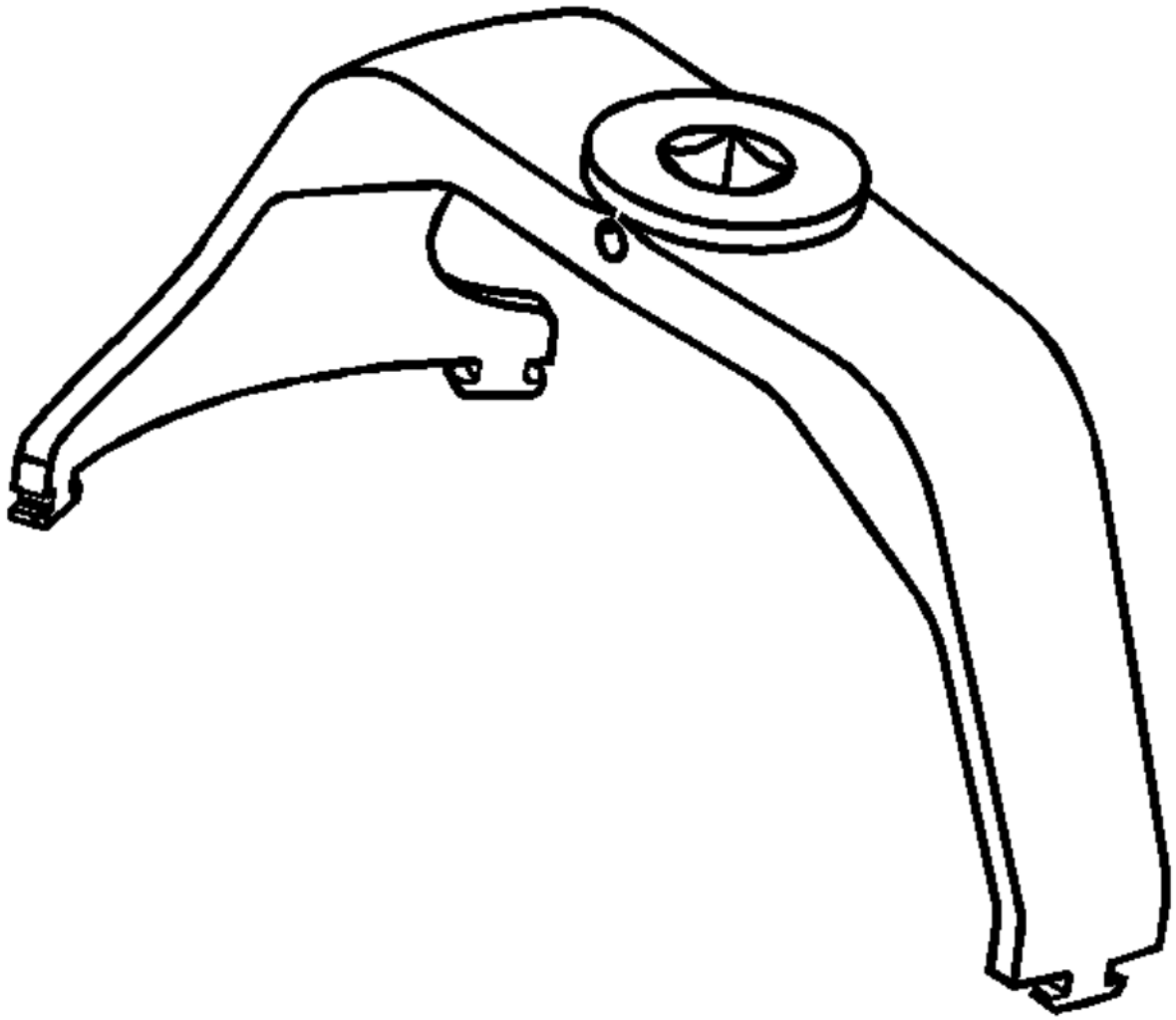


CH-445
Fuel Line Dis

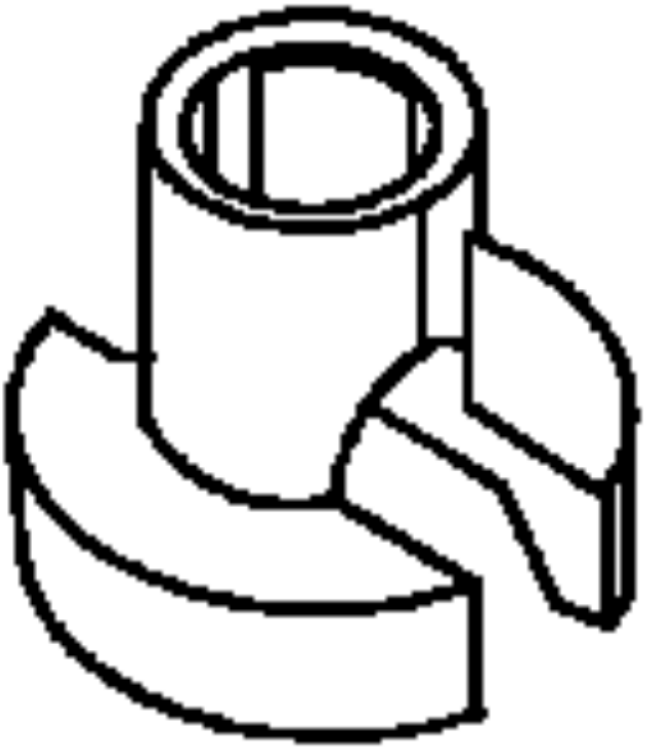
	Tool
	CH-450 J-4500 Fuel Tank I

	Hose South Americ Local Equiv
	CH-457 Fuel Sender

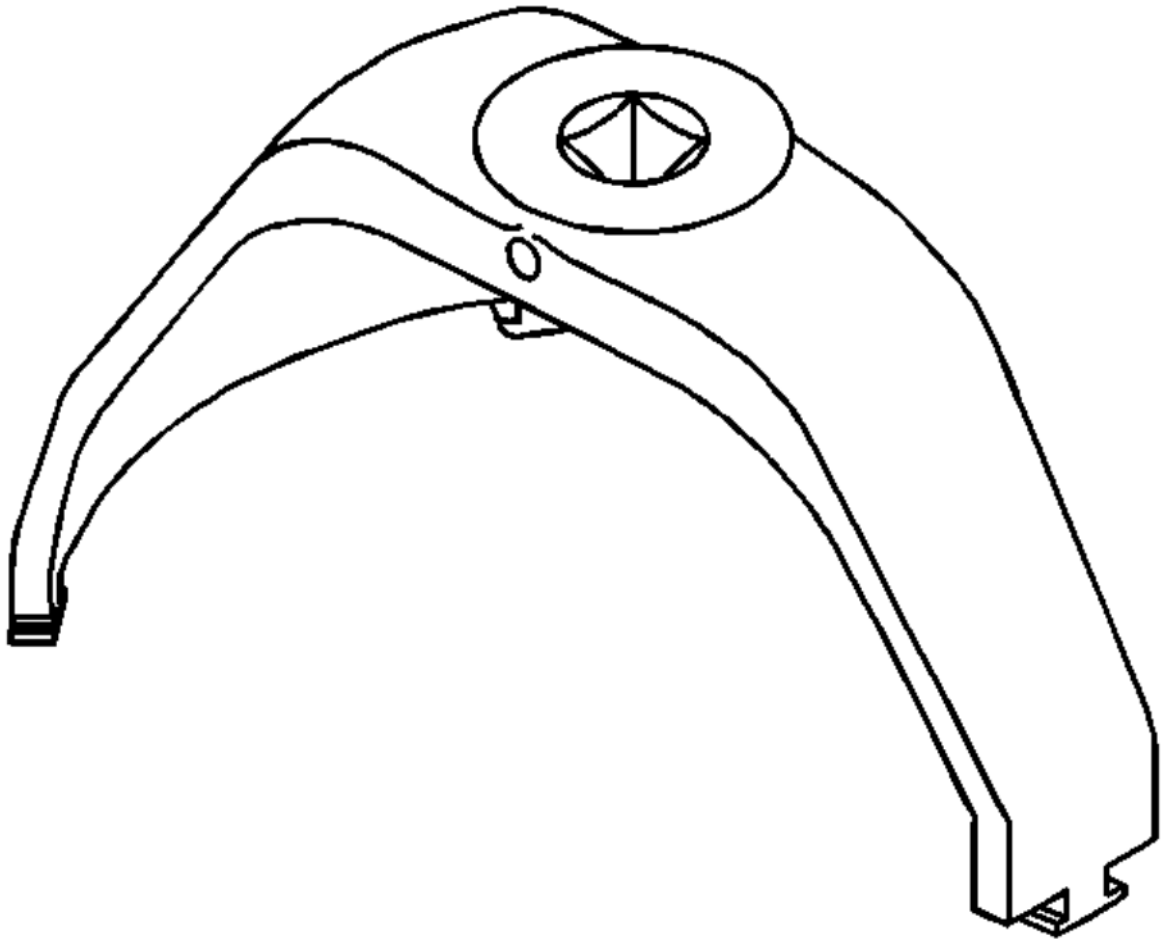
Ring Wre

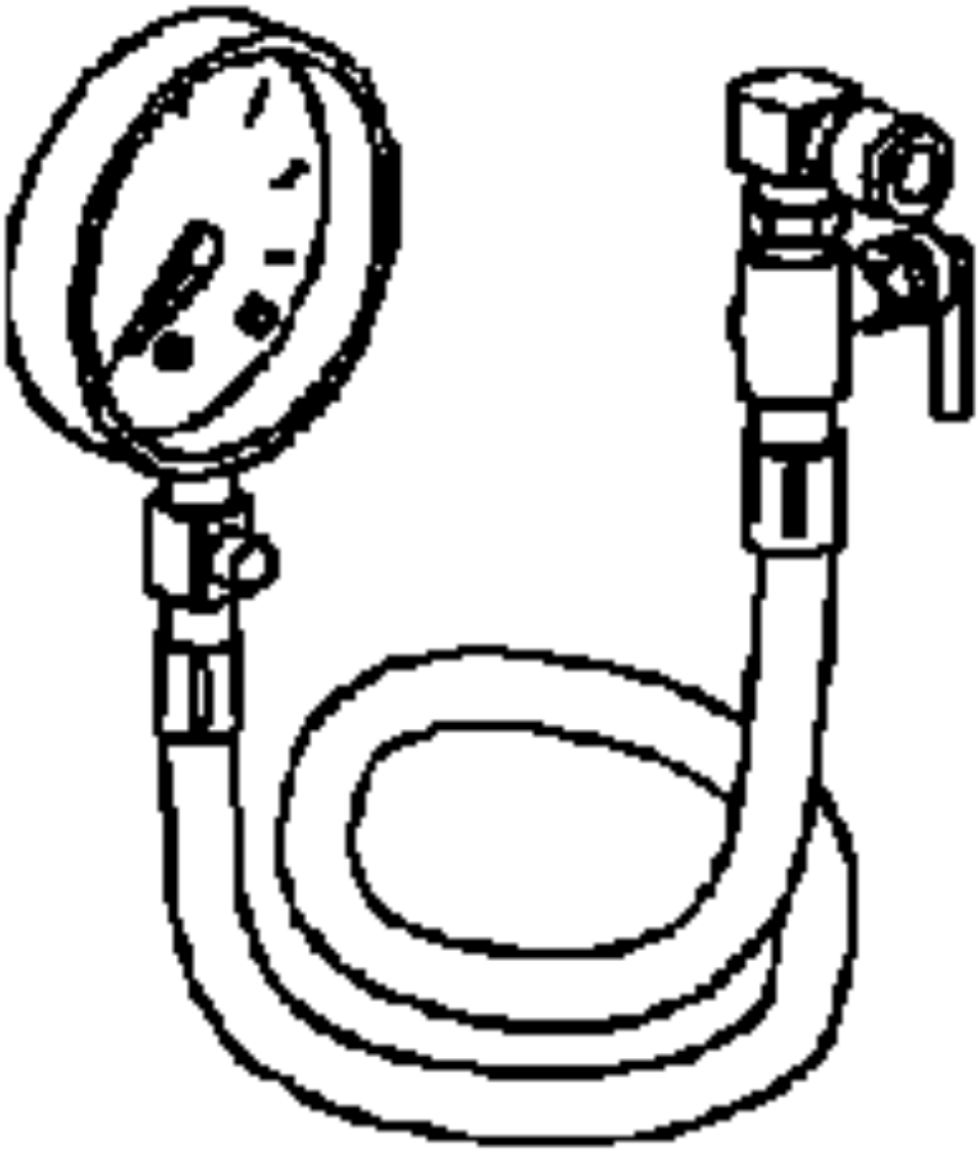


CH-478
Fuel Line Dis

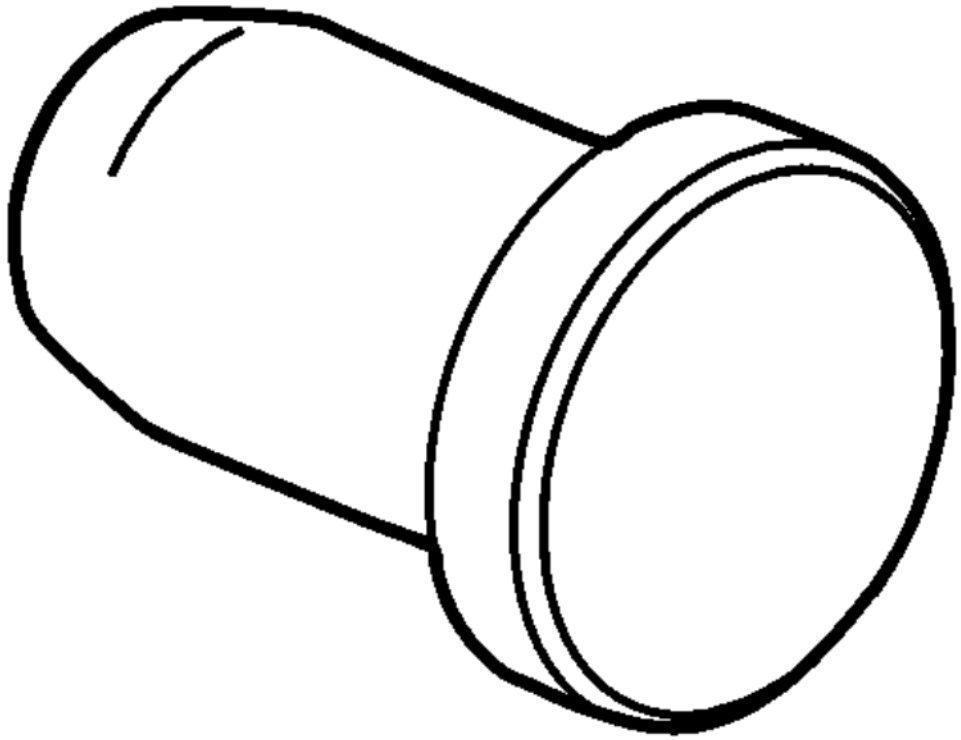
	Tool
	CH-484 Fuel Sender

Ring Wre





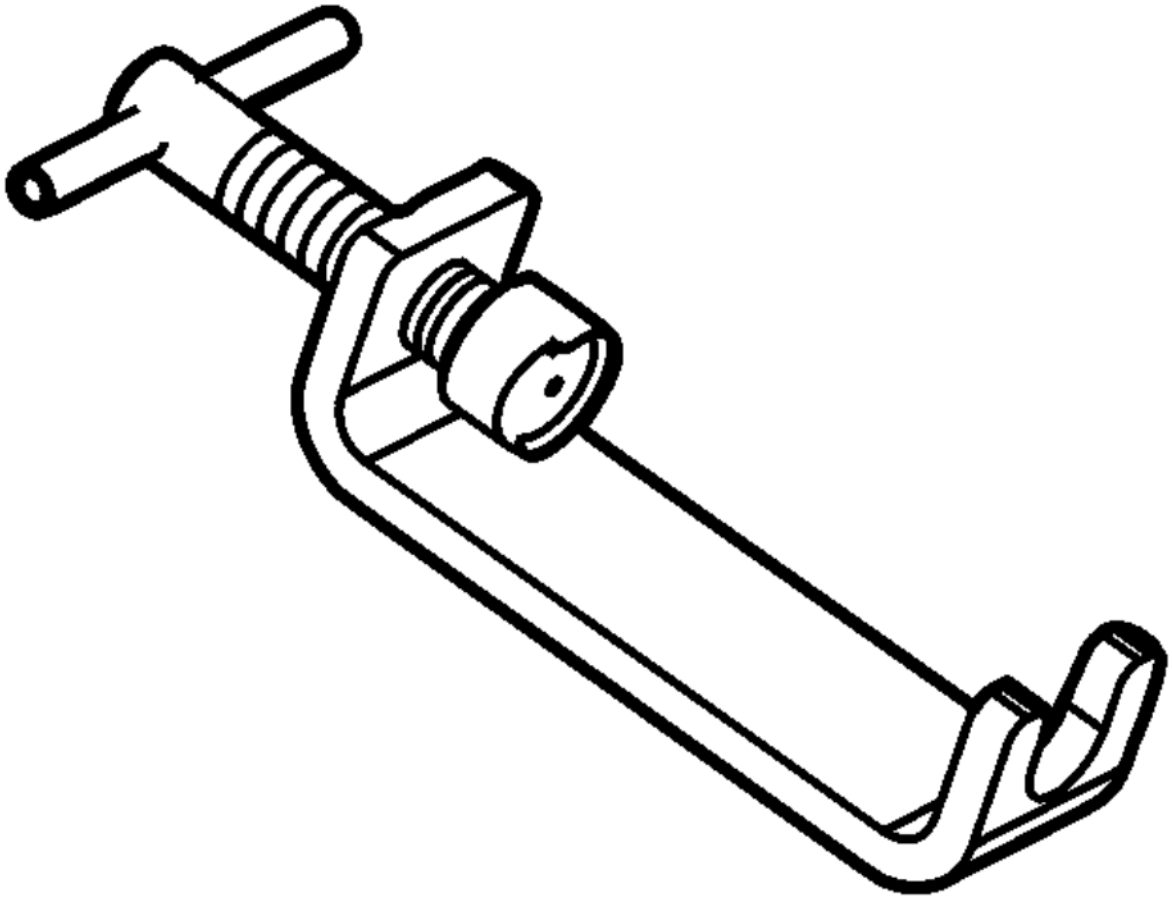
EN-34730
Pressure T



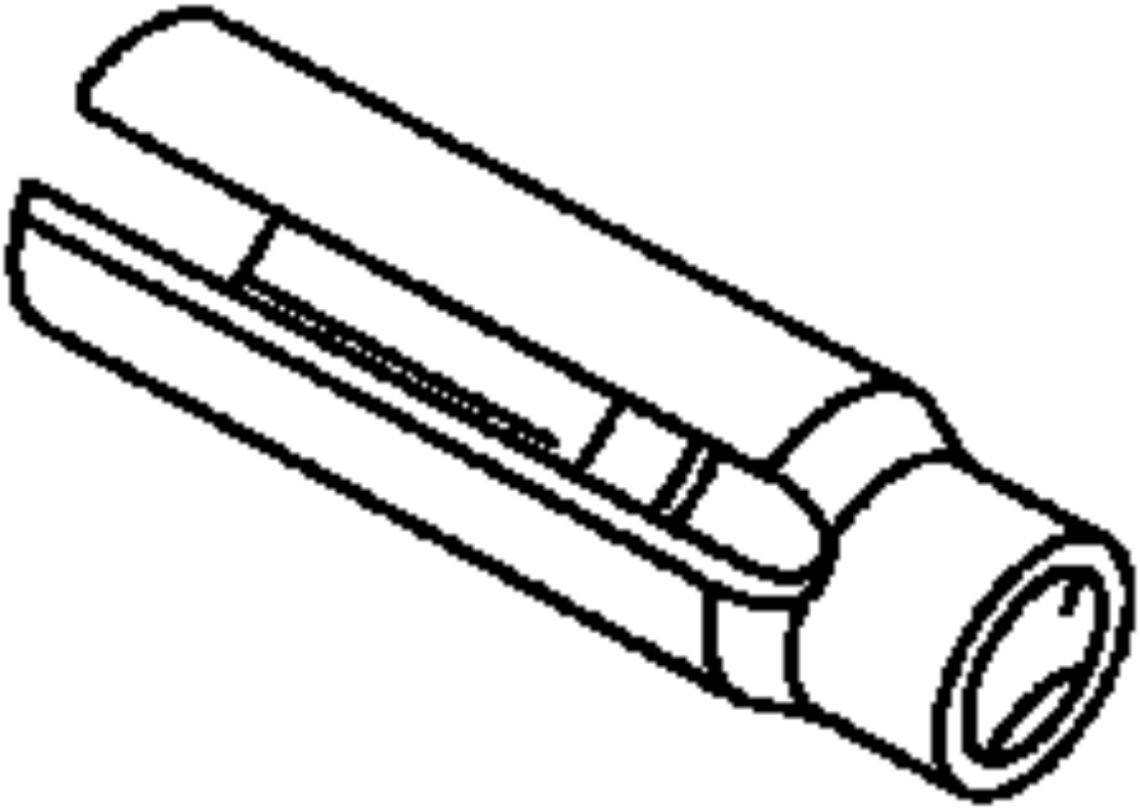
EN-507
Fuel Pun
Installati
Alignment C

EN-507
Fuel Injector

Installe

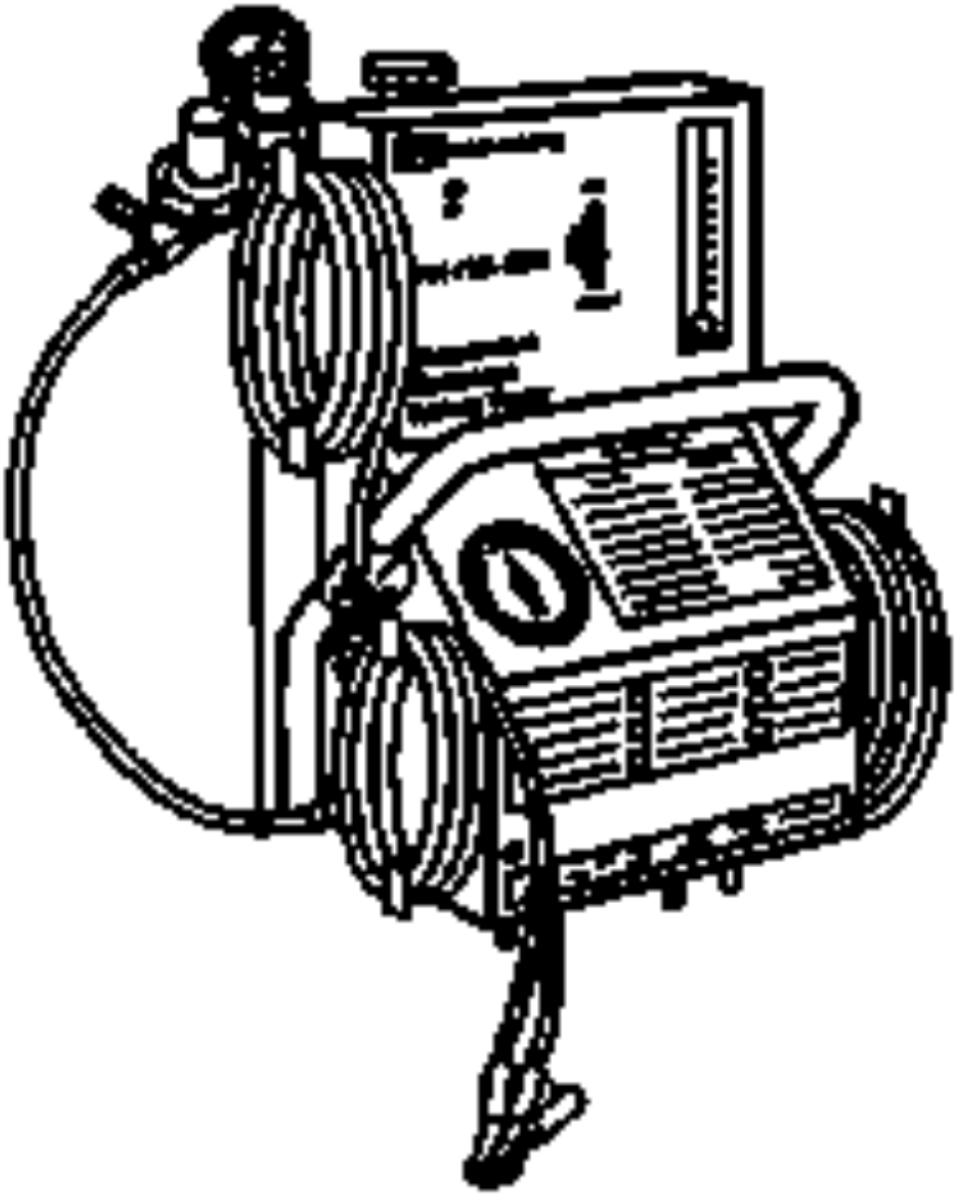


EN-619
EN-465
KM-619



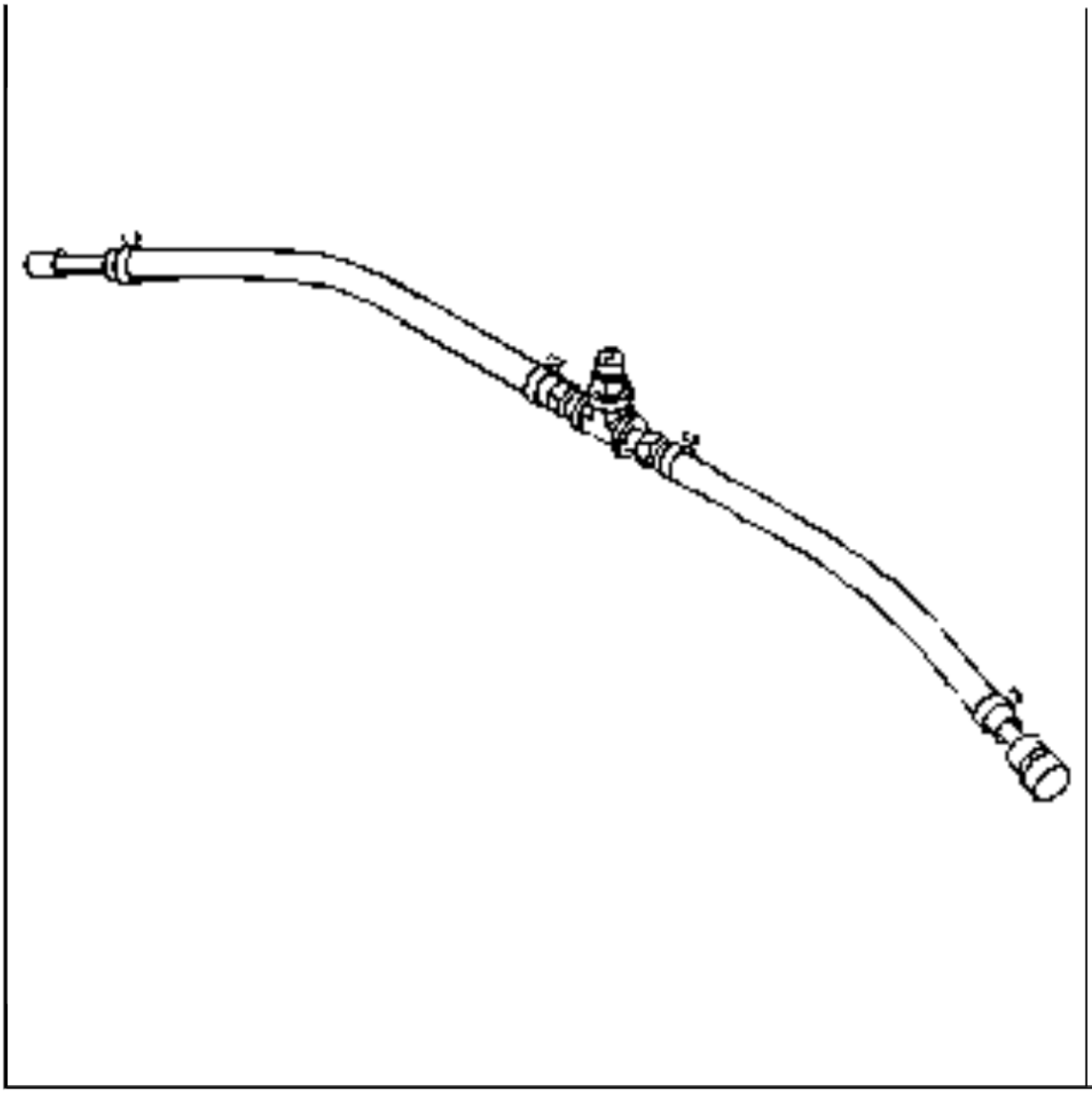
CH-3919
Oxygen Se
Remover/In

GE- 41413
Evaporative P



and Pressure
Station

J42982
Fuel Pressure

	Adapte

2014 Engine

Engine Controls and Fuel - 2.0L (LTG) - Specifications - Regal

SPECIFICATIONS

FASTENER TIGHTENING SPECIFICATIONS

Fastener Tightening Specifications

Application	Specification	
	Metric	English
Accelerator Pedal Bolt	10 N.m	89 lb in
Air Cleaner Resonator and Outlet Duct Bolt	9 N.m	80 lb in
Camshaft Position (CMP) Actuator Solenoid Valve Bolt	10 N.m	89 lb in
Camshaft Position (CMP) Sensor Bolt	10 N.m	89 lb in
Crankshaft Position (CKP) Sensor Bolt	10 N.m	89 lb in
Fuel Injection Fuel Rail Assembly Fasteners	15 N.m	11 lb ft
Fuel Injection Fuel Rail Fuel Pressure Sensor	33 N.m	24 lb ft
Fuel Pressure Sensor	9 N.m	80 lb in
Fuel Pump Fasteners	15 N.m	11 lb ft
Fuel Pump Cover Fasteners	10 N.m	89 lb in
Fuel Pump Flow Control Module Fastener	9 N.m	80 lb in
Fuel Pump Intermediate Pipe Fittings	26 N.m	19 lb ft
Fuel Rail Bolt	25 N.m	18 lb ft
Fuel Tank Fill Pipe Bracket Bolt	9 N.m	80 lb in
Fuel Tank Strap Bolt	20 N.m	15 lb ft
Heated Oxygen Sensor (HO2S)	42 N.m	31 lb ft
Ignition Coil Bolt	10 N.m	89 lb in
Knock Sensor (KS)	10 N.m	89 lb in
Manifold Absolute Pressure Sensor Fastener	10 N.m	89 lb in
Secondary Air Injection Check Valve Bolt	22 N.m	16 lb ft
Secondary Air Injection Pipe Fastener	10 N.m	89 lb in
Secondary Air Injection Pump Bolt	58 N.m	43 lb ft
Spark Plug	20 N.m	15 lb ft
Throttle Body Bolt	10 N.m	89 lb in

ADHESIVES, FLUIDS, LUBRICANTS, AND SEALERS

Adhesives, Fluids, Lubricants, and Sealers

Application	Type of Material	GM Part Number
Anti-Seize Compound	Lubricant	GM P/N 88862477 (Canadian P/N 88862478)
Camshaft Gear Access Hole Plug	Sealant	GM P/N 12346004 (Canadian P/N

		10953480)
Coolant Temperature Sensor Threads	Sealant	GM P/N 12346004 (Canadian P/N 10953480)
Engine Oil	5W-20 Oil	GM P/N 19259486 (Canadian P/N 19259783)
Fuel Injection Fuel Rail Bolts	Sealant	GM P/N 12345382 (Canadian P/N 10953489)
Intake Air Temperature Sensor Threads	Sealant	GM P/N 12346004 (Canadian P/N 10953480)
Top Engine Cleaner	Cleaner	GM P/N 1052626 (Canadian P/N 993026)

2014 Engine

Engine Controls and Fuel - 2.0L (LTG) - Specifications - Regal

SPECIFICATIONS

TEMPERATURE VERSUS RESISTANCE - INTAKE AIR TEMPERATURE SENSOR (HITACHI SENSOR)

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

Temperature C°/F°	Resistance Minimum Ohms	Resistance Maximum Ohms
Hitachi Intake Air Temperature (IAT) Sensor		
-40/-40	37,527	49,882
-20/-4	13,110	16,329
-10/14	8,145	9,851
0/32	5,205	6,122
20/68	2,298	2,570
25/77	1,900	2,100
40/104	1,073	1,226
60/140	537	639
80/176	289	356
100/212	165	210
120/248	99	129
140/284	62	83
150/302	49	67

TEMPERATURE VERSUS RESISTANCE - INTAKE AIR TEMPERATURE SENSOR (DELCO SENSOR)

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

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

140/284	67	73
150/302	54	59

TEMPERATURE VERSUS RESISTANCE - ENGINE COOLANT TEMPERATURE SENSOR

Temperature Versus Resistance - Engine Coolant Temperature Sensor

°C	°F	Sensor Resistance
Temperature vs Resistance Values (Approximate)		
100	212	155
90	194	208
80	176	283
70	158	392
60	140	552
50	122	793
45	113	958
40	104	1165
35	95	1425
30	86	1755
25	77	2176
20	68	2717
15	59	3428
10	50	4356
5	41	5578
0	32	7198
-5	23	9362
-10	14	12278
-15	5	16229
-20	-4	21653
-30	-22	39631
-40	-40	75532

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

IGNITION SYSTEM SPECIFICATIONS

Ignition System Specifications

Application	Specification
Ignition Type	Individual Ignition Coils
Firing Order	1-3-4-2
Spark Plug Torque	Refer to **Fastener Tightening Specifications**
Spark Plug Gap	Refer to **Engine Mechanical Specifications**
Spark Plug Type	Refer to Electronic Parts Catalog

2014 ENGINE

Engine Controls and Fuel - Diagnostic Code Index - 2.0L (LTG)

DIAGNOSTIC CODE INDEX

DIAGNOSTIC CODE INDEX

DTC	Description
DTC P0010, P0013, or P2088-P2091	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 Valve Control Circuit Low Voltage DTC P2089 Intake Camshaft Position Actuator Solenoid Valve Control Circuit High Voltage DTC P2090 Exhaust Camshaft Position Actuator Solenoid Valve Control Circuit Low Voltage DTC P2091 Exhaust Camshaft Position Actuator Solenoid Valve Control Circuit High Voltage
DTC P0011 or P0014	DTC P0011 Intake Camshaft Position System Performance DTC P0014 Exhaust Camshaft Position System Performance
DTC P0016 or P0017	DTC P0016 Crankshaft Position - Intake Camshaft Position Not Plausible DTC P0017 Crankshaft Position - Exhaust Camshaft Position Not Plausible
DTC P0030-P0032, P0036-P0038, P0053, P0054, P0135, or P0141	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
DTC P0033-P0035	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
DTC P0068 or P1101	DTC P0068 Throttle Body Air Flow Performance DTC P1101 Intake Air Flow System Performance
DTC P0089, P00C6, P228C, or P228D	DTC P0089 Fuel Pressure Regulator Performance DTC P00C6 Fuel Rail Pressure Low During Engine Cranking DTC P228C Fuel Pressure Regulator Control Performance - Low Pressure DTC P228D Fuel Pressure Regulator Control Performance - High Pressure
DTC P0090-P0092, P00C8, P00C9, or P00CA	DTC P0090 Fuel Pressure Regulator Control Circuit DTC P0091 Fuel Pressure Regulator Control Circuit Low Voltage DTC P0092 Fuel Pressure Regulator Control Circuit High Voltage DTC P00C8 Fuel Pressure Regulator High Control Circuit

	DTC P00C9 Fuel Pressure Regulator High Control Circuit Low Voltage DTC P00CA Fuel Pressure Regulator High Control Circuit High Voltage
DTC P0096 or P0111	DTC P0096 Intake Air Temperature (IAT) Sensor 2 Performance DTC P0111 Intake Air Temperature (IAT) Sensor 1 Performance
DTC P0097, P0098, or P0099	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
DTC P00C7 (LTG)	DTC P00C7 Intake Air Pressure Measurement System - Multiple Sensors Not Plausible
DTC P00E9	DTC P00E9 Intake Air Temperature (IAT) Sensor 3 Circuit Performance
DTC P00EA-P00EC	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
DTC P00F4-P00F6	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
DTC P0101	DTC P0101 Mass Air Flow (MAF) Sensor Performance
DTC P0102 or P0103	DTC P0102 Mass Air Flow (MAF) Sensor Circuit Low Frequency DTC P0103 Mass Air Flow (MAF) Sensor Circuit High Frequency
DTC P0106	DTC P0106 Manifold Absolute Pressure (MAP) Sensor Performance
DTC P0107 or P0108	DTC P0107 Manifold Absolute Pressure (MAP) Sensor Circuit Low Voltage DTC P0108 Manifold Absolute Pressure (MAP) Sensor Circuit High Voltage
DTC P0112, P0113, or P0114	DTC P0112 Intake Air Temperature (IAT) Sensor 1 Circuit Low Voltage DTC P0113 Intake Air Temperature (IAT) Sensor 1 Circuit High Voltage DTC P0114 Intake Air Temperature (IAT) Sensor 1 Circuit Intermittent
DTC P0116	DTC P0116 Engine Coolant Temperature (ECT) Sensor Performance
DTC P0117, P0118, or P0119	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
DTC P0121-P0123, P0222, P0223, P16A0-P16A2, or P2135	DTC P0121 Throttle Position Sensor 1 Performance DTC P0122 Throttle Position Sensor 1 Circuit Low Voltage DTC P0123 Throttle Position Sensor 1 Circuit High Voltage DTC P0222 Throttle Position Sensor 2 Circuit Low Voltage DTC P0223 Throttle Position Sensor 2 Circuit High Voltage DTC P16A0 Sensor Communication Circuit Low Voltage DTC P16A1 Sensor Communication Circuit High Voltage DTC P16A2 Sensor Communication Circuit Performance DTC P2135 Throttle Position Sensors 1-2 Not Plausible
DTC P0128	DTC P0128 Engine Coolant Temperature (ECT) Below Thermostat Regulating Temperature
DTC P0131, P0132, P0134, P0137, P0138, P0140, or P2A00	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 DTC P2A00 HO2S Performance Sensor 1
DTC P0133, P013A, P013B, P013E, P013F, P015A, P015B, P2270, or P2271	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
DTC P0171 or P0172	DTC P0171 Fuel Trim System Lean DTC P0172 Fuel Trim System Rich
DTC P018B-P018D	DTC P018B Fuel Pressure Sensor Performance DTC P018C Fuel Pressure Sensor Circuit Low Voltage DTC P018D Fuel Pressure Sensor Circuit High Voltage
DTC P0191, P0192, or P0193	DTC P0191 Fuel Rail Pressure Sensor Performance DTC P0192 Fuel Rail Pressure Sensor Circuit Low Voltage DTC P0193 Fuel Rail Pressure Sensor Circuit High Voltage
DTC P0201-P0204, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P1248, P1249, P124A, P124B, P2147, P2148, P2150, P2151, P2153, P2154, P2156, or P2157	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 DTC P1248 Cylinder 1 Injector High Control Circuit Shorted to Control Circuit DTC P1249 Cylinder 2 Injector High Control Circuit Shorted to Control Circuit DTC P124A Cylinder 3 Injector High Control Circuit Shorted to Control Circuit DTC P124B Cylinder 4 Injector High Control Circuit Shorted to Control Circuit DTC P2147 Cylinder 1 Injector High Control Circuit Low Voltage DTC P2148 Cylinder 1 Injector High Control Circuit High Voltage DTC P2150 Cylinder 2 Injector High Control Circuit Low Voltage DTC P2151 Cylinder 2 Injector High Control Circuit High Voltage DTC P2153 Cylinder 3 Injector High Control Circuit Low Voltage DTC P2154 Cylinder 3 Injector High Control Circuit High Voltage DTC P2156 Cylinder 4 Injector High Control Circuit Low Voltage DTC P2157 Cylinder 4 Injector High Control Circuit High Voltage
DTC P0231, P0232, or P023F	DTC P0231 Fuel Pump Control Circuit Low Voltage DTC P0232 Fuel Pump Control Circuit High Voltage

	DTC P023F Fuel Pump Control Circuit
DTC P0234 or P0299	DTC P0234 Engine Overboost DTC P0299 Engine Underboost
DTC P0236	DTC P0236 Turbocharger Boost Sensor Performance
DTC P0237 or P0238	DTC P0237 Turbocharger Boost Sensor Circuit Low Voltage DTC P0238 Turbocharger Boost Sensor Circuit High Voltage
DTC P0243, P0245, or P0246	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
DTC P0300-P0304	DTC P0300 Engine Misfire Detected DTC P0301 Cylinder 1 Misfire Detected DTC P0302 Cylinder 2 Misfire Detected DTC P0303 Cylinder 3 Misfire Detected DTC P0304 Cylinder 4 Misfire Detected
DTC P0315	DTC P0315 Crankshaft Position System Variation Not Learned
DTC P0324, P0326, P0331, P06B6, or P06B7	DTC P0324 Knock Sensor System Performance DTC P0326 Knock Sensor 1 Performance DTC P0331 Knock Sensor 2 Performance DTC P06B6 Control Module Knock Sensor Processor 1 Performance DTC P06B7 Control Module Knock Sensor Processor 2 Performance
DTC P0325, P0327, P0328, P0330, P0332, or P0333	DTC P0325 Knock Sensor 1 Circuit DTC P0327 Knock Sensor 1 Circuit Low Voltage DTC P0328 Knock Sensor 1 Circuit High Voltage DTC P0330 Knock Sensor 2 Circuit DTC P0332 Knock Sensor 2 Circuit Low Voltage DTC P0333 Knock Sensor 2 Circuit High Voltage
DTC P0335 or P0336	DTC P0335 Crankshaft Position Sensor Circuit DTC P0336 Crankshaft Position Sensor Performance
DTC P0340, P0341, P0365, or P0366	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
DTC P0351-P0354, P2300, P2301, P2303, P2304, P2306, P2307, P2309, or P2310	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
DTC P0420	DTC P0420 Catalyst System Low Efficiency
DTC P0442	DTC P0442 Evaporative Emission (EVAP) System Small Leak Detected
DTC P0443, P0458, or	DTC P0443 Evaporative Emission (EVAP) Purge Solenoid Valve Control

P0459	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
DTC P0446	DTC P0446 Evaporative Emission (EVAP) Vent System Performance
DTC P0449, P0498, or P0499	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
DTC P0451-P0454	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
DTC P0455	DTC P0455 Evaporative Emission (EVAP) System Large Leak Detected
DTC P0496	DTC P0496 Evaporative Emission (EVAP) System Flow During Non-Purge
DTC P0506 or P0507	DTC P0506 Idle Speed Low DTC P0507 Idle Speed High
DTC P050D	DTC P050D Cold Start Rough Idle
DTC P057B-P057D	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
DTC P05CC or P05CE	DTC P05CC Cold Start Intake Camshaft Position System Performance DTC P05CE Cold Start Exhaust Camshaft Position System Performance
DTC P0601-P0604, P0606, P062B, P062F, P0630, P16F3, or P262B (ECM)	DTC P0601 Control Module Read Only Memory Performance DTC P0602 Control Module Not Programmed DTC P0603 Control Module Long Term Memory Reset DTC P0604 Control Module Random Access Memory Performance DTC P0606 Control Module Processor Performance DTC P062B Control Module Fuel Injector Control Performance DTC P062F Control Module Long Term Memory Performance DTC P0630 VIN Not Programmed or Mismatched - Engine Control Module (ECM) DTC P16F3 Control Module Redundant Memory Performance DTC P262B Control Module Power Off Timer Performance
DTC P0628	DTC P0628 Fuel Pump Enable Circuit Low Voltage
DTC P0641, P0651, P0697, or P06A3 (ECM)	DTC P0641 5V Reference 1 Circuit DTC P0651 5V Reference 2 Circuit DTC P0697 5V Reference 3 Circuit DTC P06A3 5V Reference 4 Circuit
DTC P0650, P263A, or P263B	DTC P0650 Malfunction Indicator Lamp (MIL) Control Circuit Open DTC P263A Malfunction Indicator Lamp (MIL) Control Circuit Low Voltage DTC P263B Malfunction Indicator Lamp (MIL) Control Circuit High Voltage
DTC P0685-P0687,	DTC P0685 Engine Controls Ignition Relay Control Circuit

P0689, P0690, or P1682	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
DTC P0700	DTC P0700 Transmission Control Module Requested MIL Illumination
DTC P1255	DTC P1255 Fuel Pump Control Module Driver High Temperature
DTC P129B or P129C	DTC P129B Fuel Pump Driver Control Module System Voltage Low DTC P129C Fuel Pump Driver Control Module System Voltage High
DTC P129D	DTC P129D Fuel Pump Driver Control Module Ignition 1 Switch Circuit Low Voltage
DTC P129E	DTC P129E Fuel Pump Driver Control Module Signal Message Counter Incorrect
DTC P12A6	DTC P12A6 Fuel Pump Driver Control Module Enable Circuit Performance
DTC P12A8	DTC P12A8 Fuel Pump Control Signal Message Counter Incorrect
DTC P135A	DTC P135A Ignition Coil Supply Voltage Circuit Bank 1
DTC P1400	DTC P1400 Cold Start Emission Reduction Control System
DTC P150C	DTC P150C Transmission Control Module Engine Speed Request Signal Message Counter Incorrect
DTC P1516, P2101, P2119, or P2176	DTC P1516 Throttle Actuator Control (TAC) Module Throttle Actuator Position Performance DTC P2101 Throttle Actuator Position Performance DTC P2119 Throttle Closed Position Performance DTC P2176 Minimum Throttle Position Not Learned
DTC P163A	DTC P163A Control Module Fuel Pressure Regulator 1 Control System Circuitry Performance
DTC P2096	DTC P2096 Post Catalyst Fuel Trim System Low Limit
DTC P2097	DTC P2097 Post Catalyst Fuel Trim System High Limit
DTC P2122, P2123, P2127, P2128, or P2138	DTC P2122 Accelerator Pedal Position (APP) Sensor 1 Circuit Low Voltage DTC P2123 Accelerator Pedal Position (APP) Sensor 1 Circuit High Voltage DTC P2127 Accelerator Pedal Position (APP) Sensor 2 Circuit Low Voltage DTC P2128 Accelerator Pedal Position (APP) Sensor 2 Circuit High Voltage DTC P2138 Accelerator Pedal Position (APP) Sensors 1-2 Not Plausible
DTC P2199	DTC P2199 Intake Air Temperature (IAT) Sensor 1-2 Not Plausible
DTC P219A	DTC P219A Fuel Trim Cylinder Balance
DTC P2227-P2230	DTC P2227 Barometric Pressure (BARO) Sensor Performance DTC P2228 Barometric Pressure (BARO) Sensor Circuit Low Voltage DTC P2229 Barometric Pressure (BARO) Sensor Circuit High Voltage DTC P2230 Barometric Pressure (BARO) Sensor Circuit Erratic
DTC P2261	DTC P2261 Turbocharger Bypass Valve Stuck
DTC P2544	DTC P2544 Transmission Torque Request Signal Message Counter Incorrect
DTC P2635	DTC P2635 Fuel Pump Flow Performance