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DESCRIPTION AND OPERATION

CAMSHAFT ACTUATOR SYSTEM DESCRIPTION

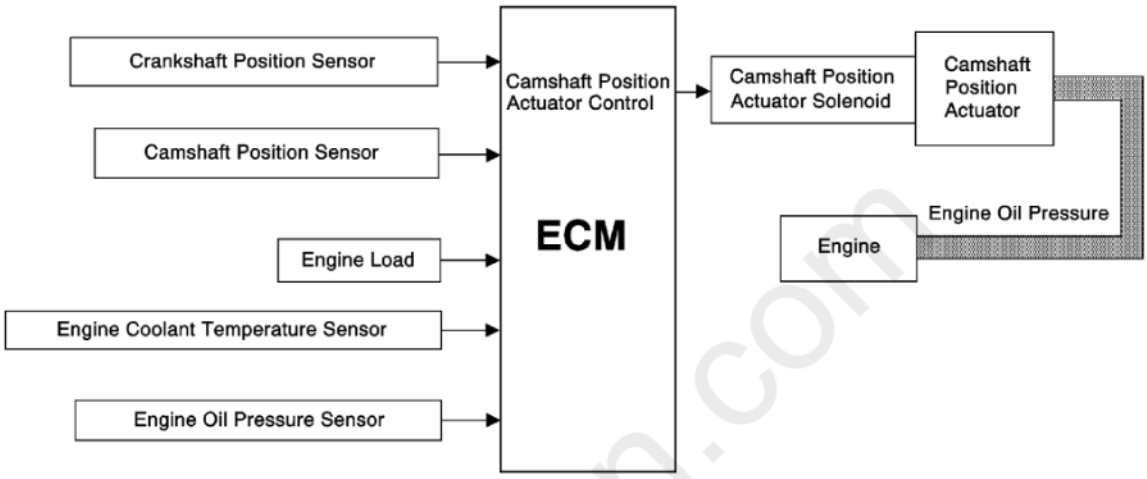

Fig. 1: Camshaft Actuator System Description
Courtesy of GENERAL MOTORS COMPANY

Camshaft Position (CMP) Actuator System

The camshaft position (CMP) actuator system is used for a variety of engine performance enhancements. These enhancements include lower emission output through exhaust gas recirculation (EGR) control, a wider engine torque range, improved gas mileage and improved engine idle stability. The CMP actuator system commanded by the ECM accomplishes these enhancements by controlling the valve timing relative to piston position.

CMP Actuator System Operation

The camshaft position (CMP) actuator system is controlled by the control module. The control module sends a pulse width modulated signal to a CMP actuator solenoid in order to control the amount of engine oil flow to a camshaft actuator passage. There are 2 different passages for oil to flow through, a passage for CAM advance and a passage for CAM retard. The camshaft actuator is attached to the front of the camshaft and is hydraulically operated in order to change the angle of the camshaft relative to crankshaft position (CKP). Engine oil pressure (EOP), viscosity, temperature, engine oil level and aftermarket engine oil additives can have an adverse affect on camshaft phaser performance.

CMP Actuator Solenoid Circuit Diagnostic

The engine control module (ECM) monitors the control circuit of the camshaft position (CMP) actuator solenoid for electrical faults. The control module has the ability to determine if a control circuit is open, shorted high or shorted low. If the control module detects a fault with the CMP actuator solenoid control, DTC P0010 will set.

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CMP Actuator System Performance Diagnostic

The engine control module (ECM) monitors the performance of the camshaft position (CMP) actuator system by monitoring the calibrated desired position and the actual position of the camshaft, through the 4X signal of the CMP sensor. If the difference between the actual and the desired position is greater than a calibrated angle for a calibrated amount of time, DTC P0011 will set.

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 near each cylinder with short integrated boots or high tension wires 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 uses engine speed, the mass air flow (MAF) sensor signal and position information from the crankshaft position and the camshaft position sensors to control 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 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 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 ECM to control the ignition timing for the best possible performance while protecting the engine from potentially damaging levels of detonation, also known as spark knock. The knock sensor system uses 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 ECM receives the knock sensor signal through the high and low signal circuits.

The ECM 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 ECM 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 ECM 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 ECM has determined that knock is present, it will retard the ignition timing to attempt to eliminate the knock. The ECM 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 ECM, the knock sensor wiring or the knock sensor voltage output. Some diagnostics are also calibrated to detect constant noise from an outside influence such as a loose/damaged component or excessive engine mechanical noise.

Ignition Coils

Each ignition coil has an ignition voltage feed and a ground circuit. The engine control module (ECM) supplies a low reference and an ignition control (IC) circuit. Each ignition coil contains a solid state driver module. The ECM will command the IC circuit ON, which allows the current to flow through the primary coil windings. When the ECM commands the IC circuit OFF, this will interrupt current flow through the primary coil windings. The magnetic field created by the primary coil windings will collapse across the secondary coil windings, which induces a high voltage across the spark plug electrodes.

Engine Control Module (ECM)

The 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) sensors
- Intake air temperature (IAT) sensors
- Vehicle speed sensor (VSS)
- Transmission gear position or range information sensors
- Engine knock sensors
- Ambient pressure sensors (BARO)

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.

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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.

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Electrostatic Discharge (ESD) Damage

NOTE: **In order to prevent possible electrostatic discharge damage to the ECM, DO NOT touch the connector pins on the ECM.**

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

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

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

Emissions Control Information Label

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

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

CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) SYSTEM DESCRIPTION

To provide maximum fuel economy under light load driving conditions, the Engine Control Module (ECM) will command the cylinder deactivation system ON to deactivate engine cylinders 2 and 5, switching to a V4 mode. The engine will operate on 6 cylinders or V6 mode, during engine starting, engine idling and medium to heavy throttle applications.

The conditions listed below determine when cylinder deactivation is enabled.

- Engine has been running for greater than 30 s
- Engine speed is between 700 and 2800 rpm
- Engine oil pressure is between 187-455 kPa (27-66 psi)
- Engine coolant temperature is between 40-129Â°C (100-264Â°F)
- Engine oil temperature is between 16-128Â°C (61-263Â°F)
- Throttle angle is 6% or less
- Ignition voltage is greater than 11 V
- Transmission is not in first, second or reverse gear
- Vehicle speed is greater than 25 kph (15.5 mph)
- Brake booster pressure is greater than 42.0 kPa (6 psi)
- Vehicle is not in fuel shut of mode
- Vehicle is not in heater performance mode
- Vehicle is not in tip in bump acceleration mode
- Vehicle is not in oil aeration mode

When cylinder deactivation is commanded, the ECM will determine what cylinder is firing and begin deactivation on the next closest deactivated cylinder in firing order sequence. Cylinder deactivation is accomplished by not allowing the intake and exhaust valves to open on the selected cylinders by using special valve lifters. The deactivation lifters contain spring loaded locking pins that connect the internal pin housing of the lifter to the outer housing.

Although both intake and exhaust valve lifters are controlled by the same Valve Rocker Arm Oil Control Valve, the intake and exhaust valves do not become deactivated at the same time. Cylinder deactivation

is timed so that the cylinder is on an intake event. During an intake event, the intake cam lobe is pushing the valve lifter upwards to open the intake valve against the force of the valve spring. The force exerted by the valve spring is acting on the side of the lifter locking pins, preventing them from moving until the intake valve has closed. When the intake valve lifter reaches the base circle of the camshaft lobe, the valve spring force is reduced, allowing the locking pins to move, deactivating the intake valve. However, when cylinder deactivation is commanded ON, the exhaust valve for the deactivated cylinder is in the closed position, allowing the locking pins on the valve lifter to move immediately and deactivate the exhaust valve.

By deactivating the exhaust valve first, this allows the capture of a burnt air/fuel charge or exhaust gas charge, in the combustion chamber. The capture of exhaust gases in the combustion chamber will contribute to a reduction in oil consumption, noise and vibration levels and exhaust emissions when operating in V4 mode cylinder deactivation mode.

During the transition from V6 to V4 mode, the fuel injectors will be turned OFF on the deactivated cylinders. To help prevent spark plug fouling, the ignition system secondary voltage or spark is still present across the spark plug electrodes on the deactivated cylinders. If all enabling conditions are met and maintained for cylinder deactivation operation, the ECM calibrations will limit cylinder deactivation to a cycle time of 10 minutes in V4 mode, then return to V6 mode for 1 minute.

Switching between V6 and V4 modes is accomplished in less than 250 milliseconds, making the transitions seamless and transparent to the vehicle operator. The 250 milliseconds includes the time for the ECM to sequence the transitions, the response time for the valve lifter oil manifold solenoids to energize and the time for the valve lifters to deactivate, all within 2 revolutions of the engine crankshaft.

Valve Lifter Oil Solenoid Valve

The cylinder deactivation system uses an electro-hydraulic actuator device called the valve lifter oil solenoid. The valve lifter oil solenoid is bolted to the top of the cylinder head valve covers. Each solenoid controls the application of engine oil pressure to the intake and exhaust valve lifters on the cylinders selected to deactivate. Engine oil pressure is routed to the valve lifter oil solenoid from an internal oil passages.

Both valve lifter oil solenoids are connected in parallel to a fused ignition 1 voltage circuit, supplied by the ignition relay. The ground or control circuit for each solenoid is connected to a low side driver internal to the Engine Control Module (ECM).

When all enabling conditions are met for cylinder deactivation, the ECM will ground each solenoid control circuit in firing order sequence, allowing current to flow through the solenoid windings. With the coil windings energized, the solenoid controls engine oil pressure through the valve lifter. When vehicle-operating conditions require a return to V6 mode, the ECM will turn OFF the control circuit for the solenoids, allowing the solenoid valves to close. With the solenoid valves closed, engine oil pressure in the control ports is exhausted through the body of the solenoids into the engine.

During service, use extreme care in keeping the valve lifter oil solenoid free of any contamination or foreign material.

Cylinder deactivation may be inhibited for many reasons including the following:

- Engine coolant temperature out of range for cylinder activation
- Engine vacuum out of range
- Brake booster vacuum out of range
- Transmission gear incorrect or shift in progress
- Accelerator pedal out of range or rate of pedal application to fast
- Engine oil pressure and temperature out of range
- Engine speed out of range
- Vehicle speed out of range
- Minimum time in V6 mode not met
- Maximum V4 mode time exceeded
- Decel fuel cutoff is active

- Reduced engine power is active
- Torque management is active
- Catalytic converter over temperature protection is active
- Piston protection is active, knock detected
- Cylinder deactivation solenoid driver circuit faults

EVAPORATIVE EMISSION CONTROL SYSTEM DESCRIPTION

Typical Evaporative Emission (EVAP) System Hose Routing Diagram

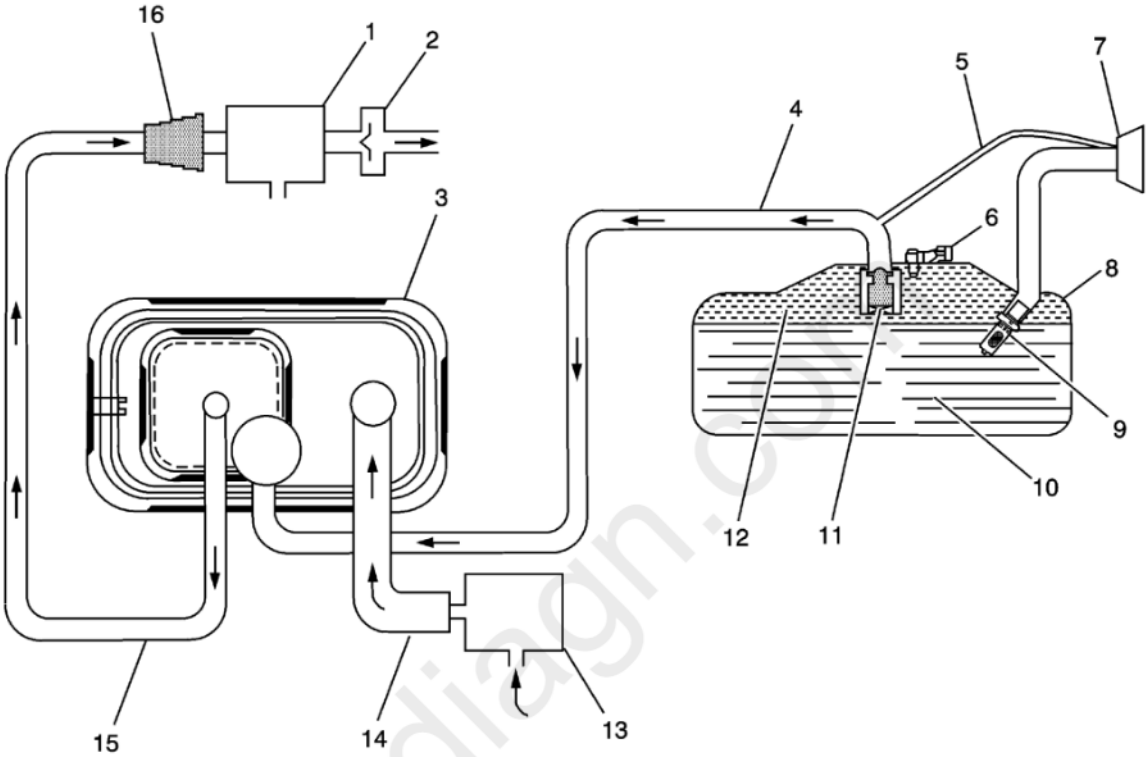

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Fig. 2: View Of Typical Evaporative Emission (EVAP) System Hose Routing Diagram
Courtesy of GENERAL MOTORS COMPANY

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

Callout	Component Name
15	EVAP Purge Tube
16	EVAP Canister Purge Tube Connector

EVAP System Operation

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

Purge Solenoid Valve Leak Test

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

Large Leak Test

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

Canister Vent Restriction Test

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

Small Leak Test

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

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

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

EVAP System Components

The EVAP system consists of the following components:

EVAP Purge Solenoid Valve

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

Purge Tube Check Valve

NOTE: **The presence of this one-way check valve prevents pressure testing the EVAP system for leaks at the EVAP canister purge tube connector.**

Turbocharged vehicles have a check valve in the purge tube between the EVAP purge solenoid valve and the intake manifold to prevent pressurization of the EVAP system under boost conditions. Some applications may have this check valve between the EVAP purge solenoid valve and the EVAP canister.

EVAP Canister

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

Vapor Recirculation Tube

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

The On-Board Refueling Vapor Recovery System is an on-board vehicle system designed to recover fuel vapors during the vehicle refueling operation. The flow of liquid fuel down the fuel filler pipe provides a liquid seal which prevents vapor from leaving the fuel filler pipe. An EVAP pipe transports the fuel vapor to the EVAP canister for use by the engine.

Fuel Tank Pressure Sensor

The fuel tank pressure sensor measures the difference between the pressure or vacuum in the fuel tank and outside air pressure. Depending on the vehicle, the sensor can be located in the vapor space on top of the fuel tank, in the vapor tube between the canister and the tank or on the EVAP canister. A high fuel tank pressure sensor voltage indicates a low fuel tank pressure or vacuum. A low fuel tank pressure sensor voltage indicates a high fuel tank pressure.

Fuel Fill Pipe Check Valve

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

EVAP Vent Solenoid Valve

The EVAP vent solenoid valve controls fresh airflow into the EVAP canister. The valve is normally open. The canister vent solenoid valve is closed only during EVAP system tests performed by the ECM like large leak and engine off natural vacuum test.

Fuel Fill Cap

The fuel fill cap is equipped with a seal and a vacuum relief valve and is tethered. A torque-limiting device prevents the cap from being over tightened. To install the cap, turn the cap clockwise until you hear clicks. This indicates that the cap is correctly torqued and fully seated. A built-in device indicates that the fuel filler cap is fully seated. A fuel filler cap that is not fully seated may cause a malfunction in the emission system.

Capless Fuel Fill

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

Fill Limit Vent Valve

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This acts as a shut off valve during refueling. This will vary based on fuel tank design. The fuel limit vent valve has the following functions:

- The fuel limit vent valve is located on the inside top of the fuel tank
- This valve is not serviced separately
- Controls the fuel tank fill level by closing the primary vent from the fuel tank and forcing the fuel fill nozzle to shut off.
- Prevents liquid fuel from exiting the fuel tank via the EVAP pipe to the canister.
- Provides fuel-spillage protection in the event of a vehicle rollover by closing the vapor path from the tank to the EVAP canister.

FUEL SYSTEM DESCRIPTION

Fuel System Overview

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

An electric turbine style fuel pump attaches to the primary 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).

The primary fuel tank fuel pump module also contains a primary jet pump. Fuel pump flow loss, caused by vapor expulsion in the pump inlet chamber, is diverted to the primary jet pump through a restrictive orifice located on the pump cover. The primary jet pump fills the reservoir of the primary fuel tank fuel pump module. The fuel tank fuel pump module has a secondary jet pump that creates a venturi action which causes the fuel to be drawn from the secondary side of the fuel tank, through the fuel transfer pipe, to the primary side of the fuel tank.

Electronic Returnless Fuel System

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

Fuel Pressure Sensor

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

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 frame. The fuel tank is molded from high-density polyethylene.

The fuel tank is a saddle configuration in order to provide space for a driveshaft through the center area of the fuel tank. Because of the saddle shape of the tank, two fuel tank fuel pump modules are required.

Mounted inside the fuel tank, as part of the tank assembly is a fuel limit vent valve that is designed to close the fuel tank vent when the fuel level reaches a calibrated level during fueling. When the fuel limit vent valve is closed the tank pressure increases during the filling process. This increase in tank pressure causes the filling station fuel pump nozzle to turn OFF. When the fuel limit vent valve is opened fuel vapors in the fuel tank are allowed to vent through the fuel limit vent valve and hose to the EVAP canister.

Fuel Fill Pipe

The fuel fill pipe has a built-in restrictor in order to prevent refueling with leaded fuel. A capless fuel fill is part of the fuel fill tube design. There is no fuel fill cap to remove. To fill the tank, open the locking fuel door and fully insert the fuel nozzle into the fill neck. Flapper valves close to seal this interface once the fill nozzle is removed.

Fuel Tank Fuel Pump Module

An electric turbine style fuel pump attaches to the primary 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 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.

Primary Fuel Tank Fuel Pump Module

The primary fuel tank fuel pump module is located inside of the right side of the fuel tank. The primary 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
- The fuel strainer
- The primary jet pump
- The secondary jet pump

Secondary Fuel Tank Fuel Pump Module

The secondary fuel tank fuel pump module is located inside of the left side of the fuel tank. The secondary fuel tank fuel pump module consists of the following major components:

- The fuel level sensor
- The fuel pick-up

Fuel Level Sensor

The fuel level sensor consists of a float, a wire float arm and a ceramic resistor card. The position of the float arm indicates the fuel level. The fuel level sensor contains a variable resistor which changes resistance in correspondence with the position of the float arm. The engine control module (ECM) sends the fuel level information via the serial data circuit to the instrument panel cluster (IPC) in order to control the fuel gauge. The control module monitors the signal circuits of the primary fuel level sensor and the secondary fuel level sensor in order to determine the fuel level.

Fuel Pump

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

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Fuel Filter

The fuel filter is located in the primary fuel tank fuel pump module. The paper filter element traps particles in the fuel that may damage the fuel injection system.

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.

Primary and Secondary Jet Pumps

The primary jet pump is located in the primary fuel tank fuel pump module. Fuel pump flow loss, caused by vapor expulsion in the pump inlet chamber, is diverted to the primary jet pump and the secondary jet pump through a restrictive orifice located on the pump cover. The primary jet pump fills the reservoir of the primary fuel tank fuel pump module.

The secondary jet pump creates a venturi action which causes the fuel to be drawn from the secondary side of the fuel tank, through the transfer pipe, to the primary side of the fuel tank.

Nylon Fuel Pipes

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

- **Replace all nylon fuel pipes that are nicked, scratched or damaged during installation, do not attempt to repair the sections of the nylon fuel pipes**
- **Do not hammer directly on the fuel harness body clips when installing new fuel pipes. Damage to the nylon pipes may result in a fuel leak.**
- **Always cover nylon vapor pipes with a wet towel before using a torch near them. Also, never expose the vehicle to temperatures higher than 115Â°C (239Â°F) for more than one hour or more than 90Â°C (194Â°F) for any extended period.**
- **Apply a few drops of clean engine oil to the male pipe ends before connecting fuel pipe fittings. This will ensure proper reconnection and prevent a possible fuel leak. (During normal operation, the O-rings located in the female connector will swell and may prevent proper reconnection if not lubricated.)**

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

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

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

Quick-Connect Fittings

Quick-connect fittings provide a simplified means of installing and connecting fuel system components. The fittings consist of a unique female connector and a compatible male pipe end. O-rings, located

inside the female connector, provide the fuel seal. Integral locking tabs inside the female connector hold the fittings together.

High Pressure Fuel Pump

The high fuel pressure necessary for direct injection is supplied by the high pressure fuel pump. The pump is mounted on the rear of the engine and is driven by a three-lobe cam on the Bank 1 exhaust 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 that prevents the pressure from exceeding 17.5 MPa (2538 psi).

Fuel Rail Assembly

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

- The direct fuel injectors
- The fuel rail pressure sensor

Fuel Rail Pressure/Temperature Sensor

The fuel rail pressure sensor transmits fuel pressure and temperature information by serial data using the Society of Automotive Engineers (SAE) J2716 Single Edge Nibble Transmission (SENT) protocol. The fuel rail pressure sensor internal micro processor allows 4 separate sensor outputs from one 3 wire sensor. The engine control module (ECM) supplies the fuel rail pressure sensor with a 5 V reference circuit, a low reference circuit and an asynchronous signal/serial data circuit. The asynchronous signal means communication is only going from the fuel rail pressure sensor to the ECM. The ECM decodes the serial data signal into separate voltages which are displayed on a scan tool as the voltage inputs from the Fuel Temperature Sensor, Fuel Rail Pressure Sensor and Fuel Rail Pressure Sensor 2.

Fuel Injectors

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

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

Fuel Metering Modes of Operation

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

Starting Mode

The ECM supplies voltage to the fuel pump control module when the ECM detects that the ignition is ON. The voltage from the ECM to the fuel pump control module remains active for 2 s, unless the

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

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

Clear Flood Mode

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

Run Mode

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

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

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

Acceleration Mode

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

Deceleration Mode

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

Battery Voltage Correction Mode

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

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

Fuel Cutoff Mode

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

- The ignition is OFF. This prevents engine run-on.
- The ignition is ON but there is no ignition reference signal. This prevents flooding or backfiring.
- The engine speed is too high, above red line.
- The vehicle speed is too high, above rated tire speed.
- During an extended, high speed, closed throttle coast down-This reduces emissions and increases engine braking.
- During extended deceleration, in order to prevent damage to the catalytic converters

Fuel Trim

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

THROTTLE ACTUATOR CONTROL (TAC) SYSTEM DESCRIPTION

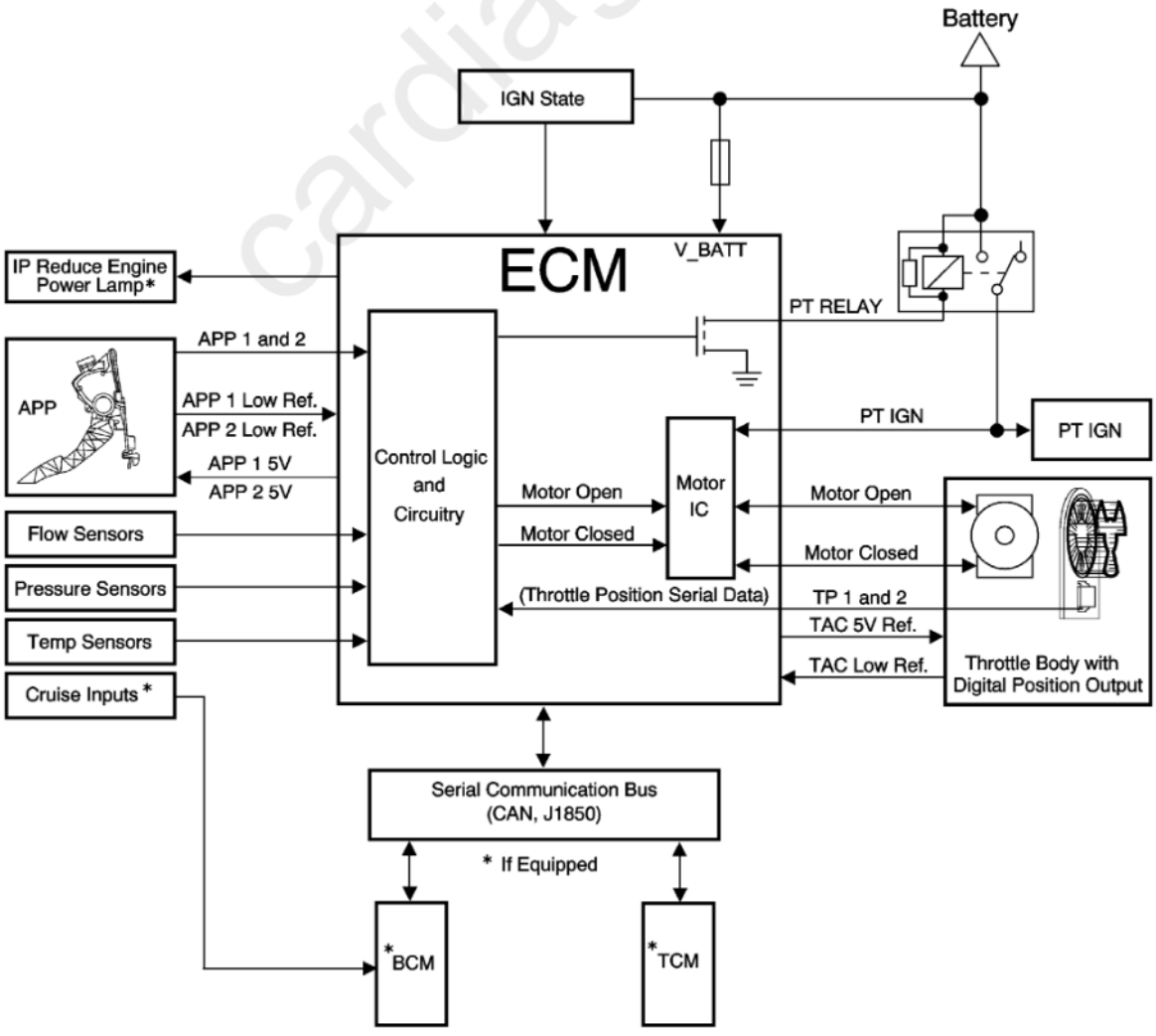

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Fig. 3: Throttle Actuator Control (TAC) System Description
Courtesy of GENERAL MOTORS COMPANY

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 actions listed below:
  - 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.

  If the throttle blade becomes stuck, a DTC will set. Depending on the position of the throttle blade, the ECM may enter Engine Shutdown Mode. If the condition remains present during the next ignition cycle, the ECM may disable engine cranking. Inspect the throttle body assembly for a stuck throttle blade if a throttle actuator DTC is current and the engine won't crank.

Throttle/Idle Learn or Throttle Body Idle Air Flow Compensation Reset

The engine control module (ECM) learns the airflow through the throttle body to ensure the correct idle. The learned airflow values are stored within the ECM. These values are learned to adjust for production variation and will continuously learn during the life of the vehicle to compensate for reduced airflow due to throttle body coking. Anytime the throttle body airflow rate changes, for example due to cleaning or replacing, the values must be relearned.

An engine that had a heavily coked throttle body that has been cleaned or replaced may take several drive cycles to unlearn the coking. To accelerate the process, the scan tool has the ability to reset the learned value back to zero. A new ECM will also have values set to zero. Cleaning the throttle body when the ECM is replaced can reduce the time it take for the ECM to relearn the minimum idle speed.

The idle may be unstable or a DTC may set if the learned values do not match the actual airflow.

A un-metered air leak in the induction system or a small vacuum leak may not set a DTC. If the condition goes undetected, the ECM may learn an incorrect Throttle Body Idle Airflow Compensation value over time. The incorrectly learned value may cause various symptoms to occur such as rough or unstable idle speeds and/or engine stall. If this condition is detected and repaired it will be necessary perform the Throttle/Idle Learn or Throttle Body Idle Air Flow Compensation Reset procedure to ensure any symptoms are corrected.

TURBOCHARGER SYSTEM DESCRIPTION

Twin Turbocharger System

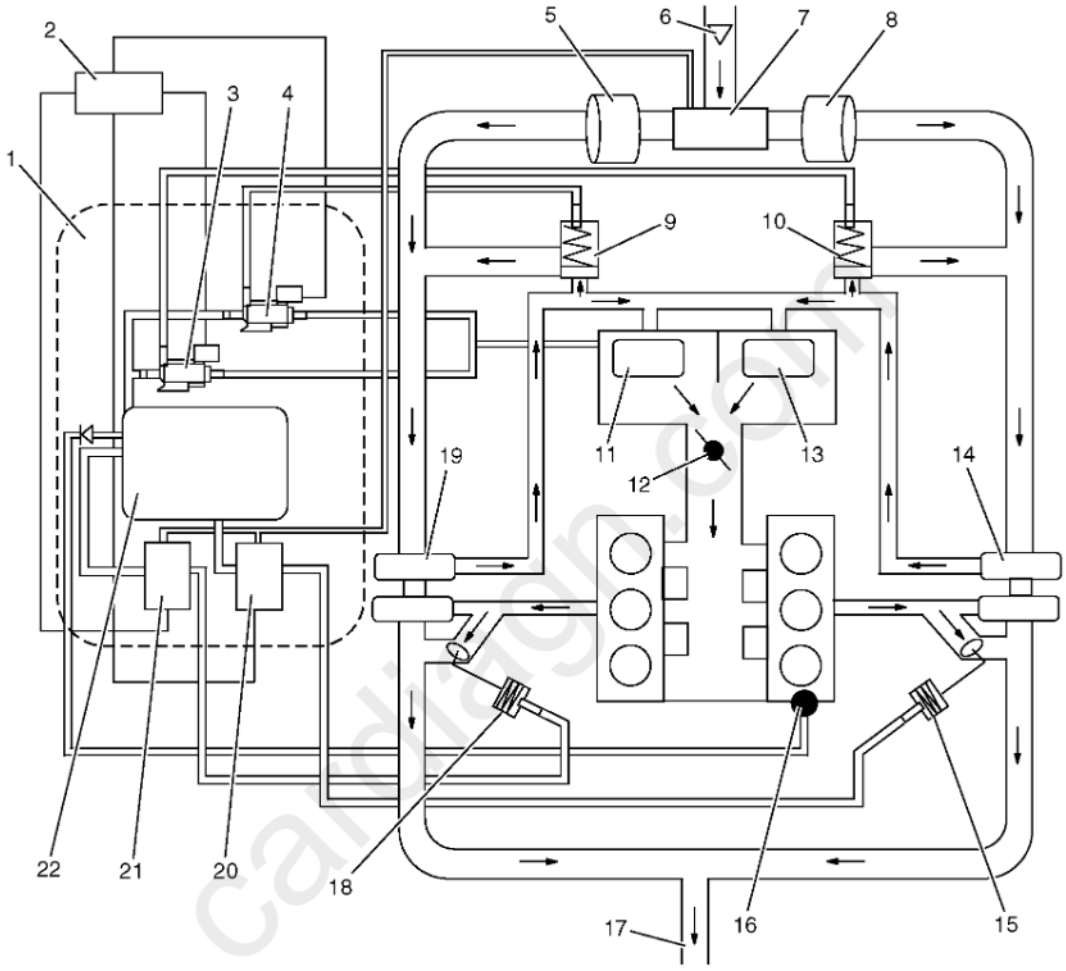

Fig. 4: Twin Turbocharger System
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Vacuum Module
2	Engine Control Module
3	RH Bypass Valve Solenoid
4	LH Bypass Valve Solenoid
5	LH Mass Air Flow Sensor
6	Air inlet (snorkel)
7	Air Box
8	RH Mass Air Flow Sensor
9	LH Compressor Bypass Valve
10	RH Compressor Bypass Valve
11	Charge Air Cooler 2
12	Throttle Body

Callout	Component Name
13	Charge Air Cooler 1
14	RH Turbocharger
15	RH Wastegate Actuator
16	Mechanical Vacuum Pump
17	Exhaust
18	LH Wastegate Actuator
19	LH Turbocharger
20	RH Wastegate Regulator Solenoid Valve
21	LH Wastegate Regulator Solenoid Valve
22	Vacuum Tank or Tanks (LF4)

Turbocharger Description and Operation

This engine is equipped with dual turbochargers. Each turbocharger is provided with its own solenoid controlled vacuum-actuated wastegate and recirculation valve. These valves are used to manage the engine's boost pressure and torque response for consistent performance across the RPM band. The wastegates regulate the boost pressure of the engine by providing a bypass path for the exhaust to flow around the turbine wheel back into the exhaust stream to maintain optimal turbine speed. The vacuum-operated wastegate valves provide consistent boost control, particularly at lower engine speeds, to enhance low-speed torque. They are independently controlled on each engine bank to balance the compressors' output to achieve more precise boost pressure response. The wastegates also work in conjunction with the recirculation valves to eliminate compressor surge and excessive noise and vibration from the turbos immediately after the throttle closes. The compressors draw air directly from the inlet box and send pressurized air across the intercoolers (charge air coolers). A single, centrally located throttle body, located under the intercooler cover, controls the air charge from both turbochargers after the temperature is reduced by the intercoolers. This design results in more immediate torque response, for a greater feeling of power on demand. The turbochargers are mounted to the exhaust manifold of each bank and are driven by the energy generated by the flow of the exhaust gases. The turbines are connected by a shaft to the compressors which are mounted in the induction side of the engine.

The turbochargers are 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 away excessive heat. Each turbocharger is also provided with a coolant circuit, from the engine cooling system, to further reduce operating temperature and passively dissipate bearing housing heat away on shut down.

Wastegate Valves

Vacuum operated, solenoid controlled, wastegate actuators are used to open and close the normally open wastegate valves. A spiral spring in the actuator housing works in the opening direction while vacuum in the diaphragm housing works in the closing direction. The engine control module (ECM) supplies a signal to the solenoid valve which regulates vacuum to the actuator. When the vacuum overcomes the spring force, the actuator rod moves, closing the wastegate valve to a corresponding degree. The ECM changes wastegate valve position by varying the signal to regulate turbine speed.

At low loads, (less than barometric pressure), the valves are open, allowing exhaust gas to bypass the turbines and reduce fuel consumption. When a request for boost pressure is received, the valves close and the pressure increases. As the boost pressure (and air flow) increase towards the desired level, the wastegate valves are gradually opened to maintain boost for the current operating condition. The force balance between this pressure and the turbine pressure on the wastegate valve itself regulates the amount of exhaust gas that flows through the turbine and the wastegate channel. Controlling the flow through the turbine regulates the power delivered to the compressor to vary the boost pressure.

When certain DTC's are set the system is limited to base boost (also known as mechanical boost). This is the boost pressure the system will create with the wastegates fully open. When a DTC is set, the solenoids feed little to no vacuum to the wastegates, allowing them to reach their full (or nearly full) open positions. This limits the boost pressure by allowing as much flow as possible to pass through the wastegate valve, this boost pressure is very close to atmospheric pressure under almost all driving conditions. Any condition or DTC that causes the intake or exhaust cams to be parked will also limit the system to base (or near base) boost.

Bypass Solenoid Valves (Compressor Recirculation Valves)

The turbocharger bypass valves are mounted between the intercooler inlet air tubes and the turbocharger air inlet adapters. They are used to prevent the turbos from exceeding the surge limit of the compressors at low flow and high pressure. This occurs when the engine is running with a high 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 undesirable noise and vibration and rapidly decelerates turbine speed. During normal operation the recirculation valves are held closed by both a light spring and high pressure exerted on the back side of the valve, which allows the spring to do minimal work. The bypass solenoids provide either high pressure (intercooler pressure) or vacuum to the valve. When vacuum is applied the change in pressure across the valve becomes large because the front side of the valve sees compressor out pressure while the rear sees vacuum. The spring is overpowered in this situation and the valve opens. The bypass valves are opened when the throttle is closed. This means little to no flow is entering the intercooler. Rather all the air is flowing in a circular path through the compressor (see diagram). The bypass valves are generally open for 1-2 seconds until the boost level drops to the new requested level.

Accelerator Pedal Depressed

The bypass valves are closed. The force of the return spring along with intercooler pressure forces the valves against their seats in the valve housings. Airflow passes through the compressors, across the charge air coolers and through the throttle body to provide maximum boost.

Accelerator Pedal Released

The bypass valves are opened. The force of the return spring is overpowered by vacuum on the rear side of the valve and compressor output pressure on the front side. Most of the airflow is directed through the bypass tubes and flows directly across the charge air coolers and through the throttle body. The turbine speed is kept relatively high and the turbochargers are prevented from exceeding the surge limit of the compressors. Under some conditions only one bypass valve may open, as each compressor is controlled independently.

Charge Air Cooler (Intercooler) System

The charge air cooler systems function is to reduce the temperature of the air charge that is heated during the turbocharging process to improve the efficiency and performance of the engine. The intercooler uses conventional coolant that is separate from the engine cooling system. The intercooler system includes a cover, two heat exchangers, water manifold, charge air cooler radiators and an electric coolant pump. The coolant pump transfers coolant from the radiator to the water manifold which then directs coolant to the heat exchangers via transfer tubes. Coolant enters the inlet port of the water manifold assembly, is directed into and through the charge air coolers/heat exchangers and exits back into the water manifold. Coolant then exits the water manifold outlet port returning to the separate cooling system radiators. The charge air coolers can reduce the compressor outlet air temperature by up to 74Â°C (133Â°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 inlet air tubes are connected to the turbochargers by flexible rubber hoses that require the use of special high torque fastening clamps. In order to prevent any type of air leak when servicing the hoses and tubes, the tightening specifications, cleanliness and proper positioning of the clamps is critical and must be strictly adhered to.

Turbocharger Vacuum System

LF3/LF4

This engine utilizes a mechanical vacuum pump to provide a vacuum source for the braking system and turbocharger waste gate actuators. The vacuum pump is driven off the right hand exhaust camshaft. A vacuum tank or tanks, hold vacuum in reserve to provide a constant vacuum supply to the turbocharger braking components under all driving conditions.

LGW

This engine utilizes a mechanical vacuum pump to provide a vacuum source for the braking system and turbocharger waste gate actuators. The vacuum pump is integrated into the oil pump assembly located in the oil pan. Both vacuum pump and oil pump are part of a common assembly, referred to as a tandem pump. Neither pump is serviceable individually. If either the oil pump or vacuum pump are defective,

replace the entire tandem pump assembly. A vacuum tank or tanks, hold vacuum in reserve to provide a constant vacuum supply to the turbocharger braking components under all driving conditions.

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DIAGNOSTIC INFORMATION AND PROCEDURES

DTC P0010, P0013, P0020, P0023, P2088, P2089, P2090, P2091, P2092, P2093, P2094 OR P2095: INTAKE/EXHAUST CAMSHAFT POSITION ACTUATOR SOLENOID VALVE CONTROL CIRCUIT

Diagnostic Instructions

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

DTC Descriptors

DTC P0010

Intake Camshaft Position Actuator Solenoid Valve Control Circuit Bank 1

DTC P0013

Exhaust Camshaft Position Actuator Solenoid Valve Control Circuit Bank 1

DTC P0020

Intake Camshaft Position Actuator Solenoid Valve Control Circuit Bank 2

DTC P0023

Exhaust Camshaft Position Actuator Solenoid Valve Control Circuit Bank 2

DTC P2088

Intake Camshaft Position Actuator Solenoid Valve Control Circuit Low Voltage Bank 1

DTC P2089

Intake Camshaft Position Actuator Solenoid Valve Control Circuit High Voltage Bank 1

DTC P2090

Exhaust Camshaft Position Actuator Solenoid Valve Control Circuit Low Voltage Bank 1

DTC P2091

Exhaust Camshaft Position Actuator Solenoid Valve Control Circuit High Voltage Bank 1

DTC P2092

Intake Camshaft Position Actuator Solenoid Valve Control Circuit Low Voltage Bank 2

DTC P2093

Intake Camshaft Position Actuator Solenoid Valve Control Circuit High Voltage Bank 2

DTC P2094

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Exhaust Camshaft Position Actuator Solenoid Valve Control Circuit Low Voltage Bank 2

DTC P2095

Exhaust Camshaft Position Actuator Solenoid Valve Control Circuit High Voltage Bank 2

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
Camshaft Position Actuator Solenoid Valve High Control	P0010, P0013, P0020, P0023, P2088, P2090, P2092, P2094	P0010, P0013, P0020, P0023	P0010, P0013, P0020, P0023	P0010, P0013, P0020, P0023, P2089, P2091, P2093, P2095	P0011, P0014, P0021, P0024
Camshaft Position Actuator Solenoid Valve Low Reference	-	P0010, P0013, P0020, P0023	P0010, P0013, P0020, P0023	-	-

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 ignition switch is in the Crank or Run position.
- The ECM commanded the Camshaft Position Actuator Solenoid Valve On.
- The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

The ECM detects that the commanded state of the driver and the actual state of the control circuit do not match for greater than 5@!~@::@thinsp;s.

Actions Taken When the DTC Sets

DTCs listed in the DTC Descriptor Category=Type B DTC - Exceptions listed below

If equipped with a turbocharger=Type A DTC

Conditions for Clearing the DTC

DTCs listed in the DTC Descriptor Category=Type B DTC - Exceptions listed below

If equipped with a turbocharger=Type A DTC

Diagnostic Aids

If the condition is intermittent, move the related harnesses and connectors, with the engine operating, while monitoring the scan tool circuit status parameters for the component. The circuit status parameters 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 (LGW) Engine Controls Schematics (LGX)

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

1. Ignition On.

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

2. Verify DTC P0335, P0336, P0340, P0341, P0345, P0346, P0365, P0366, P0390 or P0391 is not set.
   - **If any of the DTCs are set**

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

   - **If none of the DTCs are set**
3. Verify the scan tool parameters listed below do not display Malfunction when commanding the appropriate scan tool Camshaft Position Actuator with a scan tool:
   - Intake/Exhaust Camshaft Position Actuator Solenoid Valve Control Circuit Low Voltage Test Status Bank 1 or 2
   - Intake/Exhaust Camshaft Position Actuator Solenoid Valve Control Circuit Open Test Status Bank 1 or 2
   - Intake/Exhaust Camshaft Position Actuator Solenoid Valve Control Circuit High Voltage Test Status Bank 1 or 2
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing.

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- **If Malfunction is not displayed**

4. Engine running, raise the engine speed to 2, 000 RPM for 10 s.
5. Verify that DTC P0010, P0013, P0020, P0023 or P2088 - P2095 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 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 10 Ω between the test points: Low Reference circuit terminal 2/B & Ground
   - **If 10 Ω or greater**
   1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit
      - If less than 2 Ω, replace the K20 Engine Control Module
   - **If less than 10 Ω**
3. Ignition On.
4. Verify that a test lamp does not illuminate between the control circuit terminal 1/A and ground.

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.**

   - **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 and reconnect the harness connector.
6. Verify the scan tool Camshaft Position Actuator Solenoid Valve Control Circuit Low Voltage Test Status parameter does not display Malfunction when commanding the Q6 Camshaft Position Actuator Solenoid Valve On with a scan tool.
   - **If Malfunction is 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 Malfunction is not displayed**

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7. Install a 3 A fused jumper wire between the control circuit terminal 1/A and the low reference circuit 2/B.
8. Verify the scan tool Camshaft Position Actuator Solenoid Valve Control Circuit Low Voltage Test Status parameter is Malfunction when commanding the Q6 Camshaft Position Actuator Solenoid Valve 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 Ω in the control circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module
    - **If Malfunction is displayed**
9. Test or replace the 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 Ω between the control terminal 1/A and the low reference terminal 2/B.
    - **If not between 5-12 Ω**

      Replace the Q6 Camshaft Position Actuator Solenoid Valve.

    - **If between 5-12 Ω**
3. Test for infinite resistance between each terminal and the Q6 Camshaft Position Actuator Solenoid Valve housing.
    - **If not infinite resistance**

      Replace the Q6 Camshaft Position Actuator Solenoid Valve.

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

Repair Instructions

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

- **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Intake (LGW)** **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Intake (LGX)**
- **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Exhaust (LGW)** **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Exhaust (LGX)**
- **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Intake (LGX)** **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Intake (LGW)**
- **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Exhaust (LGX)** **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Exhaust (LGW)**
- **Control Module References** for K20 Engine Control Module replacement, programming and setup.

DTC P0011, P0014, P0021 OR P0024: INTAKE/EXHAUST CAMSHAFT POSITION SYSTEM PERFORMANCE

Diagnostic Instructions

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

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

DTC Descriptors

DTC P0011

Intake Camshaft Position System Performance Bank 1

DTC P0014

Exhaust Camshaft Position System Performance Bank 1

DTC P0021

Intake Camshaft Position System Performance Bank 2

DTC P0024

Exhaust Camshaft Position System Performance Bank 2

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, P0021, P0024
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, P0020, P0023, P0016, P0017, P0018, P0019, P0335, P0336, P0340, P0341, P0345, P0346, P0365, P0366, P0390 and P0391 is not set.
- The ignition voltage is greater than 11 V.
- The engine is running.
- The desired camshaft position is not changing greater than 4.5Â° for at least 1 s.
- Both of the desired and actual camshaft position actuator values cannot be greater than 20Â° or less than 5Â°.
- DTCs P0011, P0014, P0021 and P0024 run continuously when the above conditions are met.

Conditions for Setting the DTC

P0011 and P0021

The ECM detects the difference between the desired and actual camshaft position angle is greater than 5Â° for greater 2.5 s.

P0014 and P0024

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The ECM detects the difference between the desired and actual camshaft position angle is greater than 5Â° for greater 10 s.

Actions Taken When the DTC Sets

DTCs listed in the DTC Descriptor Category=Type B DTC - Exceptions listed below

If equipped with a turbocharger=Type A DTC

Conditions for Clearing the DTC

DTCs listed in the DTC Descriptor Category =Type B DTC - Exceptions listed below

If equipped with a turbocharger=Type A DTC

Diagnostic Aids

Inspect the engine for any recent engine mechanical repairs. An incorrectly installed camshaft, camshaft position actuator solenoid, mechanical camshaft actuator or timing chain can cause this DTC to set.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

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

1. Ignition On.

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**

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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 parameter. Advise the customer an oil change may be required.

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

2. Verify the engine has the correct oil pressure. Refer to **Oil Pressure Diagnosis and Testing** .
   - **If the oil level and the oil pressure are not correct**

     Repair as necessary

   - **If the oil level and the oil pressure are correct**
3. Verify that DTC P0016, P0017, P0018, P0019, P0335, P0336, P0338, P0340, P0341, P0345, P0346, P0365, P0366, P0390 or P0391 is not set.
   - **If any of the DTCs are set**

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

   - **If none of the DTCs are set**
4. Engine idling.
5. Verify the scan tool parameters are less than 2Â° in each of the commanded states when commanding the Camshaft Position Actuator from 0-20Â° and back to 0Â° with the scan tool.
   - Intake Camshaft Position Variance
   - Exhaust Camshaft Position Variance
   - **If 2Â° or greater**

     Refer to Circuit/System Testing.

   - **If less than 2Â°**
6. Verify that DTC P0011 or P0014 is not set.
   - **If any of the DTCs are set**

     Refer to Circuit/System Testing.

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

     Refer to Circuit/System Testing.

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

Circuit/System Testing

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

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- **If less than 5 Ω**

3. Ignition On.

NOTE: **A test lamp must be used for this test. The control circuit is pulled 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 1/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. Verify the test lamp illuminates when commanding the appropriate Camshaft Position Actuator Solenoid Valve On with a scan tool.
   - **If the test lamp does not illuminate**
   1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the control circuit end to end.
   - If 2 Ω or greater, repair the open/high resistance or short to ground in the circuit.
   - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If the test lamp illuminates**
6. Ignition Off, remove the Q6 Camshaft Position Actuator Solenoid Valve.
7. Verify the conditions listed below do not exist with the Q6 Camshaft Position Actuator Solenoid Valve:
   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**
8. Ignition Off, swap the Q6 Camshaft Position Actuator Solenoid Valve with the Q6 Camshaft Position Actuator Solenoid Valve that is operating correctly.

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

9. Engine idling.
10. Verify the scan tool Camshaft Position Variance parameter is less than 2Â° in each of the commanded states when commanding the Camshaft Position Actuator from 0-20Â° and back to 0Â° with a scan tool.
    - **If 2Â° or greater**

      Replace the mechanical camshaft position actuator.

    - **If less than 2Â°**
11. 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.

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2. Test for 5-12 Ω between the control terminal 1/A and the low reference circuit terminal 2/B.
    - **If not between 5-12 Ω**

      Replace the Q6 Camshaft Position Actuator Solenoid Valve.

    - **If between 5-12 Ω**
3. Test for infinite resistance between each terminal and the Q6 Camshaft Position Actuator Solenoid Valve housing.
    - **If not infinite resistance**

      Replace the Q6 Camshaft Position Actuator Solenoid Valve.

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

Repair Instructions

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

- **Camshaft Position Actuator Replacement - Bank 1**
- **Camshaft Position Actuator Replacement - Bank 2**
- **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Intake (LGW)** **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Intake (LGX)**
- **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Exhaust (LGW)** **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Exhaust (LGX)**
- **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Intake (LGX)** **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Intake (LGW)**
- **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Exhaust (LGX)** **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Exhaust (LGW)**
- **Control Module References** for ECM replacement, programming and setup.

DTC P0016, P0017, P0018 OR P0019: CRANKSHAFT POSITION - INTAKE/EXHAUST CAMSHAFT POSITION NOT PLAUSIBLE (LGX)

Diagnostic 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 Bank 1

DTC P0017

Crankshaft Position - Exhaust Camshaft Position Not Plausible Bank 1

DTC P0018

Crankshaft Position - Intake Camshaft Position Not Plausible Bank 2

DTC P0019

Crankshaft Position - Exhaust Camshaft Position Not Plausible Bank 2

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Circuit/System Description

The engine control module (ECM) uses the crankshaft position sensor and the camshaft position sensor pulses to monitor the correlation between the crankshaft and the camshaft position.

Conditions for Running the DTC

- DTC P0335, P0336, P0340, P0341, P0345, P0346, P0365, P0366, P0390, P0391, P0641 or P0642 is not set.
- The crankshaft and camshaft position signals are synchronized.
- The engine is cranking or running.
- The camshaft position actuator is in the parked position.

The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

DTC P0016, P0017, P0018 or P0019

- The ECM detects that one camshaft is mis-aligned with the crankshaft. The ECM detects one of the following conditions:
  - Bank 1 intake camshaft is greater than 9Â° advanced or 12Â° retarded in relationship to the crankshaft.
  - Bank 1 exhaust camshaft is greater than 10Â° advanced or 13Â° retarded in relationship to the crankshaft.
  - Bank 2 intake camshaft is greater than 11Â° advanced or 13Â° retarded in relationship to the crankshaft.
  - Bank 2 exhaust camshaft is greater than 9Â° advanced or 13Â° retarded in relationship to the crankshaft.
- The ECM detects that all 4 camshafts are mis-aligned with the crankshaft. The ECM detects the following conditions:
  - Bank 1 intake camshaft is greater than 9Â° advanced or 12Â° retarded in relationship to the crankshaft.
  - Bank 1 exhaust camshaft is greater than 10Â° advanced or 13Â° retarded in relationship to the crankshaft.
  - Bank 2 intake camshaft is greater than 6Â° advanced or 9Â° retarded in relationship to the crankshaft.
  - Bank 2 exhaust camshaft is greater than 7Â° advanced or 9Â° retarded in relationship to the crankshaft.

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Action Taken When the DTC Sets

DTCs P0016, P0017, P0018 and P0019 are type B DTCs.

Conditions for Clearing the DTC

DTCs P0016, P0017, P0018 and P0019 are type B DTCs.

Diagnostic Aids

- Inspect the engine for any recent engine mechanical repairs. An incorrectly installed secondary timing chain can cause this DTC to set.
- This diagnostic algorithm is designed to detect an alignment condition between a primary intermediate sprocket and the secondary timing chain or the alignment between a primary intermediate sprocket and the crankshaft. Either condition would cause the camshaft timing for both cams on one bank to be off an equal number of degrees.
- DTCs P0016, P0017, P0018 and P0019 set at the same time indicate a possible condition with the primary timing chain and the alignment between both intermediate sprockets and the crankshaft. Also, the crankshaft reluctor wheel may have moved and is no longer referenced to top dead center (TDC).

- Observing the desired and actual camshaft angle parameters with a scan tool before a DTC sets may help to isolate whether a condition is specific to one camshaft, one bank or caused by a condition with the primary crankshaft timing.

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, P0020, P0023, P0335, P0336, P0340, P0341, P0345, P0346, P0365, P0366, P0390, P0391, P2088, P2089, P2090, P2091, P2092, P2093, P2094, 20095 or P25CA-P25CE 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 conditions below do not exist:
    - 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 a condition is found**

      Repair as necessary.

    - **If no condition is found**
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**

      A mechanical condition listed above still exists.

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

Repair Instructions

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

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- Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Exhaust (LGX)
- Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Exhaust (LGX)
- Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Intake (LGX)
- Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Intake (LGX)
- Camshaft Position Sensor Replacement - Bank 1 (Right Side) Exhaust (LGX)
- Camshaft Position Sensor Replacement - Bank 2 (Left Side) Exhaust (LGX)
- Camshaft Position Sensor Replacement - Bank 1 (Right Side) Intake
- Camshaft Position Sensor Replacement - Bank 2 (Left Side) Intake (LGX)
- Camshaft Timing Drive Components Cleaning and Inspection
- Crankshaft Position Sensor Replacement
- Timing Chain Alignment Diagram

DTC P0016, P0017, P0018 OR P0019: CRANKSHAFT POSITION - INTAKE/EXHAUST CAMSHAFT POSITION NOT PLAUSIBLE (LGW)

Diagnostic 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 Bank 1

DTC P0017

Crankshaft Position - Exhaust Camshaft Position Not Plausible Bank 1

DTC P0018

Crankshaft Position - Intake Camshaft Position Not Plausible Bank 2

DTC P0019

Crankshaft Position - Exhaust Camshaft Position Not Plausible Bank 2

Circuit/System Description

The engine control module (ECM) uses the crankshaft position sensor and the camshaft position sensor pulses to monitor the correlation between the crankshaft and the camshaft position.

Conditions for Running the DTC

- DTC P0335, P0336, P0340, P0341, P0345, P0346, P0365, P0366, P0390, P0391, P0641 or P0642 is not set.
- The engine is cranking or running.
- The crankshaft and camshaft position signals are synchronized.
- The camshaft position actuator is in the parked position.

The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

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DTC P0016, P0017, P0018 or P0019

- The ECM detects that all 4 camshafts are mis-aligned with the crankshaft for 2 out of 30 camshaft revolutions. The ECM detects the following conditions:
  - Bank 1 intake camshaft is greater than 6Â° advanced or 9.9Â° retarded in relationship to the crankshaft.
  - Bank 1 exhaust camshaft is greater than 5.6Â° advanced or 9.9Â° retarded in relationship to the crankshaft.
  - Bank 2 intake camshaft is greater than 6.1Â° advanced or 9.9Â° retarded in relationship to the crankshaft.
  - Bank 2 exhaust camshaft is greater than 7.3Â° advanced or 9.9Â° retarded in relationship to the crankshaft.

Action Taken When the DTC Sets

DTCs P0016, P0017, P0018 and P0019 are type B DTCs.

Conditions for Clearing the DTC

DTCs P0016, P0017, P0018 and P0019 are type B DTCs.

Diagnostic Aids

- Inspect the engine for any recent engine mechanical repairs. An incorrectly installed secondary timing chain can cause this DTC to set.
- This diagnostic algorithm is designed to detect an alignment condition between a primary intermediate sprocket and the secondary timing chain or the alignment between a primary intermediate sprocket and the crankshaft. Either condition would cause the camshaft timing for both cams on one bank to be off an equal number of degrees.
- DTCs P0016, P0017, P0018 and P0019 set at the same time indicate a possible condition with the primary timing chain and the alignment between both intermediate sprockets and the crankshaft. Also, the crankshaft reluctor wheel may have moved and is no longer referenced to top dead center (TDC).
- Observing the desired and actual camshaft angle parameters with a scan tool before a DTC sets may help to isolate whether a condition is specific to one camshaft, one bank or caused by a condition with the primary crankshaft timing.

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, P0020, P0023, P0335, P0336, P0340, P0341, P0345, P0346, P0365, P0366, P0390, P0391, P2088, P2089, P2090, P2091, P2092, P2093, P2094 or P2095. 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.

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4. Verify DTC P0016, P0017, P0018 or P0019 is not set.
    - **If any of the DTCs are 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 none of the DTC are set**
5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify the DTC does not set.
    - **If the DTC sets**

      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 Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Exhaust (LGW)**
- **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Exhaust (LGW)**
- **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Intake (LGW)**
- **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Intake (LGW)**
- **Camshaft Position Sensor Replacement - Bank 1 (Right Side) Exhaust (LGW)**
- **Camshaft Position Sensor Replacement - Bank 2 (Left Side) Exhaust (LGW)**
- **Camshaft Position Sensor Replacement - Bank 1 (Right Side) Intake**
- **Camshaft Position Sensor Replacement - Bank 2 (Left Side) Intake (LGW)**
- **Camshaft Timing Drive Components Cleaning and Inspection**
- **Crankshaft and Bearing Cleaning and Inspection**
- **Timing Chain Alignment Diagram**

DTC P0030-P0032, P0036-P0038, P0050-P0054, P0056-P0060, P0135, P0141, P0155, P0161, P103B OR P103C: HO2S HEATER CONTROL CIRCUIT

Diagnostic Instructions

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

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DTC Descriptors

DTC P0030

HO2S Heater Control Circuit Bank 1 Sensor 1

DTC P0031

HO2S Heater Control Circuit Low Voltage Bank 1 Sensor 1

DTC P0032

HO2S Heater Control Circuit High Voltage Bank 1 Sensor 1

DTC P0036

HO2S Heater Control Circuit Bank 1 Sensor 2

DTC P0037

HO2S Heater Control Circuit Low Voltage Bank 1 Sensor 2

DTC P0038

HO2S Heater Control Circuit High Voltage Bank 1 Sensor 2

DTC P0050

HO2S Heater Control Circuit Bank 2 Sensor 1

DTC P0051

HO2S Heater Control Circuit Low Voltage Bank 2 Sensor 1

DTC P0052

HO2S Heater Control Circuit High Voltage Bank 2 Sensor 1

DTC P0053

HO2S Heater Resistance Bank 1 Sensor 1

DTC P0054

HO2S Heater Resistance Bank 1 Sensor 2

DTC P0056

HO2S Heater Control Circuit Bank 2 Sensor 2

DTC P0057

HO2S Heater Control Circuit Low Voltage Bank 2 Sensor 2

DTC P0058

HO2S Heater Control Circuit High Voltage Bank 2 Sensor 2

DTC P0059

HO2S Heater Resistance Bank 2 Sensor 1

DTC P0060

HO2S Heater Resistance Bank 2 Sensor 2

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DTC P0135

HO2S Heater Performance Bank 1 Sensor 1

DTC P0141

HO2S Heater Performance Bank 1 Sensor 2

DTC P0155

HO2S Heater Performance Bank 2 Sensor 1

DTC P0161

HO2S Heater Performance Bank 2 Sensor 2

DTC P103B

HO2S Heater Supply Voltage Sensing Circuit Performance

DTC P103C

HO2S Heater Supply Voltage Sensing Circuit Low Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
HO2S Heater Voltage Supply	P0030, P0031, P0036, P0037, P0050, P0051, P0054, P0056, P0057, P0059, P0060, P0097, P00F4, P0102, P0132, P0135, P0138, P0141, P0152, P0155, P0158, P0161, P2199 *	P0030, P0031, P0036, P0037, P0050, P0051, P0054, P0056, P0057, P0059, P0060, P0132, P0134, P0135, P0138, P0140, P0141, P0152, P0154, P0155, P0158, P0160, P0161	P0690	P0135, P0141, P0155, P0161, P103B, P103C
HO2S Heater Control	P0030, P0031, P0036, P0037, P0050, P0051, P0053, P0054, P0056, P0057, P0059, P0060, P0135, P0141, P0155, P0161	P0030, P0036, P0050, P0056, P0132, P0134, P0135, P0137, P0138, P0140, P0141, P0152, P0154, P0155, P0158, P0160, P0161	P0030, P0032, P0036, P0038, P0050, P0052, P0056, P0058, P0132, P0134, P0135, P0138, P0140, P0141, P0152, P0154, P0155, P0158, P0160, P0161, P0690, P16B3	P0135, P0141, P0155, P0161, P103B, P103C
* 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

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

Conditions for Running the DTC

P0030-P0032, P0036-P0038, P0050-P0052 or P0056-P0058

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

P0053, P0054, P0059 or P0060

- DTCs P0112, P0113, P0117, P0118 or P2610 are not set.
- The engine run time is greater than 20 s.
- The Ignition voltage is less than 18 V.
- The ignition is Off for greater than 8 h.
- The engine coolant temperature (ECT) is between -30 to +45Â°C (-22 to +113Â°F) at engine start-up.
- The ECT and the intake air temperature (IAT) are within 8Â°C (14Â°F) at engine start-up.
- The DTCs run once per drive cycle when the above conditions are met.

P0135, P0141, P0155 or P0161

- DTCs P0116, P0117, P0118, P0125 or P0128 are not set.
- The Ignition voltage is between 10-32 V.
- The HO2S is at operating temperature.
- The HO2S is commanded On.
- The DTCs run once per drive cycle when the above conditions are met for 120 s.

P103B and P103C

- The Ignition voltage is between 10-32 V.
- The engine is cranking or running.
- The heater supply circuit is within 2 V of the ignition voltage.
- The DTCs run continuously when the above conditions are met for greater than 3 s.

Conditions for Setting the DTC

P0030, P0036, P0050 or P0056

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.

P0031, P0037, P0051 or P0057

The engine control module detects a short to ground in the heater output low side driver circuit of the heated oxygen sensor when the heater is commanded Off for greater than 13 s.

P0032, P0038, P0052 or P0058

The engine control module detects a short to voltage in the heater output low side driver circuit of the heated oxygen sensor when the heater is commanded On for greater than 13 s.

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P0053, P0054, P0059 or P0060

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

P0135 or P0155

The ECM detects that the HO2S 1 heater current is greater than 3.1 amps or less than 0.3 amps for greater than 8 s.

P0141 or P0161

The ECM detects that the HO2S 2 heater current is greater than 2.9 amps or less than 0.3 amps for greater than 8 s.

P103B

The heater supply circuit is not within 2 V of the ignition voltage for greater than 3 s

P103C

The ECM detects the HO2S heater supply voltage is less than 6 V for greater than 3 s.

Action Taken When the DTC Sets

DTCs P0030-P0032, P0036-P0038, P0050-P0054, P0056-P0060, P0135, P0141, P0155, P0161, P103B and P103C are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P0030-P0032, P0036-P0038, P0050-P0054, P0056-P0060, P0135, P0141, P0155, P0161, P103B and P103C are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) **Engine Controls Schematics (LGX)**

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 Heater Control Circuit Low Voltage Test Status Bank 1 or 2, Sensor 1 or 2
    - HO2S Heater Control Circuit Open Test Status Bank 1 or 2, Sensor 1 or 2

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- HO2S Heater Control Circuit High Voltage Test Status Bank 1 or 2, Sensor 1 or 2
- **If Malfunction is displayed**

  Refer to Circuit/System Testing.

- **If Malfunction is not displayed**

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

     Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the appropriate B52 Heated Oxygen Sensor, ignition ON.
2. Verify that a test lamp illuminates between the ignition voltage circuit terminal 2 and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition/VehicleÂ» Off & RemoveÂ» Test lamp
   2. Test for less than 2 Ω in the ignition circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**
   1. Ignition/VehicleÂ» Off & RemoveÂ» 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 fuse and replace as necessary.
   - **If the test lamp illuminates**
3. Verify DTC P103B, P103C is not set.
   - **If a related DTC is set**
   1. Ignition/Vehicle OFF
   2. Disconnect the electrical connector: X2 @ K20 Engine Control Module
   3. Disconnect the electrical connector: B52A Heated Oxygen Sensor-Bank 1 Sensor 1 or B52B Heated Oxygen Sensor Bank 1 Sensor 2
   4. Test for less than 2 Ω between the test points: Ignition circuit terminal 2 @ B52D Heated Oxygen Sensor-Bank 1 Sensor 2 or B52F Heated Oxygen Sensor - Bank 2 Sensor 2. (harness side) & Terminal 28 X2 @ Control module harness
      - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
      - If less than 2 ΩÂ» Test or replace the component: K20 Engine Control Module
   - **If a related DTC is not set**
4. 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**

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5. Remove the test lamp.
6. 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**
7. Install a 10 A fused jumper wire between the control circuit terminal 1 and the ignition voltage circuit terminal 2.

NOTE:

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

8. 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.

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.**

    - **If Malfunction is not displayed**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for less than 2 Ω in the control circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If Malfunction is displayed**
9. Test or replace the B52 Heated Oxygen Sensor.

Repair Instructions

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

- **Heated Oxygen Sensor Replacement - Bank 1 Sensor 1 (LGW)** **Heated Oxygen Sensor Replacement - Bank 1 Sensor 1 (LGX)**
- **Heated Oxygen Sensor Replacement - Bank 1 Sensor 2**
- **Heated Oxygen Sensor Replacement - Bank 2 Sensor 1 (LGW)** **Heated Oxygen Sensor Replacement - Bank 2 Sensor 1 (LGX)**
- **Heated Oxygen Sensor Replacement - Bank 2 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 P0033-P0035 OR P00C0-P00C2: TURBOCHARGER BYPASS SOLENOID VALVE CONTROL CIRCUIT

Diagnostic Instructions

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

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DTC Descriptors

DTC P0033

Turbocharger Bypass Solenoid Valve Control Circuit Bank 1

DTC P0034

Turbocharger Bypass Solenoid Valve Control Circuit Low Voltage Bank 1

DTC P0035

Turbocharger Bypass Solenoid Valve Control Circuit High Voltage Bank 1

DTC P00C0

Turbocharger Bypass Solenoid Valve Control Circuit Bank 2

DTC P00C1

Turbocharger Bypass Solenoid Valve Control Circuit Low Voltage Bank 2

DTC P00C2

Turbocharger Bypass Solenoid Valve Control Circuit High Voltage Bank 2

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Bank 1 and 2	P0689, P1682*	P0033, P0034, P00C0, P00C1	P0690	-
Control Bank 1	P0033, P0034	P0033, P0034	P0035	-
Control Bank 2	P00C0, P00C1	P00C0, P00C1	P00C2	-
*Supply fuse opens.				

Circuit/System Description

Each of the turbochargers is provided with a vacuum operated bypass valve, which opens during abrupt closed throttle conditions, to prevent turbocharger surging and damage from vibrations. The bypass valve vacuum source is provided by a vacuum pump which is driven off the end of the right hand exhaust camshaft. The valves are controlled by the engine control module (ECM), by utilizing remotely mounted solenoid valves. When the valves open during closed throttle deceleration conditions, air is allowed to recirculate in the turbochargers to maintain turbocharger speed. Within a calibrated range during a closed throttle event or upon a wide open throttle command the valves close to optimize turbo response.

As engine load and engine speed increases, the turbocharger bypass solenoid valves are commanded ON by the ECM. As soon as the throttle closes the turbocharger bypass solenoid valves are commanded OFF by the ECM to allow the bypass valves to open and allow the turbocharger air to recirculate to prevent surging.

Conditions for Running the DTCs

- The ignition is ON.
- The ignition voltage is 11 V or greater.
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

P0033

The ECM detects an open circuit condition of the turbocharger bypass solenoid valve control circuit bank 1 for greater than 6 s.

P0034

The ECM detects a short to ground on the turbocharger bypass solenoid valve control circuit bank 1 for greater than 6 s.

P0035

The ECM detects a short to voltage on the turbocharger bypass solenoid valve control circuit bank 1 for greater than 6 s.

P00C0

The ECM detects an open circuit condition of the turbocharger bypass solenoid valve control circuit bank 2 for greater than 6 s.

P00C1

The ECM detects a short to ground on the turbocharger bypass solenoid valve control circuit bank 2 for greater than 6 s.

P00C2

The ECM detects a short to voltage on the turbocharger bypass solenoid valve control circuit bank 2 for greater than 6 s.

Action Taken When the DTC Sets

DTC P0033, P0034, P0035, P00C0, P00C1 and P00C2 are Type B DTCs.

Conditions for Clearing the DTC

DTC P0033, P0034, P0035, P00C0, P00C1 and P00C2 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Description and Operation

Turbocharger System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

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Scan Tool Reference

Control Module References for scan tool information.

Circuit/System Verification

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

     Refer to Circuit/System Testing.

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

     Refer to Circuit/System Testing

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

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the appropriate 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, remove the test lamp.
   2. Test for less than 2 Ω in the ignition circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**
   1. Ignition OFF, remove the test lamp.
   2. Disconnect any component that shares the ignition fuse.

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

   3. Test for infinite resistance between the ignition circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, test all components connected to the ignition voltage circuit for a short and replace as necessary.
      - **If the test lamp illuminates**
3. Verify that a test lamp does not illuminate between the control circuit terminal 2 and the ignition circuit terminal 1.
   - **If the test lamp illuminates**

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

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

4. Remove the test lamp.
5. Verify the corresponding 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 corresponding 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 Ω in the control circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If Malfunction is displayed**

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

Repair Instructions

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

- **Charge Air Bypass Valve Solenoid Replacement (Bank 1)** **Charge Air Bypass Valve Solenoid Replacement (Bank 2)** for turbocharger bypass solenoid valve replacement.
- **Control Module References** for ECM replacement, programming and setup.

DTC P0068 OR P1101: THROTTLE BODY/INTAKE AIR FLOW PERFORMANCE (LGX)

Diagnostic 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

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

Conditions for Running the DTC

DTC P0068

- The engine speed is greater than 800 RPM.
- The ignition voltage is greater than 6.5 V.
- The DTC runs continuously when the above conditions are met.

DTC P1101

- DTCs P0101, P0102, P0103, P0107, P0108 P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0128, P0335 or P0336 are not set
- The engine speed is between 500-6, 800 RPM
- The engine coolant temperature (ECT) is between -7 to +125Â°C (-4 to +257Â°F).
- The intake air temperature (IAT) sensor 1 is between -20 to +125Â°C (-4 to +257Â°F).
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

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

Action Taken When the DTC Sets

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

Conditions for Clearing the DTC

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

Reference Information

Schematic Reference

Engine Controls Schematics (LGX)

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

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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 (LGX)** for further diagnosis.

   - **If none of the DTCs are set**
3. Verify the scan tool Throttle Body Idle Air Flow Compensation parameter is less than 90%.
   - **90% or greater**

     Refer to **Throttle Body Inspection and Cleaning** .

   - **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 (LGX)** for further diagnosis.

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

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

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

     Refer to **DTC P0101 (LGX)** for further diagnosis.

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

     Refer to Circuit/System Testing.

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

Circuit/System Testing

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

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1. Verify the integrity of the entire air induction system by verifying that none of the conditions listed below exist:
    - Any damaged, improperly installed, collapsed or restricted components
    - 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 P0068 OR P1101: THROTTLE BODY/INTAKE AIR FLOW PERFORMANCE (LGW)

Diagnostic 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 air flow based on manifold absolute pressure (MAP) sensor and the two mass air flow (MAF) sensors.

Conditions for Running the DTC

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DTC P0068

- The engine speed is greater than 800 RPM.
- The ignition voltage is greater than 6.41 V.
- The DTC runs continuously when the above conditions are met.

DTC P1101

- DTCs P00E9, P00EA, P00EB, P00EC, P0101, P0102, P0103, P0107, P0108, P010B, P010C, P010D, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0128, P0335, P0336, P0237, P0238, P2227, P2228, P2229, P222B, P222C, P222D, P222E or P2230 are not set
- The engine speed is between 425-6, 500 RPM
- The engine coolant temperature (ECT) is between -8 to +150Â°C (+19.4 to +302Â°F).
- The intake air temperature (IAT) sensor 1 is between -20 to +125Â°C (-4 to +257Â°F).
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

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

Action Taken When the DTC Sets

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

Conditions for Clearing the DTC

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

Reference Information

Schematic Reference

Engine Controls Schematics (LGW)

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.

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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 (LGW)** for further diagnosis.

    - **If none of the DTCs are set**
3. Verify the scan tool Throttle Body Idle Air Flow Compensation parameter is less than 90%.
    - **90% or greater**

      Refer to **Throttle Body Inspection and Cleaning** for further diagnosis.

    - **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 (LGW)** for further diagnosis.

    - **If Agree**
5. Determine the current vehicle testing altitude.
6. Verify both the scan tool Barometric Pressure Sensor Bank 1 and Bank 2 parameters are within the range specified in the **Altitude Versus Barometric Pressure** table.
    - **Both of the parameters are not within the specified range**

      Refer to the corresponding **DTC P2227-P2230 (LGW)** or **DTC P222B-P222E** for further diagnosis.

    - **Both parameters are within the specified range**
7. Verify the following scan tool parameters are within 3 kPa (0.4 PSI) of each other.
    - Barometric Pressure Sensor Bank 1
    - Barometric Pressure Sensor Bank 2
    - Boost Pressure Sensor
    - **One or more of the parameters are not within 3 kPa (0.4 PSI) of each other**

      Refer to the corresponding **DTC P0236** , **DTC P2227-P2230 (LGW)** or **DTC P222B-P222E** for further diagnosis.

    - **All the parameters are within 3 kPa (0.4 PSI) of each other**
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** for further diagnosis.

    - **If between 26-52 kPa (3.8-7.5 PSI) and changes**
10. Verify the scan tool MAP Sensor parameter and the Boost Pressure Sensor parameter are within 20 kPa (2.9 PSI) of each other, during a WOT acceleration at the time of the 1-2 shift.
    - **The parameters are not within 20 kPa (2.9 PSI) of each other**

      Refer to the corresponding **DTC P0106** or **DTC P0236** for further diagnosis.

    - **The parameters are within 20 kPa (2.9 psi) of each other**
11. Verify the scan tool g/s parameters for MAF Sensor Bank 1 and Bank 2 change smoothly and gradually as the engine speed is increased and decreased while performing the actions listed below.
    1. Engine idling

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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 scan tool g/s parameters for MAF Sensor Bank 1 and Bank 2 frame by frame.

- **One or both of the MAF Sensor parameters do not change smoothly and gradually**

  Refer to **DTC P0101 (LGX)**, **DTC P0101 (LGW)** or **DTC P010B** as appropriate.

- **Both the MAF Sensor parameters change 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 conditions listed below 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.

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DTC P0089, P00C6, P228C OR P228D: FUEL PRESSURE REGULATOR

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

NOTE: **This procedure may also diagnose malfunctions that are not detected by a DTC.**

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

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control - High	P0091, P00C9	P0090, P00C8	P0092, P00C9, P00CA	P0089, P00C6, P228C, P228D
Control - Low	P0091, P0092, P00C9	P0090, P00C8	P0092, P00CA	P0089, P00C6, P228C, P228D

Circuit/System Description

Circuit	Description
Control - High	The output circuit is switched to 12 V to activate the component. The output is PWM controlled.
Control - Low	The output circuit is switched to ground to activate the component. The output is PWM controlled.

Component	Description
Fuel Pressure Regulator - G18 High Pressure Fuel Pump	The fuel pressure regulator is a solenoid valve that restricts the flow of fuel to the high pressure fuel pump and thereby controls the pressure the pump can produce.
K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.

The fuel pressure regulator is a part of the high pressure fuel pump. The fuel pressure regulator is the solenoid valve that controls the pressure in the fuel rail.

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Conditions for Running the DTC

P0089, P228C, P228D

- DTC P0016, P0017, P0018, P0019, P0090, P0091, P0092, P00C8, P00C9, P00CA, P0111, P0112, P0113, P0116, P0117, P0118, P0128, P0192, P0193, P0335, P0336, P0340, P0341, P0345, P0346, P0365, P0366, P0390, P0391, P0628 = Not set
- Ignition Voltage = Greater than 11 V
- Low Pressure Side of the Fuel System=Greater than 275 kPa (40 PSI)
- Engine=Running
- BARO =Greater than 70 kPa (10.1 PSI)
- IAT Sensor =Greater than -10Â°C (14Â°F)
- Fuel Temperature = -10 to 100Â°C (14 to 212Â°F)

DTCs run continuously when the above conditions are met for greater than 10 s.

P00C6

- DTC P0090, P0091, P0092, P00C8, P00C9, P00CA, P0116, P0117, P0118, P0128, P0192, P0193, P0335, P0336, P0340, P0341, P0345, P0346, P0365, P0366, P0390, P0391, P0628 = Not set
- Low Pressure Side of the Fuel System=Greater than 275 kPa (40 PSI)
- Engine=Not Running
- Run/Crank =Greater than 8 V
- ECT Sensor =Less than 85Â°C (185Â°F)
- BARO =Greater than 70 kPa (10.1 PSI)
- IAT Sensor =Greater than -10Â°C (14Â°F)

DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

P0089

Q18 Fuel Pressure Regulator=Not Within 0 to 240Â° - For greater than 10 s

P00C6

Desired Fuel Rail Pressure - IgnitionÂ» On / VehicleÂ» In Service Mode & EngineÂ» Off	Engine Run Time	Engine Coolant Temperature	Fuel Rail Pressure
Less than desired	11 s	-40Â°C (-40Â°F)	Actual pressure is not equal to the desired pressure
Less than desired	3 s	20 to 95Â°C (68 to 203Â°F)	Actual pressure is not equal to the desired pressure
Less than desired	3 s	Greater than 112Â°C (233Â°F)	Actual pressure is not equal to the desired pressure
Greater than desired	During the first 10 engine revolutions.	Less than -10Â°C (14Â°F)	Pressure drops greater than 2 MPa (290 PSI)
Greater than desired	During the first 10 engine revolutions.	0 to 8Â°C (32 to 46Â°F)	Pressure drops greater than 0.6 MPa (87 PSI)
Greater than desired	During the first 10 engine revolutions.	Greater than 8Â°C (46Â°F)	Pressure drops greater than 0.5 MPa (72 PSI)

P228C, P228D

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The following parameters are not within 3 MPa (435 PSI) of each other:

- Desired Fuel Rail Pressure
- Fuel Rail Pressure

The above condition(s) must occur for greater than 10 s.

Actions Taken When the DTC Sets

- DTCs P0089, P00C6 are Type B DTCs.
- DTCs P228C, P228D are Type A DTCs.
- {P228C, P228D} Reduced Engine Power is displayed.

Conditions for Clearing the DTC

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

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Description and Operation

Fuel System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References

Circuit/System Verification

1. IgnitionÂ» On / VehicleÂ» In Service Mode
2. Verify DTC P0016, P0017, P0018, P0019, P0090, P0091, P0092, P00C8, P00C9, P00CA, P0111, P0112, P0113, P0116, P0117, P0118, P0128, P0192, P0193, P0335, P0336, P0340, P0341, P0345, P0346, P0365, P0366, P0390, P0391, P0628 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**

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3. Engine idling.
4. Verify the scan tool parameter: Fuel Rail Pressure Sensor 1 = 1.9 to 5.0 MPa (276 to 725 PSI)
    - **If not between 1.9 and 5.0 MPa (276 and 725 PSI)**

      Refer to Circuit/System Testing

    - **If between 1.9 and 5.0 MPa (276 and 725 PSI)**
5. Perform the scan tool control function: Fuel Rail PressureÂ» Increase & Decrease

   Verify the scan tool parameter: Fuel Rail Pressure = The value should change with each command.

    - **If the value does not change**

      Refer to Circuit/System Testing

    - **If the value changes**
6. Clear the DTCs.
7. From a stop, accelerate to 7000 RPM with the throttle position greater than 95%.

   WARNING: **Road test a vehicle under safe conditions and while obeying all traffic laws. Do not attempt any maneuvers that could jeopardize vehicle control. Failure to adhere to these precautions could lead to serious personal injury and vehicle damage.**

   Verify the scan tool parameter: Fuel Rail Pressure Sensor 1 = 14 to 17 MPa (2031 to 2466 PSI)

    - **If not between 14 and 17 MPa (2031 and 2466 PSI)**

      Refer to: Circuit/System Testing

    - **If between 14 and 17 MPa (2031 and 2466 PSI)**
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.

   Verify the DTC does not set.

    - **If the DTC sets**

      Refer to: Circuit/System Testing

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

Circuit/System Testing

1. Verify the following conditions do not exist:
    - Contaminated or poor quality fuel.
    - Binding, sticking or stuck component:
        - Camshaft Position Actuator
        - Fuel Pressure Regulator
    - Leaking or restricted component:
        - Q17 Fuel Injector
        - Fuel Feed Pipe
        - Direct Fuel Injection Fuel Rail
    - **If a condition exists**

      Repair or replace as necessary.

    - **If no condition exists**

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2. Remove the component: G18 High Pressure Fuel Pump
3. Inspect the component for wear or damage: Camshaft Lobes
    - **If worn**

      Replace the component: Camshaft

    - **If not worn**
4. Test or replace the component: G18 High Pressure Fuel Pump

Component Testing

1. Ignition/Vehicle & All vehicle systemsÂ» Off

   NOTE: **As little as 2 Ω of resistance in a circuit may cause a DTC to set.**

2. Disconnect the electrical connector: G18 High Pressure Fuel Pump
3. Test for 9 to 11 Ω between the test points:Control terminal 1 & Control terminal 2
    - **If not between 9 and 11 Ω**

      Replace the component: G18 High Pressure Fuel Pump

    - **If between 9 and 11 Ω**
4. Test for infinite resistance between the test points: Each terminal of the component & The component's housing
    - **If less than infinite resistance**

      Replace the component: G18 High Pressure Fuel Pump

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

Repair Instructions

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

- **Camshaft Replacement - Left Side**
- **Fuel Pump Replacement** - G18 High Pressure Fuel Pump

DTC P0090-P0092, P00C8, P00C9 OR P00CA: FUEL PRESSURE REGULATOR CONTROL CIRCUIT (LGX)

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

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

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DTC P00C8

Fuel Pressure Regulator High Control Circuit Open

DTC P00C9

Fuel Pressure Regulator High Control Circuit Low Voltage

DTC P00CA

Fuel Pressure Regulator High Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control - High	P0091, P00C9	P0090, P00C8	P0092, P00C9, P00CA	P0089, P00C6, P228C, P228D
Control - Low	P0091, P0092, P00C9	P0090, P00C8	P0092, P00CA	P0089, P00C6, P228C, P228D

Circuit/System Description

Circuit	Description
Control - High	The output circuit is switched to 12 V to activate the component. The output is PWM controlled.
Control - Low	The output circuit is switched to ground to activate the component. The output is PWM controlled.

Component	Description
G18 High Pressure Fuel Pump	The fuel pressure regulator is a solenoid valve that restricts the flow of fuel to the high pressure fuel pump and thereby controls the pressure the pump can produce.
K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.

The fuel pressure regulator is a part of the high pressure fuel pump. The fuel pressure regulator is the solenoid valve that controls the pressure in the fuel rail.

Conditions for Running the DTC

- Battery Voltage = Greater than 11 V
- Engine Speed = Greater than 50 RPM

DTCs run continuously when the above conditions are met for greater than 2 s.

Conditions for Setting the DTC

P0090

Low Control=Open

P0091

Low Control=Short to Ground

P0092

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Low Control=Short to Voltage

P00C8

High Control=Open

P00C9

High Control=Short to Ground

P00CA

High Control=Short to Voltage

Actions Taken When the DTC Sets

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

Conditions for Clearing the DTC

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

Reference Information

Schematic Reference

Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Description and Operation

Fuel System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References

Circuit/System Verification

1. IgnitionÂ» On / VehicleÂ» In Service Mode
2. Perform the scan tool control function: Fuel Pressure RegulatorÂ» On and Off

NOTE: **This test can only be performed once per ignition cycle. To run the test again, turn the ignition/vehicle Off, allow the engine control module to shut down completely and then turn the ignition/vehicle back On.**

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Verify the scan tool parameter:

- Fuel Pressure Regulator Control Circuit High Voltage Test Status =OK or Not Run
- Fuel Pressure Regulator Control Circuit Open Test Status =OK or Not Run
- Fuel Pressure Regulator Control Circuit Low Voltage Test Status =OK or Not Run
- Fuel Pressure Regulator High Control Circuit High Voltage Test Status =OK or Not Run
- Fuel Pressure Regulator High Control Circuit Open Test Status =OK or Not Run
- Fuel Pressure Regulator High Control Circuit Low Voltage Test Status =OK or Not Run
- **If not the specified state**

  Refer to: Circuit/System Testing

- **If the specified state**

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

     Refer to Circuit/System Testing

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

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the G18 High Pressure Fuel Pump, ignition ON. It may take up to 2 min for all vehicle systems to power down.
2. Verify that a test lamp does not illuminate between the high 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 high control circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
      - **If the test lamp does not illuminate**
3. Verify that a test lamp does not illuminate between the low control circuit terminal 1 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 low control circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
      - **If the test lamp does not illuminate**
4. Verify that a test lamp does not illuminate between the high control circuit terminal 2 and B+.
   - **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 high control circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.
   - **If the test lamp does not illuminate**
5. Verify that a test lamp does not illuminate between the low control circuit terminal 1 and B+.
   - **If the test lamp illuminates**

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1. Ignition OFF, remove the test lamp, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the low control circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance, replace the K20 Engine Control Module.

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

6. Remove the test lamp, 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 Low Voltage Test Status transitions from OK to Malfunction.

NOTE: **For steps 7-9 it may be necessary to Start/Crank the engine to update the scan tool parameter.**

- **If Malfunction is not displayed**

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

- **If Malfunction is displayed**

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 High Voltage Test Status transitions from OK to Malfunction.
    - **If Malfunction is not displayed**

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

    - **If Malfunction is displayed**

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

Component Testing

1. Ignition/Vehicle & All vehicle systemsÂ» Off
2. Disconnect the electrical connector: G18 High Pressure Fuel Pump
3. Test for 9 to 11 Ω between the test points: Control terminal 1 & Control terminal 2
    - **If not between 9 and 11 Ω**

      Replace the component: G18 High Pressure Fuel Pump

    - **If between 9 and 11 Ω**
4. Test for infinite resistance between the test points: Each terminal of the component & The component's housing
    - **If less than infinite resistance**

      Replace the component: G18 High Pressure Fuel Pump

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

Repair Instructions

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

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- **Fuel Pump Replacement** - G18 High Pressure Fuel Pump
- For control module replacement, programming and setup, refer to **Control Module References**

DTC P0090-P0092, P00C8, P00C9 OR P00CA: FUEL PRESSURE REGULATOR CONTROL CIRCUIT (LGW)

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

DTC P0090

Fuel Pressure Regulator Control Circuit

DTC P0091

Fuel Pressure Regulator Control Circuit Low Voltage

DTC P0092

Fuel Pressure Regulator Control Circuit High Voltage

DTC P00C8

Fuel Pressure Regulator High Control Circuit Open

DTC P00C9

Fuel Pressure Regulator High Control Circuit Low Voltage

DTC P00CA

Fuel Pressure Regulator High Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control - High	P0091, P00C9	P0090, P00C8	P0092, P00C9, P00CA	P0089, P00C6, P228C, P228D
Control - Low	P0091, P0092, P00C9	P0090, P00C8	P0092, P00CA	P0089, P00C6, P228C, P228D

Circuit/System Description

Circuit	Description
Control - High	The output circuit is switched to 12 V to activate the component. The output is PWM controlled.
Control - Low	The output circuit is switched to ground to activate the component. The output is PWM controlled.

Component	Description
Q18 Fuel Pressure Regulator	The fuel pressure regulator is a solenoid valve that restricts the flow of fuel to the high pressure fuel pump and thereby controls the pressure the pump can produce.

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Component	Description
K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.

The fuel pressure regulator is a part of the high pressure fuel pump. The fuel pressure regulator is the solenoid valve that controls the pressure in the fuel rail.

Conditions for Running the DTC

- Battery Voltage = Greater than 11 V
- Engine Speed = Greater than 50 RPM

DTCs run continuously when the above conditions are met for greater than 2 s.

Conditions for Setting the DTC

P0090

Low Control=Open

P0091

Low Control=Short to Ground

P0092

Low Control=Short to Voltage

P00C8

High Control=Open

P00C9

High Control=Short to Ground

P00CA

High Control=Short to Voltage

Actions Taken When the DTC Sets

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

Conditions for Clearing the DTC

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

Reference Information

Schematic Reference

Engine Controls Schematics (LGW)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

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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

Circuit/System Verification

1. IgnitionÂ» On / VehicleÂ» In Service Mode
2. Perform the scan tool control function:Fuel Pressure RegulatorÂ» On and Off

   NOTE: **This test can only be performed once per ignition cycle. To run the test again, turn the ignition/vehicle Off, allow the engine control module to shut down completely and then turn the ignition/vehicle back On.**

   Verify the scan tool parameter:

   - Fuel Pressure Regulator Control Circuit High Voltage Test Status = OK or Not Run
   - Fuel Pressure Regulator Control Circuit Open Test Status = OK or Not Run
   - Fuel Pressure Regulator Control Circuit Low Voltage Test Status =OK or Not Run
   - Fuel Pressure Regulator High Control Circuit High Voltage Test Status =OK or Not Run
   - Fuel Pressure Regulator High Control Circuit Open Test Status =OK or Not Run
   - Fuel Pressure Regulator High Control Circuit Low Voltage Test Status =OK or Not Run
   - **If not the specified state**

     Refer to Circuit/System Testing

   - **If the specified state**
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/Vehicle Â» Off
2. Disconnect the electrical connector:G18 High Pressure Fuel Pump
3. Connect a test lamp between the test points: Control circuit terminal 1 & Control circuit terminal 2
4. IgnitionÂ» On / VehicleÂ» In Service Mode
5. Perform the scan tool control function:Fuel Pressure Regulator Â»On and Off

Verify the test lamp turns On and Off.

- **If the test lamp does not turn On and Off**

1. Ignition/VehicleÂ» Off & RemoveÂ» Test lamp
2. Disconnect the electrical connector: X4 @ K20 Engine Control Module
3. IgnitionÂ» On / VehicleÂ» In Service Mode
4. Test for less than 1 V between the test points:
    - Control circuit terminal 1 @ Component harness & Ground
    - Control circuit terminal 2 @ Component harness & Ground
    - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
    - If less than 1 V

1. Ignition/VehicleÂ» Off
2. Test for infinite resistance between the test points:
    - Control circuit terminal 1 @ Component harness & Ground
    - Control circuit terminal 2 @ Component harness & Ground
    - If less than infinite resistanceÂ» Repair the short to ground on the circuit.
    - If infinite resistance

1. Test for less than 2 Ω between the test points:
    - Control circuit terminal 1 @ Component harness & Terminal 32 @ Control module harness
    - Control circuit terminal 2 @ Component harness & Terminal 16 @ Control module harness
    - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
    - If less than 2 ΩÂ» Replace the component: K20 Engine Control Module

- **If the test lamp turns On and Off**

6. Test or replace the component: G18 High Pressure Fuel Pump

Component Testing

1. Ignition/Vehicle & All vehicle systemsÂ» Off
2. Disconnect the electrical connector: G18 High Pressure Fuel Pump
3. Test for 11.5 to 12 Ω between the test points: Control terminal 1 & Control terminal 2
    - **If not between 11.5 and 12 Ω**

      Replace the component: G18 High Pressure Fuel Pump

    - **If between 11.5 and 12 Ω**
4. Test for infinite resistance between the test points: Each terminal of the component & The component's housing
    - **If less than infinite resistance**

      Replace the component: G18 High Pressure Fuel Pump

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

Repair Instructions

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

- **Fuel Pump Replacement** - Q18 Fuel Pressure Regulator
- For control module replacement, programming and setup, refer to **Control Module References**

DTC P0096 OR P0111: INTAKE AIR TEMPERATURE (IAT) SENSOR (LGW)

Diagnostic Instructions

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- 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 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, P2199	P0111, P0112, P0113, P2199	P0113, P2199*	P0111, P0114, P2199
Low Reference	-	P0113, P2199, P222D, P222E	P0113, P0114, P2199, P222B, P222D*	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

IAT Sensor 2

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition	P0036, P0037, P0056, P0057, P0097, P00F4, P0102, P010C, P0141, P0161, P2199	P0036, P0037, P0056, P0057, P0097, P00F4, P0102, P010C, P0141, P0161, P2199	P0690	P0096, P010B
Signal	P0096, P0097, P00F5, P2199	P0097, P00F4, P2199,	P0097, P00F4, P2199*	P0096
Ground	-	P0097, P00F4, P0102, P2199	-	P0096, P010B
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

IAT Sensor 1

Circuit	Short to Ground	Open or High Resistance	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** Varies with ambient temperature			
Signal	150Â°C (302Â°F)	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
Low Reference	-	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
*Internal ECM or sensor damage may occur if the circuit is shorted to B+			

IAT Sensor 2

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

Circuit	Short to Ground	Open or High Resistance	Short to Voltage
Signal	-40Â°C (-40Â°F) 10 Hz	-40Â°C (-40Â°F) 10 Hz	-40Â°C (-40Â°F)* 10 Hz
Ground	-	-40Â°C (-40Â°F) 10 Hz	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

Circuit/System Description

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

The IAT sensor 2 produces a frequency signal, based on the inlet air temperature, which is equal to the humidity present within the sensor bore. The signal varies with inlet air temperature and is displayed by the scan tool as Â°C (Â°F) and Hertz (Hz) and the relative humidity is displayed in percent (%). The ECM supplies a regulated voltage to the signal 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 Bank 2 sensors listed below are integrated within the multifunction intake air sensor:

- 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	-40Â°C (-40Â°F)
Warm	302 Hz	104Â°C (219Â°F)

Conditions for Running the DTCs

P0096 and P0111

- DTCs P0097, P0098, P00EA, P00EB, P0112, P0113, P0117, P0118, P1682, P16A7 or P16BC are not set.
- The vehicle has been OFF at least 8 hours.
- Ignition voltage is at least 11 V.
- These DTCs run once per ignition cycle when the enabling conditions are met.

Conditions for Setting the DTCs

P0096

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- The ECM determines the absolute difference between IAT sensor 1 start-up temperature and the IAT sensor 2 start-up temperature is greater than 10Â°C (18Â°F).

  AND

- The ECM determines the absolute difference between IAT sensor 1 start-up temperature and the IAT sensor 3 start-up temperature is less than 15Â°C (27Â°F).

  OR

- The ECM determines the absolute difference between IAT sensor 2 start-up temperature and the IAT sensor 3 start-up temperature is greater than 15Â°C (27Â°F).
- This DTC runs once per ignition cycle when the enabling conditions are met.

P0111

- The ECM determines the absolute difference between IAT sensor 1 start-up temperature and the IAT sensor 2 start-up temperature is greater than 10Â°C (18Â°F).

  AND

- The ECM determines the absolute difference between IAT sensor 1 start-up temperature and the IAT sensor 3 start-up temperature is greater than 15Â°C (27Â°F).

  OR

- The ECM determines the absolute difference between IAT sensor 2 start-up temperature and the IAT sensor 3 start-up temperature is less than 15Â°C (27Â°F).
- 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 IAT Sensor 1 and IAT Sensor 2 are integrated with the multifunction intake air sensor.
- With the ignition ON, engine OFF and cold; properly functioning IAT sensors 1 and 2 will cause the scan tool IAT Sensor 1 and 2 parameters to increase. This is due to the heat that is generated by the multifunction intake air sensor internal heating elements.
- The humidity sensor and the IAT sensor 2 signals are sent to the ECM on the same circuit. If the IAT Sensor 2 parameters display the values: 10 Hz; -40Â°C (-40Â°F) and there are also Humidity Sensor DTCs, check for a circuit fault.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Electrical Information Reference

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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

Special Tools

EL-38522-A Variable Signal Generator

For equivalent regional tools, refer to Special Tools (Diagnostic Tools) and/or 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 (LGW)

   - **If none of the DTCs are set**
3. Ignition ON.

   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.**

4. Verify the following scan tool parameters are within 10Â°C (18Â°F) of each other.
   - Start-Up IAT Sensor 1
   - Start-Up IAT Sensor 2
   - Start-Up ECT
   - **If not within 10Â°C (18Â°F)**

     Refer to Circuit/System Testing.

   - **If within 10Â°C (18Â°F)**
5. Engine idling, verify the scan tool parameters listed below are between -38 to +149Â°C (-36 to +300Â°F).
   - IAT Sensor 1
   - IAT Sensor 2
   - ECT Sensor
   - **If not between -38 to +149Â°C (-36 to +300Â°F)**

     Refer to Circuit/System Testing.

   - **If between -38 to +149Â°C (-36 to +300Â°F)**
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**

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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 conditions listed below exist:
   - A loose or disconnected charge air cooler hose or pipe; where equipped
   - A restricted or collapsed air intake duct
   - An intake manifold leak
   - A MAP sensor seal that is leaking, missing or damaged
   - A turbocharger boost/intake air temperature sensor seal that is leaking, missing or damaged; where equipped
   - A restricted or collapsed air intake duct
   - A misaligned or damaged air intake duct
   - Any water intrusion in the induction system
   - An Intake Manifold Resonator with a leaking seal or a cracked or broken housing
   - **If a condition exists**

     Repair or replace component as appropriate.

   - **If no condition exists**
2. Ignition OFF and all systems OFF, it may take up to for 2 min for all vehicle systems to power down. Disconnect the harness connector at the B75C Multifunction Intake Air Sensor.
3. Test for less than 2 Ω between the low reference circuit terminal 3 and ground.
   - **If 2 Ω or greater**
   1. Disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open or high resistance in the circuit.
      - If less than 2 Ω replace the K20 Engine Control Module.
   - **If less than 2 Ω**
4. Test for less than 2 Ω between the ground circuit terminal 7 and ground.
   - **If 2 Ω or greater**
   1. Disconnect the sensor chassis ground.
   2. Test for less than 2 Ω in the ground circuit end to end.
      - If 2 Ω or greater, repair the open or high resistance in the circuit.
      - If less than 2 Ω, repair the open/high resistance in the ground connection.
   - **If less than 2 Ω**
5. Ignition ON, verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
   2. Test for less than 2 Ω in the ignition voltage circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**
   1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
   2. Test for infinite resistance between the ignition voltage circuit and ground.

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- If less than infinite resistance, repair the short to ground on the circuit.
- If infinite resistance, test all components connected to the ignition circuit, replace as necessary.

- **If a test lamp illuminates**

6. Verify the scan tool IAT Sensor 1 parameter is colder than -39Â°C (-38Â°F).
   - **If warmer than -39Â°C (-38Â°F).**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the signal circuit terminal 1 and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 Ω in the signal circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If colder than -39Â°C (-38Â°F).**
7. Ignition OFF, install a 3 A fused jumper wire between the signal circuit terminal 1 and the low reference circuit terminal 3, ignition ON.
8. Verify the scan tool IAT Sensor 1 parameter is warmer than 149Â°C (300Â°F).
   - **If colder than 149Â°C (300Â°F).**
   1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the signal circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V
   3. Ignition OFF.
   4. Test for less than 2 Ω in the signal circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If warmer than 149Â°C (300Â°F).**
9. Test for 4.8-5.2 V between the intake air temperature signal 2 circuit terminal 8 and ground.
   - **If less than 4.8 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the signal circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 Ω in the signal circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If greater than 5.2 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

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

   2. Test for less than 1 V between the signal circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If between 4.8-5.2 V**
10. Determine if **EL-38522-A** Variable Signal Generator or equivalent is available.
    - **EL-38522-A, Variable Signal Generator; or equivalent is not available**

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1. Test or replace the B75C Multifunction Intake Air Sensor.
2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
3. Verify the DTC does not set.
    - **If the DTC sets**

      Replace the K20 Engine Control Module.

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

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

11. Ignition OFF, connect the leads of the **EL-38522-A** Variable Signal Generator as listed below:
    - Red lead to the signal circuit terminal 8 at the harness connector
    - Black leads to ground
    - Battery voltage supply lead to B+
12. Set the **EL-38522-A** Variable Signal Generator to the specifications listed below:
    - Signal switch to 5 V
    - Duty Cycle switch to 50% (Normal)
    - Frequency switch to 30 Hz
13. Ignition ON.
14. 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. Test or replace the B75C Multifunction Intake Air Sensor.

Component Testing

Multifunction Intake Air Sensor - IAT Sensor 1

1. Ignition OFF, disconnect the harness connector at the B75C Multifunction Intake Air sensor.
2. Test the IAT sensor 1 by varying the sensor temperature while monitoring the sensor resistance. The resistance values should be in range of the table values.

    NOTE: **A thermometer can be used to monitor the air temperature while testing the sensor off the vehicle.**

3. Verify the resistance values are within the range specified in the **Temperature Versus Resistance - Intake Air Temperature Sensor (Hitachi Sensor)** table for Hitachi Sensors.
    - **If not within the table values.**

      Replace the B75C Multifunction Intake Air sensor.

    - **If within the table values.**
4. All OK

Multifunction Intake Air Sensor - IAT Sensor 2

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

      Replace the B75C Multifunction Intake Air sensor.

    - **If within 5%**

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2. All OK.

Repair Instructions

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

- **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGW)**
- **Control Module References** for engine control module replacement, programming and setup.

DTC P0096 OR P0111: INTAKE AIR TEMPERATURE (IAT) SENSOR (LGX)

Diagnostic 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, P0113, P2199	P0113, P2199	P0112*, P2199	P0111*, P2199
Low Reference	-	P0113, P2199, P2227, P2229	P0113*, P0114	P0096, P0111*, P2199
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

IAT Sensor 2 and Intake Air Humidity

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0096, P0097, P00F4, P0102, P2199	P0097, P00F4, P0102, P0103, P2199	-	P0096
Signal	P0097, P00F5, P2199	P0097, P00F4, P2199	P0097*, P00F4*, 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	150Â°C (302Â°F)	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
Low Reference	-	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
*Internal ECM or sensor damage may occur if the circuit is shorted to B+			

IAT Sensor 2 and Intake Air Humidity Sensor

Circuit	Short to Ground	Open or High Resistance	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** Varies with ambient humidity, temperature and engine bay conditions			
Ignition Voltage	-40Â°C (-40Â°F) 10 Hz 0%	-40Â°C (-40Â°F) 10 Hz 0%	-
Signal	-40Â°C (-40Â°F) 10 Hz 100%	-40Â°C (-40Â°F) 10 Hz 0%	-40Â°C (-40Â°F) 10 Hz* 0%
Ground	-	-40Â°C (-40Â°F) 10 Hz 0%	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+			

Circuit/System Description

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

The IAT sensor 2 produces a frequency signal, based on the inlet air temperature, which is equal to the humidity present within the sensor bore. The signal varies with inlet air temperature and is displayed by the scan tool as Â°C (Â°F) and Hertz (Hz) and the relative humidity is displayed in percent (%). The ECM supplies a regulated voltage to the signal 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	10 Hz	-40Â°C (-40Â°F)
Warm	302 Hz	104Â°C (219Â°F)

Conditions for Running the DTCs

P0096 and P0111

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- DTCs P0097, P0098, P0099, P0112, P0113, P0114, P0117, P00F4, P00F5, P00F6, P0118, P0119 or P1682 are not set.
- The vehicle has been OFF at least 8 hours.
- Ignition voltage is at least 11 V for greater than 1 s.
- The DTCs run once per ignition cycle when the conditions above are met.

Conditions for Setting the DTCs

P0096

- The ECM determines the absolute difference between IAT sensor 1 start-up temperature and the IAT sensor 2 start-up temperature is greater than 10Â°C (18Â°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.
- The DTCs run once per ignition cycle when the conditions above are met.

P0111

- The ECM determines the absolute difference between IAT sensor 1 start-up temperature and the IAT sensor 2 start-up temperature is greater than 10Â°C (18Â°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.
- The DTCs run once per ignition cycle when the conditions above are met.

Action Taken When the DTC Sets

- DTC P0096 is a Type B DTC.
- DTC P0111 is a Type B DTC.
- The ECM commands the cooling fans ON.

Conditions for Clearing the DTCs

- DTC P0096 is a Type B DTC.
- DTC P0111 is a Type B DTC.

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; -40Â°C (-40Â°F) and there are also Humidity Sensor DTCs, check for a circuit problem.

Reference Information

Schematic Reference

Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

- **Circuit Testing**

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- 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) and/or Special Tools (Mechanical Tools) .

Circuit/System Verification

1. Ignition On.
2. Verify that DTC P0097, P0098, P0099, P00F4, P00F5, P00F6, P0102, P0103, P0112, P0113, P0114, P0641, P0651, P0697 or P06A3 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. Ignition On.

   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.**

4. Verify the following scan tool parameters are within 10Â°C (18Â°F) of each other.
   - Start-Up IAT Sensor 1
   - Start-Up IAT Sensor 2
   - Start-Up ECT Sensor
   - **If not within 10Â°C (18Â°F)**

     Refer to Circuit/System Testing.

   - **If within 10Â°C (18Â°F)**
5. Engine running.
6. Verify the following scan tool parameters are between: -38 and +149Â°C (-36 and +300Â°F).
   - IAT Sensor 1
   - IAT Sensor 2
   - **If not between: -38 and +149Â°C (-36 and +300Â°F)**

     Refer to Circuit/System Testing.

   - **If between: -38 and +149Â°C (-36 and +300Â°F)**
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.

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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 before proceeding with Circuit/System Testing.**

1. Check the integrity of the entire air induction system and verify that none of the following conditions exist:
    - A restricted or collapsed air intake duct
    - An intake manifold leak
    - A misaligned or damaged air intake duct
    - Any water intrusion in the induction system
    - **If a condition exists**

      Repair or replace component as necessary.

    - **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.
3. Disconnect the harness connector at the B75C Multifunction Intake Air sensor.
4. Test for less than 5 Ω between the low reference circuit terminal 3 and ground.
    - **If 5 Ω or greater**
    1. Disconnect the harness connector at the K20 Engine Control Module.
    2. Test for less than 2 Ω in the low reference circuit end to end.
        - If 2 Ω or greater, repair the open or high resistance in the circuit.
        - If less than 2 Ω replace the K20 Engine Control Module.
    - **If less than 5 Ω**
5. Test for less than 5 Ω between the ground circuit terminal 7 and ground.
    - **If 5 Ω or greater**
    1. Ignition Off.
    2. Test for less than 2 Ω in the ground circuit end to end.
        - If 2 Ω or greater, repair the open or high resistance in the circuit.
        - If less than 2 Ω, repair the open/high resistance in the ground connection.
    - **If less than 5 Ω**
6. Ignition On
7. Verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.
    - **If the test lamp does not illuminate and the circuit fuse is good**
    1. Ignition Off, remove the test lamp and remove the fuse for the ignition voltage circuit.
    2. Test for less than 2 Ω in the ignition voltage circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.
    - **If the test lamp does not illuminate and the circuit fuse is open**
    1. Ignition Off, remove the test lamp, the fuse for the ignition voltage circuit and disconnect all components on the 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.

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- If infinite resistance, test all components connected to the ignition circuit, replace as necessary.

- **If a test lamp illuminates**

8. Ignition On.
9. Verify the scan tool Intake Air Temperature Sensor 1 parameter is colder than -39Â°C (-38Â°F).
    - **If warmer than -39Â°C (-38Â°F).**
    1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit terminal 1 and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance, replace the K20 Engine Control Module.
    - **If colder than -39Â°C (-38Â°F).**
10. Ignition Off, install a 3 A fused jumper wire between the IAT 1 signal circuit terminal 1 and the low reference circuit terminal 3.
11. Ignition On.
12. Verify the scan tool Intake Air Temperature Sensor 1 parameter is warmer than 148Â°C (298Â°F).
    - **If colder than 148Â°C (298Â°F).**
    1. Ignition Off, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module.
    2. Ignition On.
    3. Test for less than 1 V between the signal circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V
    4. Ignition Off.
    5. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If warmer than 148Â°C (298Â°F).**
13. Ignition On.
14. Verify the scan tool Intake Air Humidity Sensor parameter is less than 1%.

NOTE: **The intake air temperature sensor 2 signal circuit is pulled up with low current voltage within the controller. Normally, a voltage can be measured on the circuit with a DMM, but the current will not be high enough to illuminate a test lamp.**

- **If 1% or greater**
1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the IAT 2 signal circuit terminal 8 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 less than 1%**

15. Ignition Off, install a 3 A fused jumper wire between the IAT 2 signal circuit terminal 8 and the low reference circuit terminal 3.
16. Ignition On.
17. Verify the scan tool Intake Air Humidity Sensor parameter is greater than 99%.
    - **If 99% or less**
    1. Ignition Off, remove the jumper wire and disconnect the harness connector at 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.**

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2. Ignition On.
3. Test for less than 1 V between the IAT 2 signal circuit terminal 8 and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V.
4. Ignition Off.
5. Test for less than 2 Ω in the signal circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If greater than 99%**

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

Component Testing

Multifunction Intake Air Sensor

1. Vehicle OFF, disconnect the harness connector at the B75C Multifunction Intake Air Sensor.
2. Connect a DMM between the IAT sensor 1 signal terminal 1 and the low reference terminal 3
3. 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)** table for Hitachi Sensors. The resistance values should be in range of the table values.

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

    - **If not within the specified range**

      Replace the B75C Multifunction Intake Air Sensor.

    - **If within the specified range**

4. 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.

Testing with EL-38522-A

1. Perform the following test using a **EL-38522-A** Variable Signal Generator or equivalent, if available.

    NOTE: **In-correct diagnosis will result if Circuit/System Testing is not completed before performing the following test.**

2. Ignition Off, connect the leads of the **EL-38522-A** Variable Signal Generator as follows:
    1. Red lead to the signal circuit terminal 8 at the harness connector
    2. Black leads to ground
    3. Battery voltage supply lead to B+
3. Set the **EL-38522-A** Variable Signal Generator to the following specifications.
    - Signal switch to 5 V
    - Duty Cycle switch to 50% (Normal)

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- Frequency switch to 250 Hz

4. Ignition On.
5. Verify the scan tool IAT Sensor 2 parameters listed below are within the ranges listed below:
    - IAT Sensor 2 is between 248-252 Hz
    - IAT Sensor 2 is between 70-76Â°C (160-166Â°F)

      NOTE: **Changing the frequency should cause a warmer or colder IAT 2 temperature.**

    - Intake Air Humidity Sensor is between 48-52%

      NOTE: **Increasing or decreasing the duty cycle should have an inverse affect on humidity.**

    - **If a parameter is not within the specified range**

      Replace the K20 Engine Control Module.

    - **If all the parameters are within the specified range**
6. All OK.

Repair Instructions

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

- **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGX)** for B75C Multifunction Intake Air Sensor replacement
- **Control Module References** for engine control module replacement, programming and setup.

DTC P0097, P0098 OR P0099: INTAKE AIR TEMPERATURE (IAT) SENSOR CIRCUIT (LGW)

Diagnostic 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

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Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition	P0036, P0037, P0056, P0057, P0097, P00F4, P0102, P010C, P0141, P0161, P2199	P0036, P0037, P0056, P0057, P0097, P00F4, P0102, P010C, P0141, P0161, P2199	P0690	P0096, P010B
Signal	P0096, P0097, P00F5, P2199	P0097, P00F4, P2199,	P0097, P00F4, P2199*	P0096
Ground	-	P0097, P00F4, P0102, P2199	-	P0096, P010B
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

IAT Sensor 2

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

Circuit/System Description

The IAT sensor 2 produces a frequency signal, based on the inlet air temperature, which is equal to the humidity present within the sensor bore. The signal varies with inlet air temperature and is displayed by the scan tool as Â°C (Â°F) and Hertz (Hz) and the relative humidity is displayed in percent (%). The ECM supplies a regulated voltage to the signal 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 2 - Temperature, Frequency Table

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

Conditions for Running the DTCs

P0097, P0098 and P0099

- DTC P1682 is not set.

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

Conditions for Setting the DTCs

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

P0097

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

P0098

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

P0099

The ECM detects that the IAT sensor 2 signal is intermittent or has abruptly changed for greater than 5 s.

Action Taken When the DTC Sets

DTCs P0097, P0098 and P0099 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P0097, P0098 and P0099 are Type B DTCs.

Diagnostic Aids

- The IAT Sensor 1 and IAT Sensor 2 are integrated with the multifunction intake air sensor.
- With the ignition ON, engine OFF and cold; properly functioning IAT sensors 1 and 2 will cause the scan tool IAT Sensor 1 and 2 parameters to increase. This is due to the heat that is generated by the multifunction intake air sensor internal heating elements.
- The humidity sensor and the IAT sensor 2 signals are sent to the ECM on the same circuit. If the IAT Sensor 2 parameters display the values: 10 Hz; -40Â°C (-40Â°F) and there are also Humidity Sensor DTCs, check for a circuit fault.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW)

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

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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)** and/or **Special Tools (Mechanical Tools)** .

Circuit/System Verification

1. Ignition ON.
2. Verify that DTC P00F4, P00F5, P00F6, P0102, P0103, P0641, P0651, P0697 or P06A3 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 following scan tool parameters are within 30Â°C (54Â°F) of each other.

   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.**

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

     Refer to Circuit/System Testing.

   - **If within 30Â°C (54Â°F)**
4. Vehicle ON, verify the following scan tool parameters are between -38 and +149Â°C (-36 and +300Â°F).
   - IAT Sensor 1
   - IAT Sensor 2
   - **If not between: -38 and +149Â°C (-36 and +300Â°F)**

     Refer to Circuit System Testing.

   - **If between: -38 and +149Â°C (-36 and +300Â°F)**
5. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
6. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

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

Circuit/System Testing

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

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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 5 Ω between the low reference circuit terminal 3 and ground.
    - **If 5 Ω or greater**
    1. Disconnect the harness connector at the K20 Engine Control Module.
    2. Test for less than 2 Ω in the low reference circuit end to end.
        - If 2 Ω or greater, repair the open or high resistance in the circuit.
        - If less than 2 Ω replace the K20 Engine Control Module.
    - **If less than 5 Ω**
3. Test for less than 5 Ω between the ground circuit terminal 7 and ground.
    - **If 5 Ω or greater**
    1. Test for less than 2 Ω in the ground circuit end to end.
        - If 2 Ω or greater, repair the open or high resistance in the circuit.
        - If less than 2 Ω, repair the open/high resistance in the ground connection.
    - **If less than 5 Ω**
4. Ignition ON, verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.
    - **If the test lamp does not illuminate and the circuit fuse is good**
    1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
    2. Test for less than 2 Ω in the ignition voltage circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.
    - **If the test lamp does not illuminate and the circuit fuse is open**
    1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
    2. Test for infinite resistance between the ignition voltage circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance, test all components connected to the ignition circuit, replace as necessary.
    - **If a test lamp illuminates**
5. Ignition ON, verify the scan tool Intake Air Humidity Sensor parameter is less than 1%.

    NOTE: **The intake air temperature sensor 2 signal circuit is pulled up with low current voltage within the controller. Normally, a voltage near B+ can be measured on the circuit with a DMM, but the current will not be high enough to illuminate a test lamp.**

    - **If 1% or greater**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the IAT 2 signal circuit terminal 8 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 less than 1%**
6. Ignition OFF, install a 3 A fused jumper wire between the IAT 2 signal circuit terminal 8 and the low reference circuit terminal 3, Ignition ON.
7. Verify the scan tool Intake Air Humidity Sensor parameter is greater than 99%.
    - **If 99% or less**
    1. Ignition OFF, remove the jumper wire and disconnect the harness connector at 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.**

    2. Test for less than 1 V between the IAT 2 signal circuit terminal 8 and ground.

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

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

- **If greater than 99%**

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

Component Testing

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

      Replace the B75C Multifunction Intake Air sensor.

    - **If within 5%**
2. All OK.

Repair Instructions

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

- **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGW)**
- **Control Module References** for engine control module replacement, programming and setup.

DTC P0097, P0098 OR P0099: INTAKE AIR TEMPERATURE (IAT) SENSOR 2 CIRCUIT (LGX)

Diagnostic 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 and Intake Air Humidity

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

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Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	P0097, P00F5, P2199	P0097, P00F4, P2199	P0097*, P00F4*, 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 2

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

Intake Air Humidity Sensor

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

Circuit/System Description

The IAT sensor 2 produces a frequency signal, based on the inlet air temperature, which is equal to the humidity present within the sensor bore. The signal varies with inlet air temperature and is displayed by the scan tool as Â°C (Â°F) and Hertz (Hz) and the relative humidity is displayed in percent (%). The ECM supplies a regulated voltage to the signal 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 2 - Temperature, Frequency Table

IAT Sensor 2	IAT Sensor 2 Frequency	IAT Sensor 2 Temperature
Cold	45 Hz	-40Â°C (-40Â°F)

IAT Sensor 2	IAT Sensor 2 Frequency	IAT Sensor 2 Temperature
Warm	302 Hz	104Â°C (219Â°F)

Conditions for Running the DTCs

P0097, P0098 and P0099

- DTCs P0685, P0686, P0687, P0689, P0690 or P1682 are not set.
- 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.

Conditions for Setting the DTCs

P0097

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

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

P0098

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

P0099

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

Action Taken When the DTC Sets

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

Conditions for Clearing the MIL/DTC

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

Diagnostic Aids

- With the Vehicle in Service Mode, 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; -40Â°C (-40Â°F) and there are also Humidity Sensor DTCs, check for a circuit problem.

Reference Information

Schematic Reference

Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**

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- 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) and/or Special Tools (Mechanical Tools) .

Circuit/System Verification

1. Ignition On.
2. Verify that DTC P00F4, P00F5, P00F6, P0102, P0103, P0641, P0651, P0697 or P06A3 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. Engine running.
4. Verify the following scan tool IAT Sensor 2 parameter is between -38 and +149Â°C (-36 and +300Â°F).
   - **If not between: -38 and +149Â°C (-36 and +300Â°F)**

     Refer to Circuit System Testing.

   - **If between: -38 and +149Â°C (-36 and +300Â°F)**
5. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
6. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

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

Circuit/System Testing

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 5 Ω between the low reference circuit terminal 3 and ground.
   - **If 5 Ω or greater**
     1. Disconnect the harness connector at the K20 Engine Control Module.
     2. Test for less than 2 Ω in the low reference circuit end to end.

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- If 2 Ω or greater, repair the open or high resistance in the circuit.
- If less than 2 Ω replace the K20 Engine Control Module.

- **If less than 5 Ω**

3. Test for less than 5 Ω between the ground circuit terminal 7 and ground.
   - **If 5 Ω or greater**
   1. Ignition Off.
   2. Test for less than 2 Ω in the ground circuit end to end.
      - If 2 Ω or greater, repair the open or high resistance in the circuit.
      - If less than 2 Ω, repair the open/high resistance in the ground connection.
   - **If less than 5 Ω**
4. Ignition On.
5. Verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition Off, remove the test lamp and remove the fuse for the ignition voltage circuit.
   2. Test for less than 2 Ω in the ignition voltage circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**
   1. Ignition Off, remove the test lamp, the fuse for the ignition voltage circuit and disconnect all components on the circuit.

      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.**

   2. Test for infinite resistance between the ignition voltage circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, test all components connected to the ignition circuit, replace as necessary.
   - **If a test lamp illuminates**
6. Verify the scan tool Intake Air Humidity Sensor parameter is less than 1%.

   NOTE: **The intake air temperature sensor 2 signal circuit is pulled up with low current voltage within the controller. Normally, a voltage can be measured on the circuit with a DMM, but the current will not be high enough to illuminate a test lamp.**

   - **If 1% or greater**
   1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the IAT 2 signal circuit terminal 8 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 less than 1%**
7. Ignition Off, install a 3 A fused jumper wire between the IAT 2 signal circuit terminal 8 and the low reference circuit terminal 3.
8. Ignition On.
9. Verify the scan tool Intake Air Humidity Sensor parameter is greater than 99%.
   - **If 99% or less**
   1. Ignition Off, remove the jumper wire and disconnect the harness connector at 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.**

2. Ignition On.
3. Test for less than 1 V between the IAT 2 signal circuit terminal 8 and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V.
4. Ignition Off.
5. Test for less than 2 Ω in the signal circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If greater than 99%**

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.

Testing with EL-38522-A

1. Perform the following test using a **EL-38522-A** Variable Signal Generator or equivalent, if available.

    NOTE: **In-correct diagnosis will result if Circuit/System Testing is not completed before performing the following test.**

2. Ignition Off, connect the leads of the **EL-38522-A** Variable Signal Generator as follows:
    1. Red lead to the signal circuit terminal 8 at the harness connector
    2. Black leads to ground
    3. Battery voltage supply lead to B+
3. 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 250 Hz
4. Ignition On, verify the scan tool IAT Sensor 2 parameters listed below are within the ranges listed below:
    - IAT Sensor 2 is between 248-252 Hz
    - IAT Sensor 2 is between 70-76Â°C (160-166Â°F)

      NOTE: **Changing the frequency should cause a warmer or colder IAT 2 temperature.**

    - Intake Air Humidity Sensor is between 48-52%

      NOTE: **Increasing or decreasing the duty cycle should have an inverse affect on humidity.**

    - **If a parameter is not within the specified range**

      Replace the K20 Engine Control Module.

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- **If all the parameters are within the specified range**

5. All OK.

Repair Instructions

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

- **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGX)** for B75C Multifunction Intake Air Sensor replacement
- **Control Module References** for engine control module replacement, programming and setup.

DTC P00C4 OR P2261: TURBOCHARGER BYPASS VALVE STUCK BANK

Diagnostic 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 P00C4

Turbocharger Bypass Valve Stuck Bank 2

DTC P2261

Turbocharger Bypass Valve Stuck Bank 1

Circuit/System Description

Each of the turbochargers is provided with a mechanical vacuum operated bypass valve, which opens during abrupt closed throttle conditions, to prevent turbocharger surging and damage from vibrations. The bypass valve vacuum source is provided by a vacuum pump which is driven by the oil pump. The vacuum pump is a part of the oil pump assembly which is serviced as a unit. The valves are controlled by the engine control module (ECM), by utilizing remotely mounted solenoid valves. When the valves open during closed throttle deceleration conditions, air is allowed to recirculate in the turbochargers to maintain turbocharger speed. Within a calibrated range during a closed throttle event or upon a wide open throttle command the valves close to optimize turbo response.

As engine load and engine speed increases, the turbocharger bypass solenoid valves are commanded On by the ECM. As soon as the throttle closes the turbocharger bypass solenoid valves are commanded Off by the ECM to allow the bypass valves to open and allow the turbocharger air to recirculate to prevent surging.

Conditions for Running the DTC

P00C4

- DTCs P00C0, P00C1, P00C2, P0101, P0102, P0103, P010C, P010D, P0236, P0237 or P0238 are not set.
- The bank 2 charge air bypass solenoid valve has been commanded On for greater than 1 s immediately after an abrupt closed throttle has occurred and the resulting pressure ratio across the compressor exceeds the calibrated pressure ratio limit.
- The engine speed is greater than 1, 500 RPM.
- This DTC runs continuously within the enabling conditions.

P2261

- DTCs P0033, P0034, P0035, P0101, P0102, P0103, P010C, P010D, P0236, P0237 or P0238 are not set.

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- The bank 1 charge air bypass solenoid valve has been commanded On for greater than 1 s immediately after an abrupt closed throttle has occurred and the resulting pressure ratio across the compressor exceeds the calibrated pressure ratio limit.
- The engine speed is greater than 1, 500 RPM.
- This DTC runs continuously within the enabling conditions.

Conditions for Setting the DTC

The ECM has detected a series of pulsations in the induction system that exceed a calibrated threshold.

Action Taken When the DTC Sets

DTC P00C4 and P2261 are Type B DTCs.

Conditions for Clearing the DTC

DTC P00C4 and P2261 are Type B DTCs.

Diagnostic Aids

This engine utilizes a mechanical vacuum pump to provide a vacuum source for the braking system and turbocharger system actuators. The vacuum pump is integrated into the oil pump assembly located in the oil pan. Both the vacuum pump and the oil pump are part of a common assembly, referred to as a tandem pump. Neither pump is serviceable individually. If a condition is found with either the oil pump or vacuum pump, replace the entire tandem pump assembly.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

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 DTC P0033, P0034, P0035 P00C0, P00C1 or P00C2 is not set.
    - **If any of the DTCs are set**

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

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

3. Verify the scan tool Barometric Pressure Sensor Bank 1 and Bank 2 parameters are within the range specified in the **Altitude Versus Barometric Pressure** .
   - **If either parameter is not within the specified range**

     Refer to the corresponding **DTC P2227-P2230 (LGW)** , **DTC P2227-P2230 (LGX)** or **DTC P222B-P222E** .

   - **If both parameters are within the specified range**
4. Verify the scan tool Boost Pressure Sensor and Barometric Pressure Sensor Bank 1 and Bank 2 Sensor parameters are within 3 kPa (0.4 psi).
   - **If not within 3 kPa (0.4 psi)**

     Refer to **DTC P0236** .

   - **If within 3 kPa (0.4 psi)**
5. Verify a click is heard or felt from the corresponding Q40 Turbocharger Bypass Solenoid Valve when commanding the Turbocharger Bypass Solenoid Valve Bank 1 or Bank 2 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. Engine Idling.
7. Verify a click is heard or felt from the corresponding mechanical turbocharger bypass valve when commanding the Turbocharger Bypass Solenoid Valve Bank 1 or Bank 2 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**
8. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
9. Verify a DTC does not set.
   - **If a DTC sets**

     Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Verify the conditions listed below do not exist:
   - Vacuum leaks
   - Vacuum line restrictions
   - Improper routing or connection of the vacuum hoses to the Q40 Bypass Solenoid Valves, bypass valves, Q42 Turbocharger Wastegate solenoid valves, wastegate valve actuators, vacuum pump and the vacuum tank.
   - **If a condition exists**

     Repair or replace the component as necessary.

   - **If none of the conditions exist**
2. Ignition Off, disconnect the vacuum supply hose at the turbocharger vacuum tank.
3. Connect the **GE 23738-A** to the supply hose.

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4. Engine Idling, verify the vacuum value is less than or equal to 15 kPa (4.4 inches Hg).

NOTE: **To determine the vacuum value, subtract the absolute value of the vacuum gauge reading from the barometric pressure.**

- **If not within the specified range**

  Repair or replace the vacuum pump.

- **If within the specified range**

5. Ignition Off, disconnect all vacuum hoses at the turbocharger vacuum tank and cap or plug the valve outlet ports.
6. Connect the **GE 23738-A** to the vacuum tank inlet port and apply 5 kPa (1.5 inches Hg) of vacuum.
7. Verify the tank holds vacuum for at least 10 s.
   - **If the vacuum is not held for at least 10 s**

     Replace the vacuum tank.

   - **If the vacuum is held for at least 10 s**
8. Connect the vacuum hoses to the tank.
9. Disconnect the appropriate Q40 Turbocharger Bypass Solenoid Valve output to mechanical bypass valve input vacuum hose at the bypass valve and connect the **GE 23738-A** to the hose.
10. Engine idling.
11. Verify the vacuum value toggles between 0 kPa (0 inches Hg) to less than or equal to 15 kPa (4.4 inches Hg), when commanding the Turbocharger Bypass Solenoid Valve between Active and Inactive with a scan tool.

NOTE: **To determine the vacuum value, subtract the vacuum gauge reading from the barometric pressure.**

- **If not within the specified range**

  Replace the Q40 Turbocharger Bypass Solenoid Valve.

- **If within the specified range**

12. Connect any hoses that were disconnected during previous steps.
13. Verify the conditions listed below do not exist with the mechanical turbocharger bypass valve assembly:
    - Damage
    - Leaks
    - Restrictions
    - **If a condition exists**

      Repair or replace the mechanical turbocharger bypass valve as necessary.

    - **If none of the conditions exist**
14. Replace the B111B Turbocharger Boost/Intake Air Temperature Sensor.

Repair Instructions

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

- **Charge Air Bypass Valve Solenoid Replacement (Bank 1)** **Charge Air Bypass Valve Solenoid Replacement (Bank 2)** for Q40A/B Turbocharger Bypass Solenoid Valve replacement.
- **Charge Air Bypass Valve Replacement - Right Side** for mechanical turbocharger bypass valve replacement bank 1.

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- **Charge Air Bypass Valve Replacement - Left Side** for mechanical turbocharger bypass valve replacement bank 2.
- **Turbocharger Wastegate Actuator Vacuum Tank Replacement** .
- **Oil Pump Replacement**
- **Oil Pump Cleaning and Inspection**
- **Control Module References** for ECM replacement, programming and setup.

DTC P00C7: INTAKE AIR PRESSURE MEASUREMENT SYSTEM - MULTIPLE SENSORS NOT PLAUSIBLE (LGW)

Diagnostic 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 4 sensors;

- The Barometric Pressure (BARO) 1 (Turbocharged Inlet Air Pressure) TCIAP
- The Barometric Pressure (BARO) 2 (TCIAP 2)
- The Manifold Absolute Pressure (MAP) Sensor
- The Turbocharger Boost / Intake Air Temperature Sensor

Conditions for Running the DTC

- DTCs P0106, P0107, P0108, P0237, P0238, P2227, P2228, P2229, P2230, P222C or P222D are not set.
- Ignition ON, Eng. OFF.
- Time between current ignition cycle and the last time the engine was running is greater than 10 s.
- MAP 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 (LGW)

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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 that DTCs P0106, P0107, P0236, P0237, P0238, P2227, P2228, P2229, P2230, P222B, P222C, P222D or P222E 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**
3. Verify none of the following conditions exist:
   - The air intake duct system for loose connecting clamps, cracks or other damage
   - A damaged Q38 Throttle Body blade or shaft
   - Splits, kinks or improper connections at the vacuum hoses
   - Faulty positive crankcase ventilation system operation
   - Carbon deposits on the throttle blade.
   - Vacuum leaks at the intake manifold, Q38 Throttle Body, Q17 Fuel Injector O-rings and B111B Turbocharger Boost/Intake Air Temperature Sensor.
   - **If a condition exist**

     Repair as necessary.

   - **If none of the conditions exist**
4. Ignition ON.
5. Verify the following scan tool parameters are within range of the Altitude vs. Barometric Pressure table. Refer to **Altitude Versus Barometric Pressure** table.
   - BARO 1 Sensor
   - BARO 2 Sensor
   - MAP Sensor
   - Turbocharger Boost / Intake Air Temperature Sensor
   - **If a sensor parameter is not within range**

     Refer to the appropriate diagnostic below for further diagnosis.

   - Barometric Pressure (BARO) Sensor, Bank 1 or 2. Refer to **DTC P2227-P2230 (LGW)** or **DTC P222B-P222E**
   - Manifold Absolute Pressure (MAP) Sensor. Refer to **DTC P0106**
   - Turbocharger Boost Sensor. Refer to: **DTC P0236**

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

6. 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 P00C7: INTAKE AIR PRESSURE MEASUREMENT SYSTEM - MULTIPLE SENSORS NOT PLAUSIBLE (LGX)

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

DTC P00C7

Intake Air Pressure Measurement System - Multiple Sensors Not Plausible

Circuit/System Description

This system consists of the following components:

- B75C Multifunction Intake Air Sensor
- B74 Manifold Absolute Pressure Sensor

This DTC sets when the control module detects an inconsistency between the pressure sensors and cannot identify which sensor failed.

Conditions for Running the DTC

- DTC P0106, P0107, P0108, P2227, P2228, P2229, P2230, P1682 = Not set
- Engine=Not Running
- Time between current ignition cycle and the last time the engine was running=Greater than 7 min
- Manifold Absolute Pressure = 50 to 115 kPa (7.2 to 16.6 PSI)
- Barometric Pressure = 50 to 115 kPa (7.2 to 16.6 PSI)

DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

Manifold Absolute Pressure & Barometric Pressure = Not within 10 kPa (1.5 PSI) of each other.

Actions 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 (LGX)

Connector End View Reference

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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

Circuit/System Verification

1. IgnitionÂ» On / VehicleÂ» In Service Mode
2. Verify DTC P0106, P0107, P0108, P2227, P2228, P2229, 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 following conditions do not exist:
   - Loose clamps, cracks or other damages to the intake system.
   - Clogged air cleaner.
   - Clogged catalyst.
   - Vacuum hoses with kinks, leaks or improper connections.
   - Leaking or restricted positive crankcase ventilation.
   - Leaks at the intake manifold or throttle body.
   - Leaking, missing or damaged O-ring on the components listed below:
     - B75C Multifunction Intake Air Sensor
     - B74 Manifold Absolute Pressure Sensor
   - **If a condition exists**

     Repair or replace as necessary.

   - **If no condition exists**
4. Verify the scan tool parameter:
   - BARO Sensor = **Altitude Versus Barometric Pressure** - The value should be within the range listed in the table.
   - MAP Sensor = **Altitude Versus Barometric Pressure** - The value should be within the range listed in the table.
   - **If not in the specified range**
   - {BARO Sensor} Refer to **DTC P2227-P2230 (LGX)** .
   - {MAP Sensor} Refer to **DTC P0106**.
   - **If in the specified range**
5. All OK.

DTC P00E9: INTAKE AIR TEMPERATURE (IAT) SENSOR 3 PERFORMANCE

Diagnostic Instructions

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

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- 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 Performance

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

Circuit/System Description

The intake air temperature (IAT) sensor 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 Â°C (Â°F). The IAT sensor 3 is integrated with the boost pressure sensor, which is located at the rear of the charge air cooler (CAC). 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, P00EA, P00EB, P0111, P0112, P0113, P0114, P0117, P0118 or P1682 are not set.
- The vehicle has been OFF at least 8 hours.
- Ignition voltage is at least 11 V.
- These DTCs run once per ignition cycle when the enabling conditions are met.

Conditions for Setting the DTC

P00E9

- 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 30Â°C (54Â°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 25Â°C (45Â°F).

  OR

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

Action Taken When the DTC Sets

DTC P00E9 is a Type B DTC.

Conditions for Clearing the DTCs

DTC P00E9 is a Type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL-38522-A Variable Signal Generator

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** and/or **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 25Â°C (45Â°F) of each other.
   - Start-Up IAT Sensor 1
   - Start-Up IAT Sensor 2
   - IAT Sensor 3

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- **If not within 25Â°C (45Â°F)**

  Refer to Circuit/System Testing.

- **If within 25Â°C (45Â°F)**

3. Engine idling, verify the following scan tool parameters are between -38 to +149Â°C (-36 to +300Â°F).
   - IAT Sensor 1
   - IAT Sensor 2
   - IAT Sensor 3
   - **If not between -38 to +149Â°C (-36 to +300Â°F)**

     Refer to Circuit System Testing.

   - **If between -38 to +149Â°C (-36 to +300Â°F)**
4. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
5. Verify the DTC does not set.
   - **If the DTC does set**

     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. Check the integrity of the entire air induction system and verify that none of the conditions listed below 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
   - Contamination of the MAF sensor element
   - Missing, restricted or leaking exhaust components - Refer to **Symptoms - Engine Exhaust** for further diagnosis.
   - **If a condition exists**

     Repair or replace component as appropriate.

   - **If no condition exists**
2. Ignition OFF and all vehicle systems OFF, it may take up to 2 min. for all vehicle systems to power down. Disconnect the harness connector at the B111B Turbocharger Boost/Intake Air Temperature Sensor.
3. Test for less than 5 Ω between the low reference circuit terminal 3 and ground.
   - **If 5 Ω or greater**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.

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- If 2 Ω or greater, repair the open or high resistance in the circuit.
- If less than 2 Ω replace the K20 Engine Control Module.

- **If less than 5 Ω**

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

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

   2. Test for less than 1 V between the signal circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If between 4.8-5.2 V**
5. Verify the scan tool IAT Sensor 3 parameter is colder than -39Â°C (-38Â°F).
   - **If warmer than -39Â°C (-38Â°F).**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the signal circuit terminal 1 and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 Ω in the signal circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If colder than -39Â°C (-38Â°F).**
6. Ignition OFF, install a 3 A fused jumper wire between the signal circuit terminal 1 and the low reference circuit terminal 3, ignition ON.
7. Verify the scan tool IAT Sensor 3 parameter is warmer than 148Â°C (298Â°F).
   - **If colder than 148Â°C (298Â°F).**
   1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the signal circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V
   3. Ignition OFF.
   4. Test for less than 2 Ω in the signal circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If warmer than 148Â°C (298Â°F).**
8. Test or replace the B111B Turbocharger Boost/Intake Air Temperature sensor.

Component Testing

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Multifunction Intake Air Sensor - IAT Sensor 1

1. Ignition OFF, disconnect the harness connector at the B75C Multifunction Intake Air sensor.
2. Test the IAT sensor 1 by varying the sensor temperature while monitoring the sensor resistance.

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

3. Verify the resistance values are in the range specified in the **Temperature Versus Resistance - Intake Air Temperature Sensor (Hitachi Sensor)** table for Hitachi sensors.
   - **If not within the specified range.**

     Replace the B75C Multifunction Intake Air Sensor.

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

Multifunction Intake Air Sensor - IAT Sensor 2

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

     Replace the B75C Multifunction Intake Air sensor.

   - **If within 5%**
3. All OK.

Turbocharger Boost/Intake Air Temperature Sensor (IAT Sensor 3)

1. Ignition OFF, remove the B111B Turbocharger Boost/Intake Air Temperature sensor (IAT Sensor 3).
2. Connect a DMM between terminals 1 and 3.
3. Test the IAT sensor 3 by varying the sensor temperature while monitoring the sensor resistance.

   NOTE: A thermometer can be used to monitor the air temperature while testing the sensor off the vehicle.

4. Verifty the resistance values are in the range specified **Temperature Versus Resistance - Intake Air Temperature Sensor (Delco Sensor)** table for Delco Sensors
   - **If not within the specified range**

     Replace the B111B Turbocharger Boost/Intake Air Temperature sensor.

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

Repair Instructions

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

- **Intake Air Pressure and Temperature Sensor Replacement** for B111B Turbocharger Boost/Intake Air Temperature Sensor replacement.
- **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGW)** **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGX)** for B75C Multifunction Intake Air Sensor replacement.
- **Control Module References** for engine control module replacement, programming and setup.

DTC P00EA-P00EC: INTAKE AIR TEMPERATURE (IAT) SENSOR 3 CIRCUIT

Diagnostic Instructions

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- 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 Intermittent

Diagnostic Fault Information

IAT Sensor 3

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	P00EA	P00E9, P00EB, P00EC	P00EB, P00EC*	P00E9
Low Reference	-	P00E9, P00EB, P00EC, P0236, P0238	P00EB, P00EC*	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

IAT Sensor

Circuit	Short to Ground	Open or High Resistance	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** Varies with ambient temperature; and engine bay conditions			
Signal	150Â°C (302Â°F)	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
Low Reference	-	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
*Internal ECM or sensor damage may occur if the circuit is shorted to B+			

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 Â°C (Â°F). The IAT sensor 3 is integrated with the throttle inlet absolute pressure sensor, which is located at the rear of the charge air cooler housing (CAC). 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

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

P00EA

The ECM detects that the IAT sensor 3 signal is warmer than 150Â°C (302Â°F) for at least 5 s.

P00EB

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

P00EC

The ECM detects that the IAT sensor 3 signal is intermittent or has abruptly changed for at least 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 (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

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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

Special Tools

EL-38522-A Variable Signal Generator

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

Circuit/System Verification

1. Engine idling, verify the IAT Sensor 3 scan tool parameter is between -38 to +149Â°C (-36 to +300Â°F).
   - **If not between -38 to +149Â°C (-36 to +300Â°F)**

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Refer to Circuit System Testing.

- **If between -38 to +149Â°C (-36 to +300Â°F)**

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 does set**

     Refer to Circuit/System Testing.

   - **If the DTC does not set**
4. 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 Ω between the low reference circuit terminal 3 and ground.
   - **If 2 Ω or greater**
   1. Disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open or high resistance in the circuit.
      - If less than 2 Ω replace the K20 Engine Control Module.
   - **If less than 2 Ω**
3. Ignition ON.
4. Test for 4.8-5.2 V between the intake air temperature signal 3 signal circuit terminal 1 and ground.
   - **If less than 4.8 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the signal circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 Ω in the signal circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If greater than 5.2 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

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

   2. Test for less than 1 V between the signal circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If between 4.8-5.2 V**
5. Verify the scan tool IAT Sensor 3 parameter is colder than -39Â°C (-38Â°F).
   - **If warmer than -39Â°C (-38Â°F).**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the signal circuit terminal 1 and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.

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- If infinite resistance, replace the K20 Engine Control Module.
- **If colder than -39Â°C (-38Â°F).**

6. Ignition OFF, install a 3 A fused jumper wire between the signal circuit terminal 1 and the low reference circuit terminal 3, ignition ON.
7. Verify the scan tool IAT Sensor 3 parameter is warmer than 149Â°C (300Â°F).
   - **If colder than 149Â°C (300Â°F).**
   1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the signal circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V
   3. Ignition OFF.
   4. Test for less than 2 Ω in the signal circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If warmer than 149Â°C (300Â°F).**
8. Test or replace the B111B Turbocharger Boost/Intake Air Temperature sensor.

Component Testing

Turbocharger Boost/Intake Air Temperature Sensor - IAT Sensor 3

1. Ignition OFF, remove the B111B Turbocharger Boost/Intake Air Temperature sensor (IAT Sensor 3).
2. Connect a DMM between terminals 1 and 3.
3. Test the IAT sensor 3 by varying the sensor temperature while monitoring the sensor resistance with the DMM.

   NOTE: **A thermometer can be used to monitor the air temperature while testing sensor off the vehicle.**

4. Verify the resistance values are in the range specified in the **Temperature Versus Resistance - Intake Air Temperature Sensor (Delco Sensor)** table for Delco Sensors.
   - **If not within the specified range**

     Replace the B111B Turbocharger Boost/Intake Air Temperature sensor.

   - **If within the specified range**
5. 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: INTAKE AIR HUMIDITY SENSOR CIRCUIT (LGW)

Diagnostic 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

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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	P0036, P0037, P0050, P0051, P0056, P0057, P0097, P00F4, P0102, P010C, P0141, P0161, P1101, P2199	P0097, P00F4, P010C, P2199	P0690	P0096, P010B
Signal	P0097, P00F5, P2199	P0097, P00F4, P2199, P222E	P0097, P00F4, P2199*	P0096
Ground	-	P0097, P00F4, P2199, P222B or P222C	-	P0096, P010B
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

Intake Air Humidity

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

Circuit/System Description

The 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 IAT sensor 2 produces a frequency signal, based on the inlet air temperature, which is equal to the humidity present within the sensor bore. The signal varies with inlet air temperature and is displayed by the scan tool as Â°C (Â°F) and Hertz (Hz) and the relative humidity is displayed in percent (%). The ECM supplies a regulated voltage to the signal circuit. The signal circuit is shared by the IAT sensor 2 and the intake air 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

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- Humidity sensor
- MAF sensor

Conditions for Running the DTCs

P00F4, P00F5 and P00F6

- DTC P1682 is not set.
- The ignition is ON.
- The ignition voltage is at least 11 V.
- These DTCs run continuously within the enabling conditions.

Conditions for Setting the DTCs

P00F4

The ECM detects that the humidity sensor signal is less than or equal to 5% for greater than 5 s.

P00F5

The ECM detects that the humidity sensor signal is greater than or equal to 95% for greater than 5 s.

P00F6

The ECM detects that the humidity sensor signal is intermittent or has abruptly changed over a period of time greater than 5 s.

Action Taken When the DTC Sets

DTCs P00F4, P00F5, P00F6 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P00F4, P00F5, P00F6 are Type B DTCs.

Diagnostic Aids

- The Intake Air Humidity Signal parameter displays the measured humidity within the air intake system and may differ from atmospheric humidity measured outside the air intake system.
- The humidity sensor and the IAT sensor 2 signals are sent to the ECM on the same circuit. If the Intake Air Humidity parameter displays the value: 0% or 100% and there are also IAT Sensor 2 DTCs, check for a circuit problem.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW)

Connector End View Reference

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DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL-38522-A Variable Signal Generator

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** and/or **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 (LGW)**

   - **If none of the DTCs are set**
3. Ignition ON.

   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.**

4. Verify the following scan tool parameters are within 10Â°C (18Â°F) of each other.
   - Start-Up IAT Sensor 1
   - Start-Up IAT Sensor 2
   - IAT Sensor 3
   - **If not within 10Â°C (18Â°F)**

     Refer to Circuit/System Testing.

   - **If within 10Â°C (18Â°F)**
5. Engine idling, verify the scan tool Intake Air Humidity Sensor parameter is between 5 and 90%.
   - **If not between 5 and 90%**

     Refer to Circuit/System Testing.

   - **If between 5 and 90%**
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. Vehicle 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 5 Ω between the low reference circuit terminal 3 and ground.

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- **If 5 Ω or greater**

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

- **If less than 5 Ω**

3. Test for less than 5 Ω between the ground circuit terminal 7 and ground.
    - **If 5 Ω or greater**

    1. Vehicle OFF.
    2. Test for less than 2 Ω in the ground circuit end to end.
        - If 2 Ω or greater, repair the open or high resistance in the circuit.
        - If less than 2 Ω, repair the open/high resistance in the ground connection.

    - **If less than 5 Ω**

4. Vehicle in Service Mode, 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. Vehicle OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
    2. Test for less than 2 Ω in the ignition voltage circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.

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

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

    - **If a test lamp illuminates**

5. Ignition ON, verify the scan tool Intake Air Humidity Sensor parameter is less than 1%.

NOTE: **The intake air temperature sensor 2 signal circuit is pulled up with low current voltage within the controller. Normally, a voltage near B+ can be measured on the circuit with a DMM, but the current will not be high enough to illuminate a test lamp.**

- **If 1% or greater**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the IAT 2 signal circuit terminal 8 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 less than 1%**

6. Ignition OFF, install a 3 A fused jumper wire between the IAT 2 signal circuit terminal 8 and the low reference circuit terminal 3, Ignition ON.
7. Verify the scan tool Intake Air Humidity Sensor parameter is greater than 99%.
    - **If 99% or less**

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

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

    2. Test for less than 1 V between the IAT 2 signal circuit terminal 8 and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.

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- If less than 1 V.

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

- **If greater than 99%**

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

Component Testing

Multifunction Intake Air Sensor

1. Test the Intake Air Humidity Sensor by varying the air humidity in the intake duct near the sensor, while observing the scan tool Intake Air Humidity Sensor parameter.
2. Verify the parameter is between 5-95% and changes
    - **If not within 5-95% or the parameter does not change.**

      Replace the K20 Engine Control Module.

    - **If within 5-95% and the parameter does change**
3. All OK.

Repair Instructions

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

- **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGW)** - B75C Multifunction Intake Air Sensor replacement.
- **Control Module References** for engine control module replacement, programming and setup.

DTC P00F4-P00F6: INTAKE AIR HUMIDITY SENSOR CIRCUIT (LGX)

Diagnostic 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 and IAT Sensor 2

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

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Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	P0097, P00F4, P2199	P0097, P00F4, P2199	P0097*, P00F5*, P2199*	P0096
Ground	-	P0097, P00F4, P0102, P0103, P2199	-	P0096
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

Intake Air Humidity Sensor

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

Circuit/System Description

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

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

The IAT sensor 2 produces a frequency signal, based on the inlet air temperature, which is equal to the humidity present within the sensor bore. The signal varies with inlet air temperature and is displayed by the scan tool as Â°C (Â°F) and Hertz (Hz) and the relative humidity is displayed in percent (%). The ECM supplies a regulated voltage to the signal circuit. The signal circuit is shared by the IAT sensor 2 and the intake air 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

Conditions for Running the DTCs

P00F4, P00F5 and P00F6

- DTC P1682 is not active.

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- The ignition is ON.
- The Ignition voltage is at least 11 V for longer than 0.9 s.
- The DTCs run continuously within the enabling conditions.

Conditions for Setting the DTCs

P00F4

The ECM detects that the humidity sensor signal is less than or equal to 5% for greater than 4 s.

P00F5

The ECM detects that the humidity sensor signal is greater than or equal to 95% for greater than 4 s.

P00F6

The ECM monitors the humidity sensor signal every 100 ms to determine if the signal has changed more than 80%. The DTC sets when the condition exists for greater 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.
- When the ignition is On and 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.
- When the ignition is On and the engine is cold, a properly functioning IAT sensor 2 will gradually increase the scan tool IAT Sensor 2 parameter. This is due to the heat that is generated by the multifunction intake air sensor heating elements.

Reference Information

Schematic Reference

Engine Controls Schematics (LGX)

Connector End View Reference

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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)** and/or **Special Tools (Mechanical Tools)** .

Circuit/System Verification

1. Ignition On.
2. Verify that DTC P0102, P0103, P0641, P0651, P0697 or P06A3 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. Engine running.
4. Verify the scan tool Intake Air Humidity Sensor parameter is between 5 and 90%.
   - **If not between 5 and 90%**

     Refer to Circuit/System Testing.

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

     Refer to Circuit/System Testing.

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

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 5 Ω between the low reference circuit terminal 3 and ground.
   - **If 5 Ω or greater**
   1. Disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open or high resistance in the circuit.
      - If less than 2 Ω replace the K20 Engine Control Module.
   - **If less than 5 Ω**
3. Test for less than 5 Ω between the ground circuit terminal 7 and ground.
   - **If 5 Ω or greater**
   1. Ignition Off.
   2. Test for less than 2 Ω in the ground circuit end to end.
      - If 2 Ω or greater, repair the open or high resistance in the circuit.

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- If less than 2 Ω, repair the open/high resistance in the ground connection.

- **If less than 5 Ω**

4. Ignition On.
5. Verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.
    - **If the test lamp does not illuminate and the circuit fuse is good**
    1. Ignition Off, remove the test lamp and remove the fuse for the ignition voltage circuit.
    2. Test for less than 2 Ω in the ignition voltage circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.
    - **If the test lamp does not illuminate and the circuit fuse is open**
    1. Ignition Off, remove the test lamp, the fuse for the ignition voltage circuit and disconnect all components on the circuit.

        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.**

    2. Test for infinite resistance between the ignition voltage circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance, test all components connected to the ignition circuit, replace as necessary.
    - **If a test lamp illuminates**
6. Verify the scan tool Intake Air Humidity Sensor parameter is less than 1%.

    NOTE: **The intake air temperature sensor 2 signal circuit is pulled up with low current voltage within the controller. Normally, a voltage can be measured on the circuit with a DMM, but the current will not be high enough to illuminate a test lamp.**

    - **If 1% or greater**
    1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the IAT 2 signal circuit terminal 8 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 less than 1%**
7. Ignition Off, connect a 3 A fused jumper wire between the IAT 2 signal circuit terminal 8 and the low reference circuit terminal 3.
8. Ignition On.
9. Verify the scan tool Intake Air Humidity Sensor parameter is greater than 99%.
    - **If 99% or less**
    1. Ignition Off, remove the jumper wire and disconnect the harness connector at 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.**

    2. Ignition On.
    3. Test for less than 1 V between the IAT 2 signal circuit terminal 8 and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V.
    4. Ignition Off.
    5. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.

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

- **If greater than 99%**

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

Component Testing

Multifunction Intake Air Sensor

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

      Replace the B75C Multifunction Intake Air Sensor.

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

Testing with EL-38522-A

1. Perform the following test using a **EL-38522-A** Variable Signal Generator or equivalent, if available.

    NOTE: **In-correct diagnosis will result if Circuit/System Testing is not completed before performing the following test.**

2. Ignition Off, connect the leads of the **EL-38522-A** Variable Signal Generator as follows:
    1. Red lead to the signal circuit terminal 8 at the harness connector
    2. Black leads to ground
    3. Battery voltage supply lead to B+
3. 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 250 Hz
4. Ignition On.
5. Verify the scan tool IAT Sensor 2 parameters listed below are within the ranges listed below:
    - IAT Sensor 2 is between 248-252 Hz
    - IAT Sensor 2 is between 70-76Â°C (160-166Â°F)

      NOTE: **Changing the frequency should cause a warmer or colder IAT 2 temperature.**

    - Intake Air Humidity Sensor is between 48-52%

      NOTE: **Increasing or decreasing the duty cycle should have an inverse affect on humidity.**

    - **If a parameter is not within the specified range**

      Replace the K20 Engine Control Module.

    - **If all the parameters are within the specified range**
6. All OK.

Repair Instructions

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

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- **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGX)** for B75C Multifunction Intake Air Sensor replacement
- **Control Module References** for engine control module replacement, programming and setup.

DTC P00FF, P069E, P06EC, P0700, P0800, P0AC4, P1E00, P2561, P25A2, P25AF, P25C9, P26C8 OR P26C9: MODULE REQUESTED MIL ILLUMINATION

Diagnostic Instructions

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

DTC Descriptor

DTC P00FF

Body Control Module Requested MIL Illumination

DTC P069E

Fuel Pump Control Module Requested MIL Illumination

DTC P06EC

Fuel Injector Control Module Requested MIL Illumination

DTC P0700

Transmission Control Module Requested MIL Illumination

DTC P0800

Active Transfer Case Control Module Requested MIL Illumination

DTC P0AC4

Hybrid/EV Powertrain Control Module Requested MIL Illumination

DTC P1E00

Hybrid/EV Powertrain Control Module 2 Requested MIL Illumination

DTC P2561

Air Conditioning (A/C) Control Module Requested MIL Illumination

DTC P25A2

Brake System Control Module Requested MIL Illumination

DTC P25AF

Coolant Temperature Control Module Requested MIL Illumination

DTC P25C9

Brake System Control Module 2 Requested MIL Illumination

DTC P26C8

Chassis Control Module Requested MIL Illumination

DTC P26C9

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Auxiliary Chassis Control Module Requested MIL Illumination

Circuit/System Description

Control modules constantly monitor the vehicle for any condition which may adversely affect vehicle performance. If a condition is detected, the module sets a DTC and sends a serial data message to the engine control module (ECM). The ECM sets a DTC to inform the technician that the module has set a DTC. The serial data message sent by the module also contains a request for the ECM to illuminate the malfunction indicator lamp (MIL).

The technician can observe the DTC that was set by the module by reviewing the ECM Freeze Frame records on the scan tool. The ECM Freeze Frame records also contain the engine operating conditions present when the DTC set.

Conditions for Running the DTC

- The ignition is ON or the engine is running.
- These DTCs run continuously.

Conditions for Setting the DTC

The ECM receives a serial data message from a specific module indicating that DTC has set in the module.

Action Taken When the DTC Sets

DTCs P00FF, P069E, P06EC, P0700, P0800, P0AC4, P1E00, P2561, P25A2, P25AF, P25C9, P26C8 and P26C9 are Type A DTCs.

Conditions for Clearing the MIL/DTC

DTCs P00FF, P069E, P06EC, P0700, P0800, P0AC4, P1E00, P2561, P25A2, P25AF, P25C9, P26C8 and P26C9 are Type A DTCs.

Diagnostic Aids

Communication codes, U-codes and P-codes that set in a module can request a DTC 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

1. Vehicle in Service Mode.

NOTE:

- **Do not replace the engine control module for these informational DTCs.**
- **Correct any engine control and communication DTCs before diagnosing these DTCs.**

2. 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**

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3. Verify there are no DTCs set in any other control module.
    - **If a DTC is set**

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

    - **If a DTC is not set**
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 **Diagnostic Trouble Code (DTC) List - Vehicle** .

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

Repair Instructions

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

DTC P0101: MASS AIR FLOW (MAF) SENSOR PERFORMANCE (LGX)

Diagnostic 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	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0097, P00F4, P0102, P0103, P2199	P0097, P00F4, P0102, P0103, P2199	P0690	P0096, P0101, P0103
Signal	P0102	P0102	P0102*	P0101, P0103*, P1101
Ground	-	P0097, P00F4, P0102, P0103, P2199	-	P0096, P0102
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

MAF Sensor

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running at various operating conditions **Parameter Normal Range:** 1, 500-10, 000 Hz			
Ignition Voltage	0 Hz	0 Hz	-
Signal	0 Hz	0 Hz	0 Hz*
Ground	-	0 Hz	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

Circuit Description

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

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

Conditions for Running the DTCs

- DTCs P0101, P0102, P0103, P0107, P0108 P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0128, P0335 or P0336 are not set
- The engine speed is between 425 and 6, 500 RPM.
- The engine coolant temperature (ECT) is between -7 to +150Â°C (+19 to +302Â°F).
- The intake air temperature (IAT Sensor 1) is between -20 to +125Â°C (-4 to +257Â°F).
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

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

Action Taken When the DTC Sets

DTC P0101 is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P0101 is a Type B DTC.

Diagnostic Aids

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

Reference Information

Schematic Reference

Engine Controls Schematics (LGX)

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**

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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

EL-38522-A Variable Signal Generator

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** and/or **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 (LGX)** for further diagnosis.

   - **If none of the DTCs are set**
3. Verify the scan tool Throttle Body Idle Air Flow Compensation parameter is less than 90%.
   - **90% or greater**

     Refer to **Throttle Body Inspection and Cleaning** .

   - **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 (LGX)** for further diagnosis.

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

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

   - **If the MAP Sensor parameter is in range**
7. Engine idling.
8. Verify the scan tool MAP Sensor parameter is between 26-52 kPa (3.8-7.5 PSI) and changes with accelerator pedal input.
   - **If the MAP Sensor parameter is not between 26-52 kPa (3.8-7.5 PSI) or does not change**

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

   - **If the MAP Sensor parameter is between 26-52 kPa (3.8-7.5 PSI) and changes**
9. Verify the scan tool MAF Sensor g/s parameter changes smoothly and gradually as the engine speed is increased and decreased while performing the actions listed below.
   1. Engine idling
   2. Increase the engine speed slowly to 3, 000 RPM and then back to idle.

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3. Exit from the scan tool data list and review the stored data within the Stored Data function of the scan tool.
4. Observe the MAF Sensor parameter frame by frame.

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

  Refer to Circuit/System Testing for further diagnosis.

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

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

      Refer to Circuit/System Testing, for further diagnosis.

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

Circuit/System Testing

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

1. Verify the integrity of the entire air induction system by verifying that none of the conditions listed below exist:
   - Any damaged components
   - Improperly installed components
   - Collapsed, restricted or damaged components
   - Loose clamps, cracks or other damage
   - An air flow restriction
   - Restricted air filter
   - Splits, kinks, leaks or improper connections at the vacuum hoses
   - Vacuum leaks at the intake manifold, MAP sensor and throttle body
   - Water intrusion
   - Any snow or ice buildup, in cold climates
   - Contamination of the multifunction intake air sensor element
   - **If a condition is found**

     Repair or replace component as appropriate.

   - **If no condition is found**
2. Ignition OFF. Disconnect the harness connector at the B75C Multifunction Intake Air Sensor.
3. Test for less than 5 Ω between the ground circuit terminal 7 and ground.
   - **If 5 Ω or greater**
   1. Disconnect the sensor chassis ground.
   2. Test for less than 2 Ω in the ground circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, repair the open/high resistance in the ground connection.
   - **If less than 5 Ω**
4. Ignition ON, verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
   2. Test for less than 2 Ω in the ignition voltage circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.

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

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

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

- **If a test lamp illuminates**

5. Ignition ON, test for 4.8-5.2 V between the signal circuit terminal 6 and ground.

- **If less than 4.8 V**

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

- **If greater than 5.2 V**

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

- **If between 4.8-5.2 V**

6. Test or replace the B75C Multifunction Intake Air Sensor.

Component Testing

Testing with EL-38522-A

1. Ignition OFF, connect the leads of the **EL-38522-A** Variable Signal Generator as listed below:

NOTE: **In-correct diagnosis will result if Circuit/System Testing is not completed before performing the following test.**

- Red lead to the signal circuit terminal 6 at the harness connector
- Black leads to ground
- Battery voltage supply lead to B+

2. Set the **EL-38522-A** Variable Signal Generator to the specifications listed below:
    - Signal switch to 5 V
    - Frequency switch to 5 kHz
    - Duty Cycle switch to 50% (Normal)
3. Engine idling.
4. Verify the scan tool MAF Sensor parameter is between 4, 950-5, 050 Hz.

- **If not between 4, 950-5, 050 Hz.**

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

- **If between 4, 950-5, 050 Hz.**

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

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Repair Instructions

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

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

DTC P0101: MASS AIR FLOW (MAF) SENSOR PERFORMANCE BANK 1 (LGW)

Diagnostic 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 Bank 1

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition	P0036, P0037, P0056, P0057, P0097, P00F4, P0102, P010C, P0141, P0161, P2199	P0096, P0097, P00F4, P0101, P0102, P2199, P222E	P0690	P0096, P0101, P0103, P010B, P010D
Signal	P0102	P0102	P0102*	P0101, P0102, P1101
Ground	-	P0102, P2199	-	P0102
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

MAF Sensor Bank 1

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running at various operating conditions **Parameter Normal Range:** 1, 500-10, 000 Hz			
Ignition Voltage	0 Hz	0 Hz	-
Signal	0 Hz	0 Hz	0 Hz*
Ground	-	0 Hz	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

Circuit Description

NOTE: **The following applies to the intake airflow system performance diagnostic that is used in this turbocharged engine:**

- **The manifold absolute pressure (MAP) estimates are used in the engine air flow estimates. Air flow into the intake system must be the same as the air flow out of the intake system, the Intake Air Flow Rationality Diagnostics (IFRD) calculates air flowing out of the engine based on MAP estimates, volumetric efficiency and RPM.**

The engine control module (ECM) uses the following information to calculate an expected airflow rate:

- The throttle position
- The barometric pressure (BARO) Bank 1 and Bank 2
- The manifold absolute pressure (MAP)
- The intake air temperature (IAT) Sensor 1, 2 and 3
- The turbocharger boost sensor
- The engine RPM

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

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

Conditions for Running the DTCs

- DTCs P00E9, P00EA, P00EB, P00EC, P0101, P0102, P0103, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0128, P0335, P0336, P0237, P0238, P2227, P2228, P2229 or P2230 are not set
- The engine speed is between 425 and 6, 500 RPM.
- The engine coolant temperature (ECT) is between -7 to +150Â°C (+19.4 to +302Â°F).
- The intake air temperature (IAT) sensor 1 is between -20 to +125Â°C (-4 to +257Â°F).
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

The engine control module (ECM) detects that the actual measured airflow from the two MAF, MAP, turbocharger boost and the throttle position sensors are not within a range of the calculated airflow that are derived from the system of models by greater than a calibrated threshold for greater than 10 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 condition that can cause the MAF, MAP, turbocharger boost and throttle position sensors to be shifted in value may cause this DTC to set
- Any type of contamination on the either of the two MAF sensor heating elements will degrade the proper operation of the sensor(s). Certain types of contaminants act as a heat insulator, which will impair the response of the sensor to air flow changes. Water or snow can create the opposite effect and cause the signal to increase rapidly.
- Certain aftermarket air filters may cause this DTC to set.
- Certain aftermarket air induction systems may cause this DTC to set.
- Modifications to the air induction system may cause this DTC to set.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

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Component View Reference

Powertrain Component Views

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL-38522-A Variable Signal Generator

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** and/or **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 (LGW)** for further diagnosis.

   - **If none of the DTCs are set**
3. If you were sent here from DTC P0068, P0106, P010B, P0121, P012B, P0236 or P1101, refer to Circuit/System Testing.
4. Verify the scan tool Throttle Body Idle Air Flow Compensation parameter is less than 90%.
   - **90% or greater**

     Refer to **Throttle Body Inspection and Cleaning** .

   - **If less than 90%**
5. Verify the scan tool Throttle Position Sensors 1 and 2 Agree/Disagree parameter displays Agree while manually commanding the throttle from 0-99% and back to 0% with a scan tool.
   - **If Disagree**

     Refer to **DTC P0121-P0123, P0222, P0223, P16A0-P16A2 or P2135 (LGW)**

   - **If Agree**
6. Determine the current vehicle testing altitude.
7. Verify the scan tool Barometric Pressure Sensor Bank 1 and Bank 2 parameters are within the range specified in the **Altitude Versus Barometric Pressure** table.
   - **If either of the parameters is not within the specified range**

     Refer to the corresponding **DTC P2227-P2230 (LGW)** or **DTC P222B-P222E** .

   - **Both parameters are within the specified range**
8. Verify the scan tool parameters listed below are within 3 kPa (0.4 PSI) of each other.
   - Barometric Pressure Sensor Bank 1

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- Barometric Pressure Sensor Bank 2
- Boost Pressure Sensor
- **One or more of the parameters are not within 3 kPa (0.4 PSI) of each other**

  Refer to **DTC P2227-P2230 (LGW)** , **DTC P222B-P222E** or **DTC P0236** , as appropriate.

- **All the parameters are within the specified 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 MAP Sensor parameter and the Boost Pressure Sensor parameter are within 20 kPa (2.9 PSI) of each other, during a WOT acceleration at the time of the 1-2 shift.
    - **The parameters are not within 20 kPa (2.9 PSI) of each other**

      Refer to the corresponding **DTC P0106** or **DTC P0236**

    - **The parameters are within 20 kPa (2.9 psi) of each other**
12. Verify the scan tool g/s parameters for MAF Sensor Bank 1 and Bank 2 change smoothly and gradually as the engine speed is increased and decreased while performing the actions listed below.
    1. Engine idling
    2. Observe MAF Sensor Bank 1 and Bank 2 Graphical Data Display in the scan tool.
    3. Increase the engine speed slowly to 3, 000 RPM and then back to idle.
    - **One or both of the MAF Sensor parameters do not change smoothly and gradually**

      Refer to Circuit/System Testing or **DTC P010B** as appropriate.

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

      Refer to Circuit/System Testing.

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

Circuit/System Testing

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

1. Verify the integrity of the entire air induction system by verifying that none of the conditions listed below exist:
    - Any damaged components
    - Improper operation of turbocharger wastegate actuator or bypass valve
    - Improperly installed components
    - Collapsed, restricted or damaged components
    - Loose clamps, cracks or other damage
    - An air flow restriction
    - Restricted air filter

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- 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
- Contamination of the Multifunction Intake Air sensor element
- **If a condition is found**

  Repair or replace component as appropriate.

- **If no condition is found**

2. Ignition OFF. Disconnect the harness connector at the B75B Mass Airflow/Intake Air Temperature Sensor.
3. Test for less than 5 Ω between the ground circuit terminal B and ground.
   - **If 5 Ω or greater**
   1. Disconnect the sensor chassis ground.
   2. Test for less than 5 Ω in the ground circuit end to end.
      - If 5 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 5 Ω, repair the open/high resistance in the ground connection.
   - **If less than 5 Ω**
4. Ignition ON, verify that a test lamp illuminates between the ignition circuit terminal C and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
   2. Test for less than 2 Ω in the ignition voltage circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**
   1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
   2. Test for infinite resistance between the ignition voltage circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, test all components connected to the ignition circuit, replace as necessary.
   - **If a test lamp illuminates**
5. Ignition ON, test for 4.8 - 5.2 V between the signal circuit terminal A and ground.
   - **If less than 4.8 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the signal circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 Ω in the signal circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If greater than 5.2 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the signal circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If between 4.8-5.2 V**
6. Determine if **EL-38522-A** Variable Signal Generator or equivalent is available.

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- **EL-38522-A, Variable Signal Generator or equivalent is not available**

1. Test or replace the B75B Mass Airflow/Intake Air Temperature Sensor.
2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
3. Verify the DTC does not set.
    - **If the DTC sets**
    - Replace the K20 Engine Control Module.
    - **If 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 listed below:
    - Red lead to the signal circuit terminal A at the harness connector
    - Black leads to ground
    - Battery voltage supply lead to B+
8. Set the **EL-38522-A** Variable Signal Generator to the specifications listed below:
    - Signal switch to 5 V
    - Frequency switch to 5 kHz
    - Duty Cycle switch to 50% (Normal)
9. Engine idling, observe the scan tool MAF Sensor Bank 1 parameter. The scan tool MAF Sensor Bank 1 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 B75B Mass Airflow/Intake Air Temperature Sensor.

Repair Instructions

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

- **Mass Airflow Sensor Replacement (LGW)** - B75B Mass Airflow/Intake Air Temperature Sensor - Bank 1 replacement.
- **Control Module References** for engine control module replacement, programming and setup.

DTC P0102 OR P0103: MASS AIR FLOW (MAF) SENSOR CIRCUIT FREQUENCY (LGX)

Diagnostic 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	Open/High Resistance	Short to Voltage	Signal Performance

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Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0097, P00F4, P0102, P0103, P2199	P0097, P00F4, P0102, P0103, P2199	P0690	P0096, P0101, P0103
Signal	P0102	P0102	P0102*	P0101, P0103*, P1101
Ground	-	P0097, P00F4, P0102, P0103, P2199	-	P0096, P0102
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

MAF Sensor

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running at various operating conditions **Parameter Normal Range:** 1, 500-10, 000 Hz			
Ignition Voltage	0 Hz	0 Hz	-
Signal	0 Hz	0 Hz	0 Hz*
Ground	-	0 Hz	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

Circuit/System Description

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

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

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

The multifunction intake air sensor houses the following:

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

Conditions for Running the DTCs

- The engine speed is greater than 300 RPM.
- The ignition signal is greater than 10 V.
- The DTC runs continuously when the above conditions are met for greater than 1 s.

Conditions for Setting the DTC

P0102

The ECM detects that the MAF Sensor Signal is less than or equal to 400 Hz for greater than 10 s.

P0103

The ECM detects that the MAF Sensor Signal parameter is greater than 14, 500 Hz for greater than 10 s.

Action Taken When the DTC Sets

DTCs P0102 and P0103 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P0102 and P0103 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL-38522-A Variable Signal Generator

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

Circuit/System Verification

1. Engine running.
2. Verify the scan tool MAF Sensor Hz parameter is greater than 0 Hz.
   - **If 0 Hz**

     Refer to Circuit/System Testing.

   - **If greater than 0 Hz**
3. 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. Increase the engine speed slowly to 3, 000 RPM and then back to idle.
   3. Exit from the scan tool data list and review the stored data within the Stored Data function of the scan tool.

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4. Observe the MAF Sensor parameter frame by frame.
   - **The MAF Sensor parameter does not change smoothly and gradually**

     Refer to Circuit/System Testing.

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

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

- **If between 4.8-5.2 V**

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

Component Testing

Testing with EL-38522-A

1. Ignition OFF, connect the leads of the **EL-38522-A** Variable Signal Generator as listed below:

> **NOTE:** **In-correct diagnosis will result if Circuit/System Testing is not completed before performing the following test.**

    - Red lead to the signal circuit terminal 6 at the harness connector
    - Black leads to ground
    - Battery voltage supply lead to B+
2. Set the **EL-38522-A** Variable Signal Generator to the specifications listed below:
    - Signal switch to 5 V
    - Frequency switch to 5 kHz
    - Duty Cycle switch to 50% (Normal)
3. Engine idling.
4. Verify the scan tool MAF Sensor parameter is between 4, 950-5, 050 Hz.
    - **If not between 4, 950-5, 050 Hz.**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If between 4, 950-5, 050 Hz.**
5. 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 (LGX)** for multifunction intake air sensor replacement.
- **Control Module References** for engine control module replacement, programming and setup.

DTC P0102 OR P0103: MASS AIR FLOW (MAF) SENSOR CIRCUIT FREQUENCY (LGW)

Diagnostic 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 Bank 1

DTC P0103

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Mass Air Flow (MAF) Sensor Circuit High Frequency Bank 1

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0036, P0037, P0050, P0051, P0056, P0057, P0097, P00F4, P0102, P010C, P0141, P0161, P1101, P2199	P0096, P0097, P00F4, P0101, P0102, P2199, P222E	P0690	P0096, P0101, P0103, P010B, P010D
Signal	P0102	P0102	P0102*	P0101, P0102, P1101
Ground	-	P0102, P2199	-	P0102
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

MAF Sensor Bank 1

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running at various operating conditions **Parameter Normal Range:** 1, 500-10, 000 Hz			
Ignition Voltage	0 Hz	0 Hz	-
Signal	0 Hz	0 Hz	0 Hz*
Ground	-	0 Hz	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

Circuit Description

NOTE: **The following applies to the intake airflow system performance diagnostic that is used in this turbocharged engine:**

- **The manifold absolute pressure (MAP) estimates are used in the engine air flow estimates. Air flow into the intake system must be the same as the air flow out of the intake system, the Intake Air Flow Rationality Diagnostics (IFRD) calculates air flowing out of the engine based on MAP estimates, volumetric efficiency and RPM.**

The engine control module (ECM) uses the following information to calculate an expected airflow rate:

- The throttle position
- The barometric pressure (BARO) Bank 1 and Bank 2
- The manifold absolute pressure (MAP)
- The intake air temperature (IAT) Sensor 1, 2 and 3
- The turbocharger boost sensor
- The engine RPM

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

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

Conditions for Running the DTCs

- The engine speed is greater than 300 RPM.
- The ignition signal is greater than 10 V.
- The above conditions are met for greater than 1 s.
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

P0102

The ECM detects that the MAF Sensor Signal is less than or equal to 400 Hz (about 0.47 g/s) for greater than 10 s.

P0103

The ECM detects that the MAF Sensor Signal parameter is greater than 14, 500 Hz (about 500 g/s) for greater than 10 s.

Diagnostic Aids

This 5-pin MAF/IAT sensor is in the intake air duct. Only the MAF function of this sensor is used by the ECM.

Action Taken When the DTC Sets

DTCs P0102 and P0103 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P0102 and P0103 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW)

Connector End View Reference

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Electrical Information 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

EL-38522-A Variable Signal Generator

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

Circuit/System Verification

1. Ignition ON.
2. Verify the scan tool g/s parameter for MAF Sensor Bank 1 changes smoothly and gradually as the engine speed is increased and decreased while performing the actions listed below.
    1. Engine idling
    2. Observe MAF Sensor Bank 1 Graphical Data Display in the scan tool.
    3. Increase the engine speed slowly to 3, 000 RPM and then back to idle.
    - **The parameter does not change smoothly and gradually**

      Refer to Circuit/System Testing.

    - **The 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 B75B Mass Airflow/Intake Air Temperature Sensor.
2. Test for less than 2 Ω between the ground circuit terminal B and ground.
    - **If 2 Ω or greater**
    1. Disconnect the sensor chassis ground.
    2. Test for less than 2 Ω in the ground circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, repair the open/high resistance in the ground connection.
    - **If less than 2 Ω**
3. Ignition ON.
4. Verify that a test lamp illuminates between the ignition circuit terminal C and ground.
    - **If the test lamp does not illuminate and the circuit fuse is good**
    1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
    2. Test for less than 2 Ω in the ignition voltage circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.
    - **If the test lamp does not illuminate and the circuit fuse is open**
    1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
    2. Test for infinite resistance between the ignition voltage circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance, test all components connected to the ignition circuit, replace as necessary.
    - **If a test lamp illuminates**

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5. Ignition ON, test for 4.8-5.2 V between the signal circuit terminal A and ground.
    - **If less than 4.8 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If greater than 5.2 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If between 4.8-5.2 V**
6. Determine if **EL-38522-A** Variable Signal Generator or equivalent is available.
    - **EL-38522-A, Variable Signal Generator; or equivalent is not available**
    1. Test or replace the B75B MAF/IAT sensor.
    2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
    3. Verify the DTC does not set.
        - **If the DTC sets**
        - Replace the K20 Engine Control Module.
        - **If 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 listed below:
    - Red lead to the signal circuit terminal A at the harness connector
    - Black leads to ground
    - Battery voltage supply lead to B+
8. Set the **EL-38522-A** Variable Signal Generator to the specifications listed below:
    - Signal switch to 5 V
    - Frequency switch to 5 kHz
    - Duty Cycle switch to 50% (Normal)
9. Engine idling, observe the scan tool MAF Sensor Bank 1 parameter. The scan tool MAF Sensor Bank 1 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 B75B Mass Airflow/Intake Air Temperature Sensor.

Repair Instructions

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

- **Mass Airflow Sensor Replacement (LGW)** - B75B Mass Airflow/Intake Air Temperature Sensor - Bank 1 replacement.
- **Control Module References** for engine control module replacement, programming and setup.

DTC P0106: MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR PERFORMANCE

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Diagnostic 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	P0108, P0641	P0106	P0106, P0108	P0106, P0108, P0641	P00C7, P0106
Signal	P0106, P0107	P0106	P0106, P0108	P0106, P0108*	P00C7, P0106, P1101
Low Reference	-	P0106, P0108	P0106, P0108	-	P00C7 P0106, P0108
*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, transmission in Park or Neutral **Parameter Normal Range:** 20-48 kPa (2.9-7 PSI), varies with altitude			
5 V Reference	0 kPa (0 PSI)	127 kPa (18.4 PSI)	127 kPa (18.4 PSI)
Signal	0 kPa (0 PSI)	127 kPa (18.4 PSI)	127 kPa (18.4 PSI)*
Low Reference	-	0 kPa (0 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, transmission in Park or Neutral **Parameter Normal Range:** 20-48 kPa (2.9-7 PSI), varies with altitude			
5 V Reference	0 kPa (0 PSI)	435 kPa (63.1 PSI)	435 kPa (63.1 PSI)
Signal	0 kPa (0 PSI)	435 kPa (63.1 PSI)	435 kPa (63.1 PSI)*
Low Reference	-	0 kPa (0 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.

Conditions for Running the DTC

- DTC P010C, P010D, P0102, P0103, P0107, P0108, P0112, P0113, P0116, P0117, P0118, P0128, P0237, P0238, P0335 or P0336 is not set.
- The engine speed is between 425-6500 RPM.
- The intake air temperature (IAT) sensor parameter is between -20Â° to +125Â°C (-4Â° to +257Â°F).
- The engine coolant temperature (ECT) sensor parameter is between -7Â° to +150Â°C (19Â° to 302Â°F).
- This DTC runs continuously when the above conditions are met.

Conditions for Setting the DTCs

The difference between the manifold absolute pressure measured by the manifold absolute pressure sensor and a calculated value based on the throttle position exceeds the allowed range.

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 (LGW) **Engine Controls Schematics (LGX)**

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

Special Tools

GE-23738-A Vacuum Pump

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

Circuit/System Verification

1. Ignition ON, verify that DTC P0107, P0108, P0237, P0238, P0641, P0651, P0697, P06A3, P2228, P2229, P222C or P222D 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**

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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 Inspection and 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 (LGX)** and/or **DTC P0121-P0123, P0222, P0223, P16A0-P16A2 or P2135 (LGW)** 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. Engine Idling at normal operating temperature, all accessories Off.
8. Verify the scan tool MAP Sensor parameter is between 26-52 kPa (3.8-7.5 PSI) and changes with accelerator pedal input.
    - **If 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**
9. Observe the scan tool MAF and Engine Speed parameters.
10. Increase the engine speed slowly to 3000 RPM and then back to idle.
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. Increase the engine speed slowly to 3, 000 RPM and then back to idle.
    3. Exit from the scan tool data list and review the stored data within the Stored Data function of the scan tool.
    4. Observe the MAF Sensor parameter frame by frame.
    - **The MAF Sensor parameter does not change smoothly and gradually**

      Refer to **DTC P0101 (LGX)**, **DTC P0101 (LGW)** or **DTC P010B** 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 the DTC sets**

      Refer to Circuit/System Testing.
    - **If the DTC does not set**
14. All OK.

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Circuit/System Testing

1. Inspect 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
   - Proper operation of the Positive Crankcase Ventilation (PCV) 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 5 Ω between the low reference circuit terminal 2 and ground.
   - **If 5 Ω or greater**
   1. Ignition Off, disconnect the X2 harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If less than 5 Ω**
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 X2 harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the 5 V reference circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 Ω in the 5 V reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If greater than 5.2 V**

     NOTE: **If the signal circuit is shorted to a voltage the ECM or the MAP Sensor may be damaged.**

   1. Ignition Off, disconnect the X2 harness connector at the K20 Engine Control Module.
   2. Ignition On, test for less than 1 V between the 5 V reference circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If between 4.8-5.2 V**
5. Verify the scan tool MAP Sensor voltage parameter is greater than 4.7 V.
   - **If 4.7 V or less**
   1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.

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2. Test for infinite resistance between the signal circuit terminal 3 and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance, replace the K20 Engine Control Module.
- **If greater than 4.7 V**

6. Install a 3 A fused jumper wire between the signal circuit terminal 3 and the low reference circuit terminal 2.

NOTE: **If the signal circuit is shorted to a voltage the ECM or the MAP Sensor may be damaged.**

7. Verify the scan tool MAP Sensor voltage parameter is less than 0.2 V.
    - **If 0.2 V or greater**
    1. Ignition OFF, remove the jumper wire, disconnect the X2 harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit terminal 3 and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V
    3. Ignition Off.
    4. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If less than 0.2 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.

Repair Instructions

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

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- Manifold Absolute Pressure Sensor Replacement (LGW) Manifold Absolute Pressure Sensor Replacement (Baro) Manifold Absolute Pressure Sensor Replacement (LGX)
- Control Module References for ECM replacement, programming and setup

DTC P0107 OR P0108: MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR CIRCUIT

Diagnostic Instructions

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

DTC Descriptor

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	P0108, P0641	P0106	P0106, P0108	P0106, P0108, P0641	P00C7, P0106
Signal	P0106, P0107	P0106	P0106, P0108	P0106, P0108*	P00C7, P0106, P1101
Low Reference	-	P0106, P0108	P0106, P0108	-	P00C7 P0106, P0108
*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, transmission in Park or Neutral **Parameter Normal Range:** 20-48 kPa (2.9-7 PSI), varies with altitude			
5 V Reference	0 kPa (0 PSI)	127 kPa (18.4 PSI)	127 kPa (18.4 PSI)
Signal	0 kPa (0 PSI)	127 kPa (18.4 PSI)	127 kPa (18.4 PSI)*
Low Reference	-	0 kPa (0 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, transmission in Park or Neutral **Parameter Normal Range:** 20-48 kPa (2.9-7 PSI), varies with altitude			
5 V Reference	0 kPa (0 PSI)	435 kPa (63.1 PSI)	435 kPa (63.1 PSI)
Signal	0 kPa (0 PSI)	435 kPa (63.1 PSI)	435 kPa (63.1 PSI)*
Low Reference	-	0 kPa (0 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.

Conditions for Running the DTC

- DTC P010C, P010D, P0102, P0103, P0112, P0113, P0116, P0117, P0118, P0128, P0237, P0238, P0335 or P0336 is not set.
- The engine speed is between 425-6500 RPM.
- The intake air temperature (IAT) sensor parameter is between -20Â° to +125Â°C (-4Â° to +257Â°F).
- The engine coolant temperature (ECT) sensor parameter is between -7Â° to +150Â°C (19Â° to 302Â°F).
- This DTC runs continuously when the above conditions are met.

Conditions for Setting the DTCs

P0107

The ECM detects that the MAP sensor signal voltage in less than 0.16 V for greater than 4 s.

P0108

The ECM detects that the MAP sensor signal voltage is greater than 4.5 V for greater than 4 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 (LGW) Engine Controls Schematics (LGX)

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

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GE-23738-A Vacuum Pump

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** and/or **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 (LGW)** and/or **DTC P0641, P0651, P0697 or P06A3 (LGX)** 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.

    - **If the MAP Sensor parameter is within range**
4. Engine Idling at normal operating temperature, all accessories Off.
5. Verify the scan tool MAP Sensor parameter is between 26-52 kPa (3.8-7.5 PSI) and changes with accelerator pedal input.
    - **If not between 26-52 kPa (3.8-7.5 PSI) or does not change**

      Refer to Circuit/System Testing.

    - **If between 26-52 kPa (3.8-7.5 PSI) and changes**
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 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. It may take up to 2 min for all vehicle systems to power down. Disconnect the harness connector at the B74 Manifold Absolute Pressure Sensor.
2. Test for less than 5 Ω between the low reference circuit terminal 2 and ground.
    - **If 5 Ω or greater**
    1. Ignition Off, disconnect the X2 harness connector at the K20 Engine Control Module.
    2. Test for less than 2 Ω in the low reference circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If less than 5 Ω**
3. Ignition On, test for 4.8-5.2 V between the 5 V reference circuit terminal 1 and ground.
    - **If less than 4.8 V**
    1. Ignition Off, disconnect the X2 harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the 5 V reference circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance

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3. Test for less than 2 Ω in the 5 V reference circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.
- **If greater than 5.2 V**

NOTE: **If the signal circuit is shorted to a voltage the ECM or the MAP Sensor may be damaged.**

1. Ignition Off, disconnect the X2 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. Verify the scan tool MAP Sensor voltage parameter is greater than 4.7 V.
    - **If 4.7 V or less**
    1. Ignition Off, disconnect the X2 harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit terminal 3 and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance, replace the K20 Engine Control Module.
    - **If greater than 4.7 V**
5. Install a 3 A fused jumper wire between the signal circuit terminal 3 and the low reference circuit terminal 2.

NOTE: **If the signal circuit is shorted to a voltage the ECM or the MAP Sensor may be damaged.**

6. Verify the scan tool MAP Sensor voltage parameter is less than 0.2 V.
    - **If 0.2 V or greater**
    1. Ignition Off, remove the jumper wire, disconnect the X2 harness connector at the K20 Engine Control Module, ignition On.
    2. Test for less than 1 V between the signal circuit terminal 3 and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V
    3. Ignition Off.
    4. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If less than 0.2 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 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).**

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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.

Repair Instructions

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

- **Manifold Absolute Pressure Sensor Replacement (LGW)** **Manifold Absolute Pressure Sensor Replacement (Baro)** **Manifold Absolute Pressure Sensor Replacement (LGX)**
- **Control Module References** for ECM replacement, programming and setup.

DTC P010B: MASS AIR FLOW (MAF) SENSOR PERFORMANCE BANK 2

Diagnostic Instructions

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

DTC Descriptor

DTC P010B

Mass Air Flow (MAF) Sensor Performance Bank 2

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0036, P0037, P0050, P0051, P0056, P0057, P0097, P00F4, P0102, P010C, P0141, P0161, P1101, P2199	P0097, P00F4, P010C, P2199	P0690	P0096, P010B
Signal	P010C	P010C	P010C*	P010B, P1101
Ground	-	P0097, P00F4, P2199, P222B, or P222C	-	P0096, P010B
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

MAF Sensor Bank 2

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running at various operating conditions **Parameter Normal Range:** 1, 500-10, 000 Hz			
Ignition Voltage	0 Hz	0 Hz	-
Signal	0 Hz	0 Hz	0 Hz*
Ground	-	0 Hz	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

Circuit Description

NOTE: **The following applies to the intake airflow system performance diagnostic that is used in this turbocharged engine:**

- **The manifold absolute pressure (MAP) estimates are used in the engine air flow estimates. Air flow into the intake system must be the same as the air flow out of the intake system, the Intake Air Flow Rationality Diagnostics (IFRD) calculates air flowing out of the engine based on MAP estimates, volumetric efficiency and RPM.**

The engine control module (ECM) uses the following information to calculate an expected airflow rate:

- The throttle position (TP)
- The barometric pressure (BARO) Bank 1 and Bank 2
- The manifold absolute pressure (MAP)
- The intake air temperature (IAT) Sensor 1, 2 and 3
- The turbocharger boost sensor
- The engine RPM

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

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

Conditions for Running the DTCs

- DTCs P00E9, P00EA, P00EB, P00EC, P0101, P0102, P0103, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0128, P0335, P0336, P0237, P0238, P2227, P2228, P2229 or P2230 are not set
- The engine speed is between 425 and 6, 500 RPM.
- The engine coolant temperature (ECT) is between -7 to +150Â°C (+19.4 to +302Â°F).
- The intake air temperature (IAT) sensor 1 is between -20 to +125Â°C (-4 to +257Â°F).
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

The engine control module (ECM) detects that the actual measured airflow from the two MAF, MAP, turbocharger boost and the TP sensors are not within a range of the calculated airflow that are derived from the system of models by greater than a calibrated threshold for greater than 10 s.

Action Taken When the DTC Sets

DTC P010B is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P010B is a Type B DTC.

Diagnostic Aids

- Any condition that can cause the MAF, MAP, turbocharger boost and TP sensors to be shifted in value.
- Any type of contamination on the either of the two MAF sensor heating elements will degrade the proper operation of the sensor(s). Certain types of contaminants act as a heat insulator, which will

impair the response of the sensor to air flow changes. Water or snow can create the opposite effect and cause the signal to increase rapidly.

- Certain aftermarket air filters may cause this DTC to set.
- Certain aftermarket air induction systems may cause this DTC to set.
- Modifications to the air induction system may cause this DTC to set.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) **Engine Controls Schematics (LGX)**

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL-38522-A Variable Signal Generator

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** and/or **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 (LGW)** and/or **DTC P0641, P0651, P0697 or P06A3 (LGX)** for further diagnosis.

   - **If none of the DTCs are set**
3. If you were sent here from DTC P0068, P0106, P010B, P0121, P012B or P1101, refer to Circuit/System Testing.
4. Verify the scan tool Throttle Body Idle Air Flow Compensation parameter is less than 90%.
   - **90% or greater**

     Refer to **Throttle Body Inspection and Cleaning** .

   - **If less than 90%**

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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 (LGX)** and/or **DTC P0121-P0123, P0222, P0223, P16A0-P16A2 or P2135 (LGW)** for further diagnosis.

    - **If Agree**
6. Determine the current vehicle testing altitude.
7. Verify both the scan tool Barometric Pressure Sensor Bank 1 and Bank 2 parameters are within the range specified in the **Altitude Versus Barometric Pressure** table.
    - **Both of the parameters are not within the specified range**

      Refer to the corresponding **DTC P2227-P2230 (LGW)** , **DTC P2227-P2230 (LGX)** or **DTC P222B-P222E** .

    - **Both parameters are within the specified range**
8. Verify the scan tool parameters listed below are within 3 kPa (0.4 PSI) of each other.
    - Barometric Pressure Sensor Bank 1
    - Barometric Pressure Sensor Bank 2
    - Boost Pressure Sensor
    - **One or more of the parameters are not within 3 kPa (0.4 PSI) of each other**

      Refer to **DTC P2227-P2230 (LGW)** , **DTC P2227-P2230 (LGX)** , **DTC P222B-P222E** or **DTC P0236** , as appropriate.

    - **All the parameters are within the specified 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** for further diagnosis.

    - **If between 26-52 kPa (3.8-7.5 PSI) and changes**
11. Verify the scan tool MAP Sensor parameter and the Boost Pressure Sensor parameter are within 20 kPa (2.9 PSI) of each other, during a WOT acceleration at the time of the 1-2 shift.
    - **The parameters are not within 20 kPa (2.9 PSI) of each other**

      Refer to the corresponding **DTC P0106** or **DTC P0236** for further diagnosis.

    - **The parameters are within 20 kPa (2.9 psi) of each other**
12. Verify the scan tool g/s parameters for MAF Sensor Bank 1 and Bank 2 change 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 scan tool g/s parameters for MAF Sensor Bank 1 and Bank 2 frame by frame.
    - **One or both of the MAF Sensor parameters do not change smoothly and gradually**

      Refer to Circuit/System Testing or **DTC P010B** as appropriate.

    - **Both the MAF Sensor parameters change smoothly and gradually**
13. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

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

      Refer to Circuit/System Testing.

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

Circuit/System Testing

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

1. Verify the integrity of the entire air induction system by verifying that none of the conditions listed below exist:
    - Any damaged components
    - Improper operation of turbocharger wastegate actuator or bypass valve; where equipped
    - Improperly installed components
    - Collapsed, restricted or damaged components
    - Loose clamps, cracks or other damage
    - An air flow restriction
    - Restricted air filter
    - Splits, kinks, leaks or improper connections at the vacuum hoses
    - Vacuum leaks at the intake manifold, MAP sensor and throttle body
    - Water intrusion
    - Any snow or ice buildup, in cold climates
    - Contamination of the Multifunction Intake Air sensor element
    - **If a condition is found**

      Repair or replace component as appropriate.

    - **If no condition is found**
2. Ignition OFF, disconnect the harness connector at the B75C Multifunction Intake Air sensor.
3. Test for less than 5 Ω between the ground circuit terminal 7 and ground.
    - **If 5 Ω or greater**
    1. Disconnect the sensor chassis ground.
    2. Test for less than 2 Ω in the ground circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, repair the open/high resistance in the ground connection.
    - **If less than 5 Ω**
4. Ignition ON, verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.
    - **If the test lamp does not illuminate and the circuit fuse is good**
    1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
    2. Test for less than 2 Ω in the ignition voltage circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.
    - **If the test lamp does not illuminate and the circuit fuse is open**
    1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
    2. Test for infinite resistance between the ignition voltage circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for greater than 2 Ω between the ignition voltage circuit terminal 5 and ground.

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- If less than 2 Ω, repair the short to ground on the circuit.
- If greater than 2 Ω, test all the components connected to the circuit and repair or replace as necessary.

- **If a test lamp illuminates**

5. Ignition ON, test for 4.8-5.2 V between the signal circuit terminal 6 and ground.
   - **If less than 4.8 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the signal circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 Ω in the signal circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If greater than 5.2 V**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the signal circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If between 4.8-5.2 V**
6. Determine if **EL-38522-A** Variable Signal Generator or equivalent is available.
   - **EL-38522-A, Variable Signal Generator; or equivalent is not available**
   1. Test or replace the B75C Multifunction Intake Air sensor.
   2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
   3. Verify the DTC does not set.
      - **If the DTC sets**
      - Replace the K20 Engine Control Module.
      - **If 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 listed below:
   - Red lead to the signal circuit terminal 6 at the harness connector
   - Black leads to ground
   - Battery voltage supply lead to B+
8. Set the **EL-38522-A** Variable Signal Generator to the specifications listed below:
   - Signal switch to 5 V
   - Frequency switch to 5 kHz
   - Duty Cycle switch to 50% (Normal)
9. Engine idling, observe the scan tool MAF Sensor Bank 2 parameter. The scan tool MAF Sensor Bank 2 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 repair.

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- Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGW) Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGX)
- Control Module References for engine control module replacement, programming and setup.

DTC P010C OR P010D: MASS AIR FLOW (MAF) SENSOR CIRCUIT FREQUENCY BANK

Diagnostic 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 P010C

Mass Air Flow (MAF) Sensor Circuit Low Frequency Bank 2

DTC P010D

Mass Air Flow (MAF) Sensor Circuit High Frequency Bank 2

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0036, P0037, P0050, P0051, P0056, P0057, P0097, P00F4, P0102, P010C, P0141, P0161, P1101, P2199	P0096, P0097, P00F4, P0101, P0102, P010C, P2199, P222E	P0690	P0096, P0101, P0103, P010B, P010D
Signal	P010C	P010C	P010C*	P010B, P010C, P1101
Ground	-	P0097, P00F4, P2199, P222B or P222C	-	P0096, P010C
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

MAF Sensor Bank 2

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running at various operating conditions **Parameter Normal Range:** 1, 500-10, 000 Hz			
Ignition Voltage	0 Hz	0 Hz	-
Signal	0 Hz	0 Hz	0 Hz*
Ground	-	0 Hz	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

Circuit/System Description

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

The ECM applies 5 V to the MAF sensor on the MAF sensor signal circuit. The sensor uses the voltage to produce a variable frequency signal based on the inlet air flow through the sensor bore. The signal varies with engine load and is displayed by the scan tool as Hertz (Hz) and grams per second (g/s).

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

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

The multifunction intake air sensor houses the following:

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

Conditions for Running the DTCs

- The engine speed is greater than 300 RPM.
- The ignition signal is greater than 10 V.
- The above conditions are met for greater than 1 s.
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

P010C

The ECM detects that the MAF Sensor Signal is less than or equal to 400 Hz (about 0.47 g/s) for greater than 10 s.

P010D

The ECM detects that the MAF Sensor Signal parameter is greater than 14, 500 Hz (about 500 g/s) for greater than 10 s.

Diagnostic Aids

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

Action Taken When the DTC Sets

DTCs P010C and P010D are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P010C and P010D are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

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Component View Reference

Powertrain Component Views

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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

EL-38522-A Variable Signal Generator

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

Circuit/System Verification

1. Ignition ON.
2. Verify the scan tool g/s parameter for MAF Sensor Bank 2 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 scan tool g/s parameter for MAF Sensor Bank 2 frame by frame.
    - **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 5 Ω between the ground circuit terminal 7 and ground.
    - **If 5 Ω or greater**

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1. Disconnect the sensor chassis ground.
2. Test for less than 2 Ω in the ground circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, repair the open/high resistance in the ground connection.

- **If less than 5 Ω**

3. Ignition ON.
4. Verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.

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

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

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

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

- **If a test lamp illuminates**

5. Ignition ON, test for 4.8-5.2 V between the signal circuit terminal 6 and ground.

- **If less than 4.8 V**

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

- **If greater than 5.2 V**

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

- **If between 4.8-5.2 V**

6. Determine if **EL-38522-A** Variable Signal Generator or equivalent is available.

- **EL-38522-A, Variable Signal Generator; or equivalent is not available**

1. Test or replace the B75C Multifunction Intake Air sensor.
2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
3. Verify the DTC does not set.
    - **If the DTC sets**

      Replace the K20 Engine Control Module.

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

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

7. Ignition OFF, connect the leads of the **EL-38522-A** Variable Signal Generator as listed below:
    - Red lead to the signal circuit terminal 6 at the harness connector
    - Black leads to ground
    - Battery voltage supply lead to B+
8. Set the **EL-38522-A** Variable Signal Generator to the specifications listed below:
    - Signal switch to 5 V
    - Frequency switch to 5 kHz
    - Duty Cycle switch to 50% (Normal)
9. Engine idling.
10. Verify the scan tool MAF Sensor Bank 2 parameter is between 4, 950-5, 050 Hz.
    - **If not between 4, 950-5, 050 Hz.**

      Replace the K20 Engine Control Module.

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

Repair Instructions

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

- **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGW)** **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGX)**
- **Control Module References** for engine control module replacement, programming and setup.

DTC P0112, P0113 OR P0114: INTAKE AIR TEMPERATURE (IAT) SENSOR 1 CIRCUIT (LGX)

Diagnostic 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, P0113, P2199	P0113, P2199	P0112*, P2199	P0111*, P2199
Low Reference	-	P0113, P2199, P2227, P2229	P0113*, P0114	P0096, P0111*, P2199
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

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Typical Scan Tool Data

IAT Sensor 1

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running **Parameter Normal Range:** Varies with ambient temperature			
Signal	150Â°C (302Â°F)	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
Low Reference	-	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
*Internal ECM or sensor damage may occur if the circuit is shorted to B+			

Circuit/System Description

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

The multifunction intake air sensor houses the following:

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

IAT Sensor 1 - Temperature, Resistance, Voltage Table

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

Conditions for Running the DTCs

P0112 and P0113

- The engine run time is greater than 0 s.
- The DTCs run continuously when the above conditions are met.

P0114

- The ignition is ON or the engine is running.
- This DTC runs continuously within the enabling conditions.

Conditions for Setting the DTCs

P0112

The ECM detects that the IAT sensor 1 signal is warmer than 149Â°C (300Â°F) for greater than 4 s.

P0113

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

The ECM detects that the IAT sensor 1 signal is colder than -60Â°C (-76Â°F) for greater than 4 s.

P0114

- The ECM detects that the IAT sensor 1 signal has changed greater than 80Â°C (128Â°F) within 1 s.
- The condition exists for a cumulative of 4 s or greater.

Action Taken When the DTCs Set

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- 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 (LGX)

Connector End View Reference

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Component View Reference

Powertrain Component Views

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Engine idling.
2. Verify the scan tool IAT Sensor 1 parameter is between -38 to +149Â°C (-36 to +300Â°F).
    - **If not between -38 to +149Â°C (-36 to +300Â°F)**

      Refer to Circuit/System Testing.

    - **If between -38 to +149Â°C (-36 to +300Â°F)**
3. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
4. Verify the DTC does not set.
    - **If the DTC sets.**

      Refer to Circuit/System Testing.

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

Circuit/System Testing

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1. Ignition OFF and all systems OFF, it may take up to for 2 min for all vehicle systems to power down. Disconnect the harness connector at the B75C Multifunction Intake Air Sensor.
2. Test for less than 5 Ω between the low reference circuit terminal 3 and ground.
    - **If 5 Ω or greater**
    1. Disconnect the harness connector at the K20 Engine Control Module.
    2. Test for less than 2 Ω in the low reference circuit end to end.
        - If 2 Ω or greater, repair the open or high resistance in the circuit.
        - If less than 2 Ω replace the K20 Engine Control Module.
    - **If less than 5 Ω**
3. Ignition ON.
4. Test for 4.8-5.2 V between the intake air temperature sensor 1 signal circuit terminal 1 and ground.
    - **If less than 4.8 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If greater than 5.2 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

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

    2. Test for less than 1 V between the signal circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If between 4.8-5.2 V**
5. Verify the scan tool IAT Sensor 1 parameter is colder than -39Â°C (-38Â°F).
    - **If warmer than -39Â°C (-38Â°F).**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit terminal 1 and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If colder than -39Â°C (-38Â°F).**
6. Ignition OFF, install a 3 A fused jumper wire between the signal circuit terminal 1 and the low reference circuit terminal 3, ignition ON.
7. Verify the scan tool IAT Sensor 1 parameter is warmer than 149Â°C (300Â°F).
    - **If colder than 149Â°C (300Â°F).**
    1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V
    3. Ignition OFF.

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4. Test for less than 2 Ω in the signal circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.
- **If warmer than 149Â°C (300Â°F).**

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

Component Testing

Multifunction Intake Air Sensor

1. Ignition OFF, disconnect the harness connector at the B75C Multifunction Intake Air sensor.
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)** table for Hitachi Sensors. The resistance values should be in range of the table values.

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

- **If not within the table values.**

  Replace the B75C Multifunction Intake Air sensor.

- **If within the table values.**

3. All OK

Repair Instructions

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

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

DTC P0112, P0113 OR P0114: INTAKE AIR TEMPERATURE (IAT) SENSOR 1 CIRCUIT (LGW)

Diagnostic 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

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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, P222B, P222D, P222E	P0113, P0114, P2199, P222B, P222D*	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

IAT Sensor 1

Circuit	Short to Ground	Open or High Resistance	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** Varies with ambient temperature			
Signal	150Â°C (302Â°F)	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
Low Reference	-	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
*Internal ECM or sensor damage may occur if the circuit is shorted to B+			

Circuit/System Description

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

The multifunction intake air sensor houses the following:

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

IAT Sensor 1 - Temperature, Resistance, Voltage Table

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

Conditions for Running the DTCs

P0112 and P0113

- The engine run time is greater than 0 s.
- The DTCs run continuously when the above conditions are met.

P0114

- The ignition is ON or the engine is running.
- This DTC runs continuously within the enabling conditions.

Conditions for Setting the DTCs

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

P0112

The ECM detects that the IAT sensor 1 signal is warmer than 150Â°C (302Â°F) for greater than 5 s.

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P0113

The ECM detects that the IAT sensor 1 signal is colder than -60Â°C (-76Â°F) for greater than 5 s.

P0114

The ECM detects that the IAT sensor 1 signal is intermittent or has abruptly changed for greater than 5 s.

Action Taken When the DTCs Set

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

Conditions for Clearing the DTCs

DTCs P0112, P0113 and P0114 are Type B DTCs.

Diagnostic Aids

- The IAT Sensor 1 and IAT Sensor 2 are integrated with the multifunction intake air sensor.
- 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 (LGW)

Connector End View Reference

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DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL-38522-A Variable Signal Generator

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

Circuit/System Verification

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

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

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

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

3. Ignition ON.

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.**

4. Verify the following scan tool parameters are within 10Â°C (18Â°F) of each other.
   - Start-Up IAT Sensor 1
   - Start-Up IAT Sensor 2
   - Start-Up ECT
   - **If not within 10Â°C (18Â°F)**

     Refer to Circuit/System Testing.

   - **If within 10Â°C (18Â°F)**
5. Engine idling, verify the following scan tool parameters are between -38 to +149Â°C (-36 to +300Â°F).
   - IAT Sensor 1
   - IAT Sensor 2
   - ECT Sensor
   - **If not between -38 to +149Â°C (-36 to +300Â°F)**

     Refer to Circuit/System Testing.

   - **If between -38 to +149Â°C (-36 to +300Â°F)**
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, 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 5 Ω between the low reference circuit terminal 3 and ground.
   - **If 5 Ω or greater**
     1. Ignition OFF, disconnect the harness connector at the K20 engine control module.
     2. Test for less than 2 Ω in the low reference circuit end to end.
        - If 2 Ω or greater, repair the open or high resistance in the circuit.
        - If less than 2 Ω replace the K20 engine control module.
   - **If less than 5 Ω**
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.

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

3. Test for less than 2 Ω in the signal circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 engine control module.

- **If greater than 5.2 V**

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

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

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 -39Â°C (-38Â°F).
    - **If warmer than -39Â°C (-38Â°F).**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit terminal 1 and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If colder than -39Â°C (-38Â°F).**
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 148Â°C (298Â°F).
    - **If colder than 148Â°C (298Â°F).**
    1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V
    3. Ignition OFF.
    4. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If warmer than 148Â°C (298Â°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.
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)** table for Hitachi Sensors. The resistance values should be in range of the table values.

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

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- **If not within the table values.**

  Replace the B75C Multifunction Intake Air sensor.

- **If within the table values.**

3. All OK

Repair Instructions

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

- **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGW)**
- **Control Module References** for engine control module replacement, programming and setup.

DTC P0117, P0118 OR P0119: ENGINE COOLANT TEMPERATURE (ECT) SENSOR CIRCUIT (LGX)

Diagnostic 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 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, P0119	P0118, P0119	P0118*, P0119	P0116, P0128
Low Reference	-	P0118, P0119	-	P0128
*ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

ECT Sensor

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine running at various operating conditions **Parameter Normal Range:** -39 to 149Â°C (-38 to 300Â°F)			
Signal	150Â°C (302Â°F)	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)
Low Reference	-	-40Â°C (-40Â°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

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P0117

- The ignition is ON.

  OR

- The engine is running for greater than 10 s.
- 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 -7Â°C (19Â°F).
- This DTC runs continuously within the enabling conditions.

P0119

- No active DTCs set.
- The ignition is ON.
- This DTC runs continuously within the enabling conditions.

Conditions for Setting the DTC

P0117

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

P0118

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

P0119

The ECM detects that the ECT is intermittent or has abruptly changed for greater than 3 seconds.

Action Taken When the DTC Sets

- DTC P0117, P0118 and P0119 are Type B DTCs.
- 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 and P0119 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

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Component View Reference

Powertrain Component Views

Description and Operation

Cooling System Description and Operation

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information.

Circuit/System Verification

1. Ignition ON.
2. Verify the scan tool ECT Sensor parameter is between -40 and 150Â°C (-40 and 302Â°F) and changes with engine run time.
    - **If not between the specified range or does not change**

      Refer to Circuit/System Testing.

    - **If within the specified range 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 X119 Engine Harness to Coolant Temperature Jumper Harness. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal A or 2 and ground.
    - **If 5 Ω or greater**
    1. Ignition OFF, disconnect the X2 harness connector at the K20 Engine Control Module.
    2. Test for less than 2 Ω in the low reference circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If less than 5 Ω**
3. Ignition ON.
4. Verify the scan tool ECT Sensor parameter is colder than -39Â°C (-38Â°F).
    - **If warmer than -39Â°C (-38Â°F)**
    1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.

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2. Test for infinite resistance between the signal circuit terminal B or 1 and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance, replace the K20 Engine Control Module.
- **If colder than -39Â°C (-38Â°F)**

5. Install a 3 A fused jumper wire between the signal circuit terminal B or 1 and the low reference circuit terminal A or 2.
6. Verify the scan tool ECT sensor parameter is warmer than 149Â°C (300Â°F).
    - **If 149Â°C (300Â°F) or colder**

    1. Ignition OFF, remove the jumper wire, disconnect the 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
    3. Ignition OFF.
    4. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If warmer than 149Â°C (300Â°F)**
7. Test or replace the B34 Engine Coolant Temperature Sensor.

Component Testing

1. Ignition OFF, disconnect the X119 Engine Harness to Coolant Temperature Jumper Harness.
2. Test the ECT sensor by varying the sensor temperature while monitoring the sensor resistance.
3. Verify the readings are within the range specified in **Temperature Versus Resistance - Engine Coolant Temperature Sensor** table.
    - **If not within the specified range**

      Replace the B34 Engine Coolant Temperature Sensor.

    - **If within the specified range**
4. 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**
5. All OK.

Repair Instructions

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

- **Engine Coolant Temperature Sensor Replacement**
- **Control Module References** for ECM replacement, programming and setup.

DTC P0117, P0118 OR P0119: ENGINE COOLANT TEMPERATURE (ECT) SENSOR CIRCUIT (LGW)

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

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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, P0119	P0118, P0119	P0118*, P0119	P0119, P0128
Low Reference	-	P0118, P0119**	*	P0119, P0128
*Internal control module or component damage may occur if the circuit shorts to B+. **Additional DTCs may set.				

Typical Scan Tool Data

ECT Sensor

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine=Idling - At normal operating temperature. **Parameter Normal Range:** 88 to 105Â°C (190 to 221Â°F)			
Signal	150Â°C (302Â°F)	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)
Low Reference	-	-40Â°C (-40Â°F)	-

Circuit/System Description

For an overview of the component/system, refer to **Cooling System Description and Operation**

Circuit	Description
Signal	The control module input circuit has an internal resistance connected to 5 V.
Low Reference	Grounded through the control module.

Component	Description
B34 Engine Coolant Temperature Sensor	The sensor is a 2 wire negative temperature coefficient thermistor. As the temperature of the fluid increases, the resistance of the sensor decreases, varying the voltage on the signal circuit.
K20 Engine Control Module	The control module contains a microprocessor used to process input data to control outputs. The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.

Conditions for Running the DTC

P0117

Ignition=On

Frequency the DTC runs=Continuously-After the running conditions are met

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P0118

- Engine=Running -For greater than 10 s
- IAT Sensor=Warmer than -7Â°C (19Â°F)

Frequency the DTC runs=Continuously-After the running conditions are met

P0119

DTC P0117, P0118 = Not set

Frequency the DTC runs=Continuously-After the running conditions are met

Conditions for Setting the DTC

P0117

Engine Coolant Temperature= Warmer than 149Â°C (300Â°F) - For greater than 5 s

P0118

Engine Coolant Temperature= Colder than -39Â°C (-38Â°F) - For greater than 5 s

P0119

Engine Coolant Temperature= Intermittent - For greater than 3 s

Actions Taken When the DTC Sets

DTCs listed in the DTC Descriptor Category= Type B DTC

- A/C Compressor =Off
- Cooling Fan =On
- Engine Coolant Temperature - Gauge= Inoperative

Conditions for Clearing the DTC

DTCs listed in the DTC Descriptor Category=Type B DTC

Diagnostic Aids

After starting the engine, the ECT sensor parameter value should rise steadily and then stabilize after the thermostat opens.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW)

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

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Control Module References

Circuit/System Verification

1. IgnitionÂ» On / VehicleÂ» In Service Mode
2. Verify the scan tool parameter:ECT Sensor = -39 to 149Â°C (-38 to 300Â°F)
   - **If not between -39 and 149Â°C (-38 and 300Â°F)**

     Refer to Circuit/System Testing
   - **If between -39 and 149Â°C (-38 and 300Â°F)**
3. Verify the scan tool parameter:ECT Sensor =The value should not spike or drop out.

   Perform the action while monitoring the parameter:
   - Wiggle the harness and connector: B34 Engine Coolant Temperature Sensor
   - Wiggle the harness and connector: X2 @ K20 Engine Control Module
   - **If the value spikes or drops out**

     Repair as necessaryÂ» Wiring / Terminal(s) / Electrical Connector(s)
   - **If the value does not spike or drop out**
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.

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

     Refer to Circuit/System Testing
   - **If the DTC is not set**
5. All OK.

Circuit/System Testing

1. Ignition/Vehicle & All vehicle systemsÂ» Off

   NOTE: **It may take up to 2 min for all vehicle systems to power down before an accurate ground or low reference circuit continuity test can be performed.**
2. Disconnect the electrical connector: B34 Engine Coolant Temperature Sensor
3. Test for less than 10 Ω between the test points: Low Reference circuit terminal 2 & Ground
   - **If 10 Ω or greater**
     1. Disconnect the appropriate electrical connector: K20 Engine Control Module
     2. Test for less than 2 Ω between the test points: Low Reference circuit terminal 2 @ Component harness & The other end of the circuit @ Control module harness
        - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
        - If less than 2 ΩÂ» Replace the component: K20 Engine Control Module
   - **If less than 10 Ω**
4. Ignition Â» On / VehicleÂ» In Service Mode
5. Verify the scan tool parameter: ECT Sensor = Colder than -39Â°C (-38Â°F)
   - **If warmer than -39Â°C (-38Â°F)**
     1. Ignition/Vehicle Â» Off
     2. Disconnect the appropriate electrical connector:K20 Engine Control Module

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3. Test for infinite resistance between the test points:Signal circuit terminal 1/A @ Component harness & Ground
    - If less than infinite resistanceÂ» Repair the short to ground on the circuit.
    - If infinite resistanceÂ» Replace the component:K20 Engine Control Module
- **If colder than -39Â°C (-38Â°F)**

6. Connect a 3 A fused jumper wire between the test points:Signal circuit terminal 1/A & Low Reference circuit terminal 2/B
7. Verify the scan tool parameter: ECT Sensor =Warmer than 149Â°C (300Â°F)
    - **If 149Â°C (300Â°F) or colder**
    1. Ignition/VehicleÂ» Off & RemoveÂ» Jumper wire(s)
    2. Disconnect the appropriate electrical connector:K20 Engine Control Module
    3. Ignition Â» On / Vehicle Â» In Service Mode
    4. Test for less than 1 V between the test points: Signal circuit terminal 1/A @ Component harness & Ground
        - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
        - If less than 1 V
    5. Ignition/Vehicle Â» Off
    6. Test for less than 2 Ω between the test points:Signal circuit terminal 1/A @ Component harness & The other end of the circuit @ Control module harness
        - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
        - If less than 2 ΩÂ» Replace the component: K20 Engine Control Module
    - **If warmer than 149Â°C (300Â°F)**
8. Test or replace the component: B34 Engine Coolant Temperature Sensor

Component Testing

1. Ignition/VehicleÂ» Off
2. Disconnect the electrical connector:B34 Engine Coolant Temperature Sensor
3. Test for 42 to 78, 834 Ω between the test points:Signal terminal 1/A & Low Reference terminal 2/B
    - **If not between 42 and 78, 834 Ω**

      Replace the component:B34 Engine Coolant Temperature Sensor

    - **If between 42 and 78, 834 Ω**
4. Verify the value is within the range listed in the table: **Temperature Versus Resistance - Engine Coolant Temperature Sensor**
    - **If not in the specified range**

      Replace the component: B34 Engine Coolant Temperature Sensor

    - **If in the specified range**
5. Test for infinite resistance between the test points: Each terminal of the component & The component's housing
    - **If less than infinite resistance**

      Replace the component:B34 Engine Coolant Temperature Sensor

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

Repair Instructions

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

- **Engine Coolant Temperature Sensor Replacement**

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- For control module replacement, programming and setup, refer to **Control Module References**

DTC P0121-P0123, P0222, P0223, P16A0-P16A2 OR P2135: THROTTLE POSITION SENSOR/SENSOR COMMUNICATION CIRCUIT (LGX)

Diagnostic 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*, P16A1**	P0121*, P16A2, P2135*
Low Reference	-	P0123*, P0223*, P16A1	-	P0121*, P16A2, P2135*
*This DTC set indicates an internal throttle body condition. **A short to voltage causes P16A1 to set. If DTC P16A0, P16A1 and P16A2 set at the same time, an intermittent circuit condition exists.				

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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 -7 to +126Â°C (19-259Â°F).
- The intake air temperature (IAT) is -20 to +125Â°C (-4 to +257Â°F).
- The DTC runs continuously when the above conditions are met.

P0122, P0123, P0222, P0223

- DTC P06A3 is not set.
- The 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 run/crank voltage is greater than 6.41 V.
- The DTCs run continuously once the above conditions are met.

P2135

- DTCs P0122, P0123, P0222, P0223 or P06A3 are not set.
- The run/crank or powertrain relay voltage is greater than 6.41 V and reduced power is not active.

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- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

P0121

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

P0122

The ECM detects the throttle position sensor 1 signal voltage is less than 0.32 V for greater than 1 s.

P0123

The ECM detects the throttle position sensor 1 signal voltage is greater than 4.75 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 4.6 V for greater than 1 s.

P16A0

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

P16A1

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

P16A2

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

P2135

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

Action Taken When the DTC Sets

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

Conditions for Clearing the DTC

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

Diagnostic Aids

- A high resistance condition on the throttle position and throttle actuator control circuits could cause a DTC to set.

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- If the accelerator pedal is pressed to the wide open throttle position, the throttle blade angle or Throttle Position angle is limited to less than 40 percent.

Reference Information

Schematic Reference

Engine Controls Schematics (LGX)

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. If you were sent here from DTC P0068, P0101, P0106 or P1101 refer to Circuit/System Testing.
2. Ignition ON.
3. Verify that DTC P0601-P0606, P06A3 and P16F3 is not set.
   - **If any of the DTCs are set**

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

   - **If none of the DTCs are set**
4. Verify the scan tool Throttle Body Idle Air flow Compensation parameter is less than 90%.
   - **If 90% or greater**

     Refer to **Throttle Body Inspection and Cleaning** .

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

     Test or replace the Q38 Throttle Body Assembly.

   - **If DTC P16A0, P16A1 or P16A2 is set with any of the DTCs**

     Refer to Circuit/System Testing.

   - **If none of the DTCs are set**
6. Verify the 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**

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Test or replace the Q38 Throttle Body Assembly.

- **If Agree is displayed**

7. Verify DTC 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**
8. Determine the current vehicle testing altitude.
9. Verify the scan tool MAP Sensor pressure parameter is within range specified in the **Altitude Versus Barometric Pressure** table.
   - **The MAP Sensor pressure is not in range**

     Refer to **DTC P0106**.

   - **The MAP Sensor pressure is within range**
10. Engine idling.
11. Verify the scan tool MAP Sensor pressure parameter is between 26-52 kPa (3.8-7.5 psi) and changes with accelerator pedal input.
    - **If not 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**
12. Verify the scan tool MAF Sensor g/s parameter changes smoothly and gradually as the engine speed is increased and decreased while performing the actions listed below.
    1. Engine idling
    2. Perform the scan tool snapshot function.
    3. Increase the engine speed slowly to 3, 000 RPM and then back to idle.
    4. Exit from the scan tool snapshot and review the data.
    5. Observe the MAF Sensor parameter frame by frame with a scan tool.
    - **The MAF Sensor parameter does not change smoothly and gradually**

      Refer to **DTC P0101 (LGX)**.

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

      Refer to Circuit/System Testing.

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

Circuit/System Testing

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.

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

2. Test for less than 5 Ω between the low reference circuit terminal 4 and ground.
   - **If 5 Ω or greater**

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

- **If less than 5 Ω**

3. Ignition ON.
4. Test for 4.8-5.2 V between the 5 V reference circuit terminal 5 and ground.

- **If less than 4.8 V**

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

- **If greater than 5.2 V**

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

- **If between 4.8-5.2 V**

5. Test for 4.8-5.2 V between the signal circuit terminal 3 and ground.

- **If less than 4.8 V**

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

- **If greater than 5.2 V**

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

- **If between 4.8-5.2 V**

6. Test or replace the Q38 Throttle Body Assembly.

Repair Instructions

- **Throttle Body Assembly Replacement (LGX)**
- **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.

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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 displayed**

      Test or replace the Q38 Throttle Body Assembly.

    - **If Agree is not 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 P0121-P0123, P0222, P0223, P16A0-P16A2 OR P2135: THROTTLE POSITION SENSOR/SENSOR COMMUNICATION CIRCUIT (LGW)

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

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

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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*
Serial Data	P0122*, P0222*, P16A0	P0122*, P0222*, P16A1	P0123*, P0223*, P16A1**	P0121, P16A2, P2135*
Low Reference	-	P0123*, P0223*, P16A1	-	P0121, P16A2, P2135*
*This DTC sets when there is an internal component issue:Q38 Throttle Body **A short to voltage causes P16A1 to set. If DTC P16A0, P16A1, 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: • Engine=Running • Accessories=Off **Parameter Normal Range:** 3.75 to 4.75 V			
5 V Reference	5.0 V	5.0 V	5.0 V
Serial Data	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: • Engine=Running • Accessories=Off **Parameter Normal Range:** 0.45 to 0.90 V			
5 V Reference	0.0 V	0.0 V	0.0 V
Serial Data	0.0 V	5.0 V	5.0 V
Low Reference	-	0.0 V	-

Circuit/System Description

For an overview of the component/system, refer to **Throttle Actuator Control (TAC) System Description**

Circuit	Description
5 V Reference	Regulated voltage supplied by the control module.
Serial Data	The control module input circuit has an internal resistance connected to 5 V. Digitally encoded information for communication between devices.
Low Reference	Grounded through the control module.

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Component	Description
Q38 Throttle Body	The assembly has several functions: • The throttle valve is actuated by a bidirectional DC motor. A spring pulls the valve to a rest or default position, in which the valve is almost closed. The throttle actuator motor can push against the force of the spring to open or close the valve. The more current flow through the motor, the more the valve moves. • The throttle body contains a contactless inductive position sensor. A fixed transmitter coil excites a movable rotor, which in turn induces a current in a fixed receiver coil. The current varies with the angle of the rotor. Electronics inside the sensor convert the current into digital data which is transmitted via a serial data bus to the ECM.
K20 Engine Control Module	The control module contains a microprocessor used to process input data to control outputs. The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.

Conditions for Running the DTC

P0121

- DTC P00F4, P00F5, P0112, P0113, P0117, P0118 = Passed
- DTC P00F4, P00F5, P00F6, P0101, P0102, P0103, P010B, P010C, P010D, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0236, P0237, P0238, P0335, P0336, P222B, P222C, P222D, P222E, P2227, P2228, P2229, P2230 = Not set
- Engine Speed = 425 to 6, 500 RPM
- Engine Coolant Temperature = 7 to 126Â°C (19 to 259Â°F)
- Intake Air Temperature = 20 to 125Â°C (-4 to 257Â°F)

Frequency the DTC runs=Continuously After the running conditions are met

P0122, P0123, P0222, P0223, P16A0, P16A1, P16A2, P2135

- {P0122, P0123, P0222, P0223, P16A0, P16A1, P16A2} DTC P06A3 = Not set
- {P2135} DTC P0122, P0123, P0222, P0223, P06A3 = Not set
- Ignition=On or Engine=Running
- Ignition Voltage= Greater than 6.41 V
- Reduced Engine Power =Deactivated

Frequency the DTC runs=Continuously After the running conditions are met

Conditions for Setting the DTC

P0121

Throttle Position Sensor 1 =Stuck in range - For greater than 1 s

P0122

Throttle Position Sensor 1 =Less than 0.3 V - For greater than 1 s

P0123

Throttle Position Sensor 1 =Greater than 4.7 V - For greater than 1 s

P0222

Throttle Position Sensor 2 =Less than 0.3 V - For greater than 1 s

P0223

Throttle Position Sensor 2 =Greater than 4.6 V - For greater than 1 s

P16A0

Serial Data circuit=Less than 0.5 V - For greater than 1 s

P16A1

Serial Data circuit=Greater than 4.1 V - For greater than 1 s

P16A2

Serial Data circuit=Message Counter Incorrect /Too Many Pulses /Too Few Pulses

P2135

- Throttle Position Sensor 1, 2 =Not within 7-10% of each other - For greater than 1 s
- Throttle Position Sensor 1, 2 Learned Minimum Greater than 5% - 5 V Reference

Actions Taken When the DTC Sets

DTCs listed in the DTC Descriptor Category= Type A DTC - Exceptions listed below

DTC P0121=Type B DTC

- Reduced Engine Power =Active
- P16 Instrument Cluster =Reduced Engine Power
- Under certain conditions, the control module commands the engine Off.

Conditions for Clearing the DTC

DTCs listed in the DTC Descriptor Category =Type A DTC - Exceptions listed below

DTC P0121=Type B DTC

Diagnostic Aids

- A high resistance condition on the throttle position and throttle actuator control circuits could cause a DTC to set.
- If the accelerator pedal is pressed all the way down, the throttle blade angle and the scan tool Throttle Position angle parameter will only go to an angle less than 40%.
- Under cold start conditions, it might happen briefly that the desired and the actual throttle blade position do not match.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

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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

Circuit/System Verification

NOTE: **If you were sent here from DTC P0068, P0101, P010B, P0106, P0236, P1101Â» Refer to Circuit/System Testing.**

1. IgnitionÂ» On / VehicleÂ» In Service Mode
2. Verify DTC P0601-P0606, P06A3, P16F3 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 parameter:Throttle Body Idle Air Flow Compensation =Less than 90%
   - **If 90% or greater**

     Refer to:Throttle Body Inspection and Cleaning

   - **If less than 90%**
4. Verify DTC P0122, P0123, P0222, P0223, P16A0, P16A1, P16A2, P2135 is not set.
   - **If only DTC P0122, P0123, P0222, P0223, P2135 is set**

     Test or replace the component: Q38 Throttle Body

   - **If DTC P16A0, P16A1, P016A2 and one or more of the DTCs P0122, P0123, P0222, P0223, P2135 is set**

     Refer to Circuit/System Testing

   - **If none of the DTCs are set**
5. Perform the scan tool control function:Throttle Sweep Â»Start

   Verify the scan tool parameter:Throttle Position Sensors 1 and 2 =Agree

   - **If not the specified state**

     Test or replace the component:Q38 Throttle Body

   - **If the specified state**
6. Verify DTC P0122, P0123, P0222, P0223, P16A0, P16A1, P16A2, P2135 is not set.
   - **If any of the DTCs are set**

     Refer to: Circuit/System Testing

   - **If none of the DTCs are set**
7. Verify the scan tool parameter: Barometric Pressure Sensor Bank 1 & Barometric Pressure Sensor Bank 2 =The value should be within the range listed in the table: Altitude Versus Barometric Pressure

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- **If not in the specified range**

  Refer to **DTC P2227-P2230 (LGW)** or **DTC P222B-P222E**

- **If in the specified range**

8. Verify the following parameters are within 3 kPa (0.4 PSI) of each other:
   - Barometric Pressure Sensor Bank 1
   - Barometric Pressure Sensor Bank 2
   - Boost Pressure Sensor
   - **If not in the specified range**

     Refer to:**DTC P0236** , **DTC P2227-P2230 (LGW)** or **DTC P222B-P222E**

   - **If in the specified range**
9. EngineÂ»Running
10. Verify the scan tool parameter: MAP Sensor = 26 to 52 kPa (3.8 to 7.5 PSI) - The value should change with accelerator pedal input.
    - **If not in the specified range or does not change**

      Refer to **DTC P0106**

    - **If in the specified range**
11. Verify the following parameters are within 20 kPa (2.9 PSI) of each other: @1-2 Shift Time - Wide Open Throttle
    - MAP Sensor.
    - Boost Pressure Sensor
    - **If not in the specified range or does not change**

      Refer to **DTC P0106** or **DTC P0236**

    - **If in the specified range and changes**
12. Observe the following scan tool parameter:MAF Sensor & Engine Speed.
13. Increase the engine speed slowly to 3, 000 RPM and then back to idle.
14. Verify the scan tool parameter:MAF Sensor Bank 1 & MAF Sensor Bank 2 =The value should change smoothly and gradually as the engine speed is increased and decreased.
    - **If the value does not change smoothly and gradually**

      Refer to **DTC P0101 (LGW)** or **DTC P010B**

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

    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

1. Ignition/Vehicle & All vehicle systemsÂ» Off

NOTE:

- **Disconnecting the component electrical connector causes additional DTCs to set.**

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- **It may take up to 2 min for all vehicle systems to power down before an accurate ground or low reference circuit continuity test can be performed.**

2. Disconnect the electrical connector: X115 @ Q38 Throttle Body
3. Test for less than 5 Ω between the test points:Low Reference circuit terminal 4 & Ground
    - **If 5 Ω or greater**
    1. Disconnect the electrical connector:K20 Engine Control Module
    2. Test for less than 2 Ω between the test points:Low Reference circuit terminal 4 @ Component harness & The other end of the circuit @ Control module harness
        - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
        - If less than 2 ΩÂ» Replace the component:K20 Engine Control Module
    - **If less than 5 Ω**
4. Ignition Â» On / Vehicle Â» In Service Mode
5. Test for 4.8 to 5.2 V between the test points: 5 V Reference circuit terminal 5 & Ground
    - **If less than 5 V**
    1. Ignition/Vehicle Â» Off
    2. Disconnect the electrical connector:K20 Engine Control Module
    3. Test for infinite resistance between the test points: 5 V Reference circuit terminal 5 @ Component harness & Ground
        - If less than infinite resistanceÂ» Repair the short to ground on the circuit.
        - If infinite resistance
    4. Test for less than 2 Ω between the test points: 5 V Reference circuit terminal 5 @ Component harness & The other end of the circuit @ Control module harness
        - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
        - If less than 2 ΩÂ» Replace the component: K20 Engine Control Module
    - **If greater than 5.2 V**
    1. Ignition/Vehicle Â» Off
    2. Disconnect the electrical connector:K20 Engine Control Module
    3. IgnitionÂ» On / VehicleÂ» In Service Mode
    4. Test for less than 1 V between the test points: 5 V Reference circuit terminal 5 @ Component harness & Ground
        - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
        - If less than 1 VÂ» Replace the component:K20 Engine Control Module
    - **If between 4.8 and 5.2 V**
6. Test for 4.8 to 5.2 V between the test points:Serial Data circuit terminal 3 & Ground
    - **If less than 4.8 V**
    1. Ignition/VehicleÂ» Off
    2. Disconnect the electrical connector:K20 Engine Control Module
    3. Test for infinite resistance between the test points: Serial Data circuit terminal 3 @ Component harness & Ground
        - If less than infinite resistanceÂ» Repair the short to ground on the circuit.
        - If infinite resistance
    4. Test for less than 2 Ω between the test points:Serial Data circuit terminal 3 The other end of the circuit
        - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
        - If less than 2 ΩÂ» Replace the component:K20 Engine Control Module
    - **If greater than 5.2 V**
    1. Ignition/Vehicle Â» Off
    2. Disconnect the electrical connector:K20 Engine Control Module

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3. Ignition Â» On / Vehicle Â» In Service Mode
4. Test for less than 1 V between the test points: Serial Data circuit terminal 3 @ Component harness & Ground
    - If 1 V or greater Â» Repair the short to voltage on the circuit.
    - If less than 1 VÂ» Replace the component: K20 Engine Control Module

- **If between 4.8 and 5.2 V**

7. Test or replace the component: Q38 Throttle Body

Repair Instructions

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

- **Throttle Body Assembly Replacement (LGW)**
- For control module replacement, programming and setup, refer to **Control Module References**

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Back To Article

Engine Controls and Fuel - 3.0L (LGW) or 3.6L (LGX) - Diagnostic Information and Procedures - CT6

DIAGNOSTIC INFORMATION AND PROCEDURES

DTC P0128: ENGINE COOLANT TEMPERATURE (ECT) BELOW THERMOSTAT REGULATING TEMPERATURE (LGW)

Diagnostic 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
Signal	P0117, P0119	P0118, P0119	P0118*, P0119	P0119, P0128
Low Reference	-	P0118, P0119**	*	P0119, P0128
*Internal control module or component damage may occur if the circuit shorts to B+. **Additional DTCs may set.				

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 within a range of -39 to 149Â°C (-38 to 300Â°F)			
Signal	150Â°C (302Â°F)	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)
Low Reference	-	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)

Circuit/System Description

The engine control module (ECM) monitors the temperature of the engine coolant for engine control and enabling criteria for some diagnostics. The ECM estimates the amount of energy generated to calculate a target engine coolant temperature (ECT). If the ECT fails to reach the thermostat regulating temperature, before a predetermined amount of energy is generated engine, the DTC sets.

Conditions for Running the DTC

- DTC P0068, P0071, P0072, P0073, P0074, P0101, P0102, P0103, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0222, P0223, P0502, P0503, P1101, P1516, P2101 or P2135 is not set.
- The start-up ECT is between -40Â° and 66Â°C (-40Â° and 151Â°F).
- The engine OFF time is greater than 30 min.
- The engine run time is between 2 and 24 min.

- The vehicle has traveled greater than 2.4 km (1.5 mi).
- The ethanol in the fuel is less than 87%.
- This DTC runs once per ignition cycle when the above conditions are met.

Conditions for Setting the DTC

- The ECM determines that the ECT has not met its calibrated target of 71Â°C (160Â°F) when the start-up ambient temperature was between 10 and 52Â°C (50 and 126Â°F), for greater than 1 s.

  OR

- The ECM determines that the ECT has not met its calibrated target of 55Â°C (131Â°F) when the start-up ambient temperature was between -7 and 10Â°C (19 and 50Â°F), for greater than 1 s.

Action Taken When the DTC Sets

- DTC P0128 is a Type B DTC.
- The engine coolant temperature gauge defaults to cold.
- The A/C is commanded OFF and inoperative.
- The cooling fans are commanded ON.

Conditions for Clearing the MIL/DTC

DTC P0128 is a Type B DTC.

Diagnostic Aids

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

Reference Information

Schematic Reference

Engine Controls Schematics (LGW)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Description and Operation

Cooling System Description and Operation

Electrical Information Reference

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

DTC Type Reference

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Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON, verify that DTC P0116, P0117, P0118 or P0119 is not set.
   - **If a DTC is set**

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

   - **If a DTC is not set**
2. Verify the cooling system is filled to the correct coolant level. Refer to **Cooling System Draining and Filling (Static without HP9)** , **Cooling System Draining and Filling (GE 47716 without HP9)** and **Loss of Coolant** .
   - **If the coolant level is not correct**

     Repair as necessary

   - **If the coolant level is correct**
3. Engine running for 15 min with the A/C OFF, increase the engine speed to 3, 000 RPM.
4. Verify the scan tool ECT Sensor parameter is greater than 80Â°C (176Â°F).
   - **If less than 80Â°C (176Â°F)**

     Replace the engine coolant thermostat.

   - **If greater than 80Â°C (176Â°F)**
5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

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

Circuit/System Testing

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

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- **If colder than -39Â°C (-38Â°F)**

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

   Refer to **Component Testing**.

Component Testing

1. Ignition OFF, disconnect the harness connector at the B34 Engine Coolant Temperature Sensor.
2. Test the ECT sensor by varying the sensor temperature while monitoring the sensor resistance.
3. Verify the readings are within the range specified in the **Temperature Versus Resistance - Engine Coolant Temperature Sensor** table.
    - **If not within the specified range**

      Replace the B34 Engine Coolant Temperature Sensor.

    - **If within the specified range**
4. 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**
5. Refer to **Thermostat Diagnosis** .

Repair Instructions

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

- **Engine Coolant Temperature Sensor Replacement**
- **Engine Coolant Thermostat Housing Replacement (LGW, LGX)**
- **Control Module References** for engine control module replacement, programming and setup.

DTC P0128: ENGINE COOLANT TEMPERATURE (ECT) BELOW THERMOSTAT REGULATING TEMPERATURE (LGX)

Diagnostic 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

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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: Engine Running at various operating conditions **Parameter Normal Range:** -39 to 149Â°C (-38 to 300Â°F)			
ECT Sensor Signal	150Â°C (302Â°F)	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)
Low Reference	-	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)

Circuit/System Description

The purpose of this diagnostic is to analyze the performance of the thermostat, by using the ECT sensor to determine if the engine coolant will increase at the correct rate and also meet the calibrated target temperatures under various operating conditions. The ECM uses the start-up ECT and the start-up intake air temperature (IAT) to begin the diagnostic calculation. The air flow into the engine is accumulated and vehicle speed, distance and engine run time are also factored in to determine if the ECT does increase normally and reach the calibrated target temperatures.

Conditions for Running the DTC

- DTC P0068, P0071, P0072, P0073, P0074, P0101, P0102, P0103, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0222, P0223, P0502, P0503, P1101, P1516, P2101 or P2135 is not set.
- The start-up ECT is between -40Â° and 66Â°C (-40Â° and 151Â°F).
- The engine OFF time is greater than 30 m.
- The engine run time is between 2 and 24 m.
- The vehicle has traveled greater than 2.4 km (1.5 mi).
- The Ethanol in the fuel is less than 87%.
- This DTC runs once per ignition cycle when the above conditions are met.

Conditions for Setting the DTC

- The ECM determines that the ECT has not met its calibrated target of 71Â°C (160Â°F) when the start-up ambient temperature was between 10 and 52Â°C (50 and 126Â°F), for greater than 1 s.

  OR

- The ECM determines that the ECT has not met its calibrated target of 55Â°C (131Â°F) when the start-up ambient temperature was between -7 and 10Â°C (19 and 50Â°F), for greater than 1 s.

Action Taken When the DTC Sets

- DTC P0128 is a Type B DTC.
- The Engine Coolant Temperature Gauge defaults to cold.
- The A/C is commanded OFF and inoperative.
- The Cooling Fans are commanded ON.

Conditions for Clearing the MIL/DTC

DTC P0128 is a Type B DTC.

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Diagnostic Aids

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

Reference Information

Schematic Reference

Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Cooling System Description and Operation

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON, verify that DTC P0116, P0117, P0118 or P0119 is not set.
   - **If a DTC is set**

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

   - **If a DTC is not set**
2. Verify the cooling system is filled to the correct coolant level. Refer to **Cooling System Draining and Filling (Static without HP9)** , **Cooling System Draining and Filling (GE 47716 without HP9)** and **Loss of Coolant** .
   - **If the coolant level is not correct**

     Repair as necessary

   - **If the coolant level is correct**
3. Engine running for 15 min with the A/C OFF, increase the engine speed to 3, 000 RPM.
4. Verify the scan tool ECT Sensor parameter is greater than 80Â°C (176Â°F).
   - **If less than 80Â°C (176Â°F)**

     Replace the Engine Coolant Thermostat.

   - **If greater than 80Â°C (176Â°F)**

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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 X119 Engine Harness to Coolant Temperature Jumper Harness. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal A or 2 and ground.
    - **If 5 Ω or greater**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for less than 2 Ω in the low reference circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If less than 5 Ω**
3. Ignition ON.
4. Verify the scan tool ECT Sensor parameter is colder than -39Â°C (-38Â°F).
    - **If warmer than -39Â°C (-38Â°F)**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit terminal B or 1 and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance, replace the K20 Engine Control Module.
    - **If colder than -39Â°C (-38Â°F)**
5. Install a 3 A fused jumper wire between the signal circuit terminal B or 1 and the low reference circuit terminal A or 2.
6. Verify the scan tool ECT sensor parameter is warmer than 149Â°C (300Â°F).
    - **If 149Â°C (300Â°F) or colder**
    1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V
    3. Ignition OFF.
    4. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If warmer than 149Â°C (300Â°F)**
7. Test the B34 Engine Coolant Temperature Sensor.

   Refer to **Component Testing**.

Component Testing

1. Ignition OFF, disconnect the X119 Engine Harness to Coolant Temperature Jumper Harness.
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**

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Replace the B34 Engine Coolant Temperature Sensor.

- **If within the specified range**

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

     Replace the B34 Engine Coolant Temperature Sensor.

   - **If infinite resistance**
4. Refer to **Thermostat Diagnosis** .

Repair Instructions

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

- **Engine Coolant Temperature Sensor Replacement**
- **Water Outlet Replacement (LGX)** , for engine coolant thermostat replacement.
- **Control Module References** for engine control module replacement, programming and setup.

DTC P0131, P0132, P0137, P0138, P0151, P0152, P0157 OR P0158: HO2S CIRCUIT LOW VOLTAGE BANK SENSOR (LGX)

Diagnostic 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 Bank 1 Sensor 1

DTC P0132

HO2S Circuit High Voltage Bank 1 Sensor 1

DTC P0137

HO2S Circuit Low Voltage Bank 1 Sensor 2

DTC P0138

HO2S Circuit High Voltage Bank 1 Sensor 2

DTC P0151

HO2S Circuit Low Voltage Bank 2 Sensor 1

DTC P0152

HO2S Circuit High Voltage Bank 2 Sensor 1

DTC P0157

HO2S Circuit Low Voltage Bank 2 Sensor 2

DTC P0158

HO2S Circuit High Voltage Bank 2 Sensor 2

Diagnostic Fault Information

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Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
HO2S High Signal	P0131, P0137, P0151, P0157	P0132, P0138, P0152, P0158	P0132, P0138, P0152, P0158	P0132, P0138, P0152, P0158	P0133, P013A, P013B, P013C, P013D, P013E, P013F, P014A, P014B, P0153, P015A, P015B, P015C, P015D
HO2S Low Signal	P0131, P0137, P0151, P0157	P0132, P0138, P0152, P0158	P0132, P0138, P0152, P0158	P0132, P0138, P0152, P0158	P0133, P013A, P013B, P013C, P013D, P013E, P013F, P014A, P014B, P0153, P015A, P015B, P015C, P015D

Typical Scan Tool Data

HO2S Sensor 1 Voltage, HO2S Sensor 2 Voltage

Circuit	Short to Ground	Open	Short to Voltage
Parameter Normal Range: 200-800 mV			
HO2S High Signal	0.00 V	Approximately 1.9 V	Approximately 1.9 V
HO2S Low Signal	0.00 V	Approximately 1.9 V	Approximately 1.9 V

Circuit/System Description

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

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

Conditions for Running the DTC

P0131, P0137, P0151 or P0157

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0112, P0113, P0116, P0117, P0118, P0120, P0121, P0122, P0123, P0128, P0201, P0202, P0203, P0204, P0205, P0206, P0207, P0208, P0220, P0222, P0223, P0442, P0443, P0446, P0449, P0455, P0496, P1516, P2101, P2119, P2135, P2176 are not set.
- The engine is operating in Closed Loop.
- The Ignition voltage is between 10-32 V.
- The fuel level is greater than 10 percent.
- The throttle position (TP) is between 3-70 percent.
- The DTCs run continuously when the above conditions are met for 2 s.

P0132, P0138, P0152 or P0158

- 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 engine is operating in Closed Loop.
- The Ignition voltage is between 10-32 V.
- The fuel level is greater than 10 percent.
- The throttle position (TP) is between 0-70 percent.
- The DTCs run continuously when the above conditions are met for 3 s.

Conditions for Setting the DTC

P0131, P0137, P0151 or P0157

- The ECM detects that the HO2S voltage is less than 50 mV.
- The DTCs set within 50 s when the above condition is met.

P0132, P0138, P0152 or P0158

- The ECM detects that the HO2S voltage is greater than 1, 050 mV.
- The DTCs set within 50 s when the above condition is met.

Action Taken When the DTC Sets

DTCs P0131, P0132, P0137, P0138, P0151, P0152, P0157 and P0158 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P0131, P0132, P0137, P0138, P0151, P0152, P0157 and P0158 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGX)

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.

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4. Verify the scan tool HO2S Bank 1 or 2 Sensor 1 or 2 parameters are between 50-1, 050 mV.
    - **If not between 50-1, 050 mV**

      Refer to Circuit/System Testing.

    - **If between 50-1, 050 mV**
5. Operate the vehicle within the Conditions for Running 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 1.6-3.0 V between the high signal circuit terminal 4 and ground.
    - **If less than 1.7 V**
    1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the high signal circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 Ω in the high signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If greater than 3.0 V**
    1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module. Ignition On.
    2. Test for less than 1 V between the high signal circuit and ground.

       NOTE: **Sensor may be damaged if shorted to 12 V.**

        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If between 1.7-3.0 V**
3. Verify the scan tool heated oxygen sensor Bank 1 or 2 Sensor 1 or 2 parameter is between 1.7-2.1 V
    - **If less than 1.7 V**
    1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the low signal circuit terminal 3 and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance, replace the K20 Engine Control Module.
    - **If between 1.7-2.1 V**
4. Connect a 3A fused jumper wire between the high signal circuit terminal 4 and the low signal circuit terminal 3.
5. Verify the scan tool HO2S Bank 1 or 2 Sensor 1 or 2 parameter displays 0.0 V.

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.**

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- **If greater than 0.0 V**

1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
2. Test for less than 2 Ω in the low signal circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω
3. Test for less than 1 V between the low signal circuit terminal 3 and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.
    - **If 0.0 V**

6. Verify none of the conditions listed below exist:
    - Water intrusion in the B52 Heated Oxygen Sensor harness connector
    - Low or high fuel system pressure-Refer to **Fuel System Diagnosis** .
    - Fuel that is contaminated-Refer to **Alcohol/Contaminants-in-Fuel Diagnosis** .
    - Fuel saturation of the evaporative emission (EVAP) canister
    - Exhaust leaks
    - Engine vacuum leaks
    - **If any of the conditions exist**

      Repair as necessary.

    - **If none of the conditions exist.**
7. Test or replace the B52 Heated Oxygen Sensor

Repair Instructions

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

- **Heated Oxygen Sensor Replacement - Bank 1 Sensor 1 (LGX)**
- **Heated Oxygen Sensor Replacement - Bank 1 Sensor 2**
- **Heated Oxygen Sensor Replacement - Bank 2 Sensor 1 (LGX)**
- **Heated Oxygen Sensor Replacement - Bank 2 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-P013F, P014A, P014B, P0153, P015A-P015D OR P2270-P2273: HO2S SLOW/DELAYED RESPONSE, HO2S SIGNAL STUCK (LGX)

Diagnostic 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 Bank 1 Sensor 1

DTC P013A

HO2S Slow Response Rich to Lean Bank 1 Sensor 2

DTC P013B

HO2S Slow Response Lean to Rich Bank 1 Sensor 2

DTC P013C

HO2S Slow Response Rich to Lean Bank 2 Sensor 2

DTC P013D

HO2S Slow Response Lean to Rich Bank 2 Sensor 2

DTC P013E

HO2S Delayed Response Rich to Lean Bank 1 Sensor 2

DTC P013F

HO2S Delayed Response Lean to Rich Bank 1 Sensor 2

DTC P014A

HO2S Delayed Response Rich to Lean Bank 2 Sensor 2

DTC P014B

HO2S Delayed Response Lean to Rich Bank 2 Sensor 2

DTC P0153

HO2S Slow Response Bank 2 Sensor 1

DTC P015A

HO2S Delayed Response Rich to Lean Bank 1 Sensor 1

DTC P015B

HO2S Delayed Response Lean to Rich Bank 1 Sensor 1

DTC P015C

HO2S Delayed Response Rich to Lean Bank 2 Sensor 1

DTC P015D

HO2S Delayed Response Lean to Rich Bank 2 Sensor 1

DTC P2270

HO2S Signal Stuck Lean Bank 1 Sensor 2

DTC P2271

HO2S Signal Stuck Rich Bank 1 Sensor 2

DTC P2272

HO2S Signal Stuck Lean Bank 2 Sensor 2

DTC P2273

HO2S Signal Stuck Rich Bank 2 Sensor 2

Diagnostic Fault Information

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

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Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
HO2S High Signal	P0131, P0137, P0151, P0157	P0132, P0134, P0138, P0140, P0152, P0154, P0158, P0160	P0132, P0134, P0138, P0140, P0152, P0154, P0158, P0160	P0133, P013A, P013B, P013C, P013D, P013E, P013F, P014A, P014B, P0153, P015A, P015B, P015C, P015D
HO2S Low Signal	P0131, P0137, P0151, P0157	P0132, P0134, P0138, P0140, P0152, P0154, P0158, P0160	P0132, P0134, P0138, P0140, P0152, P0154, P0158, P0160	P0133, P013A, P013B, P013C, P013D, P013E, P013F, P014A, P014B, P0153, P015A, P015B, P015C, P015D

Typical Scan Tool Data

HO2S Bank 1, 2 Sensor 1, 2

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

Circuit/System Description

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

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

Conditions for Running the DTC

P0133 or P0153

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, 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 engine coolant temperature (ECT) is greater than 54Â°C (129Â°F).
- The intake air temperature (IAT) is warmer than -40Â°C (-40Â°F)
- The Ignition voltage is between 10-32 V.
- The fuel level is greater than 10%.
- The engine run time is greater than 60 s.
- The engine speed is between 1, 000-3, 000 RPM.
- The barometric (BARO) pressure is greater than 70 kPa.
- The mass airflow (MAF) is between 15-43 g/s.
- The fuel system is in Closed Loop.
- The throttle position (TP) is greater than 5%.
- The DTCs run once per drive cycle when the above conditions are met.

P013A P013C, P013E or P014A

- Before the ECM can report DTC P013A or P013C failed, DTCs P013E, P014A, P2270 and P2272 must run and pass.
- Before the ECM can report DTC P013E or P014A failed, DTCs P2270 and P2272 must run and pass.
- DTCs P0030, P0036, P0053, P0054, P0101, P0102, P0103, P0106, P0107, P0108, P0120, P0121, P0122, P0123, P0131, P0132, P0133, P0134, P0135, P0137, P0138, P013A, P013B, P013E, P013F, P0140, P0141, P0171, P0172, P0201, P0202, P0203, P0204, P0220, P0222, P0223, P0300, P0442, P0443, P0446, P0449, P0455, P0496, P1133, P1174, P1516, P2101, P2119, P2135, P2176, P2270, P2271, P2A00 are not set.
- The Ignition voltage is between 10-32 V.
- The learned heater resistance is valid.
- The fuel level is greater than 10%.
- The engine run time is equal to or greater than 5 min.
- The accelerator pedal (APP) is steady.
- The torque converter clutch (TCC) is applied.
- The DTCs run once per ignition cycle, during decel fuel cut-off (DFCO), when the above conditions are met.

P013B P013D, P013F or P014B

- Before the ECM can report DTC P013B or P013D failed, DTCs P013A, P013C, P013E, P013F, P014A, P014B, P2270, P2271, P2272 and P2273 must run and pass.
- Before the ECM can report DTC P013F or P014B failed, DTCs P013A, P013C, P013E, P014A, P2270, P2271, P2272 and P2273 must run and pass.
- DTCs P0030, P0036, P0053, P0054, P0101, P0102, P0103, P0106, P0107, P0108, P0120, P0121, P0122, P0123, P0131, P0132, P0133, P0134, P0135, P0137, P0138, P013A, P013B, P013E, P013F, P0140, P0141, P0171, P0172, P0201, P0202, P0203, P0204, P0220, P0222, P0223, P0300, P0442, P0443, P0446, P0449, P0455, P0496, P1133, P1174, P1516, P2101, P2119, P2135, P2176, P2270, P2271, P2A00 are not set.
- The Ignition voltage is between 10-32 V.
- The learned heater resistance is valid.
- The fuel level is greater than 10%.
- The engine run time is equal to or greater than 5 min.
- The DTCs run once per ignition cycle when the above conditions are met.

P015A, P015B, P015C or P015D

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0112, P0113, P0116, P0117, P0118, P0120, P0121, P0122, P0123, P0128, P0201, P0202, P0203, P0204, P0205, P0206, P0207, P0208, P0220, P0222, P0223, P0442, P0443, P0446, P0449, P0455, P0496, P1516, P2101, P2119, P2135, P2176 are not set.
- The engine coolant temperature (ECT) is warmer than 54Â°C (129Â°F).
- The intake air temperature (IAT) is warmer than -40Â°C (-40Â°F)
- The Ignition voltage is between 10-32 V.
- The fuel level is greater than 10%.
- The engine run time is greater than 60 s.
- The engine speed is between 1, 025-2, 325 RPM.
- The vehicle speed is between 70 km/h (44 mph).
- The mass airflow (MAF) is between 3-12 g/s.
- The fuel system is in Closed Loop.
- The DTCs run once per drive cycle when the above conditions are met.

P2270 or P2272

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- 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 engine speed is between 1, 100-2, 300 RPM.
- The engine airflow is between 3-11 g/s.
- The vehicle speed is between 64 km/h (39.8 mph) and 120 km/h (74 mph).
- The fuel state is in Closed Loop.
- The evaporative emission (EVAP) diagnostics are not in control of purge.
- The heated oxygen sensor heaters are ON for more than 180 s.
- The predicted catalytic converter temperature is between 600-900Â°C (1, 112-1, 652Â°F).
- This DTC runs once per trip when all of the above conditions have been met for 3 s.

P2271 or P2273

- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0112, P0113, P0116, P0117, P0118, P0120, P0121, P0122, P0123, P0128, P013A, P013B, P013E, P013F, P0171, P0172, P0201, P0202, P0203, P0204, P0220, P0222, P0223, P0300, P0411, P0412, P0418, P1174, P1516, P2101, P2119, P2135, P2176, P2270 are not set.
- The system voltage is between 10-32 V.
- The fuel level is greater than 10%.
- The engine speed is 1, 150-2, 300 RPM.
- The engine airflow is between 3-11 g/s.
- The vehicle speed is between 70-120 km/h (44-74 mph).
- The fuel state is in Closed Loop.
- The EVAP is 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 500-980Â°C (1, 112-1, 652Â°F).
- DTCs P013A, P013E and P2270 have run and passed.

  THEN

- DFCO 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, P0153, P015A, P015B, P015C or P015D

- The ECM detects that the HO2S 1 rich-to-lean or lean-to-rich average response time is greater than a calibrated value.
- The DTCs set within 60 s when the above condition is met.

P013A or P013C

The ECM detects that the accumulated mass air flow monitored during rich-to-lean transitions between 450-150 mV is greater than 75 grams.

P013B or P013D

The ECM detects that the accumulated mass air flow monitored during lean-to-rich transitions between 350-650 mV is greater than 75 grams.

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P013E or P014A

The ECM detects that the HO2S voltage has not decreased below 450 mV within a calibrated value of accumulated air flow.

P013F or P014B

The ECM detects that the HO2S voltage has not increased above 350 mV within a calibrated value of accumulated air flow.

P2270 or P2272

The ECM does not detect a HO2S voltage greater than 800 mV before accumulated mass air flow exceeds a calibrated value.

P2271 or P2273

The ECM does not detect an HO2S voltage less than 100 mV before accumulated mass air flow exceeds a calibrated value.

Action Taken When the DTC Sets

- DTCs P0133, P013E, P013F, P014A, P014B, P0153, P2270, P2271, P2272 and P2273 are Type B DTCs.
- DTCs P013A, P013B, P013C, P013D, P015A, P015B, P015C and P015D are Type A DTCs.

Conditions for Clearing the DTC

- DTCs P0133, P013E, P013F, P014A, P014B, P0153, P2270, P2271, P2272 and P2273 are Type B DTCs.
- DTCs P013A, P013B, P013C, P013D, P015A, P015B, P015C and P015D are Type A DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGX)

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**

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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-Refer to **Exhaust Leakage** .
   - Engine vacuum leaks
   - Engine oil consumption-Refer to **Oil Consumption Diagnosis** .
   - Engine coolant consumption-Refer to **Loss of Coolant** .
     - **If any of the conditions exist**

       Repair as necessary.

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

     Test or replace the appropriate B52 Heated Oxygen Sensor.

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

Repair Instructions

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

- **Heated Oxygen Sensor Replacement - Bank 1 Sensor 1 (LGX)**
- **Heated Oxygen Sensor Replacement - Bank 1 Sensor 2**
- **Heated Oxygen Sensor Replacement - Bank 2 Sensor 1 (LGX)**
- **Heated Oxygen Sensor Replacement - Bank 2 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 P0137, P0138, P013A-P013F, P014A, P014B, P0157, P0158 OR P2270-P2273: HO2S SLOW/DELAYED RESPONSE, HO2S SIGNAL STUCK (LGW)

Diagnostic 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 P0137

HO2S Circuit Low Voltage Bank 1 Sensor 2

DTC P0138

HO2S Circuit High Voltage Bank 1 Sensor 2

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DTC P013A

HO2S Slow Response Rich to Lean Bank 1 Sensor 2

DTC P013B

HO2S Slow Response Lean to Rich Bank 1 Sensor 2

DTC P013C

HO2S Slow Response Rich to Lean Bank 2 Sensor 2

DTC P013D

HO2S Slow Response Lean to Rich Bank 2 Sensor 2

DTC P013E

HO2S Delayed Response Rich to Lean Bank 1 Sensor 2

DTC P013F

HO2S Delayed Response Lean to Rich Bank 1 Sensor 2

DTC P014A

HO2S Delayed Response Rich to Lean Bank 2 Sensor 2

DTC P014B

HO2S Delayed Response Lean to Rich Bank 2 Sensor 2

DTC P0157

HO2S Circuit Low Voltage Bank 2 Sensor 2

DTC P0158

HO2S Circuit High Voltage Bank 2 Sensor 2

DTC P2270

HO2S Signal Stuck Lean Bank 1 Sensor 2

DTC P2271

HO2S Signal Stuck Rich Bank 1 Sensor 2

DTC P2272

HO2S Signal Stuck Lean Bank 2 Sensor 2

DTC P2273

HO2S Signal Stuck Rich Bank 2 Sensor 2

Diagnostic Fault Information

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

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Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
High Signal	P0131, P0137, P0151, P0157	P0132, P0134, P0138, P0140, P0152, P0154, P0158, P0160	P0132, P0134, P0138, P0140, P0152, P0154, P0158, P0160	P0133, P013A, P013B, P013C, P013D, P013E, P013F, P014A, P014B, P0153, P015A, P015B, P015C, P015D
Low Signal	P0131, P0137, P0151, P0157	P0132, P0134, P0138, P0140, P0152, P0154, P0158, P0160	P0132, P0134, P0138, P0140, P0152, P0154, P0158, P0160	P0133, P013A, P013B, P013C, P013D, P013E, P013F, P014A, P014B, P0153, P015A, P015B, P015C, P015D

Typical Scan Tool Data

HO2S Bank 1 or 2 Sensor 2

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

P0137 or P0157

- DTC P0068, P0106, P0107, P0108, P0122, P0123, P0201, P0202, P0203, P0204, P0205, P0206, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0442, P0443, P0446, P0449, P0452, P0453, P0455, P0458, P0459, P0496, P0498, P0499, P1248, P1249, P124A, P124B, P124C, P124D, P16A0, P16A1, P16A2, P16F3, P2101, P2135, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E or P216F is not set.
- The fuel system is in Closed Loop.
- Fuel and idle intrusive tests or device control are not active.
- Fuel is less than or equal to 87% ethanol.
- Decel fuel cutoff is not active.
- The DTCs run continuously when the above conditions are met for greater than 5 s.

P0138 or P0158

- DTC P0068, P0101, P0102, P0103, P0106, P0107, P0108, P010B, P010C, P010D, P0122, P0123, P0201, P0202, P0203, P0204, P0205, P0206, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0442, P0455, P0458, P0496, P1248, P1249, P124A,

P124B, P124C, P124D, P16A0, P16A1, P16A2, P16F3, P2101, P2135, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E or P216F is not set.

- The engine is running for at least 30 s.

NOTE: **There may be a 150 s or greater delay prior to the DTC running, under certain engine operating conditions.**

- The system voltage is greater than 10 V.
- The fuel system is not in fuel enrichment mode.
- The DTCs run continuously when the above conditions are met for greater than 3 s.

P013A P013C, P013E or P014A

- Before the ECM can report DTC P013A failed, DTCs P013E, P014A, P2270 and P2272 must run and pass.
- Before the ECM can report DTC P013C failed, DTCs P014A and P2272 must run and pass.
- Before the ECM can report DTC P013E failed, DTC P2270 must run and pass.
- Before the ECM can report DTC P014A failed, DTC P2272 must run and pass.
- DTC P0030, P0031, P0032, P0036, P0037, P0038, P0050, P0051, P0052, P0053, P0054, P0056, P0057, P0058, P0059, P0060, P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0128, P0131, P0132, P0133, P0135, P0137, P0138, P013A, P013B, P013C, P013D, P013E, P013F, P0141, P014A, P014B, P0151, P0152, P0153, P0155, P0157, P0158, P015A, P015B, P015C, P015D, P0161, P0171, P0172, P0174, P0175, P0201, P0202, P0203, P0204, P0205, P0206, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282, P0283, P0300, P0301, P0302, P0303, P0304, P0305, P0306, P1248, P1249, P124A, P124B, P124C, P124D, P16F3, P2101, P2135, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216C, P216E, P216F, P2270, P2271, P2272 or P2273 is not set.
- The Ignition voltage is greater than 10 V.
- The learned heater resistance is valid.
- The engine is operating in decel fuel cutoff.
- The DTCs run once per ignition cycle when the above conditions are met.

P013B P013D, P013F or P014B

- Before the ECM can report DTC P013B, DTCs P013A, P013E, P013F, P2270 and P2271 must run and pass.
- Before the ECM can report DTC P013D failed, DTCs P013C, P014A, P014B, P2272 and P2273 must run and pass.
- Before the ECM can report DTC P013F, DTCs P013A, P013E, P2270 and P2271 must run and pass.
- Before the ECM can report DTC P014B failed, DTCs P013C, P014A, P2272 and P2273 must run and pass.
- DTC P0030, P0031, P0032, P0036, P0037, P0038, P0050, P0051, P0052, P0053, P0054, P0056, P0057, P0058, P0059, P0060, P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0128, P0131, P0132, P0133, P0135, P0137, P0138, P013A, P013B, P013C, P013D, P013E, P013F, P0141, P014A, P014B, P0151, P0152, P0153, P0155, P0157, P0158, P015A, P015B, P015C, P015D, P0161, P0171, P0172, P0174, P0175, P0201, P0202, P0203, P0204, P0205, P0206, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282, P0283, P0300, P0301, P0302, P0303, P0304, P0305, P0306, P1248, P1249, P124A, P124B, P124C, P124D, P16F3, P2101, P2135, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216C, P216E, P216F, P2270, P2271, P2272 or P2273 is not set.
- The Ignition voltage is greater than 10 V.
- The learned heater resistance is valid.
- The engine is operating in fuel enrichment mode.
- The DTCs run once per ignition cycle when the above conditions are met.

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P2270 or P2272

- DTC P0030, P0031, P0032, P0036, P0037, P0038, P0050, P0051, P0052, P0053, P0054, P0056, P0057, P0058, P0059, P0060, P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0128, P0131, P0132, P0133, P0135, P0137, P0138, P013A, P013B, P013C, P013D, P013E, P013F, P0141, P014A, P014B, P0151, P0152, P0153, P0155, P0157, P0158, P015A, P015B, P015C, P015D, P0161, P0171, P0172, P0174, P0175, P0201, P0202, P0203, P0204, P0205, P0206, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282, P0283, P0300, P0301, P0302, P0303, P0304, P0305, P0306, P1248, P1249, P124A, P124B, P124C, P124D, P16F3, P2101, P2135, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216C, P216E, P216F, P2270, P2271, P2272 or P2273 is not set.
- Engine speed is between 1, 150-2, 650 RPM to enable the catalyst diagnostic. Once the engine speed is in range, the engine speed must be between 1, 100-2, 750 RPM to keep the test enabled.
- Accelerator pedal position is less than or equal to 4%.
- Ethanol estimation is not active.
- Evaporative emission (EVAP) purge is not active.
- Post HO2S heaters are ON for greater than 60 s.
- Mass air flow (MAF) is between 3-16 g/s.
- System voltage is greater than 10 V.
- Vehicle speed is between 42-80 km/h (26-50 MPH) to enable the catalyst diagnostic. To keep the test enabled the vehicle speed is between 39-82 km/h (24-51 MPH).
- Catalyst calculated temperature is between 500-880Â°C (932-1, 616Â°F).
- Engine is operating in closed loop.
- Engine is operating in decel fuel cut off (DFCO).
- This DTC runs once per trip when the above conditions are met.

P2271 or P2273

- DTC P0030, P0031, P0032, P0036, P0037, P0038, P0050, P0051, P0052, P0053, P0054, P0056, P0057, P0058, P0059, P0060, P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0128, P0131, P0132, P0133, P0135, P0137, P0138, P013A, P013B, P013C, P013D, P013E, P013F, P0141, P014A, P014B, P0151, P0152, P0153, P0155, P0157, P0158, P015A, P015B, P015C, P015D, P0161, P0171, P0172, P0174, P0175, P0201, P0202, P0203, P0204, P0205, P0206, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282, P0283, P0300, P0301, P0302, P0303, P0304, P0305, P0306, P1248, P1249, P124A, P124B, P124C, P124D, P16F3, P2101, P2135, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216C, P216E, P216F, P2270, P2271, P2272 or P2273 is not set.
- The system voltage is greater than 10 V.
- Before the ECM can report DTC P2271 failed, DTCs P013A, P013E and P2270 must run and pass.
- Before the ECM can report DTC P2273 failed, DTCs P013C, P014A and P2272 must run and pass.
- The engine is operating in decel fuel cutoff.
- No driver initiated accelerator pedal input.
- This DTC runs once per trip when the above conditions are met.

Conditions for Setting the DTC

P0137, P0157

The ECM detects that the HO2S signal is less than 50 mv for greater than 4 s.

P0138 or P0158

The ECM detects that the HO2S signal is greater than 1, 050 mv for greater than 4 s.

P013A or P013C

The ECM detects that the accumulated mass air flow during rich-to-lean transitions exceeds a calibrated threshold.

P013B or P013D

The ECM detects that the accumulated mass air flow during lean-to-rich transitions exceeds a calibrated threshold.

P013E or P014A

The ECM detects an initial delayed response to a change from rich-to-lean such that the heated oxygen sensor voltage has not decreased to 450 mV within a calibrated value of accumulated air flow.

P013F or P014B

The ECM detects an initial delayed response to a change from lean-to-rich such that the heated oxygen sensor voltage has not increased above 350 mV within a calibrated value of accumulated air flow.

P2270 or P2272

The ECM does not detect a HO2S voltage greater than 800 mV before accumulated mass air flow exceeds a calibrated value.

P2271 or P2273

The ECM does not detect an HO2S voltage less than 100 mV before accumulated mass air flow exceeds a calibrated value.

Action Taken When the DTC Sets

- DTCs P0137, P0138, P013E, P013F, P014A, P014B, P0157, P0158, P2270, P2271, P2272 and P2273 are Type B DTCs.
- DTCs P013A, P013B, P013C, P013D are Type A DTCs.

Conditions for Clearing the DTC

- DTCs P0133, P013E, P013F, P014A, P014B, P0153, P2270, P2271, P2272 and P2273 are Type B DTCs.
- DTCs P013A, P013B, P013C, P013D, P015A, P015B, P015C and P015D are Type A DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW)

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

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Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify no HO2S heater DTCs are set.
   - **If a heater DTC is set**

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

   - **If no heater DTCs are set**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
4. Verify none of the DTCs set.
   - **If any of the DTCs set**

     Refer to Circuit/System Testing

   - **If none of the DTCs set**
5. All OK.

Circuit/System Testing

1. Ignition Off and all vehicle systems Off, disconnect the 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 1.5-3.0 V between the high signal circuit terminal 4 and ground.
   - **If less than 1.5 V**
   1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the high signal circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 Ω in the high signal circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If greater than 3.0 V**
   1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module. Ignition On.
   2. Test for less than 1 V between the high signal circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If between 1.5-3.0 V**
3. Verify the scan tool HO2S Heater Bank 1 or 2 Sensor 2 parameter is between 1.5-2.1 V
   - **If less than 1.5 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 1.5-2.1 V**
4. Connect a 3 A fused jumper wire between the high signal circuit terminal 4 and the low signal circuit terminal 3.
5. Verify the scan tool HO2S Bank 1 or 2 Sensor 2 parameter displays 0.0 V.

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.**

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- **If greater than 0.0 V**

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

- **If 0.0 V**

6. Verify none of the conditions listed below exist:
    - 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 - Refer to **Exhaust Leakage** .
    - Engine vacuum leaks
    - Engine oil consumption - Refer to **Oil Consumption Diagnosis** .
    - Engine coolant consumption - Refer to **Loss of Coolant** .
    - **If any of the conditions exist**

      Repair as necessary.

    - **If none of the conditions exist**
7. Test or replace the B52 Heated Oxygen Sensor

Repair Instructions

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

- **Heated Oxygen Sensor Replacement - Bank 1 Sensor 1 (LGW)**
- **Heated Oxygen Sensor Replacement - Bank 1 Sensor 2**
- **Heated Oxygen Sensor Replacement - Bank 2 Sensor 1 (LGW)**
- **Heated Oxygen Sensor Replacement - Bank 2 Sensor 2**
- Perform the scan tool HO2S Heater Learn after replacing an HO2S.
- **Control Module References** for ECM replacement, programming and setup

DTC P0171, P0172, P0174 OR P0175: FUEL TRIM SYSTEM

Diagnostic Instructions

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

DTC Descriptors

DTC P0171

Fuel Trim System Lean Bank 1

DTC P0172

Fuel Trim System Rich Bank 1

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DTC P0174

Fuel Trim System Lean Bank 2

DTC P0175

Fuel Trim System Rich Bank 2

Circuit/System Description

The engine control module (ECM) controls a closed loop air/fuel metering system in order to provide the best possible combination of driveability, fuel economy and emission control. The ECM monitors the heated oxygen sensor (HO2S) signal voltage and adjusts the fuel delivery based on the signal voltage while in Closed Loop. A change made to the fuel delivery changes the long and short term fuel trim values. The short term fuel trim values change rapidly in response to the HO2S signal voltages. These changes fine tune the engine fueling. The long term fuel trim values change in response to trends in the short term fuel trim. The long term fuel trim makes coarse adjustments to fueling in order to re-center and restore control to short term fuel trim. The ideal fuel trim values are around 0%. A positive fuel trim value indicates that the ECM is adding fuel in order to compensate for a lean condition. A negative fuel trim value indicates that the ECM is reducing the amount of fuel in order to compensate for a rich condition.

Conditions for Running the DTC

- DTCs P0030, P0053, P0101-P0103, P0106-P0108, P010B-P010D, P0111- P0114, P0121-P0123, P012B-P012D, P0131-P0135, P015A, P0178, P0179, P0201-P0206, P0222, P0223, P0236-P0238, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0300-P0306, P0403-P0406, P0411, P042E, P0442, P0455, P0458, P0489, P0490, P0496, P0506, P0507, P1133, P1221, P1247-P1249, P124A-P124F, P1426, P1437, P2148, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F, P2227-P2230, P2269 or P2444 are not set.
- The barometric pressure is greater than 70 kPa (10.2 psi).
- The catalyst monitor diagnostic intrusive test, post HO2S diagnostic intrusive test, device control, EGR diagnostic intrusive test and EVAP leak test are not active.
- The engine is in Closed Loop status.
- The engine coolant temperature is between -20 and +150Â°C (-4 and +302Â°F).
- The engine speed is between 400-6, 600 RPM.
- The fuel level is greater than 10%.
- The intake air temperature is between -20 and +150Â°C (-4 and +302Â°F).
- The manifold absolute pressure is between 5-255 kPa (0.725-37 psi).
- The mass air flow is between 1-510 g/s.
- This diagnostic runs continuously when the above conditions have been met.

Conditions for Setting the DTC

- The average long term fuel trim weighted average value is greater or less than a calibrated value.
- The above condition is present for approximately 3 min after the Conditions for Running the DTC have been met.

Action Taken When the DTC Sets

DTCs P0171, P0172, P0174 and P0175 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P0171, P0172, P0174 and P0175 are Type B DTCs.

Diagnostic Aids

- Allow the engine to reach operating temperature. With the engine running, observe the HO2S parameter with a scan tool. The HO2S Bank 1 or 2, Sensor 1 or 2 value should vary from approximately 40 mV to approximately 900 mV and respond to fueling changes.

- With the engine running at operating temperature, the normal Short Term Fuel Trim and Long Term Fuel Trim parameters should be between +10 and -10% with 0% the optimum.
- Any un-metered air into the engine causes this DTC to set. Thoroughly inspect all areas of the engine for vacuum leaks. An un-metered air leak in the induction system or a small vacuum leak may cause the ECM to learn an incorrect Throttle Body Idle Airflow Compensation value over time. The incorrectly learned value may cause various symptoms to occur such as rough or unstable idle speeds and/or engine stall. If this condition is detected and repaired it will be necessary perform the scan tool Idle Learn procedure to ensure any symptoms are corrected
- A MAF sensor condition can cause this DTC without setting a MAF DTC. If there is a MAF sensor condition, the MAF sensor parameters will appear to be within range.
- Verify the air filter is the correct one for this application, the engine oil fill cap is in place and is tight and the engine oil dip stick is fully seated.
- Certain aftermarket air filters may cause a DTC to set.
- Certain aftermarket air induction systems or modifications to the air induction system may cause a DTC to set.
- Certain aftermarket exhaust system components may cause a DTC to set.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) **Engine Controls Schematics (LGX)**

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information.

Circuit/System Verification

1. Ignition ON.
2. Verify no other DTCs are set.
    - **If any other DTCs are set**

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

    - **If no other DTCs are set**
3. Verify DTC P0171, P0172, P0174 or P0175 is not set.
    - **If a DTC is set**

      Refer to Circuit/System Testing.

    - **If no DTC is set**

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4. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed in the Freeze Frame/Failure Records data.
5. Verify DTC P0171, P0172, P0174 or P0175 is not set.
    - **If any of the DTCs set**

      Refer to Circuit/System Testing.

    - **If none of the DTCs set**
6. All OK.

Circuit/System Testing

1. Ignition ON.
2. Verify no other DTCs are set.
    - **If any other DTCs are set**

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

    - **If no other DTCs are set**
3. Verify the MAP sensor pressure parameter is within the range specified for your altitude. Refer to **Altitude Versus Barometric Pressure** .
    - **If not within the specified range**

      Refer to **DTC P0106** .

    - **If within the specified range**
4. Engine running at the operating temperature, EVAP Purge Solenoid Valve Command 0%.

    NOTE: **Fuel vapor introduced into the intake manifold during evaporative emission system purge can temporarily cause fuel trim parameter readings to be outside the normal range.**

5. Verify the appropriate Long Term Fuel Trim Bank 1 or 2 parameter is between -10% and +10%.
    - **If greater than +10%**
    1. Ignition OFF.
    2. Verify the conditions listed below do not exist:
        - Mass air flow sensor signal skewed. If the Short Term Fuel Trim or Long Term Fuel Trim parameters for both banks changes greater than 20% when the MAF sensor is disconnected, refer to **DTC P0101 (LGX)** **DTC P0101 (LGW)** .
        - Verify the EVAP Purge Solenoid Valve is commanded to 0%
        - 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** .
        - Split, kinked or improperly connected vacuum hoses.
        - Insufficient fuel in the tank.
        - Low fuel pressure. Refer to **Fuel System Diagnosis** .
        - Vacuum leaks at the intake manifold, the throttle body and the injector O-rings.
        - Leaks in the air induction system and the air intake ducts, including mechanical sound enhancer, if equipped.
        - Missing air filter element.
        - Cracked evaporative emissions canister.
        - Evaporative pipes obstructed or leaking.
        - Leaks in the crankcase ventilation system. Refer to **Crankcase Ventilation System Inspection/Diagnosis** .
            - If a condition is found, repair as necessary.

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- If no condition is found, test the engine for a mechanical condition. Refer to **Symptoms - Engine Mechanical** .

- **If less than -10%**

1. Ignition OFF.
2. Verify the conditions listed below do not exist:
    - Mass air flow (MAF) sensor signal skewed. If the Short Term Fuel Trim or Long Term Fuel Trim parameters for both banks changes greater than 20% when the MAF sensor is disconnected, refer to **DTC P0101 (LGX)** and/or **DTC P0101 (LGW)** .
    - 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, test the engine for a mechanical condition. Refer to **Symptoms - Engine Mechanical** .
- **If between -10% and +10%**

6. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed in the Freeze Frame/Failure Records data.
7. Verify DTC P0171, P0172, P0174 or P0175 is not set.
    - **If any of the DTCs set**

      Refer to conditions listed above.

    - **If none of the DTCs set**
8. All OK.

Repair Instructions

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

Perform the scan tool Fuel Trim Reset after completing the repair.

DTC P0182, P0183, P0187, P0188, P0191, P0192, P111F, P126E, P126F, P127C, P128A-P128D, P128F, P16E4 OR P16E5: FUEL TEMPERATURE SENSOR (LGX)

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

NOTE: **This procedure may also diagnose malfunctions that are not detected by a DTC.**

DTC P0182

Fuel Temperature Sensor Circuit Low Voltage

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DTC P0183

Fuel Temperature Sensor Circuit High Voltage

DTC P0187

Fuel Rail Temperature Sensor Circuit Low Voltage

DTC P0188

Fuel Rail Temperature Sensor Circuit High Voltage

DTC P0191

Fuel Rail Pressure Sensor Performance

DTC P0192

Fuel Rail Pressure Sensor Circuit Low Voltage

DTC P111F

Fuel Temperature Sensor 1 - Fuel Temperature Sensor 2 Not Plausible

DTC P126E

Fuel Rail Temperature Sensor 1 Performance

DTC P126F

Fuel Rail Temperature Sensor 2 Performance

DTC P127C

Fuel Rail Pressure Sensor 2 Circuit Low Voltage

DTC P128A

Fuel Rail Pressure Sensor 1 Internal Performance

DTC P128B

Fuel Rail Pressure Sensor 2 Internal Performance

DTC P128C

Fuel Rail Temperature Sensor 1 Signal Message Counter Incorrect

DTC P128D

Fuel Rail Temperature Sensor 2 Signal Message Counter Incorrect

DTC P128F

Fuel Rail Pressure Sensors 1 and 2 Signals Message Counter Incorrect

DTC P16E4

Sensor Communication Circuit 3 Low Voltage

DTC P16E5

Sensor Communication Circuit 3 High Voltage

Diagnostic Fault Information

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Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P0182*, P0187*, P0641**	P128C, P128D, P128F, P16E4, P16E5	P0641**, P16E5	P111F, P126E, P126F
Signal	P16E4	P16E5	P16E5	P111F, P126E, P126F
Low Reference	-	P16E5	-	P111F, P126E, P126F
*This DTC sets when there is an internal component issue:B47B Fuel Rail Pressure Sensor **Additional DTCs may set.				

Typical Scan Tool Data

Fuel Rail Pressure Sensor 1 & Fuel Rail Pressure Sensor 2

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine at Idle **Parameter Normal Range:** 3.9 to 4.2 MPa (565 to 609 PSI)			
5 V Reference	655.4 MPa (95058 PSI)	655.4 MPa (95058 PSI)	655.4 MPa (95058 PSI)
Signal	655.4 MPa (95058 PSI)	655.4 MPa (95058 PSI)	655.4 MPa (95058 PSI)
Low Reference	-	655.4 MPa (95058 PSI)	-

Fuel Rail Temperature Sensor 1 & Fuel Rail Temperature Sensor 2

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine at Idle **Parameter Normal Range:** -40 to 115Â°C (-40 to 240Â°F)			
5 V Reference	-40	-40	-40
Signal	-40	-40	-40
Low Reference	-	-40	-

Circuit/System Description

Circuit	Description
5 V Reference	Regulated voltage supplied by the control module.
Signal	Digitally encoded information for communication between devices.
Low Reference	Grounded through the control module.

Component	Description
B47B Fuel Rail Pressure Sensor	The sensor measures fuel rail pressure and fuel rail temperature.
K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.

The control module uses the fuel rail pressure sensor to constantly adjust the high pressure fuel pump's feed rate so that the ideal pressure is permanently maintained in the high pressure section (between the high pressure fuel pump and the injectors) by means of a closed loop control. The fuel rail pressure sensor transmits fuel pressure and temperature information via serial data to the control module K20. The sensor's internal microprocessor allows 4 separate sensor outputs from one 3 wire sensor.

Conditions for Running the DTC

P0182, P0183

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- DTC P126E, P128C, P16E4, P16E5 = Not set
- DTC P126E, P128C = Not pending
- Ignition=On

DTC runs continuously when the above conditions are met.

P0187, P0188

- DTC P126E, P128C, P16E4, P16E5 = Not set
- DTC P126F, P128D= Not pending
- Ignition=On

DTC runs continuously when the above conditions are met.

P0191, P0192

- DTC P126E, P128C, P16E4, P16E5= Not set
- DTC P126F, P128D= Not pending
- Ignition=On

DTC runs continuously when the above conditions are met.

P111F

- DTC P0182, P0183, P0187, P0188, P126E, P126F, P128C, P128D, P16E4, P16E5 = Not set
- DTC P128C, P128D, P16E5 = Not pending
- Ignition = On

DTC runs continuously when the above conditions are met.

P126E, P126F

- DTC P128C, P16E4, P16E5 = Not set
- DTC P128C = Not pending
- Ignition =On

DTC runs continuously when the above conditions are met.

P127C1

- DTC P126E, P128C, P16E4, P16E5 = Not set
- DTC P126E, P128C, P16E4, P16E5 = Not pending
- Ignition = On

DTC runs continuously when the above conditions are met.

P128A, P128B

- DTC P128F, P16E4, P16E5 = Not set
- Ignition On

DTC runs continuously when the above conditions are met.

P128C, P128D, P128F

- DTC P16E4, P16E5 = Not set
- Ignition On

DTC runs continuously when the above conditions are met.

P16E4, P16E5

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- DTC P0641, P0651, P0697, P06A3 = Not set
- Ignition On

DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

P0182

Fuel Rail Temperature Sensor 1 =Less than a predefined threshold - For greater than 4 s

P0183

Fuel Rail Temperature Sensor 1 =Greater than a predefined threshold - For greater than 4 s

P0187

Fuel Rail Temperature Sensor 2 =Less than a predefined threshold - For greater than 4 s

P0188

Fuel Rail Temperature Sensor 2 =Greater than a predefined threshold - For greater than 4 s

P0191

Fuel Rail Pressure Sensor 2 =Greater than a predefined threshold - For greater than 2.6 s

P0192

Fuel Rail Pressure Sensor 2 =Greater than a predefined threshold - For greater than 2.6 s

P111F

The following parameters are not within 10Â°C (50Â°F) of each other:

- Fuel Rail Temperature Sensor 1
- Fuel Rail Temperature Sensor 2

The above condition(s) must occur for greater than 8 s.

P126E

Fuel Rail Temperature Sensor 1=Greater than the maximum threshold - For greater than 4 s

P126F

Fuel Rail Temperature Sensor 2=Greater than the maximum threshold - For greater than 4 s

P127C

Fuel Rail Pressure Sensor 2=Greater than a predefined threshold - For greater than 2.6 s

P128A

Fuel Rail Pressure Sensor 1=Greater than a predefined threshold - For greater than 2.6 s

P128B

Fuel Rail Pressure Sensor 2=Greater than a predefined threshold - For greater than 2.6 s

P128C

Fuel Rail Temperature Sensor 1=Fuel Rail Temperature Sensor 1 Signal Message Counter Incorrect

P128D

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Fuel Rail Temperature Sensor 2=Fuel Rail Temperature Sensor 2 Signal Message Counter Incorrect

P128F

Fuel Rail Pressure Sensors 1 and 2 Signals Message Counter Incorrect - For greater than 2.6 s

P16E4

Fuel Rail Pressure Sensor Signal=Less than a predefined threshold - For greater than 3.25 s

P16E5

Fuel Rail Pressure Sensor Signal=Greater than a predefined threshold - For greater than 3.25 s

Actions Taken When the DTC Sets

- DTC P0191, P0192, P127C, P128A, P128B, P128F, P16E4, P16E5 is a Type A DTC.
- DTCs P0182, P0183, P0187, P0188, P111F, P126E, P126F, P128C, P128D are Type B DTCs.

Conditions for Clearing the DTC

- DTC P0191, P0192, P127C, P128A, P128B, P128F, P16E4, P16E5 is a Type A DTC.
- DTCs P0182, P0183, P0187, P0188, P111F, P126E, P126F, P128C, P128D are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Description and Operation

Fuel System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References

Circuit/System Verification

1. IgnitionÂ» On / VehicleÂ» In Service Mode
2. Verify the scan tool parameter:Fuel Rail Temperature Sensor 1 = -39 to 115Â°C (-39 to 240Â°F)
    - **If not between -39 and 115Â°C (-39 and 240Â°F)**

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Refer to Circuit/System Testing

- **If between -39 and 115Â°C (-39 and 240Â°F)**

3. Verify the scan tool parameter:Fuel Rail Temperature Sensor 1 & Fuel Rail Temperature Sensor 2 =Within 10Â°C (50Â°F) of each other
   - **If not within 10Â°C (50Â°F) of each other**

     Refer to: Circuit/System Testing

   - **If within 10Â°C (50Â°F) of each other**
4. Verify the scan tool parameter:Fuel Rail Temperature Sensor 1 =The value should not spike or drop out.

   Perform the action while monitoring the parameter:

   - Wiggle the harness and connector:B47B Fuel Rail Pressure Sensor
   - Wiggle the harness and connector:K20 Engine Control Module
   - **If the value spikes or drops out**

     Repair as necessaryÂ» Wiring / Terminal(s) / Electrical Connector(s)

   - **If the value does not spike or drop out**
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 is not set**
7. All OK.

Circuit/System Testing

1. Ignition/Vehicle & All vehicle systemsÂ» Off

   NOTE: **It may take up to 2 min for all vehicle systems to power down before an accurate ground or low reference circuit continuity test can be performed.**

2. Disconnect the electrical connector:B47B Fuel Rail Pressure Sensor
3. Test for less than 10 Ω between the test points:Low Reference circuit terminal 1 & Ground
   - **If 10 Ω or greater**
   1. Disconnect the electrical connector: X3 @ K20 Engine Control Module
   2. Test for less than 2 Ω between the test points: Low Reference circuit terminal 1 @ Component harness & Terminal 41 @ Control module harness
      - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
      - If less than 2 ΩÂ» Replace the component:K20 Engine Control Module
   - **If less than 10 Ω**
4. Ignition Â» On / Vehicle Â» In Service Mode
5. Test for 4.8 to 5.2 V between the test points: 5 V Reference circuit terminal 3 & Low Reference circuit terminal 1
   - **If less than 4.8 V**
   1. Ignition/Vehicle Â» Off
   2. Disconnect the electrical connector: X3 @ K20 Engine Control Module
   3. Test for infinite resistance between the test points: 5 V Reference circuit terminal 3 @ Component harness & Ground

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- If less than infinite resistance Â» Repair the short to ground on the circuit.
- If infinite resistance

4. Test for less than 2 Ω between the test points: 5 V Reference circuit terminal 3 @ Component harness & Terminal 40 @ Control module harness
    - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
    - If less than 2 ΩÂ» Replace the component:K20 Engine Control Module

- **If greater than 5.2 V**

1. Ignition/VehicleÂ» Off
2. Disconnect the electrical connector: X3 @ K20 Engine Control Module
3. Ignition Â» On / VehicleÂ» In Service Mode
4. Test for less than 1 V between the test points: 5 V Reference circuit terminal 3 @ Component harness & Ground
    - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
    - If less than 1 VÂ» Replace the component:K20 Engine Control Module

- **If between 4.8 and 5.2 V**

6. Test for 4.8 to 5.2 V between the test points:Signal circuit terminal 2 & Low Reference circuit terminal 1
    - **If less than 4.8 V**

    1. Ignition/VehicleÂ» Off
    2. Disconnect the electrical connector: X3 @ K20 Engine Control Module
    3. Test for infinite resistance between the test points:Signal circuit terminal 2 @ Component harness & Ground
        - If less than infinite resistanceÂ» Repair the short to ground on the circuit.
        - If infinite resistance
    4. Test for less than 2 Ω between the test points:Signal circuit terminal 2 @ Component harness & Terminal 60 @ Control module harness
        - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
        - If less than 2 ΩÂ» Replace the component:K20 Engine Control Module

    - **If greater than 5.2 V**

    1. Ignition/Vehicle Â» Off
    2. Disconnect the electrical connector: X3 @ K20 Engine Control Module
    3. IgnitionÂ» On / VehicleÂ» In Service Mode
    4. Test for less than 1 V between the test points: Signal circuit terminal 2 @ Component harness & Ground
        - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
        - If less than 1 VÂ» Replace the component:K20 Engine Control Module

    - **If between 4.8 and 5.2 V**

7. Test or replace the component: B47B Fuel Rail Pressure Sensor

Component Testing

1. Connect a 3 A fused jumper wire between the test points: 5 V Reference terminal 3 & 5 V
2. Connect a jumper wire between the test points:Low Reference terminal 1 & Ground
3. Test for 2.5 to 4.0 V between the test points:Signal terminal 2 & Low Reference terminal 1
    - **If not between 2.5 and 4.0 V**

      Replace the component:B47B Fuel Rail Pressure Sensor

    - **If between 2.5 and 4.0 V**
4. All OK.

Repair Instructions

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

- **Fuel Pressure Sensor Replacement - Fuel Injection Fuel Rail** - B47B Fuel Rail Pressure Sensor
- For control module replacement, programming and setup, refer to **Control Module References**

DTC P0182, P0183, P0187, P0188, P0191, P0192, P111F, P126E, P126F, P127C, P128A-P128D, P128F, P16E4 OR P16E5: FUEL TEMPERATURE SENSOR (LGW)

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

NOTE: **This procedure may also diagnose malfunctions that are not detected by a DTC.**

DTC P0182

Fuel Temperature Sensor Circuit Low Voltage

DTC P0183

Fuel Temperature Sensor Circuit High Voltage

DTC P0187

Fuel Rail Temperature Sensor Circuit Low Voltage

DTC P0188

Fuel Rail Temperature Sensor Circuit High Voltage

DTC P0191

Fuel Rail Pressure Sensor Performance

DTC P0192

Fuel Rail Pressure Sensor Circuit Low Voltage

DTC P111F

Fuel Temperature Sensor 1 - Fuel Temperature Sensor 2 Not Plausible

DTC P126E

Fuel Rail Temperature Sensor 1 Performance

DTC P126F

Fuel Rail Temperature Sensor 2 Performance

DTC P127C

Fuel Rail Pressure Sensor 2 Circuit Low Voltage

DTC P128A

Fuel Rail Pressure Sensor 1 Internal Performance

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DTC P128B

Fuel Rail Pressure Sensor 2 Internal Performance

DTC P128C

Fuel Rail Temperature Sensor 1 Signal Message Counter Incorrect

DTC P128D

Fuel Rail Temperature Sensor 2 Signal Message Counter Incorrect

DTC P128F

Fuel Rail Pressure Sensors 1 and 2 Signals Message Counter Incorrect

DTC P16E4

Sensor Communication Circuit 3 Low Voltage

DTC P16E5

Sensor Communication Circuit 3 High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P0182*, P0187*, P0641**	P128C, P128D, P128F, P16E4, P16E5	P0641**, P16E5	P111F, P126E, P126F
Signal	P16E4	P16E5	P16E5	P111F, P126E, P126F
Low Reference	-	P16E5	-	P111F, P126E, P126F
*This DTC sets when there is an internal component issue:B47B Fuel Rail Pressure Sensor **Additional DTCs may set.				

Typical Scan Tool Data

Fuel Rail Pressure Sensor 1 & Fuel Rail Pressure Sensor 2

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine at Idle **Parameter Normal Range:** 3.9 to 4.2 MPa (565 to 609 PSI)			
5 V Reference	655.4 MPa (95058 PSI)	655.4 MPa (95058 PSI)	655.4 MPa (95058 PSI)
Signal	655.4 MPa (95058 PSI)	655.4 MPa (95058 PSI)	655.4 MPa (95058 PSI)
Low Reference	-	655.4 MPa (95058 PSI)	-

Fuel Rail Temperature Sensor 1 & Fuel Rail Temperature Sensor 2

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine at Idle **Parameter Normal Range:** -40 to 115Â°C (-40 to 240Â°F)			
5 V Reference	-40	-40	-40
Signal	-40	-40	-40
Low Reference	-	-40	-

Circuit/System Description

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Circuit	Description
5 V Reference	Regulated voltage supplied by the control module.
Signal	Digitally encoded information for communication between devices.
Low Reference	Grounded through the control module.

Component	Description
B47B Fuel Rail Pressure Sensor	The sensor measures fuel rail pressure and fuel rail temperature.
K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.

The control module uses the fuel rail pressure sensor to constantly adjust the high pressure fuel pump's feed rate so that the ideal pressure is permanently maintained in the high pressure section (between the high pressure fuel pump and the injectors) by means of a closed loop control. The fuel rail pressure sensor transmits fuel pressure and temperature information via serial data to the control module K20. The sensor's internal microprocessor allows 4 separate sensor outputs from one 3 wire sensor.

Conditions for Running the DTC

P0182, P0183

- DTC P126E, P128C, P16E4, P16E5 = Not set
- DTC P126E, P128C= Not pending
- Ignition=On

DTC runs continuously when the above conditions are met.

P0187, P0188

- DTC P126E, P128C, P16E4, P16E5 = Not set
- DTC P126F, P128D=Not pending
- Ignition=On

DTC runs continuously when the above conditions are met.

P0191, P0192

- DTC P126E, P128C, P16E4, P16E5 = Not set
- DTC P126F, P128D=Not pending
- Ignition=On

DTC runs continuously when the above conditions are met.

P111F

- DTC P0182, P0183, P0187, P0188, P126E, P126F, P128C, P128D, P16E4, P16E5 = Not set
- DTC P128C, P128D, P16E5=Not pending
- Ignition=On

DTC runs continuously when the above conditions are met.

P126E, P126F

- DTC P128C, P16E4, P16E5 = Not set
- DTC P128C=Not pending
- Ignition=On

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DTC runs continuously when the above conditions are met.

P127C

- DTC P126E, P128C, P16E4, P16E5 = Not set
- DTC P126F, P128D=Not pending
- Ignition=On

DTC runs continuously when the above conditions are met.

P128A, P128B

- DTC P128F, P16E4, P16E5 = Not set
- Ignition On

DTC runs continuously when the above conditions are met.

P128C, P128D, P128F

- DTC P16E4, P16E5 = Not set
- Ignition On

DTC runs continuously when the above conditions are met.

P16E4, P16E5

- DTC P0641, P0651, P0697, P06A3 = Not set
- Ignition On

DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

P0182

Fuel Rail Temperature Sensor 1=Less than a predefined threshold - For greater than 4 s

P0183

Fuel Rail Temperature Sensor 1=Greater than a predefined threshold - For greater than 4 s

P0187

Fuel Rail Temperature Sensor 2=Less than a predefined threshold - For greater than 4 s

P0188

Fuel Rail Temperature Sensor 2=Greater than a predefined threshold - For greater than 4 s

P0191

Fuel Rail Pressure Sensor 2=Greater than a predefined threshold - For greater than 2.6 s

P0192

Fuel Rail Pressure Sensor 2=Greater than a predefined threshold - For greater than 2.6 s

P111F

The following parameters are not within 10Â°C (50Â°F) of each other:

- Fuel Rail Temperature Sensor 1
- Fuel Rail Temperature Sensor 2

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The above condition(s) must occur for greater than 8 s.

P126E

Fuel Rail Temperature Sensor 1 =Greater than the maximum threshold - For greater than 4 s

P126F

Fuel Rail Temperature Sensor 2 =Greater than the maximum threshold - For greater than 4 s

P127C

Fuel Rail Pressure Sensor 2 =Greater than a predefined threshold - For greater than 2.6 s

P128A

Fuel Rail Pressure Sensor 1 =Greater than a predefined threshold - For greater than 2.6 s

P128B

Fuel Rail Pressure Sensor 2 =Greater than a predefined threshold - For greater than 2.6 s

P128C

Fuel Rail Temperature Sensor 1 =Fuel Rail Temperature Sensor 1 Signal Message Counter Incorrect

P128D

Fuel Rail Temperature Sensor 2 =Fuel Rail Temperature Sensor 2 Signal Message Counter Incorrect

P128F

Fuel Rail Pressure Sensors 1 and 2 Signals Message Counter Incorrect - For greater than 2.6 s

P16E4

Fuel Rail Pressure Sensor Signal=Less than a predefined threshold - For greater than 3.25 s

P16E5

Fuel Rail Pressure Sensor Signal=Greater than a predefined threshold - For greater than 3.25 s

Actions Taken When the DTC Sets

- DTC P0191, P0192, P127C, P128A, P128B, P128F, P16E4, P16E5 is a Type A DTC.
- DTCs P0182, P0183, P0187, P0188, P111F, P126E, P126F, P128C, P128D are Type B DTCs.

Conditions for Clearing the DTC

- DTC P0191, P0192, P127C, P128A, P128B, P128F, P16E4, P16E5 is a Type A DTC.
- DTCs P0182, P0183, P0187, P0188, P111F, P126E, P126F, P128C, P128D are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW)

Connector End View Reference

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Component 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

Circuit/System Verification

1. IgnitionÂ» On / VehicleÂ» In Service Mode
2. Verify the scan tool parameter:Fuel Rail Temperature Sensor 1 = -39 to 115Â°C (-39 to 240Â°F)
   - **If not between -39 and 115Â°C (-39 and 240Â°F)**

     Refer to Circuit/System Testing

   - **If between -39 and 115Â°C (-39 and 240Â°F)**
3. Verify the scan tool parameter:Fuel Rail Temperature Sensor 1 & Fuel Rail Temperature Sensor 2 =Within 10Â°C (50Â°F) of each other
   - **If not within 10Â°C (50Â°F) of each other**

     Refer to: Circuit/System Testing

   - **If within 10Â°C (50Â°F) of each other**
4. Verify the scan tool parameter:Fuel Rail Temperature Sensor 1 =The value should not spike or drop out.

   Perform the action while monitoring the parameter:

   - Wiggle the harness and connector: B47B Fuel Rail Pressure Sensor
   - Wiggle the harness and connector: K20 Engine Control Module
   - **If the value spikes or drops out**

     Repair as necessaryÂ» Wiring / Terminal(s) / Electrical Connector(s)

   - **If the value does not spike or drop out**
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 is not set**
7. All OK.

Circuit/System Testing

1. Ignition/Vehicle & All vehicle systemsÂ» Off

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NOTE: **It may take up to 2 min for all vehicle systems to power down before an accurate ground or low reference circuit continuity test can be performed.**

2. Disconnect the electrical connector:B47B Fuel Rail Pressure Sensor
3. Test for less than 10 Ω between the test points: Low Reference circuit terminal 1 & Ground
    - **If 10 Ω or greater**
    1. Disconnect the electrical connector: X4 @ K20 Engine Control Module
    2. Test for less than 2 Ω between the test points:Low Reference circuit terminal 1 @ Component harness & Terminal 41 @ Control module harness
        - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
        - If less than 2 ΩÂ» Replace the component:K20 Engine Control Module
    - **If less than 10 Ω**
4. Ignition Â» On / Vehicle Â» In Service Mode
5. Test for 4.8 to 5.2 V between the test points: 5 V Reference circuit terminal 3 & Low Reference circuit terminal 1
    - **If less than 4.8 V**
    1. Ignition/VehicleÂ» Off
    2. Disconnect the electrical connector: X4 @ K20 Engine Control Module
    3. Test for infinite resistance between the test points: 5 V Reference circuit terminal 3 @ Component harness & Ground
        - If less than infinite resistanceÂ» Repair the short to ground on the circuit.
        - If infinite resistance
    4. Test for less than 2 Ω between the test points: 5 V Reference circuit terminal 3 @ Component harness & Terminal 40 @ Control module harness
        - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
        - If less than 2 ΩÂ» Replace the component:K20 Engine Control Module
    - **If greater than 5.2 V**
    1. Ignition/VehicleÂ» Off
    2. Disconnect the electrical connector: X4 @ K20 Engine Control Module
    3. IgnitionÂ» On / VehicleÂ» In Service Mode
    4. Test for less than 1 V between the test points: 5 V Reference circuit terminal 3 @ Component harness & Ground
        - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
        - If less than 1 VÂ» Replace the component:K20 Engine Control Module
    - **If between 4.8 and 5.2 V**
6. Test for 4.8 to 5.2 V between the test points: Signal circuit terminal 2 & Low Reference circuit terminal 1
    - **If less than 4.8 V**
    1. Ignition/Vehicle Â» Off
    2. Disconnect the electrical connector: X4 @ K20 Engine Control Module
    3. Test for infinite resistance between the test points:Signal circuit terminal 2 @ Component harness & Ground
        - If less than infinite resistanceÂ» Repair the short to ground on the circuit.
        - If infinite resistance
    4. Test for less than 2 Ω between the test points: Signal circuit terminal 2 @ Component harness & Terminal 60 @ Control module harness
        - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
        - If less than 2 ΩÂ» Replace the component:K20 Engine Control Module
    - **If greater than 5.2 V**
    1. Ignition/VehicleÂ» Off

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2. Disconnect the electrical connector: X4 @ K20 Engine Control Module
3. IgnitionÂ» On / VehicleÂ» In Service Mode
4. Test for less than 1 V between the test points:Signal circuit terminal 2 @ Component harness & Ground
    - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
    - If less than 1 VÂ» Replace the component:K20 Engine Control Module

- **If between 4.8 and 5.2 V**

7. Test or replace the component:B47B Fuel Rail Pressure Sensor

Component Testing

1. Connect a 3 A fused jumper wire between the test points: 5 V Reference terminal 3 & 5 V
2. Connect a jumper wire between the test points:Low Reference terminal 1 & Ground
3. Test for 2.5 to 4.0 V between the test points:Signal terminal 2 & Low Reference terminal 1
    - **If not between 2.5 and 4.0 V**

      Replace the component:B47B Fuel Rail Pressure Sensor

    - **If between 2.5 and 4.0 V**
4. All OK.

Repair Instructions

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

- **Fuel Pressure Sensor Replacement - Fuel Injection Fuel Rail** - B47B Fuel Rail Pressure Sensor
- For control module replacement, programming and setup, refer to **Control Module References**

DTC P018B-P018D: FUEL PRESSURE SENSOR (LGX)

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

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	P018C	P018D*	P018B
Signal	P018C	P018C	P018D*	P018B
Low Reference	-	P018D	*	P018B
*Internal control module or component damage may occur if the circuit shorts to B+.				

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Typical Scan Tool Data

Fuel Pressure Sensor

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine=Running **Parameter Normal Range:** 2.7 to 3.8 V			
5 V Reference	0 V	0 V	5 V
Signal	0 V	0 V	5 V
Low Reference	-	5 V	-

Circuit/System Description

Circuit	Description
5 V Reference	Regulated voltage supplied by the control module.
Signal	The control module input circuit has an internal resistance connected to ground.
Low Reference	Grounded through the control module.

Component	Description
B47 Fuel Pressure Sensor	The sensor measures the fuel pressure in the fuel line. The signal voltage increases when the pressure increases.
K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.

The control module uses the fuel pressure sensor to constantly adjust the fuel pump's feed rate so that the ideal pressure is permanently maintained in the low pressure section (between the fuel pump and the high pressure fuel pump) by means of a closed loop control.

Conditions for Running the DTC

P018B

- DTC P018C, P018D, P0231, P0232, P023F, P0641, P1255, P0129, P12A6 = Not set
- Engine=Running - For greater than 5 s
- Fuel Pump Enable =On

DTC runs continuously when the above conditions are met.

P018C, P018D

Ignition=On

DTCs run continuously when the above condition is met.

Conditions for Setting the DTC

P018B

Fuel Pressure Sensor =Change is less than 30 kPa (4.4 PSI)

The above condition(s) must occur for greater than 5 s.

P018C

Fuel Pressure Sensor =Less than 0.2 V - For greater than 1 s

P018D

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Fuel Pressure Sensor =Greater than 4.8 V - For greater than 1 s

Actions Taken When the DTC Sets

DTCs P018B, P018C, P018D are Type B DTCs.

Conditions for Clearing the DTC

DTCs P018B, P018C, P018D are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGX)

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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

Circuit/System Verification

1. IgnitionÂ» On / VehicleÂ» In Service Mode
2. Verify DTC P0231, P0232, P023F, P0641, P1255, P0129, P12A6 is not set.
   - **If any of the DTCs are set**

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

   - **If none of the DTCs are set**
3. Engine running.
4. Verify the scan tool parameter:Fuel Pressure Sensor = 2.7 to 3.8 V
   - **If not between 2.7 and 3.8 V**

     Refer to Circuit/System Testing

   - **If between 2.7 and 3.8 V**
5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify the DTC does not set.

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- **If the DTC sets**

  Refer to Circuit/System Testing

- **If the DTC does not set**

7. All OK.

Circuit/System Testing

NOTE: **It may take up to 2 min for all vehicle systems to power down before an accurate ground or low reference circuit continuity test can be performed.**

1. Ignition/Vehicle & All vehicle systems Â» Off
2. Disconnect the electrical connector: B47 Fuel Pressure Sensor
3. Test for less than 10 Ω between the test points: Low Reference circuit terminal 2 & Ground
   - **If 10 Ω or greater**
   1. Disconnect the electrical connector: X1 @ K20 Engine Control Module
   2. Test for less than 2 Ω between the test points: Low Reference circuit terminal 2 @ Component harness & Terminal 44 @ Control module harness
      - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
      - If less than 2 ΩÂ» Replace the component:K20 Engine Control Module
   - **If less than 10 Ω**
4. Ignition Â» On / Vehicle Â» In Service Mode
5. Test for 4.8 to 5.2 V between the test points: 5 V Reference circuit terminal 3 & Low Reference circuit terminal 2
   - **If less than 4.8 V**
   1. Ignition/VehicleÂ» Off
   2. Disconnect the electrical connector: X3 @ K20 Engine Control Module
   3. Test for infinite resistance between the test points: 5 V Reference circuit terminal 3 @ Component harness & Ground
      - If less than infinite resistanceÂ» Repair the short to ground on the circuit.
      - If infinite resistance
   4. Test for less than 2 Ω between the test points: 5 V Reference circuit terminal 3 @ Component harness & Terminal 39 @ Control module harness
      - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
      - If less than 2 ΩÂ» Replace the component: K20 Engine Control Module
   - **If greater than 5.2 V**
   1. Ignition/VehicleÂ» Off

      NOTE: **Internal control module or component damage may occur if the circuit shorts to B+.**

   2. Disconnect the electrical connector: X3 @ K20 Engine Control Module
   3. IgnitionÂ» On / VehicleÂ» In Service Mode
   4. Test for less than 1 V between the test points: 5 V Reference circuit terminal 3 @ Component harness & Ground
      - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
      - If less than 1 VÂ» Replace the component:K20 Engine Control Module
   - **If between 4.8 and 5.2 V**
6. Verify the scan tool parameter:Fuel Pressure Sensor =Less than 0.2 V
   - **If 0.2 V or greater**
   1. Ignition/Vehicle Â» Off

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2. Disconnect the electrical connector: X3 @ K20 Engine Control Module
3. IgnitionÂ» On / VehicleÂ» In Service Mode
4. Test for less than 1 V between the test points:Signal circuit terminal 1 @ Component harness & Ground
    - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
    - If less than 1 VÂ» Replace the component:K20 Engine Control Module

- **If less than 0.2 V**

7. Connect a 3 A fused jumper wire between the test points: Signal circuit terminal 1 & 5 V Reference circuit terminal 3
8. Verify the scan tool parameter: Fuel Pressure Sensor = Greater than 4.8 V
    - **If 4.8 V or less**
    1. Ignition/VehicleÂ» Off & RemoveÂ» Jumper wire(s)
    2. Disconnect the electrical connector: X3 @ K20 Engine Control Module
    3. Test for infinite resistance between the test points: Signal circuit terminal 1 @ Component harness & Ground
        - If less than infinite resistanceÂ» Repair the short to ground on the circuit.
        - If infinite resistance
    4. Test for less than 2 Ω between the test points: Signal circuit terminal 1 @ Component harness & Terminal 59 @ Control module harness
        - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
        - If less than 2 ΩÂ» Replace the component:K20 Engine Control Module
    - **If greater than 4.8 V**
9. Test or replace the component: B47 Fuel Pressure Sensor

Repair Instructions

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

- **Fuel Pressure Sensor Replacement - Fuel Feed Pipe**
- For control module replacement, programming and setup, refer to **Control Module References**

DTC P018B-P018D: FUEL PRESSURE SENSOR (LGW)

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

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

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P018C**	P018C	P018D*	P018B
Signal	P018C	P018C	P018D*	P018B
Low Reference	-	P018D**	*	P018B
*Internal control module or component damage may occur if the circuit shorts to B+. **Additional DTCs may set.				

Typical Scan Tool Data

Fuel Pressure Sensor

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine=Running **Parameter Normal Range:** 2.7 to 3.8 V			
5 V Reference	0 V	0 V	5 V
Signal	0 V	0 V	5 V
Low Reference	-	5 V	-

Circuit/System Description

Circuit	Description
5 V Reference	Regulated voltage supplied by the control module.
Signal	The control module input circuit has an internal resistance connected to ground.
Low Reference	Grounded through the control module.

Component	Description
B47 Fuel Pressure Sensor	The sensor measures the fuel pressure in the fuel line. The signal voltage increases when the pressure increases.
K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.

The control module uses the fuel pressure sensor to constantly adjust the fuel pump's feed rate so that the ideal pressure is permanently maintained in the low pressure section (between the fuel pump and the high pressure fuel pump) by means of a closed loop control.

Conditions for Running the DTC

P018B

- DTC P018C, P018D, P0231, P0232, P023F, P0641, P1255, P0129, P12A6 = Not set
- Engine=Running - For greater than 5 s
- Fuel Pump Enable =On

DTC runs continuously when the above conditions are met.

P018C, P018D

Ignition=On

DTCs run continuously when the above condition is met.

Conditions for Setting the DTC

P018B

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Fuel Pressure Sensor =Change is less than 30 kPa (4.4 PSI)

The above condition(s) must occur for greater than 5 s.

P018C

Fuel Pressure Sensor =Less than 0.2 V - For greater than 1 s

P018D

Fuel Pressure Sensor =Greater than 4.8 V - For greater than 1 s

Actions Taken When the DTC Sets

DTCs P018B, P018C, P018D are Type B DTCs.

Conditions for Clearing the DTC

DTCs P018B, P018C, P018D are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW)

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- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References

Circuit/System Verification

1. IgnitionÂ» On / VehicleÂ» In Service Mode
2. Verify DTC P0231, P0232, P023F, P0641, P1255, P0129, P12A6 is not set.
    - **If any of the DTCs are set**

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

    - **If none of the DTCs are set**
3. Engine running.

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4. Verify the scan tool parameter:Fuel Pressure Sensor = 2.7 to 3.8 V
    - **If not between 2.7 and 3.8 V**

      Refer to Circuit/System Testing

    - **If between 2.7 and 3.8 V**
5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify the DTC does not set.
    - **If the DTC sets**

      Refer to Circuit/System Testing

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

Circuit/System Testing

NOTE: **It may take up to 2 min for all vehicle systems to power down before an accurate ground or low reference circuit continuity test can be performed.**

1. Ignition/Vehicle & All vehicle systemsÂ» Off
2. Disconnect the electrical connector: B47 Fuel Pressure Sensor
3. Test for less than 10 Ω between the test points:Low Reference circuit terminal 2 & Ground
    - **If 10 Ω or greater**
    1. Disconnect the electrical connector: X1 @ K20 Engine Control Module
    2. Test for less than 2 Ω between the test points: Low Reference circuit terminal 2 @ Component harness & Terminal 44 @ Control module harness
        - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
        - If less than 2 ΩÂ» Replace the component:K20 Engine Control Module
    - **If less than 10 Ω**
4. IgnitionÂ» On / VehicleÂ» In Service Mode
5. Test for 4.8 to 5.2 V between the test points: 5 V Reference circuit terminal 3 & Low Reference circuit terminal 2
    - **If less than 4.8 V**
    1. Ignition/VehicleÂ» Off
    2. Disconnect the electrical connector: X4 @ K20 Engine Control Module
    3. Test for infinite resistance between the test points: 5 V Reference circuit terminal 3 @ Component harness & Ground
        - If less than infinite resistanceÂ» Repair the short to ground on the circuit.
        - If infinite resistance
    4. Test for less than 2 Ω between the test points: 5 V Reference circuit terminal 3 @ Component harness & Terminal 39 @ Control module harness
        - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
        - If less than 2 ΩÂ» Replace the component:K20 Engine Control Module
    - **If greater than 5.2 V**
    1. Ignition/VehicleÂ» Off

       NOTE: **Internal control module or component damage may occur if the circuit shorts to B+.**

    2. Disconnect the electrical connector: X4 @ K20 Engine Control Module
    3. IgnitionÂ» On / VehicleÂ» In Service Mode

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4. Test for less than 1 V between the test points: 5 V Reference circuit terminal 3 @ Component harness & Ground
    - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
    - If less than 1 VÂ» Replace the component:K20 Engine Control Module
- **If between 4.8 and 5.2 V**

6. Verify the scan tool parameter: Fuel Pressure Sensor = Less than 0.2 V
    - **If 0.2 V or greater**
    1. Ignition/VehicleÂ» Off
    2. Disconnect the electrical connector: X4 @ K20 Engine Control Module
    3. IgnitionÂ» On / VehicleÂ» In Service Mode
    4. Test for less than 1 V between the test points: Signal circuit terminal 1 @ Component harness & Ground
        - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
        - If less than 1 VÂ» Replace the component:K20 Engine Control Module
    - **If less than 0.2 V**
7. Connect a 3A fused jumper wire between the test points:Signal circuit terminal 1 & 5 V Reference circuit terminal 3
8. Verify the scan tool parameter:Fuel Pressure Sensor =Greater than 4.8 V
    - **If 4.8 V or less**
    1. Ignition/VehicleÂ» Off & RemoveÂ» Jumper wire(s)
    2. Disconnect the electrical connector: X4 @ K20 Engine Control Module
    3. Test for infinite resistance between the test points:Signal circuit terminal 1 @ Component harness & Ground
        - If less than infinite resistance Â» Repair the short to ground on the circuit.
        - If infinite resistance
    4. Test for less than 2 Ω between the test points:Signal circuit terminal 1 @ Component harness & Terminal 59 @ Control module harness
        - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
        - If less than 2 ΩÂ» Replace the component: K20 Engine Control Module
    - **If greater than 4.8 V**
9. Test or replace the component: B47 Fuel Pressure Sensor

Repair Instructions

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

- **Fuel Pressure Sensor Replacement - Fuel Feed Pipe**
- For control module replacement, programming and setup, refer to **Control Module References**

DTC P0201-P0206, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E OR P216F: CYLINDER INJECTOR CONTROL CIRCUIT (LGX)

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis:**Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

DTC P0201

Cylinder 1 Injector Control Circuit

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DTC P0202

Cylinder 2 Injector Control Circuit

DTC P0203

Cylinder 3 Injector Control Circuit

DTC P0204

Cylinder 4 Injector Control Circuit

DTC P0205

Cylinder 5 Injector Control Circuit

DTC P0206

Cylinder 6 Injector Control Circuit

DTC P0261

Cylinder 1 Injector Control Circuit Low Voltage

DTC P0262

Cylinder 1 Injector Control Circuit High Voltage

DTC P0264

Cylinder 2 Injector Control Circuit Low Voltage

DTC P0265

Cylinder 2 Injector Control Circuit High Voltage

DTC P0267

Cylinder 3 Injector Control Circuit Low Voltage

DTC P0268

Cylinder 3 Injector Control Circuit High Voltage

DTC P0270

Cylinder 4 Injector Control Circuit Low Voltage

DTC P0271

Cylinder 4 Injector Control Circuit High Voltage

DTC P0273

Cylinder 5 Injector Control Circuit Low Voltage

DTC P0274

Cylinder 5 Injector Control Circuit High Voltage

DTC P0276

Cylinder 6 Injector Control Circuit Low Voltage

DTC P0277

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Cylinder 6 Injector Control Circuit High Voltage

DTC P2147

Cylinder 1 Injector High Control Circuit Low Voltage

DTC P2148

Cylinder 1 Injector High Control Circuit High Voltage

DTC P2150

Cylinder 2 Injector High Control Circuit Low Voltage

DTC P2151

Cylinder 2 Injector High Control Circuit High Voltage

DTC P2153

Cylinder 3 Injector High Control Circuit Low Voltage

DTC P2154

Cylinder 3 Injector High Control Circuit High Voltage

DTC P2156

Cylinder 4 Injector High Control Circuit Low Voltage

DTC P2157

Cylinder 4 Injector High Control Circuit High Voltage

DTC P216B

Cylinder 5 Injector High Control Circuit Low Voltage

DTC P216C

Cylinder 5 Injector High Control Circuit High Voltage

DTC P216E

Cylinder 6 Injector High Control Circuit Low Voltage

DTC P216F

Cylinder 6 Injector High Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Short Between Circuits
Control circuit terminal 2 @ Q17A Fuel Injector 1	P2147	P0201	P2148	P1248
Control circuit terminal 1 @ Q17A Fuel Injector 1	P0261	P0201	P0262	P1248
Control circuit terminal 2 @ Q17B Fuel Injector 2	P2150	P0202	P0265	P1249
Control circuit terminal 1 @ Q17B Fuel Injector 2	P0264	P0202	P0265	P1249

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Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Short Between Circuits
Control circuit terminal 2 @ Q17C Fuel Injector 3	P2153	P0203	P2154	P124A
Control circuit terminal 1 @ Q17C Fuel Injector 3	P0267	P0203	P0268	P124A
Control circuit terminal 2 @ Q17D Fuel Injector 4	P2156	P0204	P0270, P2157	P124B
Control circuit terminal 1 @ Q17D Fuel Injector 4	P0270, P2156	P0204	P0271, P2157	P124B
Control circuit terminal 2 @ Q17E Fuel Injector 5	P216B	P0205	P216C	P124C
Control circuit terminal 1 @ Q17E Fuel Injector 5	P0273	P0205	P0274	P124C
Control circuit terminal 2 @ Q17F Fuel Injector 6	P216E	P0206	P216F	P124D
Control circuit terminal 1 @ Q17F Fuel Injector 6	P0276	P0206	P0277	P124D

Typical Scan Tool Data

Fuel Injector Control Circuit Test Status

Circuit	Short to Ground	Open	Short to Voltage	Short between the circuits
Operating Conditions: Engine at Idle **Parameter Normal Range:** OK or Not Run				
Control circuit terminal 2	High Control Circuit Low Voltage	Open	High Control Circuit High Voltage	High Control Circuit Shorted to Control Circuit
Control circuit terminal 1	Control Circuit Low Voltage	Open	Control Circuit High Voltage	High Control Circuit Shorted to Control Circuit

Circuit/System Description

Circuit	Description
Control circuit terminal 2	Regulated voltage supplied by the control module.
Control circuit terminal 1	The output circuit is switched to ground to activate the component.

Component	Description
Q17 Fuel Injector	Fuel injectors are solenoid valves that inject fuel either into the intake system or directly into the cylinder. The amount of fuel injected depends on the length of the electrical pulse that is applied. The fuel injectors of this system have an operating voltage range of 50 to 90 V.
K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.

Conditions for Running the DTC

- DTC P062B = Not set
- Engine is Running
- Battery Voltage =Greater than 11 V

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DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

P0201, P0202, P0203, P0204, P0205, P0206

Control circuit=Open - For greater than 1 s

P0261, P0264, P0267, P0270, P0273, P0276

Control circuit - Low =Short to Ground - For greater than 1 s

P0262, P0265, P0268, P0271, P0274, P0277

Control circuit - Low =Short to Voltage - For greater than 1 s

P2147, P2150, P2153, P2156, P216B, P216E

Control circuit - High =Short to Ground - For greater than 1 s

P2148, P2151, P2154, P2157, P216C, P216F

Control circuit - High =Short to Voltage - For greater than 1 s

Actions Taken When the DTC Sets

DTCs P0201, P0202, P0203, P0204, P0205, P0206, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F are Type A DTCs.

Conditions for Clearing the DTC

DTCs P0201, P0202, P0203, P0204, P0205, P0206, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F are Type A DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

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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

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Scan Tool Reference

Control Module References

Special Tools

J-44603 Injector Test Lamp

Equivalent regional tools: **Special Tools (Diagnostic Tools)** **Special Tools (Mechanical Tools)**

Circuit/System Verification

1. Engine running.
2. Verify the scan tool parameter:
   - Cylinder 1 Injector Control Circuit Status =OK
   - Cylinder 2 Injector Control Circuit Status =OK
   - Cylinder 3 Injector Control Circuit Status =OK
   - Cylinder 4 Injector Control Circuit Status =OK
   - Cylinder 5 Injector Control Circuit Status =OK
   - Cylinder 6 Injector Control Circuit Status =OK
   - **If not the specified state**

     Refer to Circuit/System Testing

   - **If the specified state**
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 is not set**
5. All OK.

Circuit/System Testing

1. Ignition/VehicleÂ» Off
2. Disconnect the appropriate electrical connector: Q17 Fuel Injector
3. IgnitionÂ» On / VehicleÂ» In Service Mode
4. Test for 10.8 to 11.4 V between the test points: Control circuit terminal 2 & Ground
   - **If less than 10.8 V**
   1. Ignition/VehicleÂ» Off
   2. Disconnect the electrical connector: X3 @ K20 Engine Control Module
   3. Test for infinite resistance between the test points: Control circuit terminal 2 @ Component harness & Ground
      - If less than infinite resistance Â» Repair the short to ground on the circuit.
      - If infinite resistance
   4. Test for less than 2 Ω between the test points: Control circuit terminal 2 @ Component harness
      - {Q17A Fuel Injector 1}Terminal 69 @ Control module harness
      - {Q17B Fuel Injector 2}Terminal 68 @ Control module harness
      - {Q17C Fuel Injector 3}Terminal 72 @ Control module harness
      - {Q17D Fuel Injector 4}Terminal 70 @ Control module harness
      - {Q17E Fuel Injector 5}Terminal 67 @ Control module harness
      - {Q17F Fuel Injector 6}Terminal 71 @ Control module harness

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- If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
- If less than 2 ΩÂ» Replace the component:K20 Engine Control Module

- **If greater than 11.4 V**

1. Ignition/Vehicle Â» Off
2. Disconnect the electrical connector: X3 @ K20 Engine Control Module
3. IgnitionÂ» On / VehicleÂ» In Service Mode
4. Test for less than 1 V between the test points:Control circuit terminal 2 @ Component harness & Ground
    - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
    - If less than 1 VÂ» Replace the component:K20 Engine Control Module

- **If between 10.8 and 11.4 V**

5. Ignition/VehicleÂ» Off
6. Install the special tool: **J-44603** Injector Test Lamp @ Q17 Fuel Injector - Component harness
7. Engine cranking.
8. Verify the test lamp flashes
    - **If the test lamp does not flash**
    1. Ignition/Vehicle Â» Off & RemoveÂ» Test lamp
    2. Disconnect the electrical connector: X3 @ K20 Engine Control Module
    3. Test for infinite resistance between the test points:Control circuit terminal 1 @ Component harness & Ground
        - If less than infinite resistanceÂ» Repair the short to ground on the circuit.
        - If infinite resistance
    4. Test for less than 2 Ω between the test points:Control circuit terminal 1 @ Component harness
        - {Q17A Fuel Injector 1} Terminal 49 @ Control module harness
        - {Q17B Fuel Injector 2} Terminal 48 @ Control module harness
        - {Q17C Fuel Injector 3} Terminal 52 @ Control module harness
        - {Q17D Fuel Injector 4} Terminal 50 @ Control module harness
        - {Q17E Fuel Injector 5} Terminal 47 @ Control module harness
        - {Q17F Fuel Injector 6} Terminal 51 @ Control module harness
        - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
        - If less than 2 Ω
    5. Ignition Â» On / Vehicle Â» In Service Mode
    6. Test for less than 1 V between the test points: Control circuit terminal 1 @ Component harness & Ground
        - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
        - If less than 1 VÂ» Replace the component:K20 Engine Control Module
    - **If the test lamp flashes**
9. Test or replace the component: Q17 Fuel Injector

Component Testing

1. Ignition/VehicleÂ» Off
2. Disconnect the electrical connector: Q17 Fuel Injector
3. Test for 1 to 3 Ω between the test points: Control circuit - High Terminal 2 & Control circuit - Low Terminal 1

NOTE: **The specified resistances are valid for components at room temperature.**

- **If not between 1 and 3 Ω**

Replace the component: Q17 Fuel Injector

- **If between 1 and 3 Ω**

4. Test for infinite resistance between the test points: Each terminal of the component & The component's housing
    - **If less than infinite resistance**

      Replace the component: Q17 Fuel Injector

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

Repair Instructions

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

- **Fuel Injector Replacement**
- Fuel Rail Pressure Sensor or Fuel Rail Learn
- For control module replacement, programming and setup, refer to **Control Module References**

DTC P0201-P0206, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E OR P216F: CYLINDER INJECTOR CONTROL CIRCUIT (LGW)

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

DTC P0201

Cylinder 1 Injector Control Circuit

DTC P0202

Cylinder 2 Injector Control Circuit

DTC P0203

Cylinder 3 Injector Control Circuit

DTC P0204

Cylinder 4 Injector Control Circuit

DTC P0205

Cylinder 5 Injector Control Circuit

DTC P0206

Cylinder 6 Injector Control Circuit

DTC P0261

Cylinder 1 Injector Control Circuit Low Voltage

DTC P0262

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Cylinder 1 Injector Control Circuit High Voltage

DTC P0264

Cylinder 2 Injector Control Circuit Low Voltage

DTC P0265

Cylinder 2 Injector Control Circuit High Voltage

DTC P0267

Cylinder 3 Injector Control Circuit Low Voltage

DTC P0268

Cylinder 3 Injector Control Circuit High Voltage

DTC P0270

Cylinder 4 Injector Control Circuit Low Voltage

DTC P0271

Cylinder 4 Injector Control Circuit High Voltage

DTC P0273

Cylinder 5 Injector Control Circuit Low Voltage

DTC P0274

Cylinder 5 Injector Control Circuit High Voltage

DTC P0276

Cylinder 6 Injector Control Circuit Low Voltage

DTC P0277

Cylinder 6 Injector Control Circuit High Voltage

DTC 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

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DTC P2156

Cylinder 4 Injector High Control Circuit Low Voltage

DTC P2157

Cylinder 4 Injector High Control Circuit High Voltage

DTC P216B

Cylinder 5 Injector High Control Circuit Low Voltage

DTC P216C

Cylinder 5 Injector High Control Circuit High Voltage

DTC P216E

Cylinder 6 Injector High Control Circuit Low Voltage

DTC P216F

Cylinder 6 Injector High Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Short between the circuits
Control circuit terminal 2 @ Q17A Fuel Injector 1	P2147	P0201	P2148	P1248
Control circuit terminal 1 @ Q17A Fuel Injector 1	P0261	P0201	P0262	P1248
Control circuit terminal 2 @ Q17B Fuel Injector 2	P2150	P0202	P2151	P1249
Control circuit terminal 1 @ Q17B Fuel Injector 2	P0264	P0202	P0265	P1249
Control circuit terminal 2 @ Q17C Fuel Injector 3	P2153	P0203	P2154	P124A
Control circuit terminal 1 @ Q17C Fuel Injector 3	P0267	P0203	P0268	P124A
Control circuit terminal 2 @ Q17D Fuel Injector 4	P2156	P0204	P0270, P2157	P124B
Control circuit terminal 1 @ Q17D Fuel Injector 4	P0270, P2156	P0204	P0271, P2157	P124B
Control circuit terminal 2 @ Q17E Fuel Injector 5	P216B	P0205	P216C	P124C
Control circuit terminal 1 @ Q17E Fuel Injector 5	P0273	P0205	P0274	P124C
Control circuit terminal 2 @ Q17F Fuel Injector 6	P216E	P0206	P216F	P124D
Control circuit terminal 1 @ Q17F Fuel Injector 6	P0276	P0206	P0277	P124D

Typical Scan Tool Data

Fuel Injector Control Circuit Test Status

Circuit	Short to Ground	Open	Short to Voltage	Short between the circuits
Operating Conditions: Engine at Idle **Parameter Normal Range:** OK or Not Run				

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Circuit	Short to Ground	Open	Short to Voltage	Short between the circuits
Control circuit terminal 2	High Control Circuit Low Voltage	Open	High Control Circuit High Voltage	High Control Circuit Shorted to Control Circuit
Control circuit terminal 1	Control Circuit Low Voltage	Open	Control Circuit High Voltage	High Control Circuit Shorted to Control Circuit

Circuit/System Description

Circuit	Description
Control circuit terminal 2	Regulated voltage supplied by the control module.
Control circuit terminal 1	The output circuit is switched to ground to activate the component.

Component	Description
Q17 Fuel Injector	Fuel injectors are solenoid valves that inject fuel either into the intake system or directly into the cylinder. The amount of fuel injected depends on the length of the electrical pulse that is applied. The fuel injectors of this system have an operating voltage range of 50 to 90 V.
K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.

Conditions for Running the DTC

- DTC P062B = Not set
- Engine is Running
- Battery Voltage = Greater than 11 V

DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

P0201, P0202, P0203, P0204, P0205, P0206

Control circuit=Open - For greater than 1 s

P0261, P0264, P0267, P0270, P0273, P0276

Low Control=Short to Ground - For greater than 1 s

P0262, P0265, P0268, P0271, P0274, P0277

Low Control=Short to Voltage - For greater than 1 s

P2147, P2150, P2153, P2156, P216B, P216E

High Control=Short to Ground - For greater than 1 s

P2148, P2151, P2154, P2157, P216C, P216F

High Control=Short to Voltage - For greater than 1 s

Actions Taken When the DTC Sets

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DTCs P0201, P0202, P0203, P0204, P0205, P0206, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F are Type A DTCs.

Conditions for Clearing the DTC

DTCs P0201, P0202, P0203, P0204, P0205, P0206, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F are Type A DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Description and Operation

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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

Special Tools

J-44603 Injector Test Lamp

Equivalent regional tools: **Special Tools (Diagnostic Tools)** **Special Tools (Mechanical Tools)**

Circuit/System Verification

1. Engine running.
2. Verify the scan tool parameter:
    - Cylinder 1 Injector Control Circuit Status =OK
    - Cylinder 2 Injector Control Circuit Status =OK
    - Cylinder 3 Injector Control Circuit Status =OK
    - Cylinder 4 Injector Control Circuit Status =OK
    - Cylinder 5 Injector Control Circuit Status =OK
    - Cylinder 6 Injector Control Circuit Status =OK
    - **If not the specified state**

      Refer to Circuit/System Testing

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- **If the specified state**

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 is not set**
5. All OK.

Circuit/System Testing

1. Ignition/VehicleÂ» Off
2. Disconnect the appropriate electrical connector:Q17 Fuel Injector
3. Ignition Â» On / Vehicle Â» In Service Mode
4. Test for 11.2 to 11.7 V between the test points:Control circuit terminal 2 & Ground
    - **If less than 11.2 V**
    1. Ignition/VehicleÂ» Off
    2. Disconnect the electrical connector: X4 @ K20 Engine Control Module
    3. Test for infinite resistance between the test points:Control circuit terminal 2 @ Component harness & Ground
        - If less than infinite resistanceÂ» Repair the short to ground on the circuit.
        - If infinite resistance
    4. Test for less than 2 Ω between the test points: Control circuit terminal 2 @ Component harness
        - {Q17A Fuel Injector 1}Terminal 69 @ Control module harness
        - {Q17B Fuel Injector 2}Terminal 68 @ Control module harness
        - {Q17C Fuel Injector 3}Terminal 72 @ Control module harness
        - {Q17D Fuel Injector 4}Terminal 70 @ Control module harness
        - {Q17E Fuel Injector 5}Terminal 67 @ Control module harness
        - {Q17F Fuel Injector 6}Terminal 71 @ Control module harness
        - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
        - If less than 2 ΩÂ» Replace the component:K20 Engine Control Module
    - **If greater than 11.7 V**
    1. Ignition/VehicleÂ» Off
    2. Disconnect the electrical connector: X4 @ K20 Engine Control Module
    3. IgnitionÂ» On / VehicleÂ» In Service Mode
    4. Test for less than 1 V between the test points:Control circuit terminal 2 @ Component harness & Ground
        - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
        - If less than 1 VÂ» Replace the component:K20 Engine Control Module
    - **If between 11.2 and 11.7 V**
5. Ignition/Vehicle Â» Off
6. Install the special tool: **J-44603** Injector Test Lamp @ Q17 Fuel Injector - Component harness
7. Engine cranking.
8. Verify the test lamp flashes
    - **If the test lamp does not flash**
    1. Ignition/VehicleÂ» Off & RemoveÂ» Test lamp
    2. Disconnect the electrical connector: X4 @ K20 Engine Control Module
    3. Test for infinite resistance between the test points: Control circuit terminal 1 @ Component harness & Ground

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- If less than infinite resistance Â» Repair the short to ground on the circuit.
- If infinite resistance

4. Test for less than 2 Ω between the test points:Control circuit terminal 1 @ Component harness
   - {Q17A Fuel Injector 1}Terminal 49 @ Control module harness
   - {Q17B Fuel Injector 2}Terminal 48 @ Control module harness
   - {Q17C Fuel Injector 3}Terminal 52 @ Control module harness
   - {Q17D Fuel Injector 4}Terminal 50 @ Control module harness
   - {Q17E Fuel Injector 5}Terminal 47 @ Control module harness
   - {Q17F Fuel Injector 6}Terminal 51 @ Control module harness
   - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
   - If less than 2 Ω
5. IgnitionÂ» On / VehicleÂ» In Service Mode
6. Test for less than 1 V between the test points:Control circuit terminal 1 @ Component harness & Ground
   - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
   - If less than 1 VÂ» Replace the component:K20 Engine Control Module

- **If the test lamp flashes**

9. Test or replace the component:Q17 Fuel Injector

Component Testing

1. Ignition/Vehicle Â» Off
2. Disconnect the electrical connector: Q17 Fuel Injector
3. Test for 1 to 3 Ω between the test points: Control circuit terminal 2 & Control circuit terminal 1

NOTE: **The specified resistances are valid for components at room temperature.**

- **If not between 1 and 3 Ω**

  Replace the component: Q17 Fuel Injector

- **If between 1 and 3 Ω**

4. Test for infinite resistance between the test points: Each terminal of the component & The component's housing
   - **If less than infinite resistance**

     Replace the component: Q17 Fuel Injector

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

Repair Instructions

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

- **Fuel Injector Replacement**
- Fuel Rail Pressure Sensor or Fuel Rail Learn
- For control module replacement, programming and setup, refer to **Control Module References**

DTC P0231, P0232 OR P023F: FUEL PUMP CONTROL CIRCUIT

Diagnostic Instructions

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

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- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

DTC P0231

Fuel Pump Control Circuit Low Voltage

DTC P0232

Fuel Pump Control Circuit High Voltage

DTC P023F

Fuel Pump Control Circuit

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control	P0231	P023F	P0232	P023F
Low Reference	-	P023F	-	P023F

Circuit/System Description

Circuit	Description
Control	The output circuit is switched to 12 V to activate the component.
Low Reference	Grounded through the control module.

Component	Description
G12 Fuel Pump	The fuel pump has a DC motor that is controlled by a PWM signal to achieve the desired fuel pressure.
K111 Fuel Pump Driver Control Module	The control module K111 monitors the fuel system for any condition which may adversely affect emissions. If a condition is detected it sets a DTC and sends a serial data message to the engine control module which then sets DTC P069E.

The control module K111 supplies the fuel pump with a PWM signal in order to achieve the desired fuel line pressure.

Conditions for Running the DTC

P0231, P023F

- Ignition=On
- Ignition Voltage = 9 to 32 V

DTCs run continuously when the above conditions are met for greater than 1 s.

P0232

- Fuel Pump Enable Circuit =Off
- Fuel Pump Command = 0%

DTC runs continuously when the above conditions are met for greater than 4 s.

Conditions for Setting the DTC

P0231

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Fuel Pump Control Circuit =Greater than 14.48 A

P0232

Fuel Pump Control Circuit =Greater than 3.86 V

P023F

Fuel Pump Control Circuit =Less than 500 mA

Actions Taken When the DTC Sets

- DTCs P0231, P023F are Type A DTCs.
- DTC P0232 is a Type B DTC.

Conditions for Clearing the DTC

- DTCs P0231, P023F are Type A DTCs.
- DTC P0232 is a Type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Description and Operation

Fuel System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References

Circuit/System Verification

1. Ignition Â» On / Vehicle Â» In Service Mode
2. Perform the scan tool control function:Fuel Pump Enable Â»On and Off

   Verify the component turns On and Off:G12 Fuel Pump

   - **If the component does not turn On and Off**

     Refer to Circuit/System Testing

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- **If the component 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 is not set**
5. All OK.

Circuit/System Testing

NOTE: **It may take up to 2 min for all vehicle systems to power down before an accurate ground or low reference circuit continuity test can be performed.**

1. Ignition/Vehicle & All vehicle systemsÂ» Off
2. Disconnect the electrical connector:A7 Fuel Pump and Level Sensor Assembly
3. Test for less than 5 Ω between the test points:Low Reference circuit terminal 2 & Ground
   - **If 5 Ω or greater**
   1. Disconnect the electrical connector:K111 Fuel Pump Driver Control Module
   2. Test for less than 2 Ω between the test points:Low Reference circuit terminal 2 @ Component harness & Terminal 16 @ Control module harness
      - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
      - If less than 2 ΩÂ» Replace the component: K111 Fuel Pump Driver Control Module
   - **If less than 5 Ω**
4. Connect a test lamp between the test points:Control circuit terminal 1 & Low Reference circuit terminal 2
5. Ignition Â» On / Vehicle Â» In Service Mode
6. Perform the scan tool control function:Fuel Pump Enable Â»On and Off

   Verify the test lamp turns On and Off.

   - **If the test lamp is always Off**
   1. Ignition/VehicleÂ» Off & RemoveÂ» Test lamp
   2. Disconnect the electrical connector: K111 Fuel Pump Driver Control Module
   3. Test for infinite resistance between the test points:Control circuit terminal 2 @ Component harness & Ground
      - If less than infinite resistanceÂ» Repair the short to ground on the circuit.
      - If infinite resistance
   4. Test for less than 2 Ω between the test points:Control circuit terminal 1 @ Component harness & Terminal 2 @ Control module harness
      - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
      - If less than 2 ΩÂ» Replace the component:K111 Fuel Pump Driver Control Module
   - **If the test lamp is always On**
   1. Ignition/VehicleÂ» Off & RemoveÂ» Test lamp
   2. Disconnect the electrical connector:K111 Fuel Pump Driver Control Module
   3. IgnitionÂ» On / VehicleÂ» In Service Mode
   4. Test for less than 1 V between the test points: Control circuit terminal 1 @ Component harness & Ground
      - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
      - If less than 1 VÂ» Replace the component:K111 Fuel Pump Driver Control Module
   - **If the test lamp turns On and Off**

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7. Test or replace the component:G12 Fuel Pump

Repair Instructions

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

- **Fuel Tank Fuel Pump Module Replacement** - G12 Fuel Pump
- **Fuel Pump Power Control Module Replacement** - K111 Fuel Pump Driver Control Module

DTC P0234, P0299 OR P16E7: ENGINE/TURBOCHARGER BANK 1-2 BOOST BALANCE

Diagnostic Instructions

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

DTC Descriptor

DTC P0234

Engine Overboost

DTC P0299

Engine Underboost

DTC P16E7

Turbocharger Bank 1-2 Boost Balance

Circuit/System 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.

The turbochargers each incorporate a vacuum operated wastegate that is controlled by the engine control module (ECM) by means of a remotely mounted solenoid, to regulate the pressure ratio of the compressor. The wastegate valve vacuum source is provided by a vacuum pump which is driven off the end of the right hand exhaust camshaft.

At idle the turbocharger wastegate solenoids are open. When the engine load and RPM increase under a wide open throttle, the turbocharger wastegate valves close to increase boost pressure. When the proper level of boost pressure is attained, the ECM will partially open the wastegates to maintain the boost pressure level. When the throttle closes, the ECM commands the wastegates to open to reduce the speed of the turbines.

Conditions for Running the DTC

P0234 or P0299

- DTC P0010, P0011, P0013, P0014, P0020, P0021, P0023, P0024, P0033, P0034, P0035, P0068, P0090, P0091, P0092, P00C0, P00C1, P00C2, P00C8, P00C9, P00CA, P0101, P0102, P0103, P010B, P010C, P010D, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0122, P0123, P0128, P0191, P0192, P0193, P0222, P0223, P0236, P0237, P0238, P026A, P0601, P0604,

P0606, P0697, P06A3, P1682, P16A0, P16A1, P16A2, P16F3, P2088, P2089, P2090, P2091, P2092, P2093, P2094, P2095, P2101, P2122, P2123, P2127, P2128, P2135, P2138, P2176, P2227, P2228, P2229, P222C, P222D, P2230 or U0073 is not set.

- Engine speed is between 1, 500-6, 500 RPM.
- Desired boost pressure is between 70-245 kPa (10.1-35.5 PSI).
- BARO is between 60-120 kPa (8.7-17.4 PSI).
- Engine coolant temperature (ECT) is between -40 to +126Â°C (-40 to +258.8Â°F).
- Intake air temperature (IAT) is between -40 to +80Â°C (-40 to +176Â°F).
- Desired boost pressure is greater than basic boost pressure.
- The DTCs run continuously within the enabling conditions.

P16E7

- DTC P0101, P0102, P0103, P010B, P010C, P010D is not set.
- Engine speed is less than 2, 800 RPM.
- The DTCs run continuously within the enabling conditions.

Conditions for Setting the DTC

The ECM has detected the difference between desired and actual boost pressure is not within a calibrated threshold.

Action Taken When the DTC Sets

DTC P0234, P0299 and P16E7 are Type B DTCs.

Conditions for Clearing the DTC

DTC P0234, P0299 and P16E7 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Turbocharger System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
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- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.

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2. Verify DTC P0033, P0034, P0035, P00C0, P00C1, P00C2, P0101, P0102, P0103, P010B, P010C, P010D P0236, P0237, P0238, P0243, P0245, P0246, P0247, P0249 or P0250 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 Barometric Pressure Sensor Bank 1 and Bank 2 parameters are within the range specified in the **Altitude Versus Barometric Pressure** table.
    - **If either parameter is not within the specified range**

      Refer to the corresponding **DTC P2227-P2230 (LGW)** , **DTC P2227-P2230 (LGX)** or **DTC P222B-P222E** .
    - **If both parameters are within the specified range**
4. Verify the scan tool MAP Sensor and Barometric Pressure Sensor Bank 1 and Bank 2 parameters are within 3 kPa (0.4 psi).
    - **If not within 3 kPa (0.4 psi)**

      Refer to **DTC P0106** .
    - **If within 3 kPa (0.4 psi)**
5. Verify the scan tool Boost Pressure Sensor and Barometric Pressure Sensor Bank 1 and Bank 2 parameters are within 3 kPa (0.4 psi).
    - **If not within 3 kPa (0.4 psi)**

      Refer to **DTC P0236**.
    - **If within 3 kPa (0.4 psi)**
6. Verify a click is heard or felt from the corresponding Q40 Turbocharger Bypass Solenoid Valve when commanding the Turbocharger Bypass Solenoid Valve Bank 1 or Bank 2 between Active and Inactive with a scan tool.

    NOTE: **This step is intended to verify the electronic bypass solenoid valve operation.**

    - **If a click is not heard or felt**

      Refer to Circuit/System Testing.
    - **If a click is heard or felt**
7. Engine Idling.
8. Verify a click is heard or felt from the corresponding turbocharger bypass valve when commanding the Turbocharger Bypass Solenoid Valve Bank 1 or Bank 2 between Active and Inactive with a scan tool.

    NOTE: **This step is intended to verify the vacuum operated bypass valve operation.**

    - **If a click is not heard or felt**

      Refer to Circuit/System Testing.
    - **If a click is heard or felt**
9. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
10. Verify a DTC does not set.
    - **If a DTC sets**

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Refer to Circuit/System Testing.

- **If a DTC does not set**

11. All OK

Circuit/System Testing

1. Verify the conditions listed below do not exist:
   - Loose clamps, cracks or other damage in the air intake duct system
   - Collapsed or restricted intake duct system
   - Restricted air filter
   - Any air flow restriction
   - Any air leak between the turbochargers and the throttle body
   - Splits, kinks or improper connections at the vacuum hoses
   - Any vacuum leak
   - Restricted, leaking or incorrect routing of vacuum hoses going to the components listed below:
     - Turbocharger wastegate solenoid valves
     - Turbocharger bypass solenoid valves
     - Vacuum tank
     - Turbocharger wastegate actuators
     - Turbocharger bypass valves
   - Damaged or leaking vacuum tank
   - Missing, restricted or leaking exhaust components-Refer to **Restricted Exhaust** .
   - Exhaust leak between the turbochargers and the exhaust manifold
   - Restricted turbocharger oil supply lines
   - 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 vacuum supply hose at the turbocharger vacuum/oil pump.
3. Connect the **GE 23738-A** to the pump outlet.
4. Engine idling, verify the absolute vacuum value is less than or equal to 15 kPa (4.4 inches Hg).

   NOTE: **To determine the absolute vacuum value, subtract the vacuum gauge reading from the barometric pressure.**

   - **If not within the specified range**

     Repair or replace the vacuum/oil pump.

   - **If within the specified range**
5. Ignition OFF, disconnect all vacuum hoses at the turbocharger vacuum tank and cap or plug the valve outlet ports.
6. Connect the **GE 23738-A** to the vacuum tank inlet port and apply 5 kPa (1.5 inches Hg) of vacuum.
7. Verify the tank holds vacuum for at least 10 s.
   - **If not held for at least 10 s**

     Replace the vacuum tank.

   - **If held for at least 10 s**
8. Connect the vacuum hoses to the tank.

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9. Disconnect the appropriate Q40 Turbocharger Bypass Solenoid Valve output to bypass valve vacuum hose at the solenoid valve and connect the **GE 23738-A** to the solenoid valve.
10. Engine idling.
11. Verify the absolute vacuum value toggles between 0 kPa (0 inches Hg) to less than or equal to 15 kPa (4.4 inches Hg), when commanding the Turbocharger Bypass Solenoid Valve between Active and Inactive with a scan tool.

    NOTE: **To determine the absolute vacuum value, subtract the vacuum gauge reading from the barometric pressure.**

    - **If not within the specified range**

      Replace the Q40 Turbocharger Bypass Solenoid Valve.

    - **If within the specified range**
12. Verify the conditions listed below do not exist with the appropriate turbocharger bypass valve assembly:
    - Damage
    - Leaks
    - Restrictions
    - **If a condition exists**

      Repair or replace the turbocharger bypass valve as necessary.

    - **If none of the conditions exist**
13. Ignition OFF. Disconnect the appropriate Q42 Turbocharger Wastegate Solenoid Valve output to wastegate actuator vacuum hose at the solenoid valve and connect the **GE 23738-A** to the solenoid valve.
14. Disconnect the harness connector at the Q42 Turbocharger Wastegate Solenoid Valve and connect a 10 A fused jumper wire between terminal 1 of the solenoid valve and B+.
15. Engine idling.
16. Connect a jumper wire between terminal 2 of the solenoid valve and ground. Verify the absolute vacuum value changes from 0 kPa (0 inches Hg) to less than or equal to 15 kPa (4.4 inches Hg) of vacuum when the Q42 Turbocharger Wastegate Solenoid Valve is activated.

    NOTE: **To determine the absolute vacuum value, subtract the vacuum gauge reading from the barometric pressure.**

    - **If not within the specified range**

      Replace the Q42 Turbocharger Wastegate Solenoid Valve.

    - **If within the specified range**
17. Connect the **GE 23738-A** to the appropriate wastegate actuator vacuum hose.
18. Verify the wastegate actuator rod moves when applying between 0-5 kPa of vacuum.
    - **If the actuator does not move**
    1. Disconnect the wastegate actuator arm from the wastegate.
    2. Verify the wastegate actuator rod moves when applying between 0-5 kPa vacuum 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**
19. Connect any hoses that were disconnected during previous steps.
20. Verify the conditions listed below do not exist with the turbocharger assemblies. Refer to **Turbocharger Cleaning and Inspection** .
    - Worn or damaged wastegate pivot pin

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- Cracked, damaged or worn turbine blades
- Restricted wastegate, turbine, ports or passages
- Foreign material
- **If a condition exists**

  Repair or replace the turbocharger(s) as necessary.

- **If none of the conditions exist**

21. Replace the turbocharger.

Repair Instructions

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

- **Charge Air Bypass Valve Solenoid Replacement (Bank 1)** **Charge Air Bypass Valve Solenoid Replacement (Bank 2)** for turbocharger bypass solenoid valve replacement
- **Charge Air Bypass Valve Replacement - Right Side** for turbocharger bypass valve replacement bank 1
- **Charge Air Bypass Valve Replacement - Left Side** for turbocharger bypass valve replacement bank 2
- **Turbocharger Wastegate Actuator Vacuum Tank Replacement**
- **Turbocharger Wastegate Regulator Solenoid Valve Replacement (Bank 1)** **Turbocharger Wastegate Regulator Solenoid Valve Replacement (Bank 2)**
- **Turbocharger Wastegate Actuator Replacement - Right Side**
- **Turbocharger Wastegate Actuator Replacement - Left Side**
- **Oil Pump Replacement**
- **Control Module References** for ECM replacement, programming and setup.

DTC P0236: TURBOCHARGER BOOST SENSOR PERFORMANCE

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- **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 and is located on the charge air cooler cover. 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

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- DTC P0102, P0103, P010C, P0107, P0108, P010D, P0116, P0111, P0112, P0113, P0114, P0117, P0118, P0125, P0128, P0237, P0238, P0335, P0336, P112B, P112C, P112D, P112E, P2227, P2228, P2229 or P2230 is not set.
- DTC P0112, P0113, P0117, P0118, P112C or P112D is not pending.
- Engine speed is between 425-6, 500 RPM.
- Engine Coolant Temperature (ECT) is between -7 to +126Â°C (19.4-259Â°F).
- Intake Air Temperature (IAT) is between -20 to +125Â°C (-4 to +257Â°F).
- The DTC runs continuously when the above conditions have been met.

OR

- DTC P0106, P0107, P0108, P0237, P0238, P2228, P2229, P222C, P222D, P2230 or P2610 is not set or 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.

Conditions for Setting the DTC

- The ECM detects that various combinations of Turbocharger Intake Flow Rationality Diagnostic Failure models, derived from engine speed, the BARO sensor, the MAF sensor, the MAP sensor, the throttle position sensor and the turbocharger boost pressure sensor have failed when the engine is running.

OR

- The ECM detects that the boost pressure sensor signal is less than 50 kPa (7.3 psi) or greater than 115 kPa (16.7 psi) when the ignition is ON and the engine is NOT rotating.

OR

- The absolute value of the difference between MAP and boost pressure is greater than 10 kPa and between MAP and BARO 1 is 10 kPa or less and between MAP and BARO 2 is 10 kPa or less and between boost pressure and BARO 1 is greater than 10 kPa and the between boost pressure and BARO 2 is greater than 10 kPa and between BARO 1 and BARO 2 is 10 kPa or less.

Action Taken When the DTC Sets

- DTC P0236 is a Type B DTC.
- The ECM will disable boost control and limit the system to mechanical boost only, resulting in a substantial decrease in engine power.

Conditions for Clearing the MIL/DTC

DTC P0236 is a Type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Turbocharger System Description

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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. Verify that DTC P0237, P0238 or P0651 is not set.
   - **If the DTC is set**

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

   - **If the DTC is not set**
2. If you were sent here from DTC P0068, P0101, P0106, P010B, P0121 or P1101, refer to Circuit/System Testing.
3. Ignition ON.
4. Verify the scan tool Throttle Body Idle Airflow Compensation parameter is less than 90%.
   - **90% or greater**

     Refer to **Throttle Body Inspection and Cleaning** .

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

     Refer to **DTC P0121-P0123, P0222, P0223, P16A0-P16A2 or P2135 (LGX)** and/or **DTC P0121-P0123, P0222, P0223, P16A0-P16A2 or P2135 (LGW)** .

   - **If Agree**
6. Verify the scan tool Barometric Pressure Sensor Bank 1 and Bank 2 parameters are within the range specified in the **Altitude Versus Barometric Pressure** .
   - **If either parameter is not within the specified range**

     Refer to the corresponding **DTC P2227-P2230 (LGW)** , **DTC P2227-P2230 (LGX)** or **DTC P222B-P222E** .

   - **If both parameters are within the specified range**
7. Verify the scan tool MAP Sensor pressure and Barometric Pressure Sensor Bank 1 and Bank 2 Sensor 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**

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Refer to **DTC P0106** .

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

10. Verify the scan tool MAF Sensor Bank 1 and Bank 2 g/s parameters change 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 Bank 1 and Bank 2 parameters frame by frame with a scan tool.
    - **The either of the parameters does not change smoothly and gradually**

      Refer to **DTC P0101 (LGX)** , **DTC P0101 (LGW)** or **DTC P010B** as appropriate.

    - **Both MAF Sensor parameters change smoothly and gradually**
11. Verify the scan tool Boost Pressure Sensor pressure and Barometric Pressure Sensor Bank 1 and Bank 2 Sensor parameters are within 3 kPa (0.4 psi).
    - **If either parameter is not within the specified range**

      Refer to **DTC P2227-P2230 (LGW)** , **DTC P2227-P2230 (LGX)** or **DTC P222B-P222E** as appropriate.

    - **If both parameters are within the specified range**
12. Verify the scan tool MAP Sensor parameter and the Boost Pressure Sensor parameter are within 20 kPa (2.9 psi) during a WOT acceleration at the time of the 1-2 shift.
    - **The parameters are not within 20 kPa (2.9 psi)**

      Refer to Circuit/System Testing.

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

      Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Verify that DTC P0237 or P0238 is not set.
    - **If a DTC is set**

      Refer to **DTC P0237 or P0238**.

    - **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** .
    - Any vacuum leaks.

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- **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: TURBOCHARGER BOOST SENSOR CIRCUIT

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- **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	P0236, P0237, P0651, P2227, P222B	P0236, P0237	P0236, P0238, P0651, P2227, P222B	P00C7, P0236
Intake Air Pressure Signal	P0236, P0237, P2227, P222B	P0236, P0238	P0236, P0238, P2227, P222B	P00C7, P0236
Low Reference	-	P00EB, P0236, P0238	-	-

Typical Scan Tool Data

Boost Pressure Sensor

Circuit	Short to Ground	Open	Short to Voltage
Parameter Normal Range: BARO to 240 kPa (34.8 psi) **Operating Conditions:** Engine running			
5 V Reference	0 kPa (0 psi)	0 kPa (0 psi)	434 kPa (63 psi)
Boost Pressure Signal	0 kPa (0 psi)	434 kPa (63 psi)	434 kPa (63 psi)
Low Reference	-	434 kPa (63 psi)	-

Circuit Description

The boost pressure sensor is integrated with the turbocharger boost/intake air temperature sensor and is located on the charge air cooler cover. 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.

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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

- 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 0.72 V for greater than 5 s.

P0238

The ECM detects that the boost pressure sensor voltage is greater than 3.4 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.

Conditions for Clearing the MIL/DTC

DTCs P0237 and P0238 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

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Turbocharger System Description

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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. Verify that DTC P0651 is not set.
    - **If the DTC is set**

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Refer to **DTC P0641, P0651, P0697 or P06A3 (LGW)** and/or **DTC P0641, P0651, P0697 or P06A3 (LGX)**.

- **If the DTC is not 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.
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. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B111B turbocharger boost/intake air temperature sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal 3 and ground.
   - **If 5 Ω or greater**
   1. Disconnect the X2 harness connector at the K20 engine control module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 engine control module.
   - **If less than 5 Ω**
3. Ignition On/Vehicle in Service Mode.
4. 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/Vehicle Off, disconnect the X2 harness connector at the K20 engine control module.
   2. Test for infinite resistance between the 5 V reference circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 Ω in the 5 V reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 engine control module.
   - **If greater than 5.2 V**
   1. Ignition/Vehicle Off, disconnect the X2 harness connector at the K20 engine control module.
   2. Ignition On/Vehicle in Service Mode.
   3. 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 greater than 4.7 V.
   - **If 4.7 V or less**
   1. Ignition/Vehicle Off.
   2. Disconnect the X2 harness connector at the K20 engine control module.
   3. 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, replace the K20 engine control module.
   - **If greater than 4.7 V**

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6. Connect a 3 A fused jumper wire between the signal circuit terminal 4 and the low reference circuit terminal 3.
7. Verify the scan tool Boost Pressure Sensor voltage parameter is less than 0.2 V.
    - **If 0.2 V or greater**
    1. Ignition/Vehicle Off, disconnect the X2 harness connector at the K20 engine control module.
    2. Ignition On/Vehicle in Service Mode.
    3. 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.
    4. Ignition/Vehicle Off.
    5. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open or high resistance in the circuit.
        - If less than 2 Ω, replace the K20 engine control module.
    - **If less than 0.2 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** - B111B turbocharger boost/intake air temperature sensor.
- **Control Module References** for ECM replacement, programming and setup

DTC P023A-P023C: CHARGE AIR COOLER COOLANT PUMP CONTROL CIRCUIT

Diagnostic Instructions

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

DTC Descriptor

DTC P023A

Charge Air Cooler Coolant Pump Control Circuit

DTC P023B

Charge Air Cooler Coolant Pump Control Circuit Low Voltage

DTC P023C

Charge Air Cooler Coolant Pump Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition	3	1	-	-
Ignition Signal	3	1	-	-
Ground	-	1	-	-
Control	1	2	P023C[2]	-

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Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
1. Charge Air Cooler Coolant Pump inoperative 2. Charge Air Cooler Coolant Pump always ON 3. Opens fuse				

Circuit/System Description

The charge air coolant pump assembly is composed of an electric coolant pump and a control module. The engine control module (ECM) controls the pump using a control circuit and solid-state switch called a output driver. The ECM enables the charge air coolant pump by commanding the driver Off. The charge air coolant pump control module then commands the coolant pump On.

Conditions for Running the DTCs

- The ignition is ON.
- The ignition voltage is 11 V or greater.
- The starter motor is not engaged.
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

P023A

The ECM detects an open circuit condition of the output driver circuit for greater than 2 s.

P023B

The ECM detects a short to ground on the output driver circuit for greater than 2 s.

P023C

The ECM detects a short to voltage on the output driver circuit for greater than 2 s.

Action Taken When the DTC Sets

DTCs P023A, P023B and P023C are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P023A, P023B and P023C are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

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- Wiring Repairs
- Electrical Center Identification Views Electrical Center Identification 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. Command the M10 Charge Air Cooler Coolant Pump On and Off with a scan tool.
3. Verify the scan tool parameters listed below display OK or Not Run in each commanded state.
   - Charge Air Cooler Coolant Pump Relay Control Circuit Open Test Status
   - Charge Air Cooler Coolant Pump Relay Control Circuit Low Voltage Test Status
   - Charge Air Cooler Coolant Pump Relay Control Circuit High Voltage Test Status
   - **If Malfunction**

     Refer to Circuit/System Testing

   - **If OK or Not Run**
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.

   Verify a 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 M10 Charge Air Cooler Coolant Pump.
2. Test for less than 5 Ω between the ground circuit terminal 4 and ground.
   - **If 5 Ω or greater**
   1. Disconnect the chassis ground G104.
   2. Test for less than 2 Ω in the ground circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, repair the open/high resistance in the ground connection.
   - **If less than 5 Ω**
3. Ignition On, verify that a test lamp illuminates between the ignition circuit terminals listed below and ground:
   - Charge Air Cooler Coolant Pump circuit terminal 5
   - Charge Air Cooler Coolant Pump circuit terminal 1
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition Off, remove the test lamp and remove the fuse for the ignition voltage circuit.
   2. Test for less than 2 Ω in the ignition voltage circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**

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

- **If the test lamp illuminates**

4. Perform the scan tool control function:Charge Air Cooler Coolant PumpÂ» On

   Verify a test lamp does not turn On between the test points: B+ Control circuit terminal 3

- **If the test lamp illuminates**

1. Ignition Off and all vehicle systems OFF, it may take up to 2 minutes for all vehicle systems to power down.
2. Disconnect the harness connector X3 at the K20 Engine Control Module.
3. Test for infinite resistance between the control circuit terminal 3 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 test lamp does not illuminate**

5. Command the M10 Charge Air Cooler Coolant Pump Off with a scan tool.
6. Verify the test lamp illuminates.
    - **If the test lamp does not illuminate**

1. Ignition Off, remove the test lamp.
2. Disconnect the harness connector X3 at the K20 Engine Control Module, ignition On.
3. Test for less than 1 V between the control circuit terminal 3 and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V.
4. Ignition Off.
5. Test for less than 2 Ω in the control circuit, end to end.
    - If 2 Ω or greater, repair the open in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If the test lamp illuminates**

7. Replace the M10 Charge Air Cooler Coolant Pump.

Repair Instructions

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

- **Charge Air Cooler Coolant Pump Replacement (LGW)**
- **Control Module References** for ECM replacement, programming and setup.

DTC P0243, P0245-P0247, P0249 OR P0250: TURBOCHARGER WASTEGATE SOLENOID VALVE CONTROL CIRCUIT

Diagnostic Instructions

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

DTC Descriptors

DTC P0243

Turbocharger Wastegate Solenoid Valve Control Circuit Bank 1

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DTC P0245

Turbocharger Wastegate Solenoid Valve Control Circuit Low Voltage Bank 1

DTC P0246

Turbocharger Wastegate Solenoid Valve Control Circuit High Voltage Bank 1

DTC P0247

Turbocharger Wastegate Solenoid Valve Control Circuit Bank 2

DTC P0249

Turbocharger Wastegate Solenoid Valve Control Circuit Low Voltage Bank 2

DTC P0250

Turbocharger Wastegate Solenoid Valve Control Circuit High Voltage Bank 2

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage Control Bank 1	P0689, P1682	P0243, P0245	-	-
Control Bank 1	P0243, P0245	P0243, P0245	P0246	-
Ignition Voltage Control Bank 2	P0689	P0247, P0249	-	-
Control Bank 2	P0247, P0249	P0247, P0249	P0250	-

Circuit/System Description

When the engine is idling the turbocharger wastegate solenoids are open. When the engine load and RPM increase under a wide open throttle, the turbocharger wastegate valves close to increase boost pressure. When the proper level of boost pressure is attained, the ECM will partially open the wastegates to maintain the boost pressure level. When the throttle closes, the ECM commands the wastegates to open to reduce the speed of the turbines.

Conditions for Running the DTC

- The ignition is ON.
- The ignition voltage is 11 V or greater.
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

P0243

The ECM detects an open circuit condition of the turbocharger wastegate solenoid valve control circuit bank 1 for greater than 6 s.

P0245

The ECM detects a short to ground on the turbocharger wastegate solenoid valve control circuit bank 1 for greater than 6 s.

P0246

The ECM detects a short to voltage on the turbocharger wastegate solenoid valve control circuit bank 1 for greater than 6 s.

P0247

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The ECM detects an open circuit condition of the turbocharger wastegate solenoid valve control circuit bank 2 for greater than 6 s.

P0249

The ECM detects a short to ground on the turbocharger wastegate solenoid valve control circuit bank 2 for greater than 6 s.

P0250

The ECM detects a short to voltage on the turbocharger wastegate solenoid valve control circuit bank 2 for greater than 6 s.

Action Taken When the DTC Sets

DTCs P0243, P0245, P0246, P0247, P0249 and P0250 are Type B DTCs.

Conditions for Clearing the DTC

DTCs P0243, P0245, P0246, P0247, P0249 and P0250 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

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- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify the parameters listed below do not display Malfunction when commanding the Turbocharger Wastegate Solenoid Valve between 15-95% with a scan tool.
    - Turbocharger Wastegate Solenoid Valve Control Circuit High Voltage Test Status Bank 1
    - Turbocharger Wastegate Solenoid Valve Control Circuit Open Test Status Bank 1
    - Turbocharger Wastegate Solenoid Valve Control Circuit Low Voltage Test Status Bank 1
    - Turbocharger Wastegate Solenoid Valve Control Circuit High Voltage Test Status Bank 2
    - Turbocharger Wastegate Solenoid Valve Control Circuit Open Test Status Bank 2
    - Turbocharger Wastegate Solenoid Valve Control Circuit Low Voltage Test Status Bank 2
    - **If Malfunction is displayed**

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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.

   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. Ignition OFF, disconnect the harness connector at the appropriate Q42 Turbocharger Wastegate Solenoid Valve, Ignition ON.
2. Verify a test lamp illuminates between the circuit terminal 1 and ground.
   - **If the test lamp does not illuminate**
   1. Ignition OFF, remove the test lamp, disconnect the X3 harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the Q42 Turbocharger Wastegate Solenoid Valve terminal 1 and ground.
      - If less than infinite resistance, repair the short to ground in the circuit.
      - If infinite.
   3. Test for less than 2 Ω in the circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If the test lamp illuminates.**
3. Connect a DMM, set on the diode setting, red lead to terminal 2 and the black lead to ground.
4. Verify the DMM reading is greater than 2.5 V or displays O.L with the Q42 Turbocharger Wastegate Solenoid Valve commanded Off.
   - **If 2.5 V or less**
   1. Ignition OFF and all vehicle systems OFF, It may take up to 2 minutes for all vehicles systems to power down.
   2. Disconnect the harness connector X3 at the K20 Engine Control Module.
   3. Test for infinite resistance between the control circuit terminal 2 and ground.
      - If less than infinite resistance, repair the short to ground in the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.
   - **If greater than 2.5 V or displays O.L**
5. Command the Q42 Turbocharger Wastegate Solenoid Valve On with the a scan tool to 95%.
6. Verify the DMM reading is less than 1 V.
   - **If 1 V or greater**
   1. Ignition OFF
   2. Disconnect the harness connector X3 at the K20 Engine Control Module, ignition ON.
   3. Test for less than 1 V between the Q42 Turbocharger Wastegate Solenoid Valve terminal 2 and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V.
   4. Ignition Off and all vehicle systems Off, it may take up to 2 minutes for all vehicle systems to power down.
   5. Test for less than 2 Ω in the circuit end to end.

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- If 2 Ω or greater, repair the open in the circuit.
- If less than 2 Ω, replace the K20 Engine Control Module.

- **If less than 1 V**

7. Test or replace the Q42 Turbocharger Wastegate Solenoid Valve.

Component Testing

1. Ignition Off, disconnect the harness connector at the appropriate Q42 Turbocharger Wastegate Solenoid Valve.
2. Test for 12-20 Ω between terminal 1/A and terminal 2/B.
   - **If not between 12-20 Ω**

     Replace the Q42 Turbocharger Wastegate Solenoid Valve.

   - **If between 12-20 Ω**
3. Test for infinite resistance between each terminal and the Q42 Turbocharger Wastegate Solenoid Valve housing.
   - **If not infinite resistance**

     Replace the Q42 Turbocharger Wastegate Solenoid Valve.

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

Repair Instructions

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

- **Turbocharger Wastegate Regulator Solenoid Valve Replacement (Bank 1)** **Turbocharger Wastegate Regulator Solenoid Valve Replacement (Bank 2)**
- **Control Module References** for ECM replacement, programming and setup.

DTC P026A: CHARGE AIR COOLER (CAC) LOW EFFICIENCY

Diagnostic Instructions

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

DTC Descriptor

DTC P026A

Charge Air Cooler (CAC) Low Efficiency

Diagnostic Fault Information

IAT Sensor 3

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	P00EA	P00EB	P00EB*	P00EB
Low Reference	-	P00EB, P0236, P0238	P00EB*	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

IAT Sensor 3

Circuit	Short to Ground	Open	Short to Voltage

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Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Ignition ON or Engine Running **Parameter Normal Range:** -39 to +148Â°C (-38 to +298Â°F)			
Signal	150Â°C (302Â°F)	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
Low Reference	-	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.			

Circuit/System Description

The engine control module (ECM) monitors intake air temperature (IAT) sensor 3 signal to calculate the efficiency of the charge air cooler (CAC). The charge air cooler systems' function is to reduce the temperature of the air charge that is heated during the turbocharging process to improve the efficiency and performance of the engine. The intercooler uses conventional coolant that is separate from the engine cooling system.

The IAT sensor 3 is a variable resistor, it is integrated with the B111B Turbocharger Boost/Intake Air Temperature sensor. The sensor is located in the charge air cooler (CAC) housing. It's signal is used by the ECM to measure the temperature of the intake air leaving the CAC. The ECM supplies 5 V to the signal circuit and a ground for the sensor's low reference circuit. The ECM monitors the IAT sensor 3 signal for excessively high or low voltages.

Conditions for Running the DTC

- DTCs P00E9, P00EA, P00EB, P00EC, P0116, P0117, P0118 or P0128, are not set.
- Engine run time is 60 s or longer.
- The ECT is warmer than -10Â°C (+14Â°F).
- This DTC runs continuously when the above conditions exist.

Conditions for Setting the DTC

The ECM detects that the IAT Sensor 3 signal is warmer than 110Â°C (230Â°F), for greater than 1 s.

Action Taken When the DTC Sets

DTC P026A is a Type A DTC.

Conditions for Clearing the DTC

DTC P026A is a Type A DTC.

Diagnostic Aids

- Any leak in the charge air cooler (CAC) coolant system or improper operation of the coolant pump can set this DTC.
- The intercooler system includes a cover, two heat exchangers, water manifold, a CAC radiator and an electric coolant pump. The coolant pump transfers coolant from the radiator, located in front of the condenser and engine cooling system radiator, to the water manifold. Coolant enters the inlet port of the water manifold assembly, is directed into and through the CAC heat exchangers and exits back into the water manifold. Coolant then exits the water manifold outlet port returning to the separate cooling system radiator.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

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Component View Reference

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DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL-38522-A Variable Signal Generator

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

Circuit/System Verification

1. Ignition ON.
2. Verify that DTCs P00E9, P00EA, P00EB, P00EC, P0116, P0117, P0118, P0119, P0128, P023A, P023B, P023C, P0641, P0651, P0697 or P06A3 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 following scan tool parameters are within 15Â°C (27Â°F) of each other.

   NOTE: **To minimize the effects of residual engine heat, perform Steps 3 and 4 of this verification procedure only if the ignition has been OFF for 8 hours or more.**

   - IAT Sensor 3
   - Start-Up ECT
   - **If not within 15Â°C (27Â°F)**

     Refer to Circuit System Testing.

   - **If within 15Â°C (27Â°F)**
4. Engine idling.
5. Verify the following scan tool parameters are between the specified ranges.
   - IAT Sensor 3 Sensor; -38 to +148Â°C (-36 to +298Â°F)
   - ECT Sensor; -38 to +120Â°C (-36 to +248Â°F)
   - **If not between the specified ranges**

     Refer to Circuit System Testing; for further diagnosis of the IAT Sensor 3.

     Refer to **DTC P0117, P0118 or P0119 (LGX)** and/or **DTC P0117, P0118 or P0119 (LGW)** ; for further diagnosis of the ECT Sensor.

   - **If both are between the specified ranges**

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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 operation of the charge air cooler coolant pump

   Refer to **Charge Air Cooler Coolant Pump Diagnosis** for diagnosis.

    - **If a condition exists**

      Repair or replace the component as appropriate.

    - **If no condition exists**
2. Verify that the charge air cooling system is at the proper level, has no coolant leaks and is completely free of air.

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

   NOTE: **Make sure the intercooler system is cool and that the pump is not in the ON position.**

   Refer to **Charge Air Cooling System Draining and Filling (LGW)**

    - **If a condition exists**

      Correct as appropriate.

    - **If no condition exists**
3. Check the integrity of the entire air induction system and verify that none of the conditions listed below exist:
    - A binding or sticking condition when opening or closing the by-pass valve and linkage
    - Loose clamps, cracks or other damage in the air intake duct system
    - A loose or disconnected charge air cooler hose or pipe
    - A restricted or collapsed air intake duct
    - An intake manifold leak
    - A Turbocharger Boost/Intake Air Temperature Sensor 3 seal that is leaking, missing or damaged
    - 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**

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Repair or replace the component as appropriate.

- **If no condition exists**

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

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

   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**
8. Verify the scan tool IAT Sensor 1 parameter is colder than -39Â°C (-38Â°F).
   - **If warmer than -39Â°C (-38Â°F).**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the signal circuit terminal 1 and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 Ω in the signal circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
9. Ignition OFF, install a 3 A fused jumper wire between the signal circuit terminal 1 and the low reference circuit terminal 3, ignition ON.
10. Verify the scan tool IAT Sensor 3 parameter is warmer than 149Â°C (300Â°F).
    - **If colder than 149Â°C (300Â°F).**
    1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit and ground.

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

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

- **If warmer than 149Â°C (300Â°F).**

11. Test or replace the B111B Turbocharger Boost/Intake Air Temperature sensor (IAT Sensor 3).

Component Testing

1. Test the IAT Sensor 3 by varying the sensor temperature while monitoring the air temperature with a thermometer. Compare the readings with the scan tool IAT Sensor 3 parameter. The values should be within 5%.
    - **If not within the specified range**

      Replace the B111B Turbocharger Boost/Intake Air Temperature sensor (IAT Sensor 3).

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

Repair Instructions

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

- **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 P0300-P0306: MISFIRE DETECTED

Diagnostic Instructions

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

DTC P0305

Cylinder 5 Misfire Detected

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DTC P0306

Cylinder 6 Misfire Detected

Circuit/System Description

The engine control module (ECM) uses information from the crankshaft position sensor and the camshaft position sensor to determine when a engine cylinder misfire is occurring. By monitoring variations in the crankshaft rotation speed for each cylinder, the ECM can detect individual cylinder misfire events.

Extreme cylinder misfire events can cause catalytic converter damage. The malfunction indicator lamp (MIL) will flash when the conditions for catalytic converter damage are present. DTCs P0301 through P0306 correspond to cylinders 1 through 6. When the ECM detects that one or more specific cylinders are misfiring, the DTC for the respective misfiring cylinder will set and up to 2 of the corresponding fuel injectors are disabled for a minimum of 30 s. The ECM will then re-enable the fuel injector and, after approximately 200 engine revolutions, will determine if the misfire is still present. If the misfire is still present, the ECM will disable the fuel injector again repeating the process. If the misfire is not present, the fuel injector will remain enabled by the ECM. In Spark Ignition Direct Injection (SIDI) system applications, if a fuel injector fault DTC is set during a misfire event, the ECM will not re-enable the injector.

Conditions for Running the DTC

- DTC P0010, P0011, P0013, P0014, P0016, P0017, P0018, P0019, P0020, P0021, P0023, P0024, P0068, 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.
- DTC P0806, P0807 or P0808 is not set when equipped with manual transmission.
- The engine speed is less than 1, 000 RPM and DTC P0315 is set.
- The engine speed is greater than 1, 500 RPM.
- The crankshaft position and camshaft position sensors are synchronized.
- The engine coolant temperature (ECT) is between -7 and 130Â°C (19-266Â°F).
- If the ECT is colder than -7Â°C (19Â°F) at start-up, this diagnostic will not run until the ECT is between 21-130Â° (70-266Â°F).
- The battery voltage is between 9-32 V.
- The vehicle is not in an acceleration or deceleration condition.
- The ECM is not detecting a rough road signal.
- The fuel level is at least 11%.
- The ECM is not in fuel cut-off or deceleration fuel cut-off mode.

The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

P0300

The ECM detects a crankshaft rotation speed variation indicating a misfire rate sufficient to cause emissions levels to exceed a predetermined value or a misfire rate high enough to cause catalyst damage.

P0301, P0302, P0303, P0304, P0305 or P0306

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-P0306 are Type A DTCs.
- When a catalyst damaging level of misfire is present, the ECM may disable the fuel injectors for up to 2 misfiring cylinders and will flash the malfunction indicator lamp (MIL).

Conditions for Clearing the DTC

DTCs P0300-P0306 are Type A DTCs.

Diagnostic Aids

- A misfire DTC could be caused by an excessive vibration from sources other than the engine. Inspect for the conditions listed below:
  - A tire or wheel that is out of round or out of balance
  - Variable thickness brake rotors
  - An unbalanced drive shaft
  - Certain rough road conditions
  - Transmission operation
  - A damaged or defective accessory drive component or belt
- Observe misfire counters after Active Fuel Management is commanded Off for a sticking lifter.
- High resistance in the circuits of the injectors may set a misfire DTC without setting an injector DTC. Test the injector circuits of the affected cylinder(s) for a high resistance if you suspect a condition.
- If the condition is intermittent, observing the scan tool IC Circuit Test and Fuel Injector Circuit Test Status parameters may help isolate the condition. The circuit test status parameters will change from OK or Not Run to Fault/Malfunction if a condition exists.
- A condition in the heated O2 sensor (HO2S) heater control circuits may set a DTC P0300.

Reference Information

Description and Operation

- **Electronic Ignition System Description**
- **Fuel System Description**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL26792 HEI Spark Tester

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

Circuit/System Verification

NOTE: **Before starting the engine, review the freeze frame failure records data to determine if the misfire sets during a cold start or at operating temperature. If there is a cold start condition and the engine is started, the engine will need to be cooled down before the next attempt to start the engine within the fail conditions.**

1. Engine Running at normal operating temperature.
2. Verify there is no abnormal engine noise.
   - **If abnormal engine noise is present**

     Refer to **Symptoms - Engine Mechanical** .

   - **If abnormal engine noise is not present**

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3. Perform the scan tool **Crankshaft Position Variation Learn** procedure.
4. Verify no DTCs are set.
    - **If any DTCs other than P0300-P0306 are set**

      Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .
    - **If DTC P0300-P0306 is set**

      Refer to Circuit/System Testing.
    - **If no DTCs are set**
5. Verify the scan tool Cylinder 1-6 Current Misfire Counter parameters do not increment.
    - **If increments**

      Refer to Circuit/System Testing.
    - **If does not increment**
6. Engine Running, perform the Cylinder Power Balance Test with a scan tool.
7. Verify the engine speed changes when each injector is disabled and then enabled.
    - **If engine speed does not change**

      Refer to Circuit/System Testing.
    - **If engine speed does change**
8. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
9. Verify the DTC does not set.
    - **If the DTC sets**

      Refer to Circuit/System Testing.
    - **If the DTC does not set**
10. All OK.

Circuit/System Testing

1. Verify none of the conditions listed below exist:
    - Damage, carbon tracking or fluid intrusion of the spark plug boots and/or spark plugs
    - Vacuum hose splits, kinks and incorrect connections
    - Engine vacuum leaks
    - Crankcase ventilation system for vacuum leaks
    - Fuel pressure that is too low or too high. Refer to **Fuel System Diagnosis** .
    - Contaminated fuel. Refer to **Alcohol/Contaminants-in-Fuel Diagnosis** .
    - Exhaust system restrictions
        - **If a condition exists**

          Repair or replace as necessary.
        - **If no conditions exist**
2. Ignition OFF, remove the appropriate T8 Ignition Coil and connect the **EL 26792** to the spark plug boot, engine Cranking.

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

3. Verify the spark output.
    - **If no output or the output is weak**

      Refer to **Electronic Ignition System Diagnosis** .

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- **If the output is good**

4. Ignition OFF.
5. Verify the conditions listed below. Refer to **Ignition System Specifications** .
    - The correct spark plug type
    - The correct spark plug gap
    - The correct spark plug torque
    - **If a condition exists**

      Repair or replace as necessary.

    - **If no conditions exist**
6. Exchange the suspect spark plug with another cylinder that is operating correctly.
7. Engine Running.
8. Verify the scan tool Cylinder 1-6 Current Misfire Counter does not increment for the cylinder where the suspect spark plug was installed.
    - **If increments**

      Replace the spark plug.

    - **If does not increment**
9. Verify the conditions listed below do not exist:
    - 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 - Bank 1**
- **Ignition Coil Replacement - Bank 2**
- **Spark Plug Replacement (Bank 1)** **Spark Plug Replacement (Bank 2)**

Repair Verification

1. Install any components or connectors that have been removed or replaced during diagnosis.
2. Perform any adjustment, programming or setup procedures that are required when a component or module is removed or replaced.
3. Clear the DTCs.
4. Turn OFF the ignition for 60 s.
5. If the repair was related to a DTC, duplicate the Conditions for Running the DTC and use the Freeze Frame/Failure Records, if applicable, in order to verify the DTC does not reset. If the DTC resets or another DTC is present, refer to the **Diagnostic Trouble Code (DTC) List - Vehicle** and perform the appropriate diagnostic procedure.
6. Engine Running, verify the scan tool Cylinder 1-6 Current Misfire Counter parameters do not increment.
    - If the misfire counter parameters increment, a misfire condition still exists.
7. To verify that the performance of the catalytic converter has not been affected by the condition that set this DTC, perform the Repair Verification for DTC P0420 or P0430. Refer to **DTC P0420 or P0430**.

DTC P0315: CRANKSHAFT POSITION SYSTEM VARIATION

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

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DTC Descriptor

DTC P0315

Crankshaft Position System Variation Not Learned

Circuit/System Description

The crankshaft position sensor variation or reluctor ring learn 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 ECM to accurately compensate for reference period variations. This enhances the ability of the ECM to detect misfire events over a wider range of engine speed and load. The compensation values are stored in ECM memory after a learn procedure has been performed.

Conditions for Running the DTC

Engine=Running

Frequency the DTC runs=Continuously - After the running conditions are met

Conditions for Setting the DTC

Crankshaft Position Variation Learn =Not Learned

Actions Taken When the DTC Sets

DTCs listed in the DTC Descriptor Category =Type A DTC

Conditions for Clearing the DTC

DTCs listed in the DTC Descriptor Category =Type B DTC

Diagnostic Aids

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

Reference Information

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References

Circuit/System Verification

1. IgnitionÂ» On / VehicleÂ» In Service Mode
2. Perform the scan tool learn/reset function: **Crankshaft Position Variation Learn**
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.

   Verify the DTC does not set.

   - **If the DTC sets**

     Replace the component: K20 Engine Control Module

   - **If the DTC is not set**
4. All OK.

Repair Instructions

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

For control module replacement, programming and setup, refer to **Control Module References**

DTC P0324, P0326, P0331, P06B6 OR P06B7: KNOCK SENSOR

Diagnostic Instructions

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

DTC Descriptors

DTC P0324

Knock Sensor System Performance

DTC P0326

Knock Sensor Performance Bank 1

DTC P0331

Knock Sensor Performance Bank 2

DTC P06B6

Control Module Knock Sensor Processor 1 Performance

DTC P06B7

Control Module Knock Sensor Processor 2 Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Knock Sensor 1 High Signal	P0327, P06B6	P0325	P0328	P0324*, P0326**
Knock Sensor 2 High Signal	P0332, P06B7	P0330	P0333	P0324*, P0331**
Knock Sensor 1 Low Signal	P0327	P0325	P0328	P0324*, P0326**
Knock Sensor 2 Low Signal	P0332	P0330	P0333	P0324*, P0331**
*Signal Performance High **Signal Performance Low				

Circuit/System Description

The knock sensors enable the engine control module (ECM) to control the ignition timing for the best possible performance while protecting the engine from potentially damaging levels of detonation. The knock sensors produce an alternating current (AC) voltage signal that varies depending on the vibration level during engine operation. The ECM adjusts the spark timing based on the amplitude and the frequency of the two knock sensor signals. The ECM receives each knock sensor signal through a dedicated circuit. The ECM learns a minimum knock sensor noise level for all of the engine speed ranges and monitors the normal knock sensor signal. The ECM monitors the internal knock sensor processor test circuits which perform the open circuit diagnostic.

Conditions for Running the DTCs

P0324

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- Engine is running for 2 s or greater.
- Engine speed is 8, 500 RPM or less.
- Engine air flow is between 200-2, 000 mg per cylinder.
- The engine coolant temperature (ECT) is -40Â°C (-40Â°F) or warmer.
- The intake air temperature (IAT) sensor 1 is -40Â°C (-40Â°F) or warmer.

  AND

- Engine speed is 400 RPM or greater.

  OR

- Engine speed is 8, 500 RPM or less.

P0326 and P0331

- Engine is running for 2 s or greater.
- Engine speed is 8, 500 RPM or less.
- Engine air flow is between 200-2, 000 mg per cylinder.
- The engine coolant temperature (ECT) is -40Â°C (-40Â°F) or warmer.
- The intake air temperature (IAT) sensor 1 is -40Â°C (-40Â°F) or warmer.

  AND

- Engine speed is 400 RPM or greater for 167 or more cumulative revolutions.

  OR

- Engine speed is 8, 500 RPM or less for 100 or more cumulative revolutions.

  OR

- Engine speed is 8, 500 RPM or less for 5 or more cumulative revolutions.

P06B6 and P06B7

- Engine is running for 2 s or greater.
- Engine speed is between 400-4, 000 RPM for 200 or more cumulative revolutions.
- Engine air flow is between 10-2, 000 mg per cylinder.

The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTCs

P0324

The ECM detects that either knock sensor signal performance is out of the normal calibrated range due to excessive engine knock on a per cylinder basis.

P0326

The ECM detects that the knock sensor 1 signal performance is out of the normal calibrated range due to a low signal level.

P0331

The ECM detects that the knock sensor 2 signal performance is out of the normal calibrated range due to a low signal level.

P06B6 and P06B7

The ECM has detected a fault in the knock sensor processor open circuit diagnostic internal test circuit.

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Action Taken When the DTCs Set

- DTCs P0324, P0326, P0331, P06B6 and P06B7 are Type B DTCs.
- The ignition timing is retarded to reduce the potential of engine damaging spark knock.

Conditions for Clearing the DTCs

DTCs P0324, P0326, P0331, P06B6 and P06B7 are Type B DTCs.

Reference Information

Description and Operation

Electronic Ignition System Description

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Engine Running.
2. Verify DTC P0325, P0327, P0328, P0330, P0332, P0333, P06B6 or P06B7 is not set.
    - **If DTC P0325, P0327, P0328, P0330, P0332 or P0333 is set with P06B6 or P06B7**

      Refer to **DTC P0325, P0327, P0328, P0330, P0332 or P0333**.
    - **If only DTC P06B6 or P06B7 is set**

      Replace the K20 Engine Control Module.
    - **If none of the DTCs are set**
3. Ignition OFF.
4. Verify none of the conditions listed below exist:
    - B68 Knock Sensor or wiring harness damage.
    - Incorrect B68 Knock Sensor installation. Refer to **Fastener Specifications** .
    - B68 Knock Sensor and engine mounting surface burrs, casting flash and foreign material.
    - Close proximity of hoses, brackets and engine wiring.
    - Loose brackets.
    - Loose or broken accessory drive belts, brackets, components.
    - An engine mechanical condition. Refer to **Symptoms - Engine Mechanical** .
    - Contaminated or poor quality fuel.
    - **If a condition exists**

      Repair or replace as necessary.
    - **If no conditions exist**
5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
    - **If the DTC sets**

      Test or replace the appropriate B68 Knock Sensor.
    - **If the DTC does not set**
6. All OK.

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Repair Instructions

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

- **Knock Sensor Replacement - Bank 1**
- **Knock Sensor Replacement - Bank 2 (LGW)** **Knock Sensor Replacement - Bank 2 (LGX)**
- **Control Module References** for engine control module replacement, programming and setup.

DTC P0325, P0327, P0328, P0330, P0332 OR P0333: KNOCK SENSOR CIRCUIT

Diagnostic Instructions

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

DTC Descriptors

DTC P0325

Knock Sensor Circuit Bank 1

DTC P0327

Knock Sensor Circuit Low Voltage Bank 1

DTC P0328

Knock Sensor Circuit High Voltage Bank 1

DTC P0330

Knock Sensor Circuit Bank 2

DTC P0332

Knock Sensor Circuit Low Voltage Bank 2

DTC P0333

Knock Sensor Circuit High Voltage Bank 2

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Knock Sensor 1 High Signal	P0327, P06B6	P0325	P0328	P0324*, P0326**
Knock Sensor 2 High Signal	P0332, P06B7	P0330	P0333	P0324*, P0331**
Knock Sensor 1 Low Signal	P0327	P0325	P0328	P0324*, P0326**
Knock Sensor 2 Low Signal	P0332	P0330	P0333	P0324*, P0331**
*Signal Performance High **Signal Performance Low				

Circuit/System Description

The knock sensors enable the engine control module (ECM) to control the ignition timing for the best possible performance while protecting the engine from potentially damaging levels of detonation. The knock sensors produce an alternating current (AC) voltage signal that varies depending on the vibration level during engine operation. The ECM adjusts the spark timing based on the amplitude and the

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frequency of the two knock sensor signals. The ECM receives each knock sensor signal through a dedicated circuit. The ECM learns a minimum knock sensor noise level for all of the engine speed ranges and monitors the normal knock sensor signal. The ECM monitors the internal knock sensor processor test circuits which perform the open circuit diagnostic.

Conditions for Running the DTCs

P0325 and P0330

- Engine is running for 2 s or greater.
- Engine speed is between 400-5, 500 RPM for 100 or more cumulative revolutions.
- Engine air flow is between 10-2000 mg per cylinder.
- The engine coolant temperature (ECT) is -40Â°C (-40Â°F) or warmer.
- The intake air temperature (IAT) sensor 1 is -40Â°C (-40Â°F) or warmer.

P0327, P0328, P0332 and P0333

Engine speed is less than 8, 500 RPM.

The DTCs run continuously when the above conditions are met.

Conditions for Setting the DTCs

P0325

The ECM detects knock sensor 1 signal circuit is open.

P0327

The ECM detects knock sensor 1 signal circuit is shorted to ground.

P0328

The ECM detects knock sensor 1 signal circuit is shorted to voltage.

P0330

The ECM detects knock sensor 2 signal circuit is open.

P0332

The ECM detects knock sensor 2 signal circuit is shorted to ground.

P0333

The ECM detects knock sensor 2 signal circuit is shorted to voltage.

Action Taken When the DTCs Set

- DTCs P0325, P0327, P0328, P0330, P0332 and P0333 are Type B DTCs.
- The ignition timing is retarded to reduce the potential of engine damaging spark knock.

Conditions for Clearing the DTCs

DTCs P0325, P0327, P0328, P0330, P0332 and P0333 are Type B DTCs.

Diagnostic Aids

The following conditions listed below may cause a knock sensor DTC to set:

- Sensor damage.
- Knock sensor and engine mounting surface burrs, casting flash and foreign material.
- Close proximity of hoses, brackets and engine wiring.

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- Loose brackets.
- Loose or broken accessory drive belts, brackets, components.
- An engine mechanical condition. Refer to **Symptoms - Engine Mechanical** .

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) **Engine Controls Schematics (LGX)**

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Electronic Ignition System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Engine Running.
2. Verify DTC P0325, P0327, P0328, P0330, P0332 or P0333, is not set.
   - **If the DTC is set**

     Refer to Circuit/System Testing.

   - **If the DTC is not set**
3. Verify the appropriate B68 Knock Sensor mounting bolt is properly tightened. Refer to **Fastener Specifications** .
   - **If not tightened to the correct specification**

     Repair a necessary.

   - **If tightened to the correct specification**
4. Verify the scan tool parameters listed below display No while moving the related harnesses and connectors of the B68 Knock Sensor.
   - Cylinder 1 Knock Detected
   - Cylinder 2 Knock Detected
   - Cylinder 3 Knock Detected
   - Cylinder 4 Knock Detected
   - Cylinder 5 Knock Detected
   - Cylinder 6 Knock Detected
   - **If No is not displayed**

     Repair the wiring harness or connectors.

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- **If No is displayed**

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

      Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the B68 Knock Sensor, ignition ON.
2. Test for 1-2 V between the low signal circuit terminal 2/B and ground.
    - **If less than 1 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the low signal circuit terminal 2/B and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance.
    3. Test for less than 2 Ω in the low signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If greater than 2 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the low signal circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If between 1-2 V**
3. Test for 2-4 V between the high signal circuit terminal 1/A and ground.
    - **If less than 2 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the high signal circuit terminal 1/A and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance.
    3. Test for less than 2 Ω in the high signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If greater than 4 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the high signal circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If between 2-4 V**
4. Test or replace the B68 Knock Sensor.

Repair Instructions

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

- **Knock Sensor Replacement - Bank 1**

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- Knock Sensor Replacement - Bank 2 (LGW) Knock Sensor Replacement - Bank 2 (LGX)
- Control Module References for engine control module replacement, programming and setup.

DTC P0335 OR P0336: CRANKSHAFT POSITION SENSOR

Diagnostic Instructions

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

- DTC P0651 is not set.
- The engine is running and the starter is not engaged.

Condition 3

- DTCs P0365, P0366, P0641 and P0651 are not set.
- The engine is running or the starter is engaged.

P0336 Condition 1

- DTCs P0335 or P0651 are not set.
- The airflow into the engine is greater than 3 g/s.
- Engine speed is greater than 450 RPM.

Condition 2

- DTC P0651 is not set.
- The engine is running and the starter is not engaged.

Condition 3

- The starter is engaged and the engine control module detects camshaft position sensor pulses.

  Or

- DTCs P0101, P0102 and P0103 are not set.
- The airflow into the engine is greater than 3 g/s.

Condition 4

- DTCs P0365, P0366, P0641 and P0651, are not set.
- The engine is running or the starter is engaged.

The DTCs run continuously once the above conditions are met.

Conditions for Setting the DTC

P0335 Condition 1

The ECM does not detect a crankshaft position sensor pulse for greater than 4 s.

Condition 2

The ECM does not detect a crankshaft position sensor pulse for greater than 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

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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 A DTCs.
- An engine driveability issue occurs after the first failure.
- 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 A DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Electronic Ignition System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

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 (LGW)** and/or **DTC P0641, P0651, P0697 or P06A3 (LGX)**.

   - **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

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Crankshaft Position Sensor.

- **If greater than 0 counts and the engine stumbles or stalls**

  Refer to Circuit/System Testing.

- **If 0 counts and the engine does not stumble or stall**

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

     Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the B26 Crankshaft Position Sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal 2/B and ground.
   - **If 5 Ω or greater**
   1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If 2 Ω or less, replace the K20 Engine Control Module.
   - **If less than 5 Ω**
3. Ignition ON.
4. Test for 4.8-5.2 V between the 5 V reference circuit terminal 1/A and ground.
   - **If less than 4.8 V**
   1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the 5 V reference circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 Ω in the 5 V reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If greater than 5.2 V**
   1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the 5 V reference and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If between 4.8-5.2 V**
5. Test for 4.8-5.2 V between the signal circuit terminal 3/C and ground.
   - **If less than 4.8 V**
   1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the signal circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance.
   3. Test for less than 2 Ω in the signal circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.

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

- **If greater than 5.2 V**

1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module, ignition ON.
2. Test for less than 1 V between the signal circuit and ground.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.

- **If between 4.8-5.2 V**

6. Ignition OFF, connect a 3 A fused jumper wire to the signal circuit terminal 3/C, ignition ON.
7. Verify the scan tool Crankshaft Position Sensor Active Counter parameter increments while rapidly tapping the fused jumper wire end to ground.

NOTE: **Additional DTCs may set when performing this test.**

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

DTC P0340, P0341, P0345, P0346, P0365, P0366, P0390 OR P0391: INTAKE CAMSHAFT POSITION SENSOR

Diagnostic Instructions

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

DTC Descriptors

DTC P0340

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Intake Camshaft Position Sensor Circuit Bank 1

DTC P0341

Intake Camshaft Position Sensor Performance Bank 1

DTC P0345

Intake Camshaft Position Sensor Circuit Bank 2

DTC P0346

Intake Camshaft Position Sensor Performance Bank 2

DTC P0365

Exhaust Camshaft Position Sensor Circuit Bank 1

DTC P0366

Exhaust Camshaft Position Sensor Performance Bank 1

DTC P0390

Exhaust Camshaft Position Sensor Circuit Bank 2

DTC P0391

Exhaust Camshaft Position Sensor Performance Bank 2

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P0107, P0192, P0236, P0237, P0340, P0345, P0365, P0390, P0452, P0522, P0532, P0641, P2228	P0340, P0345, P0365, P0390	P0193, P0236, P0345, P0453, P0506, P0533, P0641, P1101, P2227, P222B	-
Signal	P0340, P0345, P0365, P0390	P0340, P0345, P0365, P0390	P0340, P0345, P0365, P0390	P0341, P0346, P0366, P0391
Low Reference	-	P0340, P0345, P0365, P0390	-	-

Circuit/System Description

The 4 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.

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Conditions for Running the DTC

P0340, P0345, P0365 or P0390 Condition 1

- DTCs P0101, P0102 and P0103 are not set.
- The airflow into the engine is greater than 3 g/s.

  OR

- The starter is engaged and the engine control module detects camshaft position sensor pulses.

Condition 2

- DTC P0651 is not set.
- The engine is running and the starter is not engaged.

Condition 3

- DTC P0335, P0336, P0641 or P0651 are not set.
- The crankshaft is synchronized.
- The starter is engaged.

Condition 4

- DTC P0335, P0336, P0641 or P0651 are not set.
- The crankshaft is synchronized.

P0341, P0346, P0366 or P0391 Condition 1

- DTC P0335, P0336, P0641 or P0651 are not set.
- The crankshaft is synchronized.
- The starter is engaged.

Condition 2

- DTC P0335, P0336, P0641 or P0651 are not set.
- The crankshaft is synchronized.

The DTCs run continuously once the above conditions are met.

Conditions for Setting the DTC

P0340, P0345, P0365 or P0390 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 pulses for greater than 3.0 s.

Condition 3

The ECM does not detect a camshaft position sensor pulse during the first 2 engine revolutions.

Condition 4

The ECM does not detect a camshaft position sensor pulse during 200 engine revolutions.

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P0341, P0346, P0366 or P0391 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.

Condition 2

The ECM detects less than 398 or greater than 402 camshaft position sensor pulses during 200 engine revolutions.

Action Taken When the DTC Sets

- DTCs P0340, P0341, P0345, P0346, P0365, P0366, P0391 and P0390 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 DTC

DTCs P0340, P0341, P0345, P0346, P0365, P0366, P0391 and P0390 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 will not set. Inspect all camshaft position sensor circuits for poor connections.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Electronic Ignition System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information.

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0641 or P0651 is not set.

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

  Refer to **DTC P0641, P0651, P0697 or P06A3 (LGW)** and/or **DTC P0641, P0651, P0697 or P06A3 (LGX)**.

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

3. Engine running.
4. Verify the scan tool parameters listed below increment:
   - Exhaust Camshaft Position Active Counter Bank 1
   - Exhaust Camshaft Position Active Counter Bank 2
   - Intake Camshaft Position Active Counter Bank 1
   - Intake Camshaft Position Active Counter Bank 2
   - **If any counter does not increment**

     Refer to Circuit/System Testing.

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

     Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the appropriate B23 Camshaft Position Sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal 1/A and ground.
   - **If 5 Ω or greater**
   1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If 2 Ω or less, replace the K20 Engine Control Module.
   - **If less than 5 Ω**
3. Ignition ON.
4. Test for 4.8-5.2 V between the 5 V reference circuit terminal 3/C and ground.
   - **If less than 4.8 V**
   1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the 5 V reference circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance.
   3. Test for less than 2 Ω in the 5 V reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If greater than 5.2 V**
   1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module, ignition ON.
   2. Test for less than 1 V between the 5 V reference circuit and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.

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- **If between 4.8-5.2 V**

5. Test for 4.8-5.2 V between the signal circuit terminal 2/B and ground.
    - **If less than 4.8 V**
    1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance.
    3. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If greater than 5.2 V**
    1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If between 4.8-5.2 V**
6. Verify DTC P0341, P0346, P0366 or P0391 is not set.
    - **If any of the DTCs are set**

      Verify the conditions listed below do not exist:

    - 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 a conditions exist, repair as necessary.
        - If none of the condition exist 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 - Bank 1 (Right Side) Exhaust (LGW)** **Camshaft Position Sensor Replacement - Bank 1 (Right Side) Exhaust (LGX)**
- **Camshaft Position Sensor Replacement - Bank 2 (Left Side) Exhaust (LGW)** **Camshaft Position Sensor Replacement - Bank 2 (Left Side) Exhaust (LGX)**
- **Camshaft Position Sensor Replacement - Bank 1 (Right Side) Intake**
- **Camshaft Position Sensor Replacement - Bank 2 (Left Side) Intake (LGW)** **Camshaft Position Sensor Replacement - Bank 2 (Left Side) Intake (LGX)**
- **Control Module References** for engine control module replacement, programming and setup.

DTC P034A OR P034B: CRANKSHAFT POSITION SENSOR

Diagnostic Instructions

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

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DTC Descriptors

DTC P034A

Crankshaft Position Sensor - Engine Start Position Incorrect

DTC P034B

Crankshaft Position Sensor - Crankshaft Direction Incorrect

Circuit/System Description

These DTCs are used to verify that the crankshaft position has been detected correctly and to monitor the number of crankshaft reversals detected from the bi-directional crankshaft position sensor during an auto-start event.

Conditions for Running the DTC

P034A

- DTC P0335, P0336 or P0651 is not set.
- The engine has started rotating during an auto-start event.
- The crankshaft position is being verified.

The DTC runs each time the engine is started once the above conditions are met.

P034B

- DTC P0335, P0336 or P0651 is not set.
- Engine speed is between 400-2000 RPM.
- The airflow into the engine is greater than 1.5 g/s.
- The engine control module (ECM) detects crankshaft position sensor pulses.

The DTCs run continuously once the above conditions are met.

Conditions for Setting the DTC

P034A

- The crankshaft position is incorrect by greater than 2 crankshaft reluctor wheel teeth during 2 out of 3 auto-start events.
- The crankshaft position is incorrect by at least 1 crankshaft reluctor wheel tooth during 4 out of 5 auto-start events.

P034B

The crankshaft position sensor detects 3 or more engine rotation reversals within 10 s or less.

Action Taken When the DTC Sets

DTC P034A and P034B are Type B DTCs.

Conditions for Clearing the DTC

DTC P034A and P034B are Type B DTCs.

Diagnostic Aids

These DTCs do not necessarily indicate there is a condition with the crankshaft position sensor or the engine control module (ECM).

Reference Information

DTC Type Reference

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Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0335, P0336 or P0651 is not set.
   - **If any of the DTCs are set**

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

   - **If none of the DTCs are set**
3. Operate the vehicle within the 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 B26 Crankshaft Position Sensor.

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

Repair Instructions

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

Crankshaft Position Sensor Replacement

DTC P0351-P0356, P2300, P2301, P2303, P2304, P2306, P2307, P2309, P2310, P2312, P2313, P2315 OR P2316: IGNITION COIL CONTROL CIRCUIT

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- **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 P0355

Ignition Coil 5 Control Circuit

DTC P0356

Ignition Coil 6 Control Circuit

DTC P2300

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Ignition Coil 1 Control Circuit Low Voltage

DTC P2301

Ignition Coil 1 Control Circuit High Voltage

DTC P2303

Ignition Coil 2 Control Circuit Low Voltage

DTC P2304

Ignition Coil 2 Control Circuit High Voltage

DTC P2306

Ignition Coil 3 Control Circuit Low Voltage

DTC P2307

Ignition Coil 3 Control Circuit High Voltage

DTC P2309

Ignition Coil 4 Control Circuit Low Voltage

DTC P2310

Ignition Coil 4 Control Circuit High Voltage

DTC P2312

Ignition Coil 5 Control Circuit Low Voltage

DTC P2313

Ignition Coil 5 Control Circuit High Voltage

DTC P2315

Ignition Coil 6 Control Circuit Low Voltage

DTC P2316

Ignition Coil 6 Control Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Coil 1 Control	P0300, P2300	P0300, P0351	P0300, P2301	P0300, P0351
Ignition Coil 2 Control	P0300, P2303	P0300, P0352	P0300, P2304	P0300, P0352
Ignition Coil 3 Control	P0300, P2306	P0300, P0353	P0300, P2307	P0300, P0353
Ignition Coil 4 Control	P0300, P2309	P0300, P0354	P0300, P2310	P0300, P0354
Ignition Coil 5 Control	P0300, P2312	P0300, P0355	P0300, P2313	P0300, P0355
Ignition Coil 6 Control	P0300, P2315	P0300, P0356	P0300, P2316	P0300, P0356

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Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Coil 1 Ground	-	P0300, P0351	-	P0300, P0351
Ignition Coil 2 Ground	-	P0300, P0352	-	P0300, P0352
Ignition Coil 3 Ground	-	P0300, P0353	-	P0300, P0353
Ignition Coil 4 Ground	-	P0300, P0354	-	P0300, P0354
Ignition Coil 5 Ground	-	P0300, P0355	-	P0300, P0355
Ignition Coil 6 Ground	-	P0300, P0356	-	P0300, P0356

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 6 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.

Action Taken When the DTC Sets

DTCs P0351, P0352, P0353, P0354, P0355, P0356, P2300, P2301, P2303, P2304, P2306, P2307, P2309, P2310, P2312, P2313, P2315 and P2316 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P0351, P0352, P0353, P0354, P0355, P0356, P2300, P2301, P2303, P2304, P2306, P2307, P2309, P2310, P2312, P2313, P2315 and P2316 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Electronic Ignition System Description

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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

Special Tools

EL 26792 HEI Spark Tester

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

Circuit/System Verification

1. Engine Running.
2. Verify the scan tool parameters listed below do not display Malfunction:
   - Ignition Coil 1-6 Control Circuit High Voltage Test Status
   - Ignition Coil 1-6 Control Circuit Low Voltage Test Status
   - Ignition Coil 1-6 Control Circuit Open Test Status
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing.

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

     Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the harness connector at the appropriate T8 Ignition Coil. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the ground circuit terminal 1/A and ground.
   - **If 5 Ω or greater**
   1. Ignition OFF.
   2. Test for less than 2 Ω in the ground circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, repair the open/high resistance in the ground connection.
   - **If less than 5 Ω**
3. Verify the scan tool Ignition Coil Control Circuit Low Voltage Test Status does not display Malfunction.
   - **If Malfunction is displayed**

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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**

4. Verify the scan tool Ignition Coil Control Circuit High Voltage Test Status does not display Malfunction.
    - **If Malfunction is displayed**
    1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
    2. Test for less than 1 V between the control circuit and ground.
        - If 1 V or greater, repair the short to voltage in the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If Malfunction is not displayed**
5. Ignition OFF, install a 3 A fused jumper wire between the control circuit terminal 3/C and ground, engine Running.
6. Verify the scan tool Ignition Coil Control Circuit Low Voltage Test Status displays Malfunction.
    - **If Malfunction is not displayed**
    1. Ignition OFF, remove the fused jumper and disconnect the X3 harness connector at the K20 Engine Control Module.
    2. Test for less than 2 Ω in the control circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If Malfunction is displayed**
7. 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 - Bank 1**
- **Ignition Coil Replacement - Bank 2**
- **Control Module References** for engine control module replacement, programming and setup.

DTC P0420 OR P0430: CATALYST SYSTEM LOW EFFICIENCY

Diagnostic Instructions

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

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DTC Descriptor

DTC P0420

Catalyst System Low Efficiency Bank 1

DTC P0430

Catalyst System Low Efficiency Bank 2

Circuit/System Description

A 3-way catalyst controls emissions of hydrocarbons, carbon monoxide (CO) and nitrogen oxide (NOx). The catalyst within the converter promotes a chemical reaction, which oxidizes the hydrocarbons and the CO that are present in the exhaust gas. This process converts the hydrocarbons and the CO into water vapor and carbon dioxide (CO2) and reduces the NOx, converting the NOx into nitrogen. The catalyst also stores oxygen. The engine control module (ECM) monitors this process by using heated oxygen sensors (HO2S) that are in the exhaust stream before and after the 3-way catalyst. The HO2S produces an output signal that the ECM uses to calculate the oxygen storage capacity of the catalyst. This indicates the ability of the catalyst to convert the exhaust emissions efficiently. The ECM monitors the efficiency of the catalyst by monitoring the HO2S during an off-idle, decel fuel cut off (DFCO) event. When the catalyst is functioning properly, the post catalyst HO2S response to the fuel conditions during the DFCO event is slow compared to the response of the pre catalyst HO2S. When the post HO2S response is near that of the pre HO2S, the oxygen storage capability and efficiency of the catalyst may be degraded below an acceptable threshold.

Conditions for Running the DTC

- DTC P0030, P0031, P0032, P0036, P0037, P0038, P0050, P0051, P0052, P0053, P0054, P0056, P0057, P0058, P0059, P0060, P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0116, P0117, P0118, P0119, P0121, P0122, P0123, P0128, P0131, P0132, P0133, P0135, P0137, P0138, P013A, P013B, P013C, P013D, P013E, P013F, P0141, P014A, P014B, P0151, P0152, P0153, P0155, P0157, P0158, P015A, P015B, P015C, P015D, P0161, P0171, P0172, P0174, P0175, P0201, P0202, P0203, P0204, P0205, P0206, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282, P0283, P0300, P0301, P0302, P0303, P0304, P0305, P0306, P1248, P1249, P124A, P124B, P124C, P124D, P16F3, P2101, P2135, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216C, P216E, P216F, P2270, P2271, P2272 or P2273 is not set.
- Engine speed is between 1, 150-2, 650 RPM to enable the catalyst diagnostic. Once the engine speed is in range, the engine speed must be between 1, 100-2, 750 RPM to keep the test enabled.
- Accelerator pedal position is less than or equal to 4%.
- Ethanol estimation is not active.
- Evaporative emission (EVAP) purge is not active.
- Post HO2S heaters are ON for greater than 60 s.
- Mass air flow (MAF) is between 3-16 g/s.
- System voltage is greater than 10 V.
- Vehicle speed is between 42-80 km/h (26-50 MPH) to enable the catalyst diagnostic. To keep the test enabled the vehicle speed is between 39-82 km/h (24-51 MPH).
- Catalyst calculated temperature is between 500-880Â°C (932-1, 616Â°F).
- Engine is operating in closed loop.
- Engine is operating in decel fuel cut off (DFCO).

This diagnostic attempts one test during each valid OFF-idle period once the above conditions have been met. This diagnostic attempts up to 3 tests during each drive cycle.

Conditions for Setting the DTC

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

Action Taken When the DTC Sets

DTC P0420 and P0430 are Type A DTCs.

Conditions for Clearing the DTC

DTC P0420 and P0430 are Type A DTCs.

Diagnostic Aids

Inspect for the following conditions, which may cause a catalytic converter to degrade:

- Engine misfire
- High engine oil or high coolant consumption
- Retarded spark timing
- Weak or poor spark
- Lean fuel mixture
- Rich fuel mixture
- Damaged oxygen sensor or wiring harness

Reference Information

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition On.
2. Verify there are no other DTCs set.
    - **If other DTCs are set**

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

    - **If no other DTCs are 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. Verify the Catalyst Monitor Test Result Bank 1 and Bank 2 parameters display Passed when performing the steps listed below:
    1. Monitor the scan tool Catalyst Monitor Test State parameter. When the parameter indicates Active, the Catalyst Monitor Test is running.
    2. Continue to monitor the parameter. When the parameter indicates Inactive, the Catalyst Monitor Test has completed.

       NOTE: **When the test has completed, the Catalyst Monitor Test Counter Bank 1 and Bank 2 parameters will increment by one and the Catalyst Monitor Test Result Bank 1 and Bank 2 parameters will indicate Passed, Failed or No Result.**

    3. Verify the scan tool Catalyst Monitor Test Result Bank 1 and Bank 2 parameter displays Passed.
    - **If No Result is displayed**

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Repeat steps 3-5 until the Test Result parameters indicate Passed or Failed

- **If Failed is displayed**

  Refer to Circuit/System Testing

- **If Passed is displayed**

6. All OK.

Circuit/System Testing

1. Verify the conditions listed below do not exist with the appropriate 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
   - Restrictions
   - Physical damage
   - Loose or missing hardware
     - **If a condition is found**

       Repair or replace the component as necessary.

     - **If no condition is found**
3. Verify the conditions listed below do not exist with the appropriate B52B Heated Oxygen Sensor 2:
   - 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. Replace the catalytic converter.

Repair Instructions

- **Warm Up Three-Way Catalytic Converter Replacement (Left, LGW) Warm Up Three-Way Catalytic Converter Replacement (Right, LGW) Warm Up Three-Way Catalytic Converter Replacement (Left, LGX) Warm Up Three-Way Catalytic Converter Replacement (Right, LGX) Warm Up Three-Way Catalytic Converter Replacement (LTG)**
- **Exhaust Leakage**
- **Heated Oxygen Sensor Replacement - Bank 1 Sensor 2**
- **Heated Oxygen Sensor Replacement - Bank 2 Sensor 2**
- Perform the HO2S Heater Learn procedure with a scan tool after replacing a heated oxygen sensor.
- **Restricted Exhaust**

Repair Verification

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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. Verify the Catalyst Monitor Test Result Bank 1 and Bank 2 parameters display Passed when performing the steps listed below:
    1. Monitor the scan tool Catalyst Monitor Test State parameter. When the parameter indicates Active, the Catalyst Monitor Test is running.
    2. Continue to monitor the parameter. When the parameter indicates Inactive, the Catalyst Monitor Test has completed.

       NOTE: **When the test has completed, the Catalyst Monitor Test Counter Bank 1 and Bank 2 parameters will increment by one and the Catalyst Monitor Test Result Bank 1 and Bank 2 parameters will indicate Passed, Failed or No Result.**

    3. Verify the scan tool Catalyst Monitor Test Result Bank 1 and Bank 2 parameter displays Passed.
    - **If No Result is displayed**

      Repeat steps 5-7 until the Test Result parameters indicate Passed or Failed

    - **If Failed is displayed**

      Refer to Circuit/System Testing

    - **If Passed is displayed**
8. All OK.

DTC P0442: EVAPORATIVE EMISSION (EVAP) SYSTEM SMALL LEAK DETECTED

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- **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 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 sensor input. With a leak in the system, the amount of pressure change will be less than that of a sealed system.

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Conditions for Running the DTC

- DTCs P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0125, P012B, P012C, P012D, P0128, P0443, P0446, P0449, P0452, P0453, P0455, P0496, P0502, P0503, P0722, P0723, P2227, P2228, P2229, P2610 are not set.
- The barometric pressure (BARO) is greater than 70 kPa.
- The engine coolant sensor (ECT) is greater than 70Â°C (158Â°F)
- No key cycle during engine off natural vacuum or test will abort.
- The fuel level is between 10-90%.
- The start-up engine coolant temperature (ECT) and the start-up intake air temperature (IAT) are within 8Â°C (14Â°F).
- The engine run time before shut-off was greater than 10 min.
- The drive distance before engine shut-off was more than 8 km (5 mi).
- The ambient air temperature at the end of the drive cycle is between 0-34Â°C (32-93Â°F).
- DTC P0442 runs once per drive cycle during the hot soak period after the ignition is turned OFF and may require up to 40 min to complete. The controller will not make more than 2 test attempts per day. The time since the last completed engine off natural vacuum test must be at least 17 h if passed or 10 h if failed.

Conditions for Setting the DTC

- The ECM detects a leak in the EVAP system that is greater than a calibrated amount.
- The ECM must complete several engine off natural vacuum tests before the diagnostic can turn the MIL on or off.

Action Taken When the DTC Sets

DTC P0442 is a Type A DTC.

Conditions for Clearing the DTC

DTC P0442 is a Type A DTC.

Diagnostic Aids

- The EVAP system can be filled with smoke more quickly and completely by opening the system opposite the end where the smoke is injected. When injecting smoke at the service port tool remove the fuel fill cap or temporarily leave the EVAP Vent Solenoid Valve open, until smoke is observed then close the system and continue testing. If using a fuel cap adapter at the filler neck, use the **EN-41413-VLV** at the service port to allow the system to fill faster.
- To help locate intermittent leaks using the **GE 41413-A** , move all EVAP components while observing smoke with the **GE 41413-SPT** .
- Individual components can be isolated and tested using adapters in the **GE 41413-300** .
- 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 EVAP Purge/Seal function to create a vacuum in the EVAP system and then observe the Fuel Tank Pressure Sensor parameter for vacuum decay.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

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Powertrain Component View

Powertrain Component Views

Description and Operation

Evaporative Emission Control System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

- **CH 48096** EVAP Service Port Access Tool
- **EN 41413-VLV** EVAP Service Port Vent Fitting
- **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)** and/or **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 or Not Venting with a scan tool to seal the EVAP system.
4. Use the flow meter on the **GE 41413-A** calibrated to 0.51 mm (0.020 in) to determine if there is a leak.
    - **If a leak is detected**
    1. Use the **GE 41413-A** to apply smoke to the EVAP system at the purge tube 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.

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Repair Instructions

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

DTC P0443, P0458 OR P0459: EVAPORATIVE EMISSION (EVAP) PURGE SOLENOID VALVE CONTROL CIRCUIT

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- **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, P0458	P0459, P0690

Circuit/System Description

The evaporative emission (EVAP) purge solenoid valve is used to purge fuel vapor from the EVAP canister to the intake manifold. The EVAP purge solenoid valve is pulse width modulated (PWM). Ignition voltage is supplied directly to the EVAP purge solenoid valve. The engine control module (ECM) controls the solenoid valve by grounding the control circuit with a solid state device called a driver. The driver is equipped with a feedback circuit that is pulled-up to a voltage. The ECM can determine if the control circuit is open, shorted to ground or shorted to a voltage by monitoring the feedback voltage. 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.

Diagnostic Aids

- 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.
- Verify the EVAP Purge Solenoid Valve control circuit parameters do not display Malfunction when moving the related harnesses and connectors of the Q12 Evaporative Emission Purge Solenoid Valve.
- Use a hand vacuum pump to verify the purge solenoid actually flows vacuum during the dynamic testing.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Evaporative Emission Control System Description

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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, verify DTC P0690 is not set.
   - **If the DTC is set**

     Refer to **DTC P0685-P0687, P0689, P0690 or P1682 (LGX)DTC P0685-P0687, P0689, P0690 or P1682 (LGW)**

   - **If the DTC is not set**
2. Verify the control circuit status parameters listed below do not display Malfunction while commanding the EVAP Purge Solenoid Valve from 0% to 50% and back to 0% with a scan tool:
   - EVAP Purge Solenoid Valve Control Circuit Open Test Status
   - EVAP Purge Solenoid Valve Control Circuit Low Voltage Test Status
   - EVAP Purge Solenoid Valve Control Circuit High Voltage Test Status
   - **If Malfunction is displayed**

     Refer to Circuit/System Testing

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- **If Malfunction is not displayed**

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

     Refer to Circuit/System Testing

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

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the 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 Ω in the ignition circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse
   - **If the test lamp does not illuminate and the circuit fuse is open**
   1. Ignition OFF, remove the test lamp.
   2. Test for infinite resistance between the ignition circuit and ground
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, test all components connected to the ignition voltage circuit for a short and replace as necessary.
   - **If the test lamp illuminates**
3. Verify that a test lamp does not illuminate between the ignition circuit terminal 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**

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

- **If Malfunction is displayed**

8. Test or replace the Q12 Evaporative Emission Purge Solenoid Valve.

Component Testing

Static Test

1. Ignition OFF, disconnect the harness connector at the Q12 Evaporative Emission Purge Solenoid Valve.
2. Test for 10-30 Ω between the control terminal B or 2 and the ignition circuit terminal A or 1.
    - **If not between 10-30 Ω**

      Replace the Q12 Evaporative Emission Purge Solenoid Valve.

    - **If between 10-30 Ω**
3. All OK.

Dynamic Test

1. Ignition OFF, disconnect the harness connector at the Q12 Evaporative Emission Purge Solenoid Valve.
2. Install a 3 A fused jumper wire between the ignition, terminal 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 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 (LGW)** **Evaporative Emission Canister Purge Solenoid Valve Replacement (LGX)**
- **Control Module References** for ECM replacement, programming and setup.

DTC P0446: EVAPORATIVE EMISSION (EVAP) VENT SYSTEM PERFORMANCE

Diagnostic Instructions

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

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Fuel Tank Pressure Sensor Signal Voltage	Fuel Tank Pressure
1.5 V	Atmospheric Pressure / BARO
Less than 1.5 V	Positive Pressure
Greater than 1.5 V	Negative Pressure / Vacuum

Circuit/System Description

This DTC tests the evaporative emission (EVAP) system for a restricted or blocked EVAP vent path that would cause excess amounts of vacuum to be developed in the EVAP system. The engine control module (ECM) commands the EVAP purge solenoid valve Open and the EVAP vent solenoid valve Closed. This allows vacuum to be applied to the EVAP system. Once a calibrated vacuum level has been reached, the ECM commands the EVAP purge solenoid valve Closed and the EVAP vent solenoid valve Open. The ECM monitors the fuel tank pressure (FTP) sensor for a decrease in vacuum. If the vacuum does not decrease to near 0 in H2O in a calibrated time, this DTC sets.

The 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

- DTC P0068, P00C8, P00C9, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0121, P0122, P0123, P0128, P0191, P0192, P0193, P0222, P0223, P0443, P0601, P0604, P0606, P16A0, P16A1, P16A2, P16F3, P2101, P2135, P2176, is not set.
- The ignition voltage is between 11-32 V.
- The start up IAT is between 4-30Â°C (39-86Â°F).
- The start up ECT is less than 35Â°C (95Â°F)
- The barometric pressure (BARO) is greater than 70 kPa.
- The fuel level is between 10-90%.
- This test will start and run once per cold start for no greater than 17 min.

Conditions for Setting the DTC

NOTE: **There are two stages to setting this DTC. Stage one, prep test, then stage two test.**

- If the fuel tank pressure sensor reading is less than -3.0 kPa (-12 in) H2O of vacuum for 5 s before 6 L (1.6 gal) of purge volume.

  OR

- If the fuel tank pressure sensor reading is greater than 0.62 kPa (2.5 in) H2O of pressure or less than -1.24 kPa (-5 in) H2O of vacuum for 60 s.
- After setting the DTC for the first time, 2 L (0.5 gal) of fuel must be consumed before setting the DTC for the second time.

Action Taken When the DTC Sets

DTC P0446 is a Type B DTC.

Conditions for Clearing the DTC

DTC P0446 is a Type B DTC.

Diagnostic Aids

An intermittent condition could be caused by:

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- A damaged EVAP vent housing
- A temporary blockage at the EVAP vent solenoid valve inlet
- A pinched vent hose
- A blockage in the vent system may also cause a poor fuel fill problem.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Powertrain Component View

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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.

Special Tools

- **CH 41415-30** Fuel Tank Cap Adapter
- **GE 41413-A** Evaporative Emissions System Tester
- **GE 41415-60** Engine Induction System Leak Test Adapter/Capless Fuel Fill Adapter

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

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0449 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 or install GE 41415-60 for capless vehicles. Ignition ON.
4. Verify the scan tool Fuel Tank Pressure Sensor voltage parameter is within 1.3-1.7 V.
   - **If not between the 1.3-1.7 V**

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Refer to P0452, P0453 within **DTC P0451-P0454**.

- **If between the 1.3-1.7 V**

5. Install the fuel tank filler cap or remove the GE 41415-60. 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. Verify a blockage or restriction does not exist in the EVAP system components listed below.
   - Evaporative Emission Vent System Hoses
   - Evaporative Emission Canister
   - Q13 Evaporative Emission Vent Solenoid Valve
   - Evaporative Emission Vent Filter
   - **If a condition exists**

     Repair or replace the component as necessary

   - **If none of the conditions exist**
2. Reconnect all previously disconnected EVAP hardware.

NOTE: **Refer to the GE 41413-A operation manual for detailed instructions in Evaporative Emission System Diagnosis.**

3. Remove the fuel fill cap and connect the CH 41415-30 to the fuel tank filler neck or install GE 41415-60 on capless fuel fill vehicles. Connect the GE 41413-A to the CH 41415-30 or GE 41415-60.
4. Ignition ON, command the EVAP Purge/Seal function to System Seal or Not Venting with a scan tool to seal the EVAP system.
5. Turn the nitrogen/smoke valve on the GE 41413-A to nitrogen.

NOTE: **DO NOT exceed the specified value in this step. Exceeding the specified value may produce incorrect test results.**

6. Use the remote switch to activate the GE 41413-A and pressurize the fuel tank to 5.0 in H20.
7. Verify the scan tool Fuel Tank Pressure Sensor parameter is 0 in H20 when commanding the EVAP Vent Solenoid Valve to OFF or Venting.
   - **If not 0 in H20**
   1. Ignition OFF
   2. Verify a blockage or a restriction does not exist in the EVAP vent hose or inlet.

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- **If a condition exists**

  Repair or replace the component as necessary

- **If none of the conditions exist**

  Replace the Q13 Evaporative Emission Vent Solenoid Valve

- **If 0 in H20**

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

     Refer to step 1 above.

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

Repair Instructions

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

- **Evaporative Emission Canister Vent Solenoid Valve Replacement**
- **Evaporative Emission Canister Replacement**
- **Fuel Tank Pressure Sensor Replacement**

DTC P0449, P0498 OR P0499: EVAPORATIVE EMISSION (EVAP) VENT SOLENOID VALVE CONTROL CIRCUIT

Diagnostic Instructions

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

Battery voltage is supplied to the evaporative emission (EVAP) vent solenoid valve through a fuse. The engine control module (ECM) grounds the EVAP vent solenoid valve control circuit through an internal switch called a driver. The ECM monitors the status of the driver. A scan tool will display the commanded state of the EVAP vent solenoid valve as ON (Not Venting) or OFF (Venting).

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Conditions for Running the DTC

The DTCs run continuously once the above conditions are met.

Conditions for Setting the DTC

P0449

The ECM detects the EVAP Vent Solenoid Valve control circuit is open within 0.25 s.

P0498

The ECM detects the EVAP Vent Solenoid Valve control circuit is shorted to ground within 0.25 s.

P0499

The ECM detects the EVAP Vent Solenoid Valve control circuit is shorted to voltage within 0.25 s.

Action Taken When the DTC Sets

DTC P0449, P0498 and P0499 are Type B DTCs.

Conditions for Clearing the DTC

DTC P0449, P0498 and P0499 are Type B DTCs.

Diagnostic Aids

- An audible click may be heard when performing verification step 2 below.
- Verify the EVAP Vent Solenoid Valve control circuit parameters do not display Malfunction when moving the related harnesses and connectors of the Q13 Evaporative Emission Vent Solenoid Valve

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

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

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Circuit/System Verification

1. Ignition ON.
2. Verify the control circuit status parameters listed below do not display Malfunction while commanding the EVAP Vent Solenoid Valve to ON (Not Venting) and OFF (Venting) with a scan tool:
    - EVAP Vent Solenoid Valve Control Circuit Open Test Status
    - EVAP Vent Solenoid Valve Control Circuit Low Voltage Test Status
    - EVAP Vent Solenoid Valve Control Circuit High Voltage Test Status
    - **If Malfunction is displayed**

      Refer to Circuit/System Testing

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

      Refer to Circuit/System Testing

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

Circuit/System Testing

1. Ignition OFF, disconnect the harness connector at the Q13 Evaporative Emission Vent Solenoid Valve, Ignition ON,
2. Verify that a test lamp illuminates between the B+ circuit terminal A or 2 and ground.
    - **If the test lamp does not illuminate and the circuit fuse is good**
    1. Ignition OFF, remove the test lamp.
    2. Test for less than 2 Ω in the B+ circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.
    - **If the test lamp does not illuminate and the circuit fuse is open**
    1. Ignition OFF, remove the test lamp.
    2. Test for infinite resistance between the B+ circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance, test all components connected to the B+ circuit for a short and replace as necessary.
    - **If the test lamp illuminates**
3. Verify that a test lamp does not illuminate between the B+ circuit terminal A or 2 and the control circuit terminal B or 1.
    - **If the test lamp illuminates**
    1. Ignition OFF, remove the test lamp, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the control circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance, replace the K20 Engine Control Module.
    - **If the test lamp does not illuminate**
4. Remove the test lamp.
5. Verify the scan tool EVAP Vent Solenoid Valve Control Circuit High Voltage Test Status parameter is OK when commanding the EVAP Vent Solenoid Valve to ON (Not Venting) with a scan tool.

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- **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 Ω in the control circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω replace the K20 Engine Control Module.

    - **If Malfunction is displayed**

8. Test or replace the Q13 Evaporative Emission Vent Solenoid Valve.

Component Testing

1. Ignition OFF, disconnect the harness connector at the Q13 Evaporative Emission Vent Solenoid Valve.
2. Test for 10-30 Ω between the control terminal B or 1 and the B+ circuit terminal A or 2.
    - **If not between 10-30 Ω**

      Replace the Q13 Evaporative Emission Vent Solenoid Valve.

    - **If between 10-30 Ω**
3. All OK.

Repair Instructions

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

- **Evaporative Emission Canister Vent Solenoid Valve Replacement**
- **Control Module References** for ECM replacement, programming and setup

DTC P0451-P0454: FUEL TANK PRESSURE SENSOR

Diagnostic Instructions

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

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Fuel Tank Pressure Sensor Circuit High Voltage

DTC P0454

Fuel Tank Pressure Sensor Circuit Intermittent

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
5 V Reference	P018C, P0192, P0452, P0522, P0532, P0641, P2227, P2228	P0451	P0446, P0452	P018D, P0193, P0453, P0523, P0641, P2227	-
Signal	P0452	P0451	P0452, P0453	P0453	P0451, P0454
Low Reference	-	P0446, P0451	P0446, P0453, P0463	-	P0451

Typical Scan Tool Data

Fuel Tank Pressure Sensor Voltage

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Ignition ON, Engine OFF **Parameter Normal Range:** 1.3-1.7 V			
5 V Reference	0 V	0 V	4.2-5 V
Signal	0 V	0 V	5 V
Low Reference	-	4.96 V	-

Circuit/System Description

The fuel tank pressure sensor measures vapor pressure or vacuum in the evaporative emission (EVAP) system. The engine control module (ECM) supplies a 5 V reference and a low reference circuit to the fuel tank pressure sensor. The fuel tank pressure sensor signal voltage varies depending on EVAP system pressure or vacuum. The controller also uses this fuel tank pressure signal to determine atmospheric pressure for use in the engine-off small leak test, DTC P0442. Before using this signal as an atmospheric reference it must first be re-zeroed.

Conditions for Running the DTC

P0451

- DTC P0451 runs only when the engine-off natural vacuum small leak test, P0442, executes.
- The number of times this test runs can range from 0-2 per engine-off period. The length of the test can be up to 10 min.

P0452 and P0453

DTC P0452 and P0453 run continuously when the ignition is ON.

P0454

- DTC P0454 runs only when the engine-off natural vacuum small leak test, P0442, executes.
- This test can run once per engine-off period. The length of the test can be up to 10 min.
- A refueling event is not detected. A refueling event is confirmed if the fuel level has a persistent change of 10% for 30 s during a 10 min refueling rationality test.

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Conditions for Setting the DTC

P0451

This DTC will set if the controller is unable to re-zero the fuel tank pressure sensor voltage within a calibrated range during the engine-off small leak test, P0442.

P0452

The fuel tank pressure sensor voltage is less than 0.15 V for more than 10 s.

P0453

The fuel tank pressure 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 fuel tank pressure signal change, other than a refueling event, this DTC will set. An abrupt change is defined as a change of greater than 0.45 in H2O in the span of 1 s but less than 1 in H2O in 12.5 ms. This test must fail twice to set this DTC.

Action Taken When the DTC Sets

- DTCs P0451 and P0454 are Type A DTCs.
- DTCs P0452 and P0453 are Type B DTCs.

Conditions for Clearing the MIL/DTC

- DTCs P0451 and P0454 are Type A DTCs.
- DTCs P0452 and P0453 are Type B DTCs.

Diagnostic Aids

P0451 and P0454

- A restriction in the EVAP canister or vent lines could prevent fuel vapor pressure from bleeding off fast enough. If the vent system cannot bleed off pressure fast enough, the re-zero procedure may not complete successfully, which could cause this code to set.
- Ensure that the reference port on the fuel tank pressure sensor is unobstructed.
- A fuel tank pressure 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 or review the data to look for erratic sensor operation. A similar test can be done for the pressure side of the sensor operation by applying pressure with the **GE 41413-A** while taking a snapshot or reviewing stored data.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

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

Special Tools

- **GE 41413-A** Evaporative Emission System Tester (EEST)
- **GE 41415-60** Engine Induction System Leak Test Adapter/Capless Fuel Fill Adapter

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

Circuit/System Verification

1. Remove the fuel cap or install GE 41415-60 for capless fuel fill vehicles.
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. Disconnect the harness connector at the B150 Fuel Tank Pressure Sensor. This may take up to 2 min, for all vehicle systems to power down..
2. Test for less than 5 Ω of resistance between the low reference circuit terminal 2 and ground.
    - **If 5 Ω or greater**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for less than 2 Ω in the low reference circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If less than 5 Ω**
3. Ignition ON.
4. Test for 4.8-5.2 V between the 5 V reference circuit terminal 3 and ground.
    - **If less than 4.8 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the 5 V reference circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 Ω in the 5 V reference circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.

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

- **If greater than 5.2 V**

1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, Ignition ON.
2. Test for less than 1 V between the 5 V reference circuit and ground.

- If 1 V or greater, repair the short to voltage on the circuit.
- If less than 1 V, replace the K20 Engine Control Module.
- **If between 4.8-5.2 V**

5. Verify the scan tool Fuel Tank Pressure 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 1 and ground.

- If 1 V or greater, repair the short to voltage on the circuit.
- If less than 1 V, replace the K20 Engine Control Module.
- **If less than 0.2 V**

6. Install a 3 A fused jumper wire between the signal circuit terminal 1 and the 5 V reference circuit terminal 3.
7. Verify the scan tool Fuel Tank Pressure Sensor parameter is greater than 4.7 V.

- **If 4.7 V or less**

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

- If 2 Ω or greater, repair the open/high resistance in the circuit.
- If less than 2 Ω, replace the K20 Engine Control Module.
- **If greater than 4.7 V**

8. Test or replace the B150 Fuel Tank Pressure Sensor.

Repair Instructions

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

- **Control Module References** for ECM replacement, programming and setup
- **Fuel Tank Pressure Sensor Replacement**

DTC P0455: EVAPORATIVE EMISSION (EVAP) SYSTEM LARGE LEAK DETECTED

Diagnostic Instructions

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

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system. The ECM monitors the fuel tank pressure sensor voltage to verify that the system is able to reach a calibrated level of vacuum before a calibrated amount of purge volume has passed through the system.

Conditions for Running the DTC

- DTCs P0068, P00C8, P00C9, P00CA, P0090, P0091, P0092, P0106, P0107, P0108, P0111, P0112, P0113, P0114 P0116, P0117, P0118, P0122, P0123, P0125, P0128, P0191, P0192, P0193, P0222, P0223, P06A3, P06DB, P06DE, P0A1D, P160D, P160E P1682, P16A0, P16A1, P16A2, P16F3, P1104, P127A, P127C, P127D, P15F2, P0443, P0449, P0452, P0453, P0502, P0503, P0601, P0604, P0606, P0697, P2100, P2101, P2102, P2103, P2122, P2123, P2127, P2128, P2135, P2138, P215B, P2176, P228C, P228D, U0073, U0074, U0293 or U1817 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 8Â°C (14Â°F).
- The startup engine coolant temperature (ECT) is less than 35Â°C (95Â°F).
- The startup intake air temperature (IAT) is between 4-34Â°C (39-93Â°F).
- DTC P0455 runs once per cold start, shortly after purge is enabled followed by vent system performance test P0446.

Conditions for Setting the DTC

- The EVAP system is not able to achieve or maintain a calibrated level of vacuum less than -2.74 kPa (-11 in H20) before a calibrated amount of purge volume has passed through the system.
- After setting the DTC for the first time, 2 L (0.5 gal) of fuel must be consumed before setting the DTC for the second time.
- With a DTC P0455 detected a weak vacuum follow-up test (fuel cap replacement test) will run and passes if tank vacuum is greater than 2.74 kPa (11 in H20). This test will run for a maximum of 22 min. This test runs until it passes.

NOTE: **The weak vacuum follow-up test and Driver Information Center message is disabled on capless fuel fill systems.**

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.
- On capless fuel fill systems inspect for damaged seals on the flapper valves.
- Inspect for a damaged fuel filler neck and 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 or capless fuel fill adapter at the filler neck, use the **J 41413-VLV** at the service port to allow the system to fill faster.
- To help locate intermittent leaks using the **GE 41413-A** , move all EVAP components while observing smoke with the **GE 41413-SPT** .
- Individual components can be isolated and tested using adapters in the **J 41413-300** .

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- When servicing the EVAP system, test pressure must not exceed 13 in H20 (0.5 PSI) as pressure in excess of this could cause system components to perform inaccurately.
- A condition may exist where a leak in the EVAP system only exists under a vacuum condition. This type of leak may be detected by using the scan tool Purge/Seal function to create a vacuum in the EVAP system and then observe the Fuel Tank Pressure Sensor parameter for vacuum decay.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) **Engine Controls Schematics (LGX)**

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Powertrain Component View

Powertrain Component Views

Description and Operation

Evaporative Emission Control System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Special Tools

- **CH 48096** EVAP Service Access Port Tool
- **GE 41415-30** Fuel Tank Cap Adapter
- **GE 41413-A** Evaporative Emissions System Tester
- **GE 41413-SPT** High Intensity White Light
- **GE 41415-60** Engine Induction System Leak Test Adapter/Capless Fuel Fill Adapter
- **J 41413-300** EVAP Cap and Plug Kit
- **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)** and/or **Special Tools (Mechanical Tools)**

Circuit/System Testing

IMPORTANT:

- Larger volume fuel tanks and/or those with lower fuel levels may require several minutes for the floating indicator to stabilize or produce smoke from a leak.
- Refer to the **GE 41413-A** operation manual for detailed instructions in Evaporative Emission System Diagnosis.

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1. Disconnect the purge tube at the quick connector on the EVAP canister side of the Q12 Evaporative Emission Purge Solenoid Valve and install the **CH 48096** .
2. Connect the **GE 41413-A** to the vehicle EVAP service access port adapter.
3. Command the EVAP Purge/Seal function to System Seal or Not Venting with a scan tool to seal the EVAP system.
4. Verify that there is no leak in the EVAP system using the flow meter on the **GE 41413-A** , calibrated to 0.51 mm (0.020 in).
    - **If a leak is detected**
    1. Apply smoke to the 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** . Capless fuel fill vehicles will need to use **GE 41415-60** connected to **GE 41413-A** .
7. Install the **GE 41415-30** , filler neck end only, to the vehicle.
8. Engine idling, command the Purge/Seal function to System Seal or Not Venting 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 but the Fuel Tank Pressure Sensor parameter does not show vacuum**

      Replace the B150 Fuel Tank Pressure Sensor.

    - **If both do not show vacuum**

      Repair the restriction in the purge path.

    - **If both show vacuum**
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.

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

DTC P0496: EVAPORATIVE EMISSION (EVAP) SYSTEM FLOW DURING NON-PURGE

Diagnostic Instructions

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

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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 greater 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 P0068, P00C8, P00C9, P00CA, P0090, P0091, P0092, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0122, P0123, P0125, P0128, P0191, P0192, P0193, P0222, P0223, P0601, P0604, P0606, P0697, P06A3, P06DB, P06DE, P0A1D, P1104, P127A, P127C, P127D, P15F2, P160D, P160E, P1682, P16A0, P16A1, P16A2, P16F3, P0443, P0449, P0452, P0453, P0454, P0502, P0503, P0722, P0723, P2100, P2101, P2102, P2103, P2122, P2123, P2127, P2128, P2135, P2138, P215B, P2176, P228C, P228D, U0073, U0074, U0293, U1817, are not set.
- The ignition voltage is between 11-32 V.
- The engine OFF time is greater than 48 min,
- The barometric pressure (BARO) is greater than 70 kPa.
- The fuel level is between 10-90%.
- The startup engine coolant temperature (ECT) is less than 35Â°C (95Â°F).
- The startup intake air temperature (IAT) is between 4-34Â°C (39-93Â°F).
- DTC P0496 runs once per cold start, for up to 17 min, when the above conditions are met. This test will run with the purge valve and the vent valve closed.

Conditions for Setting the DTC

The ECM detects greater than 10 in H2O vacuum for 5 s during a non-purge condition.

Action Taken When the DTC Sets

DTC P0496 is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P0496 is a Type B DTC.

Diagnostic Aids

An intermittent condition could be caused by:

- An improperly installed or damaged EVAP Purge Solenoid Valve
- A temporary blockage or restriction in the EVAP Purge Solenoid Valve

Reference Information

Schematic Reference

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Engine Controls Schematics (LGW) **Engine Controls Schematics (LGX)**

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Powertrain Component View

Powertrain Component Views

Description and Operation

Evaporative Emission Control System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

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. Command the EVAP Purge/Seal function to System Seal or Not Venting with a scan tool to seal the EVAP system.
3. Start the engine.
4. Observe the Fuel Tank Pressure Sensor with a scan tool. The Fuel Tank Pressure Sensor parameter should be less than 1.7 V after 90 s.
    - **If not within specifications**

      Replace the Q12 Evaporative Emission Purge Solenoid Valve

    - **Within Specifications**
5. All OK

Repair Instructions

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

Evaporative Emission Canister Purge Solenoid Valve Replacement (LGW) **Evaporative Emission Canister Purge Solenoid Valve Replacement (LGX)**

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DTC P0506 OR P0507: IDLE SPEED

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- **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 60Â°C (140Â°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 -20Â°C (-4Â°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.

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Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

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 Inspection and 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.

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- **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.

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Repair Instructions

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

Throttle Body Assembly Replacement (LGW) Throttle Body Assembly Replacement (LGX)

DTC P050D: COLD START ROUGH IDLE

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis:**Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

NOTE: **This procedure may also diagnose malfunctions that are not detected by a DTC.**

DTC P050D

Cold Start Rough Idle

Circuit/System Description

During a cold start, the engine control module (ECM) commands dual-pulse mode during Open Loop operation to improve cold start emissions. In dual-pulse mode, the fuel injectors are energized twice during each injection event. As with misfire diagnosis, in dual-pulse mode the ECM monitors the crankshaft position sensor and the camshaft position 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 DTC sets.

Conditions for Running the DTC

- DTC P0010, P0011, P0013, P0014, P0016, P0017, P0018, P0019, P0020, P0021, P0023, P0024, P0089, P0090-P0092, P00C6, P00C8, P00C9, P00CA, P0101-P0103, P0106-P0108, P0112-P0114, P0116-P0118, P0121-P0123, P0128, P0192, P0193, P0201-P0206, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0315, P0335, P0336, P0351-P0356, P0627-P0629, P069E, P0716, P0717, P0722, P0723, P0850-P0852, P1248, P1249, P124A, P124B, P124C, P124D, P1258, P135A, P135B, P150C, P163A, P1762, P1763, P1915, P2122, P2123, P2127, P2128, P2135, P2138, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F, P228C, P228D, U0109 = Not set
- Catalyst temperature=Less than 100Â°C (212Â°F)
- Engine Coolant Temperature =Greater than 10Â°C (14Â°F)
- Barometric Pressure =Greater than 70 kPa (10.1 PSI)
- Engine Speed. =450 to 1, 800 RPM
- Engine is Running & Cold Start-Up

DTC runs once per cold start-up when the above conditions are met.

Conditions for Setting the DTC

This DTC sets if the engine control module detects variations in crankshaft rotation speed caused by the lack of adequate fuel delivery during dual-pulse mode.

Action Taken When the DTC Sets

- DTC P050D is a Type B DTC.
- Dual pulse=Disabled

Conditions for Clearing the DTC

DTC P050D is a Type B DTC.

Diagnostic Aids

- This DTC has a higher priority over any misfire DTC. Diagnose the fuel system, not the ignition system.
- A restricted fuel injector may set the DTC.
- A high resistance condition on the component circuits may cause a DTC to set.
- A drop in system voltage during a cold start may set this DTC.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

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Component View Reference

Powertrain Component Views

Description and Operation

Fuel System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References

Circuit/System Verification

NOTE: Cold Start-Up=Required

1. Engine idling.
2. Verify the scan tool parameter:
    - Cylinder 1 Current Misfire Counter =Less than 1
    - Cylinder 2 Current Misfire Counter =Less than 1
    - Cylinder 3 Current Misfire Counter =Less than 1
    - Cylinder 4 Current Misfire Counter =Less than 1
    - Cylinder 5 Current Misfire Counter =Less than 1
    - Cylinder 6 Current Misfire Counter =Less than 1
    - **If greater than 1**
    1. Ignition/Vehicle Â» Off
    2. Verify the following conditions do not exist:
        - Fuel pressure low or high. Refer to **Fuel System Diagnosis** .
        - Contaminated or poor quality fuel. Refer to **Alcohol/Contaminants-in-Fuel Diagnosis**
        - If a condition existsÂ» Repair or replace as necessary
        - If no condition existsÂ» Replace the component:Q17 Fuel Injector
    - **If less than 1**
3. All OK.

Repair Instructions

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

Fuel Injector Replacement

DTC P05CC-P05CF: COLD START INTAKE/EXHAUST CAMSHAFT POSITION SYSTEM PERFORMANCE BANK

Diagnostic Instructions

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

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- 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 Bank 1

DTC P05CD

Cold Start Intake Camshaft Position System Performance Bank 2

DTC P05CE

Cold Start Exhaust Camshaft Position System Performance Bank 1

DTC P05CF

Cold Start Exhaust Camshaft Position System Performance Bank 2

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.
- The ignition voltage is greater than 11 V.
- The engine is running.
- The desired camshaft position is greater than 0 degrees.
- The desired camshaft position is not changing greater than 4.5Â° for at least 1 s.
- Both of the desired and actual camshaft position actuator values cannot be greater than 20 degrees or less than 5 degrees.
- DTCs P05CC, P05CD, P05CE and P05CF 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, P05CD, P05CE and P05CF are type B DTCs.

Conditions for Clearing the DTC

DTCs P05CC, P05CD, P05CE and P05CF are type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) **Engine Controls Schematics (LGX)**

Connector End View Reference

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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

Diagnostic Aids

- Verify the correct engine oil type and viscosity were used during recent oil changes.
- 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

1. Ignition On.

NOTE:

- **Correct engine oil type and viscosity are critical to the performance of the camshaft position actuator system.**
- **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.**

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**

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3. Verify DTC P0010, P0016, P0017, P0018, P0019, P0335, P0336, P0340, P0341, P0345, P0346, P0365, P0366, P0390 or P0391, is not set.

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

- **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 2Â° in each of the commanded states when commanding the Camshaft Position Actuator from 0Â° to maximum range and back to 0Â° with the scan tool.
   - Intake Camshaft Position Variance Bank 1
   - Exhaust Camshaft Position Variance Bank 1
   - Intake Camshaft Position Variance Bank 2
   - Exhaust Camshaft Position Variance Bank 2
   - **If 2Â° or greater**

     Refer to Circuit/System Testing.

   - **If less than 2Â°**
6. Operate the vehicle within the Conditions for Running the DTC to verify the DTC does not reset. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
   - **If any DTC sets**

     Refer to Circuit/System Testing.

   - **If a DTCs does not set**
7. All OK.

Circuit/System Testing

1. Remove the Q6 Camshaft Position Actuator Solenoid Valve and verify the following conditions do not exist:

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.**

   - 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**
2. 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.

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

3. Engine idling.

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4. Verify the scan tool Camshaft Position Variance parameter is less than 2Â° in each of the commanded states when commanding the Camshaft Position Actuator from 0Â° to maximum range and back to 0Â° with a scan tool.
    - **If 2Â° or greater**

      Replace the mechanical camshaft position actuator.

    - **If less than 2Â°**
5. 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 Ω between the control circuit terminal 1/A and the low reference circuit terminal 2/B 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 Replacement - Bank 1**
- **Camshaft Position Actuator Replacement - Bank 2**
- **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Intake (LGW)** **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Intake (LGX)**
- **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Exhaust (LGW)** **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 1 (Right Side) Exhaust (LGX)**
- **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Intake (LGX)** **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Intake (LGW)**
- **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Exhaust (LGX)** **Camshaft Position Actuator Solenoid Valve Solenoid Replacement - Bank 2 (Left Side) Exhaust (LGW)**
- **Control Module References** for K20 Engine Control Module replacement, programming and setup

DTC P057B-P057E: BRAKE PEDAL POSITION SENSOR

Diagnostic Instructions

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

DTC P057E

Brake Pedal Position Sensor Circuit Erratic

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	P057C	P057C	P057D	P057B, P057E
5 V Reference	P057C P0651	P057C	P057D, P0651	-
Low Reference	-	P057D	P057D	-

Typical Scan Tool Data

Brake Pedal Position Sensor

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Ignition ON. **Normal Range:** 0.25-4.75 V			
5 V Reference	0 V	0 V	-
Signal	0 V	0 V	5 V
Low Reference	-	5 V	-

Circuit/System Description

The brake pedal position (BPP) sensor is part of the engine brake pedal override feature. The engine control module (ECM) continuously monitors the vehicle speed and the position of the brake pedal. These two main inputs, along with other ECM inputs are used to determine if the vehicle is decelerating at the proper speed and rate with the brake pedal applied. When the engine brake pedal override system is active, the ECM reduces engine torque to assist in reducing vehicle speed.

The BPP sensor is a six wire sensor and is part of a dual brake position sensor. One BPP Sensor is used for the stop lamps and the other BPP Sensor is used for the engine brake pedal override feature. The BPP Sensor for engine brake pedal override communicates with the ECM. The ECM supplies a 5 V reference circuit, low reference circuit and signal circuit to the BPP sensor. The BPP sensor sends a voltage signal to the ECM on the signal circuit. The voltage on the signal circuit will vary from a voltage greater than 0.25 V when the brake pedal is released to a voltage less than 4.75 V when the brake pedal is fully applied.

For information on the Stop Lamps side of the BPP Sensor, refer to **Exterior Lighting Systems Description and Operation** .

Conditions for Running the DTC

P057B

- DTCs P057C or P057D are not set.
- Ignition voltage is greater than 10 V.
- Shift lever has been in Park at least once during key ON.
- Shift lever is not in Park.

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- Vehicle speed is greater than 8 km/h (5 mph).
- Accelerator Pedal Position is less than 5%.
- DTC runs once per key cycle when above conditions are met.

P057C, P057D or P057E

- 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 for greater than 1 s.

P057C

ECM detects the BPP sensor voltage is less than 0.25 V for greater than 1 s.

P057D

ECM detects the BPP sensor voltage is greater than 4.75 V for greater than 1 s.

P057E

ECM detects the BPP sensor value varies greater than a calibrated value.

Action Taken When the DTC Sets

- P057B, P057C, P057D and P057E are Type A DTCs.
- Brake Pedal Position Sensor parameter defaults to 0%.

Conditions for Clearing the DTC

P057B, P057C, P057D and P057E 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

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Circuit/System Verification

NOTE: **The Brake Pedal Position sensor scan tool data is located in the ECM automatic transmission data list.**

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

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .
   - **If none of the DTCs are set**
3. Transmission in Park and service brake pedal released.
4. Verify the scan tool Brake Pedal Position Sensor parameter in the ECM displays greater than 0.25 V.
   - **If 0.25 V or less**

     Refer to Circuit/System Testing.
   - **If greater than 0.25 V**
5. Verify the scan tool Brake Pedal Position Sensor parameter voltage changes as the brake pedal is applied and displays less than 4.75 V when the brake pedal is fully applied.
   - **If the voltage does not change or is greater than 4.74 V**

     Refer to Circuit/System Testing.
   - **If the voltage changes and less than 4.75 V**
6. Verify the scan tool Brake Pedal Position Sensor Learned Release Position parameter is within 0.1 V of the Brake Pedal Position Sensor parameter when the brake pedal is fully released.
   - **If difference is greater than 0.1 V**

     Perform the **Brake Pedal Position Sensor Learn** .
   - **If difference is 0.1 V or less**
7. Verify the Brake Pedal Position Sensor parameter transitions smoothly without any spikes or dropouts when slowly applying and releasing the brake pedal.
   - **If parameter does not transition smoothly or has spikes or dropouts**

     Refer to Circuit/System Testing.
   - **If parameter transitions smoothly and there are no spikes or dropouts**
8. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
9. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.
   - **If the DTC does not set**
10. All OK.

Circuit/System Testing

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: **You must perform the Circuit/System Verification first.**

2. Test for less than 10 Ω between the low reference circuit terminal 5 and ground.

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NOTE: **All terminal references are for the vehicle harness brake pedal position sensor connector.**

- **If 10 Ω or greater**

1. Disconnect the X1 harness connector at the K20 Engine Control Module.
2. Test for less than 2 Ω in the low reference circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If less than 10 Ω**

3. Ignition ON.
4. Test for 4.8-5.2 V between the 5 V reference circuit terminal 6 and ground.
    - **If less than 4.8 V**

    1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the 5 V reference circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance.
    3. Test for less than 2 Ω in the 5 V reference circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.

    - **If greater than 5.2 V**

    1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the 5 V reference circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.

    - **If between 4.8-5.2 V**

5. Verify the scan tool Brake Pedal Position Sensor parameter is less than 0.25 V.
    - **If 0.25 V or greater**

    1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 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 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 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.

    - **If greater than 4.8 V**

8. Replace the B22 Brake Pedal Position Sensor.

Repair Instructions

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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 P0601-P0604, P0606, P062B, P062F, P0630, P160A, P160D, P160E, P161C, P16F3 OR P262B: CONTROL MODULE/VIN NOT PROGRAMMED OR MISMATCHED/VEHICLE SPEED LIMIT/ENGINE CALIBRATION MONITORING NOT PROGRAMMED/TIRE SIZE NOT PROGRAMMED

Diagnostic 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 P160A

Vehicle Speed Limit Not Programmed

DTC P160D

Incorrect Engine Calibration Detected

DTC P160E

Engine Calibration Monitoring Not Programmed

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DTC P161C

Tire Size Not Programmed

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, P160A, P160D, P160E, P161C

These DTCs run continuously when the ignition is ON.

P0603, P062F

These DTCs run during ECM power up.

P0604

DTC P0604 runs continuously when the ignition is ON for greater than 30 s.

P0606, P062B

- The ignition is ON.
- The system voltage is greater than 11 V.
- These DTCs run continuously when the above conditions are met.

P16F3

- The engine speed is greater than 550 RPM.
- DTCs P0101, P0102, P0103, P0106, P0107, P0108, P2227, P2228, P2229 or P2230 are not set.
- DTC P16F3 runs continuously when the above conditions are met.

P262B

DTC P262B runs during ECM power down.

Conditions for Setting the DTCs

The ECM detects an internal failure or incomplete programming for more than 10 s.

Actions Taken When the DTC Sets

- DTCs P0601, P0602, P0603, P0604, P0606, P062B, P0630, P160A, P160D, P160E, P161C and P16F3 are Type A DTCs.
- DTCs P062F and P262B are Type B DTCs.

Conditions for Clearing the MIL/DTC

- DTCs P0601, P0602, P0603, P0604, P0606, P062B, P0630, P160A, P160D, P160E, P161C and P16F3 are Type A DTCs.
- DTCs P062F and P262B are Type B DTCs.

Diagnostic Aids

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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 (LGW) **Engine Controls Schematics (LGX)**

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.
2. Verify no other DTCs are set.
   - **If any other DTCs are set**

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

   - **If no other DTCs are set**
3. Verify DTC P0602, P160A, P160D, P160E, P161C 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, P160A, P160D, P160E, P161C 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**

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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: FUEL PUMP ENABLE CIRCUIT (LGX)

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

NOTE: **This procedure may also diagnose malfunctions that are not detected by a DTC.**

DTC P0628

Fuel Pump Enable Circuit Low Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control	P025A*, P0628, P069E*	P025A*, P069E*	-	-
*Additional DTCs may set.				

Circuit/System Description

Circuit	Description
Control	The output circuit is switched to 12 V to activate the component.

Component	Description
K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.
K111 Fuel Pump Driver Control Module	The control module K111 monitors the fuel system for any condition which may adversely affect emissions. If a condition is detected it sets a DTC and sends a serial data message to the engine control module which then sets DTC P069E.

When the ignition is turned On, the ECM sends a 12 V signal to the control module K111 to enable the fuel pump. If the engine is not started, the control module K111 turns the fuel pump Off after 6 s.

Conditions for Running the DTC

- Engine Speed. =Greater than 0 RPM
- Ignition Voltage =11 to 32 V
- Fuel Pump Enable Circuit =On

DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

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Control Circuit=Commanded state does not match the actual state - For greater than 2 s

Actions Taken When the DTC Sets

DTC P0628 is a Type B DTC.

Conditions for Clearing the DTC

DTCs P0628 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Description and Operation

Fuel System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References

Circuit/System Verification

1. IgnitionÂ» On / VehicleÂ» In Service Mode
2. Verify the scan tool parameter:
   - Fuel Pump Speed Output Circuit High Voltage Test Status =OK or Not Run
   - Fuel Pump Speed Output Circuit Low Voltage Test Status =OK or Not Run
   - Fuel Pump Speed Output Circuit Open Test Status =OK or Not Run
   - **If not the specified state**

     Refer to Circuit/System Testing

   - **If the specified state**
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

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- **If the DTC is not set**

5. All OK.

Circuit/System Testing

1. Ignition/Vehicle & All vehicle systemsÂ» Off
2. Disconnect the electrical connector: K111 Fuel Pump Driver Control Module
3. IgnitionÂ» On / VehicleÂ» In Service Mode
4. Perform the scan tool control function:Fuel Pump EnableÂ» Off

   Verify a test lamp does not turn On between the test points:Control circuit terminal 2 & Ground

   - **If the test lamp turns On**

   1. Ignition/VehicleÂ» Off & RemoveÂ» Test lamp
   2. Disconnect the electrical connector:K20 Engine Control Module
   3. IgnitionÂ» On / VehicleÂ» In Service Mode
   4. Test for less than 1 V between the test points:Control circuit terminal 2 @ Component harness & Ground
      - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
      - If less than 1 VÂ» Replace the component:K20 Engine Control Module
   - **If the test lamp does not turn On**

5. Remove Â» Test Lamp
6. Perform the scan tool control function:Fuel Pump Enable Â»On

   Verify the scan tool parameter:Fuel Pump Enable Circuit Low Voltage Test Status =OK

   - **If not the specified state**

   1. Ignition/Vehicle Â» Off
   2. Disconnect the electrical connector:K20 Engine Control Module
   3. Test for infinite resistance between the test points:Control circuit terminal 2 @ Component harness & Ground
      - If less than infinite resistanceÂ» Repair the short to ground on the circuit.
      - If infinite resistanceÂ» Replace the component:K20 Engine Control Module
   - **If the specified state**

7. Connect a 3 A fused jumper wire between the test points:Control circuit terminal 2 & Ground
8. Perform the scan tool control function:Fuel Pump Enable Â» On

   Verify the scan tool parameter:Fuel Pump Enable Circuit Low Voltage Test Status =Malfunction

   - **If not the specified state**

   1. Ignition/VehicleÂ» Off & RemoveÂ» Jumper wire(s)
   2. Disconnect the electrical connector: X1 @ K20 Engine Control Module
   3. Test for less than 2 Ω between the test points: Control circuit terminal 2 @ Component harness & Terminal 69 @ Control module harness
      - If 2 Ω or greater Â» Repair the open/high resistance in the circuit.
      - If less than 2 Ω Â» Replace the component:K20 Engine Control Module
   - **If the specified state**

9. Test or replace the component:K111 Fuel Pump Driver Control Module

Repair Instructions

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

- **Fuel Pump Power Control Module Replacement** - K111 Fuel Pump Driver Control Module
- For control module replacement, programming and setup, refer to **Control Module References**

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DTC P0628: FUEL PUMP ENABLE CIRCUIT (LGW)

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

NOTE: **This procedure may also diagnose malfunctions that are not detected by a DTC.**

DTC P0628

Fuel Pump Enable Circuit Low Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control	P025A*, P0628, P069E*	P025A*, P069E*	-	-
*Additional DTCs may set.				

Circuit/System Description

Circuit	Description
Control	The output circuit is switched to 12 V to activate the component.

Component	Description
K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.
K111 Fuel Pump Driver Control Module	The control module K111 monitors the fuel system for any condition which may adversely affect emissions. If a condition is detected it sets a DTC and sends a serial data message to the engine control module which then sets DTC P069E.

When the ignition is turned On, the ECM sends a 12 V signal to the control module K111 to enable the fuel pump. If the engine is not started, the control module K111 turns the fuel pump Off after 6 s.

Conditions for Running the DTC

- Engine Speed. =Greater than 0 RPM
- Ignition Voltage =11 to 32 V
- Fuel Pump Enable Circuit =On

DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

Control Circuit=Commanded state does not match the actual state - For greater than 2 s

Actions Taken When the DTC Sets

DTC P0628 is a Type B DTC.

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Conditions for Clearing the DTC

DTCs P0628 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

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Description and Operation

Fuel System Description

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**
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- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References

Circuit/System Verification

1. IgnitionÂ» On / VehicleÂ» In Service Mode
2. Verify the scan tool parameter:
   - Fuel Pump Speed Output Circuit High Voltage Test Status =OK or Not Run
   - Fuel Pump Speed Output Circuit Low Voltage Test Status =OK or Not Run
   - Fuel Pump Speed Output Circuit Open Test Status =OK or Not Run
   - **If not the specified state**

     Refer to Circuit/System Testing

   - **If the specified state**
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 is not set**
5. All OK.

Circuit/System Testing

1. Ignition/Vehicle & All vehicle systemsÂ» Off

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2. Disconnect the electrical connector:K111 Fuel Pump Driver Control Module
3. IgnitionÂ» On / VehicleÂ» In Service Mode
4. Perform the scan tool control function:Fuel Pump EnableÂ» Off

   Verify a test lamp does not turn On between the test points:Control circuit terminal 2 & Ground

   - **If the test lamp turns On**
   1. Ignition/Vehicle Â» Off & RemoveÂ» Test lamp
   2. Disconnect the electrical connector:K20 Engine Control Module
   3. IgnitionÂ» On / VehicleÂ» In Service Mode
   4. Test for less than 1 V between the test points:Control circuit terminal 2 @ Component harness & Ground
      - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
      - If less than 1 VÂ» Replace the component:K20 Engine Control Module
   - **If the test lamp does not turn On**
5. RemoveÂ» Test Lamp
6. Perform the scan tool control function:Fuel Pump EnableÂ» On

   Verify the scan tool parameter: Fuel Pump Speed Output Circuit Low Voltage Test Status =OK

   - **If not the specified state**
   1. Ignition/Vehicle Â» Off
   2. Disconnect the electrical connector:K20 Engine Control Module
   3. Test for infinite resistance between the test points:Control circuit terminal 2 @ Component harness & Ground
      - If less than infinite resistanceÂ» Repair the short to ground on the circuit.
      - If infinite resistanceÂ» Replace the component:K20 Engine Control Module
   - **If the specified state**
7. Connect a 3 A fused jumper wire between the test points:Control circuit terminal 2 & Ground
8. Perform the scan tool control function:Fuel Pump Enable Â»On

   Verify the scan tool parameter:Fuel Pump Speed Output Circuit Low Voltage Test Status =Malfunction

   - **If not the specified state**
   1. Ignition/Vehicle Â» Off & RemoveÂ» Jumper wire(s)
   2. Disconnect the electrical connector: X1 @ K20 Engine Control Module
   3. Test for less than 2 Ω between the test points:Control circuit terminal 2 @ Component harness & Terminal 69 @ Control module harness
      - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
      - If less than 2 ΩÂ» Replace the component:K20 Engine Control Module
   - **If the specified state**
9. Test or replace the component:K111 Fuel Pump Driver Control Module

Repair Instructions

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

- **Fuel Pump Power Control Module Replacement** - K111 Fuel Pump Driver Control Module
- For control module replacement, programming and setup, refer to **Control Module References**

DTC P064D OR P064E: CONTROL MODULE HO2S BANK SENSOR SYSTEM PERFORMANCE

Diagnostic Instructions

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- 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 P064D

Control Module HO2S Bank 1 Sensor 1 System Performance

DTC P064E

Control Module HO2S Bank 2 Sensor 1 System Performance

Circuit/System Description

This diagnostic applies to internal Heated Oxygen Sensor (HO2S) circuitry conditions within the engine control module (ECM).

Conditions for Running the DTC

- The engine speed is greater than 25 RPM.
- The ignition voltage is between 11-16 Volts
- The engine has cycled ON and OFF between 6-16 times dependent on coolant temperature.
- The DTCs run continuously once the conditions above have been met for greater than 20 seconds.

Conditions for Setting the DTC

The ECM detects a condition with the integrated circuits of the HO2S for greater than 20 seconds.

Action Taken When the DTC Sets

DTCs P064D and P064E are Type B DTCs.

Conditions for Clearing the DTC

DTCs P064D and P064E are Type B DTCs.

Reference Information

Description and Operation

Engine Control Module Description

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Circuit/System Verification

NOTE:

- **Diagnose all other engine control module DTCs prior to DTC P150C.**

1. Verify that no other DTCs are set except for DTC P064D or P064E.
   - **If any other DTCs are set**

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

   - **If only DTC P064D or P064E is 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.
3. Verify the DTC does not set.

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- **If the DTC sets**

  Replace the K20 Engine Control Module.

- **If the DTC does not set**

4. All OK.

Repair Instructions

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

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

DTC P0641, P0651, P0697 OR P06A3: 5V REFERENCE (LGW)

Diagnostic 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 other components connected to the same internal 5V reference circuit.

Conditions for Running the DTC

These DTCs run continuously when the ignition voltage is greater than 6.4 V.

Conditions for Setting the DTC

The ECM detects a short to voltage or ground on any of the 5V reference circuits for greater than 0.5 s.

Action Taken When the DTC Sets

DTCs P0641, P0651, P0697 and P06A3 are Type A DTCs.

Conditions for Clearing the DTC

DTCs P0641, P0651, P0697 and P06A3 are Type A DTCs.

Diagnostic Aids

DTC P0641

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The 5V reference 1 circuit provides 5 V to the sensors listed below:

- Air conditioning refrigerant pressure sensor
- All four camshaft position sensors
- Engine oil pressure sensor
- Fuel rail pressure sensor
- Fuel tank pressure sensor
- Multifunction intake air sensor
- Turbocharger boost/intake air temperature sensor (LF3 with turbocharger)
- Vehicle stability control switch

DTC P0651

The 5V reference 2 circuit provides 5 V to the sensors listed below:

- Brake pedal position sensor
- Crankshaft position sensor
- Multifunction intake air sensor
- Barometric pressure sensor

DTC P0697

The 5V reference 3 circuit provides 5 V to the sensors listed below:

- Manifold absolute pressure sensor
- Accelerator pedal position sensor 2

DTC P06A3

The 5V reference 4 circuit provides 5 V to the sensors listed below:

- Throttle position sensor
- Accelerator pedal position sensor 1

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.

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Reference Information

Schematic Reference

Engine Controls Schematics (LGW)

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 5 V reference circuit for each applicable component and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If between 4.8-5.2 V**
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.

   NOTE: **A short to voltage or ground on the signal circuit of certain components may cause this DTC to set.**

   - **If OK is not displayed when a component is connected**

     Test the signal circuit of that component for a short to voltage. If the circuit tests normal, replace the component.

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- **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 (LGW, LGX)**
- **Brake Pedal Position Sensor Replacement**
- **Camshaft Position Sensor Replacement - Bank 1 (Right Side) Intake**
- **Camshaft Position Sensor Replacement - Bank 1 (Right Side) Exhaust (LGW)**
- **Camshaft Position Sensor Replacement - Bank 2 (Left Side) Intake (LGW)**
- **Camshaft Position Sensor Replacement - Bank 2 (Left Side) Exhaust (LGW)**
- **Crankshaft Position Sensor Replacement**
- **Engine Oil Pressure Sensor and/or Switch Replacement (LGW)**
- **Fuel Pressure Sensor Replacement - Fuel Injection Fuel Rail**
- **Fuel Tank Pressure Sensor Replacement**
- **Manifold Absolute Pressure Sensor Replacement (LGW)**
- **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGW)**
- **Throttle Body Assembly Replacement (LGW)**
- **Control Module References** for engine control module replacement, programming and setup.

DTC P0641, P0651, P0697 OR P06A3: 5V REFERENCE (LGX)

Diagnostic 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 5 V reference circuits for more than one sensor. A short to ground or short to voltage on one of the external 5V reference circuits 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.

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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

P0641

The 5V reference 1 circuit provides 5 V to the sensors listed below:

- A/C refrigerant pressure sensor
- All four camshaft position sensors
- Fuel tank pressure sensor
- Fuel rail pressure sensor
- Manifold absolute pressure sensor

P0651

The 5V reference 2 circuit provides 5 V to the sensors listed below:

- Brake pedal position sensor (automatic transmission)
- Crankshaft position sensor
- Engine oil pressure sensor
- Multifunction intake air sensor
- Vehicle stability control switch

P0697

The 5V reference 3 circuit provides 5 V to the Accelerator pedal position sensor 2

P06A3

The 5V reference 4 circuit provides 5 V to the sensors listed below:

- Accelerator pedal position sensor 1
- Throttle position sensor

Disconnecting one component at a time from the affected 5V reference circuit while observing the scan tool 5V Reference Circuit Status parameter may help locate the fault. The scan tool parameter will change from Malfunction to OK when the source of the fault is disconnected. If all 5V reference components have been disconnected and a fault is still indicated, the fault may exist in the wiring harness.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

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Powertrain Component Views

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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

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**

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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.

NOTE: **A short to voltage or ground on the signal circuit of certain components may cause this DTC to set.**

- **If OK is not displayed when a component is connected**

  Test the signal circuit of that component for a short to ground or voltage. If the circuit tests normal, replace the component.

- **If OK is displayed after all components have been connected**

5. All OK.

Repair Instructions

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

- **Accelerator Pedal with Position Sensor Assembly Replacement**
- **Air Conditioning (A/C) Refrigerant Pressure Sensor Replacement (LGW, LGX)**
- **Brake Pedal Position Sensor Replacement**
- **Camshaft Position Sensor Replacement - Bank 1 (Right Side) Intake**
- **Camshaft Position Sensor Replacement - Bank 1 (Right Side) Exhaust (LGX)**
- **Camshaft Position Sensor Replacement - Bank 2 (Left Side) Intake (LGX)**
- **Camshaft Position Sensor Replacement - Bank 2 (Left Side) Exhaust (LGX)**
- **Crankshaft Position Sensor Replacement**
- **Engine Oil Pressure Sensor and/or Switch Replacement (LGX)**
- **Fuel Pressure Sensor Replacement - Fuel Injection Fuel Rail**
- **Fuel Tank Pressure Sensor Replacement**
- **Manifold Absolute Pressure Sensor Replacement (LGX)**
- **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGX)**
- **Throttle Body Assembly Replacement (LGX)**
- **Control Module References** for engine control module replacement, programming and setup.

DTC P0650, P263A OR P263B: MALFUNCTION INDICATOR LAMP (MIL) CONTROL CIRCUIT

Diagnostic Instructions

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

DTC Descriptor

DTC P0650

Malfunction Indicator Lamp (MIL) Control Circuit

DTC P263A

Malfunction Indicator Lamp (MIL) Control Circuit Low

DTC P263B

Malfunction Indicator Lamp (MIL) Control Circuit High

Diagnostic Fault Information

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

Circuit/System Description

The malfunction indicator lamp (MIL) illuminates to inform the driver that an emission system fault has occurred and the powertrain control system requires service. Ignition voltage is supplied directly to the MIL. The engine control module (ECM) turns the MIL ON by grounding the MIL control circuit when the emission system fault occurs. Under normal operating conditions, the MIL should be ON only when the ignition is ON and the engine is OFF.

Conditions for Running the DTC

- The 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 or P263A

The ECM detects low voltage during the MIL control circuit driver OFF state. This indicates either a shorted to ground or an open MIL control circuit.

DTC P263B

The ECM detects high voltage on the MIL control circuit during the driver ON state. This indicates a shorted to voltage MIL control circuit.

Action Taken When the DTC Sets

DTC P0650, P263A and P263B are Type B DTCs.

Conditions for Clearing the DTC

DTC P0650, P263A and P263B are Type B DTCs.

Diagnostic Aids

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

Reference Information

Schematic Reference

- **Engine Controls Schematics (LGW)** **Engine Controls Schematics (LGX)**
- **Instrument Cluster Schematics**

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

- **Circuit Testing**

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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. Verify that no other DTCs set except for DTC P0650, P263A or P263B.
   - **If any other DTCs are set**

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

   - **If only DTC P0650, P263A or P263B is set**
2. 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**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
   - **If the DTC sets**

     Refer to Diagnostic Trouble Code (DTC) List - Vehicle

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

Circuit/System Testing

1. Ignition OFF.
2. Disconnect the X1 harness connector at the K20 Engine Control Module.
3. Ignition ON, verify the malfunction indicator lamp does not illuminate.
   - **If the malfunction indicator lamp illuminates**
   1. Test for infinite resistance between the control circuit terminal X1 16 and ground.
      - If less than infinite resistance, repair the short to ground in the circuit.
      - If infinite resistance, replace the P16 Instrument Cluster.
   - **If the malfunction indicator lamp does not illuminate**
4. Connect a 3 A fused jumper wire between the control circuit terminal X1 16 and ground.
5. Verify the malfunction indicator lamp illuminates.
   - **If the malfunction indicator lamp illuminates**

     Replace the K20 Engine Control Module.

   - **If the malfunction indicator lamp does not illuminate**
   1. Test for less than 1 V between the control circuit terminal X1 16 and ground.
      - If 1 V or greater, repair the short to voltage on the circuit.
      - If less than 1 V
   2. Ignition OFF.

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3. Test for less than 2 Ω in the control circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω.
6. Ignition OFF, disconnect the X1 harness connector at the instrument cluster.
7. Ignition ON, verify a test lamp illuminates between the ignition voltage circuit terminal 8 and ground.
    - **If the test lamp does not illuminate and the circuit fuse is open**
    1. Ignition OFF.
    2. Test for infinite resistance between the ignition voltage circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
    - **If the test lamp does not illuminate and the circuit fuse is good**
    1. Ignition OFF.
    2. Test for less than 2 Ω in the ignition voltage circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - **If the test lamp illuminates**
8. Replace the P16 Instrument Cluster.

Repair Instructions

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

- **Instrument Cluster Replacement**
- **Control Module References** for control module replacement, programming and setup.

DTC P0685-P0687, P0689, P0690 OR P1682: ENGINE CONTROLS IGNITION RELAY/IGNITION 1 SWITCH (LGX)

Diagnostic 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

DTC P0689

Engine Controls Ignition Relay Feedback Circuit Low Voltage

DTC P0690

Engine Controls Ignition Relay Feedback Circuit High Voltage

DTC P1682

Ignition 1 Switch Circuit 2

Diagnostic Fault Information

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Engine Controls Ignition Relay

Circuit	Short to Ground	Open/High Resistance	Short to Voltage
Relay Coil Supply Voltage	-	P0685, P0689, P1682	-
Relay Control Circuit	P0686, P0690	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 and Not Run for High Voltage test • Component ON - Not Run for Open/Low Voltage test and OK for High Voltage test			
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 and Not Run for High Voltage test • Component ON - Not Run for Open/Low Voltage test and OK for High Voltage test			
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 two relays.

Conditions for Running the DTC

P0685, P0686, P0687

The DTC runs continuously when the ignition voltage is greater than 11 V.

P0689

- The engine controls ignition relay is commanded ON.
- The ignition voltage is greater than 11 V.
- DTC P0685 is not set.
- The DTC runs continuously when the above conditions are met.

P0690

- The engine controls ignition relay is commanded OFF.
- DTC P0685 is not set.
- The DTC runs continuously when the above conditions are met.

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P1682

- The engine controls ignition relay is commanded ON.
- The 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 engine controls ignition relay voltage is less than 5 V for greater than 5 s.

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 there is greater than 3 V difference between the ignition main relay signal and the engine controls ignition relay signal circuits for greater than 1 s.

Action Taken When the DTC Sets

North American Emissions

- DTC P1682 is a Type A DTC.
- DTCs P0685, P0686, P0687 and P0690 are Type B DTCs.
- DTC P0689 is a Type C DTC.

European Emissions

- DTC P1682 is a Type A DTC.
- DTCs P0685, P0686, P0687, P0689 and P0690 are Type C DTCs.

Conditions for Clearing the DTC

North American Emissions

- DTC P1682 is a Type A DTC.
- DTCs P0685, P0686, P0687 and P0690 are Type B DTCs.
- DTC P0689 is a Type C DTC.

European Emissions

- DTC P1682 is a Type A DTC.
- DTCs P0685, P0686, P0687, P0689 and P0690 are Type C DTCs.

Diagnostic Aids

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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 1 relay, the ignition run relay or the ignition relay.

Reference Information

Schematic Reference

- **Engine Controls Schematics (LGX)**
- **Power Distribution Schematics**

Connector End View Reference

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Component View Reference

Powertrain Component Views

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- **Connector Repairs**
- **Electrical Center Identification Views** **Electrical Center Identification Views**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON, observe the scan tool DTC information. Verify DTC P0685, P0686, P0687, P0689, P0690 or P1682 is not set.

   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.**

   - **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

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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 terminal 73.
      - If 1 V or greater, repair the short to voltage in the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If the test lamp does not illuminate**
5. Ignition OFF, connect a 20 A fused jumper wire between the 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 Ω in the relay switch ignition voltage circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω
   3. Test for infinite resistance between the relay switch ignition voltage circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.
   - **If B+ is displayed**
8. Ignition OFF, connect a DMM, set to the diode setting, between control circuit terminal 86 and ground.
9. Verify the DMM displays OL.
   - **If OL is not displayed**
   1. Disconnect the X1 harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between ground and the relay control circuit.
      - If less than infinite resistance, repair the short to ground in the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.

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- **If OL is displayed**

10. Ignition ON.
11. Verify the DMM displays less than 1 V.
    - **If 1 V or greater**
    1. Ignition OFF, disconnect the X1 connector at the K20 Engine Control Module.
    2. Ignition ON.
    3. Test for less than 1 V on the relay control circuit.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V
    4. Test for less than 2 Ω in the control circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - if less than 2 Ω, replace the K20 Engine Control Module.
    - **If less than 1 V**
12. Test or replace the KR75 Engine Controls Ignition Relay.

Component Testing

Relay Test

1. Ignition OFF, disconnect the KR75 Engine Controls Ignition Relay.
2. Test for 70-110 Ω between terminals 85 and 86:
    - **If less than 70 Ω or greater than 110 Ω**

      Replace the KR75 Engine Controls Ignition Relay.

    - **If between 70-110 Ω**
3. Test for infinite resistance between the terminals listed below:
    - 30 and 86
    - 30 and 87
    - 30 and 85
    - 85 and 87
    - **If less than infinite resistance**

      Replace the KR75 Engine Controls Ignition Relay.

    - **If infinite resistance**
4. Install a 20 A fused jumper wire between relay terminal 85 and 12 V. Install a jumper wire between relay terminal 86 and ground.
5. Test for less than 2 Ω between terminals 30 and 87.
    - **If 2 Ω or greater**

      Replace the KR75 Engine Controls Ignition Relay.

    - **If less than 2 Ω**
6. All OK.

Repair Instructions

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

- **Engine Wiring Harness Junction Block Replacement** for front compartment fuse block replacement.
- **Relay Replacement (Attached to Wire Harness)** **Relay Replacement (Within an Electrical Center)**
- **Control Module References** for engine control module replacement, programming and setup.

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DIAGNOSTIC INFORMATION AND PROCEDURES

DTC P0685-P0687, P0689, P0690 OR P1682: ENGINE CONTROLS IGNITION RELAY/IGNITION 1 SWITCH (LGW)

Diagnostic 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

DTC P0689

Engine Controls Ignition Relay Feedback Circuit Low Voltage

DTC P0690

Engine Controls Ignition Relay Feedback Circuit High Voltage

DTC P1682

Ignition 1 Switch Circuit 2

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage
B+	P0689, P1682, P16A7, P16AF, P16BC	P0685, P0689, P1682, P16A7, P16AF, P16BC	P0690, P16B3
Control	P0686, P0690, P16B3, P16BF	P0685, P0689, P1682, P16A7, P16AF, P16BC	P0685, P0687, P0689, P1682, P16A7, P16AF, P16BC
Feedback	P0689, P1682, P16A7, P16AF, P16BC	P0689, P1682, P16A7, P16AF, P16BC	P0690, P16B3, P16BF

Typical Scan Tool Data

Engine Controls Ignition Relay

Circuit	Short to Ground	Open	Short to Voltage

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Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Component commanded OFF **Parameter Normal Range:** The following illustrates the normal scan tool test status 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

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Component commanded ON **Parameter Normal Range:** The following illustrates the normal scan tool test status 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

- DTC P0685 is not set.
- The engine controls ignition relay is commanded ON.
- Ignition 1 signal voltage is greater than 11 V.
- The DTC runs continuously when the above conditions are met.

P0690

- DTC P0685 is not set.
- The engine controls ignition relay is commanded OFF for greater than 2 s.
- 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

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P0685

The ECM detects that the commanded state of the driver and the actual state of the control circuit do not match for greater than 2 s.

P0686

The ECM detects a short to ground on the control circuit for greater than 2 s.

P0687

The ECM detects a short to voltage on the control circuit for greater than 2 s.

P0689

The ECM detects the engine controls ignition relay feedback circuit is less than 5 V.

P0690

The ECM detects the engine controls ignition relay feedback circuit is greater than 4 V for greater than 5 s.

P1682

The ECM detects that the voltage level difference is greater than 3 V between the 2 ignition voltage circuits for greater than 1 s.

Action Taken When the DTC Sets

- DTCs P0685, P0686, P0687 and P0690 are Type B DTCs.
- DTC P0689 is a Type C DTC.
- DTC P1682 is a Type A DTC.

Conditions for Clearing the DTC

- DTCs P0685, P0686, P0687 and P0690 are Type B DTCs.
- DTC P0689 is a Type C DTC.
- DTC P1682 is a Type A DTC.

Diagnostic Aids

The engine controls ignition relay may also be labeled the powertrain relay, the engine control module relay or the main relay. The ignition main relay may also be labeled the run/crank relay, the ignition run relay, the ignition 1 relay or the ignition relay.

Reference Information

Schematic Reference

- **Engine Controls Schematics (LGW)**
- **Power Distribution Schematics**

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Electrical Information Reference

- **Circuit Testing**
- **Connector Repairs**

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- Electrical Center Identification Views Electrical Center Identification Views
- Testing for Intermittent Conditions and Poor Connections
- Wiring Repairs

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information.

Circuit/System Verification

1. Ignition ON, verify DTC P0685, P0686, P0687, P0689, P0690 or P1682 is not set.

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.**

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

     Refer to Circuit/System Testing.

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

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

     Refer to Circuit/System Testing.

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

Circuit/System Testing

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

1. Ignition OFF, disconnect the KR75 Engine Controls Ignition Relay.
2. Verify a test lamp illuminates between ground and the B+ terminals listed below:
   - Terminal 85
   - Terminal 30
   - **If the test lamp does not illuminate**

     Replace the X50A 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.

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4. Verify that a test lamp does not illuminate between the ignition voltage circuit terminal 87 and ground.
    - **If the test lamp illuminates**
    1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.
    2. Ignition ON.
    3. Test for less than 1 V between ground and connector terminal 73.
        - If 1 V or greater, repair the short to voltage in the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If the test lamp does not illuminate**
5. Ignition OFF, connect a 20 A fused jumper wire between the B+ circuit terminal 30 and the ignition voltage circuit terminal 87.
6. Ignition ON.
7. Verify the scan tool Engine Controls Ignition Relay Feedback Signal parameter displays B+.
    - **If B+ is not displayed**
    1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module
    2. Test for less than 2 Ω in the relay switch ignition voltage circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω
    3. Test for infinite resistance between the relay switch ignition voltage circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance, replace the K20 Engine Control Module.
    - **If B+ is displayed**
8. Ignition OFF, connect a DMM, set to the diode setting, between control circuit terminal 86 and ground.
9. Verify the DMM displays OL.
    - **If OL is not displayed**
    1. Disconnect the X1 harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between ground and the relay control circuit.
        - If less than infinite resistance, repair the short to ground in the circuit.
        - If infinite resistance, replace the K20 Engine Control Module.
    - **If OL is displayed**
10. Ignition ON.
11. Verify the DMM displays less than 1 V.
    - **If 1 V or greater**
    1. Ignition OFF, disconnect the X1 connector at the K20 Engine Control Module.
    2. Ignition ON.
    3. Test for less than 1 V on the relay control circuit.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V
    4. Test for less than 2 Ω in the control circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - if less than 2 Ω, replace the K20 Engine Control Module.
    - **If less than 1 V**
12. Test or replace the KR75 Engine Controls Ignition Relay.

Component Testing

Relay Test

1. Ignition OFF, disconnect the KR75 Engine Controls Ignition Relay.
2. Test for 70-110 Ω between terminals 85 and 86:

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

  Replace the KR75 Engine Controls Ignition Relay.

- **If between 70-110 Ω**

3. Test for infinite resistance between the terminals listed below:
   - 30 and 86
   - 30 and 87
   - 30 and 85
   - 85 and 87
   - **If less than infinite resistance**

     Replace the KR75 Engine Controls Ignition Relay.

   - **If infinite resistance**
4. Install a 20 A fused jumper wire between relay terminal 85 and 12 V. Install a jumper wire between relay terminal 86 and ground.
5. Test for less than 2 Ω between terminals 30 and 87.
   - **If 2 Ω or greater**

     Replace the KR75 Engine Controls Ignition Relay.

   - **If less than 2 Ω**
6. All OK.

Repair Instructions

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

- **Engine Wiring Harness Junction Block Replacement** .
- **Relay Replacement (Attached to Wire Harness)** **Relay Replacement (Within an Electrical Center)**
- **Control Module References** for engine control module replacement, programming and setup.

DTC P111E: ENGINE COOLANT TEMPERATURE SENSOR (LGW)

Diagnostic 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 P111E

Engine Coolant Temperature Sensor Not Plausible

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
Signal	P0117	P0118	P0118	P0118	P0128, P111E
Low Reference	-	P0118	P0118	-	P0128

Typical Scan Tool Data

ECT Sensor Temperature

Circuit	Short to Ground	Open	Short to Voltage

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Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** -39 to +120Â°C (-38 to +248Â°F)			
ECT Sensor	150Â°C (302Â°F)	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)
Low Reference	-	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)

Circuit/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 5V to the ECT sensor signal circuit and a ground for the low reference circuit.

The purpose of this diagnostic is to determine if the input from the ECT sensor is skewed warmer than normal. The internal clock of the ECM will record the amount of time the engine is OFF. If the required engine OFF time is met at start-up, the ECM will compare the temperature difference between the actual measured ECT and a calibrated ECT model. The information for this model is derived from the previous drive cycle and includes the accumulated mass air flow (MAF), the engine run time, the ambient air temperature and the ECT at the end of the drive cycle.

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

Conditions for Running the DTC

- DTCs P0111, P0112, P0113, P0114, P0117, P0118, P0128, P0502, P0503, P0601, P1621 or P2610 are not set.
- The vehicle has had a minimum ignition OFF time of 8 hours.
- The engine is running.
- The start-up modeled ECT is colder than 50Â°C (+122Â°F).
- The previous accumulated MAF is greater than 6, 000 grams.
- The previous engine run time is greater than 600 seconds.

OR

- The vehicle has had a minimum ignition OFF time of 8 hours.
- The engine is running.
- The previous ECT at engine shutdown is warmer than 75Â°C (+167Â°F).
- The previous accumulated MAF is greater than 6, 000 grams.
- The previous engine run time is greater than 600 seconds.
- This DTC runs once per ignition cycle within the enabling conditions.

Conditions for Setting the DTC

P111E

The ECM detects a temperature difference at initial power-up that indicates that the actual measured ECT is 10Â°C (18Â°F) greater than the modeled ECT and an active block heater has not been detected.

Action Taken When the DTC Sets

DTC P111E is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P111E 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

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ECM as a warmer ECT.

- The ECM memory which includes the ignition OFF timer is maintained by battery power. If the ECM or the battery are disconnected for less than 15 seconds the proper operation of the ECM memory and the timer can be disrupted. Always disconnect these components for greater than 30 seconds.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW)

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. Turn OFF the ignition.
2. Inspect the cooling system surge tank for the proper engine coolant level. Refer to **Cooling System Leak Testing** , **Cooling System Draining and Filling (Static without HP9)** and **Cooling System Draining and Filling (GE 47716 without HP9)** .
3. If the ignition has been OFF for 8 hours or greater, the intake air temperature (IAT) sensor, the IAT sensor 2 and the ECT sensor should be within 9Â°C (16Â°F) of each other and also the ambient temperature. Ignition ON, observe the scan tool IAT Sensor, IAT Sensor 2 and the ECT Sensor parameters. Compare those sensor parameters to each other and also to the ambient temperature to determine if the ECT sensor is skewed warmer.
4. Engine running, observe the ECT Sensor parameter. The reading should be between -39 to +120Â°C (-38 to +248Â°F) depending on the current ambient temperature and the vehicle operating conditions.
5. Operate the vehicle within the Conditions for Running the DTC to verify the DTC does not reset. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the B34 Engine Coolant Temperature Sensor harness connector at the sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal A or 2 and ground.
    - **If 5 Ω or greater**

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

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- **If less than 5 Ω**

3. Ignition ON.
4. Verify the scan tool ECT Sensor parameter is colder than -39Â°C (-38Â°F).
    - **If warmer than -39Â°C (-38Â°F)**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit terminal B or 1 and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance.
    3. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module
    - **If colder than -39Â°C (-38Â°F)**
5. Install a 3 A fused jumper wire between the signal circuit terminal B or 1 and the low reference circuit terminal A or 2.
6. Verify the scan tool ECT sensor parameter is warmer than 149Â°C (300Â°F).
    - **If 149Â°C (300Â°F) or colder**
    1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V
    3. Ignition OFF.
    4. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If warmer than 149Â°C (300Â°F)**
7. Test or replace the B34A 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 K20 Engine Control Module replacement, programming and setup.

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DTC P111E: ENGINE COOLANT TEMPERATURE SENSOR (LGX)

Diagnostic 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 P111E

Engine Coolant Temperature Sensor Not Plausible

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
Signal	P0117	P0118	P0118	P0118	P0128, P111E
Low Reference	-	P0118	P0118	-	P0128

Typical Scan Tool Data

ECT Sensor Temperature

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** -39 to +120Â°C (-38 to +248Â°F)			
ECT Sensor	150Â°C (302Â°F)	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)
Low Reference	-	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)

Circuit/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 5V to the ECT sensor signal circuit and a ground for the low reference circuit.

The purpose of this diagnostic is to determine if the input from the ECT sensor is skewed warmer than normal. The internal clock of the ECM will record the amount of time the engine is OFF. If the required engine OFF time is met at start-up, the ECM will compare the temperature difference between the actual measured ECT and a calibrated ECT model. The information for this model is derived from the previous drive cycle and includes the accumulated mass air flow (MAF), the engine run time, the ambient air temperature and the ECT at the end of the drive cycle.

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

Conditions for Running the DTC

- DTCs P0111, P0112, P0113, P0114, P0117, P0118, P0128, P0502, P0503, P0601, P1621 or P2610 are not set.
- The vehicle has had a minimum ignition OFF time of 8 hours.
- The engine is running.
- The start-up modeled ECT is colder than 50Â°C (+122Â°F).
- The previous accumulated MAF is greater than 6, 000 grams.
- The previous engine run time is greater than 600 seconds.

OR

- The vehicle has had a minimum ignition OFF time of 8 hours.
- The engine is running.

- The previous ECT at engine shutdown is warmer than 75Â°C (+167Â°F).
- The previous accumulated MAF is greater than 6, 000 grams.
- The previous engine run time is greater than 600 seconds.
- This DTC runs once per ignition cycle within the enabling conditions.

Conditions for Setting the DTC

P111E

The ECM detects a temperature difference at initial power-up that indicates that the actual measured ECT is 10Â°C (18Â°F) greater than the modeled ECT and an active block heater has not been detected.

Action Taken When the DTC Sets

DTC P111E is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P111E 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.
- The ECM memory which includes the ignition OFF timer is maintained by battery power. If the ECM or the battery are disconnected for less than 15 seconds the proper operation of the ECM memory and the timer can be disrupted. Always disconnect these components for greater than 30 seconds.

Reference Information

Schematic Reference

Engine Controls Schematics (LGX)

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. Turn OFF the ignition.
2. Inspect the cooling system surge tank for the proper engine coolant level. Refer to **Cooling System Leak Testing** , **Cooling System Draining and Filling (Static without HP9)** and **Cooling System Draining and Filling (GE 47716 without HP9)** .

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3. If the ignition has been OFF for 8 hours or greater, the intake air temperature (IAT) sensor, the IAT sensor 2 and the ECT sensor should be within 9Â°C (16Â°F) of each other and also the ambient temperature. Ignition ON, observe the scan tool IAT Sensor, IAT Sensor 2 and the ECT Sensor parameters. Compare those sensor parameters to each other and also to the ambient temperature to determine if the ECT sensor is skewed warmer.
4. Engine running, observe the ECT Sensor parameter. The reading should be between -39 to +120Â°C (-38 to +248Â°F) depending on the current ambient temperature and the vehicle operating conditions.
5. Operate the vehicle within the Conditions for Running the DTC to verify the DTC does not reset. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.

Circuit/System Testing

1. Ignition OFF and all vehicle systems OFF, disconnect the B34 Engine Coolant Temperature Sensor harness connector at the sensor. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between the low reference circuit terminal B or 1 and ground.
    - **If 5 Ω or greater**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for less than 2 Ω in the low reference circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If less than 5 Ω**
3. Ignition ON.
4. Verify the scan tool ECT Sensor parameter is colder than -39Â°C (-38Â°F).
    - **If warmer than -39Â°C (-38Â°F)**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit terminal A or 2 and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance.
    3. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module
    - **If colder than -39Â°C (-38Â°F)**
5. Install a 3 A fused jumper wire between the signal circuit terminal A or 2 and the low reference circuit terminal B or 1.
6. Verify the scan tool ECT sensor parameter is warmer than 149Â°C (300Â°F).
    - **If 149Â°C (300Â°F) or colder**
    1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V
    3. Ignition OFF.
    4. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If warmer than 149Â°C (300Â°F)**
7. Test or replace the B34A Engine Coolant Temperature Sensor.

Component Testing

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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 K20 Engine Control Module replacement, programming and setup.

DTC P1248-P124D: CYLINDER INJECTOR HIGH CONTROL CIRCUIT (LGX)

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

DTC P1248

Cylinder 1 Injector High Control Circuit Shorted to Control Circuit

DTC P1249

Cylinder 2 Injector High Control Circuit Shorted to Control Circuit

DTC P124A

Cylinder 3 Injector High Control Circuit Shorted to Control Circuit

DTC P124B

Cylinder 4 Injector High Control Circuit Shorted to Control Circuit

DTC P124C

Cylinder 5 Injector High Control Circuit Shorted to Control Circuit

DTC P124D

Cylinder 6 Injector High Control Circuit Shorted to Control Circuit

Diagnostic Fault Information

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Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Short Between Circuits
Control circuit terminal 2 @ Q17A Fuel Injector 1	P2147	P0201	P2148	P1248
Control circuit terminal 1 @ Q17A Fuel Injector 1	P0261	P0201	P0262	P1248
Control circuit terminal 2 @ Q17B Fuel Injector 2	P2150	P0202	P2151	P1249
Control circuit terminal 1 @ Q17B Fuel Injector 2	P0264	P0202	P0265	P1249
Control circuit terminal 2 @ Q17C Fuel Injector 3	P2153	P0203	P2154	P124A
Control circuit terminal 1 @ Q17C Fuel Injector 3	P0267	P0204	P0268	P124A
Control circuit terminal 2 @ Q17D Fuel Injector 4	P2156	P0204	P0270, P2157	P124B
Control circuit terminal 1 @ Q17D Fuel Injector 4	P0270, P2156	P0205	P0271, P2157	P124B
Control circuit terminal 2 @ Q17E Fuel Injector 5	P216B	P0205	P216C	P124C
Control circuit terminal 1 @ Q17E Fuel Injector 5	P0273	P0206	P0274	P124C
Control circuit terminal 2 @ Q17F Fuel Injector 6	P216E	P0206	P216F	P124D
Control circuit terminal 1 @ Q17F Fuel Injector 6	P0276	P0206	P0277	P124D

Typical Scan Tool Data

Fuel Injector Control Circuit Test Status

Circuit	Short to Ground	Open	Short to Voltage	Short between the circuits
Operating Conditions: Engine at Idle **Parameter Normal Range:** OK or Not Run				
Control circuit terminal 2	High Control Circuit Low Voltage	Open	High Control Circuit High Voltage	High Control Circuit Shorted to Control Circuit
Control circuit terminal 1	Control Circuit Low Voltage	Open	Control Circuit High Voltage	High Control Circuit Shorted to Control Circuit

Circuit/System Description

Circuit	Description
Control circuit terminal 2	Regulated voltage supplied by the control module.
Control circuit terminal 1	The output circuit is switched to ground to activate the component.

Component	Description
Q17 Fuel Injector	Fuel injectors are solenoid valves that inject fuel either into the intake system or directly into the cylinder. The amount of fuel injected depends on the length of the electrical pulse that is applied. The fuel injectors of this system have an operating voltage range of 50 to 90 V.

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Component	Description
K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.

Conditions for Running the DTC

- DTC P062B = Not set
- Engine is Running
- Battery Voltage =Greater than 11 V

DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

P1248, P1249, P124A, P124B, P124C, P124D

Control Circuit Shorted to Control Circuit - For greater than 1 s

Actions Taken When the DTC Sets

DTCs P1248, P1249, P124A, P124B, P124C, P124D are Type A DTCs.

Conditions for Clearing the DTC

DTCs P1248, P1249, P124A, P124B, P124C, P124D are Type A DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGX)

Connector End View Reference

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Component View Reference

Powertrain Component Views

Description and Operation

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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

Circuit/System Verification

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1. Engine running.
2. Verify the scan tool parameter:
    - Cylinder 1 Injector Control Circuit Status =OK
    - Cylinder 2 Injector Control Circuit Status =OK
    - Cylinder 3 Injector Control Circuit Status =OK
    - Cylinder 4 Injector Control Circuit Status =OK
    - Cylinder 5 Injector Control Circuit Status =OK
    - Cylinder 6 Injector Control Circuit Status =OK
    - **If not the specified state**

      Refer to Circuit/System Testing

    - **If the specified state**
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 is not set**
5. All OK.

Circuit/System Testing

1. Ignition/VehicleÂ» Off
2. Disconnect the appropriate electrical connector: X160 X161
3. IgnitionÂ» On / VehicleÂ» In Service Mode
4. Verify the scan tool parameter:

X160

- Cylinder 1 Injector Control Circuit Status =OK
- Cylinder 3 Injector Control Circuit Status =OK
- Cylinder 5 Injector Control Circuit Status =OK

X161

- Cylinder 2 Injector Control Circuit Status =OK
- Cylinder 4 Injector Control Circuit Status =OK
- Cylinder 6 Injector Control Circuit Status =OK
- **If not the specified state**

1. Ignition/Vehicle Â» Off
2. Disconnect the electrical connector: X3 @ K20 Engine Control Module
3. Test for infinite resistance between the test points:
    - {Q17A Fuel Injector 1} Terminal 69 & Terminal 49 @ Control module harness
    - {Q17B Fuel Injector 2} Terminal 68 & Terminal 48 @ Control module harness
    - {Q17C Fuel Injector 3} Terminal 72 & Terminal 52 @ Control module harness
    - {Q17D Fuel Injector 4} Terminal 70 & Terminal 50 @ Control module harness
    - {Q17E Fuel Injector 5} Terminal 67 & Terminal 47 @ Control module harness
    - {Q17F Fuel Injector 6} Terminal 71 & Terminal 51 @ Control module harness
    - If less than infinite resistance Â» Repair the short between the circuits.
    - If infinite resistance Â» Replace the component: K20 Engine Control Module

- **If the specified state**

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5. Ignition/Vehicle Â» Off
6. Disconnect the appropriate electrical connector:Q17 Fuel Injector
7. Test for infinite resistance between the test points:Q17 Fuel Injector Terminal 1 & Terminal 2 @ Component harness
    - **If less than infinite resistance**

      Repair the short between the circuits:High Control & Low Control
    - **If infinite resistance**

      Test or replace the component:Q17 Fuel Injector

Component Testing

1. Ignition/Vehicle Â» Off
2. Disconnect the electrical connector: Q17 Fuel Injector
3. Test for 1 to 3 Ω between the test points: Control circuit terminal 2 & Control circuit terminal 1

    NOTE: **The specified resistances are valid for components at room temperature.**

    - **If not between 1 and 3 Ω**

      Replace the component: Q17 Fuel Injector
    - **If between 1 and 3 Ω**
4. Test for infinite resistance between the test points: Each terminal of the component & The component's housing
    - **If less than infinite resistance**

      Replace the component: Q17 Fuel Injector
    - **If infinite resistance**
5. All OK.

Repair Instructions

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

- **Fuel Injector Replacement**
- Fuel Rail Pressure Sensor or Fuel Rail Learn
- For control module replacement, programming and setup, refer to **Control Module References**

DTC P1248-P124D: (LGW)

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis:**Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

DTC P1248

Cylinder 1 Injector High Control Circuit Shorted to Control Circuit

DTC P1249

Cylinder 2 Injector High Control Circuit Shorted to Control Circuit

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DTC P124A

Cylinder 3 Injector High Control Circuit Shorted to Control Circuit

DTC P124B

Cylinder 4 Injector High Control Circuit Shorted to Control Circuit

DTC P124C

Cylinder 5 Injector High Control Circuit Shorted to Control Circuit

DTC P124D

Cylinder 6 Injector High Control Circuit Shorted to Control Circuit

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Short between the circuits
Control circuit terminal 2 @ Q17A Fuel Injector 1	P2147	P0201	P2148	P1248
Control circuit terminal 1 @ Q17A Fuel Injector 1	P0261	P0201	P0262	P1248
Control circuit terminal 2 @ Q17B Fuel Injector 2	P2150	P0202	P2151	P1249
Control circuit terminal 1 @ Q17B Fuel Injector 2	P0264	P0202	P0265	P1249
Control circuit terminal 2 @ Q17C Fuel Injector 3	P2153	P0203	P2154	P124A
Control circuit terminal 1 @ Q17C Fuel Injector 3	P0267	P0203	P0268	P124A
Control circuit terminal 2 @ Q17D Fuel Injector 4	P2156	P0204	P0270, P2157	P124B
Control circuit terminal 1 @ Q17D Fuel Injector 4	P0270, P2156	P0204	P0271, P2157	P124B
Control circuit terminal 2 @ Q17E Fuel Injector 5	P216B	P0205	P216C	P124C
Control circuit terminal 1 @ Q17E Fuel Injector 5	P0273	P0205	P0274	P124C
Control circuit terminal 2 @ Q17F Fuel Injector 6	P216E	P0206	P216F	P124D
Control circuit terminal 1 @ Q17F Fuel Injector 6	P0276	P0206	P0277	P124D

Typical Scan Tool Data

Fuel Injector Control Circuit Test Status

Circuit	Short to Ground	Open	Short to Voltage	Short between the circuits
Operating Conditions: Engine at Idle **Parameter Normal Range:** OK or Not Run				
Control circuit terminal 2	High Control Circuit Low Voltage	Open	High Control Circuit High Voltage	High Control Circuit Shorted to Control Circuit
Control circuit terminal 1	Control Circuit Low Voltage	Open	Control Circuit High Voltage	High Control Circuit Shorted to Control Circuit

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Circuit/System Description

Circuit	Description
Control circuit terminal 2	Regulated voltage supplied by the control module.
Control circuit terminal 1	The output circuit is switched to ground to activate the component.

Component	Description
Q17 Fuel Injector	Fuel injectors are solenoid valves that inject fuel either into the intake system or directly into the cylinder. The amount of fuel injected depends on the length of the electrical pulse that is applied. The fuel injectors of this system have an operating voltage range of 50 to 90 V.
K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.

Conditions for Running the DTC

- DTC P062B = Not set
- Engine is Running
- Battery Voltage =Greater than 11 V

DTCs run continuously when the above conditions are met.

Conditions for Setting the DTC

P1248, P1249, P124A, P124B, P124C, P124D

Control Circuit Shorted to Control Circuit - For greater than 1 s

Actions Taken When the DTC Sets

DTCs P1248, P1249, P124A, P124B, P124C, P124D are Type A DTCs.

Conditions for Clearing the DTC

DTCs P1248, P1249, P124A, P124B, P124C, P124D are Type A DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW)

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

Circuit/System Verification

1. Engine running.
2. Verify the scan tool parameter:
   - Cylinder 1 Injector Control Circuit Status =OK
   - Cylinder 2 Injector Control Circuit Status =OK
   - Cylinder 3 Injector Control Circuit Status =OK
   - Cylinder 4 Injector Control Circuit Status =OK
   - Cylinder 5 Injector Control Circuit Status =OK
   - Cylinder 6 Injector Control Circuit Status =OK
   - **If not the specified state**

     Refer to Circuit/System Testing

   - **If the specified state**
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 is not set**
5. All OK.

Circuit/System Testing

1. Ignition/VehicleÂ» Off
2. Disconnect the appropriate electrical connector: X160 X161
3. IgnitionÂ» On / VehicleÂ» In Service Mode
4. Verify the scan tool parameter:

X160

- Cylinder 1 Injector Control Circuit Status =Open
- Cylinder 3 Injector Control Circuit Status =Open
- Cylinder 5 Injector Control Circuit Status =Open

X161

- Cylinder 2 Injector Control Circuit Status =Open
- Cylinder 4 Injector Control Circuit Status =Open
- Cylinder 6 Injector Control Circuit Status =Open
- **If not the specified state**

1. Ignition/Vehicle Â» Off
2. Disconnect the electrical connector: X4 @ K20 Engine Control Module
3. Test for infinite resistance between the test points:

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- {Q17A Fuel Injector 1}Terminal 69 & Terminal 49 @ Control module harness
- {Q17B Fuel Injector 2}Terminal 68 & Terminal 48 @ Control module harness
- {Q17C Fuel Injector 3}Terminal 72 & Terminal 52 @ Control module harness
- {Q17D Fuel Injector 4}Terminal 70 & Terminal 50 @ Control module harness
- {Q17E Fuel Injector 5}Terminal 67 & Terminal 47 @ Control module harness
- {Q17F Fuel Injector 6}Terminal 71 & Terminal 51 @ Control module harness
- If less than infinite resistance Â» Repair the short between the circuits.
- If infinite resistance Â» Replace the component:K20 Engine Control Module

- **If the specified state**

5. Ignition/Vehicle Â» Off
6. Disconnect the appropriate electrical connector:Q17 Fuel Injector
7. Test for infinite resistance between the test points:Q17 Fuel Injector Terminal 1 & Terminal 2 @ Component harness
    - **If less than infinite resistance**

      Repair the short between the circuits:High Control & Low Control

    - **If infinite resistance**

      Test or replace the component:Q17 Fuel Injector

Component Testing

1. Ignition/Vehicle Â» Off
2. Disconnect the electrical connector: Q17 Fuel Injector
3. Test for 1 to 3 Ω between the test points: Control circuit terminal 2 & Control circuit terminal 1

    NOTE: **The specified resistances are valid for components at room temperature.**

    - **If not between 1 and 3 Ω**

      Replace the component: Q17 Fuel Injector

    - **If between 1 and 3 Ω**
4. Test for infinite resistance between the test points: Each terminal of the component & The component's housing
    - **If less than infinite resistance**

      Replace the component: Q17 Fuel Injector

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

Repair Instructions

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

- **Fuel Injector Replacement**
- Fuel Rail Pressure Sensor or Fuel Rail Learn
- For control module replacement, programming and setup, refer to **Control Module References**

DTC P1255: FUEL PUMP CONTROL MODULE DRIVER HIGH TEMPERATURE

Diagnostic Instructions

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

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- Review the description of Strategy Based Diagnosis:**Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

NOTE: **This procedure may also diagnose malfunctions that are not detected by a DTC.**

DTC P1255

Fuel Pump Control Module Driver High Temperature

Circuit/System Description

Component	Description
K111 Fuel Pump Driver Control Module	The control module K111 monitors the fuel system for any condition which may adversely affect emissions. If a condition is detected it sets a DTC and sends a serial data message to the engine control module which then sets DTC P069E.

When the ignition is turned On, the ECM sends a 12 V signal to the control module K111 to enable the fuel pump. If the engine is not started, the control module K111 turns the fuel pump Off after 6 s.

Conditions for Running the DTC

- Ignition Voltage =Greater than 9 V
- Engine=Cranking or running.
- Fuel Pump Enable Command =On

DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

K111 Fuel Pump Driver Control Module=Greater than 150Â°C (302Â°F) - For greater than 1 s

Actions Taken When the DTC Sets

DTC P1255 is a Type A DTC.

Conditions for Clearing the DTC

DTC P1255 is a Type A DTC.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) **Engine Controls Schematics (LGX)**

Connector End View Reference

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

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DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References

Circuit/System Verification

1. IgnitionÂ» On / VehicleÂ» In Service Mode
2. Verify DTC P0231, P0232, P023F is not set.
   - **If any of the DTCs are set**

     Refer to:**DTC P0231, P0232 or P023F**

   - **If none of the DTCs are set**
3. Verify the component location is free of debris, clutter or any obstruction that may reduce airflow which could cause an overheat condition:K111 Fuel Pump Driver Control Module
   - **If a condition exists**
   1. Repair as necessary
   2. Clear the DTCs.
   3. Test drive the vehicle.
   4. Verify DTC P1255 is not set.
      - If the DTC setsÂ» Replace the component:K111 Fuel Pump Driver Control Module
      - If the DTC is not set
   5. All OK.
   - **If no condition exists**
4. Clear the DTCs.
5. Test drive the vehicle.
6. Verify DTC P1255 is not set.
   - **If the DTC is set**

     Replace the component: K111 Fuel Pump Driver Control Module

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

Repair Instructions

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

Fuel Pump Power Control Module Replacement - K111 Fuel Pump Driver Control Module

DTC P129B OR P129C: FUEL PUMP DRIVER CONTROL MODULE SYSTEM

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis:**Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

NOTE: **This procedure may also diagnose malfunctions that are not detected by a DTC.**

DTC P129B

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Fuel Pump Driver Control Module System Voltage Low Voltage

DTC P129C

Fuel Pump Driver Control Module System Voltage High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
B+	P018B*, P0506*, P129B, P2635*, U18A2*	P018B*, P0506*, P129B, P2635*, U18A2*	P129C	-
*Additional DTCs may set.				

Circuit/System Description

Component	Description
K111 Fuel Pump Driver Control Module	The control module K111 monitors the fuel system for any condition which may adversely affect emissions. If a condition is detected it sets a DTC and sends a serial data message to the engine control module which then sets DTC P069E.

When the ignition is turned On, the ECM sends a 12 V signal to the control module K111 to enable the fuel pump. If the engine is not started, the control module K111 turns the fuel pump Off after 6 s.

Conditions for Running the DTC

P129B, P129C

- Engine=Running
- Ignition Voltage - Greater than 7 V
- Fuel Pump Enable =On

DTC runs continuously when the above condition is met.

Conditions for Setting the DTC

P129B

Fuel Pump Enable - Less than 7 V - For greater than 1 s

P129C

Fuel Pump Enable - Greater than 18 V - For greater than 1 s

Actions Taken When the DTC Sets

DTCs P0129B, P0129C are Type C DTCs.

Conditions for Clearing the DTC

DTCs P0129B, P0129C are Type C DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

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Description and Operation

Fuel System Description

Electrical Information 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

Circuit/System Verification

1. Ignition/Vehicle & All vehicle systems Â» Off
2. Test for 12.4 to 12.8 V between the test points:Battery Positive and Negative Cable
   - **If not between 12.4 and 12.8 V**

     Refer to:**Battery Inspection/Test**

   - **If between 12.4 and 12.8 V**
3. Engine running.
4. Test for 13.4 to 15 V between the test points:Battery Positive and Negative Cable
   - **If not between 13.4 and 15 V**

     Refer to **Charging System Test**

   - **If between 13.4 and 15 V**
5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify DTC P129B, P0129C is not set.
   - **If the DTC is set**

     Refer to Circuit/System Testing

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

Circuit/System Testing

1. Ignition/Vehicle & All vehicle systems Â» Off

   NOTE: **It may take up to 2 min for all vehicle systems to power down before an accurate ground or low reference circuit continuity test can be performed.**

2. Disconnect the electrical connector:K111 Fuel Pump Driver Control Module
3. Test for less than 5 Ω between the test points:Ground circuit terminal 9 & Ground
   - **If 5 Ω or greater**
   1. Test for less than 2 Ω between the test points:Ground circuit terminal 9 @ Component harness & Ground connection G304
      - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.

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- If less than 2 ΩÂ» Repair the open/high resistance in the ground connection.

- **If less than 5 Ω**

4. Ignition Â» On / Vehicle Â» In Service Mode
5. Verify a test lamp turns On between the test points:B+ circuit terminal 1 & Ground
    - **If the test lamp does not turn On and the circuit fuse is OK**
    1. Ignition/Vehicle Â» Off & Remove Â» Test lamp
    2. Test for less than 2 Ω between the test points: B+ circuit terminal 1 & Output terminal @ X53A Fuse Block - Rear Body F39RA Fuse
        - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
        - If less than 2 ΩÂ» Verify the fuse is OK and there is voltage at the fuse.
    - **If the test lamp does not turn On and the circuit fuse is open**
    1. Ignition/Vehicle Â» Off & Remove Â» Test lamp
    2. Test for infinite resistance between the test points: B+ circuit terminal 1 & Ground
        - If less than infinite resistance Â» Repair the short to ground on the circuit.
        - If infinite resistance Â» Replace the component:K111 Fuel Pump Driver Control Module
    - **If the test lamp turns On**
6. Replace the component:K111 Fuel Pump Driver Control Module

Repair Instructions

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

Fuel Pump Power Control Module Replacement - K111 Fuel Pump Driver Control Module

DTC P129D: FUEL PUMP DRIVER CONTROL MODULE IGNITION ON/START SWITCH CIRCUIT

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

NOTE: **This procedure may also diagnose malfunctions that are not detected by a DTC.**

DTC P129D

Fuel Pump Driver Control Module Ignition On/Start Switch Circuit Low Voltage

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition	P129D	P129D	P129D	-

Circuit/System Description

Component	Description
K111 Fuel Pump Driver Control Module	The control module K111 monitors the fuel system for any condition which may adversely affect emissions. If a condition is detected it sets a DTC and sends a serial data message to the engine control module which then sets DTC P069E.

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When the ignition is turned On, the ECM sends a 12 V signal to the control module K111 to enable the fuel pump. If the engine is not started, the control module K111 turns the fuel pump Off after 6 s.

Conditions for Running the DTC

Control Module Power Moding =Enabled

DTC runs continuously when the above condition is met.

Conditions for Setting the DTC

Commanded state does not match the actual state

Actions 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 (LGW) Engine Controls Schematics (LGX)

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

Circuit/System Verification

1. IgnitionÂ» On / VehicleÂ» In Service Mode
2. Verify DTC P0562 is not set.
   - **If the DTC is set**

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

   - **If the DTC is not set**
3. Verify DTC P129D is not set.
   - **If the DTC is set**

     Refer to Circuit/System Testing

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- **If the DTC is not set**

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 DTC P129D is not set.
    - **If the DTC is set**

      Refer to Circuit/System Testing

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

Circuit/System Testing

1. Ignition/Vehicle & All vehicle systems Â» Off

> **NOTE:** **It may take up to 2 min for all vehicle systems to power down before an accurate ground or low reference circuit continuity test can be performed.**

2. Disconnect the electrical connector:K111 Fuel Pump Driver Control Module
3. Ignition Â» On / Vehicle Â» In Service Mode
4. Verify a test lamp turns On between the test points:Ignition circuit terminal 6 & Ground
    - **If the test lamp does not turn On and the circuit fuse is OK**
    1. Ignition/Vehicle Â» Off & Remove Â» Test lamp
    2. Test for less than 2 Ω between the test points: Ignition circuit terminal 6 & Output terminal @ X50A Fuse Block - Underhood F42UA Fuse
        - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
        - If less than 2 ΩÂ» Verify the fuse is OK and there is voltage at the fuse.
    - **If the test lamp does not turn On and the circuit fuse is open**
    1. Ignition/Vehicle Â» Off & Remove Â» Test lamp
    2. Test for infinite resistance between the test points:Ignition circuit terminal 6 & Ground
        - If less than infinite resistance Â» Repair the short to ground on the circuit.
        - If infinite resistance Â» Replace the component:K111 Fuel Pump Driver Control Module
    - **If the test lamp turns On**
5. Ignition/Vehicle & All vehicle systemsÂ» Off
6. Verify a test lamp does not turn On between the test points:Ignition circuit terminal 6 & Ground
    - **If the test lamp turns On**

      Repair the short to voltage on the circuit.

    - **If the test lamp does not turn On**
7. Replace the component:K111 Fuel Pump Driver Control Module

Repair Instructions

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

Fuel Pump Power Control Module Replacement - K111 Fuel Pump Driver Control Module

DTC P12A6: FUEL PUMP DRIVER CONTROL MODULE ENABLE CIRCUIT PERFORMANCE

Diagnostic Instructions

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

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- Review the description of Strategy Based Diagnosis:**Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

NOTE: **This procedure may also diagnose malfunctions that are not detected by a DTC.**

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
Signal	P0171*, P0506*, P0628*, P12A6	P0171*, P0628*, P12A6	-	P12A6
*Additional DTCs may set.				

Circuit/System Description

Component	Description
K111 Fuel Pump Driver Control Module	The control module K111 monitors the fuel system for any condition which may adversely affect emissions. If a condition is detected it sets a DTC and sends a serial data message to the engine control module which then sets DTC P069E.
K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.

When the ignition is turned On, the ECM sends a 12 V signal to the control module K111 to enable the fuel pump. If the engine is not started, the control module K111 turns the fuel pump Off after 6 s.

Conditions for Running the DTC

Ignition Voltage - Greater than 7 V

DTC runs continuously when the above condition is met.

Conditions for Setting the DTC

The commanded state of the driver and the actual state of the control circuit do not match for greater than 0.5 s.

Actions 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 (LGW) **Engine Controls Schematics (LGX)**

Connector End View Reference

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COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Description and Operation

Fuel System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References

Circuit/System Verification

1. Ignition On
2. Verify the scan tool parameter:
   - Fuel Pump Speed Output Circuit High Voltage Test Status =OK
   - Fuel Pump Speed Output Circuit Low Voltage Test Status =OK
   - Fuel Pump Speed Output Circuit Open Test Status =OK
   - **If not the specified state**

     Refer to Circuit/System Testing

   - **If the specified state**
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 is not set**
5. All OK.

Circuit/System Testing

1. Ignition/VehicleÂ» Off
2. Disconnect the electrical connector:K111 Fuel Pump Driver Control Module
3. Ignition/Vehicle Â» On - For greater than 10 s
4. Verify a test lamp does not turn On between the test points:Control circuit terminal 2 & Ground
   - **If the test lamp is always On**
   1. Ignition/VehicleÂ» Off & RemoveÂ» Test lamp
   2. Disconnect the electrical connector: X1 @ K20 Engine Control Module
   3. Ignition Â» On / Vehicle Â» In Service Mode
   4. Test for less than 1 V between the test points: Control circuit terminal 2 @ K111 Fuel Pump Driver Control Module (harness side) & Ground

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- If 1 V or greater Â» Repair the short to voltage on the circuit.
- If less than 1 V Â» Replace the component:K20 Engine Control Module

- **If the test lamp is always Off**

5. Remove Â» Test Lamp
6. Perform the scan tool control function:Fuel Pump Enable
7. Verify the scan tool parameter:Fuel Pump Speed Output Circuit Low Voltage Test Status =OK
    - **If not the specified state**
    1. Ignition/Vehicle Â» Off
    2. Disconnect the electrical connector: X1 @ K20 Engine Control Module
    3. Test for infinite resistance between the test points:Control circuit terminal 2 @ K111 Fuel Pump Driver Control Module (harness side) & Ground
        - If less than infinite resistance Â» Repair the short to ground on the circuit.
        - If infinite resistance Â» Replace the component:K20 Engine Control Module
    - **If the specified state**
8. Connect a 3 A fused jumper wire between the test points:Control circuit terminal 2 @ K111 Fuel Pump Driver Control Module (harness side) & Ground
9. Verify the scan tool parameter:Fuel Pump Speed Output Circuit Low Voltage Test Status =Malfunction
    - **If not the specified state**
    1. Ignition/Vehicle Â» Off
    2. Disconnect the electrical connector: X1 @ K20 Engine Control Module
    3. Test for less than 2 Ω between the test points:Control circuit terminal 2 @ K111 Fuel Pump Driver Control Module (harness side) & Terminal 69 X1 @ K20 Engine Control Module (harness side)
        - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
        - If less than 2 ΩÂ» Replace the component:K20 Engine Control Module
    - **If the specified state**
10. Replace the component:K111 Fuel Pump Driver Control Module

Repair Instructions

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

- **Fuel Pump Power Control Module Replacement** - K111 Fuel Pump Driver Control Module
- For control module replacement, programming and setup, refer to **Control Module References**

DTC P129E OR P12A8: FUEL PUMP

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

DTC P12A8

Fuel Pump Control Signal Message Counter Incorrect

Circuit/System Description

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The fuel pump power control module is in constant communication with the engine control module (ECM) regarding the operating state of the fuel pump power control system. Serial data messages are sent in a continuously repeating series of rolling counts with associated password protect samples. Each count/sample is assigned a value. When the ECM determines that too many of the counts/samples contain an error value, the ECM sets DTC P129E or P12A8.

Conditions for Running the DTC

- The ignition voltage is greater than 7 V.
- The DTC runs continuously when the above condition is met.

Conditions for Setting the DTC

The ECM detects an error value for over 1 s.

Action Taken When the DTC Sets

DTC P129E and P12A8 are Type A DTCs.

Conditions for Clearing the DTC

DTC P129E and P12A8 are Type A DTCs.

Diagnostic Aids

An intermittent fault in the CAN circuits will cause the ECM to set DTC P129E or P12A8.

Reference Information

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:

- **DTC P129E and P12A8 are informational DTCs.**
- **Diagnose all other engine control module DTCs prior to DTC P129E or P12A8.**

1. Verify that no other DTCs are set except for DTC P129E or P12A8.
   - **If any other DTCs are set**

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

   - **If only DTC P129E or P12A8 is set**
2. Replace the K111 Fuel Pump Power Control Module.
3. Verify the DTC does not set while operating the vehicle within the Conditions for Running the DTC.
   - **If DTC sets**

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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** for K111 Fuel Pump Power Control Module Replacement
- **Control Module References** for engine control module replacement, programming and setup.

DTC P135A OR P135B: IGNITION COIL SUPPLY VOLTAGE

Diagnostic Instructions

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

DTC Descriptor

DTC P135A

Ignition Coil Supply Voltage Circuit Bank 1

DTC P135B

Ignition Coil Supply Voltage Circuit Bank 2

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0201, P0202, P0203, P0204, P0205, P0206, P0300, P0351, P0352, P0353, P0354, P0355, P0356, P135A, P135B	P0201, P0202, P0203, P0204, P0205, P0206, P0300, P0351, P0352, P0353, P0354, P0355, P0356, P135A, P135B	-	-

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 and P135B are Type A DTCs.

Conditions for Clearing the DTC

DTC P135A and P135B are Type A DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Electronic Ignition System Description

Electrical Information Reference

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

Scan Tool Reference

Control Module References

Circuit/System Verification

1. Ignition ON.
2. Verify the appropriate scan tool Ignition Coil Supply Voltage parameter displays On.
    - **If On is not displayed**

      Refer to Circuit/System Testing.

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

      Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.
2. Connect a 3A fused jumper wire between the control circuit terminal 15 and ground, ignition ON.
3. Verify a test lamp illuminates between the appropriate ignition circuit terminal listed below and ground.
    - Terminal 49
    - Terminal 50
    - **If the test lamp does not illuminate and the circuit fuse is good**
    1. Ignition OFF.
    2. Test for less than 2 Ω in the ignition circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.

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

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

  NOTE: **The ignition circuit may supply voltage to other components. Make sure to test all circuits and components for a short to ground that share the ignition circuit.**

  1. Ignition OFF, remove the test lamp and disconnect all components on the circuit.
  2. Test for infinite resistance between the ignition circuit and ground.
     - If less than infinite resistance, repair the short to ground on the circuit.
     - If infinite resistance
  3. Replace the fuse, ignition ON.
  4. Verify the fuse is good after connecting each of the components one at a time.
     - If the fuse opens, replace the component that opens the fuse when connected.
     - If the fuse is good, all OK.

- **If the test lamp illuminates**

4. Replace the K20 Engine Control Module.

Repair Instructions

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

- **Ignition Coil Replacement - Bank 1**
- **Ignition Coil Replacement - Bank 2**
- **Control Module References** for engine control module replacement, programming and setup.

DTC P1400: COLD START EMISSION REDUCTION CONTROL SYSTEM

Diagnostic Instructions

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

DTC Descriptor

DTC P1400

Cold Start Emission Reduction Control System

Circuit/System Description

The catalytic converter must be warmed to efficiently reduce the emissions. The cold start strategy is to reduce the amount of time it takes to warm the catalytic converter. During a cold start, the engine idle speed is elevated and spark timing is retarded to allow the catalyst to warm quickly. This diagnostic monitors the following to build an exhaust energy model:

- Engine speed
- Spark advance
- Throttle position
- Engine coolant temperature
- Engine runtime
- Park/neutral position
- Vehicle speed

The actual model is then compared to the expected exhaust energy model.

Conditions for Running the DTC

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- The engine is running and a cold start has been detected.
- Vehicle speed is less than 3 km/h (2 MPH).
- The engine is at idle with no input from the accelerator pedal.
- The calculated catalyst temperature is less than 350Â°C (662Â°F).
- Engine coolant is greater than -10Â°C (14Â°F) and less than 56Â°C (132Â°F).
- Barometric pressure is greater than 74 kPa (10.7 psi).
- DTCs P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0112, P0113, P0116, P0117, P0118, P0120, P0121, P0122, P0123, P0220, P0222, P0223, P0201, P0202, P0203, P0204, P0205, P0206, P0300, P0335, P0336, P0351, P0352, P0353, P0501, P0502, P0506, P0507, P0601, P0602, P0603, P0604, P0606, P0607, P060D, P062F, P0641, P0651, P1101, P1516, P1682, P2101, P2119, P2120, P2122, P2123, P2125, P2127, P2128, P2135, P2138, P2176, P2610 are not set.
- This DTC runs for 10 s within the first 18 s of start-up or until the calculated catalyst temperature is greater than 900Â°C (1, 652Â°F). 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 MIL/DTC

DTC P1400 is a Type A DTC.

Reference Information

Description and Operation

Engine Control Module Description

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Diagnostic Aids

Any loading of the engine that lowers engine RPM, such as with partial application of the clutch, A/C cycling etc., during the first 18 s of engine run time may set this DTC.

Circuit/System Verification

1. Verify that the conditions listed below do not exist:
   - Damage, restriction, water intrusion or modification of the air intake system.
   - Dirty or deteriorating air filter element
   - Crankcase ventilation system for correct operation-Refer to **Crankcase Ventilation System Inspection/Diagnosis** .
   - Vacuum leak or other un-metered air downstream of the mass air flow (MAF) sensor
   - Intake manifold leak
   - Exhaust leak
   - Water intrusion
   - Damaged, restricted, modified or enhanced exhaust system-Refer to **Symptoms - Engine Exhaust** .
   - **If any of the conditions exist**

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Repair as necessary.

- **If none of the conditions exist**

2. Verify an engine mechanical condition does not alter the air flow into the combustion chamber. Refer to **Symptoms - Engine Mechanical** .
   - **If any of the conditions exist**

     Repair as necessary.

   - **If none of the conditions exist**
3. Vehicle OFF, allow the engine to cool to be within the temperatures listed in the Conditions for Running the DTC.
4. Engine running.
5. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
6. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to step 1

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

Repair Instructions

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

DTC P150C: TRANSMISSION CONTROL MODULE ENGINE SPEED REQUEST SIGNAL MESSAGE COUNTER INCORRECT

Diagnostic Instructions

- Perform the **Diagnostic System Check - Vehicle** prior to using this diagnostic procedure.
- Review **Strategy Based Diagnosis** for an overview of the diagnostic approach.
- **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 requests to modify engine speed or torque. These serial data messages are sent through two circuits which are part of a communication network called the controller area network (CAN). The ECM sets DTC P150C when it detects a discrepancy in the structure of this message causing its integrity to be questioned.

An intermittent fault in the controller area network (CAN) circuits will cause DTC P150C to set.

Conditions for Running the DTC

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

Conditions for Setting the DTC

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

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Action Taken When the DTC Sets

DTC P150C is a Type B DTC.

Conditions for Clearing the DTC

DTC P150C is a Type B DTC.

Reference Information

Description and Operation

Data Link Communications Description and Operation

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

NOTE:

- **DTC P150C is an informational DTC.**
- **Diagnose all other engine control module DTCs prior to DTC P150C.**

1. Verify that no other DTCs are set except for DTC P150C.
   - **If any other DTCs are set**

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

   - **If only DTC P150C is set**
2. Replace the K71 Transmission Control Module.
3. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
4. Verify the DTC does not set.
   - **If the DTC sets**

     Replace the K20 Engine Control Module.

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

Repair Instructions

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

Control Module References for ECM or TCM replacement, programming and setup

DTC P1516, P2101, P2119 OR P2176: THROTTLE ACTUATOR CONTROL (TAC) MODULE/THROTTLE ACTUATOR POSITION PERFORMANCE (LGX)

Diagnostic 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

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DTC P1516

Throttle Actuator Control (TAC) Module Throttle Actuator Position Performance

DTC P2101

Throttle Actuator Position Performance

DTC P2119

Throttle Closed Position Performance

DTC P2176

Minimum Throttle Position Not Learned

Diagnostic Fault Information

Circuit	Short to Ground	Open or High Resistance	Short to Voltage	Signal Performance
TAC Motor Control Closed	P2101	P2101	P2101	P1516, P2101, P2176
TAC Motor Control Open	P2119	P2101	P2101	P1516, P2101, P2176

Circuit/System Description

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

The ECM controls the throttle valve by applying a varying voltage to the control circuits of the throttle actuator control (TAC) motor. The ECM monitors the duty cycle that is required to actuate the throttle valve. The ECM monitors the TP sensor signal/serial data circuit to determine the actual throttle valve position.

Conditions for Running the DTC

P1516

- The run/crank or powertrain relay voltage is greater than 6.4 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 6.4 V and reduced power is not active.
- The engine is running or the following conditions are met:
  - The engine is not running.
  - The ignition voltage is greater than 11 V.
  - The TAC system is not in the Battery Saver mode.
  - The ECM is commanding the throttle.

    - The ECM has learned the minimum throttle position.
- DTC P2101 runs continuously when the above conditions are met.

P2119

- DTCs P0122, P0123, P0222, P0223 or P06A3 is not set.
- The run/crank or powertrain relay voltage is greater than 6.4 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 (TP) sensors were greater than a predetermined voltage during the minimum throttle learn procedure for greater than 2 s.

Action Taken When the DTC Sets

- DTCs P2101 and P2176 are Type A DTCs.
- DTC P1516 is a Type B DTC.
- DTC P2119 is a Type C DTC.
- The ECM commands the TAC system to operate in the Reduced Engine Power mode.
- A message center or an indicator displays Reduced Engine Power.
- Under certain conditions, the control module commands the engine OFF.

Conditions for Clearing the MIL/DTC

- DTCs P2101 and P2176 are Type A DTCs.
- DTC P1516 is a Type B DTC.
- 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

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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 (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Throttle Actuator Control (TAC) System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify DTC P0121, P0122, P0123, P0222, P0223, P0562, P0621, P0622 or P2135 is not set.

   NOTE: A low battery voltage or charging system condition may cause a DTC to 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 Inspection and 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.

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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**
9. Verify the scan tool TAC Motor parameter displays Enabled while performing the Throttle Sweep Test with a scan tool.

    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.**

    - **If Enabled is Not displayed**

      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.
2. Verify the conditions listed below do not exist with the Q38 Throttle Body:

    WARNING: **Turn OFF the ignition before inserting fingers into the throttle bore. Unexpected movement of the throttle blade could cause personal injury.**

    - A throttle blade that is not in the rest position

      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 binding open or closed

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- A throttle blade that is free to move open or closed without spring pressure
- **If a condition is found**

  Replace the Q38 Throttle Body.

- **If a condition is not found**

3. Disconnect the harness connector at the Q38 Throttle Body Assembly, ignition ON.

NOTE: **Disconnecting the throttle body harness connector may cause additional DTCs to set.**

4. Verify that a test lamp does Not illuminate continuously between each motor control circuit listed below and ground.

NOTE: **The test lamp may illuminate briefly when the ignition switch is turned on, but should not remain illuminated.**

- TAC Motor Control Closed circuit terminal 1
- TAC Motor Control Open circuit terminal 2
- **If the test lamp is always ON**

1. Ignition OFF, disconnect the harness connector X2 at the K20 Engine Control Module, ignition ON
2. Test for less than 1 V between the motor 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**

5. Verify that a test lamp does not illuminate between each motor control circuit listed below and B+.
   - TAC Motor Control Closed circuit terminal 1
   - TAC Motor Control Open circuit terminal 2
   - **If the test lamp illuminates**

   1. Ignition OFF, disconnect the harness connector X2 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**

6. Ignition OFF, remove the test lamp, set the DMM to the 40 V scale, select the Min/Max Recording Mode and set the Peak Min/Max response time to 1 ms.
7. Verify the Max voltage is within 3 V of B+, while using DMM Min/Max Recording Mode function, with the DMM connected to each control circuit listed below and ground, as the ignition is turned ON.

NOTE:

- **The ignition must be OFF and the ECM completely powered down before testing each circuit or a lower voltage will be recorded. It may take up to 2 min for all vehicle systems to power down.**
- **The DMM Min/Max Recording Mode and the response time of 1 ms must be reset after testing each circuit or a lower voltage will be recorded.**

- TAC Motor Control Closed circuit terminal 1
- TAC Motor Control Open circuit terminal 2
- **If not within 3 V of B+**

1. Ignition OFF, disconnect the harness connector X2 at the K20 Engine Control Module.
2. Test for less than 2 Ω in the control circuit end to end.

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- If 2 Ω or greater, repair the open/high resistance in the circuit.
- If less than 2 Ω, replace the K20 Engine Control Module.

- **If within 3 V of B+**

8. Replace the Q38 Throttle Body.

Repair Instructions

- **Throttle Body Assembly Replacement (LGX)**
- **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 Disabled**

     Test or replace the Q38 Throttle Body assembly.

   - **If Enabled**
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 again.
   - **If DTC sets**

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

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

DTC P1516, P2101, P2119 OR P2176: THROTTLE ACTUATOR CONTROL (TAC) MODULE/THROTTLE ACTUATOR POSITION PERFORMANCE (LGW)

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

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

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Minimum Throttle Position Not Learned

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control - Terminal 1	P2101	P2101	P2101	P1516, P2101, P2176
Control - Terminal 2	P2119	P2101	P2101	P1516, P2101, P2176

Circuit/System Description

For an overview of the component/system, refer to **Throttle Actuator Control (TAC) System Description**

Circuit	Description
Control - Terminal 1	The output circuit is switched from ground to 12 V to activate the component. The output is PWM controlled.
Control - Terminal 2	The output circuit is switched from ground to 12 V to activate the component. The output is PWM controlled.

Component	Description
K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.
Q38 Throttle Body	The throttle valve is actuated by a bidirectional DC motor. A spring pulls the valve to a rest or default position, in which the valve is almost closed. The throttle actuator motor can push against the force of the spring to open or close the valve. The more current flow through the motor, the more the valve moves.

Conditions for Running the DTC

P1516

- DTC P1682 = Not set
- Ignition Voltage =Greater than 6.4 V
- Throttle Position Learn =Not Activated Greater than 4 s

Frequency the DTC runs=Continuously - After the running conditions are met

P2101

- DTC P1682 = Not set
- Reduced Engine Power =Not Activated
- Ignition Voltage =Greater than 6.4 V
- Engine=Running or Operating Conditions:
  - Engine=Not Running
  - Ignition Voltage =Greater than 11 V
  - Battery Saver Mode Disable
  - ECM Request Throttle Position Command
  - Throttle Position Sensor 1 Learned Minimum

Frequency the DTC runs=Continuously-After the running conditions are met

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P2119

- DTC P0122, P0123, P0222, P0223, P06A3 = Not set
- Ignition Voltage =Greater than 6.4 V
- Reduced Engine Power =Disabled
- Battery Saver Mode Disable
- Throttle Position Command =Disabled

Frequency the DTC runs=Continuously-After the running conditions are met

P2176

- Ignition Voltage =Greater than 6.4 V
- Reduced Engine Power =Disabled

Frequency the DTC runs=Continuously-After the running conditions are met - For greater than 2 s

Conditions for Setting the DTC

P1516

Greater than 1 s The following parameters are not within 2% of each other:

- Desired Throttle Position
- Throttle Position

P2101 Condition 1

Greater than 1 s The following parameters are not within 8% of each other:

- Desired Throttle Position
- Throttle Position

Condition 2

- Throttle Position Learn =Active
- Throttle Malfunction

Condition 3

- Reduced Engine Power =Active
- Throttle Position =Greater than 35%

P2119

The throttle blade has not reached the closed position after the engine has been turned off.

P2176

Minimum Throttle Position Not Learned =Exceeded Number of Attempts

Actions Taken When the DTC Sets

DTC P1516=Type B DTC

DTC P2101, P2176=Type A DTC

DTC P2119=Type C DTC

- Reduced Engine Power =Active
- P16 Instrument Cluster=Reduced Engine Power
- Under certain conditions, the control module commands the engine Off.

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Conditions for Clearing the DTC

- DTC P1516=Type B DTC
- DTC P2101, P2176=Type A DTC
- DTC P2119=Type C DTC

Diagnostic Aids

- A high resistance condition on the throttle position and throttle actuator control circuits could cause a DTC to set.
- A weak battery may cause this DTC to set.
- If the throttle blade becomes stuck, a DTC will set. Depending on the position of the throttle blade, the ECM may enter Engine Shutdown Mode. The ECM will disable fuel and de-energize the throttle actuator. If the condition remains present during the next ignition cycle, the ECM may disable engine cranking. Inspect the throttle body assembly for a stuck throttle blade if a throttle actuator DTC is current and the engine won't crank.
- Inspect for a condition in which the throttle blade may have been held open. For example, ice may have formed in the throttle bore causing the throttle blade not to close.
- Under cold start conditions, it might happen briefly that the desired and the actual throttle blade position do not match.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW)

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

Circuit/System Verification

1. Ignition Â» On / Vehicle Â» In Service Mode
2. Verify DTC P0121, P0122, P0123, P0222, P0223, P0562, P0621, P0622, P16A0-P16A2, P2135 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 parameter:Throttle Body Idle Air Flow Compensation =Less than 90%
    - **If 90% or greater**

      Refer to:**Throttle Body Inspection and Cleaning**

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- **If less than 90%**

4. Clear the DTCs.
5. Ignition/Vehicle Â» Off
6. Ignition Â» On / Vehicle Â» In Service Mode
7. Perform the scan tool control function:Throttle Sweep Â»Start

   Verify the scan tool parameter:TAC Motor =Enabled

   - **If not the specified state**

     Refer to Circuit/System Testing

   - **If the specified state**
8. Verify the scan tool parameter:TAC Motor =Enabled

   Perform the action while monitoring the parameter:

   - Wiggle the harness and connector: X115 @ Intake Manifold
   - Wiggle the harness and connector: X2 @ K20 Engine Control Module
   - **If not the specified state**

     Repair as necessary Â» Wiring / Terminal(s) / Electrical Connector(s)

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

   Verify the DTC does not set.

   - **If the DTC sets**

     Refer to Circuit/System Testing

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

Circuit/System Testing

1. Ignition/VehicleÂ» Off
2. Verify the following conditions do not exist:
   - The throttle blade has not reached the closed position after the engine has been turned off.

     WARNING: **Turn OFF the ignition before inserting fingers into the throttle bore. Unexpected movement of the throttle blade could cause personal injury.**

   - The throttle blade is not closed by the spring.
   - The throttle blade is binding in open or closed position.
   - **If a condition exists**

     Replace the component:Q38 Throttle Body

   - **If no condition exists**
3. Disconnect the electrical connector: X115

   NOTE: **Disconnecting the component electrical connector causes additional DTCs to set.**

4. IgnitionÂ» On / VehicleÂ» In Service Mode

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5. Test for 1.5 to 2.5 V between the test points:
    - Control circuit terminal 1 & Ground
    - Control circuit terminal 2 & Ground
    - **If less than 1.5 V**
    1. Ignition/Vehicle Â» Off
    2. Disconnect the electrical connector: X2 @ K20 Engine Control Module
    3. Test for infinite resistance between the test points:
        - Control circuit terminal 1 @ Component harness & Ground
        - Control circuit terminal 2 @ Component harness & Ground
        - If less than infinite resistanceÂ» Repair the short to ground on the circuit.
        - If infinite resistance
    4. Test for less than 2 Ω between the test points:
        - Control circuit terminal 1 @ Component harness & The other end of the circuit & @ Control module harness
        - Control circuit terminal 2 @ Component harness & The other end of the circuit & @ Control module harness
        - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
        - If less than 2 ΩÂ» Replace the component:K20 Engine Control Module
    - **If greater than 2.5 V**
    1. Ignition/Vehicle Â» Off
    2. Disconnect the electrical connector: X2 @ K20 Engine Control Module
    3. Ignition Â» On / Vehicle Â» In Service Mode
    4. Test for less than 1 V between the test points:
        - Control circuit terminal 1 @ Component harness & Ground
        - Control circuit terminal 2 @ Component harness & Ground
        - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
        - If less than 1 VÂ» Replace the component:K20 Engine Control Module
    - **If between 1.5 and 2.5 V**
6. Ignition/Vehicle Â» Off
7. Disconnect the electrical connector: X2 @ K20 Engine Control Module
8. Test for less than 2 Ω between the test points:
    - Control circuit terminal 1 @ Component harness & The other end of the circuit @ Control module harness
    - Control circuit terminal 2 @ Component harness & The other end of the circuit @ Control module harness
    - **If 2 Ω or greater**

      Repair the open/high resistance in the circuit.

    - **If less than 2 Ω**
9. Test or replace the component:Q38 Throttle Body

Repair Instructions

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

- **Throttle Body Assembly Replacement (LGW)**
- For the system learn/reset procedure, refer to **Throttle Body Idle Air Flow Compensation Reset**
- For control module replacement, programming and setup, refer to **Control Module References**

DTC P159F OR P15A0: FUEL ECONOMY MODE SWITCH CIRCUIT

Diagnostic Instructions

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- 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 P159F

Fuel Economy Mode Switch Circuit Low Voltage

DTC P15A0

Fuel Economy Mode Switch Circuit High Voltage

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
Vehicle Stability Control Switch 5 V Reference	P159F	P159F, P15A1	P159F	P15A0, P0641	P15A1
Vehicle Stability Control Switch Signal	P159F	P159F	P159F	P15A0	P15A1
Vehicle Stability Control Switch Ground	-	P15A0, P15A1	P15A0	-	P15A1

Circuit Description

The vehicle stability control switch allows the vehicle operator to modify the traction and ride characteristics of the vehicle. The Engine Control Module (ECM) supplies a 5 V reference voltage, through the 5 V reference voltage circuit, to the vehicle stability control switch. The 5 V reference voltage induces current to flow through a series of resistors in the switch to the switch ground circuit. The ECM monitors the reference voltage through a discrete vehicle stability control switch signal circuit. To activate the system, the switch button is momentarily pressed, which allows the 5 V reference voltage to by-pass one of the resistors. The ECM detects the resulting voltage drop as a request to activate the system and sends a GMLAN message to the various control modules indicating the request. The driver information center (DIC) displays the available modes, which include Touring, Sport and Snow/Ice mode. Each additional press of the switch selects the next mode in the order it appears. When the mode has been selected, the various control modules change their calibrations in order to adjust the suspension, steering and drivetrain to fit the characteristics of the mode selected.

Conditions for Running the DTC

- Ignition key must be turned to ON.
- DTCs P159F and P15A0 run continuously when the above condition is met.

Conditions for Setting the DTC

The ECM detects that the voltage on the fuel economy mode switch signal wire is either too low or too high out of range.

Action Taken When the DTC Sets

DTCs P159F and P15A0 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P159F and P15A0 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

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

Circuit/System Verification

1. Ignition ON, observe the scan tool DTC information. Verify that DTC P159F or P15A0 is not set.
   - **If DTC P159F or P15A0 is set**

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

   - **If DTC P159F or P15A0 is not 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.
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

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

1. Ignition OFF, disconnect the harness connector at the S48E multifunction switch.
2. Ignition OFF and all vehicle systems OFF, test for less than 5 Ω between ground circuit terminal 2 of the harness connector and ground.

   NOTE: **It may take up to 2 minutes for all vehicle systems to power down.**

   - If greater than the specified value, test the ground circuit for an open/high resistance and repair as necessary.
3. Ignition ON, test for 4.8-5.2 V between 5 V reference circuit terminal 6 of the harness connector and ground.
   - If less than the specified range, test the 5 V reference circuit for a short to ground or an open/high resistance. If the circuit tests normal, replace the K20 ECM.
   - If greater than the specified range, test the 5 V reference circuit for a short to voltage. If the circuit tests normal, replace the K20 ECM.

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4. Ignition ON, test for 0.050-0.250 V between signal circuit terminal 5 of the harness connector and ground.
    - If less than the specified range, test the signal circuit for a short to ground or an open/high resistance. If the circuit tests normal, replace the K20 ECM.
    - If greater than the specified range, test the signal circuit for a short to voltage. If the circuit tests normal, replace the K20 ECM.
5. If all circuits test normal, test or replace the S48E multifunction switch.

Repair Instructions

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

- **Vehicle Stability Control System Switch Replacement**
- **Control Module References** for ECM replacement, programming and setup

DTC P15A1: FUEL ECONOMY MODE SWITCH PERFORMANCE

Diagnostic Instructions

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

DTC Descriptor

DTC P15A1

Fuel Economy Mode Switch Performance

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
Vehicle Stability Control Switch 5 V Reference	P159F	P159F, P15A1	P159F	P15A0, P0641	P15A1
Vehicle Stability Control Switch Signal	P159F	P159F	P159F	P15A0	P15A1
Vehicle Stability Control Switch Ground	-	P15A0, P15A1	P15A0	-	P15A1

Circuit/System Description

The vehicle stability control switch allows the vehicle operator to modify the traction and ride characteristics of the vehicle. The Engine Control Module (ECM) supplies a 5 V reference voltage, through the 5 V reference voltage circuit, to the vehicle stability control switch. The 5 V reference voltage induces current to flow through a series of resistors in the switch to the switch ground circuit. The ECM monitors the reference voltage through a discrete vehicle stability control switch signal circuit. To activate the system, the switch button is momentarily pressed, which allows the 5 V reference voltage to by-pass one of the resistors. The ECM detects the resulting voltage drop as a request to activate the system and sends a GMLAN message to the various control modules indicating the request. The driver information center (DIC) displays the available modes, which include Touring, Sport and Snow/Ice mode. Each additional press of the switch selects the next mode in the order it appears. When the mode has been selected, the various control modules change their calibrations in order to adjust the suspension, steering and drivetrain to fit the characteristics of the mode selected.

Conditions for Running the DTC

- The ignition key is turned to ON.
- DTC P15A1 runs continuously when the above condition is met.

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Conditions for Setting the DTC

The ECM detects that the voltage on the vehicle stability control switch signal wire is in an indeterminate range.

Action Taken When the DTC Sets

DTC P15A1 is a Type B DTC.

Conditions for Clearing the MIL/DTC

DTC P15A1 is a Type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

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

Circuit/System Verification

1. Ignition ON, observe the scan tool DTC information. Verify that DTC P159F or P15A0 is not set.
   - **If DTC P159F or P15A0 is set**
   - **If DTC P159F or P15A0 is not 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.
3. Verify the DTC does not set.
   - **If the DTC sets**
   - **If the DTC does not set**
4. 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 S48E multifunction switch.
2. Ignition OFF and all vehicle systems OFF, test for less than 5 Ω between ground circuit terminal 2 of the harness connector and ground.

NOTE: It may take up to 2 minutes for all vehicle systems to power down.

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- If greater than the specified value, test the ground circuit for an open/high resistance and repair as necessary.

3. Ignition ON, test for 4.8-5.2 V between 5 V reference circuit terminal 6 of the harness connector and ground.
    - If less than the specified range, test the 5 V reference circuit for a short to ground or an open/high resistance. If the circuit tests normal, replace the K20 ECM.
    - If greater than the specified range, test the 5 V reference circuit for a short to voltage. If the circuit tests normal, replace the K20 ECM.
4. Ignition ON, test for 0.050-0.250 V between signal circuit terminal 5 of the harness connector and ground.
    - If less than the specified range, test the signal circuit for a short to ground or an open/high resistance. If the circuit tests normal, replace the K20 ECM.
    - If greater than the specified range, test the signal circuit for a short to voltage. If the circuit tests normal, replace the K20 ECM.
5. If all circuits test normal, test or replace the S48E multifunction switch.

Repair Instructions

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

- **Vehicle Stability Control System Switch Replacement**
- **Control Module References** for ECM replacement, programming and setup

DTC P163A: CONTROL MODULE FUEL PRESSURE REGULATOR 1 CONTROL SYSTEM CIRCUITRY PERFORMANCE

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

NOTE: **This procedure may also diagnose malfunctions that are not detected by a DTC.**

DTC P163A

Control Module Fuel Pressure Regulator 1 Control System Circuitry Performance

Circuit/System Description

Circuit	Description
Control - High	The output circuit is switched to 12 V to activate the component. The output is PWM controlled.
Control - Low	The output circuit is switched to ground to activate the component. The output is PWM controlled.

Component	Description
Fuel Pressure Regulator - G18 High Pressure Fuel Pump	The fuel pressure regulator is a solenoid valve that restricts the flow of fuel to the high pressure fuel pump and thereby controls the pressure the pump can produce.
K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.

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The fuel pressure regulator is a part of the high pressure fuel pump. The fuel pressure regulator is the solenoid valve that controls the pressure in the fuel rail.

Conditions for Running the DTC

- DTC P0090, P0091, P0092, P00C8, P00CA = Not set
- Engine=Running
- Battery Voltage =Greater than 11 V
- Fuel Pressure Sensor =Greater than 275 kPa (38.8 PSI)
- Fuel Temperature = -10 to 127Â°C (14 to 260Â°F)
- BARO =Greater than 70 kPa (10 PSI)
- Intake Air Temperature =Greater than -10Â°C (+14Â°F)

DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

Fuel Pressure Regulator 1 Current =Not within a calibrated range. - For greater than 4 s

Actions 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 (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Description and Operation

Fuel System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References

Circuit/System Verification

1. IgnitionÂ» On / VehicleÂ» In Service Mode

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2. Verify DTC P0090, P0091, P0092, P00C9, P00CA is not set.
    - **If any of the DTCs are set**

      Refer to **DTC P0089, P00C6, P228C or P228D**

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

      Refer to Circuit/System Testing

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

Circuit/System Testing

1. Ignition/Vehicle Â» Off
2. Disconnect the electrical connector:Q18 Fuel Pressure Regulator
3. Ignition Â» On / Vehicle Â» In Service Mode
4. Verify a test lamp does not turn On between the test points:
    - Control circuit terminal 1 & Ground
    - Control circuit terminal 2 & Ground
    - **If the test lamp turns On**
    1. Ignition/Vehicle Â» Off & Remove Â» Test lamp
    2. Disconnect the electrical connector: X3 @ K20 Engine Control Module
    3. IgnitionÂ» On / VehicleÂ» In Service Mode
    4. Test for less than 1 V between the test points:
        - Control circuit terminal 1 @ Component harness & Ground
        - Control circuit terminal 2 @ Component harness & Ground
        - If 1 V or greater Â» Repair the short to voltage on the circuit.
        - If less than 1 V Â» Replace the component: K20 Engine Control Module
    - **If the test lamp does not turn On**
5. Test for battery voltage between the test points:Control circuit terminal 2 & Ground
    - **If less than battery voltage**
    1. Ignition/Vehicle Â» Off
    2. Disconnect the electrical connector: X3 @ K20 Engine Control Module
    3. Test for infinite resistance between the test points:Control circuit terminal 2 @ Component harness & Ground
        - If less than infinite resistance Â» Repair the short to ground on the circuit.
        - If infinite resistance
    4. Test for less than 2 Ω between the test points:Control circuit terminal 2 @ Component harness & Terminal 16 @ Control module harness
        - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
        - If less than 2 ΩÂ» Replace the component:K20 Engine Control Module
    - **If battery voltage**
6. Verify a test lamp does not turn On between the test points:Control circuit terminal 1 & B+
    - **If the test lamp turns On**
    1. Ignition/Vehicle Â» Off
    2. Disconnect the electrical connector: X3 @ K20 Engine Control Module
    3. Test for infinite resistance between the test points:Control circuit terminal 1 @ Component harness & Ground

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- If less than infinite resistance Â» Repair the short to ground on the circuit.
- If infinite resistance Â» Replace the component:K20 Engine Control Module

- **If the test lamp does not turn On**

7. Disconnect the electrical connector: X3 @ K20 Engine Control Module
8. Test for less than 2 Ω between the test points:Control circuit terminal 1 @ Component harness & Terminal 32 @ Control module harness
    - If 2 Ω or greater Â» Repair the open/high resistance in the circuit.
    - If less than 2 Ω Â» Test or replace the component:Q18 Fuel Pressure Regulator

Component Testing

1. Ignition/Vehicle & All vehicle systems Â» Off
2. Disconnect the electrical connector: Q18 Fuel Pressure Regulator
3. Test for 0.5 to 1 Ω between the test points: Control terminal 1 & Control terminal 2
    - **If not between 0.5 and 1 Ω**

      Replace the component: Q18 Fuel Pressure Regulator

    - **If between 0.5 and 1 Ω**
4. Test for infinite resistance between the test points: Each terminal of the component & The component's housing
    - **If less than infinite resistance**

      Replace the component: Q18 Fuel Pressure Regulator

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

Repair Instructions

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

- **Fuel Pump Replacement** - Q18 Fuel Pressure Regulator
- For control module replacement, programming and setup, refer to **Control Module References**

DTC P16A7, P16AF OR P16B3: ENGINE CONTROLS IGNITION RELAY FEEDBACK CIRCUIT 2 (LGX)

Diagnostic 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 P16A7

Engine Controls Ignition Relay Feedback Circuit 2

DTC P16AF

Engine Controls Ignition Relay Feedback Circuit 2 Low Voltage

DTC P16B3

Engine Controls Ignition Relay Feedback Circuit 2 High Voltage

Diagnostic Fault Information

Engine Controls Ignition Relay

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Circuit	Short to Ground	Open/High Resistance	Short to Voltage
Relay Coil Supply Voltage	P0689, P1682, P16A7, P16AF, P16BC	P0685, P0689, P1682, P16A7, P16AF, P16BC	-
Relay Control Circuit	P0686, P0690, P16B3, P16BF	P0685, P0689, P1682, P16A7, P16AF, P16BC	P0685, P0687, P0689, P1682, P16A7, P16AF, P16BC
Relay Feedback Circuit	P0689, P1682, P16A7, P16AF, P16BC	P0689, P1682, P16A7, P16AF, P16BC	P0690, P16B3, P16BF

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 3 ignition voltage circuits supplied to the engine control module (ECM). Two are 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

P16A7

- 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.

P16AF

- 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.

P16B3

The DTC runs when the engine controls ignition relay is commanded OFF.

Conditions for Setting the DTC

P16A7

The ECM detects that the voltage level difference is greater than 3 V between the engine controls ignition relay feedback circuit 2 and the ignition 1 signal circuit for greater than 1 s.

P16AF

The ECM detects the engine controls ignition relay feedback circuit 2 is less than 5 V.

P16B3

The ECM detects the engine controls ignition relay feedback circuit 2 is greater than 4 V for greater than 5 s.

Action Taken When the DTC Sets

- DTC P16A7 is a Type A DTC.
- DTC P16AF is a Type C DTC.
- DTC P16B3 is a Type B DTC.

Conditions for Clearing the DTC

- DTC P16A7 is a Type A DTC.
- DTC P16AF is a Type C DTC.
- DTC P16B3 is a Type B 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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- **Connector Repairs**
- **Electrical Center Identification Views** **Electrical Center Identification Views**
- **Testing for Intermittent Conditions and Poor Connections**

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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 scan tool DTC information. Verify DTC P16A7, P16AF or P16B3 is not set.

NOTE:

- **A short to voltage on other components may cause DTC P16B3 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.**

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

     Refer to Circuit/System Testing.

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

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

     Refer to Circuit/System Testing.

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

Circuit/System Testing

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

1. Ignition OFF, disconnect the KR75 Engine Controls Ignition Relay.
2. Verify a test lamp illuminates between ground and the B+ terminals listed below:
   - Terminal 86
   - Terminal 30
   - **If the test lamp does not illuminate**

     Replace the front compartment fuse block.

   - **If the test lamp illuminates**

NOTE:

- **High resistance in the circuit/underhood fuse block for either the KR75 Engine Controls Ignition Relay or the KR73 Ignition Main Relay can cause DTC P16A7 to set.**
- **A short to voltage on any of the circuits supplied by the engine controls ignition relay can cause DTC P16B3 to set.**

3. Ignition ON.

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4. Verify that a test lamp does not illuminate between the ignition voltage circuit terminal 87 and ground.
    - **If the test lamp illuminates**
    1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.
    2. Ignition ON.
    3. Test for less than 1 V between ground and connector terminal 73.
        - If 1 V or greater, repair the short to voltage in the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If the test lamp does not illuminate**
5. Ignition OFF, connect a 20 A fused jumper wire between the B+ circuit terminal 30 and the ignition voltage circuit terminal 87.
6. Ignition ON.
7. Verify the scan tool Engine Controls Ignition Relay Feedback Signal parameter displays B+.
    - **If B+ is not displayed**
    1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module
    2. Test for less than 2 Ω in the relay switch ignition voltage circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω
    3. Test for infinite resistance between the relay switch ignition voltage circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance, replace the K20 Engine Control Module.
    - **If B+ is displayed**
8. Ignition OFF, connect a DMM, set to the diode setting, between control circuit terminal 85 and ground.
9. Verify the DMM displays OL.
    - **If OL is not displayed**
    1. Disconnect the X1 harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between ground and the relay control circuit.
        - If less than infinite resistance, repair the short to ground in the circuit.
        - If infinite resistance, replace the K20 Engine Control Module.
    - **If OL is displayed**
10. Ignition ON.
11. Verify the DMM displays less than 1 V.
    - **If 1 V or greater**
    1. Ignition OFF, disconnect the X1 connector at the K20 Engine Control Module.
    2. Ignition ON.
    3. Test for less than 1 V on the relay control circuit.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V
    4. Test for less than 2 Ω in the control circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - if less than 2 Ω, replace the K20 Engine Control Module.
    - **If less than 1 V**
12. Test or replace the KR75 Engine Controls Ignition Relay.

Component Testing

Relay Test

1. Ignition OFF, disconnect the KR75 Engine Controls Ignition Relay.
2. Test for 70-110 Ω between terminals 85 and 86:

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

  Replace the KR75 Engine Controls Ignition Relay.

- **If between 70-110 Ω**

3. Test for infinite resistance between the terminals listed below:
   - 30 and 86
   - 30 and 87
   - 30 and 85
   - 85 and 87
   - **If less than infinite resistance**

     Replace the KR75 Engine Controls Ignition Relay.

   - **If infinite resistance**
4. Install a 20A fused jumper wire between relay terminal 85 and 12 V. Install a jumper wire between relay terminal 86 and ground.
5. Test for less than 2 Ω between terminals 30 and 87.
   - **If 2 Ω or greater**

     Replace the KR75 Engine Controls Ignition Relay.

   - **If less than 2 Ω**
6. All OK.

Repair Instructions

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

- **Relay Replacement (Attached to Wire Harness)** **Relay Replacement (Within an Electrical Center)**
- **Control Module References** for engine control module replacement, programming and setup.

DTC P16A7, P16AF OR P16B3: ENGINE CONTROLS IGNITION RELAY FEEDBACK CIRCUIT 2 (LGW)

Diagnostic 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 P16A7

Engine Controls Ignition Relay Feedback Circuit 2

DTC P16AF

Engine Controls Ignition Relay Feedback Circuit 2 Low Voltage

DTC P16B3

Engine Controls Ignition Relay Feedback Circuit 2 High Voltage

Diagnostic Fault Information

Engine Controls Ignition Relay

Circuit	Short to Ground	Open/High Resistance	Short to Voltage

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Circuit	Short to Ground	Open/High Resistance	Short to Voltage
Relay Coil Supply Voltage	P0689, P1682, P16A7, P16AF, P16BC	P0685, P0689, P1682, P16A7, P16AF, P16BC	P0690, P16B3
Relay Control Circuit	P0686, P0690, P16B3, P16BF	P0685, P0689, P1682, P16A7, P16AF, P16BC	P0685, P0687, P0689, P1682, P16A7, P16AF, P16BC
Relay Feedback Circuit	P0689, P1682, P16A7, P16AF, P16BC	P0689, P1682, P16A7, P16AF, P16BC	P0690, P16B3, P16BF

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 3 ignition voltage circuits supplied to the engine control module (ECM). Two are 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

P16A7

- 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.

P16AF

- The engine controls ignition relay is commanded ON.
- Ignition 1 signal voltage is greater than 11 V.

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- The DTC runs continuously when the above conditions are met.

P16B3

The DTC runs when the engine controls ignition relay is commanded OFF.

Conditions for Setting the DTC

P16A7

The ECM detects that the voltage level difference is greater than 3 V between the engine controls ignition relay feedback circuit 2 and the ignition 1 signal circuit for greater than 1 s.

P16AF

The ECM detects the engine controls ignition relay feedback circuit 2 is less than 5 V.

P16B3

The ECM detects the engine controls ignition relay feedback circuit 2 is greater than 4 V for greater than 5 s.

Action Taken When the DTC Sets

- DTC P16A7 is a Type A DTC.
- DTC P16AF is a Type C DTC.
- DTC P16B3 is a Type B DTC.

Conditions for Clearing the DTC

- DTC P16A7 is a Type A DTC.
- DTC P16AF is a Type C DTC.
- DTC P16B3 is a Type B 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**

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- **Wiring Repairs**

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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, observe the scan tool DTC information. Verify DTC P16A7, P16AF or P16B3 is not set.

NOTE:

- **A short to voltage on other components may cause DTC P16B3 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.**

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

  Refer to Circuit/System Testing.

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

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

     Refer to Circuit/System Testing.

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

Circuit/System Testing

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

1. Ignition OFF, disconnect the KR75 Engine Controls Ignition Relay.
2. Verify a test lamp illuminates between ground and the B+ terminals listed below:
   - Terminal 85
   - Terminal 30
   - **If the test lamp does not illuminate**

     Replace the X50A Fuse Block - Underhood.

   - **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 P16A7 to set.**
- **A short to voltage on any of the circuits supplied by the engine controls ignition relay can cause DTC P16B3 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**

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1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.
2. Ignition ON.
3. Test for less than 1 V between ground and connector terminal 73.
    - If 1 V or greater, repair the short to voltage in the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.

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

5. Ignition OFF, connect a 20 A fused jumper wire between the B+ circuit terminal 30 and the ignition voltage circuit terminal 87.
6. Ignition ON.
7. Verify the scan tool Engine Controls Ignition Relay Feedback Signal parameter displays B+.

- **If B+ is not displayed**

1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module
2. Test for less than 2 Ω in the relay switch ignition voltage circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω
3. Test for infinite resistance between the relay switch ignition voltage circuit and ground.
    - If less than infinite resistance, repair the short to ground on the circuit.
    - If infinite resistance, replace the K20 Engine Control Module.

- **If B+ is displayed**

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

- **If OL is not displayed**

1. Disconnect the X1 harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between ground and the relay control circuit.
    - If less than infinite resistance, repair the short to ground in the circuit.
    - If infinite resistance, replace the K20 Engine Control Module.

- **If OL is displayed**

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

- **If 1 V or greater**

1. Ignition OFF, disconnect the X1 connector at the K20 Engine Control Module.
2. Ignition ON.
3. Test for less than 1 V on the relay control circuit.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V
4. Test for less than 2 Ω in the control circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - if less than 2 Ω, replace the K20 Engine Control Module.

- **If less than 1 V**

12. Test or replace the KR75 Engine Controls Ignition Relay.

Component Testing

Relay Test

1. Ignition OFF, disconnect the KR75 Engine Controls Ignition Relay.
2. Test for 70-110 Ω between terminals 85 and 86:

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

  Replace the KR75 Engine Controls Ignition Relay.

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- **If between 70-110 Ω**

3. Test for infinite resistance between the terminals listed below:
    - 30 and 86
    - 30 and 87
    - 30 and 85
    - 85 and 87
    - **If less than infinite resistance**

      Replace the KR75 Engine Controls Ignition Relay.

    - **If infinite resistance**
4. Install a 20 A fused jumper wire between relay terminal 85 and 12 V. Install a jumper wire between relay terminal 86 and ground.
5. Test for less than 2 Ω between terminals 30 and 87.
    - **If 2 Ω or greater**

      Replace the KR75 Engine Controls Ignition Relay.

    - **If less than 2 Ω**
6. All OK.

Repair Instructions

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

- **Relay Replacement (Attached to Wire Harness)** **Relay Replacement (Within an Electrical Center)**
- **Control Module References** for engine control module replacement, programming and setup.

DTC P16BC OR P16BF: ENGINE CONTROLS IGNITION RELAY FEEDBACK CIRCUIT 3

Diagnostic 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 P16BC

Engine Controls Ignition Relay Feedback Circuit 3

DTC P16BF

Engine Controls Ignition Relay Feedback Circuit 3 High Voltage

Diagnostic Fault Information

Engine Controls Ignition Relay

Circuit	Short to Ground	Open/High Resistance	Short to Voltage
Relay Coil Supply Voltage	P0689, P1682, P16A7, P16AF, P16BC	P0685, P0689, P1682, P16A7, P16AF, P16BC	-
Relay Control Circuit	P0686, P0690, P16B3, P16BF	P0685, P0689, P1682, P16A7, P16AF, P16BC	P0685, P0687, P0689, P1682, P16A7, P16AF, P16BC
Relay Feedback Circuit	P0689, P1682, P16A7, P16AF, P16BC	P0689, P1682, P16A7, P16AF, P16BC	P0690, P16B3, P16BF

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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 4 ignition voltage circuits supplied to the engine control module (ECM). Three are 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

P16BC

- 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

P16BC or P16BF

The ECM detects that the voltage level difference is greater than 3 V between the engine controls ignition relay feedback circuit 3 and the ignition 1 signal circuit for greater than 1 s.

Action Taken When the DTC Sets

- DTC P16BC and P16BF are Type A DTCs.

Conditions for Clearing the DTC

- DTC P16BC and P16BF are Type A DTCs.

Diagnostic Aids

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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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- **Electrical Center Identification Views** **Electrical Center Identification Views**
- **Testing for Intermittent Conditions and Poor Connections**
- **Wiring Repairs**

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON, observe the scan tool DTC information. Verify DTC P16BC or P16BF is not set.

   NOTE:
   - **A short to voltage on other components may cause DTC P16B3 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.**

   - **If DTC P16BC or P16BF is set**

     Refer to Circuit/System Testing.

   - **If DTC P16BC or P16BF is not set**
2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

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

Circuit/System Testing

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

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Circuit/System Testing unless sent here from Engine Cranks But Does Not Run.

1. Ignition OFF, disconnect the KR75 Engine Controls Ignition Relay.
2. Verify a test lamp illuminates between ground and the B+ terminals listed below:
   - Terminal 85
   - Terminal 30
   - **If the test lamp does not illuminate**

     Replace the X50A Fuse Block - Underhood.

   - **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 P16BC to set.**

3. Ignition ON.
4. Verify that a test lamp does not illuminate between the ignition voltage circuit terminal 87 and ground.
   - **If the test lamp illuminates**
   1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module.
   2. Ignition ON.
   3. Test for less than 1 V between ground and connector terminal 73.
      - If 1 V or greater, repair the short to voltage in the circuit.
      - If less than 1 V, replace the K20 Engine Control Module.
   - **If the test lamp does not illuminate**
5. Ignition OFF, connect a 20 A fused jumper wire between the B+ circuit terminal 30 and the ignition voltage circuit terminal 87.
6. Ignition ON.
7. Verify the scan tool Engine Controls Ignition Relay Feedback Signal parameter displays B+.
   - **If B+ is not displayed**
   1. Ignition OFF, disconnect the X1 harness connector at the K20 Engine Control Module
   2. Test for less than 2 Ω in the relay switch ignition voltage circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω
   3. Test for infinite resistance between the relay switch ignition voltage circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.
   - **If B+ is displayed**
8. Ignition OFF, connect a DMM, set to the diode setting, between control circuit terminal 86 and ground.
9. Verify the DMM displays OL.
   - **If OL is not displayed**
   1. Disconnect the X1 harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between ground and the relay control circuit.
      - If less than infinite resistance, repair the short to ground in the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.
   - **If OL is displayed**
10. Ignition ON.
11. Verify the DMM displays less than 1 V.
    - **If 1 V or greater**

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1. Ignition OFF, disconnect the X1 connector at the K20 Engine Control Module.
2. Ignition ON.
3. Test for less than 1 V on the relay control circuit.
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V
4. Test for less than 2 Ω in the control circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - if less than 2 Ω, replace the K20 Engine Control Module.

- **If less than 1 V**

12. Test or replace the KR75 Engine Controls Ignition Relay.

Component Testing

Relay Test

1. Ignition OFF, disconnect the KR75 Engine Controls Ignition Relay.
2. Test for 70-110 Ω between terminals 85 and 86:
    - **If less than 70 Ω or greater than 110 Ω**

      Replace the KR75 Engine Controls Ignition Relay.

    - **If between 70-110 Ω**
3. Test for infinite resistance between the terminals listed below:
    - 30 and 86
    - 30 and 87
    - 30 and 85
    - 85 and 87
    - **If less than infinite resistance**

      Replace the KR75 Engine Controls Ignition Relay.

    - **If infinite resistance**
4. Install a 20 A fused jumper wire between relay terminal 85 and 12 V. Install a jumper wire between relay terminal 86 and ground.
5. Test for less than 2 Ω between terminals 30 and 87.
    - **If 2 Ω or greater**

      Replace the KR75 Engine Controls Ignition Relay.

    - **If less than 2 Ω**
6. All OK.

Repair Instructions

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

- **Relay Replacement (Attached to Wire Harness)** **Relay Replacement (Within an Electrical Center)**
- **Control Module References** for engine control module replacement, programming and setup.

DTC P2096 OR P2098: POST CATALYST FUEL TRIM SYSTEM LOW LIMIT BANK

Diagnostic 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.

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DTC Descriptors

DTC P2096

Post Catalyst Fuel Trim System Low Limit Bank 1

DTC P2098

Post Catalyst Fuel Trim System Low Limit Bank 2

Circuit Description

Fuel trim bias is used to keep the post catalyst air/fuel ratio within a predetermined range. This allows optimal catalyst efficiency under various operating conditions. The engine control module (ECM) constantly monitors how lean or rich the fuel trim bias is commanded, to determine if the fuel trim bias is greater than a calibrated amount.

Conditions for Running the DTC

- DTC P0016, P0017, P0018, P0019, P0030, P0036, P0050, P0053, P0054, P0056, P0059, P0060, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0128, P0131-P0135, P0137, P0138, P013A-P013F, P0140, P0141, P014A, P014B, P0151-P0155, P0157, P0158, P015A-P015D, P0160, P0161, P0178, P0179, P0201-P0206, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0300-P0306, P0340, P0341, P0345, P0346, P0365, P0366, P0390, P0391, P0442, P0443, P0446, P0449, P0452, P0453, P0455, P0496, P0498, P0499, P1248, P1249, P124A, P124B, P124C, P124D, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F, P219A, P219B, P2227, P2228, P2229, P2230, P2269, P2270, P2271, P2272 or P2273 is not set.
- The barometric pressure (BARO) is greater than 70 kPa (10.2 PSI).
- The manifold absolute pressure (MAP) is between 10-255 kPa (1.5-37 PSI).
- The intake air temperature (IAT) is between -20 and +150Â°C (-4 and +302Â°F).
- The engine start-up coolant temperature is warmer than -20Â°C (-4Â°F).
- The engine is in Closed Loop status.
- The fuel control intrusive diagnostics are not active.
- DTCs P2096 and P2098 run 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 and P2098 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P2096 and P2098 are Type B DTCs.

Diagnostic Aids

- The post catalyst fuel trim diagnostic is very sensitive to heated oxygen sensor (HO2S) design. A non-OE sensor or an incorrect part number may cause a DTC to set.
- Failure to perform the scan tool Heated Oxygen Sensor Resistance Learn Reset after replacing an HO2S, clearing HO2S diagnostic trouble codes or after battery disconnection may cause inaccurate post catalyst fuel trim readings.
- 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 (LGW) **Engine Controls Schematics (LGX)**

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify no other HO2S or fuel trim DTC is set.
   - **If any other HO2S or fuel trim DTC is set**

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

   - **If no other HO2S or fuel trim DTC is set**
3. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed in the Freeze Frame/Failure Records data.
4. Verify DTC P2096 or P2098 is not set.
   - **If a DTC is set**

     Refer to Circuit/System Testing.

   - **If no DTC is set**
5. All OK.

Circuit/System Testing

Verify the conditions listed below do not exist:

- Air intake duct collapsed or restricted.
- Air filter dirty or restricted.
- Objects blocking the throttle body.
- Excessive fuel in the crankcase. Change engine oil as necessary.
- Rich fuel injectors. Refer to **Fuel Injector Solenoid Coil Test**.
- High fuel system pressure. Refer to **Fuel System Diagnosis**.
- Contaminated fuel. Refer to **Alcohol/Contaminants-in-Fuel Diagnosis**.
- Fuel saturation of the evaporative emissions (EVAP) canister
- EVAP purge valve stuck open or leaking

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- Restricted exhaust
- Incorrect crankcase ventilation system operation. Refer to **Crankcase Ventilation System Inspection/Diagnosis**

- **If a condition is found**

  Repair as necessary.

- **If no condition is found**

  Test fuel trim cylinder balance. Refer to **DTC P219A or P219B**.

Repair Instructions

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

Perform the scan tool Fuel Trim Reset after completing the repair.

DTC P2097 OR P2099: POST CATALYST FUEL TRIM SYSTEM HIGH LIMIT BANK

Diagnostic 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 Bank 1

DTC P2099

Post Catalyst Fuel Trim System High Limit Bank 2

Circuit Description

Fuel trim bias is used to keep the post catalyst air/fuel ratio within a predetermined range. This allows optimal catalyst efficiency under various operating conditions. The engine control module (ECM) constantly monitors how lean or rich the fuel trim bias is commanded, to determine if the fuel trim bias is greater than a calibrated amount.

Conditions for Running the DTC

- DTC P0016, P0017, P0018, P0019, P0030, P0036, P0050, P0053, P0054, P0056, P0059, P0060, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0116, P0117, P0118, P0119, P0128, P0131-P0135, P0137, P0138, P013A-P013F, P0140, P0141, P014A, P014B, P0151-P0155, P0157, P0158, P015A-P015D, P0160, P0161, P0178, P0179, P0201-P0206, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0300-P0306, P0340, P0341, P0345, P0346, P0365, P0366, P0390, P0391, P0442, P0443, P0446, P0449, P0452, P0453, P0455, P0496, P0498, P0499, P1248, P1249, P124A, P124B, P124C, P124D, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F, P219A, P219B, P2227, P2228, P2229, P2230, P2269, P2270, P2271, P2272 or P2273 is not set.
- The barometric pressure (BARO) is greater than 70 kPa (10.2 PSI).
- The manifold absolute pressure (MAP) is between 10-255 kPa (1.5-37 PSI).
- The intake air temperature (IAT) is between -20 and +150Â°C (-4 and +302Â°F).
- The engine start-up coolant temperature is warmer than -20Â°C (-4Â°F).
- The engine is in Closed Loop status.
- The fuel control intrusive diagnostics are not active.
- DTCs P2097 and P2099 run continuously when the conditions above have been met.

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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 and P2099 are Type B DTCs.

Conditions for Clearing the MIL/DTC

DTCs P2097 and P2099 are Type B DTCs.

Diagnostic Aids

- The post catalyst fuel trim diagnostic is very sensitive to heated oxygen sensor (HO2S) design. A non-OE sensor or an incorrect part number may cause a DTC to set.
- Certain aftermarket air filters may cause a DTC to set.
- Certain aftermarket air induction systems or modifications to the air induction system may cause a DTC to set.
- Certain aftermarket exhaust system components may cause a DTC to set.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) **Engine Controls Schematics (LGX)**

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.
2. Verify no other HO2S or fuel trim DTC is set.
    - **If any other HO2S or fuel trim DTC is set**

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

    - **If no other HO2S or fuel trim DTC is set**
3. Verify the conditions listed below do not exist:
    - Exhaust system leaks. Refer to **Symptoms - Engine Exhaust**
    - Vacuum hoses split, kinked or improperly connected

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- Insufficient fuel in the tank
- Leaks in the air induction system and the air intake ducts
- Missing air filter element
- A cracked evaporative canister
- Evaporative pipes plugged, obstructed or leaking
- Leaks in the crankcase ventilation system. 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.

- **If no condition is found**

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 or P2099 is not set.
   - **If a DTC is set**

     Refer to Circuit/System Testing.

   - **If no DTC is set**
6. All OK.

Repair Instructions

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

Perform the scan tool Fuel Trim Reset after completing the repair.

DTC P2122, P2123, P2127, P2128 OR P2138: ACCELERATOR PEDAL POSITION (APP) SENSOR

Diagnostic Instructions

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

DTC Descriptors

DTC P2122

Accelerator Pedal Position (APP) Sensor 1 Circuit Low Voltage

DTC P2123

Accelerator Pedal Position (APP) Sensor 1 Circuit High Voltage

DTC P2127

Accelerator Pedal Position (APP) Sensor 2 Circuit Low Voltage

DTC P2128

Accelerator Pedal Position (APP) Sensor 2 Circuit High Voltage

DTC P2138

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Accelerator Pedal Position (APP) Sensors 1-2 Not Plausible

Diagnostic Fault Information

Circuit	Short to Ground	High Resistance	Open	Short to Voltage	Signal Performance
Accelerator Pedal Position (APP) Sensor 1 5 V Reference Circuit	P06A3	P2138	P2122	P06A3	P2138
Accelerator Pedal Position (APP) Sensor 2 5 V Reference Circuit	P0106, P0108, P0107, P0697	P2138	P2127	P0106, P0108, P0697	P2138
Accelerator Pedal Position (APP) Sensor 1 Signal	P2122	P2138	P2122	P2123, P2138	P2138
Accelerator Pedal Position (APP) Sensor 2 Signal	P2127	P2138	P2127	P2128, P2138	P2138
Accelerator Pedal Position (APP) Sensor 1 Low Reference	-	P2138	P2123	-	P2138
Accelerator Pedal Position (APP) Sensor 2 Low Reference	-	P2138	P2128	-	P2138

Typical Scan Tool Data

APP Sensor 1

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: The engine is operating at idle. **Parameter Normal Range:** APP Sensor 1 0.88-1.08 V			
5 V Reference	0.00 V	0.00 V	2-3 V
Signal	0.00 V	0.00 V	4-5 V
Low Reference	-	4-5 V	-

APP Sensor 2

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: The engine is operating at idle. **Parameter Normal Range:** APP Sensor 2 0.39-0.59 V			
5 V Reference	0.00 V	0.00 V	1-3 V
Signal	0.00 V	0.00 V	2-5 V
Low Reference	-	4-5 V	-

Circuit/System Description

The accelerator pedal assembly contains 2 accelerator pedal position (APP) sensors. The APP sensors are mounted to the accelerator pedal assembly and are not serviceable. The APP sensors provide a signal voltage that change relative to pedal position. The engine control module (ECM) supplies each APP sensor with a 5 V reference circuit, a low reference circuit and a signal circuit.

Both the APP sensors 1 and 2 signal percentages increase as the pedal is depressed, from approximately 0 percent at rest to above 95 percent when fully depressed.

Conditions for Running the DTC

P2122, P2123, P2127 or P2128

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- DTC P06A3 or P0697 are not set.
- The ignition is ON or the engine is operating.
- The ignition voltage is greater than 6.41 V.
- The ECM is not commanding reduced power.
- The DTCs run continuously when the above conditions are met.

P2138

- DTCs P06A3, P0697, P2122, P2123, P2127 or P2128 are not set.
- The ignition is ON or the engine is operating.
- The ignition voltage is greater than 6.41 V.
- The ECM is not commanding reduced power.
- The DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

P2122

The ECM detects that the APP sensor 1 voltage is less than 0.46 V for less than 1 s.

P2123

The ECM detects that the APP sensor 1 voltage is greater than 4.7 V for less than 1 s.

P2127

The ECM detects that the APP sensor 2 voltage is less than 0.32 V for less than 1 s.

P2128

The ECM detects that the APP sensor 2 voltage is greater than 2.6 V for less than 1 s.

P2138

The ECM detects that APP sensor 1 and APP sensor 2 disagree greater than 10 percent for less than 1 s.

OR

The ECM detects that both APP sensor 1 and APP sensor 2 are 5 percent greater than the learned minimum position for less than 1 s.

Action Taken When the DTC Sets

- DTCs P2122, P2123, P2127, P2128 and P2138 are Type A DTCs.
- The ECM commands the TAC system to operate in a Reduced Engine Power mode.

Conditions for Clearing the DTC

DTCs P2122, P2123, P2127, P2128 and P2138 are Type A DTCs.

Diagnostic Aids

- A high resistance condition on the accelerator pedal position circuits could cause a DTC to set.
- Ensure that the in-line harness connector seals are installed correctly. Improper installation could result in water intrusion into the connector and cause a DTC to set.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

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Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Throttle Actuator Control (TAC) System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

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

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

   - **If none of the DTCs are set**
3. Verify the APP Sensor 1 Circuit Status and APP Sensor 2 Circuit Status displays OK.
   - **If OK is not displayed**

     Refer to Circuit/System Testing.

   - **If OK is displayed**
4. Verify the scan tool APP Sensor 1 and 2 Agree/Disagree parameter displays Agree while performing the tests listed below:
   - Rapidly depress the accelerator pedal from the rest position to the wide open throttle position (WOT) and release pedal. Repeat the procedure several times.
   - Slowly depress the accelerator pedal to WOT and then slowly return the pedal to closed throttle. Repeat the procedure several times.
   - **If Agree is not displayed**

     Refer to Circuit/System Testing.

   - **If Agree is displayed**
5. Verify that DTC P2122, P2123, P2127, P2128 or P2138 is not set.
   - **If any of the DTCs are set**

     Refer to Circuit/System Testing.

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

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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 Assembly. It may take up to 2 minutes for all vehicle systems to power down.
2. Test for less than 5 Ω between each low reference circuit terminal listed below and ground.
    - APP Sensor 1 Low reference circuit terminal 4
    - APP Sensor 2 Low reference circuit terminal 3
    - **If 5 Ω or greater**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for less than 2 Ω in the low reference circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If less than 5 Ω**
3. Ignition ON.
4. Test for 4.8-5.2 V between each 5 V reference circuit terminal listed below and ground.
    - 5 V reference circuit terminal 6
    - 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 Ω in the 5 V reference circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If greater than 5.2 V**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the 5 V reference circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If between 4.8-5.2 V**
5. Verify each APP sensor voltage parameter is less than 0.2 V.
    - **If 0.2 V or greater**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the signal circuit terminal listed below and ground.
    - APP sensor 1 signal circuit terminal 5
    - APP sensor 2 signal circuit terminal 2
    - If 1 V or greater, repair the short to voltage on the circuit.
    - If less than 1 V, replace the K20 Engine Control Module.
    - **If less than 0.2 V**
6. Install a 3 A fused jumper wire between the appropriate signal circuit terminal listed below and the 5 V reference circuit terminal 1 or C.
    - APP sensor 1 signal circuit terminal 5
    - APP sensor 2 signal circuit terminal 2

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7. Verify the scan tool APP Sensor 1 or 2 voltage parameter is greater than 4.8 V.
    - **If 4.8 V or less**
    1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the signal circuit terminal and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance
    3. Test for less than 2 Ω in the signal circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If greater than 4.8 V**
8. Test or replace the B107 Accelerator Pedal Assembly.

Repair Instructions

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

- **Accelerator Pedal with Position Sensor Assembly Replacement**
- **Control Module References** for ECM replacement, programming and setup.

DTC P2199: INTAKE AIR TEMPERATURE (IAT) SENSORS 1-2 NOT PLAUSIBLE (LGW)

Diagnostic 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) Sensors 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, P222D, P222E	P0113, P0114, P2199, P222B, P222D*	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

IAT Sensor 2

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0036, P0037, P0050, P0051, P0097, P00F4, P0102, P010C, P2199	P0096, P0097, P00F4, P0101, P0102, P2199, P222E	P0690	P0096, P0101, P0103
Signal	P0096, P0097, P00F5, P2199	P0096, P0097, P00F4, P2199	P0096, P0097, P00F4, P2199*	P0096
Ground	-	P0096, P0097, P00F4, P0102, P2199	-	P0096, P0102
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

Typical Scan Tool Data

IAT Sensor 1

Circuit	Short to Ground	Open or High Resistance	Short to Voltage
Operating Conditions: Engine Running **Parameter Normal Range:** Varies with ambient temperature			
Signal	150Â°C (302Â°F)	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
Low Reference	-	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
*Internal ECM or sensor damage may occur if the circuit is shorted to B+			

IAT Sensor 2

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

Circuit/System Description

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

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

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

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

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

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

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

IAT Sensor 1 - Temperature, Resistance, Voltage Table

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

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IAT Sensor 2 - Temperature, Frequency Table

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

Conditions for Running the DTC

- DTC P1682 is not set.
- The ignition is ON.
- Ignition voltage is at least 11 V.
- This DTC runs continuously within the enabling conditions.

Conditions for Setting the DTC

The ECM detects that the absolute difference between the IAT sensor 1 and the IAT sensor 2 temperatures is greater than 55Â°C (99Â°F) for greater 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

- The IAT Sensor 1 and IAT Sensor 2 are integrated with the multifunction intake air sensor. With RPO LF3, this 8-pin sensor is in the intake air duct nearest to the front of the vehicle; for rear wheel drive vehicles it is on the driver's side.
- With the ignition ON, the engine OFF and the engine is cold, a properly functioning IAT sensor 2 will gradually increase the scan tool IAT Sensor 2 parameter. This is due to the heat that is generated by the multifunction intake air sensor heating elements.
- The humidity sensor and the IAT sensor 2 signals are sent to the ECM on the same circuit. If the IAT Sensor 2 parameter displays the values: 10 Hz; -40Â°C (-40Â°F) and there are Humidity Sensor DTCs, check for a circuit problem.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW)

Connector End View Reference

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Powertrain Component Views

Electrical Information 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

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Scan Tool Reference

Control Module References for scan tool information

Special Tools

EL-38522-A Variable Signal Generator

For equivalent regional tools, refer to **Special Tools (Diagnostic Tools)** and/or **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 10Â°C (18Â°F) of each other.
    - Start-Up IAT Sensor 1
    - Start-Up IAT Sensor 2
    - Start-Up ECT
    - **If not within 10Â°C (18Â°F)**

      Refer to Circuit/System Testing.

    - **If within 10Â°C (18Â°F)**
3. Engine idling, verify the following scan tool parameters are between -38 to +149Â°C (-36 to +300Â°F).
    - IAT Sensor 1
    - IAT Sensor 2
    - ECT Sensor
    - **If not between -38 to +149Â°C (-36 to +300Â°F)**

      Refer to Circuit System Testing.

    - **If between -38 to +149Â°C (-36 to +300Â°F)**
4. Operate the vehicle within the conditions for running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
5. Verify the DTC does not set.
    - **If any DTC sets**

      Refer to Circuit/System Testing.

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

Circuit/System Testing

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

1. Verify none of the conditions listed below exist:
    - A restricted or collapsed air intake duct
    - A misaligned or damaged air intake duct
    - Any water intrusion in the induction system
    - An intake manifold resonator with a leaking seal or a cracked or broken housing
    - **If a condition exists**

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Repair or replace component as appropriate.

- **If no condition exists**

2. Ignition OFF and all systems OFF, it may take up to for 2 min for all vehicle systems to power down. Disconnect the harness connector at the B75C Multifunction Intake Air Sensor.
3. Test for less than 2 Ω between the low reference circuit terminal 3 and ground.
   - **If 2 Ω or greater**
   1. Disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open or high resistance in the circuit.
      - If less than 2 Ω replace the K20 Engine Control Module.
   - **If less than 2 Ω**
4. Test for less than 2 Ω between the ground circuit terminal 7 and ground.
   - **If 2 Ω or greater**
   1. Disconnect the sensor chassis ground.
   2. Test for less than 2 Ω in the ground circuit end to end.
      - If 2 Ω or greater, repair the open or high resistance in the circuit.
      - If less than 2 Ω, repair the open/high resistance in the ground connection.
   - **If less than 2 Ω**
5. Ignition ON.
6. Verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
   2. Test for less than 2 Ω in the ignition voltage circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**
   1. Ignition OFF, remove the test lamp and remove the fuse for the ignition voltage circuit.
   2. Test for infinite resistance between the ignition voltage circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, test all components connected to the ignition circuit, replace as necessary.
   - **If a test lamp illuminates**
7. Ignition ON.
8. Verify the scan tool IAT Sensor 1 parameter is colder than -39Â°C (-38Â°F).
   - **If warmer than -39Â°C (-38Â°F).**
   1. Ignition OFF, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the signal circuit terminal 1 and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance
   3. Test for less than 2 Ω in the signal circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If colder than -39Â°C (-38Â°F).**
9. Ignition OFF, install a 3 A fused jumper wire between the signal circuit terminal 1 and the low reference circuit terminal 3, ignition ON.
10. Verify the scan tool IAT Sensor 1 parameter is warmer than 149Â°C (300Â°F).
    - **If colder than 149Â°C (300Â°F).**
    1. Ignition OFF, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module, ignition ON.

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

- **If warmer than 149Â°C (300Â°F).**

11. Ignition ON.
12. Test for 4.8-5.2 V between the intake air temperature signal 2 circuit terminal 8 and ground.
    - **If less than 4.8 V**

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

    - **If greater than 5.2 V**

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

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

    2. Test for less than 1 V between the signal circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.

    - **If between 4.8-5.2 V**

13. Determine if **EL-38522-A** Variable Signal Generator or equivalent is available.
    - **EL-38522-A, Variable Signal Generator; or equivalent is not available**

    1. Test or replace the B75C Multifunction Intake Air Sensor.
    2. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the freeze frame/failure records data.
    3. Verify the DTC does not set.
        - **If the DTC sets**

          Replace the K20 Engine Control Module.

        - **If no DTCs set**

    4. All OK.

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

14. Ignition OFF, connect the leads of the **EL-38522-A** Variable Signal Generator as listed below:
    - Red lead to the signal circuit terminal 8 at the harness connector
    - Black leads to ground
    - Battery voltage supply lead to B+
15. Set the **EL-38522-A** Variable Signal Generator to the specifications listed below:
    - Signal switch to 5 V
    - Duty Cycle switch to 50% (Normal)
    - Frequency switch to 30 Hz
16. Ignition ON.

17. Verify the scan tool IAT Sensor 2 parameter is between 28-32 Hz.
    - **If not between 28-32 Hz**

      Replace the K20 Engine Control Module.

    - **If between 28-32 Hz**
18. Test or replace the B75C Multifunction Intake Air Sensor.

Component Testing

Multifunction Intake Air Sensor - IAT Sensor 1

1. Ignition OFF, disconnect the harness connector at the B75C Multifunction Intake Air sensor.
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)** table for Hitachi Sensors. The resistance values should be in range of the table values.

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

    - **If not within the table values.**

      Replace the B75C Multifunction Intake Air sensor.

    - **If within the table values.**
3. All OK

Multifunction Intake Air Sensor - IAT Sensor 2

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

      Replace the B75C Multifunction Intake Air sensor.

    - **If within 5%**
2. All OK.

Repair Instructions

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

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

DTC P2199: INTAKE AIR TEMPERATURE (IAT) SENSOR 1-2 NOT PLAUSIBLE (LGX)

Diagnostic 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

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IAT Sensor 1

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	P0112, P0113, P2199	P0113, P2199	P0112*, P2199	P0111*, P2199
Low Reference	-	P0113, P2199, P2227, P2229	P0113*, P0114	P0096, P0111*, P2199
*Internal ECM or sensor damage may occur if the circuit is shorted to B+.				

IAT Sensor 2 and Intake Air Humidity

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition Voltage	P0096, P0097, P00F4, P0102, P2199	P0097, P00F4, P0102, P2199	-	P0096
Signal	P0097, P00F4, P2199	P0097, P00F4, P2199	P0097*, P00F5*, 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	150Â°C (302Â°F)	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
Low Reference	-	-40Â°C (-40Â°F)	-40Â°C (-40Â°F)*
*Internal ECM or sensor damage may occur if the circuit is shorted to B+			

IAT Sensor 2 and 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, temperature and engine bay conditions			
Ignition Voltage	-40Â°C (-40Â°F) 10 Hz 0%	-40Â°C (-40Â°F) 10 Hz 0%	-
Signal	-40Â°C (-40Â°F) 10 Hz 100%	-40Â°C (-40Â°F) 10 Hz 0%	-40Â°C (-40Â°F) 10 Hz* 0%
Ground	-	-40Â°C (-40Â°F) 10 Hz 0%	-
*Internal ECM or sensor damage may occur if the circuit is shorted to B+			

Circuit/System Description

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

The IAT sensor 2 produces a frequency signal, based on the inlet air temperature, which is equal to the humidity present within the sensor bore. The signal varies with inlet air temperature and is displayed by the scan tool as Â°C (Â°F) and Hertz (Hz) and the relative humidity is displayed in percent (%). The

ECM supplies a regulated voltage to the signal 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	-40Â°C (-40Â°F)
Warm	302 Hz	104Â°C (219Â°F)

Conditions for Running the DTC

- The ignition is ON.
- Ignition voltage is 11 V or greater.
- 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 warmer than 55Â°C (99Â°F) for greater than 4 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; -40Â°C (-40Â°F) and there are Humidity Sensor DTCs, check for a circuit problem.

Reference Information

Schematic Reference

Engine Controls Schematics (LGX)

Connector End View Reference

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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.
2. Verify that DTC P0097, P0098, P0099, P00F4, P00F5, P00F6, P0102, P0103, P0112, P0113, P0114, P0641, P0651, P0697 or P06A3 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. Ignition ON.
4. Verify the following scan tool parameters are within 15Â°C (27Â°F) of each other.
   - Start-Up IAT Sensor 1
   - Start-Up IAT Sensor 2
   - **If not within 15Â°C (27Â°F)**

     Refer to Circuit/System Testing.

   - **If within 15Â°C (27Â°F)**
5. Engine running, verify the following scan tool parameters are between: -38 and +149Â°C (-36 and +300Â°F).
   - IAT Sensor 1
   - IAT Sensor 2
   - **If not between: -38 and +149Â°C (-36 and +300Â°F)**

     Refer to Circuit/System Testing.

   - **If between: -38 and +149Â°C (-36 and +300Â°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.

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- **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 restricted or collapsed air intake duct
   - An intake manifold leak
   - A misaligned or damaged air intake duct
   - Any water intrusion in the induction system
   - **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 5 Ω between the low reference circuit terminal 3 and ground.
   - **If 5 Ω or greater**
   1. Disconnect the harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open or high resistance in the circuit.
      - If less than 2 Ω replace the K20 Engine Control Module.
   - **If less than 5 Ω**
4. Test for less than 5 Ω between the ground circuit terminal 7 and ground.
   - **If 5 Ω or greater**
   1. Ignition Off.
   2. Test for less than 2 Ω in the ground circuit end to end.
      - If 2 Ω or greater, repair the open or high resistance in the circuit.
      - If less than 2 Ω, repair the open/high resistance in the ground connection.
   - **If less than 5 Ω**
5. Ignition On.
6. Verify that a test lamp illuminates between the ignition circuit terminal 5 and ground.
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition Off, remove the test lamp, the fuse for the ignition voltage circuit and disconnect all components on the circuit.
   2. Test for less than 2 Ω in the ignition voltage circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**
   1. Ignition Off, remove the test lamp and remove the fuse for the ignition voltage circuit.
   2. Test for infinite resistance between the ignition voltage circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, test all components connected to the ignition circuit, replace as necessary.

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- **If a test lamp illuminates**

7. Verify the scan tool Intake Air Temperature Sensor 1 parameter is colder than -39Â°C (-38Â°F).
   - **If warmer than -39Â°C (-38Â°F).**
   1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
   2. Test for infinite resistance between the signal circuit terminal 1 and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, replace the K20 Engine Control Module.
   - **If colder than -39Â°C (-38Â°F).**
8. Ignition Off, install a 3 A fused jumper wire between the IAT 1 signal circuit terminal 1 and the low reference circuit terminal 3.
9. Ignition On.
10. Verify the scan tool Intake Air Temperature Sensor 1 parameter is warmer than 148Â°C (298Â°F).
    - **If colder than 148Â°C (298Â°F).**
    1. Ignition Off, remove the jumper wire, disconnect the harness connector at the K20 Engine Control Module.
    2. Ignition On.
    3. Test for less than 1 V between the signal circuit and ground.
       - If 1 V or greater, repair the short to voltage on the circuit.
       - If less than 1 V
    4. Ignition Off.
    5. Test for less than 2 Ω in the signal circuit end to end.
       - If 2 Ω or greater, repair the open/high resistance in the circuit.
       - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If warmer than 148Â°C (298Â°F).**
11. Ignition On.
12. Verify the scan tool Intake Air Humidity Sensor parameter is less than 1%.

NOTE: **The intake air temperature sensor 2 signal circuit is pulled up with low current voltage within the controller. Normally, a voltage can be measured on the circuit with a DMM, but the current will not be high enough to illuminate a test lamp.**

- **If 1% or greater**

1. Ignition Off, disconnect the harness connector at the K20 Engine Control Module.
2. Test for infinite resistance between the IAT 2 signal circuit terminal 8 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 less than 1%**

13. Ignition Off, install a 3 A fused jumper wire between the IAT 2 signal circuit terminal 8 and the low reference circuit terminal 3.
14. Ignition On.
15. Verify the scan tool Intake Air Humidity Sensor parameter is greater than 99%.
    - **If 99% or less**
    1. Ignition Off, remove the jumper wire and disconnect the harness connector at 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.**

    2. Ignition On.
    3. Test for less than 1 V between the IAT 2 signal circuit terminal 8 and ground.
       - If 1 V or greater, repair the short to voltage on the circuit.

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- If less than 1 V.

4. Ignition Off.
5. Test for less than 2 Ω in the signal circuit end to end.
    - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - If less than 2 Ω, replace the K20 Engine Control Module.

- **If greater than 99%**

16. 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.
2. Connect a DMM between the IAT sensor 1 signal terminal 1 and the low reference terminal 3
3. 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)** table for Hitachi Sensors. The resistance values should be in range of the table values.

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

- **If not within the specified range**

  Replace the B75C Multifunction Intake Air Sensor.

- **If within the specified range**

4. 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.

Testing with EL-38522-A

1. Perform the following test using a **EL-38522-A** Variable Signal Generator or equivalent, if available.

NOTE: **In-correct diagnosis will result if Circuit/System Testing is not completed before performing the following test.**

2. Ignition Off, connect the leads of the **EL-38522-A** Variable Signal Generator as follows:
    1. Red lead to the signal circuit terminal 8 at the harness connector
    2. Black leads to ground
    3. Battery voltage supply lead to B+
3. 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 250 Hz
4. Ignition On.
5. Verify the scan tool IAT Sensor 2 parameters listed below are within the ranges listed below:

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- IAT Sensor 2 is between 248-252 Hz
- IAT Sensor 2 is between 70-76Â°C (160-166Â°F)

NOTE: **Changing the frequency should cause a warmer or colder IAT 2 temperature.**

- Intake Air Humidity Sensor is between 48-52%

NOTE: **Increasing or decreasing the duty cycle should have an inverse affect on humidity.**

- **If a parameter is not within the specified range**

  Replace the K20 Engine Control Module.

- **If all the parameters are within the specified range**

6. All OK.

Repair Instructions

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

- **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGX)** for B75C Multifunction Intake Air sensor replacement
- **Control Module References** for engine control module replacement, programming and setup.

DTC P219A OR P219B: FUEL TRIM CYLINDER BALANCE BANK

Diagnostic 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 P219A

Fuel Trim Cylinder Balance Bank 1

DTC P219B

Fuel Trim Cylinder Balance Bank 2

Circuit/System Description

The Fuel Trim Cylinder Balance diagnostic detects a rich or lean cylinder to cylinder air/fuel ratio imbalance in each bank. 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, P0018, P0019, P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0116, P0117, P0118, P0119, P0122, P0123, P0128, P0201-P0206, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0300, P0301-P0306, P0340, P0341, P0345, P0346, P0365, P0366, P0390, P0391, P0442, P0455, P0458, P0496, P1248, P1249, P124A, P124B, P124C, P124D, P16A0, P16A1, P16A2, P16F3, P2101, P2135, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E or P216F are not set.
- The EVAP device controls and intrusive diagnostics are not active.
- The secondary air injection reaction pump is not on, if equipped.

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- The engine overspeed protection is not active.
- Engine run time is greater than 30 s.
- The engine is in Closed Loop status for greater than 5 s.
- The fuel level is greater than 10% and no fuel level sensor fault is present.
- The system voltage is greater than 11 V.
- The engine coolant temperature (ECT) is warmer than -20Â°C (-4Â°F).
- The engine speed is between 1, 600-4, 000 RPM.
- The mass air flow is between 0-1, 000 g/s.
- DTCs P219A and P219B run continuously when the above conditions have been met.

Conditions for Setting the DTC

Multiple samples of the pre-catalyst HO2S accumulated voltage are consistently greater than the desired value.

Action Taken When the DTC Sets

DTCs P219A and P219B are Type A DTCs.

Conditions for Clearing the MIL/DTC

DTCs P219A and P219B are Type A DTCs.

Diagnostic Aids

- The fuel trim cylinder balance diagnostic is very sensitive to heated oxygen sensor (HO2S) design. A non-OE sensor or an incorrect part number may cause a DTC to set.
- Monitoring the misfire current counters or misfire graph, may help to isolate the cylinder that is causing the condition.
- Certain aftermarket air filters may cause a DTC to set.
- Certain aftermarket air induction systems or modifications to the air induction system may cause a DTC to set.
- Certain aftermarket exhaust system components may cause a DTC to set.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

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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. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed in the Freeze Frame/Failure Records data.
4. Verify DTC P219A or P219B is not set.
   - **If a DTC is set**

     Refer to Circuit/System Testing.

   - **If no DTC is set**
5. 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 .

   - **If within the specified range**
2. Verify the conditions listed below do not exist:
   - Modified, damaged, leaking or restricted air induction system components.
   - Vacuum leaks at the intake manifold, the throttle body and the injector O-rings.
   - Improperly operating crankcase ventilation system. Refer to Crankcase Ventilation System Inspection/Diagnosis .
   - Split, kinked or improperly connected vacuum hoses.
   - Restricted, damaged, leaking or modified exhaust system from the catalytic converter forward. Refer to Symptoms - Engine Exhaust .
   - Improperly operating fuel injectors. Refer to Fuel Injector Solenoid Coil Test.
   - Fuel contamination. Refer to Alcohol/Contaminants-in-Fuel Diagnosis.
   - Excessive fuel in the crankcase due to leaking injectors. Change engine oil as necessary.
   - Improperly operating ignition system. Refer to Electronic Ignition System Diagnosis.
   - **If a condition is found**

     Repair as necessary.

   - **If no condition is found**
3. Test the engine for any mechanical conditions such as sticking valves, lifters, etc., which could alter the flow into the combustion chamber. Refer to Symptoms - Engine Mechanical .

Repair Instructions

Perform the Diagnostic Repair Verification after completing the repair.

Perform the scan tool Fuel Trim Reset after completing the repair.

DTC P2227-P2230: BAROMETRIC PRESSURE (BARO) SENSOR (LGW)

Diagnostic Instructions

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- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

NOTE: **This procedure may also diagnose malfunctions that are not detected by a DTC.**

DTC P2227

Barometric Pressure (BARO) Sensor Performance Bank 1

DTC P2228

Barometric Pressure (BARO) Sensor Circuit Low Voltage Bank 1

DTC P2229

Barometric Pressure (BARO) Sensor Circuit High Voltage Bank 1

DTC P2230

Barometric Pressure (BARO) Sensor Circuit Erratic Bank 1

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P0641, P2228	P2227, P2228, P2229	P0641, P2227, P2229	P00C7, P2227
Signal	P2227, P2228	P2227, P2229	P2227, P2229	P00C7, P2227
Low Reference	-	P0113, P2199, P2227, P2228, P2229	-	P00C7, P2227

Typical Scan Tool Data

BARO

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Ignition Â» On / Vehicle Â» In Service Mode & Engine Â» Off **Parameter Normal Range:** 56 to 105 kPa (8.1 to 15.2 PSI)			
5 V Reference	0 kPa (0.0 PSI)	0 kPa (0.0 PSI)	127 kPa (18.4 PSI)
Signal	0 kPa (0.0 PSI)	127 kPa (18.4 PSI)	127 kPa (18.4 PSI)
Low Reference	-	127 kPa (18.4 PSI)	-

Circuit/System Description

Circuit	Description
5 V Reference	Regulated voltage supplied by the control module.
Signal	The control module input circuit has an internal resistance connected to 5 V.
Low Reference	Grounded through the control module.

Component	Description
B17 Barometric Pressure Sensor	The barometric pressure sensor generates an analog voltage that is proportional to the ambient air pressure.

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Component	Description
K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.

Conditions for Running the DTC

P2227 Condition 1

- DTC P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0121, P0122, P0123, P0222, P0223, P0236, P0237, P0238, P0502, P0503, P0722, P0723, P16A0-P16A2, P2101, P2135, P222C, P222D, P2228, P2229 = Not set
- Engine Running

Condition 2

- DTC P0107, P0108, P0237, P0238, P2228, P2229, P222C, P222D=Not pending
- DTC P0107, P0108, P0237, P0238, P2228, P2229, P222C, P222D, P2610 = Not set
- Engine Off =For greater than 10 sÂ»Ignition=On

DTC runs continuously when the above conditions are met.

P2228, P2229

- Ignition=On

  or

- Engine Running

DTC runs continuously when the above condition is met.

P2230

- DTC P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0121, P0122, P0123, P0222, P0223, P0236, P0237, P0238, P0502, P0503, P0722, P0723, P16A0-P16A2, P2101, P2135, P222C, P222D, P2228, P2229 = Not set
- Ignition=On

DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

P2227 Condition 1

- BARO & Calculated BARO Not within 20 kPa (2.9 PSI) of each other & BARO Update =Distance Traveled Less than 2 km (1.3 mi)

  or

- BARO & Calculated BARO =Not within 25 kPa (3.6 PSI) of each other & BARO Update =Distance Traveled Greater than 2 km/h (1.3 MPH)

Condition 2

- BARO =Not between 50 and 7.3 kPa (115 and 16.7 PSI) - For greater than 4 s

  or

- BARO =Not within 10 kPa (1.5 PSI) of each other - For greater than 4 s

P2228

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BARO =Less than 2 V - For greater than 4 s

P2229

BARO =Greater than 4.5 V - For greater than 4 s

P2230

BARO =Signal noisy or erratic - For greater than 4 s

Actions Taken When the DTC Sets

DTCs listed in the DTC Descriptor Category =Type B DTC

Conditions for Clearing the DTC

DTCs listed in the DTC Descriptor Category =Type B DTC

Diagnostic Aids

B17 Barometric Pressure SensorÂ»Inspect for the following conditions:

- Moisture
- Damaged seal.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW)

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

Circuit/System Verification

1. Ignition Â» On / Vehicle Â» In Service Mode

   NOTE: **If you were sent here from DTC P222B-P222E Â» Refer to Circuit/System Testing.**

2. Verify DTC P0107, P0108, P0237, P0238, P0641, P222C, P222D 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 parameter:

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- Boost Pressure Sensor = **Altitude Versus Barometric Pressure** - The value should be within the range listed in the table.
- MAP Sensor = **Altitude Versus Barometric Pressure** - The value should be within the range listed in the table.
- Barometric Pressure Sensor Bank 2 = **Altitude Versus Barometric Pressure** - The value should be within the range listed in the table.
- **If not in the specified range**
- {Barometric Pressure Sensor Bank 2} Refer to **DTC P222B-P222E**.
- {MAP Sensor} Refer to **DTC P0106** .
- {Boost Pressure Sensor} Refer to **DTC P0236**
- **If in the specified range**

4. Verify the scan tool parameter:Barometric Pressure Sensor Bank 1 = **Altitude Versus Barometric Pressure** - The value should be within the range listed in the table.
   - **If not in the specified range**

     Refer to Circuit/System Testing

   - **If in the specified range**
5. Verify the scan tool parameter:Barometric Pressure Sensor Bank 1 =The value should not spike or drop out.

   Perform the action while monitoring the parameter:

   - Wiggle the harness and connector:B17 Barometric Pressure Sensor
   - Wiggle the harness and connector:K20 Engine Control Module
   - **If the value spikes or drops out**

     Repair as necessary Â» Wiring / Terminal(s) / Electrical Connector(s)

   - **If the value does not spike or drop out**
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 is not set**
8. All OK.

Circuit/System Testing

1. Ignition/Vehicle & All vehicle systemsÂ» Off

   NOTE: **It may take up to 2 min for all vehicle systems to power down before an accurate ground or low reference circuit continuity test can be performed.**

2. Disconnect the electrical connector:B17 Barometric Pressure Sensor
3. Test for less than 5 Ω between the test points:Low Reference circuit terminal 2 & Ground
   - **If 5 Ω or greater**
   1. Disconnect the electrical connector:K20 Engine Control Module
   2. Test for less than 2 Ω between the test points:Low Reference circuit terminal 2 @ Component harness & Terminal 12 X2 @ Control module harness
      - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
      - If less than 2 ΩÂ» Replace the component:K20 Engine Control Module
   - **If less than 5 Ω**

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4. Ignition Â» On / Vehicle Â» In Service Mode
5. Test for 4.8 to 5.2 V between the test points: 5 V Reference circuit terminal 1 & Low Reference circuit terminal 2
    - **If less than 4.8 V**
    1. Ignition/Vehicle Â» Off
    2. Disconnect the electrical connector:K20 Engine Control Module
    3. Test for infinite resistance between the test points: 5 V Reference circuit terminal 1 @ Component harness & Ground
        - If less than infinite resistance Â» Repair the short to ground on the circuit.
        - If infinite resistance
    4. Test for less than 2 Ω between the test points: 5 V Reference circuit terminal 1 @ Component harness & Terminal 38 X3 @ Control module harness
        - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
        - If less than 2 ΩÂ» Replace the component:K20 Engine Control Module
    - **If greater than 5.2 V**
    1. Ignition/Vehicle Â» Off
    2. Disconnect the electrical connector:K20 Engine Control Module
    3. Ignition Â» On / Vehicle Â» In Service Mode
    4. Test for less than 1 V between the test points: 5 V Reference circuit terminal 1 @ Component harness & Ground
        - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
        - If less than 1 VÂ» Replace the component:K20 Engine Control Module
    - **If between 4.8 and 5.2 V**
6. Verify the scan tool parameter:Barometric Pressure Sensor Bank 1 = Greater than 4.7 V
    - **If 4.7 V or less**
    1. Ignition/Vehicle Â» Off
    2. Disconnect the electrical connector:K20 Engine Control Module
    3. Test for infinite resistance between the test points:Signal circuit terminal 3 @ Component harness & Ground
        - If less than infinite resistance Â» Repair the short to ground on the circuit.
        - If infinite resistance Â» Replace the component:K20 Engine Control Module
    - **If greater than 4.7 V**
7. Connect a 3 A fused jumper wire between the test points:Signal circuit terminal 3 & Low Reference circuit terminal 2
8. Verify the scan tool parameter:Barometric Pressure Sensor Bank 1 =Less than 0.2 V
    - **If 0.2 V or greater**
    1. Ignition/Vehicle Â» Off & Remove Â» Jumper wire(s)
    2. Disconnect the electrical connector:K20 Engine Control Module
    3. Ignition Â» On / Vehicle Â» In Service Mode
    4. Test for less than 1 V between the test points:Signal circuit terminal 3 @ Component harness & Ground
        - If 1 V or greater Â» Repair the short to voltage on the circuit.
        - If less than 1 V
    5. Ignition/Vehicle Â» Off
    6. Test for less than 2 Ω between the test points:Signal circuit terminal 3 @ Component harness & Terminal 58 X3 @ Control module harness
        - If 2 Ω or greater Â» Repair the open/high resistance in the circuit.
        - If less than 2 ΩÂ» Replace the component:K20 Engine Control Module
    - **If less than 0.2 V**
9. Test or replace the component:B17 Barometric Pressure Sensor

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Repair Instructions

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

- **Manifold Absolute Pressure Sensor Replacement (LGW)** - B17 Barometric Pressure Sensor
- For control module replacement, programming and setup, refer to **Control Module References**

DTC P2227-P2230: BAROMETRIC PRESSURE (BARO) SENSOR (LGX)

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

NOTE: **This procedure may also diagnose malfunctions that are not detected by a DTC.**

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	P0651, P2228	P2227, P2228	P0651, P2227, P2229	P2227
Signal	P2227, P2228	P2227, P2228	P2229	P2227
Low Reference	-	P0113, P2199, P2227, P2229	-	P2227

Typical Scan Tool Data

BARO

Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Ignition Â» On / Vehicle Â» In Service Mode & Engine Â» Off **Parameter Normal Range:** 56 to 105 kPa (8.1 to 15.2 PSI)			
5 V Reference	0 kPa (0.0 PSI)	0 kPa (0.0 PSI)	128 kPa (18.6 PSI)
Signal	0 kPa (0.0 PSI)	128 kPa (18.6 PSI)	128 kPa (18.6 PSI)
Low Reference	-	128 kPa (18.6 PSI)	-

Circuit/System Description

Circuit	Description
5 V Reference	Regulated voltage supplied by the control module.

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Circuit	Description
Signal	The control module input circuit has an internal resistance connected to 5 V.
Low Reference	Grounded through the control module.

Component	Description

B75C Multifunction Intake Air Sensor	The assembly has several functions:
	• The mass air flow sensor is a hot film type sensor that measures the mass of air (not the volume) entering the engine. The signal varies with engine load and is displayed by the scan tool in Hertz (Hz) and grams per second (g/s).
	• The intake air humidity sensor uses the same signal circuit as the intake air temperature sensor 2. The intake air humidity sensor modulates the pulse width of the signal. The intake air temperature sensor 2 modulates the frequency of the signal. That means the signal is both, PWM and FM modulated.
	• The barometric pressure sensor generates an analog voltage that is proportional to the ambient air pressure.
	• The intake air temperature sensor 1 varies its resistance depending on the temperature.
	  • Low temperature produces a high resistance: 5.6 kΩ @ 0Â°C (32Â°F)
	  • High temperature produces a low resistance: 187 Ω @ 100Â°C (212Â°F)

K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.

Conditions for Running the DTC

P2227 Condition 1

- DTC P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0121, P0122, P0123, P0222, P0223, P1516, P2101, P2135, P2228, P2229 = Not set
- Engine Running =For greater than 30 s

Condition 2

- DTC P0106, P0107, P0108, P2228, P2229, P2230, P2610 = Not set
- Ignition =On
- Engine Off =For greater than 6 min

DTC runs continuously when the above conditions are met.

P2228, P2229

Engine Running =For greater than 30 s

DTC runs continuously when the above condition is met.

P2230

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- DTC P0068, P0101, P0102, P0103, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0117, P0118, P0119, P0121, P0122, P0123, P0222, P0223, P1516, P2101, P2135, P2228, P2229 = Not set
- Ignition=On

DTC runs continuously when the above conditions are met.

Conditions for Setting the DTC

P2227 Condition 1

BARO & Calculated BARO =Not within 15 kPa (2.2 PSI) of each other.

Condition 2

BARO & Calculated BARO =Not within 20 kPa (3.0 PSI) of each other.

P2228

BARO =Less than 2 V - For greater than 5 s

P2229

BARO =Greater than 4.5 V - For greater than 5 s

P2230

BARO =Signal noisy or erratic - For greater than 5 s

Actions Taken When the DTC Sets

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

Conditions for Clearing the DTC

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

Reference Information

Schematic Reference

Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Engine Control Module 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

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Control Module References

Circuit/System Verification

1. Ignition Â» On / Vehicle Â» In Service Mode
2. Verify DTC P0106, P0107, P0108, P0641, P0651, P0697, P06A3 is not set.
   - If any of the DTCs are set

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

   - If none of the DTCs are set
3. Determine the current vehicle testing altitude.
4. Verify the scan tool parameter:MAP Sensor =The value should be within the range listed in the table: **Altitude Versus Barometric Pressure**
   - **If not in the specified range**

     Refer to:**DTC P0106**

   - **If in the specified range**
5. Verify the scan tool parameter:BARO =The value should be within the range listed in the table: **Altitude Versus Barometric Pressure**
   - **If not in the specified range**

     Refer to Circuit/System Testing

   - **If in the specified range**
6. Verify the scan tool parameter:BARO Sensor =The value should not spike or drop out.

   Perform the action while monitoring the parameter:

   - Wiggle the harness and connector:B75C Multifunction Intake Air Sensor
   - Wiggle the harness and connector:K20 Engine Control Module
   - If the value spikes or drops out

     Repair as necessary Â» Wiring / Terminal(s) / Electrical Connector(s)

   - If the value does not spike or drop out
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 is not set**
9. All OK.

Circuit/System Testing

1. Ignition/Vehicle & All vehicle systems Â» Off

   NOTE: **It may take up to 2 min for all vehicle systems to power down before an accurate ground or low reference circuit continuity test can be performed.**

2. Disconnect the electrical connector:B75C Multifunction Intake Air Sensor
3. Test for less than 10 Ω between the test points:Low Reference circuit terminal 3 & Ground
   - **If 10 Ω or greater**
   1. Disconnect the electrical connector:K20 Engine Control Module

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2. Test for less than 2 Ω between the test points:Low Reference circuit terminal 3 @ Component harness & Terminal 63 X2 @ Control module harness
    - If 2 Ω or greater Â» Repair the open/high resistance in the circuit.
    - If less than 2 Ω Â» Replace the component:K20 Engine Control Module
- **If less than 10 Ω**

4. Ignition Â» On / Vehicle Â» In Service Mode
5. Test for 4.8 to 5.2 V between the test points: 5 V Reference circuit terminal 2 & Low Reference circuit terminal 3
    - **If less than 4.8 V**
    1. Ignition/Vehicle Â» Off
    2. Disconnect the electrical connector:K20 Engine Control Module
    3. Test for infinite resistance between the test points: 5 V Reference circuit terminal 2 @ Component harness & Ground
        - If less than infinite resistance Â» Repair the short to ground on the circuit.
        - If infinite resistance
    4. Test for less than 2 Ω between the test points: 5 V Reference circuit terminal 2 @ Component harness & Terminal 43 X2 @ Control module harness
        - If 2 Ω or greater Â» Repair the open/high resistance in the circuit.
        - If less than 2 Ω Â» Replace the component:K20 Engine Control Module
    - **If greater than 5.2 V**
    1. Ignition/VehicleÂ» Off
    2. Disconnect the electrical connector:K20 Engine Control Module
    3. IgnitionÂ» On / VehicleÂ» In Service Mode
    4. Test for less than 1 V between the test points: 5 V Reference circuit terminal 2 @ Component harness & Ground
        - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
        - If less than 1 VÂ» Replace the component:K20 Engine Control Module
    - **If between 4.8 and 5.2 V**
6. Verify the scan tool parameter:BARO Sensor =Greater than 4.7 V
    - **If 4.7 V or less**
    1. Ignition/VehicleÂ» Off
    2. Disconnect the electrical connector:K20 Engine Control Module
    3. Test for infinite resistance between the test points:Signal circuit terminal 4 @ Component harness & Ground
        - If less than infinite resistanceÂ» Repair the short to ground on the circuit.
        - If infinite resistanceÂ» Replace the component:K20 Engine Control Module
    - **If greater than 4.7 V**
7. Connect a 3 A fused jumper wire between the test points:Signal circuit terminal 4 & Low Reference circuit terminal 3
8. Verify the scan tool parameter:BARO Sensor =Less than 0.2 V
    - **If 0.2 V or greater**
    1. Ignition/Vehicle Â» Off & Remove Â» Jumper wire(s)
    2. Disconnect the electrical connector:K20 Engine Control Module
    3. Ignition Â» On / Vehicle Â» In Service Mode
    4. Test for less than 1 V between the test points:Signal circuit terminal 4 @ Component harness & Ground
        - If 1 V or greater Â» Repair the short to voltage on the circuit.
        - If less than 1 V
    5. Ignition/Vehicle Â» Off

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6. Test for less than 2 Ω between the test points:Signal circuit terminal 4 @ Component harness & Terminal 42 X2 @ Control module harness
    - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
    - If less than 2 ΩÂ» Replace the component:K20 Engine Control Module
- **If less than 0.2 V**

9. Test or replace the component:B75C Multifunction Intake Air Sensor

Repair Instructions

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

- **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGX)** - B75C Multifunction Intake Air Sensor
- For control module replacement, programming and setup, refer to **Control Module References**

DTC P222B-P222E: BAROMETRIC PRESSURE SENSOR

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

NOTE: **This procedure may also diagnose malfunctions that are not detected by a DTC.**

DTC P222B

Barometric Pressure Sensor Bank 2

DTC P222C

Barometric Pressure (BARO) Sensor Circuit Low Voltage Bank 2

DTC P222D

Barometric Pressure (BARO) Sensor Circuit High Voltage Bank 2

DTC P222E

Barometric Pressure (BARO) Sensor Circuit Erratic Bank 2

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5 V Reference	P00C7, P0651, P222C	P222B, P222D	P0651, P222B, P222D	P00C7, P222B
Signal	P222B, P222C	P222B, P222D	P222B, P222D	P00C7, P222B
Low Reference	-	P0113, P2199, P2227, P2228, P222B, P222D	-	P00C7, P2227, P2230, P222B, P222E

Typical Scan Tool Data

Barometric Pressure Sensor Bank 2

Circuit	Short to Ground	Open	Short to Voltage

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Circuit	Short to Ground	Open	Short to Voltage
Operating Conditions: Ignition Â» On / Vehicle Â» In Service Mode & Engine Â» Off **Parameter Normal Range:** 56 to 105 kPa (8.1 to 15.2 PSI)			
5 V Reference	0 kPa (0.0 PSI)	0 kPa (0.0 PSI)	127 kPa (18.4 PSI)
Signal	0 kPa (0.0 PSI)	127 kPa (18.4 PSI)	127 kPa (18.4 PSI)
Low Reference	-	127 kPa (18.4 PSI)	-

Circuit/System Description

Circuit	Description
5 V Reference	Regulated voltage supplied by the control module.
Signal	The control module input circuit has an internal resistance connected to 5 V.
Low Reference	Grounded through the control module.

Component	Description

B75C Multifunction Intake Air Sensor	The assembly has several functions:
	• The mass air flow sensor is a hot film type sensor that measures the mass of air (not the volume) entering the engine. The signal varies with engine load and is displayed by the scan tool in Hertz (Hz) and grams per second (g/s).
	• The intake air humidity sensor uses the same signal circuit as the intake air temperature sensor 2. The intake air humidity sensor modulates the pulse width of the signal. The intake air temperature sensor 2 modulates the frequency of the signal. That means the signal is both, PWM and FM modulated.
	• The barometric pressure sensor generates an analog voltage that is proportional to the ambient air pressure.
	• The intake air temperature sensor 1 varies its resistance depending on the temperature.
	  • Low temperature produces a high resistance: 5.6 kΩ @ 0Â°C (32Â°F)
	  • High temperature produces a low resistance: 187 Ω @ 100Â°C (212Â°F)

K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.

Conditions for Running the DTC

P222B Condition 1

- DTC P0068, P010C, P010D, P0106, P0107, P0108, P0111, P0112, P0113, P0114, P0121, P0122, P0123, P0222, P0223, P0236, P0237, P0238, P0502, P0503, P0722, P0723, P16A0-P16A2, P2101, P2135, P222C, P222D, P222E = Not set
- Engine Running

Condition 2

- DTC P0107, P0108, P0237, P0238, P2228, P2229, P222C, P222D=Not pending
- DTC P0107, P0108, P0237, P0238, P2228, P2229, P222C, P222D, P2610 = Not set
- Engine Off =For greater than 10 sÂ»Ignition=On

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DTC runs continuously when the above conditions are met.

P222C, P222D, P222E

- Ignition=On

  or

- Engine Running

DTC runs continuously when the above condition is met.

Conditions for Setting the DTC

P222B Condition 1

- BARO & Calculated BARO Not within 20 kPa (2.9 PSI) of each other & BARO Update =Distance Traveled Less than 2 km (1.3 mi)

  or

- BARO & Calculated BARO =Not within 25 kPa (3.6 PSI) of each other & BARO Update =Distance Traveled Greater than 2 km/h (1.3 MPH)

Condition 2

- BARO =Not between 50 and 7.3 kPa (115 and 16.7 PSI) - For greater than 4 s

  or

- BARO =Not within 10 kPa (1.5 PSI) of each other - For greater than 4 s

P222C

BARO =Less than 2 V - For greater than 4 s

P222D

BARO =Greater than 4.5 V - For greater than 4 s

P222E

BARO =Signal noisy or erratic - For greater than 4 s

Actions Taken When the DTC Sets

DTCs listed in the DTC Descriptor Category= Type B DTC

Conditions for Clearing the DTC

DTCs listed in the DTC Descriptor Category= Type B DTC

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Electrical Information Reference

- **Circuit Testing**

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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

Circuit/System Verification

NOTE: **If you were sent here from DTC P2227-P2230Â» Refer to Circuit/System Testing.**

1. Ignition Â» On / Vehicle Â» In Service Mode
2. Verify DTC P0107, P0108, P0237, P0238, P0651, P2228, P2229 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 parameter:
   - Barometric Pressure Sensor Bank 1 = Altitude Versus Barometric Pressure - The value should be within the range listed in the table.
   - Boost Pressure Sensor = Altitude Versus Barometric Pressure - The value should be within the range listed in the table.
   - MAP Sensor = Altitude Versus Barometric Pressure - The value should be within the range listed in the table.
   - **If not in the specified range**
   - {Barometric Pressure Sensor Bank 1} Refer to DTC P2227-P2230 (LGW)DTC P2227-P2230 (LGX).
   - {Boost Pressure Sensor} Refer to DTC P0236
   - {MAP Sensor} Refer to DTC P0106 .
   - **If in the specified range**
4. Verify the scan tool parameter:Barometric Pressure Sensor Bank 2 = Altitude Versus Barometric Pressure - The value should be within the range listed in the table.
   - **If not in the specified range**

     Refer to Circuit/System Testing

   - **If in the specified range**
5. Verify the scan tool parameter:Barometric Pressure Sensor Bank 2 =The value should not spike or drop out.

   Perform the action while monitoring the parameter:

   - Wiggle the harness and connector:B75C Multifunction Intake Air Sensor
   - Wiggle the harness and connector:K20 Engine Control Module
   - **If the value spikes or drops out**

     Repair as necessaryÂ» Wiring / Terminal(s) / Electrical Connector(s)

   - **If the value does not spike or drop out**
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.

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

      Refer to Circuit/System Testing

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

Circuit/System Testing

1. Ignition/Vehicle & All vehicle systems Â» Off

> **NOTE:** **It may take up to 2 min for all vehicle systems to power down before an accurate ground or low reference circuit continuity test can be performed.**

2. Disconnect the electrical connector:B75C Multifunction Intake Air Sensor
3. Test for less than 5 Ω between the test points: Low Reference circuit terminal 3 & Ground
    - **If 5 Ω or greater**
    1. Disconnect the electrical connector: X2 @ K20 Engine Control Module
    2. Test for less than 2 Ω between the test points:Low Reference circuit terminal 3 @ Component harness & Terminal 12 X2 @ Control module harness
        - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
        - If less than 2 ΩÂ» Replace the component:K20 Engine Control Module
    - **If less than 5 Ω**
4. Ignition Â» On / Vehicle Â» In Service Mode
5. Test for 4.8 to 5.2 V between the test points: 5 V Reference circuit terminal 2 & Low Reference circuit terminal 3
    - **If less than 4.8 V**
    1. Ignition/Vehicle Â» Off
    2. Disconnect the electrical connector: X3 @ K20 Engine Control Module
    3. Test for infinite resistance between the test points: 5 V Reference circuit terminal 2 @ Component harness & Ground
        - If less than infinite resistanceÂ» Repair the short to ground on the circuit.
        - If infinite resistance
    4. Test for less than 2 Ω between the test points: 5 V Reference circuit terminal 2 @ Component harness & Terminal 37 @ Control module harness
        - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
        - If less than 2 ΩÂ» Replace the component:K20 Engine Control Module
    - **If greater than 5.2 V**
    1. Ignition/VehicleÂ» Off
    2. Disconnect the electrical connector: X3 @ K20 Engine Control Module
    3. Ignition Â» On / Vehicle Â» In Service Mode
    4. Test for less than 1 V between the test points: 5 V Reference circuit terminal 2 @ Component harness & Ground
        - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
        - If less than 1 VÂ» Replace the component:K20 Engine Control Module
    - **If between 4.8 and 5.2 V**
6. Verify the scan tool parameter:Barometric Pressure Sensor Bank 2 =Greater than 4.7 V
    - **If 4.7 V or less**
    1. Ignition/Vehicle Â» Off
    2. Disconnect the electrical connector: X3 @ K20 Engine Control Module

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3. Test for infinite resistance between the test points:Signal circuit terminal 4 @ Component harness & Ground
    - If less than infinite resistanceÂ» Repair the short to ground on the circuit.
    - If infinite resistanceÂ» Replace the component:K20 Engine Control Module
- **If greater than 4.7 V**

7. Connect a 3 A fused jumper wire between the test points:Signal circuit terminal 4 & Low Reference circuit terminal 3
8. Verify the scan tool parameter:Barometric Pressure Sensor Bank 2 =Less than 0.2 V
    - **If 0.2 V or greater**
    1. Ignition/VehicleÂ» Off & RemoveÂ» Jumper wire(s)
    2. Disconnect the electrical connector: X3 @ K20 Engine Control Module
    3. Ignition Â» On / Vehicle Â» In Service Mode
    4. Test for less than 1 V between the test points:Signal circuit terminal 4 @ Component harness & Ground
        - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
        - If less than 1 V
    5. Ignition/VehicleÂ» Off
    6. Test for less than 2 Ω between the test points:Signal circuit terminal 4 @ Component harness & Terminal 57 X3 @ Control module harness
        - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
        - If less than 2 ΩÂ» Replace the component:K20 Engine Control Module
    - **If less than 0.2 V**
9. Test or replace the component:B75C Multifunction Intake Air Sensor

Repair Instructions

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

- **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGW)** **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGX)** - B75C Multifunction Intake Air Sensor
- For control module replacement, programming and setup, refer to **Control Module References**

DTC P2544: TRANSMISSION TORQUE REQUEST CIRCUIT MESSAGE COUNTER INCORRECT

Diagnostic Instructions

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

DTC Descriptors

DTC P2544

Transmission Torque Request Circuit Message Counter Incorrect

Circuit/System Description

To improve shift feel, the transmission control module (TCM) is constantly sending the engine control module (ECM) serial data messages with requests to modify engine speed or torque. These serial data messages are sent through two circuits which are part of a communication network called the controller area network (CAN). The ECM sets DTC P2544 when it detects a discrepancy in the structure of the message causing the integrity of the message to be questioned.

Conditions for Running the DTC

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- 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 TCM replacement, programming and setup.

DTC P25CA-P25CF: INTAKE CAMSHAFT POSITION ACTUATOR PARK LOCK SOLENOID VALVE CONTROL CIRCUIT

Diagnostic Instructions

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- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

DTC P25CA

Intake Camshaft Position Actuator Park Lock Solenoid Valve Control Circuit Bank 1

DTC P25CB

Intake Camshaft Position Actuator Park Lock Solenoid Valve Control Circuit Low Voltage Bank 1

DTC P25CC

Intake Camshaft Position Actuator Park Lock Solenoid Valve Control Circuit High Voltage Bank 1

DTC P25CD

Intake Camshaft Position Actuator Park Lock Solenoid Valve Control Circuit Bank 2

DTC P25CE

Intake Camshaft Position Actuator Park Lock Solenoid Valve Control Circuit High Voltage Bank 2

DTC P25CF

Intake Camshaft Position Actuator Park Lock Solenoid Valve Control Circuit Low Voltage Bank 2

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition - Terminal 1 @ Q84A Camshaft Position Actuator Park Lock Solenoid Valve - Bank 1 Intake	P0458, P25CB, P25CE, P3411, P3435	P0458, P25CB, P25CE, P3411, P3435	P0690	-
Control - Terminal 2 @ Q84A Camshaft Position Actuator Park Lock Solenoid Valve - Bank 1 Intake	P0016, P25CB	P25CA	P25CC	-
Ignition - Terminal 1 @ Q84B Camshaft Position Actuator Park Lock Solenoid Valve - Bank 2 Intake	P0458, P25CB, P25CE, P3411, P3435	P0458, P25CB, P25CE, P3411, P3435	P0690	-
Control - Terminal 2 @ Q84B Camshaft Position Actuator Park Lock Solenoid Valve - Bank 2 Intake	P0018, P25CE	P25CD	P25CF	-

Circuit/System Description

For an overview of the component/system, refer to **Camshaft Actuator System Description**

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Circuit	Description
Ignition	Supplied from a fuse.
Control	The output circuit is switched to ground to activate the component.

Component	Description
Q84 Camshaft Position Actuator Park Lock Solenoid Valve	A solenoid valve is an electro-mechanically operated valve. The valve is controlled by an electric current through the solenoid.
K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.

Conditions for Running the DTC

- Ignition Voltage =Greater than 11 V
- Ignition Switch =Crank/Run/Engine running.
- Q84 Camshaft Position Actuator Park Lock Solenoid Valve=On

Frequency the DTC runs=Continuously - After the running conditions are met

Conditions for Setting the DTC

Control circuit=Commanded state does not match the actual state - For greater than 5 s

Actions Taken When the DTC Sets

DTCs listed in the DTC Descriptor Category=Type B DTC

Conditions for Clearing the DTC

DTCs listed in the DTC Descriptor Category=Type B DTC

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

Powertrain Component Views

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Master Electrical Component List

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

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Scan Tool Reference

Control Module References

Circuit/System Verification

1. Engine Running

   NOTE: **Verify the engine has the correct oil level and the correct oil pressure before continuing with this diagnostic.**

2. Perform the appropriate scan tool control function: Intake Camshaft Position Actuator Park Lock TestÂ»Enable/OK

   Verify the scan tool parameter:

   - Intake Camshaft Position Actuator Park Lock Solenoid Valve Control Circuit High Voltage Test Status Bank 1, 2=OK or Not Run
   - Intake Camshaft Position Actuator Park Lock Solenoid Valve Control Circuit Low Voltage Test Status Bank 1, 2=OK or Not Run
   - Intake Camshaft Position Actuator Park Lock Solenoid Valve Control Circuit Open Test Status Bank 1, 2=OK or Not Run
   - **If not the specified state**

     Refer to Circuit/System Testing

   - **If the specified state**

3. Perform the appropriate scan tool control function: Intake Camshaft Position Actuator Park Lock TestÂ» Enable/OK

   Verify the scan tool parameter:

   - Intake Camshaft Position Actuator Park Lock Solenoid Valve Control Circuit High Voltage Test Status Bank 1, 2=OK or Not Run
   - Intake Camshaft Position Actuator Park Lock Solenoid Valve Control Circuit Low Voltage Test Status Bank 1, 2=OK or Not Run
   - Intake Camshaft Position Actuator Park Lock Solenoid Valve Control Circuit Open Test Status Bank 1, 2=OK or Not Run
   - Perform the action while monitoring the parameter:
   - Wiggle the harness and connector:Q84 Camshaft Position Actuator Park Lock Solenoid Valve
   - Wiggle the harness and connector:K20 Engine Control Module
   - **If not the specified state**

     Repair as necessary Â» Wiring / Terminal(s) / Electrical Connector(s)

   - **If the specified state**

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.

   Verify the DTC does not set.

   - **If the DTC sets**

     Refer to Circuit/System Testing

   - **If the DTC is not set**

5. All OK.

Circuit/System Testing

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1. Ignition/Vehicle & All vehicle systemsÂ» Off
2. Disconnect the appropriate electrical connector:Q84 Camshaft Position Actuator Park Lock Solenoid Valve
3. Ignition Â» On / Vehicle Â» In Service Mode
4. Verify a test lamp turns On between the test points:Ignition circuit terminal 1/A & Ground
    - **If the test lamp does not turn On and the circuit fuse is OK**
    1. Ignition/Vehicle Â» Off & Remove Â» Test lamp
    2. Test for less than 2 Ω between the test points:Ignition circuit terminal 1/A & Output terminal @ Fuse
        - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
        - If less than 2 ΩÂ» Verify the fuse is OK and there is voltage at the fuse.
    - **If the test lamp does not turn On and the circuit fuse is open**
    1. Ignition/Vehicle Â» Off & Remove Â» Test lamp
    2. Connect the electrical connector:Q84 Camshaft Position Actuator Park Lock Solenoid Valve
    3. Ignition Â» On / Vehicle Â» In Service Mode
    4. Replace the component:Fuse
    5. Verify the fuse does not open.
        - If the fuse opens and there are components connected to the circuit Â» Disconnect a component and repeat step 4.4
        - If the fuse opens with all components disconnected from the circuit Â» Repair the short to ground on the circuit.
        - If the fuse does not open after disconnecting a component from the circuit Â» Replace the component disconnected last.
        - If the fuse does not open with all components connected.
    6. Operate each component on the circuit, one at a time. It might be necessary to use scan tool control functions to operate the components.

        Verify the fuse does not open when any of the components are activated.

        - If the fuse opensÂ» Replace the component that caused the fuse to open when activated.
        - If the fuse does not open.
    7. All OK.
    - **If the test lamp turns On**
5. Verify a test lamp does not turn On between the test points:Control circuit terminal 2/B & B+
    - **If the test lamp turns On**
    1. Ignition/Vehicle Â» Off & Remove Â» Test lamp
    2. Disconnect the electrical connector: X3 @ K20 Engine Control Module
    3. Test for infinite resistance between the test points: Control circuit terminal 2/B @ Component harness & Ground
        - If less than infinite resistance Â» Repair the short to ground on the circuit.
        - If infinite resistance Â» Replace the component: K20 Engine Control Module
    - **If the test lamp does not turn On**
6. Remove Â» Test Lamp
7. Perform the scan tool control function: Intake Camshaft Position Actuator Park Lock Solenoid Valve Bank 1, 2Â» On

    Verify the scan tool parameter: Intake Camshaft Position Actuator Park Lock Solenoid Valve Control Circuit High Voltage Test Status Bank 1, 2=OK

    - **If not the specified state**
    1. Ignition/Vehicle Â» Off
    2. Disconnect the electrical connector: X3 @ K20 Engine Control Module

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3. Test for less than 1 V between the test points:Control circuit terminal 2/B @ Component harness & Ground
    - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
    - If less than 1 VÂ» Replace the component: K20 Engine Control Module
- **If the specified state**

8. Connect a 3A fused jumper wire between the test points:Control circuit terminal 2/B Ignition circuit terminal 1/A
9. Perform the scan tool control function: Intake Camshaft Position Actuator Park Lock Solenoid Valve Bank 1, 2Â» On

   Verify the scan tool parameter: Intake Camshaft Position Actuator Park Lock Solenoid Valve Control Circuit High Voltage Test Status Bank 1, 2=Malfunction

   - **If not the specified state**

   1. Ignition/Vehicle Â» Off & Remove Â» Jumper wire(s)
   2. Disconnect the electrical connector: X3 @ K20 Engine Control Module
   3. Test for less than 2 Ω between the test points:Control circuit terminal 2/B @ Component harness & The other end of the circuit @ Control module harness
      - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
      - If less than 2 ΩÂ» Replace the component: K20 Engine Control Module
   - **If the specified state**

10. Test or replace the component:Q84 Camshaft Position Actuator Park Lock Solenoid Valve

Component Testing

Static Test

1. Ignition/Vehicle Â» Off
2. Disconnect the appropriate electrical connector:Q84 Camshaft Position Actuator Park Lock Solenoid Valve
3. Test for 11 to 30 Ω between the test points:Control terminal 2/B Ignition terminal 1/A
   - **If not between 11 and 30 Ω**

     Replace the component:Q84 Camshaft Position Actuator Park Lock Solenoid Valve

   - **If between 11 and 30 Ω**
4. Test for infinite resistance between the test points:Each terminal of the component & The component's housing
   - **If less than infinite resistance**

     Replace the component:Q84 Camshaft Position Actuator Park Lock Solenoid Valve

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

Dynamic Test

1. Ignition/VehicleÂ» Off
2. Disconnect the appropriate electrical connector: Q84 Camshaft Position Actuator Park Lock Solenoid Valve
3. Connect a 3 A fused jumper wire between the test points:Ignition terminal 1/A & 12 V
4. Momentarily connect a jumper wire between the test points:Control terminal 2 & Ground

CAUTION: **Complete the testing as quickly as possible in order to prevent overheating and damaging the component.**

Verify the component turns On and Off when connecting and disconnecting the jumper wire:Q84 Camshaft Position Actuator Park Lock Solenoid Valve

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- **If the component does not turn On and Off**

  Replace the component:Q84 Camshaft Position Actuator Park Lock Solenoid Valve

- **If the component turns On and Off**

5. All OK.

Repair Instructions

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

- **Camshaft Position Actuator Locating Pin Control Valve Replacement (Bank 1 LGW)**
  Camshaft Position Actuator Locating Pin Control Valve Replacement (Bank 2 LGW)
  Camshaft Position Actuator Locating Pin Control Valve Replacement (Bank 1 LGX)
  Camshaft Position Actuator Locating Pin Control Valve Replacement (Bank 2 LGX)
- For control module replacement, programming and setup, refer to **Control Module References**

DTC P2615 OR P2616: CAMSHAFT POSITION SIGNAL OUTPUT CIRCUIT

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

DTC P2615

Camshaft Position Signal Output Circuit Low Voltage

DTC P2616

Camshaft Position Signal Output Circuit High Voltage

Conditions for Running the DTC

- Ignition=On
- Engine=Not Running
- Camshaft Position Sensor Circuit =Active

Frequency the DTC runs=Continuously - After the running conditions are met

Conditions for Setting the DTC

P2615

Camshaft Position Signal Output Circuit =Short to Ground or Electrically Open Symptom - For greater than 5 s

P2616

Camshaft Position Signal Output Circuit =Short to Voltage - For greater than 5 s

Actions Taken When the DTC Sets

DTCs listed in the DTC Descriptor Category=Type C DTC

Conditions for Clearing the DTC

DTCs listed in the DTC Descriptor Category=Type C DTC

Reference Information

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DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Circuit/System Verification

1. EngineÂ»Running
2. Verify there are no symptoms/DTCs related to the following system/component, if equipped:
    - P16 Instrument Cluster
    - K103 Fuel Injector Control Module
    - K108 Active Noise Cancellation Module
    - **If a symptom or DTC exists**

      Refer to:

        - Diagnostic Trouble Code (DTC) List - Vehicle
        - Symptoms - Vehicle
    - **If no symptom or DTC exists**
3. All OK.

DTC P2618 OR P2619: CRANKSHAFT POSITION SIGNAL OUTPUT CIRCUIT

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: Diagnostic System Check - Vehicle
- Review the description of Strategy Based Diagnosis: Strategy Based Diagnosis
- An overview of each diagnostic category can be found here: Diagnostic Procedure Instructions

DTC Descriptor

DTC P2618

Crankshaft Position Signal Output Circuit Low Voltage

DTC P2619

Crankshaft Position Signal Output Circuit High Voltage

Conditions for Running the DTC

- Ignition Voltage =Greater than 11 V
- Ignition=On
- Crankshaft Position Sensor Circuit =Active

Frequency the DTC runs=Continuously - After the running conditions are met

Conditions for Setting the DTC

P2618

Crankshaft Position Signal Output Circuit =Short to Ground or Open - For greater than 5 s

P2619

Crankshaft Position Signal Output Circuit =Short to Voltage - For greater than 5 s

Actions Taken When the DTC Sets

DTCs listed in the DTC Descriptor Category=Type C DTC

Conditions for Clearing the DTC

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DTCs listed in the DTC Descriptor Category=Type C DTC

Reference Information

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Circuit/System Verification

1. EngineÂ»Running
2. Verify there are no symptoms/DTCs related to the following system/component, if equipped:
   - K71 Transmission Control Module
   - K103 Fuel Injector Control Module
   - T3 Audio Amplifier
   - T6 Power Inverter Module
   - **If a symptom or DTC exists**

     Refer to:

   - **Diagnostic Trouble Code (DTC) List - Vehicle**
   - **Symptoms - Vehicle**
   - **If no symptom or DTC exists**
3. All OK.

DTC P2635: FUEL PUMP FLOW PERFORMANCE

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**
- An overview of each diagnostic category can be found here: **Diagnostic Procedure Instructions**

DTC Descriptor

NOTE: **This procedure may also diagnose malfunctions that are not detected by a DTC.**

DTC P2635

Fuel Pump Flow Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control	P0231	P023F	P0232	P023F, P2635
Low Reference	-	P023F	-	P023F, P2635

Circuit/System Description

Circuit	Description
Control	The output circuit is switched to 12 V to activate the component.
Low Reference	Grounded through the control module.

Component	Description

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Component	Description
A7 Fuel Pump and Level Sensor Assembly	The control module K111 supplies the fuel pump with a PWM signal in order to achieve the desired fuel line pressure.
K111 Fuel Pump Driver Control Module	The control module K111 monitors the fuel system for any condition which may adversely affect emissions. If a condition is detected it sets a DTC and sends a serial data message to the engine control module which then sets DTC P069E.

When the ignition is turned On, the ECM sends a 12 V signal to the control module K111 to enable the fuel pump. If the engine is not started, the control module K111 turns the fuel pump Off after 6 s.

Conditions for Running the DTC

- DTC P018B, P018C, P018D, P0231, P0232, P023F, P0641, P064A, P1255 = Not set
- Fuel Pump Command =On
- Ignition Voltage - 11 to 31 V
- Engine Run Time - Greater than 30 s
- Fuel Level Sensor - Greater than 10%

Conditions for Setting the DTC

The difference between the following parameters is greater than a predefined value:

- Desired Fuel Pressure
- Fuel Pressure

Actions Taken When the DTC Sets

DTC P2635 is a Type B DTC.

Conditions for Clearing the DTC

DTC P2635 is a Type B DTC.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

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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

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Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References

Circuit/System Verification

1. Ignition Â» On / Vehicle Â» In Service Mode
2. Verify no other DTCs are set.
   - **If other DTCs are set**

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

   - **If no other DTCs are set**
3. Verify the correct pressure:**Fuel System Diagnosis**
   - **If a condition exists**

     Refer to Circuit/System Testing

   - **If no condition exists**
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: **It may take up to 2 min for all vehicle systems to power down before an accurate ground or low reference circuit continuity test can be performed.**

1. Ignition/Vehicle & All vehicle systemsÂ» Off
2. Disconnect the electrical connector:A7 Fuel Pump and Level Sensor Assembly
3. Test for less than 5 Ω between the test points:Low Reference circuit terminal 2 & Ground
   - **If 5 Ω or greater**
   1. Disconnect the electrical connector:@K111 Fuel Pump Driver Control Module
   2. Test for less than 2 Ω between the test points:Low Reference circuit terminal 2 @ Component harness & Terminal 16 @ Control module harness
      - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
      - If less than 2 ΩÂ» Replace the component:K111 Fuel Pump Driver Control Module
   - **If less than 5 Ω**
4. Connect a test lamp between the test points:Control circuit terminal 1 & Low Reference circuit terminal 2
5. Ignition Â» On / Vehicle Â» In Service Mode
6. Perform the scan tool control function:Fuel Pump @ K111 Fuel Pump Driver Control ModuleÂ» From 0 to 70% and back to 0%.

   Verify the test lamp turns On and Off.

   - **If the test lamp is always Off**
   1. Ignition/Vehicle Â» Off & Remove Â» Test lamp
   2. Disconnect the electrical connector: K111 Fuel Pump Driver Control Module

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3. Test for infinite resistance between the test points:Control circuit terminal 2 @ Component harness & Ground
    - If less than infinite resistance Â» Repair the short to ground on the circuit.
    - If infinite resistance
4. Test for less than 2 Ω between the test points:Control circuit terminal 1 @ Component harness & Terminal 8 @ Control module harness
    - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
    - If less than 2 ΩÂ» Replace the component: K111 Fuel Pump Driver Control Module

- **If the test lamp is always On**

1. Ignition/Vehicle Â» Off & Remove Â» Test lamp
2. Disconnect the electrical connector:K111 Fuel Pump Driver Control Module
3. Ignition Â» On / Vehicle Â» In Service Mode
4. Test for less than 1 V between the test points:Control circuit terminal 1 @ Component harness & Ground
    - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
    - If less than 1 VÂ» Replace the component:K111 Fuel Pump Driver Control Module

- **If the test lamp turns On and Off**

7. Remove the component:A7 Fuel Pump and Level Sensor Assembly
8. Verify the condition does not exist:
    - Bad fuel quality.
    - Insufficient amount of fuel in the tank.
    - Restricted fuel supply line.
    - Faulty electrical connections or wiring inside the removed component.
    - Contamination of the fuel pump fuel strainer.
    - **If a condition exists**

      Repair or replace as necessary.

    - **If no condition exists**

      Replace the component:A7 Fuel Pump and Level Sensor Assembly

Repair Instructions

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

- **Fuel Tank Fuel Pump Module Replacement** - A7 Fuel Pump and Level Sensor Assembly
- **Fuel Pump Power Control Module Replacement** - K111 Fuel Pump Driver Control Module

DTC P3400: CYLINDER DEACTIVATION SYSTEM

Diagnostic Instructions

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

DTC Descriptor

DTC P3400

Cylinder Deactivation System

Circuit/System Description

The cylinder deactivation system is used to deactivate 2 cylinders of the engine under light load driving conditions. The Engine Control Module (ECM) commands the cylinder deactivation solenoids ON to

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deactivate engine cylinders 2 and 5, switching to 4 cylinders or V4 mode. The cylinder deactivation solenoids controls the oil flow to the appropriate valve lifters. The engine operates on 6 cylinders or V6 mode, during engine starting, engine idling and medium to heavy throttle conditions.

Ignition voltage is supplied directly to the 2 cylinder deactivation solenoids. The ECM controls the cylinder deactivation solenoids by grounding the control circuit with a solid state device called a driver.

The Cylinder Deactivation System Performance diagnostic is a test of the internal mechanical condition of the engine, during operation in V4 mode. The ECM determines the internal mechanical condition of the engine through the actual measured values of the Mass Air Flow (MAF) sensor, the intake Manifold Absolute Pressure (MAP) sensor and the Throttle Position Sensor (TPS). The actual measured values of the 3 sensors are then compared to the calculated values for V4 mode and stored in the ECM. If the measured values are incorrect for V4 mode, the ECM may set this code and return to V6 mode operation.

Conditions for Running the DTC

- DTCs P0102, P0103, P0107, P0108, P0112, P0113, P0117, P0119, P0335 and P0336 are not set.
- The engine speed is between 450-5, 400 RPM.
- The Engine Coolant Temperature (ECT) Sensor parameter is between -7 to +150Â°C (19 to 302Â°F).
- The Intake Air Temperature (IAT) Sensor is between -20 to 125Â°C (-4 to 257Â°F).
- Time in V6 mode is greater than 2 s.
- Time in V4 mode is greater than 2 s.
- This DTC runs continuously within the enabling conditions.

Conditions for Setting the DTC

The engine control module detects that the actual measured values from the MAF sensor, MAP sensor and throttle position sensor, are not within the range of the calculated values for V4 mode.

Action Taken When the DTC Sets

- DTC P3400 is a Type B DTC.
- The engine will return to V6 mode.

Conditions for Clearing the DTC

DTC P3400 is a Type B DTC.

Diagnostic Aids

- This DTC will not set during engine idling conditions. The vehicle will need to be driven for the DTC to set.
- This DTC may set if the PCV hose is disconnected from the inlet duct.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Cylinder Deactivation (Active Fuel Management) System Description

Electrical Information Reference

- **Circuit Testing**

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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 P0201-P0206, P0351-P0356, P3409, P3411, P3412, P3433, P3435 or P3436 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 engine oil level and engine oil pressure are within the specified ranges. Refer to Oil Pressure Diagnosis and Testing
   - **If not within specified ranges**

     Repair as necessary.

   - **If within specified ranges**
4. Engine idling at the normal operating temperature.
5. Verify there is no abnormal engine noise.
   - **If there is an abnormal engine noise**

     Refer to Symptoms - Engine Mechanical for further diagnosis.

   - **If no abnormal engine noise**
6. Clear all DTCs using scan tool. Operate the vehicle within the Conditions for Running the DTC. You may also operate the vehicle within the conditions that you observed from the Freeze Frame/Failure Records data.
7. Verify the DTC does not set.
   - **If the DTC sets**

     Refer to Circuit/System Testing.

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

Circuit/System Testing

1. Ignition OFF, disconnect the harness connectors at the Q83A and Q83B Valve Lifter Oil Solenoid Valve.

   NOTE: **Cylinder Deactivation System command control function will not operate if any DTCs are set.**

2. Disconnect the X3 harness connector at the K20 Engine Control Module.
3. Test each cylinder deactivation solenoid valve control circuit for less than 5 Ω end to end.
   - **If 5 Ω or greater**

     Repair the open/high resistance in the circuit.

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- **If less than 5 Ω**

  Refer to **Cylinder Deactivation (Active Fuel Management) System Diagnosis** for further diagnosis.

Repair Instructions

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

- **Engine Control Module Replacement (LGW)** **Engine Control Module Replacement (LGX)** for K20 Engine Control Module replacement, programming and setup.

DTC P3409, P3411, P3412, P3433, P3435 OR P3436: CYLINDER 2 DEACTIVATION SOLENOID VALVE CONTROL CIRCUIT

Diagnostic Instructions

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

DTC Descriptors

DTC P3409

Cylinder 2 Deactivation Solenoid Valve Control Circuit

DTC P3411

Cylinder 2 Deactivation Solenoid Valve Control Circuit Low Voltage

DTC P3412

Cylinder 2 Deactivation Solenoid Valve Control Circuit High Voltage

DTC P3433

Cylinder 5 Deactivation Solenoid Valve Control Circuit

DTC P3435

Cylinder 5 Deactivation Solenoid Valve Control Circuit Low Voltage

DTC P3436

Cylinder 5 Deactivation Solenoid Valve Control Circuit High Voltage

Circuit/System Description

The cylinder deactivation system is used to deactivate 2 cylinders of the engine under light load driving conditions. The Engine Control Module (ECM) commands the cylinder deactivation solenoids ON to deactivate engine cylinders 2 and 5, switching to 4 cylinders or V4 mode. The cylinder deactivation solenoids controls the oil flow to the appropriate valve lifters. The engine operates on 6 cylinders or V6 mode, during engine starting, engine idling and medium to heavy throttle conditions.

Ignition voltage is supplied directly to the 2 cylinder deactivation solenoids. The ECM controls the cylinder deactivation solenoids by grounding the control circuit with a solid state device called a driver.

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition	-	P0031, P0051, P0155, P0458, P3411, P3435	P0690	P3400

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Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Cylinder 2 Deactivation Solenoid Valve Control Circuit	P3411	P3409	P3412	P3400
Cylinder 5 Deactivation Solenoid Valve Control Circuit	P3435	P3433	P3436	P3400

Conditions for Running the DTC

- Engine speed is greater than 425 RPM.
- Ignition voltage is greater than 11 V.
- DTC run continuously when the above conditions are met.

Conditions for Setting the DTC

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

Action Taken When the DTC Sets

- DTC P3409, P3411, P3412, P3433, P3435 and P3436 are Type B DTCs.
- The engine will return to V6 mode.
- The fuel injector will turn OFF for the cylinder that has a cylinder deactivation DTC set, resulting in an engine misfire.

Conditions for Clearing the DTC

DTC P3409, P3411, P3412, P3433, P3435 and P3436 are Type B DTCs.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Cylinder Deactivation (Active Fuel Management) System Description

Electrical Information Reference

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

DTC Type Reference

Powertrain Diagnostic Trouble Code (DTC) Type Definitions

Scan Tool Reference

Control Module References for scan tool information

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Circuit/System Verification

1. Verify engine oil level and engine oil pressure are within the specified ranges. Refer to **Oil Pressure Diagnosis and Testing**
   - **If not within specified ranges**

     Repair as necessary.

   - **If within specified ranges**
2. Engine idling.

   NOTE: **DTC P3409, P3411, P3433 and P3435 will set with an open ignition circuit fuse.**

3. Verify the parameters listed below do not display Malfunction.
   - Cylinder 2 or 5 Deactivation Solenoid Valve Control Circuit High Voltage Test Status
   - Cylinder 2 or 5 Deactivation Solenoid Valve Control Circuit Open Test Status
   - Cylinder 2 or 5 Deactivation 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 the DTC does not set.
   - **If a DTC set**

     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 appropriate Q83 Valve Lifter Oil Solenoid Valve, ignition ON.

   NOTE: **If any of the scan tool circuit status parameters displayed "Malfunction" during the Circuit/System Verification, inspect the wiring harness for signs of chaffing or pinching before intake manifold removal.**

2. Verify that a test lamp illuminates between the ignition circuit terminal 1 and ground.
   - **If the test lamp does not illuminate and the fuse is good.**
   1. Ignition OFF.
   2. With fuse removed, test for less than 5 Ω between the ignition circuit terminals 1 and the fuse terminal.
      - If 5 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 5 Ω, verify there is voltage at the fuse and the fuse is good.
   - **If the test lamp does not illuminate and the fuse is open**
   1. Ignition OFF.
   2. Test for infinite resistance between the ignition circuit terminal 1 and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, test all the components connected to the ignition circuit and repair or replace as necessary.
   - **If the test lamp illuminates**

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3. Verify that a test lamp does not illuminate between the ignition circuit terminal 1 and the appropriate cylinder deactivation solenoid valve control circuit terminal listed below.
    - Cylinder 2 Deactivation Solenoid Valve terminal 2
    - Cylinder 5 Deactivation Solenoid Valve terminal 2
    - **If the test lamp illuminates**
    1. Ignition OFF, remove the test lamp, disconnect the X4 harness connector at the K20 Engine Control Module.
    2. Test for infinite resistance between the cylinder deactivation solenoid valve control circuit and ground.
        - If less than infinite resistance, repair the short to ground on the circuit.
        - If infinite resistance, replace the K20 Engine Control Module.
    - **If the test lamp does not illuminate**
4. Verify that a test lamp does not illuminate between ground and the cylinder deactivation solenoid valve control circuit terminal listed below.
    - Cylinder 2 Deactivation Solenoid Valve terminal 2
    - Cylinder 5 Deactivation Solenoid Valve terminal 2
    - **If the test lamp illuminates**
    1. Ignition OFF, remove the test lamp, disconnect the X4 harness connector at the K20 Engine Control Module, ignition ON.
    2. Test for less than 1 V between the cylinder deactivation solenoid valve control circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, replace the K20 Engine Control Module.
    - **If the test lamp does not illuminate**
5. Ignition OFF, remove the test lamp, disconnect the X4 harness connector at the K20 Engine Control Module.
6. Test the cylinder deactivation solenoid valve control circuit for less than 5 Ω end to end.
    - **If 5 Ω or greater**

      Repair the open/high resistance in the circuit.

    - **If less than 5 Ω**
7. Replace the Q83 Valve Lifter Oil Solenoid Valve.

Component Testing

Static Test

1. Ignition OFF, disconnect the harness connector at the appropriate Q83 Valve Lifter Oil Solenoid Valve.
2. Test for 11-30 Ω between cylinder deactivation oil solenoid valve terminals.
    - **If not between 11-30 Ω for each solenoid valve**

      Replace the Q83 Valve Lifter Oil Solenoid Valve.

    - **If between 11-30 Ω for each solenoid valve**
3. Test for infinite resistance between each valve lifter oil solenoid circuit terminal and the solenoid housing.
    - **If less than infinite resistance**

      Replace the Q83 Valve Lifter Oil Solenoid Valve.

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

Repair Instructions

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

- Refer to **Valve Rocker Arm Oil Control Valve Replacement (Bank 1)** **Valve Rocker Arm Oil Control Valve Replacement (Bank 2)** for Q83 Valve Lifter Oil Solenoid Valve replacement.
- **Engine Control Module Replacement (LGW)** **Engine Control Module Replacement (LGX)** for K20 Engine Control Module replacement, programming and setup.

PROACTIVE ALERT IDENTIFIER ECF001

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**

Proactive Alert Identifier Descriptor

Proactive Alert Identifier ECF001

G12 Fuel Pump - Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control	P0231	ECF002	P0232	ECF001
Low Reference	-	ECF002	-	ECF001

Mechanical Condition

Component	Proactive Alert Identifier	Condition
G12 Fuel Pump	ECF001	• Contaminated or poor quality fuel. • Contamination of the fuel pump fuel strainer. • Worn - G12 Fuel Pump

Circuit/System Description

Circuit	Description
Control	The output circuit is switched to 12 V to activate the component.
Low Reference	Fuel Pump Low Reference

Component	Description
G12 Fuel Pump	The fuel pump has a DC motor that is controlled by a PWM signal to achieve the desired fuel pressure.
K111 Fuel Pump Driver Control Module	The control module K111 monitors the fuel system for any condition which may adversely affect emissions. If a condition is detected it sets a DTC and sends a serial data message to the engine control module which then sets DTC P069E.

The control module K111 supplies the fuel pump with a PWM signal in order to achieve the desired fuel line pressure.

Conditions for Running the Proactive Alert Identifier

- Ignition=On
- Ignition Voltage =9 to 32 V

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DTCs run continuously when the above conditions are met for greater than 1 s.

Conditions for Setting the Proactive Alert Identifier

G12 Fuel Pump=Not within a calibrated range.

Actions Taken When the Proactive Alert Identifier Sets

Refer to **Proactive Alerts Description and Operation**

Conditions for Clearing the Proactive Alert Identifier

Not required

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) **Engine Controls Schematics (LGX)**

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

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

Circuit/System Verification

1. Remove the component:Fuel Tank Fuel Pump Module
2. Inspect for the following conditions:
    - Contaminated or poor quality fuel.
    - Contamination of the fuel pump fuel strainer.
    - Inspect the electrical connectors and the ground circuits of the component for poor connections.
    - If a condition exists Â» Repair or replace as necessary
    - If no condition exists
3. Replace the component:G12 Fuel Pump
4. Clear All Vehicle DTCs

Repair Instructions

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

Fuel Tank Fuel Pump Module Replacement - G12 Fuel Pump

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PROACTIVE ALERT IDENTIFIER ECF002

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis:**Strategy Based Diagnosis**

Proactive Alert Identifier Descriptor

Proactive Alert Identifier ECF002

G12 Fuel Pump - Circuit High Resistance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Control	P0231	ECF002	P0232	ECF001
Low Reference	-	ECF002	-	ECF001

Mechanical Condition

Component	Proactive Alert Identifier	Condition
G12 Fuel Pump	ECF001	• Contaminated or poor quality fuel. • Contamination of the fuel pump fuel strainer. • Worn - G12 Fuel Pump

Circuit/System Description

Circuit	Description
Control	The output circuit is switched to 12 V to activate the component.
Low Reference	Fuel Pump Low Reference

Component	Description
G12 Fuel Pump	The fuel pump has a DC motor that is controlled by a PWM signal to achieve the desired fuel pressure.
K111 Fuel Pump Driver Control Module	The control module K111 monitors the fuel system for any condition which may adversely affect emissions. If a condition is detected it sets a DTC and sends a serial data message to the engine control module which then sets DTC P069E.

The control module K111 supplies the fuel pump with a PWM signal in order to achieve the desired fuel line pressure.

Conditions for Running the Proactive Alert Identifier

- Ignition=On
- Ignition Voltage = 9 to 32 V

DTCs run continuously when the above conditions are met for greater than 1 s.

Conditions for Setting the Proactive Alert Identifier

Fuel Pump Control Circuit =Not within a calibrated range.

Actions Taken When the Proactive Alert Identifier Sets

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Refer to **Proactive Alerts Description and Operation**

Conditions for Clearing the Proactive Alert Identifier

Not required

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) **Engine Controls Schematics (LGX)**

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

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

Circuit/System Verification

NOTE: **It may take up to 2 min for all vehicle systems to power down before an accurate ground or low reference circuit continuity test can be performed.**

1. Ignition/Vehicle & All vehicle systemsÂ» Off
2. Disconnect the electrical connector:G12 Fuel Pump
3. Test for less than 5 Ω between the test points:Low Reference circuit terminal 2 & Ground
    - **If 5 Ω or greater**
    1. Disconnect the electrical connector:K111 Fuel Pump Driver Control Module
    2. Test for less than 2 Ω between the test points:Low Reference circuit terminal 2 @ Component harness & Terminal 16 @ Control module harness
        - If 2 Ω or greater Â» Repair the open/high resistance in the circuit.
        - If less than 2 Ω Â» Replace the component:K111 Fuel Pump Driver Control Module
    - **If less than 5 Ω**
4. Connect a test lamp between the test points:Control circuit terminal 1 & Low Reference circuit terminal 2
5. Ignition Â» On / Vehicle Â» In Service Mode
6. Perform the scan tool control function: Fuel Pump @ K20 Engine Control ModuleÂ»On and Off

   Verify the test lamp turns On and Off.

    - **If the test lamp is always Off**
    1. Ignition/VehicleÂ» Off & RemoveÂ» Test lamp

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2. Disconnect the electrical connector: K111 Fuel Pump Driver Control Module
3. Test for infinite resistance between the test points:Control circuit terminal 2 @ Component harness & Ground->
    - If less than infinite resistanceÂ» Repair the short to ground on the circuit.
    - If infinite resistance
4. Test for less than 2 Ω between the test points:Control circuit terminal 1 @ Component harness & Terminal 8 @ Control module harness
    - If 2 Ω or greaterÂ» Repair the open/high resistance in the circuit.
    - If less than 2 ΩÂ» Replace the component:K111 Fuel Pump Driver Control Module

- **If the test lamp is always On**

1. Ignition/Vehicle Â» Off & Remove Â» Test lamp
2. Disconnect the electrical connector:K111 Fuel Pump Driver Control Module
3. Ignition Â» On / Vehicle Â» In Service Mode
4. Test for less than 1 V between the test points:Control circuit terminal 1 @ Component harness & Ground
    - If 1 V or greaterÂ» Repair the short to voltage on the circuit.
    - If less than 1 VÂ» Replace the component: K111 Fuel Pump Driver Control Module

- **If the test lamp turns On and Off**

7. Test or replace the component:G12 Fuel Pump

Repair Instructions

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

- **Fuel Tank Fuel Pump Module Replacement** - G12 Fuel Pump
- **Fuel Pump Power Control Module Replacement** - K111 Fuel Pump Driver Control Module

PROACTIVE ALERT IDENTIFIER ECF003

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis:**Strategy Based Diagnosis**

Proactive Alert Identifier Descriptor

Proactive Alert Identifier ECF003

B47 Fuel Pressure Sensor or G12 Fuel Pump - Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5V Reference	P0641, P018C	ECF003, P018C	P0641, P018D	ECF003, P018B
Signal	P018C	ECF003, P018C	P018D	ECF003, P018B
Low Reference	-	ECF003, P018D	-	ECF003, P018B

Circuit/System Description

Circuit	Description
5V Reference	Regulated voltage supplied by the control module.
Signal	The control module input circuit has an internal resistance connected to ground.
Low Reference	Grounded through the control module.

Component	Description

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Component	Description
B47 Fuel Pressure Sensor	When the fuel pressure is low, the signal voltage is low. When the fuel pressure is high, the signal voltage is high.
K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.

The control module uses the fuel pressure sensor to constantly adjust the fuel pump's feed rate so that the ideal pressure is permanently maintained in the low pressure section (between the fuel pump and the high pressure fuel pump) by means of a closed loop control.

Conditions for Running the Proactive Alert Identifier

- Ignition=On
- Ignition Voltage =9 to 32 V

DTCs run continuously when the above conditions are met for greater than 1 s.

Conditions for Setting the Proactive Alert Identifier

B47 Fuel Pressure Sensor=Not within a calibrated range.

Actions Taken When the Proactive Alert Identifier Sets

Refer to:**Proactive Alerts Description and Operation**

Conditions for Clearing the Proactive Alert Identifier

Not required

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

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Component View Reference

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

Scan Tool Reference

Control Module References

Special Tools

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CH-48027 Digital Pressure Gauge

CH-37287-1A Fuel Pressure Gauge Adaptor

Equivalent regional tools: **Special Tools (Diagnostic Tools)** **Special Tools (Mechanical Tools)**

Circuit/System Verification

1. Ignition Off
2. Install the special tool: **CH-48027** Digital Pressure Gauge & **CH-37287-1A** Fuel Pressure Gauge Adaptor
3. Ignition On - Engine Off
4. Perform the scan tool control function:Fuel Pump Enable Command =On Command the function On several times.
5. Verify the scan tool parameter:Fuel Pressure Sensor =345 to 690 kPa (50 to 100 PSI)
   - If not between 345 and 690 kPa (50 and 100 PSI)

     Refer to **Fuel System Diagnosis**

   - If between 345 and 690 kPa (50 and 100 PSI)
6. Verify the following parameters are within 34 kPa (5 PSI) of each other:
   - Fuel Pressure Sensor
   - **CH-48027** Digital Pressure Gauge
   - If not within 34 kPa (5 PSI) of each other
   1. Inspect the fuel system for damage or external leaks before proceeding.
      - If a condition existsÂ» Repair or replace as necessary
      - If no condition exists
   2. Inspect the electrical connectors and the ground circuits of the component for poor connections.
      - If a condition existsÂ» Repair or replace as necessary
      - If no condition existsÂ» Replace the component: B47 Fuel Pressure Sensor
   - If within 34 kPa (5 PSI) of each other
7. All OK. - Clear All Vehicle DTCs

Repair Instructions

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

Fuel Pressure Sensor Replacement - Fuel Feed Pipe - B47 Fuel Pressure Sensor

PROACTIVE ALERT IDENTIFIER ECF004

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**

Proactive Alert Identifier Descriptor

Proactive Alert Identifier ECF004

B47 Fuel Pressure Sensor - Performance

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
5V Reference	P0641, P018C	ECF004, P018C	P0641, P018D	ECF004, P0418B

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Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Signal	P018C	ECF004, P018C	P018D	ECF004, P0418B
Low Reference	-	ECF004, P018D	-	ECF004, P0418B

Circuit/System Description

Circuit	Description
5V Reference	Regulated voltage supplied by the control module.
Signal	The control module input circuit has an internal resistance connected to ground.
Low Reference	Grounded through the control module.

Component	Description
B47 Fuel Pressure Sensor	When the fuel pressure is low, the signal voltage is low. When the fuel pressure is high, the signal voltage is high.
K20 Engine Control Module	The control module controls a series of actuators to ensure optimal engine performance. The control module does this by reading values from a variety of sensors, interprets the data and adjusts the engine actuators accordingly.

The control module uses the fuel pressure sensor to constantly adjust the fuel pump's feed rate so that the ideal pressure is permanently maintained in the low pressure section (between the fuel pump and the high pressure fuel pump) by means of a closed loop control.

Conditions for Running the Proactive Alert Identifier

- Ignition=On
- Ignition Voltage =9 to 32 V

DTCs run continuously when the above conditions are met for greater than 1 s.

Conditions for Setting the Proactive Alert Identifier

B47 Fuel Pressure Sensor=Not within a calibrated range.

Actions Taken When the Proactive Alert Identifier Sets

Refer to **Proactive Alerts Description and Operation**

Conditions for Clearing the Proactive Alert Identifier

Not required

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) **Engine Controls Schematics (LGX)**

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Description and Operation

Fuel System Description

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Electrical Information Reference

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

Scan Tool Reference

Control Module References

Special Tools

CH-48027 Digital Pressure Gauge

CH-37287-1A Fuel Pressure Gauge Adaptor

Equivalent regional tools: **Special Tools (Diagnostic Tools)** **Special Tools (Mechanical Tools)**

Circuit/System Verification

1. Ignition Off
2. Install the special tool: **CH-48027** Digital Pressure Gauge & **CH-37287-1A** Fuel Pressure Gauge Adaptor
3. Ignition On - Engine Running
4. Verify the following parameters are within 34 kPa (5 PSI) of each other:
    - Fuel Pressure Sensor
    - **CH-48027** Digital Pressure Gauge
    - If not within 34 kPa (5 PSI) of each other
    1. Inspect the fuel system for damage or external leaks before proceeding.
        - If a condition existsÂ» Repair or replace as necessary
        - If no condition exists
    2. Inspect the electrical connectors and the ground circuits of the component for poor connections.
        - If a condition exists Â» Repair or replace as necessary
        - If no condition exists Â» Replace the component:B47 Fuel Pressure Sensor
    - If within 34 kPa (5 PSI) of each other
5. All OK. - Clear All Vehicle DTCs

Repair Instructions

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

Fuel Pressure Sensor Replacement - Fuel Feed Pipe - B47 Fuel Pressure Sensor

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** provides 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.

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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:

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- Verify that 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, as shown on the Vehicle Emission Control Information label.
- Verify the air filter is clean and free from restrictions.
- Verify there is no water intrusion in connectors terminals and components.
- Inspect the air intake ducts for the conditions listed below:
  - Collapsed
  - Damaged areas
  - Looseness
  - Incorrect installation
  - Leaking
- If any condition listed above has allowed non-metered air to enter the air induction system, the **Throttle Body Idle Air Flow Compensation Reset** procedure must be performed after the repair is complete.
- Inspect for air leaks at the throttle body mounting area, the mass air flow (MAF) sensor and intake manifold sealing surfaces.
- Inspect the wiring harness for the following conditions:

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    - 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, 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/inspect the fuel system for any of the conditions listed below:
    - 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/inspect the ignition system for any of the conditions listed below:
    - Spark plugs with incorrect heat range or an abnormal condition - Refer to **Spark Plug Inspection** and **Ignition System Specifications** .
    - Coolant or oil fouled spark plugs - For diagnosis, refer to **Coolant in Combustion Chamber** or **Oil Consumption Diagnosis** .
    - Secondary ignition system susceptible to moisture. 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**.
- Test/inspect for any of the conditions listed below:
    - Non-metered air flow into the air induction system. If a leak is found, repair as necessary. The **Throttle Body Idle Air Flow Compensation Reset** procedure must be performed when the repair is complete.
    - An incorrectly operating 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** for vehicles equipped with M5N or M5U transmission.
    - Incorrectly operating A/C compressor.
    - An engine that runs lean or rich. Observe the Fuel Trim parameters with a scan tool.
    - Slow responding heated oxygen sensors (HO2S). The HO2S should respond quickly to different throttle positions.
    - Water intrusion in the HO2S connector

      CAUTION: **Refer to Heated Oxygen and Oxygen Sensor Caution .**

    - Incorrect mass air flow (MAF) sensor installation. A MAF sensor that is incorrectly installed may cause a hard start. Install the MAF in the proper direction. Refer to **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGW)** and/or **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGX)** .

      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 MAF sensor connections.
    - Engine oil contaminated by fuel
    - Split or kinked vacuum hoses - Verify that the routing and connections are as shown on the Vehicle Emission Control Information label.
    - Excessive knock sensor (KS) system spark retard activity - Observe the Knock Retard parameter on the scan tool for activity more than 0Â°.

- Electromagnetic interference (EMI) on the reference circuit, which can cause a misfire condition. You can usually detect EMI with a scan tool by monitoring the engine speed parameter. A sudden increase in the engine speed parameter with little change in actual engine speed indicates that EMI is present. Inspect the high voltage components near the ignition control circuit if a condition exists.
- An incorrectly operating crankcase ventilation valve - Refer to **Crankcase Ventilation System Inspection/Diagnosis** .
- A stuck open evaporative emission (EVAP) canister purge solenoid
- A crankshaft position sensor with an intermittent condition - Observe the scan tool Crankshaft Position Resync Counter parameter. The Resync Counter parameter should remain at 0 during all operating conditions and when moving the related harnesses and connectors between the crankshaft position sensor and the ECM.
- Test/inspect the exhaust system components for any of the conditions listed below:
  - Physical damage or possible internal failure
  - Restricted three-way catalytic converters

  For more information, refer to **Symptoms - Engine Exhaust** .
- Test/inspect the engine cooling system for any of the conditions listed below:
  - A thermostat with incorrect heat range. Refer to **Thermostat Diagnosis** .
  - Incorrect engine coolant level - If the level is low, refer to **Loss of Coolant** .
- Test/inspect the engine for any of the mechanical failures listed below:
  - Excessive oil in the combustion chamber or leaking valve seals
  - Oil Consumption
  - Incorrect cylinder compression
  - Sticking or leaking valves
  - Worn camshaft lobes
  - Incorrect valve timing
  - Worn rocker arms
  - Broken valve springs
  - Excessive carbon buildup in the combustion chambers - Clean the chambers with top engine cleaner, if necessary. Follow the instructions on the can.
  - Incorrect engine parts

  For additional information, refer to **Symptoms - Engine Mechanical** .
- If the above conditions do not address the symptom, refer to the additional symptoms tests.

Additional Symptoms Tests

Detonation/Spark Knock

- Test for an engine overheating condition. Refer to **Engine Overheating** .
- 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.
- 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

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Under certain conditions the ECM may limit engine power by reducing engine torque and, for some vehicles, fuel pressure as well. For most, but not all of the conditions, the ECM will illuminate the reduced engine power lamp on the instrument panel cluster, however a DTC may not be set.

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

Verify or inspect for the following:

- Vehicle being 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. Inspect the airflow passageways in front of the engine for obstructions and clear away any debris or foreign material that is found. If no obstructions are found, review approved driving habits with the customer. The customer may need to operate the vehicle at a higher engine speed to improve cooling system performance or, at a slower engine speed to reduce engine load.
- A cooling fan condition which may cause the ECM to reduce engine power. Refer to **Cooling Fan Description and Operation** and **Cooling System Description and Operation** to verify correct operation of the cooling fan.
- Temporary reduced engine power. Under extremely cold ambient temperatures some SIDI equipped vehicles may experience ECM commanded reduced engine power for a few minutes during engine warm-up. This would be a normal condition, noticeable only at wide open throttle and the reduced engine power lamp would not be illuminated.
- Turbocharger boost pressure out of range, if equipped. Refer to **DTC P0234, P0299 or P16E7** .
- Fuel temperature out of range too high.
- Incorrectly operating high pressure fuel system. Refer to **Fuel System Diagnosis** and **Fuel System Description** to verify correct high pressure fuel system pressure and operation.
- Maximum recommended engine oil life exceeded. Refer to the Owners manual for scheduled maintenance recommendations.
- Reduced engine power due to OnStarÂ® remote command. A repair may not be necessary. Verify the vehicle is not in the OnStarÂ® initiated Stolen Vehicle Slowdown mode. Refer to **OnStar Stolen Vehicle Slowdown Active** and **Remote Vehicle Speed Limiting Description and Operation** for additional information.
- Intake air temperature out of range too high. Engine running, compare the scan tool IAT Sensor 1, IAT Sensor 2 and ECT Sensor parameters. The readings should be between -38Â°C and +149Â°C (-36Â°F and +300Â°F). Refer to **DTC P0112, P0113 or P0114 (LGX)** and/or **DTC P0112, P0113 or P0114 (LGW)** for additional information.
- An incorrect learned brake pedal position (BPP) sensor. Verify the following actions have not occurred:
  - An engine control module has been replaced
  - A BPP sensor that has been replaced
  - A BPP sensor is misaligned or incorrectly installed

  If any of the above actions have occurred, the **Brake Pedal Position Sensor Learn** procedure must be performed.

Fuel Odor

- Inspect for leaking, damaged or deteriorated fuel lines and components.
- Inspect for a saturated EVAP canister - Refer to **Evaporative Emission Control System Description** .
- Inspect for a condition with the internal components of the fuel tank assembly - Refer to **Fuel System Description** .

Hard Start

- Observe the 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 Inspection and Cleaning** .

- Test the engine coolant temperature (ECT) sensor. Compare the ECT sensor value to the intake air temperature (IAT) sensor value on a cold engine. The ECT and IAT sensor values should be within Â± 3Â°C (5Â°F). If the ECT sensor is out of range with the IAT sensor, test the resistance of the ECT sensor. Refer to **Temperature Versus Resistance - 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.
- Verify that the fuel system has adequate pressure for engine start-up. Refer to **Fuel System Diagnosis** for fuel pressure specifications.
- Inspect for a condition with the internal components of the fuel tank assembly - Refer to **Fuel System Description** .
- 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** .

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 (LGW)** and/or **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGX)** .
- Test the generator. Refer to **Symptoms - Engine Electrical** . Repair the charging system if the generator output voltage is less than 9 volts or more than 16 volts.
- 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** .
- Test the manifold absolute pressure (MAP) sensor. Refer to **DTC P0106** .
- Engine warm and idling, verify the correct operation of the camshaft position actuator system. Command the intake and exhaust camshaft position actuator for each cylinder bank from 0 degrees to 20 degrees and back to zero while observing the appropriate 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.

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

- 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 Timing Drive Components Cleaning and Inspection** and **Camshaft Actuator System Description** for additional information.

Lack of Power, Sluggishness or Sponginess (LGX)

- Inspect the engine electrical system for correct operation. Refer to **Symptoms - Engine Electrical** .
- Verify that each injector harness is connected to the correct injector.
- Inspect the mass air flow (MAF) sensor for obstruction, contamination and damage. Refer to **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGW)** and/or **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGX)** .
- Engine warm and idling, verify the correct operation of the camshaft position actuator system. Command the intake and exhaust camshaft position actuator for each cylinder bank from 0 degrees to 20 degrees and back to zero while observing the appropriate 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.

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

- 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 Timing Drive Components Cleaning and Inspection** and **Camshaft Actuator System Description** for additional information.

Lack of Power, Sluggishness or Sponginess (LF3)

- Inspect the engine electrical system for correct operation. Refer to **Symptoms - Engine Electrical** .
- Verify that each injector harness is connected to the correct injector.
- Inspect the mass air flow (MAF) sensor for obstruction, contamination and damage. Refer to **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGW)** and/or **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGX)** .
- Engine warm and idling, verify the correct operation of the camshaft position actuator system. Command the intake and exhaust camshaft position actuator for each cylinder bank from 0 degrees to 20 degrees and back to zero while observing the appropriate 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.

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

  - 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 Timing Drive Components Cleaning and Inspection** and **Camshaft Actuator System Description** for additional information.
- Verify the correct operation of the turbocharger system. Perform the following.
  - Inspect the turbocharger moving components for looseness, binding, wear and damage.
  - 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 Oil Leak From Compressor Seal** and **Turbocharger Oil Leak From Turbine Seal** .
  - 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.
  - Engine running, command the scan tool Turbocharger Bypass Solenoid Bank 1 and Bank 2 between Active and Inactive. Verify that a click from the solenoids can be heard or felt. If a click is not heard or felt, refer to **DTC P0033-P0035 or P00C0-P00C2**
  - Inspect for excessive turbocharger system noise. Refer to **Turbocharger Whine Noise** and **Turbocharger Hissing Noise** .
  - Verify that the turbocharger pressure is correct. Refer to **DTC P0234, P0299 or P16E7** .
  - 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 the brake system for brake drag.
- Inspect for incorrect operation of the speedometer.
- 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.

- Inspect the mass air flow (MAF) sensor for obstruction, contamination and damage. Refer to **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGW)** and/or **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGX)** .
- 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 Inspection and Cleaning** .

Rough, Unstable or Incorrect Idle and Stalling

- An excessively high idle may be due to the floor mat interfering with the accelerator pedal. With this condition present, it may not be possible to shift the transmission into gear. Inspect the accelerator pedal for binding and verify that the floor mat is not interfering with the accelerator pedal movement.
- Engine idle speed may be unstable or the engine may stall if the ECM has learned an incorrect idle/airflow compensation value. A DTC may also set. Observe the scan tool Throttle Body Idle Airflow Compensation parameter. A value greater than 90% may indicate an excessive accumulation of deposits in the throttle bore. If the throttle body needs cleaning, refer to **Throttle Body Inspection and Cleaning** .

  The actions listed below may also cause the ECM to learn an incorrect idle value.

  - The engine control module has been replaced
  - The throttle body has been replaced
  - The throttle body has been cleaned but the idle learn procedure was not performed after completing the cleaning
  - The air induction system was leaking, allowing non-metered air to enter the combustion chamber. The leak was repaired but the idle learn procedure was not performed after repairing the leak

    If any of the actions listed above have occurred, the **Throttle Body Idle Air Flow Compensation Reset** procedure must be performed.

- Inspect the mass air flow (MAF) sensor for obstruction, contamination and damage. Refer to **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGW)** **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGX)** .
- Inspect the engine mounts. Refer to **Engine Mount Inspection** .
- Inspect the intake and exhaust manifolds for casting flash.
- Inspect all bank 1 exhaust camshaft position sensor wiring for poor connections. Start the engine and observe for engine stalling while wiggling the bank 1 exhaust camshaft position sensor wiring harness. Refer to **Inducing Intermittent Fault Conditions** for further diagnosis.

NOTE: **The ECM uses the bank 1 exhaust camshaft position sensor to determine camshaft to crankshaft relationship in order to control fuel injector and ignition system synchronization. If the bank 1 exhaust camshaft position sensor signal to the ECM is intermittent, a stalling condition will occur and a DTC will not set.**

Surges/Chuggles

- Inspect the mass air flow (MAF) sensor for obstruction, contamination and damage. Refer to **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGW)** and/or **Mass Airflow Sensor with Intake Air Temperature Sensor Replacement (LGX)** .
- 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.
- Verify that each injector harness is connected to the correct injector.

CHARGE AIR COOLER COOLANT PUMP 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.

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Ignition	3	1	-	-
Ignition Signal	3	1	-	-
Ground	-	1	-	-
Control	1	2	P023C[2]	-

1. Charge Air Cooler Coolant Pump inoperative
2. Charge Air Cooler Coolant Pump always ON
3. Opens fuse

Circuit/System Description

The charge air coolant pump assembly is composed of an electric coolant pump and a control module. The engine control module (ECM) controls the pump using a control circuit and solid-state switch called a output driver. The ECM enables the charge air cooler coolant pump by commanding the driver Off. The charge air cooler coolant pump control module then commands the coolant pump On.

Reference Information

Schematic Reference

Engine Heating/Cooling 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**
- **Electrical Center Identification Views** **Electrical Center Identification Views**

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition On.
2. Command the M10 Charge Air Cooler Coolant Pump On and Off with a scan tool.
3. Verify the scan tool parameters listed below display OK or Not Run in each commanded state.

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- Charge Air Cooler Coolant Pump Relay Control Circuit Open Test Status
- Charge Air Cooler Coolant Pump Relay Control Circuit Low Voltage Test Status
- Charge Air Cooler Coolant Pump Relay Control Circuit High Voltage Test Status
- **If Malfunction**

  Refer to Circuit/System Testing

- **If OK or Not Run**

4. Command the M10 Charge Air Cooler Coolant Pump On and Off with a scan tool.
5. Verify the pump activates when commanded On and deactivates when commanded Off.
   - **The Charge Air Cooler Coolant Pump does not activate or deactivate**

     Refer to Circuit/System Testing

   - **The Charge Air Cooler Coolant Pump activates and deactivates**
6. All OK

Circuit/System Testing

1. Ignition Off, disconnect the harness connector at the M10 Charge Air Cooler Coolant Pump.
2. Test for less than 5 Ω between the ground circuit terminal 4 and ground.
   - **If 5 Ω or greater**
   1. Disconnect the chassis ground G104.
   2. Test for less than 2 Ω in the ground circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, repair the open/high resistance in the ground connection.
   - **If less than 5 Ω**
3. Ignition On, verify that a test lamp illuminates between the ignition circuit terminals listed below and ground:
   - Charge Air Cooler Coolant Pump circuit terminal 5
   - Charge Air Cooler Coolant Pump circuit terminal 1
   - **If the test lamp does not illuminate and the circuit fuse is good**
   1. Ignition Off, remove the test lamp and remove the fuse for the ignition voltage circuit.
   2. Test for less than 2 Ω in the ignition voltage circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.
   - **If the test lamp does not illuminate and the circuit fuse is open**
   1. Ignition Off, remove the test lamp and remove the fuse for the ignition voltage circuit.
   2. Disconnect all the components supplied by the fuse.
   3. Test for infinite resistance between the ignition voltage circuit and ground.
      - If less than infinite resistance, repair the short to ground on the circuit.
      - If infinite resistance, test all the components connected to the circuit and repair or replace as necessary.
   - **If the test lamp illuminates**
4. Perform the scan tool control function:Charge Air Cooler Coolant Pump Â»On

   Verify a test lamp does not turn On between the test points: B+ Control circuit terminal 3

   - **If the test lamp illuminates**
   1. Ignition Off and all vehicle systems OFF, it may take up to 2 minutes for all vehicle systems to power down.
   2. Disconnect the harness connector X3 at the K20 Engine Control Module.
   3. Test for infinite resistance between the control circuit terminal 3 and ground.

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- If less than infinite resistance, repair the short to ground in the circuit.
- If infinite resistance, replace the K20 Engine Control Module.

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

5. Command the M10 Charge Air Cooler Coolant Pump Off with a scan tool.
6. Verify the test lamp illuminates.
    - **If the test lamp does not illuminate**
    1. Ignition Off, remove the test lamp.
    2. Disconnect the harness connector X3 at the K20 Engine Control Module, ignition On.
    3. Test for less than 1 V between the control circuit terminal 3 and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V.
    4. Ignition Off.
    5. Test for less than 2 Ω in the control circuit, end to end.
        - If 2 Ω or greater, repair the open in the circuit.
        - If less than 2 Ω, replace the K20 Engine Control Module.
    - **If the test lamp illuminates**
7. Replace the M10 Charge Air Cooler Coolant Pump.

Repair Instructions

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

- **Charge Air Cooler Coolant Pump Replacement (LGW)**
- **Control Module References** for ECM replacement, programming and setup.

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

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Problem	Causes
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

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 powertrain control system requires service. Ignition voltage is supplied directly to the MIL. The engine control module (ECM) turns the MIL ON by grounding the MIL control circuit when the emission system fault occurs. Under normal operating conditions, the MIL should be ON only when the ignition is ON and the engine is OFF.

Diagnostic Aids

If the condition is intermittent, move the related harnesses and connectors while monitoring the scan tool MIL control circuit status parameters. Perform this test with the ignition ON and the engine OFF and with the engine running. The MIL control circuit status parameters change from OK or Not Run to Malfunction if there is a condition with a circuit or a connection.

Reference Information

Schematic Reference

- **Engine Controls Schematics (LGW)** **Engine Controls Schematics (LGX)**
- **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

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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 MIL On and Off with a scan tool.
    - MIL Control Circuit Low Voltage Test Status
    - MIL Control Circuit Open Test Status
    - 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 MIL On and Off with a scan tool.
    - MIL Control Circuit Low Voltage Test Status
    - MIL Control Circuit Open Test Status
    - 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 MIL On and Off with a scan tool.
    - **If the MIL does not turn ON and OFF**

      Refer to Circuit/System Testing

    - **If the MIL 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 MIL does not illuminate.
    - **If the MIL illuminates**
    1. Test for infinite resistance between the control circuit terminal 16 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 MIL does not illuminate**
4. Connect a 3A fused jumper wire between the control circuit terminal 16 and ground.
5. Verify the MIL illuminates.
    - **If the MIL illuminates**

      Replace the K20 Engine Control Module.

    - **If the MIL does not illuminate**
    1. Test for less than 1 V between the control circuit terminal 16 and ground.
        - If 1 V or greater, repair the short to voltage in the circuit.
        - If less than 1 V
    2. Ignition OFF.
    3. Test for less than 2 Ω in the control circuit end to end.

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- If 2 Ω or greater, repair the open/high resistance in the circuit.
- If less than 2 Ω.

6. Ignition OFF, disconnect the X1 harness connector at the instrument cluster.
7. Ignition ON, verify a test lamp illuminates between the ignition voltage circuit terminal 8 and ground.
    - **If the test lamp does not illuminate and the circuit fuse is open**
    1. Ignition OFF.
    2. Test for infinite resistance between the ignition voltage circuit and ground.
        - If less than infinite resistance, repair the short to ground in the circuit.
    - **If the test lamp does not illuminate and the circuit fuse is good**
    1. Ignition OFF.
    2. Test for less than 2 Ω in the ignition voltage circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
    - **If the test lamp illuminates**
8. Replace the P16 Instrument Cluster.

Repair Instructions

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

- **Instrument Cluster Replacement**
- **Control Module References** for control module replacement, programming and setup

ENGINE CRANKS BUT DOES NOT RUN

Diagnostic Instructions

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

Circuit/System Description

This Engine Cranks but Does Not Run diagnostic procedure is an organized approach to identify a condition which causes the engine to crank but not start. This diagnostic procedure directs the technician to the appropriate system diagnosis.

Diagnostic Aids

Inspect for any of the conditions listed below:

- If equipped with a key type ignition system, a partially retracted or folded over ignition key. 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.
- A crankshaft position sensor condition. When this condition is present, the engine control module (ECM) uses the camshaft position sensors to determine engine speed and position. If the condition exists in the signal circuit of the sensor, the engine will go into a limp home mode after a hard restart. The ECM then calculates engine speed from one of the camshaft position sensors. However, the engine will operate with a crankshaft position sensor condition only if the ECM has stored the learned reference position of the camshafts in memory.
- An in-tank fuel pump condition. The chassis control module controls and monitors the operation of the in-tank fuel pump. If the chassis control module detects a fault, a DTC sets in the chassis control module. The chassis control module will then send a serial data message to the engine control module (ECM) requesting the illumination of the malfunction indicator lamp (MIL).

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- The fuel injectors are calibrated to begin operating when the fuel rail pressure reaches 2 MPa (290 psi) at 20-32Â°C (68-90Â°F). This specification will vary when the temperature is outside of this range.
- Insufficient fuel. 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. Refer to **Fuel Injector Solenoid Coil Test** for diagnosis.
- Fuel injector ON time inadequate. When this condition is present, 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 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.
- Loose unsecured engine electrical grounds. Inspect the engine for good secure electrical grounds.
- Water or foreign material in the fuel, which can cause either a no start or a engine will not stay running condition. During freezing weather water can freeze inside the fuel system. The engine may start after 30 min in a heated repair shop. The malfunction may not recur until parked overnight in freezing temperatures. Extreme weather conditions can cause contaminated fuel to prevent the vehicle from starting.
- An ignition system that is susceptible to moisture. An engine that starts and runs after being brought into a warm, dry repair shop, may be susceptible to moisture. Spray water on the ignition system components and wiring while cranking the engine in order to check for an engine starting or will not stay running concern.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) **Engine Controls Schematics (LGX)**

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

- **Electronic Ignition System Description**
- **Fuel System Description**
- **Immobilizer Description and Operation**

Electrical Information Reference

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

Scan Tool Reference

Control Module References for scan tool information

Special Tools

J 26792 HEI Spark Tester

Circuit/System Verification

NOTE: **This diagnostic assumes the following:**

- **The battery is completely charged.**

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- **There is adequate fuel in the fuel tank.**

1. Crank the engine for up to 15 s.
2. Verify DTC P0116, P0118, P0119, P0191, P0192, P0193, P0201-P0206, P0232, P023F, P025A, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0335, P0336, P0351-P0356, P0601, P0602, P0603, P0604, P0606, P06A6, P062B, P062F, P069E, P0627, P0628, P0629, P0630, P0641, P064A, P1255, P1631, P16F3, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F, P2534, P262B, P2635 or U0109 is not set.
   - **If any of the DTCs are set**

     Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** .
   - **If none of the DTCs are set**
3. Ignition ON.
4. Verify the Security Indicator on the instrument cluster illuminates momentarily.
   - **If the security indicator stays ON or is flashing**

     Review the scan tool DTC information for Immobilizer system DTCs--Refer to **Diagnostic Trouble Code (DTC) List - Vehicle** . For additional information, refer to **Immobilizer Description and Operation** .
   - **If the security indicator does not stay ON and is not flashing**
5. Verify the scan tool Engine Speed parameter displays greater than 0 RPM while cranking the engine.
   - **If 0 RPM**

     Refer to **DTC P0335 or P0336** .
   - **If greater than 0 RPM**
6. Verify the scan tool Mass Airflow Sensor parameter displays greater than 0 HZ while cranking the engine.

   NOTE: **A condition with the MAF sensor or MAF sensor circuits may cause an Engine Cranks But Does Not Run condition without setting a DTC.**
   - **If 0 Hz**

     Refer to **DTC P0101 (LGX)** **DTC P0101 (LGW)** and **DTC P0102 or P0103 (LGX)** **DTC P0102 or P0103 (LGW)** .
   - **If greater than 0 Hz**
7. Ignition ON.
8. Verify the scan tool BARO parameter is within the value specified in the **Altitude Versus Barometric Pressure** table.
   - **If not within the specified value**

     Refer to **DTC P2227-P2230 (LGW)** **DTC P2227-P2230 (LGX)**.
   - **If within the specified value**
9. Install the **J 26792** HEI Spark Tester between the boot of a spark plug wire and ground.
10. Verify the spark tester sparks while cranking the engine.

    NOTE:
    - **Perform this test on at least one cylinder of each cylinder bank.**
    - **An erratic or weak spark is considered a no spark condition.**

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- **If the spark tester does not spark**

  Refer to **Electronic Ignition System Diagnosis**.

- **If the spark tester sparks**

11. Ignition ON, command the Fuel Pump Enable ON several times with a scan tool.

NOTE:

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

12. Verify the Chassis Control Module Fuel Pressure Sensor parameter is between 345-690 kPa (50-100 psi) with the fuel pump running.
    - **If not within the specified value**

      Refer to **Fuel System Diagnosis**.

    - **If within the specified value**
13. Verify the Chassis Control Module Fuel Pressure Sensor parameter, after the fuel pump turns OFF, decreases to 500-599 kPa (72-87 psi) and does not decrease more than 34 kPa (5 psi) in 1 minute.

NOTE: **The fuel pressure may vary slightly when the fuel pump stops operating. After the fuel pump stops operating, the fuel pressure should stabilize and remain constant.**

    - **If not within the specified value**

      Refer to **Fuel System Diagnosis**.

    - **If within the specified value**
14. Verify the Fuel Rail Pressure Sensor parameter is between 1.9-2.1 MPa (279-305 psi) while cranking the engine.
    - **If not within the specified range**

      Perform the Circuit/System Testing section of the **Fuel Injector Circuit Diagnosis**.

    - **If within the specified range**
15. Verify none of the conditions listed below exist:
    - Collapsed air intake duct to throttle body
    - Restricted air filter element
    - A skewed engine coolant temperature (ECT) sensor-Refer to **Temperature Versus Resistance - Engine Coolant Temperature Sensor** .
    - Spark plugs gas or coolant fouled-Refer to **Spark Plug Inspection** and **Coolant in Combustion Chamber** .
    - Exhaust system restricted-Refer to **Restricted Exhaust** .
    - Fuel contaminated-Refer to **Alcohol/Contaminants-in-Fuel Diagnosis**.
    - Engine mechanical condition, for example, worn timing chain and gears or low compression-Refer to **Symptoms - Engine Mechanical** .
        - **If a condition exists**

          Repair as necessary

    - **If no conditions exist**

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16. All OK.

Repair Instructions

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

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 driver control module when the ECM detects that the ignition is ON. The voltage from the ECM to the fuel pump driver control module remains active for 2 s, unless the engine is in Crank or Run. While this voltage is being received, the fuel pump driver control module closes the ground switch of the fuel pump and also supplies a varying voltage to the fuel tank fuel pump module in order to maintain the desired fuel rail pressure.

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

The fuel tank stores the fuel supply. An electric turbine style fuel pump attaches to the fuel tank fuel pump module inside the fuel tank. The fuel pump supplies fuel through the fuel feed pipe to the high pressure fuel pump. The fuel pump also supplies fuel to a venturi pump located on the bottom of the fuel tank fuel pump module. The function of the venturi pump is to fill the fuel tank fuel pump module reservoir. The fuel tank fuel pump module contains a reverse flow check valve. The check valve maintains fuel pressure in the fuel feed pipe in order to prevent long cranking times.

Diagnostic Aids

Observe the Misfire Counters or perform the Fuel Injector Balance Test to help identify a leaking fuel injector. Refer to **Fuel Injector Balance Test**.

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

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NOTE:

- **Repair all fuel system related DTCs before performing this diagnostic.**
- **Inspect the fuel system for damage or external leaks before proceeding.**
- **Verify that adequate fuel is in the fuel tank before proceeding.**
- **The Fuel Pump Enable may need to be commanded On a few times in order to obtain the highest possible fuel pressure.**
- **DO NOT perform the Fuel System Diagnosis if the engine coolant temperature is above 60Â°C (150Â°F). High fuel pressure readings may result due to hot soak fuel boiling. With the engine OFF, the fuel pressure may increase beyond the pressure relief regulator valve's setting point of 690 kPa (100 PSI) Â± 5 percent.**

1. Ignition ON, engine OFF, command the Fuel Pump Enable On several times with a scan tool.
2. Verify the Fuel Pressure Sensor parameter is between 345-690 kPa (50-100 PSI) with the fuel pump running.
   - **If less than 345 kPa (50 PSI)**

     Refer to Circuit/System Testing - Fuel Pressure Low.

   - **If greater than 690 kPa (100 PSI)**

     Replace the G12 Fuel Pump.

   - **If between 345-690 kPa (50-100 PSI)**
3. Verify that the Fuel Pressure Sensor parameter decreases to 500-599 kPa (72-87 PSI) after the fuel pump is turned off.

   NOTE: **The fuel pressure may vary slightly when the fuel pump stops operating. After the fuel pump stops operating, the fuel pressure should stabilize and remain constant.**

   - **If the fuel pressure does not decrease to 500-599 kPa (72-87 PSI)**

     Replace the G12 Fuel Pump.

   - **If the fuel pressure decreases to 500-599 kPa (72-87 PSI)**
4. Verify the Fuel Pressure Sensor parameter does not decrease greater than 34 kPa (5 PSI) in 1 min.
   - **If the fuel pressure decreases greater than 34 kPa (5 PSI)**

     Refer to Circuit/System Testing - Fuel Pressure Leaks Down.

   - **If the fuel pressure does not decrease greater than 34 kPa (5 PSI)**
5. Engine idling.
6. Verify that 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.

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.

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- **If less than 1.5**

8. 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.

WARNING: **Road test a vehicle under safe conditions and while obeying all traffic laws. Do not attempt any maneuvers that could jeopardize vehicle control. Failure to adhere to these precautions could lead to serious personal injury and vehicle damage.**

- **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**.

Circuit/System Testing

Fuel Pressure Low

1. Verify none of the conditions listed below exist:
   - Restricted fuel feed pipe
   - Restricted or plugged strainer
   - Inspect the harness connectors and the ground circuits of the fuel pump for poor connections.
   - **If a condition exist**

     Repair as necessary.

   - **If a condition does not exist**
2. Test or replace the G12 Fuel Pump.

Fuel Pressure Leaks Down

1. Ignition OFF, relieve the fuel pressure. Refer to **Fuel Pressure Relief** .
2. Install the **EN-37287** Fuel Line Shut-Off Adapters between the fuel feed pipe and the fuel rail.
3. Open the valve on the **EN-37287** Fuel Line Shut-Off Adapters.
4. Ignition ON, command the Fuel Pump Enable On with a scan tool.
5. Close the valve on the **EN-37287** Fuel Line Shut-Off Adapters.
6. Verify the Fuel Pressure parameter does not decrease greater than 34 kPa (5 PSI) in 1 min.
   - **If the fuel pressure drops**

     Replace the G12 Fuel Pump.

   - **If the fuel pressure does not drop**
7. Locate and replace the leaking Q17 Fuel Injector.

Fuel Pressure Drops OFF

1. Verify none of the conditions listed below exist:
   - Restricted fuel feed pipe
   - Restricted or plugged strainer
   - Inspect the harness connectors and the ground circuits of the fuel pump for poor connections.
   - **If a condition exist**

     Repair as necessary.

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- **If a condition does not exist**

2. Test or replace the G12 Fuel Pump.

Repair Instructions

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

- **Fuel Feed Pipe Replacement (LGW)** **Fuel Feed Pipe Replacement (LGX)**
- **Fuel Injector Replacement**
- **Fuel Tank Fuel Pump Module Replacement** for G12 Fuel Pump replacement

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 fuel 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 a fuel injector, allowing for initial injector opening. The fuel 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 (LGW) **Engine Controls Schematics (LGX)**

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**

Component Testing

NOTE:

- **The resistance test must be performed at the fuel injector or mis-diagnosis will occur.**
- **The DMM and test leads must be calibrated to 0 Ω in order to prevent mis-diagnosis.**

1. Ignition OFF, all vehicle system OFF, Disconnect the harness connector at the appropriate Q17 Fuel Injector. It may take up to 2 m for all vehicle systems to power down.
2. Test for 1-3 Ω at 18-23Â°C (65-75Â°F) between the high voltage supply circuit terminal 2 and the high voltage control circuit terminal 1 at the Q17 fuel injector.

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- **If not within the specified range**

  Replace the Q17 Fuel Injector.

- **If within the specified range**

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**.

Repair Instructions

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

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 scan tool fuel injector balance test is performed while the engine is running at idle. The scan tool pressurizes the fuel rail to a predetermined pressure before each fuel injector is pulsed for a precise amount of time allowing a measured amount of the fuel to be injected. This causes a drop in the system fuel pressure that is recorded and used to compare each fuel injector.

Diagnostic Aids

- Monitoring the Current Misfire Counters may help to isolate the fuel injector that is causing the condition.
- Operating the vehicle over a wide temperature range may help isolate the fuel injector that is causing the condition.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) **Engine Controls Schematics (LGX)**

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

1. Ignition ON.

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2. Verify the scan tool Remaining Fuel In Tank parameter is greater than 10%.
    - **If the Fuel Remaining parameter is less than 10%** , add fuel to the fuel tank.
    - **If the Fuel Remaining parameter is 10% or greater**
3. Verify the battery is fully charged and all accessories are Off.
    - **If the battery is not fully charged** , charge or repair battery as necessary.
    - **If the battery is fully charged**
4. Preform the appropriate Fuel Injector Balance Test in Circuit System Testing.

Circuit System Testing

Fuel Injector Balance Test with Active Fuel Injector Tester

1. Ignition OFF, all vehicle systems OFF. Install the **CH-47976** Active Fuel Injector Tester and the CH-47976-500 Active Fuel Injection Tester (AFIT) SIDI Adapter Kit, refer to the Active Fuel Injector Tester User Guide. It may take up to 2 minutes for all vehicle systems to power down.
2. Turn ON the Active Fuel Injector Tester and select the vehicle.
3. Ignition ON, perform the Injector Test with the Active Fuel Injector Tester.
    - **If the Active Fuel Injector Tester aborts testing due to fuel pressure or fuel leak down**

      Refer to **Fuel System Diagnosis**
    - **If the Active Fuel Injector Tester does not abort testing**
4. Compare the test results with the appropriate recommended tolerance.
    - **If any fuel injector exceeds the recommended tolerance**

      Replace the appropriate Q17 Fuel Injector(s).
    - **If all fuel injectors are within the recommended tolerance**
5. Perform **Fuel Injector Circuit Diagnosis**

Fuel Injector Balance Test with Scan Tool

1. Ignition ON.
2. Command the Fuel Pump Enable ON with a scan tool.
3. Verify the Fuel Pressure Sensor parameter is between 345-690 kPa (50-100 PSI) with the fuel pump running.
    - **If not within 345-690 kPa (50-100 PSI)**

      Refer to **Fuel System Diagnosis**.
    - **If within 345-690 kPa (50-100 PSI)**
4. Verify the Fuel Pressure Sensor parameter does not decrease greater than 34 kPa (5 PSI) within 1 minute.

    NOTE: **The fuel pressure may vary slightly when the fuel pump stops operating. After the fuel pump stops operating, the fuel pressure should stabilize and remain constant.**

    - **If greater than the specified value**

      Refer to **Fuel System Diagnosis**.
    - **If less than the specified value**
5. Engine idling.
6. Verify the scan tool Fuel Rail Pressure Sensor parameter is between 1.9-5.0 MPa (276-725 PSI).
    - **If not between 1.9-5.0 MPa (276-725 PSI)**

      Refer to **Fuel System Diagnosis**.

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- **If between 1.9-5.0 MPa (276-725 PSI)**

7. Select the scan tool Fuel Injector Balance function.

NOTE: **The engine speed must be between 600-1, 000 RPM to perform this test.**

8. Test a Q17 Fuel Injector.
9. Record a fuel pressure drop value for each Q17 Fuel Injector.
10. Add all of the individual pressure drop values except for the fuel injector suspected of being faulty. This is the total pressure drop.
11. Divide the total pressure drop by the number of fuel injectors that were added together. This is the average pressure drop.
12. Multiply the average pressure drop by 0.20. This is the acceptable variance from the average pressure drop, 20%).
13. Verify the difference between any individual pressure drop and the average pressure drop is not greater than the acceptable variance.
    - **If greater than the acceptable variance**

      Replace the Q17 Fuel Injector.

    - **If within the acceptable variance**
14. Perform **Fuel Injector Circuit Diagnosis**.

Repair Instructions

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

Fuel Injector Replacement

FUEL INJECTOR CIRCUIT DIAGNOSIS

Diagnostic Instructions

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

Diagnostic Fault Information

Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Fuel Injector 1 Control +	P2147	P0201	P2148	P1248
Fuel Injector 1 Control -	P0261	P0201	P0262	P1248
Fuel Injector 2 Control +	P2150	P0202	P2151	P1249
Fuel Injector 2 Control -	P0264	P0202	P0265	P1249
Fuel Injector 3 Control +	P2153	P0203	P2154	P124A
Fuel Injector 3 Control -	P0267	P0203	P0268	P124A
Fuel Injector 4 Control +	P2156	P0204	P2157	P124B
Fuel Injector 4 Control -	P0270	P0204	P0271	P124B
Fuel Injector 5 Control +	P216B	P0205	P216C	P124C

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Circuit	Short to Ground	Open/High Resistance	Short to Voltage	Signal Performance
Fuel Injector 5 Control -	P0273	P0205	P0274	P124C
Fuel Injector 6 Control +	P216E	P0206	P216F	P124D
Fuel Injector 6 Control -	P0276	P0206	P0277	P124D

Circuit/System Description

The engine control module (ECM) supplies voltage to each fuel injector on the injector high voltage supply circuits. The ECM energizes each fuel injector by grounding the high voltage control circuit of the fuel injector. The ECM monitors the status of the injector high voltage supply circuits and the injector high voltage control circuits. When a fuel injector circuit condition is detected by the ECM, the affected fuel injector(s) is disabled.

Diagnostic Aids

- Performing the fuel injector coil test may help isolate an intermittent condition. Refer to **Fuel Injector 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 (LGW) **Engine Controls Schematics (LGX)**

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Fuel System Description

Scan Tool Reference

Control Module References for scan tool information

Circuit/System Verification

NOTE: **Do Not perform this procedure unless directed here from the Fuel Injector Balance Test.**

1. Engine idling.
2. Verify the scan tool Cylinder 1-6 Current Misfire Counter parameters do not increment.
   - **If the Cylinder 1-6 Current Misfire Counters increment**

     Refer to Circuit/System Testing.

   - **If the Cylinder 1-6 Current Misfire Counters do not increment**
3. Verify the scan tool Cylinder 1-6 Injector Control Circuit Status parameters display OK.
   - **If the Cylinder 1-6 Injector Control Circuit Status parameters do not display OK**

     Refer to Circuit/System Testing.

   - **If the Cylinder 1-6 Injector Control Circuit Status parameters display OK**

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4. All OK.

Circuit/System Testing

1. Ignition OFF, all vehicle systems OFF. Disconnect the X3 harness connector at the K20 Engine Control Module. It may take up to 2 min for all vehicle systems to power down.
2. Test for infinite resistance between the appropriate Q17 Fuel Injector control + circuit and ground.
    - **If less than infinite resistance**
    1. Disconnect the harness connector of the Q17 Fuel Injector.
    2. Test for infinite resistance between the Q17 Fuel Injector control + circuit and ground.
        - If infinite resistance
    3. Test for infinite resistance between the Q17 Fuel Injector control - circuit and ground.
        - If less than infinite, repair the short to ground in the circuit.
        - If infinite, replace the Q17 Fuel Injector.
    - **If infinite resistance**
3. Ignition ON.
4. Test for less than 1 V between the Q17 Fuel Injector control + circuit and ground.
    - **If 1 V or greater**
    1. Disconnect the harness connector of the Q17 Fuel Injector, ignition ON.
    2. Test for less than 1 V between the Q17 Fuel Injector control + circuit and ground.
        - If 1 V or greater, repair the short to voltage on the circuit.
        - If less than 1 V, repair the short to voltage on the control - circuit.
    - **If less than 1 V**
5. Ignition OFF.
6. Test for less than 3 Ω between the Q17 Fuel Injector control + circuit and control - circuit.
    - **If 3 Ω or greater**
    1. Disconnect the harness connector of the Q17 Fuel Injector.
    2. Test for less than 2 Ω on the control + circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω
    3. Test for less than 2 Ω on the control - circuit end to end.
        - If 2 Ω or greater, repair the open/high resistance in the circuit.
        - If less than 2 Ω, replace the Q17 Fuel Injector.
    - **If less than 3 Ω**
7. Replace the K20 Engine Control Module.

Repair Instructions

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

- **Fuel Injector Replacement**
- **Control Module References** for K20 Engine Control Module replacement, programming and setup.

ALCOHOL/CONTAMINANTS-IN-FUEL DIAGNOSIS

Diagnostic Instructions

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

Circuit/System Description

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Water contamination in the fuel system may cause driveability conditions such as hesitation, stalling, no start or misfires in one or more cylinders. Water may collect near a single fuel injector at the lowest point in the fuel injection system and cause a misfire in that cylinder. If the fuel system is contaminated with water, inspect the fuel system components for rust or deterioration.

Ethanol concentrations of greater than 10% in non-blended gasoline or greater than 85% with E85 blended gasoline for flexible fuel applications can cause driveability conditions such as hesitation, lack of power, stalling or no start. Excessive concentrations of ethanol used in vehicles not designed for it may cause fuel system corrosion, deterioration of rubber components and fuel filter restriction.

Reference Information

Special Tools

CH 44175-A Alcohol Tester Kit, if available

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

Circuit/System Verification

1. Remove a sample of fuel from the bottom of the fuel tank and place in a clean, clear container.
2. Place the sample on a level surface for 2 minutes.
3. Verify the sample is clear and bright in color.
    - **If the sample appears cloudy or contaminated with water, as indicated by a water layer at the bottom of the sample**

      Refer to Circuit/System Testing - Particulate Contaminants in Fuel.

    - **If alcohol contamination is suspected**

      Refer to Circuit/System Testing - Alcohol in Fuel Testing.

    - **If the sample remains clear and bright**
4. All OK.

Circuit/System Testing

Alcohol in Fuel Testing with Special Tool, If Available

1. Test the fuel composition using **CH 44175-A** and Instruction Manual.
2. Verify no water appears in the fuel sample.
    - **If water appears in the fuel sample**

      Clean the fuel system.

    - **If no water appears in the fuel sample**
3. Subtract 50 from the reading on the DMM in order to obtain the percentage of alcohol in the fuel sample.
4. Verify the non-blended gasoline fuel sample does not measure greater than 15% or an E85 blended gasoline fuel sample does not measure greater than 91% ethanol.
    - **If greater than the specified value**
    1. Add fresh regular gasoline to the vehicle's fuel tank.
    2. Remove a new sample of fuel from the tank.
    3. Test the fuel composition using **CH 44175-A** and Instruction Manual.
    4. Subtract 50 from the reading on the DMM in order to obtain the percentage of alcohol in the fuel sample.
    5. Verify the non-blended gasoline fuel sample does not measure greater than 15% or an E85 blended gasoline fuel sample does not measure greater than 91% ethanol.

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- If additional testing indicates that the ethanol percentage is still above 15% for a non-blended gasoline sample, drain and replace the vehicle's fuel. Refer to **Fuel Tank Draining** .
- If additional testing indicates that the E85 blended gasoline sample still measures above 91%, continue adding fresh, regular gasoline until the ethanol content is 85% or less.

- **If the specified value or less**

5. All OK.

Alcohol in Fuel Testing without Special Tool

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.

NOTE: **This procedure is for non-blended gasoline only. If excessive alcohol content is suspected with E85 fuel add 15% tank volume of fresh, regular gasoline to the fuel tank.**

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 minutes to allow adequate liquid separation. If alcohol is present in the fuel, the volume of the lower layer, which would now contain both alcohol and water, will be more than 10 ml (0.34 oz). For example, if the volume of the lower layer is increased to 15 ml (0.51 oz), this indicates at least 5% alcohol in the fuel. The actual amount of alcohol may be somewhat more because this procedure does not extract all of the alcohol from the fuel.
7. Verify the non-blended gasoline fuel sample does not measure greater than 15%.
   - **If greater than the specified value**
   1. Add fresh regular gasoline to the vehicle's fuel tank.
   2. Remove a new sample of fuel from the tank.
   3. Test the fuel composition of the new sample.
   4. Verify the non-blended gasoline fuel sample does not measure greater than 15%.
      - If greater than the specified value, drain and replace the vehicle's fuel. Refer to **Fuel Tank Draining** .
      - If the specified value or less, all OK.
   - **If the specified value or less**
8. All OK.

Particulate Contaminants in Fuel

1. Using an approved fuel container, draw approximately 0.5 liter (0.53 qt) of fuel from the bottom of the fuel tank.
2. Place the container on a level surface for approximately 5 minutes in order to allow settling of the particulate contamination. Particulate contamination will show up in various shapes and colors. Sand will typically be identified by a white or light brown crystals. Rubber will appear as black and irregular particles.
3. Verify there are no physical contaminants or water present in the fuel sample.
   - **If any physical contaminants or water are present**

     Clean the fuel system.

   - **If no physical contaminants or water are present**
4. All OK.

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Repair Instructions

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

- **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

Vehicle Setup

1. Engine OFF, open the hood. Position a large fan to blow air under the vehicle onto the fuel tank area.

WARNING: **Refer to Fuel and Evaporative Emission Pipe Warning .**

CAUTION: **Refer to Clean, Dry, Low Pressure Gas Source Caution .**

NOTE: **When servicing the evaporative emission (EVAP) system, test pressure must not exceed 13 in H20 (0.5 PSI) as pressure in excess of this could cause system components to perform inaccurately.**

NOTE: **A large difference between the vehicle temperature and shop temperature will seriously affect the accuracy of the tests. Always allow at least 15 min for the vehicle temperature to adjust to the shop temperature. Refer to Temperature Variation Instructions for more information about vehicle versus shop temperatures.**

2. Connect the red battery clip from the tester to the positive battery terminal.
3. Connect the black battery clip from the tester to chassis ground.

NOTE: **The vehicle battery must be fully charged for optimum tester performance.**

Flow Meter Test - Leak Detection

CAUTION: **Refer to Fuel and Evaporative Emission Hose/Pipe Connection Cleaning Caution .**

1. Open the Nitrogen tank valve and turn the NITROGEN / SMOKE valve on the front control panel to NITROGEN.
2. Connect the hose to the correct test orifice on the bottom front of the tester. For orifice size, refer to the vehicle specific information found in service procedures for DTCs that relate to EVAP system leaks.
3. Press and release the remote switch to activate the tester.
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.

NOTE: **The tester will time out after about 15 min. You may press the remote switch to reactivate the tester as desired.**

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.
7. Press and release the remote switch to activate the nitrogen flow and fill the system.

NOTE:

- **Larger volume fuel tanks and/or those with lower fuel levels, may require several minutes to fill with nitrogen.**
- **Static buildup may cause the float indicator to stick. It may be necessary to tap on the flow meter to free up the float.**
- **If fuel level is 90% or greater it will take longer to fill the system with smoke because the fuel fill tube check valve will be closed and force any smoke to pass through the on-board refueling vapor recovery pipe and orifice.**

8. Verify the stable floating indicator position to the red flag.
   - **Above the red flag, result is unacceptable - fail**

     Go to the Smoke Procedure

   - **Below the red flag - pass. Test complete**
9. Press and release the remote switch to deactivate the tester.

Smoke Procedure - Locate the Leak

1. Turn OFF any fans that may cause air movement around or near the vehicle.

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.**

2. Connect the nitrogen/smoke hose to the vehicle as directed in the service procedures. Some vehicles require that the nitrogen/smoke hose be connected at the front of the EVAP system at the EVAP service port. An adapter may be necessary. Other vehicles require the connection be made at the rear of the system using an adapter at the fuel fill cap or capless fuel fill. Consult the service procedures for DTCs that relate to EVAP system leaks for vehicle specific instructions regarding connection location and adapters.

NOTE: **Completely unwind the nitrogen/smoke hose from the bracket to optimize the tester's performance.**

3. Open the Nitrogen tank valve and turn the nitrogen/smoke valve on the control panel to smoke.
4. Press and release the remote switch to activate the tester and inject smoke into the EVAP system.

NOTE: **The remote switch operates on a push ON, push OFF fashion.**

5. Verify smoke has filled the EVAP system by opening the system opposite the end where smoke is injected.
6. Press and release the remote switch to deactivate the tester.

NOTE:

- **When injecting smoke at the service port, remove the fuel fill cap until smoke is observed. Then close the system and continue testing.**
- **If using a special tool fuel fill cap adapter at the filler neck, vent the system at the service port, with special tool EN-41413-VLV until smoke is observed then remove the vent fitting tool and close the system to continue with the test.**
- **Inject smoke in less than 2 min cycles for optimum tester performance.**

7. Introduce smoke into the system for an additional 60 s. Continue introducing smoke at 15 s intervals, as necessary until leak source is identified.

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.**

8. Using a high-intensity white light, inspect the entire EVAP system path and look for the source of the leak indicated by the exiting smoke.
    - **Smoke seen leaking**

      Repair or replace the affected component.

    - **No smoke seen leaking**
9. All OK

Temperature Variation Instructions

The Concern

Ideal circumstances for conducting the EVAP flow meter test require equal temperatures between the Nitrogen gas and the vehicle EVAP system. Significant differences in temperature between them can result in a flow or pressure change during testing, causing misleading results. Typically, the evaporative emission system tester is stored indoors, approximately 21Â°C (70Â°F). Vehicles brought in for diagnosis may have an EVAP system at significantly different temperatures.

For Example

NOTE: **With no temperature difference between the Nitrogen gas and EVAP system, the resulting vehicle EVAP system pressure will remain stable at 13 in. 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.

CYLINDER DEACTIVATION (ACTIVE FUEL MANAGEMENT) SYSTEM DIAGNOSIS

Diagnostic Instructions

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

Circuit/System Description

Cylinder Deactivation (Active Fuel Management) System Description

Diagnostic Aids

- Review scan tool Cylinder Deactivation Disable History to determine reason for disabling cylinder deactivation.

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- DTC P3400 may set if the PCV hose is disconnected from the inlet duct.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) Engine Controls Schematics (LGX)

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Description and Operation

Cylinder Deactivation (Active Fuel Management) System Description

Electrical Information Reference

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

Scan Tool Reference

Control Module References

Circuit/System Verification

1. Verify no other DTCs are set.

   NOTE: **The engine oil level and the oil pressure are critical to the correct operation of the system.**

   - **If other DTCs are set**

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

   - **If no other DTCs are set**
2. Verify the condition does not exist:Engine Oil - Fill Level=Low
   - **If a condition exists**

     Repair or replace as necessary.

   - **If no condition exists**
3. Verify the engine oil pressure: Refer to:**Oil Pressure Diagnosis and Testing**
   - **If not in the specified range**

     Repair or replace as necessary.

   - **If in the specified range**
4. EngineÂ» Idling - At normal operating temperature - Verify there is no abnormal noise from the component:
   - **If an abnormal noise is present**

     Refer to:**Symptoms - Engine Mechanical**

   - **If no abnormal noise is present**
5. Refer to Circuit/System Testing

Circuit/System Testing

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1. Operate the vehicle within the conditions of the customer's concern while monitoring the special tool: Scan Tool

WARNING: **Road test a vehicle under safe conditions and while obeying all traffic laws. Do not attempt any maneuvers that could jeopardize vehicle control. Failure to adhere to these precautions could lead to serious personal injury and vehicle damage.**

2. Verify the scan tool parameter:Cylinder Deactivation Inhibit =No
   - **If not the specified state**

     Refer to the appropriate diagnostic procedure listed below:

   - **Symptoms - Engine Controls**
   - **Symptoms - Engine Cooling**
   - **Symptoms - Wiring Systems**
   - **Symptoms - Engine Mechanical**
   - **If the specified state**
3. Test or replace the component: Q83 Valve Lifter Oil Solenoid Valve

Component Testing

Static Test

1. Ignition/Vehicle Â» Off
2. Disconnect the appropriate electrical connector: Q83 Valve Lifter Oil Solenoid Valve
3. Test for 11 to 30 Ω between the test points: Control terminal 2/B & Ignition terminal 1/A
   - **If not between 11 and 30 Ω**

     Replace the component: Q83 Valve Lifter Oil Solenoid Valve

   - **If between 11 and 30 Ω**
4. Test for infinite resistance between the test points: Each terminal of the component & The component's housing
   - **If less than infinite resistance**

     Replace the component: Q83 Valve Lifter Oil Solenoid Valve

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

Dynamic Test

1. Ignition/Vehicle Â» Off
2. Disconnect the electrical connector: Q83 Valve Lifter Oil Solenoid Valve
3. Connect a 3 A fused jumper wire between the test points: Ignition terminal 1/A & 12 V
4. Momentarily connect a jumper wire between the test points: Control terminal 2/B & Ground

CAUTION: **Complete the testing as quickly as possible in order to prevent overheating and damaging the component.**

Verify the component turns On and Off when connecting and disconnecting the jumper wire: Q83 Valve Lifter Oil Solenoid Valve

- **If the component does not turn On and Off**

  Replace the component: Q83 Valve Lifter Oil Solenoid Valve

- **If the component turns On and Off**

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5. All OK.

Repair Instructions

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

- **Valve Rocker Arm Oil Control Valve Replacement (Bank 1)** **Valve Rocker Arm Oil Control Valve Replacement (Bank 2)** - Q83 Valve Lifter Oil Solenoid Valve
- For control module replacement, programming and setup, refer to **Control Module References**

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 ignition coil for each cylinder. The Engine Control Module (ECM) controls the spark events by transmitting the timing pulses on the ignition control circuits to the individual ignition coil in firing order sequence.

Diagnostic Aids

- This engine application may use 2 fuses, one for each bank, to supply ignition voltage to the ignition module/coil assemblies. A good indication that a fuse is open is that all misfire counters are incrementing on one side of the engine.
- An open/high resistance on the low reference circuit to the ignition coil may cause a misfire.
- An erratic or weak spark is considered a no spark condition.

Reference Information

Schematic Reference

Engine Controls Schematics (LGW) **Engine Controls Schematics (LGX)**

Connector End View Reference

COMPONENT CONNECTOR END VIEWS - INDEX

Component View Reference

Powertrain Component Views

Description and Operation

Electronic Ignition System Description

Electrical Information Reference

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

Scan Tool Reference

Control Module References

Special Tools

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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 Ω between the ground circuit terminal 1/A and ground.
   - **If 5 Ω or greater**
   1. Ignition OFF.
   2. Test for less than 2 Ω in the ground circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, repair the open/high resistance in the ground connection.
   - **If less than 5 Ω**
3. Test for less than 5 Ω between the low reference circuit terminal 2/B and ground.
   - **If 5 Ω or greater**
   1. Ignition OFF, disconnect the X3 harness connector at the K20 Engine Control Module.
   2. Test for less than 2 Ω in the low reference circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, replace the K20 Engine Control Module.
   - **If less than 5 Ω**
4. Ignition ON.
5. Verify a test lamp illuminates between the ignition circuit terminal 4/D and ground.
   - **If the test lamp does not illuminate**
   1. Ignition OFF.
   2. Test for less than 2 Ω in the ignition circuit end to end.
      - If 2 Ω or greater, repair the open/high resistance in the circuit.
      - If less than 2 Ω, verify the fuse is not open and there is voltage at the fuse.
   - **If the test lamp illuminates**
6. Ignition OFF, exchange the suspect T8 Ignition Coil with the T8 Ignition Coil of a known functioning cylinder.
7. Engine Running.
8. Verify the scan tool Cylinder 1-6 Current Misfire Counter does not increment for the same cylinder that the suspect T8 Ignition Coil was removed from.
   - **If increments**

     Replace the K20 Engine Control Module.

   - **If does not increment**
9. Test or replace the T8 Ignition Coil.

Component Testing

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

1. Ignition OFF, connect the **EL 26792** to the appropriate T8 Ignition Coil.
2. Engine Running.
3. Verify the spark output of the T8 Ignition Coil.

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- **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 - Bank 1**
- **Ignition Coil Replacement - Bank 2**
- **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

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

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 malfunction indicator lamp (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 by disconnecting power to the controller. I/M Test DTCs are supported by all emissions related electronic control units, such as engine control modules (ECMs), transmission control modules (TCMs), fuel pump control modules, etc. An I/M Test DTC will not be stored or erased from the electronic control unit except at the end of trip processing which occurs 5 s after ignition OFF.

Conditions for Updating the I/M System Status

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

Each system requires at least one and sometimes several, diagnostic tests. The results of these tests are reported by a 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 MIL. Once all of the tests are completed, the Inspection/Maintenance System Status or Data will indicate YES in the Completed or Value column.

For example, when the HO2S Heater Status indicates YES, either all of the oxygen sensor heater tests have passed or one of the tests has illuminated the MIL. If the vehicle has four heated oxygen sensors, either all four heater circuit tests have passed or one of the heater circuit tests has illuminated the MIL. The Inspection/Maintenance System Status or Data will indicate NO under the Completed or Value column when any of the required tests for that system have not run. The following is a list of conditions that would set the Inspection/Maintenance System or Data indicator to NO:

- The vehicle is new from the factory and has not yet been driven through the necessary drive conditions to complete the tests.
- The battery has been disconnected or discharged below operating voltage.
- The 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 I/M Test DTCs. 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 off due to 3 passing drive cycles and the 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, therefore the DTC must PASS and not FAIL during the drive cycle. 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 greater than 600 s.
    - Cumulative vehicle operation above 41 km/h (25 mph) over 300 s.
    - Continuous vehicle idle greater than 30 s.
    - Ignition OFF for 5 s to allow the code to clear.

Monitored Emission Control Systems

The OBD II system monitors all emission control systems that are on-board, but not all vehicles need every possible emission control system. For example, a vehicle may not be equipped with secondary air injection 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 (LGX)** and/or **Inspection/Maintenance (I/M) System DTC Table (LGW)**. 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 Inspection/Maintenance System Status or Data 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.

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The Inspection/Maintenance System Status or Data information may be useful for a technician to determine if diagnostics have run when verifying repairs.

Circuit/System Verification

1. Verify that all Inspection/Maintenance System Status or Data indicators report YES and that no I/M Test DTCs are present.
   - **If any I/M Test DTCs are set**

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

   - **If no I/M Test DTCs are set**
2. All OK.

Circuit/System Testing

1. Verify no I/M DTCs are present.

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

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

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

   - **If no I/M DTCs are set**
2. Review applicable service bulletins for software updates that would prevent the I/M System Status tests from completing.
   - **If a control module re-program or other repair is required,**

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

   - **If no repair is required**
3. Observe the Inspection/Maintenance System Status or Data indicators.
   - **If any Inspection/Maintenance System Status or Data indicators report NO**

     Perform the **Inspection/Maintenance Complete System Set Procedure**.

   - **If no Inspection/Maintenance System Status or Data indicators report NO**
4. All OK.

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

The purpose of the Inspection/Maintenance (I/M) complete system set procedure is to satisfy the enable criteria necessary to execute all of the I/M readiness diagnostics and complete the trips 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 (I/M) Complete System Set Procedure if any I/M System Status indicators are set to NO.

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Conditions for Meeting a Cold Start

- The ignition voltage between 10 and 15 V.
- The barometric pressure (BARO) is more than 75 kPa (10.9 PSI).
- The engine coolant temperature (ECT) at start-up is less than 42Â°C (108Â°F).
- The intake air temperature (IAT) is between 2-32Â°C (36-90Â°F).
- The engine is OFF for greater than 6 hours or the following conditions must be met:
  - The start-up IAT minus start-up ECT are within 12Â°C (22Â°F).
  - The start-up ECT minus start-up IAT are within 50Â°C (90Â°F).
- Fuel level is between 25 and 75%.

Circuit/System Verification

1. Verify that all I/M System Status indicators report YES and that no I/M Test DTCs are present.
   - **If any I/M Test DTCs are set**

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

   - **If no I/M Test DTCs are set**
2. All OK.

Inspection/Maintenance (I/M) System Set Procedure

1. Ensure that the vehicle meets the conditions for a cold start listed above.
   - If the EVAP I/M System Status indicator displays NO, perform the EVAP Service bay test if applicable.
2. Turn OFF all accessories; HVAC system, other electrical loads, including aftermarket/add-on equipment, etc. and open the hood.
3. Set the vehicle parking brake and ensure the vehicle is in park for automatic transmission or neutral for manual transmission.
4. Start and idle the engine for 2 min.
5. Close the hood, release the parking brake and Accelerate at part throttle to 72-80 km/h (45-50 MPH) with this speed maintained until the engine reaches operating temperature, 8-10 min.

   WARNING: **Refer to Road Test Warning .**

6. Continue operation under these conditions for an additional 6 min.
7. Accelerate at part throttle to 90 km/h (55 MPH) with this speed maintained for 2 min.
8. Release the accelerator pedal for at least 10 s. This will allow the vehicle to enter the decel fuel cut off.
9. Safely stop the vehicle, with the engine in drive for automatic or neutral with the clutch pedal depressed and parking brake applied for manual. Allow the vehicle to idle for 2 min.

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

10. Shift the vehicle to park for automatic and neutral for manual. Turn OFF the ignition and exit the vehicle. Do NOT disturb the vehicle for 45 min.
11. Observe the Inspection/Maintenance (I/M) System Status with a scan tool. All of the I/M System Status indicators should display YES.
    - If the EVAP I/M System Status indicator displays NO, turn OFF the ignition, ensure that the vehicle meets the conditions for a cold start and repeat steps 6-11 three more times or until the EVAP I/M System Status indicator transitions to YES. If the indicator continues to display NO, refer to the **Inspection/Maintenance (I/M) System DTC Table (LGX)** and/or **Inspection/Maintenance (I/M) System DTC Table (LGW)** to identify the DTCs that did not run.

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- If any of the I/M System Status indicators display NO, refer to the **Inspection/Maintenance (I/M) System DTC Table (LGX)** and/or **Inspection/Maintenance (I/M) System DTC Table (LGW)** for the indicator which did not display YES. The I/M System DTC Table identifies the DTCs associated with each I/M System Status Indicator.

12. Observe the I/M Test DTC information with a scan tool. Verify there are no I/M Test DTCs present.

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.**

- 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**.

13. Observe the engine DTC information with a scan tool. Verify no DTCs are present.
    - If a DTC is set, diagnose using the **Diagnostic Trouble Code (DTC) List - Vehicle** . After repairs, perform the **Inspection/Maintenance Complete System Set Procedure** to verify no further DTCs are set.

INSPECTION/MAINTENANCE (I/M) SYSTEM DTC TABLE (LGX)

System	DTCs Required to Set System Status to YES
If an I/M System Status indicator did NOT update to YES during the **Inspection/Maintenance Complete System Set Procedure**, review each indicator and reference this table to determine each DTC associated with the I/M System Status Indicator. Each DTC listed below has specific conditions that must be met for the diagnostic to run. Included within the conditions are additional DTCs, which if set, may inhibit the DTCs listed below from running. Reviewing and operating the vehicle within the Conditions for Running for each DTC listed below will allow the I/M System Status Indicators to transition to YES.	
Catalyst	**DTC P0420 or P0430**
CMP Actuator	**DTC P05CC-P05CF**
EVAP	• **DTC P0442** • **DTC P0446** • **DTC P0455**
Fuel System	• **DTC P0089, P00C6, P228C or P228D** • **DTC P219A or P219B**
Oxygen Sensor	**DTC P0133, P013A-P013F, P014A, P014B, P0153, P015A-P015D or P2270-P2273 (LGX)**
Oxygen Sensor Heater	**DTC P0030-P0032, P0036-P0038, P0050-P0054, P0056-P0060, P0135, P0141, P0155, P0161, P103B or P103C**
Camshaft System	**DTC P0011, P0014, P0021 or P0024**

INSPECTION/MAINTENANCE (I/M) SYSTEM DTC TABLE (LGW)

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.	
Boost System	• **DTC P0234, P0299 or P16E7** • **DTC P026A**

System	DTCs Required to Set System Status to YES
Catalyst	DTC P0420 or P0430
CMP Actuator	DTC P05CC-P05CF
EVAP	• DTC P0442 • DTC P0446 • DTC P0455
Fuel System	• DTC P0089, P00C6, P228C or P228D • DTC P219A or P219B
Oxygen Sensor	DTC P0133, P013A-P013F, P014A, P014B, P0153, P015A-P015D or P2270-P2273 (LGX)
Oxygen Sensor Heater	DTC P0030-P0032, P0036-P0038, P0050-P0054, P0056-P0060, P0135, P0141, P0155, P0161, P103B or P103C
Camshaft System	DTC P0011, P0014, P0021 or P0024

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REPAIR INSTRUCTIONS

BRAKE PEDAL POSITION SENSOR LEARN

Calibration Criteria

NOTE: **Do not apply the brake pedal during the brake pedal position sensor calibration procedure. Any movement of the brake pedal during this procedure will cause the calibration procedure to fail. If this occurs, the brake pedal position sensor calibration must be repeated.**

Brake pedal position sensor calibration must be performed after the brake pedal position sensor, body control module (BCM) or engine control module (ECM) have been serviced. The calibration procedure will set the brake pedal position sensor home value. This value is used by the BCM and ECM to determine the action of the driver applying the brake system and to provide this information to the vehicle subsystems via serial data.

Calibration Procedure

1. Apply the parking brake.
2. Ignition ON, engine OFF, place the transmission in the PARK position for automatic transmission or NEUTRAL position for manual transmission.
3. Install a scan tool.
4. Clear all DTCs before proceeding.
5. Navigate to the Configuration/Reset Functions menu of the BCM.
6. Select the Brake Pedal Position Sensor Learn procedure and follow the directions displayed on the screen.
7. Navigate to the Configuration/Reset Functions menu of the ECM.
8. Select the Learn Functions menu.
9. Select the Brake Pedal Position Sensor Learn procedure and follow the directions displayed on the screen.

CRANKSHAFT POSITION VARIATION LEARN

The Crankshaft Position Variation Learn procedure is required when the following service procedures have been performed, regardless of whether DTC P0315 is set:

- An engine replacement.
- A engine control module (ECM) replacement.
- A crankshaft balancer replacement.
- A crankshaft replacement.
- A crankshaft position sensor replacement.
- Any engine repairs which disturb the crankshaft to crankshaft position sensor relationship.

The ECM monitors certain component signals to determine if all the conditions are met to continue with the Crankshaft Position Variation Learn procedure. The scan tool only displays the condition that inhibits the procedure. The scan tool displays the signals of the components listed below:

- Crankshaft position sensors activity: If there is a crankshaft position sensor condition, refer to the applicable DTC set.

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- Camshaft position sensor signal activity: If there is a camshaft position sensor signal condition, refer to the applicable DTC set.
- Engine coolant temperature (ECT): If the engine coolant temperature is not warm enough, idle the engine until the engine coolant temperature reaches the correct temperature.

1. Verify no DTCs are set.
    - **If any DTCs other than P0300-P0308 or P0315 are set**

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

    - **If DTC P0300-P0308, P0315 or no DTCs are set**
2. Engine Running at normal operating temperature, perform the scan tool Crankshaft Position Variation Learn procedure and follow the on screen instructions.

   NOTE: **The Crankshaft Position Variation Learn may have to be repeated up to 5 times before the procedure is successful.**

3. Verify the scan tool displays Test Passed Successfully when completed.
    - **If Test Passed Successfully is not displayed**

      Verify that none of the conditions listed below exist:

    - The ignition switch is in the ON position until there is insufficient system voltage.
    - An ECM power disconnect with the ignition ON that may have erased the crankshaft position system variation values and set DTC P0315.
    - Interference in the signal circuit of the crankshaft position sensor.
    - Debris between the crankshaft position sensor and the reluctor wheel.
    - A damaged or misaligned reluctor wheel.
    - Worn crankshaft main bearings.
    - Excessive crankshaft runout.
    - A damaged crankshaft.
    - If a condition is exists, repair or replace as necessary.
    - If no conditions exist, replace the K20 Engine Control Module.
    - **If Test Passed Successfully is displayed**
4. Clear all DTCs.
5. Engine Running.
6. Verify a DTC is not set.
    - **If a DTC is set**

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

    - **If a DTC is not set**
7. All OK.

Repair Instructions

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

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

INTAKE SYSTEM LEARNED VALUES RESET (LGW)

Diagnostic Instructions

- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis: **Strategy Based Diagnosis**

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Description

For an overview of the component/system, refer to **Turbocharger System Description**

This procedure resets the control module learned values of the component/system: Induction System - Airflow Adaptive Values

When to Perform the Procedure

NOTE: **Failure to perform this procedure may result in poor system performance, DTCs being set or customer dissatisfaction.**

This procedure is required when the following component has been repaired, replaced, removed or serviced:

- B17 Barometric Pressure Sensor
- B74 Manifold Absolute Pressure Sensor
- B75B Mass Air Flow/Intake Air Temperature Sensor
- B75C Multifunction Intake Air Sensor
- B111B Turbocharger Boost/Intake Air Temperature Sensor
- Q38 Throttle Body
- Q40A Turbocharger 1 Bypass Solenoid Valve
- Q40B Turbocharger 2 Bypass Solenoid Valve
- Q42A Turbocharger 1 Wastegate Solenoid Valve
- Q42B Turbocharger 2 Wastegate Solenoid Valve
- Intake Air Duct - Collapsed/Leaking/Loose/Restricted
- Turbocharger - Left Side
- Turbocharger - Right Side

Conditions for Running the Procedure

- DTC P00C7, P0068, P0101, P0102, P0103, P0106, P0107, P0108, P010B, P010C, P010D, P0236, P0237, P0238, P1101, P2227-P2230, P222B-P222E = Not set
- Engine=Off
- Ignition=On

Reference Information

Scan Tool Reference

Control Module References

With Scan Tool

1. Ignition Â» On / Vehicle Â» In Service Mode
2. Select:Module Diagnostics
3. Select:Engine Control Module
4. Select:Configuration/Reset Functions
5. Select:Reset Functions
6. Select:Intake System Learned Values Reset
7. Follow the instructions on the scan tool.

Repair Instructions

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

THROTTLE BODY IDLE AIR FLOW COMPENSATION RESET

Diagnostic Instructions

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- Perform the Diagnostic System Check prior to using this diagnostic procedure: **Diagnostic System Check - Vehicle**
- Review the description of Strategy Based Diagnosis:**Strategy Based Diagnosis**

Description

For an overview of the component/system, refer to **Throttle Actuator Control (TAC) System Description**

This procedure triggers the control module to learn the values of the component: Q38 Throttle Body - Airflow Adaptive Values

When to Perform the Procedure

NOTE: **Failure to perform this procedure may result in poor system performance, DTCs being set or customer dissatisfaction.**

Perform this procedure when the following component has been serviced: Q38 Throttle Body - Cleaned/Replaced

Conditions for Running the Procedure

- DTC P0068, P0101, P0102, P010B, P0103, P010C, P010D, P0106, P0107, P0108, P0116, P0117, P0118, P0120, P0122, P0123, P0128, P0171, P0172, P0174, P0175, P0201-P0208, P0220, P0222, P0223, P0261, P0262, P0264, P0265, P0267, P0268, P0270, P0271, P0273, P0274, P0276, P0277, P0279, P0280, P0282, P0283, P0300-P0308, P0351-P0358, P0496, P0601, P0604, P0606, P060D, P0641, P0651, P0697, P06A3, P06D2, P1248, P1249, P124A, P124B, P1516, P16A0-P16A2, P2101, P2119, P2120, P2122, P2123, P2125, P2127, P2128, P2135, P2138, P2147, P2148, P2150, P2151, P2153, P2154, P2156, P2157, P216B, P216C, P216E, P216F, P217B, P217C, P217E, P217F, P2176, P2300, P2301, P2303, P2304, P2306, P2307, P2309, P2310, P2312, P2313, P2315, P2316, P2318, P2319, P2321, P2322 = Not set
- Ignition=On
- Vehicle Speed Sensor = 0 km/h (0 MPH)

Reference Information

Scan Tool Reference

Control Module References

With Scan Tool

1. IgnitionÂ» On / VehicleÂ» In Service Mode
2. Select: Module Diagnostics
3. Select: Engine Control Module
4. Select: Configuration/Reset Functions
5. Select: Learn Functions
6. Select: Idle Learn
7. Follow the instructions on the scan tool.
8. Verify the scan tool parameter: Throttle Body Idle Air Flow Compensation = 0%
    - **If greater than 0**

      Repeat step 1

    - **If 0**
9. Engine Â» Idling - At normal operating temperature
10. Verify the scan tool parameter:Engine Speed = -100 to +200 RPM of the Desired Idle Speed - Desired Idle Speed
    - **{Test failed 1 time(s)} If not in the specified range**
    1. Engine idling. - For greater than 3 min

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2. Ignition/Vehicle Â» Off - For greater than 1 min
3. Engine idling. - For greater than 3 min
4. Repeat step 9

- **{Test failed 2 time(s)} If not in the specified range**

1. Perform the following action: Road test the vehicle.
2. Vehicle Speed - Greater than 70 km (44 mi)
3. Decelerate - For 2 s
4. Repeat step 10.2 - 3 times
5. Engine idling. - For greater than 3 min
6. Repeat step 9

- **{Test failed 3 time(s)} If not in the specified range**

  Refer to **Diagnostic System Check - Vehicle**

- **If in the specified range**

11. All OK.

Repair Instructions

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

WIRE TO WIRE REPAIR - ENGINE CONTROLS AND FUEL

Special Tools

- **EL-38125-10** Splice Sleeve Crimping Tool (non GMNA)
- **J-38125-5A** Ultra Torch Special Tool
- **J-38125-8** Splice Sleeve Crimping Tool (GMNA)

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

WARNING: **In order to reduce the risk of personal injury, loss of high voltage isolation to ground and higher system impedance, do not attempt to repair any HV wiring, connector or terminal that is damaged. High voltage coaxial type cables are not repairable. Never attempt to repair a coaxial type cable. The entire cable/harness or component must be replaced. In order to maintain system integrity and personal safety, never attempt to repair any high voltage wiring, cables or terminals. Performing this procedure on high voltage circuits may result in serious injury or death.**

NOTE: **If the wiring harness internal to the transmission is damaged, the wiring harness must be replaced. The use of splice sleeves in an attempt to repair the internal transmission wires, connectors or terminals could result in performance issues.**

NOTE: **Do not splice wires in Door Harness Grommets.**

NOTE: **The DuraSeal splice sleeves have the following 2 critical features:**

- **A special heat shrink sleeve environmentally seals the splice. The heat shrink sleeve contains a sealing adhesive inside.**
- **A cross hatched (knurled) core crimp provides the necessary low resistance contact integrity for these sensitive, low energy circuits.**

Use only DuraSeal splice sleeves to form a one-to-one splice on all types of insulation except high voltage and specialty cables. Use DuraSeal splice sleeves where there are special requirements such as

moisture sealing. Follow the instructions below in order to splice copper wire using DuraSeal splice sleeves.

Splice Sleeve Selection

Splice Sleeve Color	Crimp Tool Nest Color		Wire Gauge mm^2 / (AWG)
	3 Crimp Nests	4 Crimp Nests	
Salmon (Yellow-Pink) 19300089	Red (1) or Red/Green (1)	Red (2)	0.22-0.8/(18-26)
Blue 19168447	Blue (2)	Blue (3)	1.0-2.0/(14-16)
Yellow 19168448	Yellow (3)	Yellow (4)	3.0-5.0/(10-12)

1. Open the harness by removing any tape:

   NOTE: **You must perform the following procedures in the listed order. Repeat the procedure if any wire strands are damaged. You must obtain a clean strip with all of the wire strands intact.**

   - Use a sewing seam ripper, available from sewing supply stores, in order to cut open the harness in order to avoid wire insulation damage.
   - Use the DuraSeal splice sleeves on all types of insulation except Tefzel and coaxial.
   - Do not use the crimp and DuraSeal splice sleeve to form a splice with more than 2 wires coming together.
2. Cut as little wire off the harness as possible. You may need the extra length of wire in order to change the location of a splice.

   Adjust splice locations so that each splice is at least 40 mm (1.5 in) away from the other splices, harness branches or connectors.

3. Strip the insulation:
   - When adding a length of wire to the existing harness, use the same size wire as the original wire.
   - Perform one of the following items in order to find the correct wire size:
     - Find the wire on the schematic and convert to regional wiring gauge size.
     - If you are unsure of the wire size, begin with the largest opening in the wire stripper and work down until achieving a clean strip of the insulation.
   - Strip approximately 5.0 mm (0.20 in) of insulation from each wire to be spliced.
   - Do not nick or cut any of the strands. Inspect the stripped wire for nicks or cut strands.
   - If the wire is damaged, repeat this procedure after removing the damaged section.
4. For high temperature wiring, slide a section of high temperature SCT1 shrink tubing down the length of wire to be spliced. Ensure that the shrink tubing will not interfere with the splice procedure.
5. Select the proper DuraSeal splice sleeve according to the wire size. Refer to the above table at the beginning of the repair procedure for the color coding of the DuraSeal splice sleeves and the crimp tool nests.
6. The **EL-38125-10** splice sleeve crimping tool has four crimp nests. The largest crimp nest (4) is used for crimping 10 and 12 gauge wires. The second largest crimp nest (3) is used for crimping 14 and 16 gauge wires. The third largest crimp nest (2) is used for crimping 18 and 20 gauge wires. The smallest crimp nest (1) is used for crimping 22 to 26 gauge wires. The crimp nests are referenced in the table (farther above) under the crimp tool nest color.

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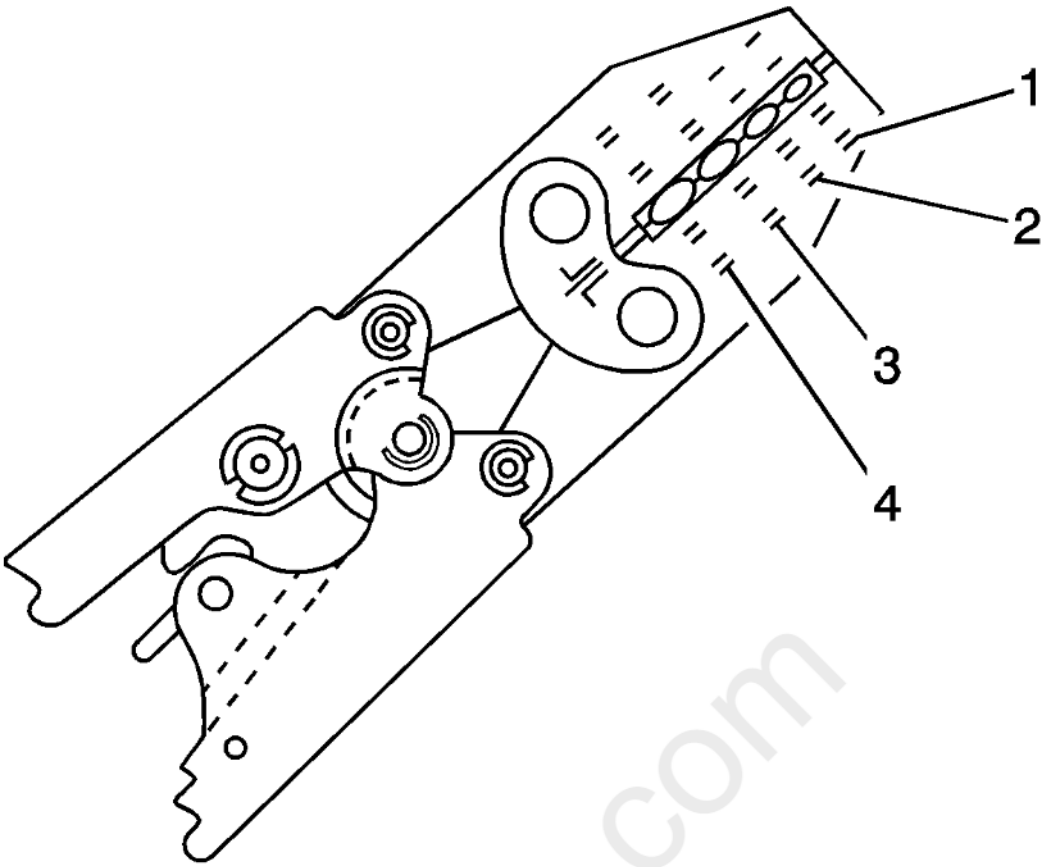

Fig. 1: Crimping Tool
Courtesy of GENERAL MOTORS COMPANY

7. The **J-38125-8** splice sleeve crimping tool has three crimp nests. The largest crimp nest (3) is used for crimping 10 and 12 gauge wires. The second largest crimp nest (2) is used for crimping 14 and 16 gauge wires. The smallest crimp nest (1) is used for crimping 18 to 20 gauge wires. The crimp nests are referenced in the table (farther above) under the crimp tool nest color.

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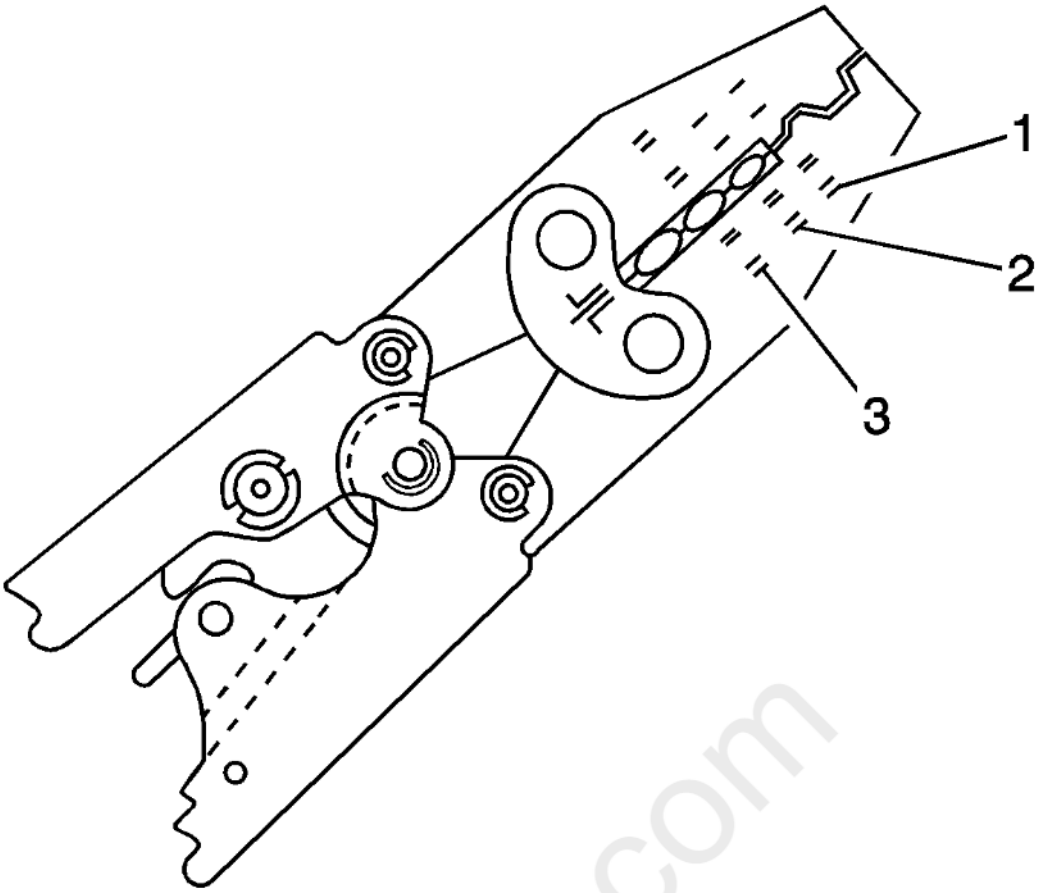

Fig. 2: Identifying Splice Crimp Tool Nests Terminal Identification
Courtesy of GENERAL MOTORS COMPANY

8. Use the splice sleeve crimp tool in order to position the DuraSeal splice sleeve in the proper color nest of the splice sleeve crimp tool. For the four crimp nest tool, use the three largest crimp nests to crimp the splice sleeves. For the three crimp nest tool, use all three crimp nests to crimp the splice sleeves. Use the four and three crimp tool diagrams (above) and the table (farther above) to match the splice sleeve with the correct crimp nest. The crimp tool diagram callout numbers match the numbers in the table (under crimp tool nest color).
9. Place the DuraSeal splice sleeve in the nest. Ensure that the crimp falls midway between the end of the barrel and the stop. The sleeve has a stop (3) in the middle of the barrel (2) in order to prevent the wire (1) from going further. Close the hand crimper handles slightly in order to firmly hold the DuraSeal splice sleeve in the proper nest.

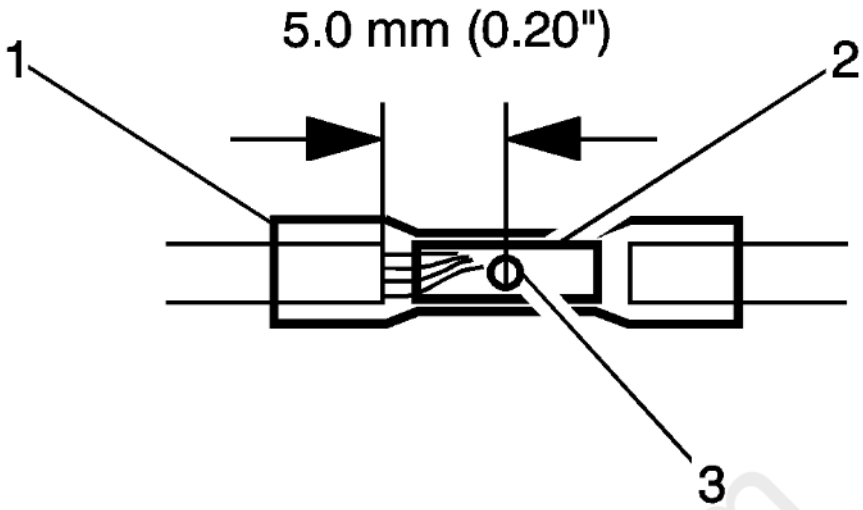

Fig. 3: Identifying Duraseal Splice Sleeve
Courtesy of GENERAL MOTORS COMPANY

10. Insert the wire into the splice sleeve barrel until the wire hits the barrel stop. Refer to **Folded-Over Wire Repair** for splicing wires of 0.35 mm or less (22, 24, 26 gauge sizes) and for splicing wires of different gauges.

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Fig. 4: Crimped Duraseal Splice Sleeve
Courtesy of GENERAL MOTORS COMPANY

11. Tightly close the handles of the crimp tool until the crimper handles open when released.

    The crimper handles will not open until you apply the proper amount of pressure to the DuraSeal splice sleeve. Repeat steps 4 and 6 for the opposite end of the splice.

12. Using the heat torch, apply heat to the crimped area of the barrel.

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Fig. 5: Crimped Duraseal Splice Sleeve
Courtesy of GENERAL MOTORS COMPANY

13. Start in the middle and gradually move the heat barrel to the open ends of the tubing:
    - The tubing will shrink completely as the heat is moved along the insulation.
    - A small amount of sealant will come out of the end of the tubing when sufficient shrinkage is achieved.

Weatherpack™ Wiring Repair

NOTE: **Some replacement pigtail connectors may be delivered without the terminated leads installed into the connector. For Weatherpack™ connectors, all terminated leads included in the package should to be installed into the connector. If the connector end view shows that a terminal is not occupied, the extra terminated lead(s) need to be installed and the end(s) sealed using a DuraSeal splice sleeve and taped back into the harness.**

1. Insert the wire into the splice sleeve barrel until the wire hits the barrel stop. Refer to **Folded-Over Wire Repair** for splicing wires of 0.35 mm or less (22, 24, 26 gauge sizes) and for splicing wires of different gauges.

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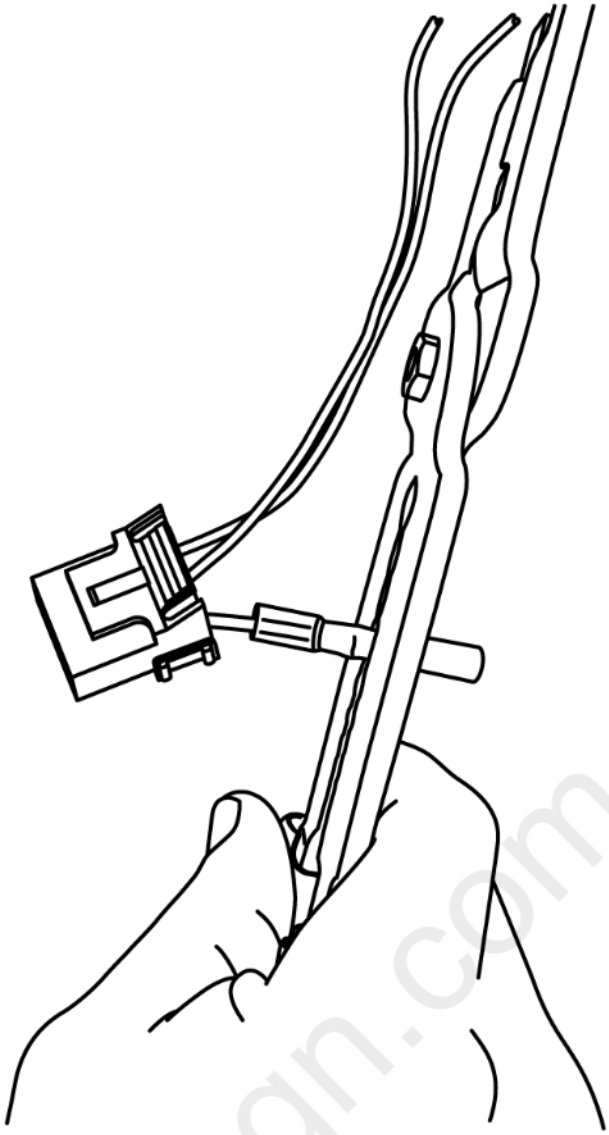

Fig. 6: Tightly Close Handles Of Crimp Tool
Courtesy of GENERAL MOTORS COMPANY

2. Tightly close the handles of the crimp tool until the crimper handles open when released.

   The crimper handles will not open until you apply the proper amount of pressure to the DuraSeal splice sleeve. Holding the DuraSEAL with one hand gently tug on the wire to ensure it is crimped in the DuraSeal.

3. Using the heat torch, apply heat to the crimped area of the barrel.
4. Start in the middle and gradually move the heat barrel to the open ends of the tubing:

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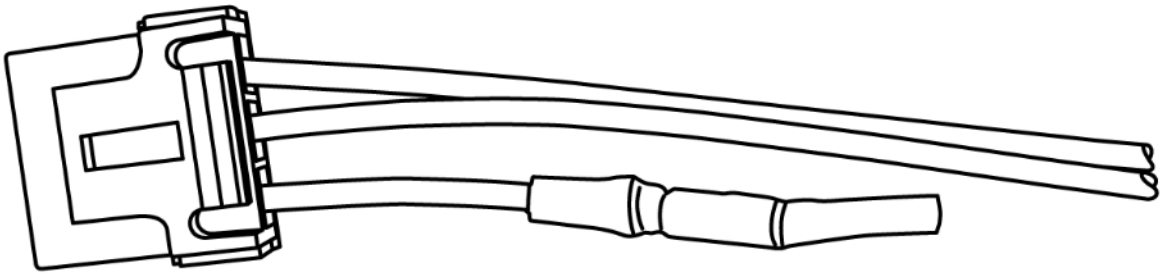

Fig. 7: Heat To Crimped Area Of Barrel
Courtesy of GENERAL MOTORS COMPANY

- The tubing will shrink completely as the heat is moved along the insulation.
- A small amount of sealant will come out of the end of the tubing when sufficient shrinkage is achieved.

5. Tape the extra terminated lead(s) back into the harness.

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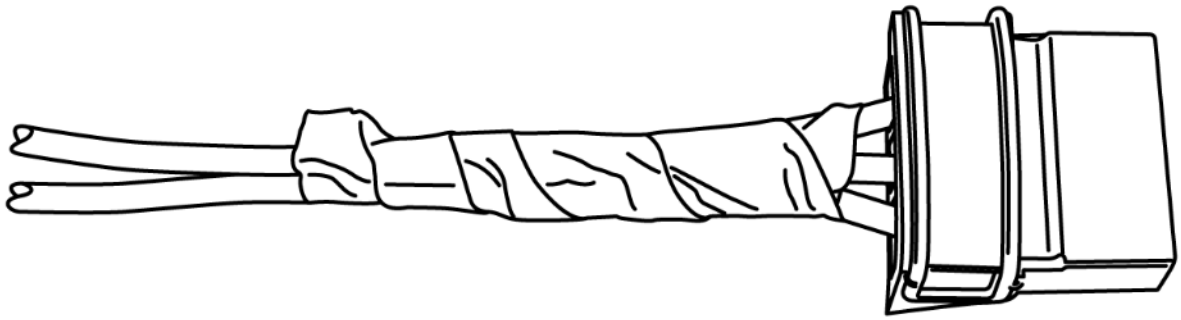

Fig. 8: Taping Extra Terminated Leads Back Into Harness
Courtesy of GENERAL MOTORS COMPANY

High Temperature Wiring Repairs

Use the following procedures to perform high temperature wiring repairs:

1. Center the high temperature SCT1 shrink tube over the DuraSeal splice sleeve.
2. Using the heat torch, apply heat to the high temperature heat shrink tubing.
3. Gradually move the heat from the center to the open end of the tubing:
    - The tubing will shrink completely as the heat is moved along the insulation.
    - A small amount of sealant will come out of the end of the tubing when sufficient shrinkage is achieved.
4. Replace any reflective tape and clips that may have been removed during the repair.

CONNECTOR RECONNECTION - ENGINE CONTROLS AND FUEL

Special Tools

EL-35616 Terminal Test Probe Kit

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

When the condition is not currently present, but is indicated in DTC history, the cause may be intermittent. An intermittent may also be the cause when there is a customer complaint, but the symptom cannot be duplicated. Refer to the Symptom Table of the system that is suspect of causing the condition before trying to locate an intermittent condition.

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Most intermittent conditions are caused by faulty electrical connections or wiring. Inspect for the following items:

- Loose, corroded or painted terminal stud/fastener
- Wiring broken inside the insulation
- Poor connection between the male and female terminal at a connector
- A terminal not seated all the way into the connector body
- Poor terminal to wire connection - Some conditions which fall under this description are poor crimps, poor solder joints, crimping over the wire insulation rather than the wire itself and corrosion in the wire to terminal contact area, etc.
- Pierced or damaged insulation can allow moisture to enter the wiring causing corrosion. The conductor can corrode inside the insulation, with little visible evidence. Look for swollen and stiff sections of wire in the suspect circuits.
- Wiring which has been pinched, cut or its insulation rubbed through may cause an intermittent open or short as the bare area touches other wiring or parts of the vehicle.
- Wiring that comes in contact with hot or exhaust components
- Refer to **Inducing Intermittent Fault Conditions** in order to duplicate the conditions required, in order to verify the customer concern.
- Refer to **Testing for Electrical Intermittents** for test procedures to detect intermittent open, high resistance, short to ground and short to voltage conditions.
- Refer to **Scan Tool Snapshot Procedure** for advanced intermittent diagnosis and Vehicle Data Recorder operation.

Testing for Terminal Fretting

Some intermittent conditions can be caused by wire terminal fretting corrosion. Fretting corrosion is a build-up of insulating, oxidized wear debris that can form when there is a small motion between electrical contacts. The oxidized wear debris can pile up enough at the electrical contact spots that the electrical resistance across the connection increases. Movement between the contacting surfaces as small as 10 to 100 microns can cause fretting. To put this in perspective, a sheet of paper is about 100 microns thick, so fretting motion is small and hard to see. Vibration and thermal expansion/contraction are the main sources that create fretting motion. Since vehicles vibrate and can experience large temperature swings, they are a good source for fretting motion. Tin, copper, nickel and iron surfaces are all susceptible to fretting corrosion. Fretting corrosion can be difficult to see but it looks like small, dark smudges on the terminals contact surface.

To correct a fretting condition disconnect the suspect connector and add dielectric grease / lubricant (Nyogel 760G or equivalent, meeting GM specification 9986087) to both sides of the connector terminals. Then reconnect the connector and wipe away any excess lubricant. This will correct the additional terminal contact resistance due to the terminal fretting corrosion.

Testing for Proper Terminal Contact

It is important to test terminal contact at the component and any inline connectors before replacing a suspect component. Mating terminals must be inspected to ensure good terminal contact. A poor connection between the male and female terminal at a connector may be the result of contamination or deformation.

Contamination may be caused by the connector halves being improperly connected. A missing or damaged connector seal, damage to the connector itself or exposing the terminals to moisture and dirt can also cause contamination. Contamination, usually in the underhood or underbody connectors, leads to terminal corrosion, causing an open circuit or intermittently open circuit.

Deformation is caused by probing the mating side of a connector terminal without the proper adapter. Always use the **EL-35616** kit when probing connectors. Other causes of terminal deformation are improperly joining the connector halves or repeatedly separating and joining the connector halves. Deformation, usually to the female terminal contact tang, can result in poor terminal contact causing an open or intermittently open circuit.

Testing for Proper Terminal Contact in Bussed Electrical Centers

It is very important to use the correct test adapter when testing for proper terminal contact of fuses and relays in a bussed electrical center. Use the **EL-35616** kit to test for proper terminal contact. Failure to use the **EL-35616** kit can result in improper diagnosis of the bussed electrical center.

Follow the procedure below in order to test terminal contact:

1. Separate the connector halves.
2. Visually inspect the connector halves for contamination. Contamination may result in a white or green build-up within the connector body or between terminals. This causes high terminal resistance, intermittent contact or an open circuit. An underhood or underbody connector that shows signs of contamination should be replaced in its entirety: terminals, seals and connector body.
3. Using an equivalent male terminal/terminated lead, verify that the retention force is significantly different between a known good terminal and the suspect terminal. Replace the female terminal in question.

Flat Wire Connectors

There are no serviceable parts for flat wire connectors on the harness side or the component side.

Follow the procedure below in order to test terminal contact:

1. Remove the component in question.
2. Visually inspect each side of the connector for signs of contamination. Avoid touching either side of the connector as oil from your skin may be a source of contamination as well.
3. Visually inspect the terminal bearing surfaces of the flat wire circuits for splits, cracks or other imperfections that could cause poor terminal contact. Visually inspect the component side connector to ensure that all of the terminals are uniform and free of damage or deformation.
4. Insert the appropriate adapter into the flat wire harness connector in order to test the circuit in question.

Control Module/Component Voltage and Grounds

Poor voltage or ground connections can cause widely varying symptoms.

- Test all control module voltage supply circuits. Many vehicles have multiple circuits supplying voltage to a control module. Other components in the system may have separate voltage supply circuits that may also need to be tested. Inspect connections at the module/component connectors, fuses and any intermediate connections between the voltage source and the module/component. A test lamp or a DMM may indicate that voltage is present, but neither tests the ability of the circuit to carry sufficient current. Operate the component to test the ability of the circuit to carry sufficient current. Refer to **Circuit Testing** and **Power Distribution Schematics** .
- Test all control module ground and system ground circuits. The control module may have multiple ground circuits. Other components in the system may have separate grounds that may also need to be tested. Inspect grounds for clean and tight connections at the grounding point (screw or stud). Inspect the connections at the component and in splice packs, where applicable. Operate the component to test the ability of the circuit to carry sufficient current. Refer to **Circuit Testing** and **Ground Distribution Schematics** .

Temperature Sensitivity

- An intermittent condition may occur when a component/connection reaches normal operating temperature. The condition may occur only when the component/connection is cold or only when the component/connection is hot.
- Freeze Frame, Failure Records, Snapshot or Vehicle Data Recorder data may help with this type of intermittent condition, where applicable.
- If the intermittent is related to heat, review the data for a relationship with the following:
  - High ambient temperatures
  - Underhood/engine generated heat
  - Circuit generated heat due to a poor connection or high electrical load

    - Higher than normal load conditions, towing, etc.
- If the intermittent is related to cold, review the data for the following:
    - Low ambient temperatures - In extremely low temperatures, ice may form in a connection or component. Inspect for water intrusion.
    - The condition only occurs on a cold start.
    - The condition goes away when the vehicle warms up.
- Information from the customer may help to determine if the trouble follows a pattern that is temperature related.
- If temperature is suspected of causing an intermittent fault condition, attempt to duplicate the condition. Refer to **Inducing Intermittent Fault Conditions** in order to duplicate the conditions required.

Electromagnetic Interference and Electrical Noise

Some electrical components/circuits are sensitive to electromagnetic interference or other types of electrical noise. Inspect for the following conditions:

- A mis-routed harness that is too close to high voltage/high current devices such as secondary ignition components, motors, generator etc. - These components may induce electrical noise on a circuit that could interfere with normal circuit operation.
- Electrical system interference caused by a malfunctioning relay or a control module driven solenoid or switch - These conditions can cause a sharp electrical surge. Normally, the condition will occur when the malfunctioning component is operating.
- Installation of non-factory or aftermarket add on accessories such as lights, 2-way radios, amplifiers, electric motors, remote starters, alarm systems, cell phones, etc. - These accessories may create interference in other circuits while operating and the interference would disappear when the accessory is not operating. Refer to **Checking Aftermarket Accessories** .
- Test for an open diode across the A/C compressor clutch and for other open diodes. Some relays may contain a clamping diode.
- The generator may be allowing AC noise into the electrical system.

Incorrect Control Module

- There are only a few situations where reprogramming a control module is appropriate:
    - A new service control module is installed.
    - A control module from another vehicle is installed.
    - Revised software/calibration files have been released for this vehicle.
- Verify that the control module contains the correct software/calibration. If incorrect programming is found, reprogram the control module with the most current software/calibration. Refer to **Control Module References** for replacement, setup and programming.

NOTE: **DO NOT re-program the control module with the SAME software/calibration files that are already present in the control module. This is not an effective repair for any type of concern.**

ENGINE CONTROL MODULE REPLACEMENT (LGW)

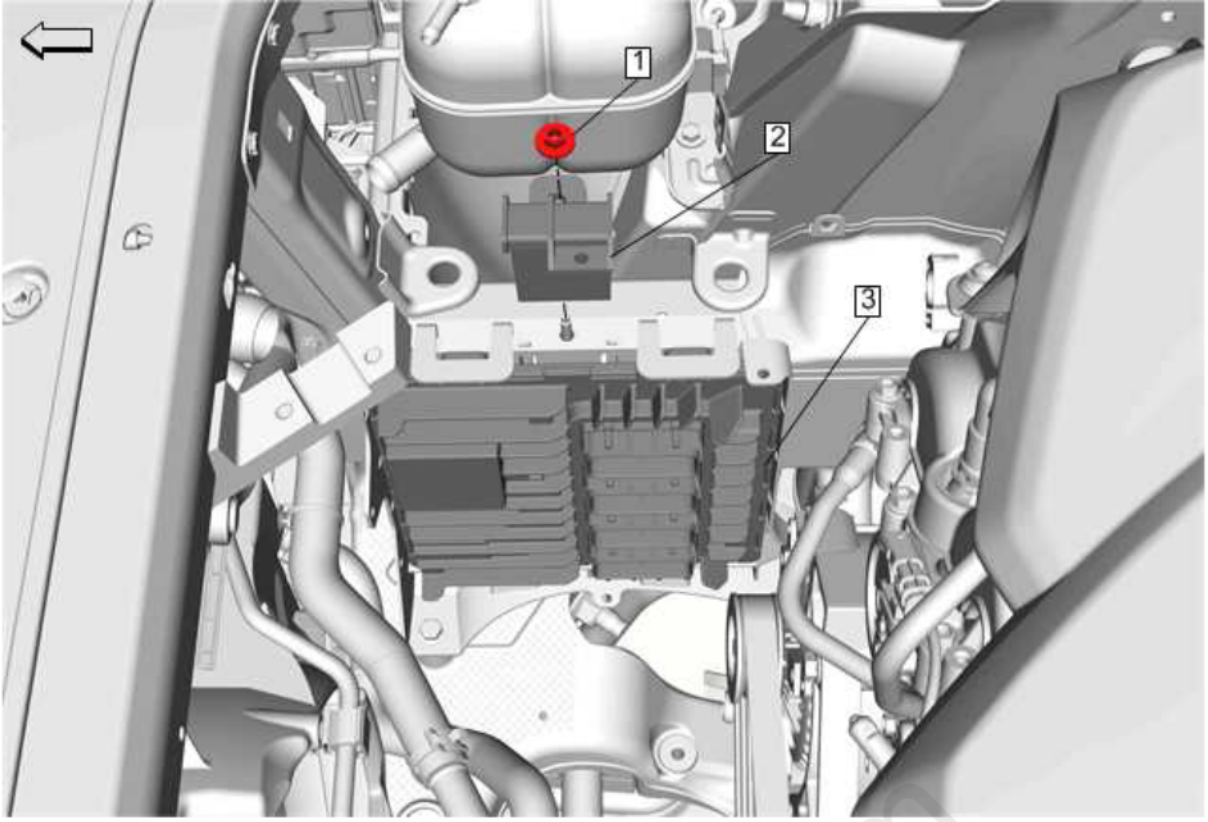

Fig. 9: Engine Control Module (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. **Battery Negative Cable Disconnection and Connection** 2. **Front Wheelhouse Panel Brace Replacement (Front)** @ Front Â» Remove 3. **Radiator Surge Tank Inlet Hose Replacement (LGW)** Â» Reposition 4. **Radiator Inlet Hose Replacement (LGW)** Â» Reposition	
1	Engine Control Module Bracket Nut **CAUTION:** **Refer to Fastener Caution .** **Tighten** 9 N.m (80 lb in)
2	Engine Control Module Bracket Clip

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Callout	Component Name
3	Engine 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 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. If replacing, program the ECM. Refer to **Control Module References** **NOTE:** **Before removing the engine control module (ECM), record the oil life percentage remaining. Use the scan tool to reset the Engine Oil Life remaining back to the original percentage recorded.**

ENGINE CONTROL MODULE REPLACEMENT (LGX)

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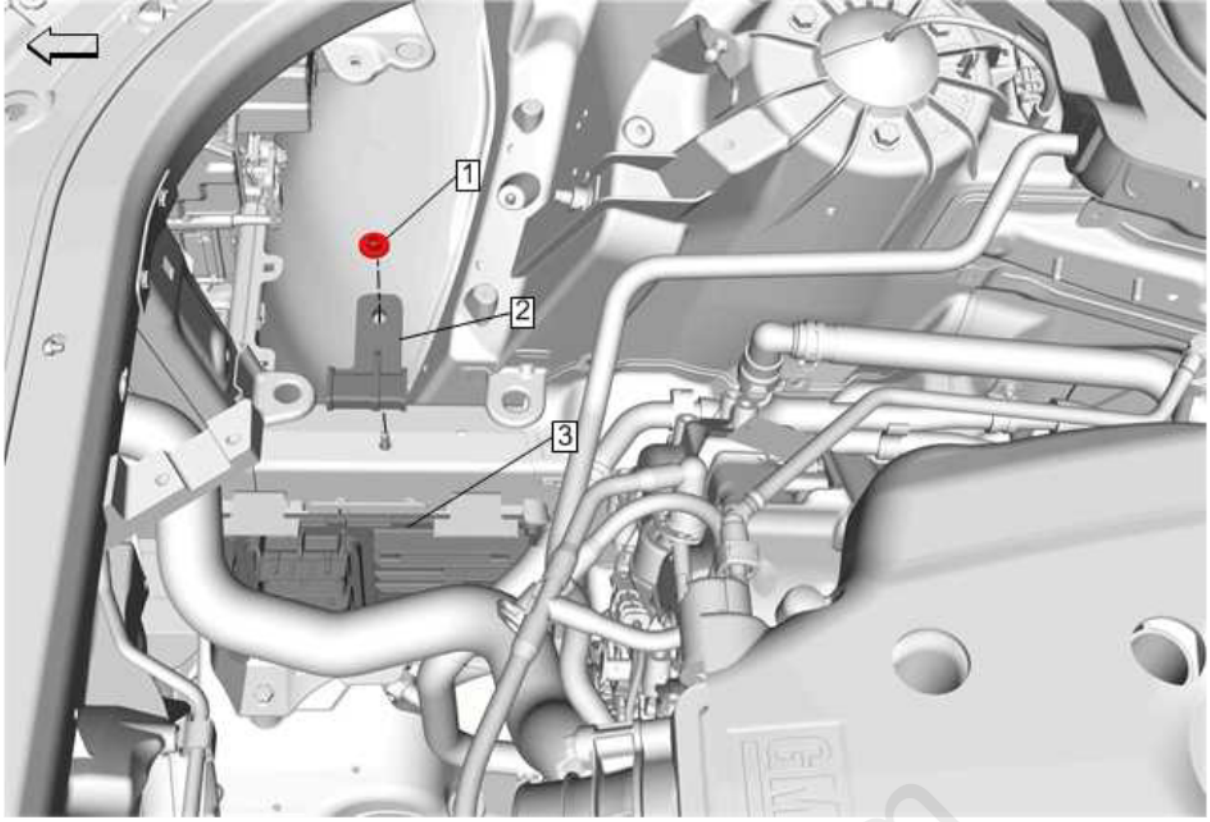

Fig. 10: Engine Control Module (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Air Cleaner Assembly Replacement (LGX)	
1	Engine Control Module Bracket Nut **CAUTION:** **Refer to Fastener Caution .** **Tighten** 9 N.m (80 lb in)
2	Engine Control Module Bracket Clip

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Callout	Component Name
3	Engine 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 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. If replacing, program the ECM. Refer to **Control Module References** **NOTE:** **Before removing the engine control module (ECM), record the oil life percentage remaining. Use the scan tool to reset the Engine Oil Life remaining back to the original percentage recorded.**

ENGINE CONTROL MODULE BRACKET REPLACEMENT (LGW)

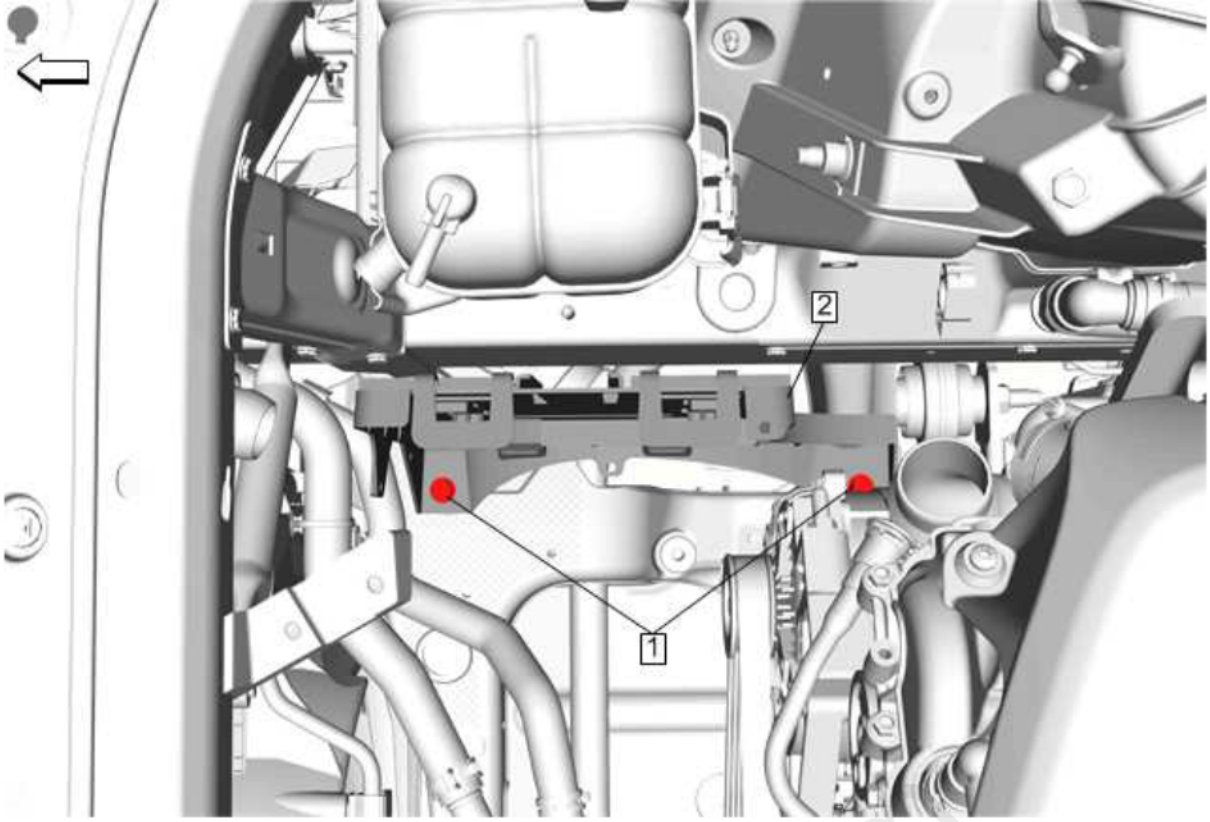

Fig. 11: Engine Control Module Bracket (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Engine Control Module Replacement (LGW)	
1	Engine Control Module Bracket Bolt [2x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 9 N.m (80 lb in)
2	Engine Control Module Bracket

ENGINE CONTROL MODULE BRACKET REPLACEMENT (LGX)

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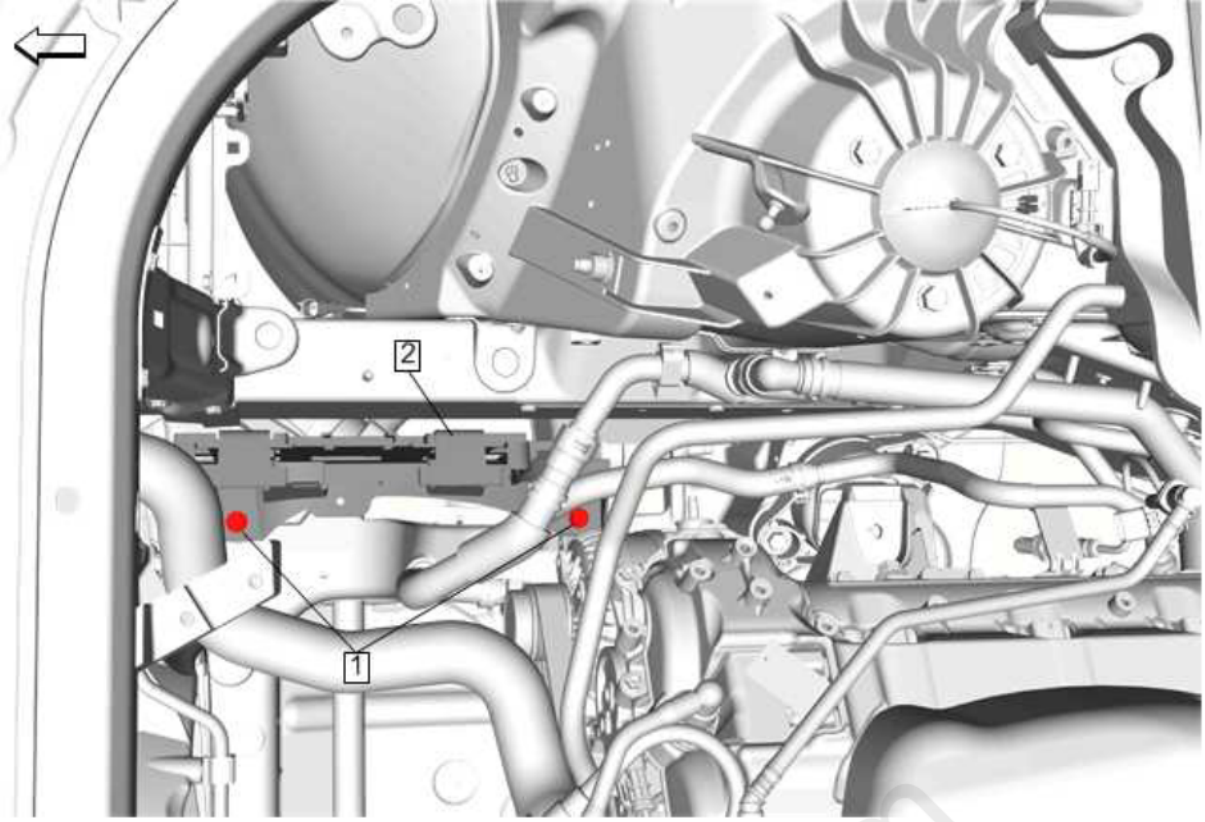

Fig. 12: Engine Control Module Bracket (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Engine Control Module Replacement (LGX)	
1	Engine Control Module Bracket Bolt [2x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 9 N.m (80 lb in)
2	Engine Control Module Bracket

ENGINE COOLANT TEMPERATURE SENSOR REPLACEMENT

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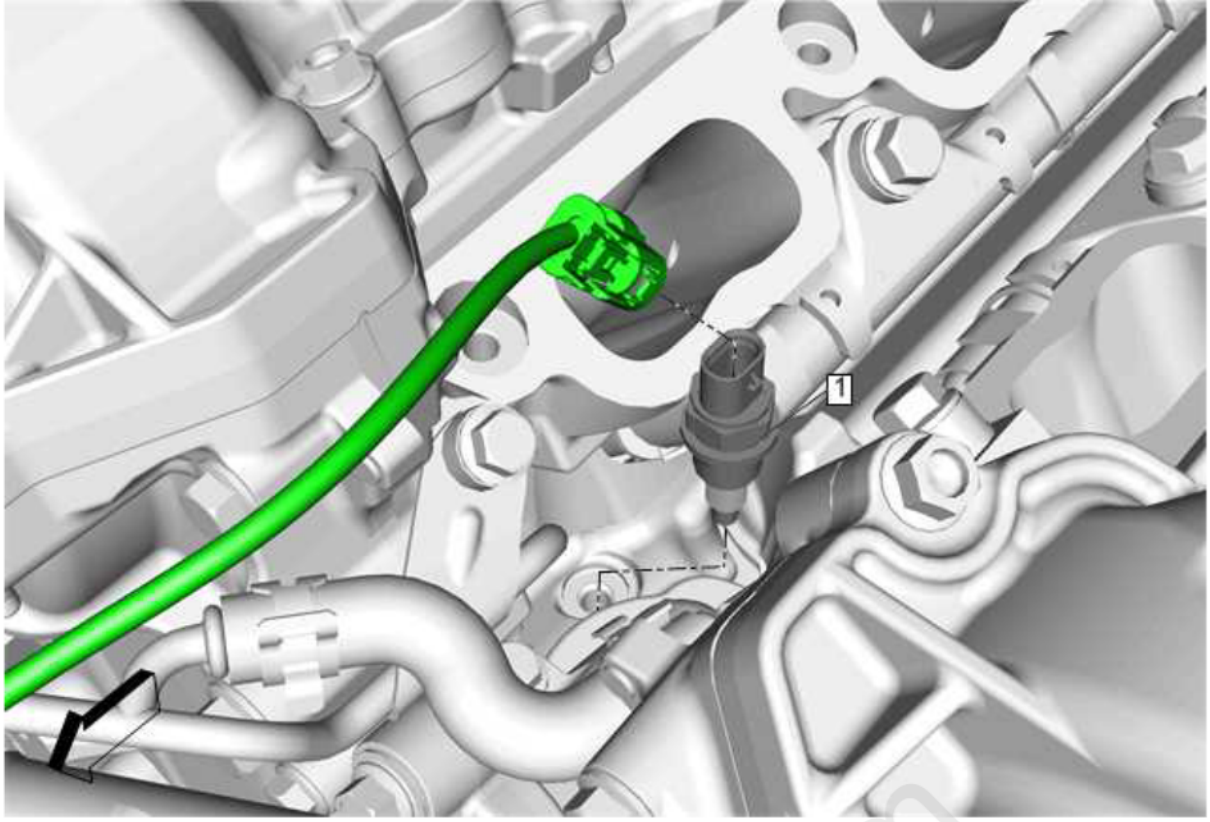

Fig. 13: Engine Coolant Temperature Sensor (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Cooling System Draining and Filling (Static without HP9) Cooling System Draining and Filling (GE 47716 without HP9) Cooling System Draining and Filling (Static LTG with HP9) Cooling System Draining and Filling (GE 47716 LTG with HP9) 2. Fuel Injection Fuel Rail Noise Shield Replacement 3. Engine Coolant Thermostat Housing Replacement (LGW, LGX)	
1	Engine Coolant Temperature Sensor **CAUTION:** **Refer to Component Fastener Tightening Caution .** **Procedure** Electrical Connector @ Engine Coolant Temperature SensorÂ» Remove **Tighten** 9 N.m (80 lb in)

MASS AIRFLOW SENSOR REPLACEMENT (LGW)

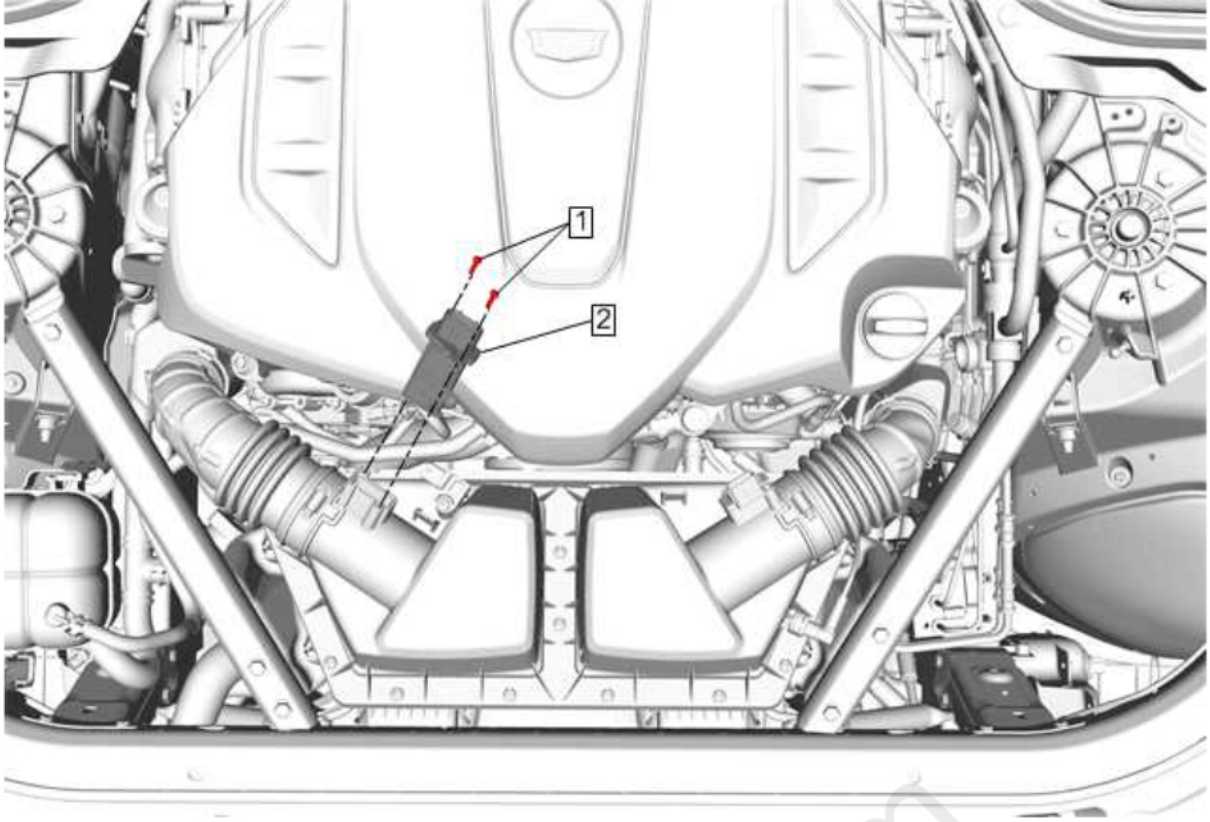

Fig. 14: Mass Airflow Sensor (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Mass Airflow Sensor Bolt [2x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 4 N.m (35 lb in)
2	Mass Airflow Sensor **Procedure** Disconnect the electrical connector.

MASS AIRFLOW SENSOR WITH INTAKE AIR TEMPERATURE SENSOR REPLACEMENT (LGW)

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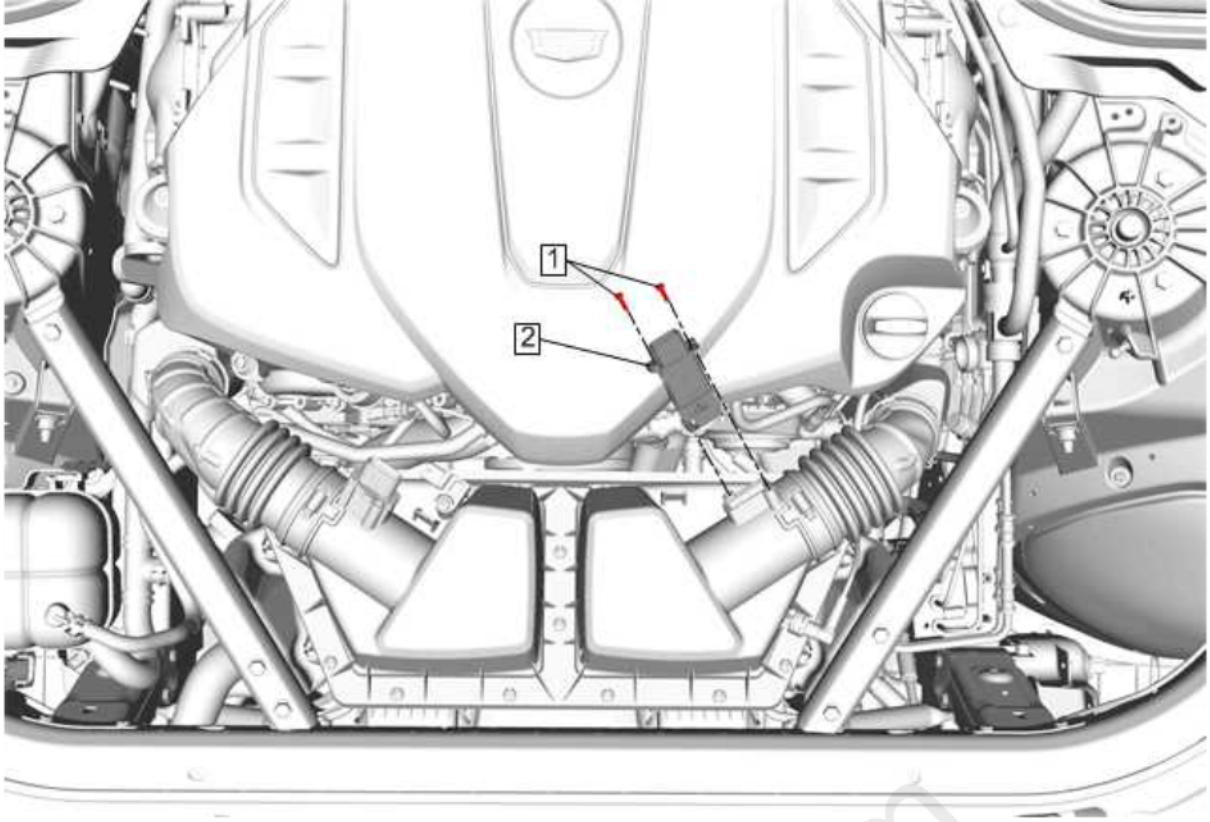

Fig. 15: Mass Airflow Sensor with Intake Air Temperature Sensor (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Mass Airflow Sensor with Intake Air Temperature Sensor Bolt [2x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 4 N.m (35 lb in)
2	Mass Airflow Sensor with Intake Air Temperature Sensor **Procedure** Disconnect the electrical connector.

MASS AIRFLOW SENSOR WITH INTAKE AIR TEMPERATURE SENSOR REPLACEMENT (LGX)

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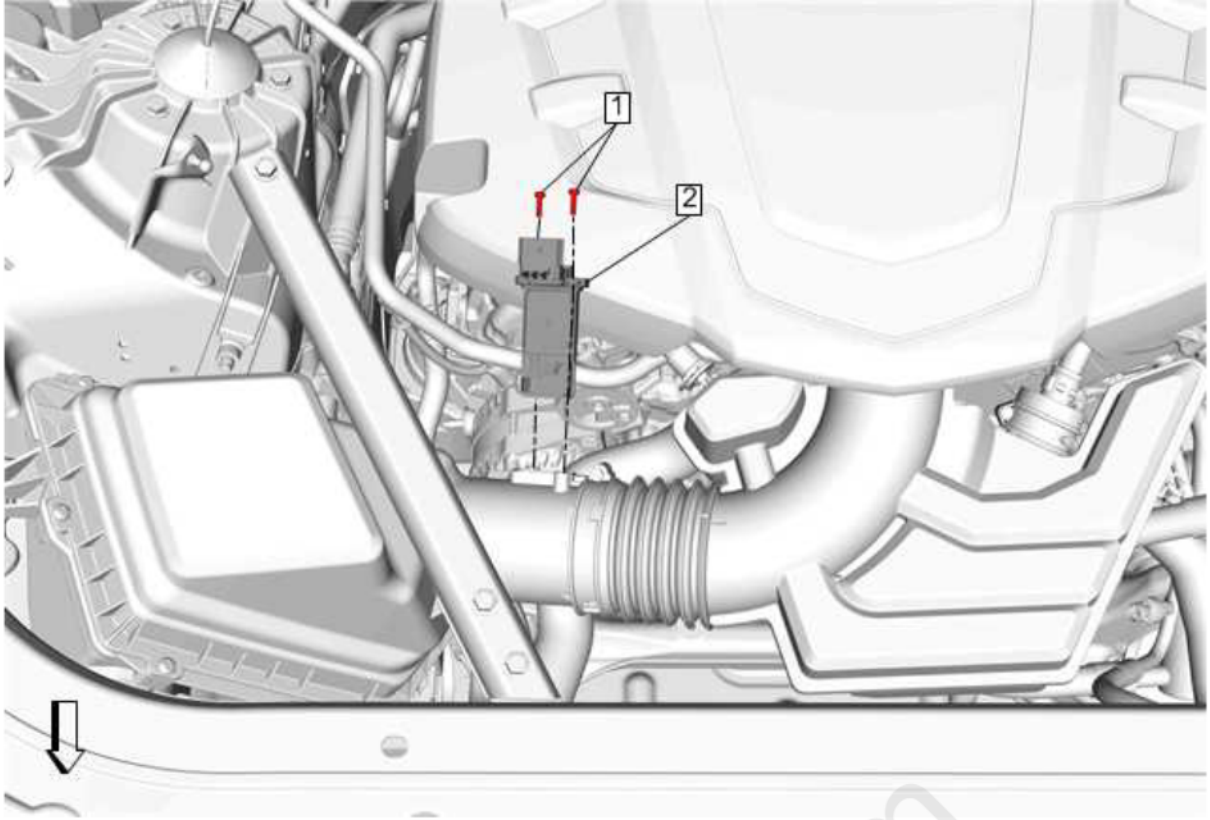

Fig. 16: Mass Airflow Sensor with Intake Air Temperature Sensor (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Mass Airflow Sensor Bolt [2x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 4 N.m (35 lb in)
2	Mass Airflow Sensor **Procedure** Disconnect the electrical connector.

MANIFOLD ABSOLUTE PRESSURE SENSOR REPLACEMENT (LGW)

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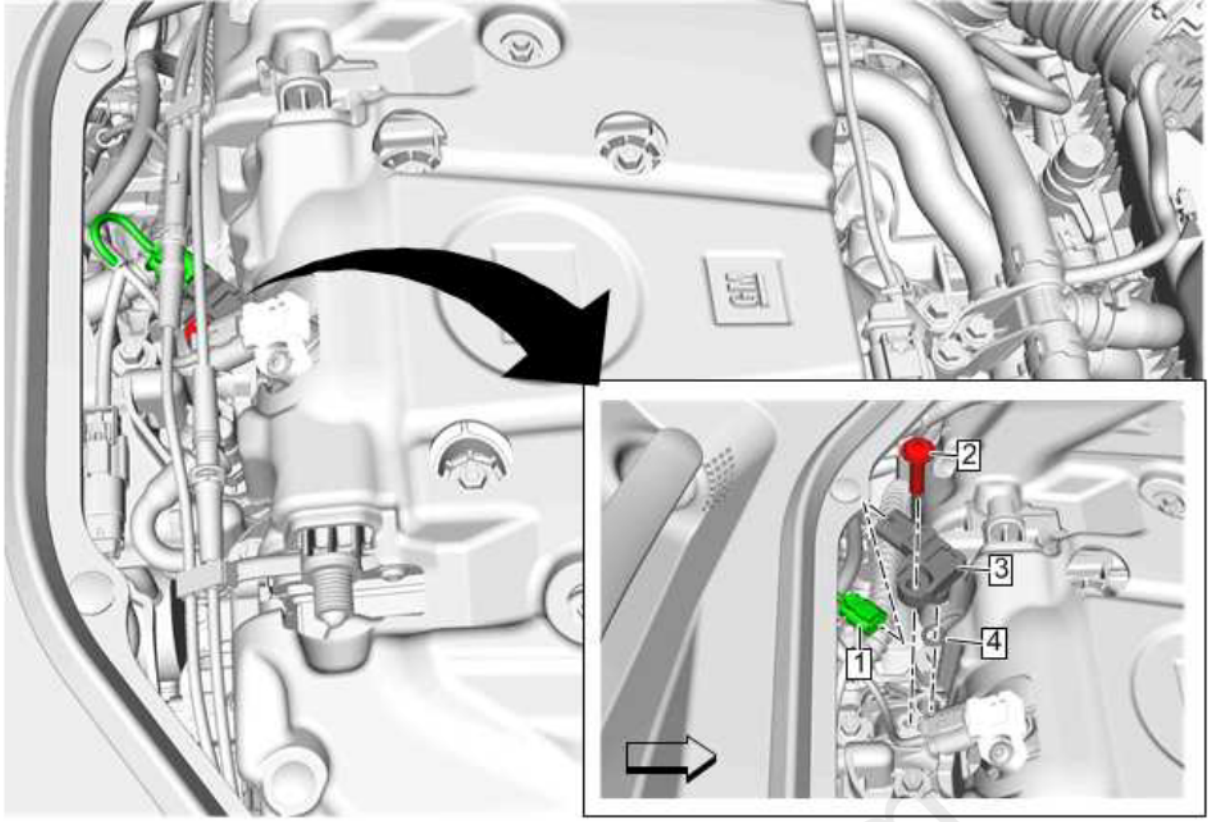

Fig. 17: Manifold Absolute Pressure Sensor (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Intake Manifold Cover Replacement (LGW)	
1	Electrical Connector
2	Manifold Absolute Pressure Sensor Fastener **CAUTION:** **Refer to Fastener Caution .** **Tighten:** 4 N.m (35 lb in)
3	Manifold Absolute Pressure Sensor
4	O-Ring **Procedure** Install a NEW O-ring seal.

MANIFOLD ABSOLUTE PRESSURE SENSOR REPLACEMENT (BARO)

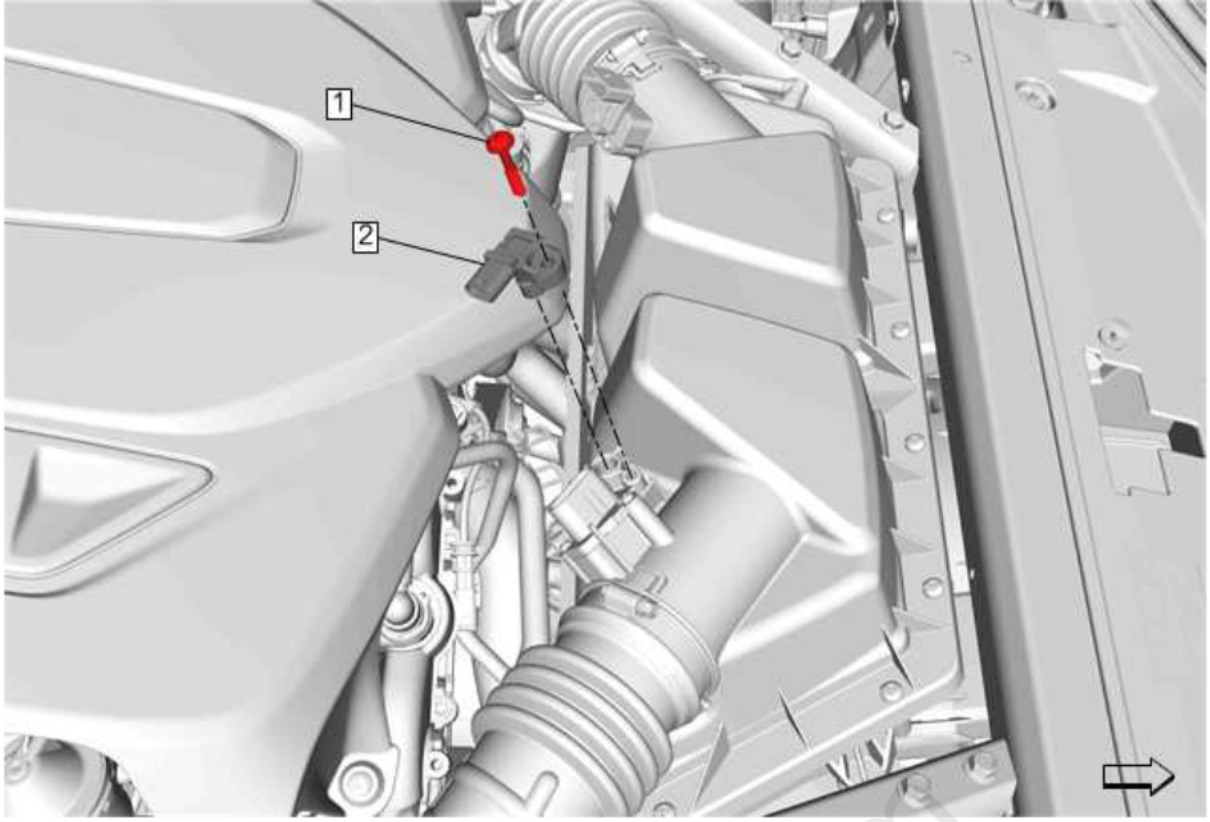

Fig. 18: Manifold Absolute Pressure Sensor (Baro)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Manifold Absolute Pressure Sensor Fastener **CAUTION:** **Refer to Fastener Caution .** **Tighten** 4 N.m (35 lb in)
2	Manifold Absolute Pressure Sensor **Procedure** Disconnect the electrical connector.

MANIFOLD ABSOLUTE PRESSURE SENSOR REPLACEMENT (LGX)

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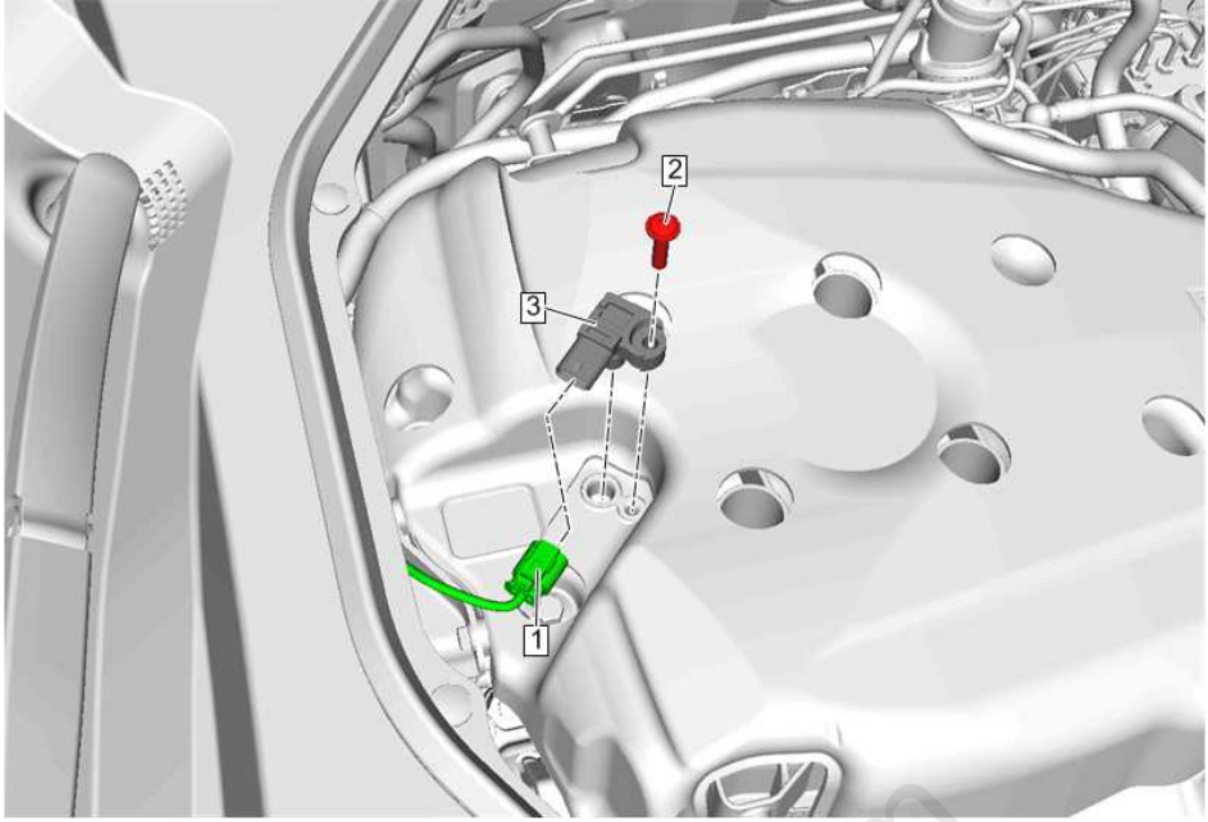

Fig. 19: Manifold Absolute Pressure Sensor (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Intake Manifold Cover Replacement (LGX)	
1	Electrical Connector
2	Manifold Absolute Pressure Sensor Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 7.3 N.m (65 lb in)
3	Manifold Absolute Pressure Sensor **NOTE:** **If re-using the manifold absolute pressure sensor, inspect the O-ring and replace as necessary.**

HEATED OXYGEN SENSOR REPLACEMENT - BANK 1 SENSOR 1 (LGW)

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Fig. 20: Heated Oxygen Sensor - Bank 1 Sensor 1 (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Warm Up Three-Way Catalytic Converter Replacement (Left, LGW) Warm Up Three-Way Catalytic Converter Replacement (Right, LGW)	

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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 .** **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 48Â°C (120Â°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. Refer to Adhesives, Fluids, Lubricants and Sealers .** **Tighten** 42 N.m (31 lb ft) **Special Tools** **J 39194** Oxygen Sensor Wrench For equivalent regional tools, refer to Special Tools (Diagnostic Tools) and/or Special Tools (Mechanical Tools) .

HEATED OXYGEN SENSOR REPLACEMENT - BANK 1 SENSOR 1 (LGX)

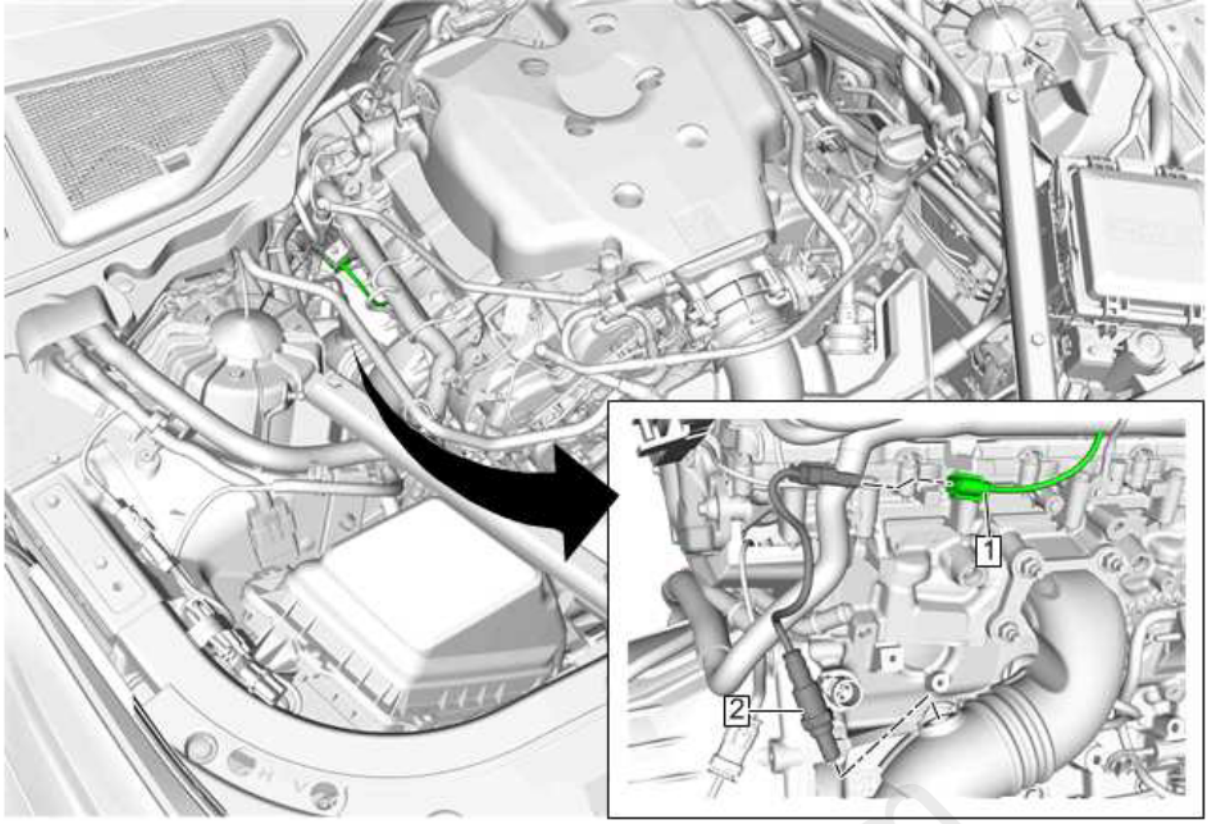

Fig. 21: Heated Oxygen Sensor - Bank 1 Sensor 1 (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure **Heater Water Bypass Inlet Hose Replacement (LGX)**	
1	Electrical Connector

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Callout	Component Name
2	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 .** **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 48Â°C (120Â°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 N.m (31 lb ft) **Special Tools** **J 39194** Oxygen Sensor Wrench Equivalent regional tools:**Special Tools (Diagnostic Tools)** **Special Tools (Mechanical Tools)**

HEATED OXYGEN SENSOR REPLACEMENT - BANK 1 SENSOR 2

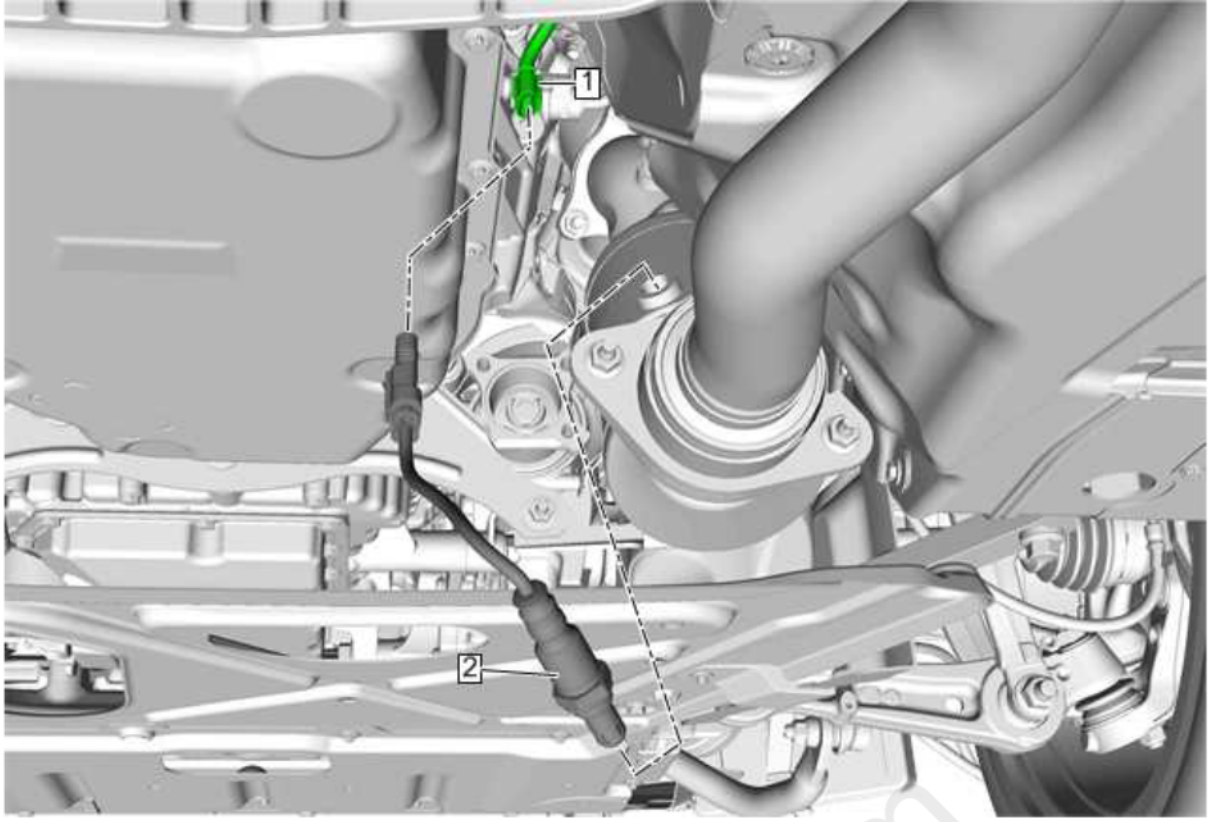

Fig. 22: Heated Oxygen Sensor - Bank 1 Sensor 2
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Electrical Connector

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Callout	Component Name
2	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 .** **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 48Â°C (120Â°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. Refer to Adhesives, Fluids, Lubricants and Sealers .** **Tighten** 42 N.m (31 lb ft) **Special Tools** **J 39194** Oxygen Sensor Wrench For equivalent regional tools, refer to **Special Tools** .

HEATED OXYGEN SENSOR REPLACEMENT - BANK 2 SENSOR 1 (LGW)

Fig. 23: Heated Oxygen Sensor - Bank 2 Sensor 1 (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Warm Up Three-Way Catalytic Converter Replacement (Left, LGW) Warm Up Three-Way Catalytic Converter Replacement (Right, LGW)	

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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 .** **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 48Â°C (120Â°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. Refer to Adhesives, Fluids, Lubricants and Sealers .** **Tighten** 42 N.m (31 lb ft) **Special Tools** **J 39194** Oxygen Sensor Wrench For equivalent regional tools, refer to Special Tools (Diagnostic Tools) and/or Special Tools (Mechanical Tools) .

HEATED OXYGEN SENSOR REPLACEMENT - BANK 2 SENSOR 1 (LGX)

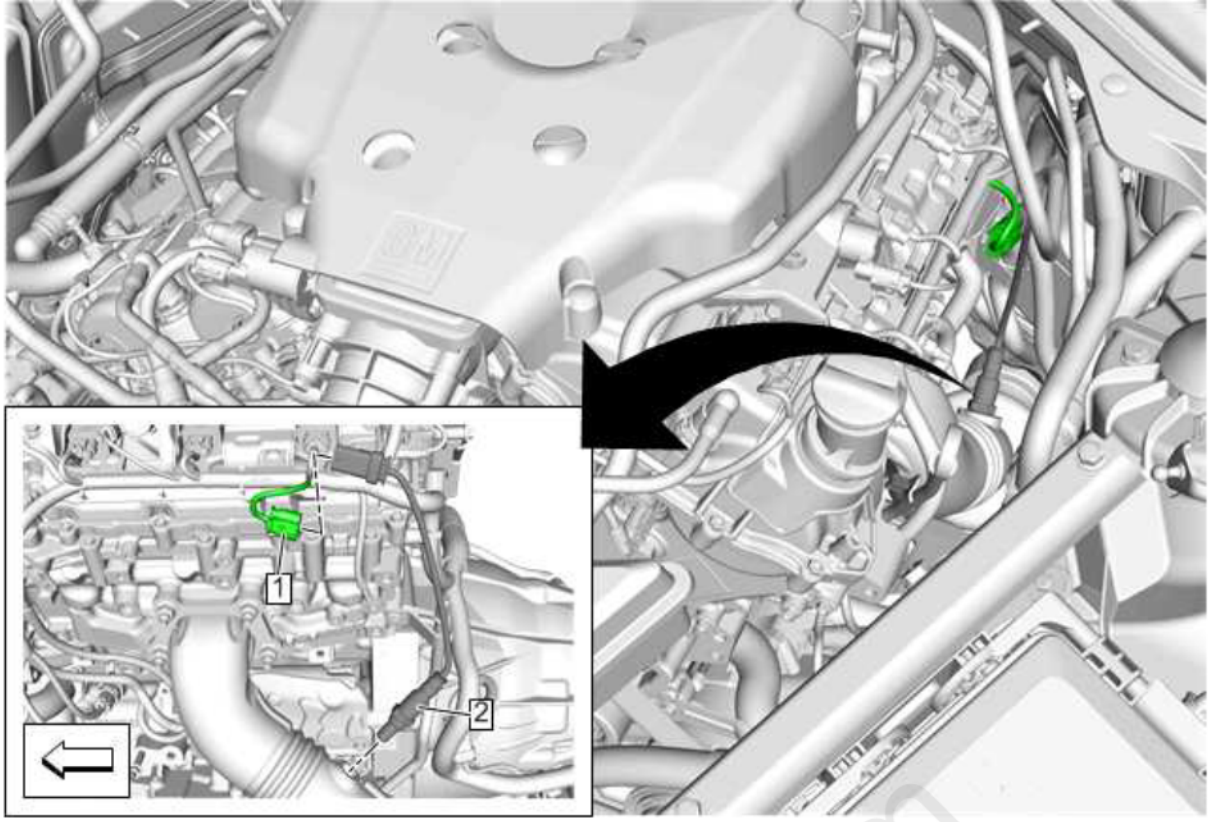

Fig. 24: Heated Oxygen Sensor - Bank 2 Sensor 1 (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Intake Manifold Cover Replacement (LGX)	
1	Electrical Connector

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Callout	Component Name
2	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 .** **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 48Â°C (120Â°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. Refer to Adhesives, Fluids, Lubricants and Sealers .** **Tighten** 42 N.m (31 lb ft) **Special Tools** **J 39194** Oxygen Sensor Wrench Equivalent regional tools: **Special Tools (Diagnostic Tools)** **Special Tools (Mechanical Tools)**

HEATED OXYGEN SENSOR REPLACEMENT - BANK 2 SENSOR 2

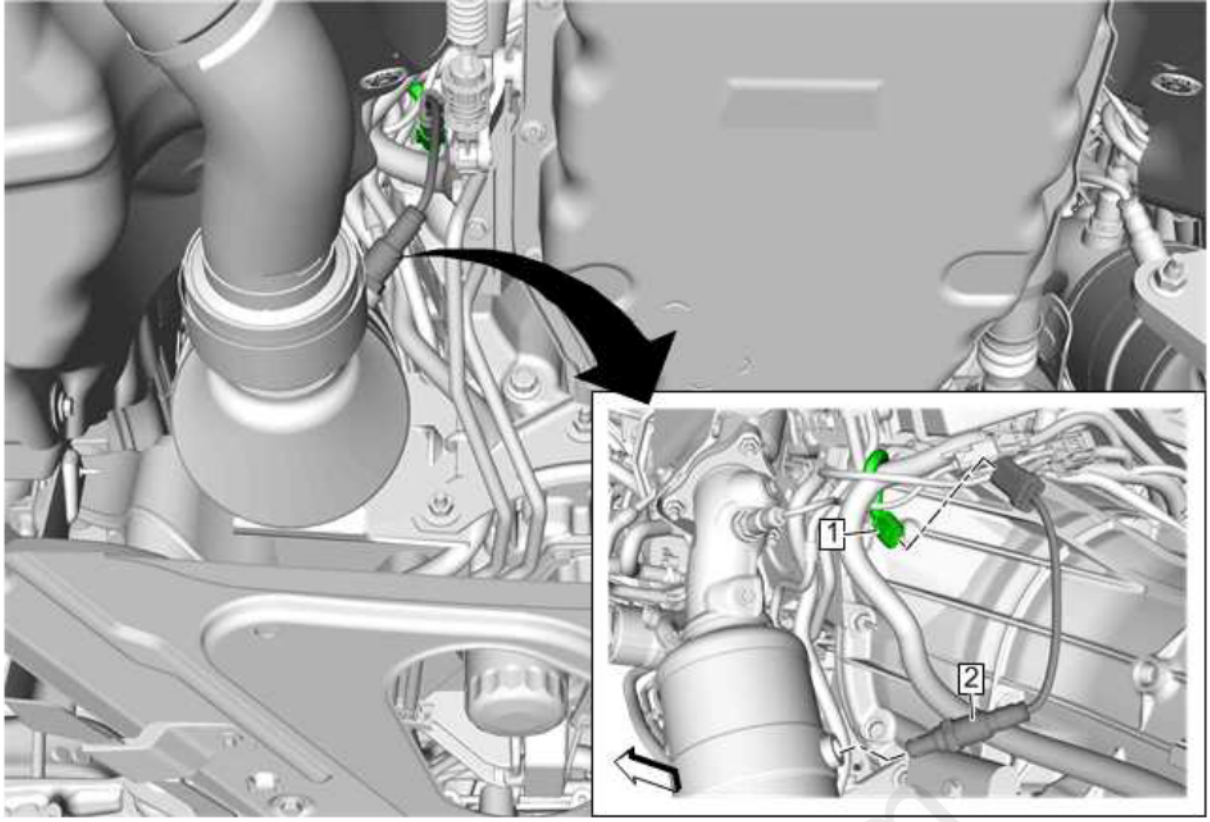

Fig. 25: Heated Oxygen Sensor - Bank 2 Sensor 2
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Electrical Connector

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Callout	Component Name
2	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 .** **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 48Â°C (120Â°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. Refer to Adhesives, Fluids, Lubricants and Sealers .** **Tighten** 42 N.m (31 lb ft) **Special Tools** **J 39194** Oxygen Sensor Wrench For equivalent regional tools, refer to Special Tools (Diagnostic Tools) and/or Special Tools (Mechanical Tools) .

ACCELERATOR PEDAL WITH POSITION SENSOR ASSEMBLY REPLACEMENT

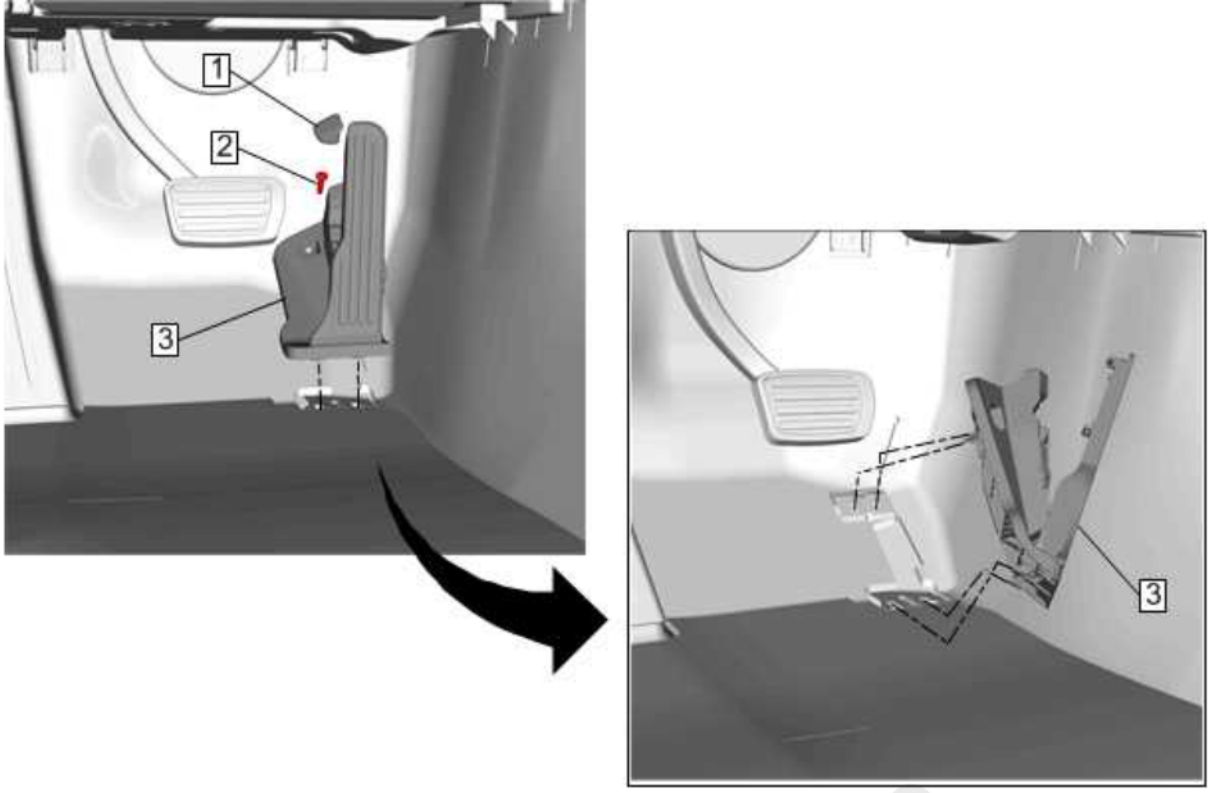

Fig. 26: Accelerator Pedal with Position Sensor Assembly
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Accelerator Pedal Position Sensor Cover
2	Accelerator Pedal Position Sensor Fastener **CAUTION:** **Refer to Fastener Caution .** **Tighten** 9 N.m (80 lb in)
3	Accelerator Pedal Position Sensor **Procedure** 1. Disconnect the connector from the accelerator pedal position sensor. 2. Tilt the top of the accelerator pedal position sensor rearward. 3. Slide the accelerator pedal position sensor back to disengage its lower retaining tabs.

THROTTLE BODY ASSEMBLY REPLACEMENT (LGW)

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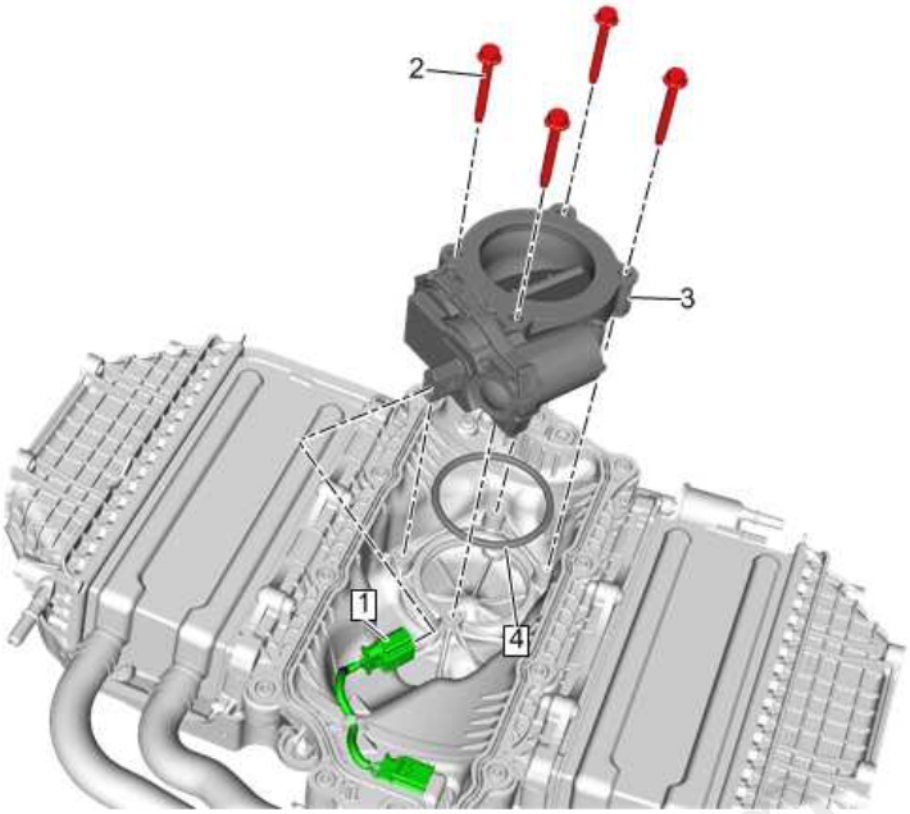

Fig. 27: Throttle Body Assembly (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Charge Air Cooler Cover Replacement	
1	Electrical Connector
2	Throttle Body Assembly Fastener [4x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
3	Throttle Body **NOTE:** **Clean any debris prior to removing the throttle body. Cover any openings to prevent debris from entering into the intake manifold.** **Procedure** After replacement is complete, perform the throttle learn procedure. Refer to Throttle Body Idle Air Flow Compensation Reset
4	Throttle Body Gasket **NOTE:** **Install a NEW throttle body gasket when installing the throttle body.**

THROTTLE BODY ASSEMBLY REPLACEMENT (LGX)

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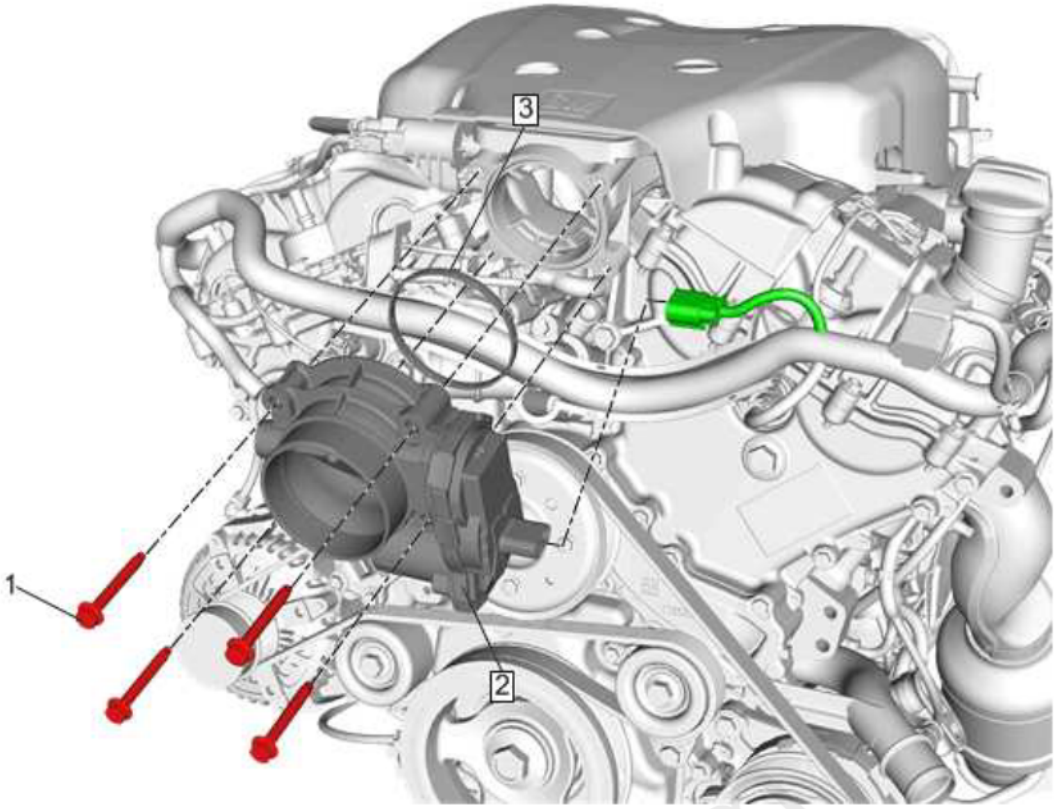

Fig. 28: Throttle Body Assembly (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Air Cleaner Outlet Duct Replacement (LGX)	
1	Throttle Body Assembly Fastener [4x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
2	Throttle Body **NOTE:** **Clean any debris prior to removing the throttle body. Cover any openings to prevent debris from entering into the intake manifold.** **Procedure** 1. Disconnect the electrical connector. 2. After replacement is complete, perform the throttle learn procedure. Refer to Throttle Body Idle Air Flow Compensation Reset
3	Throttle Body Gasket **NOTE:** **Install a NEW throttle body gasket when installing the throttle body.**

THROTTLE BODY INSPECTION AND CLEANING

1. Remove the air cleaner outlet duct. Refer to Air Cleaner Outlet Duct Replacement (LGX).

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2. Fully open the throttle valve in order to Inspect the throttle body bore and the throttle valve plate for any deposits.
3. Use a clean shop towel and Top Engine Cleaner GM P/N 1052626 or equivalent product in order to clean the throttle body bore and the throttle valve plate.

   If necessary, use a parts cleaning brush in order to remove heavy deposits.

CAUTION: **Do not subject a throttle body assembly which contains the following components to an immersion cleaner or a strong solvent:**

- **Throttle position (TP) sensor**
- **Idle air control (IAC) valve**
- **Sealed throttle shaft bearings**

The cleaners will damage the electric components or sensors.

The cleaners will damage some of these components that contain seals or O-rings.

Solvents can wash away or break down the grease used on non-serviceable throttle shaft bearings.

Never use a wire brush or scraper to clean the throttle body. A wire brush or sharp tools may damage the throttle body components.

Do not use a cleaner that contains methyl ethyl ketone. This extremely strong solvent may damage components and is not necessary for this type of cleaning.

4. Install the air cleaner outlet duct. Refer to **Air Cleaner Outlet Duct Replacement (LGX)**.
5. Perform the Throttle/Idle Learn procedure. Refer to **Throttle Body Idle Air Flow Compensation Reset**.

FUEL PRESSURE RELIEF

WARNING: **Fuel that flows out at high pressure can cause serious injury to the skin and eyes. ALWAYS depressurize the fuel system before removing components that are under high fuel pressure.**

WARNING: **Remove the fuel tank cap and relieve the fuel system pressure before servicing the fuel system in order to reduce the risk of personal injury. After you relieve the fuel system pressure, a small amount of fuel may be released when servicing the fuel lines, the fuel injection pump or the connections. In order to reduce the risk of personal injury, cover the fuel system components with a shop towel before disconnection. This will catch any fuel that may leak out. Place the towel in an approved container when the disconnection is complete.**

Scan Tool Method - Preferred

1. Install a scan tool and turn the ignition ON.
2. Using the scan tool, command the fuel pump OFF allowing the low pressure fuel pump to shut off.
3. Start the vehicle and allow the engine to idle until the engine stops. The engine will stop in approximately 5-20 seconds.
4. Repeat step 3. Using the scan tool, verify pressure has dropped to a minimal level.
5. Turn the ignition OFF.

Alternate Method - If a scan tool is not available

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1. Disable the fuel pump by removing the B+ fuel pump control module fuse. Refer to **Electrical Center Identification Views** and/or **Electrical Center Identification Views** .
2. Start the vehicle and allow the engine to idle until the engine stops. The engine will stop in approximately 5-20 seconds.
3. Attempt to restart the vehicle to ensure pressure has dropped to a minimal level.
4. Turn the ignition OFF.

FUEL PRESSURE GAUGE INSTALLATION AND REMOVAL

Special Tools

- **CH-47831** Fuel Line Disconnect Tool
- **CH-37287-1A** Fuel Pressure Gauge Adapter 3/8"
- **CH-42982** Fuel Pressure Gauge Adapter

Equivalent regional tools:**Special Tools (Diagnostic Tools)** **Special Tools (Mechanical Tools)**

Installation Procedure

WARNING: **Fuel/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 system pressure. Refer to **Fuel Pressure Relief**
2. Disconnect the quick connect coupling of the fuel feed hose from the fuel feed pipe of the fuel rail. Use a shop towel in order to catch any remaining fuel that may leak.
3. Install the **CH-42982** adapter (2) between the fuel feed pipe of the fuel rail and of the fuel feed hose.
4. Install the **CH-37287-1A** gauge (1) to the **CH-42982** adapter (2) and tighten securely.

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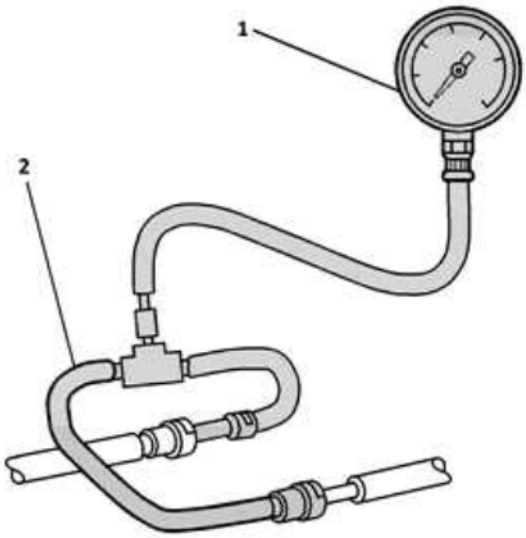

Fig. 29: Gauge And Adapter
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Component Fastener Tightening Caution .**

5. Turn ON the ignition in order to pressurize the fuel system.
6. Turn OFF the ignition.
7. Check for any fuel leaks.

Removal Procedure

1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief**

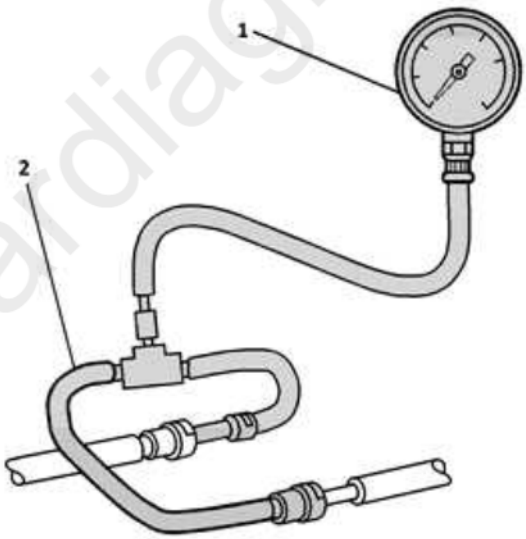

Fig. 30: Gauge And Adapter
Courtesy of GENERAL MOTORS COMPANY

2. Remove the **CH-37287-1A** gauge (1) from the **CH-42982** adapter (2).
3. Using the **CH-47831** tool, disconnect the quick connect coupling of the **CH-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 from the **CH-42982** adapter (2) 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 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.

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METAL COLLAR QUICK CONNECT FITTING SERVICE

Special Tools

- **CH-41769** Fuel Line Disconnect Tool Set
- **CH-44581** Fuel Line Disconnect Tool

Equivalent regional tools: **Special Tools (Diagnostic Tools)** **Special Tools (Mechanical Tools)**

Removal Procedure

1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief**

   WARNING: **Refer to Gasoline/Gasoline Vapors Warning .**

2. Remove the retainer from the quick connect fitting.

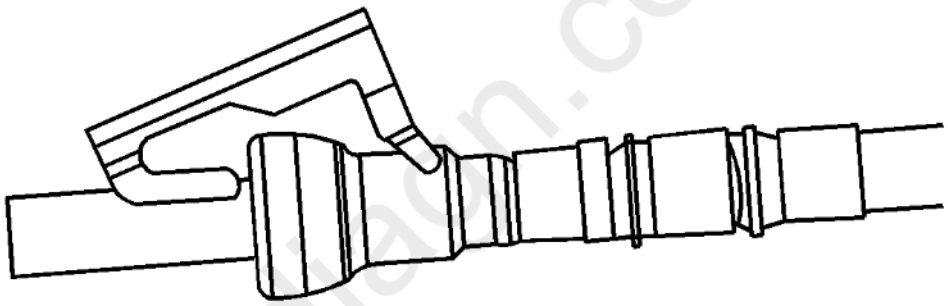

Fig. 31: View Of Quick-Connect Fitting Retainer
Courtesy of GENERAL MOTORS COMPANY

3. Blow dirt out of the fitting using compressed air.

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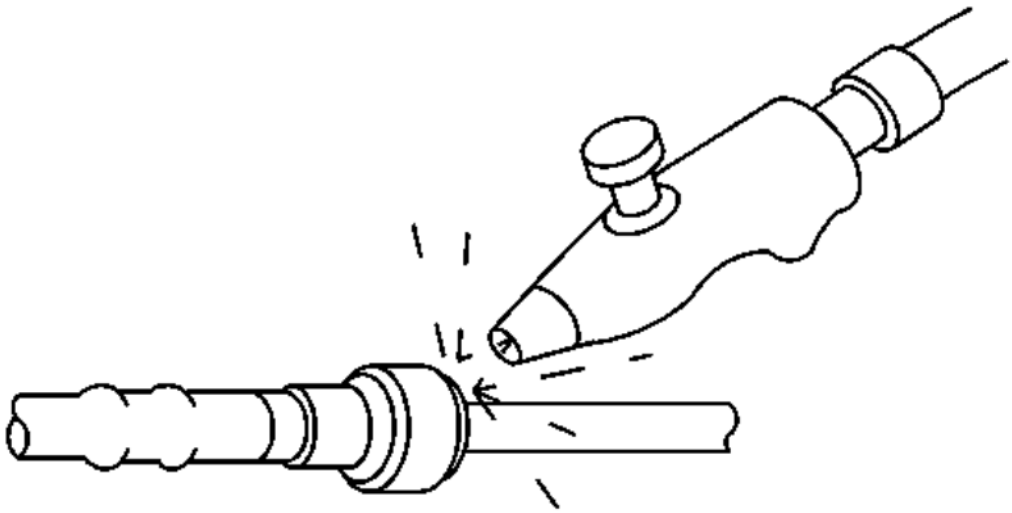

Fig. 32: Blowing Dirt Out Of Fitting (Metal Collar)
Courtesy of GENERAL MOTORS COMPANY

WARNING: **Wear safety glasses when using compressed air, as flying dirt particles may cause eye injury.**

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.

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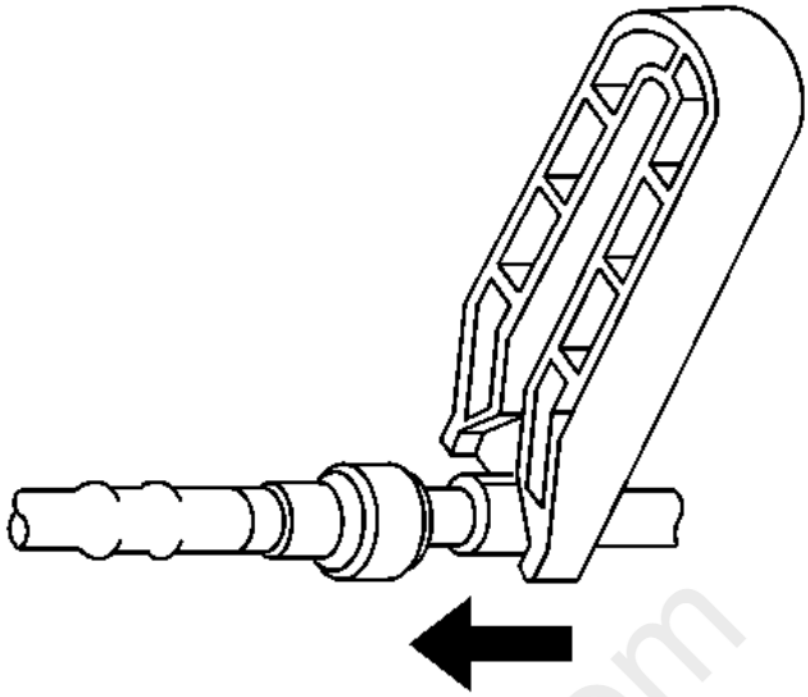

Fig. 33: View Of Quick Connect Locking Tabs (Metal Collar)
Courtesy of GENERAL MOTORS COMPANY

5. Pull the connection apart.

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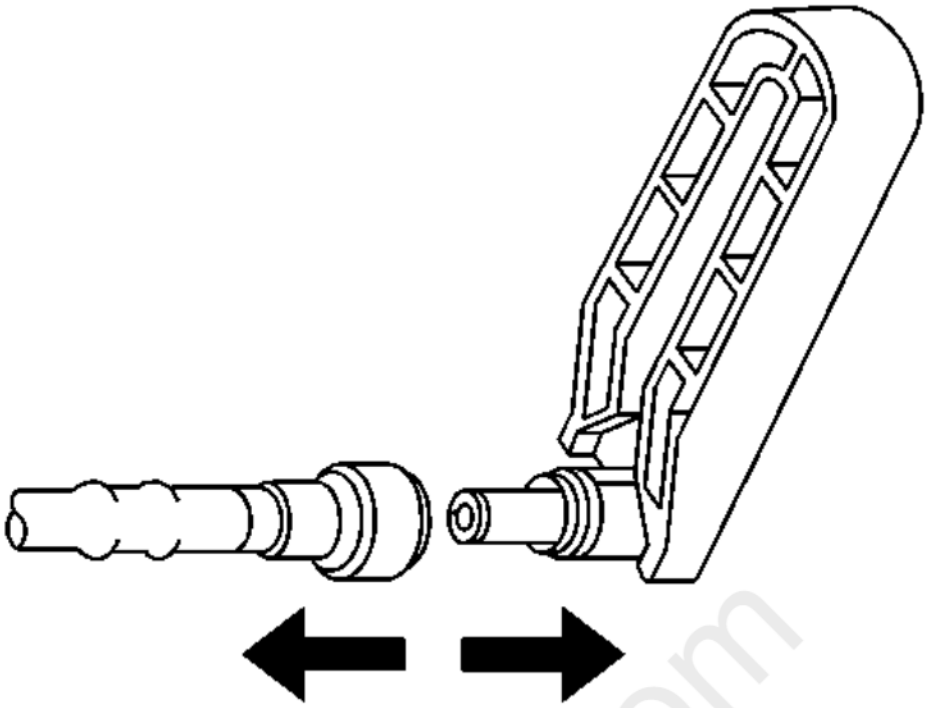

Fig. 34: View Of Quick Connect Locking Tabs (Metal Collar)
Courtesy of GENERAL MOTORS COMPANY

6. Using a clean shop towel, wipe off the male pipe end.

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.**

7. Inspect both ends of the fitting for dirt and burrs.
8. Clean or replace the components as required.

Installation Procedure

1. Apply a few drops of clean engine oil to the male pipe end.

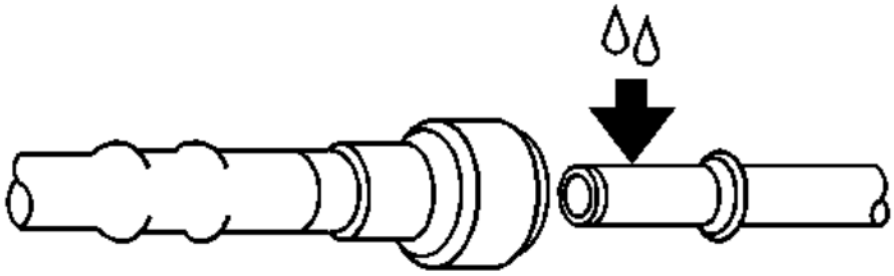

Fig. 35: Oiling Male Pipe Ends (Metal Collar)
Courtesy of GENERAL MOTORS COMPANY

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.

2. Push both sides of the quick-connect fitting together to cause the retaining tabs to snap into place.

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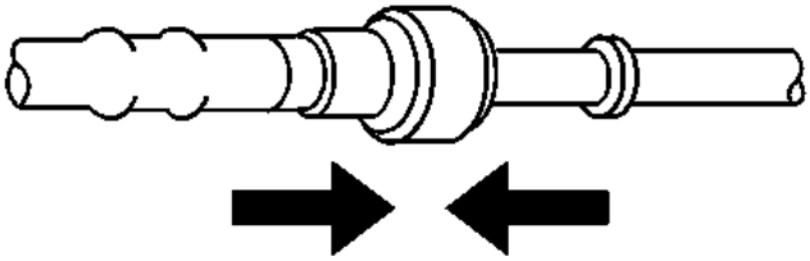

Fig. 36: View Of Connectors (Metal Collar)
Courtesy of GENERAL MOTORS COMPANY

3. Pull on both sides of the quick-connect fitting to make sure the connection is secure.

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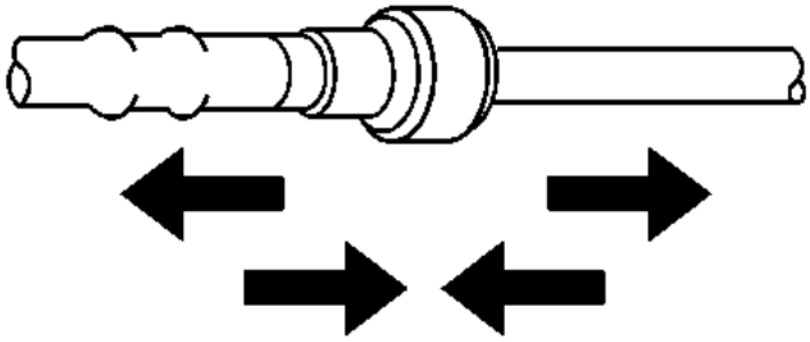

Fig. 37: Ensuring Connection (Metal Collar) Is Secure
Courtesy of GENERAL MOTORS COMPANY

4. Install the retainer to the quick-connect fitting.

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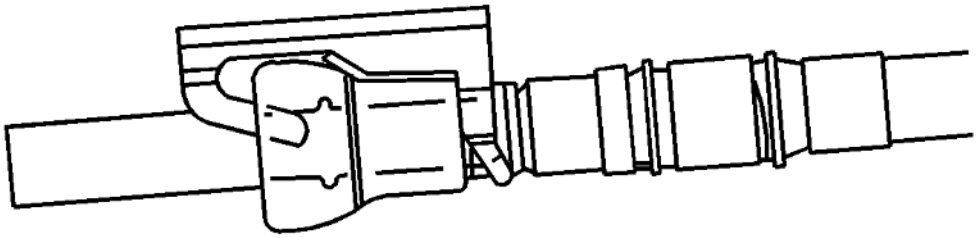

Fig. 38: View Of Fuel Pipe Retainer
Courtesy of GENERAL MOTORS COMPANY

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.

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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.

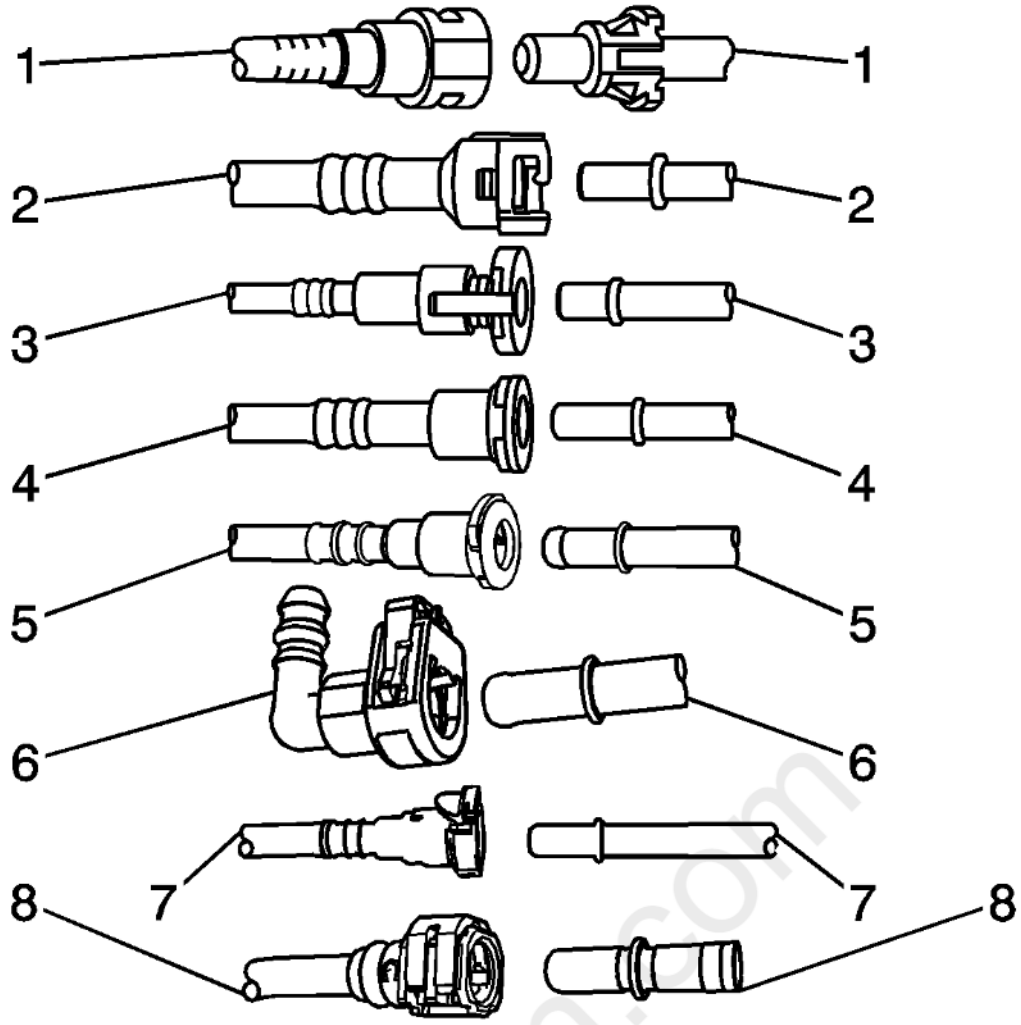

Fig. 39: Plastic Collar Quick Connect Fitting Service
Courtesy of GENERAL MOTORS COMPANY

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)**
- **TI 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.

1. Using compressed air, blow any dirt out of the quick-connect fitting.

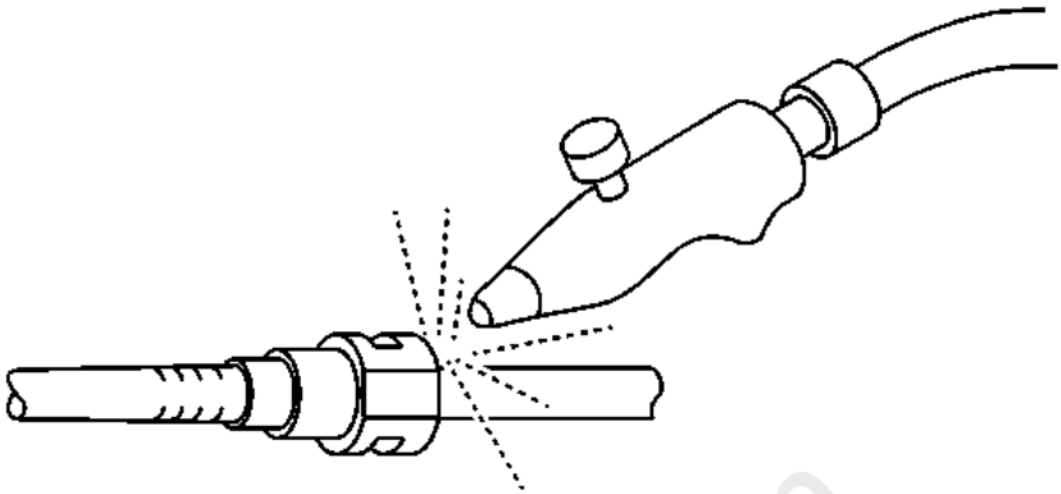

Fig. 40: Blowing Dirt Out Of Fitting (Plastic Collar)
Courtesy of GENERAL MOTORS COMPANY

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.**

2. This step applies to Bartholomew style connectors ONLY. Squeeze the plastic quick-connect fitting release tabs.

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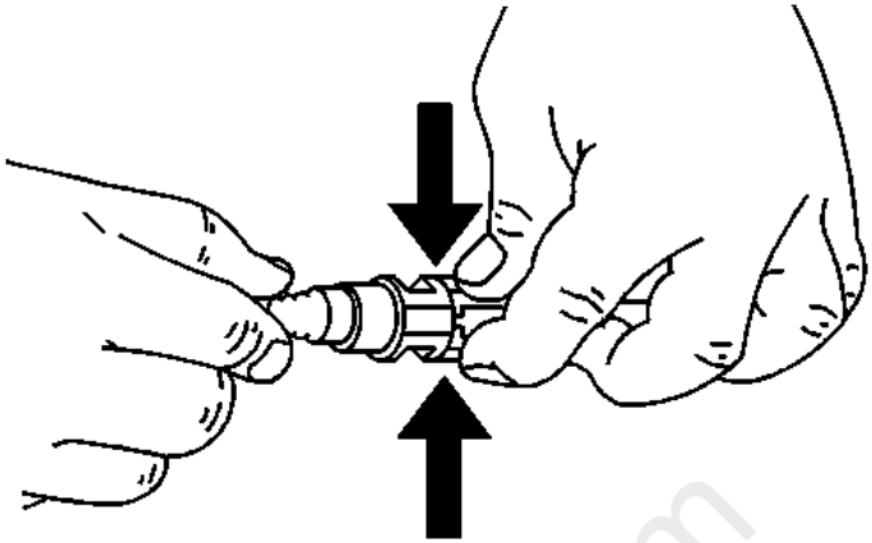

Fig. 41: View Of Quick Connect Fitting Release Tabs (Plastic Collar)
Courtesy of GENERAL MOTORS COMPANY

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.

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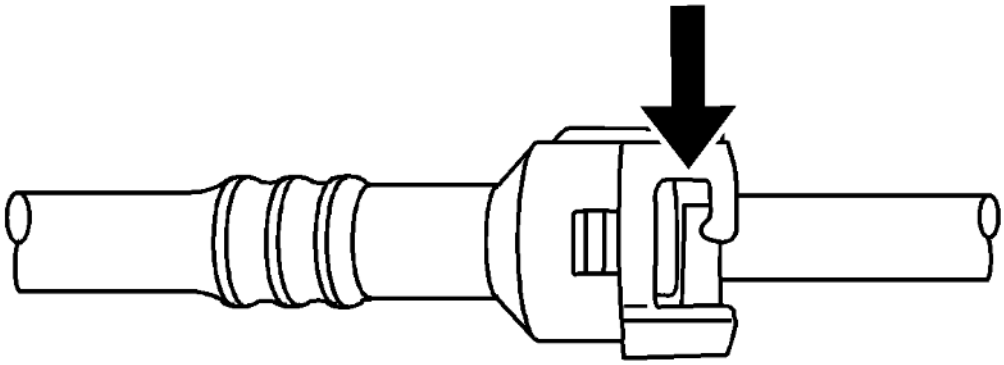

Fig. 42: Releasing Q Release Style Connectors (Plastic Collar)
Courtesy of GENERAL MOTORS COMPANY

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.

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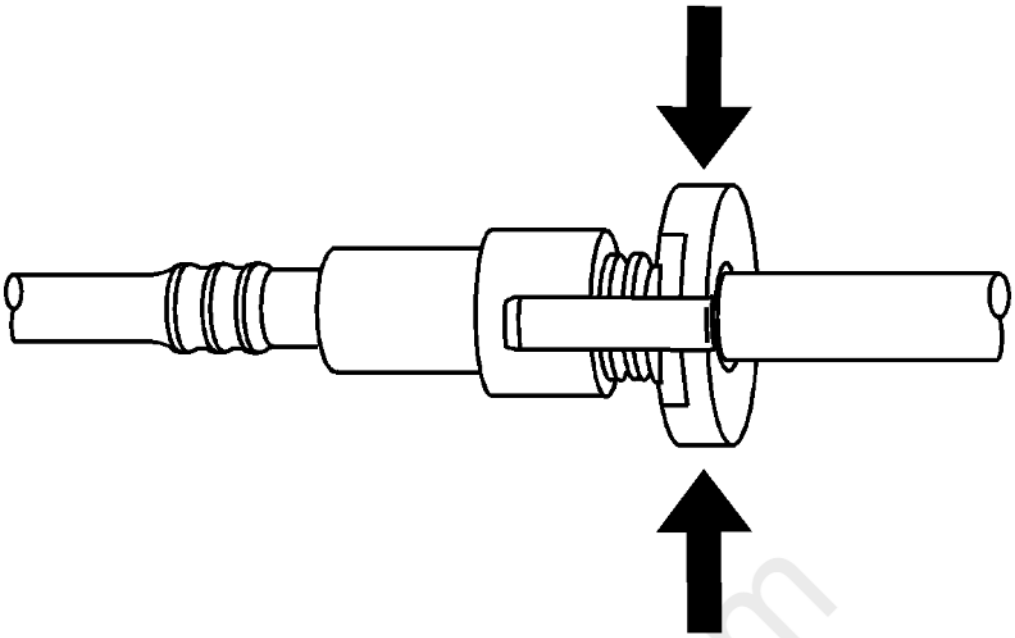

Fig. 43: Disengaging Quick Connect Fitting (Plastic Collar)
Courtesy of GENERAL MOTORS COMPANY

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.

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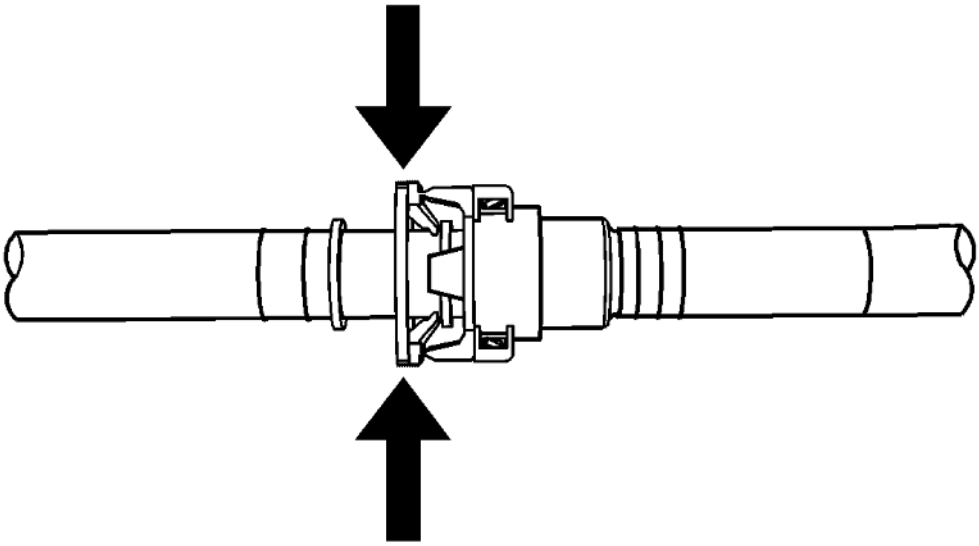

Fig. 44: Pushing In Male Side Of Connector
Courtesy of GENERAL MOTORS COMPANY

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. 45: Variants Of Sliding Retainer Style Connectors
Courtesy of GENERAL MOTORS COMPANY

NOTE: **There are two variants of sliding retainer style connectors shown above, both have the same release and installation procedure.**

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.

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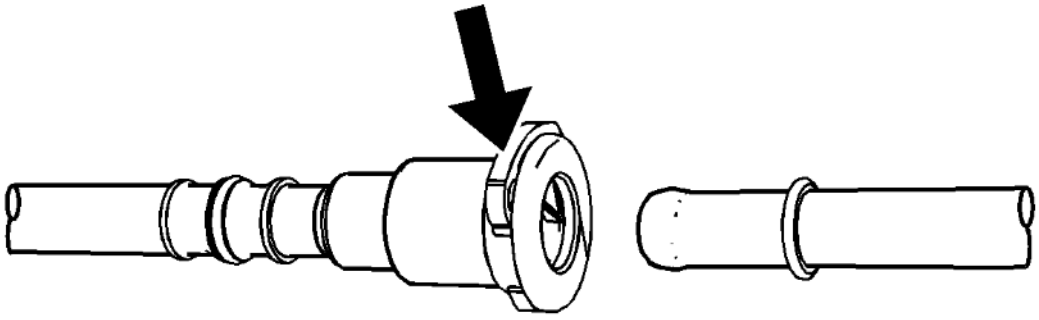

Fig. 46: Global Connector Style
Courtesy of GENERAL MOTORS COMPANY

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.

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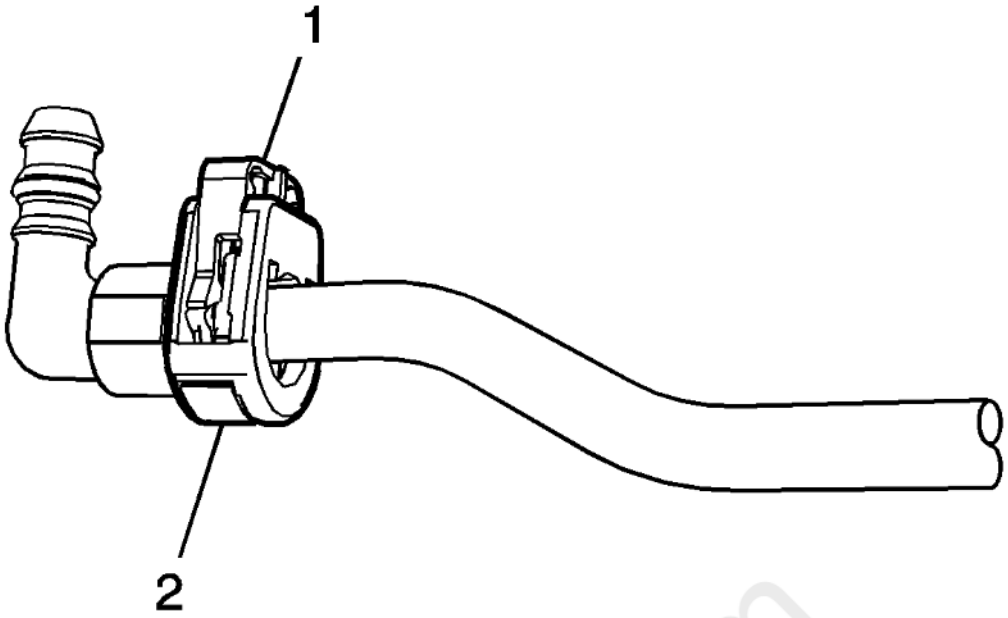

Fig. 47: TI Loc Style
Courtesy of GENERAL MOTORS COMPANY

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.

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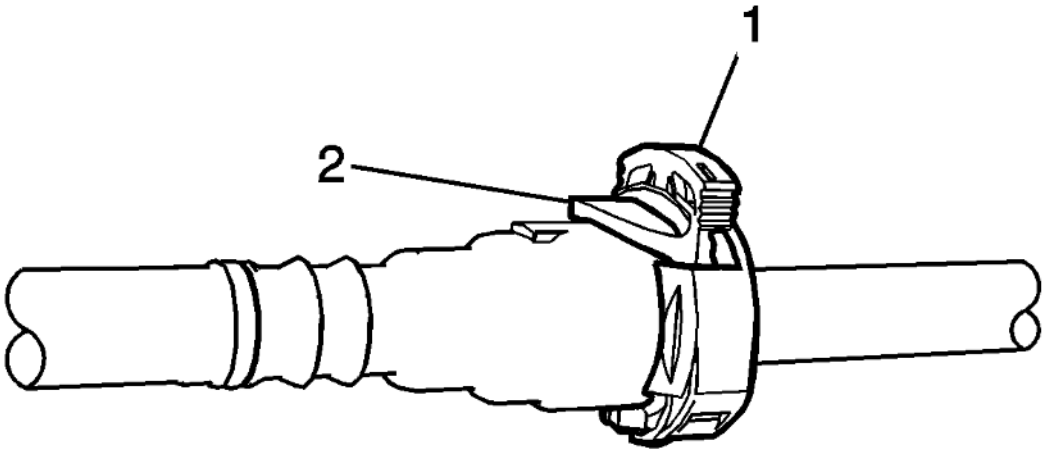

Fig. 48: Safe Lock Style
Courtesy of GENERAL MOTORS COMPANY

WARNING: **Refer to Relieving Fuel Pressure Warning .**

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.

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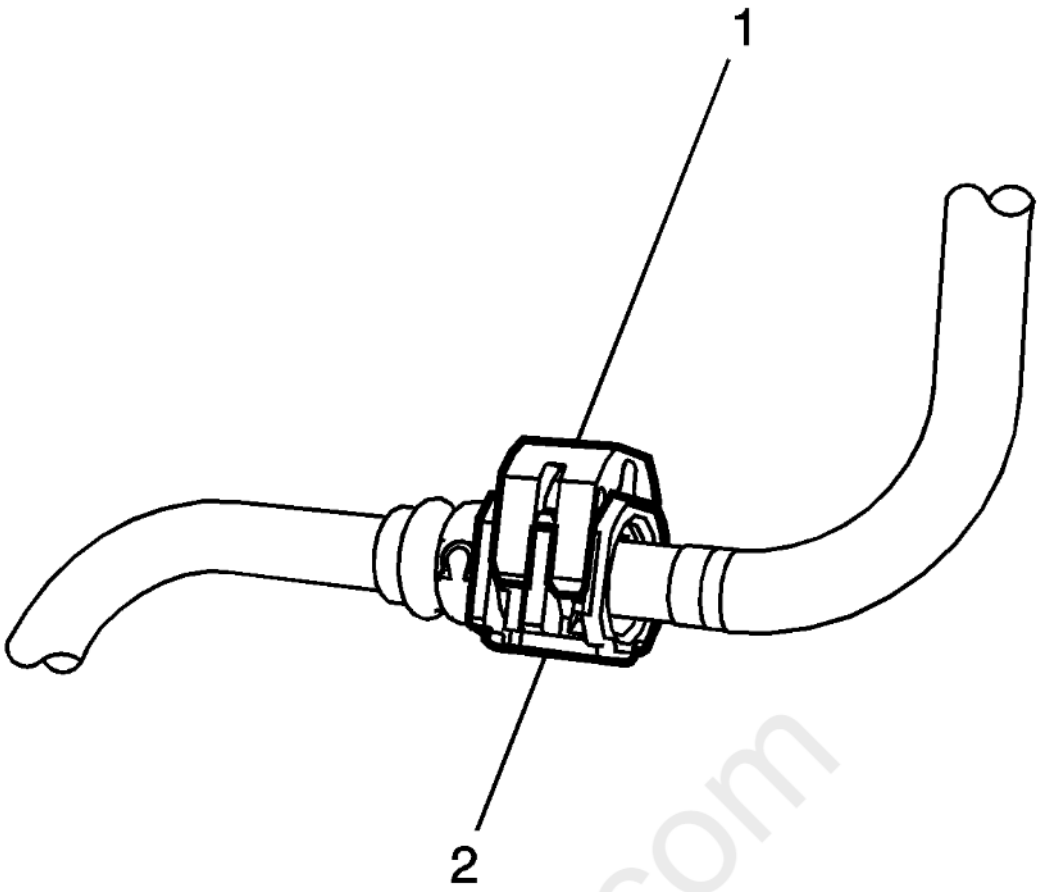

Fig. 49: Latch And Connector Straight Out
Courtesy of GENERAL MOTORS COMPANY

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

1. Apply a few drops of clean engine oil to the male pipe end.

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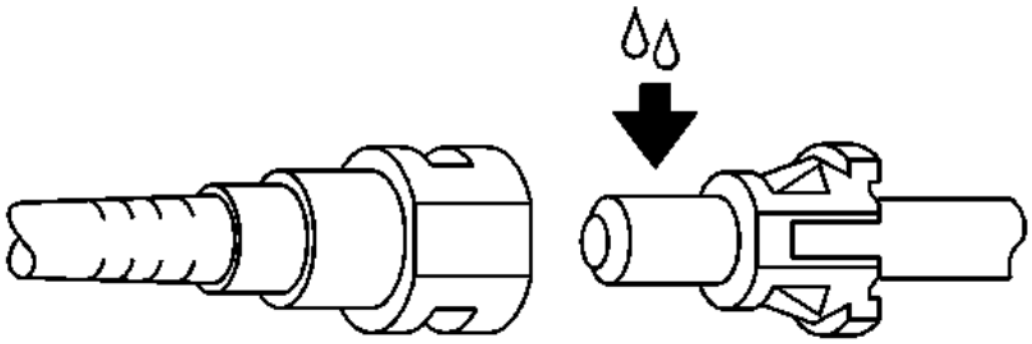

Fig. 50: Lubricating Male Pipe End
Courtesy of GENERAL MOTORS COMPANY

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.**

2. Push both sides of the quick-connect fitting together in order to cause the retaining feature to snap into place.

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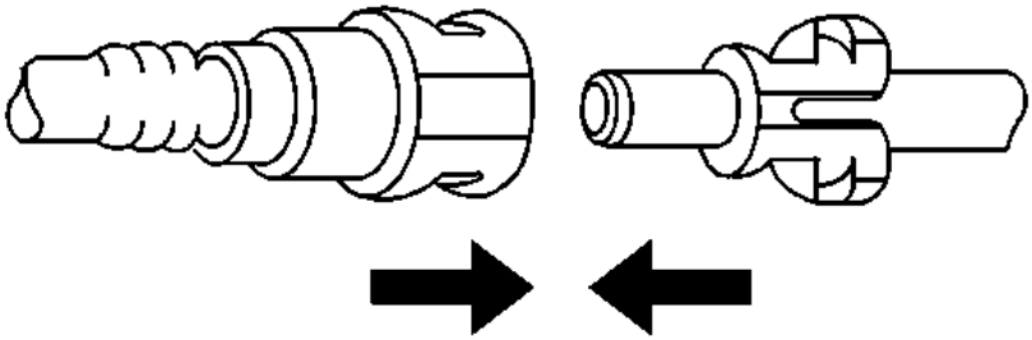

Fig. 51: Connecting Quick-Connect Fittings
Courtesy of GENERAL MOTORS COMPANY

3. Pull on both sides of the quick-connect fitting to make sure the connection is secure.

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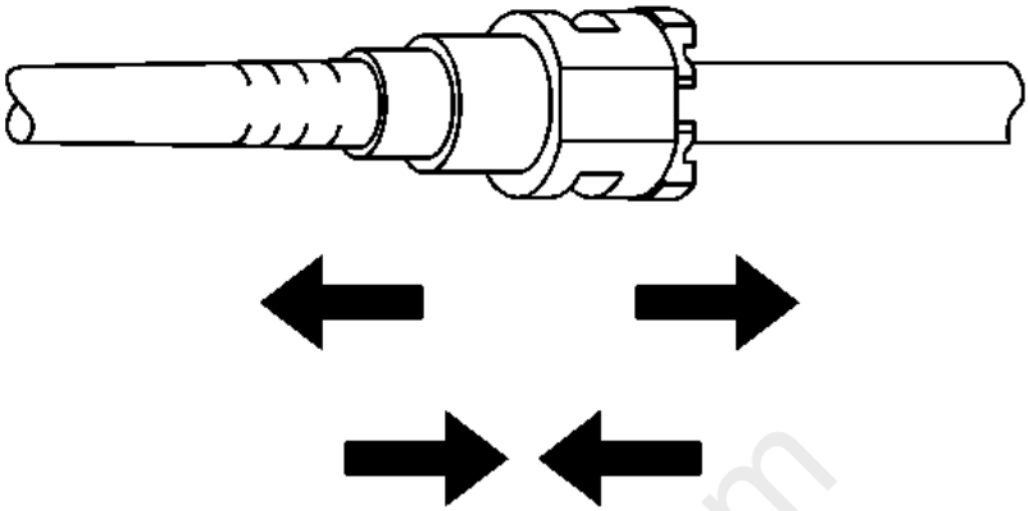

Fig. 52: View Of Quick-Connect Fitting
Courtesy of GENERAL MOTORS COMPANY

4. Insert the tube in the connector until the retainer snaps in place.

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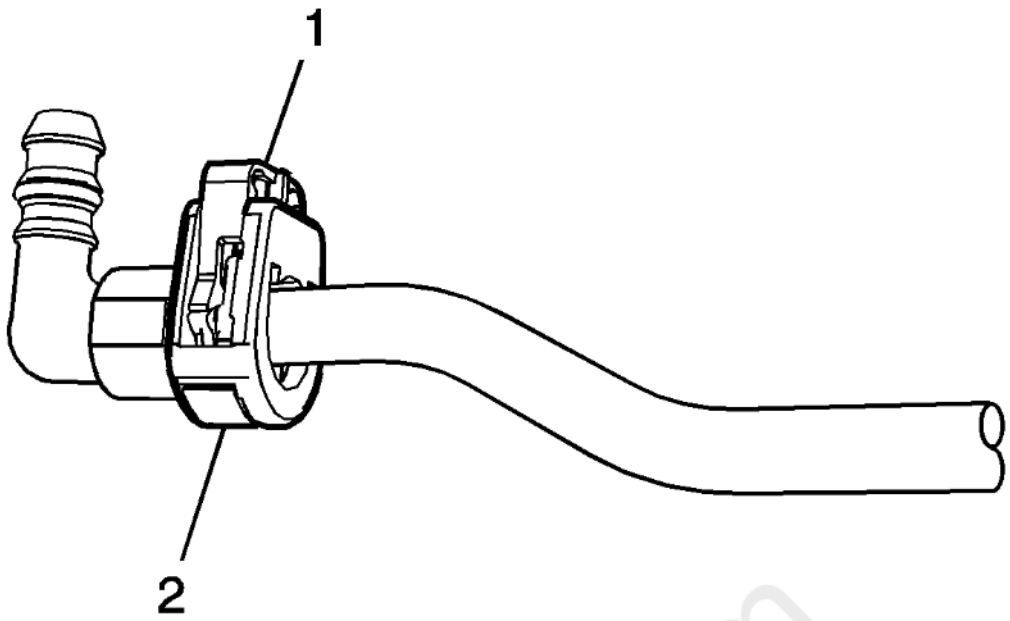

Fig. 53: TI Loc Style
Courtesy of GENERAL MOTORS COMPANY

5. Push down on the redundant latch (1) until it is fully engaged and snapped into position.
6. Insert the tube in the connector until the retainer snaps in place.

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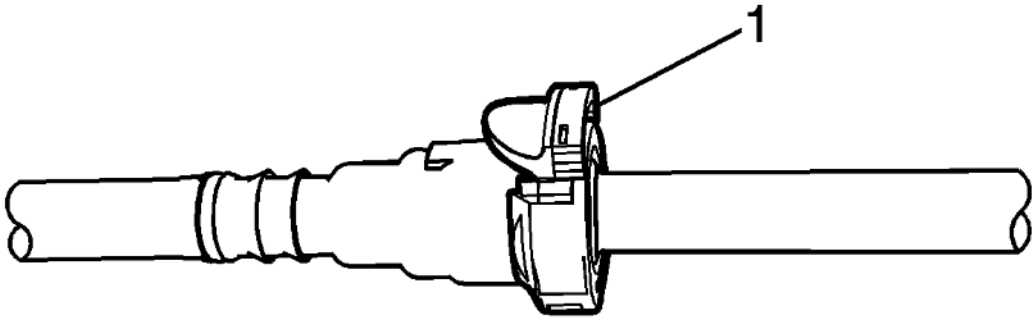

Fig. 54: Redundant Latch
Courtesy of GENERAL MOTORS COMPANY

7. Push down on the second latch (1) in order to secure the connection.
8. For the plastic connector type 8, depress the latch (1) while inserting the connector (3) on to the pipe (2).

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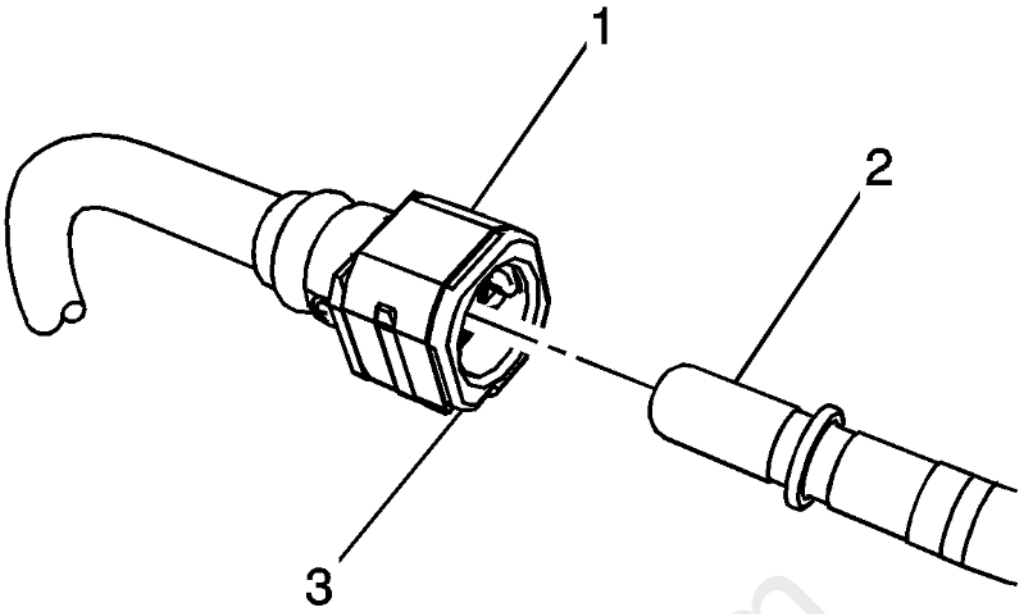

Fig. 55: Latch And Connector
Courtesy of GENERAL MOTORS COMPANY

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 Tool

- **CH 45004** Fuel Tank Drain Hose
- **CH 44284-2** Fuel Flapper Door Holder

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. Insert the **CH 44284-2** Fuel Flapper Door Holder prior to inserting the drain hose.

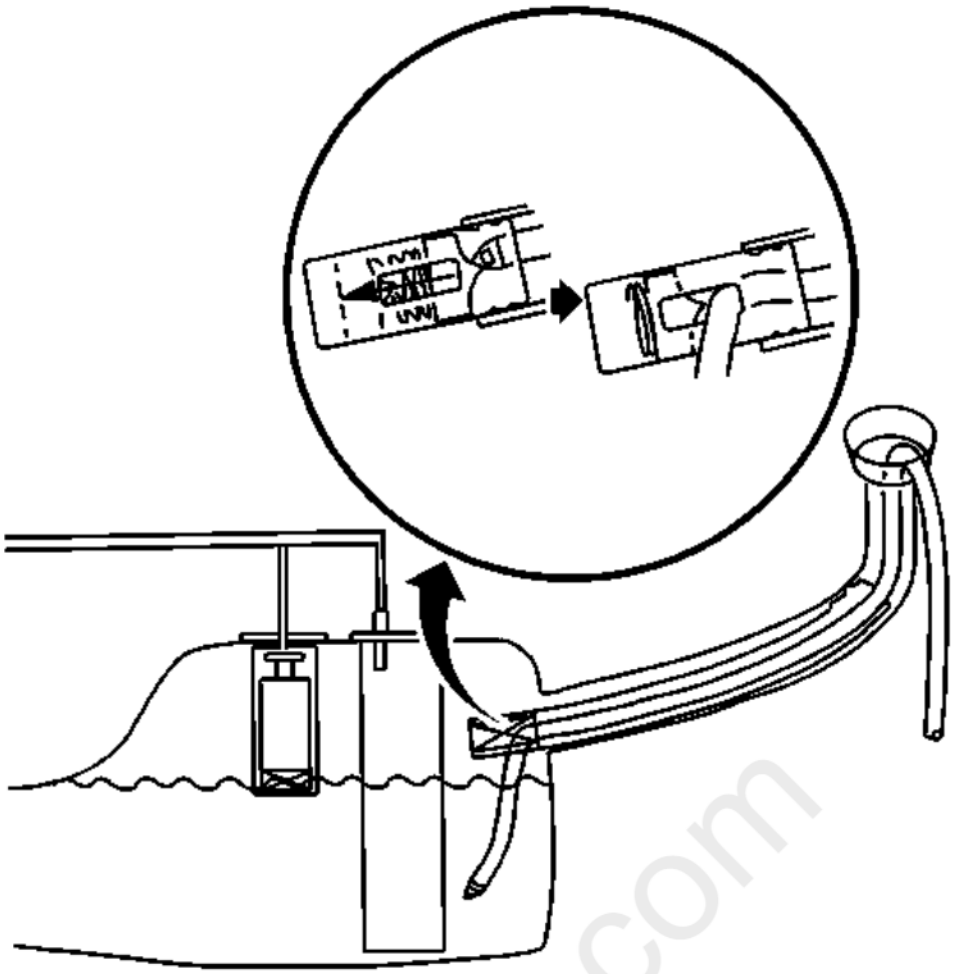

Fig. 56: Draining Fuel Tank
Courtesy of GENERAL MOTORS COMPANY

2. Insert the **CH 45004** hose into the fuel tank until the bottom is reached.

NOTE: **Lubricate the fuel drain hose with Transjel Lubricant or equivalent to aid in hose insertion.**

3. Use a hand or air operated pump device in order to drain as much fuel through the fuel fill pipe as possible.

FUEL TANK REPLACEMENT

Removal Procedure

1. Relieve the fuel system pressure. Refer to **Fuel Pressure Relief**

WARNING: **Refer to Gasoline/Gasoline Vapors Warning .**

WARNING: **Refer to Safety Glasses Warning .**

2. Drain the fuel tank. Refer to **Fuel Tank Draining**
3. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle**
4. Propeller Shaft Â» Remove - **Propeller Shaft Replacement**
5. Underbody Rear Air Deflector - Right SideÂ» Remove - **Underbody Rear Air Deflector Replacement - Right Side**
6. Underbody Rear Air Deflector - Left SideÂ» Remove **Underbody Rear Air Deflector Replacement - Left Side**

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7. Rear Cradle Mount Bolt BracketÂ» Remove - **Rear Cradle Mount Bolt Bracket Replacement (Bracket)** **Rear Cradle Mount Bolt Bracket Replacement (Brace)**
8. Rear Wheelhouse Liner - Right SideÂ» Remove - **Rear Wheelhouse Liner Replacement (LGX, LGW)**
9. Retainer (1)Â» Remove [2x]

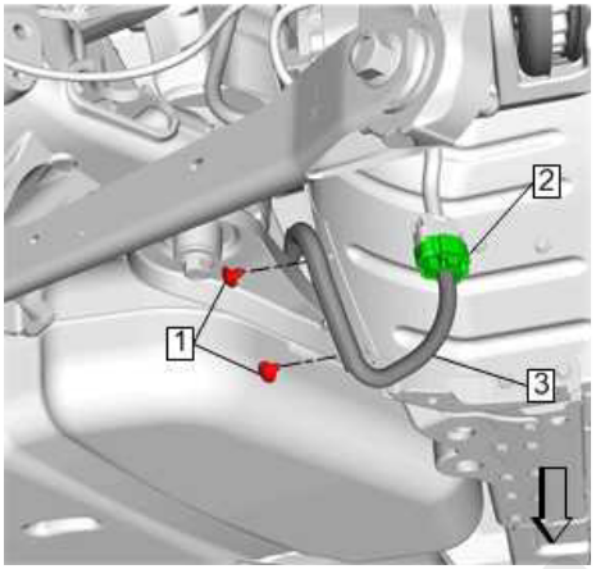

Fig. 57: Retainer And Wiring Harness Connector
Courtesy of GENERAL MOTORS COMPANY

10. Wiring Harness Connector (2)Â» Disconnect
11. Wiring Harness (3)Â» Remove
12. Fuel Feed Hose (1)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**

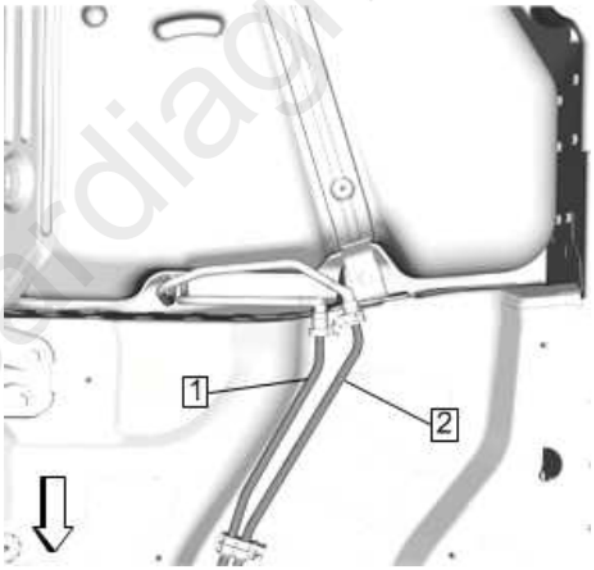

Fig. 58: Fuel Feed Hose And Evaporative Emission Pipe
Courtesy of GENERAL MOTORS COMPANY

13. Evaporative Emission Pipe (2)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**
14. Fuel Tank Filler Pipe (1)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**

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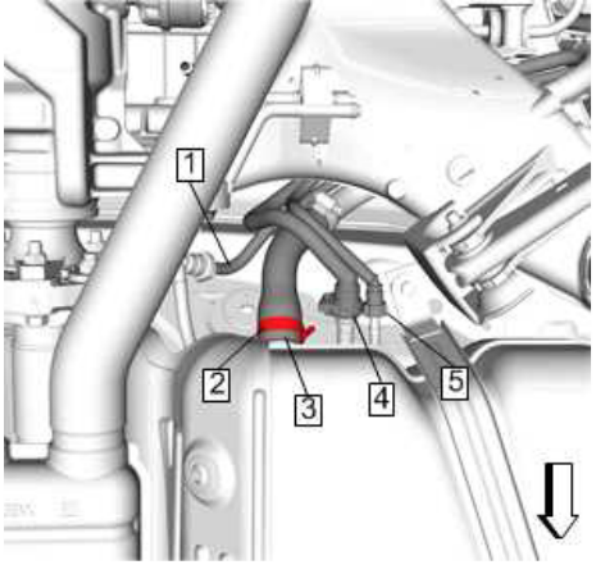

Fig. 59: Fuel Tank Filler Hose, Pipe And Evaporative Emission Canister Hoses
Courtesy of GENERAL MOTORS COMPANY

15. Fuel Tank Filler Hose Clamp (2)Â» Remove
16. Fuel Tank Filler Hose (3)Â» Remove
17. Evaporative Emission Canister Hose (4)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**
18. Evaporative Emission Canister Purge Hose (5)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**
19. Place a suitable adjustable jack under the fuel tank.

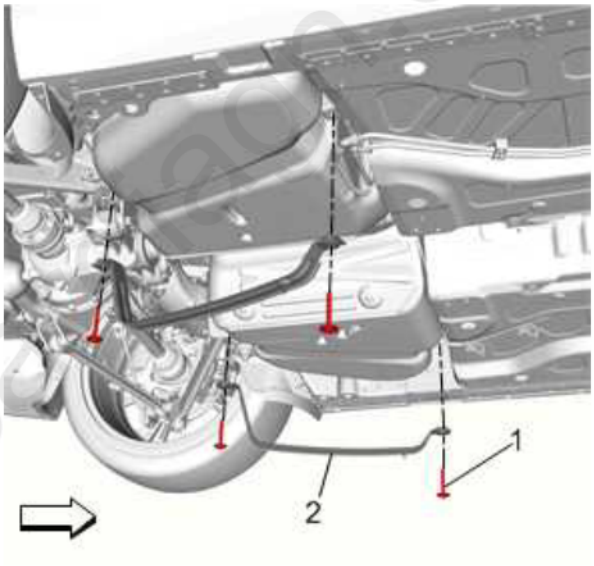

Fig. 60: Fuel Tank Strap And Fuel Tank Strap Bolts
Courtesy of GENERAL MOTORS COMPANY

20. Fuel Tank Strap Bolt (1)Â» Remove [4x]
21. Fuel Tank Strap (2)Â» Remove [2x]
22. Fuel Tank (1)Â» Remove

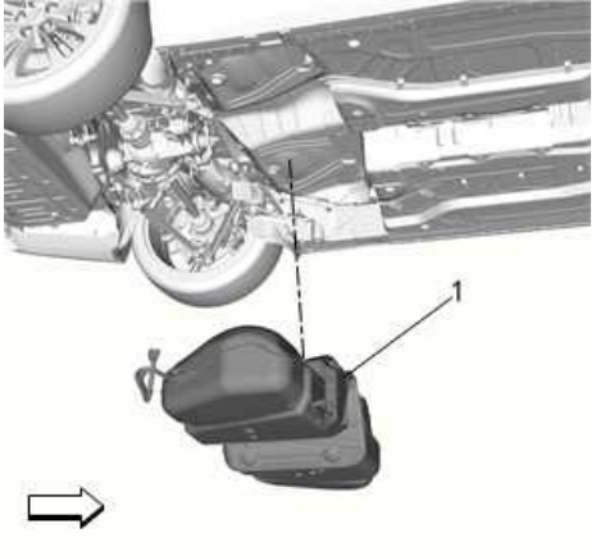

Fig. 61: Fuel Tank
Courtesy of GENERAL MOTORS COMPANY

23. If replacing fuel tank transfer parts as necessary.

Installation Procedure

1. Place a suitable adjustable jack under the fuel tank.

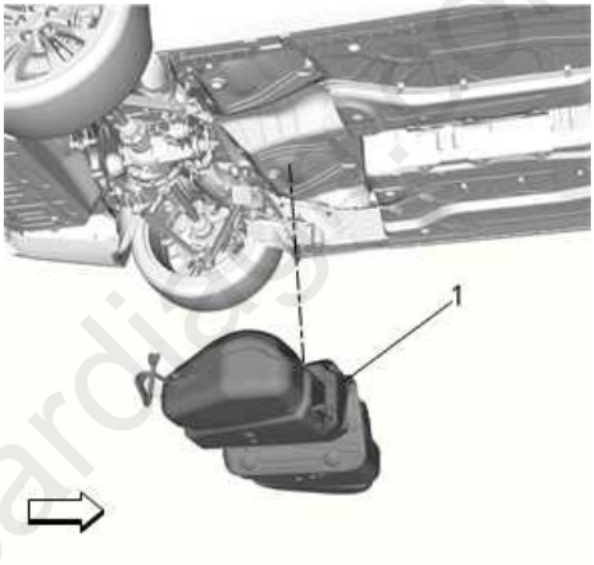

Fig. 62: Fuel Tank
Courtesy of GENERAL MOTORS COMPANY

2. Fuel Tank (1)Â» Install
3. Fuel Tank Strap (2)Â» Install [2x]

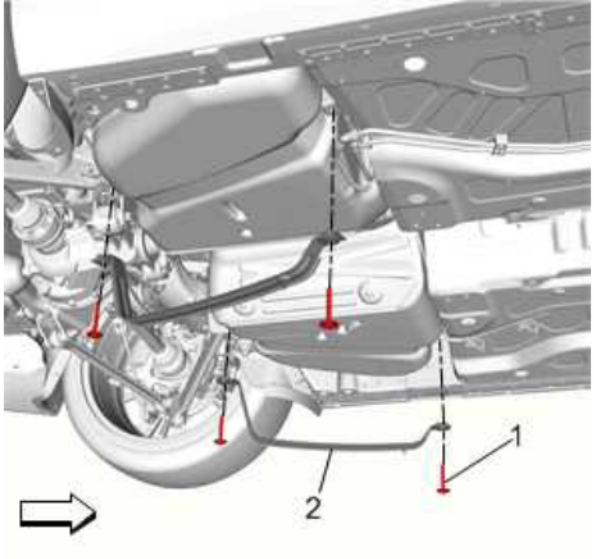

Fig. 63: Fuel Tank Strap And Fuel Tank Strap Bolts
Courtesy of GENERAL MOTORS COMPANY

4. Fuel Tank Strap Bolt (1)Â» Install [4x] 27 N.m (20 lb ft)

CAUTION: **Refer to Fastener Caution .**

5. Evaporative Emission Canister Purge Hose (5)Â» Connect - **Plastic Collar Quick Connect Fitting Service**

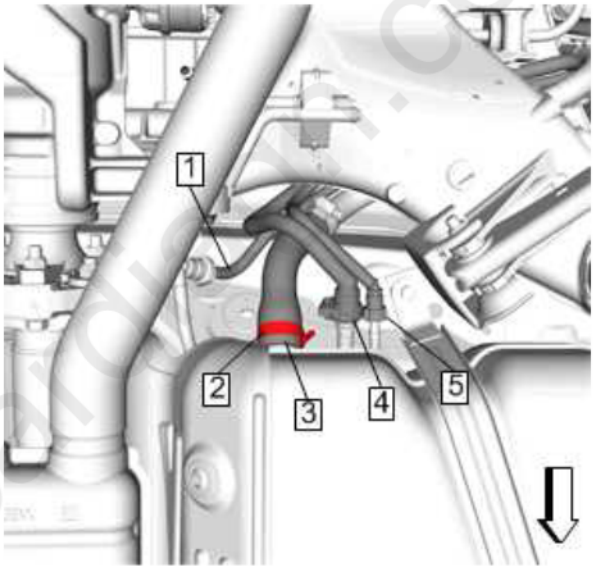

Fig. 64: Fuel Tank Filler Hose, Pipe And Evaporative Emission Canister Hoses
Courtesy of GENERAL MOTORS COMPANY

6. Evaporative Emission Canister Hose (4)Â» Connect - **Plastic Collar Quick Connect Fitting Service**
7. Fuel Tank Filler Hose (3)Â» Install
8. Fuel Tank Filler Hose Clamp (2)Â» Install
9. Fuel Tank Filler Pipe (1)Â» Connect - **Plastic Collar Quick Connect Fitting Service**
10. Evaporative Emission Pipe (2)Â» Connect - **Plastic Collar Quick Connect Fitting Service**

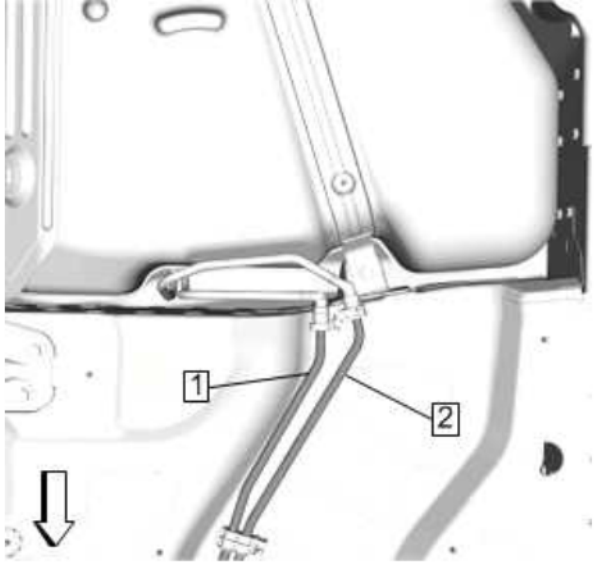

Fig. 65: Fuel Feed Hose And Evaporative Emission Pipe
Courtesy of GENERAL MOTORS COMPANY

11. Fuel Feed Hose (1)Â» Connect - **Plastic Collar Quick Connect Fitting Service**
12. Wiring Harness (3)Â» Install

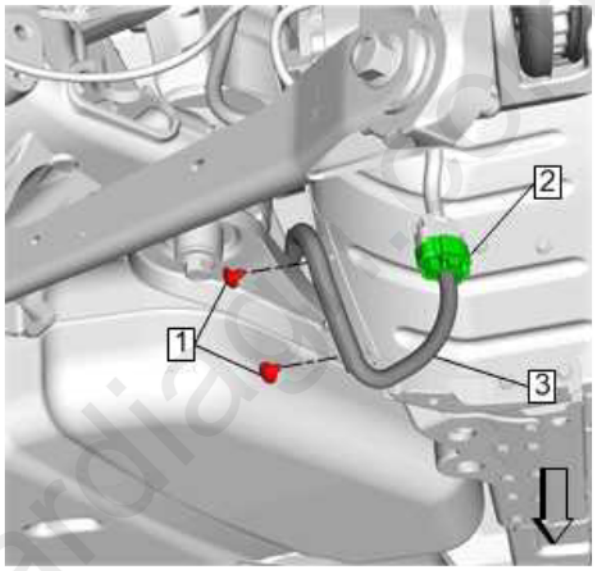

Fig. 66: Retainer And Wiring Harness Connector
Courtesy of GENERAL MOTORS COMPANY

13. Wiring Harness Connector (2)Â» Connect
14. Retainer (1)Â» Install [2x]
15. Rear Wheelhouse Liner - Right SideÂ» Install - **Rear Wheelhouse Liner Replacement (LGX, LGW)**
16. Rear Cradle Mount Bolt BracketÂ» Install - **Rear Cradle Mount Bolt Bracket Replacement (Bracket)** **Rear Cradle Mount Bolt Bracket Replacement (Brace)**
17. Underbody Rear Air Deflector - Left SideÂ» Install **Underbody Rear Air Deflector Replacement - Left Side**
18. Underbody Rear Air Deflector - Right SideÂ» Install - **Underbody Rear Air Deflector Replacement - Right Side**
19. Propeller ShaftÂ» Install - **Propeller Shaft Replacement**
20. Lower the vehicle.
21. Refill the fuel tank.
22. Inspect for fuel leaks.

FUEL TANK SHIELD REPLACEMENT

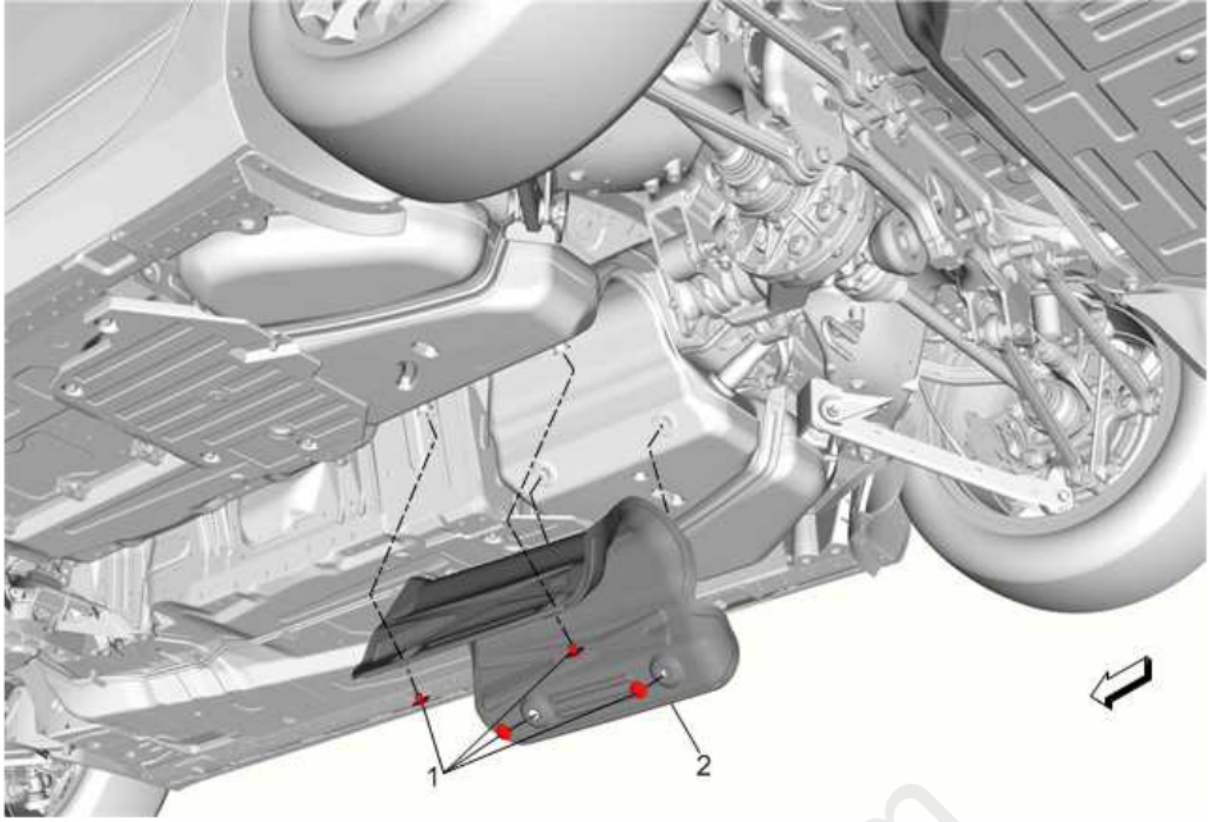

Fig. 67: Fuel Tank Shield
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Propeller Shaft Replacement	
1	Fuel Tank Shield Retainer [4x] **CAUTION:** Refer to Fastener Caution .
2	Fuel Tank Shield

FUEL TANK FUEL PUMP MODULE REPLACEMENT

Special Tools

CH 45722 Fuel Sender Lock Ring Wrench

Equivalent regional tools: Special Tools (Diagnostic Tools) Special Tools (Mechanical Tools)

Removal Procedure

1. Fuel Tank ReplacementÂ» Remove

   WARNING: Refer to Gasoline/Gasoline Vapors Warning .

   WARNING: Refer to Safety Glasses Warning .

2. Electrical Connector (1)Â» Disconnect [2x]

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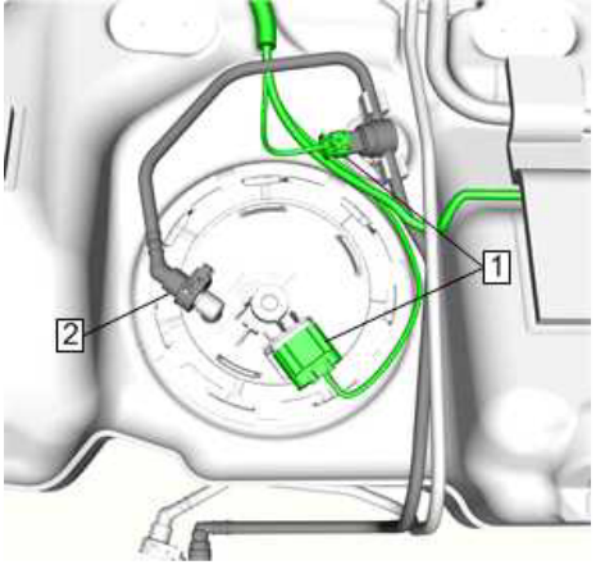

Fig. 68: Fuel Pump Feed Hose And Fuel Pump Electrical Connectors
Courtesy of GENERAL MOTORS COMPANY

3. Fuel Pump Fuel Feed Hose (2)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**
4. Fuel Sender Ring (1)Â» Remove - **CH 45722** wrench

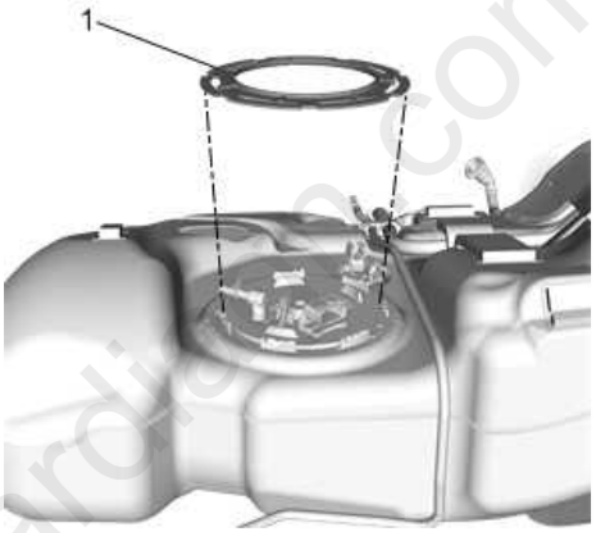

Fig. 69: Fuel Sender Ring
Courtesy of GENERAL MOTORS COMPANY

5. Transfer Hose (1)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**

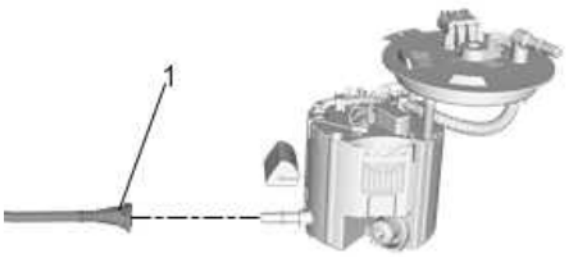

Fig. 70: Transfer Hose
Courtesy of GENERAL MOTORS COMPANY

6. Fuel Tank Fuel Pump Module (1)Â» Remove

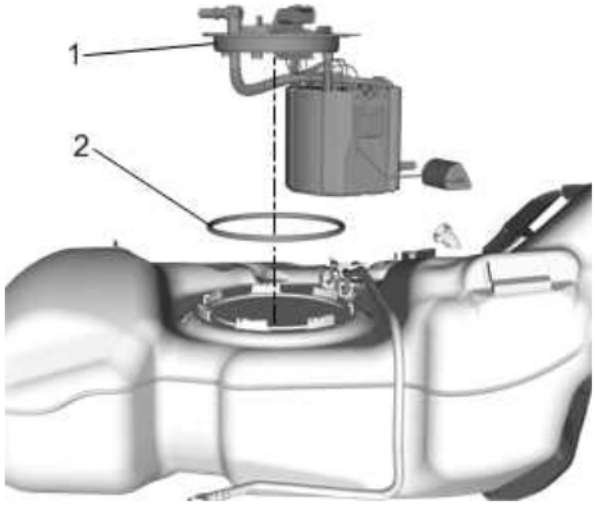

Fig. 71: Fuel Tank Fuel Pump Module
Courtesy of GENERAL MOTORS COMPANY

7. O-Ring (2)Â» Remove and DISCARD

Installation Procedure

1. O-Ring (2)Â» Install NEW

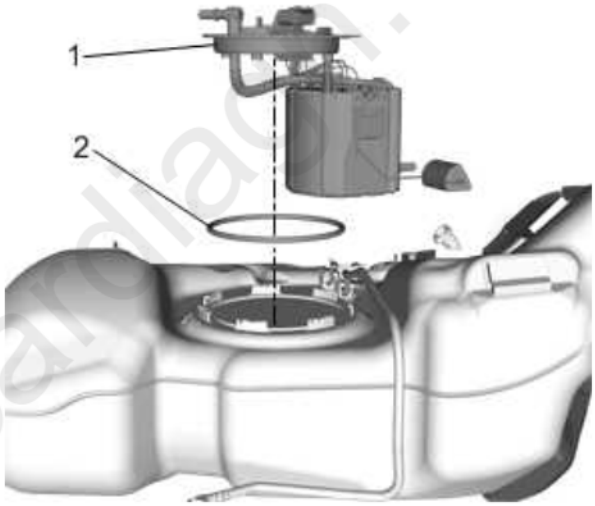

Fig. 72: Fuel Tank Fuel Pump Module
Courtesy of GENERAL MOTORS COMPANY

2. Fuel Tank Fuel Pump Module (1)Â» Install
3. Transfer Hose (2)Â» Connect - **Plastic Collar Quick Connect Fitting Service**

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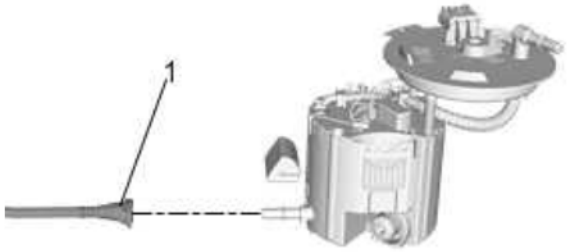

Fig. 73: Transfer Hose
Courtesy of GENERAL MOTORS COMPANY

4. Fuel Sender Ring (1)Â» Install - **CH 45722** wrench

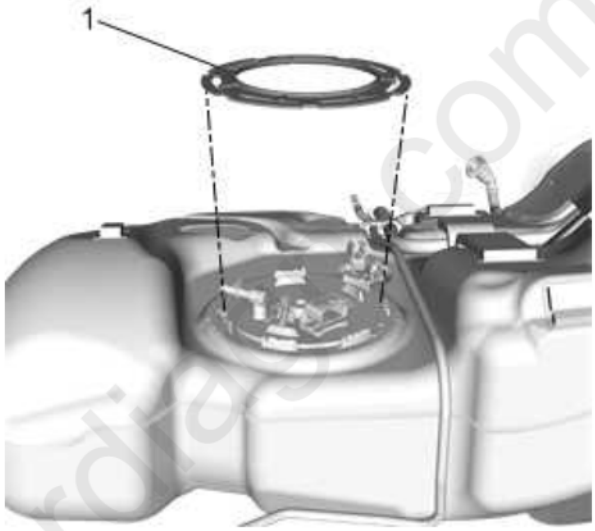

Fig. 74: Fuel Sender Ring
Courtesy of GENERAL MOTORS COMPANY

5. Fuel Pump Fuel Feed Hose (2)Â» Connect - **Plastic Collar Quick Connect Fitting Service**

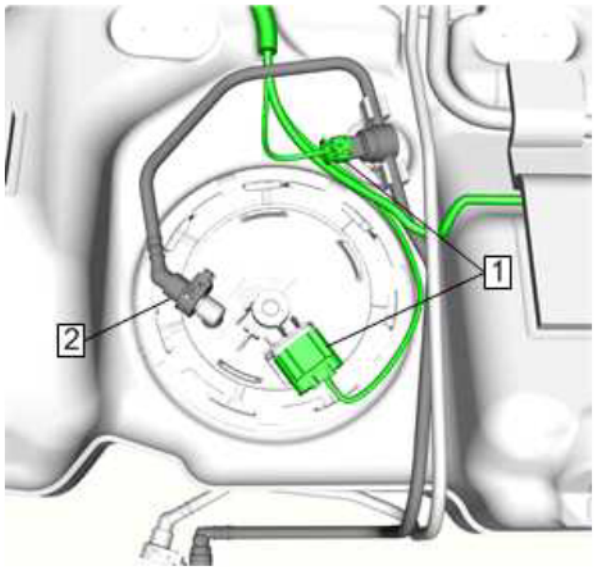

Fig. 75: Fuel Pump Feed Hose And Fuel Pump Electrical Connectors
Courtesy of GENERAL MOTORS COMPANY

6. Electrical Connector (1)Â» Connect [2x]
7. Fuel Tank ReplacementÂ» Install

FUEL PUMP POWER CONTROL MODULE REPLACEMENT

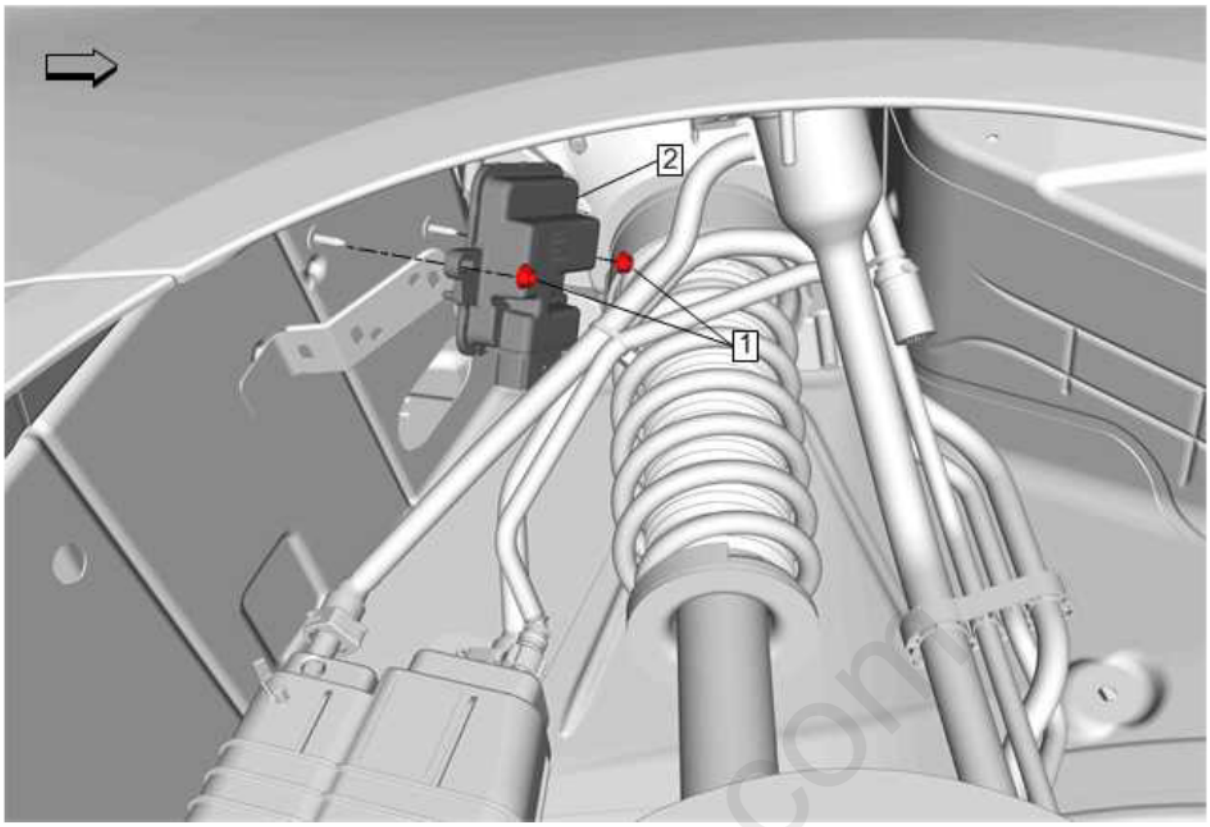

Fig. 76: Fuel Pump Power Control Module
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Rear Wheelhouse Liner Replacement (LGX, LGW)	
1	Fuel Pump Power Control Module Fastener [2x] **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

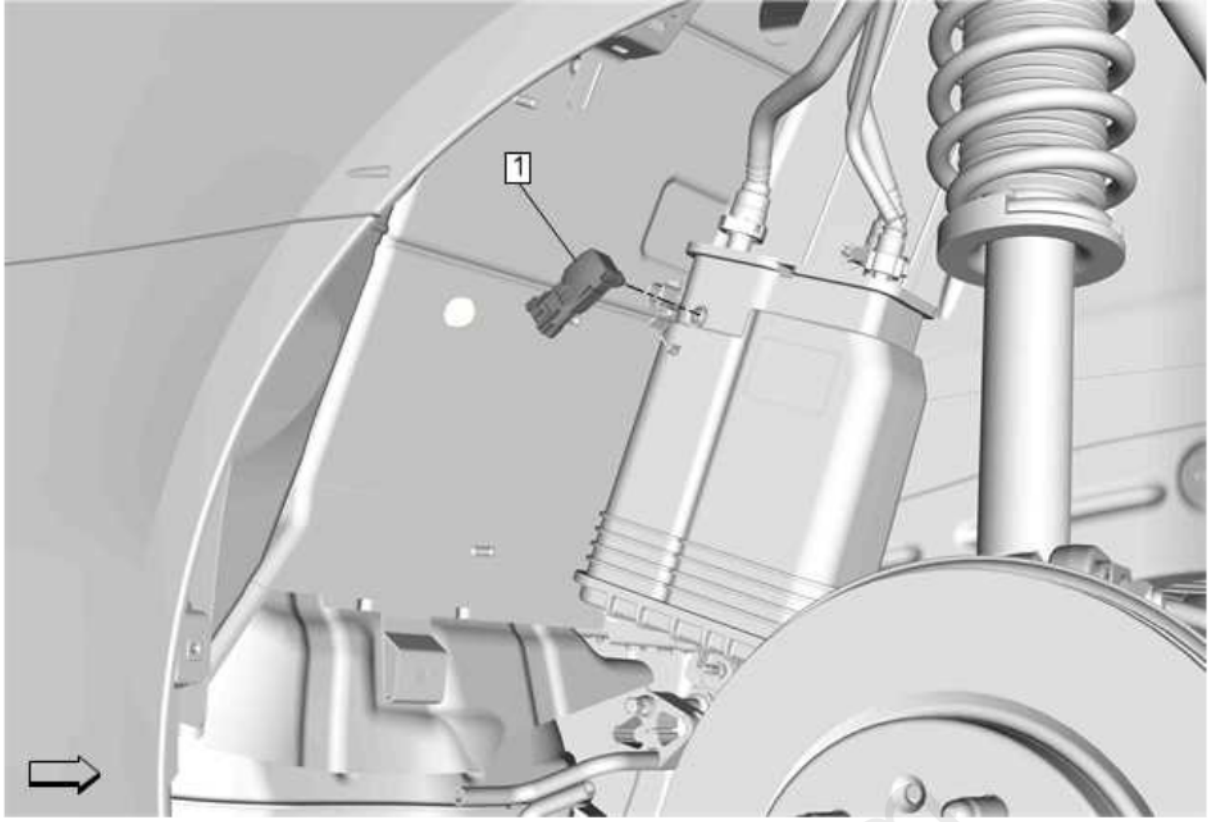

Fig. 77: Fuel Tank Pressure Sensor
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
WARNING: Refer to Gasoline/Gasoline Vapors Warning . **WARNING:** Refer to Safety Glasses Warning . **Preliminary Procedure** Rear Wheelhouse Liner Replacement (LGX, LGW)	
1	Fuel Tank Pressure Sensor **Procedure** Disconnect the electrical connector.

FUEL TANK FILLER PIPE REPLACEMENT

Removal Procedure

1. Drain the fuel enough to remove hose. Refer to Fuel Tank Draining

   WARNING: Refer to Gasoline/Gasoline Vapors Warning .

   WARNING: Refer to Safety Glasses Warning .

2. Fuel Tank Filler Pipe HousingÂ» Remove - Fuel Tank Filler Pipe Housing Replacement
3. Fuel Tank Filler Evaporative Emission Valve Hose (1)Â» Disconnect - Plastic Collar Quick Connect Fitting Service

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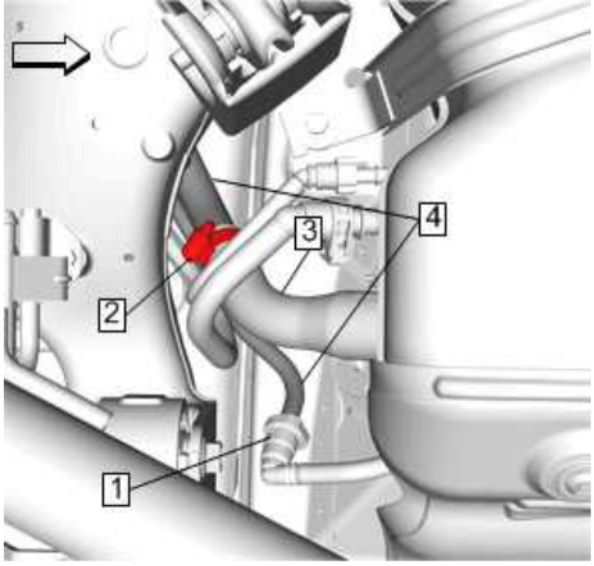

Fig. 78: Fuel Tank Filler Hose, Filler Pipe And Fuel Tank Filler Evaporative Emission Valve Hose
Courtesy of GENERAL MOTORS COMPANY

4. Fuel Tank Filler Hose Clamp (2)Â» Remove
5. Fuel Tank Filler Hose (3)Â» Remove
6. Fuel Tank Filler Pipe (4)Â» Remove
7. **Rear Wheelhouse Liner Replacement (LGX, LGW)** Â» Remove
8. Fuel Tank Filler Pipe (1) @ Retainer (2)Â» Remove

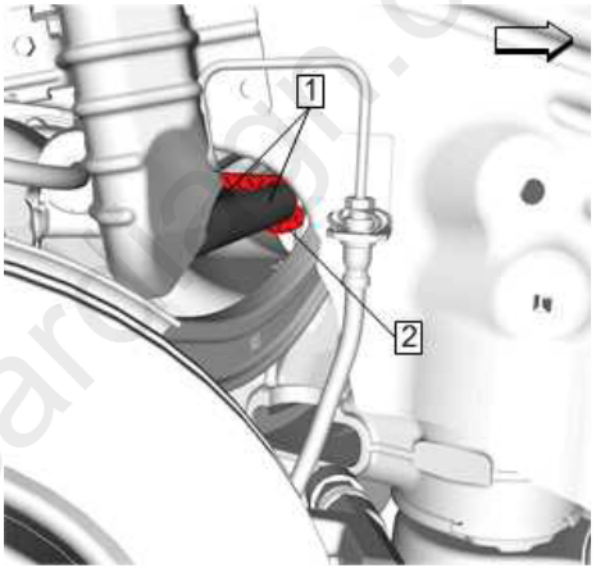

Fig. 79: Fuel Tank Filler Pipe & Retainer
Courtesy of GENERAL MOTORS COMPANY

9. Fuel Tank Filler Pipe Shield Bolt (1)Â» Remove [2x]

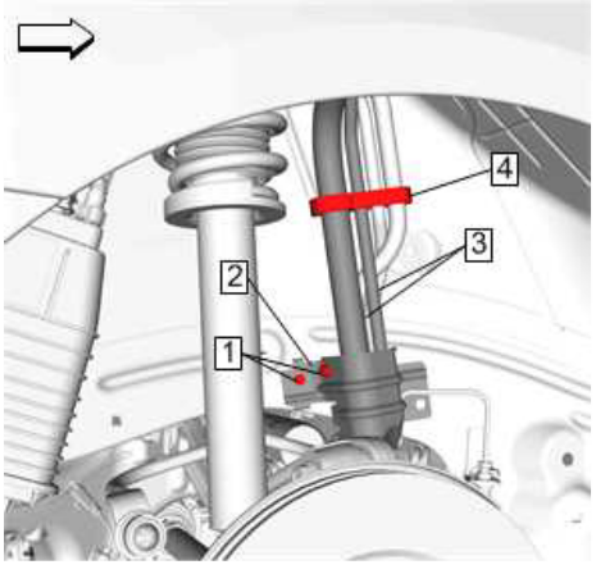

Fig. 80: Fuel Tank Filler Pipe, Fuel Tank Filler Pipe Shield And Fuel Tank Filler Pipe Shield Bolts
Courtesy of GENERAL MOTORS COMPANY

10. Fuel Tank Filler Pipe Shield (2)Â» Remove
11. Fuel Tank Filler Pipe (3) @ Retainer (4)Â» Remove
12. Fuel Tank Filler Pipe Bolt (1)Â» Remove

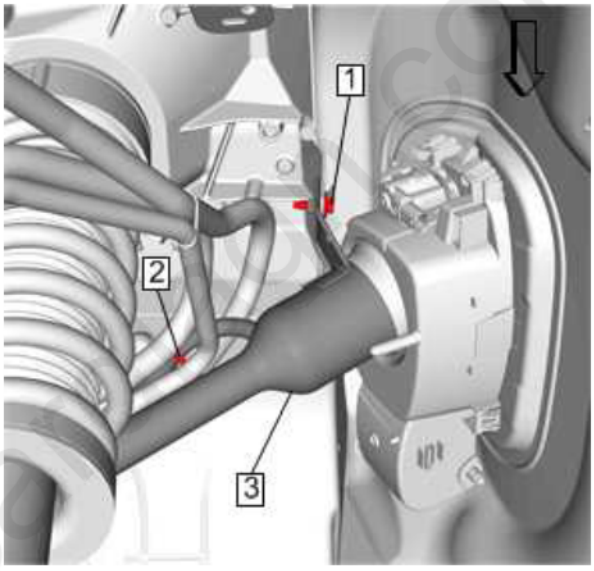

Fig. 81: Fuel Tank Filler Pipe, Fuel Tank Filler Pipe Bolt And Tie Strap
Courtesy of GENERAL MOTORS COMPANY

13. Tie Strap (2)Â» Remove and DISCARD
14. Fuel Tank Filler Pipe (3)Â» Remove

Installation Procedure

1. Fuel Tank Filler Pipe (3)Â» Install

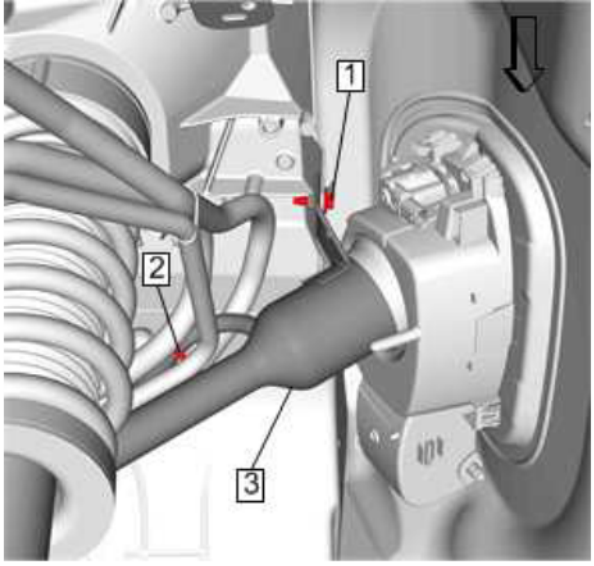

Fig. 82: Fuel Tank Filler Pipe, Fuel Tank Filler Pipe Bolt And Tie Strap
Courtesy of GENERAL MOTORS COMPANY

2. Tie Strap (2)Â» Install NEW
3. Fuel Tank Filler Pipe Bolt (1)Â» Install 9 N.m (80 lb in)

CAUTION: **Refer to Fastener Caution .**

4. Fuel Tank Filler Pipe (3) @ Retainer (4)Â» Install

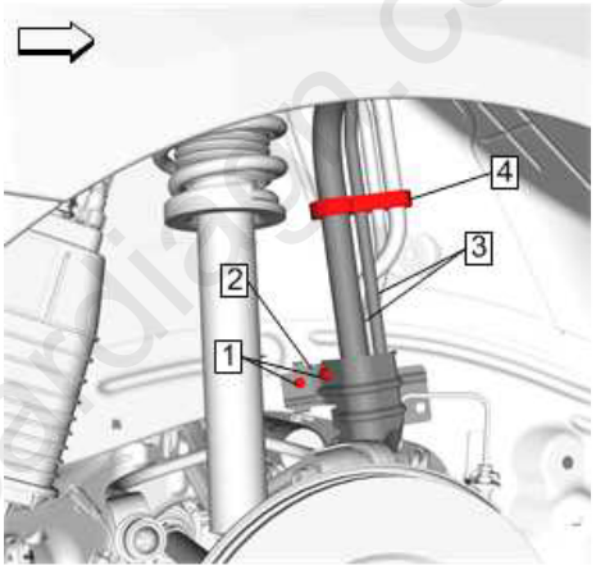

Fig. 83: Fuel Tank Filler Pipe, Fuel Tank Filler Pipe Shield And Fuel Tank Filler Pipe Shield Bolts
Courtesy of GENERAL MOTORS COMPANY

5. Fuel Tank Filler Pipe Shield (2)Â» Install
6. Fuel Tank Filler Pipe Shield Bolt (1)Â» Install [2x] 9 N.m (80 lb in)
7. Fuel Tank Filler Pipe (1) @ Retainer (2)Â» Install

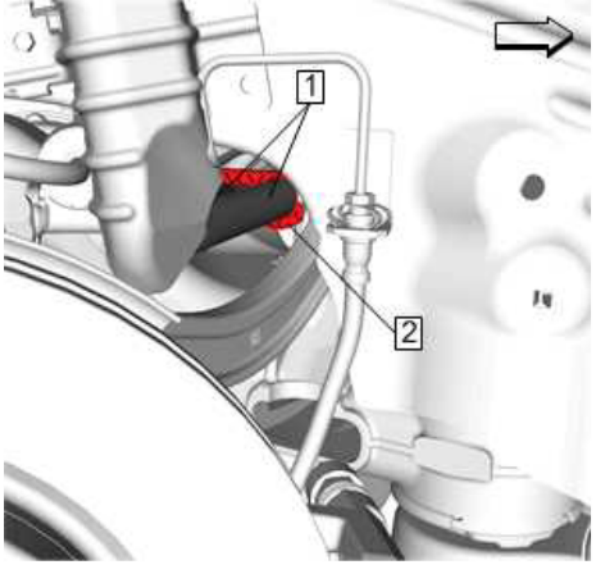

Fig. 84: Fuel Tank Filler Pipe & Retainer
Courtesy of GENERAL MOTORS COMPANY

8. **Rear Wheelhouse Liner Replacement (LGX, LGW)** Â» Install
9. Fuel Tank Filler Pipe (4)Â» Install

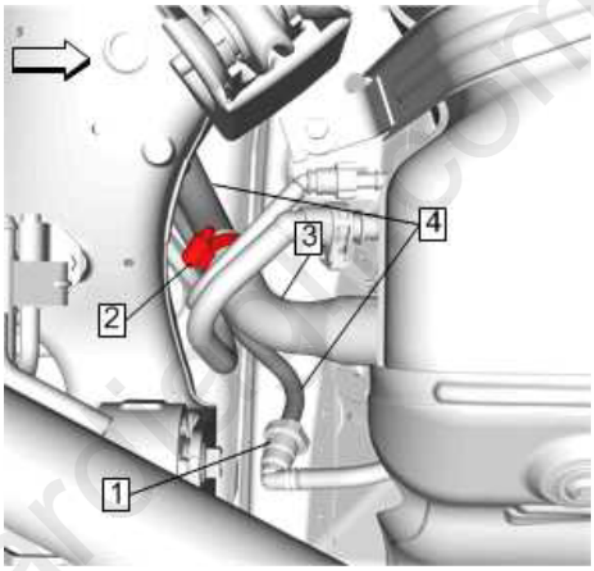

Fig. 85: Fuel Tank Filler Hose, Filler Pipe And Fuel Tank Filler Evaporative Emission Valve Hose
Courtesy of GENERAL MOTORS COMPANY

10. Fuel Tank Filler Hose (3)Â» Install
11. Fuel Tank Filler Hose Clamp (2)Â» Install 4 N.m (35 lb in)
12. Fuel Tank Filler Evaporative Emission Valve Hose (1)Â» Connect - **Plastic Collar Quick Connect Fitting Service**
13. Fuel Tank Filler Pipe HousingÂ» Install - **Fuel Tank Filler Pipe Housing Replacement**
14. Fill the fuel tank.

FUEL TANK FILLER HOSE REPLACEMENT

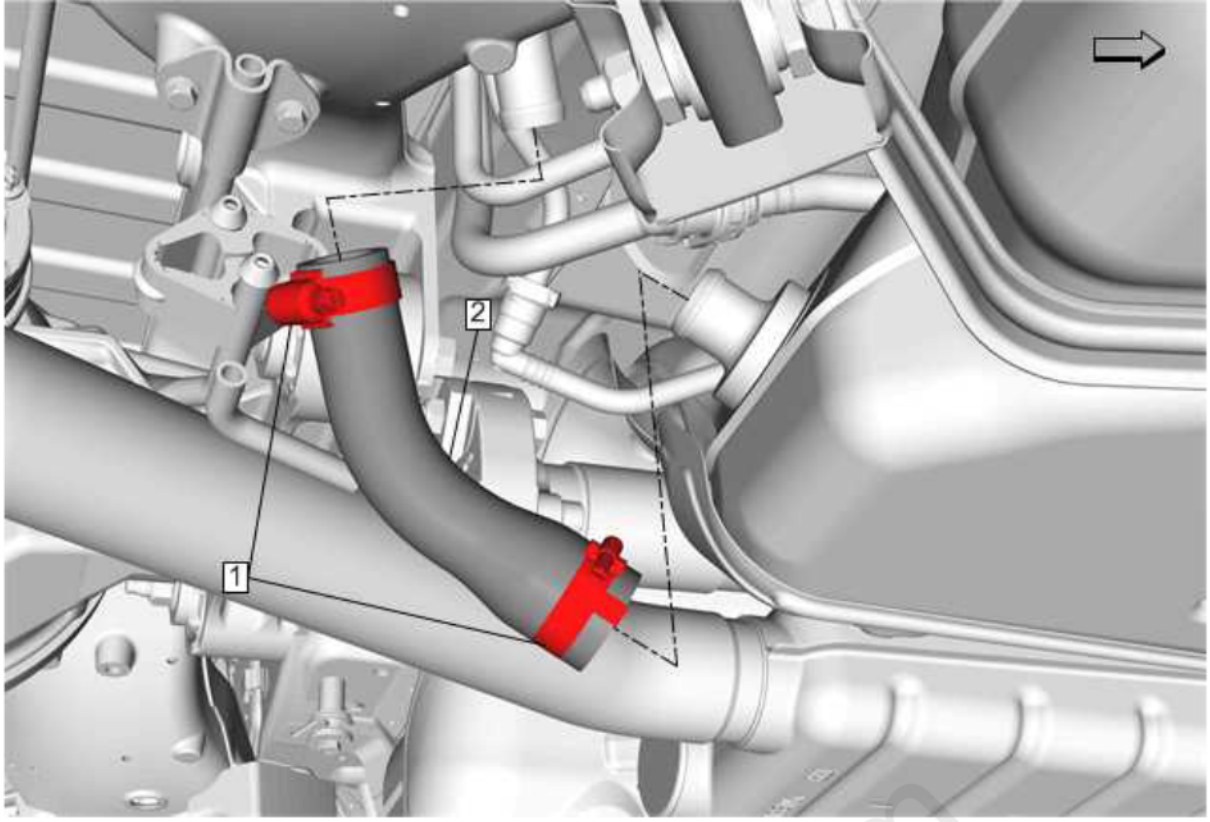

Fig. 86: Fuel Tank Filler Hose
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Fuel Tank Draining 2. Lifting and Jacking the Vehicle	
1	Fuel Tank Filler Hose Clamp [2x] **CAUTION:** Refer to Fastener Caution . **Tighten** 4 N.m (35 lb in)
2	Fuel Tank Filler Hose

FUEL TANK VENT HOSE REPLACEMENT (AT TANK)

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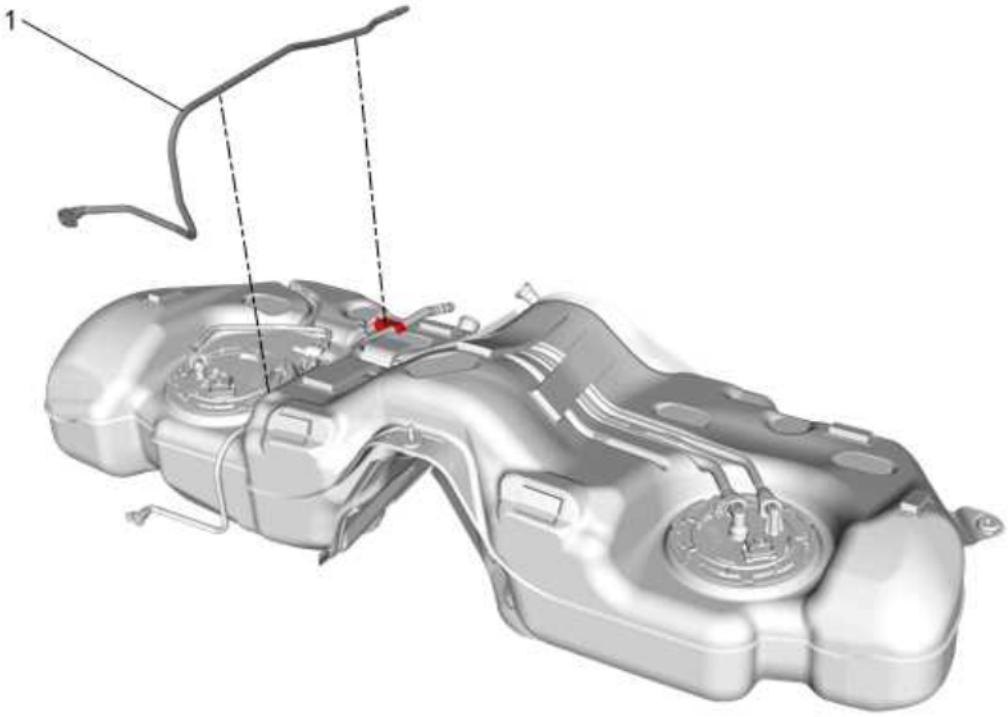

Fig. 87: Fuel Tank Vent Hose (At Tank)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
WARNING: Refer to Gasoline/Gasoline Vapors Warning . **WARNING:** Refer to Safety Glasses Warning . **Preliminary Procedure** Fuel Tank Replacement	
1	Fuel Tank Vent Valve Hose **Procedure** Remove fuel tank vent valve hose from retainer.

FUEL LEVEL SENSOR REPLACEMENT (FUEL TANK FUEL PUMP MODULE)

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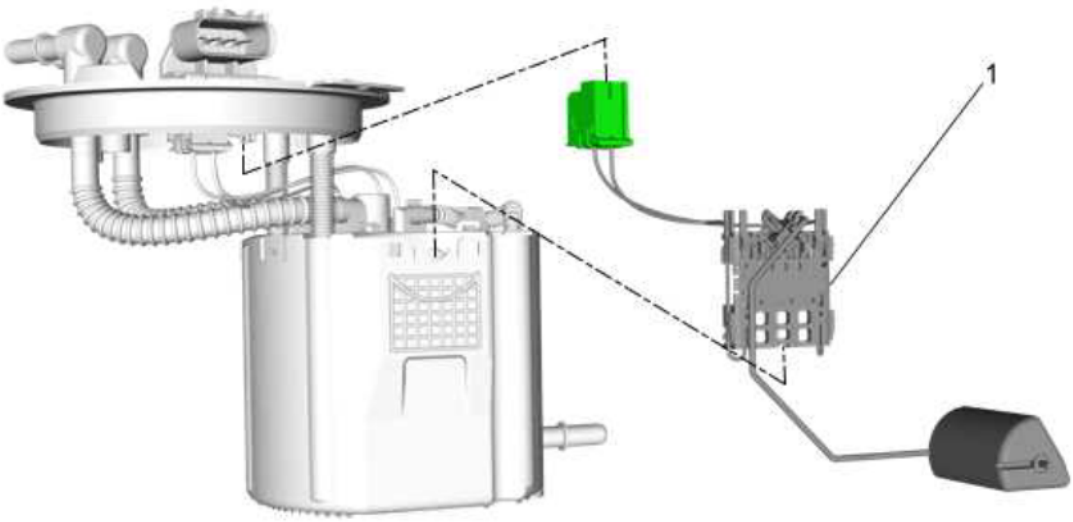

Fig. 88: Fuel Level Sensor (Fuel Tank Fuel Pump Module)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
WARNING: Refer to Gasoline/Gasoline Vapors Warning . **WARNING:** Refer to Safety Glasses Warning . **Preliminary Procedure** Fuel Tank Fuel Pump Module Replacement	
1	Fuel Level Sensor **Procedure** 1. Disconnect the electrical connector. 2. Release the retaining tabs.

FUEL LEVEL SENSOR REPLACEMENT (FUEL SENDER ASSEMBLY)

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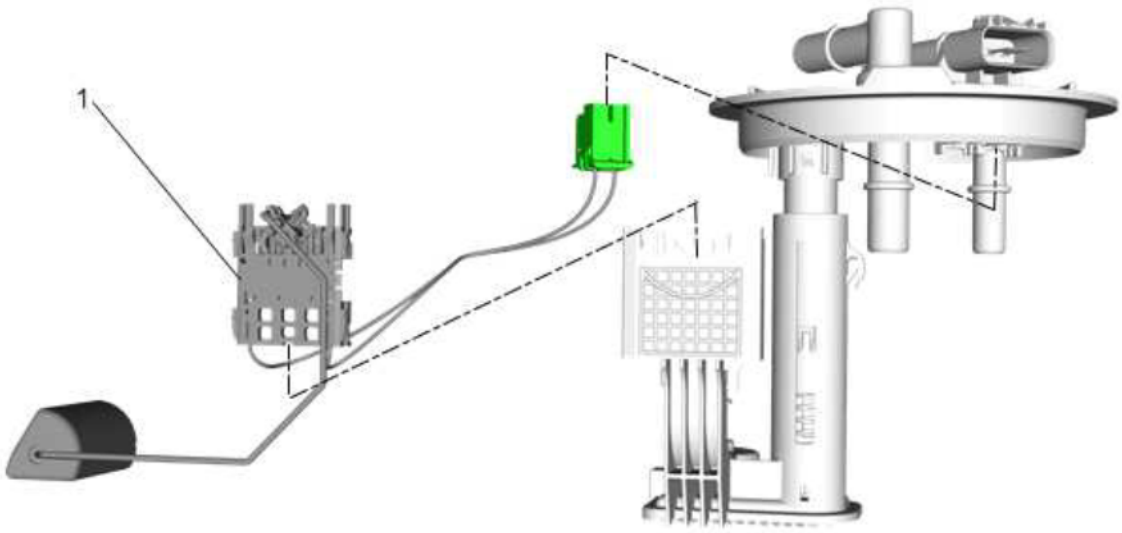

Fig. 89: Fuel Level Sensor (Fuel Sender Assembly)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
WARNING: Refer to Gasoline/Gasoline Vapors Warning . **WARNING:** Refer to Safety Glasses Warning . **Preliminary Procedure** Fuel Sender Assembly Replacement	
1	Fuel Level Sensor **Procedure** 1. Disconnect the electrical connector. 2. Release the retaining tabs.

FUEL PULSE DAMPENER REPLACEMENT (LGW)

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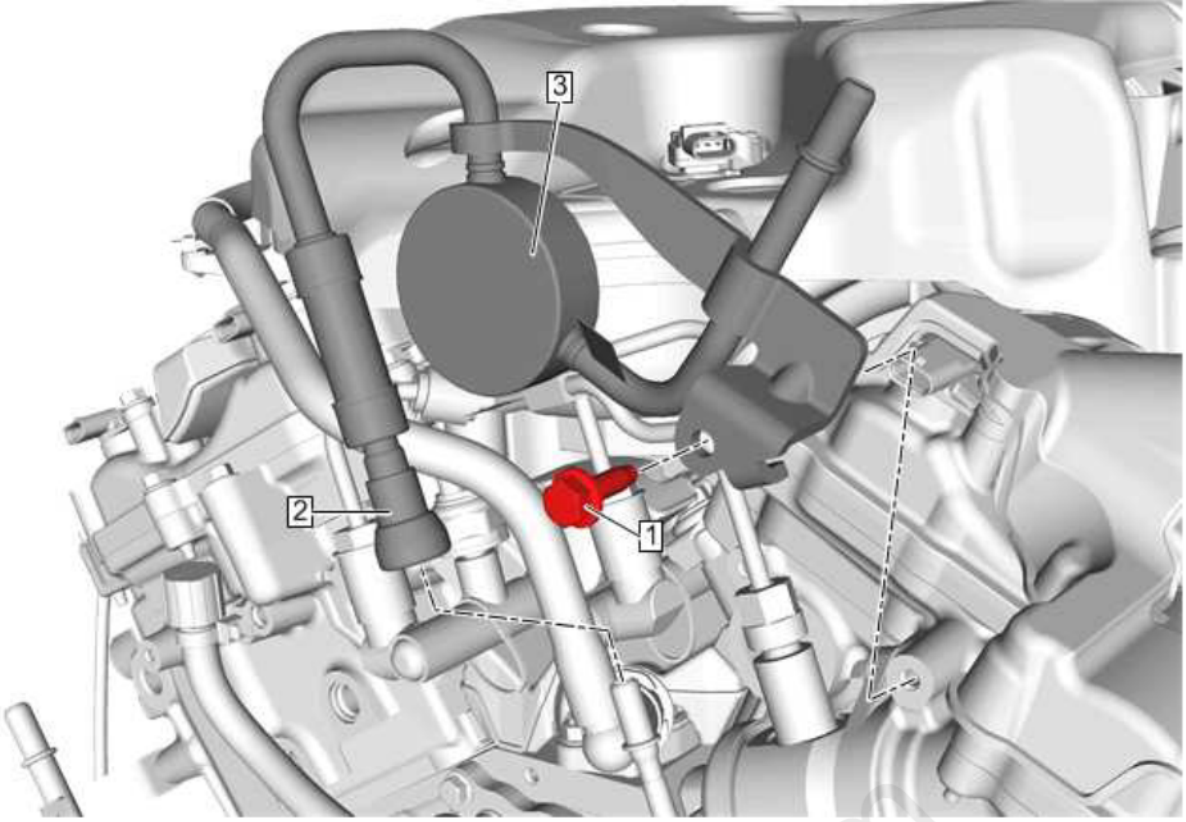

Fig. 90: Fuel Pulse Dampener
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Engine Rear Noise Shield Replacement	
1	Fuel Feed Pipe Bolt **CAUTION:** Refer to Fastener Caution . **Tighten** 10 N.m (89 lb in)
2	Quick Connect Fitting **Procedure** Metal Collar Quick Connect Fitting Service
3	Fuel Pulse Dampener

FUEL PULSE DAMPENER REPLACEMENT (LGX)

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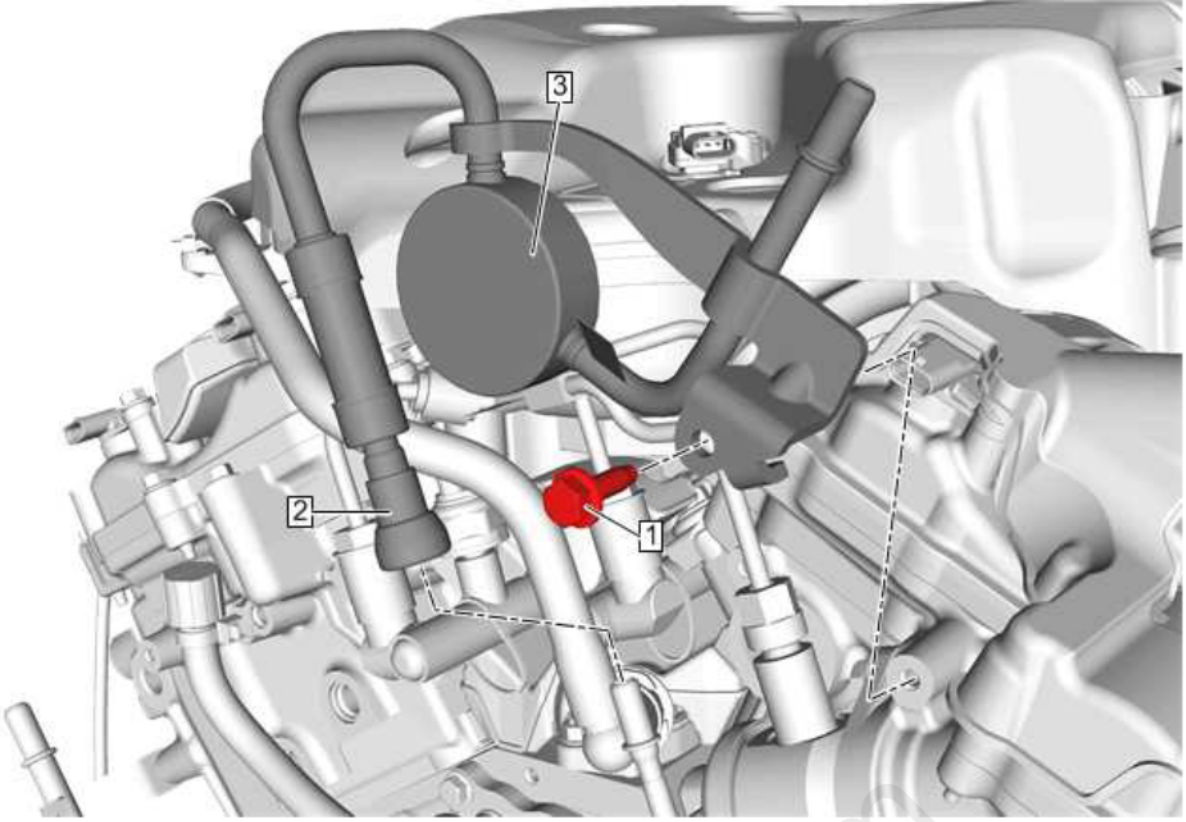

Fig. 91: Fuel Pulse Dampener
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Engine Rear Noise Shield Replacement	
1	Fuel Feed Pipe Bolt **CAUTION:** Refer to Fastener Caution . **Tighten** 10 N.m (89 lb in)
2	Quick Connect Fitting **Procedure** Metal Collar Quick Connect Fitting Service
3	Fuel Pulse Dampener

FUEL PUMP FUEL FEED HOSE REPLACEMENT

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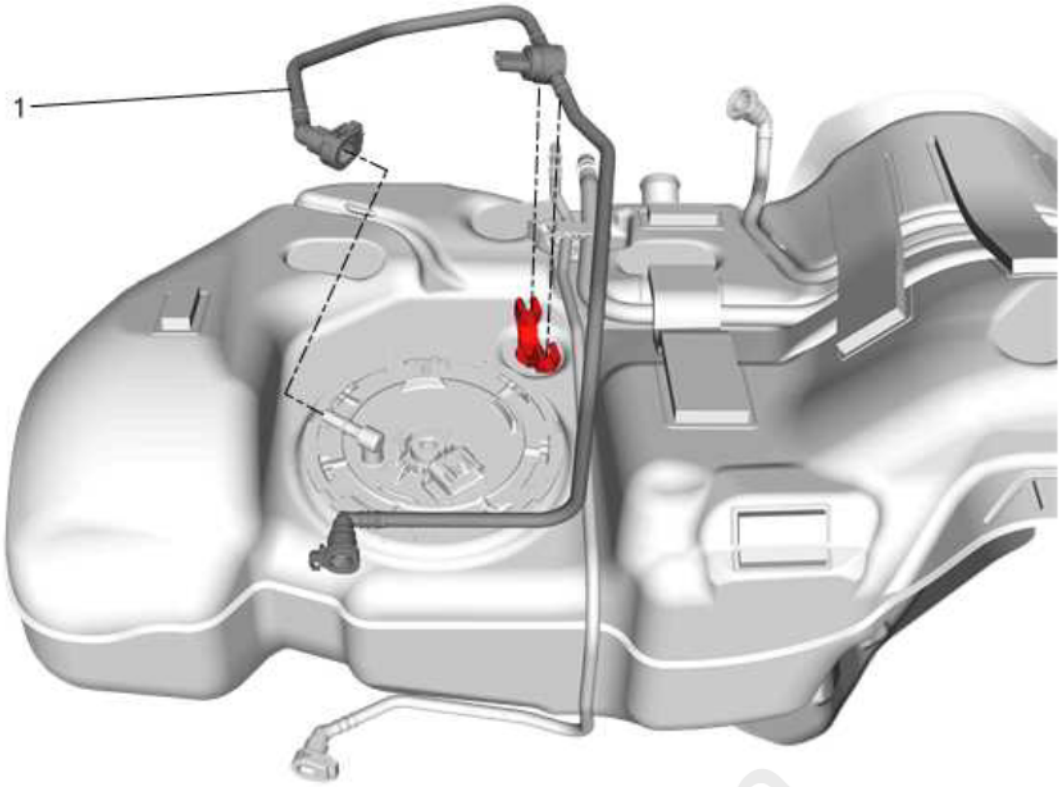

Fig. 92: Fuel Pump Fuel Feed Hose
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
WARNING: Refer to Gasoline/Gasoline Vapors Warning . **WARNING:** Refer to Safety Glasses Warning . **Preliminary Procedure** Fuel Tank Replacement	
1	Fuel Pump Fuel Feed Hose **Procedure** 1. Disconnect the electrical connector. 2. Disconnect quick connect fittings. Refer to Plastic Collar Quick Connect Fitting Service 3. Remove from retainer.

FUEL FEED HOSE REPLACEMENT

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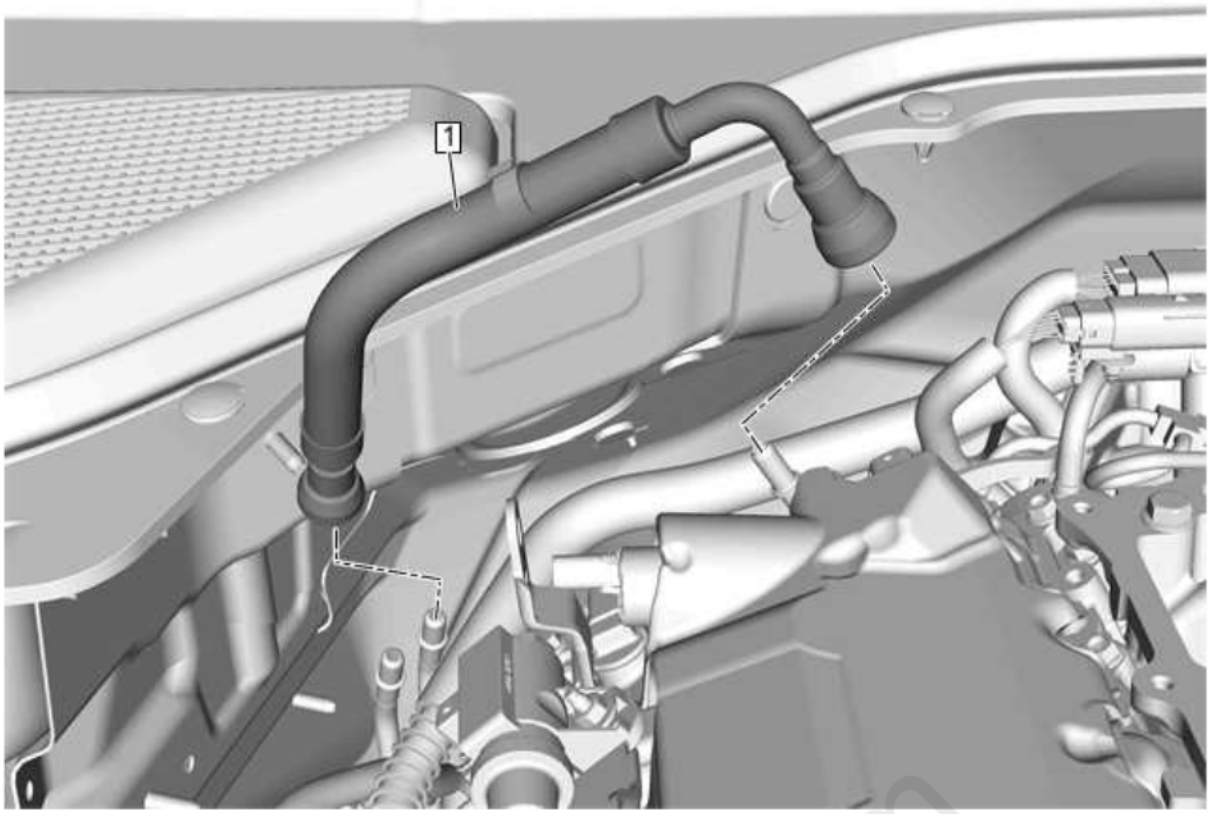

Fig. 93: Fuel Feed Pipe
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Intake Manifold Cover Replacement (LGW) Intake Manifold Cover Replacement (LGX)	
1	Fuel Feed Pipe **Procedure** Metal Collar Quick Connect Fitting ServiceÂ»Disconnect [2x]

FUEL PRESSURE SENSOR REPLACEMENT - FUEL FEED PIPE

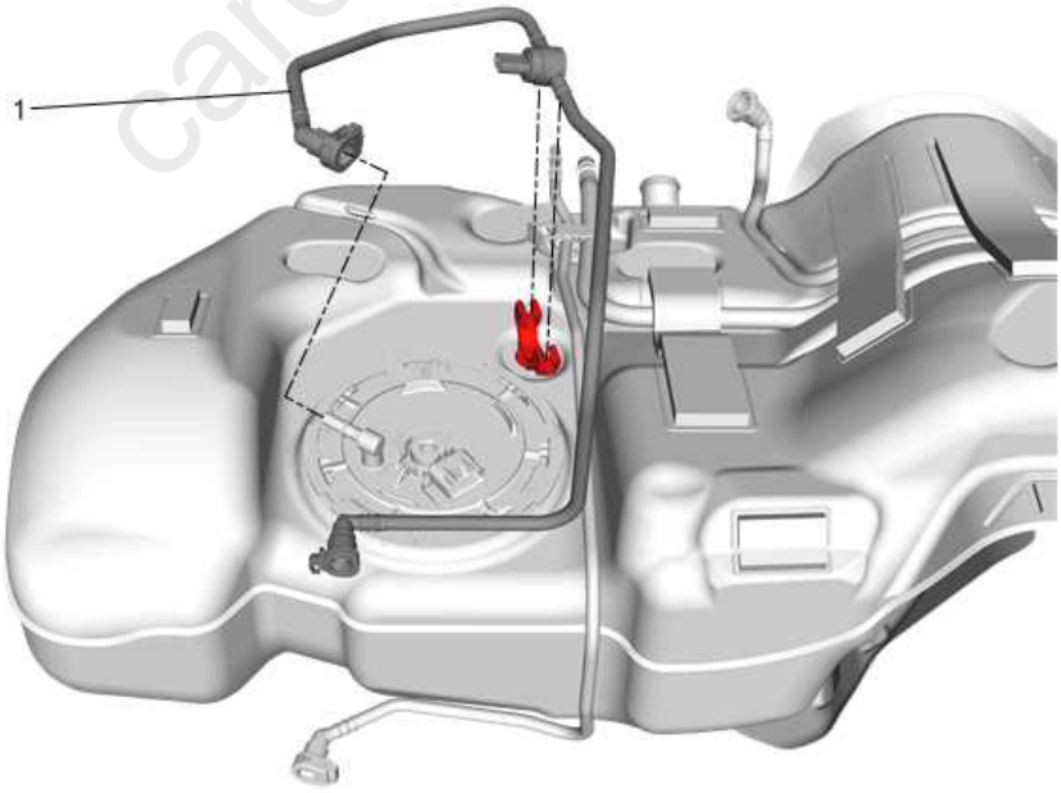

Fig. 94: Fuel Pump Fuel Feed Hose
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
WARNING: Refer to Gasoline/Gasoline Vapors Warning . **WARNING:** Refer to Safety Glasses Warning . **Preliminary Procedure** Fuel Tank Replacement	
1	Fuel Pressure Sensor **NOTE:** **Fuel pressure sensor is serviced as part of fuel pump fuel feed hose assembly.** **Procedure** 1. Disconnect the electrical connector. 2. Disconnect quick connect fittings. Refer to Plastic Collar Quick Connect Fitting Service 3. Remove from retainer.

FUEL FEED PIPE REPLACEMENT (LGW)

Removal Procedure

1. Fuel Feed Hose ReplacementÂ» Remove

   WARNING: Refer to Gasoline/Gasoline Vapors Warning .

   WARNING: Refer to Safety Glasses Warning .

2. Front Body Exhaust Heat Shield Replacement (Right Side, LGW, LGX) Front Body Exhaust Heat Shield Replacement (Left Side, LGW, LGX) Â» Remove
3. Underbody Rear Air Deflector Replacement - Right Side Â» Remove
4. Fuel Feed Hose (1) @ Retainer (2)Â» Remove

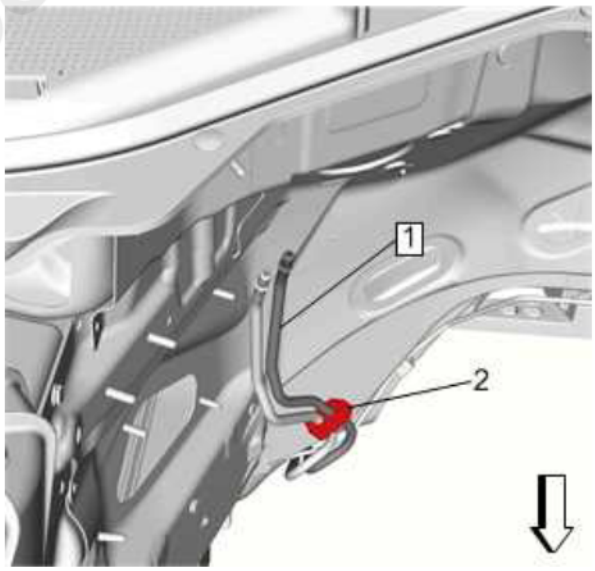

Fig. 95: Fuel Feed Hose And Retainer
Courtesy of GENERAL MOTORS COMPANY

5. Fuel Feed Hose (1) @ Fuel Pump Fuel Feed Hose (2)Â» Disconnect - Plastic Collar Quick Connect Fitting Service

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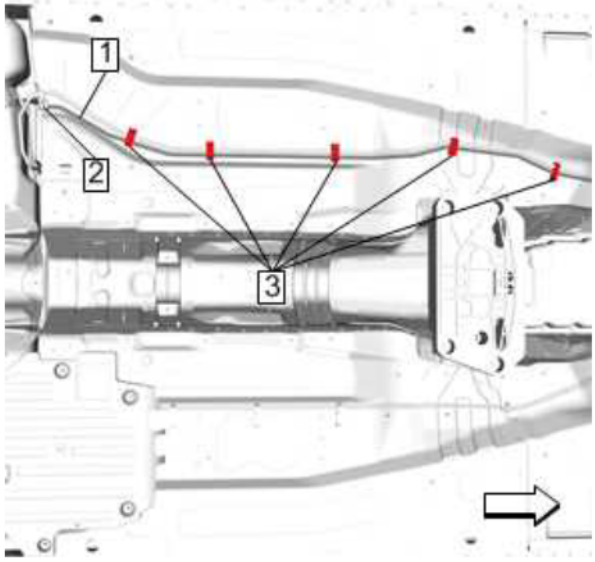

Fig. 96: Fuel Feed Hose, Fuel Pump Feed Hose And Retainer
Courtesy of GENERAL MOTORS COMPANY

6. Fuel Feed Hose (1) @ Retainer (3)Â» Remove [5x]

Installation Procedure

1. Fuel Feed Hose (1) @ Retainer (3)Â» Install [5x]

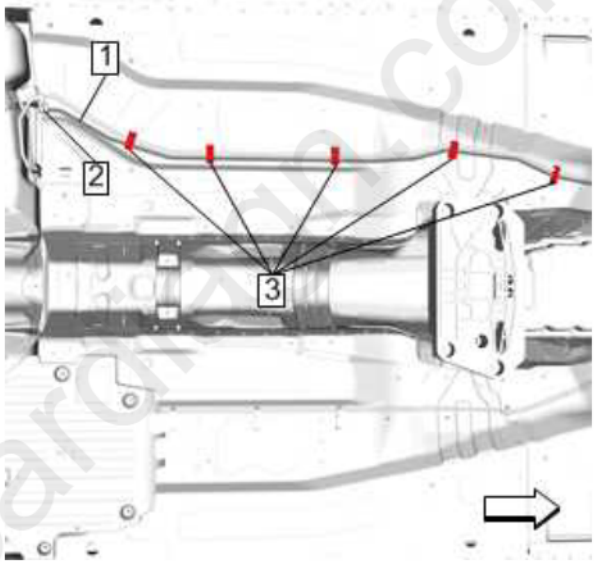

Fig. 97: Fuel Feed Hose, Fuel Pump Feed Hose And Retainer
Courtesy of GENERAL MOTORS COMPANY

2. Fuel Feed Hose (1) @ Fuel Pump Fuel Feed Hose (2)Â» Connect - **Plastic Collar Quick Connect Fitting Service**
3. Fuel Feed Hose (1) @ Retainer (2)Â» Install

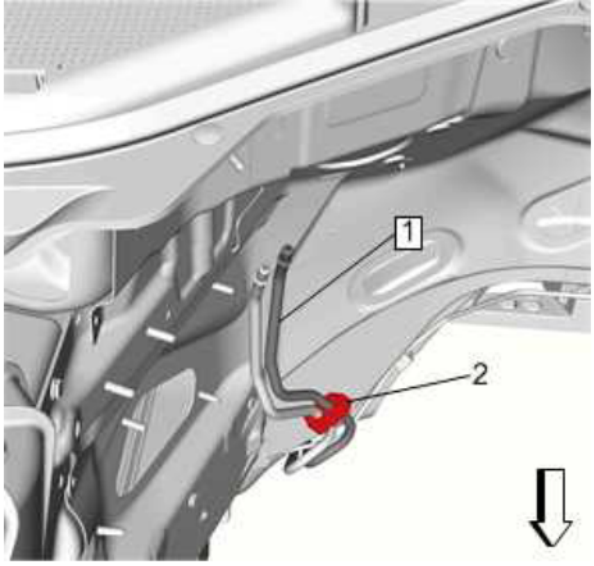

Fig. 98: Fuel Feed Hose And Retainer
Courtesy of GENERAL MOTORS COMPANY

4. Underbody Rear Air Deflector Replacement - Right Side Â» Install
5. Front Body Exhaust Heat Shield Replacement (Right Side, LGW, LGX) Front Body Exhaust Heat Shield Replacement (Left Side, LGW, LGX) Â» Install
6. Fuel Feed Hose ReplacementÂ» Install

FUEL FEED PIPE REPLACEMENT (LGX)

Removal Procedure

1. Fuel Feed Hose ReplacementÂ» Remove

   WARNING: Refer to Gasoline/Gasoline Vapors Warning .

   WARNING: Refer to Safety Glasses Warning .

2. Front Body Exhaust Heat Shield Replacement (Right Side, LGW, LGX) Front Body Exhaust Heat Shield Replacement (Left Side, LGW, LGX) Â» Remove
3. Underbody Rear Air Deflector Replacement - Right Side Â» Remove
4. Fuel Feed Hose (1) @ Retainer (2)Â» Remove

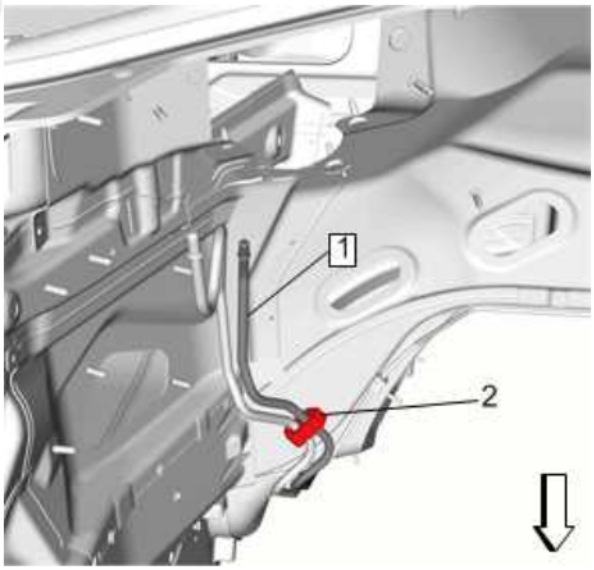

Fig. 99: Fuel Feed Hose And Retainer
Courtesy of GENERAL MOTORS COMPANY

5. Fuel Feed Hose (1) @ Fuel Pump Fuel Feed Hose (2)Â» Disconnect - Plastic Collar Quick Connect Fitting Service

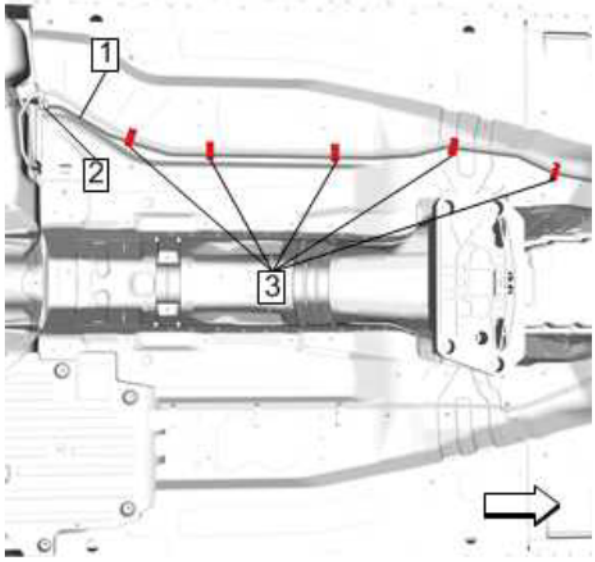

Fig. 100: Fuel Feed Hose, Fuel Pump Feed Hose And Retainer
Courtesy of GENERAL MOTORS COMPANY

6. Fuel Feed Hose (1) @ Retainer (3)Â» Remove [5x]

Installation Procedure

1. Fuel Feed Hose (1) @ Retainer (3)Â» Install [5x]

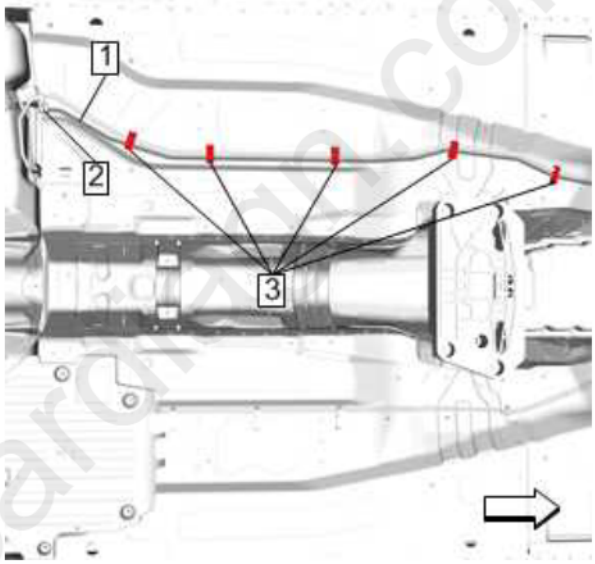

Fig. 101: Fuel Feed Hose, Fuel Pump Feed Hose And Retainer
Courtesy of GENERAL MOTORS COMPANY

2. Fuel Feed Hose (1) @ Fuel Pump Fuel Feed Hose (2)Â» Connect - **Plastic Collar Quick Connect Fitting Service**
3. Fuel Feed Hose (1) @ Retainer (2)Â» Install

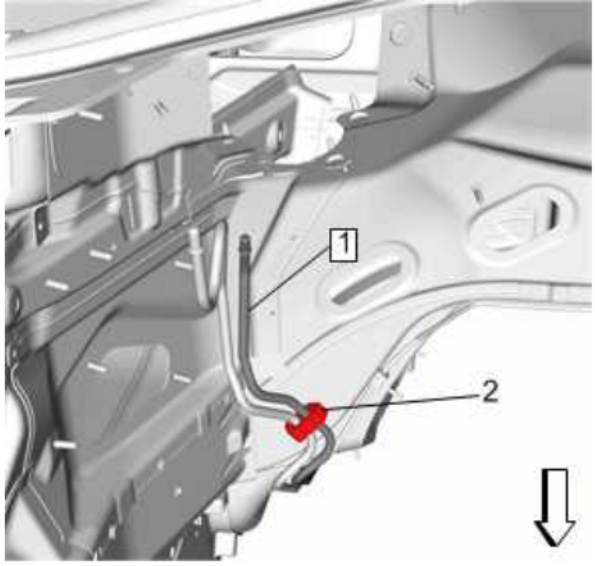

Fig. 102: Fuel Feed Hose And Retainer
Courtesy of GENERAL MOTORS COMPANY

4. Underbody Rear Air Deflector Replacement - Right Side Â» Install
5. Front Body Exhaust Heat Shield Replacement (Right Side, LGW, LGX) Front Body Exhaust Heat Shield Replacement (Left Side, LGW, LGX) Â» Install
6. Fuel Feed Hose ReplacementÂ» Install

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.
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.

FUEL PRESSURE SENSOR REPLACEMENT - FUEL INJECTION FUEL RAIL

Removal Procedure

1. Fuel Pressure ReliefÂ» Relieve the fuel system pressure.
2. Fuel Injection Fuel Rail Noise Shield ReplacementÂ» Remove
3. Electrical Connector (1) @ Fuel Injection Fuel Rail Fuel Pressure Sensor (2)Â» Disconnect

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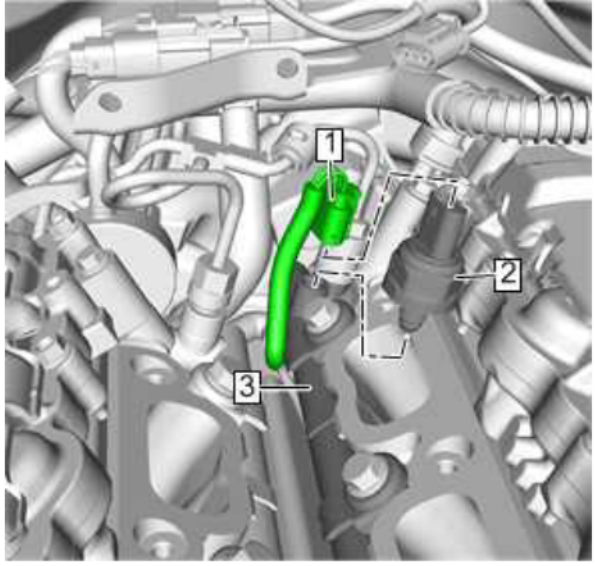

Fig. 103: Fuel Injection Fuel Rail Fuel Pressure Sensor And Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Fuel and Evaporative Emission Hose/Pipe Connection Cleaning Caution .

NOTE: Applying force to the plastic housing of the sensor may damage the sensor. To tighten or loosen, apply force only to the attached hexagon.

4. Fuel Injection Fuel Rail Fuel Pressure Sensor (2) @ Fuel Injection Fuel Rail (3)Â» Remove and DISCARD

NOTE: Some fuel may leak from the fuel injection fuel rail fuel pressure sensor orifice after the sensor is removed. Dry the area around this orifice after the removal of the sensor using a lint free cloth and inspect the fuel injection fuel rail fuel pressure sensor sealing surface. The surface should be free of fuel, debris and burrs.

Installation Procedure

1. Lubricate the threads and sealing surface of the NEW fuel injection fuel rail fuel pressure sensor with one drop of clean engine oil.

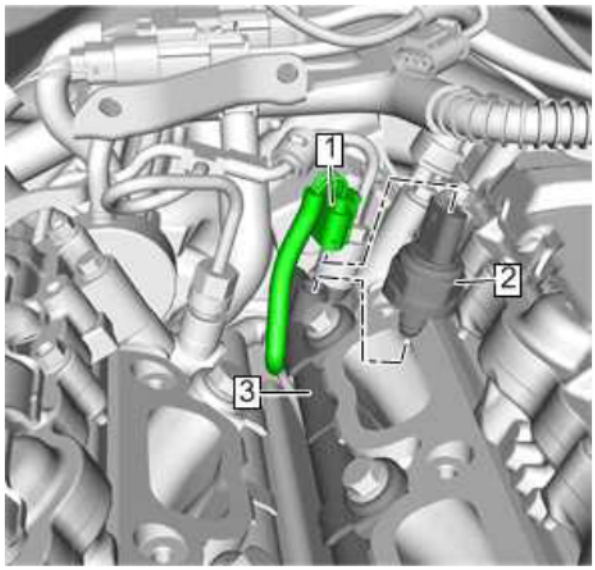

Fig. 104: Fuel Injection Fuel Rail Fuel Pressure Sensor And Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

NOTE: Applying force to the plastic housing of the sensor may damage the sensor. To tighten or loosen, apply force only to the attached

hexagon.

NOTE: **Ensure the fuel rail threads are clean and free of any excess fuel or the fuel injection fuel rail fuel pressure sensor will NOT seal properly.**

2. Install the NEW fuel injection fuel rail fuel pressure sensor (2) and hand tighten.
3. Fuel Injection Fuel Rail Fuel Pressure Sensor (2) @ Fuel Injection Fuel Rail (3)Â» Remove and re-lubricate with one drop of clean engine oil.
4. Fuel Injection Fuel Rail Fuel Pressure Sensor (2) @ Fuel Injection Fuel Rail (3)Â» Install and tighten 33 N.m (24 lb ft)

CAUTION: **Refer to Component Fastener Tightening Caution .**

5. Electrical Connector (1) @ Fuel Injection Fuel Rail Fuel Pressure Sensor (2)Â» Connect
6. Pressurize the fuel system and inspect for leaks.

NOTE: **If a fuel leak occurs at the fuel rail, the fuel rail will need to be replaced.**

7. Fuel Injection Fuel Rail Noise Shield ReplacementÂ» Install

FUEL INJECTION FUEL RAIL ASSEMBLY REPLACEMENT - BANK 1

Special Tools

EN-49248 Injector Rail Assembly Remover

For equivalent regional tools, refer to Special Tools (Diagnostic Tools) and/or Special Tools (Mechanical Tools) .

Removal Procedure

1. Fuel Feed Intermediate Pipe Replacement (LGW)Fuel Feed Intermediate Pipe Replacement (LGX)Â» Remove and DISCARD
2. Intake ManifoldÂ» Remove - Intake Manifold Replacement (LGW) Intake Manifold Replacement (LGX)
3. Fuel Injection Fuel Rail Fastener (2)Â» Remove [3x]

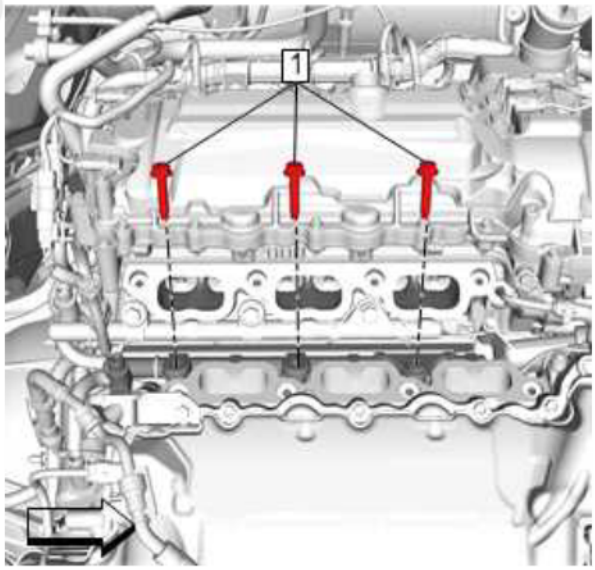

Fig. 105: Fuel Injection Fuel Rail Fasteners
Courtesy of GENERAL MOTORS COMPANY

4. Using the **EN-49248** Injector Rail Assembly Remover (1), evenly raise the fuel injection fuel rail (2) as an assembly.

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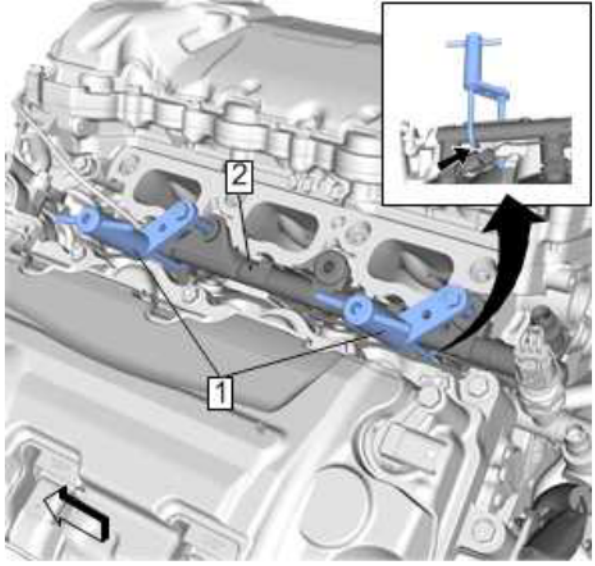

Fig. 106: Injector Rail Assembly Remover
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Ensure the hook of the Injector Rail Assembly Remover is properly seated across the underside of the fuel rail as shown.**

NOTE: **Use care when removing the fuel injection fuel rail assembly in order to prevent damage to the fuel injector spray tips.**

5. Once the fuel injection fuel rail is free, remove the **EN-49248** Injector Rail Assembly Remover (1).
6. Once the fuel injection fuel rail is removed, remove the fuel injectors and rebuild them. Refer to **Fuel Rail and Injectors Cleaning and Inspection**

NOTE: **The direct fuel injectors must be rebuilt whenever the injector has been released from the fuel rail or cylinder head.**

Installation Procedure

1. Fuel Injection Fuel Rail AssemblyÂ» Install into the cylinder head evenly.
2. Hand tighten the two outer fuel rail fasteners to seat the injectors.

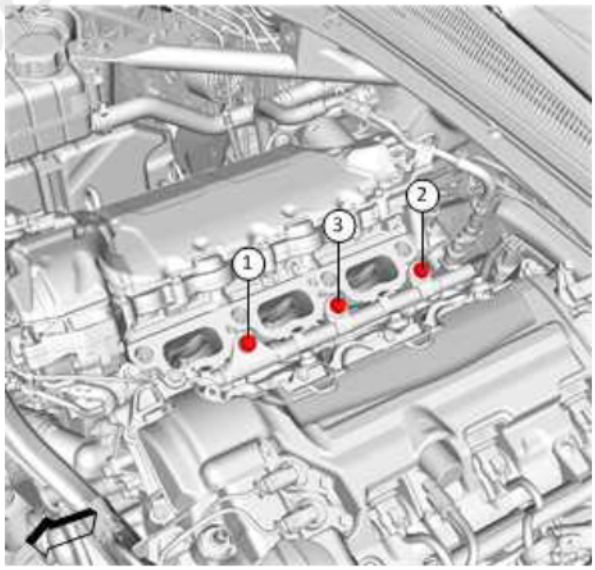

Fig. 107: Fuel Injection Fuel Rail Bolt Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Fastener Caution .**

3. Start and hand tighten the remaining fuel rail fastener.

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4. Tighten the fuel rail fasteners in the sequence shown above:
    1. Fuel Injection Fuel Rail FastenerÂ» Install and tighten 25 N.m (18 lb ft)
5. Intake ManifoldÂ» Install - **Intake Manifold Replacement (LGW)** **Intake Manifold Replacement (LGX)**
6. Install the NEW fuel feed intermediate pipe. Refer to **Fuel Feed Intermediate Pipe Replacement (LGW)** **Fuel Feed Intermediate Pipe Replacement (LGX)**

FUEL INJECTION FUEL RAIL ASSEMBLY REPLACEMENT - BANK 2

Special Tools

EN-49248 Injector Rail Assembly Remover

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

Removal Procedure

1. **Fuel Feed Intermediate Pipe Replacement (LGW)** and/or **Fuel Feed Intermediate Pipe Replacement (LGX)**Â» Remove and DISCARD
2. Intake ManifoldÂ» Remove - **Intake Manifold Replacement (LGW)** **Intake Manifold Replacement (LGX)**
3. Fuel Injection Fuel Rail Fastener (1)Â» Remove [3x]

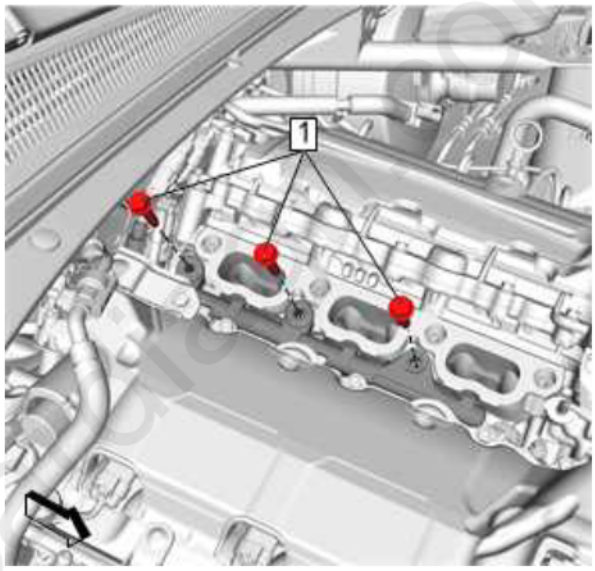

Fig. 108: Fuel Injection Fuel Rail
Courtesy of GENERAL MOTORS COMPANY

4. Using the **EN-49248** Injector Rail Assembly Remover (1), evenly raise the fuel injection fuel rail (2) as an assembly.

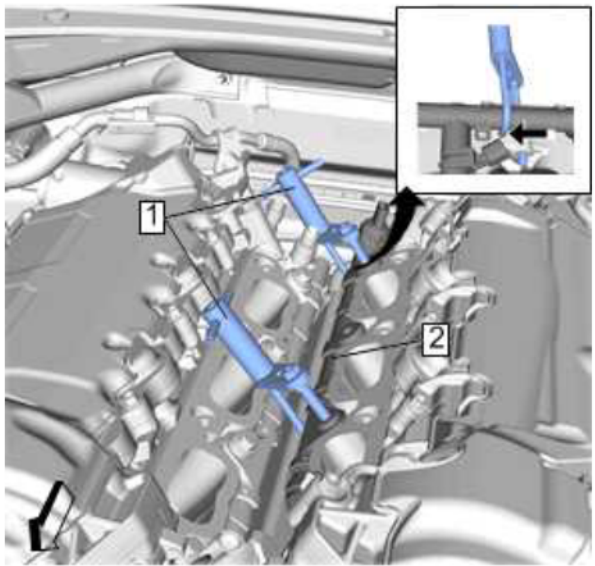

Fig. 109: Injector Rail Assembly Remover
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Ensure the hook of the Injector Rail Assembly Remover is properly seated across the underside of the fuel rail as shown.**

NOTE: **Use care when removing the fuel injection fuel rail assembly in order to prevent damage to the fuel injector spray tips.**

5. Once the fuel injection fuel rail is free, remove the **EN-49248** Injector Rail Assembly Remover (1).
6. Once the fuel injection fuel rail is removed, remove the fuel injectors and rebuild them. Refer to **Fuel Rail and Injectors Cleaning and Inspection**

NOTE: **The direct fuel injectors must be rebuilt whenever the injector has been released from the fuel rail or cylinder head.**

Installation Procedure

1. Fuel Injection Fuel Rail AssemblyÂ»Install into the cylinder head evenly.
2. Hand tighten the two outer fuel rail fasteners to seat the injectors.

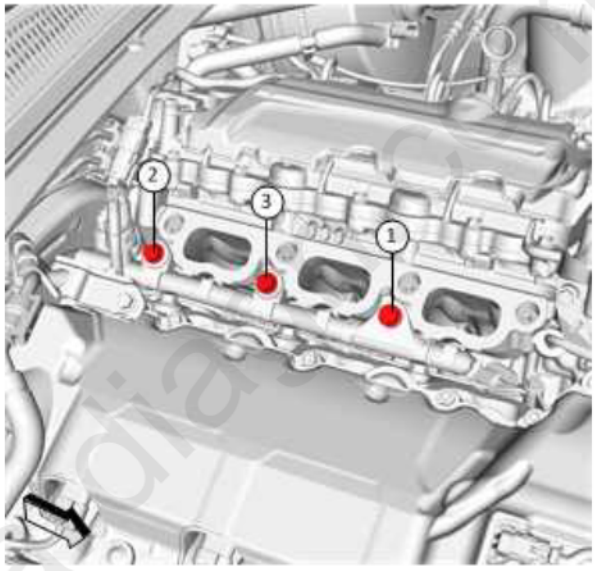

Fig. 110: Fuel Rail Fastener Tightening Sequence
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Fastener Caution .**

3. Start and hand tighten the remaining fuel rail fastener.
4. Tighten the fuel rail fasteners in the sequence shown above:
    1. Fuel Injection Fuel Rail FastenerÂ»Install and tighten 25 N.m (18 lb ft) [3x]
5. Intake ManifoldÂ» Install - **Intake Manifold Replacement (LGW)** **Intake Manifold Replacement (LGX)**
6. Install the NEW fuel feed intermediate pipe. Refer to **Fuel Feed Intermediate Pipe Replacement (LGW)** and/or **Fuel Feed Intermediate Pipe Replacement (LGX)**

FUEL INJECTION FUEL RAIL NOISE SHIELD REPLACEMENT

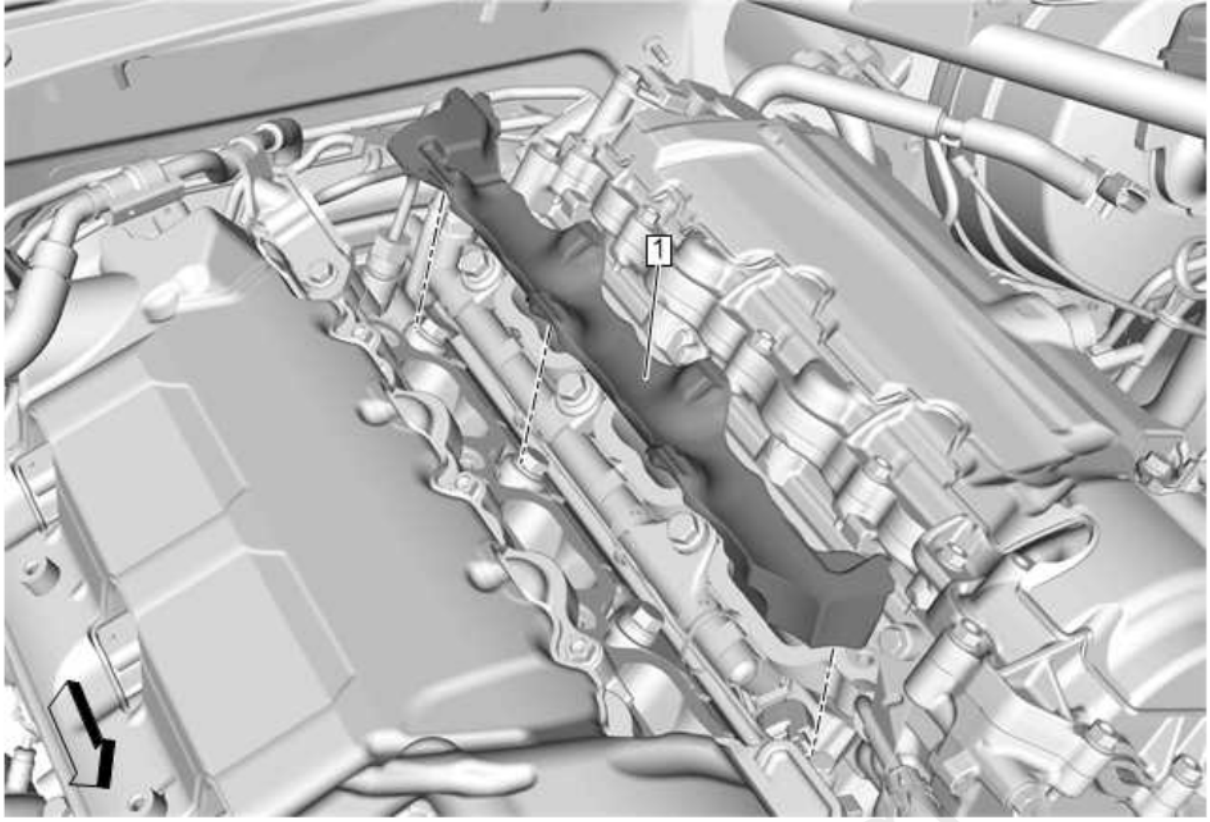

Fig. 111: Fuel Injection Fuel Rail Noise Shield
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Intake Manifold Replacement (LGW) Intake Manifold Replacement (LGX)	
1	Fuel Injection Fuel Rail Noise Shield **WARNING:** **The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage and possible injury or death.** **NOTE:** **The fuel injection fuel rail noise shield snaps into place.**

FUEL FEED INTERMEDIATE PIPE REPLACEMENT (LGW)

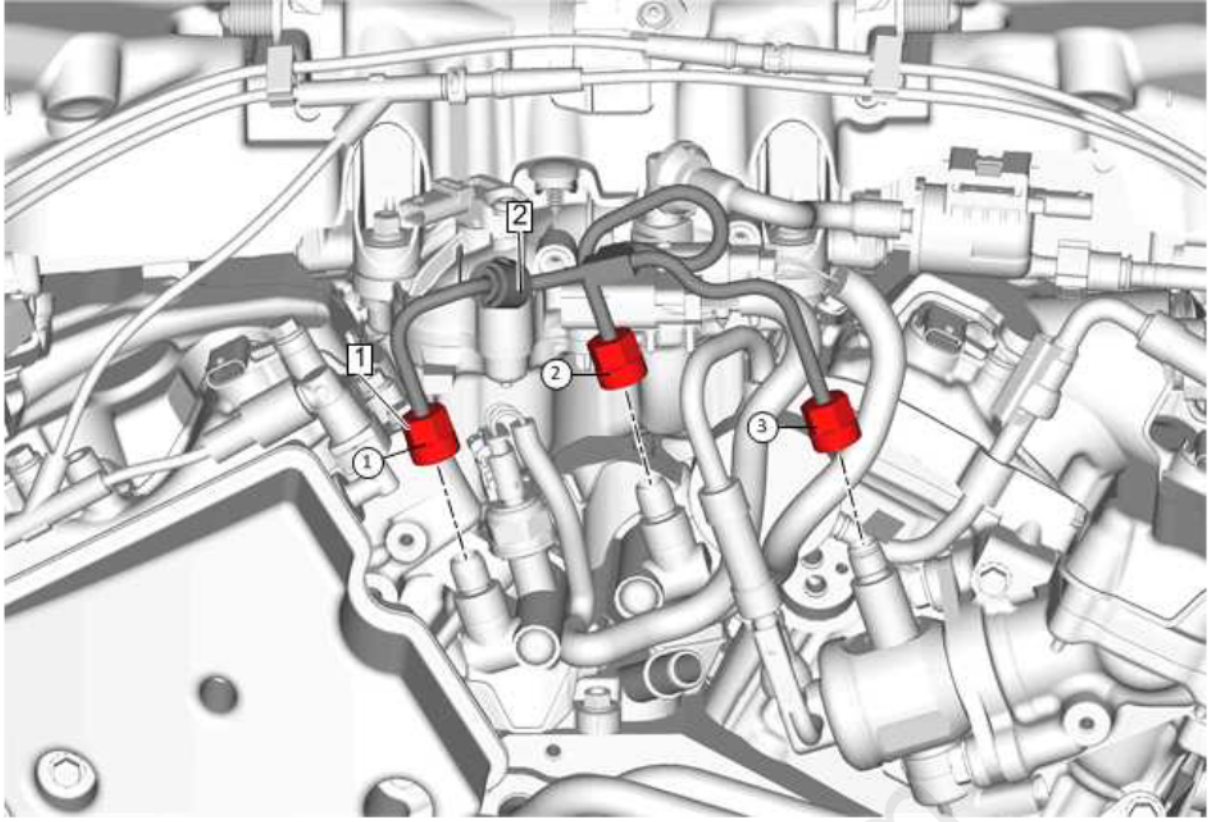

Fig. 112: Fuel Feed Intermediate Pipe (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Fuel Pressure Relief 2. Engine Rear Noise Shield Replacement	
1	Fuel Feed Intermediate Pipe Fitting [3x] **CAUTION:** **Refer to Component Fastener Tightening Caution .** **Procedure** Tighten the fittings evenly in sequence as numbered (1, 2, 3) to 30 N.m (22 lb ft)
2	Fuel Feed Intermediate Pipe **Procedure** 1. DISCARD the pipe when removed and install a NEW pipe. 2. Pressurize the fuel system and inspect for leaks.

FUEL FEED INTERMEDIATE PIPE REPLACEMENT (LGX)

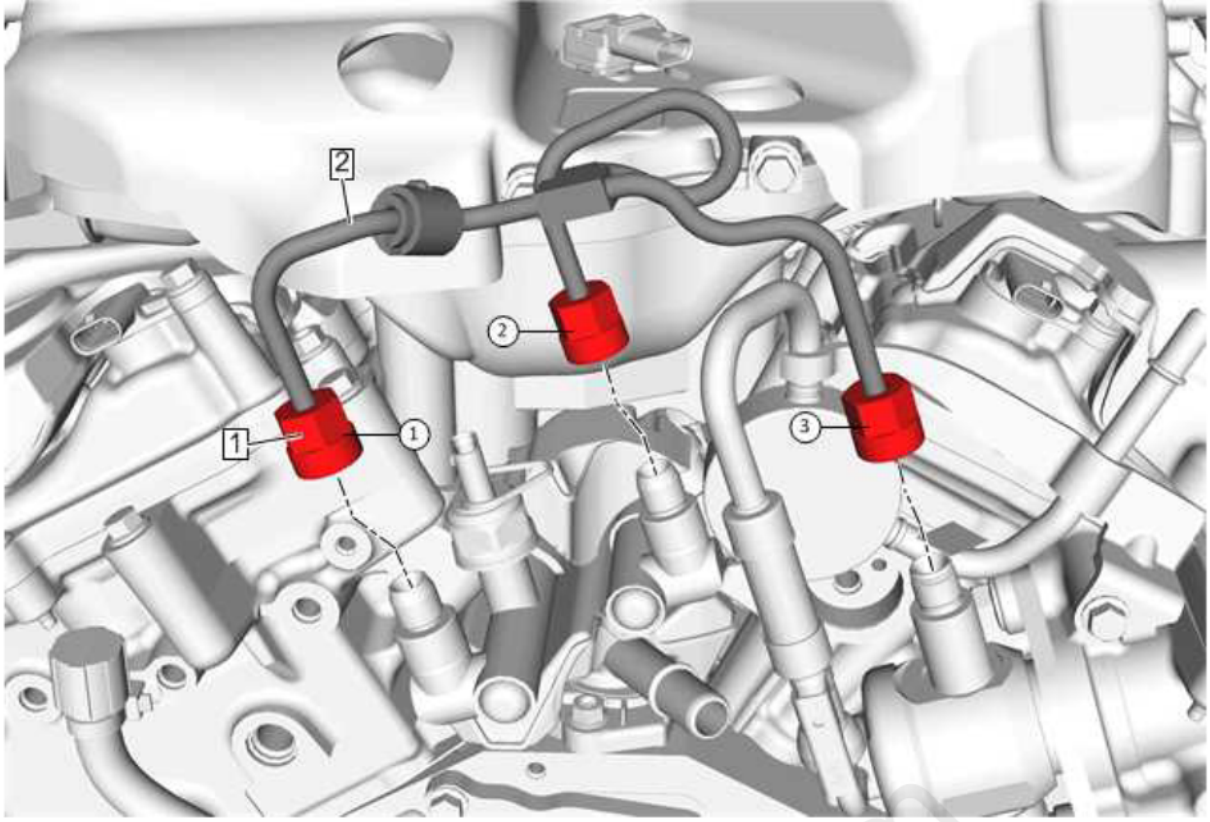

Fig. 113: Fuel Feed Intermediate Pipe
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Fuel Pressure Relief 2. Engine Rear Noise Shield Replacement	
1	Fuel Feed Intermediate Pipe Fitting [3x] **CAUTION:** **Refer to Component Fastener Tightening Caution .** **Procedure** Tighten the fittings evenly in sequence as numbered (1, 2, 3) to 30 N.m (22 lb ft)
2	Fuel Feed Intermediate Pipe **Procedure** 1. DISCARD the pipe when removed and install a NEW pipe. 2. Pressurize the fuel system and inspect for leaks.

FUEL PIPE SHIELD REPLACEMENT (LGW)

Removal Procedure

1. Charge Air Cooler CoverÂ» Remove - Charge Air Cooler Cover Replacement
2. Engine Support FixtureÂ» Install - Engine Support Fixture (LGW)
3. Raise the vehicle. Refer to Lifting and Jacking the Vehicle

WARNING: **Ensure that the vehicle is properly supported and squarely positioned. To help avoid personal injury when a vehicle is on a hoist, provide additional support for the vehicle on the opposite end from which the components are being removed.**

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4. Floor Panel Number 2 Cross Bar Reinforcement (2)Â» Remove - **Floor Panel Number 2 Cross Bar Reinforcement Replacement**

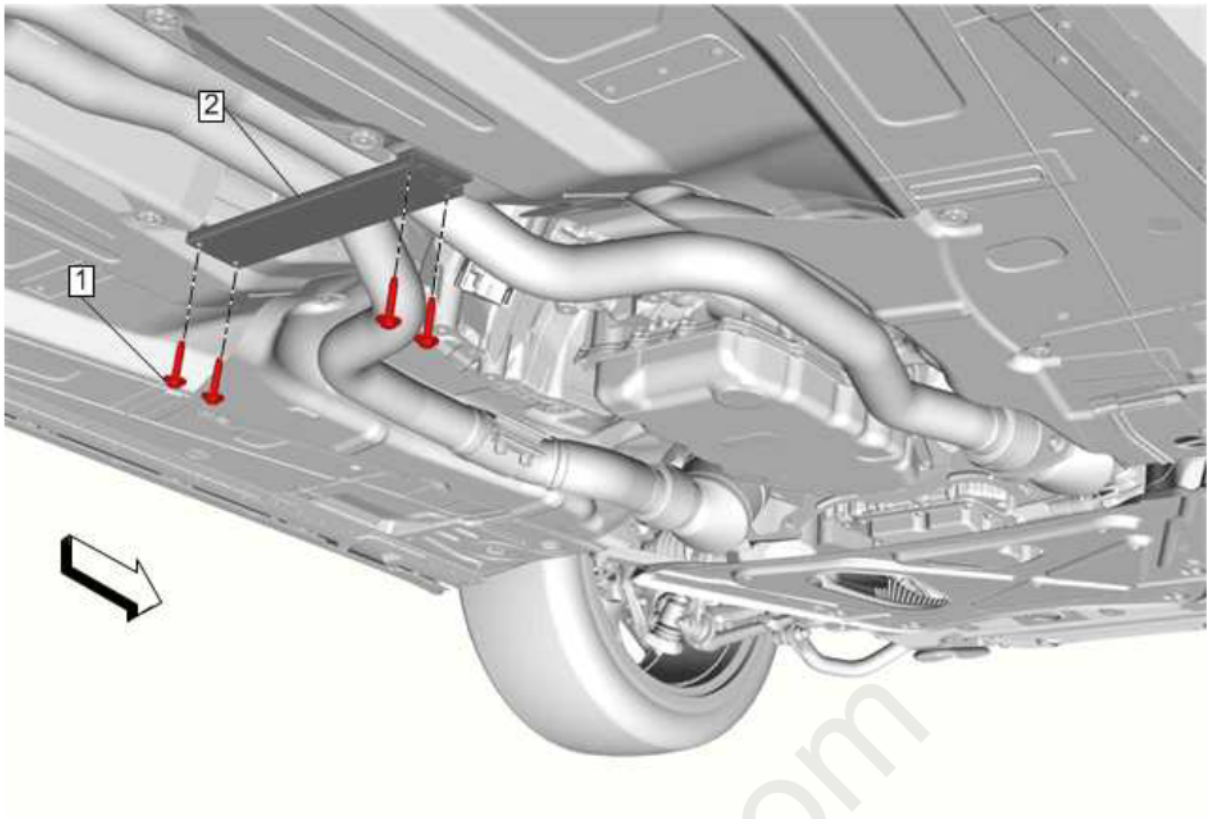

Fig. 114: Floor Panel Number 2 Cross Bar Reinforcement
Courtesy of GENERAL MOTORS COMPANY

5. Floor Panel Number 4 Cross Bar Reinforcement (2)Â» Remove - **Floor Panel Number 4 Cross Bar Replacement**

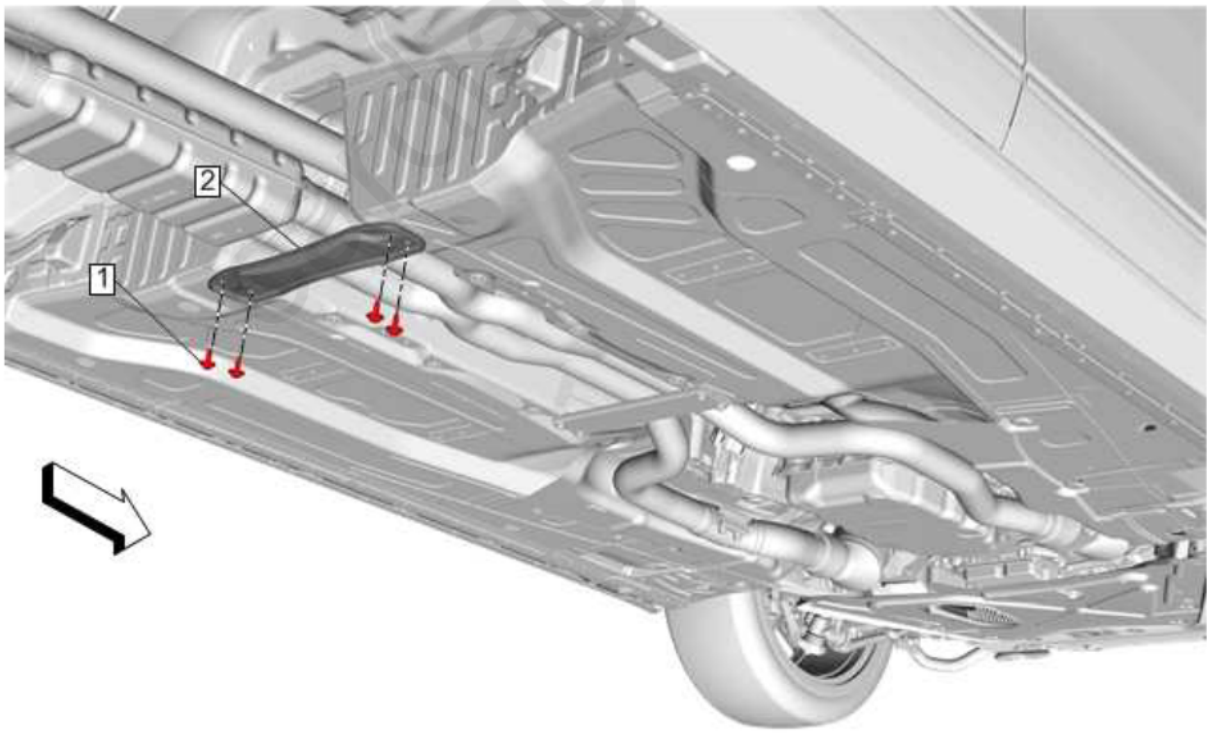

Fig. 115: Floor Panel Number 4 Cross Bar
Courtesy of GENERAL MOTORS COMPANY

6. Exhaust Muffler Isolator (1)Â» Disconnect [4x]

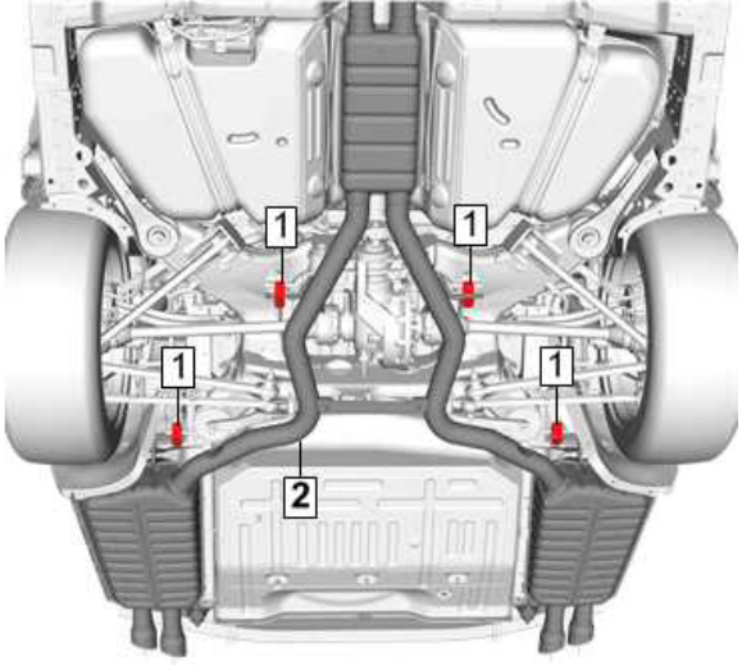

Fig. 116: Exhaust Muffler Assembly
Courtesy of GENERAL MOTORS COMPANY

7. Front Wheelhouse Liner (2)Â» Remove [2x] - **Front Wheelhouse Liner Replacement**

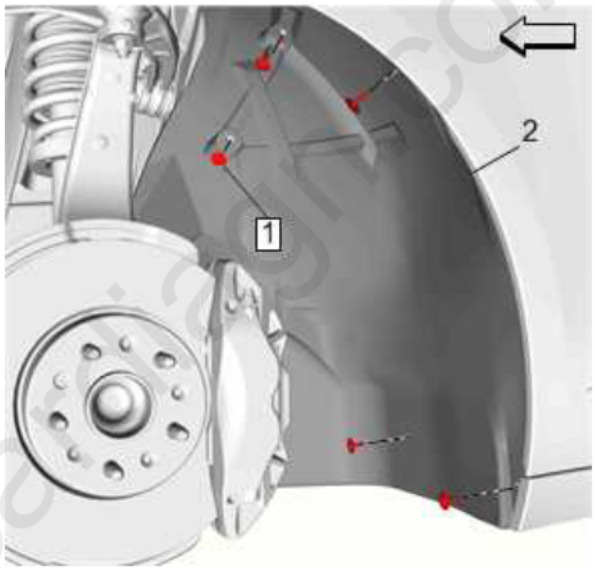

Fig. 117: Front Wheelhouse Liner
Courtesy of GENERAL MOTORS COMPANY

8. Front Tire Front Air Deflector (2)Â» Remove [2x] - **Front Tire Front Air Deflector Replacement**

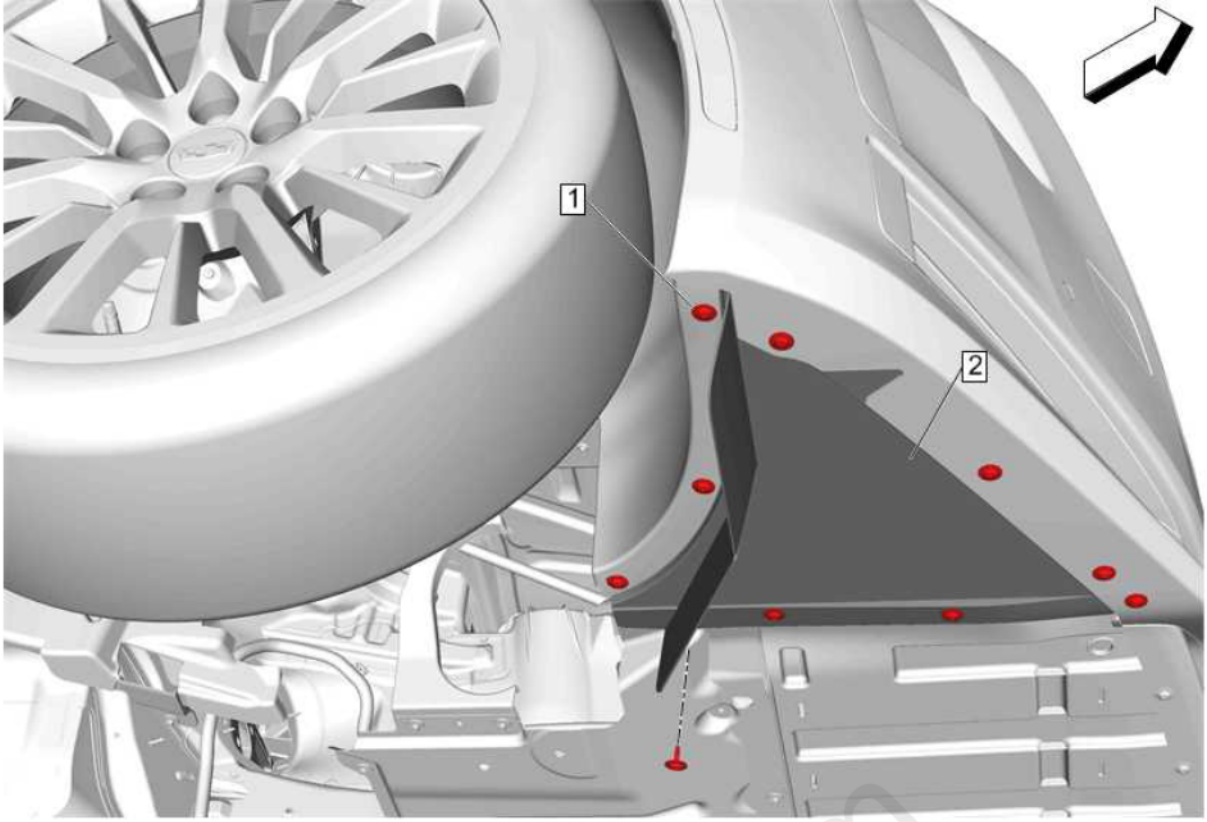

Fig. 118: Front Tire Front Air Deflector
Courtesy of GENERAL MOTORS COMPANY

9. Underbody Front Air Deflector (3)Â» Remove - **Underbody Front Air Deflector Replacement**

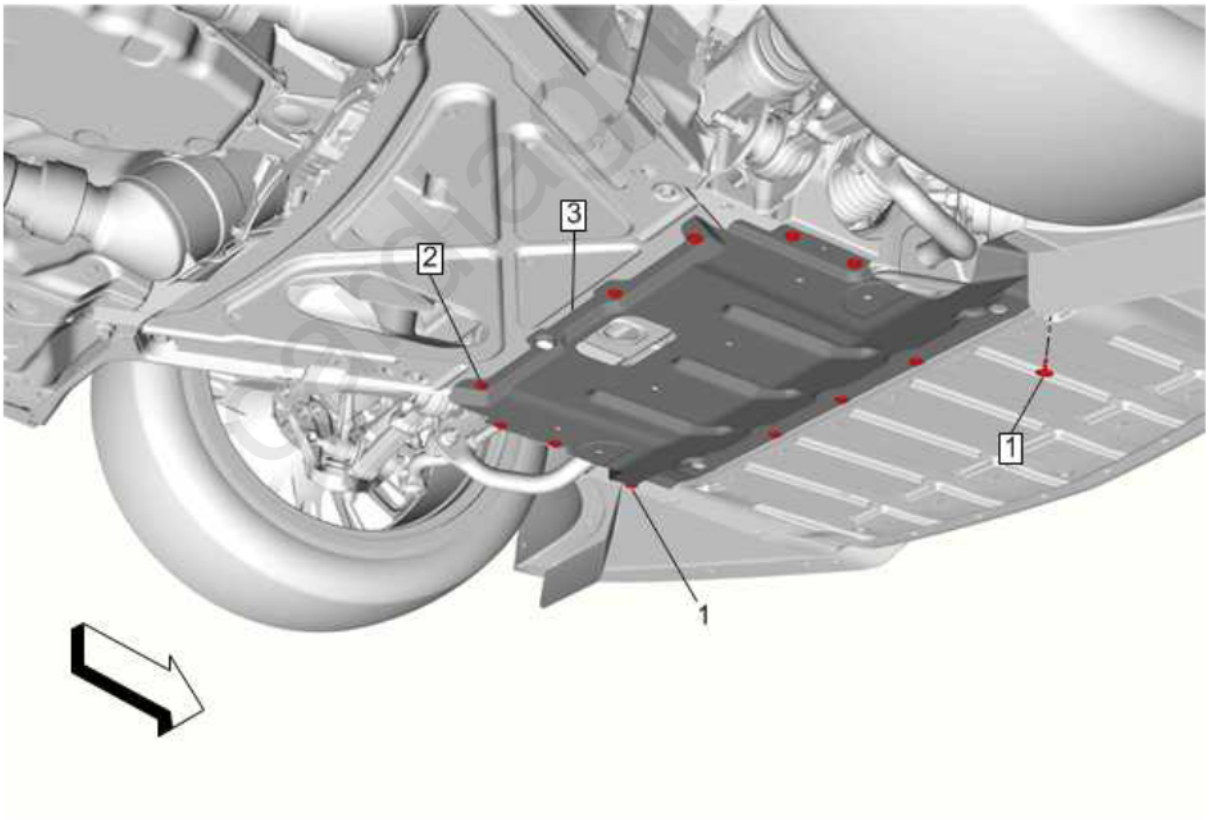

Fig. 119: Underbody Front Air Deflector
Courtesy of GENERAL MOTORS COMPANY

10. Front Bumper Fascia Lower Stiffener (1)Â» Remove - **Front Bumper Fascia Lower Stiffener Replacement**

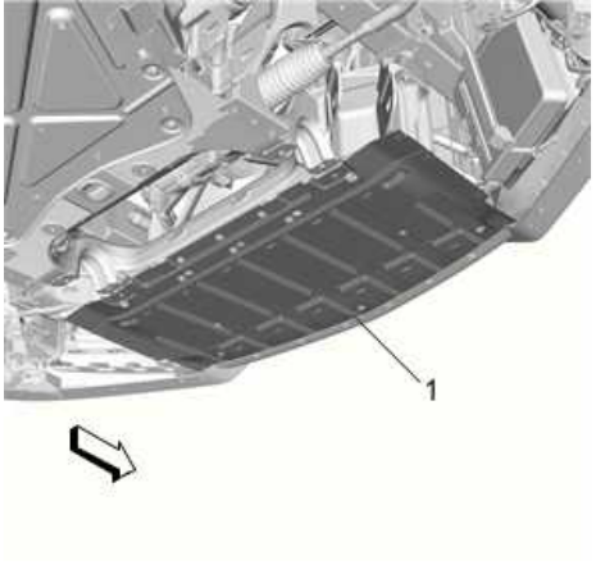

Fig. 120: Front Bumper Fascia Lower Stiffener
Courtesy of GENERAL MOTORS COMPANY

11. Support the radiator.
12. Drivetrain and Front Suspension Cradle Plate (3)Â» Remove - **Drivetrain and Front Suspension Cradle Plate Replacement**

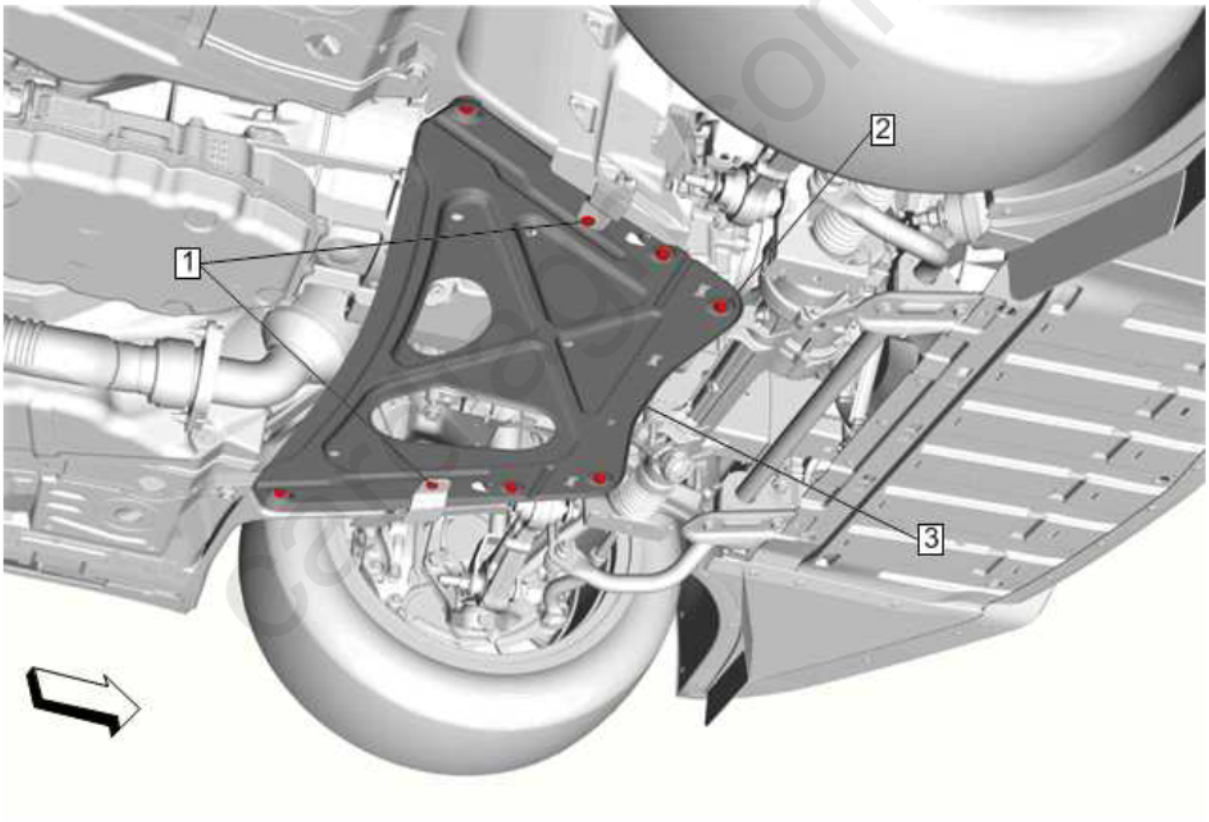

Fig. 121: Drivetrain and Front Suspension Cradle Plate
Courtesy of GENERAL MOTORS COMPANY

13. Intermediate Steering Shaft (1) @ Steering GearÂ» Remove - **Intermediate Steering Shaft Replacement (RWD)** **Intermediate Steering Shaft Replacement (AWD)**

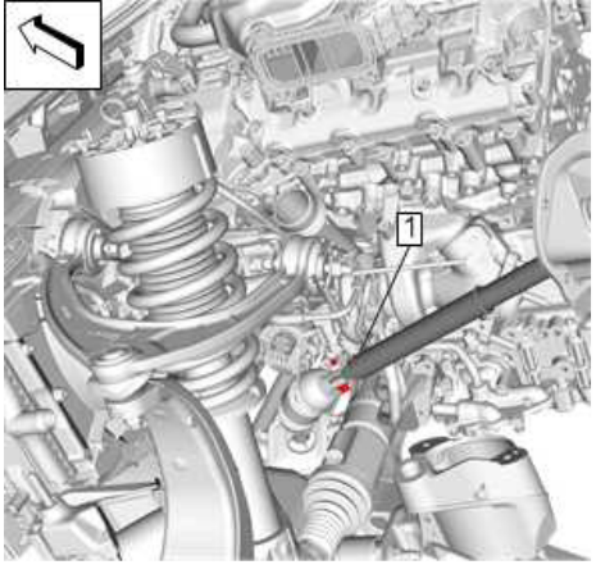

Fig. 122: Intermediate Steering Shaft
Courtesy of GENERAL MOTORS COMPANY

14. Drivetrain and Front Suspension Cradle Mounting Bolts (1)Â» Remove and DISCARD [6x]

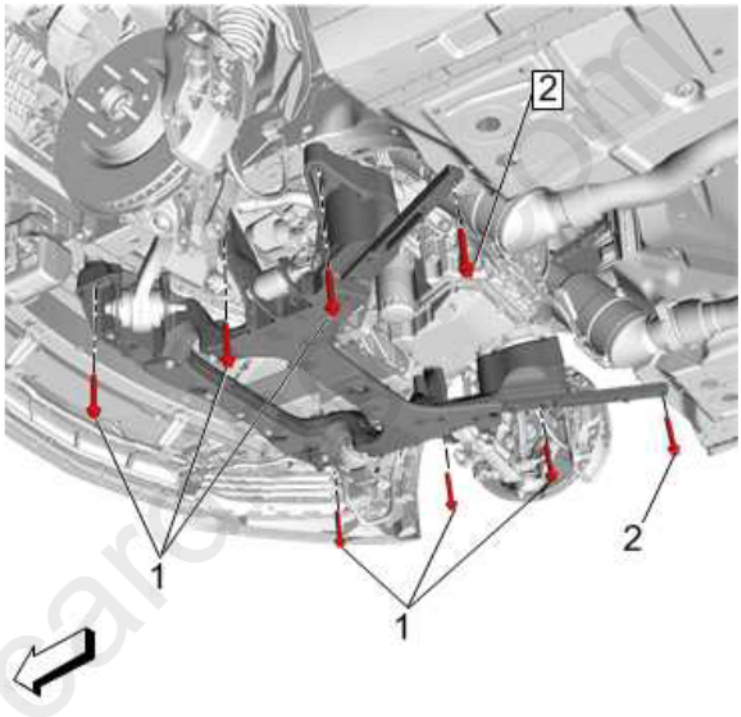

Fig. 123: Drivetrain and Front Suspension Cradle Mounting Bolts
Courtesy of GENERAL MOTORS COMPANY

15. Drivetrain and Front Suspension Cradle Mounting Bolts (2)Â» Remove and DISCARD [2x]
16. Lower the vehicle.
17. Unbolt the front shock absorbers from the front suspension upper mounts. Refer to **Shock Absorber and Spring Removal and Installation (RWD Without F55)** , **Shock Absorber and Spring Removal and Installation (AWD Without F55)** , **Shock Absorber and Spring Removal and Installation (RWD With F55)** and/or **Shock Absorber and Spring Removal and Installation (AWD With F55)**

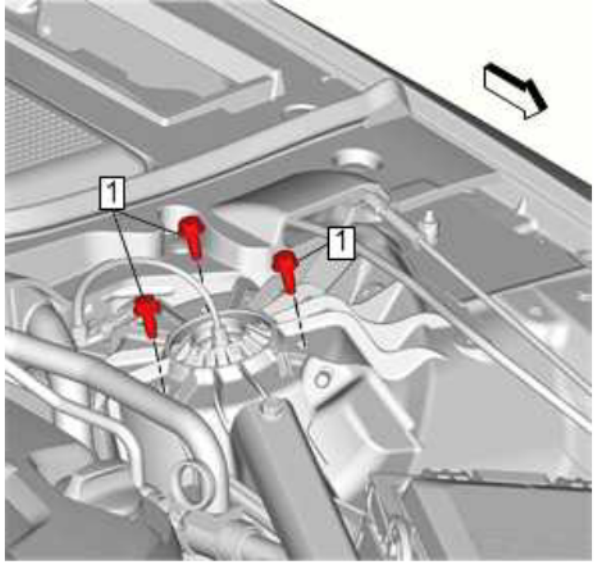

Fig. 124: Front Suspension Upper Mounts
Courtesy of GENERAL MOTORS COMPANY

18. Ensure the following items are clear from the frame:
    - Vacuum lines
    - Electrical wiring harnesses
    - Oil cooler lines
19. Using the engine support fixture, slowly lower the powertrain assembly with the drivetrain and front suspension cradle until the fuel pipe shield is accessible.
20. Support the drivetrain and front suspension cradle with suitable jack stands (1).

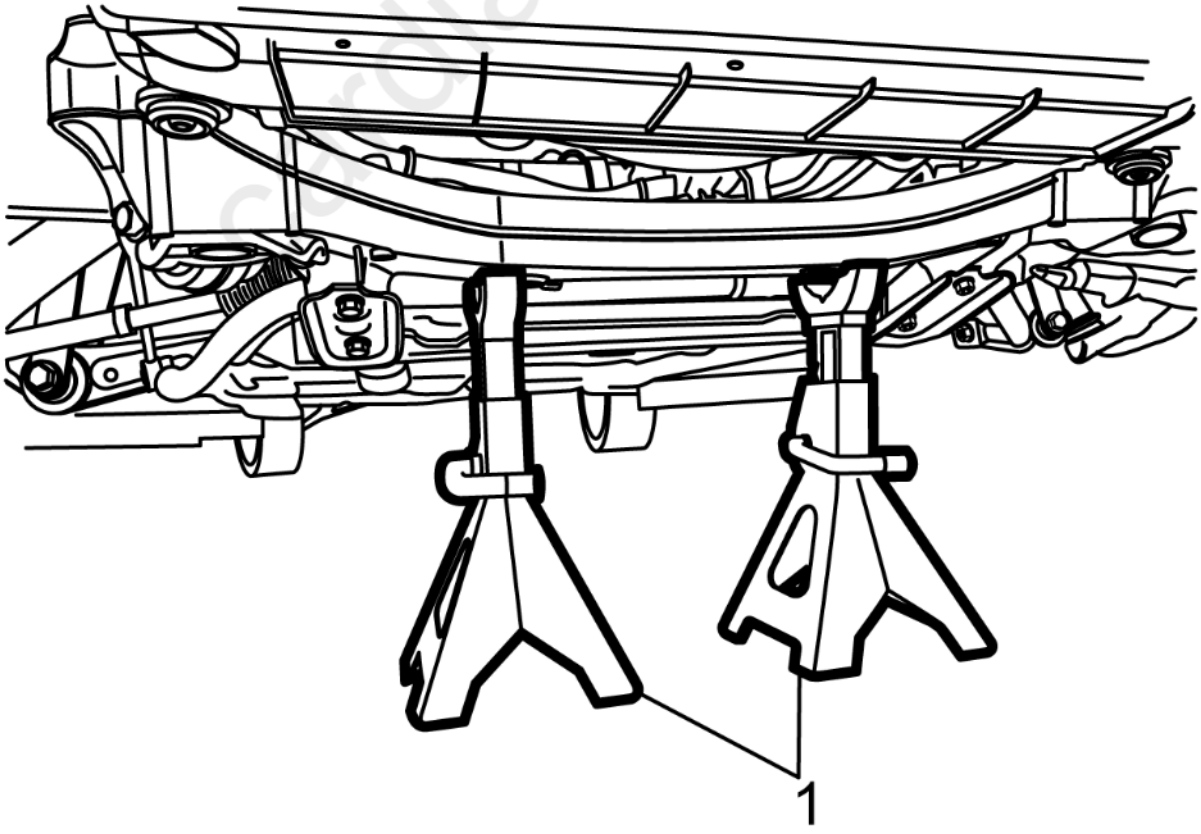

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Fig. 125: Jack Stands Supporting Drivetrain And Front Suspension Cradle
Courtesy of GENERAL MOTORS COMPANY

21. Retainer (1)Â» Unclip [3x]

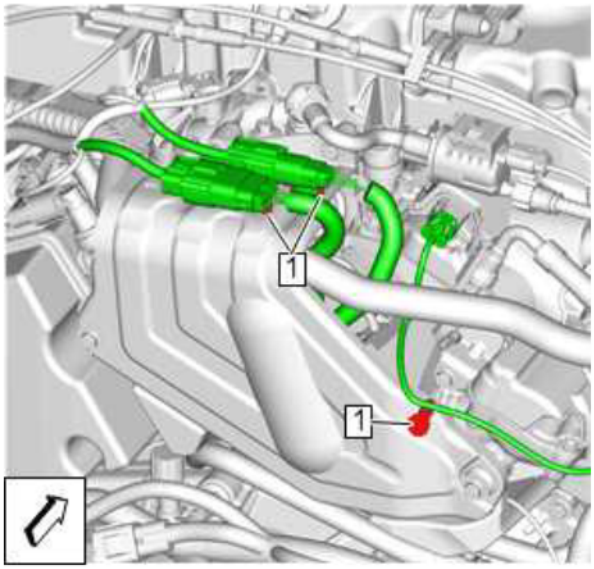

Fig. 126: Retainers
Courtesy of GENERAL MOTORS COMPANY

22. Fuel Pipe Shield Bolt (1)Â» Remove

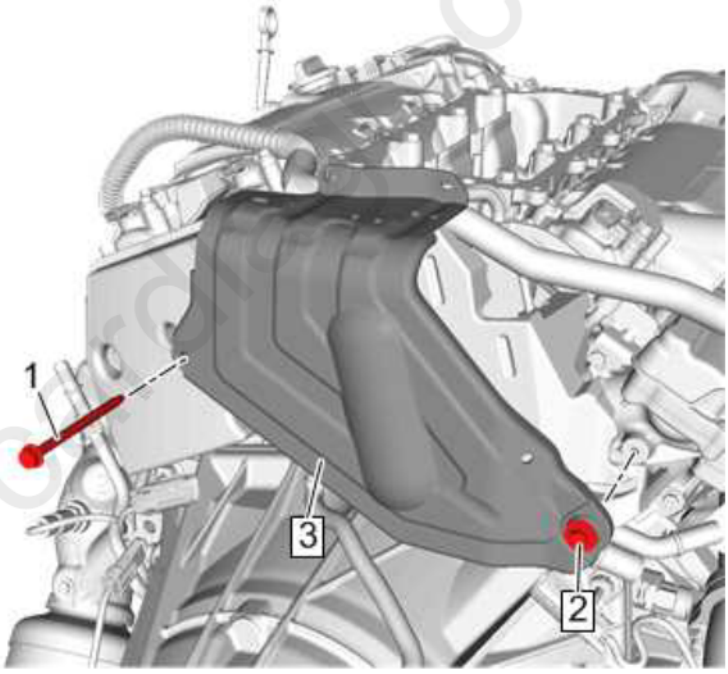

Fig. 127: Fuel Pipe Shield And Fuel Pipe Shield Bolts
Courtesy of GENERAL MOTORS COMPANY

23. Fuel Pipe Shield Bolt (2) @ Cylinder HeadÂ» Remove

NOTE: **Fuel pipe shield bolt (2) is retained in the fuel pipe shield by an insulator, it is not necessary to remove it from the fuel pipe shield.**

24. Fuel Pipe Shield (3)Â» Remove

Installation Procedure

1. Fuel Pipe Shield (3)Â» Install

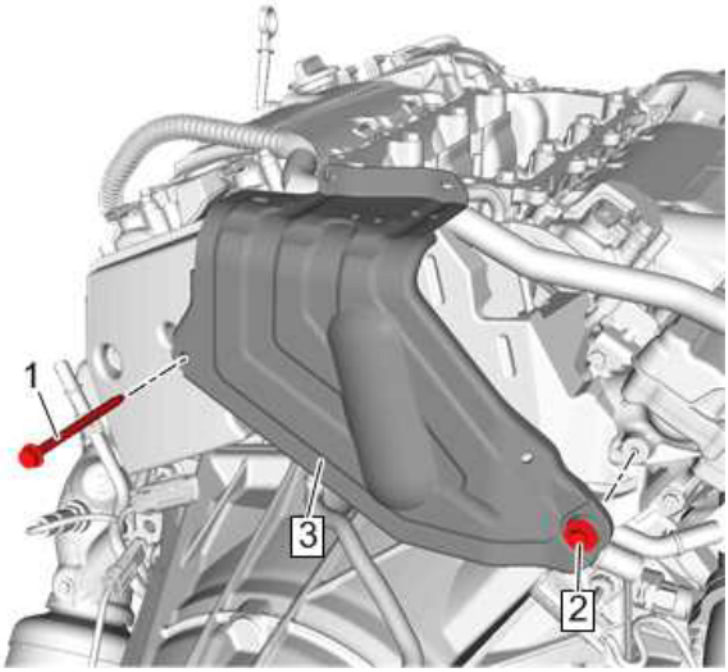

Fig. 128: Fuel Pipe Shield And Fuel Pipe Shield Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Fuel Pipe Shield Bolt (2) @ Cylinder HeadÂ» Install and tighten 9 N.m (80 lb in)

CAUTION: **Refer to Fastener Caution .**

3. Fuel Pipe Shield Bolt (1)Â» Install and tighten 9 N.m (80 lb in)
4. Retainer (1)Â» Install [3x]

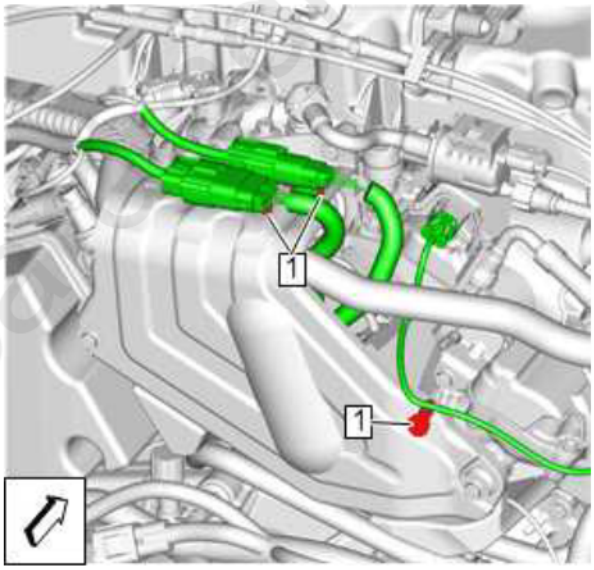

Fig. 129: Retainers
Courtesy of GENERAL MOTORS COMPANY

5. Ensure the following items are clear from the frame:
   - Vacuum lines
   - Electrical wiring harnesses
   - Oil cooler lines
6. Using the engine support fixture, slowly raise the powertrain assembly with the drivetrain and front suspension cradle into position.
7. Bolt the front shock absorbers to the front suspension upper mounts. Refer to **Shock Absorber and Spring Removal and Installation (RWD Without F55)** , **Shock Absorber and Spring Removal and Installation (AWD Without F55)** , **Shock Absorber and Spring Removal and Installation (RWD With F55)** and/or **Shock Absorber and Spring Removal and Installation (AWD With F55)**

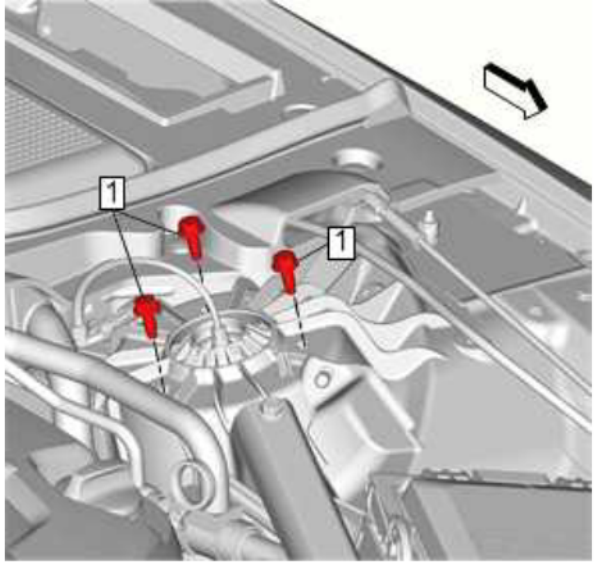

Fig. 130: Front Suspension Upper Mounts
Courtesy of GENERAL MOTORS COMPANY

8. Raise the vehicle.
9. Install NEW drivetrain and Front Suspension Cradle Mounting Bolts (1, 2). Refer to **Drivetrain and Front Suspension Cradle Removal and Installation**

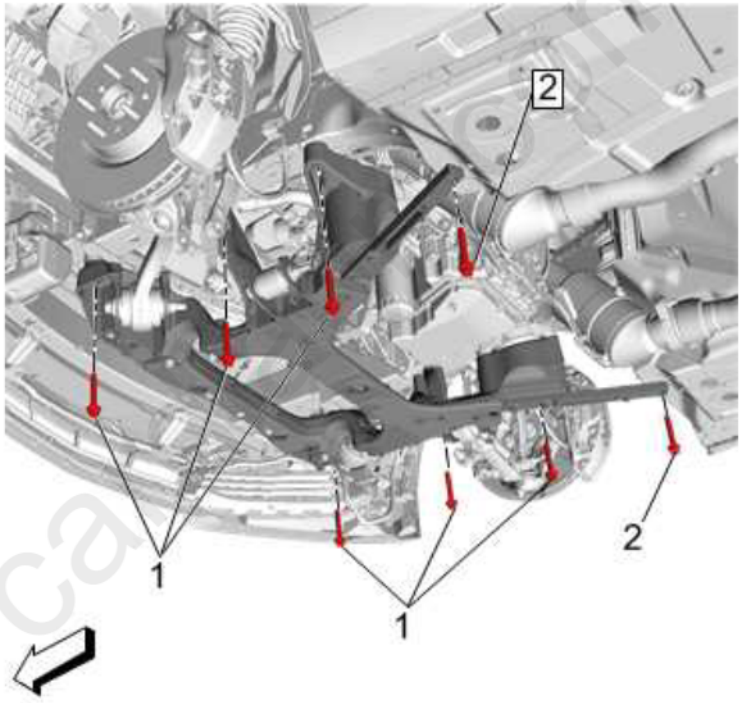

Fig. 131: Drivetrain and Front Suspension Cradle Mounting Bolts
Courtesy of GENERAL MOTORS COMPANY

10. Intermediate Steering Shaft (1) @ Steering GearÂ» Install - **Intermediate Steering Shaft Replacement (RWD)** **Intermediate Steering Shaft Replacement (AWD)**

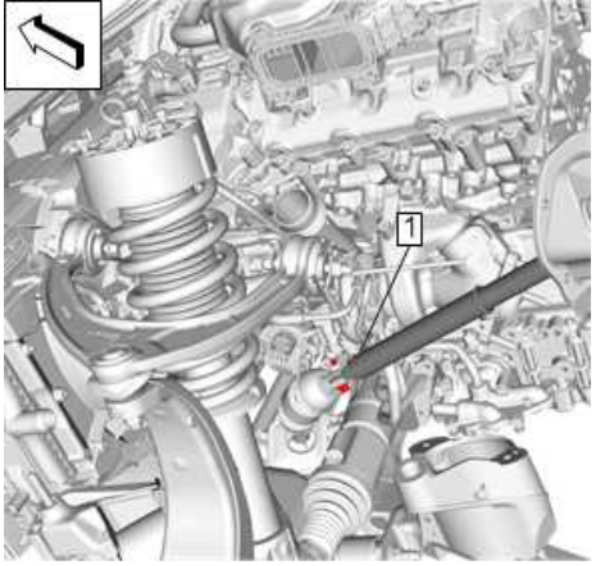

Fig. 132: Intermediate Steering Shaft
Courtesy of GENERAL MOTORS COMPANY

11. Drivetrain and Front Suspension Cradle Plate (3)Â» Install - **Drivetrain and Front Suspension Cradle Plate Replacement**

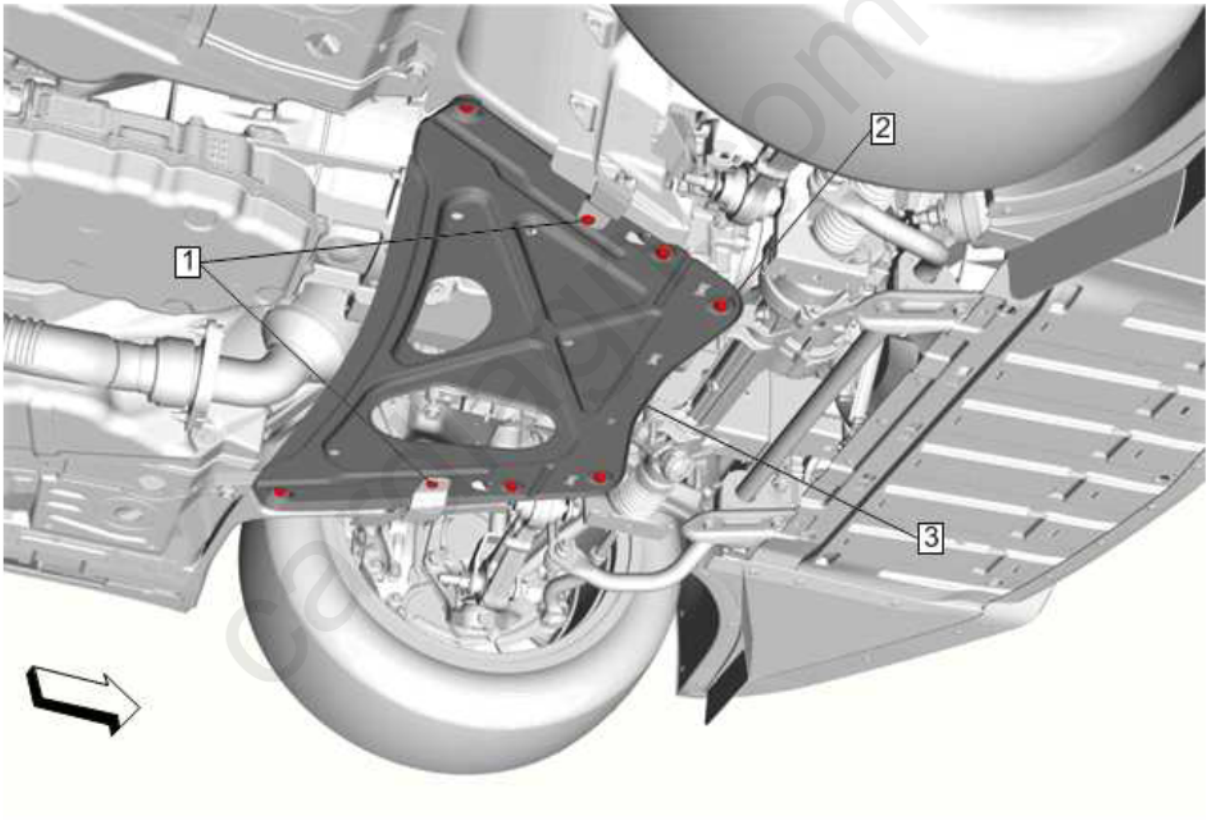

Fig. 133: Drivetrain and Front Suspension Cradle Plate
Courtesy of GENERAL MOTORS COMPANY

12. Remove the support from the radiator.
13. Front Bumper Fascia Lower Stiffener (1)Â» Install - **Front Bumper Fascia Lower Stiffener Replacement**

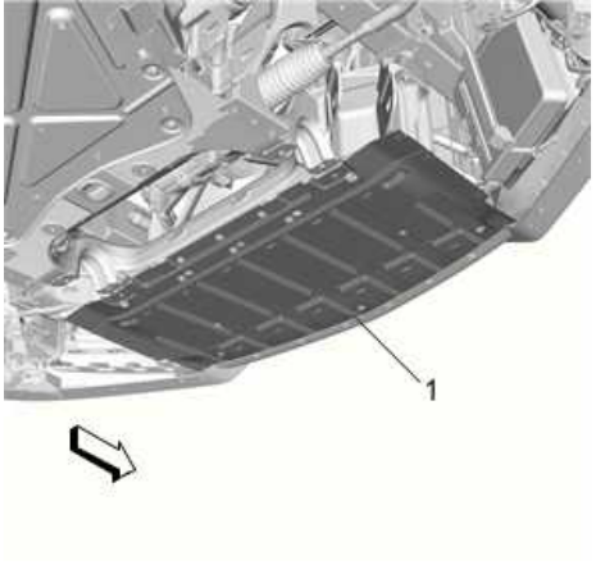

Fig. 134: Front Bumper Fascia Lower Stiffener
Courtesy of GENERAL MOTORS COMPANY

14. Underbody Front Air Deflector (3)Â» Install - **Underbody Front Air Deflector Replacement**

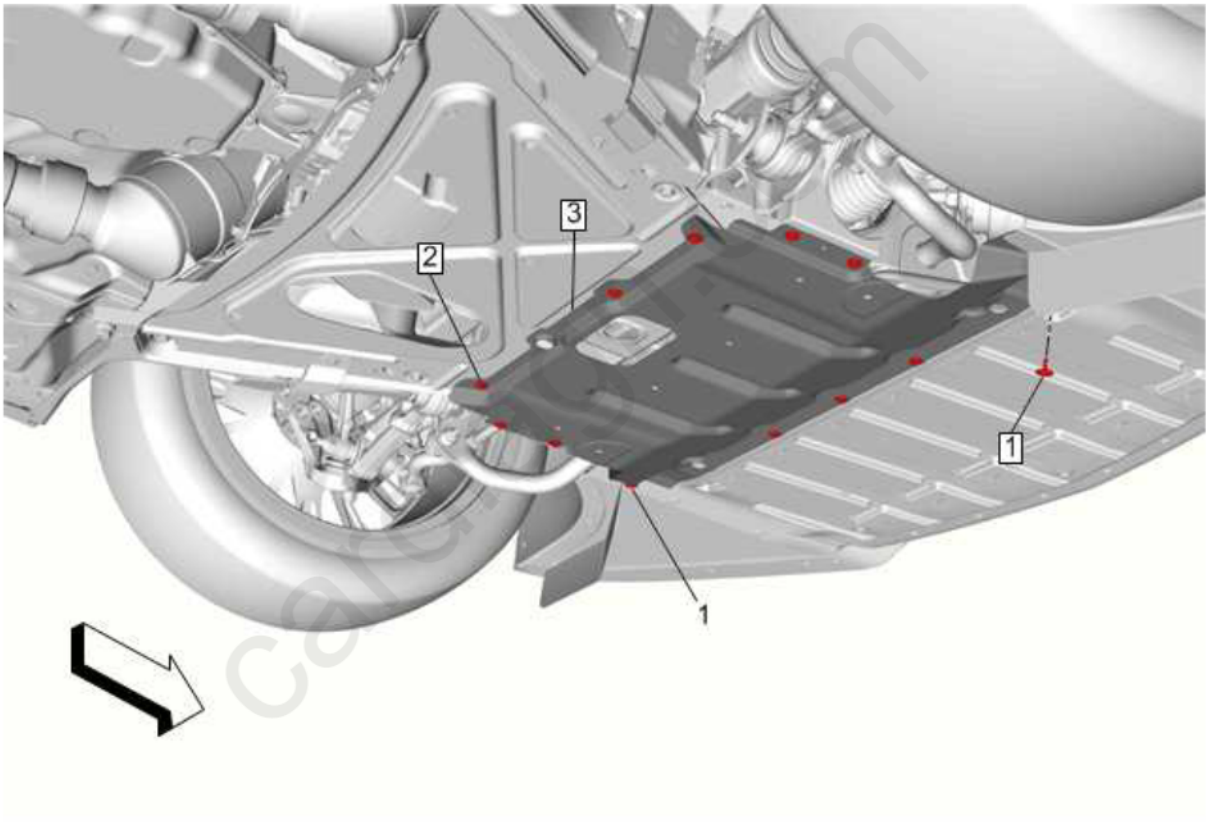

Fig. 135: Underbody Front Air Deflector
Courtesy of GENERAL MOTORS COMPANY

15. Front Tire Front Air Deflector (2)Â» Install [2x] - **Front Tire Front Air Deflector Replacement**

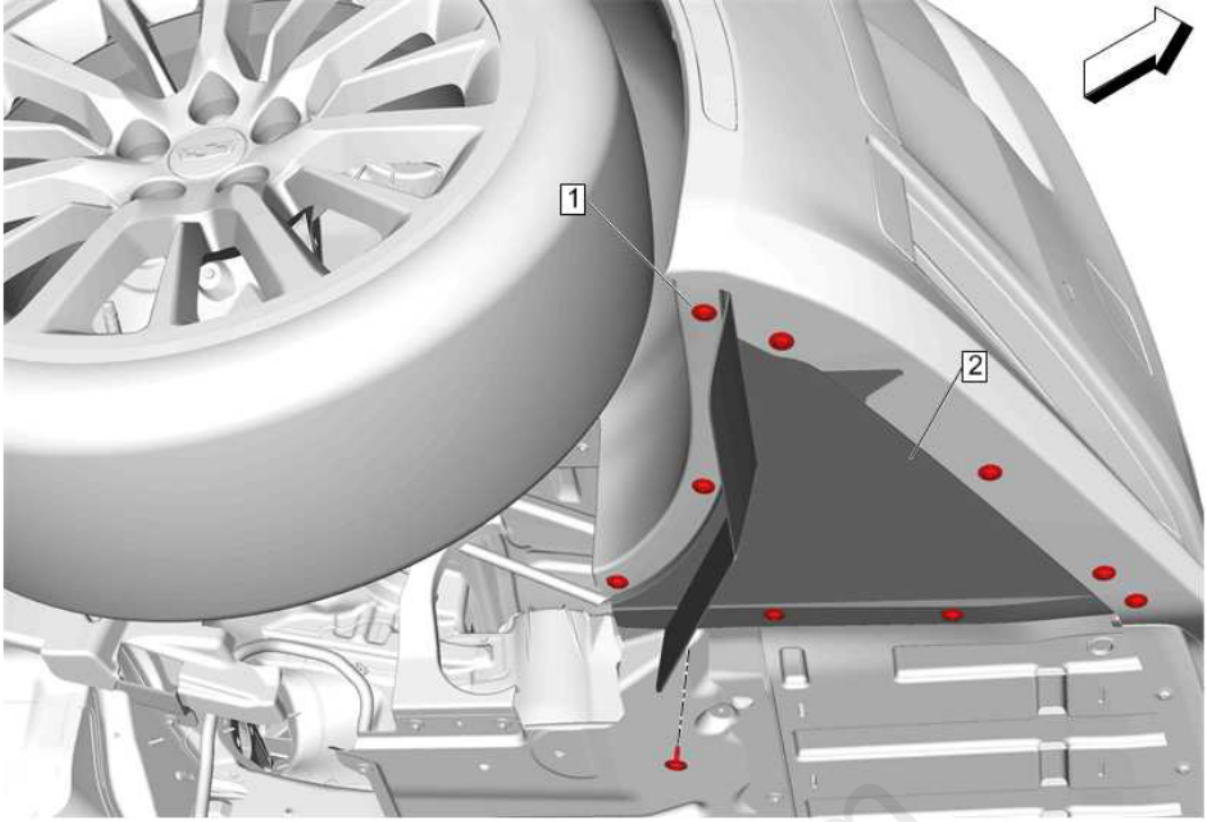

Fig. 136: Front Tire Front Air Deflector
Courtesy of GENERAL MOTORS COMPANY

16. Front Wheelhouse Liner (2)Â» Install [2x] - **Front Wheelhouse Liner Replacement**

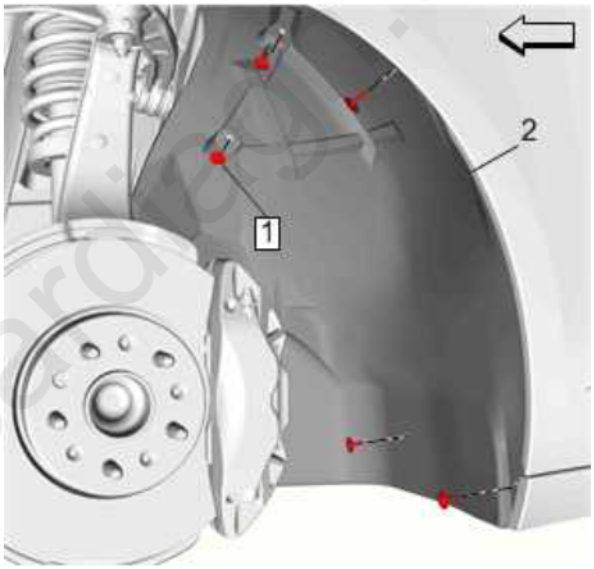

Fig. 137: Front Wheelhouse Liner
Courtesy of GENERAL MOTORS COMPANY

17. Exhaust Muffler Isolator (1)Â» Connect [4x]

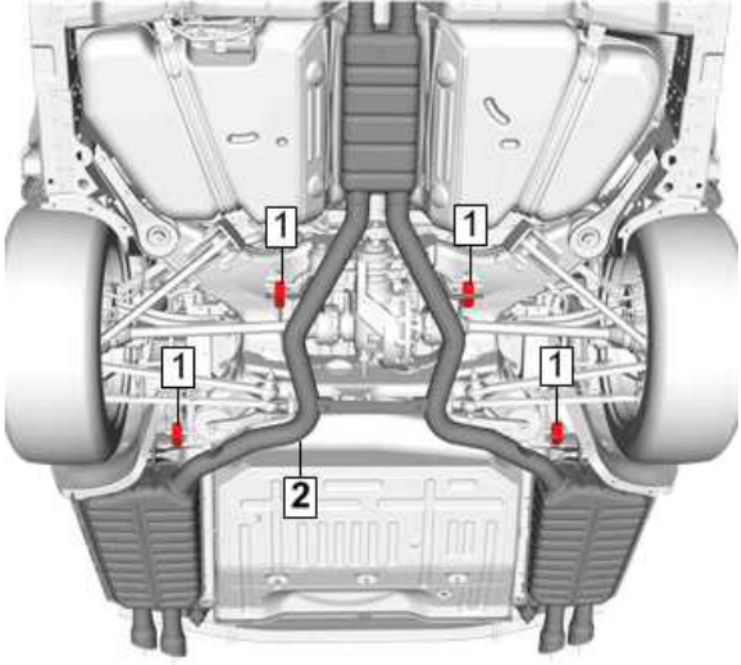

Fig. 138: Exhaust Muffler Assembly
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Clean and lubricate the exhaust isolators for ease of installation.**

18. Floor Panel Number 4 Cross Bar Reinforcement (2)Â» Install - **Floor Panel Number 4 Cross Bar Replacement**

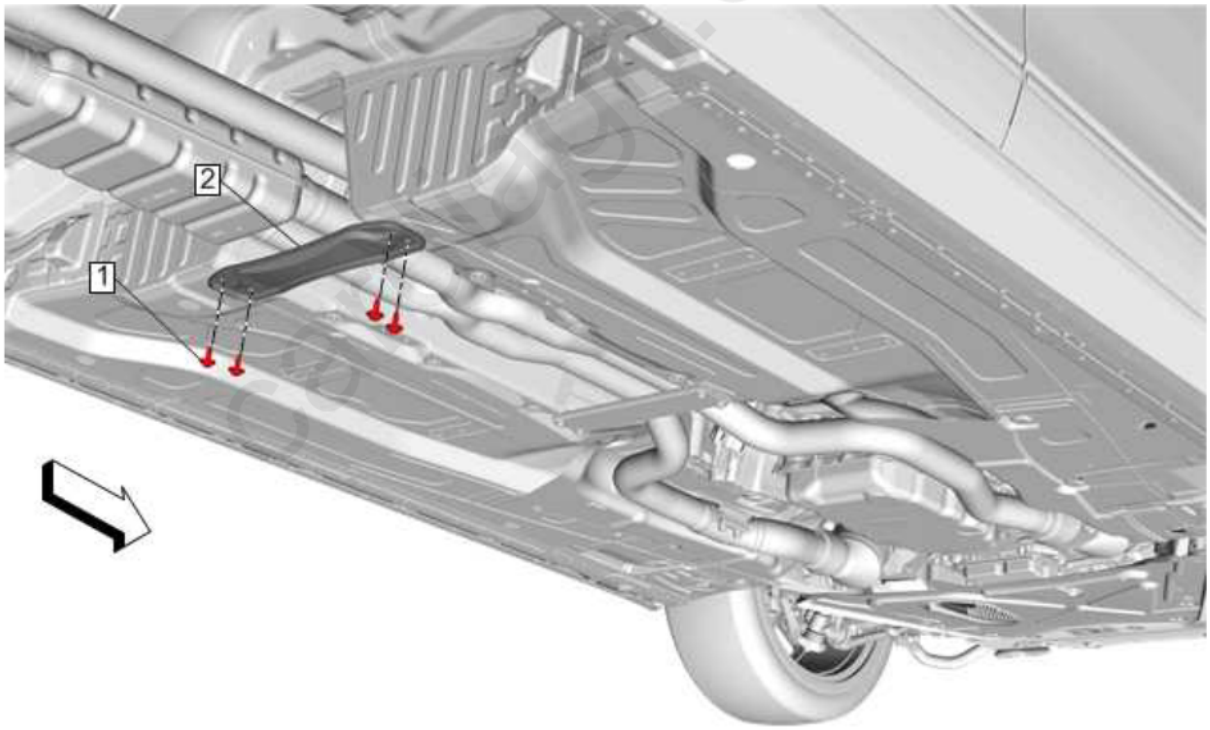

Fig. 139: Floor Panel Number 4 Cross Bar
Courtesy of GENERAL MOTORS COMPANY

19. Floor Panel Number 2 Cross Bar Reinforcement (2)Â» Install - **Floor Panel Number 2 Cross Bar Reinforcement Replacement**

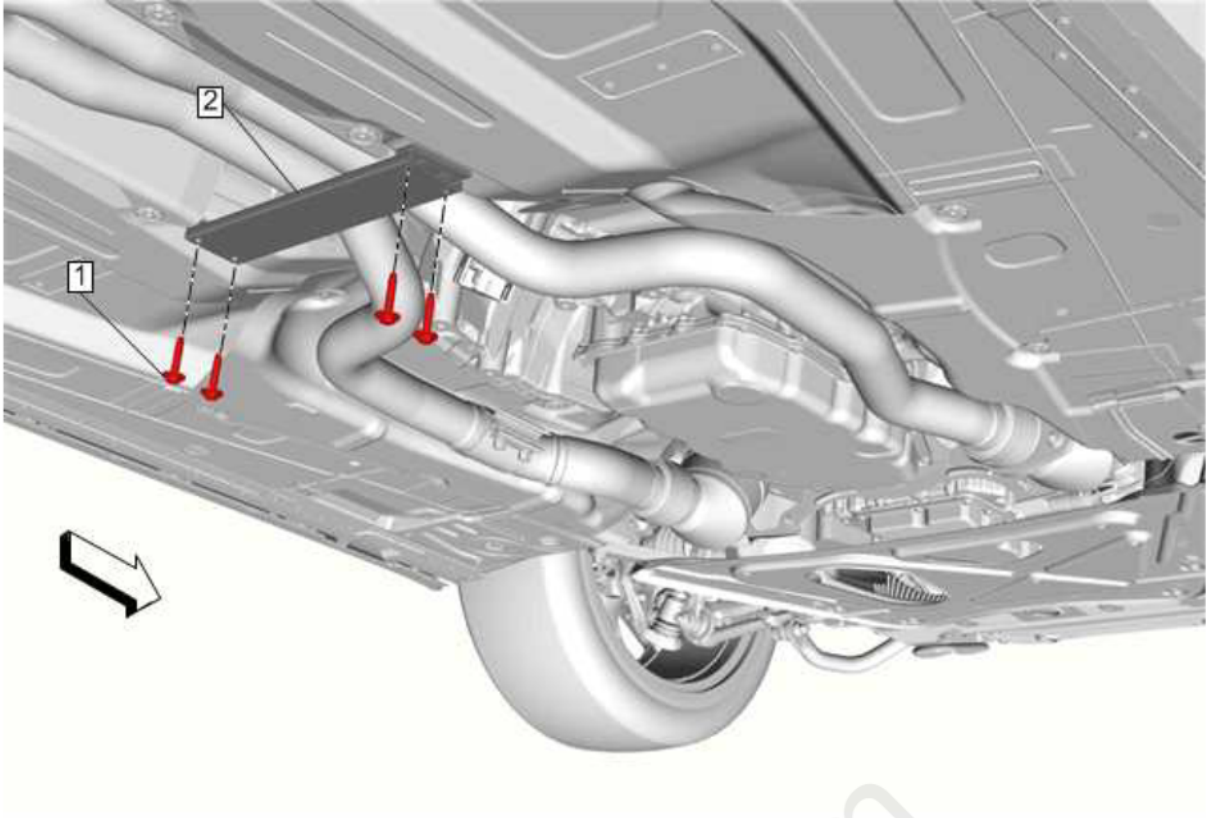

Fig. 140: Floor Panel Number 2 Cross Bar Reinforcement
Courtesy of GENERAL MOTORS COMPANY

20. Lower the vehicle.
21. Engine Support FixtureÂ» Remove - **Engine Support Fixture (LGW)**
22. Charge Air Cooler CoverÂ» Install - **Charge Air Cooler Cover Replacement**

FUEL PIPE SHIELD REPLACEMENT (LGX)

Removal Procedure

1. Intake ManifoldÂ» Remove - **Intake Manifold Replacement (LGX)**
2. Engine Support FixtureÂ» Install - **Engine Support Fixture (LGX)**
3. Raise the vehicle. Refer to **Lifting and Jacking the Vehicle**

WARNING: **Ensure that the vehicle is properly supported and squarely positioned. To help avoid personal injury when a vehicle is on a hoist, provide additional support for the vehicle on the opposite end from which the components are being removed.**

4. Floor Panel Number 2 Cross Bar Reinforcement (2)Â» Remove - **Floor Panel Number 2 Cross Bar Reinforcement Replacement**

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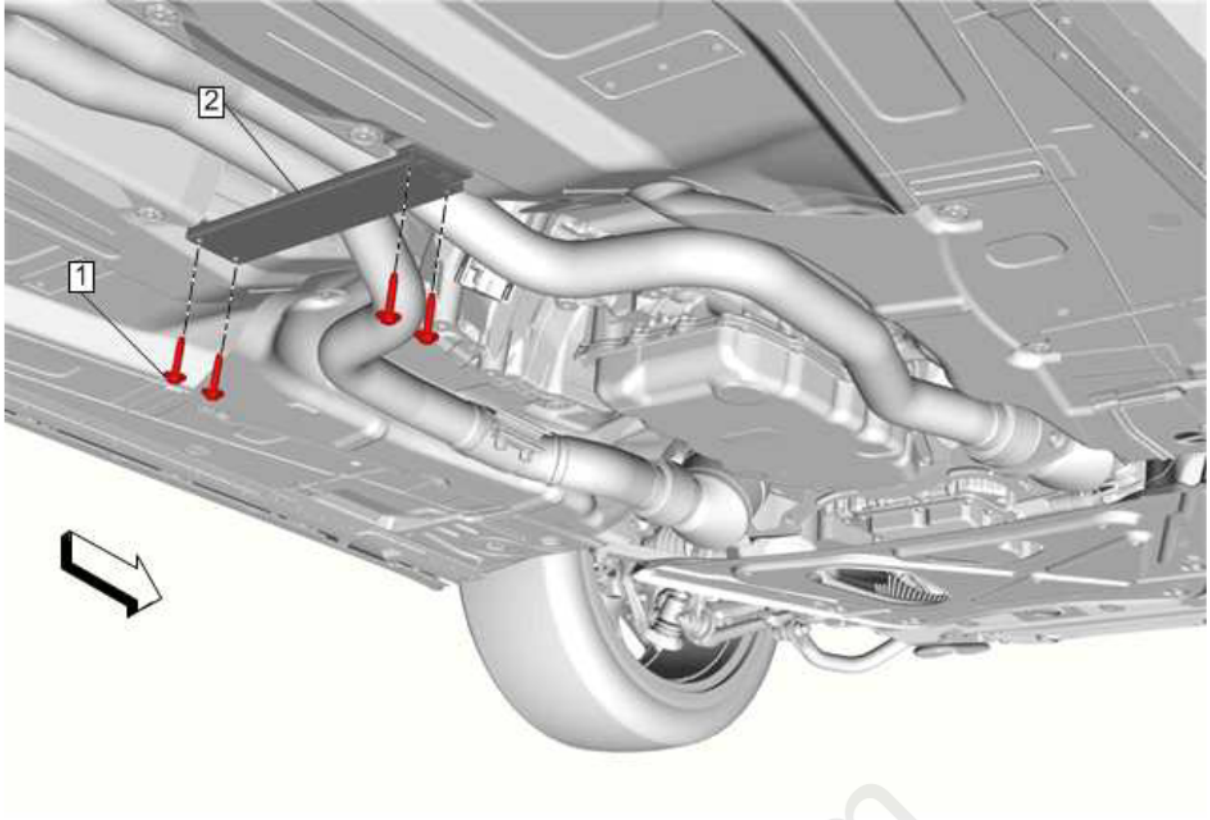

Fig. 141: Floor Panel Number 2 Cross Bar Reinforcement
Courtesy of GENERAL MOTORS COMPANY

5. Floor Panel Number 4 Cross Bar Reinforcement (2)Â» Remove - **Floor Panel Number 4 Cross Bar Replacement**

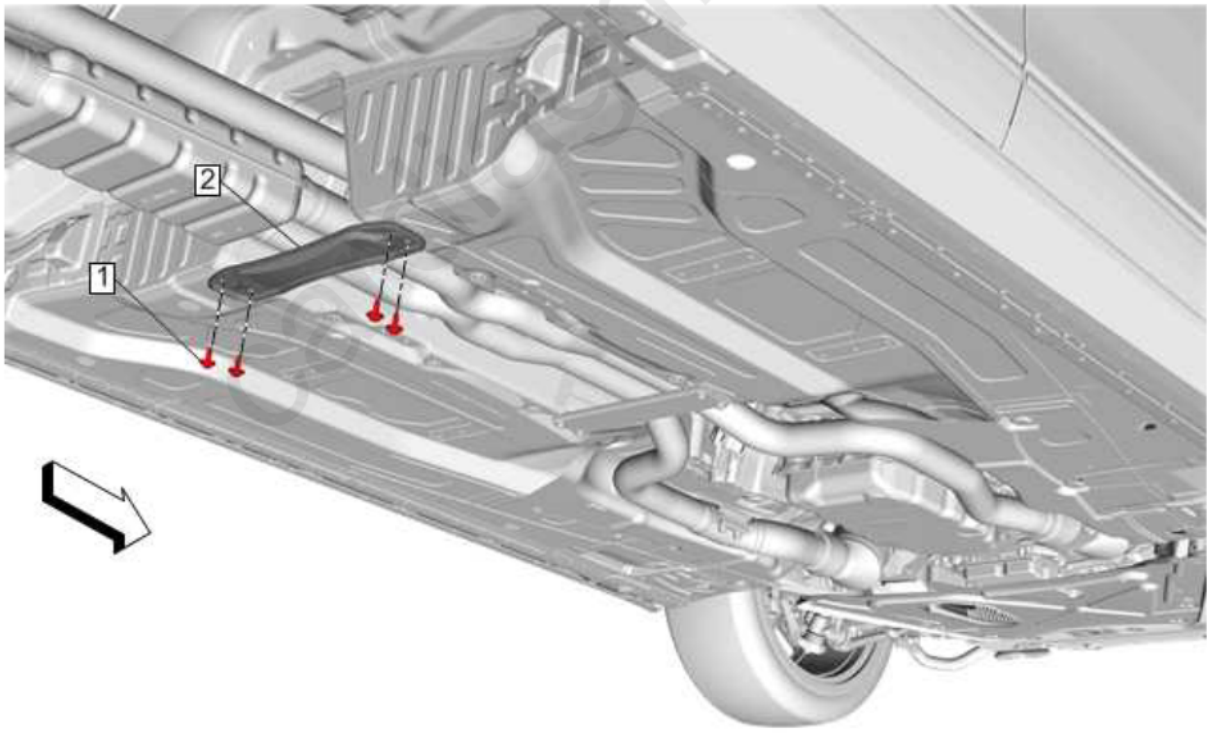

Fig. 142: Floor Panel Number 4 Cross Bar
Courtesy of GENERAL MOTORS COMPANY

6. Exhaust Muffler Isolator (1)Â» Disconnect [4x]

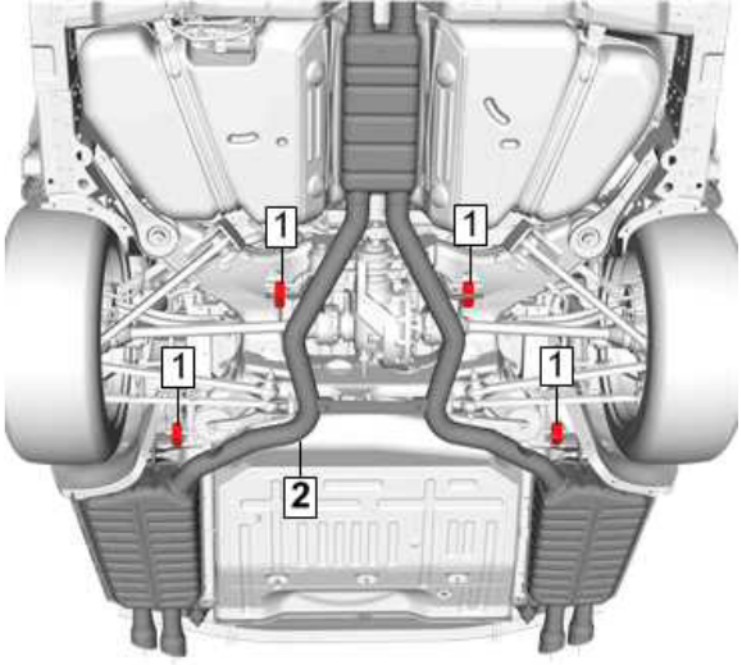

Fig. 143: Exhaust Muffler Assembly
Courtesy of GENERAL MOTORS COMPANY

7. Front Wheelhouse Liner (2)Â» Remove [2x] - **Front Wheelhouse Liner Replacement**

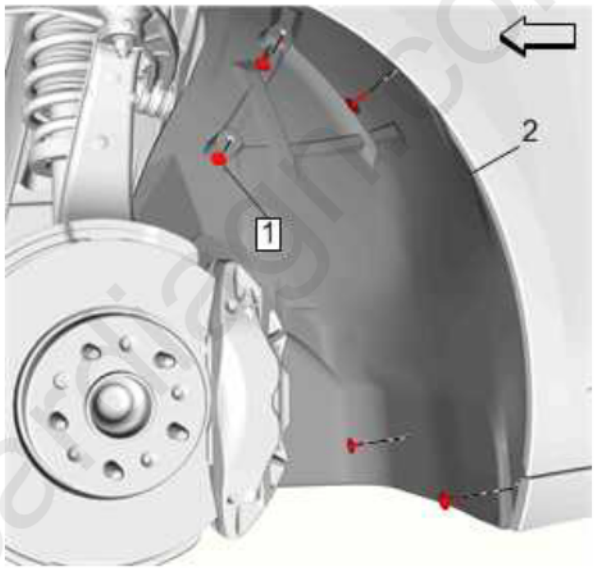

Fig. 144: Front Wheelhouse Liner
Courtesy of GENERAL MOTORS COMPANY

8. Front Tire Front Air Deflector (2)Â» Remove [2x] - **Front Tire Front Air Deflector Replacement**

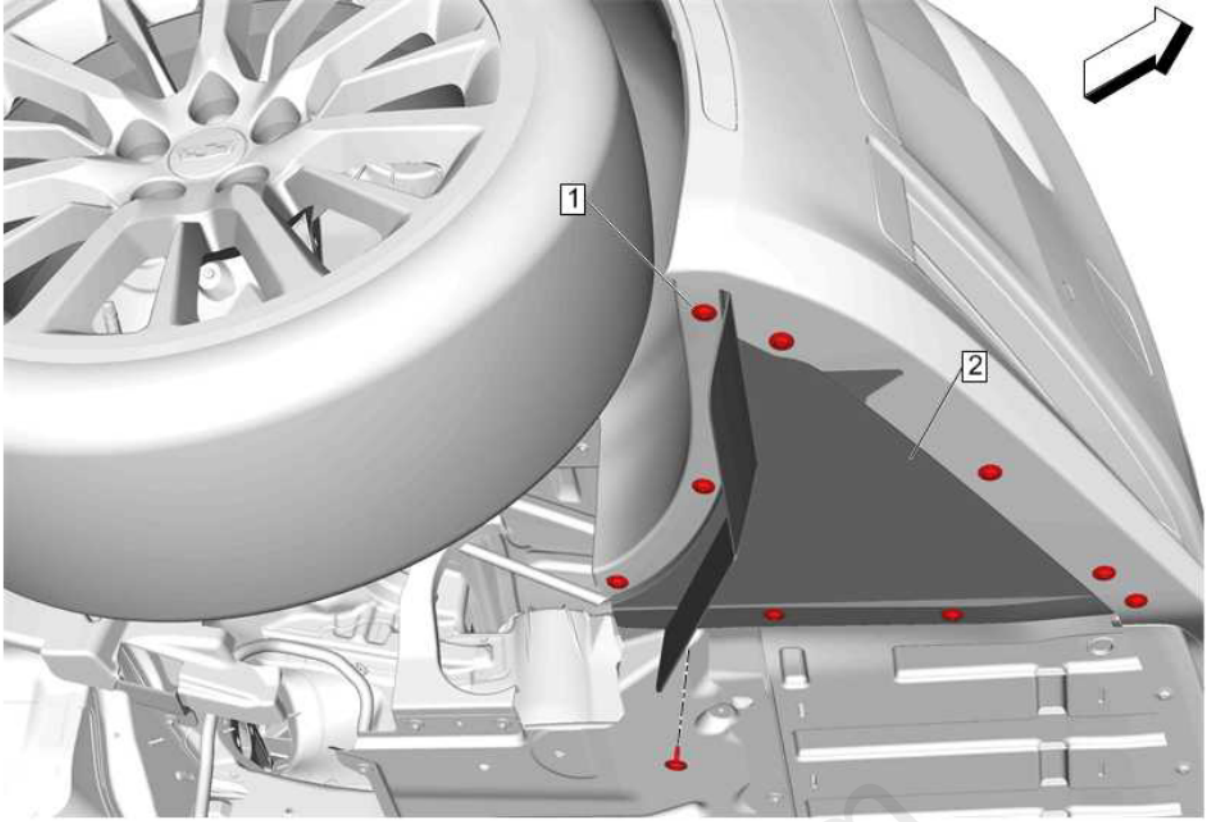

Fig. 145: Front Tire Front Air Deflector
Courtesy of GENERAL MOTORS COMPANY

9. Underbody Front Air Deflector (3)Â» Remove - **Underbody Front Air Deflector Replacement**

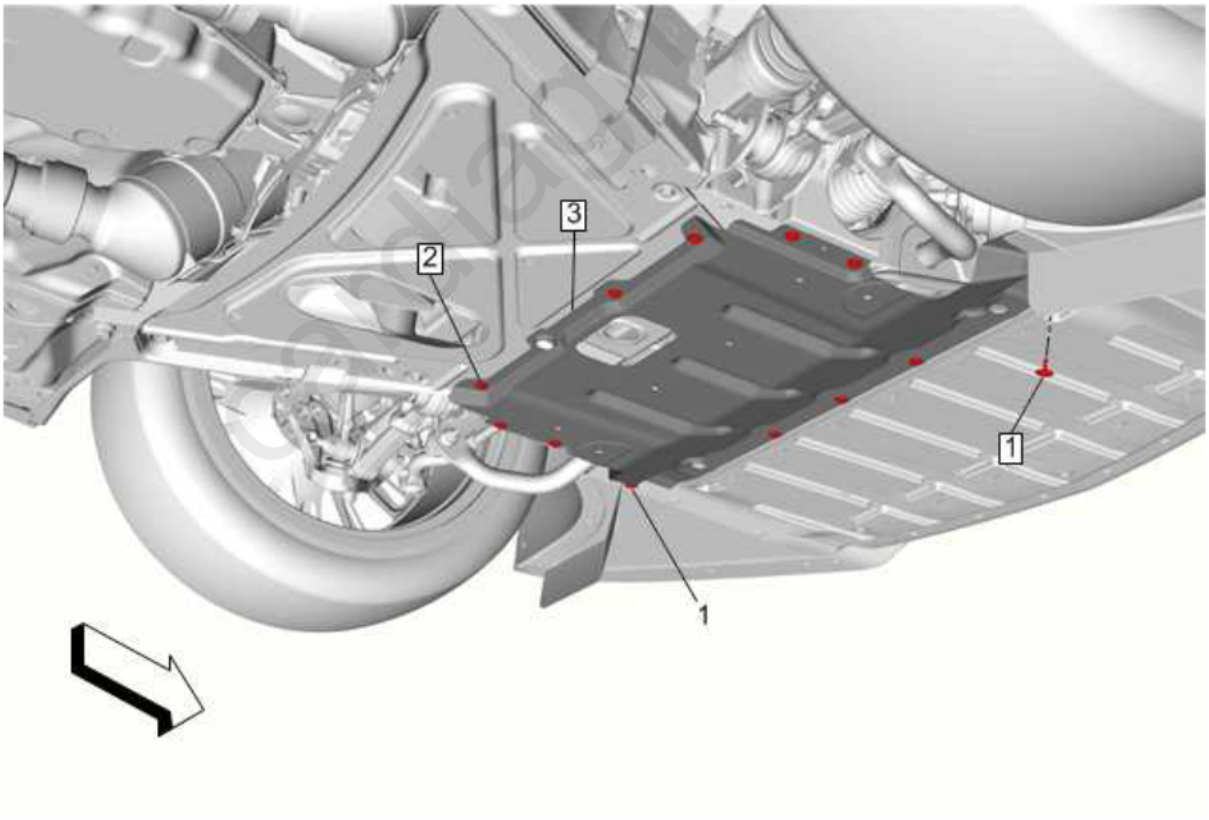

Fig. 146: Underbody Front Air Deflector
Courtesy of GENERAL MOTORS COMPANY

10. Front Bumper Fascia Lower Stiffener (1)Â» Remove - **Front Bumper Fascia Lower Stiffener Replacement**

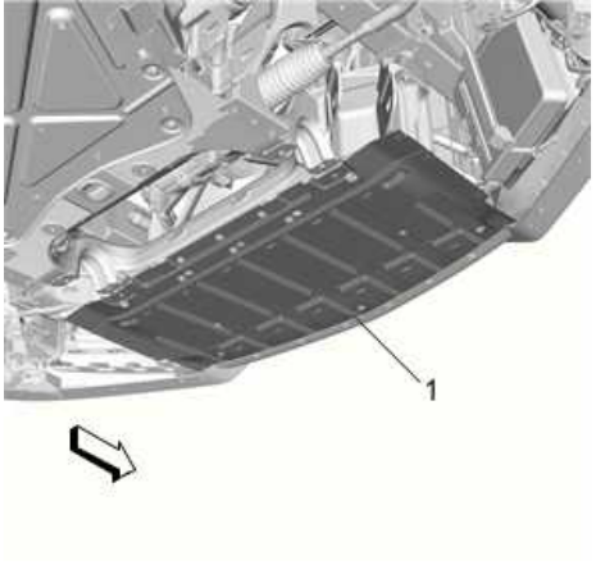

Fig. 147: Front Bumper Fascia Lower Stiffener
Courtesy of GENERAL MOTORS COMPANY

11. Support the radiator.
12. Drivetrain and Front Suspension Cradle Plate (3)Â» Remove - **Drivetrain and Front Suspension Cradle Plate Replacement**

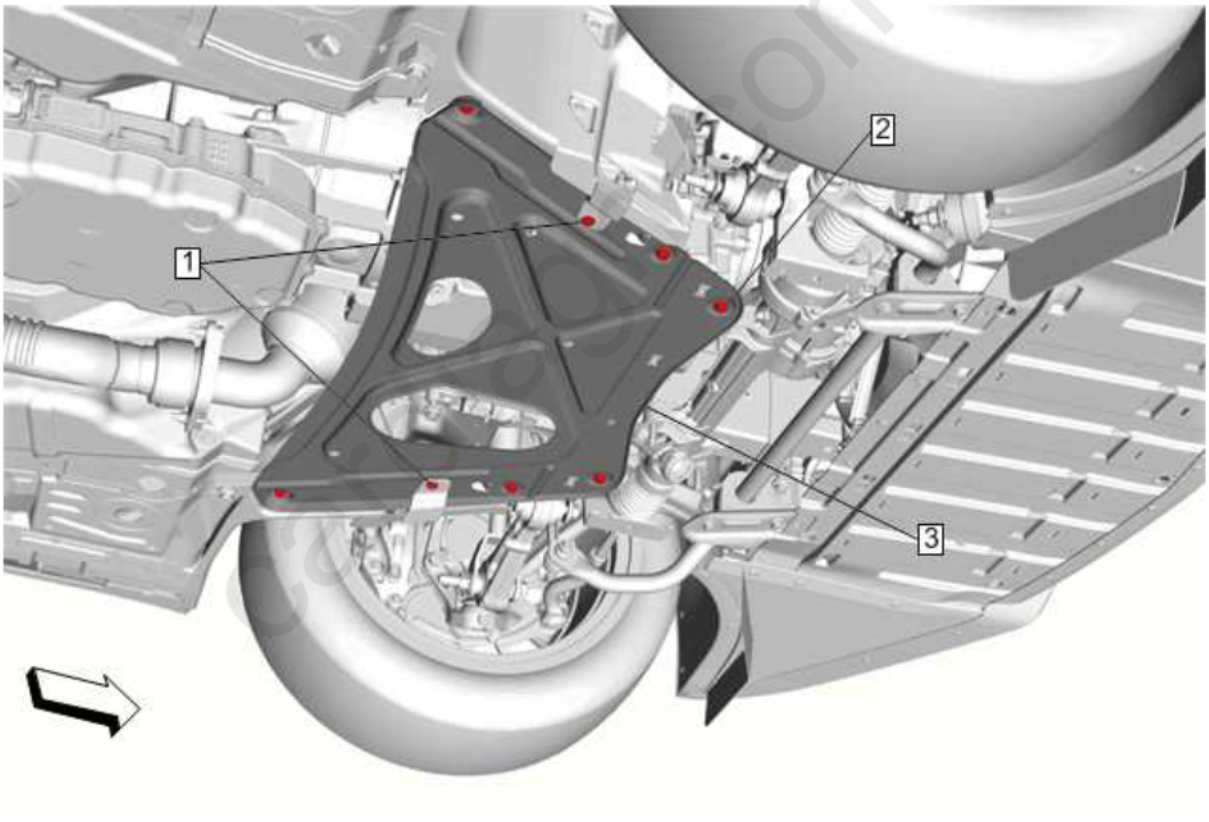

Fig. 148: Drivetrain and Front Suspension Cradle Plate
Courtesy of GENERAL MOTORS COMPANY

13. Intermediate Steering Shaft (1) @ Steering GearÂ» Remove - **Intermediate Steering Shaft Replacement (RWD)** **Intermediate Steering Shaft Replacement (AWD)**

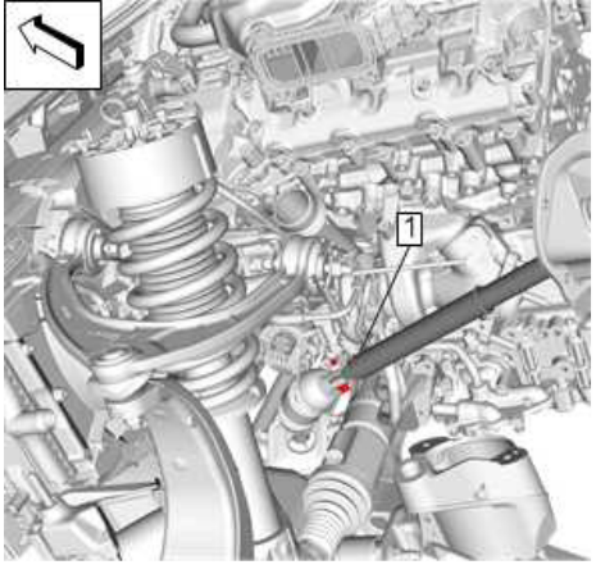

Fig. 149: Intermediate Steering Shaft
Courtesy of GENERAL MOTORS COMPANY

14. Drivetrain and Front Suspension Cradle Mounting Bolts (1)Â» Remove and DISCARD [6x]

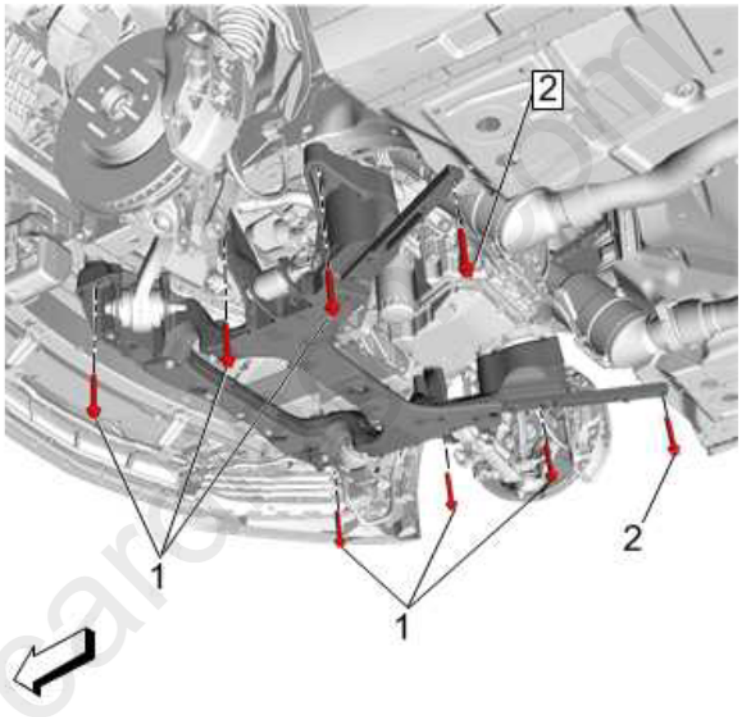

Fig. 150: Drivetrain and Front Suspension Cradle Mounting Bolts
Courtesy of GENERAL MOTORS COMPANY

15. Drivetrain and Front Suspension Cradle Mounting Bolts (2)Â» Remove and DISCARD [2x]
16. Lower the vehicle.
17. Unbolt the front shock absorbers from the front suspension upper mounts. Refer to **Shock Absorber and Spring Removal and Installation (RWD Without F55)** , **Shock Absorber and Spring Removal and Installation (AWD Without F55)** , **Shock Absorber and Spring Removal and Installation (RWD With F55)** and/or **Shock Absorber and Spring Removal and Installation (AWD With F55)**

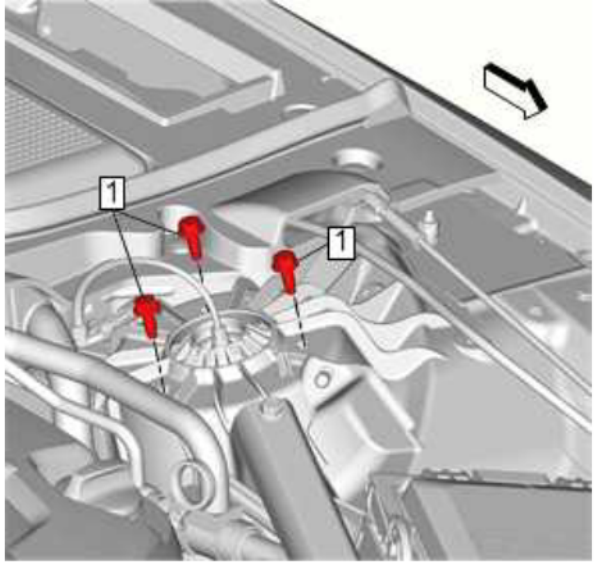

Fig. 151: Front Suspension Upper Mounts
Courtesy of GENERAL MOTORS COMPANY

18. Ensure the following items are clear from the frame:
    - Vacuum lines
    - Electrical wiring harnesses
    - Oil cooler lines
19. Using the engine support fixture, slowly lower the powertrain assembly with the drivetrain and front suspension cradle until the fuel pipe shield is accessible.
20. Support the drivetrain and front suspension cradle with suitable jack stands (1).

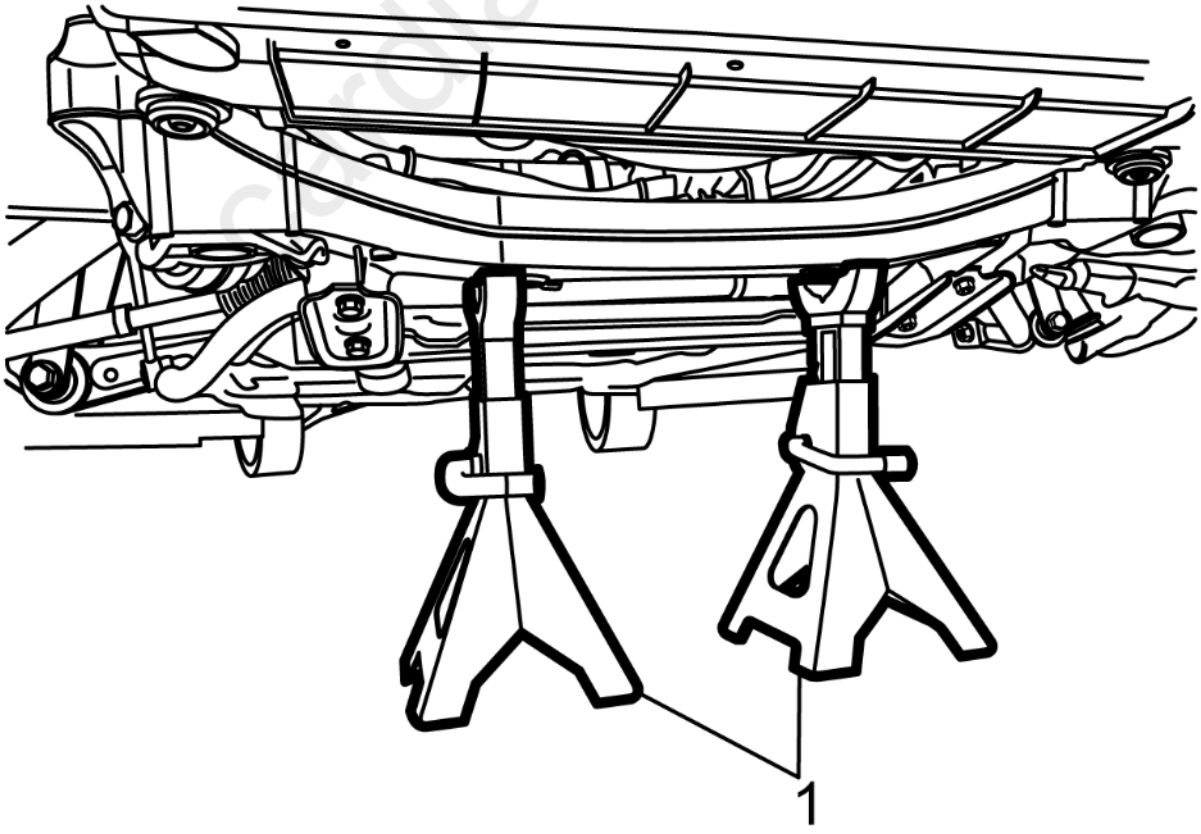

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Fig. 152: Jack Stands Supporting Drivetrain And Front Suspension Cradle
Courtesy of GENERAL MOTORS COMPANY

21. Retainer (1)Â» Unclip [3x]

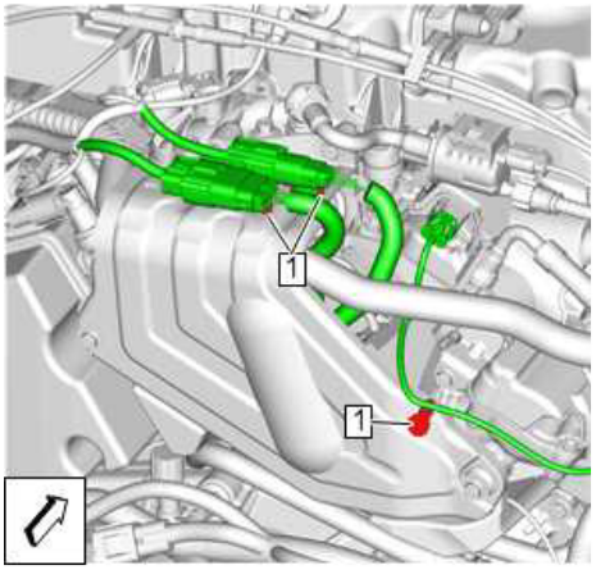

Fig. 153: Retainers
Courtesy of GENERAL MOTORS COMPANY

22. Fuel Pipe Shield Bolt (1)Â» Remove

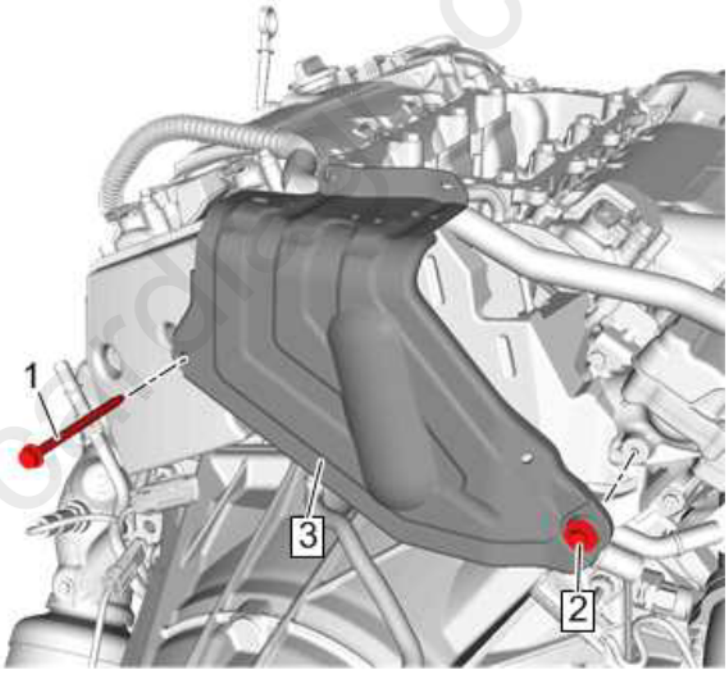

Fig. 154: Fuel Pipe Shield And Fuel Pipe Shield Bolts
Courtesy of GENERAL MOTORS COMPANY

23. Fuel Pipe Shield Bolt (2) @ Cylinder HeadÂ» Remove

NOTE: **Fuel pipe shield bolt (2) is retained in the fuel pipe shield by an insulator, it is not necessary to remove it from the fuel pipe shield.**

24. Fuel Pipe Shield (3)Â» Remove

Installation Procedure

1. Fuel Pipe Shield (3)Â» Install

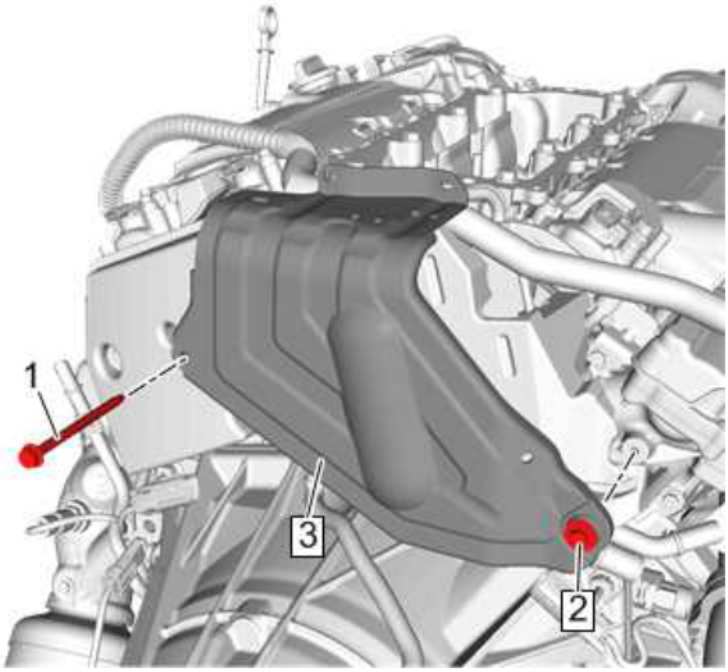

Fig. 155: Fuel Pipe Shield And Fuel Pipe Shield Bolts
Courtesy of GENERAL MOTORS COMPANY

2. Fuel Pipe Shield Bolt (2) @ Cylinder HeadÂ» Install and tighten 9 N.m (80 lb in)

CAUTION: **Refer to Fastener Caution .**

3. Fuel Pipe Shield Bolt (1)Â» Install and tighten 9 N.m (80 lb in)
4. Retainer (1)Â» Install [3x]

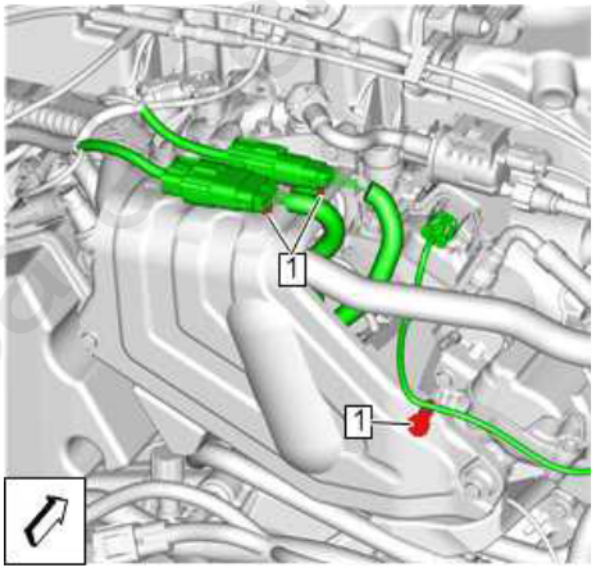

Fig. 156: Retainers
Courtesy of GENERAL MOTORS COMPANY

5. Ensure the following items are clear from the frame:
   - Vacuum lines
   - Electrical wiring harnesses
   - Oil cooler lines
6. Using the engine support fixture, slowly raise the powertrain assembly with the drivetrain and front suspension cradle into position.
7. Bolt the front shock absorbers to the front suspension upper mounts. Refer to **Shock Absorber and Spring Removal and Installation (RWD Without F55)** , **Shock Absorber and Spring Removal and Installation (AWD Without F55)** , **Shock Absorber and Spring Removal and Installation (RWD With F55)** and/or **Shock Absorber and Spring Removal and Installation (AWD With F55)**

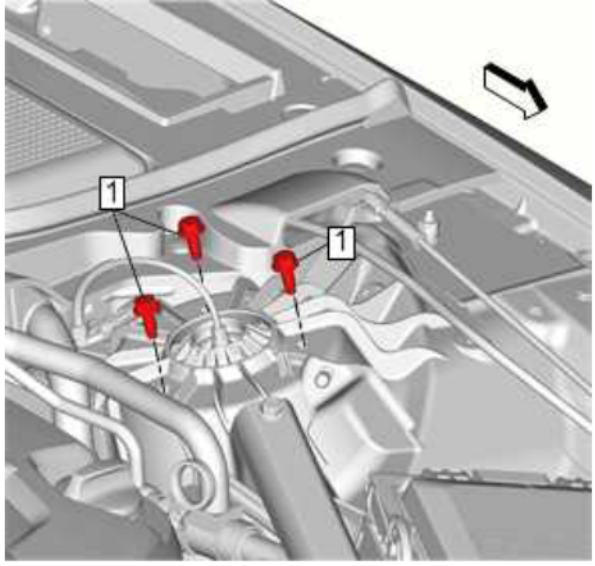

Fig. 157: Front Suspension Upper Mounts
Courtesy of GENERAL MOTORS COMPANY

8. Raise the vehicle.
9. Install NEW drivetrain and Front Suspension Cradle Mounting Bolts (1, 2). Refer to **Drivetrain and Front Suspension Cradle Removal and Installation**

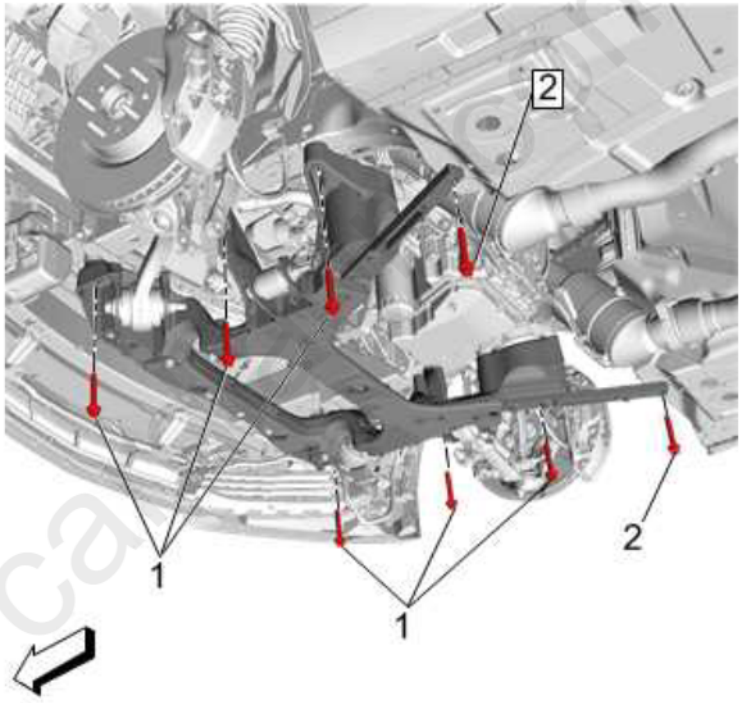

Fig. 158: Drivetrain and Front Suspension Cradle Mounting Bolts
Courtesy of GENERAL MOTORS COMPANY

10. Intermediate Steering Shaft (1) @ Steering GearÂ» Install - **Intermediate Steering Shaft Replacement (RWD)** and/or **Intermediate Steering Shaft Replacement (AWD)**

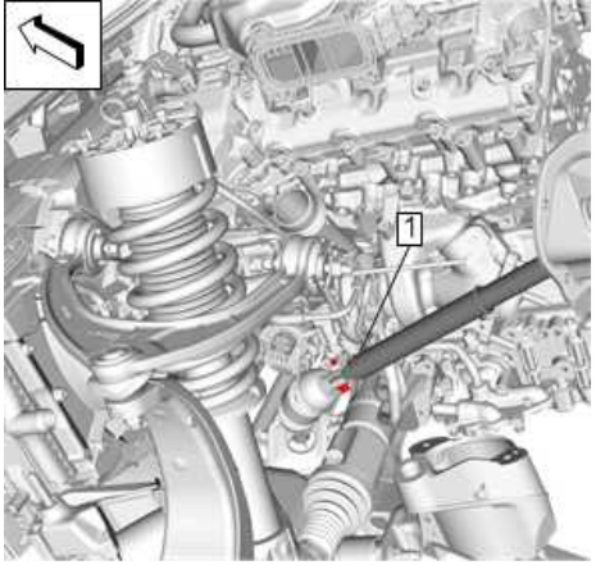

Fig. 159: Intermediate Steering Shaft
Courtesy of GENERAL MOTORS COMPANY

11. Drivetrain and Front Suspension Cradle Plate (3)Â» Install - **Drivetrain and Front Suspension Cradle Plate Replacement**

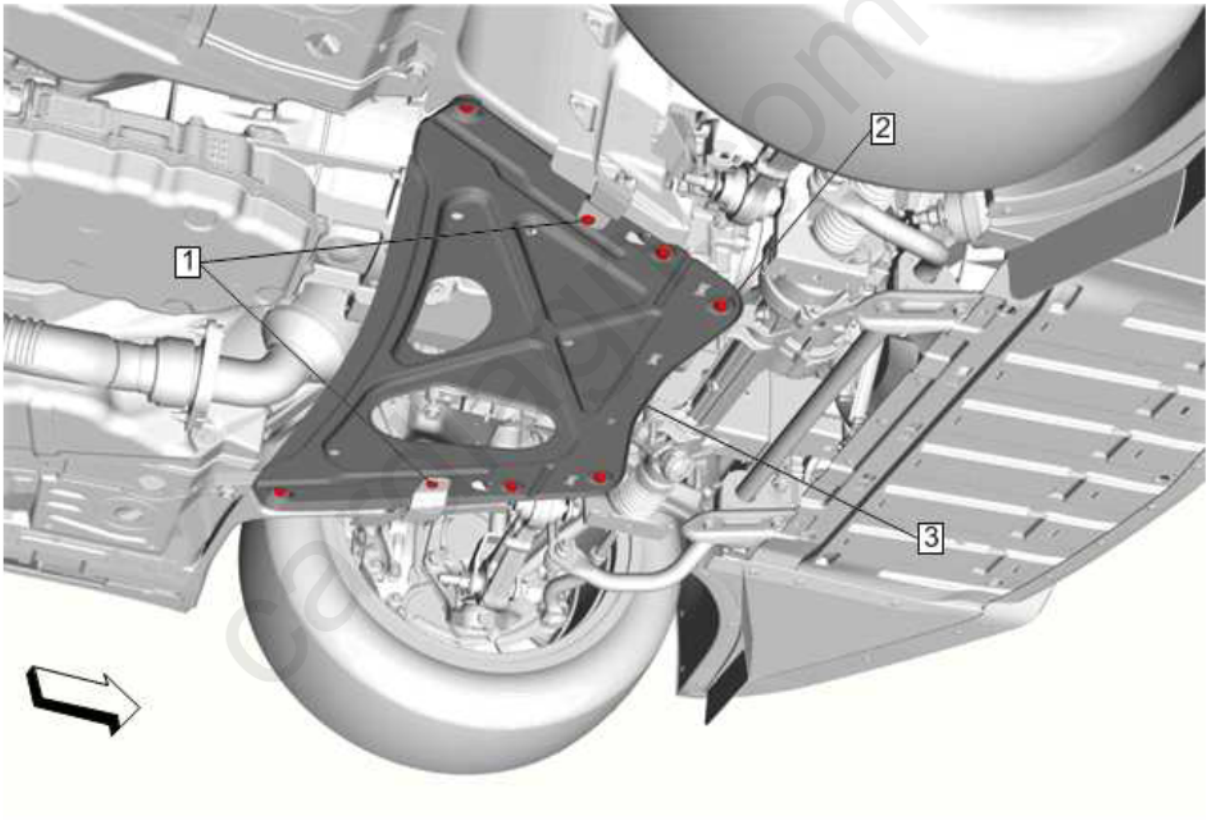

Fig. 160: Drivetrain and Front Suspension Cradle Plate
Courtesy of GENERAL MOTORS COMPANY

12. Remove the support from the radiator.
13. Front Bumper Fascia Lower Stiffener (1)Â» Install - **Front Bumper Fascia Lower Stiffener Replacement**

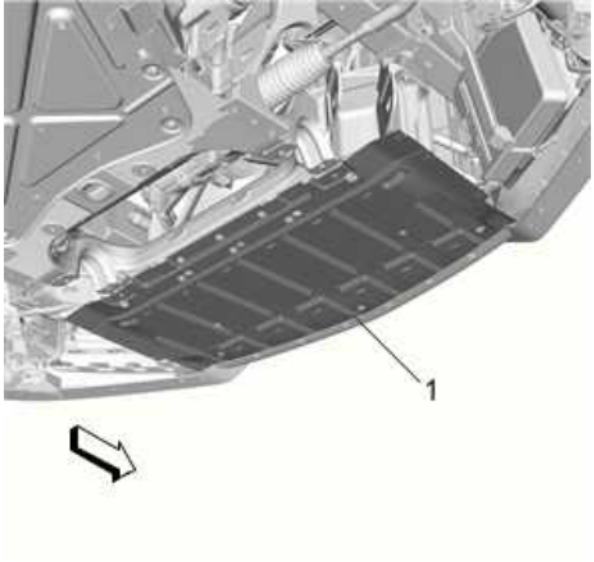

Fig. 161: Front Bumper Fascia Lower Stiffener
Courtesy of GENERAL MOTORS COMPANY

14. Underbody Front Air Deflector (3)Â» Install - **Underbody Front Air Deflector Replacement**

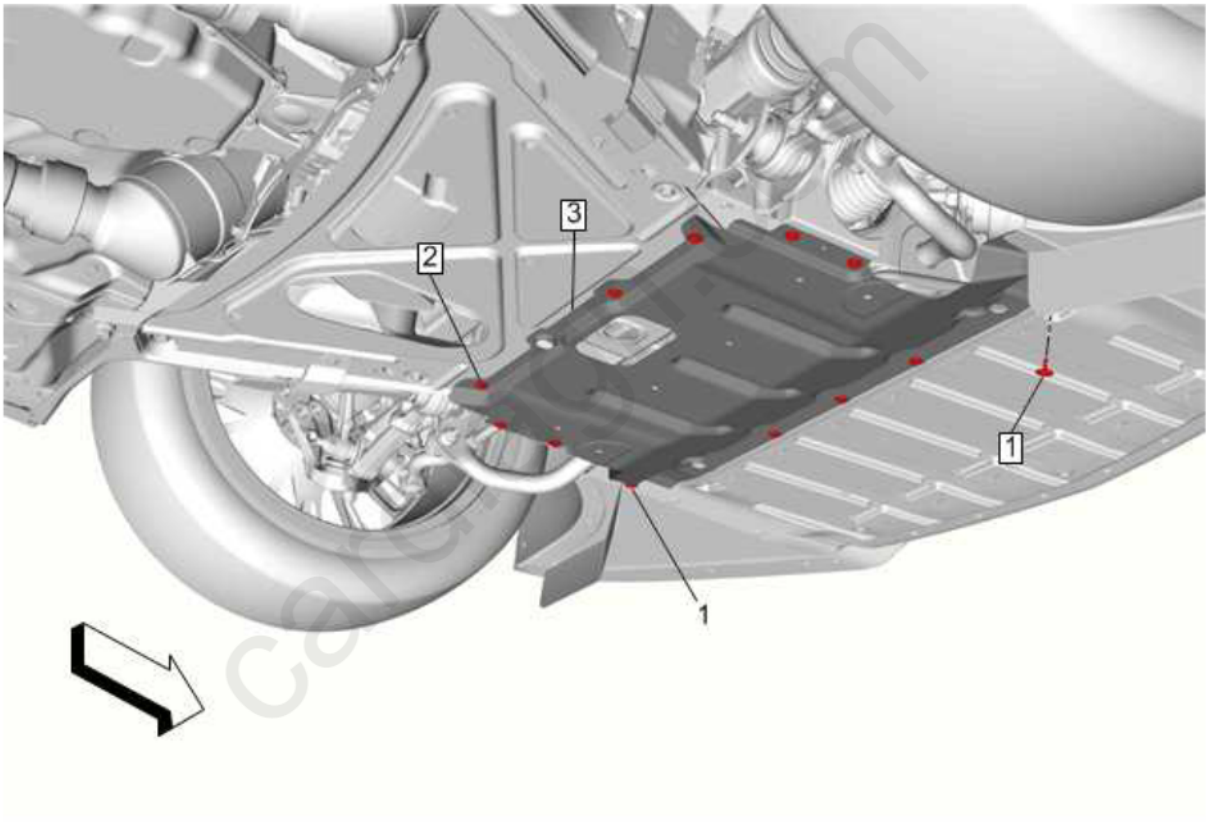

Fig. 162: Underbody Front Air Deflector
Courtesy of GENERAL MOTORS COMPANY

15. Front Tire Front Air Deflector (2)Â» Install [2x] - **Front Tire Front Air Deflector Replacement**

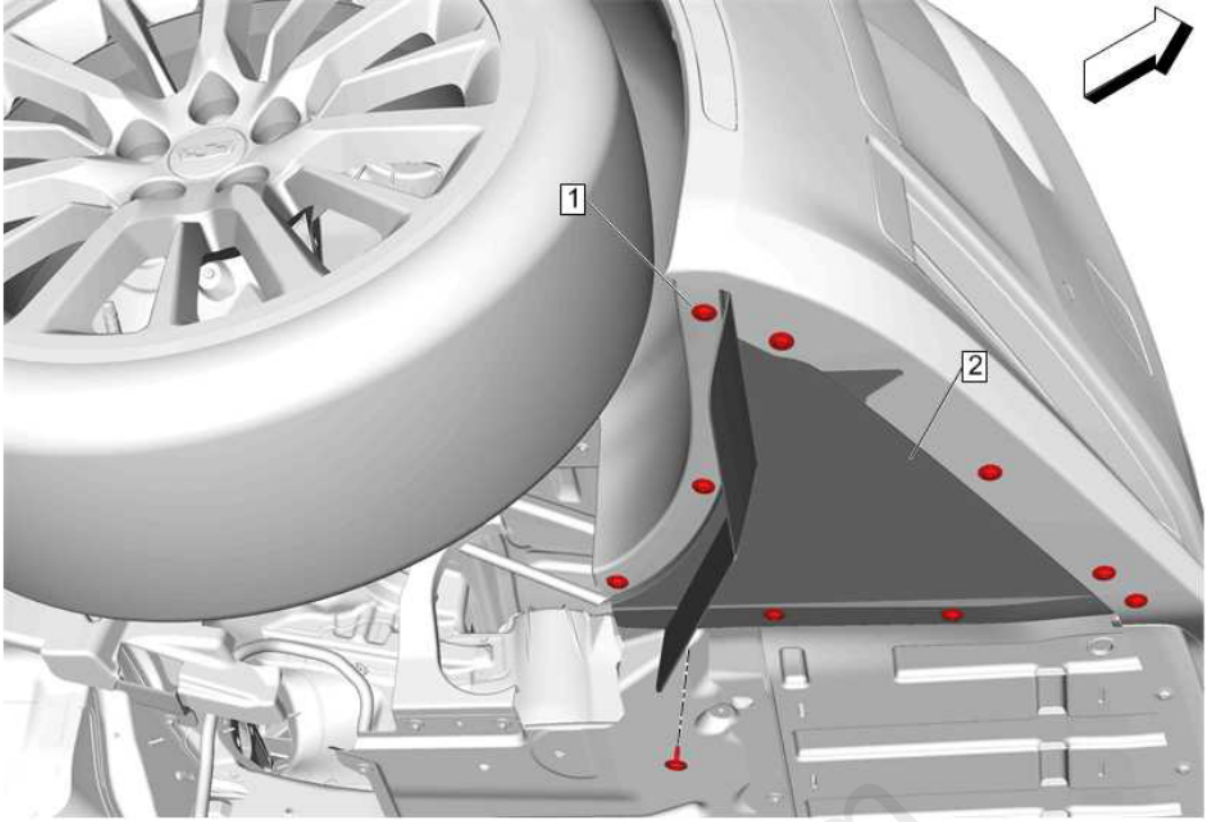

Fig. 163: Front Tire Front Air Deflector
Courtesy of GENERAL MOTORS COMPANY

16. Front Wheelhouse Liner (2)Â» Install [2x] - **Front Wheelhouse Liner Replacement**

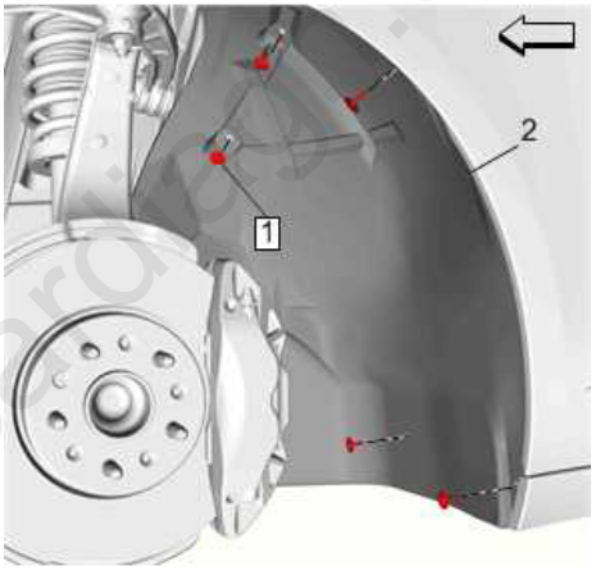

Fig. 164: Front Wheelhouse Liner
Courtesy of GENERAL MOTORS COMPANY

17. Exhaust Muffler Isolator (1)Â» Connect [4x]

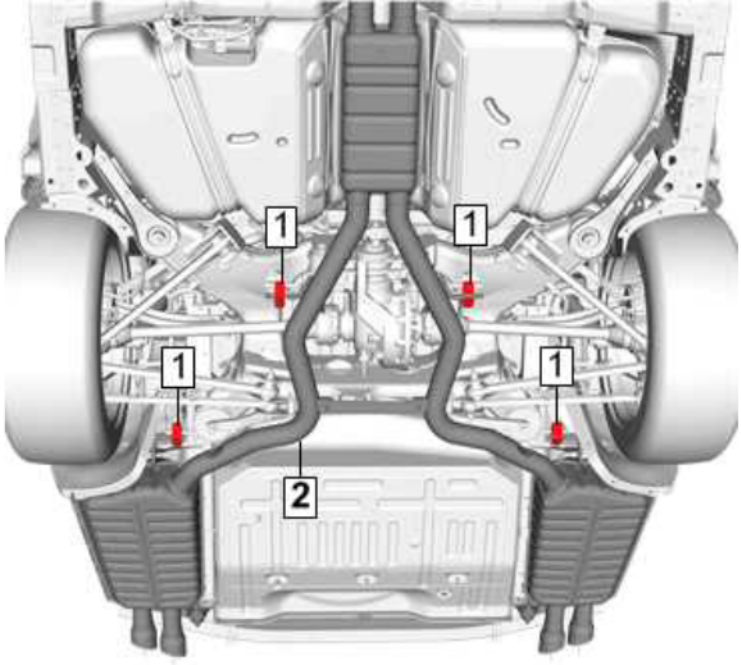

Fig. 165: Exhaust Muffler Assembly
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Clean and lubricate the exhaust isolators for ease of installation.**

18. Floor Panel Number 4 Cross Bar Reinforcement (2)Â» Install - **Floor Panel Number 4 Cross Bar Replacement**

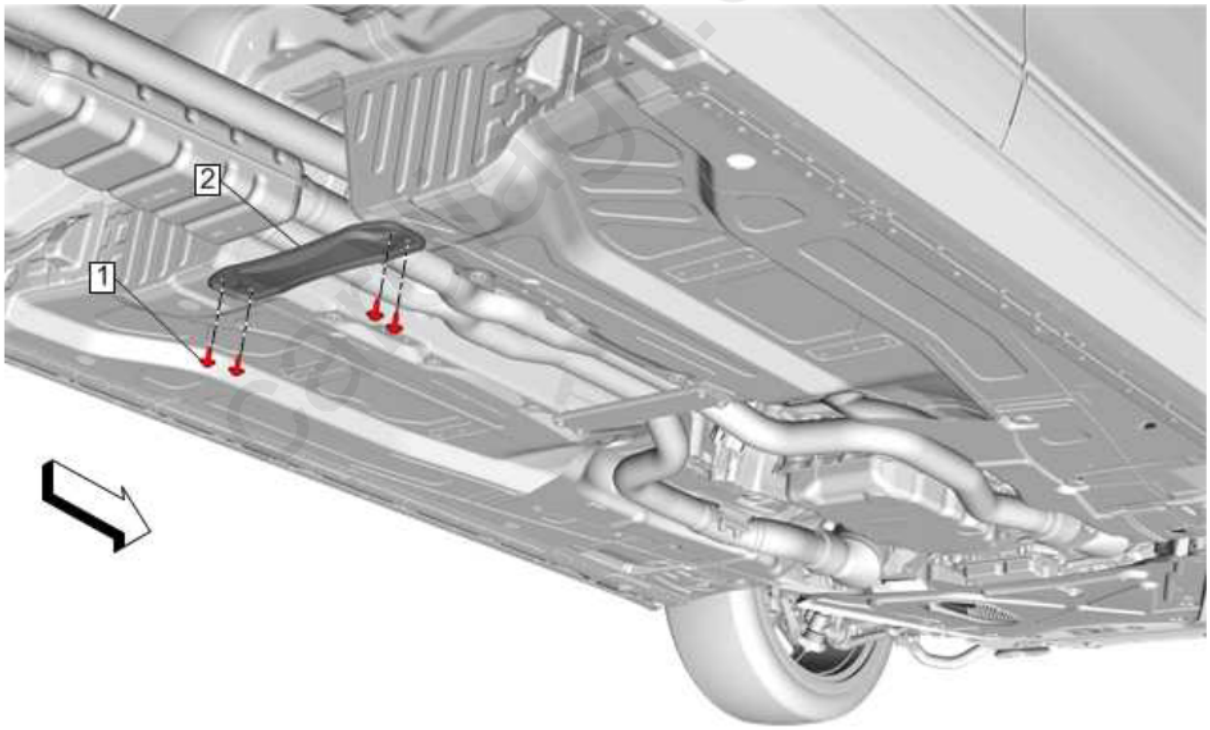

Fig. 166: Floor Panel Number 4 Cross Bar
Courtesy of GENERAL MOTORS COMPANY

19. Floor Panel Number 2 Cross Bar Reinforcement (2)Â» Install - **Floor Panel Number 2 Cross Bar Reinforcement Replacement**

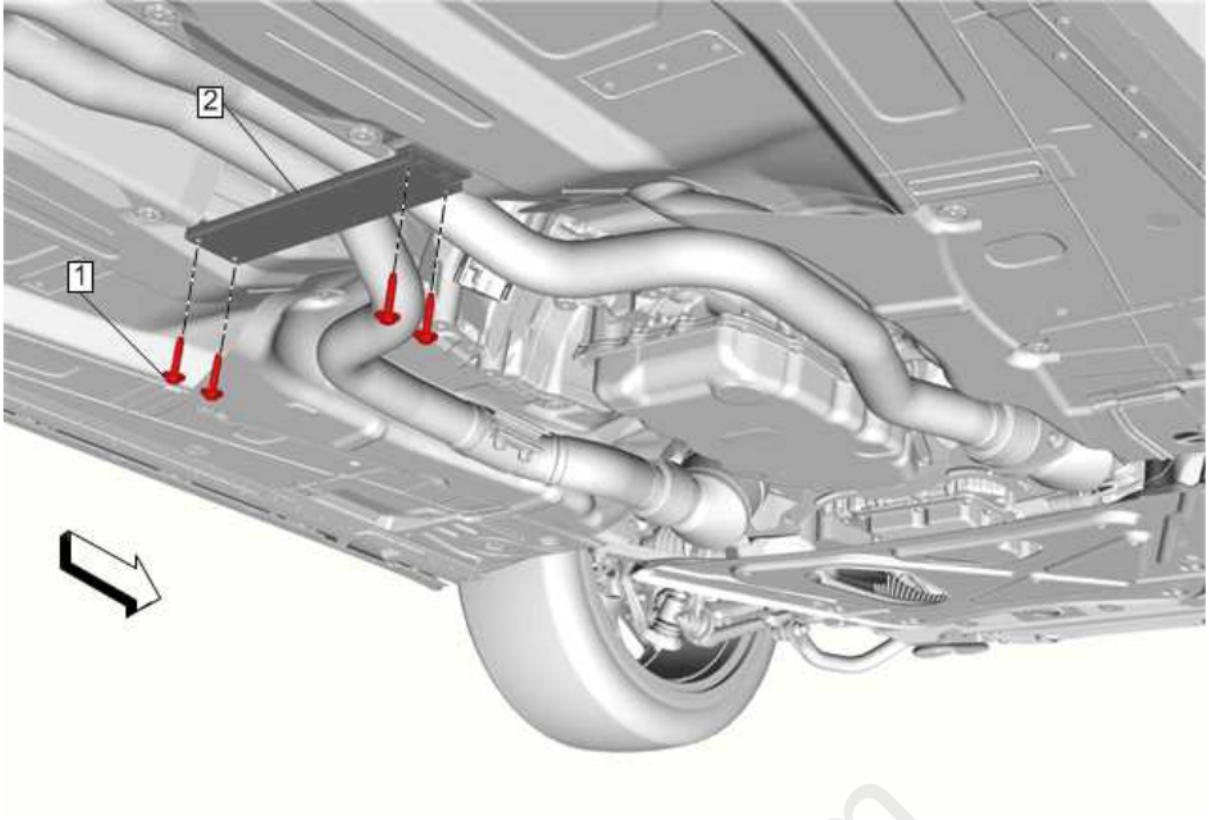

Fig. 167: Floor Panel Number 2 Cross Bar Reinforcement
Courtesy of GENERAL MOTORS COMPANY

20. Lower the vehicle.
21. Engine Support FixtureÂ» Remove - **Engine Support Fixture (LGX)**
22. Intake ManifoldÂ» Install - **Intake Manifold Replacement (LGX)**

ENGINE REAR NOISE SHIELD REPLACEMENT

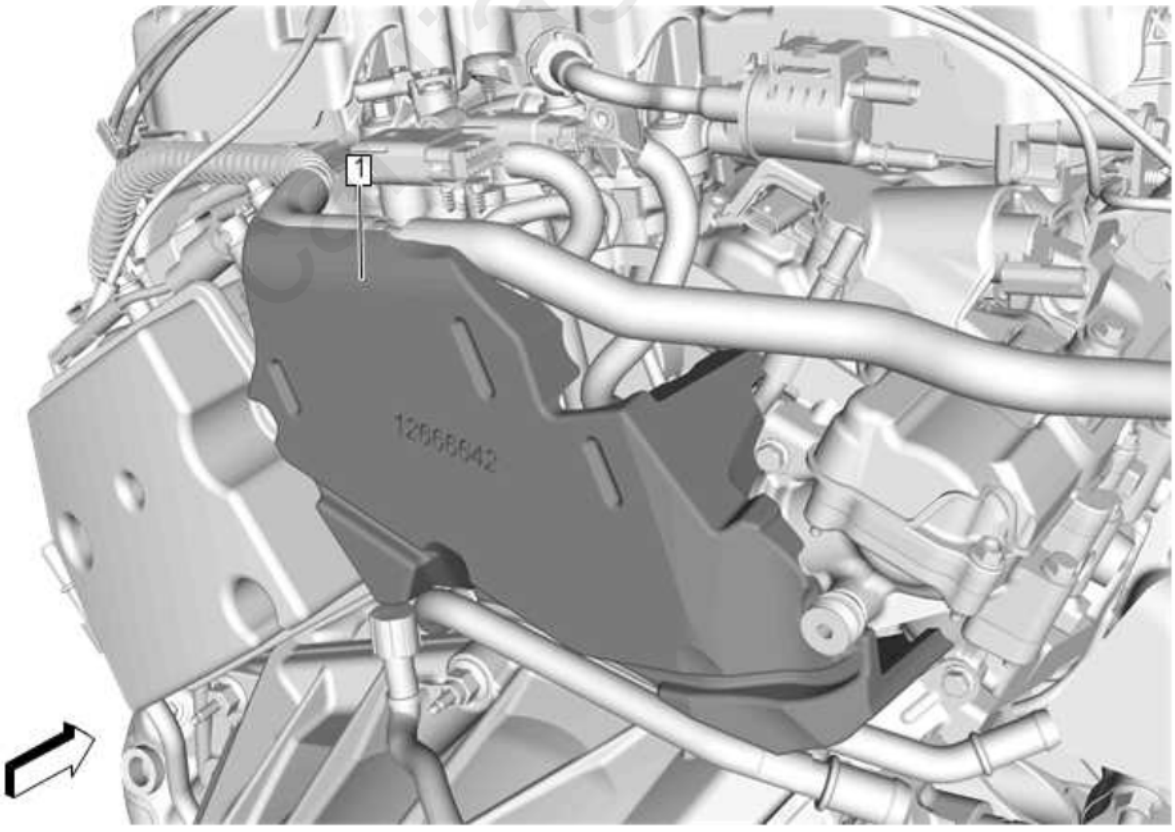

Fig. 168: Engine Rear Noise Shield
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Callout	Component Name
Preliminary Procedures 1. Fuel Pipe Shield Replacement (LGW)Fuel Pipe Shield Replacement (LGX) 2. Heater Inlet And Outlet Pipe Replacement (LGW, LGX)	
1	Engine Rear Noise Shield **WARNING:** **The noise cancelling foam component MUST be replaced if it has been exposed to engine fluids. Failure to replace the noise cancelling foam component that has been exposed to engine fluids may result in an engine fire resulting in catastrophic engine damage and possible injury or death.** **NOTE:** **The engine noise shield snaps into place.** **Procedure** Unsnap the engine noise shield from the rear of the engine.

FUEL PUMP REPLACEMENT

Special Tools

EN 48896 HP Fuel Pump Installation Alignment Gauge

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

Removal Procedure

1. Engine Rear Noise Shield ReplacementÂ» Remove
2. Fuel Feed Intermediate Pipe Replacement (LGW)Fuel Feed Intermediate Pipe Replacement (LGX)Â» Remove and DISCARD
3. Fuel Pulse Dampener (1) @ Fuel Pump (2)Â» Disconnect - Fuel Pulse Dampener Replacement (LGW)Fuel Pulse Dampener Replacement (LGX)

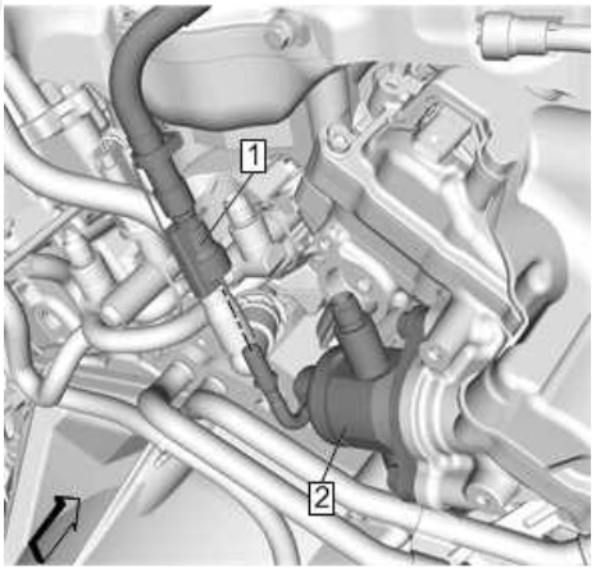

Fig. 169: Fuel Feed Pipe
Courtesy of GENERAL MOTORS COMPANY

4. Disconnect the electrical connector from the fuel pump.
5. Fuel Pump Bolt (1)Â» Remove [2x]

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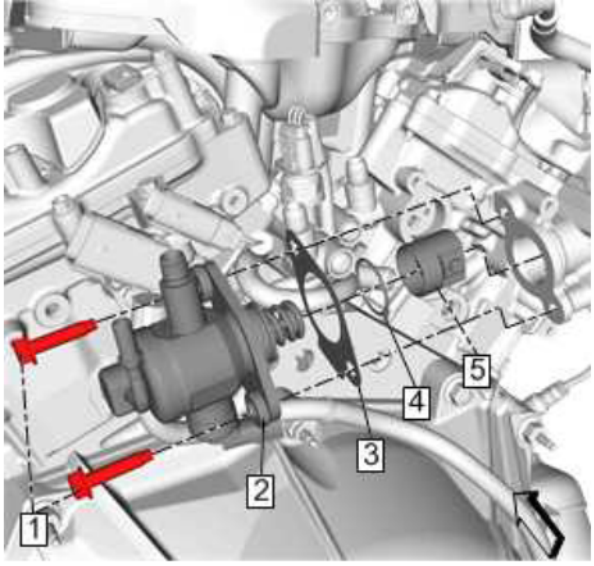

Fig. 170: Fuel Pump
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Alternately loosen the fuel pump bolts one turn at a time until the pump is fully disengaged from fuel pump lifter follower. Trying to remove the pump bolts without even side-to-side loosening may result in pump plunger damage**

6. Fuel Pump (2)Â» Remove
7. Gasket (3)Â» Remove and DISCARD
8. Fuel Pump O-Ring (4)Â» Remove and DISCARD
9. Valve Lifter Follower (5)Â» Remove

NOTE: **Take note of the orientation of the valve lifter follower (5).**

Installation Procedure

1. Use the **EN 48896** alignment gauge (1) to ensure that the camshaft lobe is in the base circle position. At base circle position, the tool will be flush with the cylinder head (2) as shown.

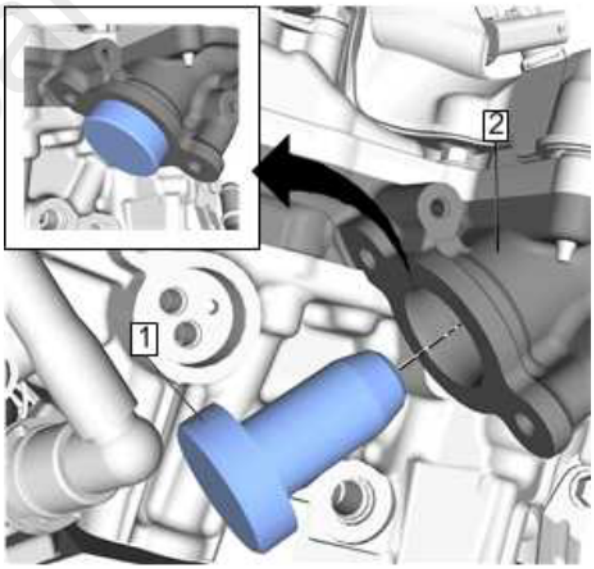

Fig. 171: Alignment Gauge
Courtesy of GENERAL MOTORS COMPANY

NOTE: **The camshaft must be in the base circle position before the high pressure fuel pump is installed.**

2. Lubricate the high pressure fuel pump cylinder head bore with clean engine oil. Refer to **Adhesives, Fluids, Lubricants and Sealers**

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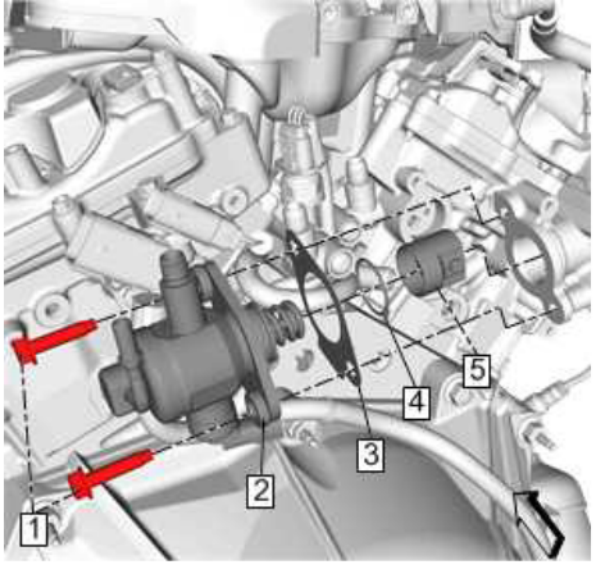

Fig. 172: Fuel Pump
Courtesy of GENERAL MOTORS COMPANY

3. Lubricate the valve lifter follower (5) with clean engine oil and install it into the cylinder head bore.

NOTE: **Ensure that the valve lifter follower (5) is oriented properly, the camshaft is at base circle and the number 1 piston is at top dead center (TDC) on the exhaust stroke.**

4. Fuel Pump O-Ring (4)Â» Install a NEW fuel pump O-ring.

NOTE: **Lubricate the NEW O-ring seals with clean engine oil.**

5. Gasket (3)Â» Install a NEW gasket.

NOTE: **The locator tab on the fuel pump gasket should be positioned away from the engine block.**

6. Fuel Pump (2)Â» Install

NOTE: **Ensure the plastic bolt retainers are installed in the high pressure fuel pump mounting holes before installing.**

7. Start and hand-tighten the high pressure fuel pump bolts (1) evenly.

CAUTION: **Refer to Fastener Caution .**

CAUTION: **Alternately hand-tighten the fuel pump bolts one turn at a time until the pump is fully seated. Trying to draw down the pump without even side-to-side tightening may result in pump plunger damage.**

1. Fuel Pump Bolt (1)Â» Tighten [2x] 25 N.m (18 lb ft)

8. Connect the electrical connector to the fuel pump.

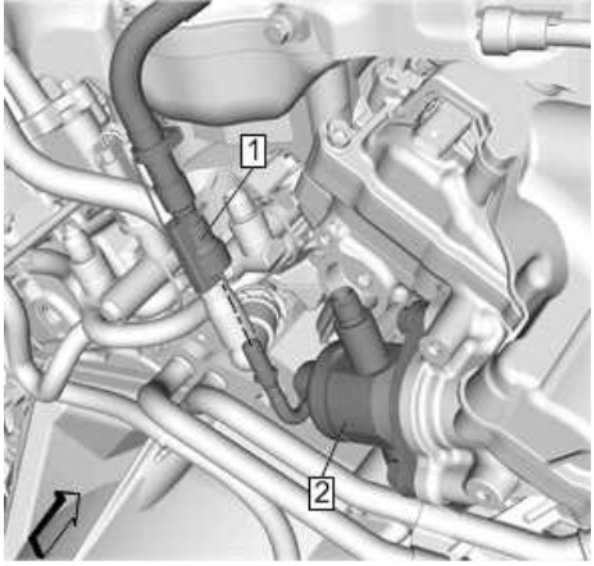

Fig. 173: Fuel Feed Pipe
Courtesy of GENERAL MOTORS COMPANY

9. Fuel Pulse Dampener (1) @ Fuel Pump (2)Â» Connect **Fuel Pulse Dampener Replacement (LGW)Fuel Pulse Dampener Replacement (LGX)**
10. **Fuel Feed Intermediate Pipe Replacement (LGW)Fuel Feed Intermediate Pipe Replacement (LGX)**Â»Install
11. **Engine Rear Noise Shield Replacement**Â» Install

FUEL INJECTOR REPLACEMENT

Removal Procedure

1. Relieve the high side fuel system pressure. Refer to **Fuel Pressure Relief**.
2. Remove the fuel injection fuel rail assembly. Refer to **Fuel Injection Fuel Rail Assembly Replacement - Bank 1** or **Fuel Injection Fuel Rail Assembly Replacement - Bank 2**.

NOTE: **The fuel injectors have an alignment feature, note the position of the injectors alignment for installation.**

3. For removal of the fuel injectors, refer to **Fuel Rail and Injectors Cleaning and Inspection** .

Installation Procedure

1. Prepare the fuel injectors for assembly, refer to **Fuel Rail and Injectors Cleaning and Inspection** .
2. Install the fuel injection fuel rail assembly. Refer to **Fuel Injection Fuel Rail Assembly Replacement - Bank 1** or **Fuel Injection Fuel Rail Assembly Replacement - Bank 2**.

NOTE: **The fuel injectors have an alignment feature and must be reinstalled as noted during removal.**

3. Pressure up the fuel system and check for leaks.

EVAPORATIVE EMISSION CANISTER PURGE SOLENOID VALVE REPLACEMENT (LGW)

Removal Procedure

1. Air Inlet Grille PanelÂ» Remove - **Air Inlet Grille Panel Replacement**
2. Front Wheelhouse Panel BraceÂ» Remove - **Front Wheelhouse Panel Brace Replacement (Rear) Front Wheelhouse Panel Brace Replacement (Front)**
3. Electrical Connector (1) @ Evaporative Emission Canister Purge Solenoid Valve (2)Â» Disconnect

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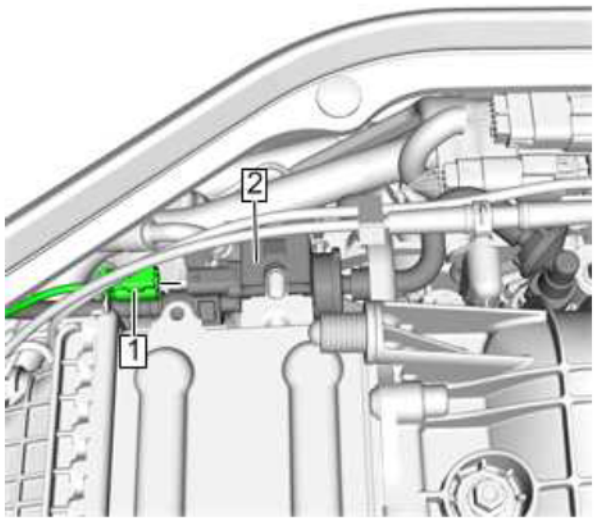

Fig. 174: Evaporative Emission Canister Purge Solenoid Valve And Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

4. Evaporative Emission Canister Purge Tube (1) @ Evaporative Emission Canister Purge Solenoid Valve (2)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**

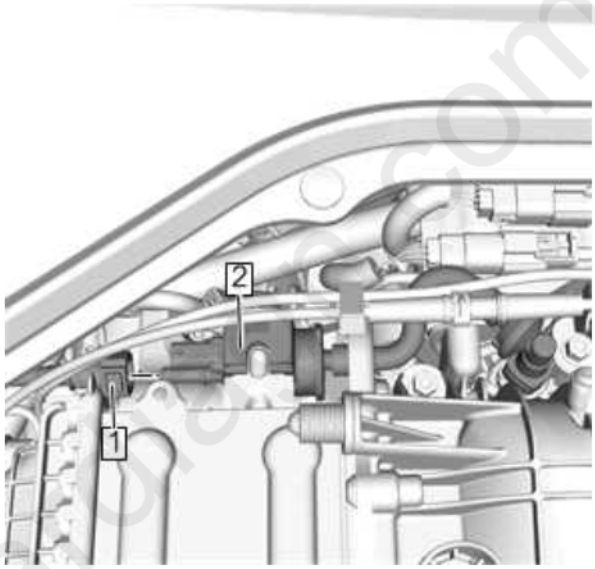

Fig. 175: Evaporative Emission Canister Purge Solenoid Valve And Evaporative Emission Canister Purge Tube
Courtesy of GENERAL MOTORS COMPANY

5. Quick Connect Fitting (1)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**

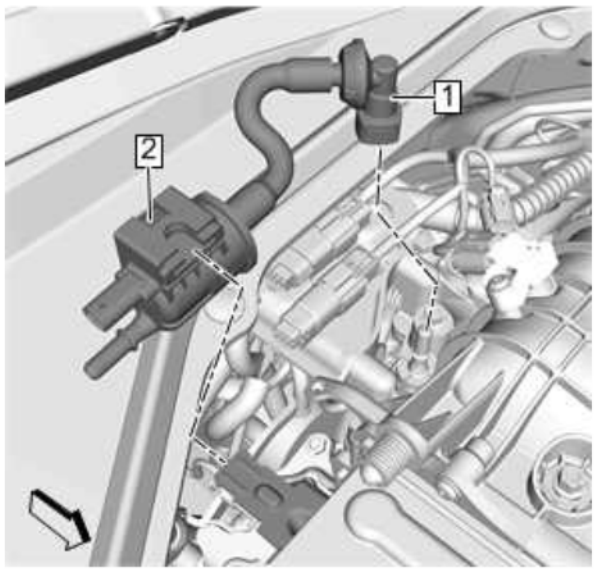

Fig. 176: Evaporative Emission Canister Purge Solenoid Valve And Quick Connect Fitting
Courtesy of GENERAL MOTORS COMPANY

6. Evaporative Emission Canister Purge Solenoid Valve (2)Â» Unclip

Installation Procedure

1. Evaporative Emission Canister Purge Solenoid Valve (2)Â» Install

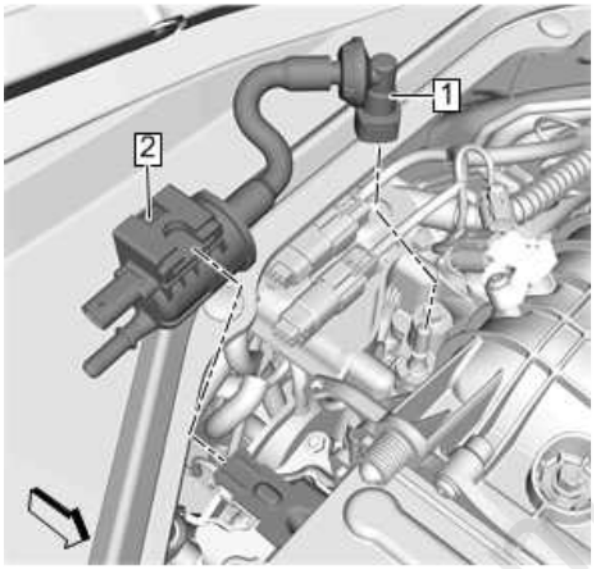

Fig. 177: Evaporative Emission Canister Purge Solenoid Valve And Quick Connect Fitting
Courtesy of GENERAL MOTORS COMPANY

2. Quick Connect Fitting (1)Â» Connect - **Plastic Collar Quick Connect Fitting Service**
3. Evaporative Emission Canister Purge Tube (1) @ Evaporative Emission Canister Purge Solenoid Valve (2)Â» Connect - **Plastic Collar Quick Connect Fitting Service**

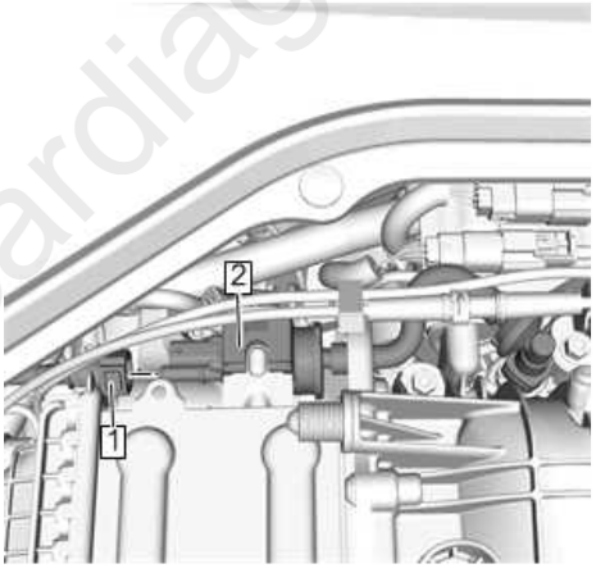

Fig. 178: Evaporative Emission Canister Purge Solenoid Valve And Evaporative Emission Canister Purge Tube
Courtesy of GENERAL MOTORS COMPANY

4. Electrical Connector (1) @ Evaporative Emission Canister Purge Solenoid Valve (2)Â» Connect

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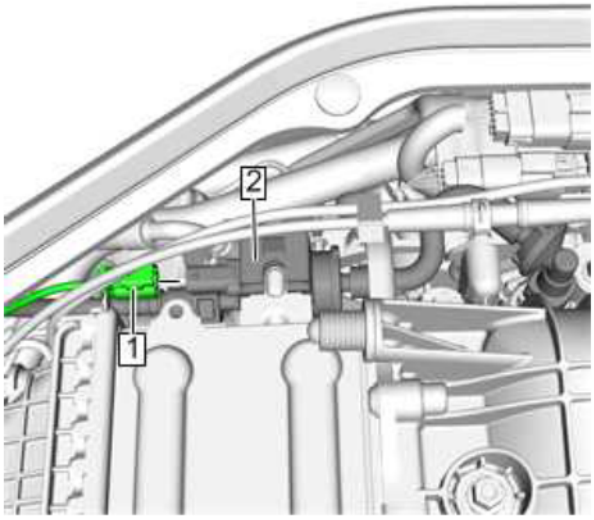

Fig. 179: Evaporative Emission Canister Purge Solenoid Valve And Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

5. Front Wheelhouse Panel BraceÂ» Install - Front Wheelhouse Panel Brace Replacement (Rear) Front Wheelhouse Panel Brace Replacement (Front)
6. Air Inlet Grille PanelÂ» Install - Air Inlet Grille Panel Replacement

EVAPORATIVE EMISSION CANISTER PURGE SOLENOID VALVE REPLACEMENT (LGX)

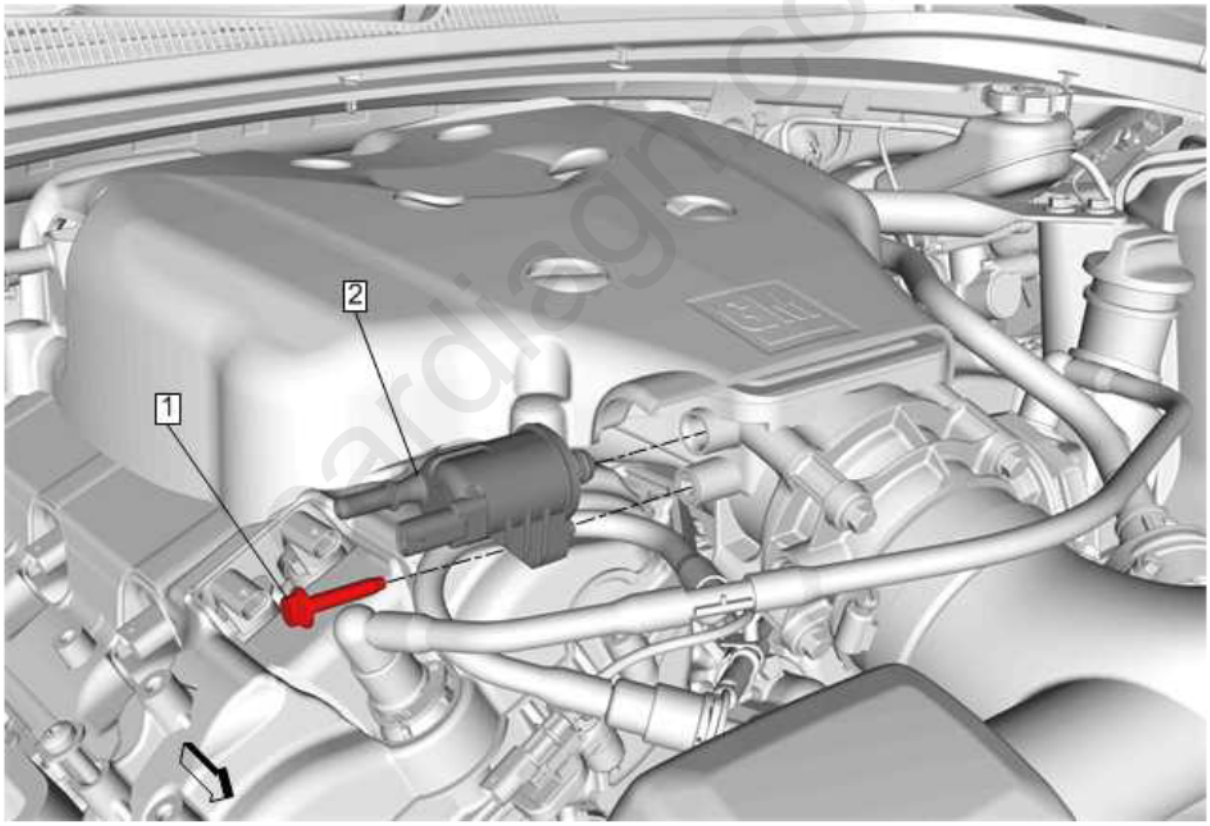

Fig. 180: Evaporative Emission Canister Purge Solenoid Valve (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Intake Manifold Cover Replacement (LGX) 2. Evaporative Emission Canister Purge Pipe Replacement (LGX) 3. Disconnect the electrical connector.	

Callout	Component Name
1	Evaporative Emission Canister Purge Solenoid Valve Bolt **CAUTION:** Refer to Fastener Caution . **Tighten** 10 N.m (89 lb in)
2	Evaporative Emission Canister Purge Solenoid Valve

FUEL TANK FILLER EVAPORATIVE EMISSION VALVE HOSE REPLACEMENT

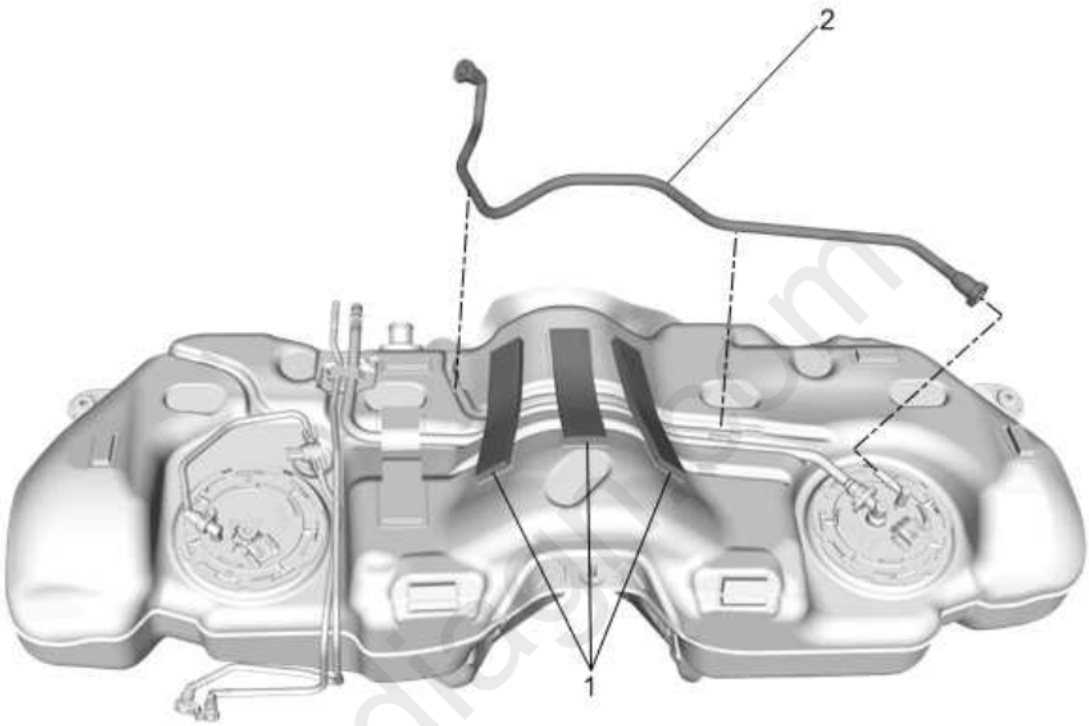

Fig. 181: Fuel Tank Filler Evaporative Emission Valve Hose
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
	WARNING: Refer to Gasoline/Gasoline Vapors Warning . **WARNING:** Refer to Safety Glasses Warning . **Preliminary Procedure** Fuel Tank Replacement
1	Fuel Tank Insulator [3x]
2	Fuel Tank Filler Evaporative Emission Valve Hose **Procedure** Disconnect the quick connect fittings. Refer to Plastic Collar Quick Connect Fitting Service

TURBOCHARGER WASTEGATE ACTUATOR VACUUM TANK REPLACEMENT

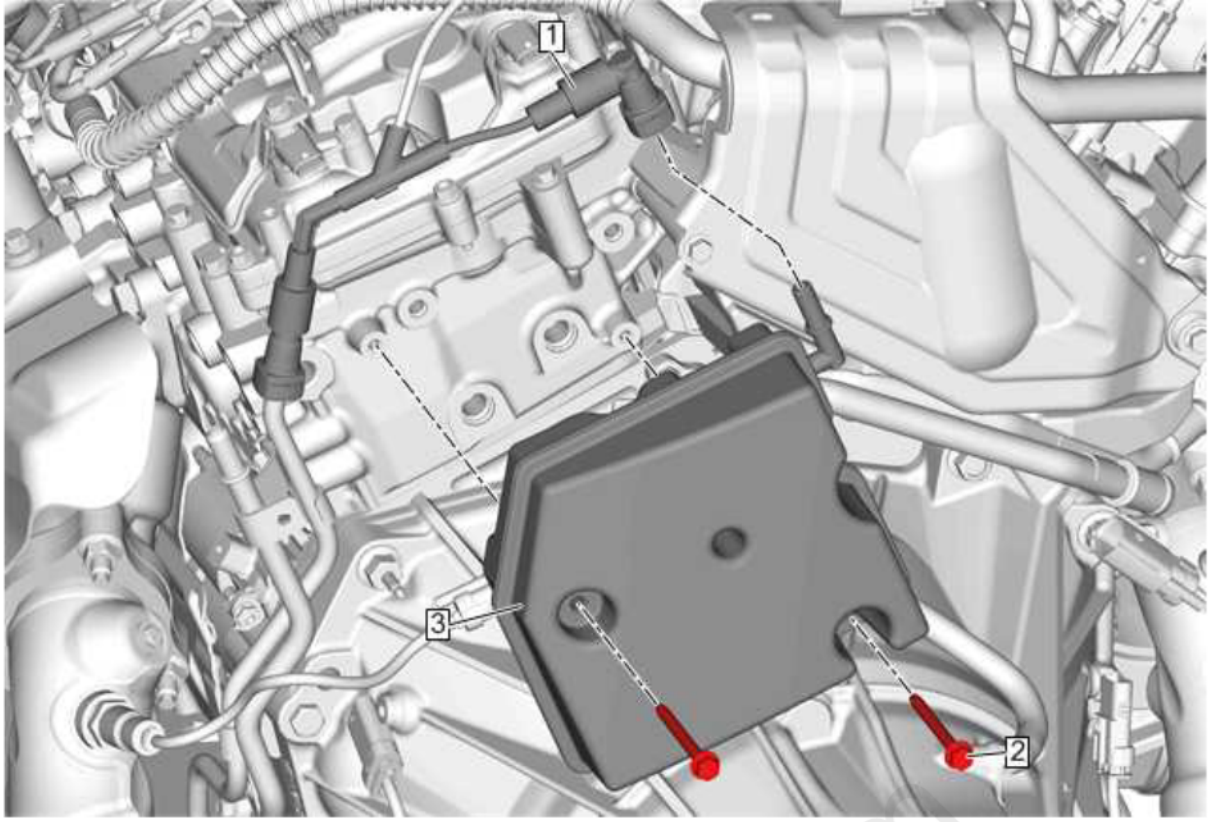

Fig. 182: Turbocharger Wastegate Actuator Vacuum Tank
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Engine Replacement (LGW) Engine Replacement (LGX)	
1	Vacuum Hose Plastic Collar Quick Connect Fitting Service
2	Turbocharger Wastegate Actuator Vacuum Tank Bolt [2x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 9 N.m (80 lb in)
3	Turbocharger Wastegate Actuator Vacuum Tank

TURBOCHARGER WASTEGATE REGULATOR SOLENOID VALVE REPLACEMENT (BANK 1)

Removal Procedure

1. Charge Air Cooler Cover Replacement Â» Remove
2. Hose Clamp (1)Â» Disengage [3x] - Hose Clamp Replacement Guidelines - Spring Type

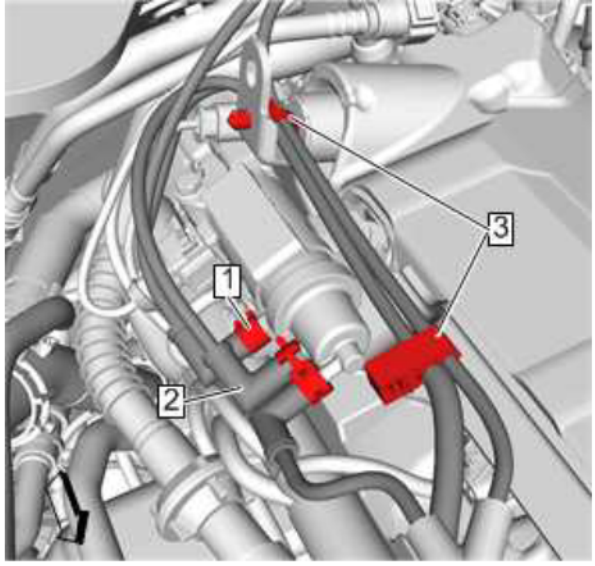

Fig. 183: Vacuum Hoses, Hose Clamps And Retainers
Courtesy of GENERAL MOTORS COMPANY

3. Vacuum Hose (2)Â» Disconnect [3x]
4. Retainer (3)Â» Unclip [2x]
5. Electrical Connector (1)Â» Disconnect

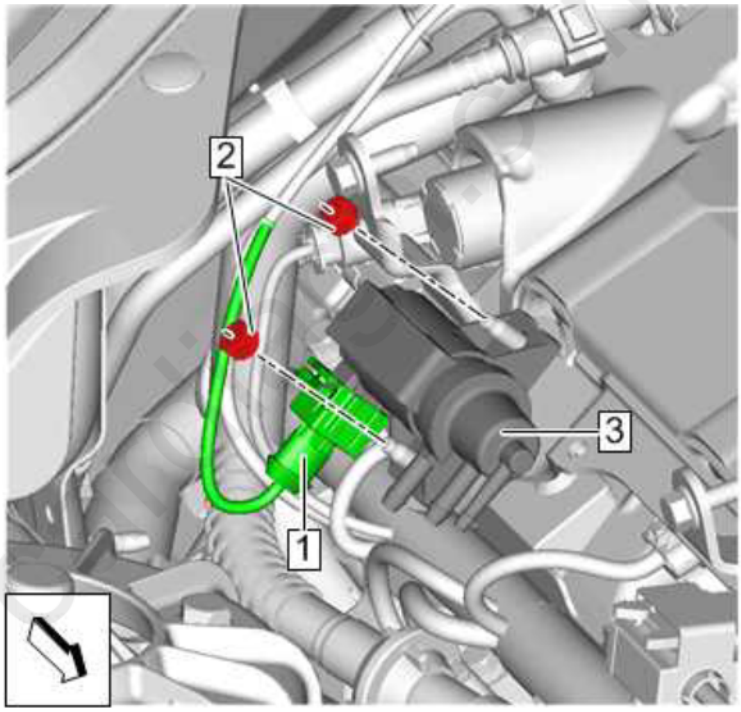

Fig. 184: Turbocharger Wastegate Regulator Solenoid Valve And Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

6. Nut (2)Â» Remove [2x]
7. Turbocharger Wastegate Regulator Solenoid Valve (3)Â» Remove

Installation Procedure

1. Turbocharger Wastegate Regulator Solenoid Valve (3)Â» Install

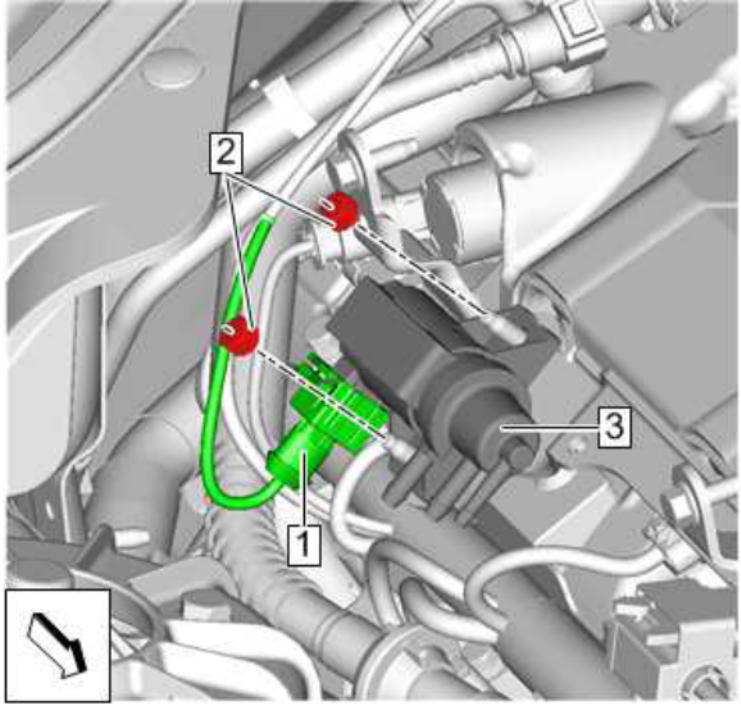

Fig. 185: Turbocharger Wastegate Regulator Solenoid Valve And Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

2. Nut (2)Â» Install and tighten 9 N.m (80 lb in)

CAUTION: Refer to Fastener Caution .

3. Electrical Connector (1)Â» Connect
4. Retainer (3)Â» Install [2x]

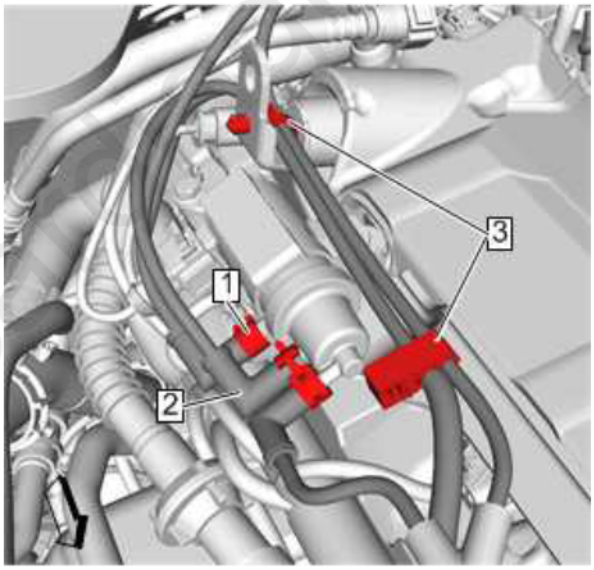

Fig. 186: Vacuum Hoses, Hose Clamps And Retainers
Courtesy of GENERAL MOTORS COMPANY

5. Vacuum Hose (2)Â» Connect [3x]

CAUTION: Refer to Solenoid Valve Caution .

6. Hose Clamp (1)Â» Engage [3x] - Hose Clamp Replacement Guidelines - Spring Type
7. Charge Air Cooler Cover Replacement Â» Install

TURBOCHARGER WASTEGATE REGULATOR SOLENOID VALVE REPLACEMENT (BANK 2)

Removal Procedure

1. **Charge Air Cooler Cover Replacement** Â» Remove
2. Hose Clamp (1)Â» Disengage [3x] - **Hose Clamp Replacement Guidelines - Spring Type**

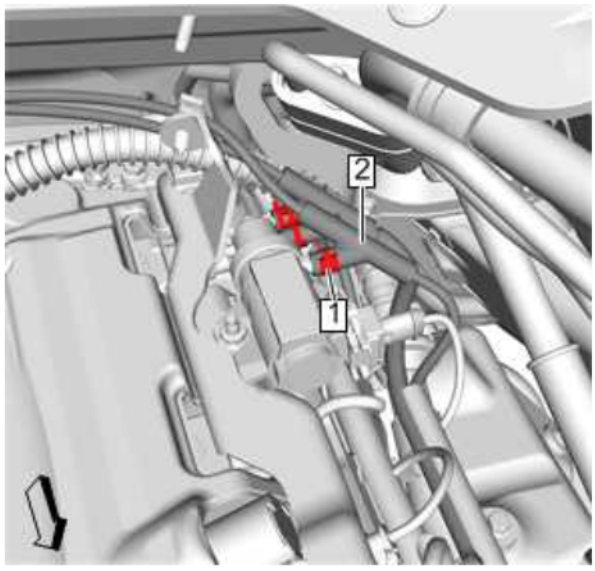

Fig. 187: Vacuum Hoses And Hose Clamps
Courtesy of GENERAL MOTORS COMPANY

3. Vacuum Hose (2)Â» Disconnect [3x]
4. Electrical Connector (1)Â» Disconnect

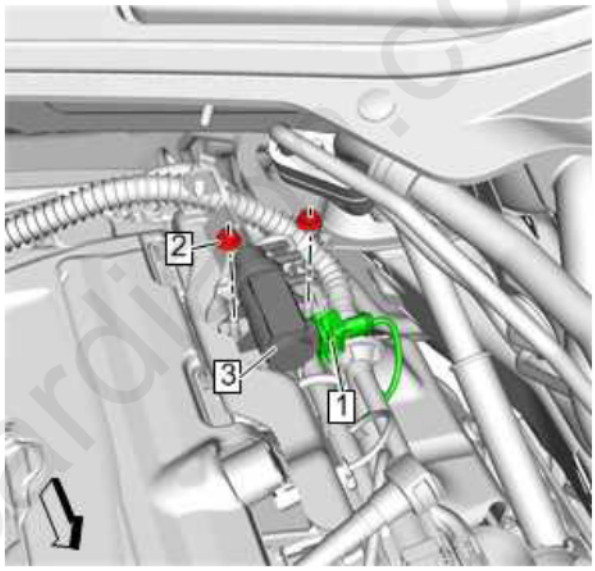

Fig. 188: Turbocharger Wastegate Regulator Solenoid Valve And Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

5. Nut (2)Â» Remove [2x]
6. Turbocharger Wastegate Regulator Solenoid Valve (3)Â» Remove

Installation Procedure

1. Turbocharger Wastegate Regulator Solenoid Valve (3)Â» Install

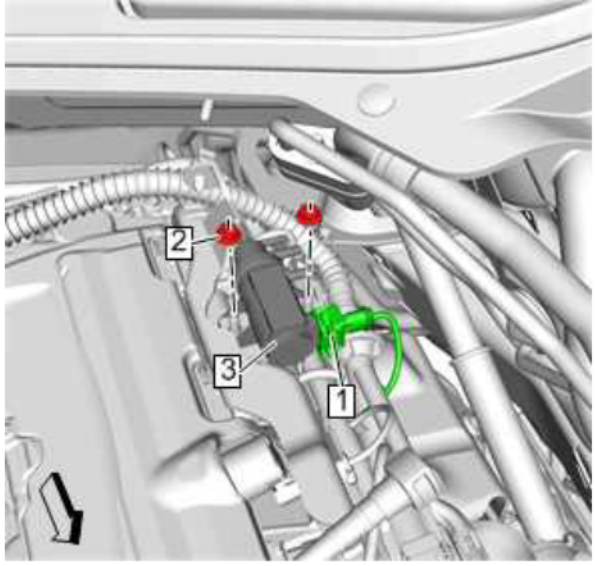

Fig. 189: Turbocharger Wastegate Regulator Solenoid Valve And Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

2. Nut (2)Â» Install and tighten 9 N.m (80 lb in) [2x]

CAUTION: **Refer to Fastener Caution .**

3. Electrical Connector (1)Â» Connect
4. Vacuum Hose (2)Â» Connect [3x]

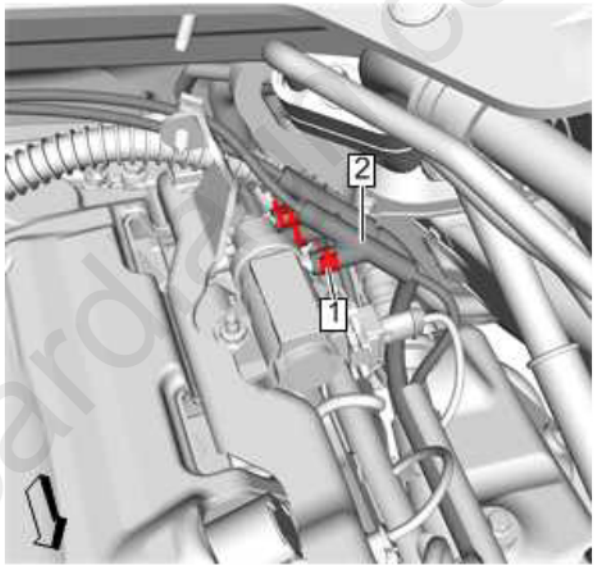

Fig. 190: Vacuum Hoses And Hose Clamps
Courtesy of GENERAL MOTORS COMPANY

CAUTION: **Refer to Solenoid Valve Caution .**

5. Hose Clamp (1)Â» Engage [3x] - **Hose Clamp Replacement Guidelines - Spring Type**
6. **Charge Air Cooler Cover Replacement** Â» Install

TURBOCHARGER WASTEGATE ACTUATOR VACUUM SOURCE TUBE REPLACEMENT (LEFT SIDE)

Removal Procedure

1. Charge Air Cooler Inlet Air Tube - Left SideÂ» Remove - **Charge Air Cooler Inlet Air Tube Replacement (Left Side)**
2. Quick Connect Fitting (1)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**

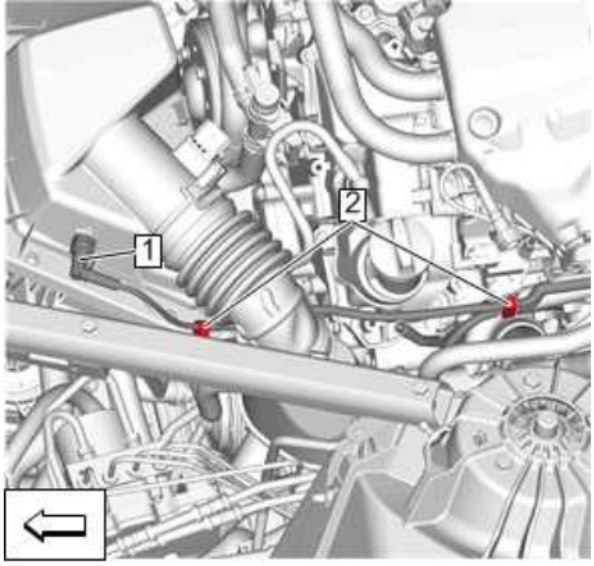

Fig. 191: Quick Connect Fitting And Retainer
Courtesy of GENERAL MOTORS COMPANY

3. Retainer (2)Â» Unclip [2x]
4. Quick Connect Fitting (1)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**

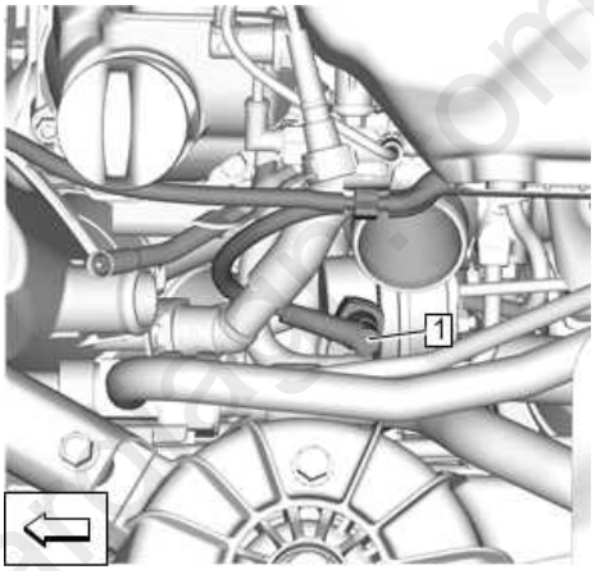

Fig. 192: Quick Connect Fitting
Courtesy of GENERAL MOTORS COMPANY

5. Hose Clamp (1)Â» Disengage [2x] - **Hose Clamp Replacement Guidelines - Spring Type**

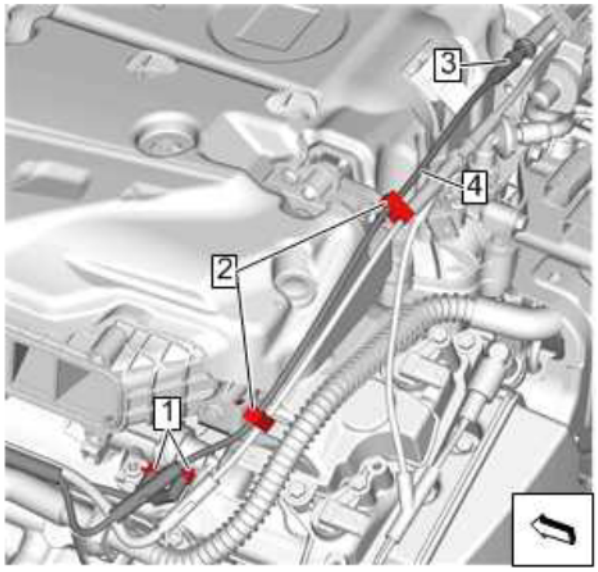

Fig. 193: Turbocharger Wastegate Actuator Vacuum Source Tube, Quick Connect Fitting, Retainer And Hose Clamp

Courtesy of GENERAL MOTORS COMPANY

6. Retainer (2)Â» Unclip [2x]
7. Quick Connect Fitting (3)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**
8. Turbocharger Wastegate Actuator Vacuum Source Tube (4)Â» Remove

Installation Procedure

1. Turbocharger Wastegate Actuator Vacuum Source Tube (4)Â» Install

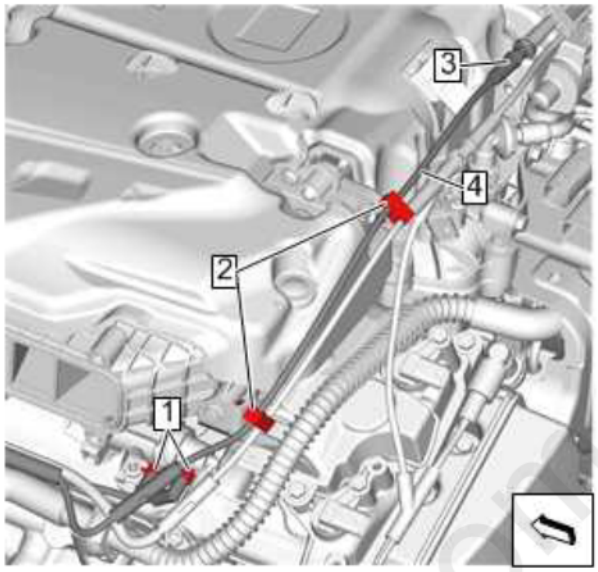

Fig. 194: Turbocharger Wastegate Actuator Vacuum Source Tube, Quick Connect Fitting, Retainer And Hose Clamp
Courtesy of GENERAL MOTORS COMPANY

2. Quick Connect Fitting (3)Â» Connect - **Plastic Collar Quick Connect Fitting Service**
3. Retainer (2)Â» Install [2x]
4. Hose Clamp (1)Â» Engage [2x] - **Hose Clamp Replacement Guidelines - Spring Type**
5. Quick Connect Fitting (1)Â» Connect - **Plastic Collar Quick Connect Fitting Service**

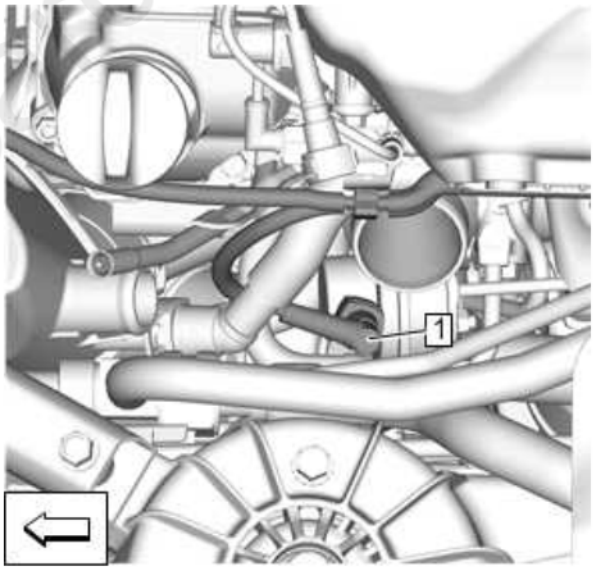

Fig. 195: Quick Connect Fitting
Courtesy of GENERAL MOTORS COMPANY

6. Retainer (2)Â» Install [2x]

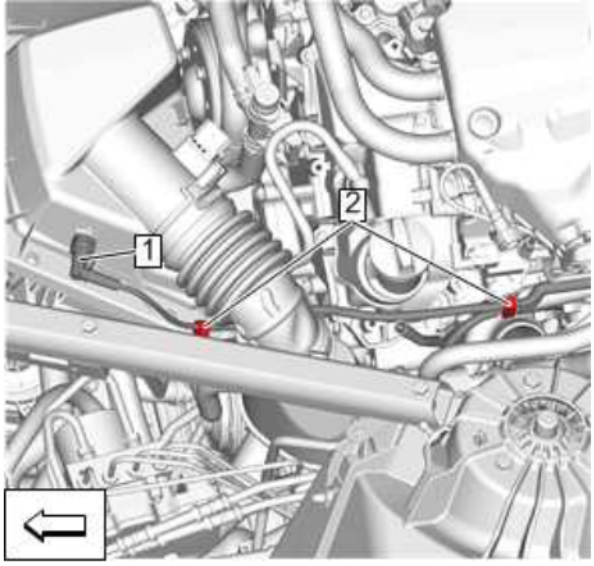

Fig. 196: Quick Connect Fitting And Retainer
Courtesy of GENERAL MOTORS COMPANY

7. Quick Connect Fitting (1)Â» Connect - Plastic Collar Quick Connect Fitting Service
8. Charge Air Cooler Inlet Air Tube - Left SideÂ» Install - Charge Air Cooler Inlet Air Tube Replacement (Left Side)

TURBOCHARGER WASTEGATE ACTUATOR VACUUM SOURCE TUBE REPLACEMENT (RIGHT SIDE - FRONT)

Removal Procedure

1. Charge Air Cooler Cover Replacement Â» Remove
2. Quick Connect Fitting (1)Â» Disconnect - Plastic Collar Quick Connect Fitting Service

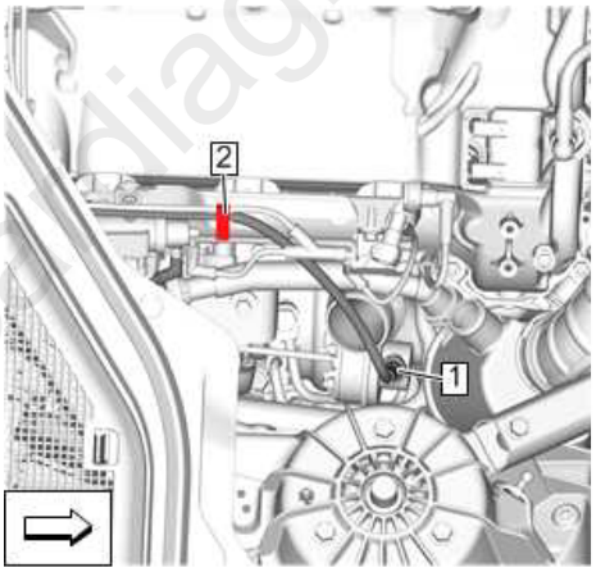

Fig. 197: Quick Connect Fitting And Retainer
Courtesy of GENERAL MOTORS COMPANY

3. Retainer (2)Â» Unclip
4. Hose Clamp (1)Â» Disengage - Hose Clamp Replacement Guidelines - Spring Type

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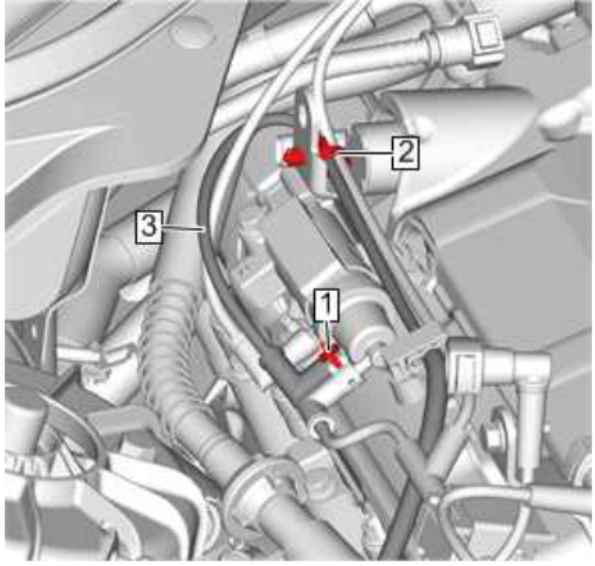

Fig. 198: Turbocharger Wastegate Actuator Vacuum Source Tube, Hose Clamp And Retainer
Courtesy of GENERAL MOTORS COMPANY

5. Retainer (2)Â» Unclip
6. Turbocharger Wastegate Actuator Vacuum Source Tube (3)Â» Remove

Installation Procedure

1. Turbocharger Wastegate Actuator Vacuum Source Tube (3)Â» Install

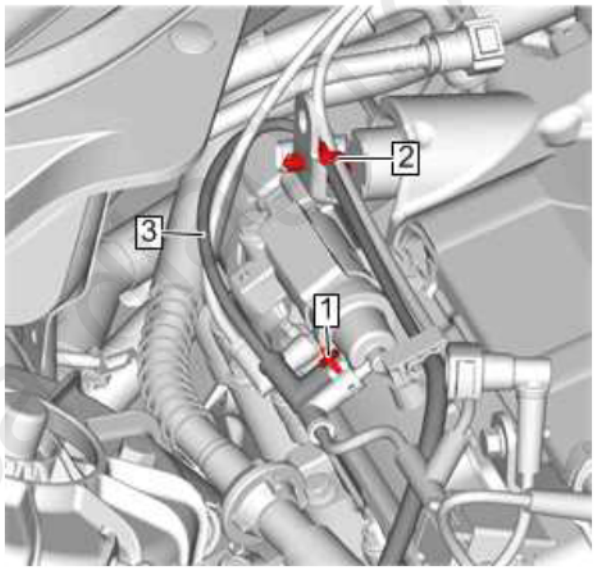

Fig. 199: Turbocharger Wastegate Actuator Vacuum Source Tube, Hose Clamp And Retainer
Courtesy of GENERAL MOTORS COMPANY

2. Retainer (2)Â» Install
3. Hose Clamp (1)Â» Engage - **Hose Clamp Replacement Guidelines - Spring Type**
4. Retainer (2)Â» Install

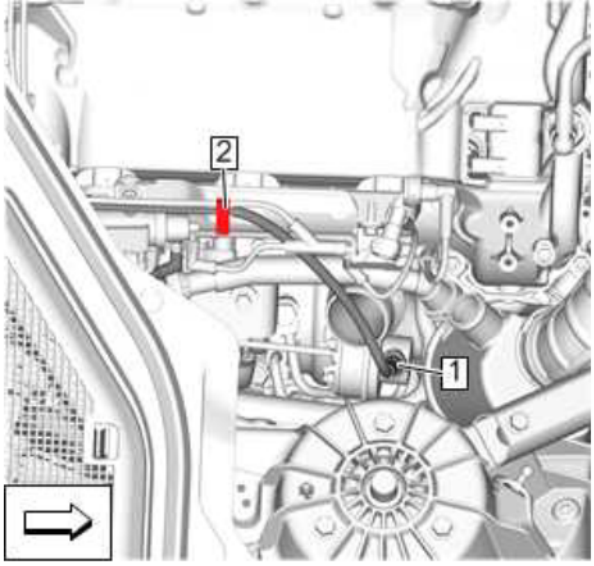

Fig. 200: Quick Connect Fitting And Retainer
Courtesy of GENERAL MOTORS COMPANY

5. Quick Connect Fitting (1)Â» Connect - Plastic Collar Quick Connect Fitting Service
6. Charge Air Cooler Cover Replacement Â» Install

TURBOCHARGER WASTEGATE ACTUATOR VACUUM SOURCE TUBE REPLACEMENT (RIGHT SIDE - REAR)

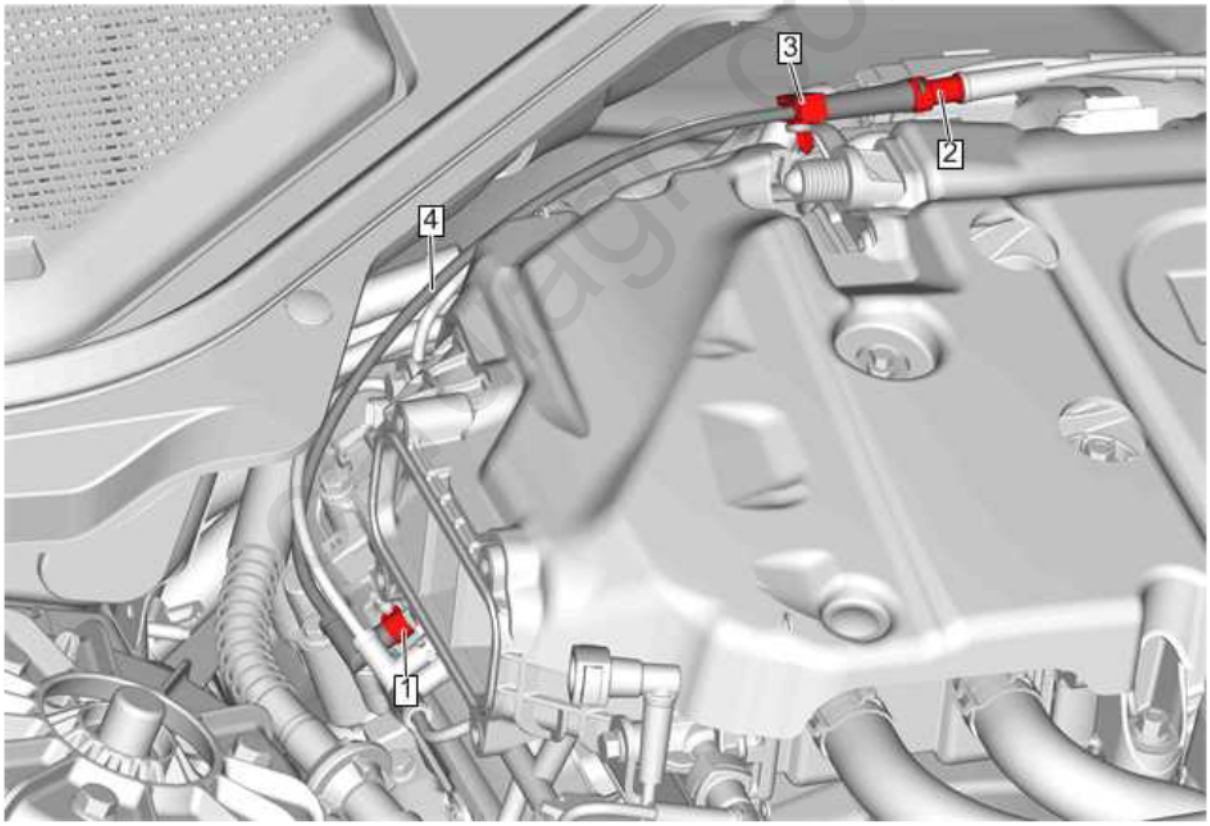

Fig. 201: Turbocharger Wastegate Actuator Vacuum Source Tube (Right Side - Rear)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Charge Air Cooler Inlet Air Tube - Right SideÂ» Remove - Charge Air Cooler Inlet Air Tube Replacement (Right Side)	
1	Hose Clamp **Procedure** Hose Clamp Replacement Guidelines - Spring Type

Callout	Component Name
2	Quick Connect Fitting **Procedure** **Plastic Collar Quick Connect Fitting Service**
3	Retainer
4	Turbocharger Wastegate Actuator Vacuum Source Tube

TURBOCHARGER WASTEGATE ACTUATOR REPLACEMENT - RIGHT SIDE

Removal Procedure

1. **Air Cleaner Outlet Rear Duct Replacement (LGW)**Â» Remove
2. **Turbocharger Heat Shield Replacement (Right, LGW)** Â» Remove
3. Turbocharger Wastegate Actuator Vacuum Source Tube (1) @ Turbocharger Wastegate Actuator (3)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**

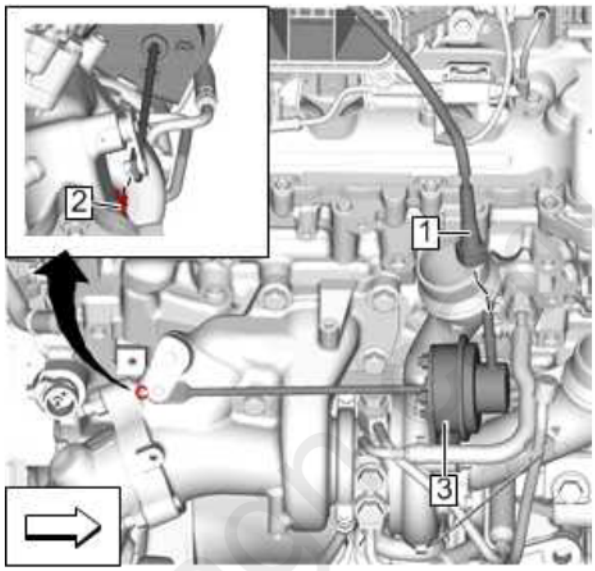

Fig. 202: Turbocharger Wastegate Actuator, Actuator Vacuum Source Tube And Actuator Arm Retainer
Courtesy of GENERAL MOTORS COMPANY

4. Turbocharger Wastegate Actuator Arm Retainer (2)Â» Remove

NOTE: **Note the position of the retainer for future installation.**

5. Turbocharger Wastegate Actuator Fastener (1)Â» Remove [2x]

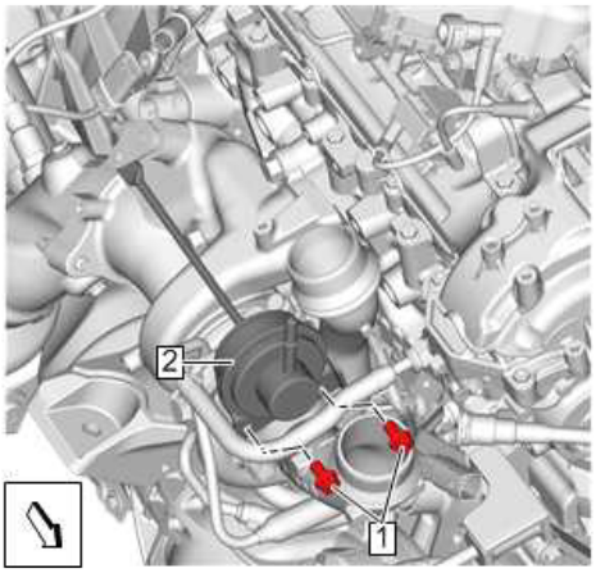

Fig. 203: Turbocharger Wastegate Actuator And Fastener
Courtesy of GENERAL MOTORS COMPANY

6. Turbocharger Wastegate Actuator (2)Â» Remove

Installation Procedure

1. Turbocharger Wastegate Actuator (2)Â» Install

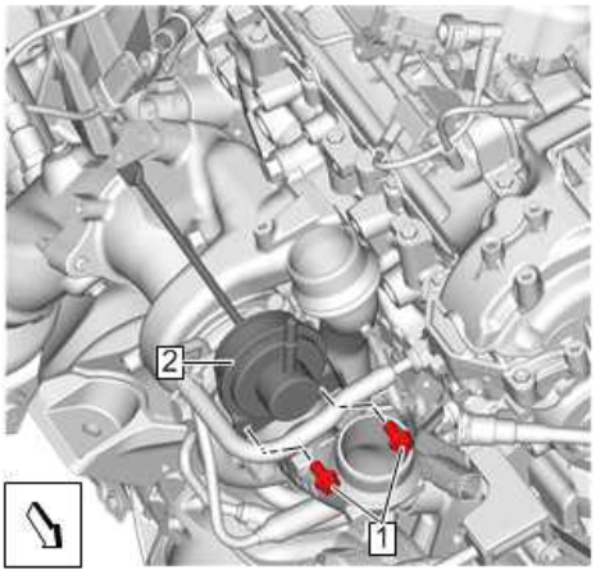

Fig. 204: Turbocharger Wastegate Actuator And Fastener
Courtesy of GENERAL MOTORS COMPANY

2. Turbocharger Wastegate Actuator Fastener (1)Â» Install and tighten 25 N.m (18 lb ft)

CAUTION: **Refer to Fastener Caution .**

3. Turbocharger Wastegate Actuator Arm Retainer (2)Â» Install

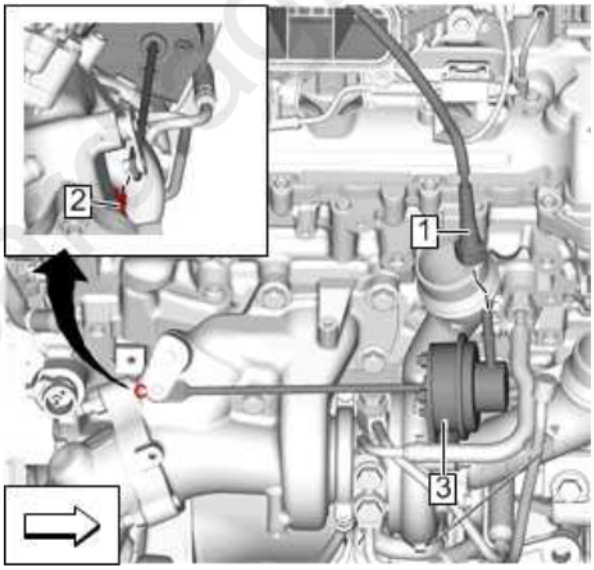

Fig. 205: Turbocharger Wastegate Actuator, Actuator Vacuum Source Tube And Actuator Arm Retainer
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Ensure that the actuator arm retainer is installed as previously noted.**

4. Turbocharger Wastegate Actuator Vacuum Source Tube (1) @ Turbocharger Wastegate Actuator (3)Â» Connect - **Plastic Collar Quick Connect Fitting Service**

NOTE: **Ensure the wastegate vacuum connection is fully seated and secure. A poor connection can result in a DTC and lead to misdiagnosis.**

5. Turbocharger Heat Shield Replacement (Right, LGW) Â» Install
6. Air Cleaner Outlet Rear Duct Replacement (LGW)Â» Install

TURBOCHARGER WASTEGATE ACTUATOR REPLACEMENT - LEFT SIDE

Removal Procedure

1. Air Cleaner Outlet Front Duct Replacement (LGW)Â» Remove
2. Turbocharger Heat Shield Replacement (Left, LGW) Â» Remove
3. Turbocharger Wastegate Actuator Vacuum Source Tube (1) @ Turbocharger Wastegate Actuator (3)Â» Disconnect - Plastic Collar Quick Connect Fitting Service

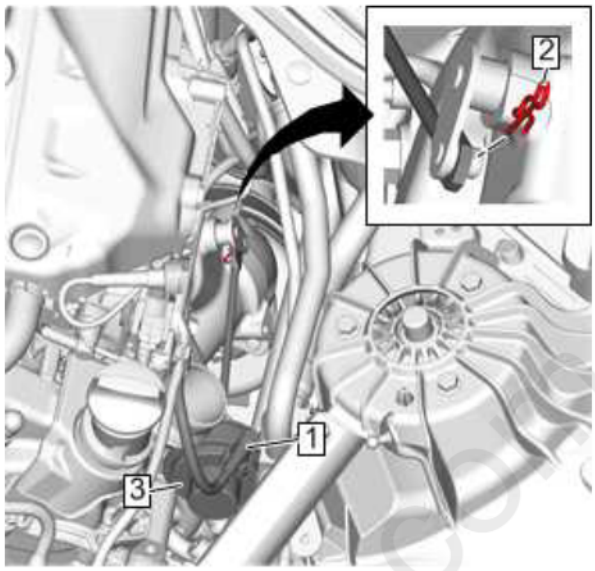

Fig. 206: Turbocharger Wastegate Actuator, Actuator Vacuum Source Tube And Actuator Arm Retainer
Courtesy of GENERAL MOTORS COMPANY

4. Turbocharger Wastegate Actuator Arm Retainer (2)Â» Remove

NOTE: **Note the position of the retainer for future installation.**

5. Turbocharger Oil Feed Pipe - Left Side @ TurbochargerÂ» Disconnect - Turbocharger Oil Feed Pipe Replacement (Left Side)
6. Turbocharger Wastegate Actuator Fastener (1)Â» Remove [2x]

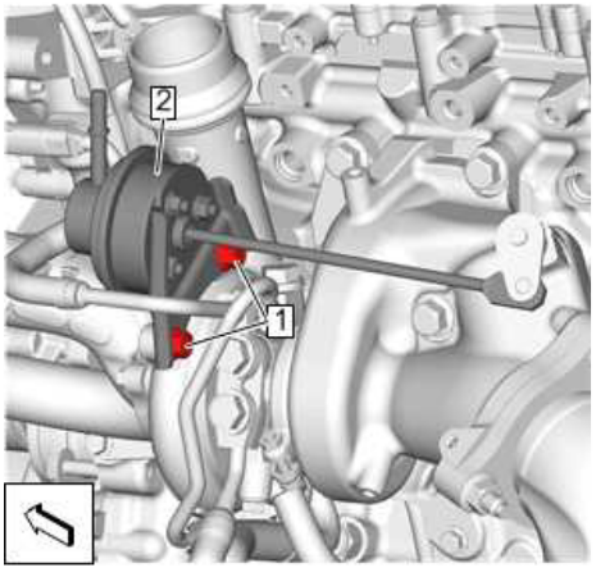

Fig. 207: Turbocharger Wastegate Actuator And Actuator Fastener
Courtesy of GENERAL MOTORS COMPANY

7. Turbocharger Wastegate Actuator (2)Â» Remove

Installation Procedure

1. Turbocharger Wastegate Actuator (2)Â» Install

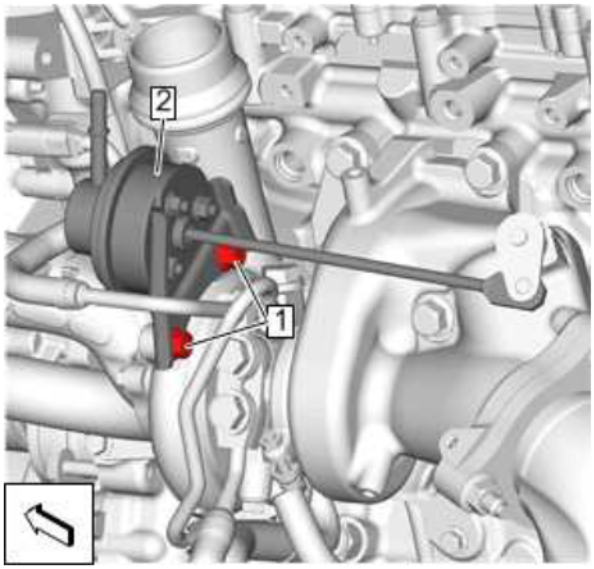

Fig. 208: Turbocharger Wastegate Actuator And Actuator Fastener
Courtesy of GENERAL MOTORS COMPANY

2. Turbocharger Wastegate Actuator Fastener (1)Â» Install and tighten 25 N.m (18 lb ft) [2x]

CAUTION: **Refer to Fastener Caution .**

3. Turbocharger Oil Feed Pipe - Left Side @ TurbochargerÂ» Connect - **Turbocharger Oil Feed Pipe Replacement (Left Side)**
4. Turbocharger Wastegate Actuator Arm Retainer (2)Â» Install

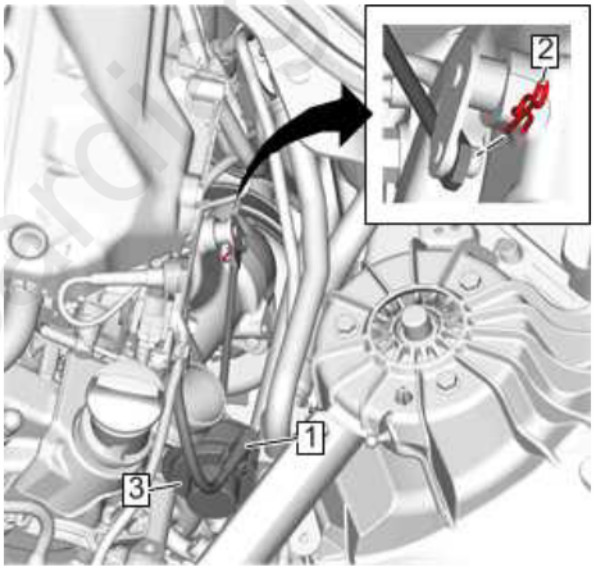

Fig. 209: Turbocharger Wastegate Actuator, Actuator Vacuum Source Tube And Actuator Arm Retainer
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Ensure that the actuator arm retainer is installed as previously noted.**

5. Turbocharger Wastegate Actuator Vacuum Source Tube (1) @ Turbocharger Wastegate Actuator (3)Â» Connect - **Plastic Collar Quick Connect Fitting Service**

NOTE: **Ensure the wastegate vacuum connection is fully seated and secure. A poor connection can result in a DTC and lead to misdiagnosis.**

6. Turbocharger Heat Shield Replacement (Left, LGW) Â» Install
7. Air Cleaner Outlet Front Duct Replacement (LGW)Â» Install

EVAPORATIVE EMISSION CANISTER VENT SOLENOID VALVE REPLACEMENT

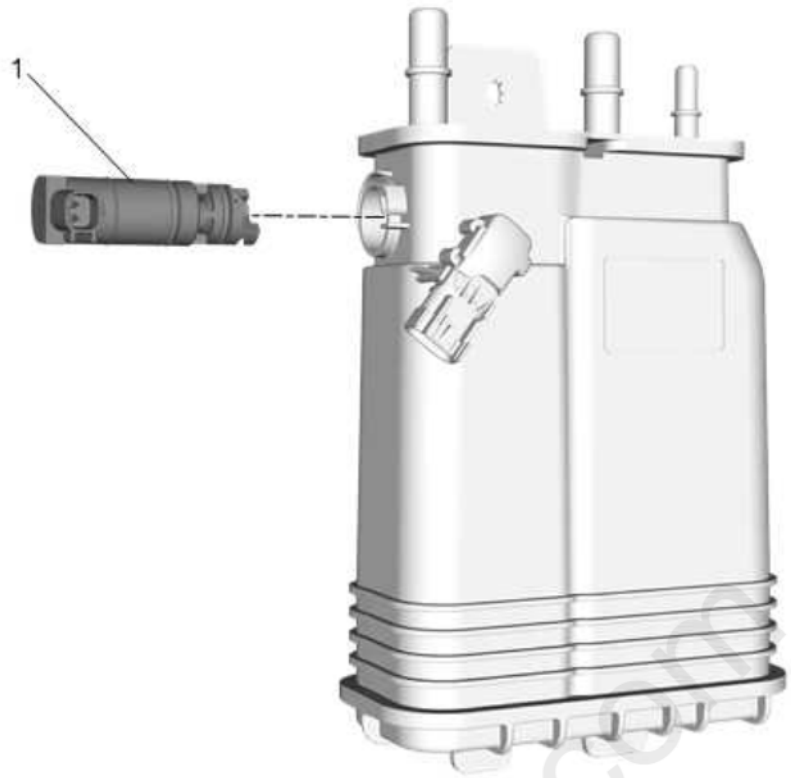

Fig. 210: Evaporative Emission Canister Vent Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
WARNING: Refer to Gasoline/Gasoline Vapors Warning . **WARNING:** Refer to Safety Glasses Warning . **Preliminary Procedure** Evaporative Emission Canister Replacement	
1	Evaporative Emission Canister Vent Solenoid Valve **Procedure** Disconnect the electrical connector.

EVAPORATIVE EMISSION PIPE REPLACEMENT (LGW)

Removal Procedure

1. Evaporative Emission Canister Purge Pipe Replacement (LGW)Â» Remove

   WARNING: Refer to Gasoline/Gasoline Vapors Warning .

   WARNING: Refer to Safety Glasses Warning .

2. Front Body Exhaust Heat Shield Replacement (Right Side, LGW, LGX) Front Body Exhaust Heat Shield Replacement (Left Side, LGW, LGX) Â» Remove
3. Underbody Rear Air Deflector Replacement - Right Side Â» Remove
4. Evaporative Emission Pipe (1) @ Retainer (2)Â» Remove

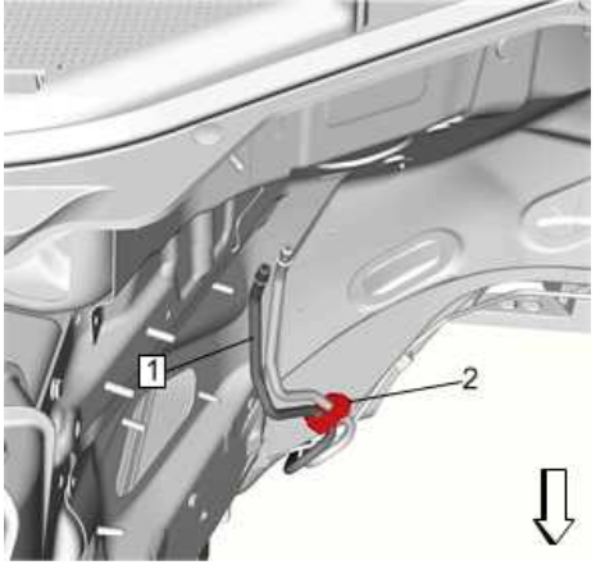

Fig. 211: Evaporative Emission Pipe And Retainer
Courtesy of GENERAL MOTORS COMPANY

5. Evaporative Emission Pipe (1) @ Fuel Tank Vent Valve Hose (2)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**

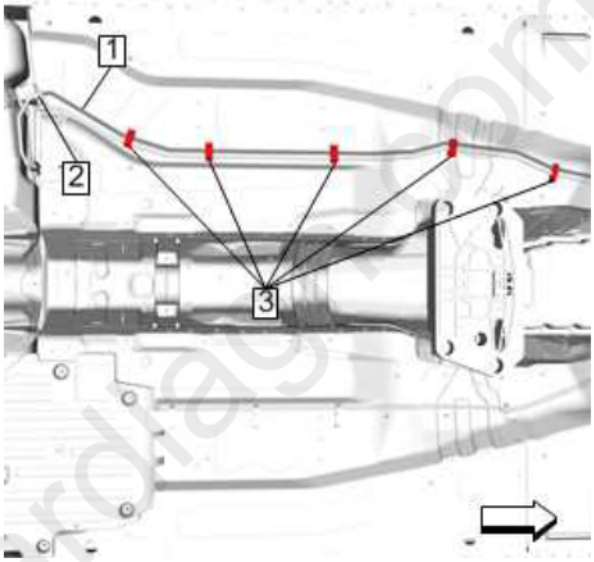

Fig. 212: Evaporative Emission Pipe, Retainer And Fuel Tank Vent Valve Hose
Courtesy of GENERAL MOTORS COMPANY

6. Evaporative Emission Pipe (1) @ Retainer (3)Â» Remove [5x]

Installation Procedure

1. Evaporative Emission Pipe (1) @ Retainer (3)Â» Install [5x]

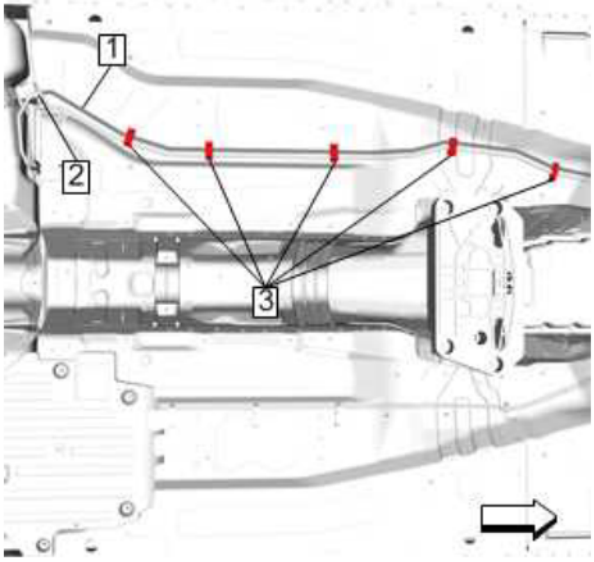

Fig. 213: Evaporative Emission Pipe, Retainer And Fuel Tank Vent Valve Hose
Courtesy of GENERAL MOTORS COMPANY

2. Evaporative Emission Pipe (1) @ Fuel Tank Vent Valve Hose (2)Â» Connect - **Plastic Collar Quick Connect Fitting Service**
3. Evaporative Emission Pipe (1) @ Retainer (2)Â» Install

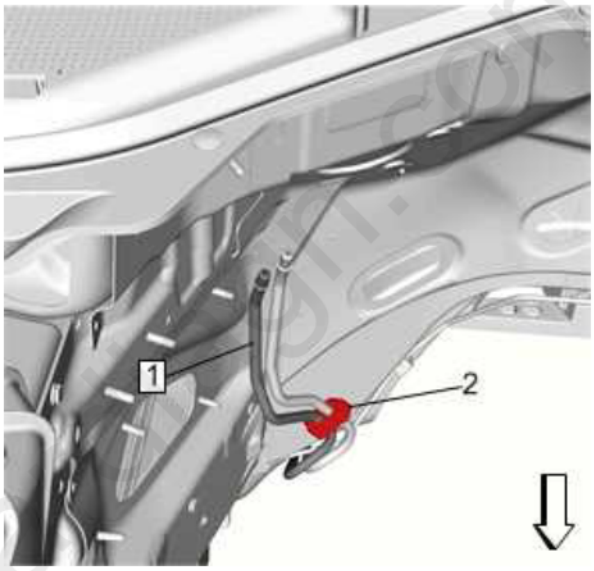

Fig. 214: Evaporative Emission Pipe And Retainer
Courtesy of GENERAL MOTORS COMPANY

4. **Underbody Rear Air Deflector Replacement - Right Side** Â» Install
5. **Front Body Exhaust Heat Shield Replacement (Right Side, LGW, LGX)** **Front Body Exhaust Heat Shield Replacement (Left Side, LGW, LGX)** Â» Install
6. **Evaporative Emission Canister Purge Pipe Replacement (LGW)**Â» Install

EVAPORATIVE EMISSION PIPE REPLACEMENT (LGX)

Removal Procedure

1. **Evaporative Emission Canister Purge Pipe Replacement (LGX)**Â» Remove

WARNING: Refer to **Gasoline/Gasoline Vapors Warning** .

WARNING: Refer to **Safety Glasses Warning** .

2. **Front Body Exhaust Heat Shield Replacement (Right Side, LGW, LGX)** **Front Body Exhaust Heat Shield Replacement (Left Side, LGW, LGX)** Â» Remove
3. **Underbody Rear Air Deflector Replacement - Right Side** Â» Remove

4. Evaporative Emission Pipe (1) @ Retainer (2)Â» Remove

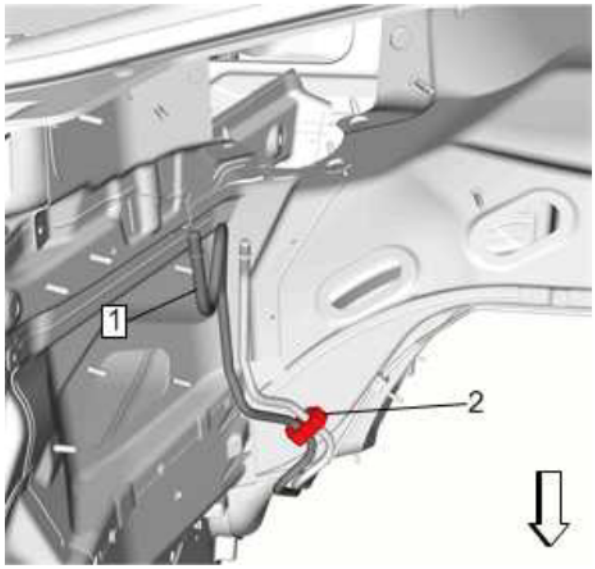

Fig. 215: Evaporative Emission Pipe And Retainer
Courtesy of GENERAL MOTORS COMPANY

5. Evaporative Emission Pipe (1) @ Fuel Tank Vent Valve Hose (2)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**

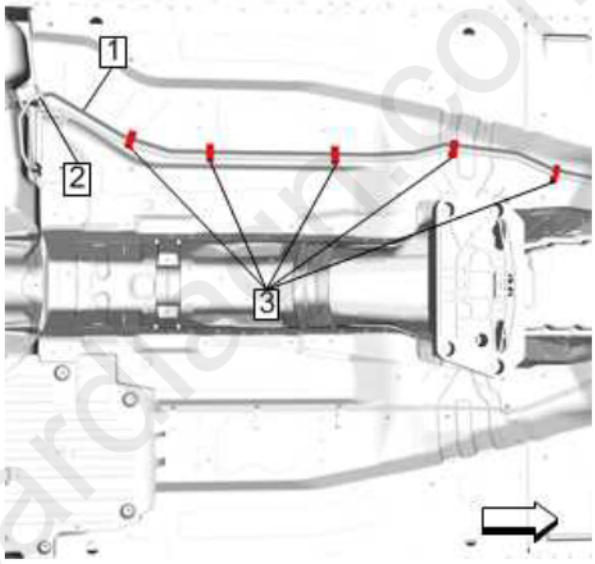

Fig. 216: Evaporative Emission Pipe, Retainer And Fuel Tank Vent Valve Hose
Courtesy of GENERAL MOTORS COMPANY

6. Evaporative Emission Pipe (1) @ Retainer (3)Â» Remove [5x]

Installation Procedure

1. Evaporative Emission Pipe (1) @ Retainer (3)Â» Install [5x]

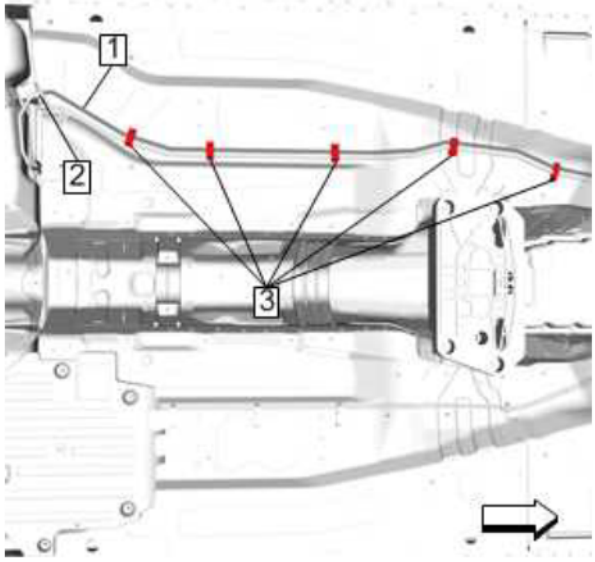

Fig. 217: Evaporative Emission Pipe, Retainer And Fuel Tank Vent Valve Hose
Courtesy of GENERAL MOTORS COMPANY

2. Evaporative Emission Pipe (1) @ Fuel Tank Vent Valve Hose (2)Â» Connect - **Plastic Collar Quick Connect Fitting Service**
3. Evaporative Emission Pipe (1) @ Retainer (2)Â» Install

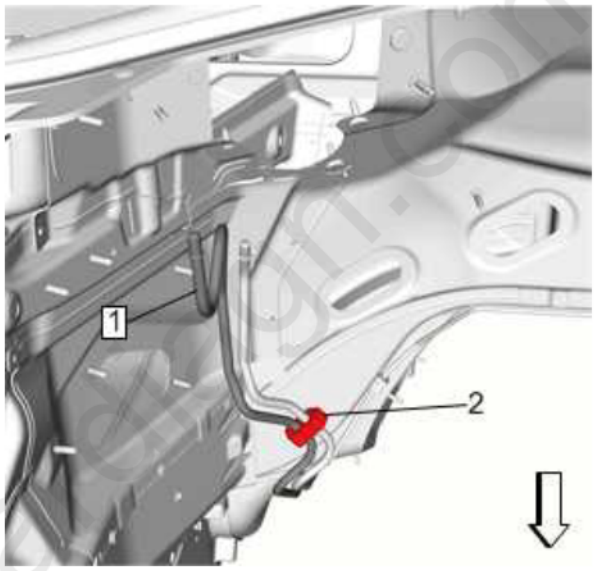

Fig. 218: Evaporative Emission Pipe And Retainer
Courtesy of GENERAL MOTORS COMPANY

4. **Underbody Rear Air Deflector Replacement - Right Side** Â» Install
5. **Front Body Exhaust Heat Shield Replacement (Right Side, LGW, LGX)** **Front Body Exhaust Heat Shield Replacement (Left Side, LGW, LGX)** Â» Install
6. **Evaporative Emission Canister Purge Pipe Replacement (LGX)**Â» Install

EVAPORATIVE EMISSION CANISTER AIR INLET HOSE REPLACEMENT

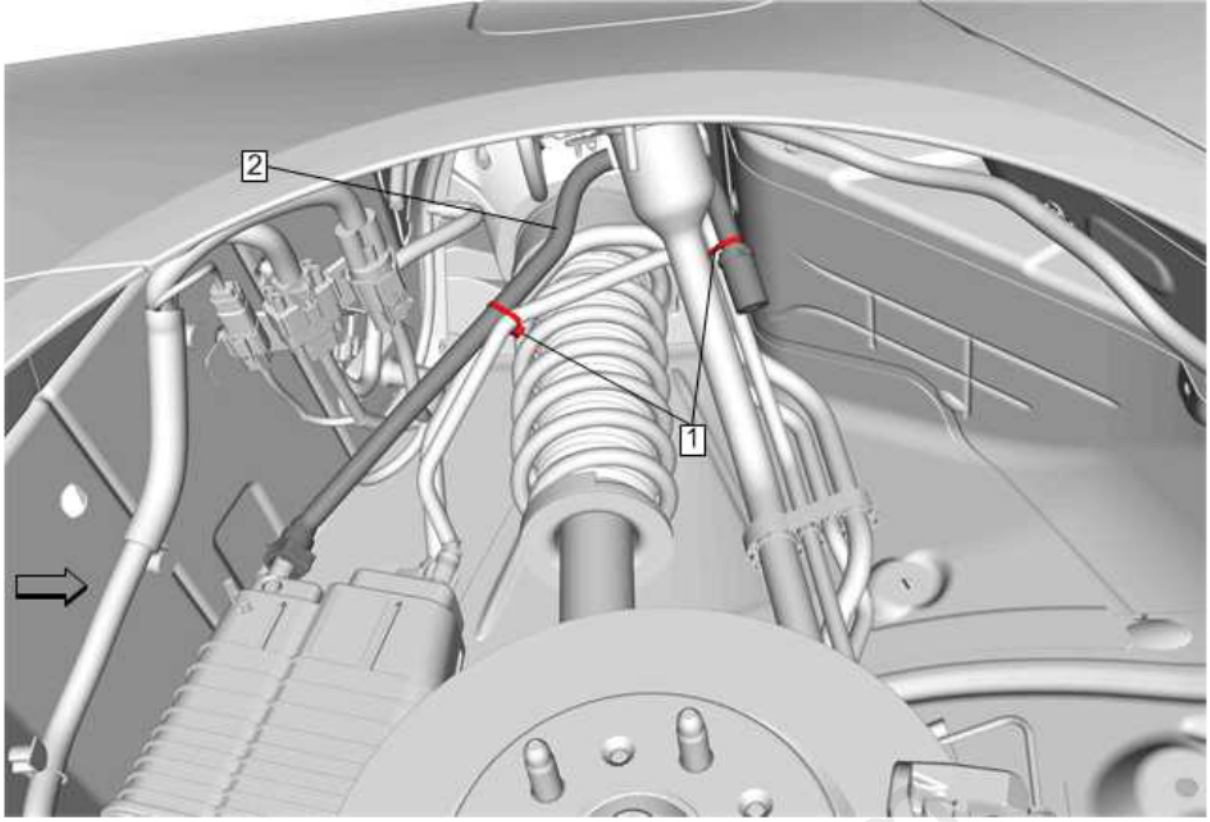

Fig. 219: Evaporative Emission Canister Air Inlet Hose
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Rear Wheelhouse Liner Replacement (LGX, LGW)	
1	Tie Strap [2x]
2	Evaporative Emission Canister Air Inlet Hose **Procedure** Disconnect the quick connect fitting. Refer to Plastic Collar Quick Connect Fitting Service

EVAPORATIVE EMISSION CANISTER PURGE PIPE REPLACEMENT (LGW)

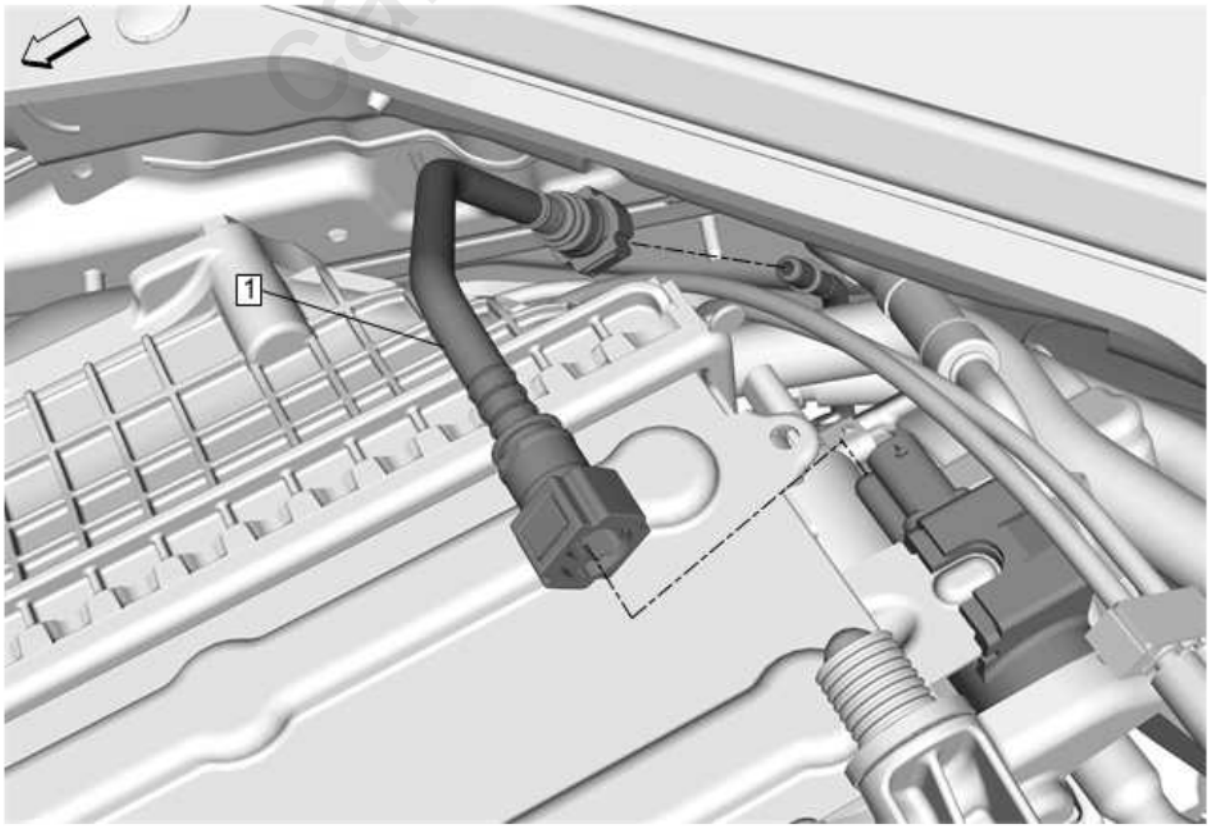

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Fig. 220: Evaporative Emission Canister Purge Pipe (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Intake Manifold Cover Replacement (LGW) 2. Front Wheelhouse Panel Brace - RearÂ» Remove - Front Wheelhouse Panel Brace Replacement (Rear)	
1	Evaporative Emission Canister Purge Pipe **WARNING:** Refer to Gasoline/Gasoline Vapors Warning . **WARNING:** Refer to Safety Glasses Warning . **Procedure** Disconnect the quick connect fittings. Refer to Plastic Collar Quick Connect Fitting Service

EVAPORATIVE EMISSION CANISTER PURGE PIPE REPLACEMENT (LGX)

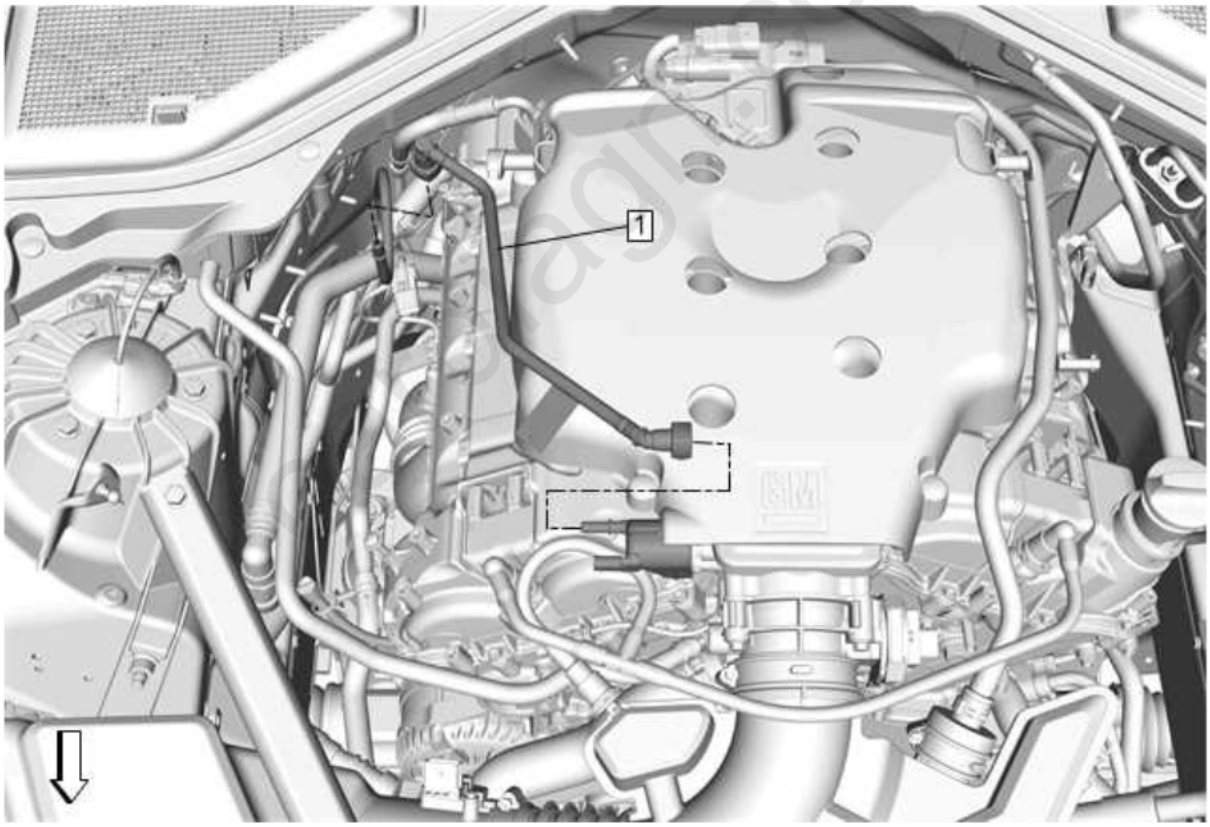

Fig. 221: Evaporative Emission Canister Purge Pipe (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Intake Manifold Cover Replacement (LGX)	

Callout	Component Name
1	Evaporative Emission Canister Purge Pipe **WARNING:** **Refer to Gasoline/Gasoline Vapors Warning .** **WARNING:** **Refer to Safety Glasses Warning .** **Procedure** Disconnect the quick connect fittings. Refer to **Plastic Collar Quick Connect Fitting Service**

EVAPORATIVE EMISSION CANISTER PURGE HOSE REPLACEMENT

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle**

   WARNING: **Refer to Gasoline/Gasoline Vapors Warning .**

   WARNING: **Refer to Safety Glasses Warning .**

2. Evaporative Emission Canister Purge Hose (1)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**

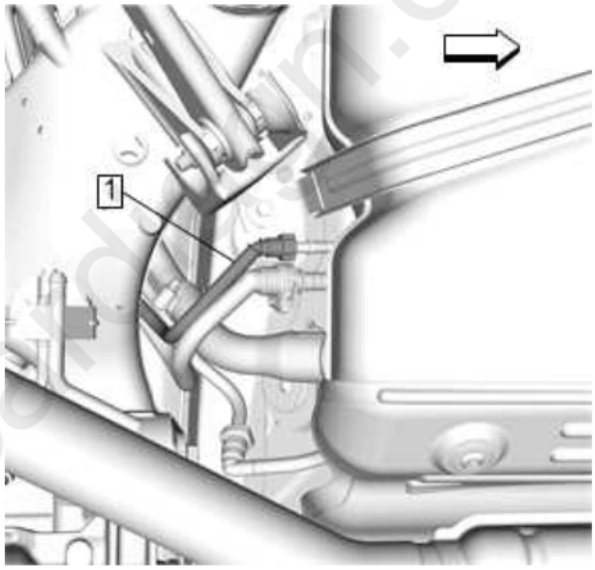

Fig. 222: Evaporative Emission Canister Purge Hose
Courtesy of GENERAL MOTORS COMPANY

3. **Rear Wheelhouse Liner Replacement (LGX, LGW)** Â» Remove
4. Fuel Tank Filler Pipe Shield Bolt (1)Â» Remove [2x]

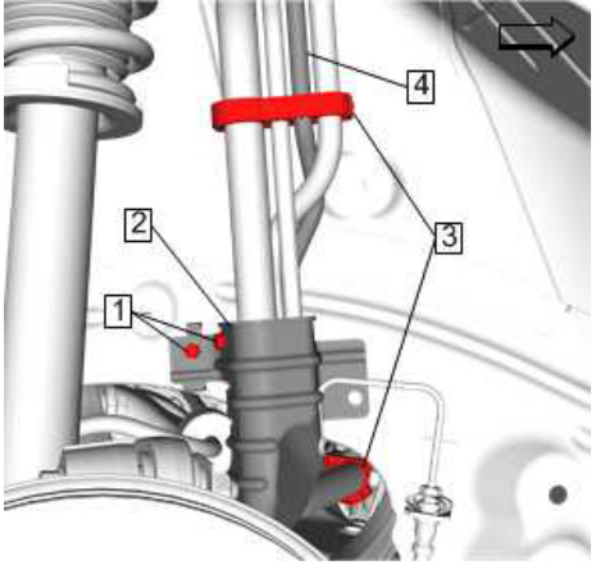

Fig. 223: Fuel Tank Filler Pipe Shield And Evaporative Emission Canister Purge Hose
Courtesy of GENERAL MOTORS COMPANY

5. Fuel Tank Filler Pipe Shield (2)Â» Remove
6. Evaporative Emission Canister Purge Hose (4) @ Retainer (3)Â» Remove [2x]
7. Tie Strap (1)Â» Remove and DISCARD

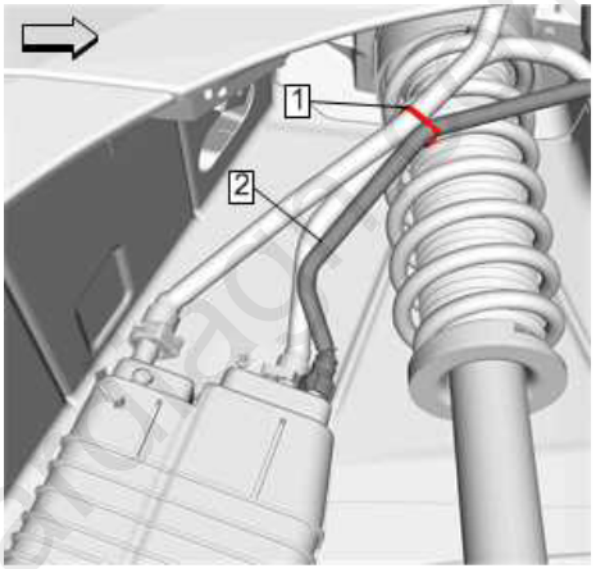

Fig. 224: Evaporative Emission Canister Purge Hose And Tie Strap
Courtesy of GENERAL MOTORS COMPANY

8. Evaporative Emission Canister Purge Hose (2)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**

Installation Procedure

1. Evaporative Emission Canister Purge Hose (2)Â» Connect - **Plastic Collar Quick Connect Fitting Service**

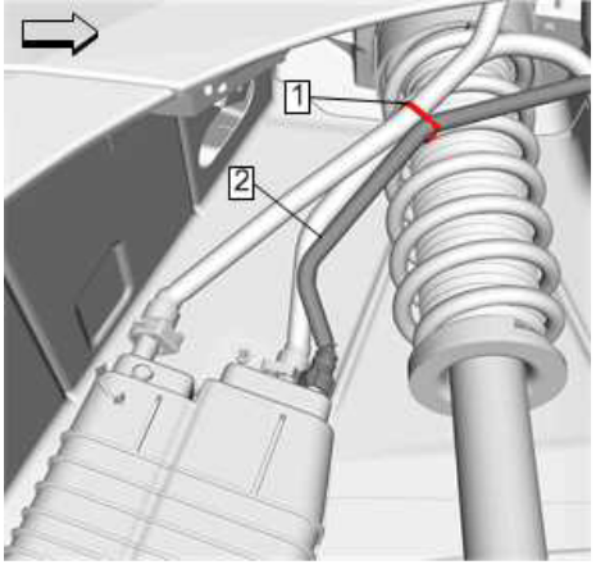

Fig. 225: Evaporative Emission Canister Purge Hose And Tie Strap
Courtesy of GENERAL MOTORS COMPANY

2. Tie Strap (1)Â» Install NEW
3. Evaporative Emission Canister Purge Hose (4) @ Retainer (3)Â» Install [2x]

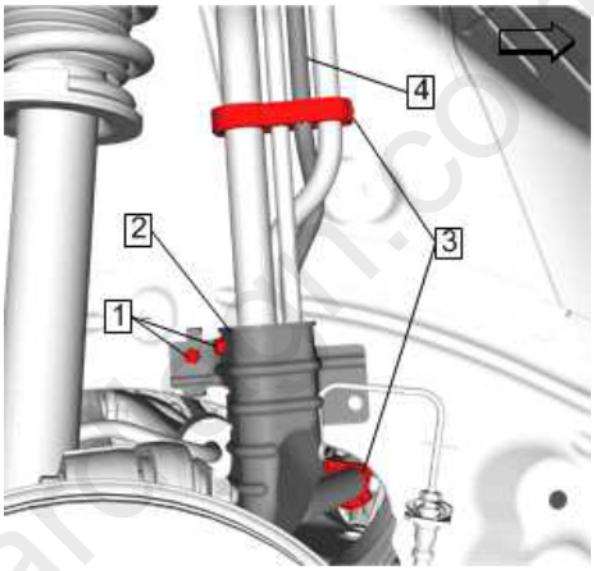

Fig. 226: Fuel Tank Filler Pipe Shield And Evaporative Emission Canister Purge Hose
Courtesy of GENERAL MOTORS COMPANY

4. Fuel Tank Filler Pipe Shield (2)Â» Install
5. Fuel Tank Filler Pipe Shield Bolt (1)Â» Install [2x] 9 N.m (80 lb in)

CAUTION: **Refer to Fastener Caution .**

6. **Rear Wheelhouse Liner Replacement (LGX, LGW)** Â» Install
7. Evaporative Emission Canister Purge Hose (1)Â» Connect - **Plastic Collar Quick Connect Fitting Service**

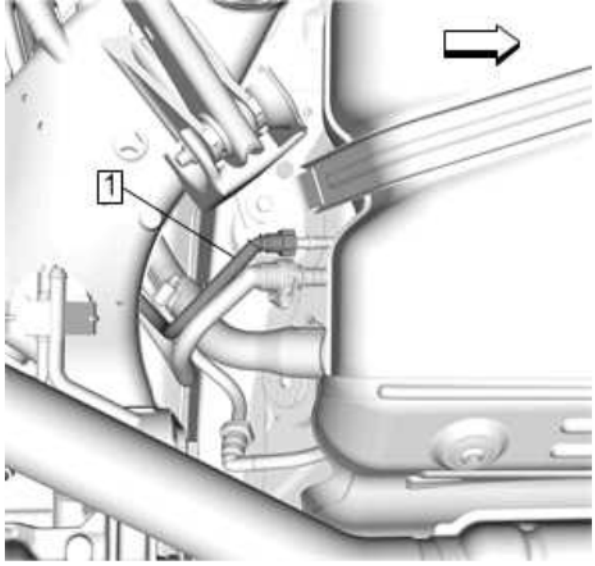

Fig. 227: Evaporative Emission Canister Purge Hose
Courtesy of GENERAL MOTORS COMPANY

8. Lower the vehicle.

EVAPORATIVE EMISSION CANISTER HOSE REPLACEMENT (AT CANISTER)

Removal Procedure

1. Raise and support the vehicle. Refer to Lifting and Jacking the Vehicle

   WARNING: Refer to Gasoline/Gasoline Vapors Warning .

   WARNING: Refer to Safety Glasses Warning .

2. Evaporative Emission Canister Hose (1)Â» Disconnect - Plastic Collar Quick Connect Fitting Service

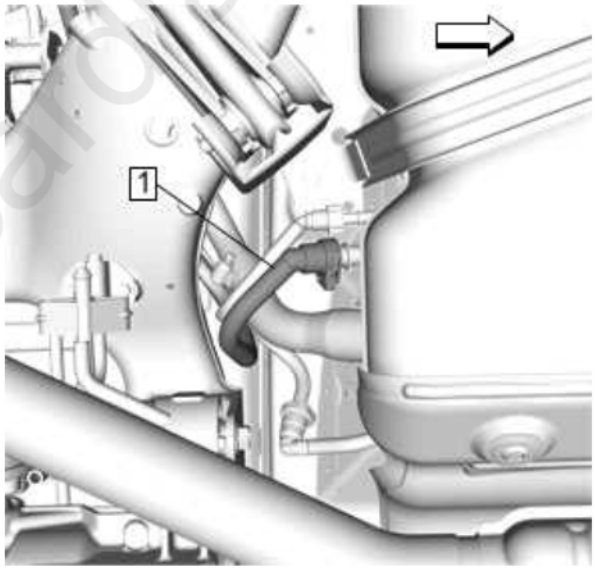

Fig. 228: Evaporative Emission Canister Hose
Courtesy of GENERAL MOTORS COMPANY

3. Rear Wheelhouse Liner Replacement (LGX, LGW) Â» Remove
4. Fuel Tank Filler Pipe Shield Bolt (1)Â» Remove [2x]

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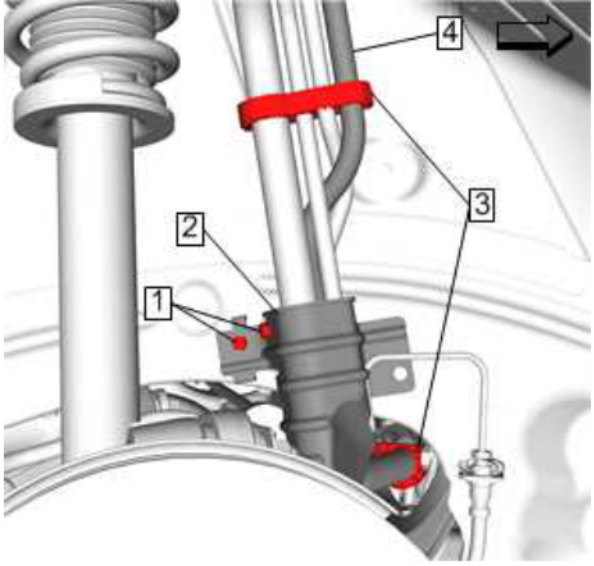

Fig. 229: Fuel Tank Filler Pipe Shield And Evaporative Emission Canister Hose
Courtesy of GENERAL MOTORS COMPANY

5. Fuel Tank Filler Pipe Shield (2)Â» Remove
6. Evaporative Emission Canister Hose (4) @ Retainer (3)Â» Remove [2x]
7. Tie Strap (1)Â» Remove and DISCARD

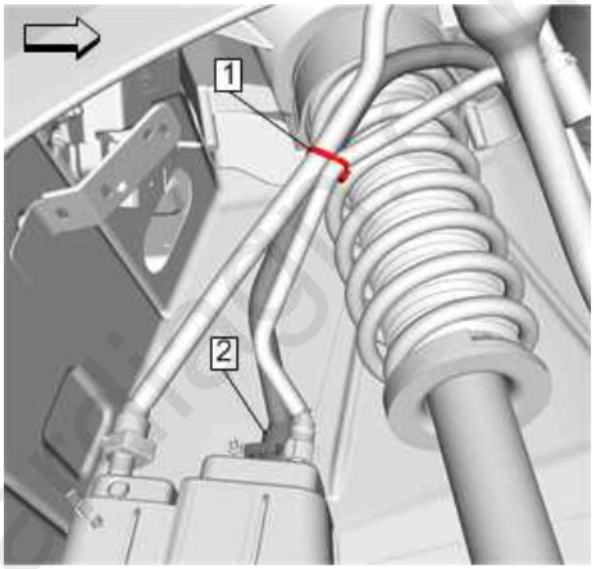

Fig. 230: Evaporative Emission Canister Hose And Tie Strap
Courtesy of GENERAL MOTORS COMPANY

8. Evaporative Emission Canister Hose (2)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**

Installation Procedure

1. Evaporative Emission Canister Hose (2)Â» Connect - **Plastic Collar Quick Connect Fitting Service**

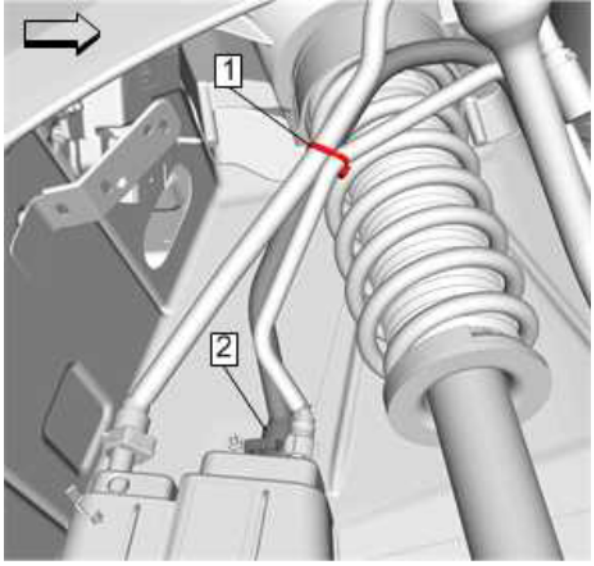

Fig. 231: Evaporative Emission Canister Hose And Tie Strap
Courtesy of GENERAL MOTORS COMPANY

2. Tie Strap (1)Â» Install NEW
3. Evaporative Emission Canister Hose (4) @ Retainer (3)Â» Install [2x]

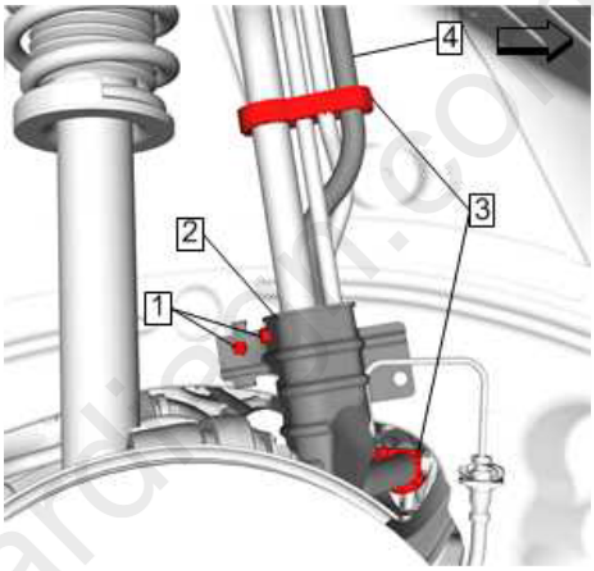

Fig. 232: Fuel Tank Filler Pipe Shield And Evaporative Emission Canister Hose
Courtesy of GENERAL MOTORS COMPANY

4. Fuel Tank Filler Pipe Shield (2)Â» Install
5. Fuel Tank Filler Pipe Shield Bolt (1)Â» Install [2x] 9 N.m (80 lb in)

CAUTION: **Refer to Fastener Caution .**

6. **Rear Wheelhouse Liner Replacement (LGX, LGW)** Â» Install
7. Evaporative Emission Canister Hose (1)Â» Connect - **Plastic Collar Quick Connect Fitting Service**

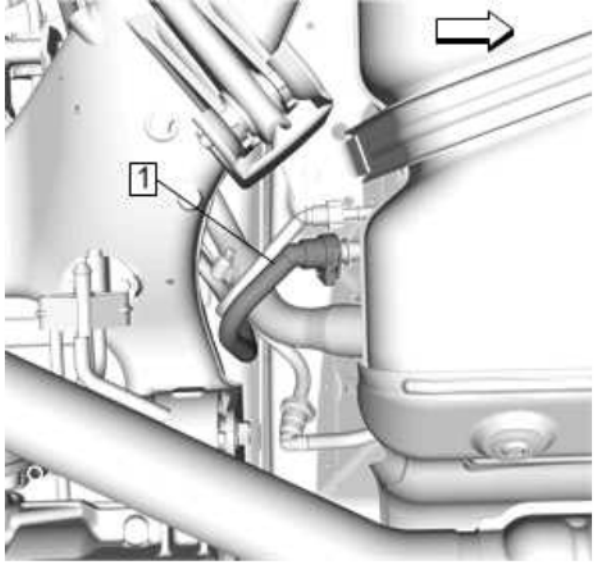

Fig. 233: Evaporative Emission Canister Hose
Courtesy of GENERAL MOTORS COMPANY

8. Lower the vehicle.

EVAPORATIVE EMISSION CANISTER HOSE REPLACEMENT (AT TANK)

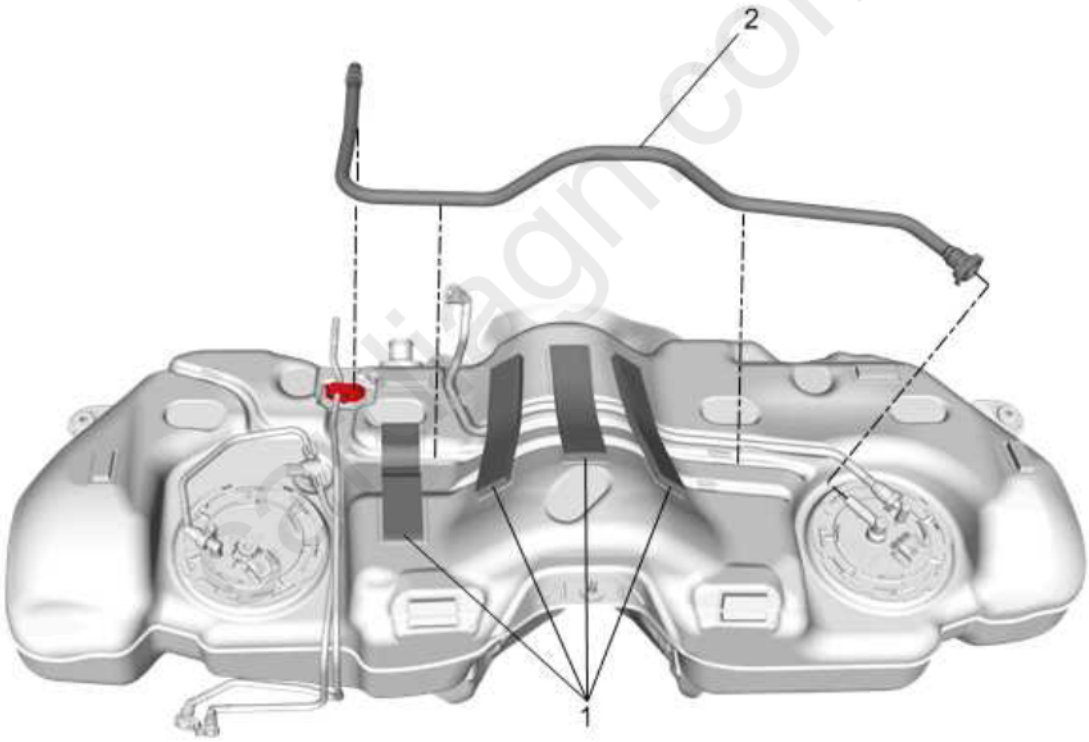

Fig. 234: Evaporative Emission Canister Hose (At Tank)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
WARNING: Refer to Gasoline/Gasoline Vapors Warning . **WARNING:** Refer to Safety Glasses Warning . **Preliminary Procedure** Fuel Tank Replacement	
1	Fuel Tank Insulator [4x]

Callout	Component Name
2	Evaporative Emission Canister Hose **Procedure** Disconnect the quick connect fittings and remove from retainer. Refer to **Plastic Collar Quick Connect Fitting Service**

EVAPORATIVE EMISSION CANISTER REPLACEMENT

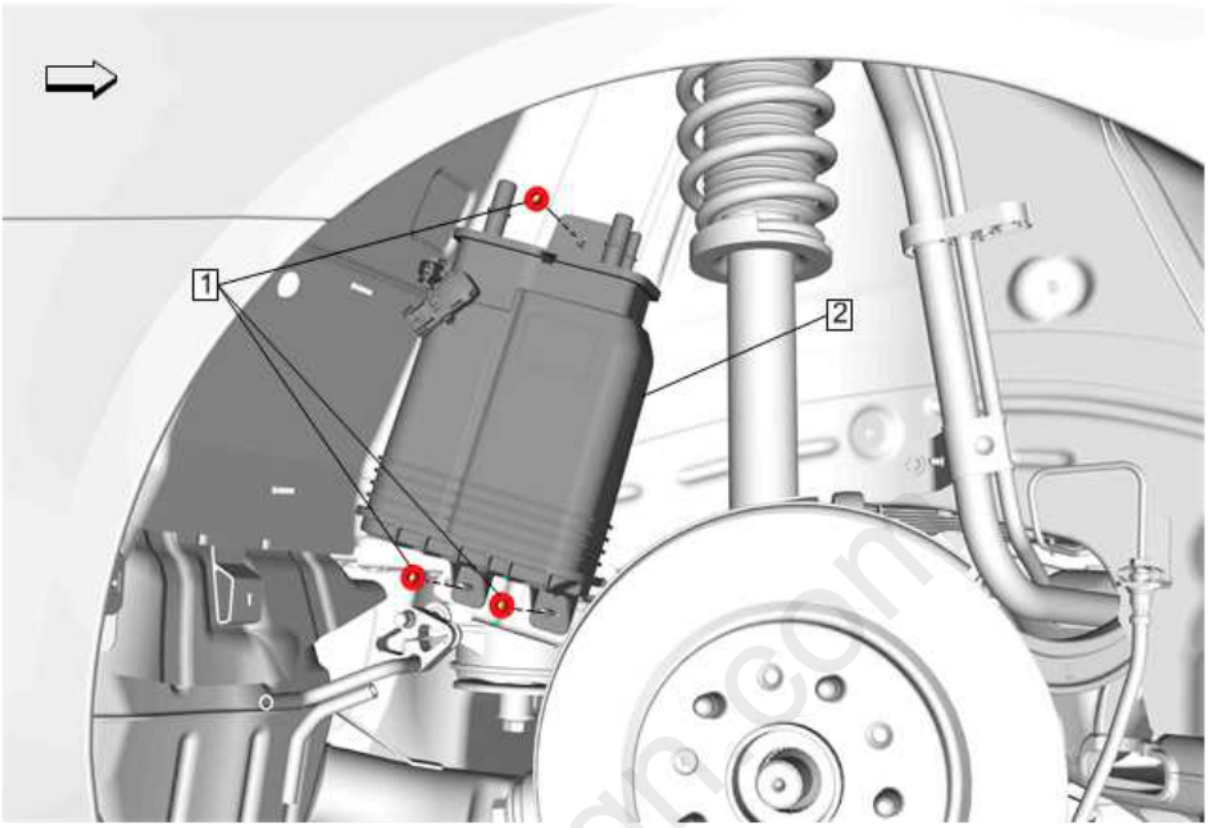

Fig. 235: Evaporative Emission Canister
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
	WARNING: **Refer to Gasoline/Gasoline Vapors Warning .** **WARNING:** **Refer to Safety Glasses Warning .** **Preliminary Procedures** 1. **Evaporative Emission Canister Air Inlet Hose Replacement**Â» Disconnect 2. **Evaporative Emission Canister Hose Replacement (At Canister)Evaporative Emission Canister Hose Replacement (At Tank)**Â» Disconnect 3. **Evaporative Emission Canister Purge Hose Replacement**Â» Disconnect
1	Evaporative Emission Canister Fastener [3x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 9 N.m (80 lb in)
2	Evaporative Emission Canister **Procedure** Disconnect the electrical connector.

EVAPORATIVE EMISSION SYSTEM CLEANING

Special Tools

GE 41413-200 Evaporative Pressure and Purge Station

Equivalent regional tools: **Special Tools (Diagnostic Tools)** **Special Tools (Mechanical Tools)**

Inspection Procedure

CAUTION: **Use the Evaporative Emission (EVAP) System Tester GE 41413-A in order to provide a clean, dry, low pressure nitrogen gas source. Do not substitute any other pressurized source, gas or otherwise. Damage may result to the EVAP system, test equipment or cause a safety risk.**

1. Turn OFF the ignition.

NOTE: **Proceed with the following procedure only if referenced by an evaporative emission (EVAP) diagnostic or repair procedure.**

2. Remove the EVAP canister purge valve. Refer to **Evaporative Emission Canister Purge Solenoid Valve Replacement (LGW)** and/or **Evaporative Emission Canister Purge Solenoid Valve Replacement (LGX)**
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**
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**
11. Lower the vehicle.
12. Install a new EVAP canister purge valve. Refer to **Evaporative Emission Canister Purge Solenoid Valve Replacement (LGW)** and/or **Evaporative Emission Canister Purge Solenoid Valve Replacement (LGX)**
13. Return to the diagnostic table that sent you here.

IGNITION COIL REPLACEMENT - BANK 1

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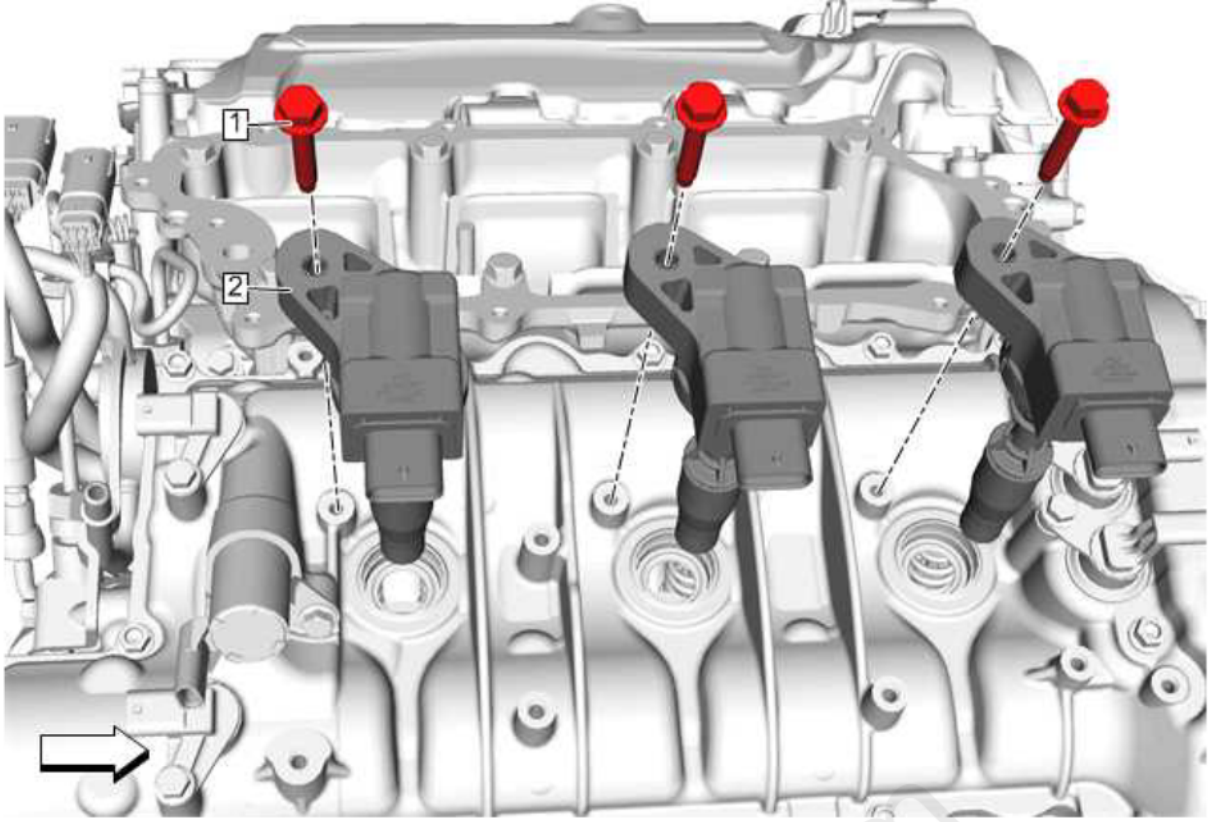

Fig. 236: Ignition Coil - Bank 1
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Camshaft Housing Cover Insulator Replacement - Right Side (LGX) Camshaft Housing Cover Insulator Replacement - Right Side (LGW)	
1	Ignition Coil Bolt [3x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
2	Ignition Coil [3x]

IGNITION COIL REPLACEMENT - BANK 2

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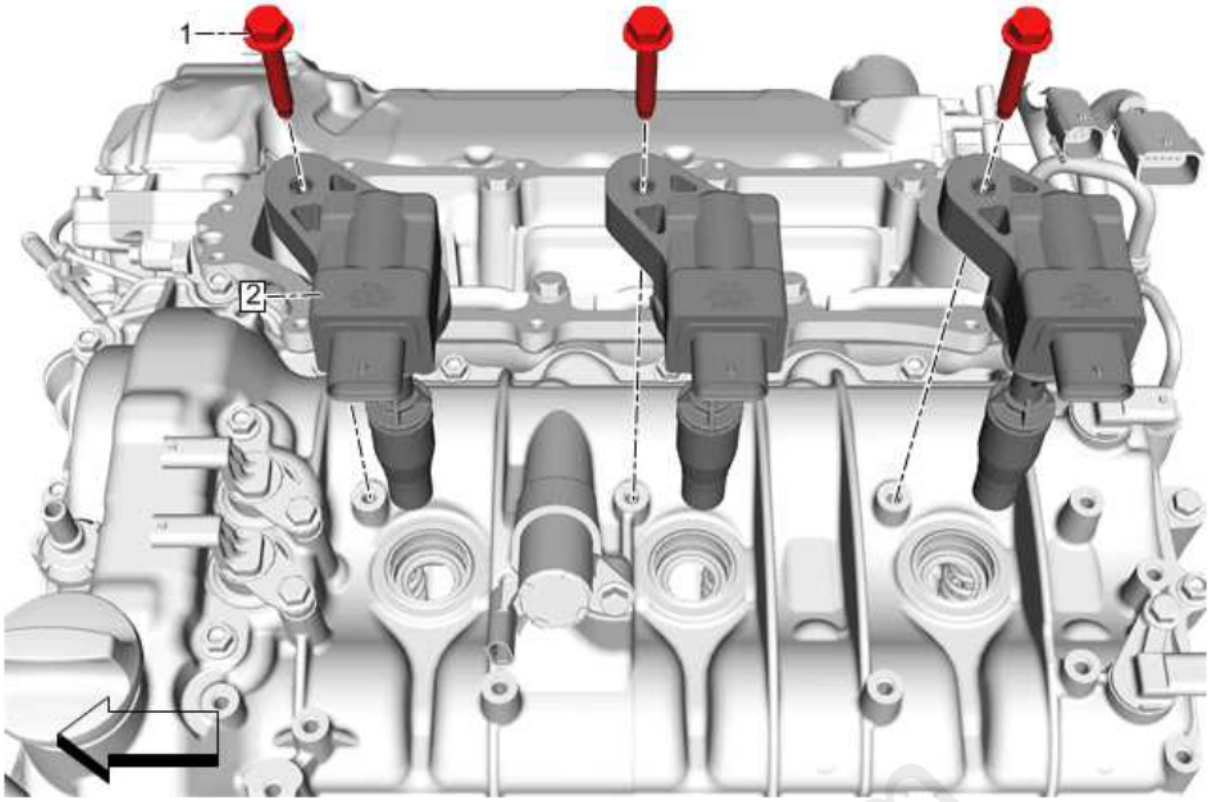

Fig. 237: Ignition Coil - Bank 2
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Camshaft Housing Cover Insulator Replacement - Left Side (LGX) Camshaft Housing Cover Insulator Replacement - Left Side (LGW)	
1	Ignition Coil Bolt [3x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
2	Ignition Coil [3x]

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

- Inspect the terminal post (1) for damage.

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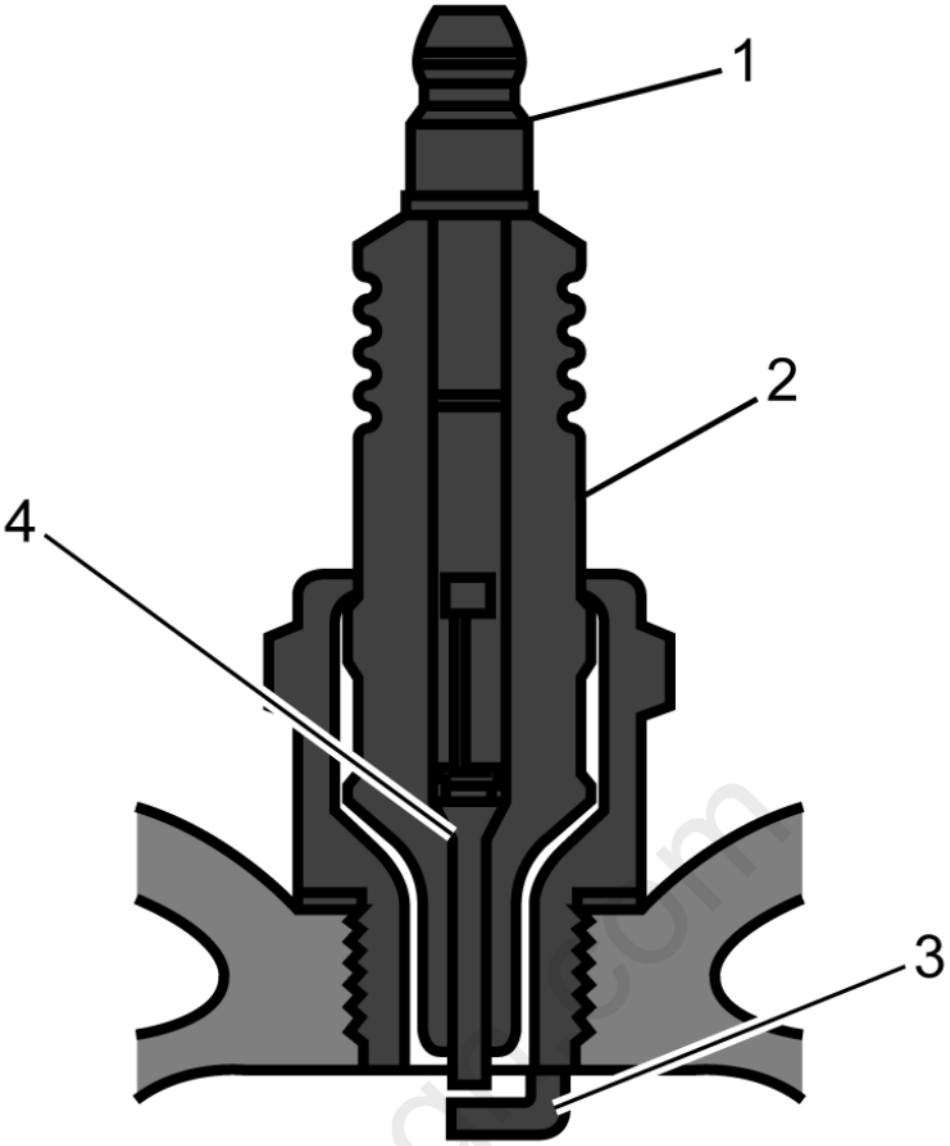

Fig. 238: Cross Sectional View Of Spark Plug
Courtesy of GENERAL MOTORS COMPANY

- 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.
- If carbon tracking occurs on spark plug tower (1), replace spark plug and spark plug wire or coil boot.

Fig. 239: Inspect For Carbon On Spark Plug Tower
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Carbon on spark plug tower means carbon will also be on inside of**

spark plug wire boot or coil boot and will cause both new spark plug and spark plug wire or coil boot to fail again.

SPARK PLUG REPLACEMENT (BANK 1)

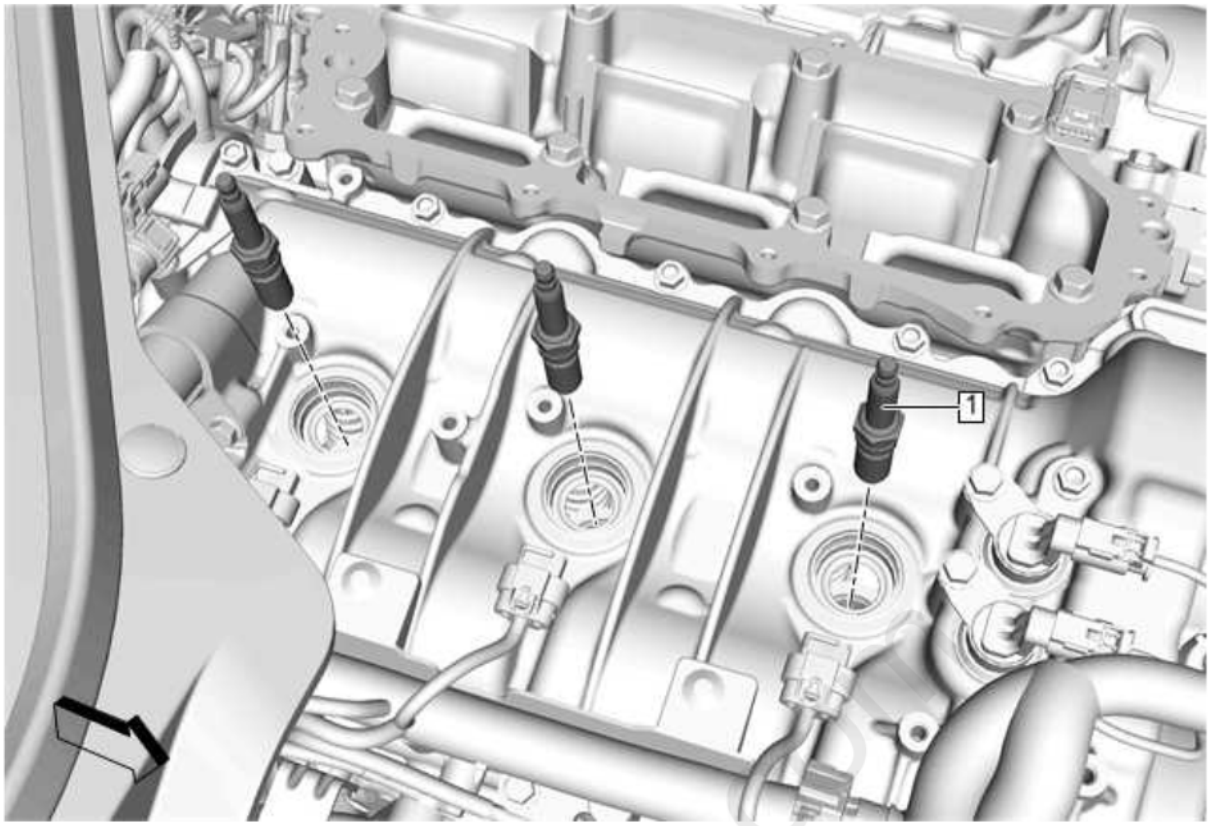

Fig. 240: Spark Plug (Bank 1)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Ignition Coil Replacement - Bank 1	
1	Spark Plug [3x] **CAUTION:** **Refer to Component Fastener Tightening Caution .** **Procedure** 1. If reusing the spark plugs, inspect for wear or damage. Refer to **Spark Plug Inspection** 2. If using NEW spark plugs do NOT attempt to check gap or damage can occur, plugs come pre gapped. **Tighten** 18 N.m (13 lb ft)

SPARK PLUG REPLACEMENT (BANK 2)

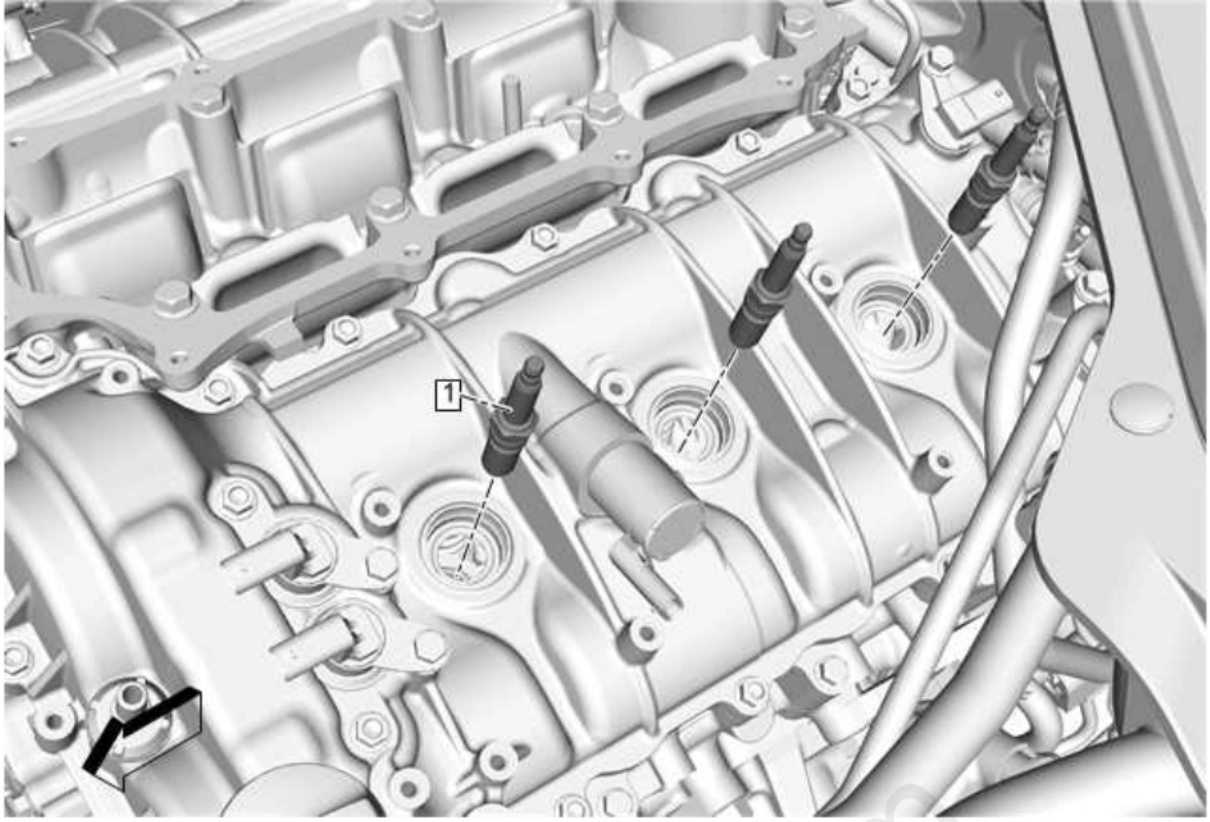

Fig. 241: Spark Plug (Bank 2)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Ignition Coil Replacement - Bank 2	
1	Spark Plug [3x] **CAUTION:** **Refer to Component Fastener Tightening Caution .** **Procedure** 1. If reusing the spark plugs, inspect for wear or damage. **Spark Plug Inspection** 2. If using NEW spark plugs do NOT attempt to check gap or damage can occur, plugs come pre gapped. **Tighten** 18 N.m (13 lb ft)

CRANKSHAFT POSITION SENSOR REPLACEMENT

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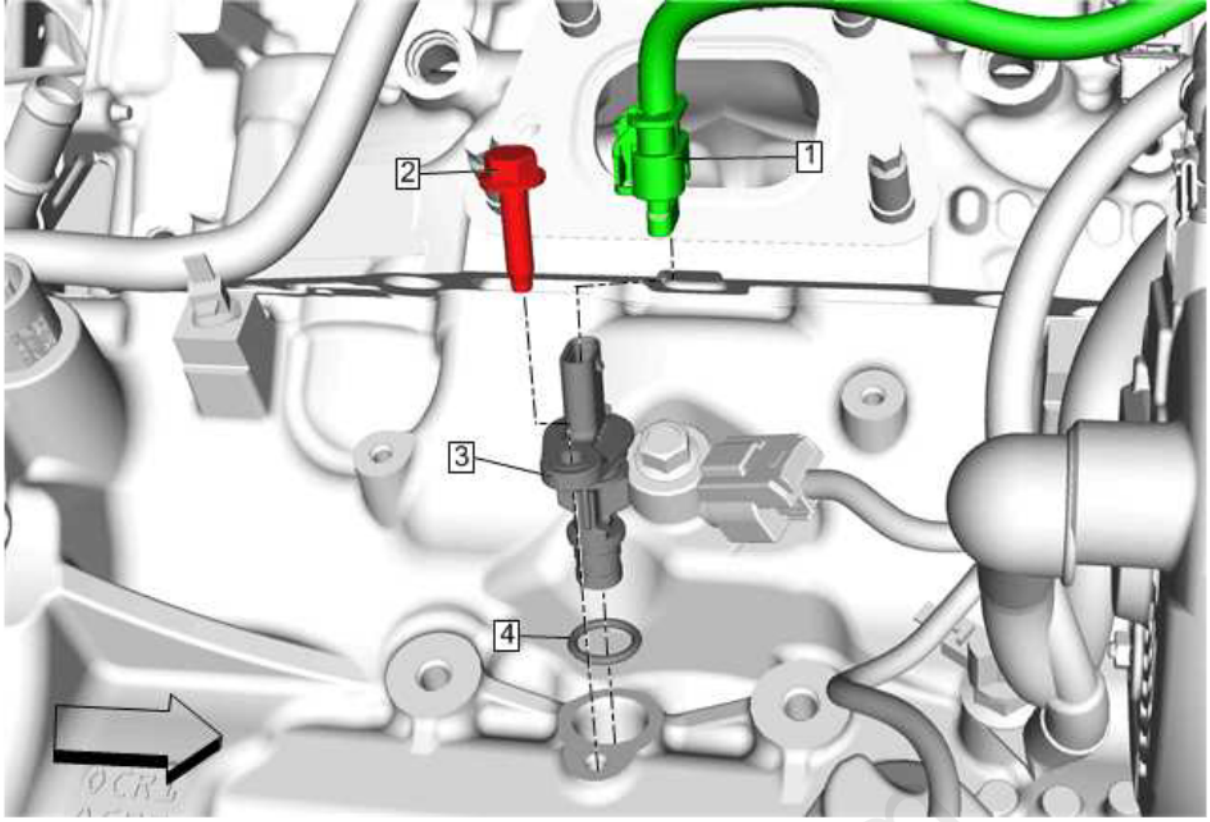

Fig. 242: Crankshaft Position Sensor
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Engine Mount Bracket Replacement - Right Side (LGW) Engine Mount Bracket Replacement - Right Side (LGX)	
1	Electrical Connector **Procedure** Disconnect the electrical connector.
2	Crankshaft Position Sensor Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
3	Crankshaft Position Sensor **Procedure** After the sensor is installed, perform the crankshaft position system variation learn procedure. Refer to Crankshaft Position Variation Learn
4	O-Ring **Procedure** Install a NEW O-ring seal. **NOTE:** **Lubricate the NEW O-ring seals with clean engine oil.**

CAMSHAFT POSITION SENSOR REPLACEMENT - BANK 2 (LEFT SIDE) EXHAUST (LGW)

Removal Procedure

1. Charge Air Cooler Upper InsulatorÂ» Remove - Charge Air Cooler Upper Insulator Replacement

2. Engine Wiring Harness Retainer (1)Â» Unclip

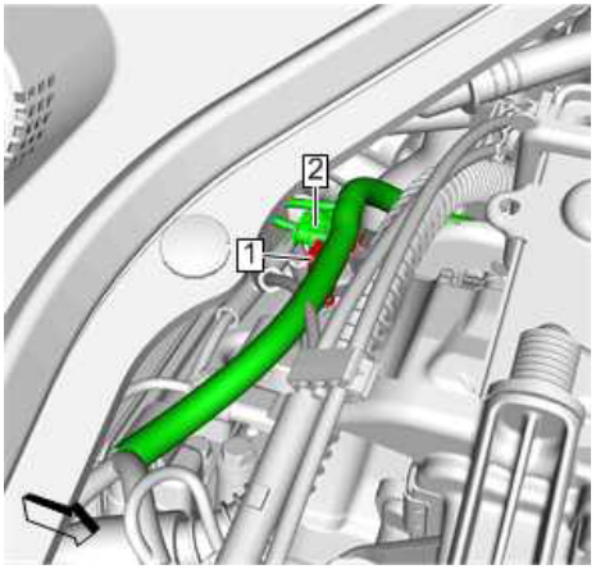

Fig. 243: Camshaft Position Sensor Electrical Connector And Wiring Harness Retainer
Courtesy of GENERAL MOTORS COMPANY

3. Camshaft Position Sensor Electrical Connector (2)Â» Disconnect
4. Reposition the wiring harness.
5. Use compressed air to remove debris from the Camshaft Position Sensor and surrounding cavities.

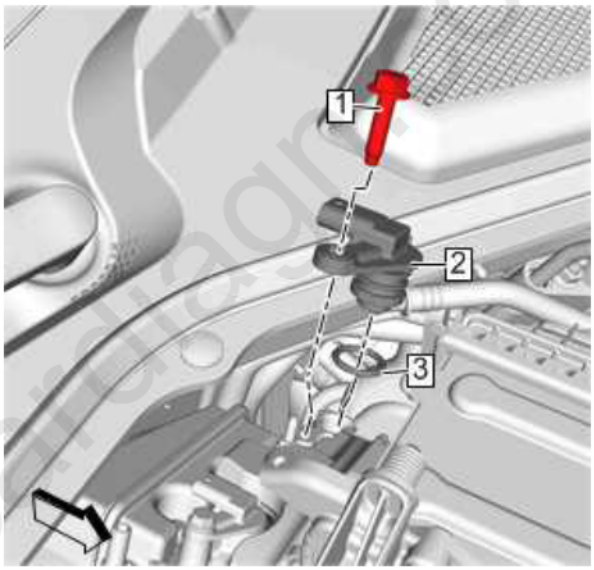

Fig. 244: Camshaft Position Sensor And Retaining Bolt
Courtesy of GENERAL MOTORS COMPANY

WARNING: **Refer to Safety Glasses Warning .**

6. Camshaft Position Sensor Bolt (1)Â» Remove
7. Camshaft Position Sensor (2)Â» Remove

Installation Procedure

1. Camshaft Position Sensor (2)Â» Install

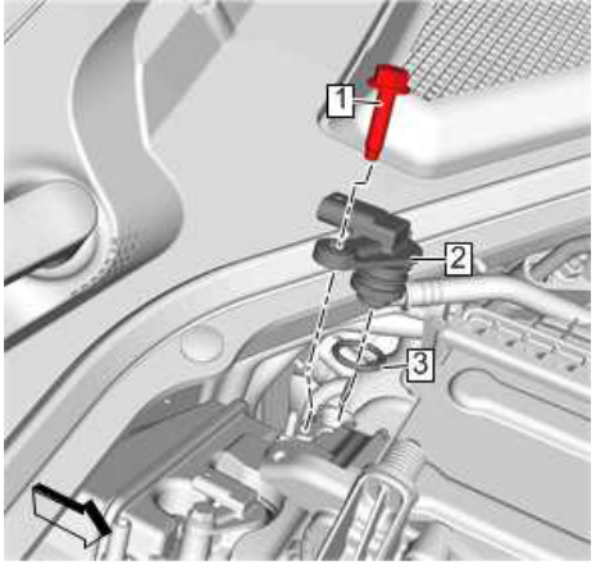

Fig. 245: Camshaft Position Sensor And Retaining Bolt
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Always install the camshaft position sensor O-ring (3) supplied with the NEW camshaft position sensor. If reinstalling the sensor, inspect the camshaft position sensor O-ring (3) and replace as necessary. Lubricate the camshaft position sensor O-ring (3) with clean engine oil prior to installing the camshaft position sensor.**

2. Camshaft Position Sensor Bolt (1)Â» Install and tighten 10 N.m (89 lb in).

CAUTION: **Refer to Fastener Caution .**

3. Camshaft Position Sensor Electrical Connector (2)Â» Connect

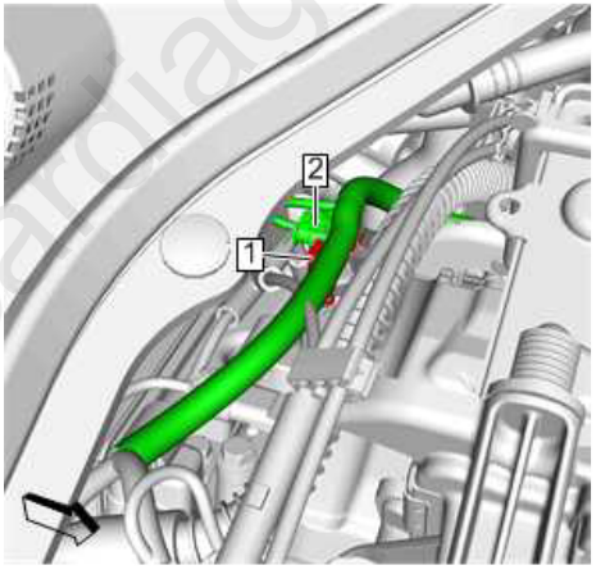

Fig. 246: Camshaft Position Sensor Electrical Connector And Wiring Harness Retainer
Courtesy of GENERAL MOTORS COMPANY

4. Engine Wiring Harness Retainer (1)Â» Install
5. Charge Air Cooler Upper InsulatorÂ» Install - **Charge Air Cooler Upper Insulator Replacement**

CAMSHAFT POSITION SENSOR REPLACEMENT - BANK 2 (LEFT SIDE) EXHAUST (LGX)

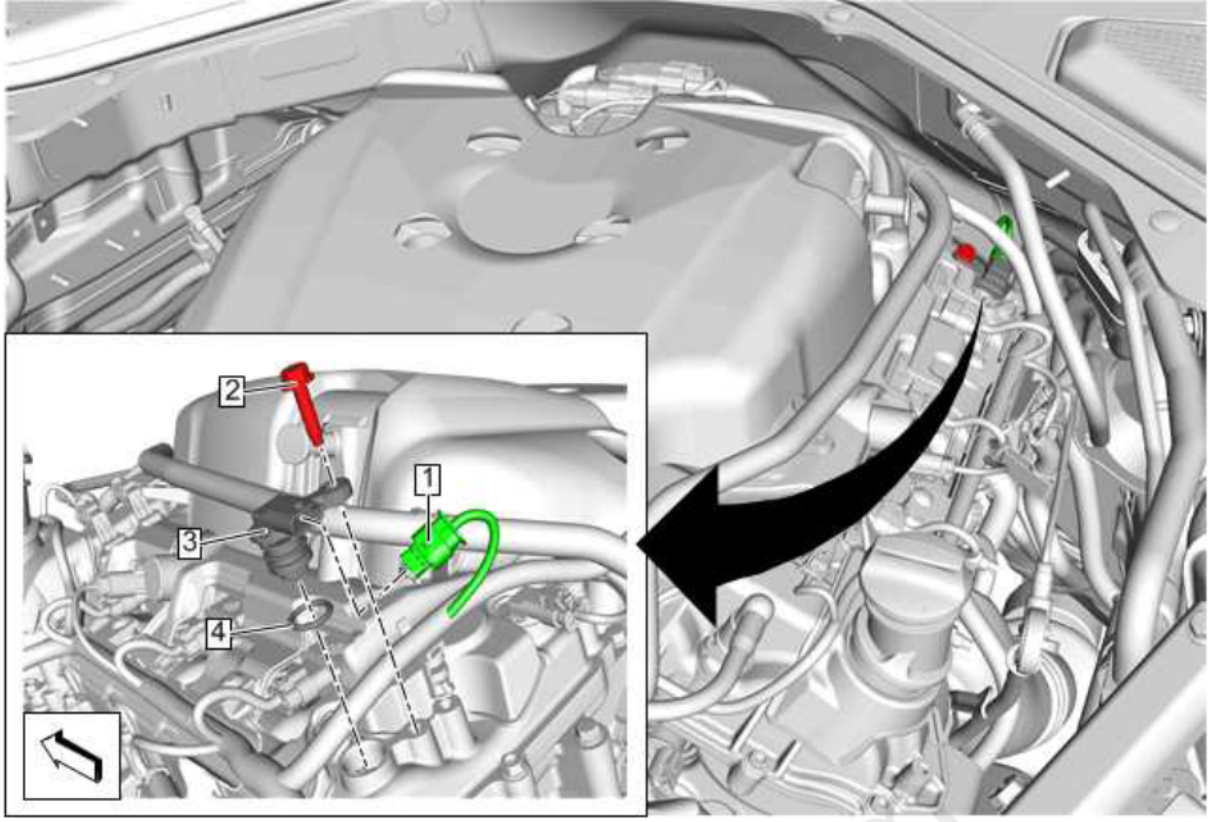

Fig. 247: Camshaft Position Sensor - Bank 2 (Left Side) Exhaust (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Intake Manifold Cover Replacement (LGX)	
1	Electrical Connector
2	Camshaft Position Sensor Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
3	Camshaft Position Sensor **WARNING:** **Refer to Safety Glasses Warning .** **Procedure** Use compressed air to remove debris from the Camshaft Position Sensor and surrounding cavities prior to removing.
4	Camshaft Position Sensor Seal Ring **NOTE:** **Always install the camshaft position sensor O-ring supplied with the NEW camshaft position sensor. If reinstalling the sensor, inspect the camshaft position sensor O-ring and replace as necessary. Lubricate the camshaft position sensor O-ring with clean engine oil prior to installing the camshaft position sensor.**

CAMSHAFT POSITION SENSOR REPLACEMENT - BANK 2 (LEFT SIDE) INTAKE (LGW)

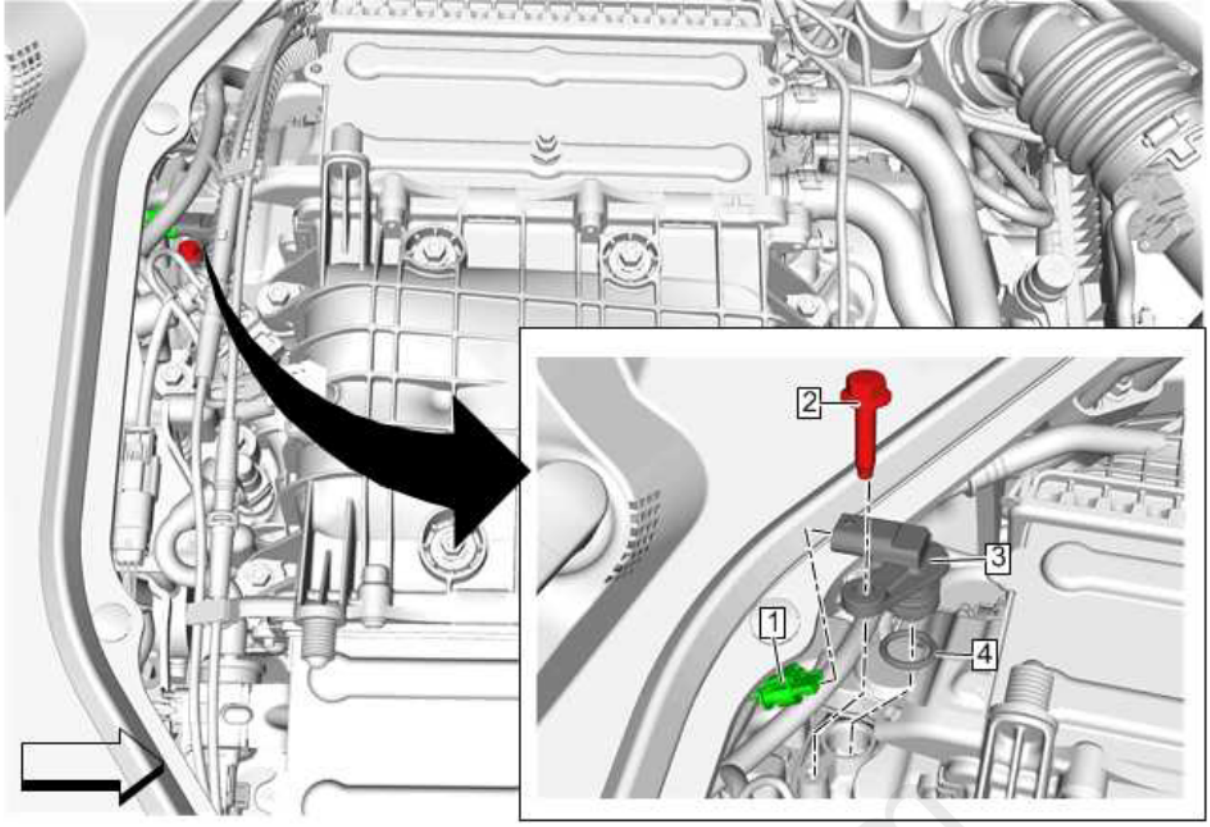

Fig. 248: Camshaft Position Sensor - Bank 2 (Left Side) Intake (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Charge Air Cooler Cover Replacement	
1	Electrical Connector
2	Camshaft Position Sensor Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
3	Camshaft Position Sensor **WARNING:** **Refer to Safety Glasses Warning .** **Procedure** Use compressed air to remove debris from the Camshaft Position Sensor and surrounding cavities prior to removing.
4	Camshaft Position Sensor Seal Ring **NOTE:** **Always install the camshaft position sensor O-ring supplied with the NEW camshaft position sensor. If reinstalling the sensor, inspect the camshaft position sensor O-ring and replace as necessary. Lubricate the camshaft position sensor O-ring with clean engine oil prior to installing the camshaft position sensor.**

CAMSHAFT POSITION SENSOR REPLACEMENT - BANK 2 (LEFT SIDE) INTAKE (LGX)

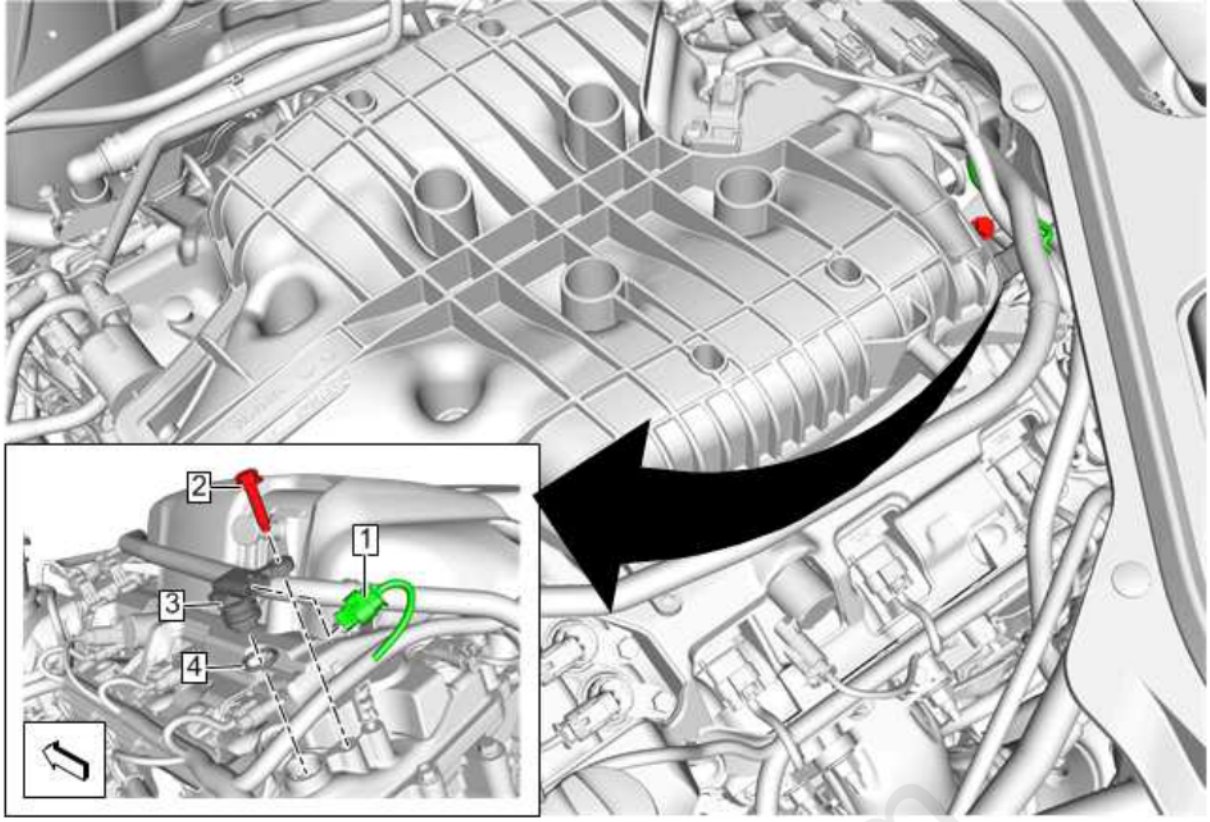

Fig. 249: Camshaft Position Sensor - Bank 2 (Left Side) Intake (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Intake Manifold Insulator Replacement (LGX)	
1	Electrical Connector
2	Camshaft Position Sensor Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
3	Camshaft Position Sensor **Procedure** **WARNING:** **Refer to Safety Glasses Warning .** Use compressed air to remove debris from the Camshaft Position Sensor and surrounding cavities prior to removing.
4	Camshaft Position Sensor Seal Ring **NOTE:** **Always install the camshaft position sensor O-ring supplied with the NEW camshaft position sensor. If reinstalling the sensor, inspect the camshaft position sensor O-ring and replace as necessary. Lubricate the camshaft position sensor O-ring with clean engine oil prior to installing the camshaft position sensor.**

CAMSHAFT POSITION SENSOR REPLACEMENT - BANK 1 (RIGHT SIDE) EXHAUST (LGW)

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Removal Procedure

1. Camshaft Housing Cover Insulator Replacement - Right Side (LGW) Â» Remove
2. Use compressed air to remove debris from the Camshaft Position Sensor and surrounding cavities.

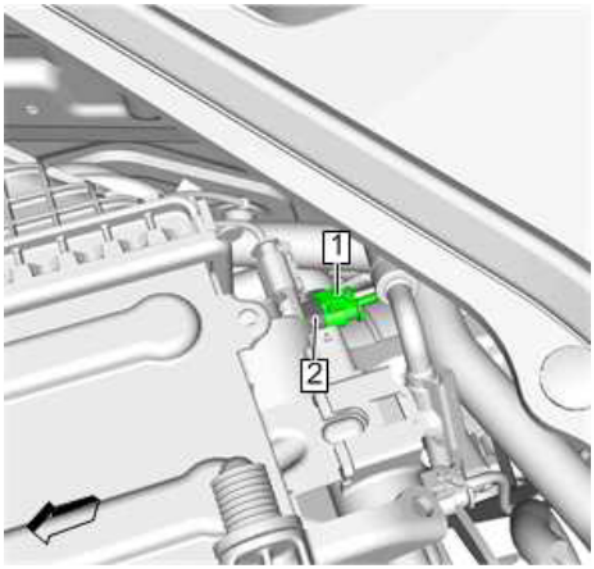

Fig. 250: Camshaft Position Sensor And Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

WARNING: **Refer to Safety Glasses Warning .**

3. Camshaft Position Sensor Electrical Connector (1) @ Camshaft Position Sensor (2)Â» Disconnect
4. Camshaft Position Sensor Bolt (1)Â» Remove

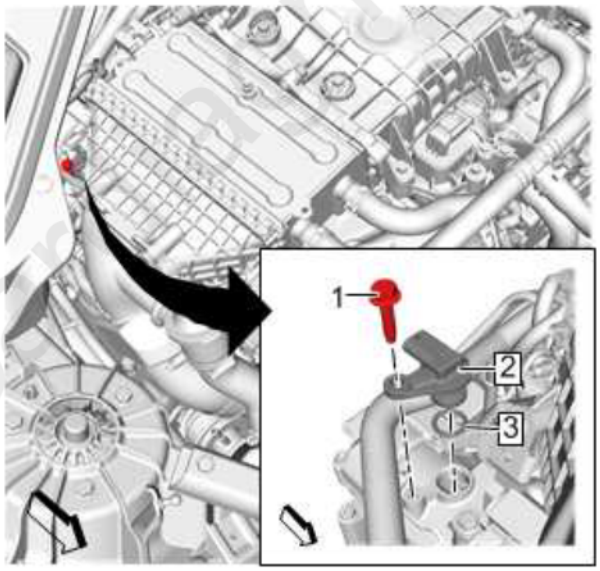

Fig. 251: Camshaft Position Sensor And Retaining Bolt
Courtesy of GENERAL MOTORS COMPANY

5. Camshaft Position Sensor (2)Â» Remove

Installation Procedure

1. Camshaft Position Sensor (2)Â» Install

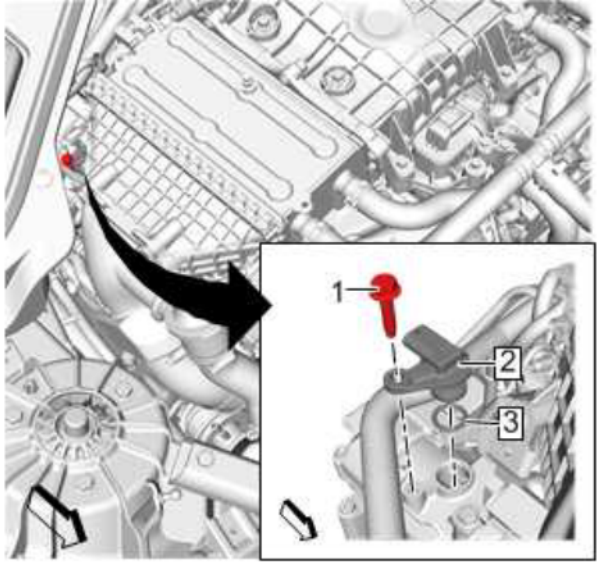

Fig. 252: Camshaft Position Sensor And Retaining Bolt
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Always install the camshaft position sensor O-ring (3) supplied with the NEW camshaft position sensor. If reinstalling the sensor, inspect the camshaft position sensor O-ring (3) and replace as necessary. Lubricate the camshaft position sensor O-ring (3) with clean engine oil prior to installing the camshaft position sensor.**

2. Camshaft Position Sensor Bolt (1)Â» Install and tighten 10 N.m (89 lb in).

CAUTION: **Refer to Fastener Caution .**

3. Camshaft Position Sensor Electrical Connector (1) @ Camshaft Position Sensor (2)Â» Connect

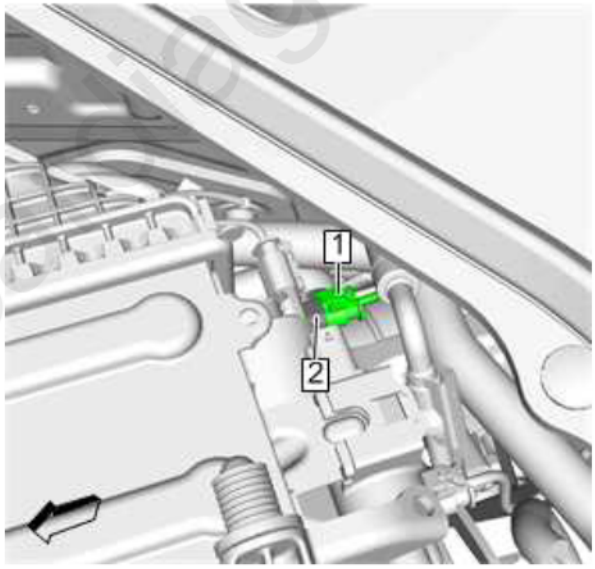

Fig. 253: Camshaft Position Sensor And Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

4. Camshaft Housing Cover Insulator Replacement - Right Side (LGW) Â» Install

CAMSHAFT POSITION SENSOR REPLACEMENT - BANK 1 (RIGHT SIDE) EXHAUST (LGX)

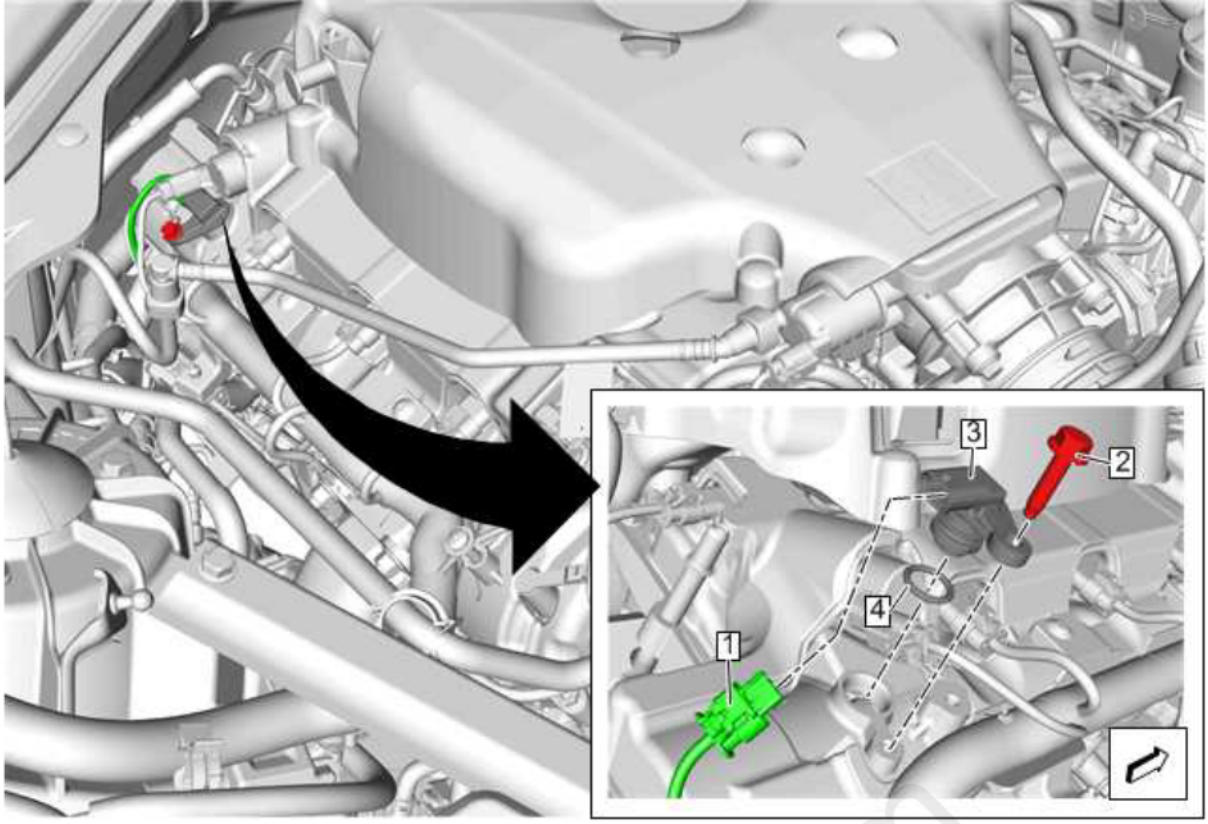

Fig. 254: Camshaft Position Sensor - Bank 1 (Right Side) Exhaust (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Intake Manifold Cover Replacement (LGX)	
1	Electrical Connector
2	Camshaft Position Sensor Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
3	Camshaft Position Sensor **WARNING:** **Refer to Safety Glasses Warning .** **Procedure** Use compressed air to remove debris from the Camshaft Position Sensor and surrounding cavities prior to removing.
4	Camshaft Position Sensor Seal Ring **NOTE:** **Always install the camshaft position sensor O-ring supplied with the NEW camshaft position sensor. If reinstalling the sensor, inspect the camshaft position sensor O-ring and replace as necessary. Lubricate the camshaft position sensor O-ring with clean engine oil prior to installing the camshaft position sensor.**

CAMSHAFT POSITION SENSOR REPLACEMENT - BANK 1 (RIGHT SIDE) INTAKE

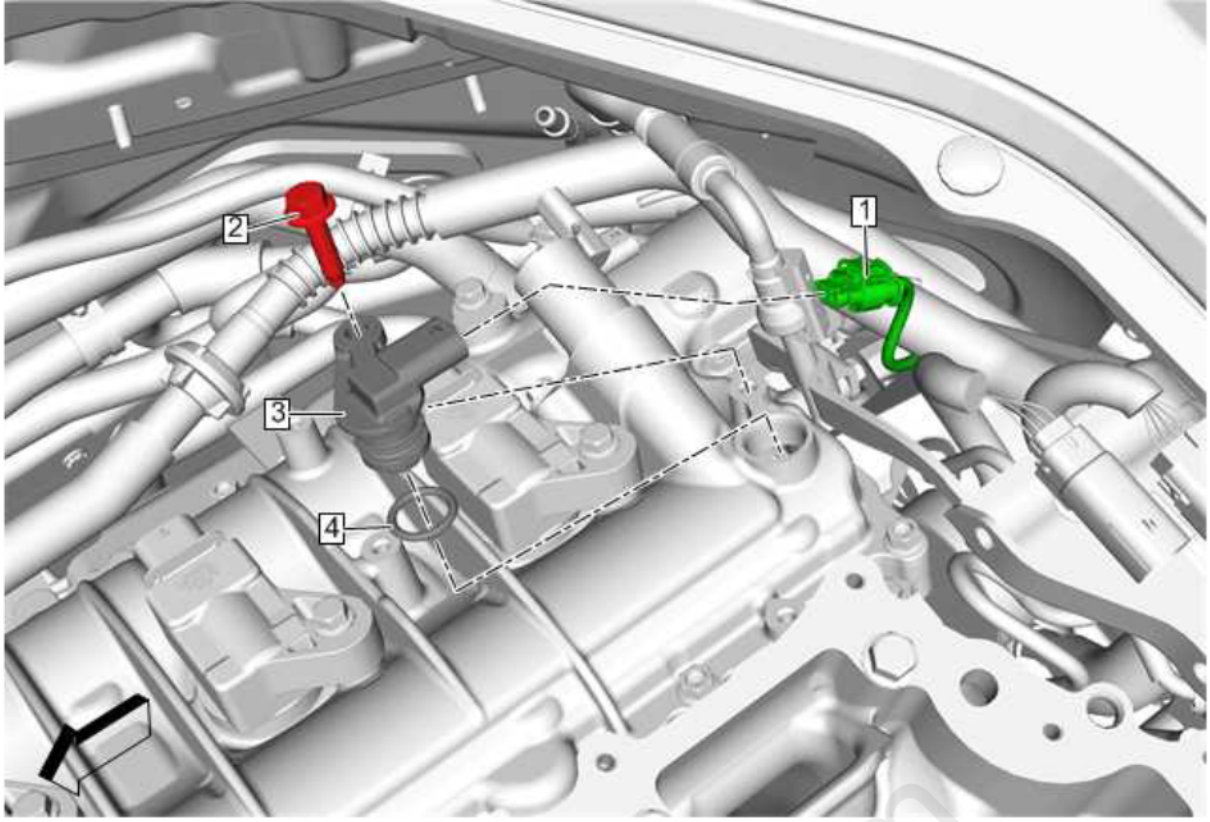

Fig. 255: Camshaft Position Sensor - Bank 1 (Right Side) Intake
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Camshaft Housing Cover Insulator Replacement - Right Side (LGX) Camshaft Housing Cover Insulator Replacement - Right Side (LGW)	
1	Electrical Connector
2	Camshaft Position Sensor Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
3	Camshaft Position Sensor **WARNING:** **Refer to Safety Glasses Warning .** **Procedure** Use compressed air to remove debris from the Camshaft Position Sensor and surrounding cavities prior to removing.
4	Camshaft Position Sensor Seal Ring **NOTE:** **Always install the camshaft position sensor O-ring supplied with the NEW camshaft position sensor. If reinstalling the sensor, inspect the camshaft position sensor O-ring and replace as necessary. Lubricate the camshaft position sensor O-ring with clean engine oil prior to installing the camshaft position sensor.**

CAMSHAFT POSITION ACTUATOR SOLENOID VALVE SOLENOID REPLACEMENT - BANK 1 (RIGHT SIDE) INTAKE (LGW)

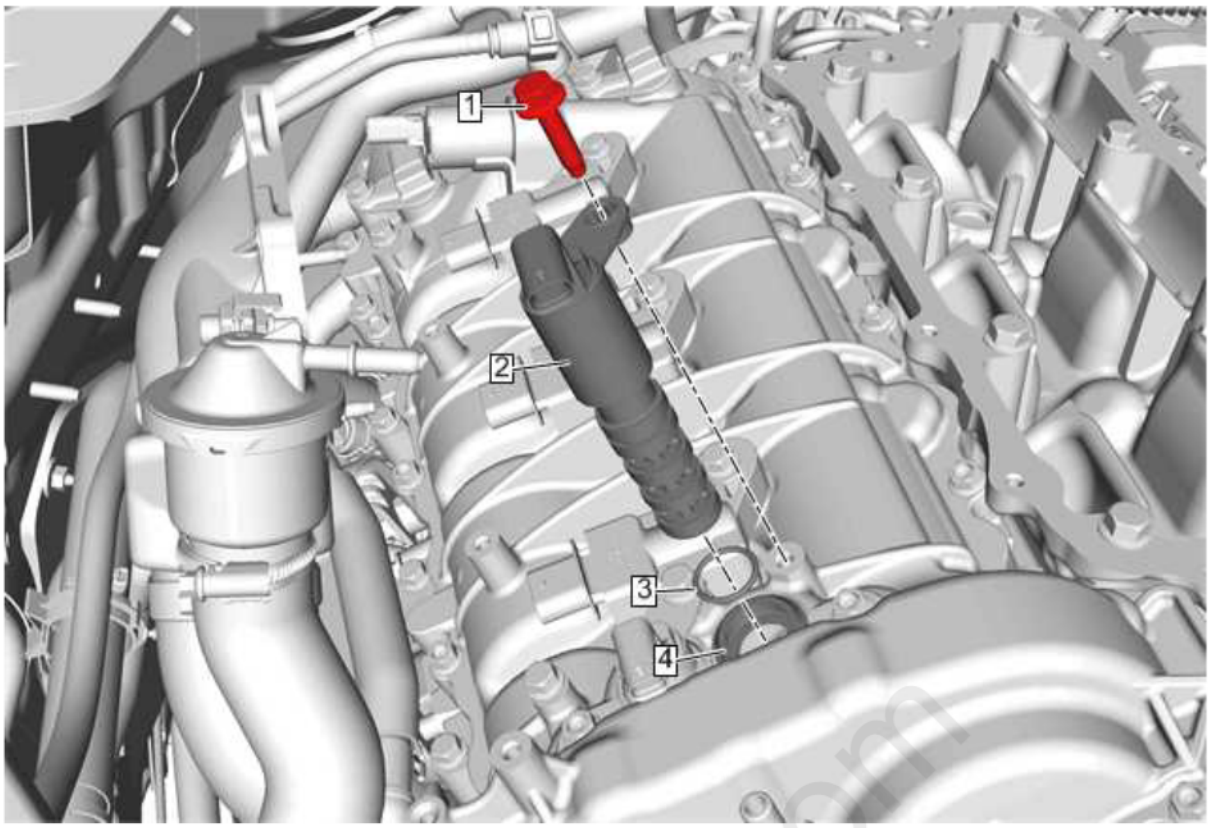

Fig. 256: Camshaft Position Actuator Solenoid Valve Solenoid - Bank 1 (Right Side) Intake (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Camshaft Housing Cover Insulator Replacement - Right Side (LGW)	
1	Camshaft Position Actuator Solenoid Valve Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
2	Camshaft Position Actuator Solenoid Valve
3	O-Ring **NOTE:** **Install a NEW O-ring seal.** **NOTE:** **Lubricate the NEW O-ring seals with clean engine oil.**
4	Camshaft Position Actuator Solenoid Valve Seal **NOTE:** **Always install the camshaft position actuator solenoid valve seal supplied with the NEW camshaft position actuator solenoid valve. If reinstalling the valve, inspect the camshaft position actuator solenoid valve seal and replace as necessary.**

CAMSHAFT POSITION ACTUATOR SOLENOID VALVE SOLENOID REPLACEMENT - BANK 1 (RIGHT SIDE) INTAKE (LGX)

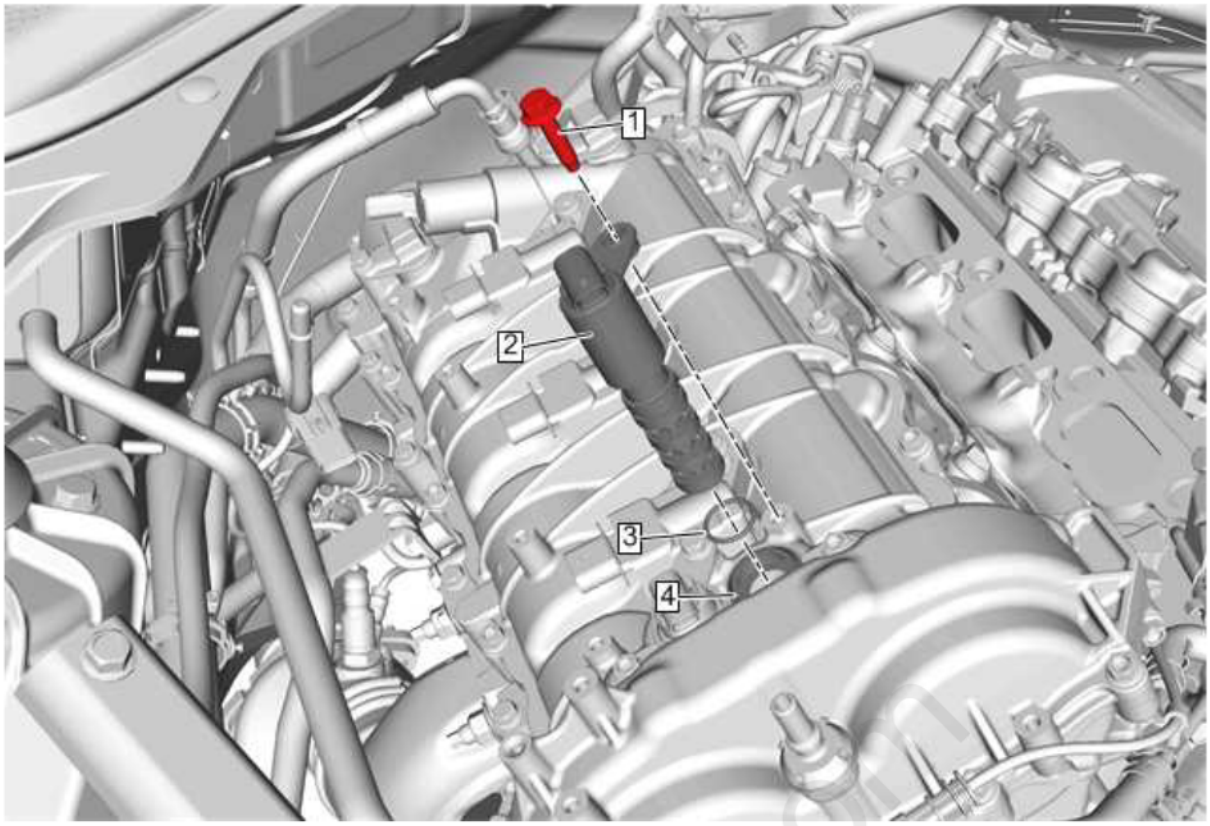

Fig. 257: Camshaft Position Actuator Solenoid Valve Solenoid - Bank 1 (Right Side) Intake (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Camshaft Housing Cover Insulator Replacement - Right Side (LGX)	
1	Camshaft Position Actuator Solenoid Valve Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
2	Camshaft Position Actuator Solenoid Valve
3	O-Ring **NOTE:** **Install a NEW O-ring seal.** **NOTE:** **Lubricate the NEW O-ring seals with clean engine oil.**
4	Camshaft Position Actuator Solenoid Valve Seal **NOTE:** **Always install the camshaft position actuator solenoid valve seal supplied with the NEW camshaft position actuator solenoid valve. If reinstalling the valve, inspect the camshaft position actuator solenoid valve seal and replace as necessary.**

CAMSHAFT POSITION ACTUATOR SOLENOID VALVE SOLENOID REPLACEMENT - BANK 1 (RIGHT SIDE) EXHAUST (LGW)

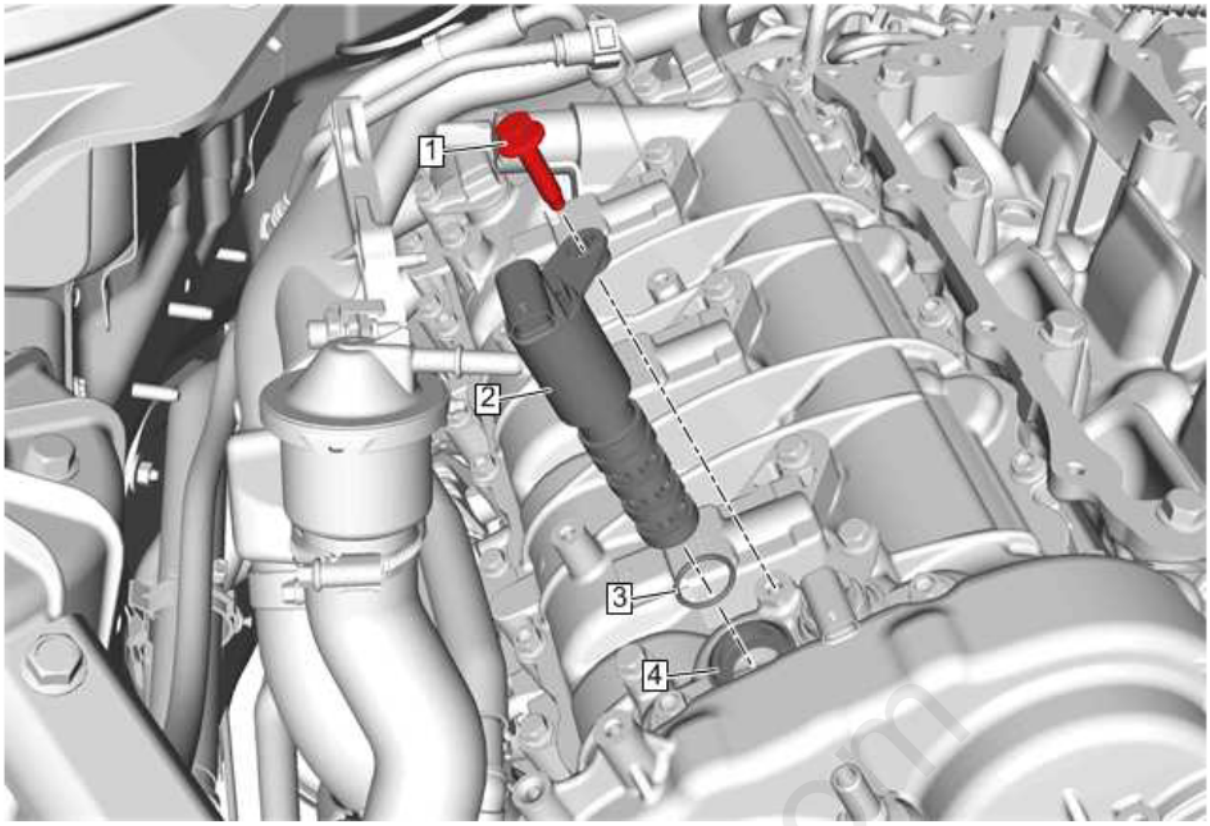

Fig. 258: Camshaft Position Actuator Solenoid Valve Solenoid - Bank 1 (Right Side) Exhaust (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Camshaft Housing Cover Insulator Replacement - Right Side (LGW)	
1	Camshaft Position Actuator Solenoid Valve Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
2	Camshaft Position Actuator Solenoid Valve
3	O-Ring **NOTE:** **Install a NEW O-ring seal.** **NOTE:** **Lubricate the NEW O-ring seals with clean engine oil.**
4	Camshaft Position Actuator Solenoid Valve Seal **NOTE:** **Always install the camshaft position actuator solenoid valve seal supplied with the NEW camshaft position actuator solenoid valve. If reinstalling the valve, inspect the camshaft position actuator solenoid valve seal and replace as necessary.**

CAMSHAFT POSITION ACTUATOR SOLENOID VALVE SOLENOID REPLACEMENT - BANK 1 (RIGHT SIDE) EXHAUST (LGX)

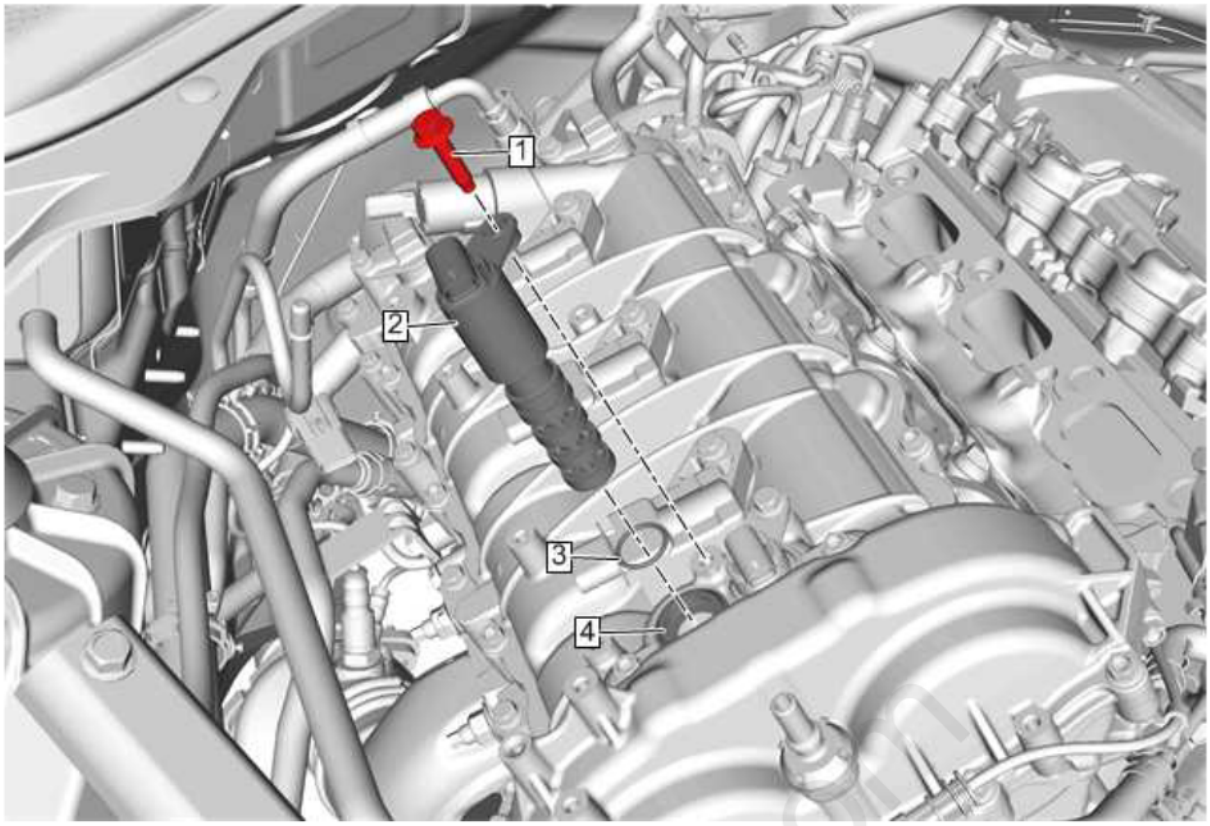

Fig. 259: Camshaft Position Actuator Solenoid Valve Solenoid - Bank 1 (Right Side) Exhaust (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Camshaft Housing Cover Insulator Replacement - Right Side (LGX)	
1	Camshaft Position Actuator Solenoid Valve Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
2	Camshaft Position Actuator Solenoid Valve
3	O-Ring **NOTE:** **Install a NEW O-ring seal.** **NOTE:** **Lubricate the NEW O-ring seals with clean engine oil.**
4	Camshaft Position Actuator Solenoid Valve Seal **NOTE:** **Always install the camshaft position actuator solenoid valve seal supplied with the NEW camshaft position actuator solenoid valve. If reinstalling the valve, inspect the camshaft position actuator solenoid valve seal and replace as necessary.**

CAMSHAFT POSITION ACTUATOR SOLENOID VALVE SOLENOID REPLACEMENT - BANK 2 (LEFT SIDE) INTAKE (LGX)

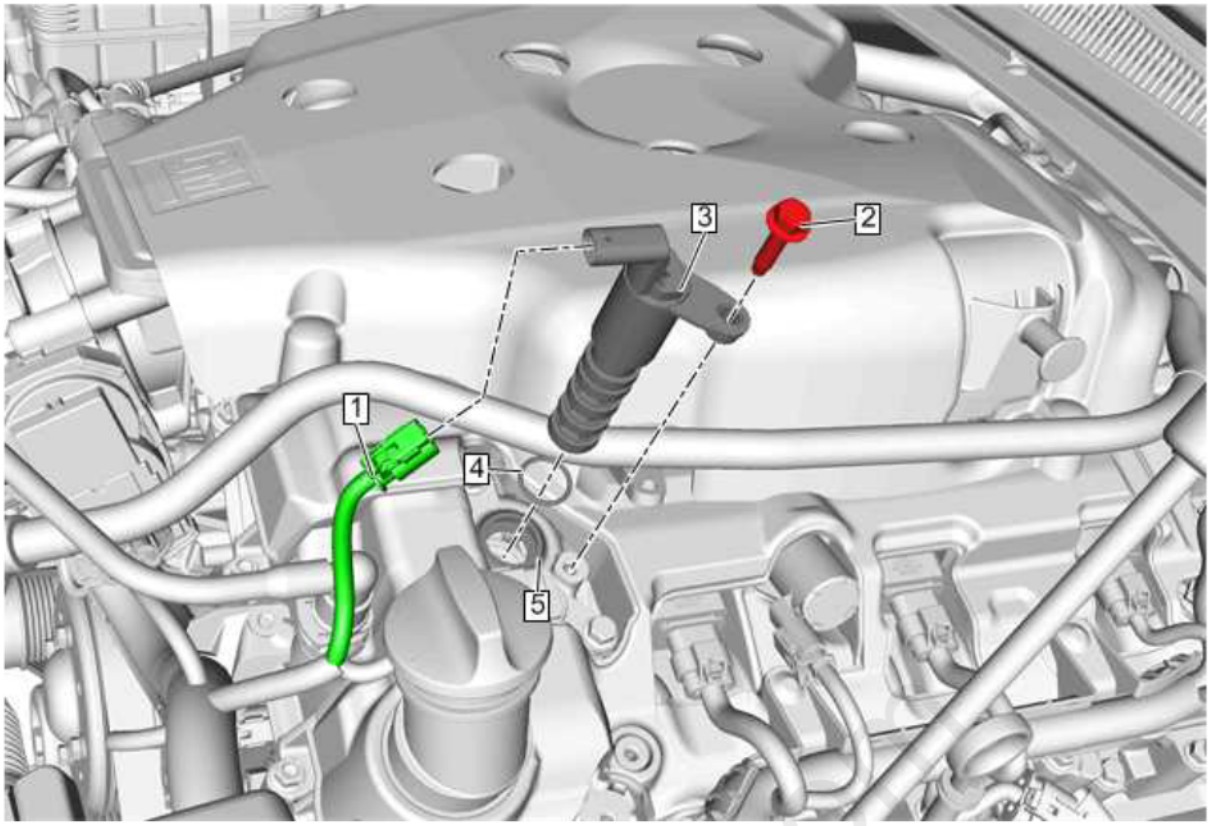

Fig. 260: Camshaft Position Actuator Solenoid Valve Solenoid - Bank 2 (Left Side) Intake (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Intake Manifold Cover Replacement (LGX)	
1	Electrical Connector
2	Camshaft Position Actuator Solenoid Valve Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
3	Camshaft Position Actuator Solenoid Valve
4	O-Ring **NOTE:** **Install a NEW O-ring seal.** **NOTE:** **Lubricate the NEW O-ring seals with clean engine oil.**
5	Camshaft Position Actuator Solenoid Valve Seal **NOTE:** **Always install the camshaft position actuator solenoid valve seal supplied with the NEW camshaft position actuator solenoid valve. If reinstalling the valve, inspect the camshaft position actuator solenoid valve seal and replace as necessary.**

CAMSHAFT POSITION ACTUATOR SOLENOID VALVE SOLENOID REPLACEMENT - BANK 2 (LEFT SIDE) INTAKE (LGW)

Removal Procedure

1. **Charge Air Cooler Cover Replacement** Â» Remove
2. Electrical Connector (1)Â» Disconnect

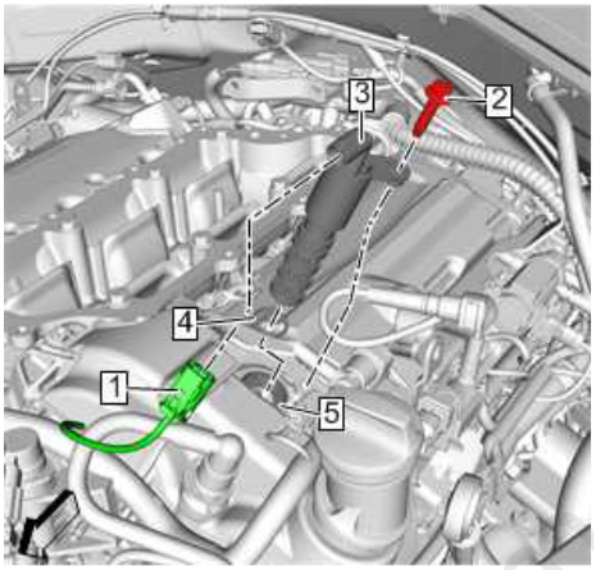

Fig. 261: Camshaft Position Actuator Solenoid Valve, Retaining Bolt And Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

3. Camshaft Position Actuator Solenoid Valve Bolt (2)Â» Remove
4. Camshaft Position Actuator Solenoid Valve (3)Â» Remove
5. O-Ring (4)Â» Remove and DISCARD
6. Camshaft Position Actuator Solenoid Valve Seal (5)Â» Remove

Installation Procedure

1. Camshaft Position Actuator Solenoid Valve Seal (5)Â» Install

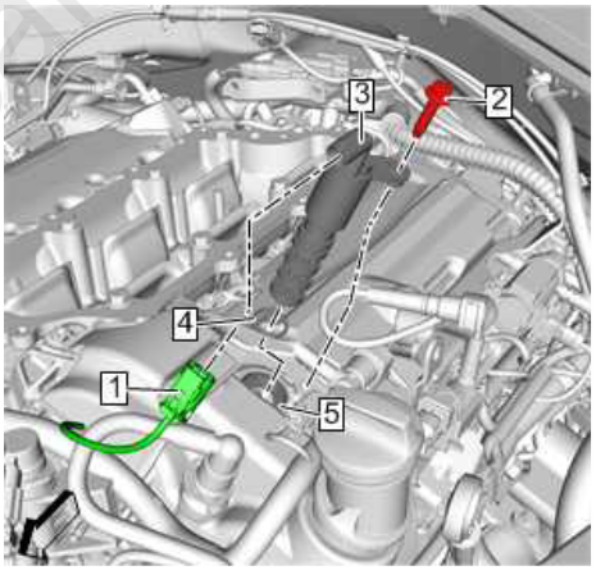

Fig. 262: Camshaft Position Actuator Solenoid Valve, Retaining Bolt And Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Always install the camshaft position actuator solenoid valve seal supplied with the NEW camshaft position actuator solenoid valve. If reinstalling the valve, inspect the camshaft position actuator solenoid valve seal and replace as necessary.**

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2. O-Ring (4)Â» Install a NEW O-ring seal.

NOTE: **Lubricate the NEW O-ring seals with clean engine oil.**

3. Camshaft Position Actuator Solenoid Valve (3)Â» Install
4. Camshaft Position Actuator Solenoid Valve Bolt (2)Â» Install and tighten 10 N.m (89 lb in)

CAUTION: **Refer to Fastener Caution .**

5. Electrical Connector (1)Â» Connect
6. Charge Air Cooler Cover Replacement Â» Install

CAMSHAFT POSITION ACTUATOR SOLENOID VALVE SOLENOID REPLACEMENT - BANK 2 (LEFT SIDE) EXHAUST (LGX)

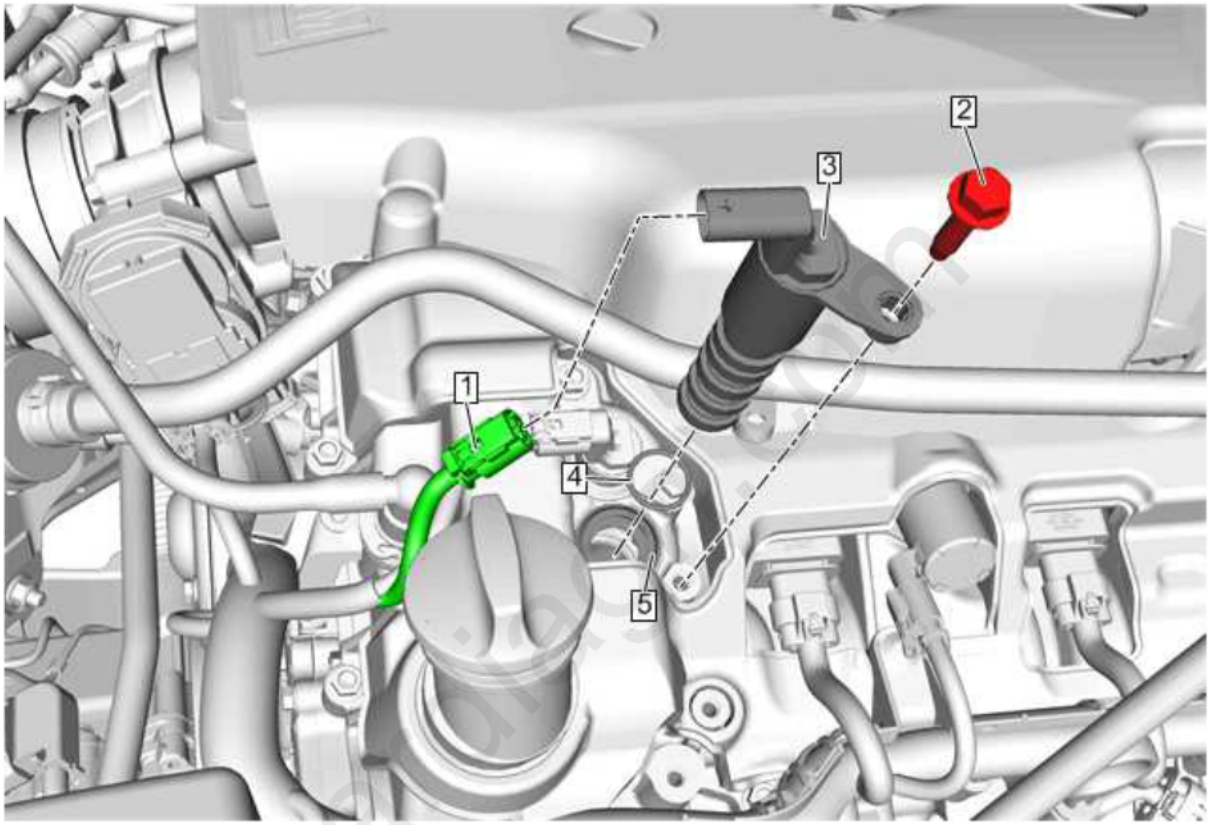

Fig. 263: Camshaft Position Actuator Solenoid Valve Solenoid - Bank 2 (Left Side) Exhaust (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Intake Manifold Cover Replacement (LGX)	
1	Electrical Connector
2	Camshaft Position Actuator Solenoid Valve Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
3	Camshaft Position Actuator Solenoid Valve

Callout	Component Name
4	O-Ring **NOTE:** **Install a NEW O-ring seal.** **NOTE:** **Lubricate the NEW O-ring seals with clean engine oil.**
5	Camshaft Position Actuator Solenoid Valve Seal **NOTE:** **Always install the camshaft position actuator solenoid valve seal supplied with the NEW camshaft position actuator solenoid valve. If reinstalling the valve, inspect the camshaft position actuator solenoid valve seal and replace as necessary.**

CAMSHAFT POSITION ACTUATOR SOLENOID VALVE SOLENOID REPLACEMENT - BANK 2 (LEFT SIDE) EXHAUST (LGW)

Removal Procedure

1. **Charge Air Cooler Cover Replacement** Â» Remove
2. Electrical Connector (1)Â» Disconnect

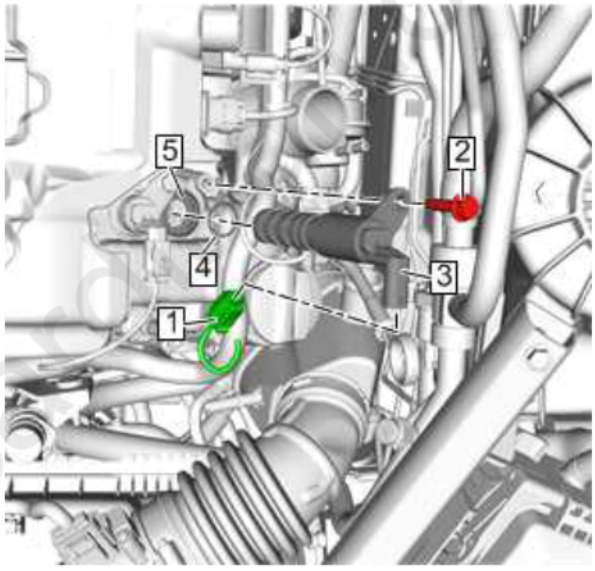

Fig. 264: Camshaft Position Actuator Solenoid Valve, Retaining Bolt And Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

3. Camshaft Position Actuator Solenoid Valve Bolt (2)Â» Remove
4. Camshaft Position Actuator Solenoid Valve (3)Â» Remove
5. O-Ring (4)Â» Remove and DISCARD
6. Camshaft Position Actuator Solenoid Valve Seal (5)Â» Remove

Installation Procedure

1. Camshaft Position Actuator Solenoid Valve Seal (5)Â» Install

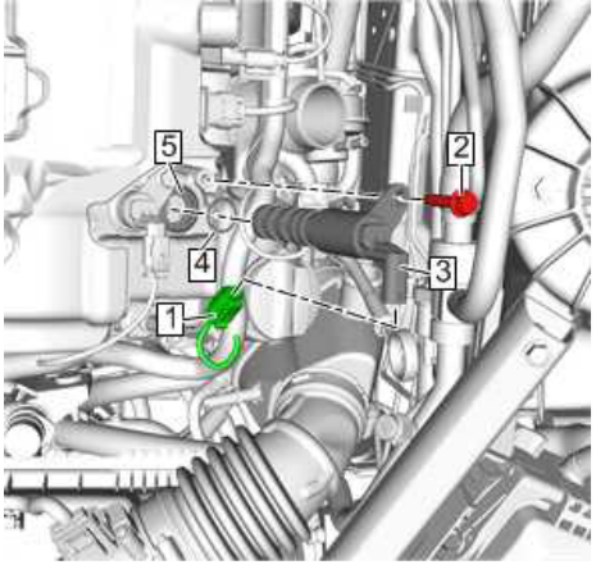

Fig. 265: Camshaft Position Actuator Solenoid Valve, Retaining Bolt And Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

NOTE: **Always install the camshaft position actuator solenoid valve seal supplied with the NEW camshaft position actuator solenoid valve. If reinstalling the valve, inspect the camshaft position actuator solenoid valve seal and replace as necessary.**

2. O-Ring (4)Â» Install a NEW O-ring seal.

NOTE: **Lubricate the NEW O-ring seals with clean engine oil.**

3. Camshaft Position Actuator Solenoid Valve (3)Â» Install
4. Camshaft Position Actuator Solenoid Valve Bolt (2)Â» Install and tighten 10 N.m (89 lb in)

CAUTION: **Refer to Fastener Caution .**

5. Electrical Connector (1)Â» Connect
6. Charge Air Cooler Cover Replacement Â» Install

CAMSHAFT POSITION ACTUATOR LOCATING PIN CONTROL VALVE REPLACEMENT (BANK 1 LGW)

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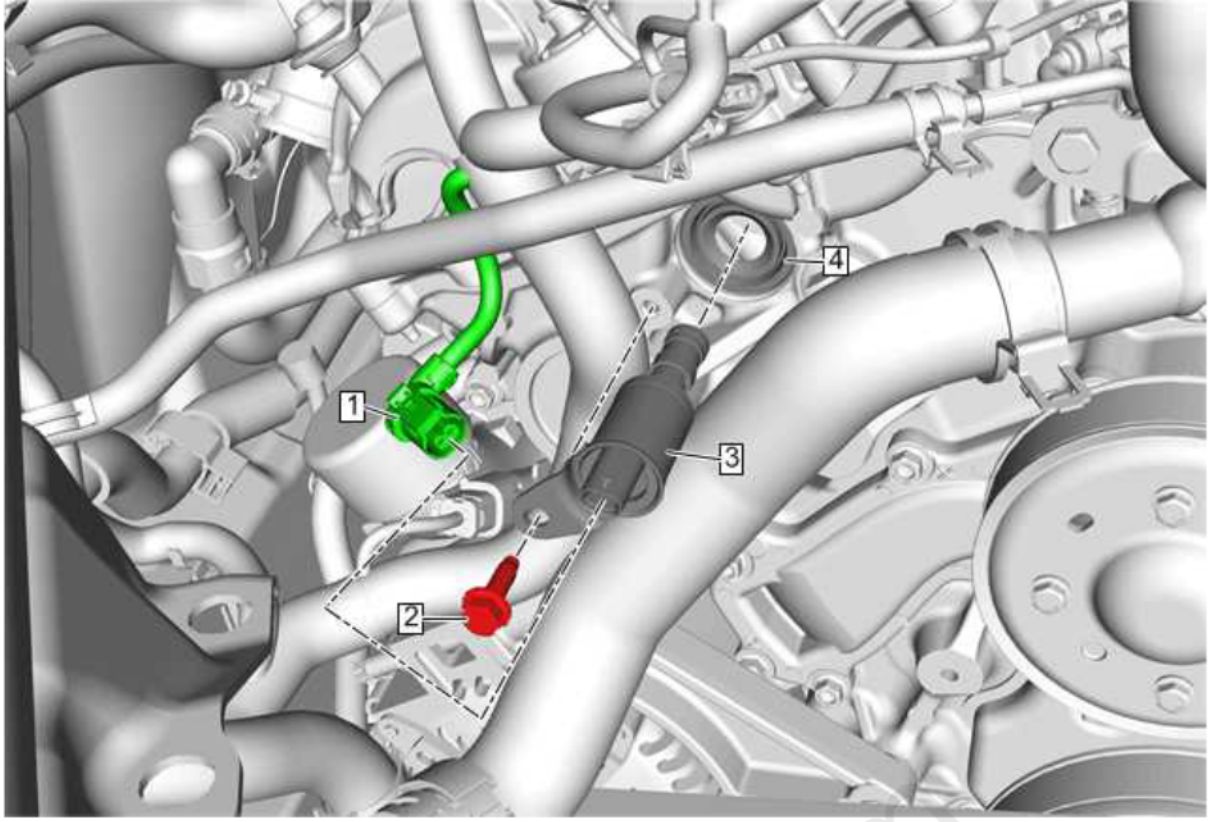

Fig. 266: Camshaft Position Actuator Locating Pin Control Valve (Bank 1 LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Air Cleaner Assembly Replacement (LGW)	
1	Electrical Connector
2	Camshaft Position Actuator Locating Pin Control Valve Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
3	Camshaft Position Actuator Locating Pin Control Valve
4	Camshaft Position Actuator Solenoid Valve Seal **Procedure** Inspect the Camshaft Position Actuator Solenoid Valve Seal and replace as necessary. Refer to Engine Front Cover Disassemble , Engine Front Cover Assemble

CAMSHAFT POSITION ACTUATOR LOCATING PIN CONTROL VALVE REPLACEMENT (BANK 2 LGW)

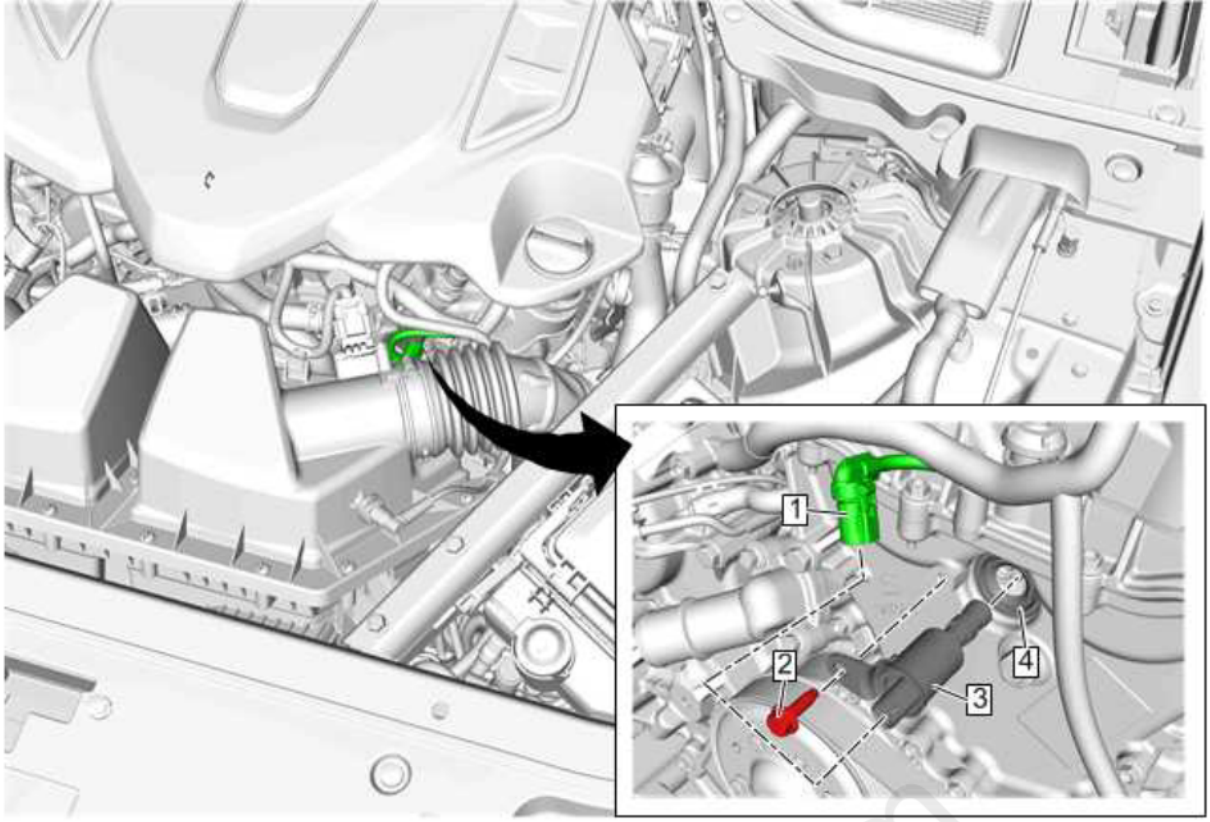

Fig. 267: Camshaft Position Actuator Locating Pin Control Valve (Bank 2 LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
1	Electrical Connector
2	Camshaft Position Actuator Locating Pin Control Valve Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
3	Camshaft Position Actuator Locating Pin Control Valve
4	Camshaft Position Actuator Solenoid Valve Seal **Procedure** Inspect the Camshaft Position Actuator Solenoid Valve Seal and replace as necessary. Refer to **Engine Front Cover Disassemble** , **Engine Front Cover Assemble**

CAMSHAFT POSITION ACTUATOR LOCATING PIN CONTROL VALVE REPLACEMENT (BANK 1 LGX)

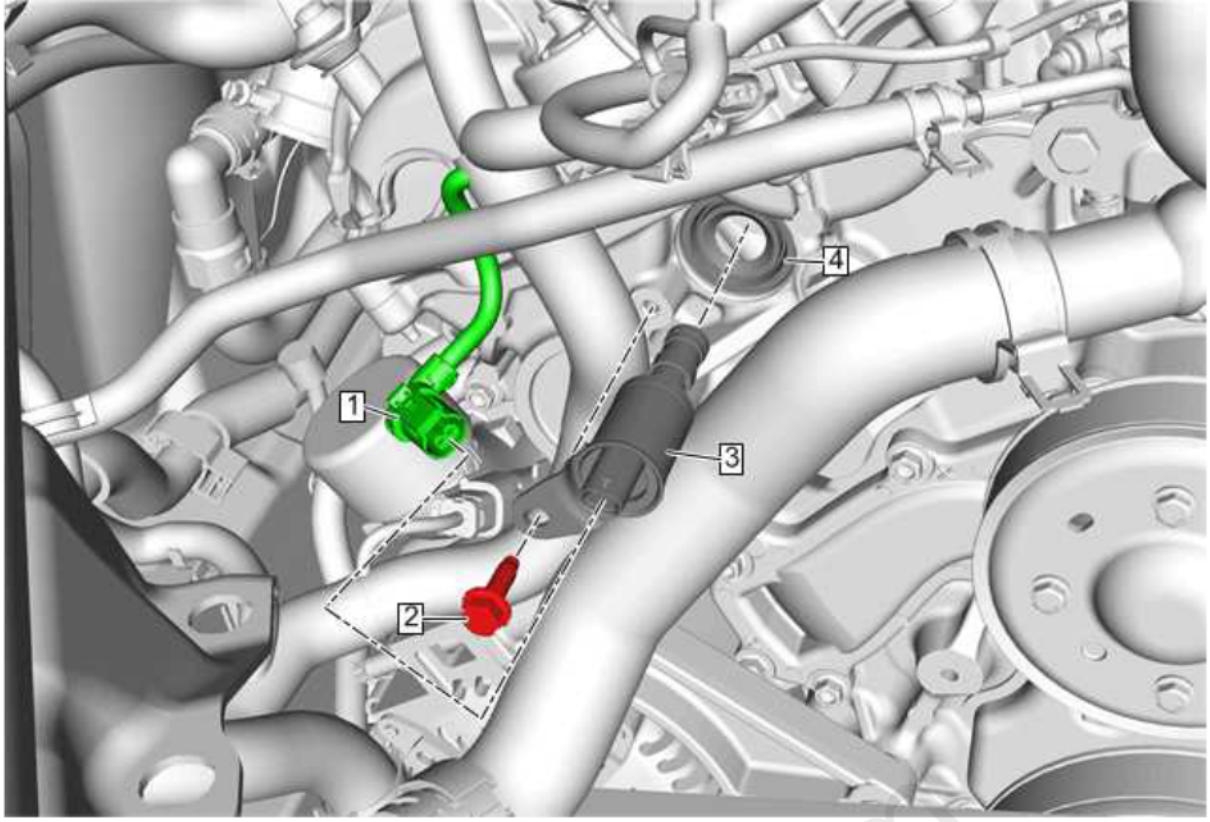

Fig. 268: Camshaft Position Actuator Locating Pin Control Valve (Bank 1 LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Intake Manifold Cover Replacement (LGX)	
1	Electrical Connector
2	Camshaft Position Actuator Locating Pin Control Valve Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
3	Camshaft Position Actuator Locating Pin Control Valve
4	Camshaft Position Actuator Solenoid Valve Seal **Procedure** Inspect the Camshaft Position Actuator Solenoid Valve Seal and replace as necessary. Refer to **Engine Front Cover Disassemble** , **Engine Front Cover Assemble**

CAMSHAFT POSITION ACTUATOR LOCATING PIN CONTROL VALVE REPLACEMENT (BANK 2 LGX)

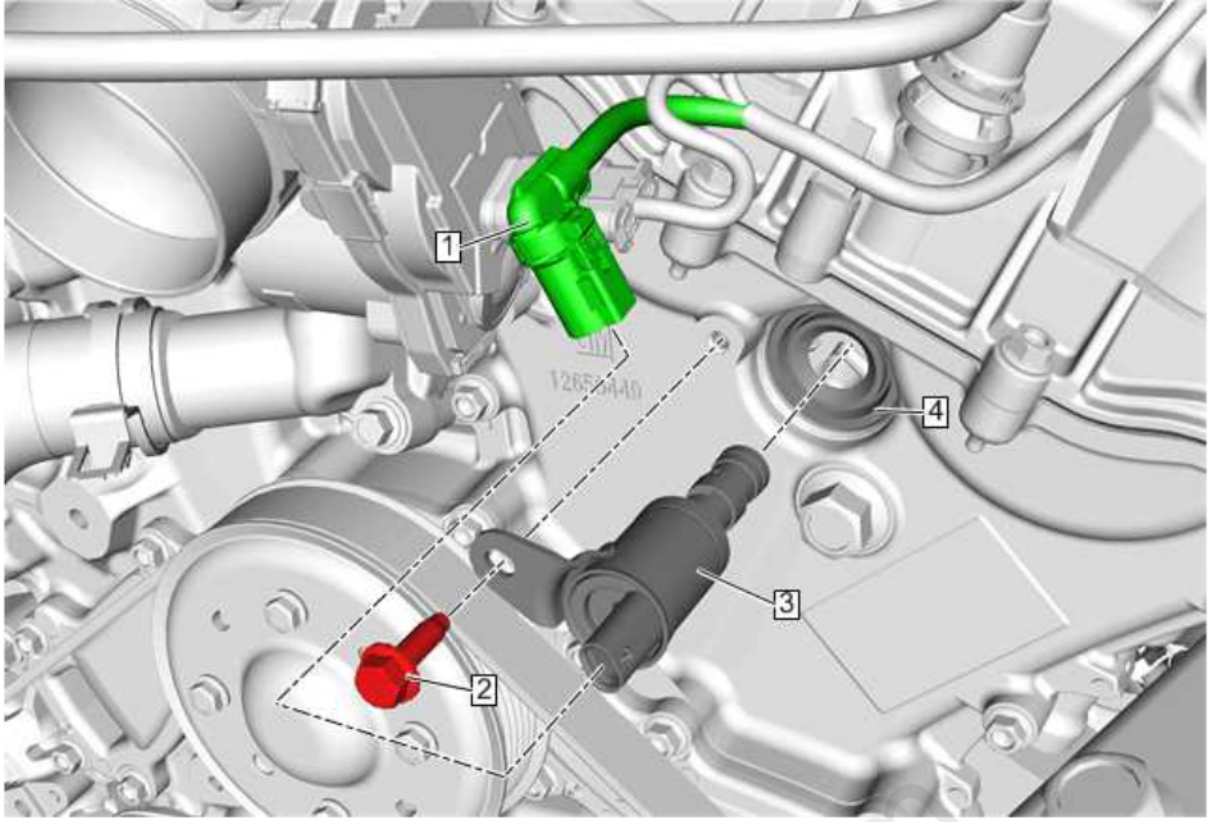

Fig. 269: Camshaft Position Actuator Locating Pin Control Valve
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Procedure Air Cleaner Outlet Duct Replacement (LGX)	
1	Electrical Connector
2	Camshaft Position Actuator Locating Pin Control Valve Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
3	Camshaft Position Actuator Locating Pin Control Valve
4	Camshaft Position Actuator Solenoid Valve Seal **Procedure** Inspect the Camshaft Position Actuator Solenoid Valve Seal and replace as necessary. Refer to Engine Front Cover Disassemble , Engine Front Cover Assemble

KNOCK SENSOR REPLACEMENT - BANK 1

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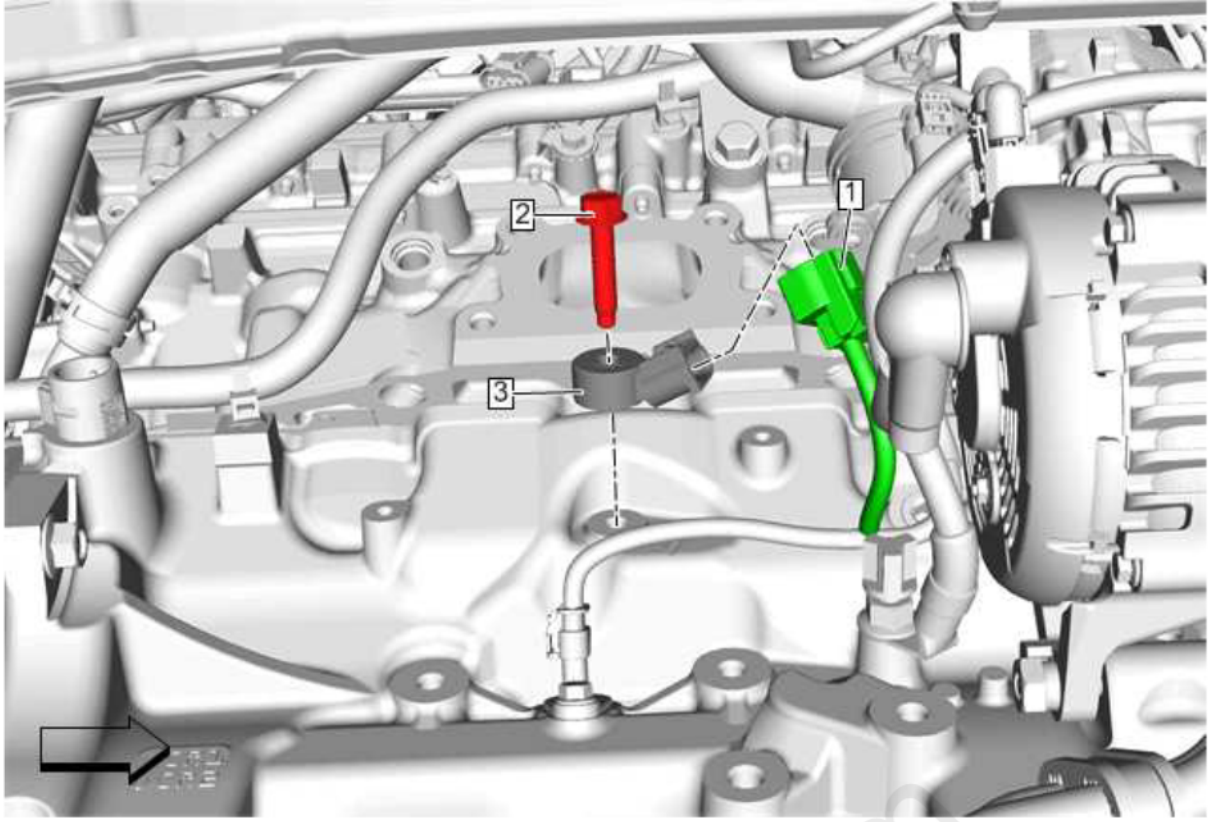

Fig. 270: Knock Sensor - Bank 1
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Turbocharger - Right SideÂ» Remove - Turbocharger Replacement (Right Side) Turbocharger Replacement (Left Side)	
1	Electrical Connector
2	Knock Sensor Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 25 N.m (18 lb ft)
3	Knock Sensor

KNOCK SENSOR REPLACEMENT - BANK 2 (LGW)

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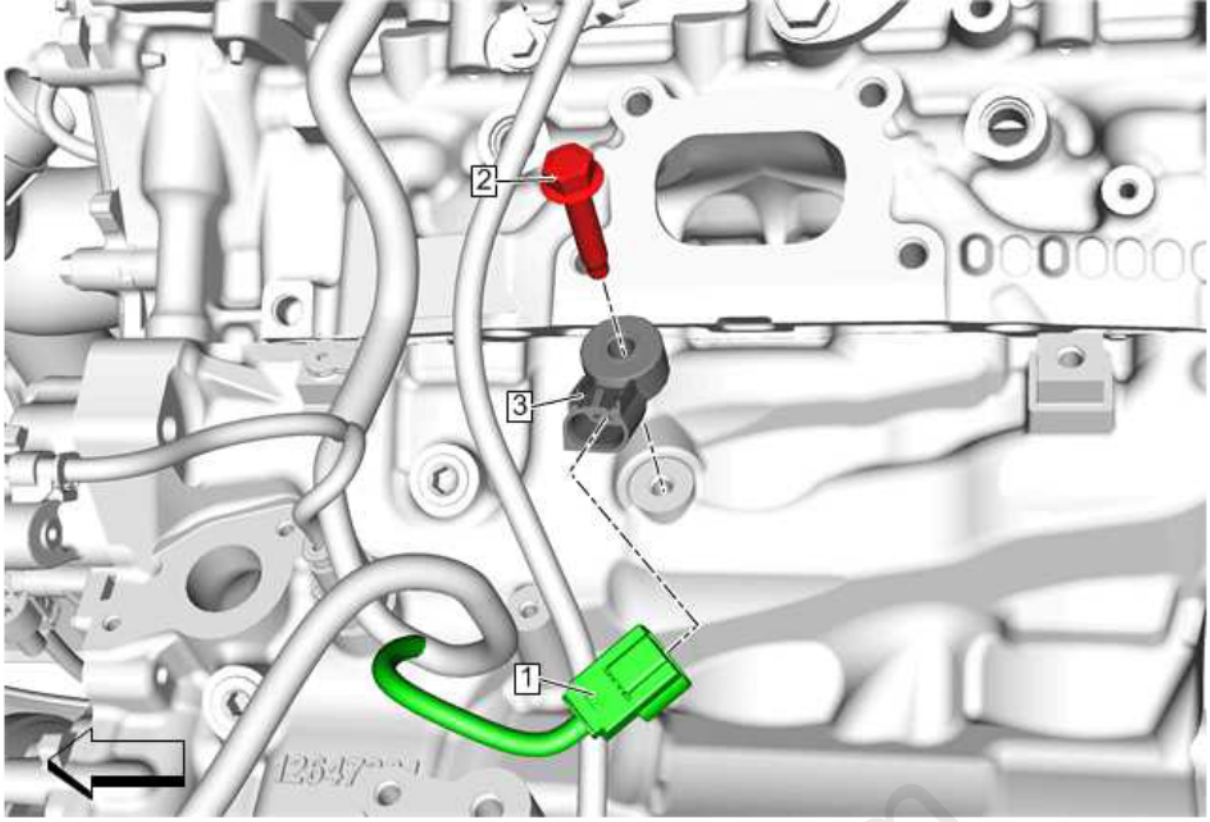

Fig. 271: Knock Sensor - Bank 2
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Turbocharger - Left SideÂ» Remove - Turbocharger Replacement (Left Side)	
1	Electrical Connector
2	Knock Sensor Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 25 N.m (18 lb ft)
3	Knock Sensor

KNOCK SENSOR REPLACEMENT - BANK 2 (LGX)

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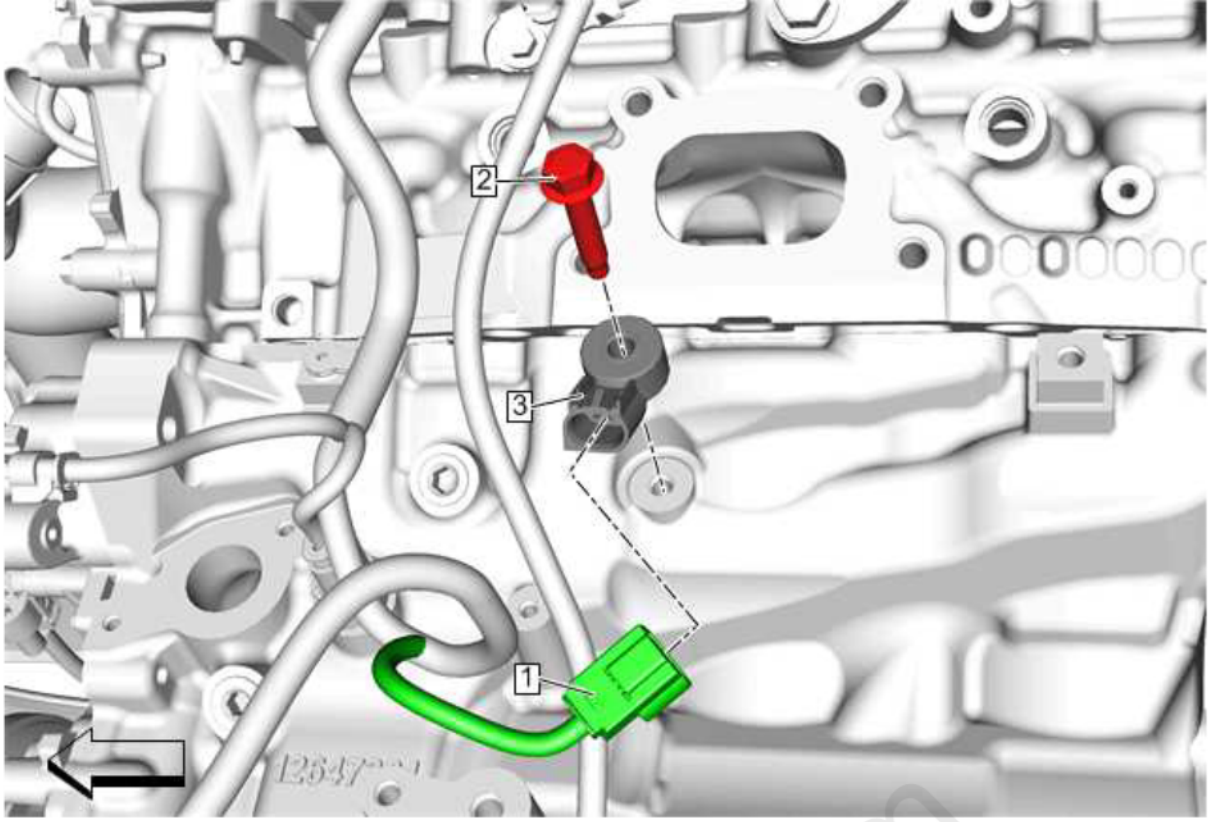

Fig. 272: Knock Sensor - Bank 2
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Starter Replacement (LGX)	
1	Electrical Connector
2	Knock Sensor Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 25 N.m (18 lb ft)
3	Knock Sensor

INTAKE AIR DUCT REPLACEMENT (LGW)

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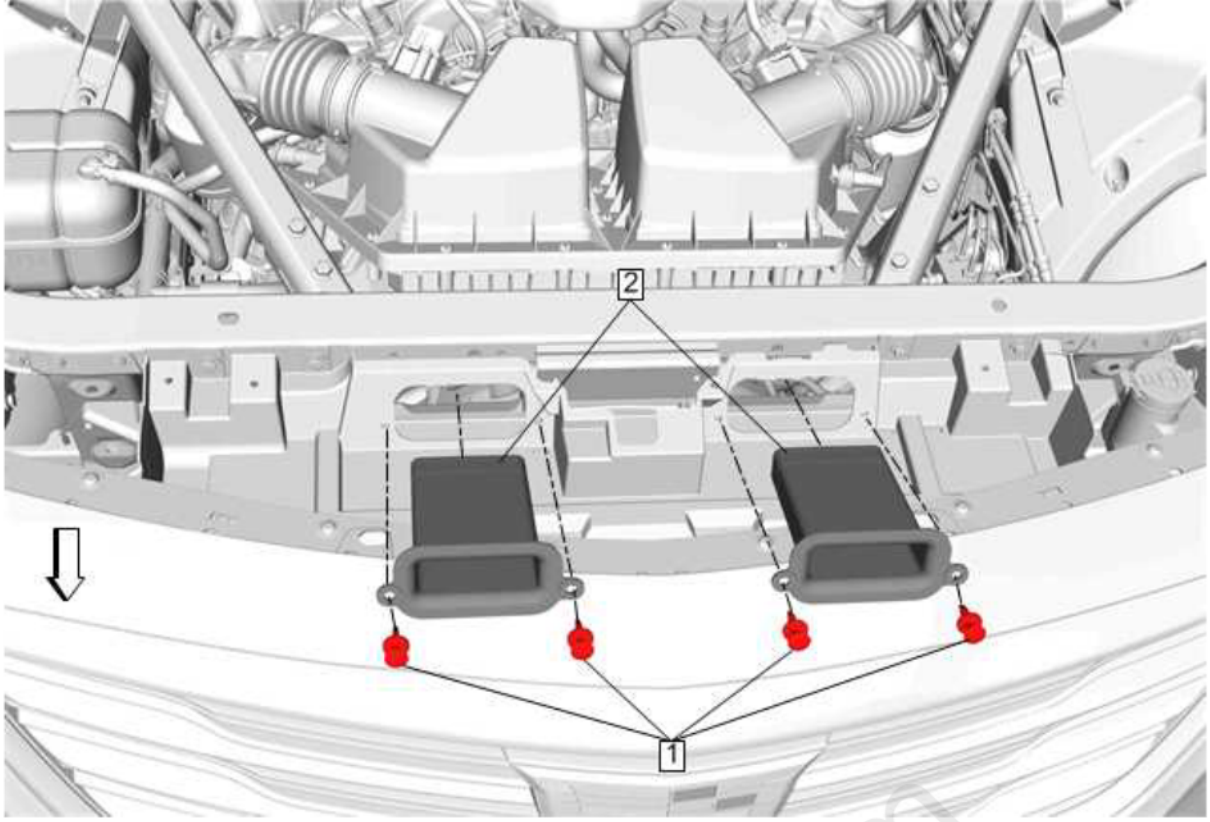

Fig. 273: Intake Air Duct (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Front Compartment Front Sight Shield Replacement	
1	Intake Air Duct Retainer [4x] **CAUTION:** Refer to Fastener Caution .
2	Intake Air Duct [2x]

INTAKE AIR DUCT REPLACEMENT (LGX)

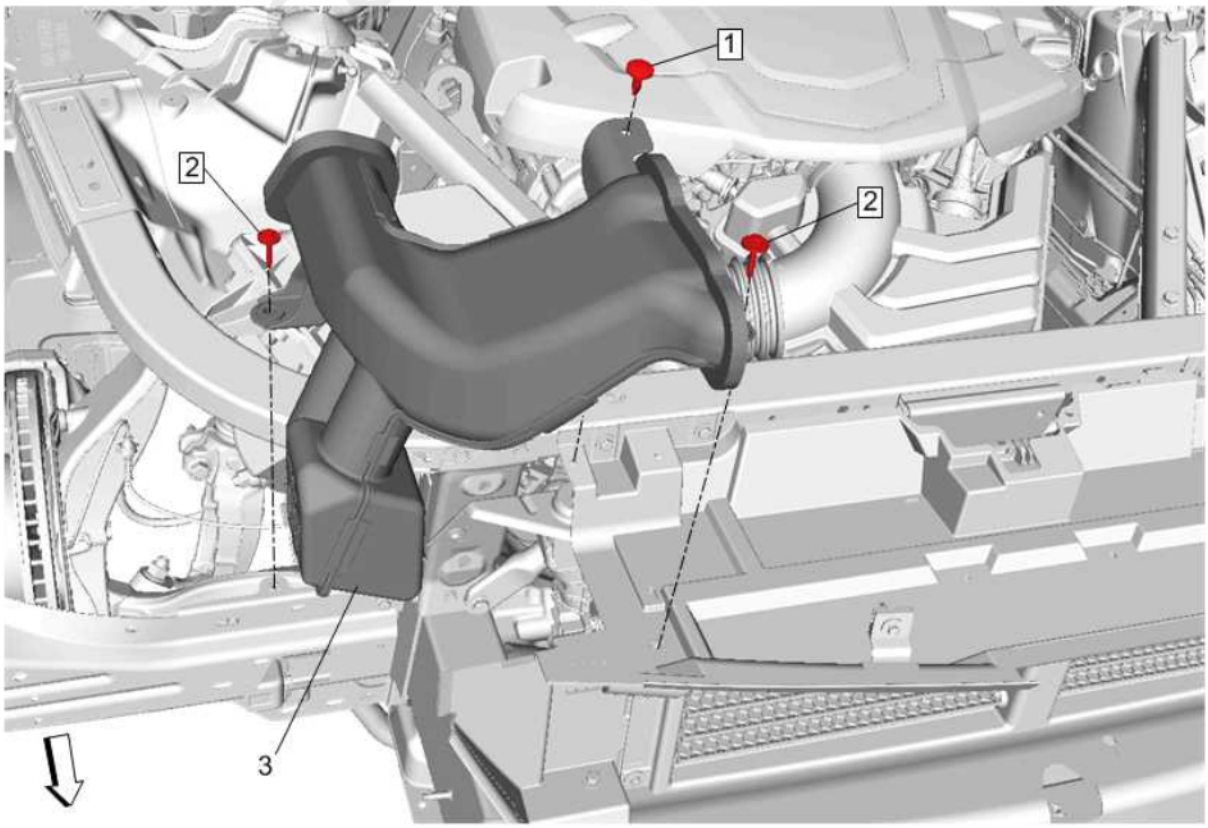

Fig. 274: Intake Air Duct (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Front Bumper Fascia Support Replacement	
1	Intake Air Duct Retainer **CAUTION:** **Refer to Fastener Caution .**
2	Intake Air Duct Bolt [2x] **Tighten** 2.5 N.m (22 lb in)
3	Intake Air Duct

VALVE ROCKER ARM OIL CONTROL VALVE REPLACEMENT (BANK 1)

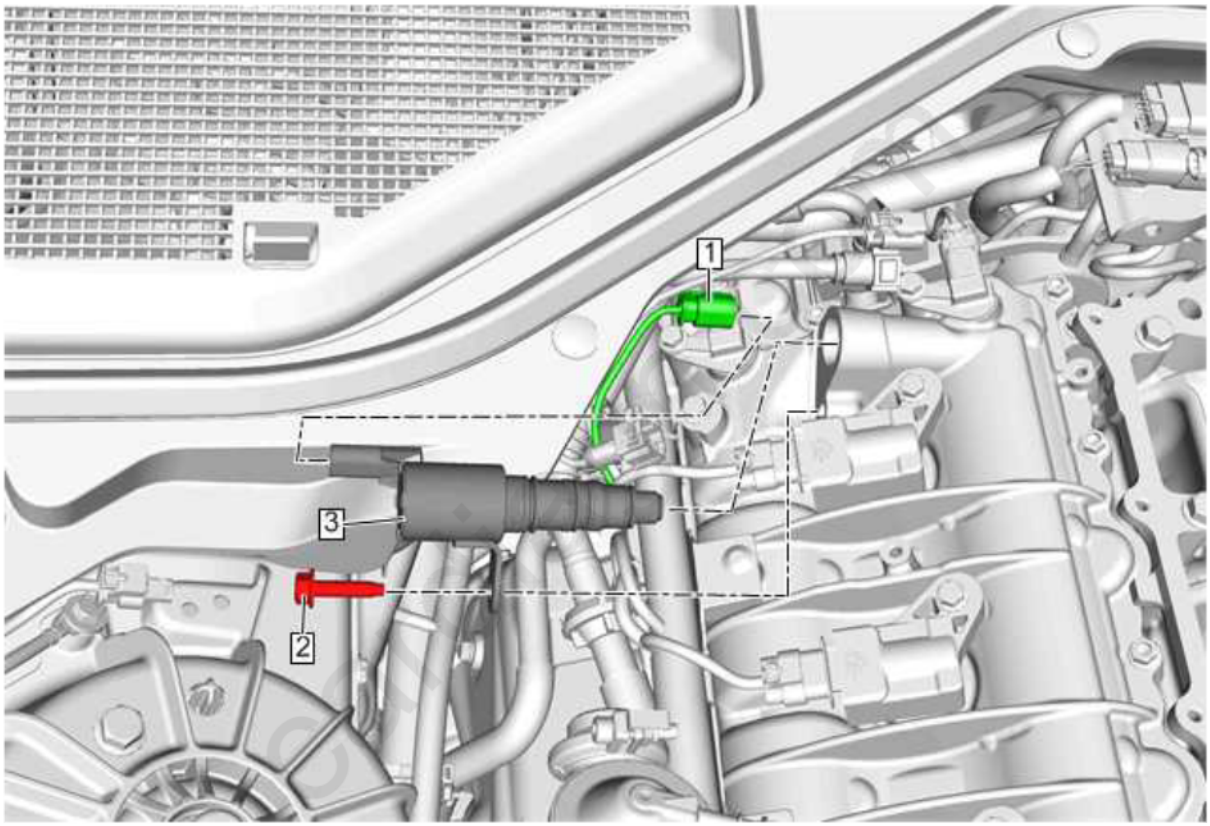

Fig. 275: Valve Rocker Arm Oil Control Valve (Bank 1)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Camshaft Housing Cover Insulator Replacement - Right Side (LGX) Camshaft Housing Cover Insulator Replacement - Right Side (LGW)	
1	Electrical Connector
2	Valve Rocker Arm Oil Control Valve Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)

Callout	Component Name
3	Valve Rocker Arm Oil Control Valve **Procedure** Install a NEW O-ring seal. [3x] **NOTE:** **Lubricate the NEW O-ring seals with clean engine oil.**

VALVE ROCKER ARM OIL CONTROL VALVE REPLACEMENT (BANK 2)

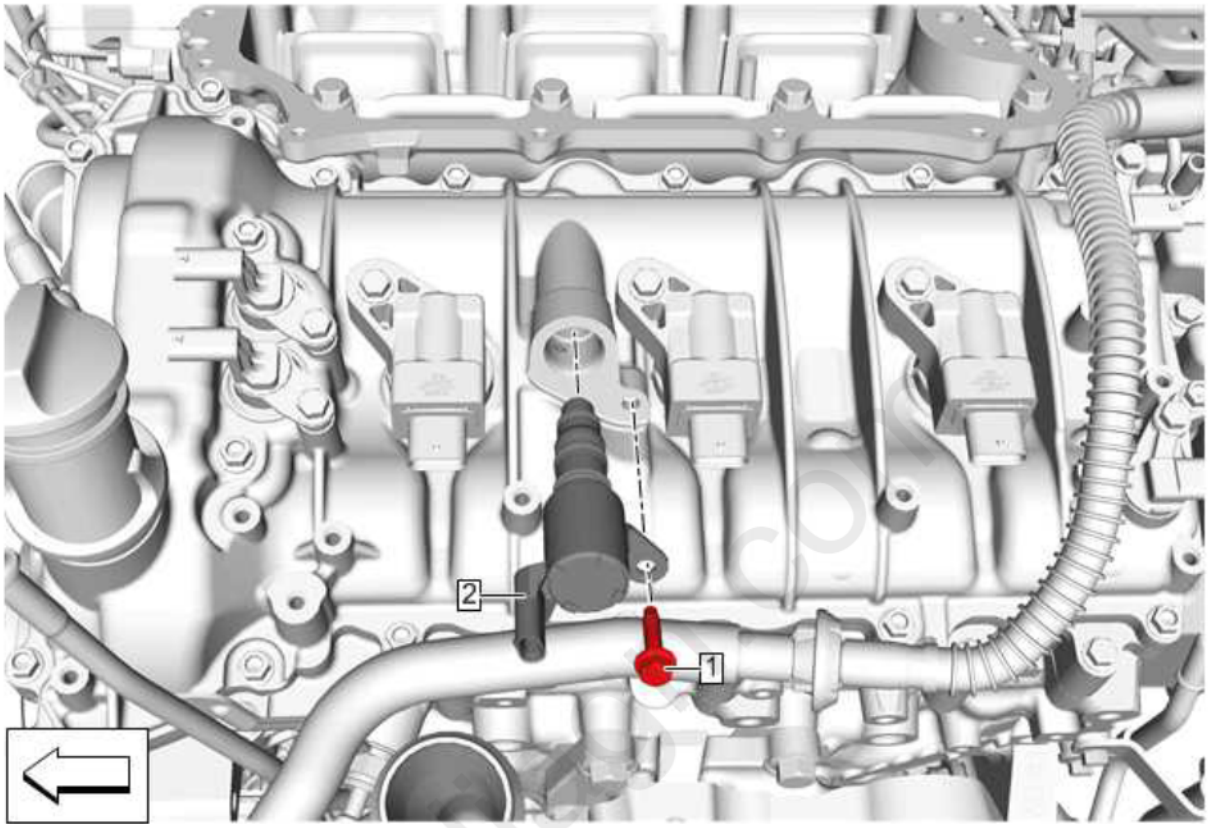

Fig. 276: Valve Rocker Arm Oil Control Valve (Bank 2)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Camshaft Housing Cover Insulator Replacement - Left Side (LGX) Camshaft Housing Cover Insulator Replacement - Left Side (LGW)	
1	Electrical Connector
2	Valve Rocker Arm Oil Control Valve Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
3	Valve Rocker Arm Oil Control Valve **Procedure** Install a NEW O-ring seal. [3x] **NOTE:** **Lubricate the NEW O-ring seals with clean engine oil.**

OIL PUMP FLOW CONTROL VALVE REPLACEMENT

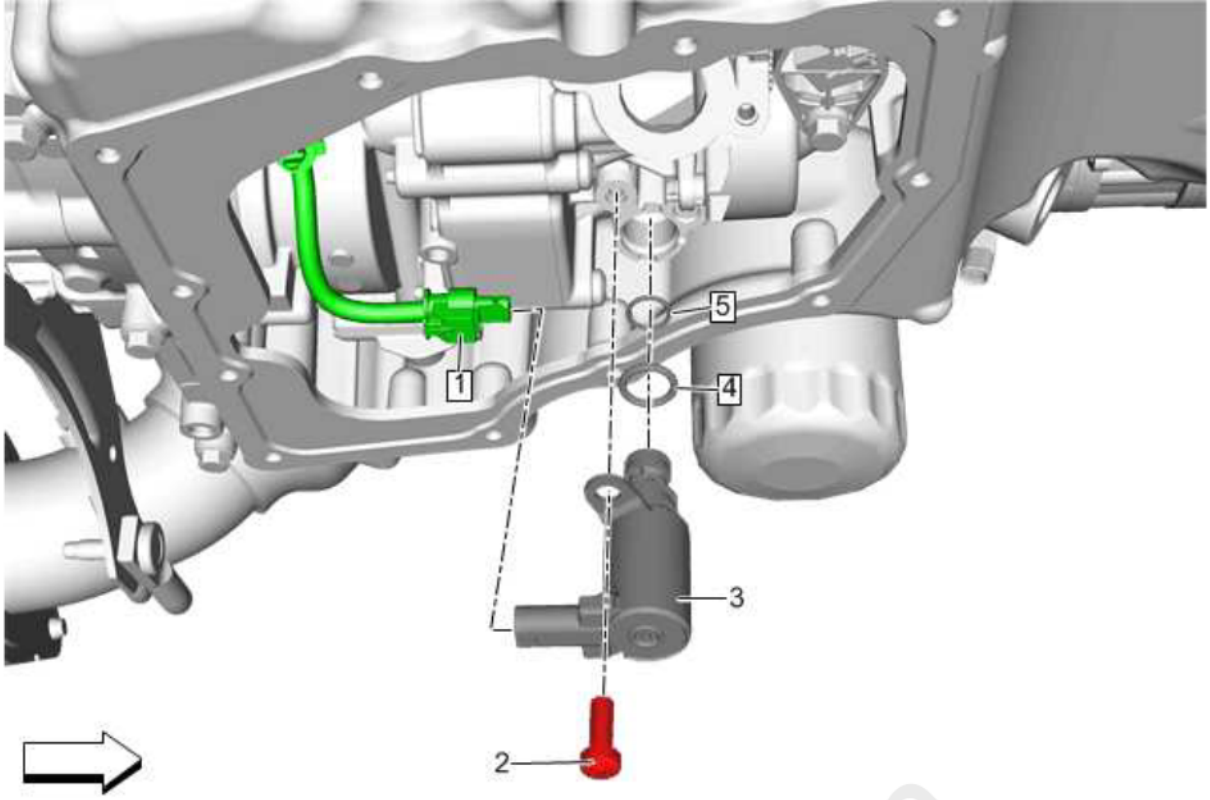

Fig. 277: Oil Pump Flow Control Valve
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Lower Oil Pan Replacement 2. Oil Pump Suction Pipe and Screen Assembly Replacement	
1	Electrical Connector
2	Oil Pump Flow Control Solenoid Valve Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten** 5 N.m (44 lb in)
3	Oil Pump Flow Control Valve with Insulator **CAUTION:** **After removing the oil pump flow control valve, ensure the entire valve has been removed and there is no debris left in the oil pump bore. Failure to ensure the oil pump bore is free from debris may result in engine damage.** **NOTE:** **The engine should be allowed to cool for 2 hours, or until the pump is near ambient temperature or there is a high risk of breaking the oil pump flow control valve off in the bore when attempting removal.**
4	O-Ring **Procedure** Lubricate the O-ring seal with clean engine oil.

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Callout	Component Name
5	O-Ring **Procedure** Lubricate the O-ring seal with clean engine oil.

OIL PUMP FLOW CONTROL SOLENOID VALVE HARNESS REPLACEMENT

Removal Procedure

1. **Underbody Front Air Deflector Replacement** Â» Remove
2. **Lower Oil Pan Replacement** Â» Remove
3. Oil Pump Flow Control Solenoid Valve Harness (1) @ Oil Pump Flow Control Solenoid Valve (2)Â» Disconnect

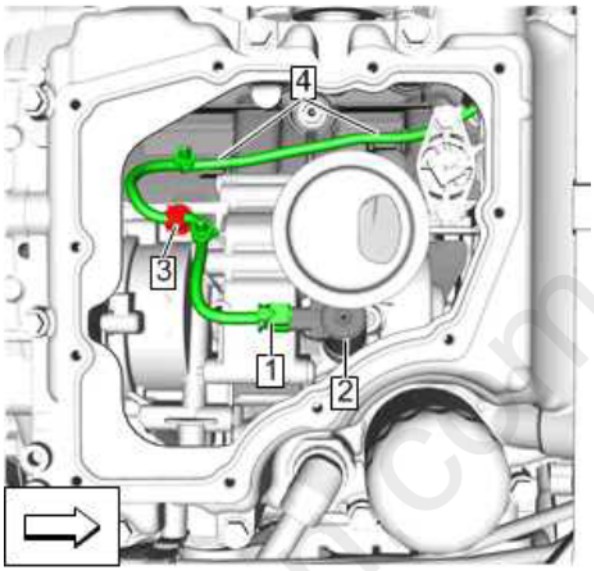

Fig. 278: Oil Pump Flow Control Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

4. Securely attach mechanics wire to the end of the oil pump flow control solenoid valve harness (1).

NOTE: **Mechanics wire is used to guide the harness into place during installation and must be of sufficient length to pass through the engine front cover from inside the oil pan.**

5. Oil Pump Flow Control Solenoid Valve Harness (1) @ Retainer (3)Â» Unclip
6. Oil Pump Flow Control Solenoid Valve Harness (1) @ Crankshaft Oil Deflector (4)Â» Unclip
7. Engine Wiring Harness (1)Â» Disconnect

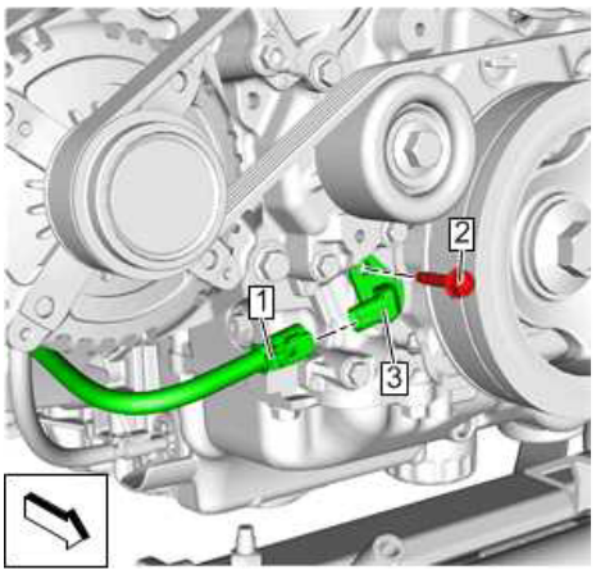

Fig. 279: Engine Wiring Harness
Courtesy of GENERAL MOTORS COMPANY

8. Oil Pump Flow Control Solenoid Valve Harness Bolt (2)Â» Remove
9. Remove the oil pump flow control solenoid valve harness (3) through the engine front cover.

NOTE: **Ensure the mechanics wire stays attached to the end of the harness during removal and remains in place within the engine after harness removal. It will be used to guide the harness into place during installation.**

NOTE: **The retaining clips attached to the oil pump flow control solenoid harness are used for initial production only and should be removed and discarded.**

Installation Procedure

1. Using the mechanics wire, guide the oil pump flow control solenoid valve harness (3) into place, then remove the wire.

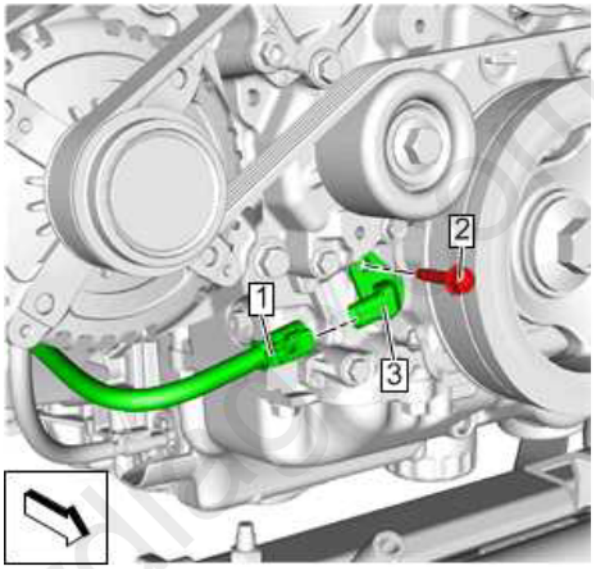

Fig. 280: Engine Wiring Harness
Courtesy of GENERAL MOTORS COMPANY

2. Oil Pump Flow Control Solenoid Valve Harness Bolt (2)Â» Install and tighten 15 N.m (11 lb ft)

CAUTION: **Refer to Fastener Caution .**

3. Engine Wiring Harness (1)Â» Connect
4. Oil Pump Flow Control Solenoid Valve Harness (1) @ Crankshaft Oil Deflector (4)Â» Install

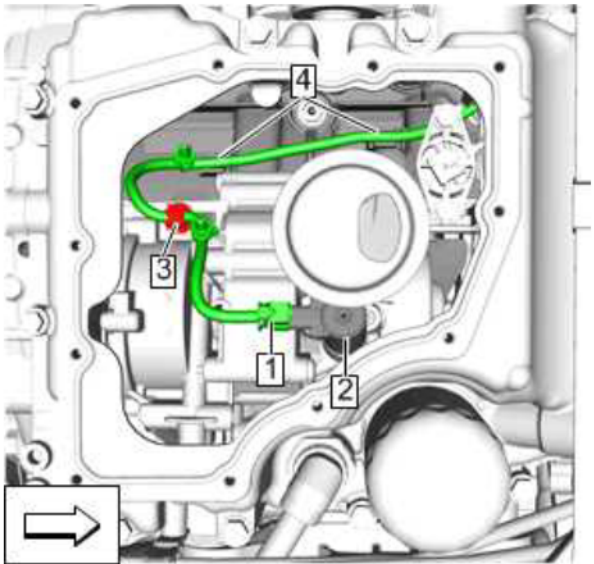

Fig. 281: Oil Pump Flow Control Solenoid Valve
Courtesy of GENERAL MOTORS COMPANY

5. Oil Pump Flow Control Solenoid Valve Harness (1) @ Retainer (3)Â» Install
6. Oil Pump Flow Control Solenoid Valve Harness (1) @ Oil Pump Flow Control Solenoid Valve (2)Â» Connect
7. Lower Oil Pan Replacement Â» Install
8. Underbody Front Air Deflector Replacement Â» Install

CHARGE AIR COOLER INLET AIR TUBE REPLACEMENT (RIGHT SIDE)

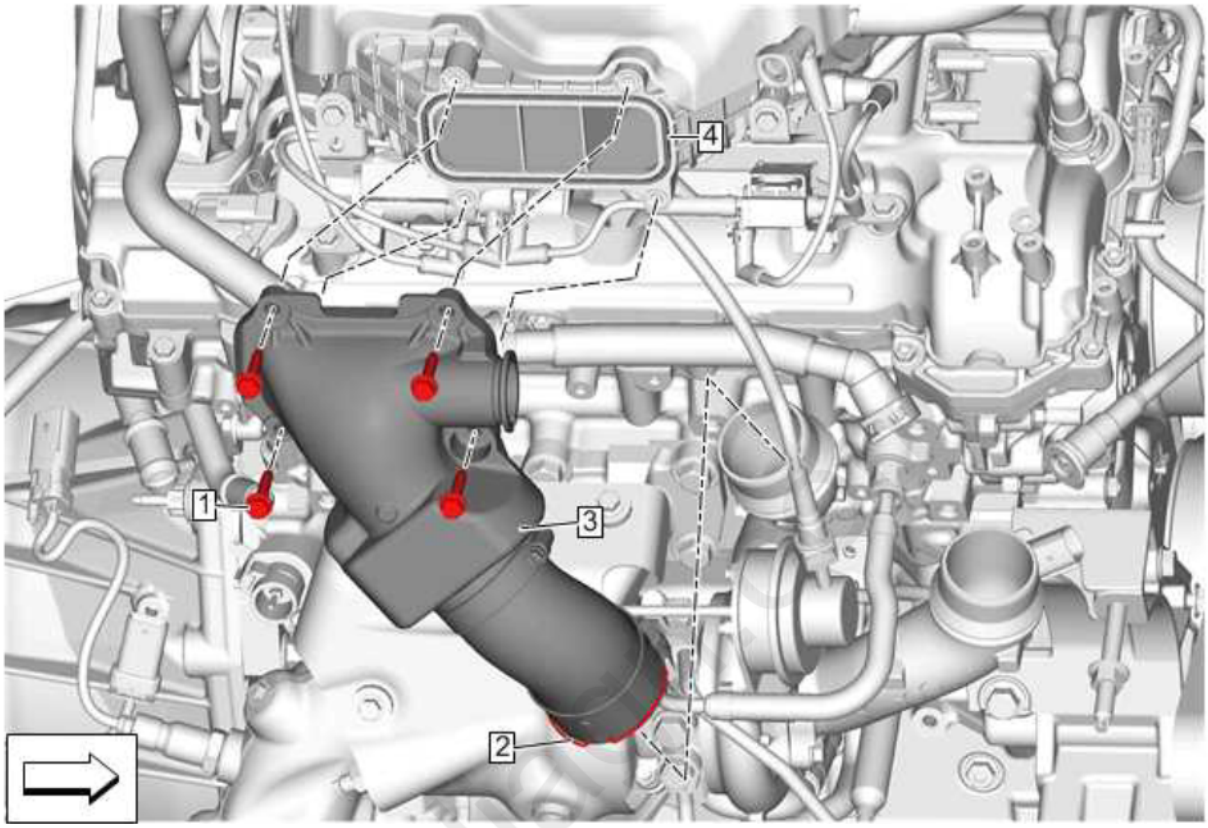

Fig. 282: Charge Air Cooler Inlet Air Tube (Right Side)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Intake Manifold Cover Replacement (LGW) Intake Manifold Cover Replacement (LGX) 2. Charge Air Bypass Valve Replacement - Right Side	
1	Charge Air Cooler Inlet Air Tube Bolt [4x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 9 N.m (80 lb in)
2	Charge Air Cooler Inlet Hose Quick Connector
3	Charge Air Cooler Inlet Air Tube
4	Charge Air Cooler Inlet Air Tube Seal **Procedure** Install a NEW seal.

CHARGE AIR COOLER INLET AIR TUBE REPLACEMENT (LEFT SIDE)

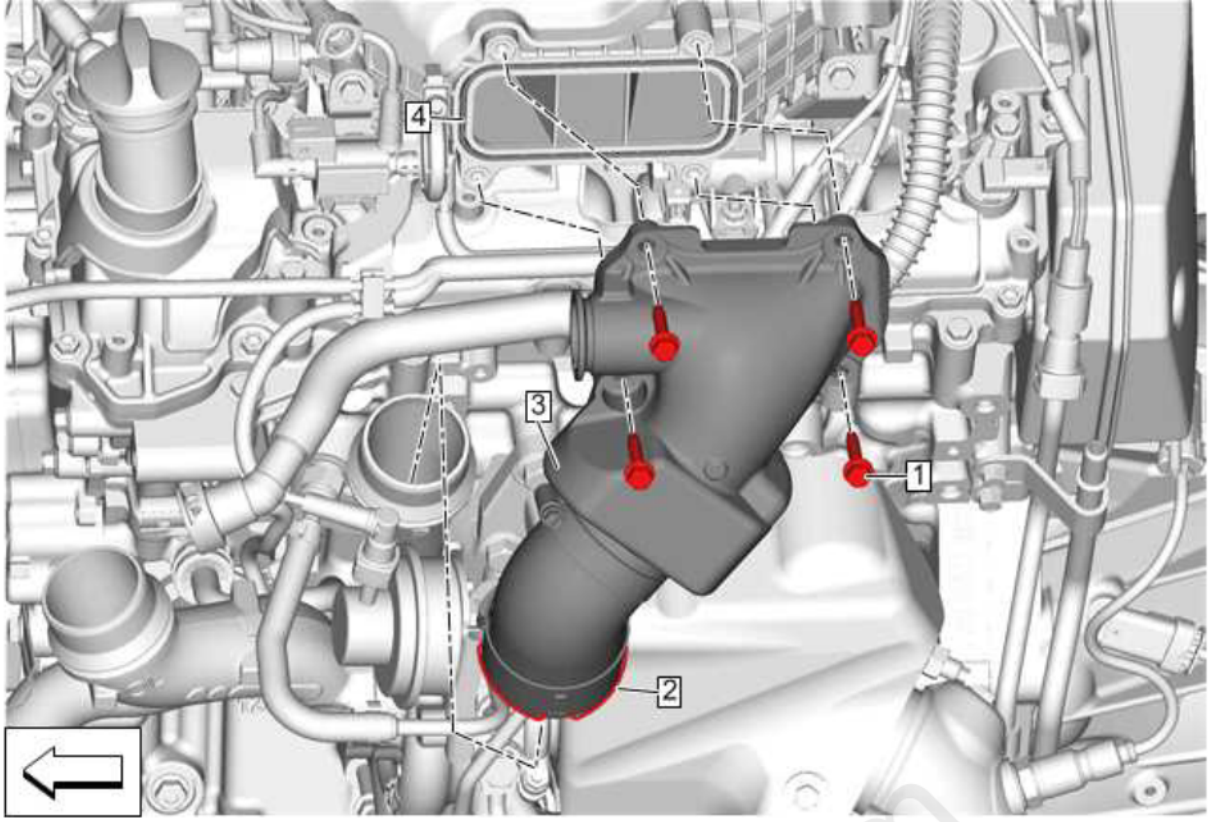

Fig. 283: Charge Air Cooler Inlet Air Tube
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Intake Manifold Cover Replacement (LGW) Intake Manifold Cover Replacement (LGX) 2. Charge Air Bypass Valve Replacement - Left Side 3. Air Conditioning Refrigerant Heat Exchanger Replacement (LGW, LGX)	
1	Charge Air Cooler Inlet Air Tube Bolt [4x] **CAUTION:** Refer to Fastener Caution . **Tighten** 9 N.m (80 lb in)
2	Charge Air Cooler Inlet Hose Quick Connector
3	Charge Air Cooler Inlet Air Tube
4	Charge Air Cooler Inlet Air Tube Seal **Procedure** Install a NEW seal.

CHARGE AIR BYPASS VALVE SOLENOID REPLACEMENT (BANK 1)

Removal Procedure

1. Charge Air Cooler Cover Replacement Â» Remove
2. Turbocharger Wastegate Regulator Solenoid Valve - Bank 1Â» Remove Turbocharger Wastegate Regulator Solenoid Valve Replacement (Bank 1)
3. Electrical Connector (1)Â» Disconnect

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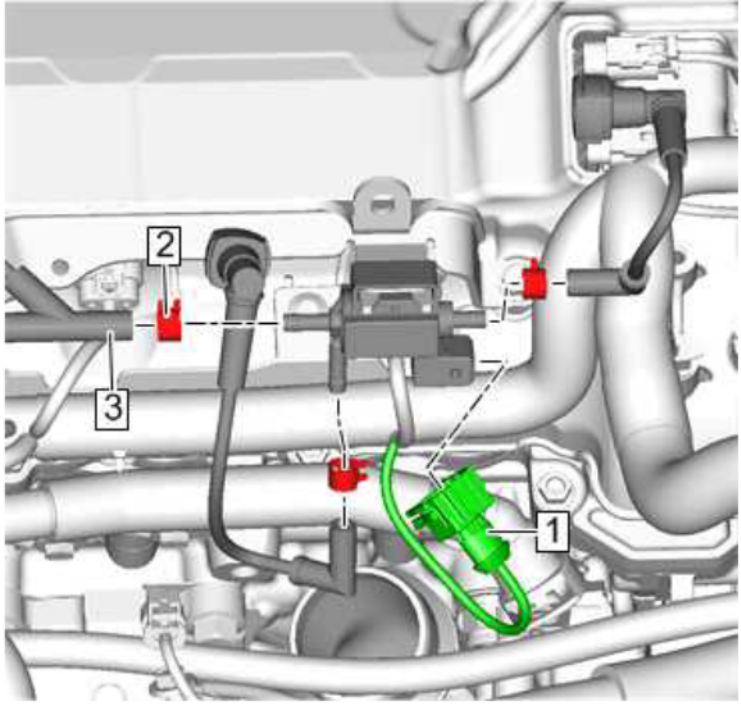

Fig. 284: Electrical Connector, Hose Clamp And Vacuum Hose
Courtesy of GENERAL MOTORS COMPANY

4. Hose Clamp (2)Â» Disengage [3x] - **Hose Clamp Replacement Guidelines - Spring Type**
5. Vacuum Hose (3)Â» Disconnect [3x]
6. Bolt (1)Â» Remove [2x]

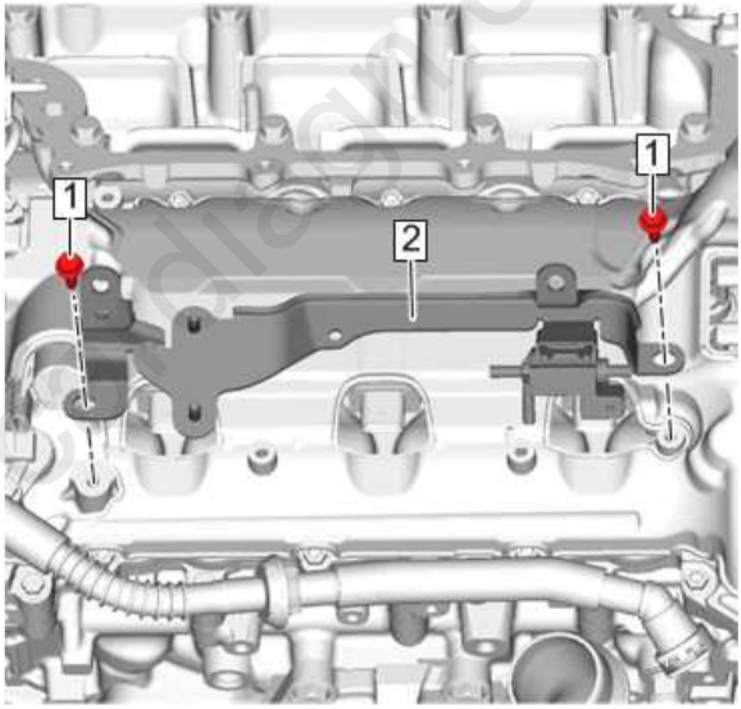

Fig. 285: Turbocharger Wastegate Actuator Vacuum Control Solenoid Valve Bracket And Retaining Bolt
Courtesy of GENERAL MOTORS COMPANY

7. Turbocharger Wastegate Actuator Vacuum Control Solenoid Valve Bracket (2)Â» Remove

Installation Procedure

1. Turbocharger Wastegate Actuator Vacuum Control Solenoid Valve Bracket (2)Â» Install

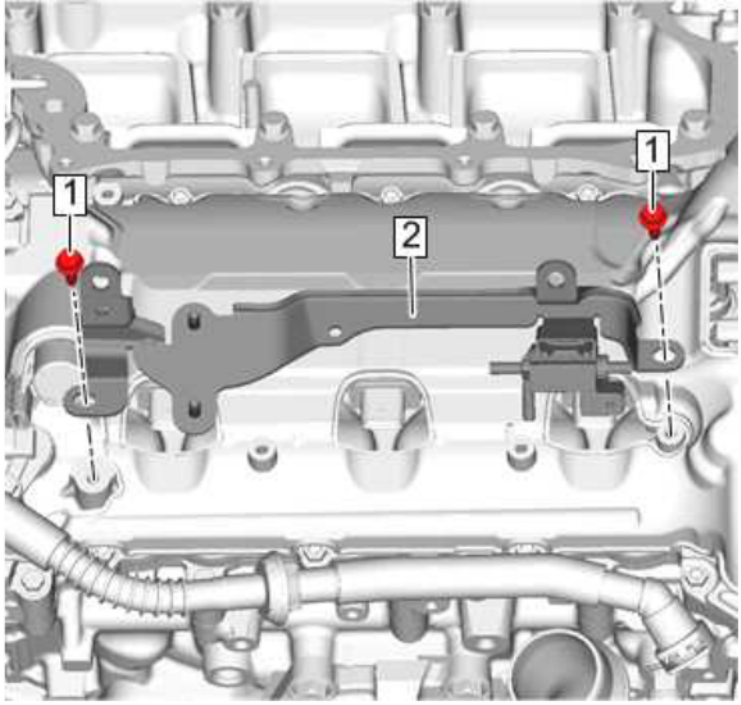

Fig. 286: Turbocharger Wastegate Actuator Vacuum Control Solenoid Valve Bracket And Retaining Bolt
Courtesy of GENERAL MOTORS COMPANY

2. Bolt (1)Â» Install and tighten [2x] 10 N.m (89 lb in)

CAUTION: Refer to Fastener Caution .

3. Vacuum Hose (3)Â» Connect [3x]

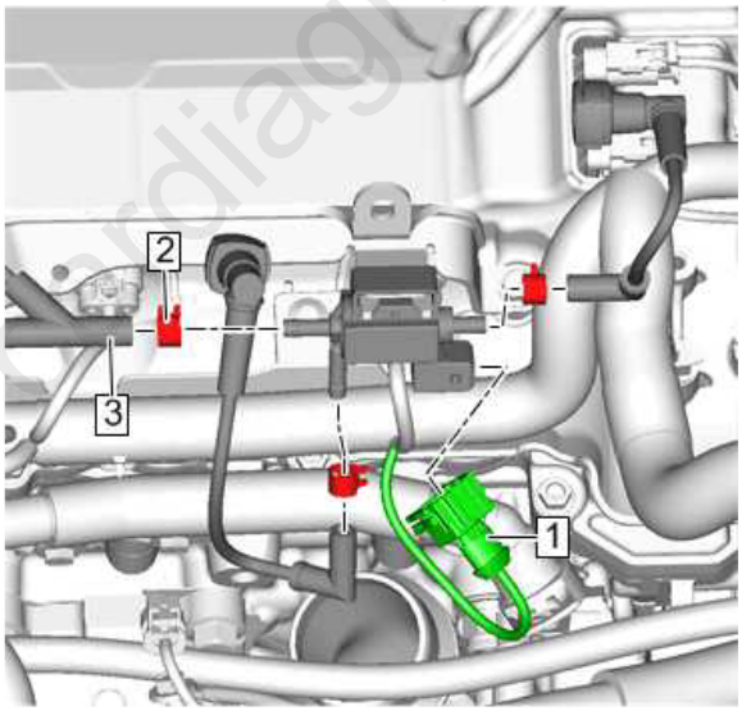

Fig. 287: Electrical Connector, Hose Clamp And Vacuum Hose
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Solenoid Valve Caution .

4. Hose Clamp (2)Â» Engage [3x] - Hose Clamp Replacement Guidelines - Spring Type
5. Electrical Connector (1)Â» Connect
6. Turbocharger Wastegate Regulator Solenoid Valve - Bank 1Â» Install Turbocharger Wastegate Regulator Solenoid Valve Replacement (Bank 1)
7. Charge Air Cooler Cover Replacement Â» Install

CHARGE AIR BYPASS VALVE SOLENOID REPLACEMENT (BANK 2)

Removal Procedure

1. **Charge Air Cooler Cover Replacement** Â» Remove
2. Turbocharger Wastegate Regulator Solenoid Valve - Bank 2Â» Remove **Turbocharger Wastegate Regulator Solenoid Valve Replacement (Bank 2)**
3. Retainer (1)Â» Unclip [2x]

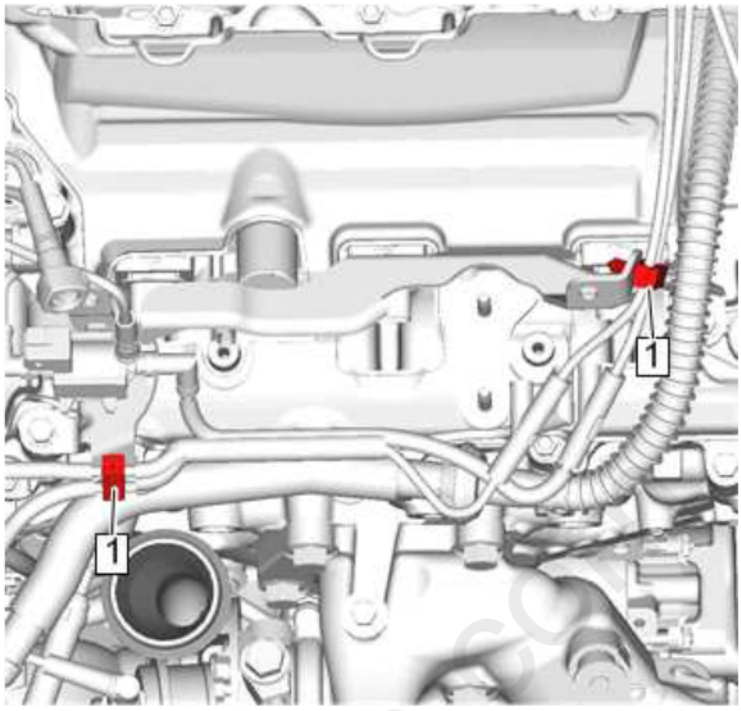

Fig. 288: Retainers
Courtesy of GENERAL MOTORS COMPANY

4. Electrical Connector (1)Â» Disconnect

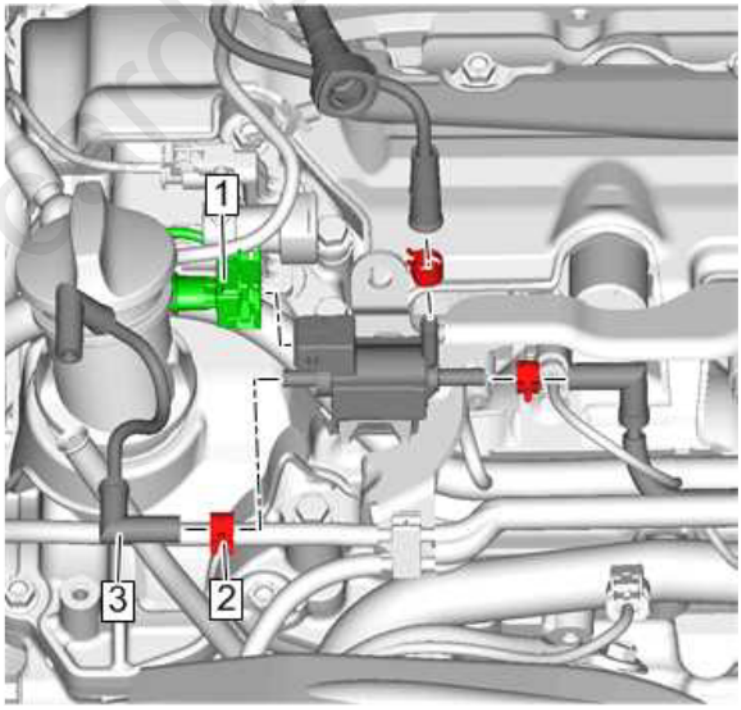

Fig. 289: Electrical Connector, Hose Clamp And Vacuum Hose
Courtesy of GENERAL MOTORS COMPANY

5. Hose Clamp (2)Â» Disengage [3x] - **Hose Clamp Replacement Guidelines - Spring Type**
6. Vacuum Hose (3)Â» Disconnect [3x]
7. Bolt (1)Â» Remove [2x]

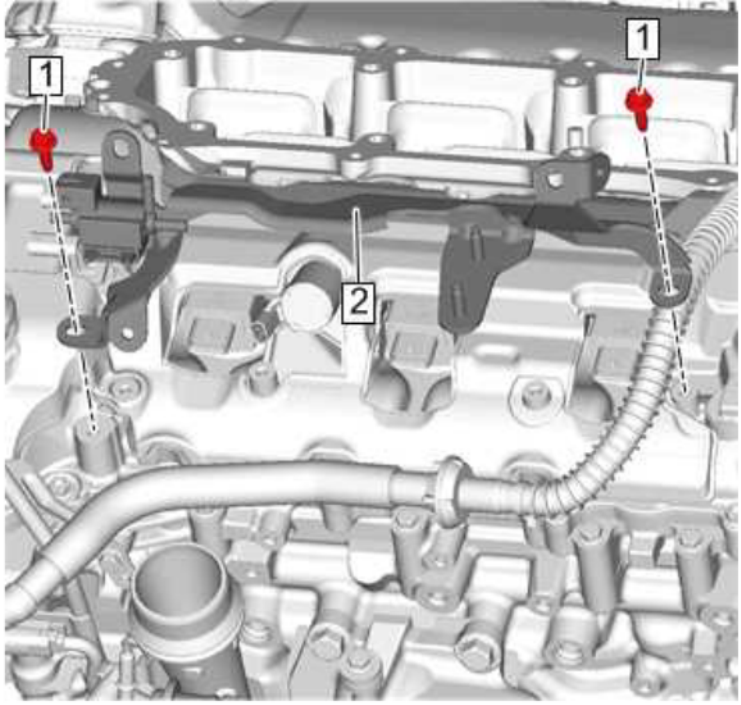

Fig. 290: Turbocharger Wastegate Actuator Vacuum Control Solenoid Valve Bracket And Retaining Bolt
Courtesy of GENERAL MOTORS COMPANY

8. Turbocharger Wastegate Actuator Vacuum Control Solenoid Valve Bracket (2)Â» Remove

Installation Procedure

1. Turbocharger Wastegate Actuator Vacuum Control Solenoid Valve Bracket (2)Â» Install

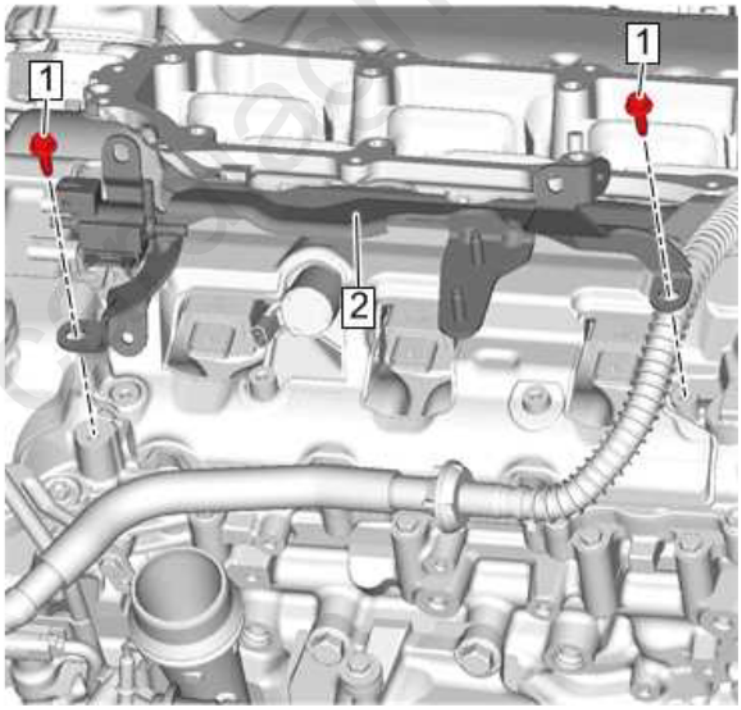

Fig. 291: Turbocharger Wastegate Actuator Vacuum Control Solenoid Valve Bracket And Retaining Bolt
Courtesy of GENERAL MOTORS COMPANY

2. Bolt (1)Â» Install and tighten [2x] 10 N.m (89 lb in)

CAUTION: **Refer to Fastener Caution .**

3. Vacuum Hose (3)Â» Connect [3x]

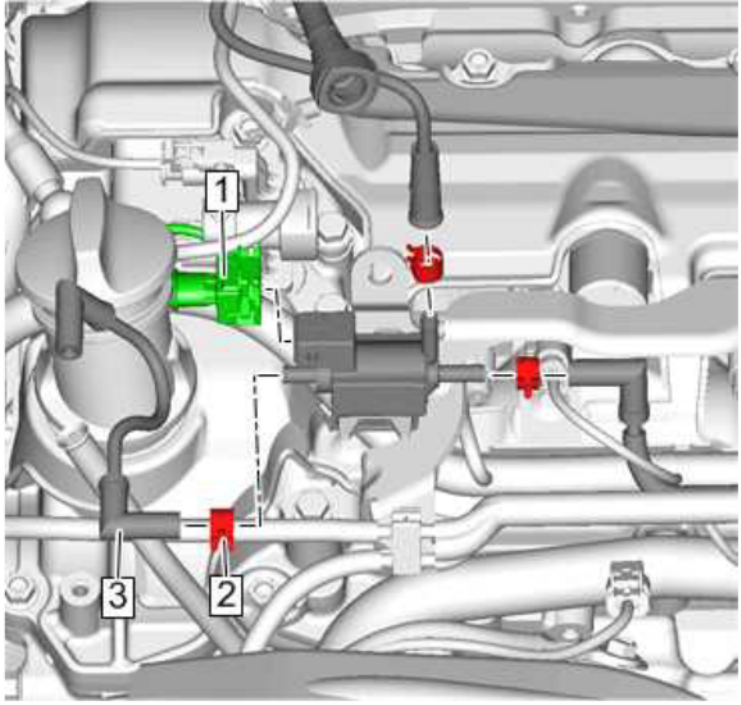

Fig. 292: Electrical Connector, Hose Clamp And Vacuum Hose
Courtesy of GENERAL MOTORS COMPANY

CAUTION: Refer to Solenoid Valve Caution .

4. Hose Clamp (2)Â» Engage [3x] - Hose Clamp Replacement Guidelines - Spring Type
5. Electrical Connector (1)Â» Connect
6. Retainer (1)Â» Install [2x]

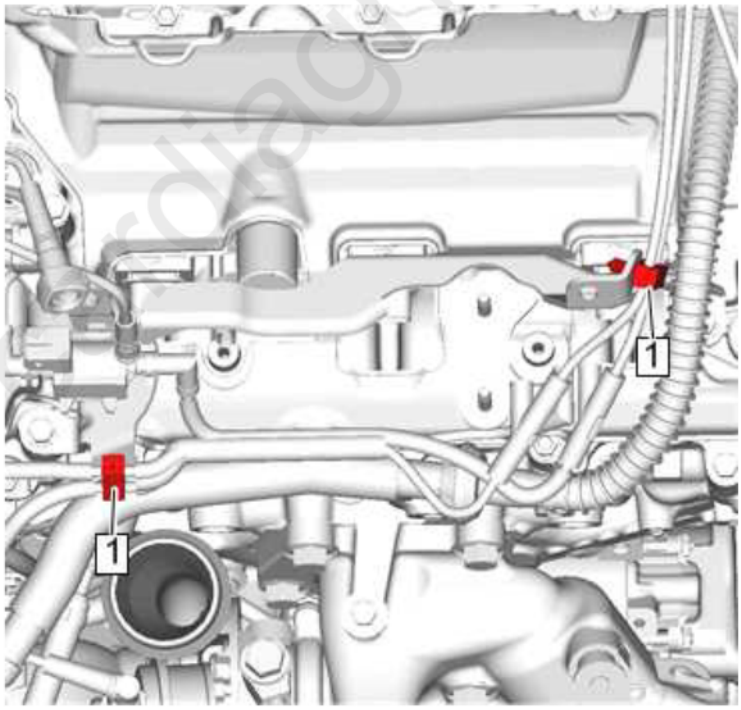

Fig. 293: Retainers
Courtesy of GENERAL MOTORS COMPANY

7. Turbocharger Wastegate Regulator Solenoid Valve - Bank 2Â» Install Turbocharger Wastegate Regulator Solenoid Valve Replacement (Bank 2)
8. Charge Air Cooler Cover Replacement Â» Install

CHARGE AIR BYPASS VALVE VACUUM TANK TUBE REPLACEMENT (RIGHT SIDE)

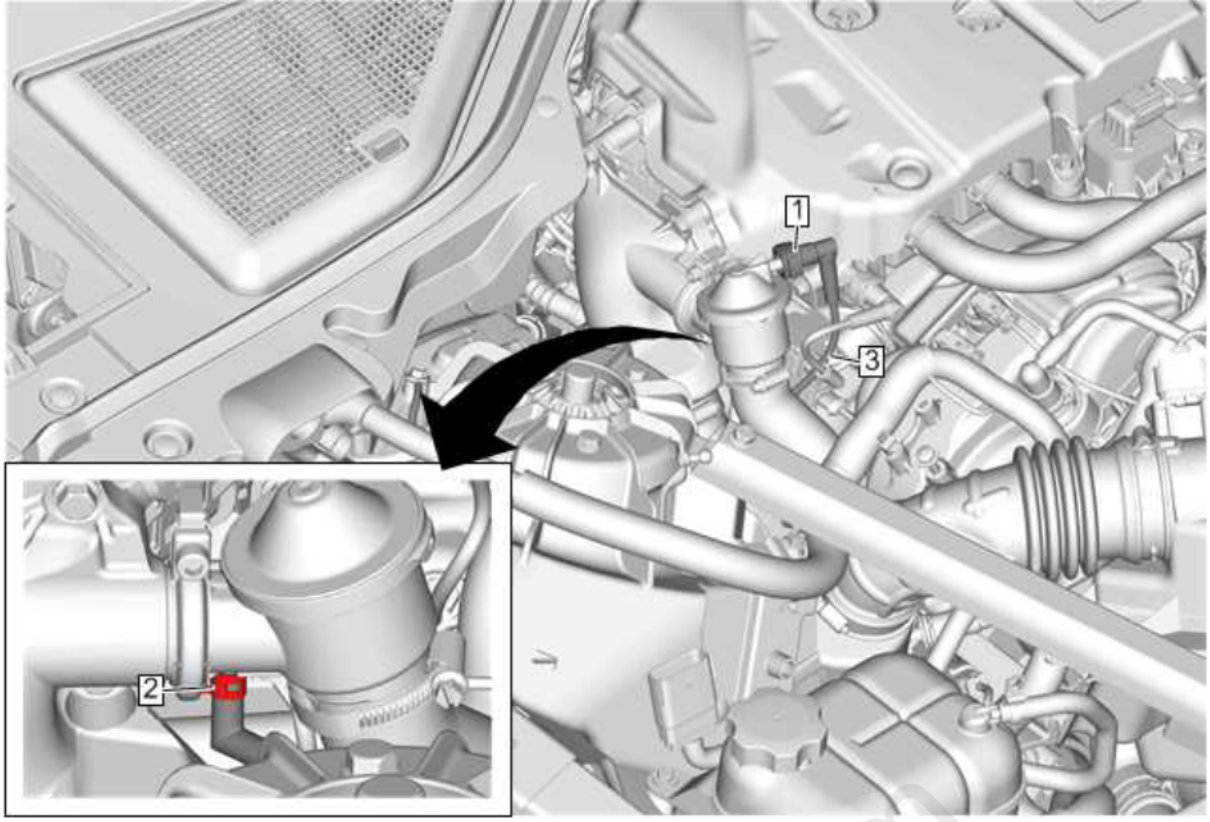

Fig. 294: Charge Air Bypass Valve Vacuum Tank Tube (Right Side)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Intake Manifold Cover Replacement (LGW) Intake Manifold Cover Replacement (LGX)	
1	Quick Connect Fitting **Procedure** Plastic Collar Quick Connect Fitting Service
2	Hose Clamp **Procedure** Hose Clamp Replacement Guidelines - Spring Type
3	Charge Air Bypass Valve Vacuum Source Tube

CHARGE AIR BYPASS VALVE VACUUM TANK TUBE REPLACEMENT (LEFT SIDE)

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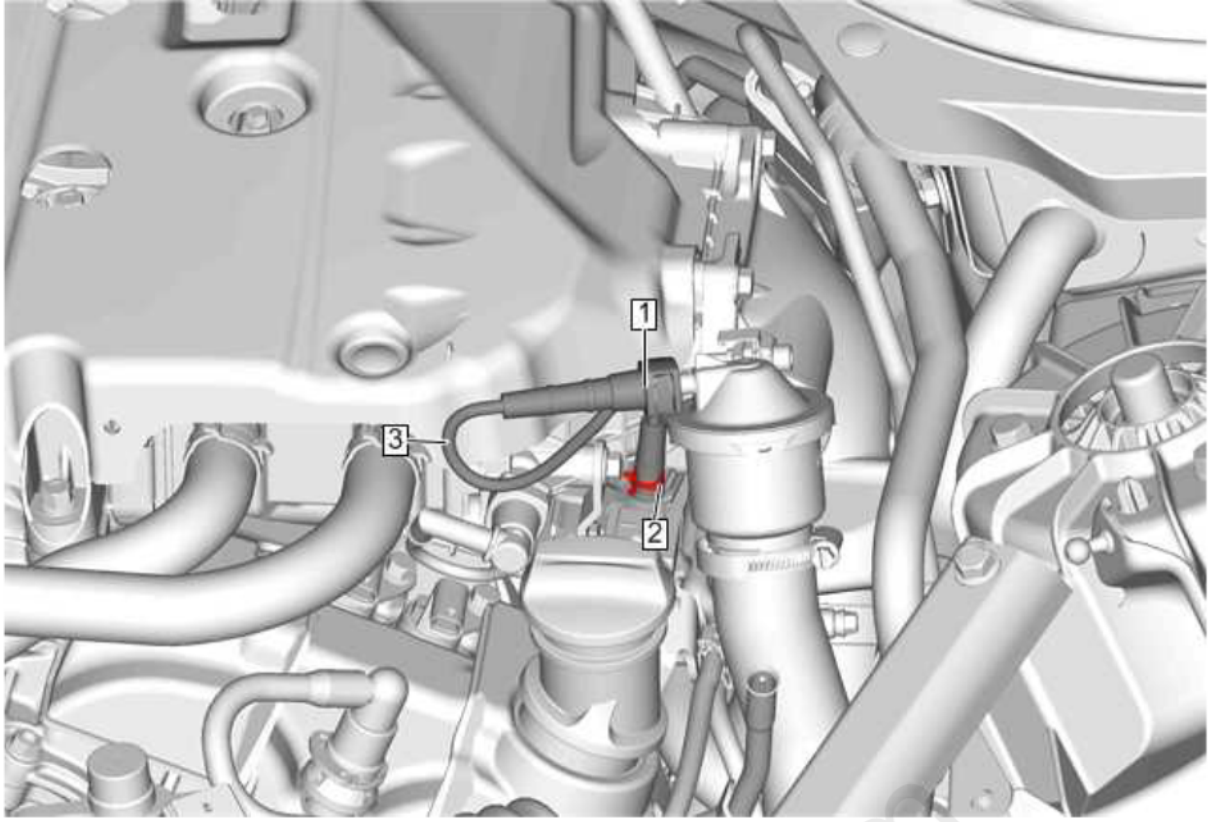

Fig. 295: Charge Air Bypass Valve Vacuum Tank Tube (Left Side)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Intake Manifold Cover Replacement (LGW) Intake Manifold Cover Replacement (LGX)	
1	Quick Connect Fitting **Procedure** Plastic Collar Quick Connect Fitting Service
2	Hose Clamp **Procedure** Hose Clamp Replacement Guidelines - Spring Type
3	Charge Air Bypass Valve Vacuum Source Tube

CHARGE AIR BYPASS VALVE REPLACEMENT - RIGHT SIDE

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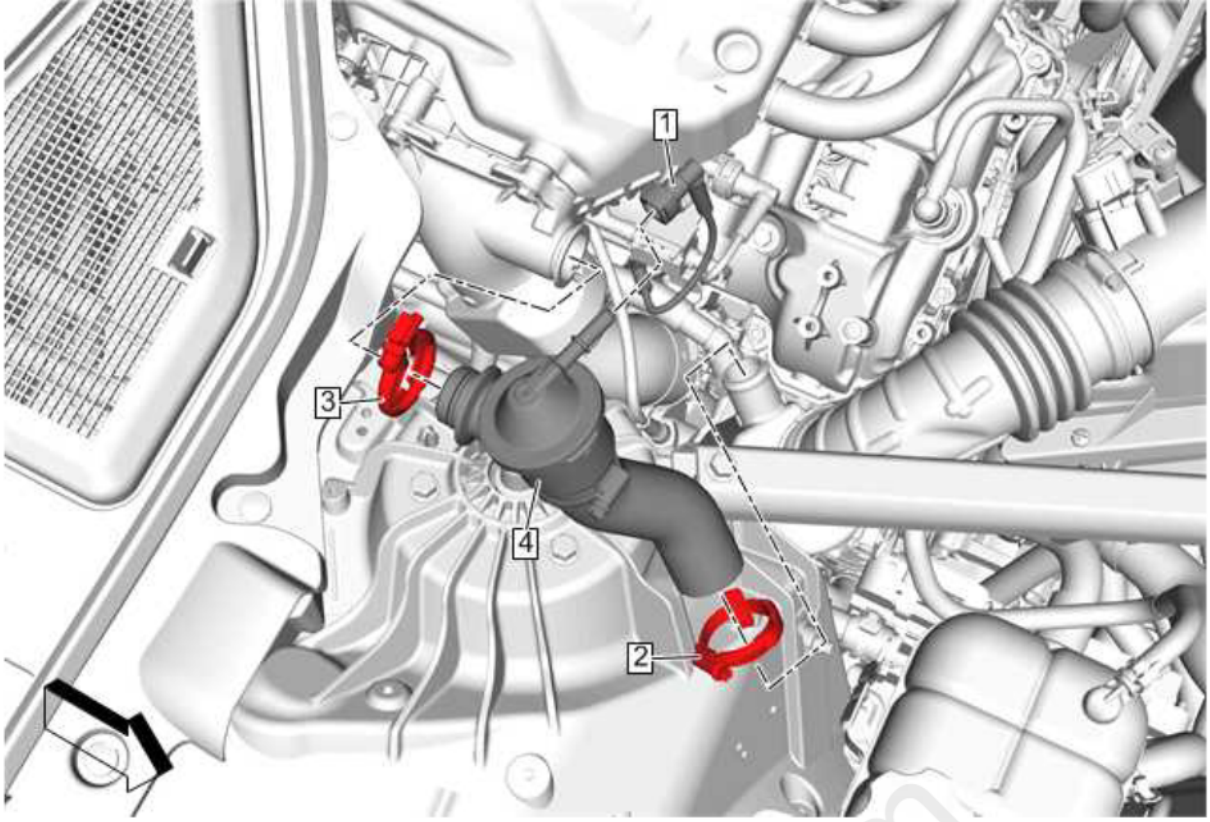

Fig. 296: Charge Air Bypass Valve - Right Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Intake Manifold Cover Replacement (LGW) Intake Manifold Cover Replacement (LGX)	
1	Charge Air Bypass Valve Vacuum Source Tube Plastic Collar Quick Connect Fitting Service
2	Charge Air Bypass Valve Hose Clamp **CAUTION:** **Refer to Fastener Caution .** **Tighten** 3.5 N.m (31 lb in)
3	Charge Air Bypass Valve Tube Clamp **Tighten** 3.5 N.m (31 lb in)
4	Charge Air Bypass Valve

CHARGE AIR BYPASS VALVE REPLACEMENT - LEFT SIDE

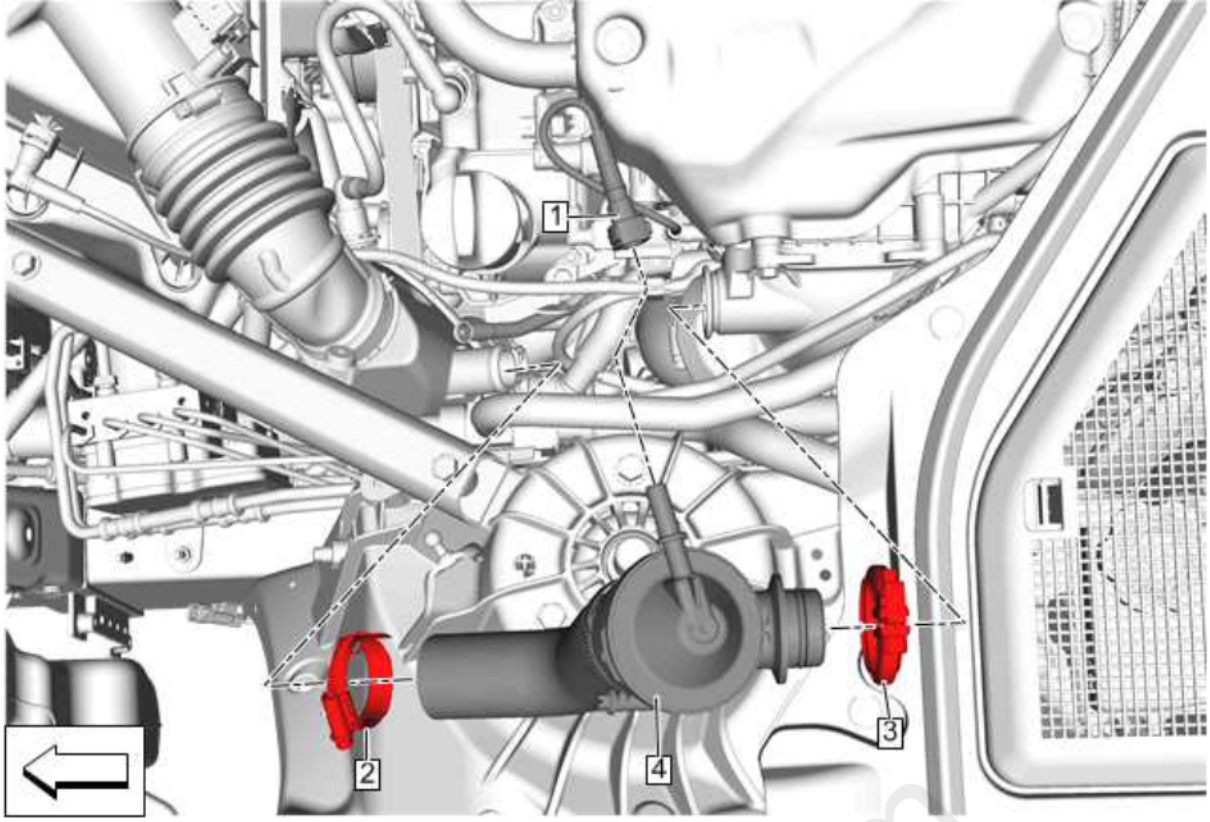

Fig. 297: Charge Air Bypass Valve - Left Side
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Intake Manifold Cover Replacement (LGW) Intake Manifold Cover Replacement (LGX)	
1	Charge Air Bypass Valve Vacuum Source Tube Plastic Collar Quick Connect Fitting Service
2	Charge Air Bypass Valve Hose Clamp **CAUTION:** **Refer to Fastener Caution .** **Tighten** 3.5 N.m (31 lb in)
3	Charge Air Bypass Valve Tube Clamp **Tighten** 3.5 N.m (31 lb in)
4	Charge Air Bypass Valve

TURBOCHARGER AIR INLET ADAPTER REPLACEMENT - BANK 1

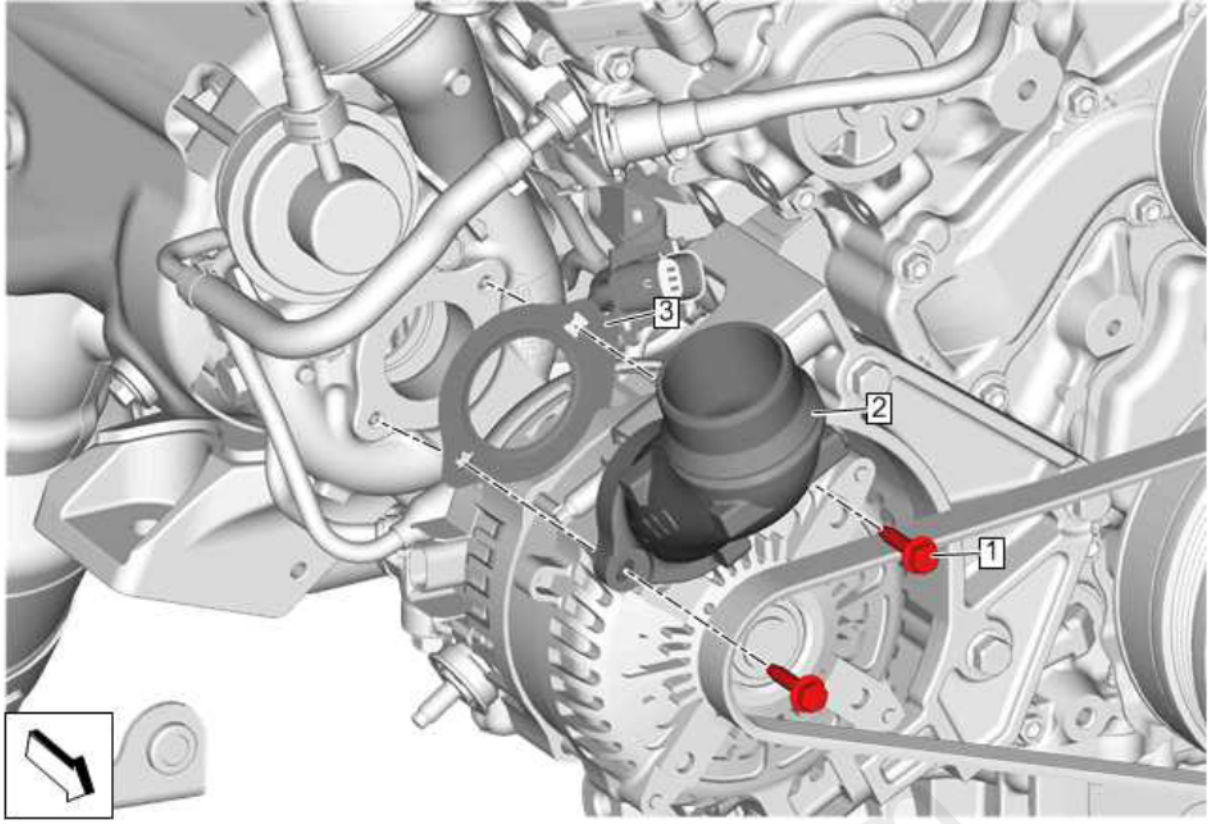

Fig. 298: Turbocharger Air Inlet Adapter - Bank 1
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Intake Manifold Cover Replacement (LGW) Intake Manifold Cover Replacement (LGX) 2. Air Cleaner Outlet Rear Duct Replacement (LGW)	
1	Turbocharger Air Inlet Adapter Bolt [2x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
2	Turbocharger Air Inlet Adapter
3	Turbocharger Air Inlet Adapter Seal **Procedure** Install a NEW seal.

TURBOCHARGER AIR INLET ADAPTER REPLACEMENT - BANK 2

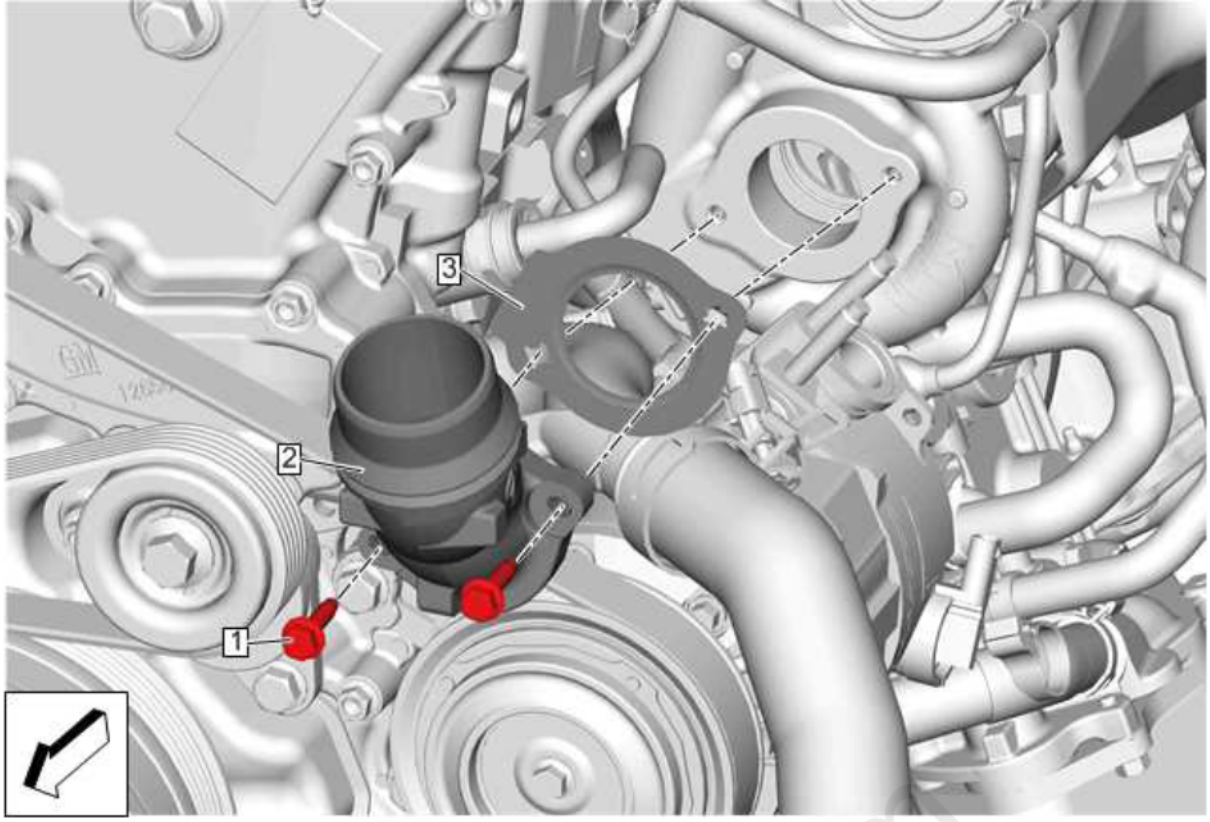

Fig. 299: Turbocharger Air Inlet Adapter - Bank 2
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Intake Manifold Cover Replacement (LGW) Intake Manifold Cover Replacement (LGX) 2. Air Cleaner Outlet Front Duct Replacement (LGW)	
1	Turbocharger Air Inlet Adapter Bolt [2x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 10 N.m (89 lb in)
2	Turbocharger Air Inlet Adapter
3	Turbocharger Air Inlet Adapter Seal **Procedure** Install a NEW seal.

INTAKE AIR PRESSURE AND TEMPERATURE SENSOR REPLACEMENT

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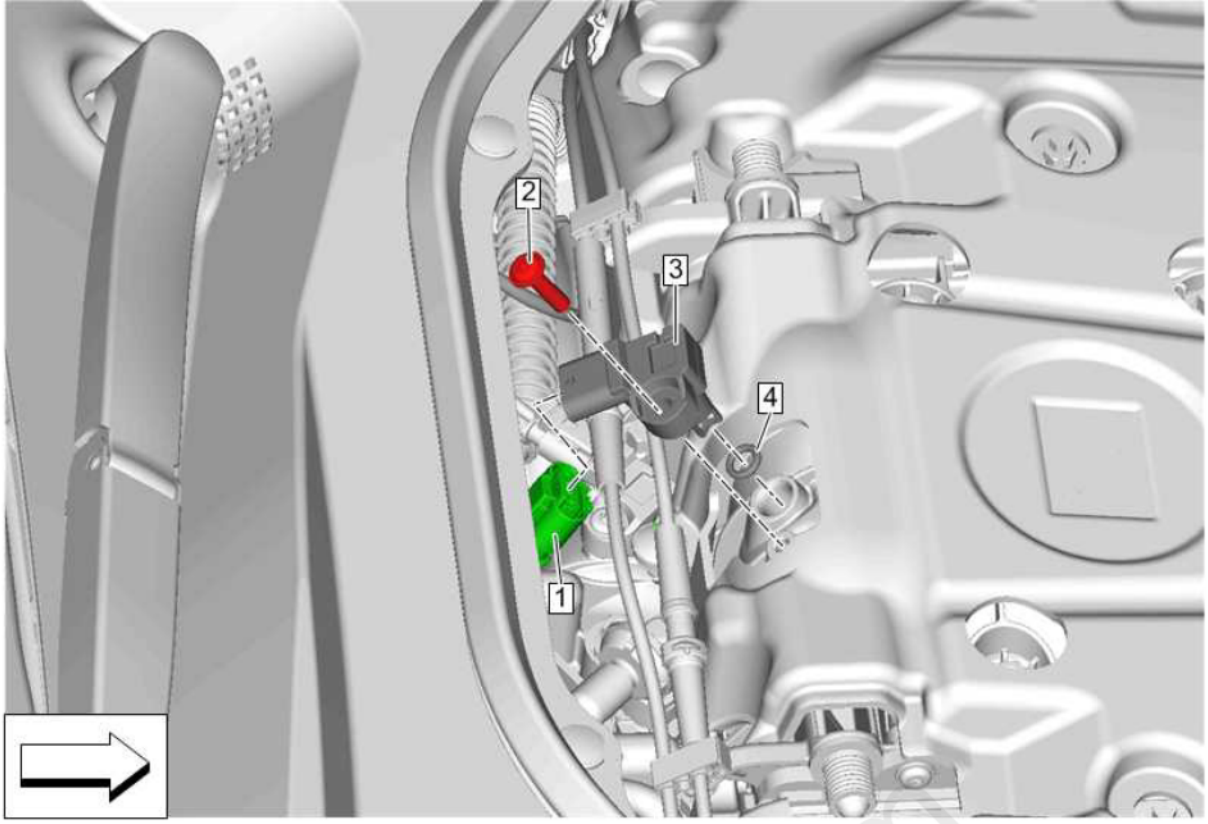

Fig. 300: Intake Air Pressure and Temperature Sensor
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedure Intake Manifold Cover Replacement (LGW) Intake Manifold Cover Replacement (LGX)	
1	Electrical Connector
2	Intake Air Pressure and Temperature Sensor Bolt **CAUTION:** **Refer to Fastener Caution .** **Tighten:** 4 N.m (35 lb in)
3	Intake Air Pressure and Temperature Sensor
4	O-Ring **Procedure** Install a NEW O-ring seal.

VACUUM PUMP PIPE REPLACEMENT (TO BRAKE BOOSTER VACUUM HOSE)

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle**
2. Left Side Warm Up Three-Way Catalytic ConverterÂ» Remove - **Warm Up Three-Way Catalytic Converter Replacement (Left, LGW) Warm Up Three-Way Catalytic Converter Replacement (Right, LGW) Warm Up Three-Way Catalytic Converter Replacement (Left, LGX) Warm Up Three-Way Catalytic Converter Replacement (Right, LGX)**
3. Power Brake Booster Vacuum Hose (1)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**

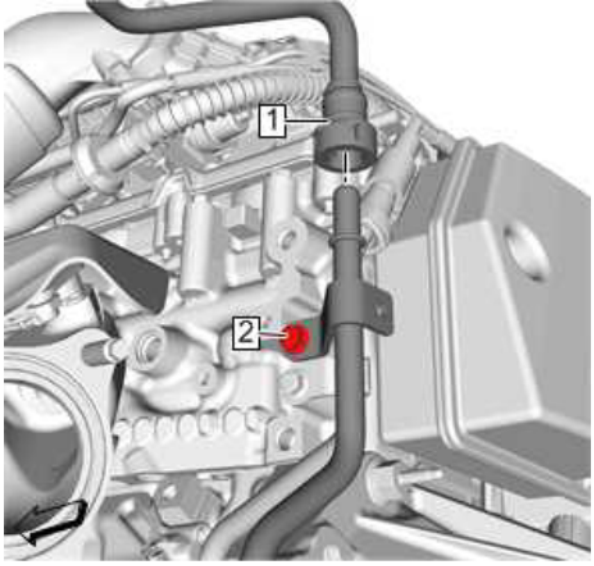

Fig. 301: Power Brake Booster Vacuum Hose And Vacuum Pump Pipe Retaining Bolt
Courtesy of GENERAL MOTORS COMPANY

4. Vacuum Pump Pipe Bolt (2)Â» Remove
5. Vacuum Pump Pipe Bolt (1)Â» Remove

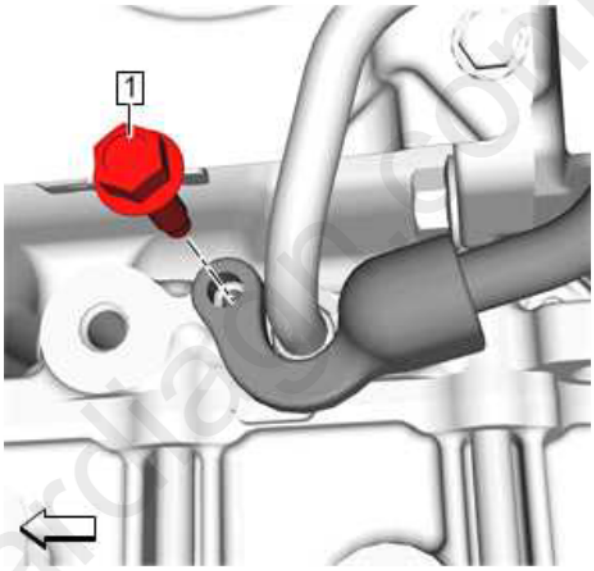

Fig. 302: Vacuum Pump Pipe Bolt
Courtesy of GENERAL MOTORS COMPANY

6. Vacuum Pump Pipe (1)Â» Remove

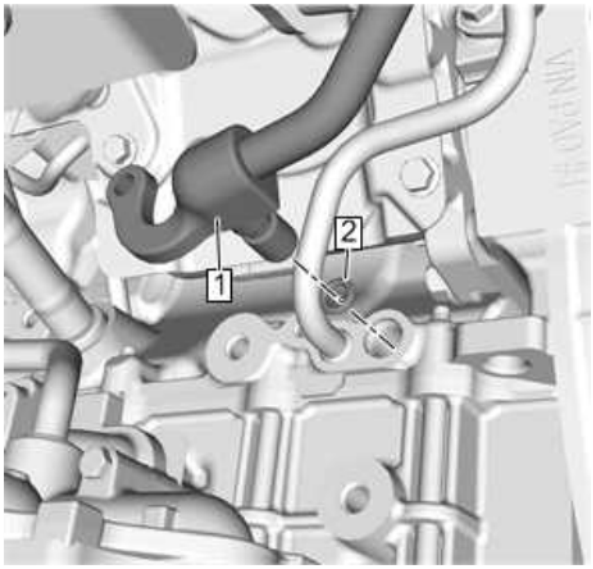

Fig. 303: Vacuum Pump Pipe And Seal
Courtesy of GENERAL MOTORS COMPANY

7. Vacuum Pump Pipe Seal (2)Â» Remove and DISCARD

Installation Procedure

1. Vacuum Pump Pipe Seal (2)Â» Install a NEW O-ring seal.

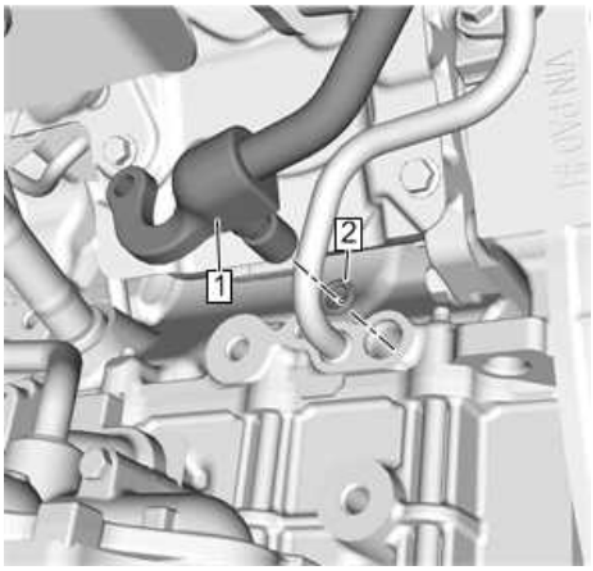

Fig. 304: Vacuum Pump Pipe And Seal
Courtesy of GENERAL MOTORS COMPANY

2. Vacuum Pump Pipe (1)Â» Install
3. Vacuum Pump Pipe Bolt (1)Â» Install and tighten 10 N.m (89 lb in)

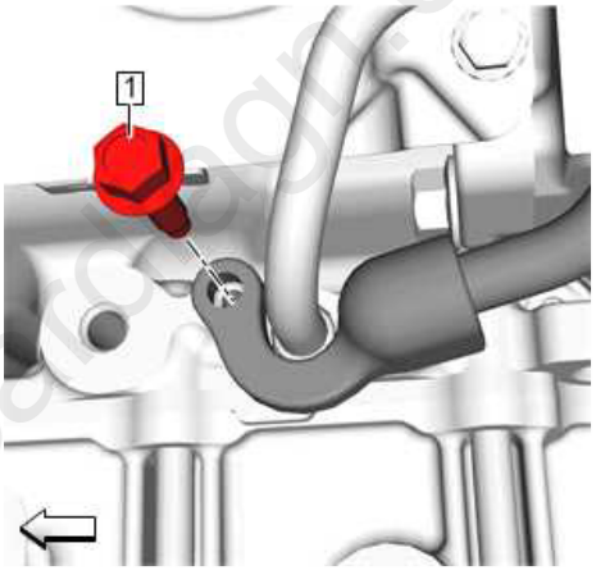

Fig. 305: Vacuum Pump Pipe Bolt
Courtesy of GENERAL MOTORS COMPANY

WARNING: **Refer to Fastener Caution .**

4. Vacuum Pump Pipe Bolt (2)Â» Install and tighten 10 N.m (89 lb in)

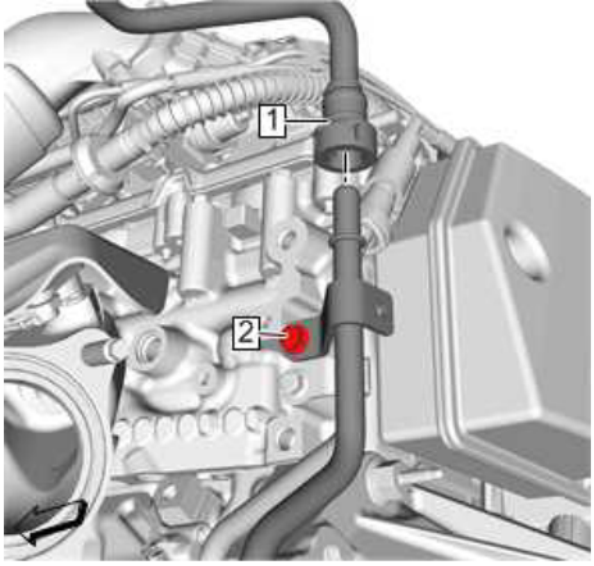

Fig. 306: Power Brake Booster Vacuum Hose And Vacuum Pump Pipe Retaining Bolt
Courtesy of GENERAL MOTORS COMPANY

5. Power Brake Booster Vacuum Hose (1)Â» Connect - **Plastic Collar Quick Connect Fitting Service**
6. Left Side Warm Up Three-Way Catalytic ConverterÂ» Install - **Warm Up Three-Way Catalytic Converter Replacement (Left, LGW) Warm Up Three-Way Catalytic Converter Replacement (Right, LGW) Warm Up Three-Way Catalytic Converter Replacement (Left, LGX) Warm Up Three-Way Catalytic Converter Replacement (Right, LGX)**
7. Lower the vehicle. Refer to **Lifting and Jacking the Vehicle**

VACUUM PUMP PIPE REPLACEMENT (TO TURBOCHARGER CONTROL SOLENOID VALVE VACUUM HOSE)

Removal Procedure

1. Raise and support the vehicle. Refer to **Lifting and Jacking the Vehicle**
2. Left Side Warm Up Three-Way Catalytic ConverterÂ» Remove - **Warm Up Three-Way Catalytic Converter Replacement (Left, LGW) Warm Up Three-Way Catalytic Converter Replacement (Right, LGW) Warm Up Three-Way Catalytic Converter Replacement (Left, LGX) Warm Up Three-Way Catalytic Converter Replacement (Right, LGX)**
3. Vacuum Pump Pipe to Brake Booster Vacuum HoseÂ» Remove - **Vacuum Pump Pipe Replacement (To Brake Booster Vacuum Hose)Vacuum Pump Pipe Replacement (To Turbocharger Control Solenoid Valve Vacuum Hose)**
4. Turbocharger Wastegate Actuator Vacuum Control Solenoid Valve Hose (1)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**

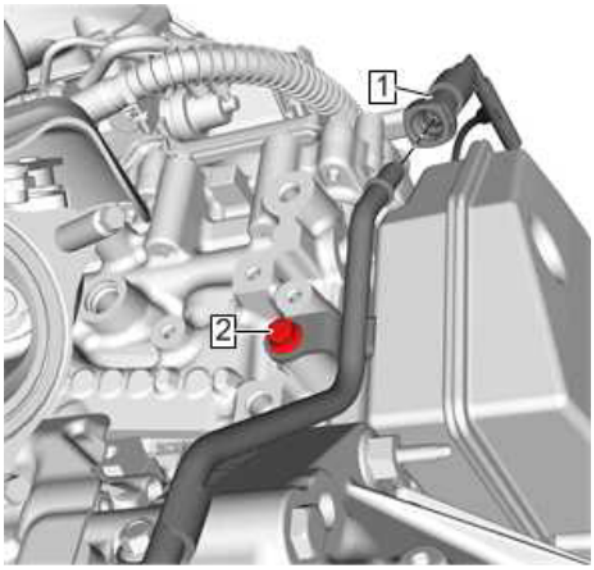

Fig. 307: Vacuum Pump Pipe Bolt
Courtesy of GENERAL MOTORS COMPANY

5. Vacuum Pump Pipe Bolt (2)Â» Remove
6. Vacuum Pump Pipe Bolt (1)Â» Remove

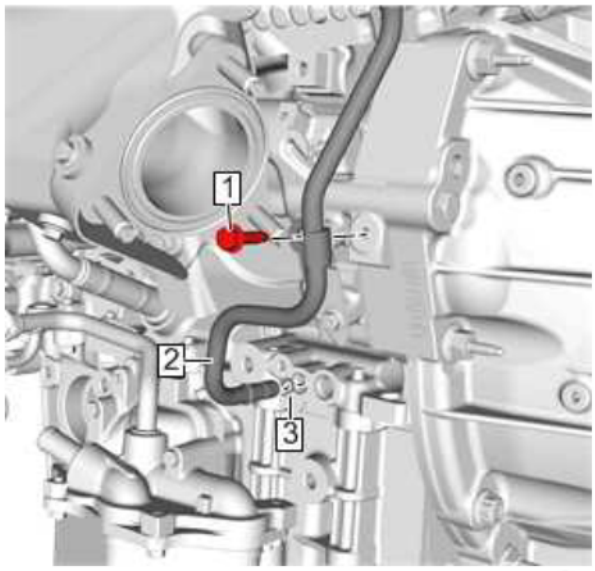

Fig. 308: Vacuum Pump Pipe, Retaining Bolt And Seal
Courtesy of GENERAL MOTORS COMPANY

7. Vacuum Pump Pipe (2)Â» Remove
8. Vacuum Pump Pipe Seal (3)Â» Remove and DISCARD

Installation Procedure

1. Vacuum Pump Pipe Seal (3)Â» Install a NEW O-ring seal.

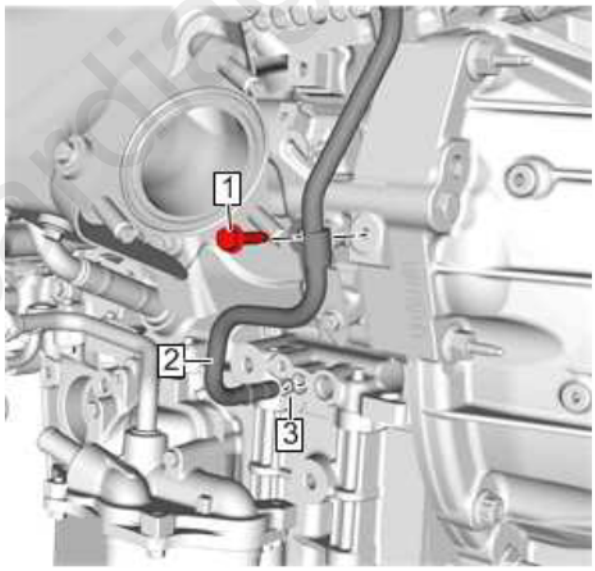

Fig. 309: Vacuum Pump Pipe, Retaining Bolt And Seal
Courtesy of GENERAL MOTORS COMPANY

2. Vacuum Pump Pipe (2)Â» Install
3. Vacuum Pump Pipe Bolt (1)Â» Install and tighten 10 N.m (89 lb in)

WARNING: **Refer to Fastener Caution .**

4. Vacuum Pump Pipe Bolt (2)Â» Install and tighten 10 N.m (89 lb in)

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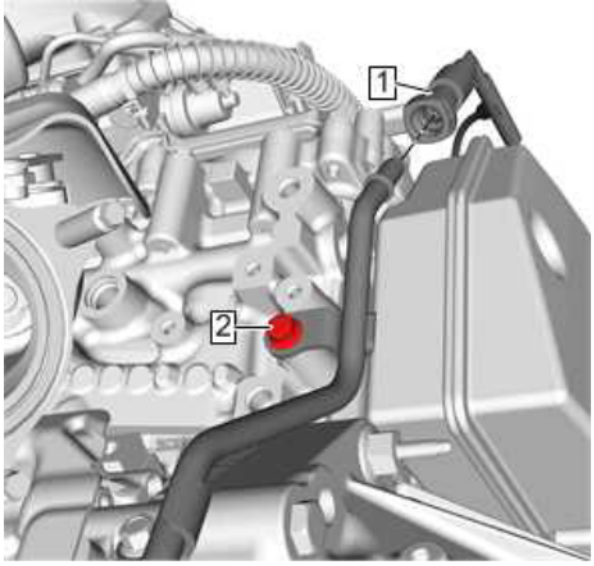

Fig. 310: Vacuum Pump Pipe Bolt
Courtesy of GENERAL MOTORS COMPANY

5. Turbocharger Wastegate Actuator Vacuum Control Solenoid Valve Hose (1)Â» Connect - **Plastic Collar Quick Connect Fitting Service**
6. Vacuum Pump Pipe to Brake Booster Vacuum HoseÂ» Install - **Vacuum Pump Pipe Replacement (To Brake Booster Vacuum Hose)Vacuum Pump Pipe Replacement (To Turbocharger Control Solenoid Valve Vacuum Hose)**
7. Left Side Warm Up Three-Way Catalytic ConverterÂ» Install - **Warm Up Three-Way Catalytic Converter Replacement (Left, LGW) Warm Up Three-Way Catalytic Converter Replacement (Right, LGW) Warm Up Three-Way Catalytic Converter Replacement (Left, LGX) Warm Up Three-Way Catalytic Converter Replacement (Right, LGX)**
8. Lower the vehicle. Refer to **Lifting and Jacking the Vehicle**

AIR CLEANER ELEMENT REPLACEMENT (LGW)

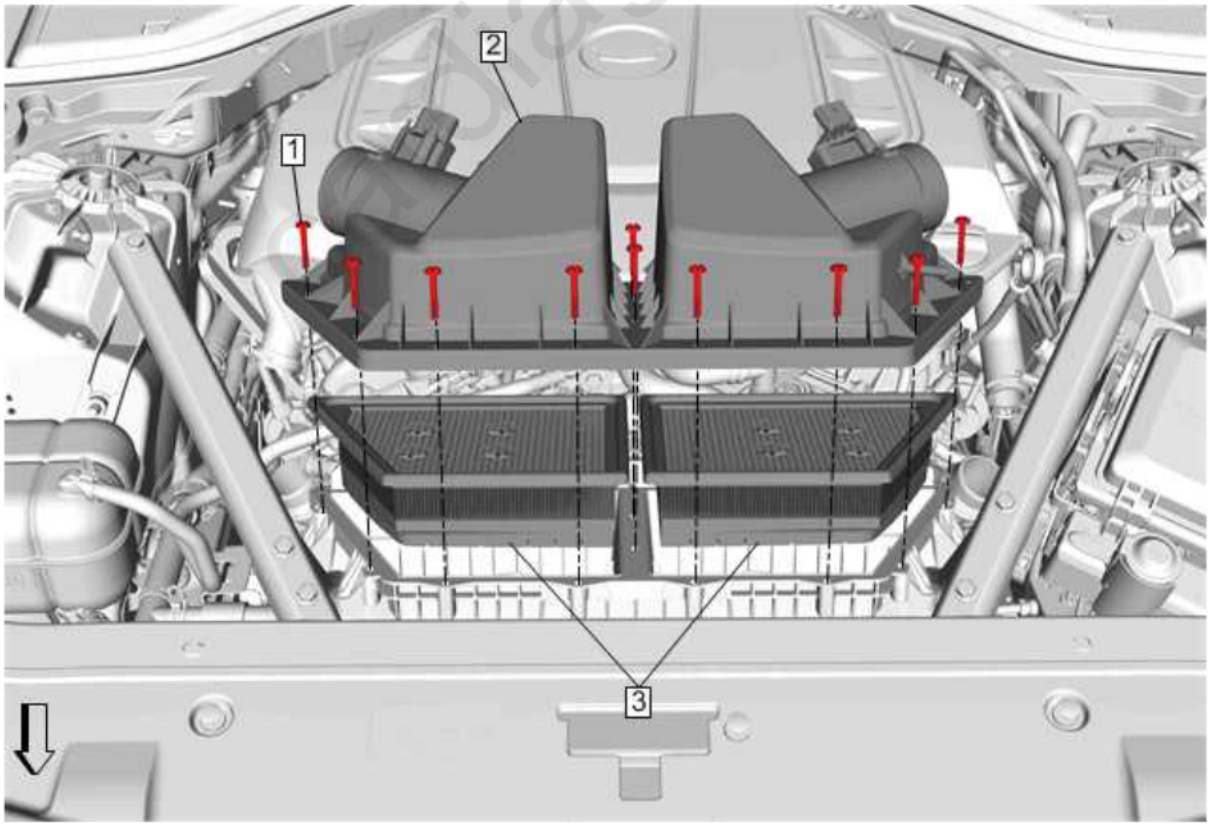

Fig. 311: Air Cleaner Element (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Callout	Component Name
Preliminary Procedures 1. Turbocharger Wastegate Actuator Vacuum Source Tube Replacement (Left Side)Turbocharger Wastegate Actuator Vacuum Source Tube Replacement (Right Side - Front)Turbocharger Wastegate Actuator Vacuum Source Tube Replacement (Right Side - Rear) @ Air Cleaner AssemblyÂ» Disconnect 2. Air Cleaner Outlet Rear Duct Replacement (LGW) @ Air Cleaner AssemblyÂ» Remove 3. Air Cleaner Outlet Front Duct Replacement (LGW) @ Air Cleaner AssemblyÂ» Remove 4. Intake Air Duct Replacement (LGW)Intake Air Duct Replacement (LGX) 5. Disconnect the electrical connector.	
1	Air Cleaner Upper Housing Bolt [10x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 4 N.m (35 lb in)
2	Air Cleaner Upper Housing
3	Air Cleaner Element [2x]

AIR CLEANER ELEMENT REPLACEMENT (LGX)

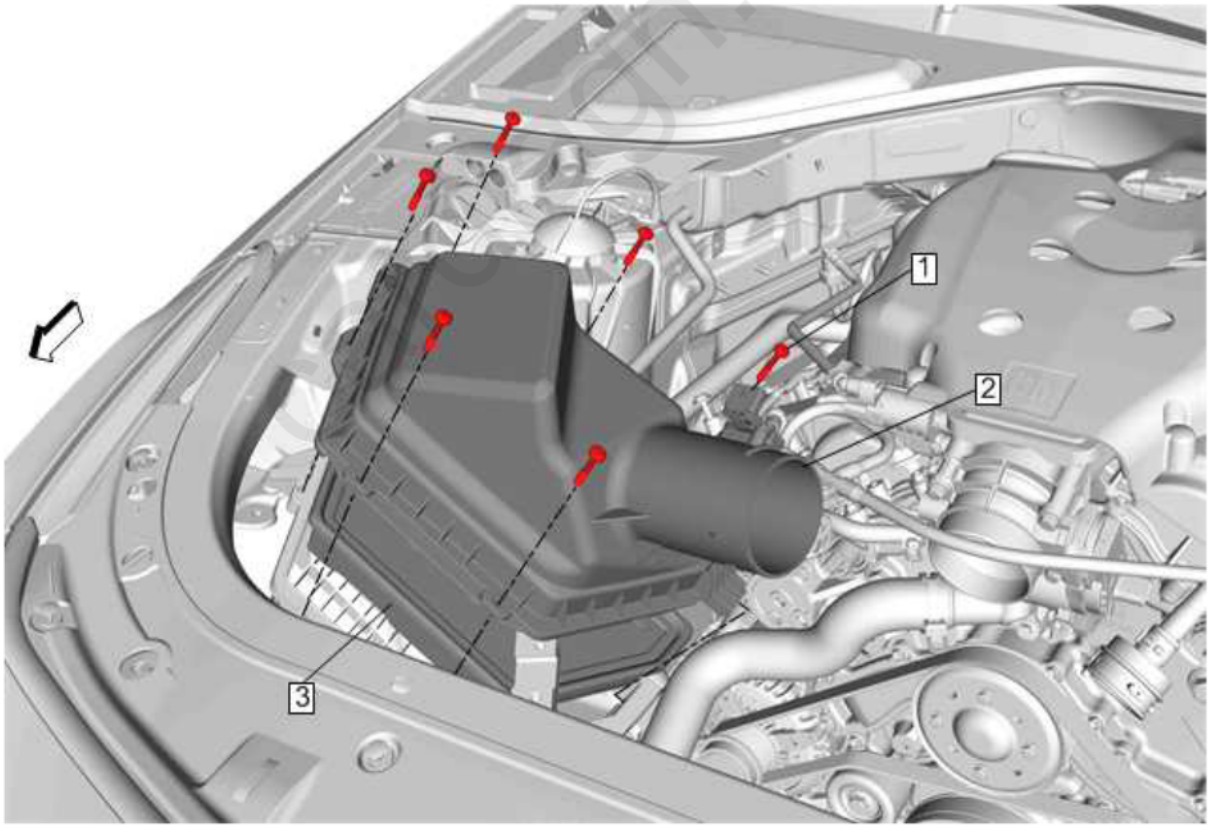

Fig. 312: Air Cleaner Element (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Callout	Component Name
Preliminary Procedures 1. **Front Wheelhouse Panel Brace Replacement (Rear)** **Front Wheelhouse Panel Brace Replacement (Front)** @ Front Â» Remove 2. **Air Cleaner Outlet Duct Replacement (LGX)** 3. Disconnect the electrical connector.	
1	Air Cleaner Upper Housing Bolt [6x] **CAUTION:** **Refer to Fastener Caution .** **Tighten** 4 N.m (35 lb in)
2	Air Cleaner Upper Housing
3	Air Cleaner Element

AIR CLEANER ASSEMBLY REPLACEMENT (LGW)

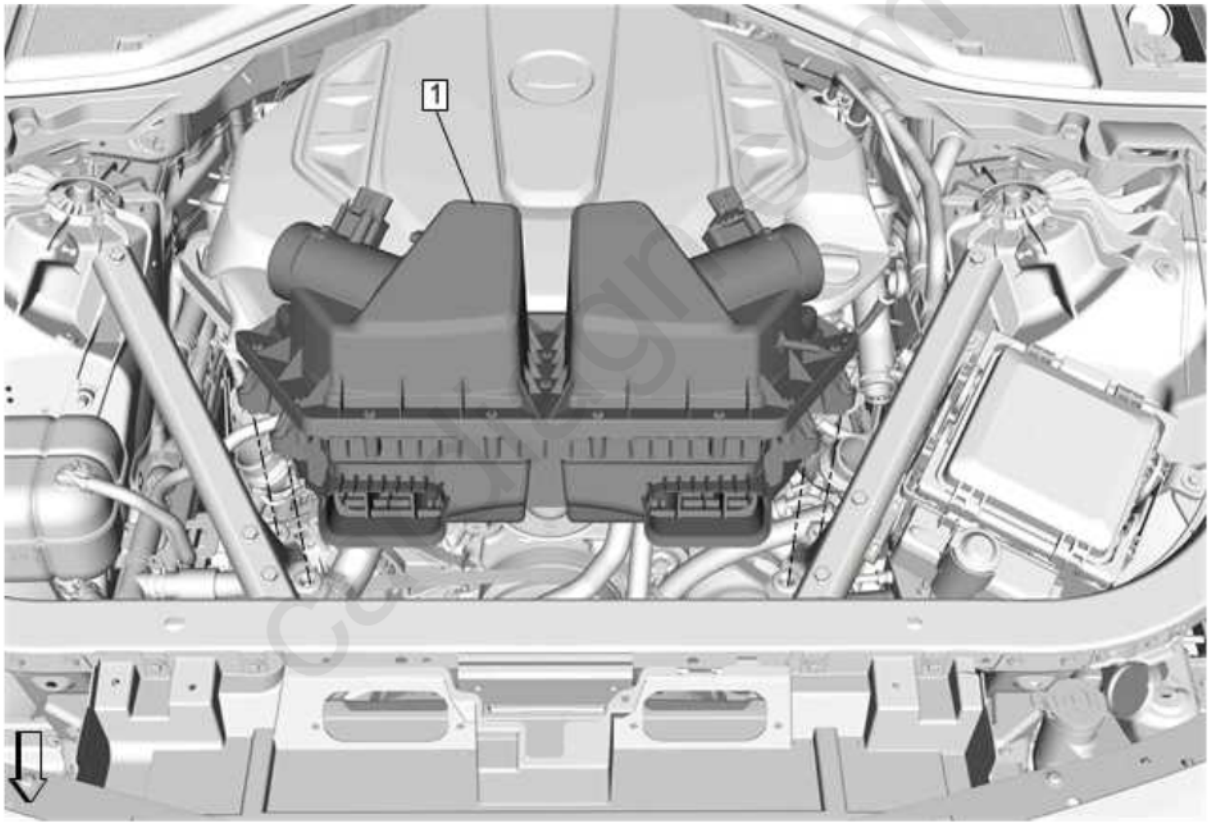

Fig. 313: Air Cleaner Assembly (LGW)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name

Callout	Component Name
Preliminary Procedures 1. Turbocharger Wastegate Actuator Vacuum Source Tube Replacement (Left Side)Turbocharger Wastegate Actuator Vacuum Source Tube Replacement (Right Side - Front)Turbocharger Wastegate Actuator Vacuum Source Tube Replacement (Right Side - Rear) @ Air Cleaner AssemblyÂ» Disconnect 2. Air Cleaner Outlet Rear Duct Replacement (LGW) @ Air Cleaner AssemblyÂ» Remove 3. Air Cleaner Outlet Front Duct Replacement (LGW) @ Air Cleaner AssemblyÂ» Remove 4. Intake Air Duct Replacement (LGW) 5. Disconnect the electrical connector.	
1	Air Cleaner Assembly **Procedure** 1. Remove the air cleaner housing from the retainers. 2. Transfer parts as necessary.

AIR CLEANER ASSEMBLY REPLACEMENT (LGX)

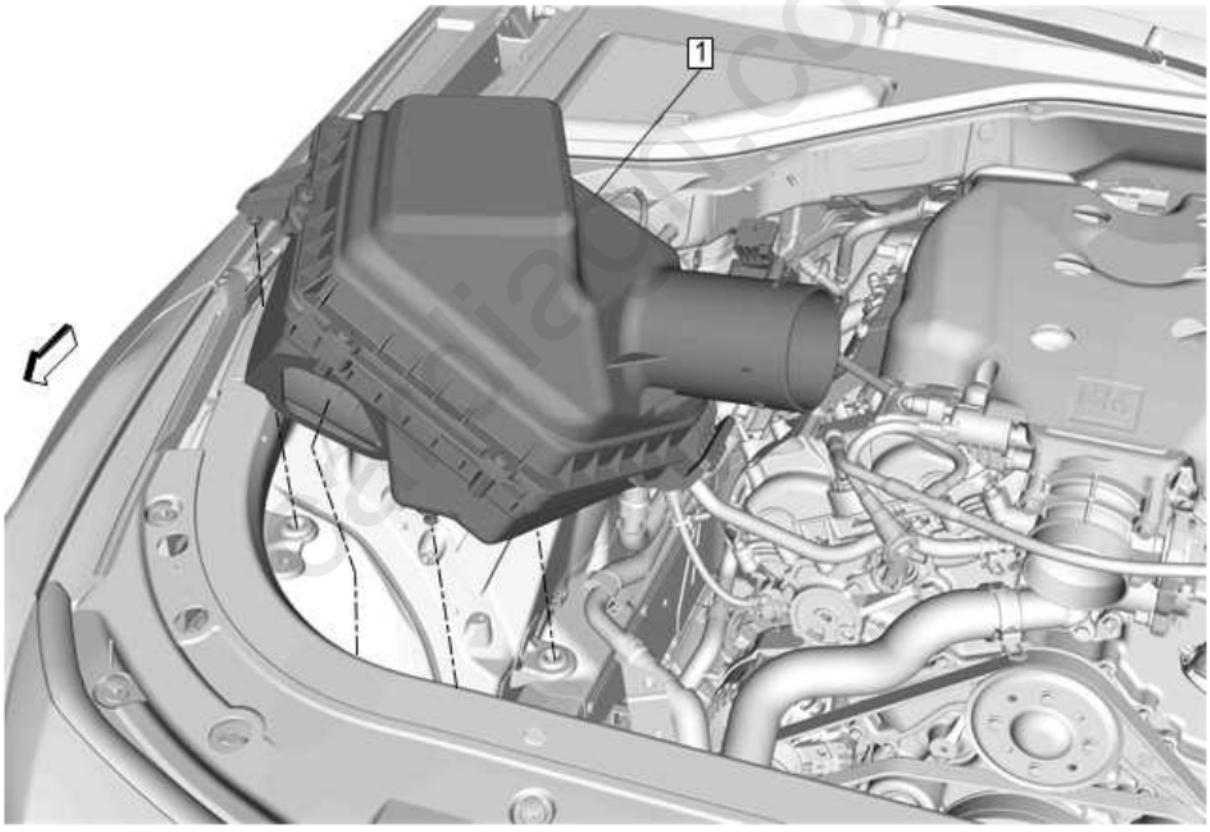

Fig. 314: Air Cleaner Assembly (LGX)
Courtesy of GENERAL MOTORS COMPANY

Callout	Component Name
Preliminary Procedures 1. Front Wheelhouse Panel Brace Replacement (Rear) Front Wheelhouse Panel Brace Replacement (Front) @ Front Â» Remove 2. Air Cleaner Outlet Duct Replacement (LGX) 3. Disconnect the electrical connector. 4. Cut the tie strap retaining the mass air flow harness.	

Callout	Component Name
1	Air Cleaner Assembly **Procedure** 1. Remove the air cleaner housing from the retainers, while guiding the housing out of the intake air duct. 2. Transfer parts as necessary.

AIR CLEANER OUTLET DUCT REPLACEMENT (LGX)

Removal Procedure

1. **Intake Manifold Cover Replacement (LGX)** Â» Remove
2. Positive Crankcase Ventilation Tube (1) @ Air Cleaner Outlet Duct (4)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**

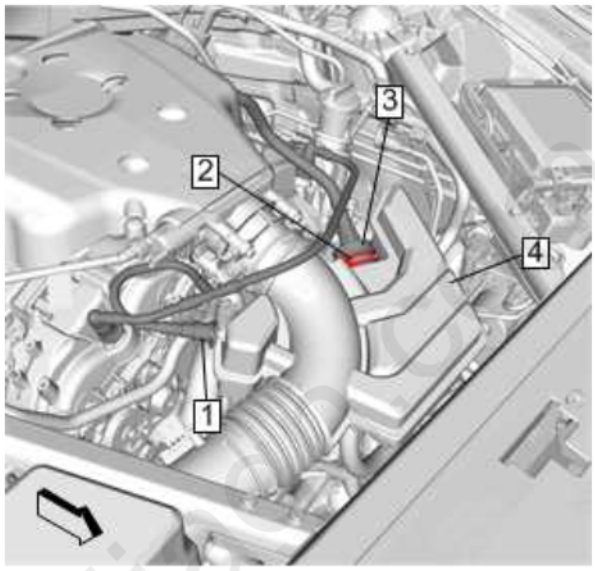

Fig. 315: Positive Crankcase Ventilation Tube And Air Cleaner Outlet Duct
Courtesy of GENERAL MOTORS COMPANY

3. Positive Crankcase Ventilation Tube Clamp (2) @ Positive Crankcase Ventilation Tube (3)Â» Remove
4. Positive Crankcase Ventilation Tube (3) @ Air Cleaner Outlet Duct (4)Â» Remove
5. Air Cleaner Outlet Duct Clamp (1) @ Air Cleaner Outlet Duct (2)Â» Remove [2x]

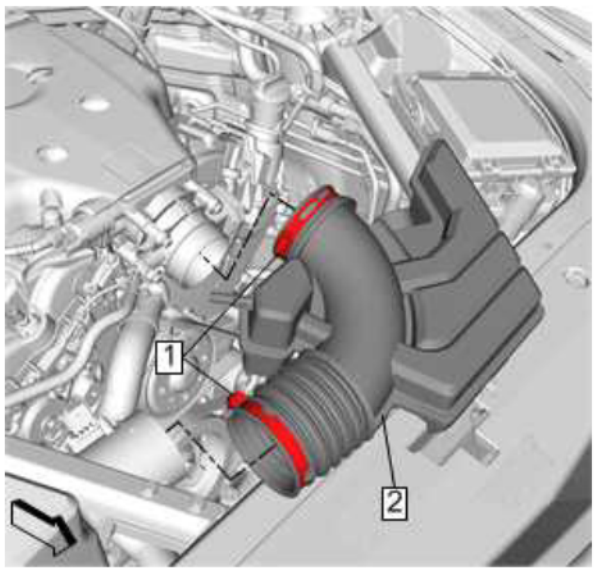

Fig. 316: Air Cleaner Outlet Duct
Courtesy of GENERAL MOTORS COMPANY

6. Air Cleaner Outlet Duct (2)Â» Remove

Installation Procedure

1. Air Cleaner Outlet Duct (2)Â» Install

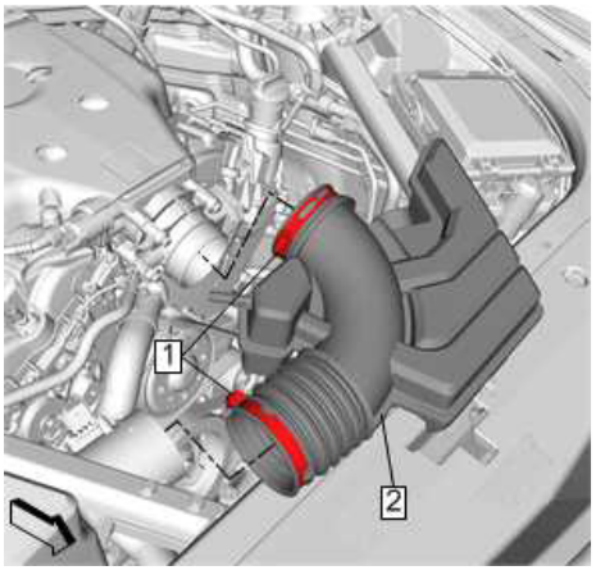

Fig. 317: Air Cleaner Outlet Duct
Courtesy of GENERAL MOTORS COMPANY

2. Air Cleaner Outlet Duct Clamp (1) @ Air Cleaner Outlet Duct (2)Â» Install 4 N.m (35 lb in) [2x]

CAUTION: **Refer to Fastener Caution .**

3. Positive Crankcase Ventilation Tube (3) @ Air Cleaner Outlet Duct (4)Â» Install

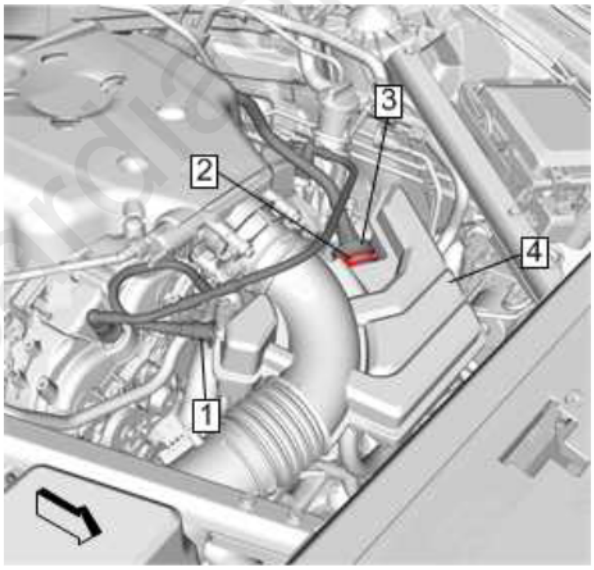

Fig. 318: Positive Crankcase Ventilation Tube And Air Cleaner Outlet Duct
Courtesy of GENERAL MOTORS COMPANY

4. Positive Crankcase Ventilation Tube Clamp (2) @ Positive Crankcase Ventilation Tube (3)Â» Install 4 N.m (35 lb in)
5. Positive Crankcase Ventilation Tube (1) @ Air Cleaner Outlet Duct (4)Â» Connect - **Plastic Collar Quick Connect Fitting Service**
6. **Intake Manifold Cover Replacement (LGX)** Â» Install

AIR CLEANER OUTLET REAR DUCT REPLACEMENT (LGW)

Removal Procedure

1. Front Wheelhouse Panel Brace - FrontÂ» Remove - **Front Wheelhouse Panel Brace Replacement (Rear)** **Front Wheelhouse Panel Brace Replacement (Front)**

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2. Charge Air Bypass Valve - Right Side @ Air Cleaner Outlet Rear Duct Â» Remove - **Charge Air Bypass Valve Replacement - Right Side**
3. Air Cleaner Outlet Rear Duct Clamp (1)Â» Remove

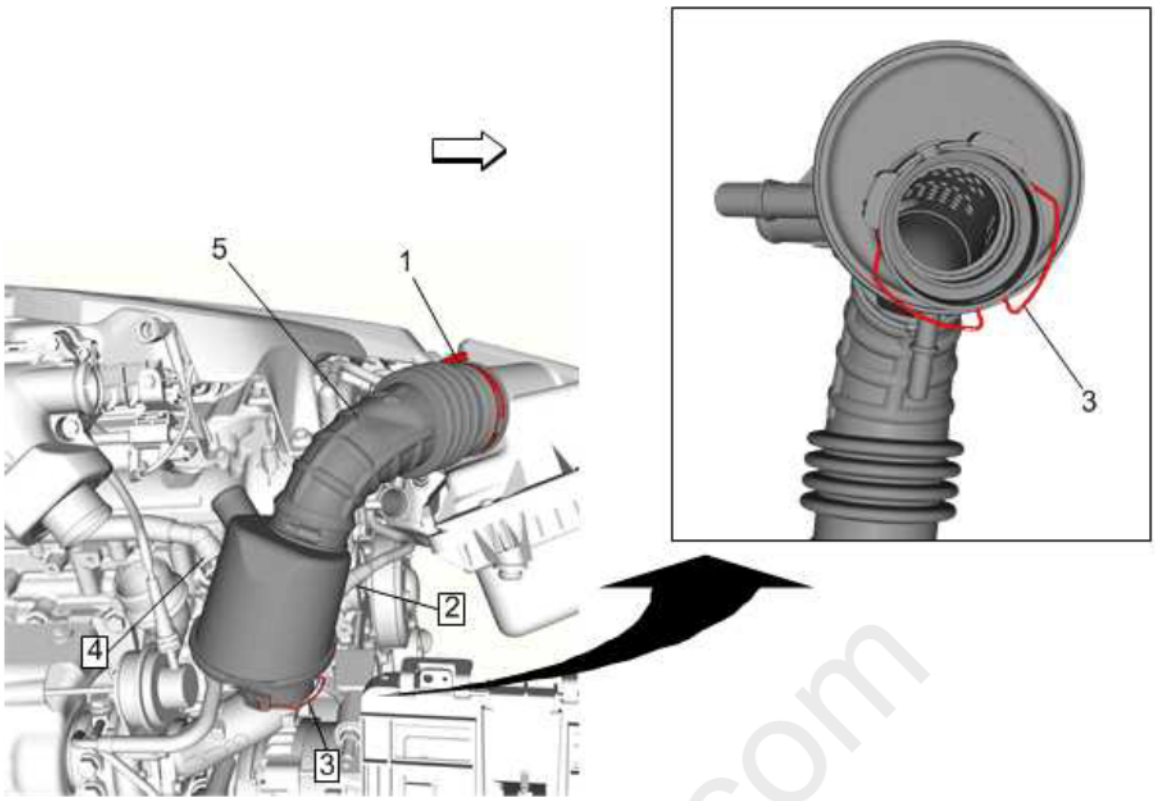

Fig. 319: Air Cleaner Outlet Rear Duct And PCV Tube
Courtesy of GENERAL MOTORS COMPANY

4. PCV Tube (2)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**
5. Retaining spring (3)Â» Release
6. PCV Tube (4) leave connected to air cleaner outlet rear duct (5) and reposition together to allow access of removal of other components from the vehicle.

NOTE: **PCV Tube has a tamper-proof fitting and cannot be disconnected without damage to the PCV Tube.**

7. PCV Tube (4) Disconnect - **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (LGW)** **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (LGX)**

NOTE: **PCV Tube has a tamper-proof fitting and cannot be disconnected without damage to the PCV Tube. Only disconnect if replacing the air cleaner outlet rear duct.**

8. Air Cleaner Outlet Rear Duct (5)Â» Remove

Installation Procedure

1. Air Cleaner Outlet Rear Duct (5)Â» Install

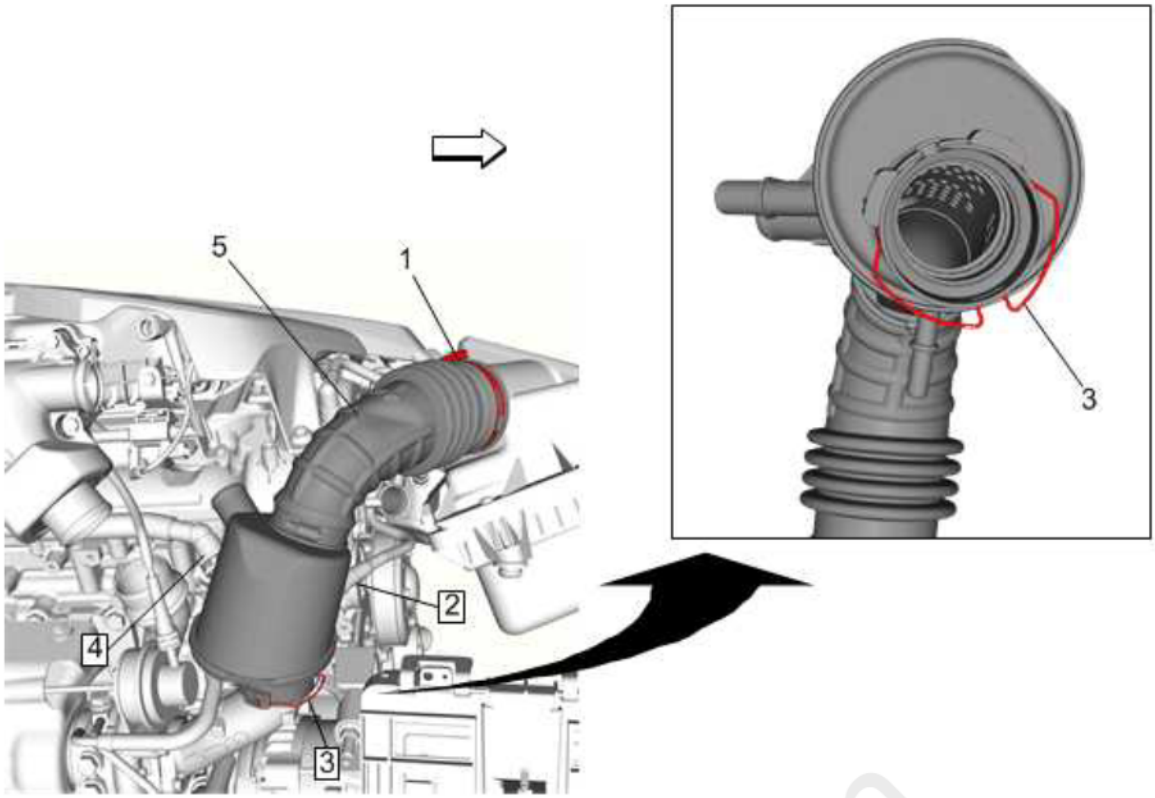

Fig. 320: Air Cleaner Outlet Rear Duct And PCV Tube
Courtesy of GENERAL MOTORS COMPANY

2. PCV Tube (4) Connect - **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (LGW)** **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (LGX)**

   NOTE: **PCV Tube has a tamper-proof fitting and cannot be disconnected without damage to the PCV Tube.**

3. PCV Tube (4) leave connected to air cleaner outlet rear duct (5) and reposition together back into vehicle position.

   NOTE: **PCV Tube has a tamper-proof fitting and cannot be disconnected without damage to the PCV Tube.**

4. Retaining spring (3)Â» Engage
5. PCV Tube (2)Â» Connect - **Plastic Collar Quick Connect Fitting Service**
6. Air Cleaner Outlet Rear Duct Clamp (1)Â» Install 4 N.m (35 lb in)

   CAUTION: **Refer to Fastener Caution .**

7. Charge Air Bypass Valve - Right Side @ Air Cleaner Outlet Rear DuctÂ» Install - **Charge Air Bypass Valve Replacement - Right Side**
8. Front Wheelhouse Panel Brace - FrontÂ» Install - **Front Wheelhouse Panel Brace Replacement (Front)**

AIR CLEANER OUTLET FRONT DUCT REPLACEMENT (LGW)

Removal Procedure

1. Front Wheelhouse Panel Brace - FrontÂ» Remove - **Front Wheelhouse Panel Brace Replacement (Front)**
2. Charge Air Bypass Valve - Left Side @ Air Cleaner Outlet Front DuctÂ» Remove - **Charge Air Bypass Valve Replacement - Left Side**
3. Air Cleaner Outlet Front Duct Clamp (1)Â» Remove

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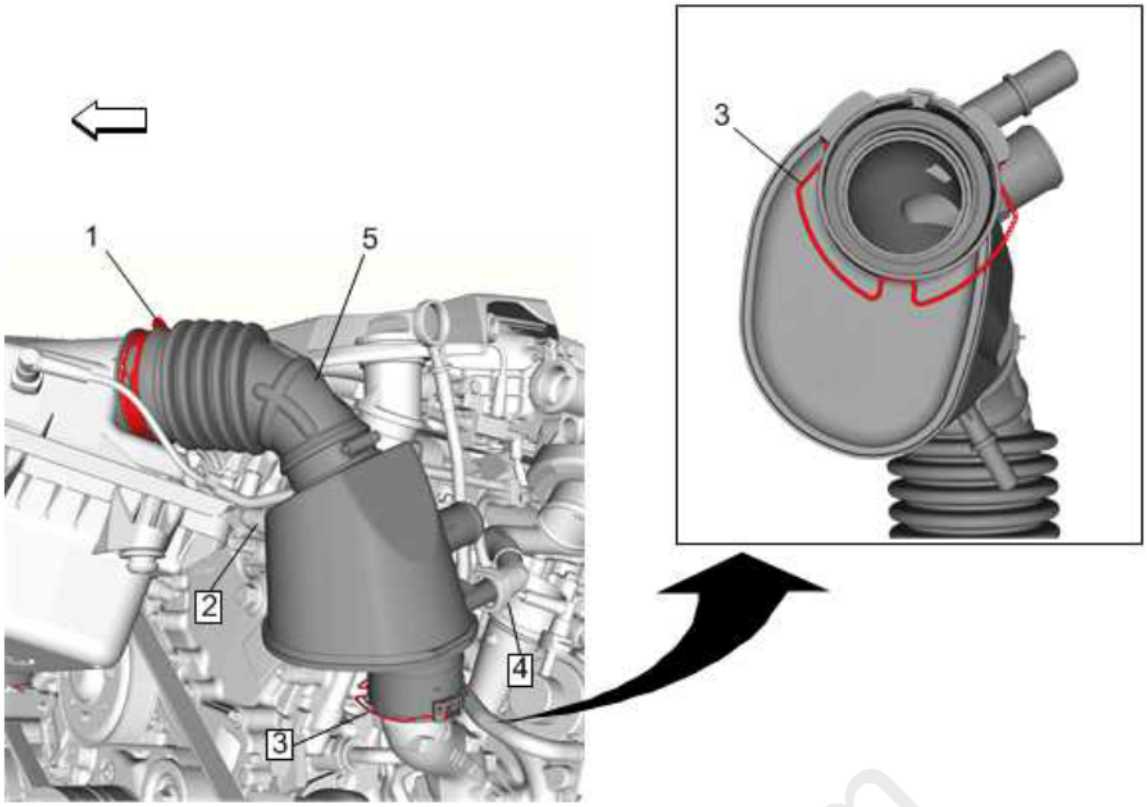

Fig. 321: Air Cleaner Outlet Front Duct And PCV Tube
Courtesy of GENERAL MOTORS COMPANY

4. PCV Tube (2)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**
5. Retaining spring (3)Â» Release
6. PCV Tube (4) leave connected to air cleaner outlet front duct (5) and reposition together to allow access of removal of other components from the vehicle.

NOTE: **PCV Tube has a tamper-proof fitting and cannot be disconnected without damage to the PCV Tube.**

7. PCV Tube (4) Disconnect - **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (LGW)**

NOTE: **PCV Tube has a tamper-proof fitting and cannot be disconnected without damage to the PCV Tube. Only disconnect if replacing the air cleaner outlet front duct.**

8. Air Cleaner Outlet Front Duct (5)Â» Remove

Installation Procedure

1. Air Cleaner Outlet Front Duct (5)Â» Install

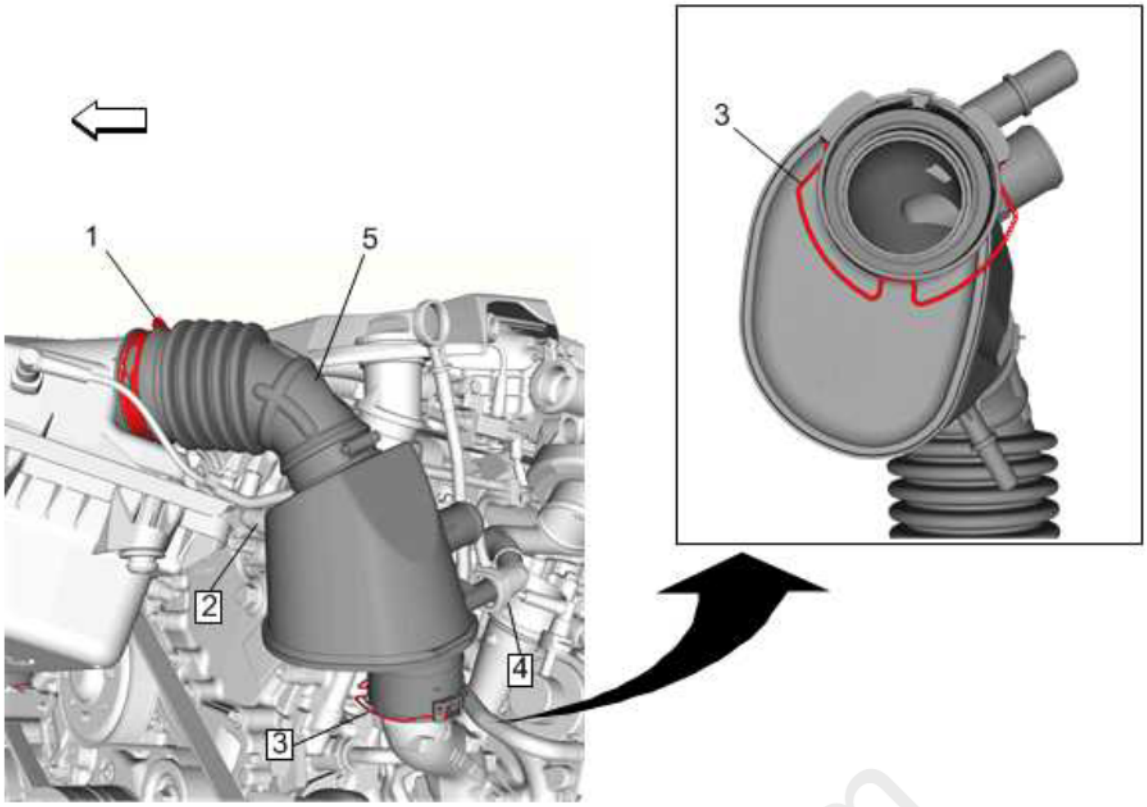

Fig. 322: Air Cleaner Outlet Front Duct And PCV Tube
Courtesy of GENERAL MOTORS COMPANY

2. PCV Tube (4) Connect - **Positive Crankcase Ventilation Hose/Pipe/Tube Replacement (LGW)**

NOTE: **PCV Tube has a tamper-proof fitting and cannot be disconnected without damage to the PCV Tube.**

3. PCV Tube (4) leave connected to air cleaner outlet front duct (5) and reposition together back into vehicle position.

NOTE: **PCV Tube has a tamper-proof fitting and cannot be disconnected without damage to the PCV Tube.**

4. Retaining spring (3)Â» Engage
5. PCV Tube (2)Â» Connect - **Plastic Collar Quick Connect Fitting Service**
6. Air Cleaner Outlet Front Duct Clamp (1)Â» Install 4 N.m (35 lb in)

CAUTION: **Refer to Fastener Caution .**

7. Charge Air Bypass Valve - Left Side @ Air Cleaner Outlet Rear DuctÂ» Install - **Charge Air Bypass Valve Replacement - Left Side**
8. Front Wheelhouse Panel Brace - FrontÂ» Install - **Front Wheelhouse Panel Brace Replacement (Front)**

FUEL SENDER ASSEMBLY REPLACEMENT

Special Tools

CH 45722 Fuel Sender Lock Ring Wrench

Equivalent regional tools: **Special Tools (Diagnostic Tools)** **Special Tools (Mechanical Tools)**

Removal Procedure

1. **Fuel Tank Replacement**Â» Remove

WARNING: **Refer to Gasoline/Gasoline Vapors Warning .**

WARNING: Refer to Safety Glasses Warning .

2. Electrical Connector (1)Â» Disconnect

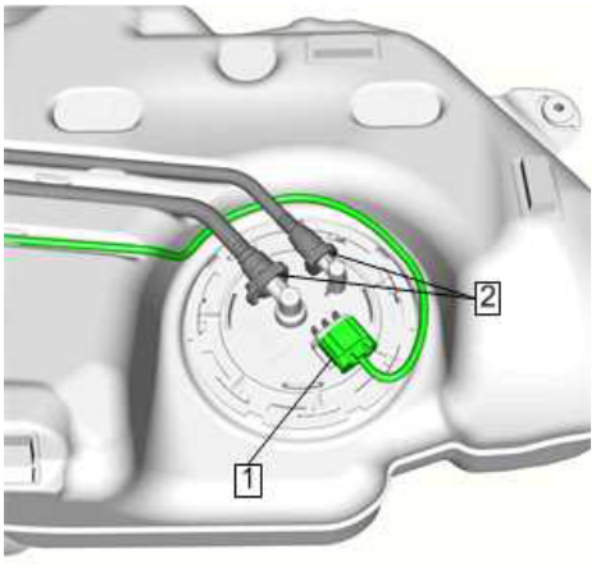

Fig. 323: Evaporative Emission Pipe And Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

3. Evaporative Emission Pipe (2)Â» Disconnect [2x] - Plastic Collar Quick Connect Fitting Service
4. Fuel Sender Ring (1)Â» Remove - **CH 45722** wrench

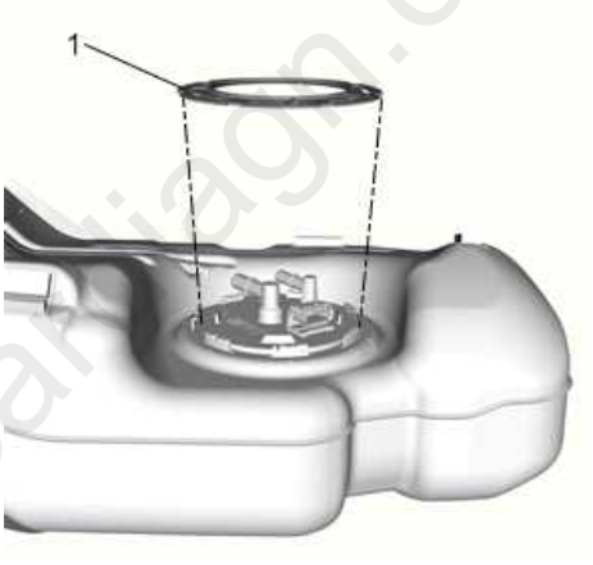

Fig. 324: Fuel Sender Ring
Courtesy of GENERAL MOTORS COMPANY

5. Fuel Vent Pipe (1)Â» Disconnect [2x] - Plastic Collar Quick Connect Fitting Service.

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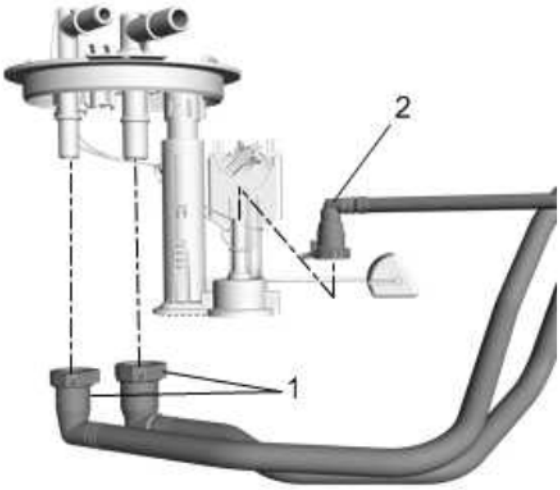

Fig. 325: Fuel Vent Pipes And Transfer Hose
Courtesy of GENERAL MOTORS COMPANY

6. Transfer Hose (2)Â» Disconnect - **Plastic Collar Quick Connect Fitting Service**
7. Fuel Sender (1)Â» Remove

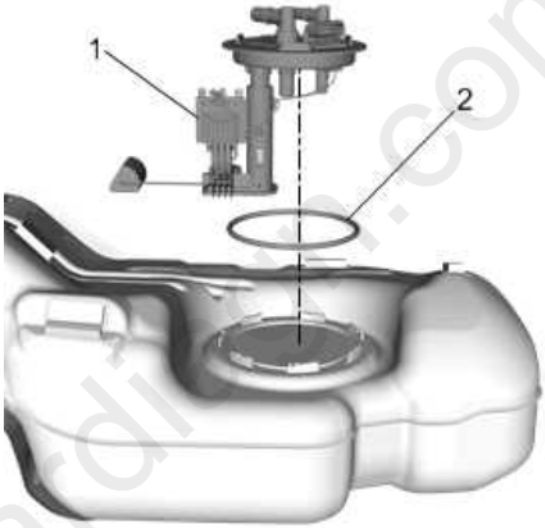

Fig. 326: Fuel Sender And O-Ring
Courtesy of GENERAL MOTORS COMPANY

8. O-Ring (2)Â» Remove and DISCARD

Installation Procedure

1. O-Ring (2)Â» Install NEW

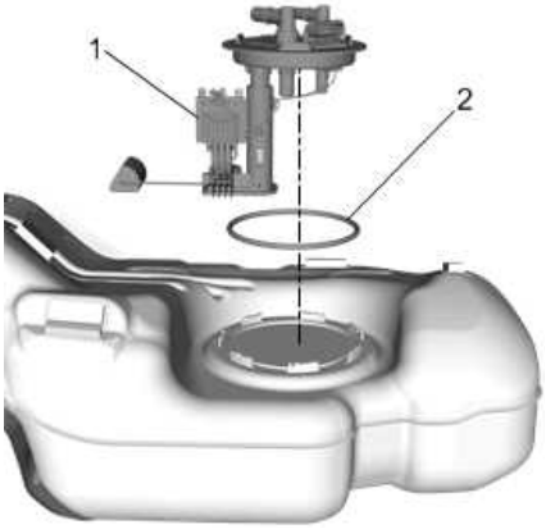

Fig. 327: Fuel Sender And O-Ring
Courtesy of GENERAL MOTORS COMPANY

2. Fuel Sender (1)Â» Install
3. Transfer Hose (2)Â» Connect - **Plastic Collar Quick Connect Fitting Service**

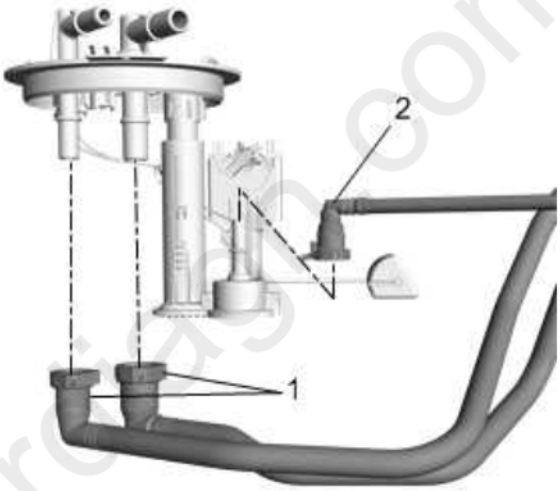

Fig. 328: Fuel Vent Pipes And Transfer Hose
Courtesy of GENERAL MOTORS COMPANY

4. Fuel Vent Pipe (1)Â» Connect [2x] - **Plastic Collar Quick Connect Fitting Service**.
5. Fuel Sender Ring (1)Â» Install - **CH 45722** wrench

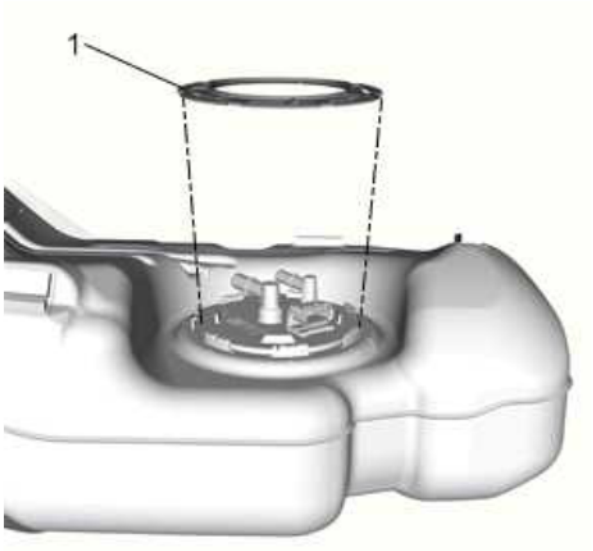

Fig. 329: Fuel Sender Ring
Courtesy of GENERAL MOTORS COMPANY

6. Evaporative Emission Pipe (2)Â» Connect [2x] - **Plastic Collar Quick Connect Fitting Service**

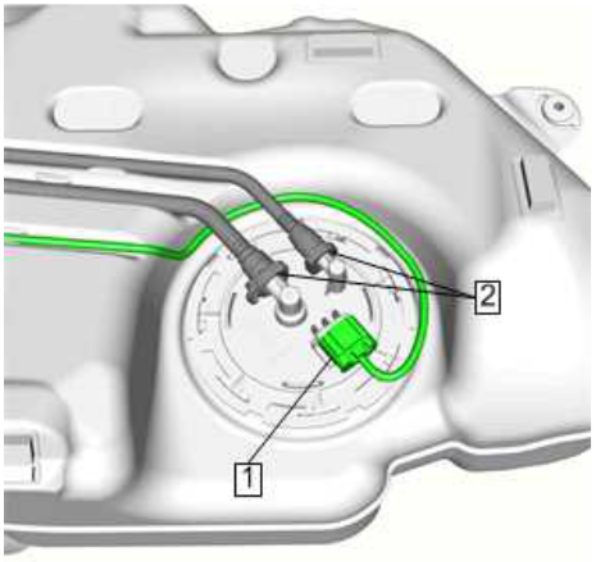

Fig. 330: Evaporative Emission Pipe And Electrical Connector
Courtesy of GENERAL MOTORS COMPANY

7. Electrical Connector (1)Â» Connect
8. **Fuel Tank Replacement**Â» Install

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Back To Article

SCHEMATIC WIRING DIAGRAMS

ENGINE CONTROLS WIRING SCHEMATICS (LGW)

Power, Ground, Serial Data and MIL

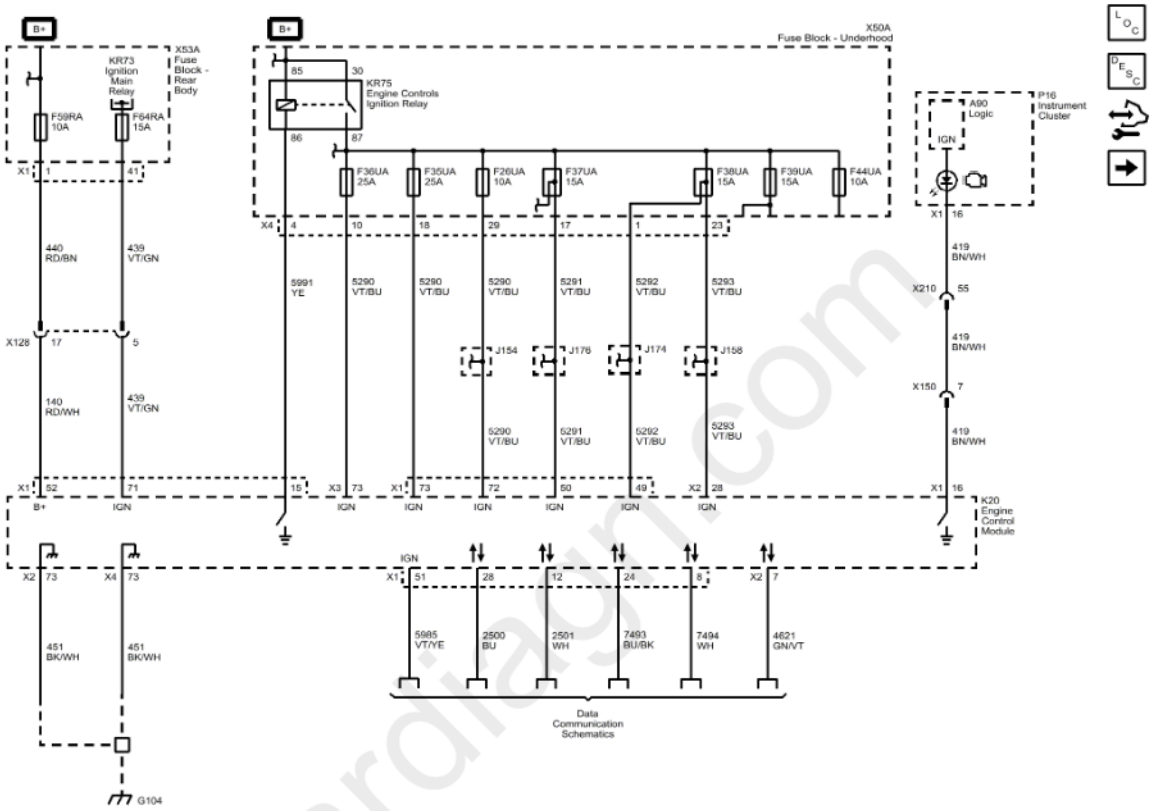

Fig. 1: Power, Ground, Serial Data and MIL
Courtesy of GENERAL MOTORS COMPANY

Controls - Mode Switch

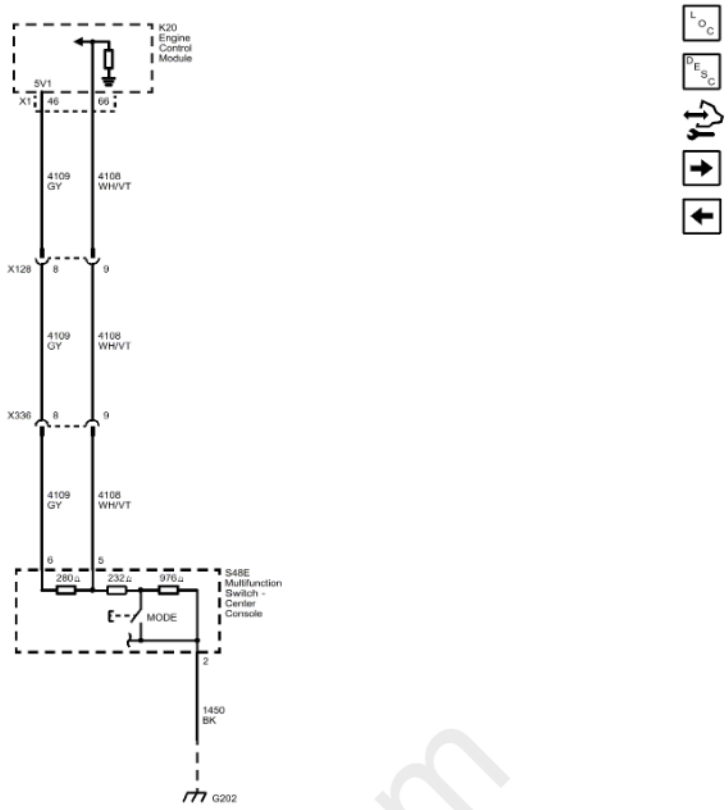

Fig. 2: Controls - Mode Switch
Courtesy of GENERAL MOTORS COMPANY

5V1 and Low Reference Bus (1 of 3)

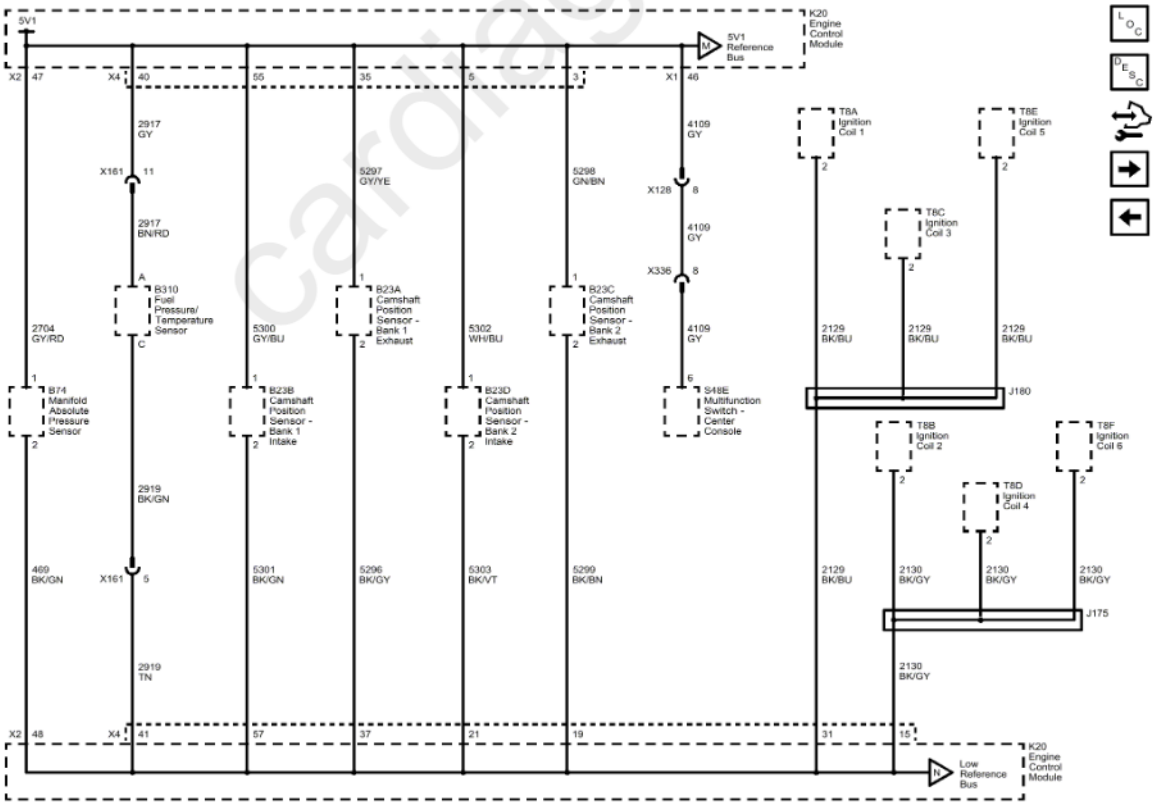

Fig. 3: 5V1 and Low Reference Bus (1 of 3)
Courtesy of GENERAL MOTORS COMPANY

5V1, 5V2 and Low Reference Bus (2 of 3)

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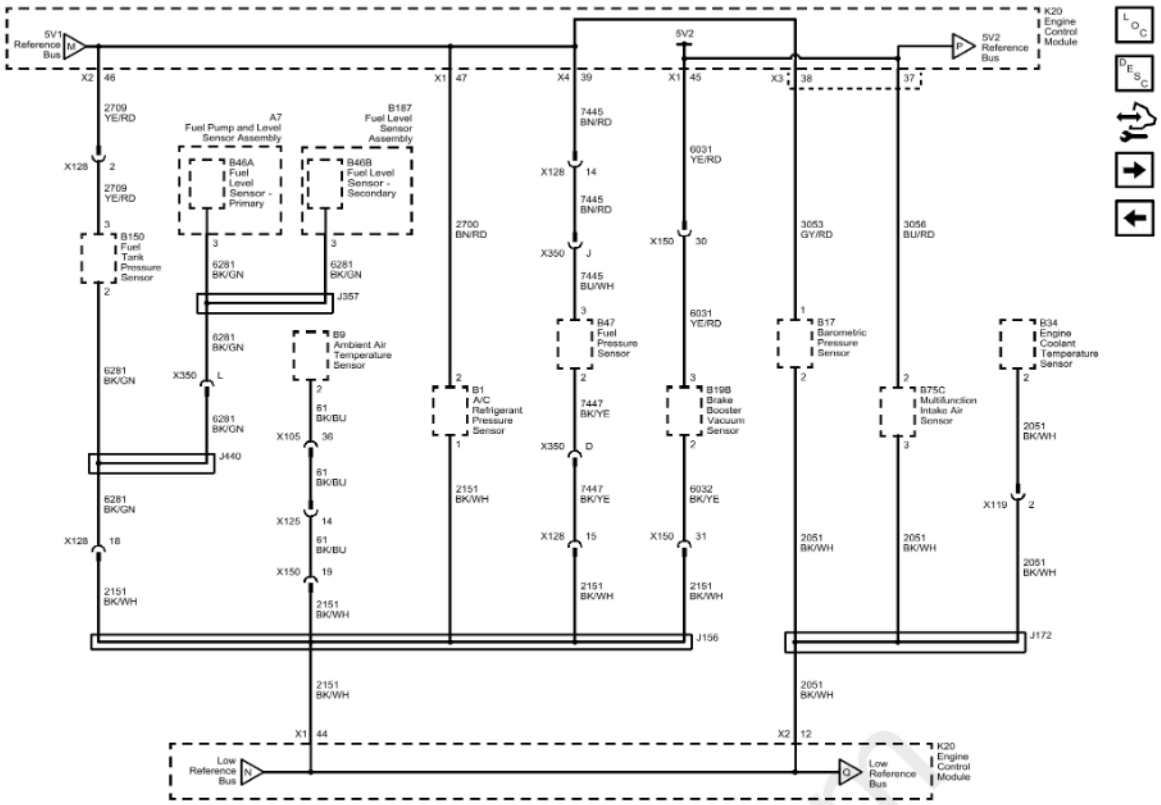

Fig. 4: 5V1, 5V2 and Low Reference Bus (2 of 3)
Courtesy of GENERAL MOTORS COMPANY

5V2, 5V3, 5V4 and Low Reference Bus (3 of 3)

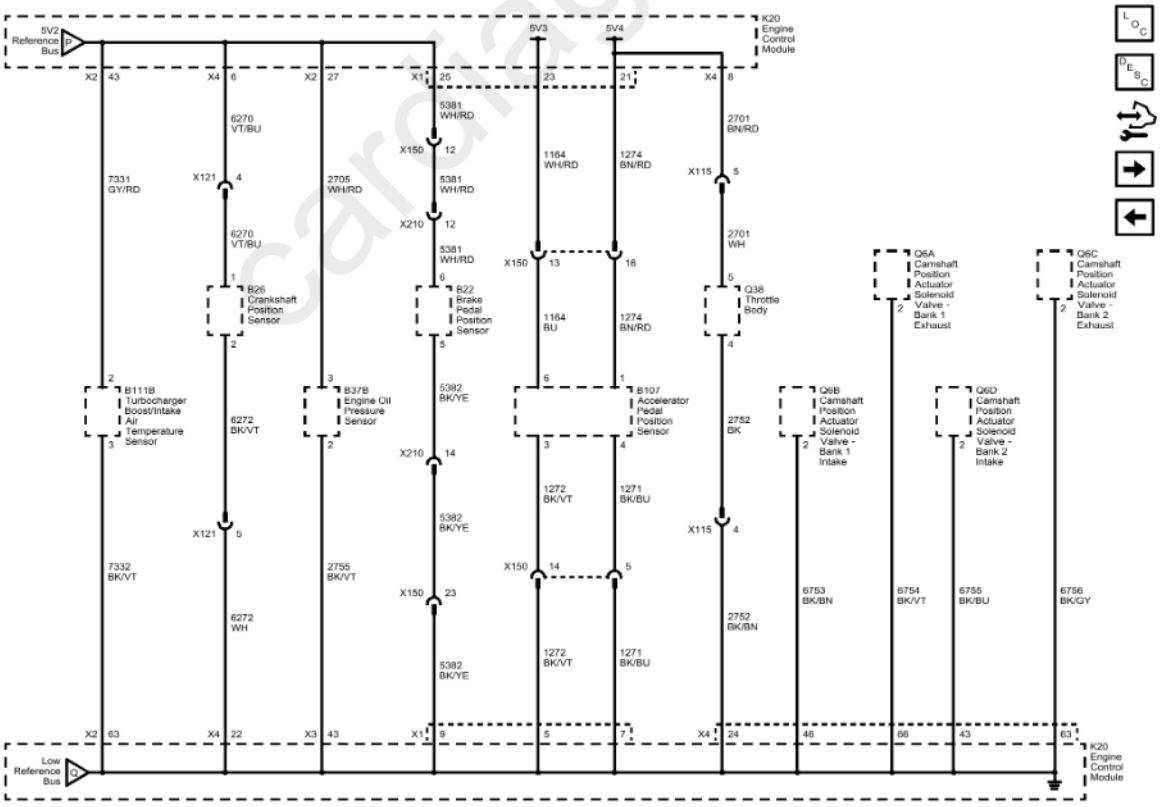

Fig. 5: 5V2, 5V3, 5V4 and Low Reference Bus (3 of 3)
Courtesy of GENERAL MOTORS COMPANY

Engine Data Sensors - Pressure and Temperature

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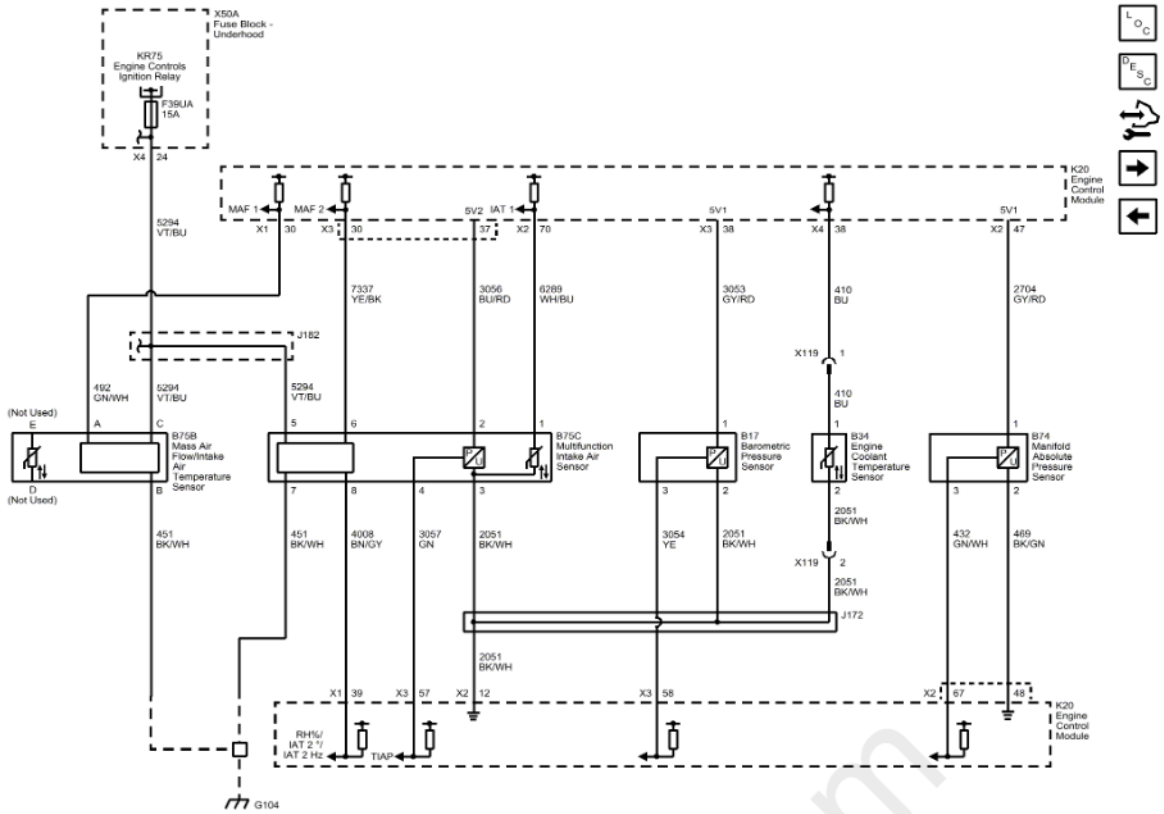

Fig. 6: Engine Data Sensors - Pressure and Temperature
Courtesy of GENERAL MOTORS COMPANY

Engine Data Sensors - Oxygen Sensors

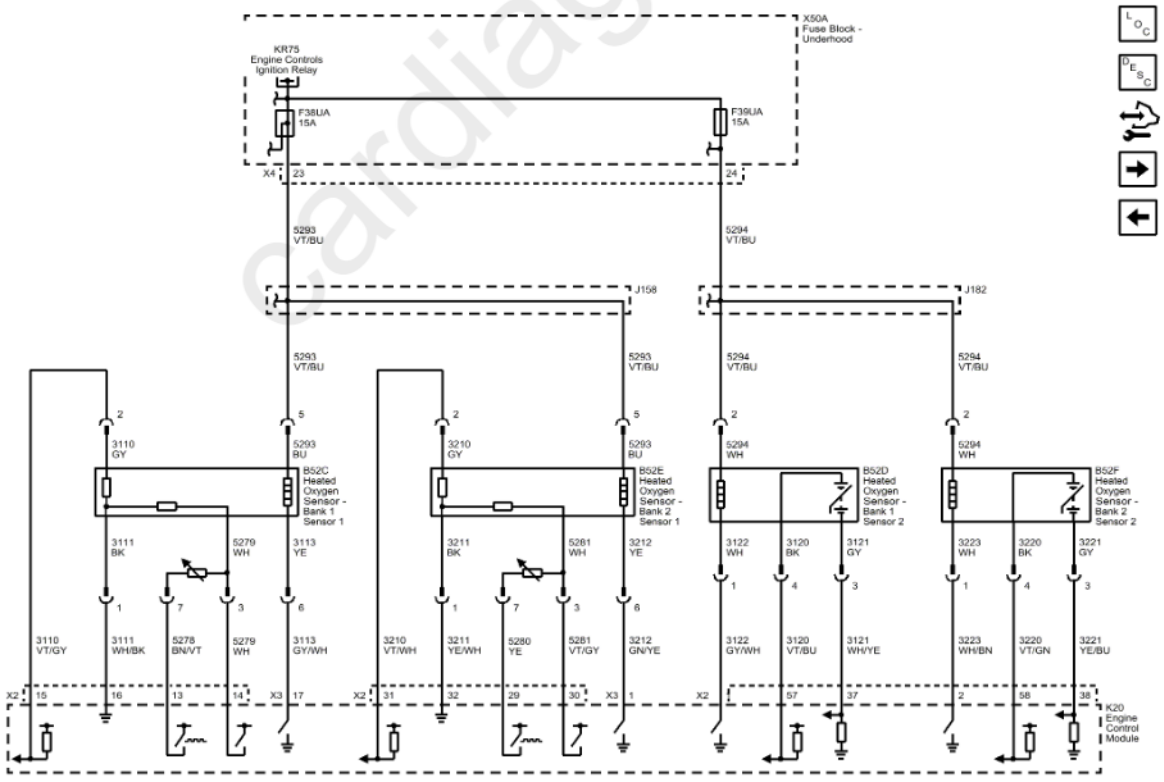

Fig. 7: Engine Data Sensors - Oxygen Sensors
Courtesy of GENERAL MOTORS COMPANY

Engine Data Sensors - Throttle Controls and Override

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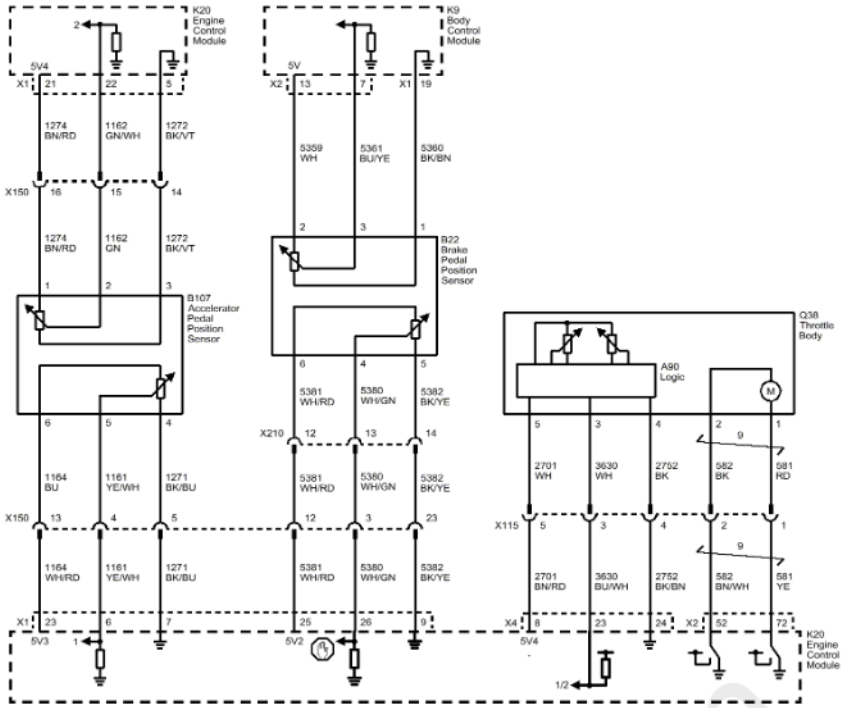

Fig. 8: Engine Data Sensors - Throttle Controls and Override
Courtesy of GENERAL MOTORS COMPANY

Ignition Controls - Ignition System Bank 1

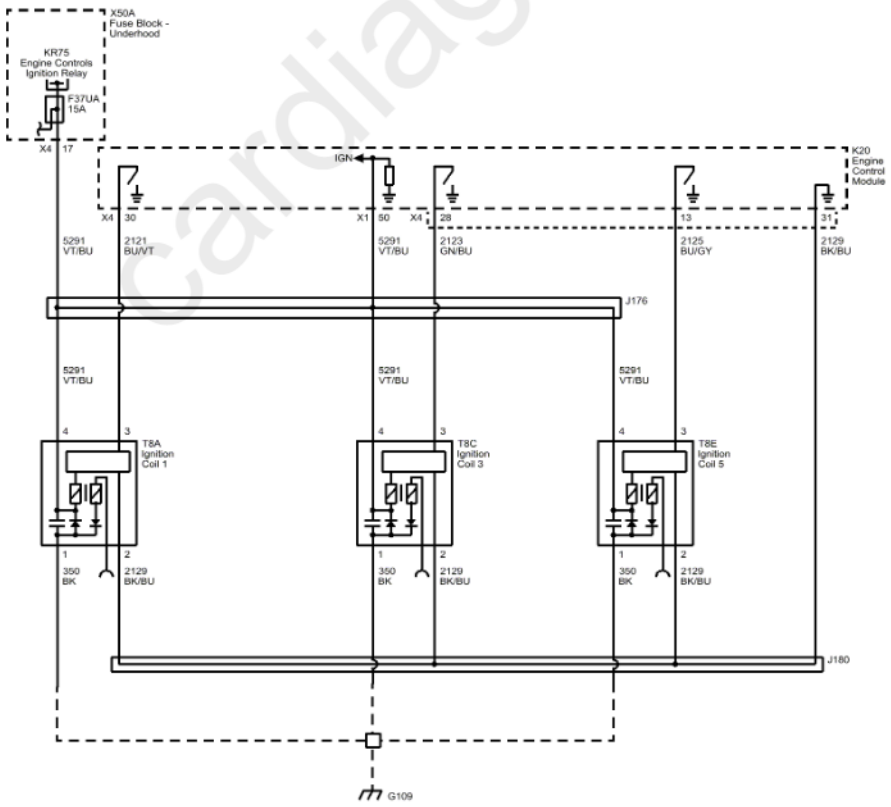

Fig. 9: Ignition Controls - Ignition System Bank 1
Courtesy of GENERAL MOTORS COMPANY

Ignition Controls - Ignition System Bank 2

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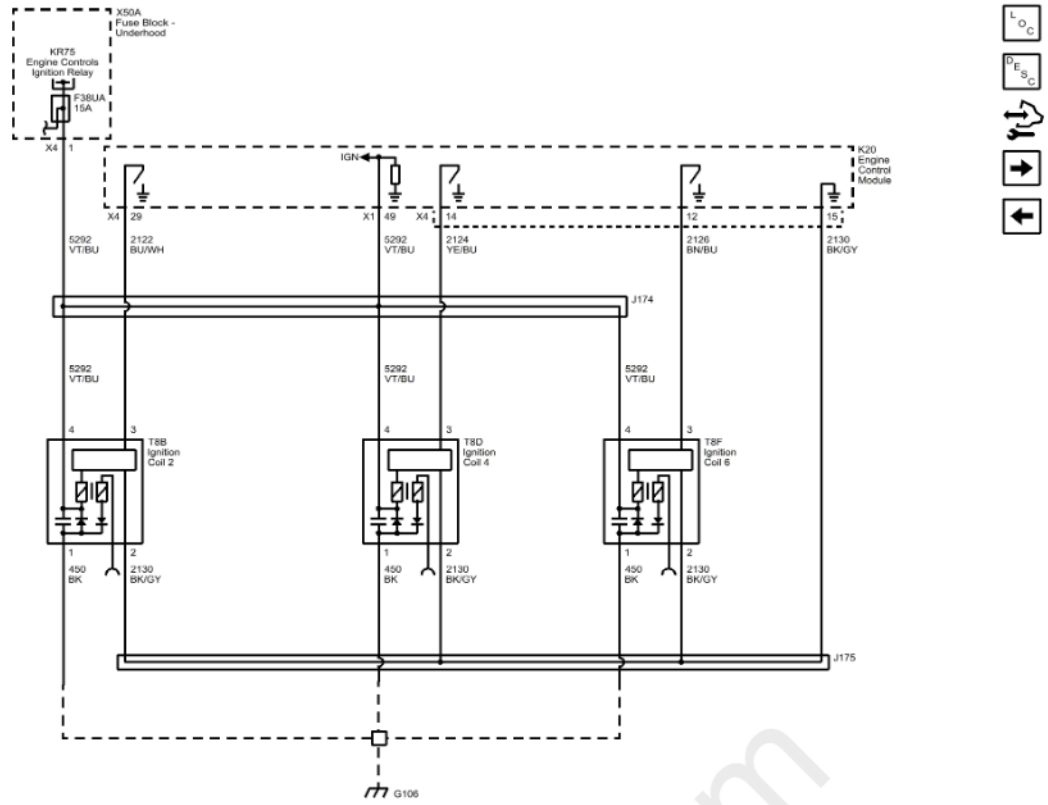

Fig. 10: Ignition Controls - Ignition System Bank 2
Courtesy of GENERAL MOTORS COMPANY

Ignition Controls - Ignition Sensors and Camshaft Actuators

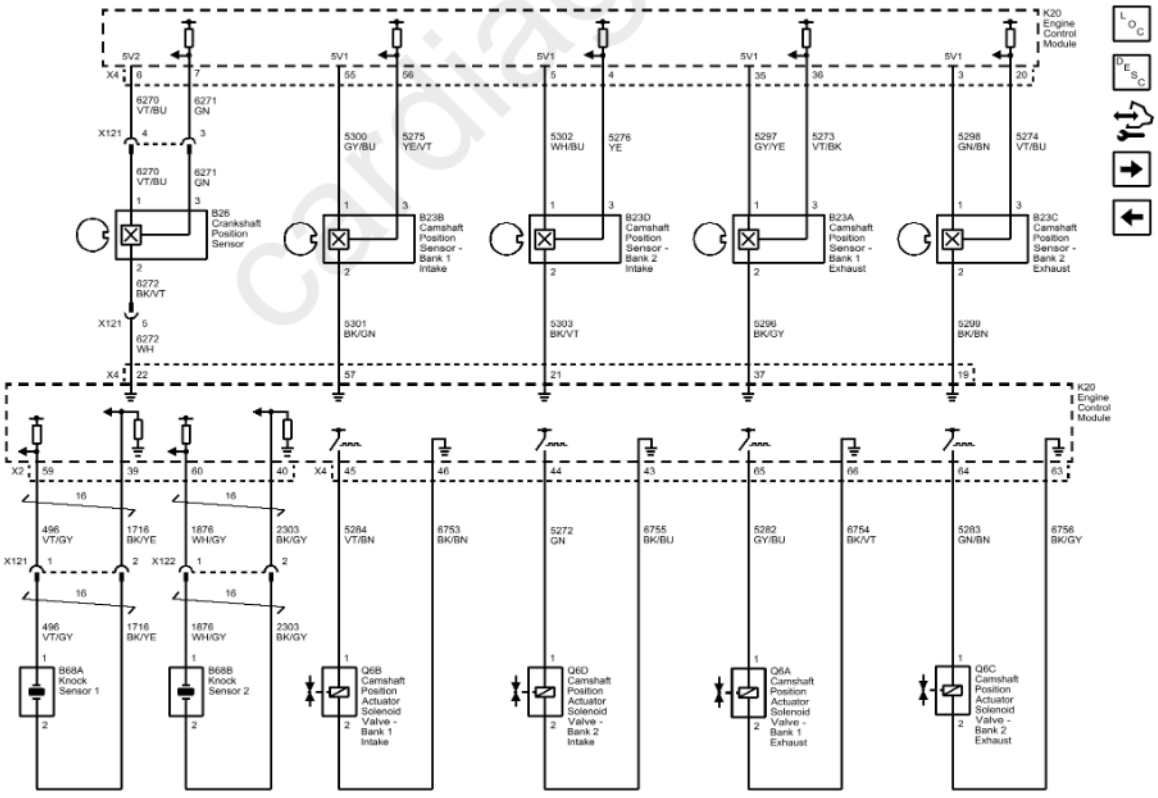

Fig. 11: Ignition Controls - Ignition Sensors and Camshaft Actuators
Courtesy of GENERAL MOTORS COMPANY

Fuel Controls - Fuel Pump Controls

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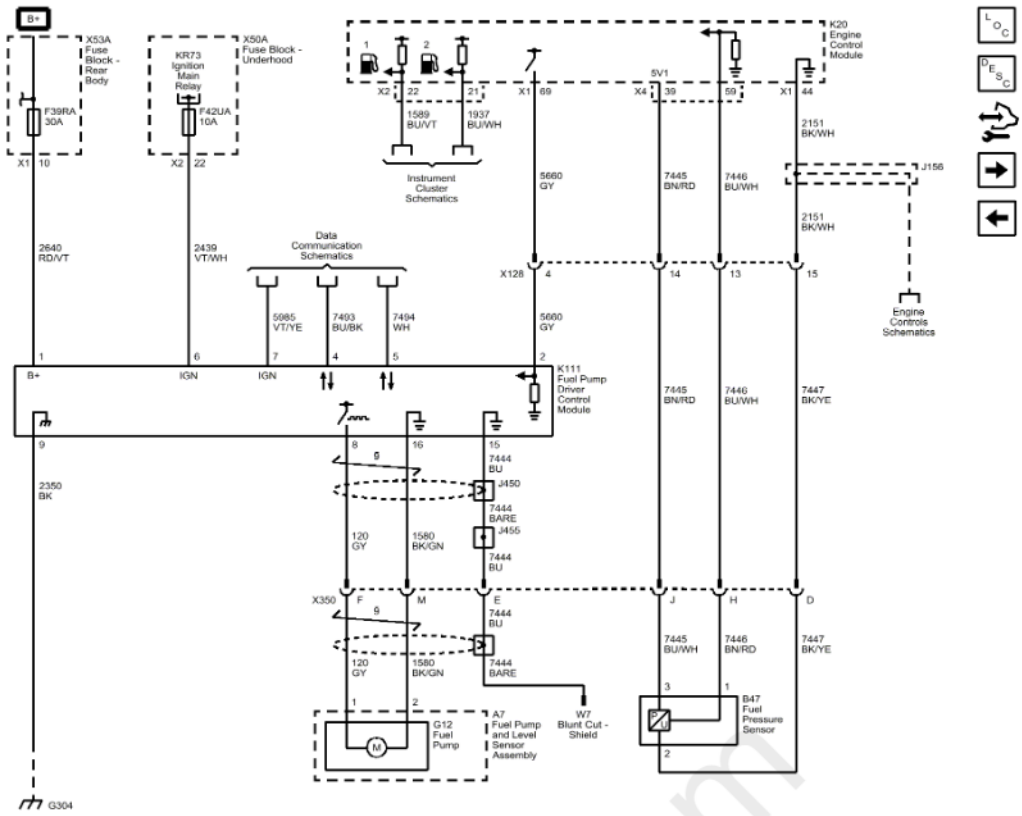

Fig. 12: Fuel Controls - Fuel Pump Controls
Courtesy of GENERAL MOTORS COMPANY

Fuel Controls - Fuel Injectors and High Pressure Control

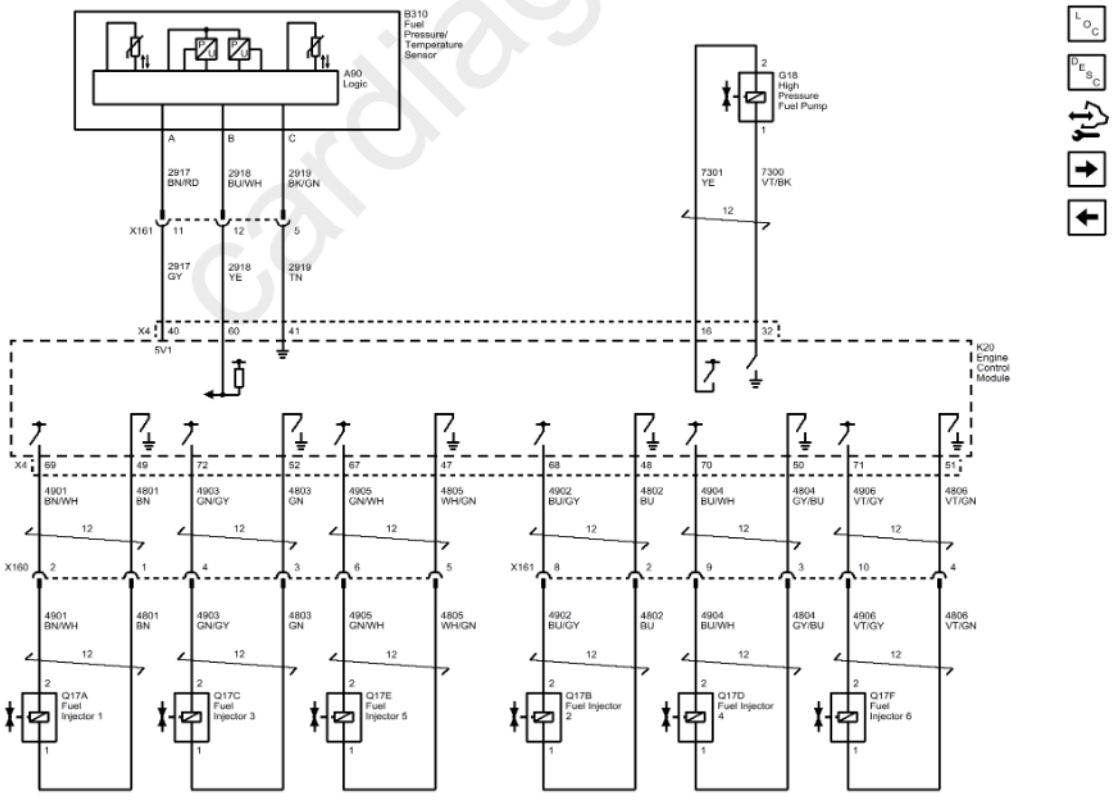

Fig. 13: Fuel Controls - Fuel Injectors and High Pressure Control
Courtesy of GENERAL MOTORS COMPANY

Fuel Controls - Turbocharger Controls and Boost Sensor

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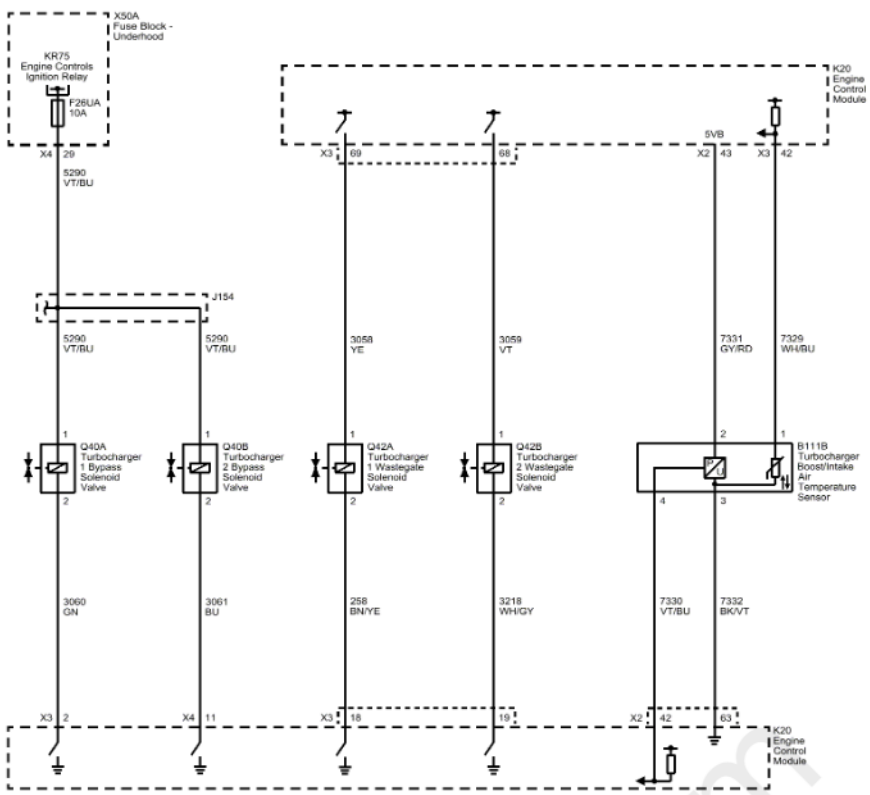

Fig. 14: Fuel Controls - Turbocharger Controls and Boost Sensor
Courtesy of GENERAL MOTORS COMPANY

Fuel Controls - Evaporative Emissions Controls

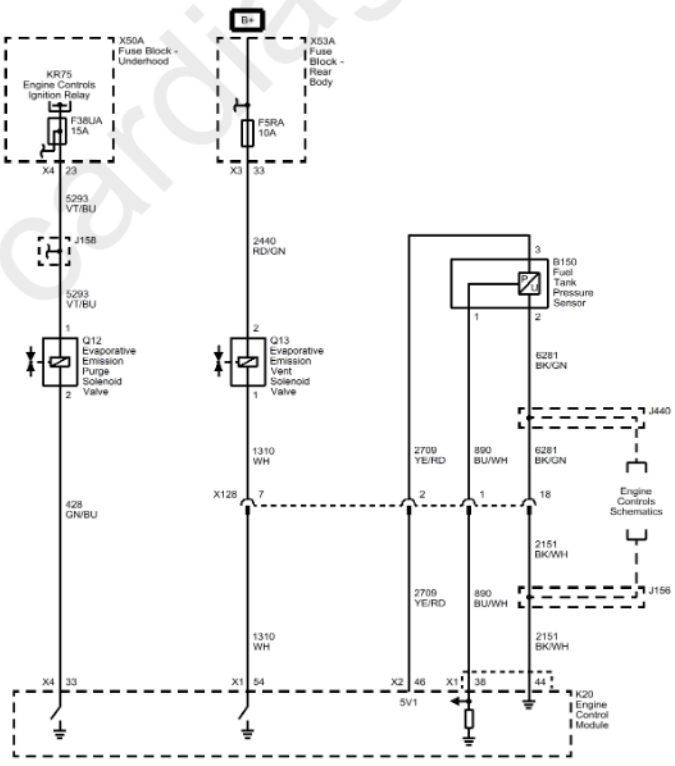

Fig. 15: Fuel Controls - Evaporative Emissions Controls
Courtesy of GENERAL MOTORS COMPANY

Device Controls - Displacement on Demand

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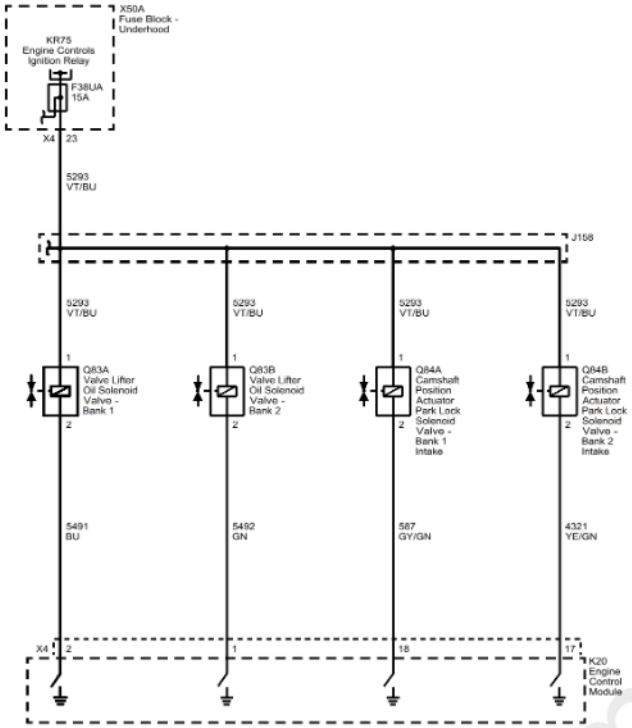

Fig. 16: Device Controls - Displacement on Demand
Courtesy of GENERAL MOTORS COMPANY

Monitored/Controlled Subsystem References

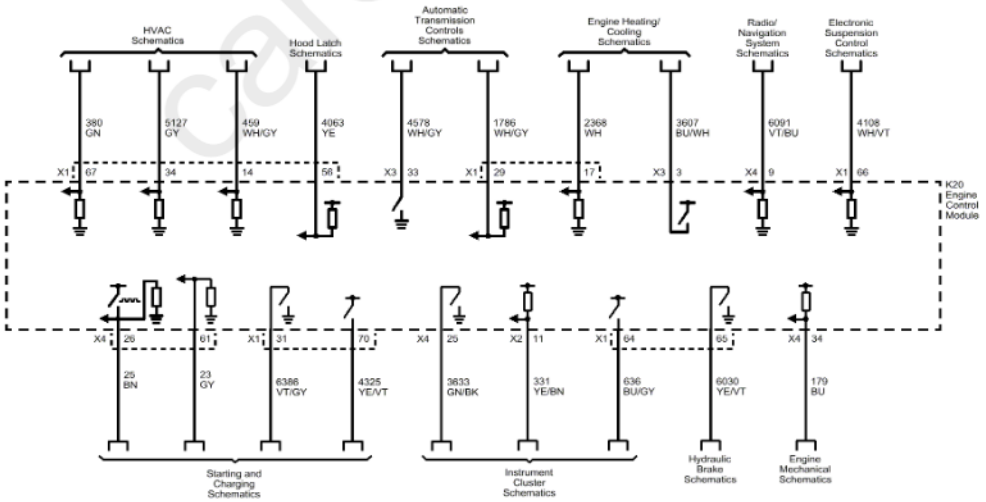

Fig. 17: Monitored/Controlled Subsystem References
Courtesy of GENERAL MOTORS COMPANY

ENGINE CONTROLS WIRING SCHEMATICS (LGX)

Power, Ground, Serial Data and MIL

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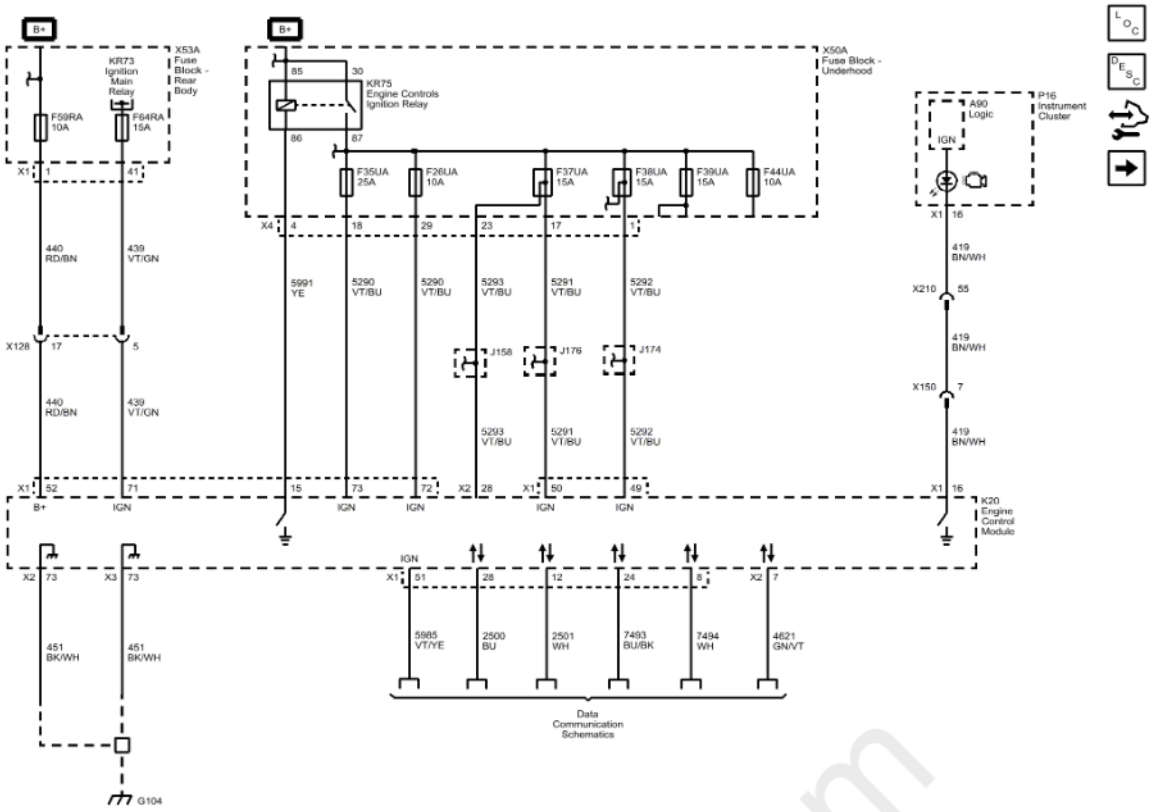

Fig. 18: Power, Ground, Serial Data and MIL
Courtesy of GENERAL MOTORS COMPANY

Controls - Mode Switch

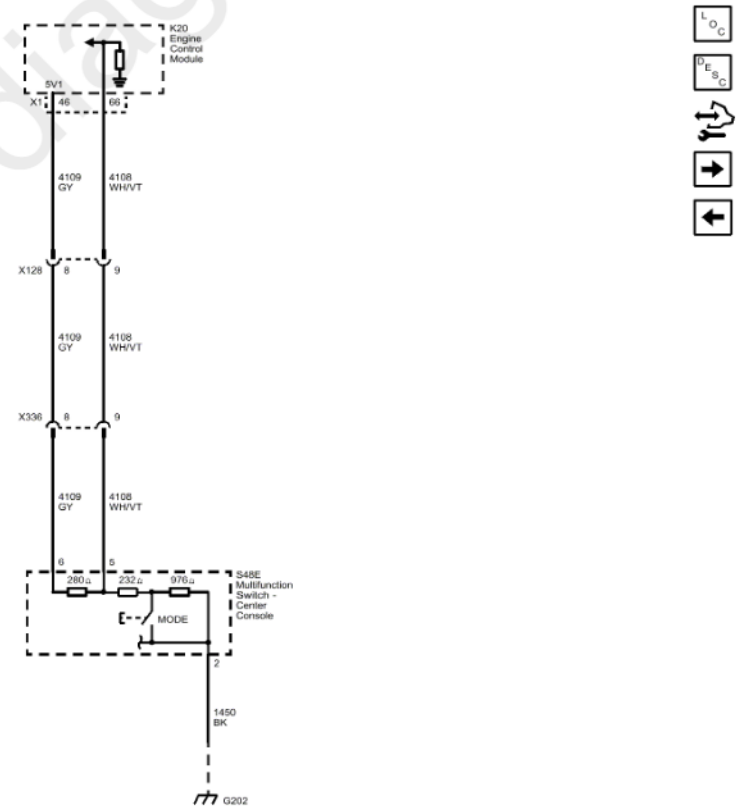

Fig. 19: Controls - Mode Switch
Courtesy of GENERAL MOTORS COMPANY

5V1 and Low Reference Bus (1 of 3)

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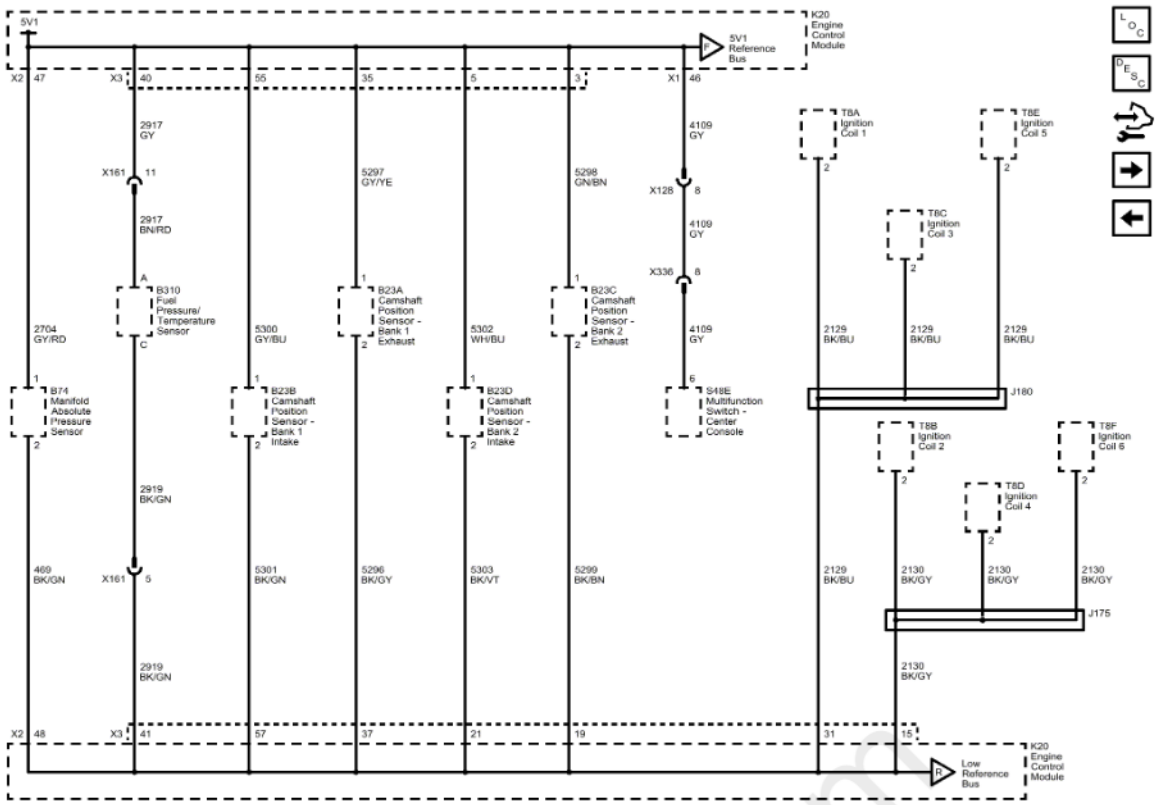

Fig. 20: 5V1 and Low Reference Bus (1 of 3)
Courtesy of GENERAL MOTORS COMPANY

5V1, 5V2 and Low Reference Bus (2 of 3)

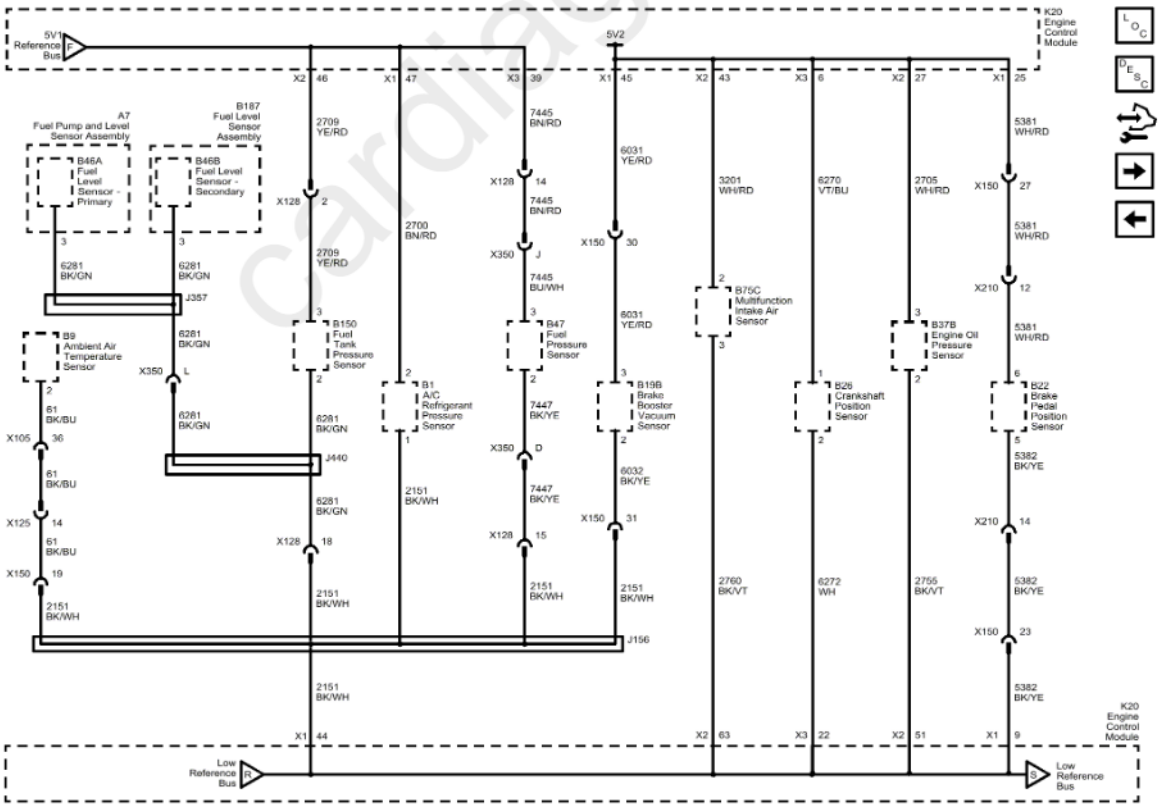

Fig. 21: 5V1, 5V2 and Low Reference Bus (2 of 3)
Courtesy of GENERAL MOTORS COMPANY

5V3, 5V4 and Low Reference Bus (3 of 3)

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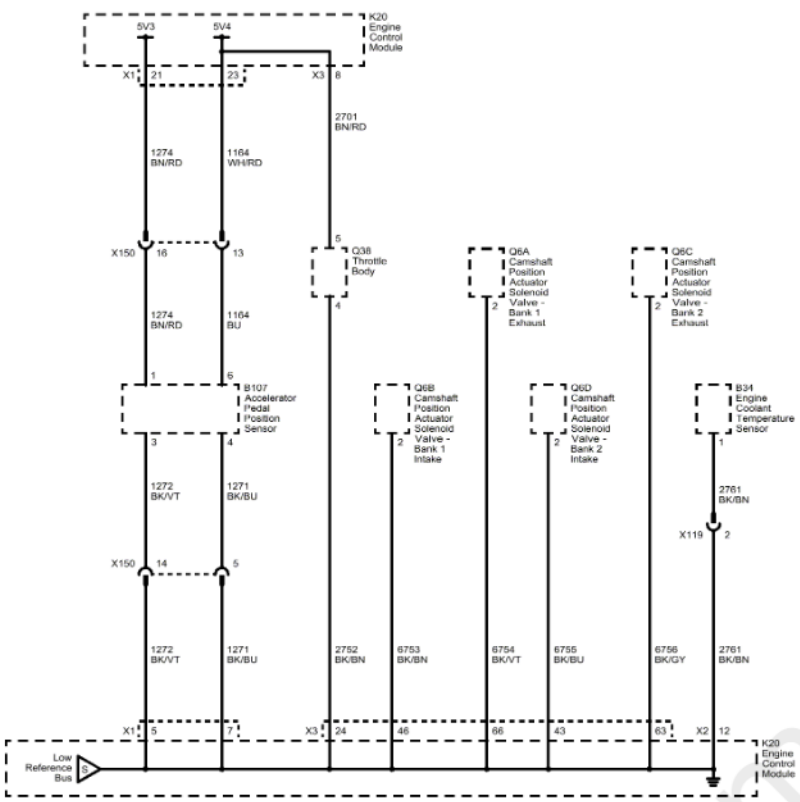

Fig. 22: 5V3, 5V4 and Low Reference Bus (3 of 3)
Courtesy of GENERAL MOTORS COMPANY

Engine Data Sensors - Pressure and Temperature

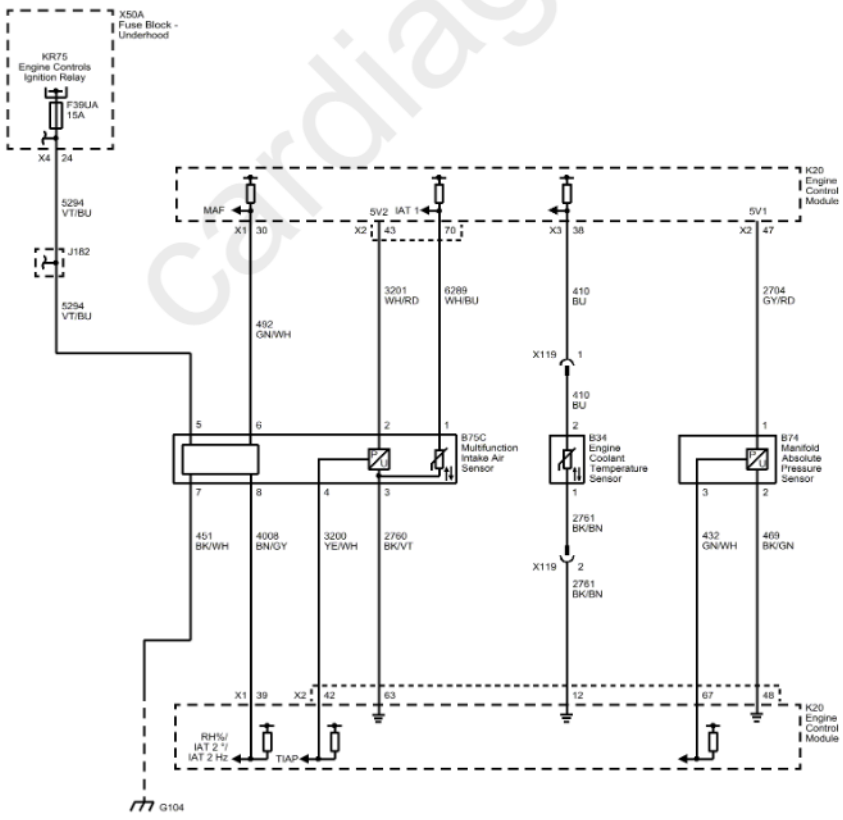

Fig. 23: Engine Data Sensors - Pressure and Temperature
Courtesy of GENERAL MOTORS COMPANY

Engine Data Sensors - Oxygen Sensors

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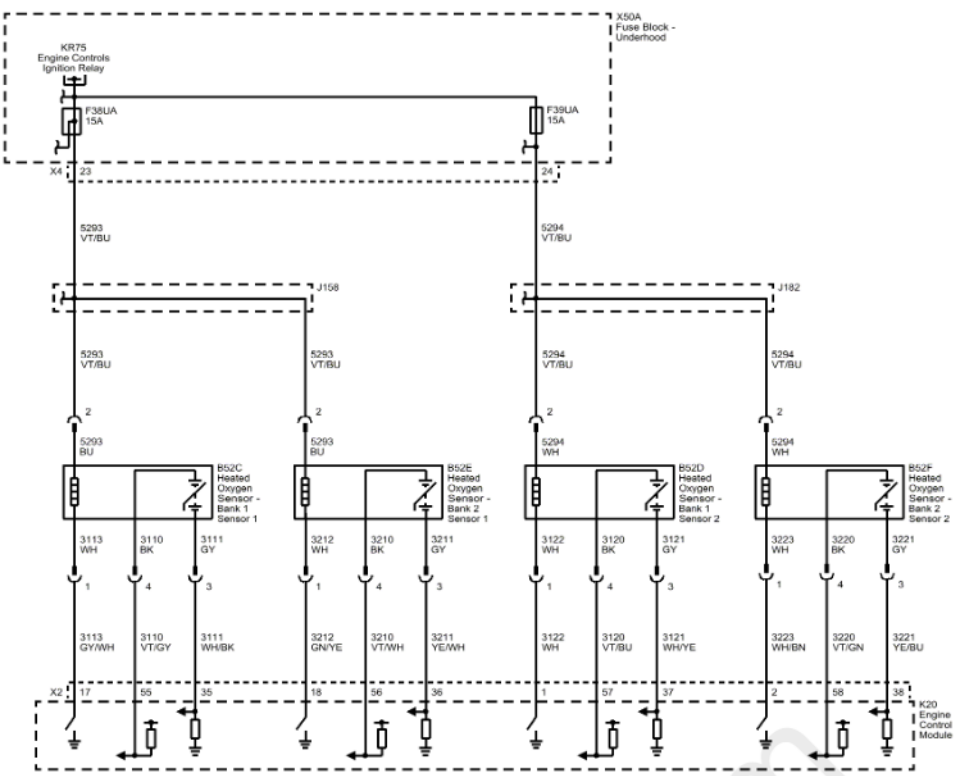

Fig. 24: Engine Data Sensors - Oxygen Sensors
Courtesy of GENERAL MOTORS COMPANY

Engine Data Sensors - Throttle Controls and Override

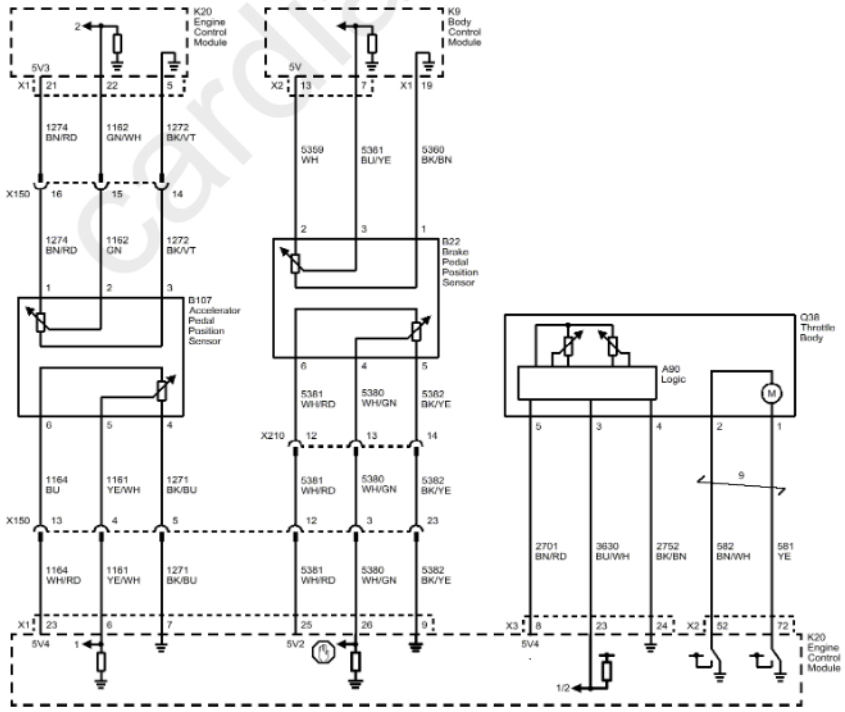

Fig. 25: Engine Data Sensors - Throttle Controls and Override
Courtesy of GENERAL MOTORS COMPANY

Ignition Controls - Ignition System Bank 1

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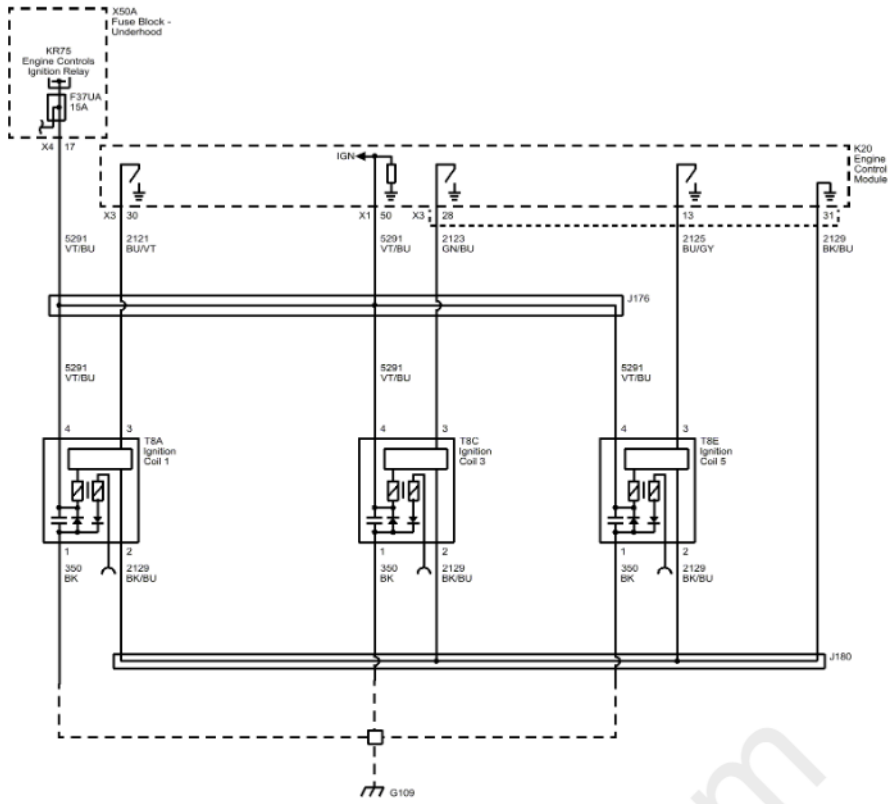

Fig. 26: Ignition Controls - Ignition System Bank 1
Courtesy of GENERAL MOTORS COMPANY

Ignition Controls - Ignition System Bank 2

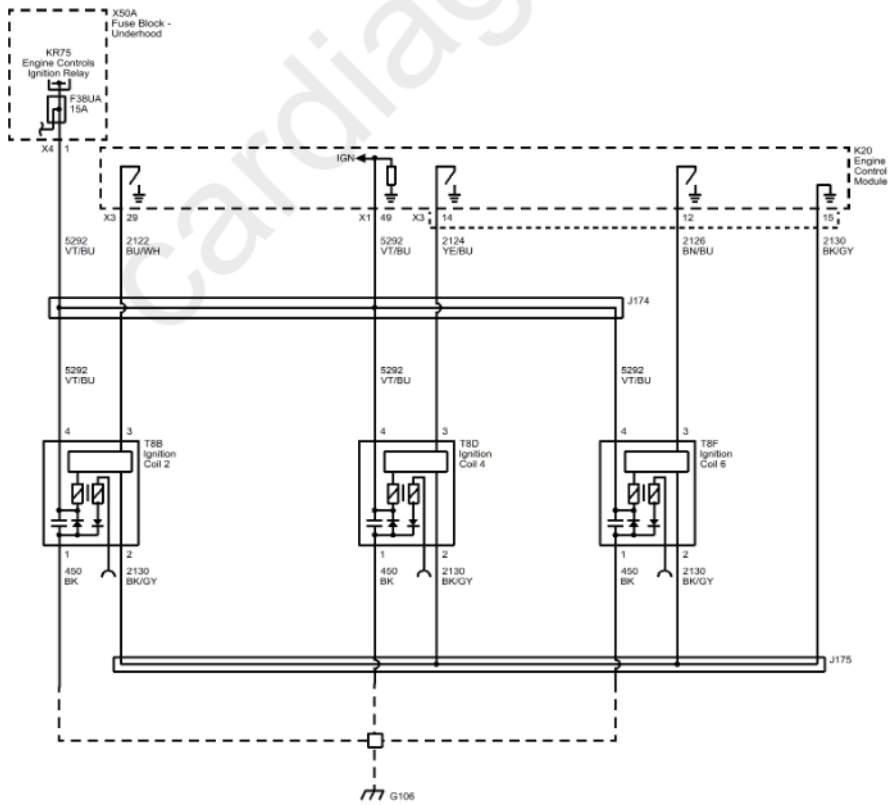

Fig. 27: Ignition Controls - Ignition System Bank 2
Courtesy of GENERAL MOTORS COMPANY

Ignition Controls - Ignition Sensors and Camshaft Actuators

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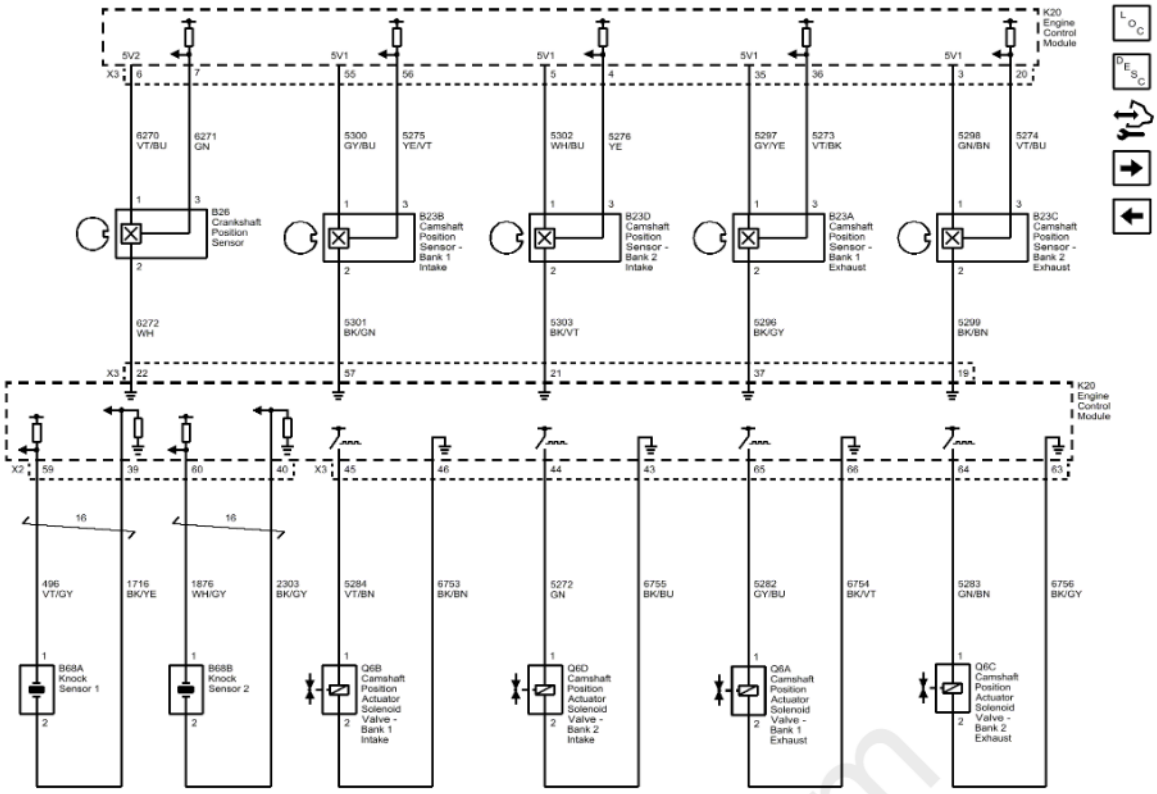

Fig. 28: Ignition Controls - Ignition Sensors and Camshaft Actuators
Courtesy of GENERAL MOTORS COMPANY

Fuel Controls - Fuel Pump Controls

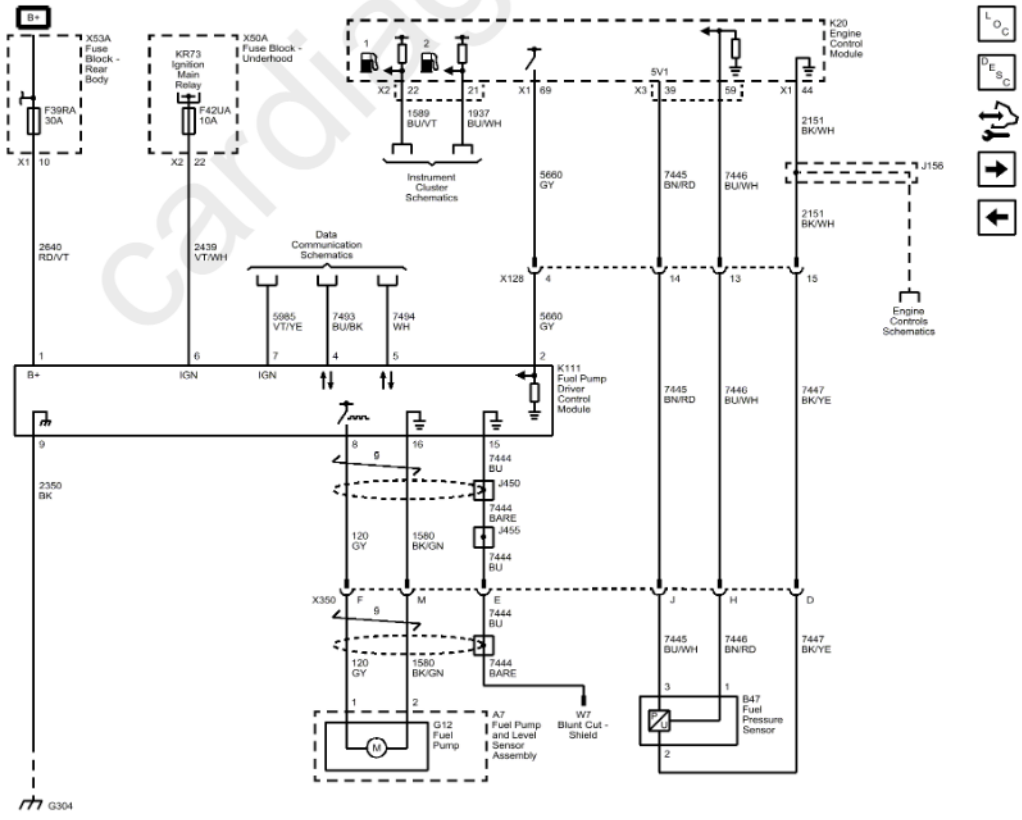

Fig. 29: Fuel Controls - Fuel Pump Controls
Courtesy of GENERAL MOTORS COMPANY

Fuel Controls - Fuel Injectors and High Pressure Control

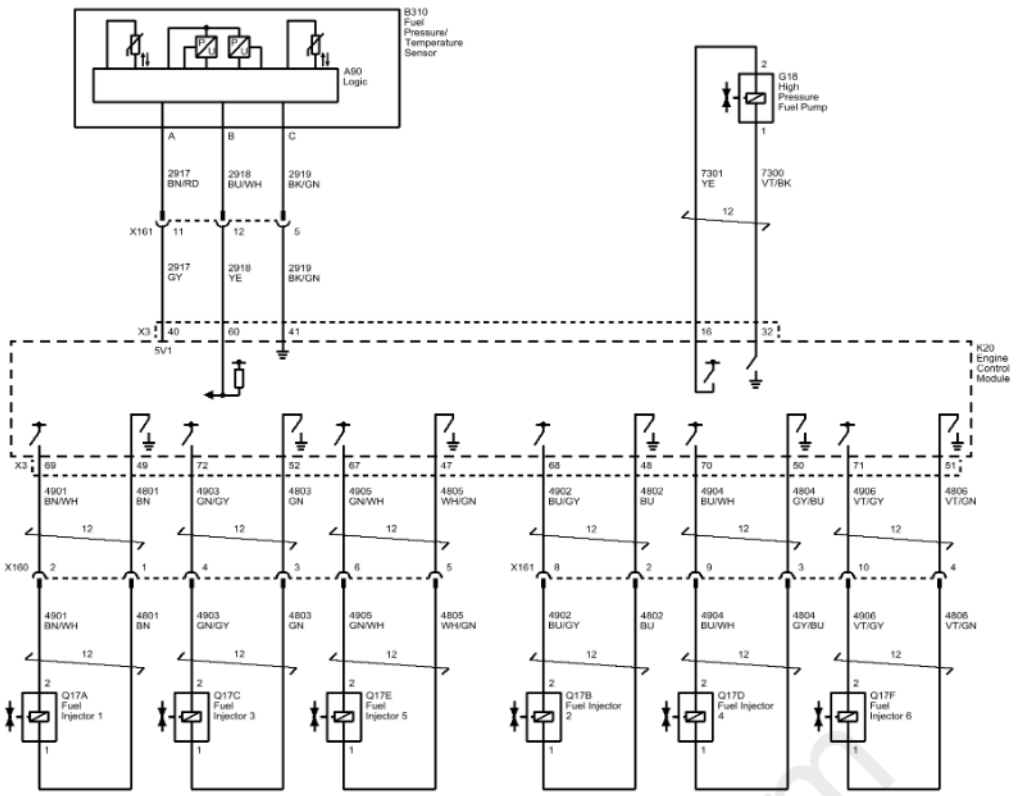

Fig. 30: Fuel Controls - Fuel Injectors and High Pressure Control
Courtesy of GENERAL MOTORS COMPANY

Fuel Controls - Evaporative Emissions Controls

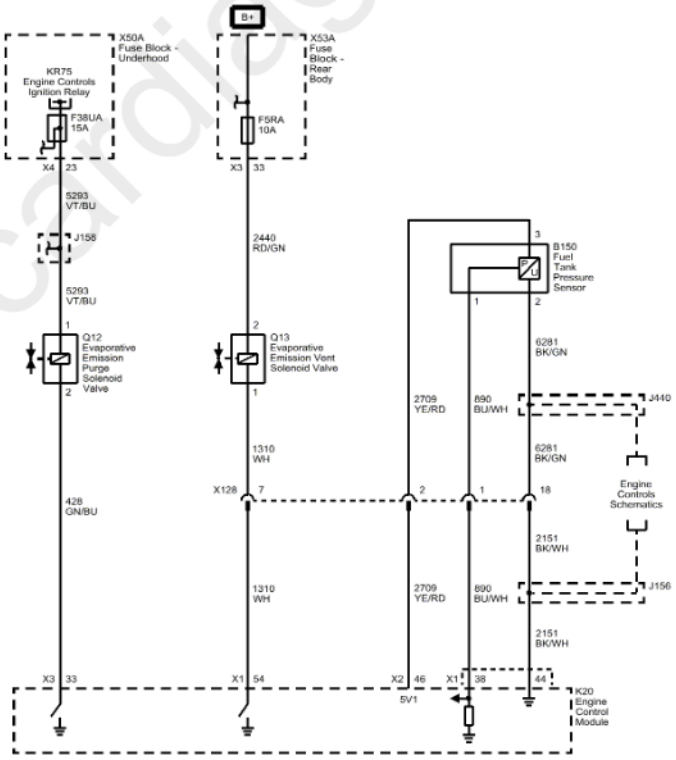

Fig. 31: Fuel Controls - Evaporative Emissions Controls
Courtesy of GENERAL MOTORS COMPANY

Device Controls - Displacement on Demand

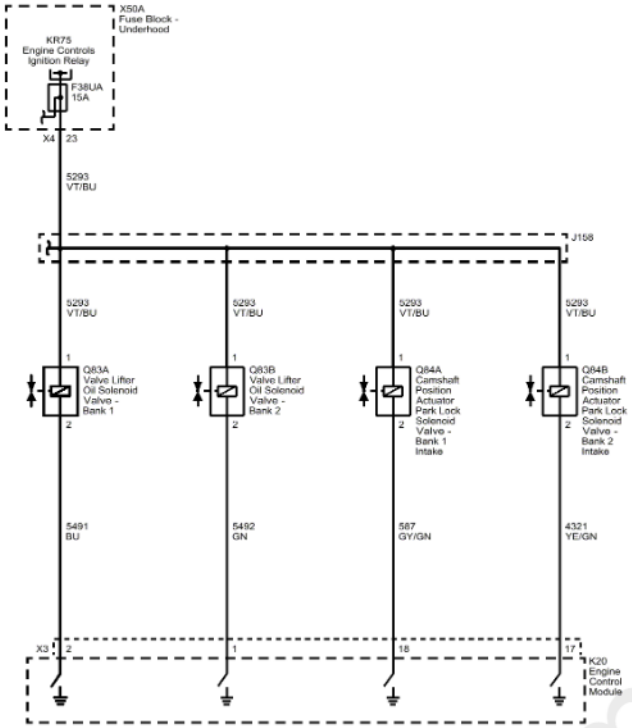

Fig. 32: Device Controls - Displacement on Demand
Courtesy of GENERAL MOTORS COMPANY

Monitored/Controlled Subsystem References

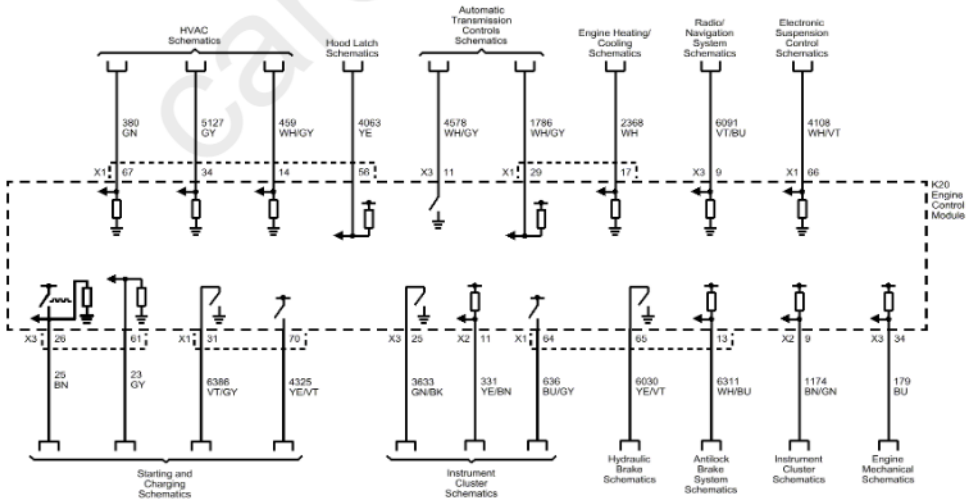

Fig. 33: Monitored/Controlled Subsystem References
Courtesy of GENERAL MOTORS COMPANY

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SPECIAL TOOLS AND EQUIPMENT

SPECIAL TOOLS (DIAGNOSTIC TOOLS)

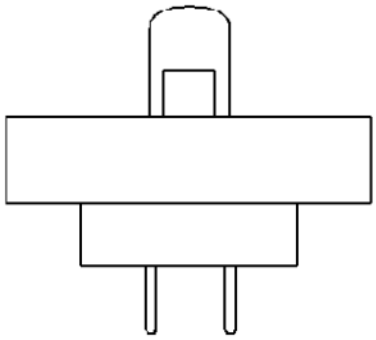
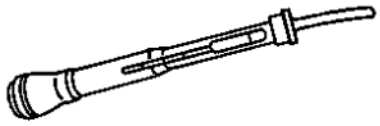
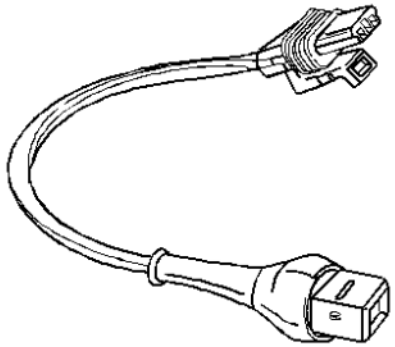
Illustration	Tool Number/Description
	CH-34730-2C J-34730-2C Injector Test Lamp
	CH-37287-1A Fuel Pressure Gauge Adapter 3/8"
	CH-38641-B J-38641-B Diesel Fuel Quality Tester
	CH-39021-301 J-39021-301 Fuel Injector Harness Adapter

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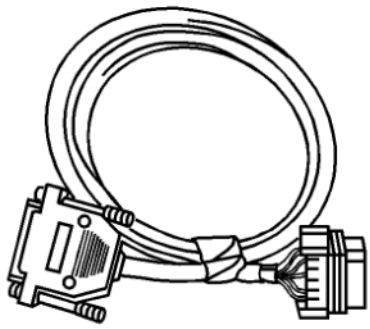
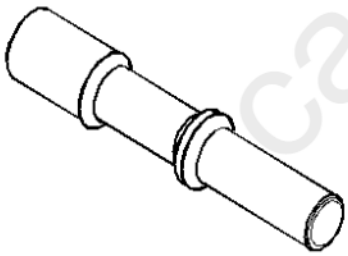
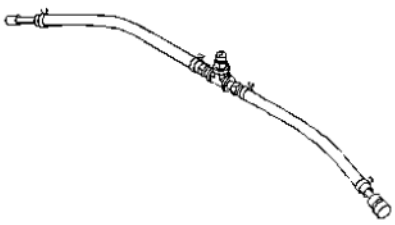
Illustration	Tool Number/Description
	CH-39021-460 J-39021-460 Fuel Injector Test Adapter
	CH-41415-30 GE-41415-30 J-41415-30 Fuel Tank Cap Adapter
	CH-41769 J-41769 Fuel Line Quick Disconnect Tool
	CH-44284-2 J-44284-2 Fuel Flapper Door Holder
	CH-42982 J-42982 Fuel Pressure Gauge Adapter

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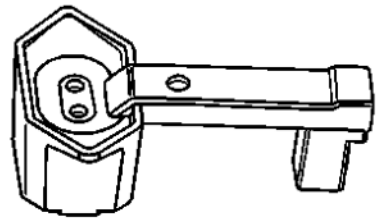
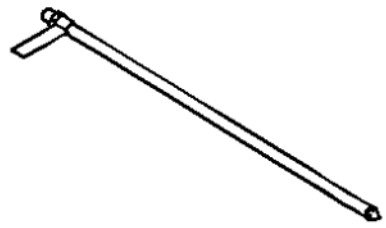
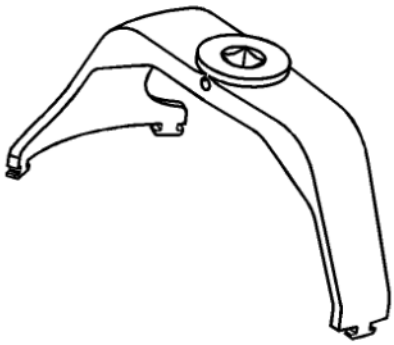
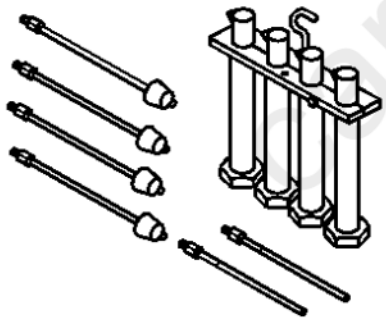
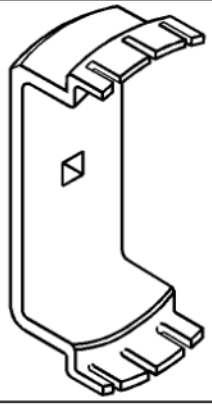
Illustration	Tool Number/Description
	CH-44175-A J-44175-A Fuel Composition Tester
	CH-45004 J-45004 Fuel Tank Drain Hose
	CH-45722 J-45722 Fuel Sender Lock Ring Wrench
	CH-45873 J-45873 Fuel Return Volume Test Kit
	CH-47717 Lock Ring Wrench

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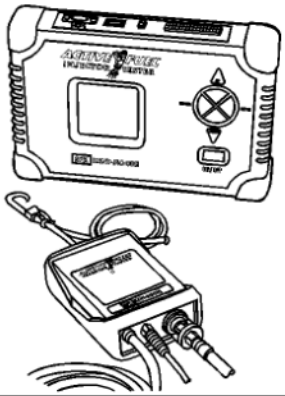
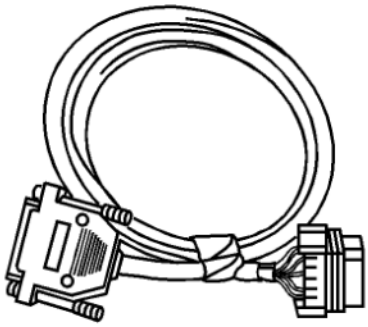
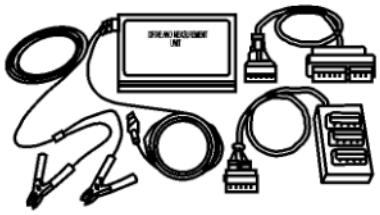
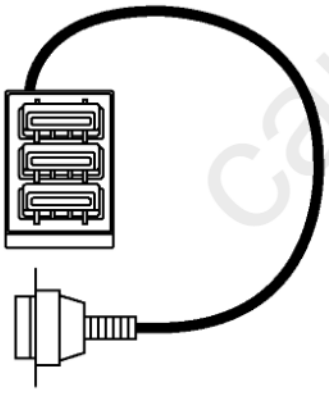
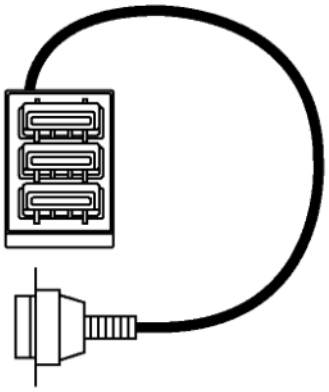
Illustration	Tool Number/Description
	CH-47976 Active Fuel Injector Tester (AFIT)
	CH-47976-75 Fuel Injector Harness Adapter
	CH-47976-500A Active Fuel Injection Tester (AFIT) SIDI Adapter Kit
	CH-47976-502A AFIT SIDI E92 G2A Adapter Cable
	CH-47976-503 AFIT SIDI E80 G3 Adapter Cable

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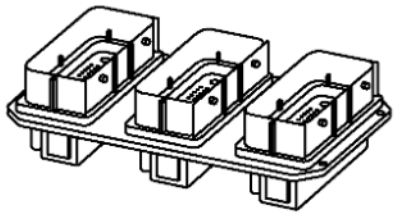
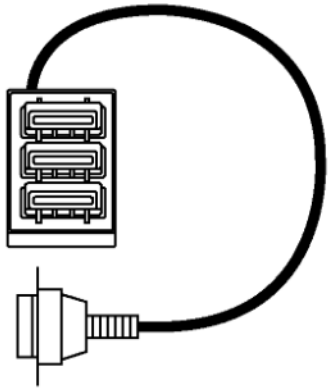
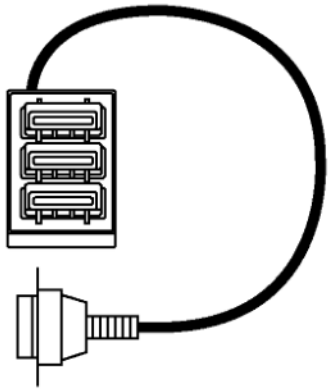
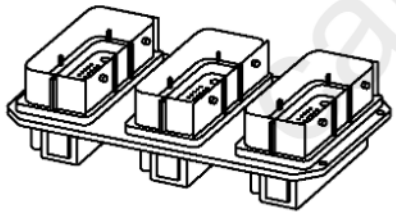
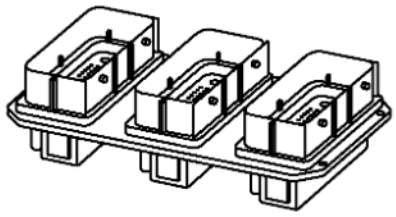
Illustration	Tool Number/Description
	CH-47976-504 E92/E39A G2B Start/Stop Adapter
	CH-47976-509 AFIT SIDI E81 G4 Adapter Cable
	CH-47976-511 AFIT SIDI E82 G5 Adapter Cable
	CH-47976-512 E80 G3B Stop/Start Adapter
	CH-47976-513 E92 G2C Stop/Start and SENT Adapter

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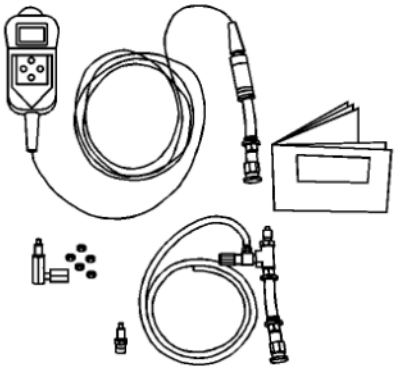
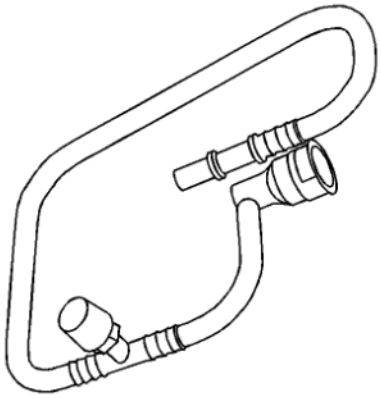
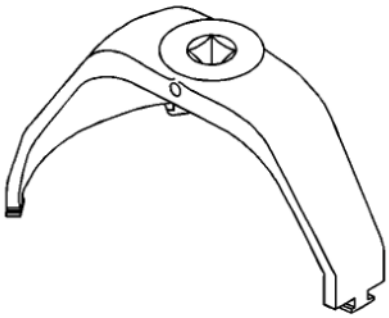
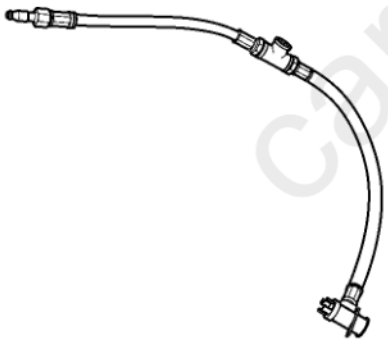
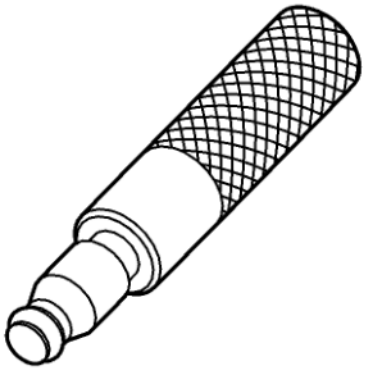
Illustration	Tool Number/Description
	CH-48027 Fuel Pressure Gauge
	CH-48096 EVAP Service Access Port Tool
	CH-48482 Fuel Sender Lock Ring Wrench
	CH-50375 Diesel Injector Return Line Pressure Adapter
	CH-50377-A Injector Return Line Cap

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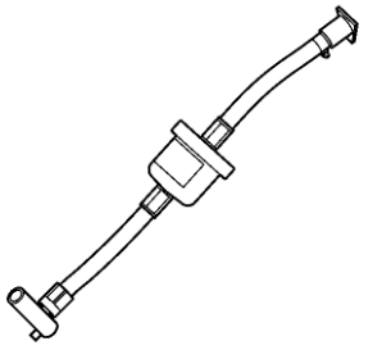
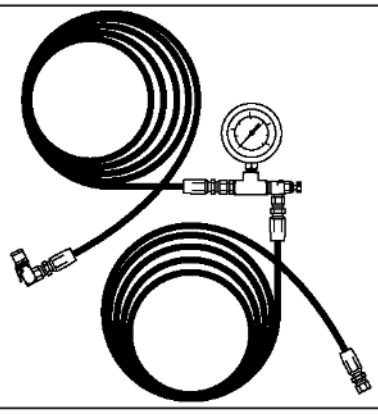
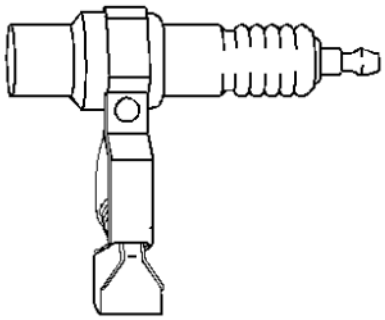
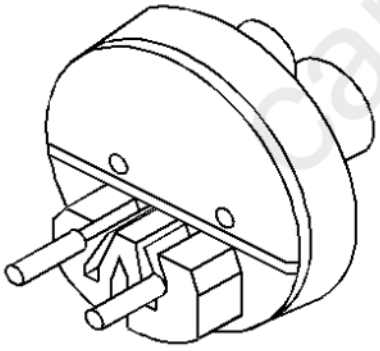
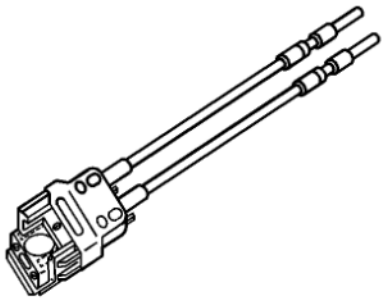
Illustration	Tool Number/Description
	CH-50378 Injector Return Leakage Test Adapter
	CH-50933 Gauge Assembly, Liquid Propane Gas (LPG)
	EL-26792 J-26792 HEI Spark Tester
	EL-34730-405 J-34730-405 Injector Test Lamp
	EL-36169-HD Heavy Duty Fused Jumper

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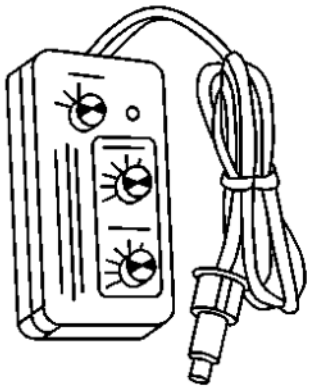
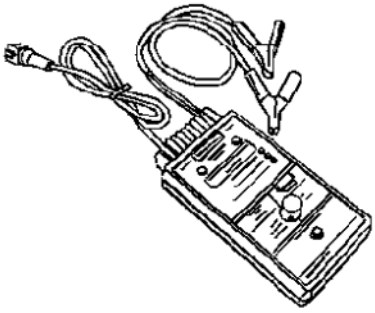
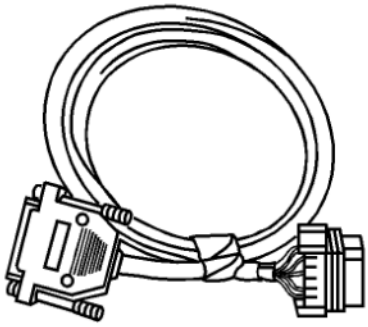
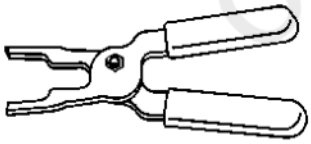
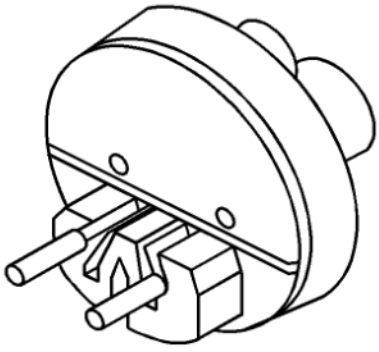
Illustration	Tool Number/Description
	EL-38522-A J-38522-A Variable Signal Generator
	EL-39021 J-39021 Fuel Injector Coil Balance Tester
	EL-39021-460 J-39021-460 Fuel Injector Test Adapter
	EL-43244 J-43244 Relay Puller Pliers
	EL-44603 J-44603 Injector Test Lamp

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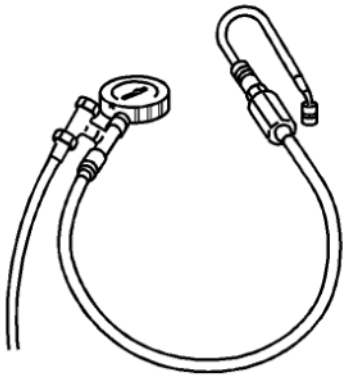
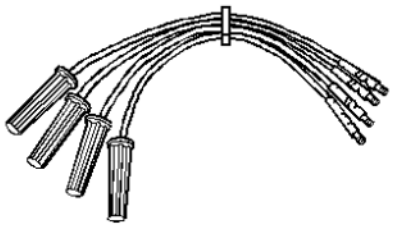
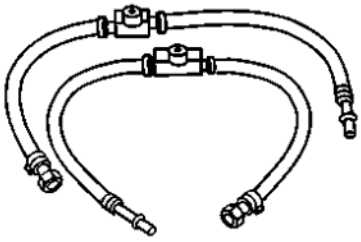
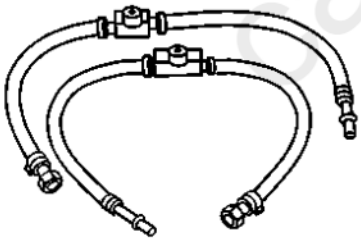
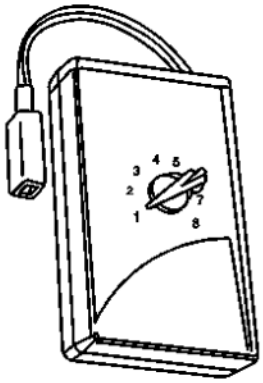
Illustration	Tool Number/Description
	EN-34730-91 J-34730-91 KM-J-34730-91 Pressure Tester
	EN-36012-A J-36012-A Ignition System Diagnosis Harness
	EN-37287 J-37287 Fuel Line Shut-off Adapters
	EN-37287-FF Fuel Line Shut-off Adapters
	EN-39021-210 J-39021-210 Injector Tester Adapter Box

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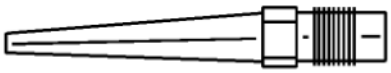
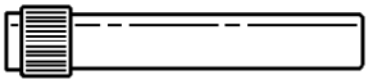
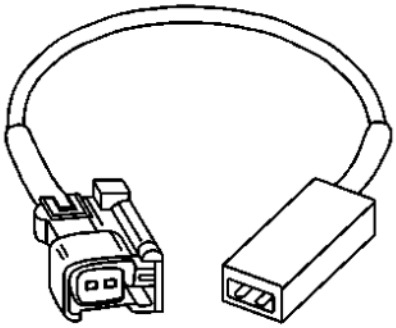
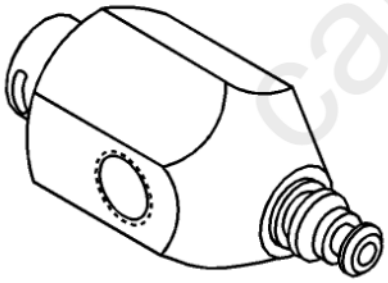
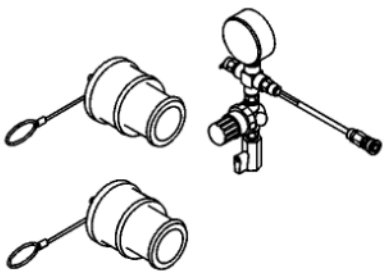
Illustration	Tool Number/Description
	EN-41413-311 J-41413-311 EVAP Plug
	EN-41413-VLV J-41413-VLV EVAP Service Port Vent Fitting
	EN-44602 J-44602 Injector Test Adapter
	EN-45873-30 J-45873-30 Injector Flow Test Adapter
	EN-46091 J-46091 Charge Air Cooler Tester

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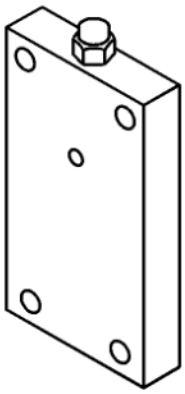
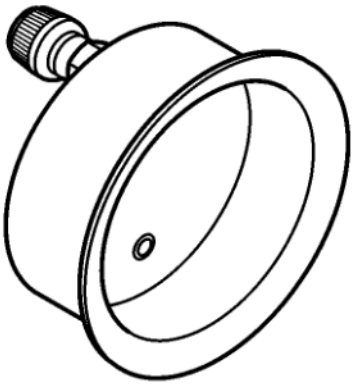
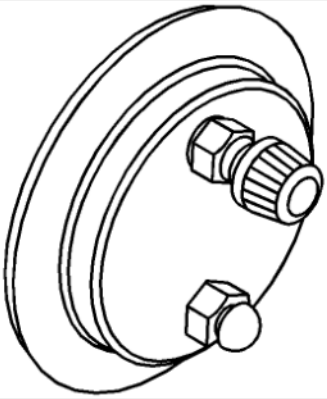
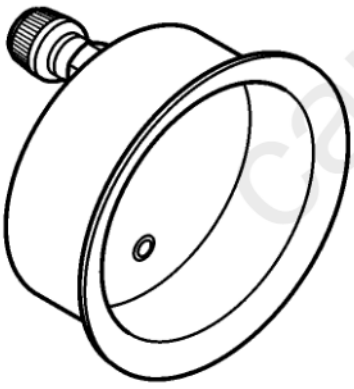
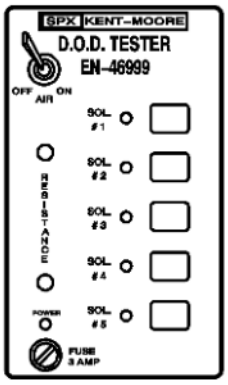
Illustration	Tool Number/Description
	EN-46091-5 J-46091-5 Charge Air Cooler Tester Adapter
	EN-46091-10A Diesel Engine Pressure Test Adapter
	EN-46091-15 J-46091-15 Engine Pressure Test Adapter
	EN-46091-15A J-46091-15A Diesel Engine Pressure Test Adapter
	EN-46999 Displacement On Demand Tester

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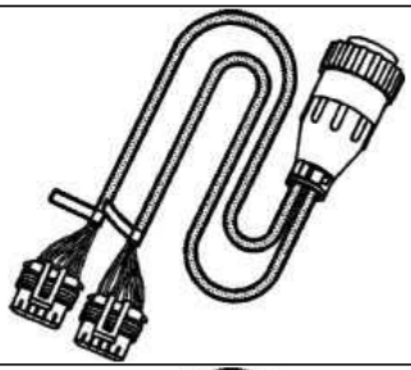
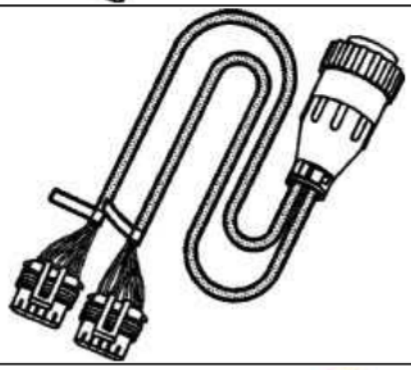
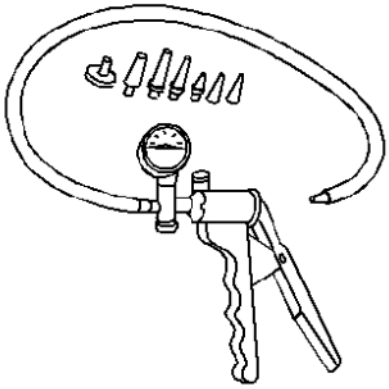
Illustration	Tool Number/Description
	EN-46999-15 Active Fuel Management Tester Harness - V6
	EN-46999-20 Active Fuel Management Tester Harness - Small Block V8
	EN-47603 Compression Gauge Adapter
	EN-47656-NA Pressure Test Plugs
	GE-23738-A J-23738-A Vacuum Pump

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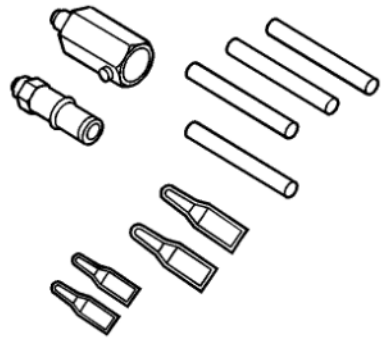
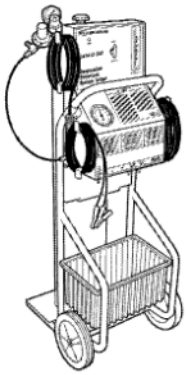
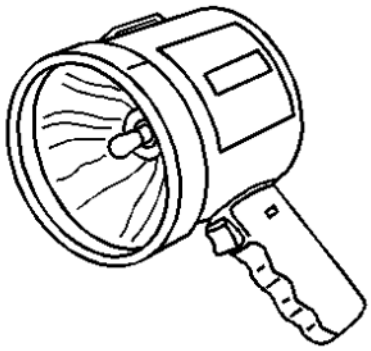
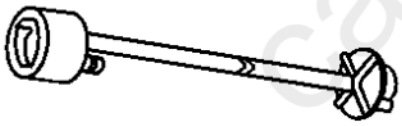
Illustration	Tool Number/Description
	GE-41413-300 EN-41413-300 J-41413-300 EVAP Cap and Plug Kit
	GE-41413-A EN-41413-A J-41413-A Evaporative Emissions System Tester (EEST)
	GE-41413-SPT J-41413-SPT High Intensity White Light
	GE-41415-50 J-41415-50 Fuel Tank Cap Adapter
	GE-41415-60 Engine Induction System Leak Test Adapter/Capless Fuel Fill Adapter

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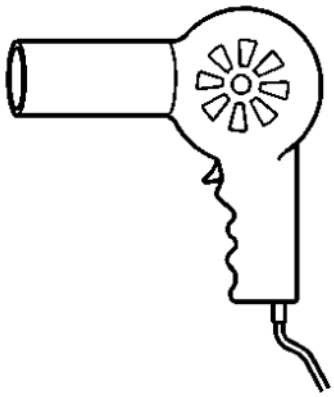
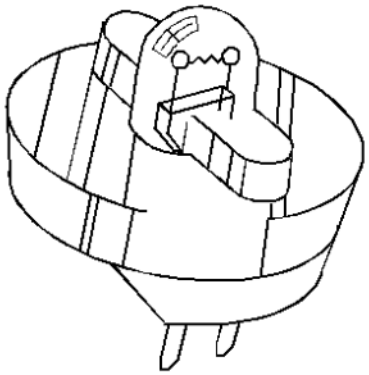
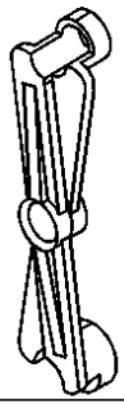
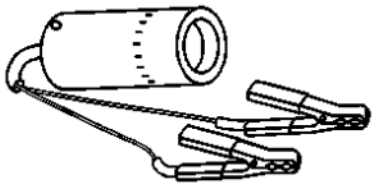
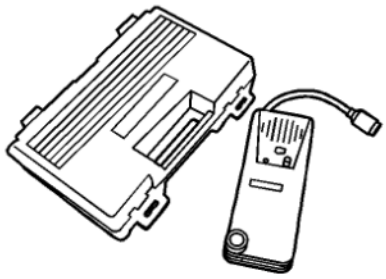
Illustration	Tool Number/Description
	J-25070 Heat Gun 260-399Â°C (500-750Â°F)
	J-34730-375 Injector Test Lamp
	J-44581 Fuel Line Disconnect Tool
	J-28428-E J 42220 CH 42220 Universal 12-Volt Leak Detection Lamp
	J-45878 Combustible Gas Detector

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SPECIAL TOOLS (MECHANICAL TOOLS)

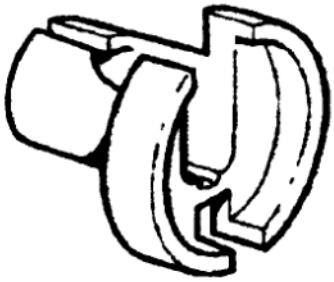
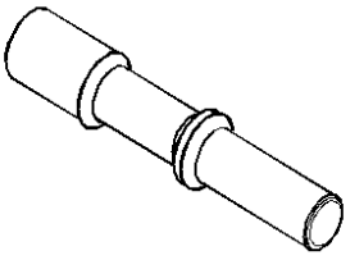
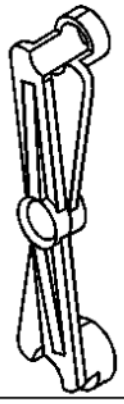
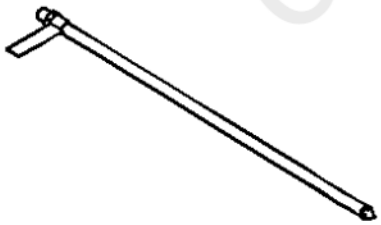
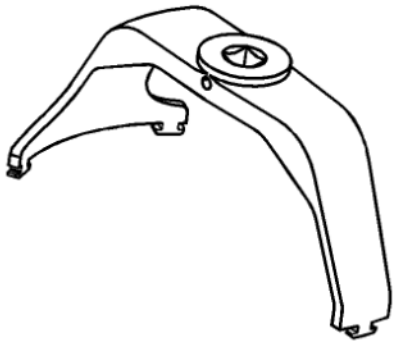
Illustration	Tool Number/Description
	CH-41769 Fuel Line Disconnect Tool Set
	CH-44284-2 Fuel Flapper Door Holder
	CH-44581 J-44581 Fuel Line Disconnect Tool
	CH-45004 Fuel Tank Drain Hose
	CH-45722 J-45722 Fuel Sender Lock Ring Wrench

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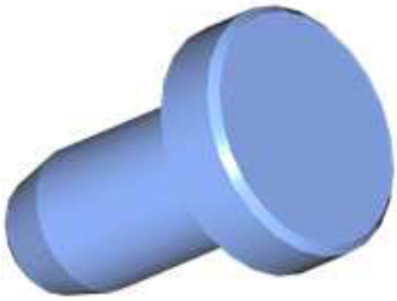
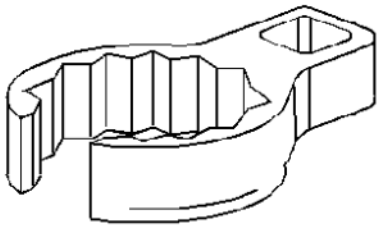
Illustration	Tool Number/Description
	EN-48896 High Pressure Fuel Pump Installation Alignment Gauge
	EN-49248 Injector Rail Assembly Remover
	J-39194 Oxygen Sensor Wrench

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SPECIFICATIONS

TEMPERATURE VERSUS RESISTANCE - ENGINE COOLANT TEMPERATURE SENSOR

Temperature	Resistance
150Â°C (302Â°F)	42 to 44 Ω
140Â°C (284Â°F)	53 to 57 Ω
130Â°C (266Â°F)	68 to 72 Ω
120Â°C (248Â°F)	88 to 92 Ω
110Â°C (230Â°F)	114 to 120 Ω
100Â°C (212Â°F)	151 to 159 Ω
90Â°C (194Â°F)	203 to 215 Ω
80Â°C (176Â°F)	275 to 293 Ω
70Â°C (158Â°F)	379 to 405 Ω
60Â°C (140Â°F)	532 to 572 Ω
50Â°C (122Â°F)	762 to 824 Ω
45Â°C (113Â°F)	921 to 997 Ω
40Â°C (104Â°F)	1118 to 1212 Ω
35Â°C (95Â°F)	1366 to 1484 Ω
30Â°C (86Â°F)	1683 to 1829 Ω
25Â°C (77Â°F)	2088 to 2266 Ω
20Â°C (68Â°F)	2608 to 2828 Ω
15Â°C (59Â°F)	3289 to 3567 Ω
10Â°C (50Â°F)	4182 to 4532 Ω
5Â°C (41Â°F)	5356 to 5800 Ω
0Â°C (32Â°F)	6914 to 7484 Ω
-5Â°C (23Â°F)	8994 to 9732 Ω
-10Â°C (14Â°F)	11796 to 12762 Ω
-15Â°C (5Â°F)	15589 to 16871 Ω
-20Â°C (-4Â°F)	20791 to 22517 Ω
-30Â°C (-22Â°F)	37991 to 41273 Ω
-40Â°C (-40Â°F)	72230 to 78834 Ω

TEMPERATURE VERSUS RESISTANCE - INTAKE AIR TEMPERATURE SENSOR (HITACHI SENSOR)

Temperature CÂ°/FÂ°	Resistance Minimum Ohms	Resistance Maximum Ohms
Hitachi Intake Air Temperature (IAT) Sensor		
-40/-40	37, 527	49, 882
-20/-4	13, 110	16, 329
-10/14	8, 145	9, 851
0/32	5, 205	6, 122
20/68	2, 298	2, 570
25/77	1, 900	2, 100
40/104	1, 073	1, 226
60/140	537	639
80/176	289	356

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

ALTITUDE VERSUS BAROMETRIC PRESSURE

Altitude Measured in Meters (m)	Altitude Measured in Feet (ft)	Barometric Pressure Measured in Kilopascals (kPa)	Barometric Pressure Measured in Pounds Per Square Inch (PSI)
Determine your altitude by contacting a local weather station or by using another reference source.			
4, 267	14, 000	56-64	8.1-9.3
3, 962	13, 000	58-66	8.4-9.6
3, 658	12, 000	61-69	8.8-10.0
3, 353	11, 000	64-72	9.3-10.4
3, 048	10, 000	66-74	9.6-10.7
2, 743	9, 000	69-77	10.0-11.2
2, 438	8, 000	71-79	10.3-11.5
2, 134	7, 000	74-82	10.7-11.9
1, 829	6, 000	77-85	11.2-12.3
1, 524	5, 000	80-88	11.6-12.8
1, 219	4, 000	83-91	12.0-13.2
914	3, 000	87-95	12.6-13.8
610	2, 000	90-98	13.1-14.2
305	1, 000	94-102	13.6-14.8
0	0 Sea Level	96-104	13.9-15.1
-305	-1, 000	101-105	14.6-15.2

IGNITION SYSTEM SPECIFICATIONS

Application	Specification

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Application	Specification
Firing Order	1-2-3-4-5-6
Spark Plug Torque	Refer to Fastener Specifications (LGW) Fastener Specifications (LGX)
Spark Plug Gap	Refer to Engine Mechanical Specifications (LGX) Engine Mechanical Specifications (LGW)
Spark Plug Type	Refer to Electronic Parts Catalog

FASTENER SPECIFICATIONS

Single Use Non-Threaded Fasteners/Components

NOTE:

All fasteners/components listed in this table MUST BE DISCARDED and replaced with NEW after removal.

Application
Camshaft Position Actuator Solenoid Valve O-Ring
Charge Air Cooler Inlet Air Tube Seal
Crankshaft Position Sensor O-Ring
Fuel Pump Gasket
Fuel Pump O-Ring
Fuel Sender Assembly O-Ring
Fuel Tank Fuel Pump Module O-Ring
Intake Air Pressure and Temperature Sensor O-Ring
Manifold Absolute Pressure Sensor O-Ring
Throttle Body Gasket
Turbocharger Air Inlet Adapter Seal
Vacuum Pump Pipe Seal
Valve Rocker Arm Oil Control Valve O-Ring

Single Use Threaded Fastener/Component Tightening Specifications

NOTE:

All fasteners/components listed in this table MUST BE DISCARDED and replaced with NEW after removal.

Application	Specification
	Metric (English)
Fuel Feed Intermediate Pipe Fitting	30 N.m (22 lb ft)
Fuel Injection Fuel Rail Fuel Pressure Sensor @ Fuel Injection Fuel Rail	33 N.m (24 lb ft)

Reusable Threaded Fastener Tightening Specifications

NOTE:

All fasteners listed in this table can be reused after removal.

Application	Specification
	Metric (English)
Accelerator Pedal Position Sensor Fastener	9 N.m (80 lb in)
Air Cleaner Outlet Front Duct Clamp	4 N.m (35 lb in)
Air Cleaner Outlet Rear Duct Clamp	4 N.m (35 lb in)
Air Cleaner Upper Housing Bolt	4 N.m (35 lb in)
Camshaft Position Actuator Locating Pin Control Valve Bolt	10 N.m (89 lb in)
Camshaft Position Actuator Solenoid Valve Bolt	10 N.m (89 lb in)

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NOTE:

All fasteners listed in this table can be reused after removal.

Application	Specification
	Metric (English)
Camshaft Position Sensor Bolt	10 N.m (89 lb in)
Charge Air Bypass Valve Hose Clamp	3.5 N.m (31 lb in)
Charge Air Bypass Valve Tube Clamp	3.5 N.m (31 lb in)
Charge Air Cooler Inlet Air Tube Bolt	9 N.m (80 lb in)
Crankshaft Position Sensor Bolt	10 N.m (89 lb in)
Engine Control Module Bracket Bolt	9 N.m (80 lb in)
Engine Control Module Bracket Nut	9 N.m (80 lb in)
Engine Coolant Temperature Sensor	9 N.m (80 lb in)
Evaporative Emission Canister Fastener	9 N.m (80 lb in)
Evaporative Emission Canister Purge Solenoid Valve Bolt	10 N.m (89 lb in)
Fuel Feed Pipe Bolt	10 N.m (89 lb in)
Fuel Injection Fuel Rail Fastener	25 N.m (18 lb ft)
Fuel Pipe Shield Bolt	9 N.m (80 lb in)
Fuel Pump Bolt	25 N.m (18 lb ft)
Fuel Pump Power Control Module Fastener	9 N.m (80 lb in)
Fuel Tank Filler Hose Clamp	4 N.m (35 lb in)
Fuel Tank Filler Pipe Bolt	9 N.m (80 lb in)
Fuel Tank Filler Pipe Shield Bolt	9 N.m (80 lb in)
Fuel Tank Strap Bolt	27 N.m (20 lb ft)
Heated Oxygen Sensor	42 N.m (31 lb ft)
Ignition Coil Bolt	10 N.m (89 lb in)
Intake Air Duct Bolt	2.5 N.m (22 lb in)
Intake Air Pressure and Temperature Sensor Bolt	4 N.m (35 lb in)
Knock Sensor Bolt	25 N.m (18 lb ft)
Manifold Absolute Pressure Sensor Fastener (LGW)	4 N.m (35 lb in)
Manifold Absolute Pressure Sensor Bolt (LGX)	7.3 N.m (65 lb in)
Mass Airflow Sensor Bolt	4 N.m (35 lb in)
Mass Airflow Sensor with Intake Air Temperature Sensor Bolt	4 N.m (35 lb in)
Oil Pump Flow Control Solenoid Valve Bolt	5 N.m (44 lb in)
Oil Pump Flow Control Solenoid Valve Harness Bolt	15 N.m (11 lb ft)
Positive Crankcase Ventilation Tube Clamp	4 N.m (35 lb in)
Spark Plug	18 N.m (13 lb ft)
Throttle Body Assembly Fastener	10 N.m (89 lb in)
Turbocharger Air Inlet Adapter Bolt	10 N.m (89 lb in)
Turbocharger Wastegate Actuator Fastener	25 N.m (18 lb ft)
Turbocharger Wastegate Actuator Vacuum Control Solenoid Valve Bracket Bolt	10 N.m (89 lb in)
Turbocharger Wastegate Actuator Vacuum Tank Bolt	9 N.m (80 lb in)
Turbocharger Wastegate Regulator Solenoid Valve Nut	9 N.m (80 lb in)
Vacuum Pump Pipe Bolt	10 N.m (89 lb in)
Valve Rocker Arm Oil Control Valve Bolt	10 N.m (89 lb in)

APPROXIMATE FLUID CAPACITIES

Application	Specification	
	Metric	English
Fuel Tank Capacity	72.7 liters	19.2 gallons

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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)
Dielectric Grease for Spark Plug Wires	Lubricant	GM P/N 19260901 (Canadian P/N 19260902)
Fuel Injection Fuel Rail Bolt	Threadlocker	GM P/N 12345382 (Canadian P/N 10953489)
High Pressure Fuel Pump Bolt	Threadlocker	GM P/N 12345382 (Canadian P/N 10953489)
Silicon Free Engine Oil	5W-30	GM P/N 19293000 (Canadian P/N 19386321)
Top Engine Cleaner	Cleaner	GM P/N 1052626 (Canadian P/N 993026)

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